THE DIFFERENTIATION AND SPECIFICITY OF STARCHES IN RELATION TO GENERA, SPECIES, ETC.

STEREOCHEMISTRY APPLIED TO PROTOPLASMIC PROCESSES AND PRODUCTS, AND AS A STRICTLY SCIENTIFIC BASIS FOR THE CLASSIFICATION OF PLANTS AND ANIMALS

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Part II.

PREFATORY NOTES.

VARIOUS FEATURES OF THE RESEARCH.

The routine laboratory studies included in Part II were made, as stated in the Introduction (page 14), by Dr. Elizabeth E. Clark and Miss Martha Bunting. The former carried out all of the observations herein recorded except those of a group comprising *Vicia, Lathyrus, Quercus, Castanea, Lilium, Tulipa, Convallaria, Amaryllis, Crinum, Sprekelia, Hæmanthus, Hymenocallis, Leucoium, Crocus, Sparaxis, Curcuma, Maranta,* and *Zamia,* together with the temperature reactions. Miss Bunting made all of the studies included in this group as well as the important determinations of the *temperatures of gelatinization.*

The methods employed in this research are described in ChapterVI (page 295), in which portion of the memoir is also explained the scheme of construction of the *Curves of Reaction-Intensities,* which constitute a very important feature of this part of the report. Additional charts of a different character, which show comparatively the reaction-intensities of all of the starches studied with each agent, a table of the temperatures of gelatinization of all of the starches, and also statements relating to the comparative values and individual peculiarities and certain other matters pertaining to these methods, will be found in Chapter VII (page 303).

According to the literature available at the inception of this investigation it seemed questionable as to what data of value in indicating stereochemic differences in different starches, different starch-grains, and parts of grains were to be gained by such gross histological investigations as were recorded especially by Fritzsche, Schleiden, and Nägeli, and by such refined methods as those pursued by Kraemer, Denniston, and others. The gross histological properties of starches have been shown to be so readily affected by various incidental conditions that starches from genera of a given family (as now constituted by the data of the systematic botanist) may have very unlike gross histological features, while on the other hand those from genera without the remotest relationship may be so much alike microscopically as to lead to the belief that they had a common plant-origin. While it seemed probable that the refined methods by which the minute structure of the starch-grain is analyzed would elicit data of importance in correlating histological and stereochemic relationships, it seemed equally likely that they would not in general yield results so valuable, on the whole, as could be obtained by other methods far less exacting in technical skill and time. Hence, the histological examinations have been limited to the grosser characters of the grains, with especial reference to their application to the sciences, arts, and trades. It would have been well worth the time and labor, as was discovered rather late in the research, had these examinations been carried out *in extenso*, because there are very many more or less inconspicuous characteristics pertaining to the form of the grain, the size and form and exact location of the hilum, the fissuration, the primary lamellæ, the positions and the general and special characters of the secondary lamellæ, the characters of the grains as regards isolation and aggregation and compoundness, etc., which are of undoubted importance not only in the identification of the source of the starch but also in expressing biological peculiarities of the starch-forming plastids, and hence of the peculiar constitutional form of the starch.

HISTOLOGICAL AND STEREOCHEMIC TYPES.

Notwithstanding the very superficial character of the records included under *Histological Characteristics*, it will be found that definite relationships can be traced between the histology of the starch-grain and the curve of reaction-intensity, or in other words between histological type and stereochemic type. Thus, in the starch of a member of a given genus (such as *Convallaria*, page 616), having two entirely different types of starch-grains, there are corresponding differences in the types of reaction-intensities. The starches obtained from members of a genus, such as *Lilium* (page 474), have the same histological and reaction types; likewise starches from closely related genera, such as those of the tribe *Tulipeæ* (page 613), have histological and reaction types which are in entire harmony. On the other hand, where starches of the same gross histological type occur in genera of unrelated families, as in *Arum* (plate 13, fig. 77, chart 92), *Colchicum* (plate 51, fig. 301, chart 206), and *Crocus* (plate 75, fig. 441, chart 289), or as in *Canna* (plate 83, fig. 497, chart 338) and *Solanum* (plate 100, fig. 595, chart 389), the reaction curves are so different that the starches could not be confounded, although histologically it might be difficult to differentiate one positively from the other.

Moreover, when grains of the same histological type are found in different genera which at present are assigned by the systematic botanist to a given family, as *Tigridia* (plate 68, fig. 405, chart 306) and *Gladiolus* (plate 68, fig. 407, chart 307), both of which are classed among the *Iridaceæ*, the reaction-curves may exhibit such marked differences as to indicate misclassification on the part of the one, if there is a correspondence of one with the family prototype, which we assume to be that of *Iris*.

Then again, when starches of different genera of a family, as constituted upon the data of the systematic botanist, exhibit different histological types, as in *Aroideæ*, where the *Dieffenbachia* type is entirely different from that common to *Arum*, *Arisæma*, *Dracunculus*, and *Richardia*, corresponding differences may not be found in the reaction types, there being merely a modification of a family prototype, so that the erratic form of the *Dieffenbachia* grain is an expression more of differences in incidental conditions than of the constitution of the plastids and the starch.

It will also be noticed that in a given family, such as *Iridaceæ,* there may be represented among the various genera many entirely different types of starch-grains, with generally corresponding differences in the types of the reaction curves, as is represented for instance in *Iris* (plates 63 to 67, figs. 373 to 397, chart 303) and *Freesia* (plate 73, figs. 433 and 435, chart 310), in which both histological and reaction types indicate an absence of generic relationship and suggest that *Freesia* should not be classed with *Iris* (see Chapter VIII, page 340). Such instances as the latter are of frequent occurrence, not only among *Iridaceæ* but also throughout the research. Owing to the generally tentative character of botanical classification and the very limited range and preliminary nature of this research further consideration of the problem of correct classification must be postponed.

QUANTITATIVE AND QUALITATIVE METHODS.

The methods used in this investigation are both *quantitative* and *qualitative,* and in effect chiefly the former, although considerable and even disproportionate time and space have been given to the latter. The greater importance associated with the quantitative side is, however, not to be taken as a measure of its relative value, but as an indication of conditions which at the inception of the work misled to the belief that comparatively little was to be gained by the strictly qualitative method unless the studies were carried out to a degree of refinement that seemed absolutely prohibitory in a preliminary investigation of such scope as that of the present. In all of the experiments, except a few with the latest starches studied, very little attention was given to qualitative phenomena beyond the grossest kinds of observations, and even in the latter really not more than is sufficient to indicate how much is available by detailed examinations. Thus, in comparing the records generally with those of the group made by Miss Bunting (which represent the later work) it will be found that phenomena are recorded in the latter which have not had corresponding notice in the former. Subsequent to the completion of this report investigations have been made with a number of starches in very much more detail, especially with starches from closely related species and varieties, and particularly with the chemical reagents, with the result of finding qualitative variations which often are of considerable importance, especially in the differentiation and grouping of members of a genus.

In the studies of each genus the qualitative reactions of each reagent with one representative of that genus was taken as a type, and when the term "qualitatively the same," or a synonymous expression, is recorded it is intended to signify that the reactions qualitatively are of the same *generic type,* and not to imply that there are not finer differences that may be expressive of individualities of species and varieties. In fact, as intimated, such differences can in most cases be made out without difficulty, and oftentimes of a surprisingly distinctive character. Occasionally, in a given reaction of a given starch, phenomena will be noted which were not found in others of the same genus, or they may be variations from the generic type, but such records are so sporadic and the observations generally so superficial that it was not deemed advisable to attempt the presentation of the qualitative peculiarities in tabular form, as was done with the quantitative records. A few, however, have systematically been included in the quantitative tables. The qualitative observations, notwithstanding their superficial and generally very inadequate character, will nevertheless be found to be very valuable in a number of directions: for instance, in showing differences in the characters of the starch of the capsular and intracapsular parts of a given grain, a given starch, and different starches; general relationships between the type of grain and the type of qualitative reaction with each chemical reagent; the lack of uniformity of composition of different lamellæ, and of primary and secondary lamellæ and other deposits at different periods; and the existence of more or less pronounced generic types of reaction.

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PART II.

THE DIFFERENTIATION AND SPECIFICITY OF STARCHES.

IN RELATION TO

CERTAIN CLASSES, ORDERS, FAMILIES, GENERA, SPECIES, VARIETIES, AND HORTICULTURAL FORMS.

THE STARCHES.

STARCHES OF GRAMINACEÆ.

Class, Monocotyledones. Order, Graminales. Family, Graminaceæ. Genera represented: Zea, Andropogon, Panicum, Oryza, Triticum, Secale, Hordeum, Avena, Arrhenatherum.

The Graminaceæ make up an enormous family, including about 300 genera and 3,000 species, and comprises not only the various grasses which serve as the main or sole food of graminivorous animals, but also the cereals which constitute, directly or indirectly, the most important single class of plant foodstuffs consumed by man. Representatives of nine of these genera were studied.

GENUS ZEA.

The genus *Zea*, as now limited, is founded on the single polymorphous cultivated species *Z. mays*, whose place of origin is probably Mexico and whose parentage is still a matter of speculation. According to some authors, it is a true species of an unknown wild prototype; others regard it as an offshoot of *Euchlæna mexicana* Schrad. (teosinte); and others as a hybrid of *E. mexicana* with some unknown species or variety. The varieties or horticultural forms are quite numerous; they have been classified by Sturtevant (U. S. Dept. Agriculture, Office Experiment Stations Bulletin 57, 1899) into seven "species groups" in accordance with peculiarities of the ears and kernels: (1) *Z. tunicata*, the pod corns; (2) *Z. everta*, the pop corns; (3) *Z. indurata*, the flint corns; (4) *Z. indentata*, the dent corns; (5) *Z. amylacea*, the soft corns; (6) *Z. saccharata*, the sweet corns; and (7) *Z. amylea-saccharata*, the starchy sweet corns, of which latter very little is known.

According to Sturtevant's data, in the species group *Zea mays* var. *tunicata* (*Z. mays tunicata* Sturtevant) "each kernel is inclosed in a pod or husks, and the ear thus formed is inclosed in husks." The species group *Z. mays* var. *everta* "is characterized by an excessive proportion of the corneous endosperm and the small size of the kernels and ear. The best varieties have a corneous endosperm throughout. This gives the property of popping, which is the complete eversion or turning inside out of the kernel through the explosion of the contained moisture on the application of heat. A small deposit of starchy endosperm does not greatly interfere with this property of popping, but when the starch endosperm is in excess, as in flint corn, the kernel does not evert, but the corneous portion only explodes or splits, leaving the starchy portion unchanged." *Z. mays* var. *indurata* is recognized by "the occurrence of a starchy endosperm inclosed in a corneous endosperm, as shown in the split seed. The corneous endosperm varies in thickness with varieties. When very thin at the summit of the kernel the shrinkage of the starchy endosperm may cause a depression, thus simulating externally a dent from which its structure at once differentiates it." The group *Z. mays* var. *indentata* is "recognized by the presence of corneous endosperm at the sides of the kernel, the starchy endosperm extending to the summit. By drying and shrinkage of the starch matter the summit of the kernel is drawn in or together, and indented in various forms. In different varieties the corneous endosperm varies in height and thickness, thus determining the character of the indented surface." The group *Z. mays* var. *amylacea* "is recognized by the absence of corneous endosperm. Through the uniformity of the shrinkage in ripening there is usually no indentation, yet in some varieties an indentation may more or less frequently disappear, but splitting the kernel invariably determines the class." *Z. mays* var. *saccharata* "is characterized by the translucent, horny appearance of the kernels and their more or less crinkled, wrinkled or shriveled condition."

In *Z. mays* var. *amylea-saccharata* "the external appearance of the grain is that of a sweet, but examination shows that the lower half of the kernel is starchy, the upper half horny and translucent." East has recently pointed out (Science, 1909, XXIX, 465) that the "sweet corn varieties do not belong to a unit group, but consist both of dent corns and of flint corns which have lost their original starch-forming power." It is of interest to note that it has been shown by Correns (Bibliotheca Botanica, 1901; quoted by East) that the presence or absence of the starch-forming property acts as an independent character pair in inheritance.

The specimens of starch studied in this research fall, according to the foregoing data, under the following heads:

Z. mays var. *everta* (Golden Queen and White Rice).
Z. mays var. *indurata* (North Dakota, and Compton's Early).
Z. mays var. *indentata* (Early Leaming, and Hickory King).
Z. mays var. *saccharata* (Stowell's Evergreen, a *dent* sweet corn; and Black Mexican and Golden Bantam, both *flint* sweet corns).

STARCH OF ZEA MAYS VAR. EVERTA (GOLDEN QUEEN). (Plate 1, figs. 1 and 2. Chart 1.)

Histological Characteristics.—In *form* all of the grains are simple and isolated, with the exception of components of a few small aggregates and many clumps. The grains are more or less angular, owing to mutual pressure, and many have three or four or more pressure facets. The surface is usually irregular owing to the pressure facets. The conspicuous forms are polygonal, with sharp or rounded angles, usually 4- to 6-sided; oval, round to nearly round, both sometimes faceted. There are some ovoid, hemispherical, and triangular forms.

The *hilum*, when it can be made out, appears either as a small or large, usually centric or occasionally slightly eccentric, round or irregularly shaped cavity which in most grains has radiating from it three small, regular, narrow fissures. The presence of the cavity may be due to the beginning of gelatinization caused by the heat of grinding the seeds. In many of the grains extensive and irregular fissures nearly divide the grain into two or more pieces.

The *lamellæ* are not demonstrable.

The *size* varies from the smaller, which are 4 by 4μ, to the larger, which are 18 by 18μ or 18 by 14μ in length and breadth. The common size is 12μ.

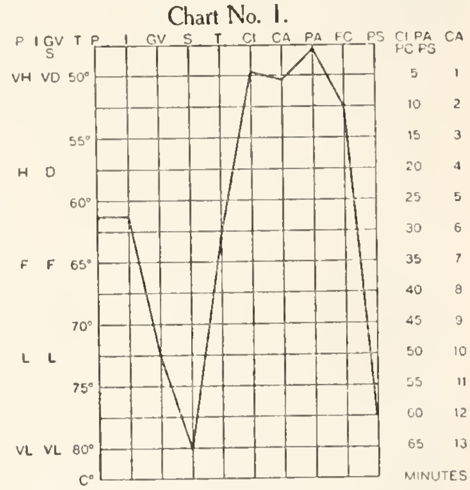
Polariscopic Properties.—The *figure* is usually centric, distinct, fairly clear-cut, and usually regular. The lines are generally straight and at right angles.

The degree of *polarization* is fairly high. It varies somewhat in different grains, but not much in different aspects of the same grain.

With *selenite* the quadrants are generally well defined, irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution, the grains all color a fair violet; with a 0.125 per cent solution they color lightly, and the shade does not deepen rapidly. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules become a reddish-violet color with an excess of iodine.

Chart No. 1.



Curve of Reaction-Intensities of Starch of Zea mays var. everta (Golden Queen).

Staining Reactions.—When viewed in masses, the grains show a slight tint of violet at once with *gentian violet.* After remaining in the solution for 30 minutes they are lightly and unevenly stained.

With *safranin* the grains, when viewed in masses, show a slight tint of pink at once. After remaining in the solution for 30 minutes they are very lightly and unevenly stained. The color is generally deeper at the hilum or the fissures at this point.

Temperature Reaction.—The temperature of gelatinization is 62.5° to 64° C., mean 63.25°.

Effects of Various Reagents.—The grains begin to react at once with *chloral hydrate-iodine.* Most are gelatinized in 30 seconds and all in 4 minutes. The grains color an old-rose at once, and a dark spot or line appears at the hilum. The color deepens at one or more points on the margin and spreads towards the hilum, around which a lighter area persists for some time; finally, the entire grain is colored a deep purple, the area around the hilum having a slightly lighter tint. During gelatinization the swelling is usually uniform, so that the gelatinized grain commonly retains the general shape of the untreated grain.

The grains begin to react at once with *chromic acid.* A few are dissolved in 20 seconds and all in 75 seconds. The starch around the hilum becomes clear, and delicate striæ radiate from this central mass. The grain swells uniformly and gradually becomes gelatinized. The envelope is finally ruptured, and with the extruded contents is completely dissolved.

The reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 20 seconds and all in 35 seconds. The hilum appears as a clear spot, or a deep fissure at this point becomes clearly marked. The clear space around the hilum enlarges, and fine striæ radiate from this central mass towards the margin. The grain swells uniformly, and the starch-substance, with exception of the capsule and possibly an outermost lamellar layer, becomes entirely gelatinized. The gelatinized grain is slightly wrinkled, but it retains the general shape of the untreated grain.

With *ferric chloride* the reaction begins at once. A few grains are gelatinized in a minute, most in 4 minutes, and all in 10 minutes. The hilum, or the cleft at this point, becomes very distinct. The hilum or cleft enlarges, a bubble is formed, and fine striæ radiate from hilum or cleft or from the gelatinized portion around the hilum towards the margin. The grain swells, the bubble collapses, there is an invagination at one end, and all of the grain becomes gelatinized, with the exception, apparently, of a marginal layer and a few refractive granules. Sometimes an irregular striated border of more clearly defined lamellæ appears, which may be ruptured at one or more points, and the grain then swells rapidly at these places. Gelatinization proceeds until the entire grain is involved. The gelatinized grain is swollen and somewhat irregular in shape, but retains in general the form of the untreated grain.

The reaction begins at once with *Purdy's solution.* A few grains are gelatinized in a minute and about one-third in 30 minutes, and there is little further reaction in an hour. The hilum or the cleft at this point becomes more distinct, and usually two and sometimes three or four clear, prominent lines, as well as numerous fine striæ, pass from the hilum or cleft towards the margin. The lamellæ become sharply defined and the grain swells, but there is no further change in most of the grains even when kept under observation for 30 minutes. In a few grains in which gelatinization is practically completed the space around the hilum gradually clears until the entire grain is gelatinized; or if there is a cleft at the hilum with three or more deep, radiating fissures, the solution of the two proceeds along their course. When the cleft at the hilum is very deep a bubble is sometimes formed here which increases in size with the swelling of the grain and then suddenly collapses. The gelatinized grains are swollen, but retain in general the shape of the untreated grain.

STARCH OF ZEA MAYS VAR. EVERTA (WHITE RICE). (Plate 1, figs. 1 and 2. Chart 2.)

Histological Characteristics.—In *form* the grains are simple and isolated, excepting a few that occur in small aggregates and clumps. The surface of the grains is generally irregular, owing to pressure facets. The conspicuous forms are the polygonal, with sharp or rounded angles, and having usually four or five facets; the oval, and the round or nearly round, both sometimes faceted. There are also some ovoid, triangular, and hemispherical grains. There are usually one or more pressure facets on each of the grains.

The *hilum,* when not fissured, may appear as a small or rather large round spot or cavity, which is usually centric or slightly eccentric. It is generally fissured, and commonly there is an arrangement of three rather small, narrow, regular fissures extending from a central cavity. There are grains which are nearly divided into two or more pieces by large, deep, irregular fissures.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 17 by 16μ. The common size is 12μ.

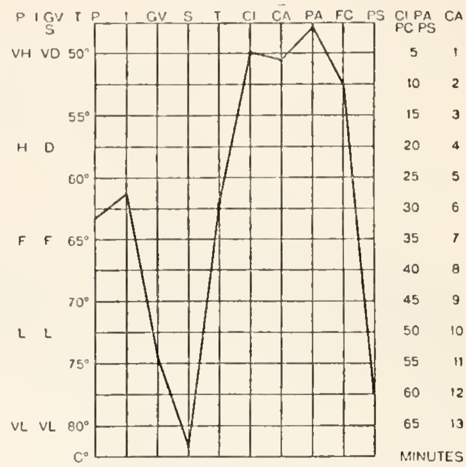
Polariscopic Properties.—The *figure* is usually eccentric, distinct, and generally clear-cut. In some of the grains the lines grow broader and less well defined at the margin. They are commonly straight and at right angles to one another.

The degree of *polarization* is fairly high. It varies somewhat in different grains, but not much in different aspects of the same grain. It is slightly less than that of the grains of Golden Queen.

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are generally pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fair violet; with a 0.125 per cent solution they color lightly. The depth of color is the same as that of the grains of Golden Queen. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color a red-violet with an excess of iodine.

Chart No. 2.



Curve of Reaction-Intensities of Starch of Zea mays var. everta (White Rice).

Staining Reactions.—The grains when viewed in masses show a slight tint of violet with *gentian violet.* After remaining in the solution for 30 minutes they are lightly and unevenly stained. The color is rather lighter than in Golden Queen.

With *safranin* the grains, when viewed in masses, show a slight tint of pink at once. After remaining in the solution for 30 minutes they are very lightly and unevenly stained. The color is lighter than in Golden Queen.

Temperature Reaction.—The temperature of gelatinization is 61.5° to 63° C., mean 62.25°.

Effects of Various Reagents.—The grains begin to react at once with *chloral hydrate-iodine.* Most are gelatinized in a minute and all in 5 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction with *chromic acid* begins at once. A few grains are dissolved in 25 seconds and all in 80 seconds. The reaction is qualitatively the same as in Golden Queen.

With *pyrogallic acid* the reaction begins at once. A few grains are gelatinized in 25 seconds and all in 45 seconds. A bubble is sometimes formed at the hilum. The reaction is qualitatively the same as in Golden Queen.

The grains begin to react at once with *ferric chloride.* A few grains are gelatinized in 1 minute, most in 3½ minutes, and all in 10 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction with *Purdy's solution* begins at once. A few grains are gelatinized in 1½ minutes and about one-third in 30 minutes. There was little further reaction in an hour. The reaction is qualitatively the same as in Golden Queen.

STARCH OF ZEA MAYS VAR. INDURATA (NORTH DAKOTA). (Plate 1, figs. 1 and 2. Chart 3.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few in aggregates and clumps. The surface of the grains is generally very irregular, owing to the variations in size, position, and number of the pressure facets. The conspicuous forms are the polygonal with four to six facets. There are also round or nearly round, ovoid, hemispherical, triangular forms with much-rounded angles and various irregular forms.

The *hilum* is a small round spot or irregularly shaped cavity, usually centric. There is commonly present at the hilum three fissures which radiate from a central cavity. In some grains there is one fissure, and in a few there is a very extensive deep and irregular fissuring.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smallest, which are from 2 by 2μ, to the largest, which are 22 by 16μ and 20 by 20μ. The common size is 12μ.

Polariscopic Properties.—The *figure* is usually centric, distinct, and for the most part clear-cut, and generally regular. The lines composing it are sometimes slightly curved and generally at right angles to one another.

The degree of *polarization* is fairly high. It varies somewhat in different grains, but not in different aspects of the same grain. It is slightly higher than in Golden Queen.

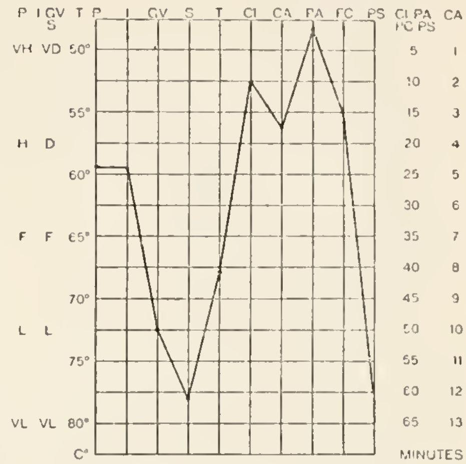
With *selenite* the quadrants are not well defined, fairly regular in form, and usually equal in size. The colors are generally pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fair violet; and with a 0.125 per cent solution they color lightly. The color is slightly more than Golden Queen. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red-violet with an excess of iodine.

Staining Reactions.—The grains are unevenly stained at once with *gentian violet,* the body of the grain very lightly; but when the fissures are broad the grains are frequently stained deeply. Small globular bodies adhering to the larger grains stain deeply. After remaining in the solution for 30 minutes there is very little change. The color is light and the same as in Golden Queen.

With *safranin* the grains are unevenly stained at once, the body of the grain lightly; but if fissures are marked they stain deeply. Small globular bodies which stain deeply are adherent to the grain. After remaining in the solution for 30 minutes they remain lightly stained, with exception of the deep color sometimes found at the fissures. There is an occasional oval grain noted with two longitudinal branched fissures, and these grains are also slightly stained. The color is slightly deeper than in Golden Queen.

Chart No. 3.



Curve of Reaction-Intensities of Starch of Zea mays var. indurata (North Dakota).

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 68°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, nearly all in 5 minutes, and all in 10 minutes, with rare exceptions. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *chromic acid.* A few grains are dissolved in 40 seconds and all in 3½ minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction with *pyrogallic acid* begins at once. Some grains are gelatinized in 30 seconds and all in 1½ minutes, with the exception of a few scattered grains (one in several hundred) in which the reaction is complete in 8 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction with *ferric chloride* begins at once. A few grains are gelatinized in 2 minutes, nearly all in 6 minutes, and all in 15 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *Purdy's solution.* A few grains are gelatinized in a minute, and only a few scattered grains are fully gelatinized in 30 minutes, and a very few within an hour. The reaction is qualitatively the same as in Golden Queen.

STARCH OF ZEA MAYS VAR. INDURATA (COMPTON'S EARLY). (Plate 1, figs. 1 and 2. Chart 4.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of some in aggregates and clumps. The aggregates consist of from two to five components. There are clearly defined pressure facets on nearly all the isolated grains. The grains are usually quite irregular, owing to pressure facets which vary in size, shape, and number. The conspicuous forms are the polygonal with four, five, or six facets, oval, round, or nearly round. There are also a few hemispherical, dome-shaped to hemispherical, and triangular forms with rounded angles.

The *hilum* is a small or large round spot or irregularly shaped cavity, centric or slightly eccentric, and usually fissured. The fissures are commonly three in number, straight, narrow, and radiating from a cavity. There is sometimes but one straight, narrow fissure. A few grains were deeply and irregularly fissured.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 22 by 22μ or 18 by 14μ. The common size is 14μ.

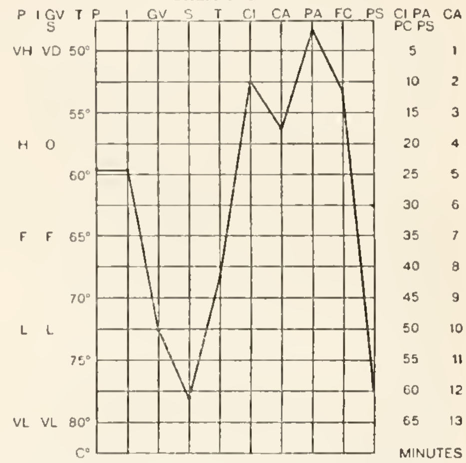
Polariscopic Properties.—The *figure* is usually centric, distinct, and generally clear-cut. The lines composing it are sometimes bent or slightly curved, and are commonly placed at right angles to one another.

The degree of *polarization* is fairly high. It varies slightly in different grains, but not in different aspects of the same grain. It is higher than in Golden Queen, and the same as in North Dakota.

With *selenite*, the quadrants are not very well defined; they are fairly regular in form and commonly equal in size. The colors are usually pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fair deep violet; and with a 0.125 per cent solution they color lightly. The color is deeper than in Golden Queen and the same as in North Dakota. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the gelatinized grain-residues not at all. The capsules all color red-violet with an excess of iodine.

Chart No. 4.



Curve of Reaction-Intensities of Starch of Zea mays var. indurata (Compton's Early).

Staining Reactions.—The large grains stain at once very lightly with *gentian violet*, but deeper at the central fissure. There are some deeply stained, very small globules that are lodged chiefly at the fissures, but which do not react with Lugol's solution. After remaining in the solution for 30 minutes the grains show very little change. The color is light and about the same as Golden Queen.

With *safranin* the grains stain lightly at once, excepting the fissure and some small globular bodies attached to the larger grains at various points which are sometimes fairly well stained. After remaining in the solution for 30 minutes there is very little change. The color is light, but deeper than Golden Queen.

Temperature Reaction.—The temperature of gelatinization is 68° to 69° C., mean 68.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, most of them in 4½ minutes, and all with rare exceptions in 10 minutes. The resistant grains retain a deep old-rose tint for 20 minutes, gradually becoming a reddish-purple in 30 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction with *chromic acid* begins in a few seconds. A few grains are dissolved in a minute and all in 3½ minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *pyrogallic acid.* A few grains are gelatinized in 30 seconds and all in 2 minutes, with exception of a few scattered grains (one in several hundred) which are gelatinized in 3½ minutes. The reaction is qualitatively the same as in Golden Queen.

With *ferric chloride* a few grains are gelatinized in 2 minutes, most in 5 minutes, and all in 12 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *Purdy's solution.* A few grains are gelatinized in 2 minutes, and only a few scattered grains are gelatinized in 30 minutes, and very few in an hour. The reaction is qualitatively the same as in Golden Queen.

STARCH OF ZEA MAYS VAR. INDENTATA (EARLY LEAMING). (Plate 1, figs. 1 and 2. Chart 5.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few small aggregates and some clumps. Most of the grains have from one to five or six pressure facets. The surface of the grains is generally irregular, owing to variations in the size, position, and number of the pressure facets. The conspicuous forms are the polygonal, which are usually 4- or 5-sided, oval, and round or nearly round. There are in addition some dome-shaped to hemispherical, triangular with rounded angles, and indefinite forms.

The *hilum* is a small or large round spot, irregularly shaped, usually centric, and when not fissured is indistinct. When it is fissured there is a small cavity from which two or three rather irregular fissures radiate, and there are in some grains three short, straight, radiating fissures.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 20 by 16μ or 20 by 20μ. The common size is 14μ.

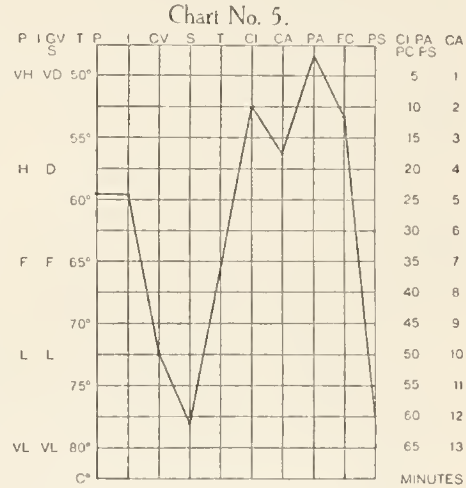
Polariscopic Properties.—The *figure* is usually centric, distinct, regular, and fairly clear-cut. The lines become broader near the margin, not infrequently slightly curved, and generally placed at right angles to one another.

The degree of *polarization* is fairly high. It does not vary much in different grains, nor in different aspects of the same grain. It is higher in Golden Queen.

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are generally pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet; and with a 0.125 per cent solution they color lightly and the shade does not deepen rapidly. The color is a little deeper than in Golden Queen. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red-violet with an excess of iodine.

Chart No. 5.



Curve of Reaction-Intensities of Starch of Zea mays var. indentata (Early Leaming).

Staining Reactions.—With *gentian violet* the grains when viewed in masses show a slight tint of violet at once. After remaining in the solution for 30 minutes they are unevenly and still lightly stained. If the fissures at the hilum are quite broad the color is deeper at this point. The color is the same as in Golden Queen.

The grains, when viewed in masses, show a slight tint of pink with *safranin.* After remaining in the solution for 30 minutes they are unevenly and still lightly stained. The color is deeper than in Golden Queen.

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 66.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once; most of them are gelatinized in 2½ minutes and all in 10 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *chromic acid.* A few grains are dissolved in a minute and all in 3½ minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 30 seconds, and all in 2 minutes with the exception of a few scattered grains (one in several hundred) in which the reaction is complete in 3½ minutes. A bubble is formed in many of the grains at the hilum during the process of gelatinization. The reaction is qualitatively the same as in Golden Queen.

With *ferric chloride* the reaction begins at once. A few grains are gelatinized in a minute, most in 5 minutes, and all in 12 minutes. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *Purdy's solution.* A few grains are gelatinized in 2 minutes and about one-fifth in 30 minutes, and there is little further change in an hour. The reaction is qualitatively the same as in Golden Queen.

STARCH OF ZEA MAYS VAR. INDENTATA (HICKORY KING). (Plate 1, figs. 1 and 2. Chart 6.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a number of small aggregates consisting of from two to six or seven components, and some clumps. There are usually from one to five or six pressure facets on each of the grains. The grains are generally irregular in outline, owing to irregularities caused by variation in the size, number, and position of the facets. The conspicuous forms are the polygonal with usually five to six facets, round, oval, and ovoid. There are some triangular and hemispherical or dome-shaped grains.

The *hilum* is a rather indistinct, small or large round spot or irregularly shaped cavity, centrally or slightly eccentrically situated. It is often fissured either by a large, irregular fissure, or by a single short, straight line; or by three straight radiating lines.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 16 by 12μ. The common size is 8μ.

Polariscopic Properties.—The *figure* is usually centric, distinct, regular, and for the most part fairly clear-cut. The lines composing it are straight, as a rule, and commonly placed at right angles, but in a few grains at varying angles.

The degree of *polarization* is fair. It varies somewhat in different grains, but not in different aspects of the same grain. It is less than in Golden Queen.

With *selenite* the quadrants are generally well defined, irregular in form, and usually unequal in size. The colors are not ordinarily so pure as in Early Leaming.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with a 0.125 per cent solution they color lightly. The color is slightly deeper than in Golden Queen and the same as in Early Leaming. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red-violet with an excess of iodine.

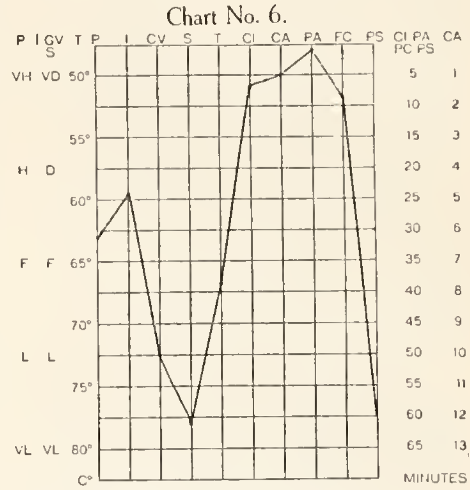
Staining Reactions.—With *gentian violet* the grains are lightly stained at once. After remaining in the solution for 30 minutes there is very little change. The color is deeper at the fissure. The color is about the same as in Golden Queen and in Early Leaming.

The grains are lightly stained at once with *safranin.* After remaining in the solution for 30 minutes there is very little change. The color is deeper than in Golden Queen and about the same as in Early Leaming.

Temperature Reaction.—The temperature of gelatinization is 66° to 67.5° C., mean 66.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Most of them are gelatinized in a minute and all in 7 minutes. The reaction is qualitatively the same as in Golden Queen.

Chart No. 6.



Curve of Reaction-Intensities of Starch of Zea mays var. indentata (Hickory King).

The reaction begins at once with *chromic acid.* Some grains are gelatinized in 35 seconds and all are dissolved in a minute. The reaction is qualitatively the same as in Golden Queen.

The reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 30 seconds and all in a minute. The reaction is qualitatively the same as in Golden Queen.

The grains begin to react at once with *ferric chloride.* A few grains are gelatinized in a minute, most in 3 minutes, and all in 8 minutes. The reaction is qualitatively the same as in Golden Queen.

With *Purdy's solution* the reaction begins at once. A few small grains are gelatinized in 1½ minutes, about one-fifth in 30 minutes, and gelatinization is very incomplete in an hour. The reaction is qualitatively the same as in Golden Queen.

STARCH OF ZEA MAYS VAR. SACCHARATA (STOWELL'S EVERGREEN, A DENT SWEET CORN).

(Plate 1, figs. 1 and 2. Chart 7.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few aggregates and clumps. The surface is generally irregular, owing to pressure facets which vary in number, form, and position. The conspicuous forms are polygonal which usually have five or six facets, oval, and round, both of which are often faceted. There are also some hemispherical and triangular grains, and dome-shaped to hemispherical.

The *hilum,* when not fissured, is a fairly small or large round spot or irregularly shaped cavity which is centrally or slightly eccentrically situated. It is often fissured and there is usually an arrangement of three straight, narrow lines which proceed from a common center. There are some grains which are very deeply and irregularly fissured.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 20 by 19μ. The common size is 14μ.

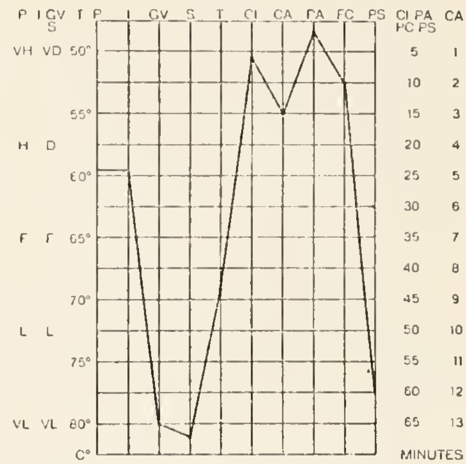
Polariscopic Properties.—The *figure* is usually centric, distinct, regular, and fairly clear-cut. The lines are straight and generally at right angles.

The degree of *polarization* is fairly high. It does not vary much in different grains, or in different aspects of the same grain. It is higher than in Golden Queen.

With *selenite* the quadrants are commonly fairly well defined, irregular in shape, and for the most part unequal in size. The colors are not quite pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with a 0.125 per cent solution they color lightly, and the shade does not deepen rapidly. The coloration is slightly more than in Golden Queen. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red-violet on the addition of an excess of iodine.

Chart No. 7.



Curve of Reaction-Intensities of Starch of Zea mays var. saccharata (Stowell's Evergreen).

Staining Reactions.—With *gentian violet* the grains stain very slightly at once, but after remaining in the solution for 30 minutes there is very little change. The color is somewhat deeper at the central fissure. Large, oval, simple grains, in addition to the angular grains, are occasionally noted, but they also stain very lightly. The reaction is less than in Golden Queen.

With *safranin* the grains stain very slightly and evenly at once, and after remaining in the solution for 30 minutes there is very little change. The stain is deep if the central fissure is broad, and also at eroded points on the surface of the grain. The reaction is less than in Golden Queen.

Temperature Reaction.—The temperature of gelatinization is 66.2° to 67.5° C., mean 66.85°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once; a few are gelatinized in 30 seconds, the majority in 2 minutes, and all in 6 minutes. The reaction is the same qualitatively as in Golden Queen.

The reaction begins in a few seconds with *chromic acid.* A few grains are dissolved in a minute and all in 3 minutes. The reaction is the same qualitatively as in Golden Queen.

The reaction with *pyrogallic acid* begins at once. Many of the grains are gelatinized in 30 seconds and all in 2 minutes, with the exception of scattered grains (one in several hundred), in which latter the reaction is complete in 4 minutes. The reaction is qualitatively the same as in Golden Queen, but the gelatinized grains are less irregular in outline.

With *ferric chloride* the reaction begins at once; a few are gelatinized in 2 minutes, the majority in 5 minutes, and all in 10 minutes. The reaction is the same as in Golden Queen, except that the striated border is seen in fewer grains and the gelatinized grains are less irregular.

The reaction begins at once with *Purdy's solution.* A few small grains are gelatinized in 1½ minutes and about one-tenth in 30 minutes. The reaction is very incomplete at the end of an hour.

STARCH OF ZEA MAYS VAR. SACCHARATA (BLACK MEXICAN, A FLINT SWEET CORN).

(Plate 1, figs. 1 and 2. Chart 8.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few that occur in small aggregates and clumps. The isolated grains each usually have five or six pressure facets. The surface of the grains is usually irregular, owing to pressure facets which differ in size, position, and number of the facets. The conspicuous forms are polygonal which usually have four or five facets having sharp or somewhat rounded angles, round or nearly round, and oval. There are also triangular, dome-shaped, and hemispherical grains.

The *hilum* is centric or slightly eccentric, and when it is not fissured is an indistinct, small or large round spot, or a round or irregularly shaped, rather large, distinct cavity. In many others there are one or more ragged irregular fissures; and in a few there is a single short, straight, narrow line traversing the hilum.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 16 by 16μ. The common size is 10μ.

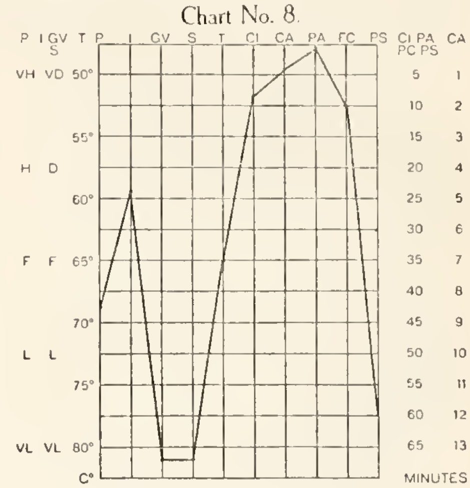
Polariscopic Properties.—The *figure* is usually centric, distinct, regular, and fairly clear-cut. Sometimes the lines composing it are broad and not sharply defined. The lines are also often curved and generally placed at right angles to one another.

The degree of *polarization* is low to fair. It does not vary much in different aspects of the same grain, but in the same aspect of a grain it is sometimes lower between one of the facets and the hilum than elsewhere. It is much less than in Golden Queen and Stowell's Evergreen.

With *selenite* the quadrants are not well defined, and are ordinarily irregular in shape and commonly unequal in size. The colors are less pure than in Golden Queen and Stowell's Evergreen.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with a 0.125 per cent solution they color lightly. The color is slightly deeper than in Golden Queen, but the same as in Stowell's Evergreen. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red-violet with an excess of iodine.

Chart No. 8.



Curve of Reaction-Intensities of Starch of Zea mays var. saccharata (Black Mexican).

Staining Reactions.—With *gentian violet* the grains are very slightly stained at once, and after remaining in the solution for 30 minutes there appears to be no change. The color is lighter than in Golden Queen and Stowell's Evergreen.

With *safranin* the grains are very lightly but unevenly stained at once, and after remaining in the solution for 30 minutes there is very little if any change. The color is less than in Golden Queen and about the same as in Stowell's Evergreen.

Temperature Reaction.—The temperature of gelatinization is 64° to 66° C., mean 65°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once; all but a few scattered grains are gelatinized in 30 seconds, and these scattered grains (one in several hundred) in 8 minutes. If the pressure facets are strongly marked the deeper color appears first at the angles, or along one flattened surface, and gradually spreads over the grain. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *chromic acid.* Some are dissolved in 20 seconds and all in 50 seconds. The reaction is qualitatively the same as in Golden Queen.

The reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 20 seconds and all in 40 seconds. The reaction is qualitatively the same as in Golden Queen.

With *ferric chloride* the reaction begins at once. A few grains are gelatinized in a minute, most in 4 minutes, and all in 10 minutes. The lamelliform layers are ruptured at more points at the margin than in Stowell's Evergreen, and the gelatinized grain is more irregular in outline than those of Stowell's Evergreen. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *Purdy's solution.* A few grains are gelatinized in 2 minutes, and four-fifths in 30 minutes, but incomplete in an hour. The reaction is qualitatively the same as in Golden Queen.

STARCH OF ZEA MAYS VAR. SACCHARATA (GOLDEN BANTAM, A FLINT SWEET CORN).

(Plate 1, figs. 1 and 2. Chart 9.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few small aggregates and clumps. Pressure facets appear on practically all of the isolated grains. The surface of the grains is usually irregular, owing to pressure facets which differ in size, position, and number on the different grains. The conspicuous forms are polygonal which usually have from four to six facets, oval, and round to nearly round. There are also a few dome-shaped to hemispherical, triangular, and indefinite forms.

The *hilum* is centric or slightly eccentric, and when not fissured it appears as a rather indistinct, small or large round spot. In some grains there is a distinct, comparatively large, round or irregularly shaped cavity. In many there is a single straight, narrow line through the hilum, and in others there is an arrangement of three lines proceeding from a common center.

The *lamellæ* are not demonstrable.

The grains vary in *size* from the smaller, which are 3 by 3μ, to the larger, which are 20 by 20μ. The common size is 12μ.

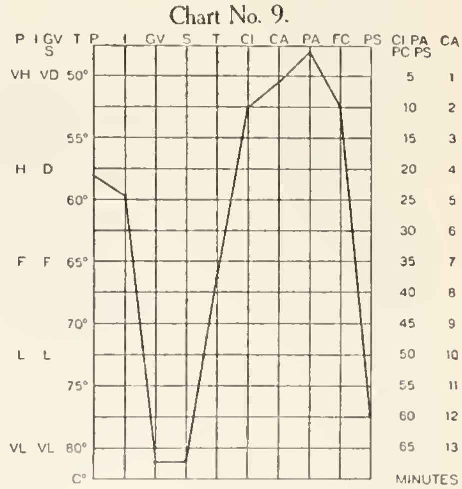
Polariscopic Properties.—The *figure* is usually centric, distinct, regular, and generally clear-cut. The lines are for the most part straight, but may be curved and are sometimes broken, and they are commonly placed at right angles to one another.

The degree of *polarization* is high. It does not vary much in different grains nor in different aspects of the same grain. It is much higher than in Golden Queen, slightly higher than in Stowell's Evergreen, and distinctly higher than in Black Mexican.

With *selenite* the quadrants are fairly well defined, usually irregular in shape, and commonly unequal in size. The colors are purer than in Golden Queen and Stowell's Evergreen.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with a 0.125 per cent solution they color very lightly. The shade is slightly more than in Golden Queen and less than in Stowell's Evergreen. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red-violet with an excess of iodine.

Chart No. 9.



Curve of Reaction-Intensities of Starch of Zea mays var. saccharata (Golden Bantam).

Staining Reactions.—With *gentian violet* the grains stain very slightly at once, but after remaining in the solution for 30 minutes there is no further change. The color is lighter than in Golden Queen and in Stowell's Evergreen.

With *safranin* the grains stain unevenly and lightly at once, but after remaining in the solution for 30 minutes there is no further change. The color is less than in Golden Queen and in Stowell's Evergreen.

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 66.50°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Most are gelatinized in 30 seconds and a few scattered grains (one in several hundred) not until 10 minutes. The reaction is qualitatively the same as in Golden Queen.

With *chromic acid* the reaction begins at once. Some grains are dissolved in 25 seconds and all in 70 seconds. The reaction is qualitatively the same as in Golden Queen.

The reaction begins at once with *pyrogallic acid*. A few grains are gelatinized in 30 seconds and all in a minute. The reaction is qualitatively the same as in Golden Queen.

The reaction with *ferric chloride* begins at once. A few grains are gelatinized in 1½ minutes, most in 4 minutes, and all with the exception of a few scattered grains (one in several hundred) in 10 minutes. The reaction is qualitatively the same as in Golden Queen.

With *Purdy's solution* the reaction begins at once. A few grains are gelatinized in 1½ minutes, and about half in 30 minutes, but incomplete in an hour. The reaction is qualitatively the same as in Golden Queen.

Differentiation of the Starches of the Genus Zea.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

Z. mays var. *everta:*
Golden Queen. Simple, usually isolated, surface irregular, pressure facets common. Polygonal usually 4- to 6-sided, oval and round to nearly round, both sometimes faceted.
White Rice. Essentially the same as in Golden Queen.
Z. mays var. *indurata:*
North Dakota. Essentially the same as in Golden Queen.
Compton's Early. Essentially the same as in Golden Queen.
Z. mays var. *indentata:*
Early Leaming. Essentially the same as in Golden Queen.
Hickory King. Essentially the same as in Golden Queen.
Z. mays var. *saccharata:*
Stowell's Evergreen. Essentially the same as in Golden Queen.
Black Mexican. Essentially the same as in Golden Queen.
Golden Bantam. Essentially the same as in Golden Queen.

Hilum—Form, Number, and Position.

Z. mays var. *everta:*
Golden Queen. Form small or large, round spot or irregularly shaped cavity; commonly 3 small regular, narrow, radiating fissures. Position usually centric, occasionally slightly eccentric.
White Rice. Form essentially the same as in Golden Queen. Position same as in Golden Queen.
Z. mays var. *indurata:*
North Dakota. Form essentially the same as in Golden Queen. Position same as in Golden Queen.
Compton's Early. Form essentially the same as in Golden Queen. Position same as in Golden Queen.
Z. mays var. *indentata:*
Early Leaming. Form essentially the same as in Golden Queen. Position same as in Golden Queen.
Hickory King. Form essentially the same as in Golden Queen. Position same as in Golden Queen.
Z. mays var. *saccharata:*
Stowell's Evergreen. Form essentially the same as in Golden Queen. Position same as in Golden Queen.
Black Mexican. Form essentially the same as in Golden Queen. Position same as in Golden Queen.
Golden Bantam. Form essentially the same as in Golden Queen. Position same as in Golden Queen.

Lamellæ—General Characteristics.

Z. mays var. *everta:*
Golden Queen. Not demonstrable.
White Rice. Not demonstrable.
Z. mays var. *indurata:*
North Dakota. Not demonstrable.
Compton's Early. Not demonstrable.
Z. mays var. *indentata:*
Early Leaming. Not demonstrable.
Hickory King. Not demonstrable.
Z. mays var. *saccharata:*
Stowell's Evergreen. Not demonstrable.
Black Mexican. Not demonstrable.
Golden Bantam. Not demonstrable.

Size.

Z. mays var. *everta:*
Golden Queen. From 4 to 18μ, usually 12μ.
White Rice. From 4 to 17μ, usually 12μ.
Z. mays var. *indurata:*
North Dakota. From 2 to 22μ, usually 12μ.
Compton's Early. From 4 to 22μ, usually 14μ.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Size.—Continued.

Z. mays var. *indentata:*
Early Leaming. From 4 to 20μ, usually 14μ.
Hickory King. From 2 to 16μ, usually 8μ.
Z. mays var. *saccharata:*
Stowell's Evergreen. From 4 to 20μ, usually 14μ.
Black Mexican. From 2 to 16μ, usually 10μ.
Golden Bantam. From 3 to 20μ, usually 12μ.

POLARISCOPIC PROPERTIES.

Figure.

Z. mays var. *everta:*
Golden Queen. Usually centric, sometimes slightly eccentric, distinct, fairly clear-cut, commonly regular, lines generally straight and at right angles.
White Rice. Essentially the same as Golden Queen.
Z. mays var. *indurata:*
North Dakota. Essentially the same as in Golden Queen.
Compton's Early. Essentially the same as in Golden Queen.
Z. mays var. *indentata:*
Early Leaming. Essentially the same as in Golden Queen.
Hickory King. Essentially the same as in Golden Queen.
Z. mays var. *saccharata:*
Stowell's Evergreen. Essentially the same as in Golden Queen.
Black Mexican. Essentially the same as in Golden Queen.
Golden Bantam. Essentially the same as in Golden Queen.

Degree of Polarization.

Z. mays var. *everta:*
Golden Queen. Fairly high.
White Rice. Fairly high, slightly less than in Golden Queen.
Z. mays var. *indurata:*
North Dakota. Fairly high, slightly higher than in Golden Queen.
Compton's Early. Fairly high, higher than in Golden Queen, and the same as in North Dakota.
Z. mays var. *indentata:*
Early Leaming. Fairly high, higher than in Golden Queen.
Hickory King. Fair, less than in Golden Queen, and not so high as in Early Leaming.
Z. mays var. *saccharata:*
Stowell's Evergreen. High, higher than in Golden Queen.
Black Mexican. Low to fair, much less than in Golden Queen, and much less than in Stowell's Evergreen.
Golden Bantam. High, much higher than in Golden Queen, slightly higher than in Stowell's Evergreen, and distinctly higher than in Black Mexican.

Polarization with Selenite—Quadrants and Colors.

Z. mays var. *everta:*
Golden Queen. Quadrants usually well defined, irregular in shape, unequal in size. Colors usually pure.
White Rice. Quadrants the same as in Golden Queen. Colors usually pure.
Z. mays var. *indurata:*
North Dakota. Quadrants not very well defined, fairly regular in form, usually equal in size. Colors usually pure.
Compton's Early. Quadrants essentially the same as in North Dakota. Colors usually pure.

Differentiation of the Starches of the Genus Zea.—Continued.

POLARISCOPIC PROPERTIES.—Continued.

Polarization with Selenite—Quadrants and Colors.—Cont'd.

Z. mays var. *indentata:*
Early Leaming. Quadrants essentially the same as in Golden Queen. Colors usually pure.
Hickory King. Quadrants essentially the same as in Golden Queen. Colors not so pure as in Early Leaming.

Z. mays var. *saccharata:*
Stowell's Evergreen. Quadrants essentially the same as in Golden Queen. Colors quite pure.
Black Mexican. Quadrants not well defined, usually irregular in shape and unequal in size. Colors less pure than Golden Queen and Stowell's Evergreen.
Golden Bantam. Quadrants not well defined, usually irregular in shape, and unequal in size. Colors purer than Golden Queen and Stowell's Evergreen.

IODINE REACTIONS.

Intensity and Color.

Z. mays var. *everta:*
Golden Queen. Fairly deep, violet.
White Rice. Same as in Golden Queen, violet.

Z. mays var. *indurata:*
North Dakota. Fairly deep, more than in Golden Queen, about the same as Stowell's Evergreen, violet.
Compton's Early. Fairly deep, more than in Golden Queen and the same as in North Dakota, violet.

Z. mays var. *indentata:*
Early Leaming. Fairly deep, more than in Golden Queen, violet.
Hickory King. Fairly deep, more than in Golden Queen and Early Leaming, violet.

Z. mays var. *saccharata:*
Stowell's Evergreen. Fairly deep, slightly more than in Golden Queen, violet.
Black Mexican. Fairly deep, slightly more than in Golden Queen, violet.
Golden Bantam. Fairly deep, slightly more than in Golden Queen, violet.

STAINING REACTIONS.

With Gentian Violet.

Z. mays var. *everta:*
Golden Queen. Light.
White Rice. Light, less than in Golden Queen.

Z. mays var. *indurata:*
North Dakota. Light, same as in Golden Queen.
Compton's Early. Light, same as in Golden Queen and North Dakota.

Z. mays var. *indentata:*
Early Leaming. Light, same as in Golden Queen.
Hickory King. Light, same as in Golden Queen and Early Leaming.

Z. mays var. *saccharata:*
Stowell's Evergreen. Very light, less than in Golden Queen.
Black Mexican. Very light, less than in Golden Queen and Stowell's Evergreen.
Golden Bantam. Very light, less than in Golden Queen and Stowell's Evergreen.

With Safranin.

Z. mays var. *everta:*
Golden Queen. Very light.
White Rice. Very light, slightly less than in Golden Queen.

Z. mays var. *indurata:*
North Dakota. Light, more than in Golden Queen.
Compton's Early. Light, more than in Golden Queen, the same as in North Dakota.

STAINING REACTIONS.—Continued.

With Safranin.—Continued.

Z. mays var. *indentata:*
Early Leaming. Light, more than in Golden Queen.
Hickory King. Light, more than in Golden Queen, same as in Early Leaming.

Z. mays var. *saccharata:*
Stowell's Evergreen. Very light, less than in Golden Queen.
Black Mexican. Very light, less than in Golden Queen, and the same as in Stowell's Evergreen.
Golden Bantam. Very light, less than in Golden Queen, and the same as in Stowell's Evergreen.

TEMPERATURE OF GELATINIZATION.

Z. mays var. *everta:*
Golden Queen. 62.5 to 64° C., mean 63.25°.
White Rice. 61.5 to 63° C., mean 62.25°.

Z. mays var. *indurata:*
North Dakota. 67 to 69° C., mean 68°.
Compton's Early. 68 to 69° C., mean 68.5°.

Z. mays var. *indentata:*
Early Leaming. 66 to 67° C., mean 66.5°.
Hickory King. 66 to 67.5° C., mean 66.75°.

Z. mays var. *saccharata:*
Stowell's Evergreen. 66.2 to 67.5° C., mean 66.85°.
Black Mexican. 64 to 66° C., mean 65°.
Golden Bantam. 66 to 67° C., mean 66.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

Z. mays var. *everta:*
Golden Queen. Begins immediately; complete in most in 30 seconds, in all in 4 minutes.
White Rice. Begins immediately; complete in most in a minute, in all in 5 minutes.

Z. mays var. *indurata:*
North Dakota. Begins immediately; complete in most in 5 minutes, in practically all in 10 minutes.
Compton's Early. Begins immediately; complete in most in 4½ minutes, in practically all in 10 minutes.

Z. mays var. *indentata:*
Early Leaming. Begins immediately; complete in most in 2½ minutes, in all in 10 minutes.
Hickory King. Begins immediately; complete in most in a minute, in all in 7 minutes.

Z. mays var. *saccharata:*
Stowell's Evergreen. Begins immediately; complete in most in 2 minutes, in all in 6 minutes.
Black Mexican. Begins immediately; complete in most in 30 seconds, in all in 8 minutes.
Golden Bantam. Begins immediately; complete in most in 30 seconds, in all in 10 minutes.

Reaction with Chromic Acid.

Z. mays var. *everta:*
Golden Queen. Begins immediately; complete in a few in 20 seconds, in all in 75 seconds.
White Rice. Begins immediately; complete in a few in 25 seconds, in all in 80 seconds.

Z. mays var. *indurata:*
North Dakota. Begins immediately; complete in a few in 40 seconds, in all in 3½ minutes.
Compton's Early. Begins immediately; complete in a few in a minute, in all in 3½ minutes.

Z. mays var. *indentata:*
Early Leaming. Begins immediately; complete in a few in a minute, in all in 3½ minutes.
Hickory King. Begins immediately; complete in a few in 35 seconds, in all in a minute.

Differentiation of the Starches of the Genus Zea.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chromic Acid.—Continued.

Z. mays var. *saccharata:*
- Stowell's Evergreen. Begins immediately; complete in a few in a minute, in all in 3 minutes.
- Black Mexican. Begins immediately; complete in some in 20 seconds, in all in 50 seconds.
- Golden Bantam. Begins immediately; complete in some in 25 seconds, in all in 70 seconds.

Reaction with Pyrogallic Acid.

Z. mays var. *everta:*
- Golden Queen. Begins immediately; complete in all in 35 seconds.
- White Rice. Begins immediately; complete in all in 45 seconds.

Z. mays var. *indurata:*
- North Dakota. Begins immediately; complete in some in 30 seconds, in all in 1½ minutes.
- Compton's Early. Begins immediately; complete in a few in 30 seconds, in all in 2 minutes.

Z. mays var. *indentata:*
- Early Leaming. Begins immediately; complete in a few in 30 seconds, in all in 2 minutes.
- Hickory King. Begins immediately; complete in a few in 30 seconds, in all in a minute.

Z. mays var. *saccharata:*
- Stowell's Evergreen. Begins immediately; complete in many in 30 seconds, in all in 2 minutes.
- Black Mexican. Begins immediately; complete in all in 40 seconds.
- Golden Bantam. Begins immediately; complete in a few in 30 seconds, in all in a minute.

Reaction with Ferric Chloride.

Z. mays var. *everta:*
- Golden Queen. Begins immediately; complete in most in 4 minutes, in all in 10 minutes.
- White Rice. Begins immediately; complete in most in 3½ minutes, in all in 10 minutes.

Z. mays var. *indurata:*
- North Dakota. Begins immediately; complete in most in 6 minutes, in all in 15 minutes.
- Compton's Early. Begins immediately; complete in most in 5 minutes, in all in 12 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.—Continued.

Z. mays var. *indentata:*
- Early Leaming. Begins immediately; complete in most in 5 minutes, in all in 12 minutes.
- Hickory King. Begins immediately; complete in most in 3 minutes, in all in 8 minutes.

Z. mays var. *saccharata:*
- Stowell's Evergreen. Begins immediately; complete in most in 5 minutes, in all in 10 minutes.
- Black Mexican. Begins immediately; complete in most in 4 minutes, in all in 10 minutes.
- Golden Bantam. Begins immediately; complete in most in 4 minutes, in all in 10 minutes.

Reaction with Purdy's Solution.

Z. mays var. *everta:*
- Golden Queen. Begins immediately; complete in one-third in 30 minutes; but little further reaction in an hour.
- White Rice. Begins immediately; complete in one-third in 30 minutes, but little further reaction in 1 hour.

Z. mays var. *indurata:*
- North Dakota. Begins immediately; complete in rare grains in 30 minutes, in very few in an hour.
- Compton's Early. Begins immediately; complete in rare grains in 30 minutes, in very few in an hour.

Z. mays var. *indentata:*
- Early Leaming. Begins immediately; complete in one-fifth in 30 minutes, little further change in an hour.
- Hickory King. Begins immediately; complete in one-fifth in 30 minutes, very incomplete in an hour.

Z. mays var. *saccharata:*
- Stowell's Evergreen. Begins immediately; complete in one-tenth in 30 minutes, but very incomplete in 1 hour.
- Black Mexican. Begins immediately; complete in four-fifths in 30 minutes, but incomplete in an hour.
- Golden Bantam. Begins immediately; complete in half in 30 minutes, but incomplete in 1 hour.

NOTES ON THE STARCHES OF ZEA.

The corn starches differ so little and so indefinitely in their gross microscopical characteristics that it is not possible to differentiate one from another in this way, and it is doubtful if even detailed histological examination, unless possibly with the assistance of reagents, would be of real service. The curves of the reaction-intensities, on the other hand, show not only specific differentiations of one variety from another, but also a more or less positive grouping that is in accord with that of the agriculturist. Inasmuch as all of the corn starches are products of varieties or forms of a single species, but little differences, upon general principles, should be expected to be found among the different specimens; yet it will be noted that not only are no two curves identical, even in members of the same agricultural group, but also that the composite curves of each group must differ in characteristic ways from those of the others. While some of the differences are slight and fall within the limits of error of experiment, they are as a whole distinctly diagnostic. In the polarization reactions there are small and unimportant differences, except in the Black Mexican variety, in which polarization is distinctly lower than in the others, but this may be accounted for in the presence of dark coloring matter which clung tenaciously to the starch-grains. The intensities of the iodine reactions are the same throughout, except in the case of the *evertæ*, in both of which the reaction is slightly less than in the other groups. In the gentian-violet reactions there is distinct evidence of grouping, the reactions of all of the *saccharatæ* being distinctly lower than the others, which are about the same. With safranin there is an obvious grouping, the reactions with the *saccharatæ* being very low, those of the *evertæ* on the whole higher, and the *induratæ* and *indentatæ* the highest and the same. Likewise is there grouping in the temperature reactions, the *evertæ* having the same and the lowest temperature of gelatinization (63.25°), the *induratæ* the highest (68° and 68.5°), and the *indentatæ* and *saccharatæ* about the same and of an intermediate standard (66.5°, 66.75°, 66.85°, 65°, and 66.5°; mean 66.31°), with perhaps the *saccharatæ* having a somewhat lower temperature than the *indentatæ*. Grouping is also indicated in the chloral hydrate-iodine reaction, the *evertæ* being the most sensitive, and then in order the *saccharatæ*, the *indentatæ*, and *induratæ*. In both the chromic acid and pyrogallic acid reactions the *evertæ* and *saccharatæ* appear, on the whole, to be more sensitive than the *induratæ* and *indentatæ*, and a corresponding condition is suggested in the ferric chloride records. With Purdy's solution the reactions are slow, so much so that at the end of an hour gelatinization is incomplete in all of the starches; but if the relative intensities of the reactions are taken at the end of 30 minutes, there will be found clear evidences of grouping: about 33 per cent of the *evertæ* starches being gelatinized, only a few grains of the *induratæ*, about 20 per cent of the *indentatæ*, and an average of 47 per cent (10, 80, and 50 per cent, respectively) of the *saccharatæ*. From the foregoing data it seems clear that by careful experimentation and by extension of the methods there should be no difficulty in not only distinguishing one form of *Zea* starch from another, but also in positively specifying the group to which it belongs.

GENUS ANDROPOGON.

The polymorphous genus *Andropogon* contains a number of species that have been found useful for forage, ornamental, medicinal, textile, or other economic purposes. Included here are the various cultivated forms of sorghum, which are regarded by some authorities as having been derived from *Andropogon halpensis* Brot., and by others as having come from *A. sorghum* Brot. (*Sorghum vulgare* Linn.). The sorghums, Hitchcock notes, fall into three classes, in accordance with their uses: (1) Broom corn, used in the manufacture of brooms; (2) sugar or saccharine sorghum, cultivated for the sweet juice, etc.; and (3) non-saccharine sorghum, grown for forage and seed. Starches were prepared from three forms, all of which belong to the non-saccharine group.

STARCH OF ANDROPOGON SORGHUM VAR. (WHITE KAFFIR CORN).

(Plate 1, figs. 3 and 4. Chart 10.)

Histological Characteristics.—In *form* there are both simple and compound grains, almost solely the former. The simple grains are isolated, excepting a few that are found in aggregates. The conspicuous forms of the single grains are polygonal, round, and rounded oval. Triangular grains, with a rounded apex and curved base, and lenticular forms are rarely observed. Among the aggregates there is often one large grain having a globular grain fitted into a slight depression. There are also doublets formed of components of equal size. The isolated grains are usually dome-shaped with either a flattened or a pointed base. There are a number of partially gelatinized grains in the preparation.

The *hilum* is a fairly refractive, round spot, which is centric in most of the grains and very slightly eccentric in some of the oval forms. Multiple hila, without lines of separation, are observed in some of the grains. Generally there is at the hilum either a cavity or one or more clefts which usually form a cross or a Y, although sometimes there is a clean-cut, slightly curved, transverse cleft, and occasionally a much-branched fissure. The last-named type of fissuration is probably due to the beginning of gelatinization of the grain.

The *lamellæ* are not generally visible, and neither the character nor number can satisfactorily be determined.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 22 by 26μ, and 26 by 26μ in length and breadth. The common size is 16 by 16μ.

Polariscopic Properties.—The *figure* is usually centric, very distinct, regular, and fairly clear-cut. The lines of the figure are thick and generally straight, broadening towards the margin. In some grains a large central area is dark.

The degree of *polarization* is high, but varies sometimes in one aspect and in different aspects of a grain.

With *selenite* the quadrants are clearly defined, but often irregular in shape and unequal in size. The colors are pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet, with a 0.125 per cent solution they are lightly colored, but the shade does not deepen rapidly. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color a red or red-violet with an excess of iodine.

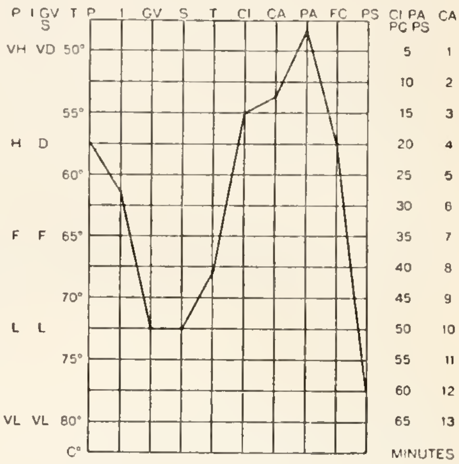
Staining Reactions.—With *gentian violet* the grains begin to stain at once, and in 30 minutes they are lightly stained, some more than others.

With *safranin* the grains begin to stain at once, and in 30 minutes they are lightly stained, some more than others. This stain is more effective than *gentian violet.*

Temperature Reaction.—The temperature of gelatinization is 67 to 69° C., mean 68°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in all of the grains in 45 seconds, it is over in nearly all in 8 minutes, and in all in 15 minutes. The grains first color a bright violet, which becomes very dark. The reaction begins at the prominent angles and corners of the grain, at which points the starch becomes dark, but does not swell very much. The process then proceeds into the interior of the grain, first along a number of straight lines converging towards the hilum. The starch along these lines becomes dark, then the starch between them darkens, usually more rapidly on one side of the grain than on the other. When the whole grain is darkened it swells somewhat. The gelatinized grains are not very large, they are of a uniform dark color, and retain some of the original form, but often are more rounded than the normal grains.

Chart No. 10.



Curve of Reaction-Intensities of Starch of Andropogon sorghum var. (White Kaffir Corn).

The reaction with *chromic acid* begins in some of the grains in 20 seconds and is over in $2\frac{1}{2}$ minutes. The grain first shows a number of very distinct striæ radiating from the hilum to the margin. Then the central portion becomes coarsely granular and melts down into a semiliquid mass, and the grain swells. The resistant portions of the grain form a very broad, distinctly striated band which gradually becomes thinner. Finally, one or two of the outer layers of the grain peel off, and the marginal band already described is dissolved at one or two places. The pieces thus separated float away from one another, and the semiliquid starch in the interior of the grain flows out, and is entirely dissolved. The rest of the marginal band also dissolves very rapidly.

The reaction begins in 30 seconds with *pyrogallic acid,* and is over in 2 minutes. The grain first shows a number of very distinct striæ which radiate from the hilum to the margin; then the starch about the hilum becomes a granular mass and the grain swells. The more resistant starch forms a broad, striated band at the margin. This band becomes thinner and homogeneous in appearance as the grain continues to swell, and finally forms a rather thick limiting envelope, while at the same time the starch in the interior of the grain is changed to a gelatinous, granular mass. The granules finally disappear with the formation of a completely gelatinized grain. The gelatinized grains are large, and the capsules are usually folded, wrinkled, and creased, thus distorting the original form of the grain.

With *ferric chloride* the reaction begins in many of the grains in a minute. It is over in most of the grains in 10 minutes and in all in 20 minutes. The reaction begins at one side of the grain, usually at the prominent corners and angles. The starch here becomes gelatinous and the process spreads over the rest of that side, then inward over the whole grain. Small portions become broken from the ungelatinized portion and are gelatinized; finally, the whole mass is broken up into two or three pieces, which become gelatinized. The gelatinized grains are large, with thin, much wrinkled, folded, and creased capsules. In some grains the reaction begins in the interior of the grain in the region of the hilum. The starch at this point becomes gelatinous and the grain swells, the less resistant starch forming a gelatinous mass in the interior, and the more resistant starch a broad, homogeneous-looking band at the margin, which becomes very thin as the grain swells.

With *Purdy's solution* the reaction, which consists in a little gelatinization about the hilum, begins in some grains in a minute, but the change does not proceed much farther even at the end of an hour.

STARCH OF ANDROPOGON SORGHUM VAR. (YELLOW BRANCHING SORGHUM).

(Plate 1, figs. 3 and 4. Chart 11.)

Histological Characteristics.—In *form* both simple and compound grains are present, almost solely the former. There are a few aggregates. Some of the grains have pressure facets. The conspicuous forms of the simple grains are polygonal, round, and rounded oval. The isolated grains are often dome-shaped or sugar-loaf-shaped. The aggregates frequently consist of one large grain and one minute grain. The grains very closely resemble those of White Kaffir sorghum.

The *hilum* is a clear, rather refractive spot, which is centric in the round grains and slightly eccentric in some of the oval and polygonal forms. There may be more than one hilum without lines of separation. Sometimes three are arranged at the angles of an imaginary triangle. Deep clefts are usually found at the hilum, frequently ragged in character, and usually in the form of a Y or diagonal cross. If but one cleft is found it is more often either slightly arched or diagonally placed. The arrangements of the clefts are very similar to those noted in White Kaffir sorghum.

The *lamellæ* are not usually visible, and neither their structure nor number could be determined, as was also the case with White Kaffir sorghum.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 22 by 24μ in length and breadth. The common size is 16 by 16μ.

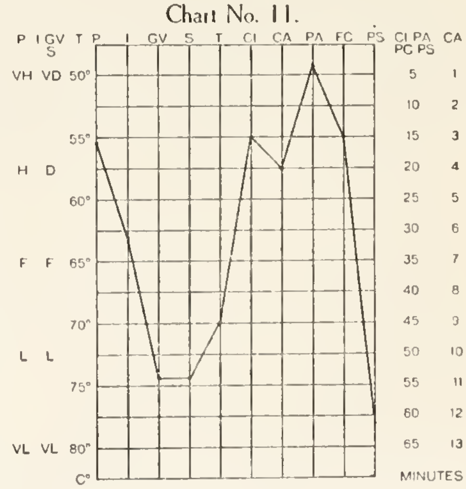
Polariscopic Properties.—The *figure* is usually centric, regular, and very distinct. The lines are thick, commonly straight, and broadening towards the margin. There is a greater proportion of figures with lines slightly bent than in White Kaffir corn.

The degree of *polarization* is high, occasionally varying slightly in the same aspect of a grain. It is a very little higher than in White Kaffir corn.

With *selenite* the quadrants are well defined, and usually unequal in size and irregular in shape. The colors are pure. There is a greater variation among the quadrants as to size and shape than in White Kaffir corn.

Iodine Reactions.—With a 0.25 per cent Lugol's solution all the grains color a fairly deep violet; with a 0.125 per cent solution they all color lightly, but the shade does not deepen rapidly. It is slightly less than that of the grains of White Kaffir corn. After heating in water until all the grains are completely gelatinized the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red or violet with an excess of iodine.

Chart No. 11.



Curve of Reaction-Intensities of Starch of Andropogon sorghum var. (Yellow Branching Sorghum).

Staining Reactions.—With *gentian violet* the grains begin to stain at once. In 30 minutes they are lightly stained, some more than others. The staining is slightly less than that of the grains of White Kaffir corn.

With *safranin* the grains begin to stain at once; in 30 minutes they are lightly stained, some more than others. The staining is slightly less than that of the grains of White Kaffir corn.

Temperature Reaction.—The temperature of gelatinization is 69.1° to 70.8° C., mean 69.95°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most of the grains in 30 seconds. It is complete in nearly all in 10 minutes, and in all in 15 minutes. It is the same qualitatively as that of the grains of White Kaffir corn.

The reaction with *chromic acid* begins in some grains in 20 seconds and in all in 45 seconds, and is over in 4 minutes. It is the same qualitatively as that of the grains of White Kaffir corn.

With *pyrogallic acid* the reaction begins in 30 seconds and is over in 3½ minutes. It is the same qualitatively as that of the grains of White Kaffir corn.

The reaction begins in some of the grains in 1½ minutes with *ferric chloride*. It is over in most of the grains in 10 minutes and in all in 15 minutes. The reaction is the same qualitatively as that of the grains of White Kaffir corn.

The reaction with *Purdy's solution* begins in some of the grains in a minute, but it does not advance appreciably further even during an hour.

STARCH OF ANDROPOGON SORGHUM VAR. (SHALLU). (Plate 1, figs. 3 and 4. Chart 12.)

Histological Characteristics.—In *form* both simple and compound grains are found, chiefly the former. There are a few aggregates. The conspicuous forms are the polygonal, round or rounded oval. Grains are occasionally observed that are broadly triangular, with a curved base and rounded angles; also, some that are lenticular and diamond-shaped. Among the aggregates, the type most frequently found is one large grain, usually broadly triangular in shape, with a small one closely attached to it. Some of the isolated grains are dome-shaped, with either pointed or flattened base, or finger-shaped, or polygonal. The grains are rather more angular and more varied in form than those observed in White Kaffir corn.

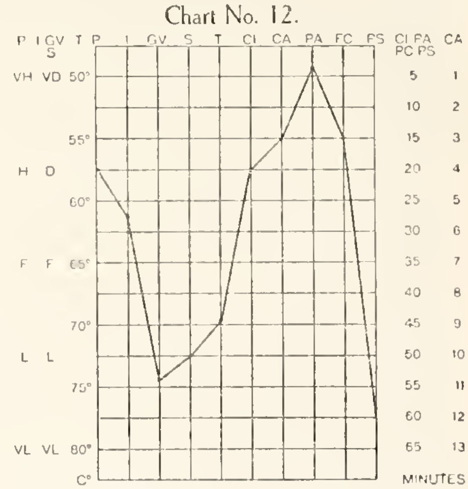
The *hilum* is a clear, refractive spot which is centric in the round forms and slightly eccentric in the oval and polygonal grains. More than one hilum is occasionally observed in a grain. There may be either a cavity, or one or more clefts, at the hilum. One short, transverse cleft may be present; but more often two are arranged in the form of a cross, or three in a Y-shaped figure. The clefts have the same character and shape as noted for White Kaffir corn.

The *lamellæ* are generally invisible. Their character and number could not be determined, as is the case of the other sorghums.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 24 by 24μ. The common size is 15 by 15μ.

Polariscopic Properties.—The *figure* is centric, regular, and very distinct. The lines are rather thick and generally straight and broadening towards the margin. The figure is more often irregular in size and shape than in White Kaffir corn.

Chart No. 12.



Curve of Reaction-Intensities of Starch of Andropogon sorghum var. (Shallu).

The degree of *polarization* is high. There is a slight variation among the grains, and also occasionally in the same aspect of a grain. It is about the same as in White Kaffir corn.

With *selenite* the quadrants are well defined, and vary less in size and shape than in White Kaffir corn. The colors are pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet; and with a 0.125 per cent solution they color lightly, but the shade does not deepen rapidly. The color is the same as that of the grains of White Kaffir corn. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the gelatinized grain-residues not at all. The capsules all color red or red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once, and in 30 minutes they are lightly stained, some more than others. The stain is less than that of the grains of White Kaffir corn.

With *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained, some more than others. The stain is slightly less than that of the grains of White Kaffir corn.

Temperature Reaction.—The temperature of gelatinization is 66° to 67.8° C., mean 66.9°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds. It is over in two-thirds of the grains in 6 minutes, in nearly all in 15 minutes, and in all in 20 minutes. It is the same qualitatively as that of the grains of White Kaffir corn.

The reaction with *chromic acid* begins in all the grains in 30 seconds and is over in 3 minutes. It is the same qualitatively as that of the grains of White Kaffir corn.

With *pyrogallic acid* the reaction begins in some of the grains in 15 seconds and in all in 45 seconds. It is over in 3 minutes. It is the same qualitatively as that of the grains of White Kaffir corn.

The reaction begins in some of the grains in 45 seconds with *ferric chloride*. It is over in most of them in 7 minutes and all in 15 minutes. It is the same qualitatively as that of the grains of White Kaffir corn.

The reaction with *Purdy's solution* begins in a minute, but does not advance appreciably further even in an hour.

Differentiation of the Starches of the Genus Andropogon.

Histological Characteristics.

Conspicuous Forms.

White Kaffir corn: Simple, few compound. Polygonal, round, rounded oval.
Yellow Branching sorghum: Same as in White Kaffir corn.
Shallu: Same as in White Kaffir corn, but rather more angular and varied in form.

Hilum—Form, Number, and Position.

White Kaffir corn: Form fairly distinct, round; sometimes more than one hilum; a spot or usually a cavity; often fissured, clefts usually form a cross or a 3-armed figure. Position centric or slightly eccentric.
Yellow Branching sorghum: Same as in White Kaffir corn.
Shallu: Same as in White Kaffir corn.

Lamellæ—General Characteristics.

White Kaffir corn: Usually not visible.
Yellow Branching sorghum: Usually not visible.
Shallu: Usually not visible.

Size.

White Kaffir corn: From 2 to 26μ, usually 16μ.
Yellow Branching sorghum: From 2 to 24μ, usually 16μ.
Shallu: From 2 to 24μ, usually 15μ.

Polariscopic Properties.

Figure.

White Kaffir corn: Usually centric, very distinct, fairly clear-cut, regular, commonly straight.
Yellow Branching sorghum: Same as in White Kaffir corn, but the figure and lines are less often regular and straight.
Shallu: Same as Yellow Branching sorghum.

Degree of Polarization.

White Kaffir corn: High.
Yellow Branching sorghum: High, slightly higher than in White Kaffir corn.
Shallu: High, same as in White Kaffir corn.

Polarization with Selenite—Quadrants and Colors.

White Kaffir corn: Quadrants well defined, usually irregular in shape and unequal in size. Color pure.
Yellow Branching sorghum: Quadrants same as in White Kaffir corn, but vary more in size and shape. Color pure.
Shallu: Same as in White Kaffir corn, but less irregular in size and shape. Color pure.

Iodine Reactions.

Intensity and Color.

White Kaffir corn: Fairly deep; violet.
Yellow Branching sorghum: Fairly deep, slightly less than in White Kaffir corn; violet.
Shallu: Fairly deep, same as in White Kaffir corn; violet.

Staining Reactions.

With Gentian Violet.

White Kaffir corn: Light.
Yellow Branching sorghum: Light, slightly less than in White Kaffir corn.
Shallu: Light, less than in White Kaffir corn.

With Safranin.

White Kaffir corn: Light.
Yellow Branching sorghum: Light, slightly less than in White Kaffir corn.
Shallu: Light, slightly less than in White Kaffir corn.

Temperature of Gelatinization.

White Kaffir corn: 67 to 69° C., mean 68°.
Yellow Branching sorghum: 69.1 to 70.8° C., mean 69.95°.
Shallu: 66 to 67.8° C., mean 66.9°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

White Kaffir corn: Begins in all in 45 seconds; complete in nearly all in 8 minutes and in all in 15 minutes.
Yellow Branching sorghum: Begins in all in 45 seconds; complete in nearly all in 10 minutes and in all in 15 minutes.
Shallu: Begins in all in 45 seconds; complete in nearly all in 15 minutes and in all in 20 minutes.

Reaction with Chromic Acid.

White Kaffir corn: Begins in some in 20 seconds; complete in all in 2½ minutes.
Yellow Branching sorghum: Begins in some in 20 seconds; complete in all in 4 minutes.
Shallu: Begins in all in 30 seconds; complete in all in 3 minutes.

Reaction with Pyrogallic Acid.

White Kaffir corn: Begins in all in 30 seconds; complete in all in 2 minutes.
Yellow Branching sorghum: Begins in all in 30 seconds; complete in all in 3½ minutes.
Shallu: Begins in all in 45 seconds; complete in all in 3 minutes.

Reaction with Ferric Chloride.

White Kaffir corn: Begins in many in 1 minute; complete in most in 10 minutes and in all in 20 minutes.
Yellow Branching sorghum: Begins in some in 1½ minutes; complete in most in 10 minutes and in all in 15 minutes.
Shallu: Begins in some in 45 seconds; complete in most in 7 minutes and in all in 16 minutes.

Reaction with Purdy's Solution.

White Kaffir corn: Begins in some in a minute; no further progress in an hour.
Yellow Branching sorghum: Begins in some in a minute; no further progress in an hour.
Shallu: Begins in some in a minute; no further progress in an hour.

NOTES ON THE STARCHES OF ANDROPOGON.

The starches of the three forms of *Andropogon* are so alike in their gross histological characters that differentiation by this means is not possible. They are also very much alike in their polarization, iodine, and aniline reactions, the differences being within the limits of error of experiment. In the temperature of gelatinization they show distinct differences, the order being, shallu (66.9° C.), White Kaffir corn (68° C.), and Yellow Branching sorghum (70° C.). In the chemical reactions there are only minor differences, and such as to suggest very closely related botanical forms.

GENUS PANICUM.

Panicum is an immense genus of grasses, comprising about 300 species that are world-wide in distribution, but especially abundant in the tropics. The specimen studied as a type of the genus is the cultivated form of *Panicum crus-galli* Linn., known as the Japanese or barnyard millet.

STARCH OF PANICUM CRUS-GALLI VAR. (JAPANESE OR BARNYARD MILLET).

(Plate 1, figs. 5 and 6. Chart 13.)

Histological Characteristics.—In *form* the grains are simple and occur isolated, excepting a few in aggregates which consist of two or more components. The conspicuous forms are polygonal and spherical, the former predominating.

A cavity is usually found at the *hilum*, and sometimes radial fissures pass out from it.

The *lamellæ* are not visible.

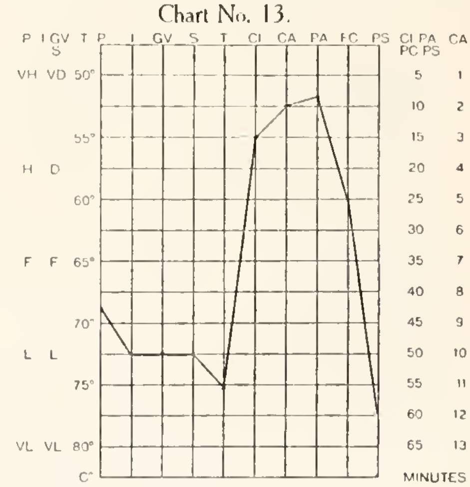
The grains vary in *size* from the smaller, which are 1.5 by 1.5μ, to the larger, which are 10 by 10μ. The common size is 7μ.

Polariscopic Properties.—The *figure* is usually centric, but owing to the smallness of the grain is obscure. The lines of the figure appear to be fairly thick and are generally straight and sometimes bisected.

The degree of *polarization* is low to fair. In some grains there is a variation in the same aspect of the same grain.

With *selenite* the quadrants are distinct, and in some grains are equal in size and regular in form. They are so minute that it is impossible to state the peculiarities with accuracy in the majority of the grains. The blue and yellow colors vary in brightness and purity, the blue being less bright than the yellow. The yellow is generally not quite pure, but the blue appears to be pure.

Chart No. 13.



Curve of Reaction-Intensities of Starch of Panicum crus-galli var. (Japanese or Barnyard Millet).

Iodine Reactions.—With a 0.25 per cent Lugol's solution most of the grains color a light violet at once, and the color deepens rather slowly; with a 0.125 per cent solution they do not color immediately, but gradually assume a very light violet tint, some grains staining more deeply than others. After heating in water until all the grains are completely gelatinized, the solution becomes a light bluish-violet, and the majority of the grains color a deep blue, while others have a reddish tint. After boiling for 2 minutes the solution colors very deeply on the addition of iodine, but most of the gelatinized grain-residues are not colored. With an excess of iodine, the capsules become an old-rose to a wine-red tint.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once, and in 30 minutes they are but lightly stained.

With *safranin* the grains begin to stain very lightly at once, and in 30 minutes they are but lightly stained.

Temperature Reaction.—The temperature of gelatinization is 74.5° to 76° C., mean 75.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most of the grains in 30 seconds to a minute, and is over in nearly all of the grains in 15 minutes. The reaction begins at the corners and angles of the facets and the starch at these points darkens and swells slightly, and the process spreads inward over the whole grain. The marginal starch is affected first, and then the central portions of the grain. The gelatinized grains are not very large and retain much of the original forms. They usually appear to consist of a light central portion surrounded by a fairly broad, dark, marginal band.

The reaction with *chromic acid* begins in a few seconds and is over in 2 minutes. The hilum becomes clear and is connected with the corners of the facets by clear lines that are formed probably by the gelatinization of the less resistant starch. The grain swells, and the more resistant starch is divided into several parts which lie along the margin. As the grain continues to swell these pieces of ungelatinized starch are forced further and further apart and are gradually gelatinized and transformed into a thin, transparent envelope. This envelope is dissolved at one or two points, and the contents flow out and dissolve, followed by solution of the rest of the envelope.

With *pyrogallic acid* the reaction begins in most of the grains in 30 seconds to a minute, and is over in 8 minutes. The reaction starts at the hilum, which grows clearer. The less resistant starch of the grain becomes gelatinous and occupies the central part, and the more resistant starch is pushed peripherally and forms a fairly broad, dense band. This band becomes rather slowly less broad and less dense until finally it is quite transparent. The gelatinized grains are fairly large and retain much of their original form.

The reaction with *ferric chloride* begins in a few grains in 2 minutes and is over in 25 minutes. The hilum becomes clear, and the less resistant starch is gelatinized and occupies the central part of the grain, while as the grain swells the more resistant starch is pushed out to form a fairly broad, dense, marginal band. This band becomes less broad and dense, until it is only a thin transparent capsule. The gelatinized grains are large, but they do not retain much of their original form. The capsules are often much folded and wrinkled.

With *Purdy's solution* there is a slight reaction in a few grains in 4 minutes and but little further change in an hour.

GENUS ORYZA.

According to Hitchcock, *Oryza* is a tropical genus of six species. *O. sativa* Linn. is originally native to the Old World tropics, but now naturalized in Brazil and cultivated extensively in China and India and in the coast region of the southern United States. It yields the rice of commerce. Starch from an unnamed agricultural form of *O. sativa* was studied as a type of the genus.

STARCH OF ORYZA SATIVA VAR. (Plate 2, figs. 7 and 8. Chart 14.)

Histological Characteristics.—In *form* the grains are simple, but frequently observed either in oval or rounded aggregates which consist of from two to many components. Pressure facets, variable in number, are present on the isolated grains. The conspicuous form of the isolated grains is sharply polygonal and even crystalline in character. The number of angles varies, but the pentagonal type rather predominates. Rarely oval grains with one margin rounded and the other flattened or concave are found. The conspicuous forms of the aggregates are somewhat rounded or ovoid. They closely resemble those found in the oats, but the angular character of the component grains is more marked and the aggregates break up more readily into individual grains.

The *hilum* is usually centric and may appear either as a round central spot or as a cleft, but generally it can not be distinguished.

The *lamellæ* are not visible.

The simple grains vary in *size* from 1 by 1μ to 8 by 6μ. The common size is 5μ. The aggregates are as large as 30 by 20μ.

Polariscopic Properties.—The *figure* is usually centric, but so small that its details can not be determined. The lines appear to be straight and at right angles, so as to form a cross.

The degree of *polarization* is low to fair. The grains are so minute that it is impossible to determine clearly whether there are any variations in the same aspect of a grain.

With *selenite* the quadrants are so very small that it is impossible to determine in most cases their relative shape and size. They appear, as a rule, to be irregular in shape and unequal in size. The colors are usually not pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution, the grains are colored a light violet with a slight reddish tint, and the color deepens rather slowly; with a 0.125 per cent solution they stain a light reddish-violet, the color deepening rather slowly. After heating in water until the grains are completely gelatinized, the solution colors a deep blue with a reddish tint and the grains a light blue. After boiling for 2 minutes the solution colors a deep indigo-blue, but the gelatinized grain-residues do not color at all. The capsules assume an old-rose tint when an excess of iodine is added.

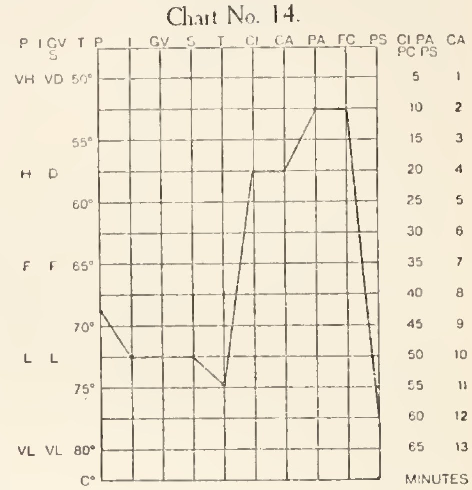
Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are rather lightly stained.

With *safranin* the grains begin to stain at once and in 30 minutes they are rather lightly stained.

Temperature Reaction.—The temperature of gelatinization is 74° to 75.5° C., mean 74.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in many of the grains in 30 seconds. It is over in nearly all in 10 minutes and in all in 20 minutes. The reaction starts at the most prominent points on the margin, which become dark and swell somewhat, and the process goes inward from these points all over the grain. The gelatinized grains are not very large and usually have a central light space surrounded by a thick, dark marginal band. They retain much of their original form.

Chart No. 14.



Curve of Reaction-Intensities of Starch of Oryza sativa var.

The reaction with *chromic acid* begins in most of the grains in 30 seconds, and is over in 4 minutes. The central part of the grain becomes clearer, and clear lines extend from this part to each angle, attended by gelatinization of the interior and swelling of the grain; but the starch between these lines retains for a time its original character. The capsule of the grain dissolves at one point and the contents flow out. The solid more resistant starch before noted then slowly dissolves, and finally the entire grain disappears.

With *pyrogallic acid* the reaction begins in many grains in 30 seconds and is over in 10 minutes. The central part of the grains becomes clear, and clear lines extend from it to each angle, but the starch between these lines is more resistant. The grain swells, and the ungelatinized resistant portions are forced further and further apart; finally, they also become gelatinized and a large capsule is formed that is filled with a semifluid mass. The gelatinized grains are large and retain some of their original form.

The reaction with *ferric chloride* begins in many grains in 30 seconds and is over in 10 minutes. The central part of the grain grows larger and clearer, and the whole grain swells, usually suddenly and very rapidly. In some grains the angles become gelatinous first, this being followed by a clearing of the central part and swelling of the grain. The starch between the angles is usually gelatinized after the other part. The gelatinized grains are large and rather irregular in outline, but they retain some of the original form of the grain.

The reaction with *Purdy's solution* begins in some of the grains in one minute, and a few are completely gelatinized in 10 minutes, but there is little further progress in an hour. The reaction appears to be the same as that with *pyrogallic acid.*

GENUS TRITICUM.

The genus, as now limited, comprises *Ægilops* and *Triticum.* The former includes twelve species which grow wild in Southern Europe and in parts of Asia, one of which is believed to be the probable source of our cultivated wheats. The polymorphous *Triticum* includes among its number three species of cultivated wheats (*T. monococcum* Linn., *T. polonicum* Linn., and *T. sativum* Lam.). The many varieties of *T. sativum* are classified in three races—the *spelts*, the *emmers*, and the *wheats.* The starch of an agricultural variety of the common wheat (*T. vulgare* Vill.) and that of one of the emmers (*T. dicoccum* Schrank) were examined as types of these races.

STARCH OF TRITICUM SATIVUM VAR. VULGARE. (Plate 2, figs. 9 and 10. Chart 15.)

Histological Characteristics.—In *form* the grains are simple and isolated, excepting a few that are found in aggregates and clumps. There are two distinct classes of grains, large and small. The conspicuous forms of the large grains are nearly round, oval, and irregular ovoid. When viewed on edge they are lenticular, spindle-shaped, or occasionally either elliptical or plano-convex. In addition, there are rarely some bean-shaped or reniform and hemispherical grains. The minute grains are usually globular or ovoid, but occasionally hemispherical (perhaps broken grains) or spindle-shaped. The outline of the large grains is often slightly irregular, which is chiefly due to indentations on the surface which probably have been caused by the adherence and pressure of small globular grains. A few of the grains are partially gelatinized, probably by the heat of grinding. These two classes of grains represent non-identical forms of starch. In the photograph extremely few of the small grains, which are very abundant, are shown.

The *hilum* is not usually visible, but occasionally in the rather small, round grains it can be seen as a clear spot. It is centric or slightly eccentric. There is in the center of the grains sometimes either a cavity or a cleft, and rarely there are several fissures which radiate from the center. When the large grains are viewed on edge, a light, mesial longitudinal line is observed which has somewhat the appearance of a cleft.

The *lamellæ* are rarely visible, but occasionally they can be determined on a part of the grain as fine regular circles or parts of circles. In a few grains 8 to 10 were counted.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 38 by 34μ. The common size is 20μ.

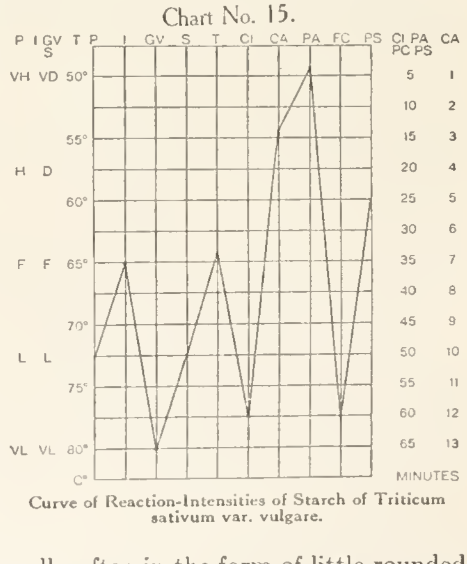
Polariscopic Properties.—The *figure* is usually centric, although occasionally slightly eccentric, and while fairly distinct in the majority of the grains, it is very indistinct in many. The lines of the figure are generally broad, and they broaden towards the margin of the grain. In a few grains they are sharply defined, but in most they are very broad and diffused. The lines are commonly straight; but they may be curved, or vary in thickness, or be bisected.

The degree of *polarization* is low in the large grains to fair in the medium to smaller forms. It is high when the large grains are observed on edge. There is usually some variation in the same aspect of a grain.

With *selenite*, in a great many of the grains, consisting chiefly of the largest, the quadrants are not clearly marked and are generally somewhat irregular in shape and unequal in size. In the small grains the quadrants are equal in size and regular in shape. The colors in the large grains are usually not pure, but in the small grains they are pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution all of the grains color a fair blue-violet to a reddish-violet; with a 0.125 per cent solution they color lightly. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the gelatinized grain-residues very lightly. The capsules, which are much twisted and folded, color a red-violet with an excess of iodine.

Chart No. 15.



Curve of Reaction-Intensities of Starch of Triticum sativum var. vulgare.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once, and in 30 minutes they are very lightly stained.

With *safranin* the grains begin to stain very lightly at once, and in 30 minutes they are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 63° to 65° C., mean 64°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some of the grains in 45 seconds, and in most of the grains in 3 minutes. In 30 minutes nearly all are affected, and one-fifth are completely gelatinized, with but little further change in an hour. The reaction begins at one or at several points on the margin. The starch at these places becomes dark and swells, often in the form of little rounded protuberances. If several areas are affected the process spreads along the margin from each point until all of the marginal starch is affected. Then the process spreads inward over the rest of the grain, often more rapidly from one or two points than from others. If the reaction begins at but one part on the margin, the starch here darkens and swells, and the process spreads centrally, and then over all parts. The gelatinized grains are not very large, they are of a uniform dark indigo color, and retain much of their original form.

The reaction with *chromic acid* begins in some of the grains in 15 to 30 seconds and is over in 2¾ minutes. The hilum becomes more distinct, and coarse striæ appear which radiate from the hilum in all directions. The less resistant starch is transformed into a semiliquid mass which occupies the central portion of the grain, thus causing the whole grain to swell gradually and equally in all directions and forcing the more resistant starch into the form of a fairly broad, coarsely striated, marginal ring which shows two or three concentric refractive and non-refractive bands, the remains of the lamellar structure. These bands fade gradually as the marginal ring grows thinner and clearer, until there is a thin, homogeneous-looking, clear envelope. This envelope or capsule is now indented at one point, solution occurring at the bottom of the indentation. The semiliquid contents flow out through this opening and dissolve, followed by solution of the envelope.

The reaction with *pyrogallic acid* begins in most of the grains in 30 seconds and is over in 3 minutes. The hilum and lamellæ often become more distinct, and striæ appear radiating from the hilum throughout the grains. The less resistant starch passes rapidly into a gelatinous mass which occupies the center of the grain, causing the grain to swell rapidly. The more resistant starch is forced to the margin, where it forms a striated band, which, as the grain swells rapidly, becomes a thin and clear envelope. The resulting swollen grain is very large, and the envelope is often invaginated, folded, and wrinkled, the folds sometimes being concentric and seeming to follow the lines of the prominent lamellæ.

The reaction begins in a few grains in a minute with *ferric chloride*. About half are completely gelatinized in 30 minutes, and three-fourths in an hour. The central portion of the grain assumes a granular appearance; the starch at one or two points on the margin begins to gelatinize, and the process spreads from these points either about the margin, leaving the central portion for a time ungelatinized, or it spreads over the whole grain, the margin not being gelatinized before the adjacent central portion. The gelatinized grains are very large, with wrinkled and folded capsules.

With *Purdy's solution* the reaction begins in a few grains in 20 seconds, about two-thirds are gelatinized in 5 minutes, nine-tenths in 10 minutes, and all in 25 minutes. The reaction is the same in appearance as that to pyrogallic acid.

STARCH OF TRITICUM SATIVUM VAR. DICOCCUM. (Plate 2, figs. 9 and 10. Chart 16.)

Histological Characteristics.—In *form* the grains are simple and for the most part isolated. A few have pressure facets. The grains vary rather more in form and are more irregular in outline than in the specimen of *T. sativum* var. *vulgare*. The conspicuous forms are the same as *T. sativum* var. *vulgare*, but there are more of semicircular forms and grains having their outline flattened at various points. A larger proportion of grains of this preparation were partially gelatinized than in the first specimen. One grain of *T. sativum* var. *vulgare* was deeply fissured in the process of breaking apart in the middle, and since aggregates in the form of doublets with grains of equal size were not observed it is quite possible that the large hemispherical grains referred to are half grains. There are a few minute globular and ovoid grains, but they are not nearly so numerous as in *T. sativum* var. *vulgare*. More of the small grains are spindle-shaped, and the aggregates usually consist of clusters of rather larger grains than those noted in the other variety, and the components appear to be mostly of the pointed type. The grains are usually broader than thick.

The *hilum* and cleft have the same characters and structure as noted for *T. sativum* var. *vulgare*.

The *lamellæ* are visible in a larger portion of grains than in *T. sativum* var. *vulgare*. Since the lamellæ are usually more clearly marked in grains which are undergoing gelatinization or solution, it is probable that the relative prominence of the lamellæ in this specimen is to be attributed to this cause. There were ten to fourteen lamellæ counted on some of the large grains.

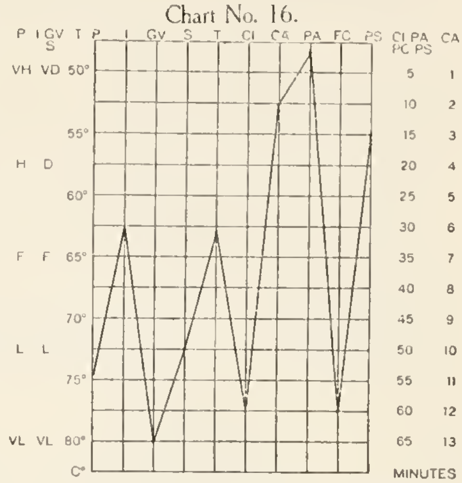
The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 40 by 30μ and 32 by 32μ. The common size is 22μ.

Polariscopic Properties.—The *figure* is usually centric, but occasionally slightly eccentric. The lines of the figure are similar to those noted in *T. sativum* var. *vulgare*, but in a greater number of grains they are very indistinct, and more often either bent or bisected.

The degree of *polarization* is very low in the large grains to fair in a few of the smaller grains. Variations are usually observed in the same aspect of a grain. It is high when the grains are viewed on edge. It is lower on the whole than in *T. sativum* var. *vulgare*.

With *selenite* the quadrants are rarely well defined, and generally unequal in size and irregular in shape. The colors in the large grains are commonly not pure, and this lack of purity occurs in a greater proportion of grains than in the previous preparation.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fair blue-violet to reddish-violet; and with a 0.125 per cent solution they color lightly, and the color deepens slowly. The color is slightly deeper than that of the grains of *T. sativum* var. *vulgare*. After heating in water until all the grains are completely gelatinized the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and most of the gelatinized grain-residues very lightly. The capsules, which are much twisted and folded, all color violet with an excess of iodine.



Curve of Reaction-Intensities of Starch of Triticum sativum var. dicoccum.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes they are very lightly stained. The color is the same as that of the grains of *T. sativum* var. *vulgare.*

With *safranin* the grains begin to stain very lightly at once and in 30 minutes they are lightly stained. The color is the same as that of the grains of *T. sativum* var. *vulgare.*

Temperature Reaction.—The temperature of gelatinization is 62° to 63.8° C., mean 62.9°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some of the grains in 15 to 45 seconds, and in most of the grains in 5 minutes. About one-fifth are fully gelatinized in 20 minutes, without much further reaction in an hour. The reaction is the same qualitatively as that of the grains of *T. sativum* var. *vulgare.*

The reaction with *chromic acid* begins in from 10 to 20 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *T. sativum* var. *vulgare.*

The reaction begins in 20 seconds and is over in 2 minutes with *pyrogallic acid.* It is the same qualitatively as that of the grains of *T. sativum* var. *vulgare.*

With *ferric chloride* the reaction begins in a few grains in a minute. Nearly all are completely gelatinized in 50 minutes and all in an hour. The reaction is qualitatively the same as that of the grains of *T. sativum* var. *vulgare.*

The reaction with *Purdy's solution* begins in some of the grains in 20 seconds, and in many in a minute. About four-fifths are completely gelatinized in 5 minutes, nearly all in 10 minutes, and all in 15 minutes. The reaction is qualitatively the same as that of the grains of *T. sativum* var. *vulgare.*

Differentiation of the Starches of the Genus Triticum.

Histological Characteristics.

Conspicuous Forms.

T. sativum var. *vulgare:* Simple, large grains are nearly round, oval, and irregularly ovoid; minute grains globular and ovoid.

T. sativum var. *dicoccum:* Same as in *T. sativum* var. *vulgare,* but minute grains are very much less numerous and the larger grains vary more in form and are more irregular in outline.

Hilum—Form, Number, and Position.

T. sativum var. *vulgare:* Form usually not visible; in large grains there may be a cavity or cleft and occasionally radial fissures; in minute grains a clear spot. Centric or slightly eccentric.

T. sativum var. *dicoccum:* Same as in *T. sativum* var. *vulgare.* Position centric or slightly eccentric.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.

T. sativum var. *vulgare:* Rarely visible; fine, regular, continuous rings. Occasionally 8 to 10 on the larger grains.

T. sativum var. *dicoccum:* Same as in *T. sativum* var. *vulgare,* but they are visible on a larger proportion of grains. Occasionally 10 to 14 on the larger grains.

Size.

T. sativum var. *vulgare:* From 2 to 38μ, usually 20μ.

T. sativum var. *dicoccum:* From 2 to 40μ, usually 22μ.

Polariscopic Properties.

Figure.

T. sativum var. *vulgare:* Usually centric, commonly fairly distinct, generally regular, lines usually straight.

Differentiation of the Starches of the Genus Triticum.—Continued.

POLARISCOPIC PROPERTIES.—Continued.

Figure.—Continued.

T. sativum var. *dicoccum:* Same as in *T. sativum* var. *vulgare*, but the lines are on the whole less distinct and show more tendency to be bent or bisected.

Degree of Polarization.

T. sativum var. *vulgare:* Low in the larger grains to fair in medium to small grains.
T. sativum var. *dicoccum:* Same as in *T. sativum* var. *vulgare*, but lower on the whole.

Polarization with Selenite—Quadrants and Colors.

T. sativum var. *vulgare:* Quadrants in the large grains usually not well defined, irregular in shape, and unequal in size; small grains, well defined, regular, and equal. Color in large grains impure, in small grains pure.
T. sativum var. *dicoccum:* Quadrants in large grains less well defined, more irregular, and more unequal than in *T. sativum* var. *vulgare;* in small grains the same. Color in large grains more impure than in *T. sativum* var. *vulgare*, same in small grains.

IODINE REACTIONS.

Intensity and Color.

T. sativum var. *vulgare:* Fair; blue-violet to reddish-violet.
T. sativum var. *dicoccum:* Fair, slightly deeper than in *T. sativum* var. *vulgare;* blue-violet to reddish-violet.

STAINING REACTIONS.

With Gentian Violet.

T. sativum var. *vulgare:* Very light.
T. sativum var. *dicoccum:* Very light, same as in *T. sativum* var. *vulgare.*

With Safranin.

T. sativum var. *vulgare:* Light.
T. sativum var. *dicoccum:* Light, same as in *T. sativum* var. *vulgare.*

TEMPERATURE OF GELATINIZATION.

T. sativum var. *vulgare:* 63 to 65° C., mean 64°.
T. sativum var. *dicoccum:* 62 to 63.8° C., mean 62.9°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

T. sativum var. *vulgare:* Begins in some in 45 seconds; partial in half and complete in one-fifth in 30 minutes; incomplete in an hour.
T. sativum var *dicoccum:* Begins in some in 30 to 45 seconds; partial in most and complete in one-fifth in 20 minutes; incomplete in an hour.

Reaction with Chromic Acid.

T. sativum var. *vulgare:* Begins in 15 to 30 seconds; complete in all in 2¾ minutes.
T. sativum var. *dicoccum:* Begins in 10 to 20 seconds; complete in all in 2 minutes.

Reaction with Pyrogallic Acid.

T. sativum var. *vulgare:* Begins in most in 30 seconds; complete in all in 3 minutes.
T. sativum var. *dicoccum:* Begins in all in 20 seconds; complete in all in 2 minutes.

Ferric Chloride.

T. sativum var. *vulgare:* Begins in a few in a minute; complete in three-fourths in an hour.
T. sativum var. *dicoccum:* Begins in a few in a minute; complete in all in an hour.

Reaction with Purdy's Solution.

T. sativum var. *vulgare:* Begins in a few in 20 seconds; complete in all in 25 minutes.
T. sativum var. *dicoccum:* Begins in some in 20 seconds, in many in 1 minute; complete in all in 15 minutes.

NOTES ON THE STARCHES OF TRITICUM.

The wheat starches are closely alike in all respects. Apart from the fact that in *T. sativum* var. *vulgare* the grains are somewhat less irregular and less variable in form, that the lamellæ are visible in a less number of grains and fewer in number, and the slightly smaller size of the grains, all of which differences are minor and may be incidental, there are no noticeable differences in the gross histological characteristics. In the reactions, in this starch polarization is slightly higher, the iodine reaction slightly lower, the temperature of gelatinization higher (1.1°), and the sensitivity less to all of the chemical reagents. While the differences are not marked they are sufficient to permit of a positive differentiation.

GENUS SECALE.

Secale cereale Linn., which is the only cultivated rye, is regarded by Hackel as originating from *S. montanum*, a native of the region between the Black Sea and the Caspian. Two agricultural forms of this species, Mammoth Winter rye and Spring rye, were studied as types.

STARCH OF SECALE CEREALE VAR. (MAMMOTH WINTER).

(Plate 2, figs. 11 and 12. Chart 17.)

Histological Characteristics.—In *form* the grains are simple and generally isolated. Aggregates are frequently observed which consist usually either of numerous minute grains or of one large grain with several very small ones adhering to it. There are, as in *Triticum*, two classes of grains, large and small, which represent different forms of starch. The conspicuous forms among the large grains are round, oval, and ovoid. In addition, there are occasional bean-shaped, slightly polygonal, triangular with rounded angles, and hemispherical grains. When viewed on edge the grains are elliptical, spindle-shaped, or lenticular. The conspicuous forms of the small grains are globular to oval, but since so many of them were parts of aggregates they vary considerably in shape and tend to have angular and somewhat irregular forms, such as triangular, polygonal, dome-shaped, and spindle-shaped. The grains of *Secale* closely resemble those of *Triticum*, but the largest grains are of greater size, and the small grains tend to be more angular and variable in shape.

The *hilum* is not usually visible. It is rarely observed as a small, clear, round spot which is centric in position. Either an irregular cavity or clefts are often found at the position of the hilum, and the clefts are clean-cut and arranged so as to form a cross, a star, or a Y-shaped figure. When viewed on edge, a mesial line or groove similar to that noted under *Triticum* may be present. The grains of *Secale* differ from those of *Triticum* in having the central clefts, but in general the resemblance is well marked.

The *lamellæ* are usually indistinct, but occasionally fine, concentric, regular rings can be observed, the number of which on large grains is from 12 to 16.

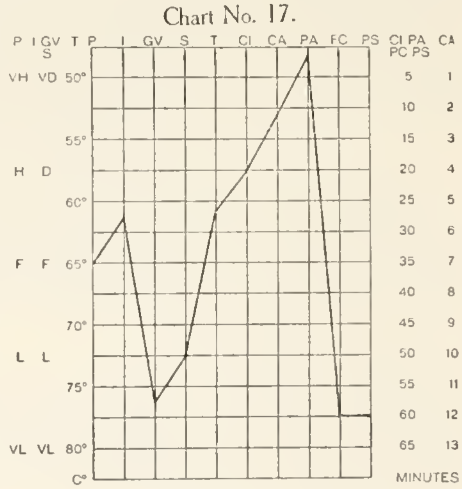
The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 48 by 44μ and 44 by 44μ. The common size is 28μ.

Polariscopic Properties.—The *figure* is usually centric. It usually is distinct in the medium and small grains, but not in the larger grains. The lines in case of a distinct figure are generally rather thick and straight, broadening towards the margin of the grain. In the indistinct figure of the large grains the lines are diffused and more clearly defined at the margin of the grain. A large central dark space is frequently observed. The lines are sometimes either bent or bisected.

The degree of *polarization* is low to fairly high when the grains are viewed on the flat, and quite high when viewed on edge. It is lowest in the large grains, and often varies in the aspect of a grain, being higher at the margin than at the center of the large grain. Polarization is higher in a larger proportion of grains than in *Triticum*. On the whole it is low.

With *selenite* the quadrants are not well defined, are slightly irregular in shape, and unequal in size in most of the grains. In a few grains they are regular in shape and equal in size. The colors in most of the grains are not quite pure.

Chart No. 17.



Curve of Reaction-Intensities of Starch of Secale cereale var. (Mammoth Winter).

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep blue to reddish-violet; with a 0.125 per cent solution they color lightly, and the color deepens fairly rapidly. After heating in water until all the grains are completely gelatinized the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and most of the gelatinized grain-residues very lightly. The capsules, which are much folded and crumpled, all color red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once, and in 30 minutes they are very lightly to lightly stained.

With *safranin* the grains begin to stain lightly at once, and in 30 minutes they are very lightly to lightly stained.

Temperature Reaction.—The temperature of gelatinization is 60° to 62° C., mean 61°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most of the grains at once. About half are gelatinized in 5 minutes, nearly all in 10 minutes, and all in 20 minutes. The reaction starts at one or more points on the margin, or on the margin generally, and the process moves inward from all parts, and as a rule more rapidly from certain areas. The gelatinized grains are not very large and retain much of their original form.

The reaction with *chromic acid* begins in from 10 to 20 seconds and is over in 2¼ minutes. The hilum and lamellæ sometimes become more distinct, and in some grains the starch at one or two points on the margin, where erosion or gelatinization has probably started, begins to gelatinize and dissolve. In normal grains fine striæ appear, radiating from the hilum in all directions towards the periphery. The less resistant starch passes into a semiliquid mass which occupies the central part of the grain, and the more resistant starch forms a marginal ring which is finely striated, and becomes a thin, transparent, homogeneous-looking capsule as the grain swells. This capsule is dissolved at one or two points, and the semiliquid inclosed starch flows out and is dissolved, followed by solution of the capsule.

With *pyrogallic acid* the reaction begins in all the grains in from 30 to 45 seconds and is over in 1¾ minutes. The hilum and lamellæ become very distinct, and fine striæ appear radiating from the hilum in all directions. The grain swells, but the less resistant starch, whose early gelatinization is the primary cause of the swelling, does not collect in the center, but remains distributed throughout the grain, and the more resistant starch also remains in place, so that there are in the swollen grains several striated, concentric bands separated by clear spaces. These bands become clearer, until in many grains it is very difficult to distinguish them. The gelatinized grains are large, clear, and often retain much of their original form and some of their lamellar markings, while the capsules of others are folded and wrinkled.

The reaction with *ferric chloride* begins in a few grains in 1½ minutes. In 30 minutes about half of the grains are completely gelatinized, and in an hour nearly all are completely gelatinized. The reaction begins at several points on the margin. The starch at these parts gelatinizes and swells irregularly, and the process extends inward over the rest of the grain. In some cases the process at first affects all the starch of the margin, and then proceeds inward. The central starch meanwhile becomes granular and rather clear. The swollen grains are large and do not retain much of their original form. The capsule is usually much wrinkled and folded.

The reaction begins in some of the grains in a minute with *Purdy's solution.* A few grains are partially gelatinized in 20 minutes, but there is not much further change in an hour. The reaction, as far as it goes, is much like that with pyrogallic acid, the main difference being that with Purdy's solution the marginal starch appears more sensitive to the reagent than the central starch.

STARCH OF SECALE CEREALE VAR. (SPRING). (Plate 2, figs. 11 and 12. Chart 18.)

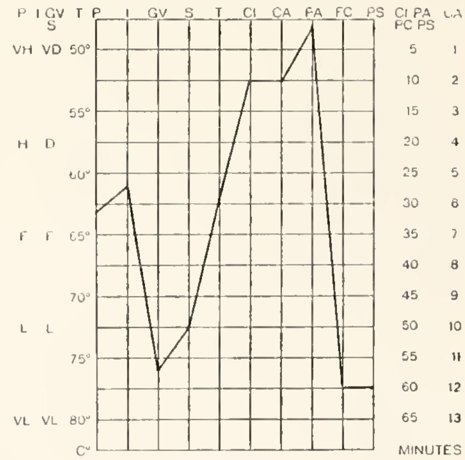
Histological Characteristics.—In *form* the grains are usually simple and for the most part isolated. There are some aggregates which consist usually either of numerous minute grains, or of one large grain with several very small ones adhering to it. The conspicuous forms, both of the large grains and small grains, are the same as those noted for Mammoth Winter rye.

In some of the medium-sized grains the *hilum* may be distinguished as a clear spot which is centric or slightly eccentric in position. Usually the hilum is not visible. Quite often either an irregular cavity or clefts are found in the region of the hilum similar to those noted under Mammoth Winter rye.

The *lamellæ,* both as to number and character, closely resemble those of Mammoth Winter rye.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 48 by 48μ and 40 by 40μ. The common size is 28μ.

Chart No. 18.



Curve of Reaction-Intensities of Starch of Secale cereale var. (Spring).

Polariscopic Properties.—The *figure* is usually centric and is distinct in the medium-sized and small grains. It is distinct in a larger proportion of large grains than in Mammoth Winter rye. The figure and lines are the same as noted for Mammoth Winter rye.

The degree of *polarization* is low to fairly high when grains are viewed on the flat, and quite high when viewed on edge. It is on the whole low, but somewhat higher in a greater proportion of grains than in Mammoth Winter rye.

With *selenite* the quadrants and the colors are the same as those noted for Mammoth Winter rye.

Iodine Reactions.—With a 0.25 per cent Lugol's solution, the grains all color a fairly deep blue to a reddish-violet; with a 0.125 per cent solution they are lightly colored. The coloration is the same as that of the grains of Mammoth Winter rye. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply. After boiling for 2 minutes the solution colors very deeply and most of the grain-residues very lightly. The capsules, which are much crumpled and folded, are colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes they are lightly stained. The color is a little deeper than that of the grains of Mammoth Winter rye.

With *safranin* the grains begin to stain lightly at once and in 30 minutes they are lightly stained. The color is slightly deeper than that of the grains of Mammoth Winter rye.

Temperature Reaction.—The temperature of gelatinization is 61° to 63° C., mean 62°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in many of the grains immediately. About nine-tenths are gelatinized in 5 minutes, and all in 10 minutes. The reaction is the same qualitatively as that of the grains of Mammoth Winter rye.

The reaction with *chromic acid* begins in from 20 to 30 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of Mammoth Winter rye.

With *pyrogallic acid* the reaction begins in some of the grains in 10 to 15 seconds and in the rest in 30 minutes. It is over in 1½ minutes. It is the same qualitatively as that of the grains of Mammoth Winter rye.

The reaction begins in a few grains in a minute with *ferric chloride*. In 30 minutes about two-thirds of the grains are completely gelatinized, and in an hour practically all are completely gelatinized. The reaction is the same qualitatively as that of the grains of Mammoth Winter rye.

The reaction with *Purdy's solution* begins in some of the grains in a minute and in most in 3 minutes. There is but little change after this, even at the end of an hour.

Differentiation of the Starches of the Genus Secale.

Histological Characteristics.

Conspicuous Forms.

Mammoth Winter rye: Simple. Large grains round, oval, ovoid; small grains globular to oval.
Spring rye: Same as in Mammoth Winter rye.

Hilum—Form, Number, and Position.

Mammoth Winter rye: Form not usually visible; clear, round spot, or irregular cavity or clefts. Position centric or slightly eccentric.
Spring rye: Form same as for Mammoth Winter rye. Position centric or slightly eccentric.

Lamellæ—General Characteristics and Number.

Mammoth Winter rye: Usually indistinct; fine concentric, regular rings. From 12 to 16 on the larger grains.
Spring rye: Same as in Mammoth Winter rye. From 12 to 16 on the larger grains.

Size.

Mammoth Winter rye: From 2 to 48μ, usually 28μ.
Spring rye: From 2 to 48μ, usually 28μ.

Polariscopic Properties.

Mammoth Winter rye: Usually centric, not distinct in large grains, but distinct in medium and small-sized grains; central dark area in large grains; lines usually rather thick and straight.
Spring rye: Same as for Mammoth Winter rye, but the figure is distinct in a larger proportion of the larger grains.

Degree of Polarization.

Mammoth Winter rye: Low to fairly high, on the whole low.
Spring rye: Low to fairly high, on the whole somewhat higher than in Mammoth Winter rye.

Polariscopic Properties.—Continued.

Polarization with Selenite—Quadrants and Colors.

Mammoth Winter rye: Quadrants not well defined, slightly irregular in shape and unequal in size. Color not pure.
Spring rye: Quadrants same as in Mammoth Winter rye. Color not pure.

Iodine Reactions.

Intensity and Color.

Mammoth Winter rye: Fairly deep; blue to reddish-violet.
Spring rye: Fairly deep, the same as in Mammoth Winter rye; blue to reddish-violet.

Staining Reactions.

With Gentian Violet.

Mammoth Winter rye: Very light to light.
Spring rye: Light, slightly deeper than in Mammoth Winter rye.

With Safranin.

Mammoth Winter rye: Very light to light.
Spring rye: Light, slightly deeper than Mammoth Winter rye.

Temperature of Gelatinization.

Mammoth Winter rye: 60 to 62° C., mean 61°.
Spring rye: 61 to 63° C., mean 62°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

Mammoth Winter rye: Begins in most in 2 minutes; complete in all in 20 minutes.
Spring rye: Begins in most in 2 minutes; complete in all in 10 minutes.

Differentiation of the Starches of the Genus Secale.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chromic Acid.

Mammoth Winter rye: Begins in 10 to 20 seconds; complete in all in 2¼ minutes.
Spring rye: Begins in 20 to 30 seconds; complete in all in 2 minutes.

Reaction with Pyrogallic Acid.

Mammoth Winter rye: Begins in 30 to 45 seconds; complete in all in 1¾ minutes.
Spring rye: Begins in 10 to 30 seconds; complete in all in 1½ minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.

Mammoth Winter rye: Begins in a few in 1½ minutes; complete in half in 30 minutes, and in nearly all in an hour.
Spring rye: Begins in a few in a minute; complete in about two-thirds in 30 minutes, and in nearly all in an hour.

Reaction with Purdy's Solution.

Mammoth Winter rye: Begins in some in a minute; a few partially gelatinized in 20 minutes, and but little further change in an hour.
Spring rye: Begins in some in a minute; little further change during an hour.

NOTES ON THE STARCHES OF SECALE.

The two starches examined do not exhibit any appreciable differences in their gross histological characters. In the reactions it is seen that the Mammoth Winter rye has a lower degree of polarization, lower reactions with the aniline dyes, a lower temperature of gelatinization (1°), a higher sensitivity to chloral hydrate-iodine and Purdy's solution, and a lower sensitivity to chromic acid, pyrogallic acid, and ferric chloride.

GENUS HORDEUM.

This genus comprises about twelve known species. The origin of *Hordeum sativum* Jess., the cultivated barley which occurs in various agricultural forms, is yet unknown, but according to Hackel it originated from *H. spontaneum* C. Koch, "which grows wild from Asia Minor and Caucasian countries to Persia and Beloochistan, as well as in Syria, Palestine, and Arabia Petræa." An agricultural form of *H. sativum* known as Champion barley was used as a type of the genus.

STARCH OF HORDEUM SATIVUM VAR. (CHAMPION). (Plate 3, figs. 13 and 14. Chart 19.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few in the form of aggregates and clumps. The aggregates consist generally either of numerous grains of variable size, or of one large grain with very small grains closely adherent. The conspicuous forms of the large grains are round, oval, ovoid, and reniform. When viewed on edge they are spindle-shaped, elliptical, or occasionally plano-convex. In addition, triangular forms with rounded angles and sides may be observed. The minute grains are usually globular, but are sometimes spindle-shaped or oval. Hemispherical and dome-shaped grains are also present among both the large and small grains. The starch of barley closely resembles that of wheat, but the grains are not so large, and more reniform or bean-shaped forms are found. The large and small grains respectively represent different forms of starch.

The *hilum* is not usually visible, but it may occasionally be observed as a clear, round spot, which is centric or slightly eccentric. Either a cavity or one or more clefts are rarely found in the region of the hilum. When viewed on edge the longitudinal medial cleft or groove similar to that noted in *T. sativum* var. *vulgare* is sometimes observed.

The *lamellæ* are often invisible, but when observed they are rather coarse and complete concentric rings. On grains of common size from 6 to 8 lamellæ have been counted.

The grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 28 by 26μ. The common size is 19μ.

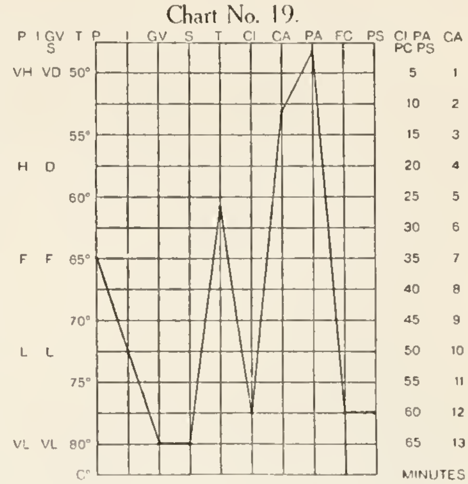
Polariscopic Properties.—The *figure* is usually centric. It is distinct in the small grains, but not well marked in the large ones. In the small grains the lines of the figure are rather thick and commonly straight. In the large grains they are generally more distinct towards the margin, and for the most part straight, although they may be bent and also bisected. The figure resembles closely that of *Triticum sativum* var. *vulgare,* but is not quite so distinct in the large and more irregular grains.

The degree of *polarization* is low in the large grains to fairly high in the small grains. It is higher at the margin than at the center in the large grains; and in some grains there is a variation in the different quadrants. Polarization is fairly high when the grains are viewed on edge. On the whole it is low. In some grains only parts of the extreme margin are anisotropic.

With *selenite*, in most of the small grains the quadrants are well defined, regular in shape, and usually equal in size. The colors are pure. In the large grains the quadrants are not as a rule well defined, and are often irregular in shape and of unequal size. The colors are not pure.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all begin to color a rather light blue-violet to violet; with a 0.125 per cent solution they color very lightly, and the color deepens fairly rapidly. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues do not color at all. The capsules all color a red-violet with an excess of iodine.

Chart No. 19.



Curve of Reaction-Intensities of Starch of Hordeum sativum var. (Champion).

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once, but in 30 minutes they are still very lightly stained.

With *safranin* the grains begin to stain very lightly at once, but in 30 minutes they are still very lightly stained.

Temperature Reaction.—The temperature of gelatinization is 60° to 62° C., mean 61°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most of the grains in 1½ to 2 minutes; about one-fourth are gelatinized in 30 minutes, and one-half in an hour. The reaction begins at one or less often at two points on the margin, where the starch becomes dark and swells somewhat. The reaction spreads over the rest of the grain, usually slightly more rapidly over the marginal starch than over the inner parts of the grain, until only the part opposite the point at which the coloration began remains unaffected. This finally is gelatinized. The gelatinized grains are not very large, and they retain much of their original form.

The reaction with *chromic acid* begins in from 10 to 20 seconds and is over in 2¼ minutes. The hilum often becomes distinct, or the central portion of the grain assumes a granular appearance. Fine striæ appear radiating from the hilum or central portion in all directions. The less resistant portions of the grain are now changed into a somewhat granular semiliquid mass, which occupies the central portion of the grain, attended by swelling of the grain. The more resistant outer starch in some cases remains in place until the starch in other parts is dissolved. This resistant starch forms a rather thin, striated marginal ring, which becomes thinner and transparent until it is only a thin capsule, which incloses a granular gelatinous mass. This capsule is dissolved at one point, and through this opening the semifluid gelatinized starch pours out and is dissolved, followed by solution of the remainder of the capsule.

With *pyrogallic acid* the reaction begins in many of the grains in 30 seconds and is over in 2 minutes. The central portion of the grain assumes a granular appearance, and in some grains the hilum becomes distinct and fine striæ appear radiating from the central portion. The less resistant starch passes into a semiliquid mass and the grain swells. The more resistant outer starch retains for the most part its original position and presents the appearance of a number of irregular rings, or parts of rings, of varying breadth and density, located between the central portion of the grain and the margin. These rings become thin and clearer, but they never entirely disappear. The gelatinized grains are fairly large and often retain much of the original form of the grain. Their capsules are sometimes much wrinkled, folded, and twisted.

The reaction begins in a few grains in a minute with *ferric chloride.* It is over in one-half of the grains in 15 minutes, in two-thirds in 35 minutes, and in nearly all in an hour. The reaction begins at one or two points on the margin. At these points the starch becomes gelatinous and swells out irregularly, and from them the reaction spreads quite uniformly over the whole grain. The gelatinized grains are large, but do not retain much of the original form of the grain. The capsules are very much wrinkled and folded.

The reaction with *Purdy's solution* begins in some grains in 1½ minutes, but there is little further change at the end of an hour. The reaction, as far as it goes, appears to possess the same characteristics as that with pyrogallic acid.

GENUS AVENA.

Included in this genus are about 50 species which are native to the temperate regions of the Old and New Worlds. The most important species is *A. sativa* Linn., of which there are quite a number of cultivated forms. The agricultural variety or form known as Clydesdale oats was used as a type of the genus.

STARCH OF AVENA SATIVA VAR. (CLYDESDALE). (Plate 2, figs. 15 and 16. Chart 20.)

Histological Characteristics.—In *form* the grains are usually simple and are in part isolated, and in part in aggregates which consist of two or more components, and in clumps. The conspicuous forms of the aggregates, which are very prominent in oat starch, are oval, ovoid, and pyriform. The component grains vary in number from two to very many. The conspicuous forms of the isolated grains are polygonal, spindle-shaped, oval, ovoid, round, and irregular oval with one side either flattened or concave. The large round grains resemble those of *Triticum.*

The *hilum* is frequently invisible. It is occasionally observed as a clear round spot, centric or slightly eccentric. Either a nearly round cavity or a longitudinal cleft may sometimes be found. Spindle-shaped grains are often doublets having a cavity at the region of each hilum.

The *lamellæ* are not visible.

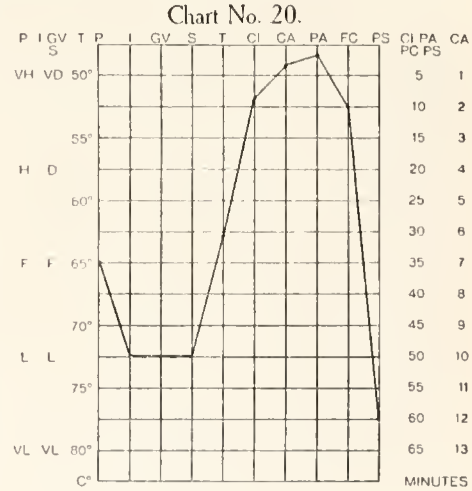
The isolated grains vary in *size* from the smaller, which are 2 by 2μ, to the larger polygonal, which are 12 by 10μ, and to the large ovoid and round grains, which are about 20 by 18μ. The common size of the isolated grains is 8μ. The aggregates may be as large as 40 by 30μ.

Polariscopic Properties.—The *figure* in the smaller grains appears to be centric, but it is so small and polarization so low that the details of its form can not be accurately determined. The figure in the larger grains is centric or slightly eccentric. The lines of the figure are usually not distinct, excepting towards the margin; and they are rather thick and sometimes straight, but often either bent or bisected.

The degree of *polarization* is low in most of the grains, but rather high in a few. It frequently varies in the same aspect of a grain. The different quadrants in the small grains often show a variation, and in the majority of the larger grains the polarization of the margin is higher than of the central portion, and it may be entirely or almost entirely absent. Occasionally it is rather high throughout the grain. It is higher when the grain is viewed on edge. On the whole, it is low.

With *selenite*, in the small grains the quadrants are well defined, somewhat irregular in shape, and unequal in size. In the larger grains the quadrants are seldom well defined, and they are irregular in shape and unequal in size. The colors are not pure; the yellow is proportionately brighter than the blue. In a few grains the colors are quite bright and almost pure.

Chart No. 20.



Curve of Reaction-Intensities of Starch of Avena sativa var. (Clydesdale).

Iodine Reactions.—With a 0.25 per cent Lugol's solution, most of the grains color a very light old-rose to a light reddish-violet; a few do not color at all, while a few color deeply. The color gradually deepens until in 30 minutes most of the grains are either of a rather dark reddish-violet or a fairly deep old-rose. With a 0.125 per cent solution the grains color a light reddish-violet, which becomes fairly deep in 5 minutes, and quite deep in 30 minutes. After heating in water until the grains are completely gelatinized, the solution does not color, but the grains assume a deep purple tint on the addition of iodine. After boiling for 2 minutes the solution colors a very deep purple and the grain-residues a light reddish-violet. The capsules assume a deep old-rose or wine color when an excess of iodine is added.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes they are lightly stained.

With *safranin* the grains begin to stain very lightly at once and in 30 minutes they are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 62° to 64° C., mean 63°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds to a minute and is over in 8 minutes. The reaction originates at the prominent angles and edges of the facets, which darken and swell slightly, and from these points it spreads inward evenly and without much swelling over the rest of the grain. The gelatinized grains are not very large and retain much of the original form of the grain. They have a central light portion surrounded by a broad marginal band of dark starch.

The reaction with *chromic acid* begins at once and is over in 40 seconds. It is so rapid that it was impossible to distinguish the different steps.

With *pyrogallic acid* the reaction begins in 15 to 30 seconds and is over in 1½ minutes. The hilum becomes distinct and clear, and clear lines often extend from the hilum nearly to the angles of the facets. The grain swells as the less resistant starch becomes gelatinous, forming a large mass which is clear in the central portion and has a fairly broad, dense marginal band formed by the more resistant outer starch. This band is less dense and not so broad at the angles of the facets, and it becomes transparent and less broad and dense, until finally there remains only a thin, transparent capsule. The gelatinized grains are large and retain some of their original form. The capsules are often wrinkled, crumpled, and folded. The components of the aggregates often separate or partially separate from one another during the process of gelatinization.

The reaction with *ferric chloride* begins in many grains in a minute and is over in 10 minutes. The reaction starts at the angles and edges of the facets, and the starch at these points becomes gelatinous and swells out irregularly. The hilum now becomes distinct, and the less resistant starch of the inner part of the grain gelatinizes, causing the grain to swell. The resistant marginal starch is gelatinized at first only at the angles and edges of the facets, but later all parts become gelatinous. The gelatinized grains are very large and retain some of the original form of the grain. The capsules are often wrinkled and crumpled.

The reaction with *Purdy's solution* begins in some of the grains in a minute and in 20 minutes about one-fourth are partially or completely gelatinized. The reaction is very incomplete at the end of an hour. The reaction, as far as it goes, presents the same appearances as that with pyrogallic acid.

GENUS ARRHENATHERUM.

This is a genus of pasture grasses. One member, commonly known as *Avena elatior* Beauv., is of agricultural importance, the seed being sold as a cereal under the same name.

STARCH OF ARRHENATHERUM ELATIUS VAR. (Plate 3, figs. 17 and 18. Chart 21.)

Histological Characteristics.—In *form* the grains are usually simple, but there are many aggregates consisting of from two to many components. Pressure facets are well marked on the separated grains. The conspicuous forms of the aggregates which characterize this starch are round, oval, and ovoid, and resemble those of *Avena*, but are of smaller size. The conspicuous forms of the simple grains which consist of the "filling-in grains" (Füllstärke, Tschirch) and the separated-grains are usually polygonal, but there are a few round, oval, ovoid, and dome-shaped. These grains resemble those of *Avena*, but there are more separated-grains, and these are more crystalline in appearance because of the more marked angularities caused by the pressure facets.

The *hilum* may be found as a round central spot, but generally there is either a cavity or cleft at the position of the hilum. From the cavity small radiating fissures occasionally emerge.

No *lamellæ* can be seen.

The simple grains vary in *size* from the smaller, which are 2 by 2μ, to the larger, which are 14 by 12μ. The common size of the isolated grains is 8 by 8μ. The aggregates are as large as 18 by 10μ.

Polariscopic Properties.—The *figure* appears usually to be centric. In grains in which the figure can be distinguished the lines are rather thick and mostly straight. The majority of the grains are so small and the polarization so low that it is impossible to satisfactorily determine the details of the figure, but as far as can be determined the figure and lines are about the same as in *Avena*.

The degree of *polarization* is low to fair and varies in a majority of the grains in the same aspect of the grain. On the whole it is low. In the large grains it may be almost or entirely absent.

With *selenite* the quadrants are sometimes fairly well defined, and in the majority in which they can be distinguished they are slightly unequal in size and irregular in shape. The blue is generally pure, but the yellow not quite pure. The colors appear to be purer in a larger proportion of grains than in *Avena*.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the most of the grains color a very light old-rose, a very few take on a deep reddish-purple, while some do not color at all; with a 0.125 per cent solution the grains color a light old-rose, which in 5 minutes has become fairly deep. It is lighter and much redder than in grains of *Avena*. After heating in water until all are gelatinized, the solution does not color at all, but the gelatinized grains color a very deep purple, rather darker than in *Avena*. After boiling for 2 minutes, the solution colors a very dark bluish-purple and the grain-residues a very light old-rose tint. When an excess of iodine is added the capsules assume a deep wine-red color.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes they are lightly stained, the color being the same as that of *Avena*.

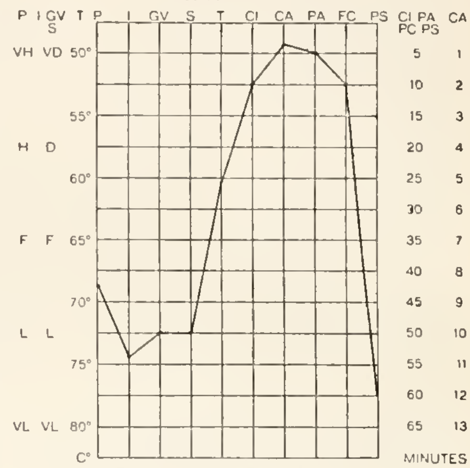
With *safranin* the grains begin to stain very lightly at once and in 30 minutes they are lightly stained, the color being the same as that of *Avena*.

Temperature Reaction.—The temperature of gelatinization is 59.5° to 61° C., mean 60.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* most of the grains begin to react in 45 seconds and the reaction is over in 10 minutes. It is the same qualitatively as that of *Avena*.

The reaction begins at once with *chromic acid* and is over in 40 seconds. It is so rapid that it is not possible to distinguish the separate steps.

Chart No. 21.



Curve of Reaction-Intensities of Starch of Arrhenatherum elatius var.

The reaction with *pyrogallic acid* begins in 30 to 45 seconds, and is over in 5 minutes. It is the same qualitatively as that of *Avena*.

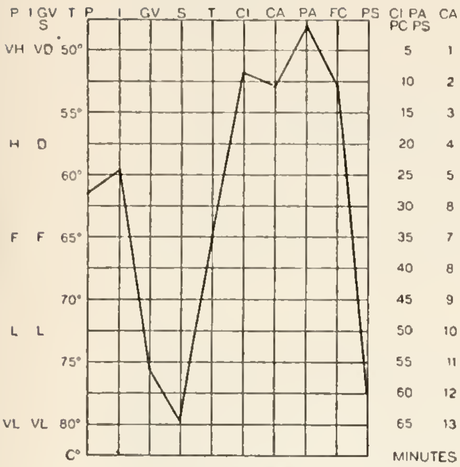
With *ferric chloride* the reaction begins in a few grains in 1½ minutes and is over in 10 minutes. It is the same qualitatively as that of *Avena*.

With *Purdy's solution* there is a slight reaction in a few grains in 2 minutes. About one-fifth are completely gelatinized in 15 minutes and about two-fifths in 40 minutes. There is little further change in an hour. It is the same qualitatively as that of *Avena*.

NOTES ON THE STARCHES OF GRAMINACEÆ. (Charts 22 to 30.)

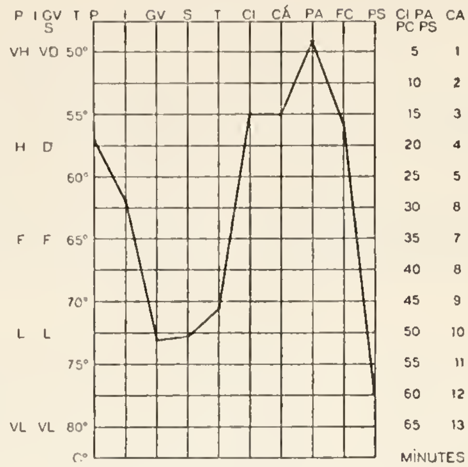
Comparing the gross histological peculiarities of the starches of the different genera, it will be seen that there is a distinct grouping, as instanced in *Zea* and *Andropogon*, *Triticum* and *Secale* and *Hordeum*, and *Avena* and *Arrhenatherum*, respectively. The types of the starch-grains are distinctly different in all three groups: In *Zea* and *Andropogon* the grains are essentially polygonal; in the *Triticum* group they are essentially in the form of large, round, ovoid, and oval disks; and in the *Avena* group the type is polygonal with few large round, ovoid, and oval disks. Comparing the reaction curves it will be noticed that the same marked group relationships are strikingly exhibited, except of a single reaction in each in the case of *Secale* and *Triticum* of the *Triticum* group. The curves of *Zea* and *Andropogon* closely correspond; those of *Panicum* and *Oryza*, respectively, which represent different genera, are modifications of the preceding; those of the *Triticum* group are in accord with the exception of *Secale*, in which there is shown a distinctly higher reactivity with chloral hydrate-iodine, and of *Triticum*, in which there is a distinctly higher responsivity with Purdy's solution than is observed with the other members; while those of the *Avena* group are nearly alike. Botanically, the relationships of *Zea* and *Andropogon* are recognized especially in the fact that they are among the few grasses that have a solid stem; and the relationships of the *Triticum* and *Avena* groups, respectively, are well marked. The *Graminaceæ* starches do not exhibit in their reactions the generic diversities which commonly are conspicuous in the starches of the seeds of *Leguminosæ* and in those from genera that have been obtained from parts other than seeds, such as bulbs, tubers, rhizomes, root-stocks, etc.

Chart No. 22.



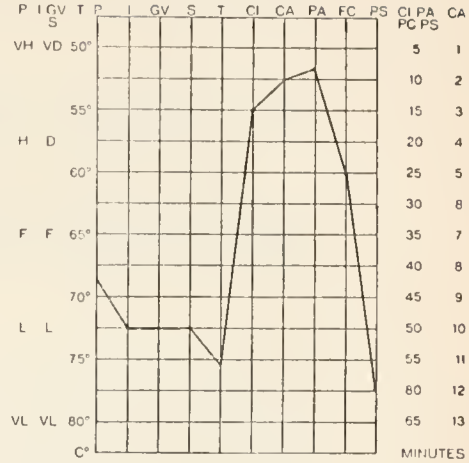
Composite Curve of Mean Reaction-Intensities of Starches of Zea.

Chart No. 23.



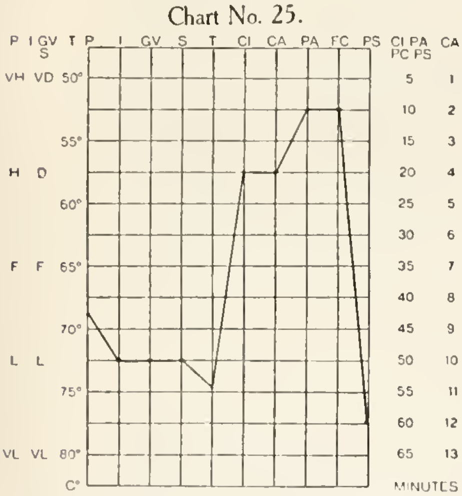
Composite Curve of Mean Reaction-Intensities of Starch of Andropogon.

Chart No. 24.



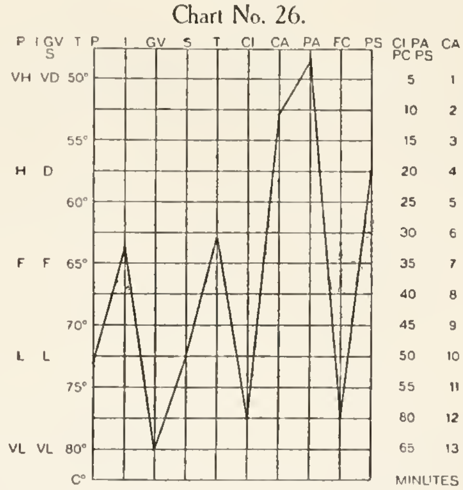
Curve of Reaction-Intensities of Starch of Panicum.

Chart No. 25.



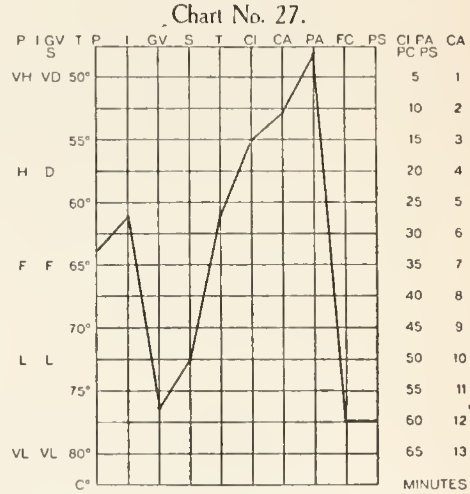
Curve of Reaction-Intensities of Starch of Oryza.

Chart No. 26.



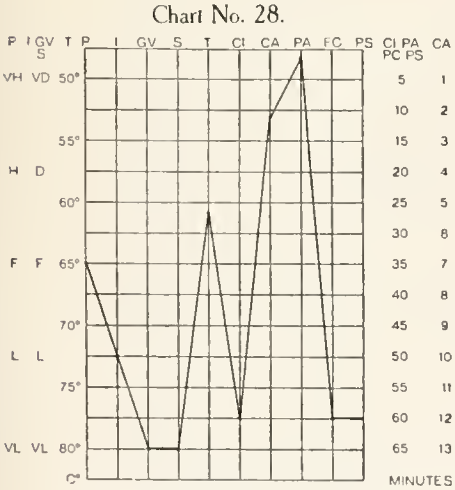
Composite Curve of Mean Reaction-Intensities of Starches of Triticum.

Chart No. 27.



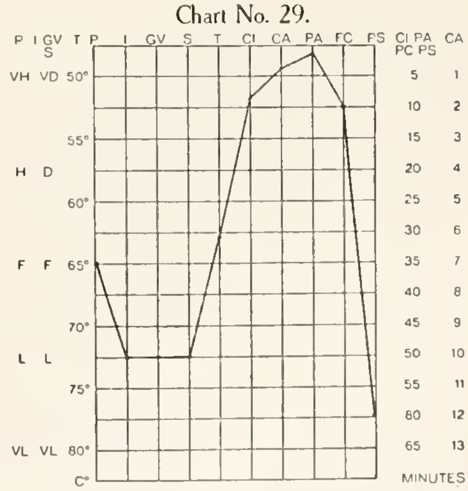
Composite Curve of Mean Reaction-Intensities of Starches of Secale.

Chart No. 28.



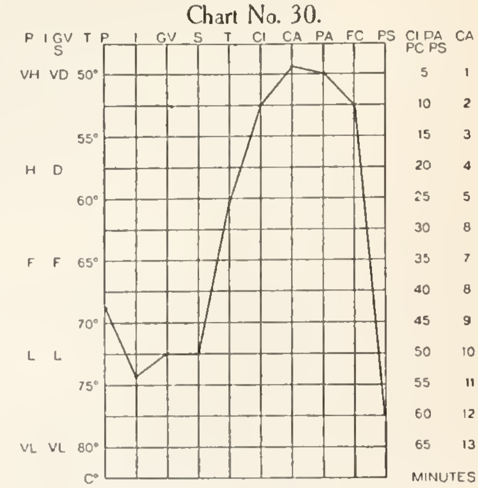
Curve of Reaction-Intensities of Starch of Hordeum.

Chart No. 29.



Curve of Reaction-Intensities of Starch of Avena.

Chart No. 30.



Curve of Reaction-Intensities of Starch of Arrhenatherum.

STARCHES OF LEGUMINOSÆ.

Class, Dicotyledones. Order, Rosales. Family, Leguminosæ. Genera represented: Vicia, Phaseolus, Dolichos, Mucuna, Lens, Lathyrus, Pisum, Wistaria, Arachis.

The *Leguminosæ*, or pulse family, or legumes, are distributed over almost every country of the earth, and include about 430 genera and 7,000 species, many of which are of considerable importance, serving a great diversity of purposes. Of this large number of genera we had the opportunity of studying the starches of only nine representatives.

GENUS VICIA.

The genus *Vicia* is closely related to *Phaseolus, Dolichos, Mucuna,* and *Glycine. Lens* probably serves as a connecting link between them and *Lathyrus* and *Pisum. Vicia* is stated to comprise about 200 species, of which about 120 are well defined. They are widely distributed in North and South America and Europe, and to some extent in Central America. The starches of the following five species in common cultivation were studied: *Vicia sativa* Linn. (spring vetch or tare) is cultivated in both the Old and New Worlds as a fodder crop or cover crop, or for its seeds, which are rich in starch and yield a starchy flour, etc. *V. villosa* Roth. (sand, winter, or hairy vetch) is cultivated chiefly as a cover crop. *V. faba* Linn. (*Faba vulgaris* Mœnch., *F. sativa* Bernh.) is grown for forage and for the seeds. This species has been cultivated since prehistoric times and is known as the field, horse, broad, tick, and Windsor bean. *V. fulgens* Batt and *V. gerardi* Vill. are garden species that are cultivated for their pea-shaped flowers.

According to the agriculturist the beans in common cultivation may be grouped in five classes: (1) the broad bean, of which *Vicia faba* is the type, as instanced in the well-known English horse bean above referred to; (2) the kidney bean (*Phaseolus vulgaris*), including the many varieties of the string and snap beans of the garden and field; (3) the flat, kidney-shaped beans (*Phaseolus lunatus*), which include the lima beans; (4) the small flattened or rounded beans of *Dolichos*, well known as the velvet bean, asparagus bean, etc.; (5) the small, pea-like beans of *Glycine*, and typified by the common soy or soja bean, which contains little or no starch.

STARCH OF VICIA SATIVA. (Plate 4, figs. 19 and 20. Chart 31.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few in aggregates. The grains are most commonly bean-shaped, elongated oval, ovoid, lenticular and broadly lenticular, pyriform, and round to nearly round. There are some polygonal with rounded corners, and rarely triangular or heart-shaped. There are many irregularities of the surface in these forms caused by bulgings and indentations. Most of them show also deep, branching cracks running along the median line. The central part of such a grain appears to be a more or less homogeneous mass. This part is surrounded by a lamellated portion which is often fissured radially. Many of the grains in this preparation were partially gelatinized, owing probably to heat generated during grinding. The grains are not as thick as broad.

In some of the rounded forms a *hilum* may be observed in the form of a central clear, slightly refractive spot; but in other of these grains, and in the elongated grains, the position of the hilum is marked by a mesial fissure which often has branches which run to the sides and end. The central mass, when not fissured, appears more or less finely granular and occupies a large area, and in some grains is surrounded by a fissure.

The *lamellæ* are very distinct. In some of the forms they are coarse, concentric rings, and in others those adjacent to the central mass follow the irregularities of its margin, while the outer rings tend to follow the irregularities of the margin of the grain. Those nearer the central part are coarser and more prominent than those near the margin. They vary in number from four to twelve.

The grains vary in *size* from 6 to 42μ. The common size is 26μ.

Polariscopic Properties.—The *figure* is variable in accordance with the shape of the grain and other conditions. In most of the grains there is a central dark area from which four or more lines radiate. The presence of fissuration gives rise to more or less modification. In the unfissured grains it was in the form usually of a long, broad line with bisected ends occupying the long diameter of the grain, or a cross, commonly with a large dark area at the intersection of the lines. The lines are generally broad and not clear-cut. The mesial line with bisected ends is very conspicuous and may be referred to as the bean type.

The degree of *polarization* is high, as a rule, although it is absent in some places because of irregularities, such as depressions and fissures on the surface of the grains. It is higher when the grain is viewed from edge or end.

With *selenite* the quadrants are well defined, but irregular in shape, very unequal in size, and often subdivided. The colors as a rule are pure or fairly pure.

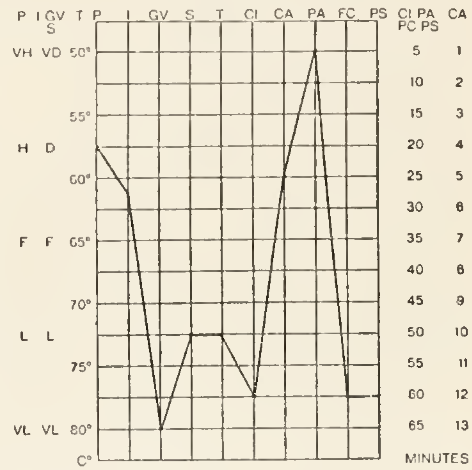
Iodine Reactions.—With a 0.25 per cent Lugol's solution, the grains color a fairly deep blue-violet; with a 0.125 per cent solution, the grains are at first tinted lightly and the color deepens somewhat. After heating in water until all the grains are completely gelatinized, the solution is quite deeply colored and the capsules very deeply on the addition of iodine. The grains are much swollen and distorted. After boiling for 2 minutes the solution becomes more deeply colored, but the grain-residues much less deeply. With an excess of iodine most of the capsules become a violet color, and usually inclose some blue-reacting starch.

Staining Reactions.—With *gentian violet* the reaction begins immediately in some of the grains, while others are only very lightly stained after $1\frac{1}{2}$ minutes. In 30 minutes the color is scarcely deeper than at the beginning. The partially gelatinized grains are more deeply stained than the uninjured grains.

With *safranin* the reaction begins in $1\frac{1}{2}$ minutes, but after 30 minutes the color is light.

Temperature Reaction.—The temperature of gelatinization is 72° to 73° C., mean 72.5°.

Chart No. 31.



Curve of Reaction-Intensities of Starch of Vicia sativa.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some of the grains in 30 seconds. About half are gelatinized in 30 minutes, two-thirds in 15 minutes, three-fourths in 30 minutes, and nine-tenths in an hour. Both the hilum or the fissures or spaces representing the hilum and the lamellæ are rendered very distinct. Gelatinization begins by the darkening of one end, the process spreading rapidly over the whole grain and attended by slight and uniform swelling. When the whole grain has darkened, swelling continues evenly. The gelatinized grains are in the form of an irregular mass in which the center is separated more or less completely from the dark marginal ring by a lighter space. The marginal ring shows alternate light and dark concentric bands. The swollen grains are not much distorted, nor very large.

The reaction with *chromic acid* begins immediately in some of the grains, and in 30 seconds in all. It is over in 5 minutes. Both hilum and lamellæ are very distinct. The reaction begins by fissuring of the hilum or region of the hilum, and frequently by an extension of radial fissures throughout the grain. The region of the hilum swells, and the more resistant starch of the outer part of the grain is formed into a ring which shows fine striæ and concentric, alternate, refractive and non-refractive lines, and also occasionally irregular granules on the inner side. This ring becomes clear and thinner as the grain continues to swell, until a large, ovoid, thin-walled mass is formed. All parts of the gelatinized grain dissolve with the same readiness.

The reaction with *pyrogallic acid* begins in all in 30 seconds and it is over in 5 minutes. Both hilum and lamellæ are rendered very distinct. The reaction begins in a swelling of the hilum; the inner part of the grain becomes a finely granular mass; and the marginal portion is changed to a distinctly striated ring that is marked with concentric light and dark lines. This ring may become invaded by deep, stellate fissures as the grain continues to swell. The gelatinized grain is very large and much distorted by many rounded, small, saccular projections at the margin.

With *ferric chloride* the reaction begins in a few grains in a minute and about two-fifths are completely gelatinized in 13 minutes. Other grains are not affected at all even after an hour. Both hilum and lamellæ are very prominent. The reaction begins with gelatinization, great swelling and protrusion at one end, and it advances slowly over the whole grain, proceeding more rapidly in the central part. The reaction reaches the other end, at which point the grain may be divided by fissures, and the pieces suddenly separate, and then undergo swelling independently. The swollen grains are very large and irregular, and much distorted by lobulations.

The reaction with *Purdy's solution* begins in some of the grains in 30 seconds. About three-fourths are affected and about half are fully gelatinized in 15 minutes. The reaction is not complete in an hour. Both hilum and lamellæ are very prominent. The character of the reaction is identical with that with pyrogallic acid, with the exception that very often the grains are not greatly swollen.

STARCH OF VICIA VILLOSA. (Plate 4, figs. 21 and 22. Chart 32.)

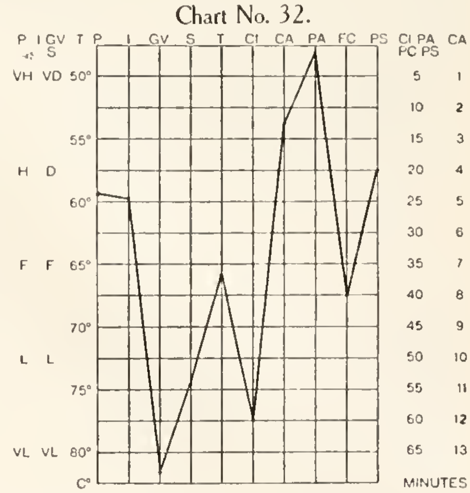
Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few found in some closely fitting aggregates. The surface of the grains is frequently rather irregular, owing either to incidental elevations or indentations at various points. The conspicuous forms are the bean-shaped, elongated, irregular oval and regular oval, and small rounded forms. There are some polygonal, triangular with rounded angles, and irregular heart-shaped grains. The grains are usually not so thick as broad.

In some of the small, simple, rounded forms the *hilum* appears to be round, and centric or slightly centric, but in other rounded forms and in the bean-shaped and other larger forms, the position of the hilum is represented by a fissure. The central non-lamellated portion of the grain is frequently fissured. A conspicuous fissure, which is long, broad, and deep and extends along the middle of the grain, is quite often observed. It may be clear-cut, but frequently is rather ragged, and usually has branches extending on each side into the substance of the grain almost to the margin. There is in some grains a central granulated mass which may be surrounded by a branched wreath-like fissure.

In the round forms the *lamellæ* are distinct, rather coarse, continuous, concentric lines. In many of the elongated grains they are coarse, continuous bands, the outermost following the outline of the margin, and therefore showing irregularities of the contour of the grain. In some of the grains the lamellæ are more distinct centrally than peripherally, but in others the reverse. They vary in number from four to ten, and resemble those observed in *Vicia sativa.*

The grains vary in *size* from the smaller, which are 6 by 6μ, to the larger, which are 44 by 24μ in length and breadth. The common sizes are 28 by 21μ or 30 by 26μ in length and breadth.

Chart No. 32.



Curve of Reaction-Intensities of Starch of Vicia villosa.

Polariscopic Properties.—The *figure* is centric or slightly eccentric. In the majority of the grains there is a large, central dark space from which several dark lines pass at irregular intervals. The lines of the figure of the small grains are rather thick, and may be either straight or bisected. Peculiarities of the figures and lines, as a whole, are the same as those observed in *Vicia sativa.*

The degree of *polarization* is high, although it is absent from a considerable space in the medial part of most of the larger grains, and it sometimes varies in the same aspect of a grain. It is higher when the grain is viewed from the side. It is scarcely as high, and the mesial non-illuminated area is larger, than in *Vicia sativa.*

With *selenite* the quadrants in some grains are well defined throughout, while in others they are only distinct near the margin of the grain. They are usually irregular in shape and unequal in size, and often subdivided. The colors are commonly pure and about the same as in *Vicia sativa.*

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains are colored a fairly deep violet; with a 0.125 per cent solution they color a very light violet, and the color deepens fairly rapidly. The tint is deeper than in *V. sativa.* After heating in water until all the grains are gelatinized, the solution colors an indigo-blue and the gelatinized grains a blue-black on the addition of iodine. After boiling for 2 minutes the solution colors a deep indigo-blue and the grain-residues a bright blue of much lighter color. The capsules are colored a deep reddish-purple with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain in a minute and in 30 minutes they are very lightly stained, slightly less than the grains of *V. sativa.*

With *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained, slightly less than the grains of *V. sativa.*

Temperature Reaction.—The temperature of gelatinization is 65° to 67° C., mean 66°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some of the grains begin to react in 20 seconds. About one-third are gelatinized in 5 minutes, two-thirds in 15 minutes, four-fifths in 30 minutes, and nine-tenths in an hour. The reactions are the same qualitatively as those of *V. sativa.*

The reaction with *chromic acid* begins in some grains in 15 seconds and in all in 45 seconds. It is over in most in 1¾ minutes and in all in 2½ minutes. It is the same qualitatively as that of *V. sativa.*

With *pyrogallic acid* the reaction begins in most of the grains in 15 seconds and is over in all in 1½ minutes. It is the same qualitatively as that of the grains of *V. sativa.*

The reaction with *ferric chloride* begins in a few grains in a minute. About two-thirds are completely gelatinized in 15 minutes and practically all in 40 minutes. It is the same qualitatively as of *V. sativa.*

The grains begin to react in a minute with *Purdy's solution.* About three-fourths are completely and all but a few are partially gelatinized in 8 minutes, and all are completely gelatinized in 20 minutes. The reaction is the same qualitatively as of *V. sativa.*

STARCH OF VICIA FABA. (Plate 4, figs. 23 and 24. Chart 33.)

Histological Characteristics.—In *form* the grains are simple and isolated. In a few grains well-marked depressions divide the grain into several distinct portions, each of which has its central cavity, irregular fissures, or hilum, thus suggesting a compound grain. The conspicuous forms are the ovoid to oval and elliptical. There are in addition reniform, pyriform, triangular, and quadrangular with rounded angles, and spherical forms, the latter especially among the smaller grains. The grains are in many cases about two-thirds as thick as they are broad.

Most of the grains are so subdivided by cavities and irregular fissures that no *hila* can be demonstrated. Characteristically the fissuration in the ovoid to elliptical grains takes the form of a very prominent single fissure which runs the length of the grain, with many side fissures branching from it.

The *lamellæ* are not visible in most of the grains, but in some they may be seen to be rather coarse, continuous rings which follow closely the outline of the grain. The absence of demonstrable hila and of multiple systems of lamellæ indicate that the grains are simple. There are from six to eight lamellæ on the larger grains.

The grains vary in *size* from the smaller, which are 5 by 4μ in length and breadth, to the larger, which are 42 by 28μ in length and breadth. The common size is 29 by 22μ in length and breadth.

Polariscopic Properties.—The *figure* is centric or slightly eccentric. It is distinct, but not clear-cut. The lines composing it are usually straight, but on account of the fissures and cavities in most of the grains its exact character can not be determined. In general characters it agrees with that of *V. villosa.*

The degree of *polarization* is high, as a rule. It varies somewhat in different grains, and it is higher in the same grain when seen on end or edge. It is higher than that of *V. sativa.* Very often there is a large dark area corresponding to the point of intersection of the lines.

With *selenite* the quadrants, which often can scarcely be recognized as such, are not well defined, irregular in shape, and unequal in size, and sometimes subdivided. The colors are generally pure, particularly the blue.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep blue or pinkish-violet; with a 0.125 per cent solution they all color fairly. The color is deeper than that of *V. sativa.* After heating in water until all the grains are completely gelatinized, both the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues fairly. The capsules all color a violet with an excess of iodine.

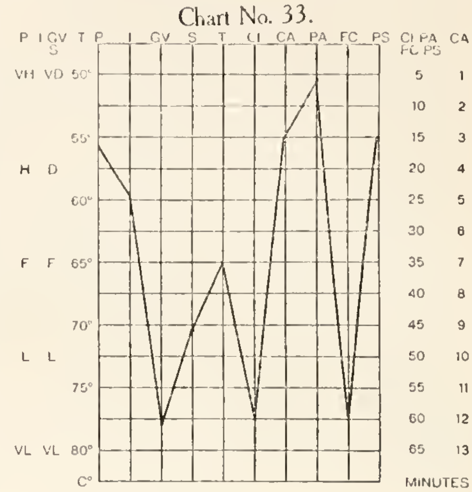
Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes they are rather lightly stained. The stain is deeper than that of *V. sativa.*

With *safranin* the grains begin to stain very lightly at once and in 30 minutes they are lightly stained. The stain is more than that of *V. sativa*.

Temperature Reaction.—The temperature of gelatinization is 64° to 66° C., mean 65°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some of the grains which are probably injured or partly eroded begin to react at once, but other grains which appear to be normal begin to react in 20 seconds. About one-fifth of the grains are gelatinized in 5 minutes, two-thirds in 15 minutes, three-fourths in 30 minutes, and seven-eighths in an hour. The process may begin at one or both ends. If it begins at one end, the starch at this point becomes of a dark indigo color and swells slightly, and the process spreads gradually over the whole grain, more rapidly in the central portion than near the margin. If it begins at both ends, the starch at these points becomes of a dark indigo color and swells slightly, and the process spreads gradually from over the whole grain. The starch in the central portion is gelatinized more rapidly than that at or near the margin, so that the processes spreading from the two ends become united through the central part of the grain, and later spreads over the sides. The gelatinized grains are fairly large, but not much distorted, and retain much of their original form.

Chart No. 33.



Curve of Reaction-Intensities of Starch of Vicia faba.

With *chromic acid* many of the grains begin to react in 15 seconds and are dissolved in 1½ minutes. The remainder begin to react in 30 seconds to a minute, and are dissolved in 3 minutes. The central fissure or group of fissures and hila becomes distinct, and the starch surrounding it is seen to be finely striated. Then as the starch nearest the mesial fissure is transformed into a semiliquid mass the whole grain begins to swell, and most of the remaining ungelatinized starch is also rapidly transformed into a semiliquid gelatinous mass, except the most resistant outer portion, which forms a capsule. This capsule is now dissolved at one point and the semiliquid contents flow out and pass into solution. Other parts of the capsule are dissolved later.

The reaction with *pyrogallic acid* begins in from a few seconds to 1½ minutes and is over in 6 minutes. It appears to consist of the gradual reduction of the less resistant starch to a semiliquid mass, accompanied by slow swelling of the entire grain. The grain gradually becomes larger and clearer, and the inner portion assumes the appearance of semitransparent masses of gelatinous starch surrounded by numerous clear channels, while the marginal portion appears to consist of a fairly broad, translucent, homogeneous-looking band of resistant starch which is often of very irregular form because of folds and indentations of the margin.

With *ferric chloride* some of the grains begin to react in 1¾ minutes. About one-third are gelatinized in 15 minutes and two-thirds in 50 minutes. The reaction is complete in an hour. The process may begin at one or both ends of the grains. If the former, the starch at this point becomes gelatinous and swells irregularly, and the reaction spreads over the rest of the grain about as rapidly over one part as over another. If the reaction begins at both ends, the starch at these points becomes gelatinous and swells irregularly, and then spreads over the rest of the grain until often only a small, central, unswollen portion is left that is surrounded or nearly surrounded by gelatinized starch. This center is also finally gelatinized. The gelatinized grain is very large and irregularly shaped, and the capsule is wrinkled, sacculated, and crumpled.

Most of the grains become clearer with *Purdy's solution*, and the central fissure, or fissures, or hila, or cavities become very distinct and somewhat larger in a minute. In 10 minutes the majority of the grains are nearly completely gelatinized, and in 15 minutes all are nearly completely gelatinized.

STARCH OF VICIA FULGENS. (Plate 5, figs. 25 and 26. Chart 34.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few which occur in aggregates. The surface of the grains is somewhat irregular, owing to indentations and elevations. The conspicuous forms are bean-shaped, elongated, irregular and regular oval, ovoid, and rounded. There are also forms which are irregular rhomboidal, polygonal with rounded corners, round, irregular heart-shaped, and triangular with rounded angles. There is a larger proportion of rounded forms than in *Vicia sativa.*

The *hilum* may be observed in the round or rounded grains as a clear, slightly refractive, round spot that is located in a depression in the central part of the grain. In other forms the position of the hilum is frequently marked by a deep fissure, which in the elongated grains extends along the middle of the grain. This fissure may be clear-cut, but is more often ragged, and from it numerous lateral branches may proceed through the substance of the grain almost to the margin. Often it is bisected at both ends. There is sometimes a central, non-lamellated, granular area which is surrounded by an irregularly branched, wreath-like fissure.

The *lamellæ* in the round forms are coarse, distinct, concentric rings. In the elongated grains they are continuous, coarse bands which for the most part tend to follow the margin of the grain, and therefore have the same irregularities as noted in the contour of the grain. They have the same characters as recorded for *V. sativa.* They vary in number from 5 to 12.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 40 by 28μ or 36 by 20μ in length and breadth. The common sizes are 27 by 23μ and 26 by 14μ in length and breadth.

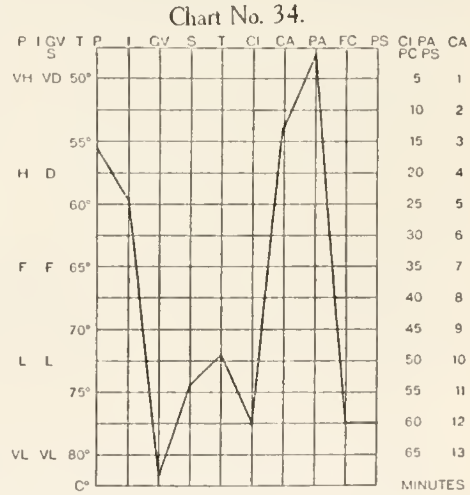
Polariscopic Properties.—The *figure* is centric or slightly eccentric, and in all essential respects corresponds with that observed in *V. sativa.*

The degree of *polarization* varies from high to very high. There is often a variation in the same aspect of a grain. It is higher when the grain is viewed from the edge or end. It is higher and there is greater range than in *V. sativa.*

With *selenite* the peculiarities of the quadrants are essentially the same as those observed in *V. sativa.* The colors are generally pure, but the yellow is sometimes not quite pure throughout the entire quadrant. There is a slightly greater variation in the purity of the colors than in the grains of *V. sativa.*

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet at once; with a 0.125 per cent solution they color a rather lighter violet, and the color deepens fairly rapidly. The color of the grains is deeper than that of *V. sativa.* After heating in water until all the grains are completely gelatinized, the solution colors a greenish-blue and the gelatinized grains a very deep reddish-blue on the addition of iodine. After boiling for 2 minutes the solution colors a deep indigo-blue, but most of the grain-residues color very lightly. With an excess of iodine the capsules become a deep reddish-purple.

Chart No. 34.



Curve of Reaction-Intensities of Starch of Vicia fulgens.

Staining Reactions.—With *gentian violet* the grains begin to stain in a minute and in 30 minutes they are very lightly stained. The stain is very slightly less than that of *V. sativa.*

With *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained. The stain is very slightly less than that of *V. sativa.*

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains in 20 seconds. About one-fifth are gelatinized in 5 minutes, one-half in 15 minutes, two-thirds in 30 minutes, and five-sixths in an hour. The reaction is qualitatively the same as that of the grains of *V. sativa.*

The reaction with *chromic acid* begins in most of the grains in 15 seconds, and in all in a minute. It is over in most of the grains in 1 minute and in all in 2½ minutes. It is the same qualitatively as that of the grains of *V. sativa.*

The reaction with *pyrogallic acid* begins in most of the grains in 15 seconds and is over in all in 1¼ minutes. It is the same qualitatively as that of the grains of *V. sativa.*

With *ferric chloride* the reaction begins in a few grains in a minute. About one-half are completely gelatinized in 20 minutes and nearly all in an hour. The reaction is the same qualitatively as that of the grains of *V. sativa.*

The reaction with *Purdy's solution* begins in nearly all the grains in a minute. A few are completely gelatinized and many partially gelatinized in 4 minutes, and two-thirds are completely gelatinized and one-third partially gelatinized in 25 minutes. The reaction is not fully completed in an hour. It is the same qualitatively as that of the grains of *V. sativa*.

STARCH OF VICIA GERARDI. (Plate 5, figs. 27 and 28. Chart 35.)

Histological Characteristics.—In *form* the grains are simple and with the exception of a few are isolated. The surface of the grains is frequently irregular, owing to elevations or indentations. The conspicuous forms are bean-shaped, elongated irregular and regular oval, and ovoid. There are also some round, triangular with rounded angles, irregularly heart-shaped, and broadly lenticular.

The *hilum* may be observed in some of the round forms as a clear, slightly refractive, somewhat irregularly outlined spot which is centric or slightly eccentric. The position of the hilum in the elongated forms is usually marked by a long, deep mesial fissure. This fissure may be clean-cut, but is frequently ragged and generally much broadened and may have bisected ends. Lateral fissures from it may extend almost to the margin of the grain. There is sometimes a central, granulated non-lamellated area which may or may not be surrounded by a branched, wreath-like fissure.

The *lamellæ* in the round forms are distinct, rather coarse, concentric rings; and in the elongated grains they are continuous, coarse bands which tend for the most part to follow the contour of the grain, and therefore show corresponding irregularities. The lamellæ are more distinct throughout the grain, and more distinct in a greater majority of grains than in those of *V. sativa*. They vary from 5 to 12 in number.

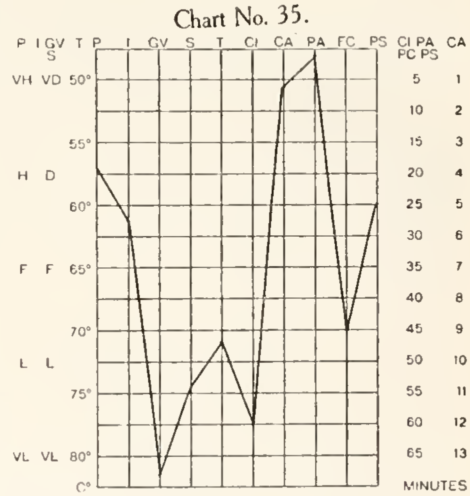
The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 40 by 28μ or 36 by 33μ in length and breadth. The common sizes are 28 by 22μ and 24 by 22μ in length and breadth.

Polariscopic Properties.—The *figure* is centric in some of the grains, while in others it is slightly eccentric. In the majority of the grains there is a large, dark, central space from which several dark lines proceed. The lines of the figure in the small simple grains are rather thick and broaden towards the margin. They may be straight or bisected. The peculiarities of the figure are essentially the same as those observed in *V. sativa*.

The degree of *polarization* is high, as a rule. It is absent from the central part of most of the grains, and it sometimes varies in the same aspect of a grain. It is higher when the grain is viewed from the edge or side. It is about the same as or higher than in *V. sativa*, and there is a larger number of grains in which it is high.

With *selenite* the quadrants in some grains are well defined throughout, while in others they are only distinct in the marginal parts of the grain. They are generally irregular in shape and unequal in size, and they may be subdivided. The colors are usually pure. In some grains the yellow is not quite pure. The colors, on the whole, are slightly purer than in *V. sativa*.

Chart No. 35.



Curve of Reaction-Intensities of Starch of Vicia gerardi.

Iodine Reactions.—With a 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with a 0.125 per cent solution they color a very light violet, which deepens gradually. They color about the same as those of *V. sativa*. After heating in water until all the grains are completely gelatinized, the solution is changed to an indigo-blue and the grains to a dark-blue on the addition of iodine. After boiling for 2 minutes the solution is colored very deeply, and some of the grain-residues a light blue and others a bright, rather light blue. With an excess of iodine the capsules stain a deep reddish-purple.

Staining Reactions.—With *gentian violet* the grains begin to stain in a minute and in 30 minutes they are very lightly stained, a few deeper than others. The color is less than that of *V. sativa*.

With *safranin* the grains begin to stain at once, and in 30 minutes they are lightly stained, a few deeper than others. The color is less than that of *V. sativa*.

Temperature Reaction.—The temperature of gelatinization is 70° to 72° C., mean 71°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some of the grains in 20 seconds. About one-fifth are completely gelatinized in 5 minutes, one-half in 15 minutes, two-thirds in 30 minutes, and five-sevenths in an hour. It is the same qualitatively as that of the grains of *V. sativa*.

The reaction with *chromic acid* begins in most of the grains in 30 seconds and in all in 50 seconds. It is over in 1¼ minutes. It is the same qualitatively as that of the grains of *V. sativa*.

The reaction with *pyrogallic acid* begins in all of the grains in 30 seconds and is over in 1½ minutes. It is the same qualitatively as that of the grains of *V. sativa*.

With *ferric chloride* the reaction begins in a few grains in 2 minutes. About three-fifths are gelatinized in 25 minutes and nearly all in three-fourths of an hour. It is the same qualitatively as that of the grains of *V. sativa*.

The reaction with *Purdy's solution* begins in nearly all the grains in a minute. A few are completely and many partially gelatinized in 4 minutes, and most are completely gelatinized in 25 minutes. It is the same qualitatively as that of the grains of *V. sativa*.

Differentiation of Certain Starches of the Genus Vicia.

Histological Characteristics.

Conspicuous Forms.

V. sativa: Simple. Bean-shaped, elongated oval, ovoid, lenticular and broadly lenticular, pyriform, round to nearly round.
V. villosa: Essentially the same as in *V. sativa*.
V. faba: Essentially the same as in *V. sativa*.
V. fulgens: Essentially the same as in *V. sativa*, but with a larger proportion of rounded forms.
V. gerardi: Essentially the same as in *V. sativa*.

Hilum—Form, Number, and Position.

V. sativa: In rounded forms it may be a small, clear, round, slightly refractive spot; in elongated forms it is usually represented by a median fissure which tends to have bisected ends. Position centric or slightly eccentric.
V. villosa: Essentially the same as in *V. sativa*. Position centric or slightly eccentric.
V. faba: Essentially the same as in *V. sativa*. Position centric or slightly eccentric.
V. fulgens: Essentially the same as in *V. sativa*. Position centric or slightly eccentric.
V. gerardi: Essentially the same as in *V. sativa*. Position centric or slightly eccentric.

Lamellæ—General Characteristics and Number.

V. sativa: Very distinct, coarse, continuous; tending generally to follow the margin of the grain. 4 to 12.
V. villosa: Essentially the same as in *V. sativa*. 4 to 10.
V. faba: Essentially the same as in *V. sativa*. 6 to 8.
V. fulgens: Essentially the same as in *V. sativa*. 5 to 12.

Size.

V. sativa: 6 to 42μ, commonly 26μ.
V. villosa: 6 to 44μ, commonly 28μ.
V. faba: 4 to 42μ, commonly 29μ.
V. fulgens: 4 to 40μ, commonly 27μ.
V. gerardi: 4 to 40μ, commonly 28μ.

Polariscopic Properties.

Figure.

V. sativa: Centric or slightly eccentric, variable in form; in the round grains a cross; in the elongated grains chiefly a long, broad mesial line with bisected ends.
V. villosa: Essentially the same as in *V. sativa*.
V. faba: Essentially the same as in *V. sativa*.
V. fulgens: Essentially the same as in *V. sativa*.
V. gerardi: Essentially the same as in *V. sativa*.

Polariscopic Properties.—Continued.

Degree of Polarization.

V. sativa: High, as a rule.
V. villosa: High, but lower than in *V. sativa*.
V. faba: High, higher than in *V. sativa*.
V. fulgens: High, higher than in *V. sativa*, with greater range.
V. gerardi: High, about the same or higher than in *V. sativa*.

Polarization with Selenite—Quadrants and Colors.

V. sativa: Quadrants well-defined, irregular in shape, unequal in size, often subdivided. Colors usually pure.
V. villosa: Quadrants same as in *V. sativa*. Colors usually pure.
V. faba: Quadrants same as in *V. sativa*. Colors usually pure.
V. fulgens: Quadrants same as in *V. sativa*. Colors usually pure, but greater variation than in *V. sativa*.
V. gerardi: Quadrants same as in *V. sativa*. Colors usually pure, slightly purer than in *V. sativa*.

Iodine Reactions.

Intensity and Color.

V. sativa: Fairly deep; blue-violet.
V. villosa: Fairly deep, deeper than in *V. sativa;* violet.
V. faba: Fairly deep, deeper than in *V. sativa*, pinkish violet.
V. fulgens: Fairly deep, deeper than in *V. sativa;* blue-violet.
V. gerardi: Fairly deep, the same as in *V. sativa;* violet.

Staining Reactions.

With Gentian Violet.

V. sativa: Very light.
V. villosa: Very light, slightly less than in *V. sativa*.
V. faba: Light, deeper than in *V. sativa*.
V. fulgens: Very light, slightly less than in *V. sativa*.
V. gerardi: Very light, slightly less than in *V. sativa*.

With Safranin.

V. sativa: Light.
V. villosa: Light, slightly less than in *V. sativa*.
V. faba: Light, slightly more than in *V. sativa*.
V. fulgens: Light, slightly less than in *V. sativa*.
V. gerardi: Light, slightly less than in *V. sativa*.

Temperature of Gelatinization.

V. sativa: 72 to 73° C., mean 72.5°.
V. villosa: 65 to 67° C., mean 66°.
V. faba: 64 to 66° C., mean 65°.
V. fulgens: 71 to 73° C., mean 72°.
V. gerardi: 70 to 72° C., mean 71°.

Differentiation of Certain Starches of the Genus Vicia.—Continued.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

V. sativa: Begins in some in 30 seconds; complete in three-fourths in 30 minutes, and in nine-tenths in an hour.
V. villosa: Begins in some in 20 seconds; complete in four-fifths in 30 minutes, and in nine-tenths in an hour.
V. faba: Begins in some in 20 seconds; complete in three-fourths in 30 minutes, and in seven-eighths in an hour.
V. fulgens: Begins in some in 20 seconds; complete in two-thirds in 30 minutes, and in five-sixths in an hour.
V. gerardi: Begins in some in 20 seconds; complete in two-thirds in 30 minutes, and in five-sevenths in an hour.

Reaction with Chromic Acid.

V. sativa: Begins in all in 30 seconds; complete in all in 5 minutes.
V. villosa: Begins in all in 45 seconds; complete in all in 2½ minutes.
V. faba: Begins in all in 30 to 60 seconds; complete in all in 3 minutes.
V. fulgens: Begins in all in 60 seconds; complete in all in 2½ minutes.
V. gerardi: Begins in all in 50 seconds; complete in all in 80 seconds.

Reaction with Pyrogallic Acid.

V. sativa: Begins in all in 30 seconds; complete in all in 5 minutes.
V. villosa: Begins in most in 15 seconds; complete in all in 1½ minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

V. faba: Begins in a few seconds to 1½ minutes; complete in all in 6 minutes.
V. fulgens: Begins in most in 15 seconds; complete in all in 1¼ minutes.
V. gerardi: Begins in all in 30 seconds; complete in all in 1½ minutes.

Reaction with Ferric Chloride.

V. sativa: Begins in a few in a minute; complete in two-fifths in 13 minutes; incomplete in all in an hour.
V. villosa: Begins in a few in a minute; complete in nearly all in 40 minutes.
V. faba: Begins in a few in 1¾ minutes; complete in two-thirds in 50 minutes, but incomplete in all in an hour.
V. fulgens: Begins in a few in a minute; complete in nearly all in an hour.
V. gerardi: Begins in a few in 2 minutes; complete in nearly all in three-fourths of an hour.

Reaction with Purdy's Solution.

V. sativa: Begins in some in 30 seconds; complete in one-half and partial in one-fourth of the grains in 15 minutes.
V. villosa: Begins in some in a minute; complete in all in 20 minutes.
V. faba: Begins in most in a minute; complete in nearly all in 15 minutes.
V. fulgens: Begins in nearly all in a minute; complete in two-thirds and partial in one-third in 25 minutes.
V. gerardi: Begins in nearly all in 1 minute; complete in nearly all in 25 minutes.

NOTES ON THE STARCHES OF VICIA.

The *Vicia* starches show so close a correspondence in their histological properties and polariscopic reactions and in their reactions with iodine and the anilines that whatever differences exist may fall within the limits of error, or at all events are insignificant. The differences in the temperatures of gelatinization are, however, quite marked, the lowest being 65° and the highest 72.5°, those of *V. sativa, V. fulgens,* and *V. gerardi* being about the same (72.5°, 72°, and 71°), and those of *V. villosa* and *V. faba* nearly the same (66° and 65°). With the chemical reagents the order of sensitivity is different in the case of each starch with each reagent, making diagnosis easy.

GENUS PHASEOLUS.

The genus *Phaseolus,* which is so well known because of the large number of agricultural forms, comprises about 60 well-defined species and perhaps over 100 garden and field varieties or forms. Some botanists make many types and subtypes of the cultivated beans, but all may be resolved into two fundamental types—the kidney-bean type, which is exemplified in the common kidney or wax bean; and the sieva or civet-bean type, or the small, flat bean which is familiar in the Lima beans. Representatives of these were examined in the form of the red kidney bean (*Phaseolus vulgaris* Linn.), and Henderson's bush Lima bean (*Phaseolus lunatus* Linn.), both of which are agricultural varieties.

STARCH OF PHASEOLUS VULGARIS VAR. (RED KIDNEY BEAN).

(Plate 6, figs. 31 and 32. Chart 36.)

Histological Characteristics.—In *form* the grains are simple, and are with a few exceptions isolated. The surfaces of the grains are often somewhat irregular, owing to large rounded projections or to well-marked, sharp depressions. The conspicuous forms are ovoid, oval, elliptical, reniform, and round; a few triangular forms have rounded corners and various modifications of the foregoing. The grains are in many cases from one-half to two-thirds as thick as they are broad.

The *hila* are almost invariably obscured or absent because of fissures and cavities. In most of the grains there is a large, ragged, mesial fissure which extends the length of the grain, from which short, irregular, side fissures extend. The hilum is centric in the small unfissured grains.

The *lamellæ* are usually fairly distinct, rather fine, continuous rings which follow closely the outline of the grain. There are 8 to 12 on the larger grains.

The grains vary in *size* from the smaller, which are 8 by 8μ, to the larger, which are 46 by 30μ or 40 by 30μ in length and breadth. The common sizes are 30 by 24μ and 34 by 26μ in length and breadth.

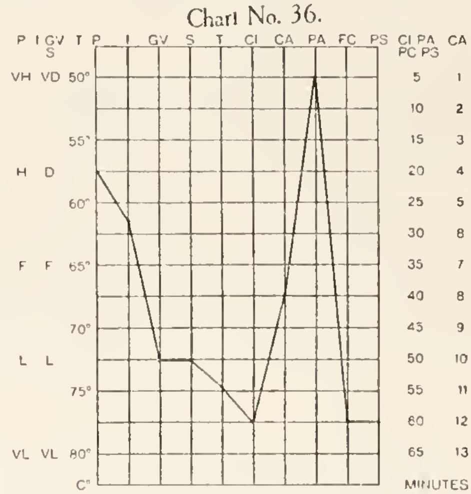
Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and usually clear-cut. In the unfissured grains it consists of a single central line bisected at each end. In the other grains the figure is confused by the fissures. The lines composing the figure are usually broad and regular.

The degree of *polarization* is high, not varying much in different aspects of the same grain.

With *selenite* the quadrants are well defined, commonly irregular in form, unequal in size, and sometimes subdivided. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue to a pinkish-violet; with 0.125 per cent solution they color fairly. After heating in water until all the grains are completely gelatinized, the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues fairly. The capsules all color violet or pinkish-violet with an excess of iodine.

Chart No. 36.



Curve of Reaction-Intensities of Starch of Phaseolus vulgaris var. (Red Kidney Bean).

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain very lightly at once and in 30 minutes they are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 74° to 75° C., mean 74.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains begin to react in 20 seconds. About one-tenth are completely gelatinized in 5 minutes, one-fifth in 30 minutes, and two-fifths in an hour. The effects are the same qualitatively as in *Vicia.*

With *chromic acid* some grains begin to react in 15 seconds and are dissolved in a minute. Most of them begin to react in from 1 to 2½ minutes and all are dissolved in 8 minutes. The effects are qualitatively the same as in *Vicia.*

The reaction with *pyrogallic acid* begins in a minute and is over in 5 minutes. The effects are qualitatively the same as in *Vicia.*

With *ferric chloride* a few grains begin to react in 2½ minutes and a very few are gelatinized in 30 minutes, with no further reaction in an hour. The reaction is qualitatively the same as in *Vicia.*

The reaction with *Purdy's solution* begins in some in a minute and a few are partially gelatinized in 20 minutes, with no further reaction in an hour. The effects are qualitatively the same as in *Vicia.*

STARCH OF PHASEOLUS LUNATUS VAR. (HENDERSON'S BUSH LIMA BEAN).

(Plate 6, figs. 33 and 34. Chart 37.)

Histological Characteristics.—In *form* the grains are simple and isolated. The surface is sometimes irregular, owing to rounded projections. The conspicuous forms are ovoid, oval, reniform or bean-shaped, elliptical, and round. There are also a few triangular and quadrangular grains with rounded corners. The grains are about one-half to two-thirds as thick as they are broad.

The *hilum* in most of the grains is obscured or absent, owing to fissures. In many grains the fissuring is very irregular, but in the majority it consists of a single ragged fissure, which may be straight or bent, extending along the middle line to the margin and having a number of irregular fissures branching from it. In small unfissured grains the hilum is centric.

The *lamellæ* are usually distinct, rather fine rings, which are discontinuous only when broken by the fissures; they follow the outline of the grain. They are more distinct than in *P. vulgaris.* There are about 8 to 12 on the larger grains.

The grains vary in *size* from the smaller, which are 8 by 8μ, to the larger, which are 48 by 34μ and 42 by 27μ in length and breadth. The common size is 30 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and usually clear-cut. It appears generally to consist of a single mesial line which is bisected at each end. Some of the grains show what appears to be a confusion of figures, probably caused by the fissures. The lines composing the figures are broad, clear-cut, sometimes bent and otherwise irregular.

The degree of *polarization* is high and does not vary much in different aspects of the same grain. It is slightly less than in *P. vulgaris.*

With *selenite* the quadrants are, as a rule, well defined, irregular in form, unequal in size, and sometimes subdivided. The colors are commonly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue to a pinkish-violet; with 0.125 per cent solution they all color fairly. The color is slightly less than in *P. vulgaris.* After heating in water until all the grains are completely gelatinized, the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues fairly. The capsules all color a violet with an excess of iodine.

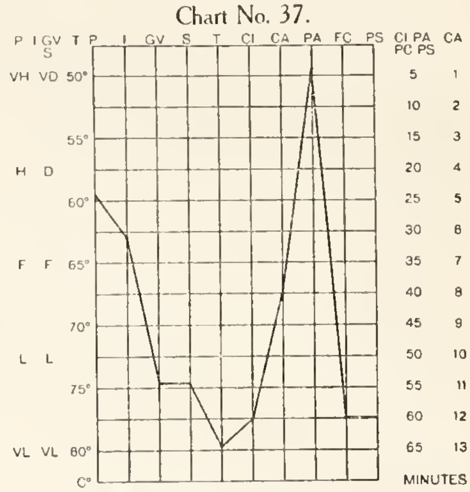
Staining Reactions.—With *gentian violet* and *safranin* the grains begin to stain very lightly at once and in 30 minutes are very lightly stained, slightly less than in *P. vulgaris.*

Temperature Reaction.—The temperature of gelatinization is 79° to 80.5° C., mean 79.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few small grains begin to react in 30 seconds. About one-fifth of the total number are completely gelatinized in 10 minutes, two-fifths in 30 minutes, and one-half in an hour. The reaction is qualitatively the same as in *Vicia.*

With *chromic acid* some grains begin to react in 30 seconds and are completely dissolved in 2 minutes. The other grains begin to react in 1 to 2 minutes, and the reaction is over in all in 8 minutes. The reaction is qualitatively the same as in *Vicia.*

Chart No. 37.



Curve of Reaction-Intensities of Starch of Phaseolus lunatus var. (Henderson's Bush Lima Bean).

The reaction with *pyrogallic acid* begins in most grains in a minute and is over in 4 minutes. The reaction is qualitatively the same as in *Vicia.*

The reaction begins in a few grains in 2 minutes with *ferric chloride,* and a few are gelatinized in 5 minutes, about one-fifth in 25 minutes, and one-third in 50 minutes, with no further reaction in an hour. The reaction is qualitatively the same as in *Vicia.*

With *Purdy's solution* some grains begin to react in a minute. About one-sixth are nearly completely gelatinized in 15 minutes and about one-fourth in 45 minutes, with no further reaction. The reaction is qualitatively the same as in *Vicia.*

Differentiation of Certain Starches of the Genus Phaseolus.

Histological Characteristics.

Conspicuous Forms.

P. vulgaris: Simple, usually isolated, often somewhat irregular. Ovoid, oval, elliptical, reniform, and round.
P. lunatus: Same as in *P. vulgaris.*

Hilum—Form, Number, and Position.

P. vulgaris: Usually obscured by irregular fissures. Position centric or slightly eccentric.
P. lunatus: Same as in *P. vulgaris.* Position centric or slightly eccentric.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.

P. vulgaris: Fairly distinct, rather fine, continuous rings, following the outline of the grain. 8 to 12 on the larger grains.
P. lunatus: Same as in *P. vulgaris,* but more distinct. 8 to 12 on the larger grains.

Size.

P. vulgaris: From 8 to 46μ, commonly 30μ.
P. lunatus: From 8 to 48μ, commonly 30μ.

Differentiation of Certain Starches of the Genus Phaseolus.—Continued.

POLARISCOPIC PROPERTIES.

Figure.

P. vulgaris: Centric, or slightly eccentric, distinct, usually clear-cut, regular, commonly a single mesial line bisected at each end.
P. lunatus: Same as in *P. vulgaris.*

Degree of Polarization.

P. vulgaris: High.
P. lunatus: High, slightly less than in *P. vulgaris.*

Polarization with Selenite—Quadrants and Colors.

P. vulgaris: Quadrants well-defined, generally irregular, unequal in size, and sometimes subdivided. Colors usually pure.
P. lunatus: Same as in *P. vulgaris.* Colors usually pure.

IODINE REACTIONS.

Intensity and Color.

P. vulgaris: Fairly deep; blue to pinkish-violet.
P. lunatus: Fairly deep, slightly less than in *P. vulgaris;* blue to pinkish-violet.

STAINING REACTIONS.

With Gentian Violet.

P. vulgaris: Light.
P lunatus: Light, slightly less than in *P. vulgaris.*

With Safranin.

P. vulgaris: Light.
P. lunatus: Light, slightly less than in *P. vulgaris.*

TEMPERATURE OF GELATINIZATION.

P. vulgaris: 74° to 75° C., mean 74.5°.
P. lunatus: 79° to 80° C., mean 79.75°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

P. vulgaris: Begins in a few in 20 seconds; complete in one-fifth in 30 minutes, and in two-fifths in an hour.
P. lunatus: Begins in a few in 30 seconds; complete in two-fifths in 30 minutes, and in half in an hour.

Reaction with Chromic Acid.

P. vulgaris: Begins in most in 1 to 2½ minutes; complete in all in 8 minutes.
P. lunatus: Begins in most in 1 to 2 minutes; complete in all in 8 minutes.

Reaction with Pyragallic Acid.

P. vulgaris: Begins in all in a minute; complete in all in 5 minutes.
P. lunatus: Begins in most in a minute; complete in all in 4 minutes.

Reaction with Ferric Chloride.

P. vulgaris: Begins in a few in 2½ minutes; complete in a very few in 30 minutes; no further reaction in an hour.
P. lunatus: Begins in a few in 2 minutes; complete in one-third in 50 minutes; no further reaction in an hour.

Reaction with Purdy's Solution.

P. vulgaris: Begins in some in a minute; a few are partially gelatinized in 20 minutes, no further reaction in an hour.
P. lunatus: Begins in some in 1 minute; about one-fourth are nearly completely gelatinized in 45 seconds, no further reaction.

NOTES ON THE STARCHES OF PHASEOLUS.

These starches do not exhibit any notable differences in their gross histological characters except that in *P. vulgaris* fissuration appears to be more marked and the lamellæ somewhat less distinct than in *P. lunatus.* In comparing the reaction-curves it will be seen that *P. vulgaris* has a higher degree of polarization, greater responsivity with iodine, anilines, and heat; somewhat less responsivity to chloral hydrate-iodine, pyrogallic acid, ferric chloride, and Purdy's solution; and the same reactiveness with chromic acid. The most marked differences are in the temperatures of gelatinization, the starch of *P. vulgaris* being gelatinized at 74.5° C., and that of *P. lunatus* at 79.75°, a difference of 5.25°. The differences apart from the temperature reactions are unimportant.

GENUS DOLICHOS.

The genus *Dolichos,* which is closely related to *Phaseolus,* includes about 50 species, several of which are in common cultivation. The best known is *D. lablab* Linn. (*D. cultratus* Thumb., *D. purpureus* Lindl.), the hyacinth, Egyptian, or black bean. The starch of this species was studied as the type of the genus.

STARCH OF DOLICHOS LABLAB. (Plate 6, figs. 35 and 36. Chart 38.)

Histological Characteristics.—In *form* the grains are simple, although peculiarities of fissuration make some of them appear as compounds. The surface of the grains is usually somewhat regular, the irregularities being due to low, rounded prominences or slight depressions of the margin. The conspicuous forms are the ovoid to oval and elliptical, and nearly round, with some triangular with rounded angles and rounded base, a few bean-shaped, quadrangular with rounded angles, and various modifications of the foregoing. The grains are generally about two-thirds as thick as they are broad.

There may be several *hila* in each grain, grouped rather irregularly in a central non-lamellated space of the same general outline as the margin of the grain. These hila are small and indistinct and their number can not be exactly determined. This space is often fissured. Frequently there is a single, long, fairly straight fissure extending in the longitudinal axis. In some grains the fissure extends the length of the grain and it may be ragged or curved or variously modified.

The *lamellæ* are not, as a rule, very distinct. They appear as continuous, rather fine rings which follow closely the marginal outline. There are 8 to 10 on the larger grains.

The grains vary in *size* from the smaller, which are 10 by 6μ in length and breadth, to the larger, which are 32 by 26μ and 32 by 32μ in length and breadth. The common size is 20 by 18μ in length and breadth.

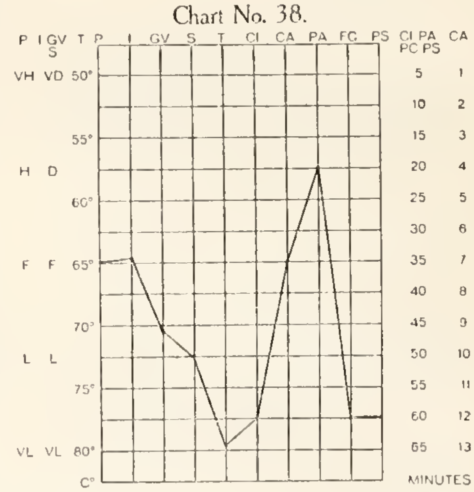
Polariscopic Properties.—The *figure* is usually decidedly eccentric. The lines almost invariably intersect obliquely. They are broad, generally not clear-cut, more or less modified by fissures, and sometimes bisected. Rarely a bean type of figure (single line with bisected ends) is observed.

The degree of *polarization* is high to very high, varying more or less in different parts of the same aspect of a given grain. In some grains only small parts of the quadrants are light.

With *selenite* the quadrants are usually fairly well defined, unequal in size, and irregular in shape. The colors are generally pure; the yellow is sometimes not pure throughout the entire grain.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very light violet, some more deeply than others, and in 5 minutes they become a deep blue-violet; with 0.125 per cent solution the grains show at once a faint trace of red-violet, which in 5 minutes deepens to a light reddish-violet; the color is deeper in some grains than in others. After heating in water until all the grains are completely gelatinized, the solution colors a deep indigo-blue and the grains a bright indigo-blue on the addition of iodine. When the grains are boiled for 2 minutes and then treated with iodine, the solution becomes a deeper indigo-blue; some of the grain-residues not coloring at all, while others become a light blue with a reddish tint or a red-violet. With an excess of iodine the grain-residues color a deep reddish-purple and the capsules a wine-red.

Chart No. 38.



Curve of Reaction-Intensities of Starch of Dolichos lablab.

Staining Reactions.—With *gentian violet* most of the grains show a faint trace of violet at once and in 30 minutes they are lightly stained, some more deeply than others.

With *safranin* most of the grains exhibit a faint trace of pink at once, and in 30 minutes they are lightly stained. There is a fairly deep pink color in the delicate fissures of the grains, but none in the deep fissures.

Temperature Reaction.—The temperature of gelatinization is 73° to 75° C., mean 74°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains, which are either injured or partially digested or eroded, begin to react at once and a small number are gelatinized in a minute. About one-third are gelatinized in 10 minutes, one-half in 15 minutes, two-thirds in 30 minutes, and three-fourths in 60 minutes. The reactions are the same qualitatively as in *Vicia*.

The reaction with *chromic acid* begins in 30 seconds to 1¼ minutes and is over in 7 minutes. The reaction is qualitatively the same as in *Vicia*.

The reaction with *pyrogallic acid* begins in many of the grains in 1½ minutes and practically all are completely gelatinized in 20 minutes. The effects are qualitatively the same as in *Vicia*.

With *ferric chloride* the reaction begins in a few grains in 5 minutes and is over in one-fifth in 30 minutes and in nearly one-fourth in an hour. The effects are qualitatively the same as in *Vicia*.

The reaction with *Purdy's solution* begins slightly in a few in 3 minutes, about one-fourth are partially gelatinized in 30 minutes, and about three-fifths are partially gelatinized in an hour. The effects are qualitatively the same as in *Vicia*.

GENUS MUCUNA.

The genera *Mucuna*, *Vicia*, *Phaseolus*, and *Dolichos* are closely allied. *Mucuna* includes over 20 species. *M. pruriens* DeCand. (*Dolichos pruriens* Linn., *D. multiflorus* Hort.) is a variable species, and the most prominent representative of the genus. It is popularly known as cow-itch or cowhage, because of the very marked itching produced when the hairs of the pods penetrate the skin. Starch from this species, probably an agricultural variety, was examined.

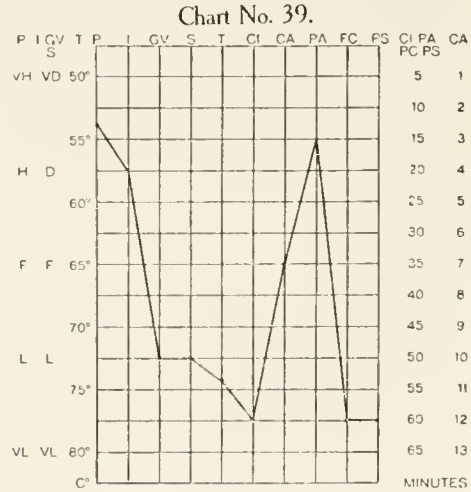
STARCH OF MUCUNA PRURIENS. (Plate 5, figs. 29 and 30. Chart 39.)

Histological Characteristics.—In *form* the grains are usually simple, and are isolated, except a small number which occur either in aggregates or as compound grains of few components. The surface of the grains is occasionally marked by a protuberance which is located generally at or near the proximal end. The conspicuous forms are ovoid to oval, nearly round, pyriform, sometimes with distal end squared, broadly triangular with curved base and rounded angles. There are some ellipsoidal, bean-shaped, and various incidental forms.

The *hilum* is usually fissured, but is sometimes observed as a clear, round or lenticular, refractive spot which is generally about one-sixth eccentric of the longitudinal axis. It may be slightly eccentric or centric in the nearly round grains. At the region of the hilum a very deep, dark cleft often occurs, from which either one oblique, very coarse, dark fissure, or two or more irregularly branched oblique fissures may proceed. Groups of short, irregularly placed, oblique fissures are frequently found, and sometimes the fissuration is of a very diffuse character.

The *lamellæ* are frequently not demonstrable near or in the region of the hilum, but occasionally they may be observed as fine, complete circular or elliptical rings. Those near the margin and distal end are coarse and have the form of the outline of the grain, and in some instances appear to be incomplete. There is frequently one quite coarse, refractive lamella at varying distances from the hilum, which sometimes forms a line of demarcation between the delicate lamellæ near the hilum and the comparatively coarse lamellæ near the margin. On large grains 32 to 40 lamellæ can be counted.

Chart No. 39.



Curve of Reaction-Intensities of Starch of Mucuna pruriens.

The grains vary in *size* from the smaller ones, which are 10 by 6μ, to the larger, which are 36 by 24μ in length and breadth. The common size is 24 by 14μ in length and breadth.

Polariscopic Properties.—The *figure* is centric, and usually distinct, but not clear-cut. In the unfissured, elongated grains it consists of a long line bisected at each end and occupying the greater part of the longitudinal axis of the grain. In the fissured grains it is so confused by the fissures that there appear to be parts of many figures. In the rounded forms the figure is in the form of a cross. The lines are for the most part thick and straight. Sometimes they are slightly curved and may vary in width between the center of the figure and the margin.

The degree of *polarization* is low to high in different grains. It varies also in different aspects of the same grain, being more when the grain is viewed on end or edge. It varies also in some grains in different parts of the same aspect of a grain.

With *selenite* the quadrants are generally not sharply defined and are usually unequal in size and irregular in form. In some grains the portions of the quadrants seen are very small. The colors are generally not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep pinkish-violet; with 0.125 per cent solution they color lightly. After heating in water until all of the grains are gelatinized, both the solution and the grains color deeply. After boiling for 2 minutes, the solution colors very deeply and the grain-residues rather lightly. The capsules all color a violet or red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain very lightly at once and in 30 minutes are still lightly stained.

Temperature Reaction.—The temperature of gelatinization is 79° to 80° C., mean 79.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a very few grains in 45 seconds. It is complete in about one-fifteenth in 5 minutes, in about one-fourth in 15 minutes, in half in 30 minutes, and in about seven-eighths in an hour. The lamellæ become more sharply defined, and the hilum, or the cleft, at this region swells and often becomes very irregular in outline. Gelatinization begins at the distal end and proceeds gradually over the grain, accompanied by uniform swelling. The gelatinized starch at the distal end colors a deep blue and the remainder of the grain an old-rose color. During gelatinization the blue coloration sweeps towards the proximal end, obscuring the cleft at this point. Finally the entire grain is gelatinized and deeply colored. Sometimes the gelatinized portion of the grain is sharply differentiated from the ungelatinized, and as the reaction proceeds towards the proximal end, the blue-colored starch pushes before it a colorless, ungelatinized mass. The gelatinized grain is much swollen, but retains the shape of the untreated grain. The color is a deep blue with light areas which correspond with the positions of the clefts in the normal grains.

Reaction with *chromic acid* begins immediately. A few are dissolved in 2 minutes, all but a few resistant grains in 5 minutes, and all in 7 minutes. The hilum, or the cleft at this point, swells, and frequently a bubble is formed which enlarges and then suddenly collapses. The lamellæ become very sharply defined and striated. Longitudinal branched fissures, if not already present, are formed and extend obliquely from the region of the hilum towards the distal margin. Solution of the grain occurs first around the hilum and proximal end, and then advances between the fissures, many refractive particles resisting the reaction for some time. During gelatinization the grain often swells slowly and uniformly until it has become a large, clear, ellipsoidal body before the capsule ruptures at the proximal end, when the extruded mass and the capsule pass into solution. The lamellæ at the distal margin and for a short distance at the sides of the grain are the last to be gelatinized, and frequently appear as a transient, serrated, inner lining of the capsule. The starch at the distal end may be so resistant that it remains after the rupturing at the proximal end and the outflow of the semi-liquid gelatinized starch, but it soon disappears.

The reaction with *pyrogallic acid* begins in a few grains in 30 seconds. It is complete in a few in 2½ minutes, in about two-thirds in 5 minutes, in nine-tenths in 10 minutes, and in all but a few very resistant grains in 15 minutes. The latter may show very little effect, even after treatment for an hour. The hilum or the cleft located at this point begins to swell and a bubble often appears which is expelled before general gelatinization begins. If not already present, two main, longitudinal, branched fissures are formed which pass obliquely from the hilum towards the distal margin. The lamellæ become very sharply defined and striated, gelatinization begins at the region of the hilum, and the lamellæ at the proximal end are gelatinized. As the starch is gelatinized along the fissures the lamellæ are often affected in such a manner as to form a serrated lining to the capsule. During the gelatinization of the lamellæ refractive bodies remain which are often arranged irregularly, but sometimes in a row, at about the region of the highly refractive lamella which is found on some grains. Usually some of the lamellæ remain at the distal end. If the fissures are very deep, the grain is sometimes divided into two parts, which may separate at one or both ends of the cleft; the lamellæ are thrown into folds in which the refractive bodies are collected. The gelatinized grain is much swollen and distorted.

Gelatinization with *ferric chloride* begins in a small number of grains in 3½ minutes. A few are gelatinized in 10 minutes, about one-sixth in 30 minutes, and about one-fifth in an hour. A narrow border of gelatinized starch is formed, the hilum or the cleft at this region begins to swell, and the lamellæ become sharply defined and striated. Radiating fissures, if not already present, are formed and pass from the hilum or cleft at that region towards the distal end; and delicate fissures are also formed which pass through the lamellæ at the distal end. Gelatinization with distension of the capsule usually starts at one end and may spread gradually over the grain, and a similar swelling appears at the opposite end and spreads in the opposite direction. During the reaction small particles are detached from the main body of the grain and gelatinized separately, and near the completion of the process the most resistant starch is separated forcibly into two or three rather large fragments, which are finally gelatinized. The gelatinized grains are much swollen and distorted.

The reaction with *Purdy's solution* begins in a few grains in 1½ minutes and only gradual changes are noted for about 30 minutes, at which time the central portion of only about one-tenth of the grains is gelatinized. In an hour there is little if any progress in the reaction. The hilum, or cleft at this region, at the outstart of the reaction begins to swell, and if not already present, two large, longitudinal, branched fissures are formed which pass obliquely from the hilum or cleft to the distal margin. The lamellæ become very sharply defined and striated and delicate lines pass from the distal end towards the hilum. The grains in which the fissures are not very dark gelatinize more quickly. Rarely a grain gelatinizes partially quite rapidly, and a number of refractive particles become apparent during the process. The gelatinized grains are usually not much swollen, and only a limited area becomes gelatinized. Very rarely in an hour gelatinized grains are observed which are much swollen and almost all of the starch has been gelatinized, but it is quite probable that such grains were partially gelatinized by the heat of grinding before treatment with the reagent.

GENUS LENS.

The small genus *Lens*, which according to some botanists comprises only 2 species and according to others 8, is native to the region of the Mediterranean and the Orient, and has been placed by Bentham and Hooker between *Vicia* and *Lathyrus*. The species *L. esculenta* is one of the oldest-known plants cultivated by man for food purposes, and the seeds have an especial interest because of their constituting the mess of pottage which figured in the sale of the birthright of Esau to Jacob. The specimen from which we obtained the starch was an unknown variety in common cultivation.

STARCH OF LENS ESCULENTA VAR. (Plate 7, figs. 37 and 38. Chart 40.)

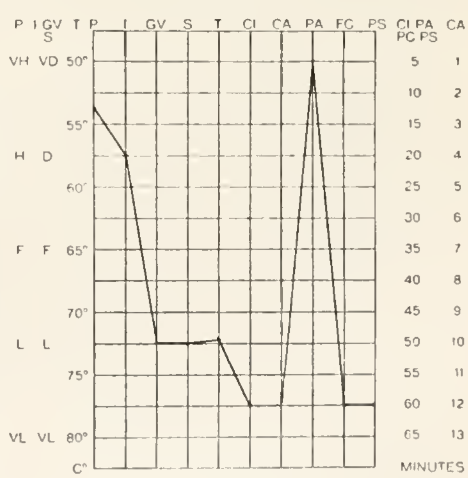
Histological Characteristics.—In *form* the grains are usually simple and they are isolated, except a small number which occur either in compound grains or in aggregates of few components. Some of the grains are irregular in outline, which is chiefly due to one or more rounded elevations on the surface. The conspicuous forms are ellipsoidal, rounded-oval, and reniform. There are some ovoid, shield-shaped, heart-shaped, round, pyriform, and irregular grains of indefinite form.

The *hilum* is usually obscured or destroyed by fissures, but rarely it may be observed as a clear centric or slightly eccentric spot in the round grains of medium size and of elongated form in the unfissured, elongated grains. There is commonly an elongated mesial, somewhat ragged cleft from which frequently radiating fissures proceed. The cleft and fissures are generally very dark, but often delicate and less opaque than the remainder of the grain. Rarely an eccentric fissure may be observed which intersects the main cleft either at a right or slightly oblique angle.

The *lamellæ* are not demonstrable in the mesial part of the grains, but over at least two-thirds of the grain they are seen to be complete and coarse and to follow closely the outline of the grain. On the elongated grains there are from 8 to 14 lamellæ and on the rounded grains from 6 to 10.

The grains vary in *size* from the smaller, which are 4 by 6μ, to the larger, which are 22 by 38μ in length and breadth. The common size is 13 by 24μ in length and breadth.

Chart No. 40.



Curve of Reaction-Intensities of Starch of Lens esculenta var.

Polariscopic Properties.—The *figure* may be in the form of a cross or of the bean type (a mesial line with bisected ends). It is centric or slightly eccentric. The lines are thick and usually more or less ragged.

The degree of *polarization* is high to very high, with frequent variations in the same aspect of a given grain.

With *selenite* the quadrants are not usually sharply defined, and are unequal in size and irregular in shape. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very light violet with a reddish tint, which in 5 minutes becomes a deep blue-violet; with 0.125 per cent solution they show a slight trace of red-violet, which becomes deeper in 5 minutes. After heating in water until the grains are gelatinized, both the solution and the grains color a deep indigo-blue on the addition of iodine. After boiling for 2 minutes and then treating with iodine, the solution colors more deeply and the grain-residues a less deep blue. When an excess of iodine is added the capsules color a red-violet to red-purple.

Staining Reactions.—With *gentian violet* a few grains color slightly immediately and in 30 minutes some of them are stained a light violet. The grains in which the mesial cleft is not deep or is absent are more quickly stained.

With *safranin* a few grains color slightly at once and in 30 minutes they are all lightly stained.

Temperature Reaction.—The temperature of gelatinization is 71.5° to 73° C., mean 72.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains in a minute and gelatinization is complete in a small number in 5 minutes. About one-fifth are gelatinized in 10 minutes, about two-fifths in 30 minutes, and about two-thirds in an hour. The lamellæ become sharply defined, but the mesial cleft is not so well marked, although a thorn-like transparent structure is sometimes formed in the mesial, non-lamellated portion of the grain.

Occasionally either a dark ring or slit-like formation appears in the central part of the grain, which becomes irregular in outline and is finally obscured as gelatinization and the accompanying deep-blue coloration advance towards this region. Gelatinization usually begins at one end and proceeds gradually over the grain, accompanied by uniform swelling. The gelatinized starch colors a deep blue and the rest of the grain an old-rose. In reniform grains and indented forms, gelatinization may start at the depression or indentation and be followed by another focus of reaction at a point on the opposite side. The grains which are not completely gelatinized become granular in appearance and of an old-rose to a light reddish-brown tint, with a lighter central area and surrounded by a clearer border. The gelatinized grains are much swollen, but retain the general shape of the untreated grain. They are deep blue in color and frequently with clear lines which are located at the region of the clefts in the untreated grain.

The reaction with *chromic acid* begins in 20 seconds. A few grains are dissolved in a minute, the majority in 3 minutes, about six-sevenths in 5 minutes, and practically all in 13 minutes. The refractive and non-refractive lamellæ become very sharply defined, and fine striæ appear in the former. The clefts, or hilum if demonstrable, become very distinct, but if a cleft is not present a thorn-like fissure is quickly formed in the mesial non-lamellated portion of the grain. Gelatinization proceeds along the course of the branched fissures and the grain swells uniformly, assuming an oval shape. During the solution of the lamellæ, irregularly distributed, refractive bodies appear which remain for some time embedded in the dissolved starch. These grains become clearer until finally the entire mass is in solution. In the very resistant grains, as the refractive bodies pass into solution, the capsule becomes distorted and ruptures simultaneously at two or more points.

Reaction with *pyrogallic acid* begins in a few grains in 30 seconds and practically all are in various stages of dissolution in 1½ minutes. The reaction is complete in a few in a minute, in nearly all in 2½ minutes, and in practically all in 5 minutes. The clefts, hilum, and lamellæ become very distinct. If clefts were not present at the position of the hilum, they are quickly formed, and delicate branches pass from them to all parts of the grains. The lamellæ become striated, and as they are gelatinized, refractive bodies appear which remain embedded in the altered starch. In many of the gelatinized grains the structure of the lamellæ can be detected, the lamellæ being thrown into folds and held in place by refractive bodies. A deep, elongated cleft frequently passes through the center of the gelatinized grains, completely dividing the grains at one or both ends. A small number of the grains are completely gelatinized, except a few refractive bodies embedded in the gelatinized starch. The gelatinized grains are so swollen and distorted that they do not resemble the shape of the untreated grain.

With *ferric chloride* swelling begins in a few grains in 2 minutes. It is complete in a very small number in 18 minutes, in about one twenty-fifth in 30 minutes, and one-tenth in an hour. A narrow, transparent border is formed around the grain and the lamellæ become striated and sharply defined. Gelatinization accompanied by distension of the capsule usually begins at one point and may proceed gradually over the entire grain, or swelling may also appear at the opposite end of the grain. The central part of the grain is the last to undergo gelatinization. In some grains the transparent, narrow border becomes broader and irregular in outline, followed by simultaneous gelatinization at several points. In the reniform grains the swelling frequently begins at the depression at one side of the grain. During the reaction small particles of ungelatinized starch may from time to time be broken from the main mass and be gelatinized separately, this breaking up going on until near the completion of the process, when the more resistant starch is forcibly divided into two or three rather large fragments, which are finally gelatinized. The gelatinized grains are so much swollen and distorted that they do not retain the shape of the untreated grains.

The reaction with *Purdy's solution* begins in a few grains in 2 minutes; about one-tenth are gelatinized in 5 minutes, one-fifth in 15 minutes, one-third in 30 minutes, and one-half in an hour. The hilum and the clefts enlarge, and the lamellæ become sharply defined and striated. In the body of the grain delicate fissures form which radiate from the clefts or the hilum. Gelatinization in ellipsoidal grains that have mesial, elongated clefts often proceeds more rapidly towards one end of the grain. As gelatinization progresses along the course of the radiating fissures, the lamellæ are often broken down in such a manner as to form a serrated lining to the capsule. During the solution of the lamellæ, refractive bodies appear embedded in the gelatinized starch. If a mesial, elongated cleft is not present in the untreated grain, a gelatinized area with embedded refractive bodies is more quickly formed. The gelatinized grains, as a rule, are not much swollen, and the reaction is chiefly limited to a central area which represents about one-third of the grain. A few grains, possibly one-fiftieth, are swollen, and all the starch within the capsule is gelatinized, but no grains in good condition were observed to reach this stage previous to the addition of the reagent. Since several grains in the preparation are partially gelatinized, probably from the heat generated during grinding, such a result may be reached only in these grains.

GENUS LATHYRUS.

Lathyrus is a genus of about 120 species, which are natives of the Northern Hemisphere and South America; this includes both annuals and perennials, some of the latter being cultivated as annuals. Both wild and cultivated forms are known as variously designated kinds of peas, the most familiar being the sweet pea (*Lathyrus odoratus* Linn.) of common garden cultivation. The starches of 4 species or their representatives were studied as types of the genus: *L. odoratus* var. *shahzada*, the sweet pea, which is an annual and a native of Sicily; *L. sylvestris* Hort., the flat pea, a perennial and a native of Europe; *L. latifolius* var. *albus* Hort., or everlasting pea, also a perennial and a native of Europe; and *L. magellanicus* var. *albus* Hort., a perennial and a native of the Straits of Magellan, and a maritime plant.

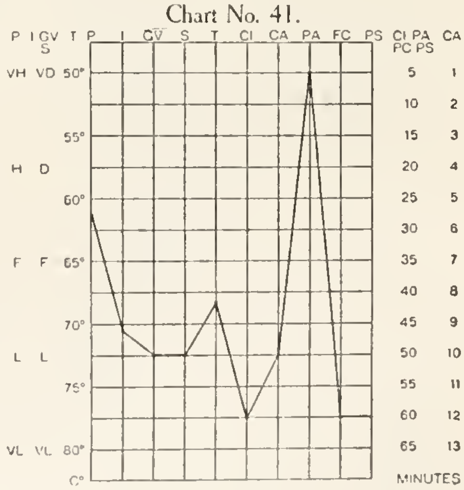
STARCH OF LATHYRUS ODORATUS VAR. SHAHZADA. (Plate 7, figs. 39 and 40. Chart 41.)

Histological Characteristics.—In *form* the grains are simple and isolated. The surface is often irregular, owing to depressions or rounded protuberances. The conspicuous forms are the ovoid, ellipsoidal to elliptical, oval, reniform or bean-shaped, and round; there are also irregularly quadrilateral, triangular with rounded corners, and various modifications of the foregoing forms. The grains are usually not so thick as broad.

A central, rather indistinct *hilum* may be observed in the unfissured, round, or rounded forms; in others may be seen a number of small, granular, slightly refractive bodies, whose exact number can not be determined. Whether these represented hila is doubtful. Quite frequently the grains are fissured and the fissure is usually long, broad, and deep, extending through the middle of the grain. It may be straight and clean-cut, but commonly is more or less ragged, and it may have very deep branches extending out on each side almost to the margin. In some grains the fissuration is quite diffuse.

The *lamellæ* are very distinct, coarse, continuous bands, which quite regularly follow the outline of the grain. There are from 10 to 12 on the larger grains.

Chart No. 41.



Curve of Reaction-Intensities of Starch of Lathyrus odoratus var. shahzada.

The grains vary in *size* from the smaller ones, which are 6 by 6μ, to the larger, which are 38 by 25μ in length and breadth. The common size is 25 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, but usually not clear-cut. In the least fissured and in the unfissured grains there may be observed a cross or a figure which appears as a thick line, bisected at the ends and located in the longitudinal axis. The lines are generally broad, irregular, and not clear-cut.

The degree of *polarization* is fair to high, in most grains fairly high. It does not vary much in different aspects of the same grain, but sometimes varies in the same aspect of a grain. Sometimes only very small portions of the grain are observed.

With *selenite* the quadrants are, as a rule, not well defined, irregular in shape, and unequal in size. The colors are pure to fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution most grains color a rather light violet; with 0.125 per cent solution they color a very light-violet. After heating in water until the grains are completely gelatinized, the solution colors a deep blue and the gelatinized grains a fairly deep blue on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues rather lightly. The capsules all color violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* and with *safranin* when viewed in masses, the grains appear slightly stained at once and after remaining in the solution for 30 minutes they are lightly colored.

Temperature Reaction.—The temperature of gelatinization is 68° to 69° C., mean 68.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains in a minute, gelatinization is complete in a small number in 3 minutes, about one-fifth are gelatinized in 5 minutes, and about one-half in 30 minutes. After an hour very little further gelatinization is noted, but the grains that are not gelatinized have become a golden-brown color and are finely granular, the center being lighter in color and less granular, while the entire grain appears to be surrounded by a clear capsule. The grains that are soon affected take on a very light violet color, and the lamellæ and the hilum become more distinct. Gelatinization frequently begins by the darkening of one end of the grain, which spreads over the entire grain accompanied by uniform swelling. The formation of protuberances during this reaction, which is observed in grains of so many other sources, is absent. In the bean-shaped grains gelatinization often starts at the depression located about the middle of one side of the grain and proceeds slowly both forward and laterally, a clear, irregular line being pushed ahead of the advancing gelatinization. Occasionally one or more strands of color extend from the deeply stained, gelatinized mass through the grain. In round forms, a ring of more deeply stained substance appears around a light, unstained central mass and slowly advances over the grain.

Reaction with *chromic acid* begins immediately. A few grains are gelatinized and dissolved in 25 seconds and all in 10 minutes. The lamellæ become very distinct, the refractive and non-refractive lamellæ being sharply defined, and fine striæ appear on the refractive lamellæ. One or more branched clefts are formed in the central non-lamellated area, and fine fissures penetrate every part of the grain, which now swells uniformly and assumes an oval shape, gradually becoming very clear and then collapsing suddenly. A round grain with a distinct hilum is occasionally observed, in which the hilum as well as the lamellæ become distinct, followed by the process already noted. A few refractive granules are sometimes formed during the reaction. These are dissolved with the rest of the grain.

The reaction with *pyrogallic acid* begins in a few grains immediately. It is complete in some in a minute, in the majority in 3 minutes, and in all in 5 minutes. The hilum in the round forms swells and becomes more distinct. In the elongated forms the hilum is not observed, but there are oval granular masses which may be deeply fissured and surrounded by sharply defined refractive and non-refractive lamellæ. The irregular clefts when present increase in size, and the smaller fissures radiating from them penetrate to all parts of the grain. If clefts are not present in the untreated grain at the position of the hilum, either irregularly branched ones are formed there, or the central mass is gelatinized with the formation of many refractive granules, and delicate fissures radiate from this region towards the margin. The gelatinized grains are much swollen and the outline is quite irregular. Some of the grains are completely gelatinized, except a few refractive granules embedded in a gelatinous mass surrounded by the outermost layers. In other grains, more layers of lamellæ have partly resisted gelatinization, and these are much convoluted, and a deep longitudinal cleft frequently passes through the center of the mass. Occasionally the cleft divides the grain at one or both ends. There are refractive granules in the folds of the gelatinized grain.

With *ferric chloride* the grains begin to react in 4 minutes. A few are gelatinized in 7 minutes, about one-tenth in 30 minutes, and about one-fifth in an hour. The hilum if unfissured becomes distinct; lines dividing the grains as well as the lamellæ are more clearly defined; the striated border appears more transparent and darker than the central opaque mass, and a clear line borders the entire grain. An invagination occurs and the grain begins to swell at this point. In the rounded forms this usually appears at one place, often followed later by swelling at one or more such invaginated parts. In the bean-shaped grains the swelling frequently occurs at the depression on one side of the grain and gradually spreads around the margin. During the process the gelatinized part of the grains shows light lines of division, which frequently fly apart at these points, the segments later breaking into pieces and becoming gelatinized.

With *Purdy's solution* reaction begins in a few grains in 30 seconds and all are affected in 4 minutes. About one-third are gelatinized in 15 minutes and one-half in 30 minutes. There is very little if any further change in an hour. The hilum in the round grains, if unfissured, swells and becomes more distinct, and delicate radiating lines pass from it towards the margin. When clefts are present at the hilum before the addition of the reagent, both clefts and refractive and non-refractive lamellæ become very sharply defined. The appearances of the phenomena of this reaction are similar to those observed when the grains are treated with pyrogallic acid, but during gelatinization the lamellæ are more distinct, and as they are dissolved rows of bodies having a crystalline appearance are more frequently observed. The remains of the lamellæ are generally less convoluted and the gelatinized grain more regular in shape than when treated with pyrogallic acid.

STARCH OF LATHYRUS SYLVESTRIS. (Plate 7, figs. 41 and 42. Chart 42.)

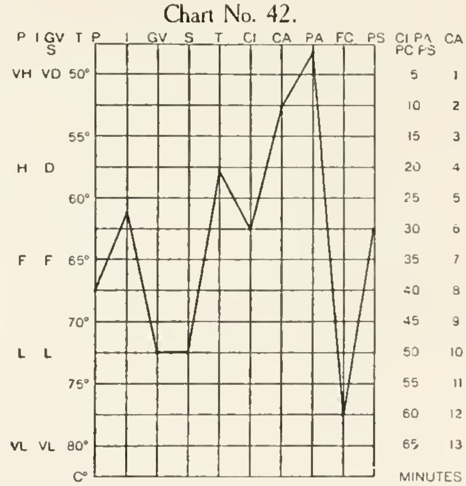
Histological Characteristics.—In *form* the grains are simple and isolated. The surface is generally somewhat irregular. The grains are marked very irregularly by fissures which often appear to border a non-lamellated space in the central part of the grain and separate it from the rest of the grain. The conspicuous forms are the ovoid, oval, ellipsoidal, and elliptical, with a few reniform, small, round or nearly round grains, which may be quite regular in form, pyriform, and various modifications of the foregoing. The grains are usually not so thick as broad.

The *hila* are so indistinct, even in the grains in which the central portion is unfissured, that it is impossible to determine anything definite about them. In some such grains a number of faintly refractive granules may be seen in the central, non-lamellated space. Many of the grains have fissures extending through them in various directions, but some have a single, long, clear-cut line located mesially.

The *lamellæ* are not very distinct, rather coarse, continuous bands which follow quite regularly the outline of the grain. There are 10 or 12 on the larger grains.

The grains vary in *size* from the smaller, which are 8 by 8μ, to the larger, which are 28 by 28μ in length and breadth. The common size is 24 by 19μ in length and breadth.

Chart No. 42.



Curve of Reaction-Intensities of Starch of Lathyrus sylvestris.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and usually not clear-cut. In the unfissured or slightly fissured, elongated grains it consists of a single broad line extending along the longitudinal axis of the grain and divided at each end into two lines. In rounded forms the figure is in the shape of a cross. The lines may be curved, ragged, and otherwise distorted.

The degree of *polarization* is low to fairly high, usually fairly high. It does not vary much in different aspects of the same grain, but in the same aspect of some grains it is commonly lacking centrally in a large area, and in others it is lower in different parts. It is lower than in *L. odoratus* var. *shahzada.*

With *selenite* the quadrants are generally not well defined, irregular in shape, and unequal in size. The colors are as a rule fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they stain rather lightly and the tint deepens rather rapidly. The color is much deeper than in *L. odoratus* var. *shahzada.* After heating in water until all the grains are gelatinized, the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the grain-residues not at all, with iodine. If an excess is added all of the capsules color violet.

Staining Reactions.—With *gentian violet* the grains when viewed in masses show a very slight tint of violet at once, but there is scarcely any change after remaining in the solution for 30 minutes. The color is the same as in *L. odoratus* var. *shahzada.*

With *safranin* the grains when viewed in masses show a very slight tint of red at once, but after remaining in the solution for 30 minutes there is scarcely any change. The color is the same as in the grains of *L. odoratus* var. *shahzada.*

Temperature Reaction.—The temperature of gelatinization is 57° to 59° C., mean 58°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 30 seconds, about three-fourths in 5 minutes, seven-eighths in 10 minutes, nine-tenths in 15 minutes, and all but rare resistant grains in 30 minutes. The ungelatinized grains have the same peculiar color as the ungelatinized grains observed in this reaction in *L. odoratus* var. *shahzada.* Protuberances are formed at one or more points on the margin during gelatinization, so that the outline of the gelatinized grain is scalloped. The process is qualitatively the same as in *L. odoratus* var. *shahzada.*

The reaction with *chromic acid* begins in 20 seconds. Many are dissolved in 30 seconds and all in 2 minutes. During solution the outlines of the majority are distorted, while in those which resist solution longest it is regular. The process is qualitatively the same as in *L. odoratus* var. *shahzada.*

The reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 30 seconds, the majority in a minute, and all in 1½ minutes. The gelatinized grain is rather more irregular in outline than in *L. odoratus* var. *shahzada,* but the reaction is qualitatively essentially the same.

With *ferric chloride* the grains begin to react in 30 seconds. Several are gelatinized in 2 minutes, one-third in 5 minutes, nine-tenths in 30 minutes, and all, with the exception of about 1 in 500, in an hour. The lamellæ are not so distinct as in *L. odoratus* var. *shahzada.* The swelling usually begins at one point, but is almost instantly followed by reaction in several others, until the entire margin is involved. The reaction is qualitatively essentially the same as in *L. odoratus* var. *shahzada.*

Reaction with *Purdy's solution* begins at once. A few are gelatinized in a minute, the majority in 10 minutes, and all in 30 minutes, with the exception of a few scattered grains, possibly 1 in 300, in which the reaction is not complete. The reaction is qualitatively essentially the same as in *L. odoratus* var. *shahzada.* The bodies of crystalline appearance, which are arranged in rows during gelatinization of the lamellæ, are not usually observed, and the gelatinized grain is more irregular in shape and gelatinization proceeds farther than in *L. odoratus* var. *shahzada.*

STARCH OF LATHYRUS LATIFOLIUS VAR. ALBUS. (Plate 8, figs. 43 and 44. Chart 43.)

Histological Characteristics.—In *form* the grains are simple and isolated, often widely and deeply fissured, the surface commonly much wrinkled. A central non-lamellated area is sometimes marked from the rest of the grain by circular or semicircular fissuration. Many of the grains show a long, mesial, wide, clean-cut or ragged fissure. A number of rather fine but irregular fissures often extend from this in various directions. In some grains there are disseminated fissures. The outlines of the grains are usually somewhat irregular. The conspicuous forms are the ovoid, oval, ellipsoidal, and round to nearly round. There are also many irregularly elliptical, quadrilateral, pyriform, reniform or bean-shaped, and many irregular forms.

A central *hilum* is faintly visible in a few of the round grains, but generally the hila are obscured or destroyed by fissuring.

The *lamellæ* are fairly distinct, rather coarse, continuous bands which follow quite regularly the outline of the grain. They are often made discontinuous by the fissures. There are about 10 on the larger grains.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 36 by 28μ in length and breadth. The common size is 23 by 20μ in length and breadth.

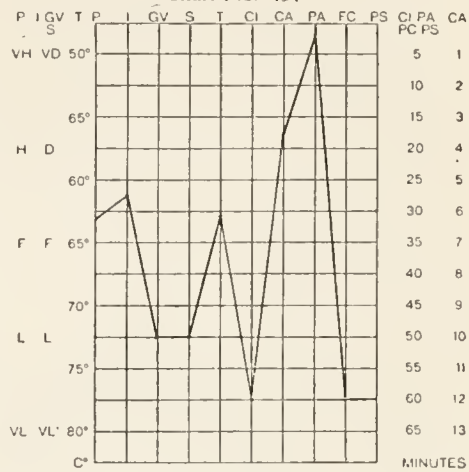
Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, but usually not clear-cut. It is often difficult to distinguish the lines composing the figure from those of the fissures. In the rounded forms the figure is in the form of a cross with a large dark area at the point of intersection of the lines. In the elongated forms it may be in the form of a cross or of the bean type—a longitudinal line with bisected ends. The lines are broad, usually straight, but not as a rule clear-cut.

The degree of *polarization* is low to high, usually fairly high. It does not vary much in different aspects of a grain. Areas in which there is an absence of polarization are common in the central parts of grains and in some grains only very small marginal parts transmit light. Polarization is less than in *L. odoratus* var. *shahzada.*

With *selenite* the quadrants are usually not well defined, are generally irregular in form and unequal in size, and often subdivided. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. It is darker than in *L. odoratus* var. *shahzada.* After heating in water until the grains are completely gelatinized, the solution colors deeply and the majority of the gelatinized grains very slightly on the addition of iodine. After boiling for 2 minutes the solution colors deeply, but only an occasional grain-residue is colored, probably 1 in 1,000. When an excess of iodine is added the capsules color a bright blue, probably because of the retention of a small amount of blue-reacting starch, but by a further addition they become a deep reddish-violet.

Chart No. 43.



Curve of Reaction-Intensities of Starch of Lathyrus latifolius var. albus.

Staining Reactions.—With *gentian violet* and with *safranin* the grains when viewed in masses show a very slight tint of violet, and after remaining in the solution for 30 minutes they are very lightly stained. The coloration is the same as in the grains of *L. odoratus* var. *shahzada.*

Temperature Reaction.—The temperature of gelatinization is 62° to 64° C., mean 63°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in a minute, about two-thirds in 5 minutes, five-sixths in 15 minutes, nine-tenths in 30 minutes, with slight progress in an hour. The gelatinized grain is rather more irregular in outline than in *L. odoratus* var. *shahzada,* owing to the frequent formation of protuberances during gelatinization; otherwise the reaction is qualitatively the same as in *L. odoratus* var. *shahzada.*

The grains begin to react at once with *chromic acid.* A few are dissolved in 30 seconds and all in 3½ minutes. The outlines of the grains during the reaction are more irregular than in *L. odoratus* var. *shahzada;* otherwise the reaction is the same.

With *pyrogallic acid* the grains begin to react at once. A few are gelatinized in 30 seconds and all in 2 minutes. More of the gelatinized grains break up than in *L. odoratus* var. *shahzada.* The reaction is qualitatively the same as in the latter.

Reaction with *ferric chloride* begins in a minute. A few grains are gelatinized in 3 minutes, one-fifth in 15 minutes, one-third in 30 minutes, and about nine-tenths in an hour. The reaction is qualitatively the same as in *L. odoratus* var. *shahzada.*

The grains begin to react at once with *Purdy's solution.* A few are gelatinized in a minute, more than half in 6 minutes, about two-thirds in 15 minutes, and nearly all are partially or completely gelatinized in 30 minutes. There is little if any further change in an hour. The reaction is qualitatively the same as in the grains of *L. odoratus* var. *shahzada.*

STARCH OF LATHYRUS MAGELLANICUS VAR. ALBUS. (Plate 8, figs. 45 and 46. Chart 44.)

Histological Characteristics.—In *form* the grains are simple and isolated, and a large proportion are deeply fissured. In some grains there is a central, clean-cut or ragged fissure; in others there are two or more deep fissures; in others a combination of deep fissures arranged in a ring incloses a central area; in others the fissures are numerous and irregularly disseminated. The surface of the grains is quite irregular, distinctly more so than in the other *Lathyrus* starches. The conspicuous forms are the ovoid, oval, nearly round, pyriform, triangular, and quadrangular with well-rounded corners and reniform, all of which are more or less irregular. There are also grains of various irregular shapes. The grains are not so thick as they are broad.

Some of the nearly round grains have a small, indistinct, central *hilum*. In the few unfissured grains there may be seen sometimes a number of faintly refractive granules grouped together in a central non-lamellated space, but they are too indistinct to admit of their exact number or shape being determined.

The *lamellæ* are fairly distinct, usually rather coarse continuous bands which follow quite regularly the outline of the grain. They are less coarse near the margin than near the central part. There are 12 to 14 on the larger grains.

The grains vary in *size* from the smaller, which are 6 by 6μ, to the larger, which are 50 by 44μ, in length and breadth. The common size is 34 by 24μ in length and breadth.

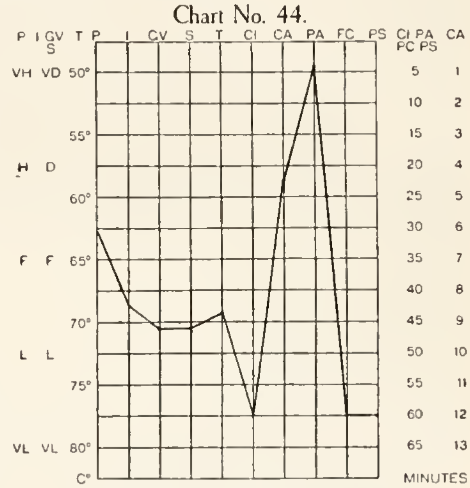
Polariscopic Properties.—The *figure* is centric or slightly eccentric, generally in the form of a cross; in a few grains it is of the bean type. The lines are broad and rarely clear-cut, tending to broaden near the margin of the grain. A large dark area is commonly observed at the point of intersection.

The degree of *polarization* is low to fairly high, but usually fairly high. A large part of the central area of many grains, sometimes all except small marginal parts, does not polarize. The degree of polarization does not vary much in different aspects of the same grain.

With *selenite* the quadrants, as a rule, consist of several portions of the same color grouped together, in most of the grains the yellow predominating. The colors usually are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a light violet; with 0.125 per cent solution the color is very light and deepens rather slowly. It is slightly deeper than in *L. odoratus* var. *shahzada*. After heating in water until the grains are completely gelatinized, the solution colors deeply and the gelatinized grains fairly deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the majority of the grain-residues fairly deeply. The capsules become a deep reddish-violet with an excess of iodine.

Chart No. 44.



Curve of Reaction-Intensities of Starch of Lathyrus magellanicus var. albus.

Staining Reactions.—With *gentian violet* the grains when viewed in masses show a very slight tint at once. After remaining in the solution for 30 minutes they are still only lightly stained, but slightly deeper than the grains of *L. odoratus* var. *shahzada*.

With *safranin* the grains when viewed in masses show a very slight tint of red. After remaining in the solution for 30 minutes they are still only very lightly stained, but slightly deeper than the grains of *L. odoratus* var. *shahzada*.

Temperature Reaction.—The temperature of gelatinization is 68° to 70° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains begin to react at once. A few are gelatinized in a minute, about one-third in 5 minutes, one-half in 15 minutes, and two-thirds in an hour. The grains assume a light violet tint at once, which later becomes a pinkish-brown. An interrupted band of dark blue a little distance from the margin is more often connected with the stained gelatinous mass which has formed at one or more points on the border than in *L. odoratus* var. *shahzada*. Rounded protuberances appear during the swelling of the grain, and the outline of the gelatinized grain is more or less scalloped. The reaction is qualitatively the same as in *L. odoratus* var. *shahzada*.

With *chromic acid* the grains begin to react at once. A few are gelatinized in 30 seconds and all in 4½ minutes. The reaction is qualitatively the same as in *L. odoratus* var. *shahzada*.

The grains begin to react at once with *pyrogallic acid*. A few are gelatinized in 45 seconds, the majority in 2½ minutes, and all in 4 minutes. The gelatinized grains are convoluted, and one or both ends are divided. The reaction is qualitatively the same as in the grains of *L. odoratus* var. *shahzada*.

Reaction with *ferric chloride* begins at once. A few grains are gelatinized in 5 minutes, about one-fifth in 15 minutes, and two-fifths in 30 minutes. After remaining in the reagent for an hour, there is little further change. During the reaction the striated border is more sharply defined from the central opaque mass than in *L. odoratus* var. *shahzada*; otherwise it is qualitatively the same.

The reaction with *Purdy's solution* begins in 30 seconds. All of the grains are affected in 5 minutes, one-fifth are gelatinized in 15 minutes, about one-third in 30 minutes, and one-half in an hour, with little further change. The refractive granules noted in *L. odoratus* var. *shahzada* during the reaction are frequently observed. The reaction is qualitatively the same as in the latter.

Differentiation of Certain Starches of the Genus Lathyrus.

Histological Characteristics.

Conspicuous Forms.

L. odoratus var. *shahzada:* Simple and isolated; surface irregular. Ovoid, ellipsoidal to elliptical, oval, reniform or bean-shaped, round.
L. sylvestris: Essentially the same as in *L. odoratus* var. *shahzada.*
L. latifolius var. *albus:* Essentially the same as in *L. odoratus* var. *shahzada.*
L. magellanicus var. *albus:* Essentially the same as in *L. odoratus* var. *shahzada,* but more irregular.

Hilum—Form, Number, and Position.

L. odoratus var. *shahzada:* When not fissured a number of small indistinct spots grouped together in a non-lamellated space. Usually deeply and extensively fissured; single longitudinal fissure prominent. Centric or slightly eccentric.
L. sylvestris: Form essentially the same as in *L. odoratus* var. *shahzada.* Position centric or slightly eccentric.
L. latifolius var. *albus:* Form essentially the same as in *L. odoratus* var. *shahzada.* Position centric or slightly eccentric.
L. magellanicus var. *albus:* Form essentially the same as in *L. odoratus* var. *shahzada,* but fissuration more pronounced. Position centric or slightly eccentric.

Lamellæ—General Characteristics and Number.

L. odoratus var. *shahzada:* Very distinct, coarse, continuous bands, following outline of grain. 10 to 12 on larger grains.
L. sylvestris: Same as in *L. odoratus* var. *shahzada,* but not quite so coarse. 10 to 12 on larger grains.
L. latifolius var. *albus:* Same as *L. odoratus* var. *shahzada,* but not quite so coarse. 10 on larger grains.
L. magellanicus var. *albus:* Same as in *L. odoratus* var. *shahzada* but not quite so coarse. 12 to 14 on larger grains.

Size.

L. odoratus var. *shahzada:* From 6 to 38μ, commonly 25μ.
L. sylvestris: From 8 to 38μ, commonly 24μ.
L. latifolius var. *albus:* From 4 to 36μ, commonly 23μ.
L. magellanicus var. *albus:* From 6 to 50μ, commonly 34μ.

Polariscopic Properties.

Figure.

L. odoratus var. *shahzada:* Centric or slightly eccentric, distinct, generally not clear-cut, lines usually broad and irregular, cross or bean type.
L. sylvestris: Same as in *L. odoratus* var. *shahzada.*
L. latifolius var. *albus:* Same as in *L. odoratus* var. *shahzada.*
L. magellanicus var. *albus:* Same as in *L. odoratus* var. *shahzada.*

Degree of Polarization.

L. odoratus var. *shahzada:* Fair to high, usually fairly high.
L. sylvestris: Low to fairly high, less than in *L. odoratus* var. *shahzada.*
L. latifolius var. *albus:* Low to high, slightly less than in *L. odoratus* var. *shahzada.*
L. magellanicus var. *albus:* Low to fairly high, less than in *L. odoratus* var. *shahzada.*

Polariscopic Properties.—Continued.

Polarization with Selenite—Quadrants and Colors.

L. odoratus var. *shahzada:* Quadrants usually not well-defined, irregular in shape and unequal in size. Colors pure or fairly pure.
L. sylvestris: Quadrants same as in *L. odoratus* var. *shahzada.* Colors fairly pure.
L. latifolius var. *albus:* Quadrants same as in *L. odoratus* var. *shahzada.* Colors fairly pure.
L. magellanicus var. *albus:* Quadrants same as in *L. odoratus* var. *shahzada.* Colors fairly pure.

Iodine Reactions.

Intensity and Color.

L. odoratus var. *shahzada:* Rather light; violet.
L. sylvestris: Fairly deep, much deeper than in *L. odoratus* var. *shahzada;* blue-violet.
L latifolius var. *albus*: Fairly deep, much deeper than in *L. odoratus* var. *shahzada;* blue-violet.
L. magellanicus var. *albus:* Light, slightly more than in *L. odoratus* var. *shahzada;* violet.

Staining Reactions.

With Gentian Violet.

L. odoratus var. *shahzada:* Light.
L. sylvestris: Light, same as in *L. odoratus* var. *shahzada.*
L. latifolius var. *albus:* Light, same as in *L. odoratus* var. *shahzada.*
L. magellanicus var. *albus:* Light, slightly more than in *L. odoratus* var. *shahzada.*

With Safranin.

L. odoratus var. *shahzada:* Light.
L. sylvestris: Light, same as in *L. odoratus* var. *shahzada.*
L. latifolius var. *albus:* Light, same as in *L. odoratus* var. *shahzada.*
L. magellanicus var. *albus:* Light, slightly more than in *L. odoratus* var. *shahzada.*

Temperature of Gelatinization.

L. odoratus var. *shahzada:* 68 to 69° C., mean 68.5°.
L. sylvestris: 57 to 59° C., mean 58°.
L. latifolius var. *albus:* 62 to 64° C., mean 63°.
L. magellanicus var. *albus:* 68 to 70° C., mean 69°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

L. odoratus var. *shahzada:* Begins in a few in a minute; complete in half in 30 minutes, little further change in an hour.
L. sylvestris: Begins in all at once; complete in nine-tenths in 15 minutes and practically all in 30 minutes, little further change in an hour.
L. latifolius var. *albus*: Begins in all at once; complete in nine-tenths in 30 minutes, little further change in an hour.
L. magellanicus var. *albus:* Begins in a few at once; complete in half in 15 minutes, little progress in 30 minutes, complete in two-thirds in an hour.

Reaction with Chromic Acid.

L. odoratus var. *shahzada:* Begins at once; complete in all in 10 minutes.
L. sylvestris: Begins in all in 20 seconds; complete in all in 2 minutes.

Differentiation of Certain Starches of the Genus Lathyrus.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chromic Acid.—Continued.

L. latifolius var. *albus:* Begins at once; complete in all in 3½ minutes.
L. magellanicus var. *albus:* Begins at once; complete in all in 4½ minutes.

Reaction with Pyrogallic Acid.

L. odoratus var. *shahzada:* Begins in a few at once; complete in all in 5 minutes.
L. sylvestris: Begins at once; complete in all in 1½ minutes.
L. latifolius var. *albus:* Begins at once; complete in all in 2 minutes.
L. magellanicus var. *albus:* Begins at once; complete in all in 4 minutes.

Reaction with Ferric Chloride.

L. odoratus var. *shahzada:* Begins in all in 4 minutes; complete in one-fifth in 1 hour.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.—Continued.

L. sylvestris: Begins in all in 30 seconds; complete in nine-tenths in 30 minutes and in practically all in an hour.
L. latifolius var. *albus:* Begins in all in a minute; complete in nine-tenths in an hour.
L. magellanicus var. *albus:* Begins in a few in 1 minute; complete in two-fifths in 30 minutes and incomplete in an hour.

Reaction with Purdy's Solution.

L. odoratus var. *shahzada:* Begins in a few in 30 seconds, in all in 4 minutes; complete in one-half in 30 minutes, but incomplete in an hour.
L. sylvestris: Begins at once; complete in all in 30 minutes.
L. latifolius var. *albus:* Begins at once; complete in practically all in 30 minutes.
L. magellanicus var. *albus:* Begins in some in 30 seconds, in all in 5 minutes. Complete in half in an hour.

NOTES ON THE STARCHES OF LATHYRUS.

It will be noticed from the photographs that the starches of the first three Lathyri are almost identical in general appearances, and that such differences as are detectable are to be found in variations in the degree of regularity of the grains, the extent of fissuration, and the visibility of the lamellæ, all of which may be merely incidental and due to transient conditions, and therefore of no real value in differentiation. But the starch of *L. magellanicus* var. *albus* stands by itself, the grains being on the whole distinctly larger, more irregular, and more fissured. In the reactions more or less marked differences are observed, the sum of which in the case of each starch is diagnostic. The range of variation is particularly noticeable in the polarization, iodine, and temperature records, and in all of the records of the chemical reactions. The wide range in the temperature reaction is very striking, the lowest record being observed in *L. sylvestris* (58° C.), and the highest in *L. magellanicus* var. *albus* (69°), a difference of 11°. In general, *L. sylvestris* and *L. latifolius* var. *albus* are closely in accord in their reactions, while *L. odoratus* var. *shahzada* and *L. magellanicus* are in correspondence.

GENUS PISUM.

The small genus *Pisum* is allied to *Vicia, Phaseolus, Lens,* and *Lathyrus,* especially the latter, and is composed of about a half a dozen species of climbing plants which are native chiefly to the Mediterranean region and Asia. *P. sativum* Linn., the common garden pea, of which a considerable number of agricultural forms are cultivated, is the best known of the genus. Apart from the members of this genus, there are a large number of plants or seeds which are known as peas, some of which, however, have not even a family relationship. Starches were prepared from five garden varieties of *P. sativum,* the selection being based upon external characteristics of the seeds, including Eugenie (a large, *yellow* or *green wrinkled* seed, the larger proportion being *yellow* and the remainder various *tints of green,* mostly light); Thomas Laxton (a large *yellow, wrinkled* pea); Electric Extra Early (a small, *green, round, indent*); Mammoth Grey Seeded (a large, *brown,* or *greenish-brown,* or *gray,* with minute black specks, *pitted, sugar* pea); and Large White Marrowfat (a large *yellow, smooth, round*). The Eugenie, Large White Marrowfat, and Mammoth Grey Seeded are late blooming varieties; Thomas Laxton and Electric Extra Early are early blooming. Great importance was attached to the properties expressed by the terms *round* and *wrinkled,* and *green* and *yellow,* in the experiments by Mendel, which laid the foundation for the present-day Mendelism. (See Part I, page 72, for starch in relation to Mendelism.)

STARCH OF PISUM SATIVUM VAR. (EUGENIE, GREEN). (Plate 8, figs. 47 and 48. Chart 45.)

The starch was prepared from the greenest of the separated green grains.

Histological Characteristics.—In *form* the grains appear to be simple and chiefly as rosette and linear aggregates. They may be divided into two groups; those appearing to be the original grains and those appearing to be pieces of broken-down originals. The former are of round, ovoid, oval, or linear types, but all are divided by deep, wide, often irregular fissures into from two to eight parts, generally five or six, which give the round, ovoid, and oval forms a rosette-like appearance. Some of the linear forms are aggregates of the round and oval forms. Extension of the fissuration separates these grains into part-grains, which are generally somewhat triangular, quadrangular, crescentic, or hemispherical in form. Whether or not these part-grains are individual grains and therefore parts of grains that are aggregates could not be determined in the normal grains because of an absence of hila and lamellæ, but by means of Purdy's solution lamellæ were demonstrated in the part-grains to be discontinuous lines, indicating that these part-grains are broken-off components of primary grains. There are a few grains resembling those of *Vicia*, *Phaseolus*, and *Lathyrus*, but with these exceptions they are quite unlike the bean starches. The marked dissimilarity may, however, be more apparent than real, since it may be due to peculiarities of fissuring, although the histological differentiation is borne out by the results of the other methods of study. In some of the grains of reniform shape there was a long longitudinal fissure, with deep lateral branches, almost entirely separating the several parts of the grain from one another. The fissuration of the round, ovoid, and oval types is merely a modification of this.

No *hila* are demonstrable.

There are no *lamellæ* visible in normal grains. When treated with Purdy's solution, lamellæ appear as discontinuous lines on each of the part-grains, showing that these part-grains are segments of the normal simple grains. They are regular, rather coarse, and have the outline of the margin. There are about 6 or 7 on the larger part-grains.

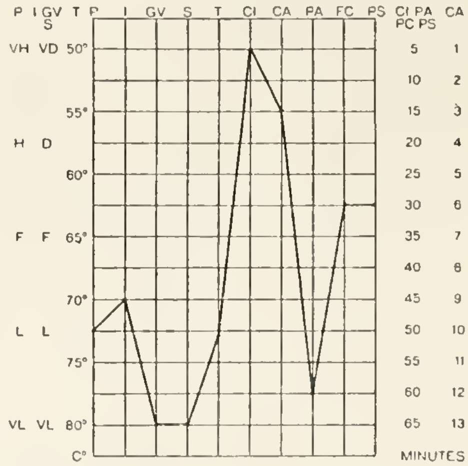
The grains vary in *size*, from the part-grains, which are 10 by 10μ, to the larger rounded grains, which are 38 by 38μ, and the larger oval grains, which are 44 by 32μ in length and breadth. The common size is 28 by 28μ.

Polariscopic Properties.—No definite *figure* can be made out. The oval and round forms show a large dark area with usually a half dozen or more short, radial lines which border small bright spots. The part-grains appear as bright spots without a figure.

The degree of *polarization* is low. It does not vary much in different grains, but in most of the grains it is obscured or largely obliterated by the deep fissuration. In the grains of the bean type it is fairly high. It does not vary much in different aspects of the same grain.

With *selenite* there is no definite division into quadrants, but spaces of blue and of yellow may be seen which are not very definitely outlined and which are grouped with others of the same color. Sometimes the blue and sometimes the yellow spaces predominate, according to the position of the grains in the field. The colors are not pure.

Chart No. 45.



Curve of Reaction-Intensities of Starch of Pisum sativum var. (Eugenie, green).

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a fairly light violet; with 0.125 per cent solution they color a lighter violet and the color deepens fairly rapidly. After heating in water until all the grains are completely gelatinized, the solution is colored a deep blue-green and the gelatinized grains a deep bluish-purple on the addition of iodine. After boiling for 2 minutes, the solution colors a very deep indigo-blue and the grain-residues a deep purplish-blue, the latter coloring a dark reddish-purple when an excess of iodine is added. The grain-residues were again boiled for 5 minutes, and even then the capsules nearly always contained some gelatinized starch which on addition of iodine became a deep-purple. Very rarely grains are seen which resemble those of *Lathyrus odoratus* var. *shahzada*, and the capsules of these grains stain a reddish-violet.

Staining Reactions.—The grains when viewed in masses show with *gentian violet* a slight tint of violet at once; with *safranin*, a slight tint of red at once. After remaining in the solution 30 minutes they are very lightly stained. The color of the grain is not uniform in tint and usually deeper along the course of the fissures.

Temperature Reaction.—The temperature of gelatinization is 73° to 74° C., mean 73.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains take on a deep indigo-blue color immediately. The majority are gelatinized in 2 minutes and all but about 1 in 200 in 5 minutes; after an hour a few are still not gelatinized; these are the grains of the bean type. They gradually assume a golden-brown color. The grains which become gelatinized are stained either a light violet or light rose tint, and the lamellæ become very distinct and have delicate striæ, especially in unfissured grains. In the forms with deep stellate clefts, this color is a golden-brown at once, but later the blue color starts centrally and spreads throughout the grain, accompanied by uniform swelling. Gelatinization usually starts at one end, or at the lines of separation of the aggregates or part-grains, and advances slowly. The gelatinized grain, while much swollen, retains in general the form of the untreated grain. There is a central light space from which light lines extend, dividing the grain into segments which sometimes are practically separated from one another.

The grains begin to react at once with *chromic acid*. The grains with stellate fissures are frequently dissolved in 20 seconds, except a refractive mass of granules which do not pass into solution. The grains, which resemble those of *Lathyrus*, are all dissolved in 3 minutes. The former swell rapidly, sometimes breaking into segments or part-grains during the reaction, and are dissolved, except the mass of refractive substance referred to. In the few grains which resemble those of *Lathyrus* the mesial fissure becomes very distinct; the lamellæ are sharply differentiated into refractive and non-refractive lamellæ, the refractive lamellæ exhibiting striæ; and delicate radiating fissures pass from the central fissure to every part of the grain. The grain swells uniformly, becomes very clear, and then suddenly collapses and passes into solution.

Reaction with *pyrogallic acid* begins in some grains at once. A few are gelatinized in 2 minutes and all are more or less affected in that time. There is very little further change even after an hour. The lamellæ become very distinct and exhibit striæ. In the forms with stellate fissures bubbles collect in the fissures and disappear as the grains swell. In some grains the starch immediately surrounding the fissures becomes gelatinized, while most of the grain continues unaffected after the first steps of the process. In other grains a clear spot appears at the apex of each part-grain of the grain, and these part-grains occasionally separate and the parts swell independently. A number of refractive granules are found along the course of the clefts in all swollen grains. The gelatinized grain, though much enlarged, retains the general shape of the untreated grain. A few grains similar to those observed in *Lathyrus odoratus* var. *shahzada* are completely gelatinized in 2 minutes. The reaction and the shape of the gelatinized grain are the same as in *L. odoratus* var. *shahzada*.

The grains begin to react in 30 seconds with *ferric chloride*, the lamellæ becoming distinct. In 15 minutes practically all are partially gelatinized, and the reaction is complete in a few in 20 minutes. Nearly all are gelatinized in 30 minutes, but after remaining in the reagent for an hour there is little if any further change in the few remaining ungelatinized grains. The lamellæ become distinct, the stellate fissure swells and bubbles usually form in it. If the fissure is very deep, the grain frequently separates into segments. Some of the outer lamellæ appear to break as the gelatinized starch expands. Some of the grains do not separate into parts, in which case the gelatinized grain retains much of the shape of the untreated grain.

With *Purdy's solution* the grains begin to react in 30 seconds. A few are gelatinized in 5 minutes, all of the grains are in process of reacting in 15 minutes, and the reaction is complete in 30 minutes. The phenomena of the reaction are similar to those noted for pyrogallic acid, but gelatinization proceeds somewhat further in the fissured forms. The few grains resembling those of *Lathyrus odoratus* var. *shahzada* are completely gelatinized. The gelatinized grain still retains much of the shape of the untreated grain, and parts of the outermost lamellæ are ungelatinized.

STARCH OF PISUM SATIVUM VAR. (EUGENIE, YELLOW). (Plate 8, figs. 47 and 48. Chart 46.)

Histological Characteristics.—In *form*, as in the green Eugenie peas, these grains appear to be simple. There are few aggregates. Most of the grains are partially divided, usually into four to nine parts, commonly five or six, by very deep, wide, and somewhat irregular fissures. The grains are of the round, ovoid, and oval type, but the marginal outline is so broken up, owing to the fissuring of the grain, that they have a rosette-like appearance. Many part-grains also arise from the breaking up of the primary grain, and these pieces are irregularly wedge-shaped, crescentic, triangular, or quadrangular. Grains of the type common to *Vicia* and *Phaseolus*, which have but one long fissure extending down the middle, are rarely to be found.

No *hilum* is demonstrable.

The *lamellæ* are not demonstrable except by treatment, as with Purdy's solution. When the grains are so treated the lamellæ appear as rather coarse, regular lines, which are made discontinuous by the fissuring. There are about 8 or 9 on the larger grains.

The grains vary in *size* from the small, which are 8 by 8μ, to the larger round and ovoid forms, which are 38 by 38μ. The common size is 26 by 26μ.

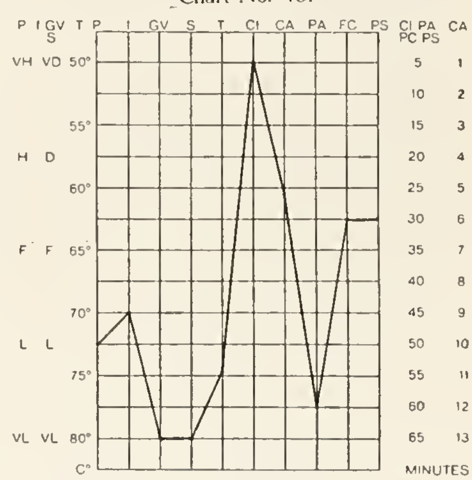
Polariscopic Properties.—There is no true *figure* in the rosette grains, but there are portions of figures confused with the lines of the fissures. In the grains of the bean type it corresponds with the peculiarities described under *Vicia* and *Phaseolus.*

The degree of *polarization* is low. It does not vary much in different grains. In the few grains of the bean type it is fairly high. It does not vary much in different aspects of the same grain, except when it is obscured by the fissures. It is slightly higher than in the green seeds.

With *selenite* there are no quadrants, but poorly defined areas of blue and of yellow are grouped together. In some grains the yellow and in some the blue predominates, according to their position in the field. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly light violet; with 0.125 per cent solution they color a light violet which deepens rather rapidly. The color is the same as that of the green seeds. After heating in water until all the grains are completely gelatinized, the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues a bright blue. If an excess of iodine is added the solution becomes a deep blue-green, and the grain-residues a rich reddish-purple. After boiling for 5 minutes the shape of the grains is still retained. The solution colors very deeply, and some of the grain-residues color a bright blue and others not at all when iodine is added. With an excess of iodine the same results were obtained as noted for the green seeds.

Chart No. 46.



Curve of Reaction-Intensities of Starch of Pisum sativum var. (Eugenie, yellow).

Staining Reactions.—With *gentian violet* the grains when examined in masses show a very slight tint at once. After remaining in the solution for 30 minutes they are still very lightly stained. The coloration of the grain is uneven, usually deeper along the course of the fissures. Occasionally a very deeply stained grain is found. The depth of staining is the same as of the green seeds.

With *safranin* the grains when examined in masses show a slight tint at once. After remaining in the solution for 30 minutes they are still very lightly stained. The coloration is uneven, usually being deeper along the course of the fissures. The depth of staining is the same as that of the green seeds.

Temperature Reaction.—The temperature of gelatinization is 74° to 75° C., mean 74.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once. A few grains are deeply colored in 30 seconds. The majority are gelatinized in 2 minutes, and practically all in 5 minutes. After an hour those of the bean type remain ungelatinized. They are colored a golden-brown by the reagent. The reaction is qualitatively the same as in the green seeds.

The grains begin to react at once with *chromic acid.* A few with stellate fissures are dissolved in 20 seconds and all in a minute. All those of the bean type pass into solution in 5½ minutes. The reaction is qualitatively the same as in green seeds, but the grains with stellate fissures pass more completely into solution, only very little of the least refractive starch remaining.

Reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 2½ minutes, but there is little if any further change after an hour. The reaction is qualitatively the same as that noted for the green peas.

Reaction with *ferric chloride* begins in 30 seconds. An occasional part of a broken-down grain is gelatinized in 5 minutes, and a whole grain in 10 minutes. All are in process of reaction in 15 minutes, and the reaction is complete in nearly all in 30 minutes. After remaining in the reagent for an hour there is little if any further change. The reaction is qualitatively the same as in the green seeds.

With *Purdy's solution* the grains begin to react in 30 seconds. All are in process of reaction in 15 minutes, and the reaction is complete in 30 minutes. After remaining in the solution for an hour there is very little if any further change. The phenomena of the reaction are identical with those observed when the grains are treated with pyrogallic acid. The reaction is qualitatively the same as that noted for the green peas.

STARCH OF PISUM SATIVUM VAR. (THOMAS LAXTON). (Plate 9, figs. 49 and 50. Chart 47.)

Histological Characteristics.—In *form* the grains are probably simple, although practically all are divided into from four to nine parts, commonly five or six, by very deep, broad fissures which reach to the outer margin of the grain. They very closely resemble the Eugenic pea in all respects. In some cases the grains have split entirely into many pieces or part-grains. The grains are evidently round, ovoid, and oval in type, though the fissuring causes the margin to have a fairly regular scalloped appearance, the whole grain looking somewhat like a rosette and suggestive of aggregates of distorted spherical grains. The parts of the broken grains are wedge-shaped, triangular, irregularly quadrangular, and crescent-shaped. There are rarely grains of the bean type common to *Vicia* and *Phaseolus*. The grains usually are not so thick as they are broad.

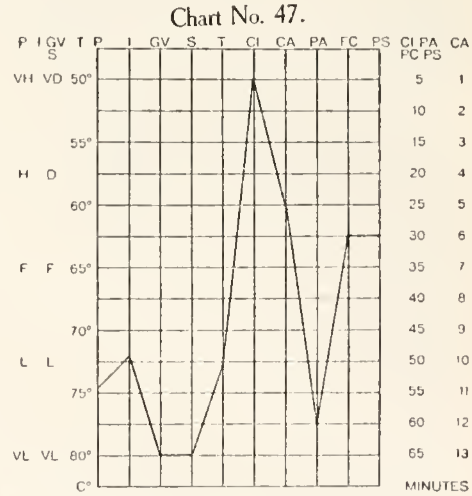
No *hila* could be distinguished.

No *lamellæ* can be distinguished, except when the grains are treated, as with Purdy's solution, and then they appear as rather coarse, regular lines, following the outline of the margin and broken by the fissures. There are eight to nine on the larger grains.

The grains vary in *size* from the smaller, which are 8 by 8μ, to the larger, which are 32 by 32μ. The common size is 24 by 24μ.

Polariscopic Properties.—The characteristics of the *figure* can not be satisfactorily determined, owing to the confusion of its lines with those of the fissures. In the few grains of the bean type present the figure corresponds with the peculiarities described under *Vicia*.

Chart No. 47.



Curve of Reaction-Intensities of Starch of Pisum sativum var. (Thomas Laxton).

The degree of *polarization* is low. It does not vary much in different aspects of the same grain, but is lower in some grains than in others. It is in general less than that of the grains of the Eugenie peas. In the grains of the bean type polarization is fairly high.

With *selenite* there is no division into definite quadrants, but into small spaces of blue and of yellow not very definitely defined and grouped in each case with others of the same color. In some grains blue is the predominating color, but the yellow usually predominates. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly light violet; with 0.125 per cent solution they color a lighter violet, and the color deepens fairly rapidly. The color is not quite so deep as in Eugenie peas. After heating in water until all of the grains are completely gelatinized, the solution colors a deep blue-green and the gelatinized grains a deep purplish-blue on the addition of iodine. After boiling for 2 minutes the solution colors a very deep indigo-blue and the grain-residues a bright, rather light blue. The gelatinized grains all color a deep purplish-blue when an excess of iodine is added, and even when the grains are boiled for 5 minutes the results are the same as for Eugenic peas, showing great resistance to breaking down and extrusion of the inner, less resistant starch from the capsule.

Staining Reactions.—With *gentian violet* the grains when viewed in masses show a slight tint of violet, the color being somewhat deeper along the course of the stellate fissure. After remaining in the solution for 30 minutes they are still very lightly stained. The color is the same as in Eugenic peas.

With *safranin* the grains are slightly stained at once, the color being deeper along the course of the stellate fissure. After remaining in the solution for 30 minutes they are still only very lightly stained. The color is the same as in Eugenie peas.

Temperature Reaction.—The temperature of gelatinization is 72.5° to 74° C., mean 73.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, the majority in 2 minutes, and all in 5 minutes, except about 1 in

200, these being of the bean type. The latter are not gelatinized in an hour. The reaction is qualitatively the same as that noted for Eugenie peas.

The grains begin to react at once with *chromic acid*, and all parts of the grains are almost wholly dissolved in 30 seconds and completely in 5 minutes. The reaction is qualitatively the same as for Eugenie peas.

Reaction with *pyrogallic acid* begins at once. In 5 minutes all the grains are affected, but there is little further change in an hour. The lamellæ become very distinct and the fissures very refractive. Very rarely a grain of the bean type is observed which is completely gelatinized, the others are slightly affected. The reaction is qualitatively the same as that observed for Eugenie peas.

With *ferric chloride* the grains begin to react in a minute. A few are gelatinized in 4 minutes, the majority in 30 minutes, and nearly all in an hour. The reaction is qualitatively the same as that observed for Eugenie peas.

With *Purdy's solution* the reaction begins at once, the grains are swollen in 3½ minutes, and gelatinization is complete, except in the outermost lamellæ, in 30 minutes. After remaining in the solution for an hour the general shape of the normal grain is retained, but most of the lamellæ are gelatinized, and there are many refractive granules of ungelatinized starch. The reaction is qualitatively the same as that observed in Eugenie peas.

STARCH OF PISUM SATIVUM VAR. (ELECTRIC EXTRA EARLY). (Plate 9, figs. 51 and 52. Chart 48.)

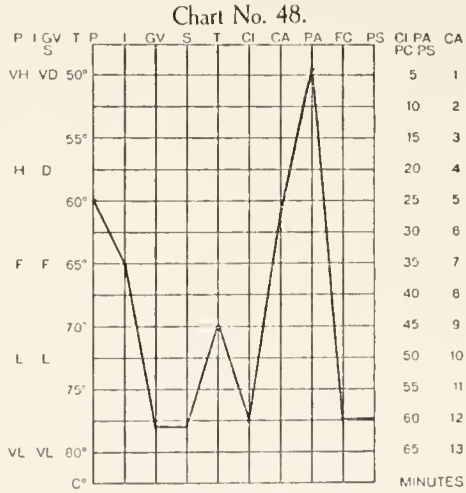
Histological Characteristics.—In *form* the grains are simple and isolated, and there are no pressure facets. The grains are frequently somewhat irregular in outline, owing usually to slight depressions. The conspicuous forms are ovoid, oval, elliptical, and reniform. There are in addition round to nearly round grains, and some incidental forms. The grains are not so thick as they are broad. They correspond in general characteristics with the bean type, as, for instance, those of *Vicia, Phaseolus, Lathyrus*, etc.

When an elongated form of grain is not fissured the *hilum* may be regarded as represented by a granular, non-lamellated space appearing in the middle, and in the round or nearly round grains by a small, rather obscure spot. When the grains are fissured this mesial space is either not visible or is divided into many parts.

The *lamellæ* are very distinct, rather coarse, continuous lines which follow the outline of the grain. There are from 7 to 8 on the larger grains.

The grains vary in *size* from the smaller, which are 6 by 6μ, to the larger elongated forms, which are 44 by 24μ in length and breadth. The common size is 32 by 20μ in length and breadth.

Chart No. 48.



Curve of Reaction-Intensities of Starch of Pisum sativum var. (Electric Extra Early).

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and in most cases fairly clear-cut. In the unfissured grains it is of the bean type, having the form of a single line extending down the middle of the grain, with each end bisected. When fissures are present the figure is more or less broken up and distorted. Sometimes the lines or parts of lines composing it are bisected and occasionally curved or bent.

The degree of *polarization* is fairly high to high, not varying much in different aspects of a grain, but sometimes less at some points than at others. It is much higher than that of Eugenie peas.

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the majority of the grains color at once a fair violet, which deepens gradually to a deep blue-violet; with 0.125 per cent solution they color a very delicate violet, deeper than that of the grains of Eugenie peas. After heating in water until the grains are completely gelatinized, the solution colors a deep blue-green and the grains a blue-black on the addition of iodine. After boiling for 2 minutes the solution colors a deep indigo-blue and the grain-residues a bright, light blue. The capsules all color a deep reddish-purple with an excess of iodine.

Staining Reactions.—The grains when viewed in masses show a slight tint of violet with *gentian violet* and of red with *safranin*. After remaining in the solution for 30 minutes they are lightly stained. The grains are more stained than those of Eugenie peas.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once. A few grains are gelatinized in 2 minutes, about one-fourth in 15 minutes, and two-thirds in 30 minutes. After remaining in the reagent for an hour very few if any more grains are gelatinized, but they have the same golden-brown color already mentioned in connection with Eugenie peas. The reaction is qualitatively the same as in the Large White Marrowfat peas.

Reaction with *chromic acid* begins at once; a few grains are dissolved in 2 minutes, the majority in 5½ minutes, while an occasionally resistant grain may take 12 minutes to pass into solution. The reaction is qualitatively the same as in the Large White Marrowfat peas.

Reaction with *pyrogallic acid* begins at once and a few grains are gelatinized in 50 seconds; most are gelatinized in 2½ minutes, and practically all in 4 minutes. The reaction is qualitatively the same as in the Large White Marrowfat peas.

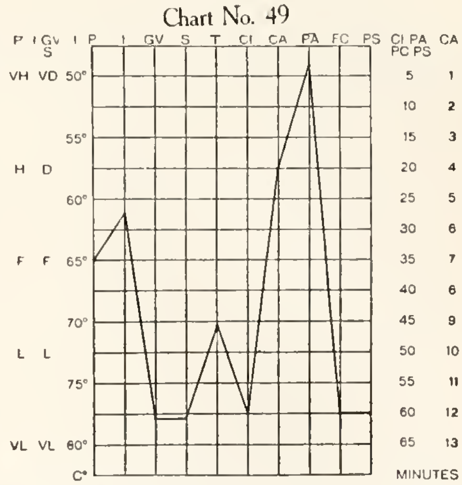
With *ferric chloride* the grains begin to react in 30 seconds, the lamellæ becoming very distinct. A few are gelatinized in 15 minutes, and about one-sixth in an hour. The reaction is qualitatively the same as in the Large White Marrowfat peas.

With *Purdy's solution* some of the grains begin to react in about 30 seconds. A few are gelatinized in 5 minutes, about one-tenth in 30 minutes, and two-thirds in an hour. The reaction is qualitatively the same as in the Large White Marrowfat peas.

STARCH OF PISUM SATIVUM VAR. (MAMMOTH GREY SEEDED). (Plate 9, figs. 53 and 54. Chart 49.)

Histological Characteristics.—In *form* the grains are simple, and are isolated except a few aggregates in the form of doublets. There are no pressure facets. The grains are usually somewhat irregular in outline, owing generally to slight depressions. The conspicuous forms are ovoid to oval, elliptical, and reniform. There are also round and nearly round, especially among the small grains, and some incidental irregular forms. The grains are not so thick as broad and correspond in general characters with those of *Vicia*, *Phaseolus*, etc.

Chart No. 49



Curve of Reaction-Intensities of Starch of Pisum sativum var. (Mammoth Grey Seeded).

The *hilum* is probably represented by a small mesial, granular non-lamellated space when the grain is not fissured. In the small round grains there is a small central hilum. Many of the grains show very extensive fissuring, usually in the form of a deep, ragged, longitudinal fissure.

The *lamellæ* are distinct, rather coarse, continuous lines which follow the outline of the grain, usually not so coarse or distinct near the margin as in other parts and not so distinct as in Electric Extra Early. There are 7 to 10 on the larger grains.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, which are 40 by 28μ in length and breadth. The common size is 29 by 22μ in length and breadth.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, usually distinct, but not clear-cut; it is often impossible to determine the exact characteristics of the figure, owing to interference of the fissures; in grains not fissured it generally appears as a broad line along the longitudinal axis of the grains that is bisected at each end.

The degree of *polarization* is fair, ranging from low to fairly high, not varying much in different aspects of the same grain; sometimes lower at some points than others, and in many grains completely lacking in the central parts. It is higher than that in Eugenic peas.

With *selenite* the quadrants are commonly fairly well defined, irregular in form, and unequal in size. The colors are, as a rule, pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet, some having a more reddish tint than others; with 0.125 per cent solution they color a light violet and the color deepens rather slowly. It is deeper than that of the grains of Eugenie peas. After heating in water until all the grains are completely gelatinized, the solution colors a blue-green and the gelatinized grains a deep violet-blue on the addition of iodine. After boiling for 2 minutes, the solution colors a deep indigo-blue and the grain-residues a reddish-blue. With an excess of iodine the capsules stain a deep violet.

Staining Reactions.—When viewed in masses the grains are at once very lightly stained with *gentian violet,* and show a tint of red with *safranin.* After remaining in the solution for 30 minutes they are still very lightly stained. The color is slightly deeper than in Eugenie peas.

Temperature Reaction.—The temperature of gelatinization is 70° to 71° C., mean 70.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Swelling starts in a minute in a few grains and a few are gelatinized in 2 minutes. About half are gelatinized in 30 minutes, with but little further change in an hour. Those which are not stained a deep indigo-blue have either a golden or a reddish-brown color. The reaction is qualitatively the same as that in the Large White Marrowfat peas.

The grains begin to react at once with *chromic acid.* A few are gelatinized in 45 seconds, nearly all in 4 minutes, and all in 12 minutes. The reaction is qualitatively the same as in the Large White Marrowfat peas.

Reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in a minute and all in 3 minutes. The reaction is qualitatively the same as in the Large White Marrowfat peas.

With *ferric chloride* the grains begin to react in a minute. A few are gelatinized in 6 minutes, about one-tenth in 30 minutes, and about one-sixth in an hour. The reaction is qualitatively the same as in the Large White Marrowfat peas.

With *Purdy's solution* the grains begin to react in 30 seconds. A few are gelatinized in 3 minutes, practically all are affected in 10 minutes; about one-sixth are gelatinized in 30 minutes, and about one-third in an hour. The reaction is qualitatively the same as in the Large White Marrowfat peas.

STARCH OF PISUM SATIVUM VAR. (LARGE WHITE MARROWFAT). (Plate 10, figs. 55 and 56. Chart 50.)

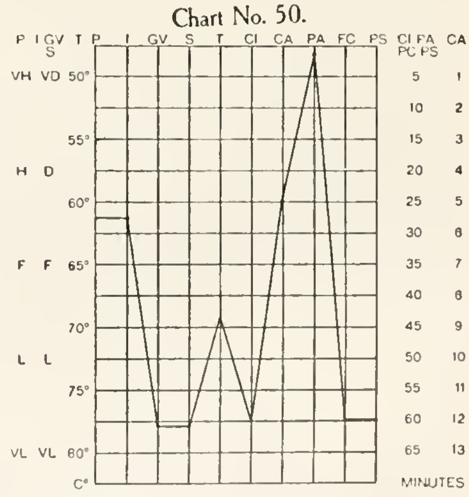
Histological Characteristics.—In *form* the figures are simple and isolated. There are no pressure facets. The outlines of the grains are usually somewhat irregular, owing to depressions. The conspicuous grains are ovoid, oval, elliptical, and reniform; there are also round or nearly round, triangular and quadrangular grains with rounded angles, lenticular, and various irregular incidental forms. The grains are not so thick as wide. They correspond in general characteristics with the grains of *Vicia* and *Phaseolus.*

There is a small central *hilum* in the small round grains. If the grain is unfissured there is seen a central non-lamellated, granular space which is probably to be considered as the hilum.

The *lamellæ* appear as distinct, regular, rather coarse, continuous lines, which have the form of the outline of the grain. Those near the margin are less distinct than those of other parts. They are not so distinct or coarse as in Electric Extra Early. There are 10 to 12 on the larger grains.

The grains vary in *size* from small, which are 6 by 6μ, to the larger elliptical, which are 50 by 28μ in length and breadth, and the ovoid and oval, which are 42 by 28μ in length and breadth. The common size is 34 by 24μ in length and breadth.

Chart No. 50.



Curve of Reaction-Intensities of Starch of Pisum sativum var. (Large White Marrowfat).

Polariscopic Properties.—The *figure* is usually fairly distinct, but sometimes the lines composing it are confused because of the fissures. In the unfissured grains it commonly has the form of long, longitudinal, dark lines with bisected ends. The lines are thick but fairly clear-cut, and not, as a rule, bent.

The degree of *polarization* is fair to high, not varying much in different aspects of the same grain, but often lower at some points than at others of the same aspect of a grain; it is much higher than in Eugenie peas.

With *selenite* the quadrants in the unfissured grains are fairly well defined, irregular in form, and unequal in size. The fissured grains have many areas of each color grouped together, and in some grains the blue predominates, but in most there is more yellow. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with 0.125 per cent solution they color a light violet, and the color deepens rather slowly. The color is deeper than that in Eugenie peas. After heating in water until all the grains are completely gelatinized, the solution colors a deep blue-green and the grains a very dark blue on the addition of iodine. After boiling for 2 minutes, the solution colors a deep indigo-blue and most of the grain-residues a bright blue. The capsules stain a reddish-violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* and with *safranin* the grains when viewed in masses show a light tint of violet at once; after remaining in the solution for 30 minutes they are lightly stained. The color of the grains is slightly deeper than in Eugenie peas.

Temperature Reaction.—The temperature of gelatinization is 68° to 69° C., mean 68.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains begin to react at once. About one-eighth are gelatinized in 5 minutes, one-third in 15 minutes, and two-thirds in 30 minutes. After remaining in the solution for an hour no more appear to be gelatinized, but they are changed to a golden-brown color by the reagent. The grains on adding the reagent at once assume a light violet tint, which soon becomes of a light rose color. The refractive and non-refractive lamellæ are sharply differentiated, and striæ are clearly observed on the refractive lamellæ. Gelatinization begins either at one end or at the clear line of division in the reniform grains, as a mass of deeply stained starch, sometimes irregular in shape. From this mass strands of color often pass, but eventually the mass of color advances over the entire grain. The gelatinized grain is usually regular in outline, but occasionally broken and ragged at some points. The reaction resembles those observed in the starches of *Vicia, Phaseolus,* and *Lathyrus.*

Reaction begins at once with *chromic acid.* A few grains are dissolved in 2 minutes, the majority in 5 minutes, while an occasional resistant grain may take 12 minutes before it passes completely into solution. The reaction is qualitatively the same as in the bean starches generally.

The reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 40 seconds, the majority in 1½ minutes, and all in 2 minutes. The reaction is qualitatively the same as noted in the bean starches generally.

With *ferric chloride* the grains begin to react in 30 seconds by the hilum and lamellæ becoming distinct. A few are gelatinized in 15 minutes, and about one-fourth are gelatinized in an hour. The reaction is qualitatively the same as noted in the bean starches generally.

Reaction with *Purdy's solution* begins in 30 seconds. A few grains are gelatinized in 8 minutes and about nine-tenths in 30 minutes. Rows of brilliant granules, which seem to be remains of lamellæ, appear during solution of the grain. The phenomena of this reaction are similar to those observed with pyrogallic acid, but the remains of the lamellæ are generally less convoluted and the outline of the gelatinized grain is more regular. The reaction is qualitatively similar to those observed in bean starches generally.

Differentiation of Certain Starches of the Genus Pisum.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

Eugenie (green): Simple and isolated, much fissured. Round, ovoid, and oval rosettes, linear aggregates; part-grains triangular, and quadrangular, crescentic, hemispherical. Few grains of bean type.
Eugenie (yellow): Same as in Eugenie (green).
Thomas Laxton: Same as in Eugenie (green).
Electric Extra Early: Simple and isolated, often fissured. Ovoid, oval, elliptical, reniform.
Mammoth Grey Seeded: Essentially the same as in Electric Extra Early.
Large White Marrowfat: Essentially the same as in Electric Extra Early.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.

Eugenie (green): Not demonstrable. Position probably centric or slightly eccentric.
Eugenie (yellow): Same as in Eugenie (green). Position probably centric or slightly eccentric.
Thomas Laxton: Same as in Eugenie (green). Position probably centric or slightly eccentric.
Electric Extra Early: Hilum probably a granular non-lamellated space, usually fissured. Position centric or slightly eccentric.
Mammoth Grey Seeded: Same as in Electric Extra Early. Position centric or slightly eccentric.
Large White Marrowfat: Same as in Electric Extra Early. Position centric or slightly eccentric.

Differentiation of Certain Starches of the Genus Pisum.—Continued.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.

Eugenie (green): Regular, rather coarse, lines discontinuous on account of fissuring. 6 to 7 on parts of large grains.
Eugenie (yellow): Same as in Eugenie (green). 8 to 9 on parts of large grains.
Thomas Laxton: Same as in Eugenie (green), but not so coarse. 8 to 9 on parts of large grains.
Electric Extra Early: Very distinct, rather coarse, regular and continuous, following outline of grain. 7 to 8 on larger grains.
Mammoth Grey Seeded: Same as in Electric Extra Early, but not so distinct. 7 to 10 on the larger grains.
Large White Marrowfat: Same as in Electric Extra Early, but not so distinct or coarse. 10 to 12 on the larger grains.

Size.

Eugenie (green): From 10 to 44μ, commonly 28μ.
Eugenie (yellow): From 8 to 38μ, commonly 26μ.
Thomas Laxton: From 8 to 32μ, commonly 24μ.
Electric Extra Early: From 6 to 44μ, commonly 32μ.
Mammoth Grey Seeded: From 4 to 40μ, commonly 29μ.
Large White Marrowfat: From 6 to 50μ, commonly 34μ.

Polariscopic Properties.

Figure.

Eugenie (green): Not definite.
Eugenie (yellow): Same as in Eugenie (green).
Thomas Laxton: Same as in Eugenie (green).
Electric Extra Early: Centric or slightly eccentric, usually distinct but not clear-cut, and of bean type.
Mammoth Grey Seeded: Essentially the same as in Electric Extra Early, but less distinct.
Large White Marrowfat: Essentially the same as in Electric Extra Early, but less distinct.

Degree of Polarization.

Eugenie (green): Low.
Eugenie (yellow): Low, slightly higher than in Eugenie (green).
Thomas Laxton: Low, slightly lower than in Eugenie (green).
Electric Extra Early: Fairly high to high, much higher than in Eugenie (green).
Mammoth Grey Seeded: Low to fairly high, higher than in Eugenie (green).
Large White Marrowfat: Fair to high, much higher than in Eugenie (green).

Polarization with Selenite—Quadrants and Colors.

Eugenie (green): Quadrants not defined; poorly defined spaces of same color grouped together. Colors not pure.
Eugenie (yellow): Quadrants same as in Eugenie (green). Colors not pure.
Thomas Laxton: Quadrants same as in Eugenie (green). Colors not pure.
Electric Extra Early: Quadrants usually fairly well defined, irregular in shape and unequal in size. Colors usually pure.
Mammoth Grey Seeded: Quadrants same as in Electric Extra Early. Colors usually pure.
Large White Marrowfat: Quadrants same as in Electric Extra Early. Colors usually pure.

Iodine Reactions.

Intensity and Color.

Eugenie (green): Fairly light; violet.
Eugenie (yellow): Fairly light, same as in Eugenie (green); violet.

Iodine Reactions.—Continued.

Intensity and Color.—Continued.

Thomas Laxton: Fairly light, less than in Eugenie (green); violet.
Electric Extra Early: Fair, more than in Eugenie (green); violet.
Mammoth Grey Seeded: Fairly deep, decidedly more than in Eugenie (green); violet.
Large White Marrowfat: Fairly deep, decidedly more than in Eugenie (green); violet.

Staining Reactions.

With Gentian Violet.

Eugenie (green): Very light.
Eugenie (yellow): Very light, same as in Eugenie (green).
Thomas Laxton: Very light, same as in Eugenie (green).
Electric Extra Early: Light, more than in Eugenie (green).
Mammoth Grey Seeded: Light, more than in Eugenie (green).
Large White Marrowfat: Light, slightly more than in Eugenie (green).

With Safranin.

Eugenie (green): Very light.
Eugenie (yellow): Very light, same as in Eugenie (green).
Thomas Laxton: Very light, same as in Eugenie (green).
Electric Extra Early: Light, more than in Eugenie (green).
Mammoth Grey Seeded: Light, slightly more than in Eugenie (green).
Large White Marrowfat: Light, slightly more than in Eugenie (green).

Temperature of Gelatinization.

Eugenie (green): 73 to 74° C., mean 73.5°.
Eugenie (yellow): 74 to 75° C., mean 74.5°.
Thomas Laxton: 72.5 to 74° C., mean 73.25°.
Electric Extra Early: 69 to 71° C., mean 70°.
Mammoth Grey Seeded: 70 to 71° C., mean 70.5°.
Large White Marrowfat: 68 to 69° C., mean 68.5°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

Eugenie (green): Begins in a few at once; complete in most in 2 minutes and in practically all in 5 minutes; bean type not gelatinized in an hour.
Eugenie (yellow): Begins in a few at once; complete in most in 2 minutes and in practically all in 5 minutes; bean type not gelatinized in an hour.
Thomas Laxton: Begins in a few at once; complete in most in 2 minutes and in practically all in 5 minutes; bean type not gelatinized in an hour.
Electric Extra Early: Begins in a few at once; complete in two-thirds of the grains in 30 minutes; little change after an hour.
Mammoth Grey Seeded: Begins in a few at once; complete in half of the grains in 30 minutes; with little further change in an hour.
Large White Marrowfat: Begins in a few at once; complete in two-thirds of the grains in 30 minutes; little further change in an hour.

Reaction with Chromic Acid.

Eugenie (green): Begins at once; complete in all in 3 minutes.
Eugenie (yellow): Begins at once; complete in all in 5½ minutes.
Thomas Laxton: Begins at once; complete in all in 5 minutes.
Electric Extra Early: Begins at once; complete in practically all in 5½ minutes.
Mammoth Grey Seeded: Begins at once; complete in practically all in 4 minutes.
Large White Marrowfat: Begins at once; complete in practically all in 5 minutes.

Differentiation of Certain Starches of the Genus Pisum.—Continued.

Effects of Various Reagents.—Continued.

Reaction with Pyrogallic Acid.

Eugenie (green): Begins in some at once; all slightly affected and a few gelatinized in 2 minutes; very little change after an hour.
Eugenie (yellow): Begins in some at once; all affected and a few gelatinized in 2½ minutes; very little change after an hour.
Thomas Laxton: Begins in some at once; all affected in 5 minutes; very little change in an hour.
Electric Extra Early: Begins in all at once; complete in most in 2½ minutes, in all in 4 minutes.
Mammoth Grey Seeded: Begins in all at once; complete in all in 3 minutes.
Large White Marrowfat: Begins in all at once; complete in all in 2 minutes.

Reaction with Ferric Chloride.

Eugenie (green): Begins in all in 30 seconds; complete in nearly all in 30 minutes.
Eugenie (yellow): Begins in all in 30 seconds; same as Eugenie (green).

Effects of Various Reagents.—Continued.

Reaction with Ferric Chloride.—Continued.

Thomas Laxton: Begins in all in a minute; complete in nearly all in 30 minutes; incomplete in an hour.
Electric Extra Early: Begins in all in 30 seconds; complete in one-sixth in an hour.
Mammoth Grey Seeded: Begins in all in a minute; complete in one-sixth in an hour.
Large White Marrowfat: Begins in all in 30 seconds; complete in one-fourth in an hour.

Purdy's Solution.

Eugenie (green): Begins in some in 30 seconds; all nearly completely gelatinized in 30 minutes.
Eugenie (yellow): Begins in some in 30 seconds; same as Eugenie (green).
Thomas Laxton: Begins in some at once; same as in Eugenie (green).
Electric Extra Early: Begins in some in 30 seconds; complete in two-thirds in an hour.
Mammoth Grey Seeded: Begins in some in 30 seconds; complete in one-third in an hour.
Large White Marrowfat: Begins in some in 30 seconds; complete in nine-tenths in 30 minutes.

NOTES ON THE STARCHES OF PISUM.

The members of *Pisum* may be grouped in accordance with the peculiarities of the seeds into the *wrinkled*, *smooth*, and *indent*, and further distinguished by color, sweetness, and other incidental properties. The six specimens of starches studied were prepared from five garden varieties—two wrinkled, one smooth, and two indent forms. Upon examination of text and photographic data it will be seen that there are two conspicuous types of starch-grains present—those of the rosette type and those of the bean type—and that in the Eugenie and Thomas Laxton peas, which are of the wrinkled kind, the starch is typically of the rosette type, with very few grains of the bean type; while in the Electric Extra Early and Mammoth Grey Seeded, both indent peas, and in the Large White Marrowfat, a smooth pea, the grains are of the bean type. These differences in the starch-grains, coupled with peculiarities of the surface of the seeds, were so striking as to have led to an examination of a number of garden varieties to determine if all wrinkled peas are characterized by the rosette type and all smooth and indent peas by the bean type. The following were selected for comparison in addition to those named:

Wrinkled: Heroine, Surprise, Early Morn, Sutton's Excelsior, Admiral Dewey, Gradus.
Smooth: Alaska, Black Eyed Marrowfat, Tall White Sugar.
Indent: Lightning, Small French Canner, Extra Early Pioneer, Giant Sugar, Blue Imperial, Early June, Bountifully Early, Michell's Special Extra Early, Dandy Extra Early, Eureka Extra Early.
Smooth, Indent, and *Wrinkled,* Vilmorin Marrow.

It was found in all of the wrinkled peas that the starch is of the rosette type; in the smooth and indent peas, of the bean type; and in the Vilmorin Marrow, which was made up of a mixture of the three kinds of seeds, that there was mixture of the rosette type and bean type, and that those of the first type were derived from the wrinkled seeds. This differentiation is most striking. Very interesting results have been recorded by Gregory (Part I, page 72) on the effects of hybridization in case of peas bearing seeds distinguished by having these different types of grains.

The green and yellow Eugenie seeds do not, as might be expected, show any marked differences in either their histological properties or reactions, the only noticeable variations being shown by the green-pea starch having a slightly lower polarization, a lower temperature of gelatinization (1°), a greater sensitiveness to chromic acid, and slightly more sensitivity to pyrogallic acid. The close correspondences of the starch of the Thomas Laxton variety to the Eugenie starch are as marked as those between the green and yellow Eugenie seeds, suggesting extremely close botanical forms of plants. The likenesses of the starches of the second group (the round and indent peas) is equally marked. These starches are readily distinguished from those of the first group (wrinkled peas) by the bean type of grains, the distinctly higher degree of polarization, the more marked iodine and aniline reactions, the lower temperature of gelatinization, the less sensitivity to chloral hydrate-iodine, a much greater sensitivity to pyrogallic acid, and the less sensitivity to ferric chloride and Purdy's solution.

GENUS WISTARIA.

This is a small and imperfectly understood genus which consists of four definite and two doubtful species, all natives of China and Japan. *W. chinensis*, the commonest species in cultivation, was studied as a representative of the genus.

STARCH OF WISTARIA CHINENSIS. (Chart 51.)

Histological Characteristics.—In *form* the grains are simple and nearly always isolated. The surface of the grains is usually quite regular. The conspicuous forms are oval, rounded oval, and ovoid, with some polygonal, some approaching the reniform type, and some small round grains. (This preparation is very unsatisfactory, as most of the grains are contaminated with so much foreign material.)

The *hilum* may appear in the small round grains as a centric or slightly eccentric circular cavity, but the more numerous elongated forms have a longitudinal cleft, from which short, radiating fissures sometimes run.

The *lamellæ* are not usually visible, but in some of the large rounded oval forms 12 rather coarse concentric rings were counted.

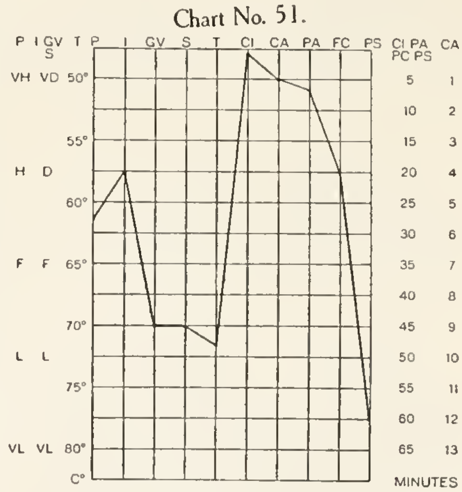
The grains vary in *size* from the small, which are 4 by 4μ, to the elongated, which are 12 by 10μ in length and breadth. The size of the greater number of grains is about 8 by 6μ in length and breadth.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, and distinct. Its lines are usually rather thick and fairly clear-cut, may be in the form of a cross, or more commonly of the bean type—a longitudinal line with bisected ends.

The degree of *polarization* is fairly high to high. It often varies in the same aspect of a grain and differs in different aspects of the grain.

With *selenite* the quadrants are well defined and commonly irregular in shape and unequal in size. The colors are fairly bright and generally pure. The blue is occasionally not quite pure. The grains of the preparation are so small as to be unsatisfactory for detailed study.

Chart No. 51.



Curve of Reaction-Intensities of Starch of Wistaria chinensis.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet, which deepens rapidly; with 0.125 per cent solution most of the grains color immediately a rather light blue-violet, which deepens rather quickly. After heating in water until all the grains are gelatinized, the solution assumes a light olive tint and the grains become a very deep blue on the addition of iodine. If the grains are boiled for 2 minutes and then treated with iodine, the solution becomes a deep indigo-blue and most of the grain-residues a deep blue, while some are a reddish-blue. When an excess of iodine is added the grain-residues become blue with a reddish tint, while the capsules become a reddish-purple to deep wine color.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes they are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 71° to 72° C., mean 71.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once and is over in practically all in a minute. It begins usually at the marginal starch at each end of the grain, the starch becoming dark and swelling slightly. The reaction spreads to other points, from which it advances throughout the grain. It usually proceeds more rapidly in the central than in the marginal portion. The gelatinized grains are not very large and they retain their original form. They are of a uniform dark color, except those portions which have been fissured, where there are light lines of the same shape and size as the fissures. In unfissured grains there are one or more indistinct light spots which represent the hila.

With *chromic acid* reaction begins in a few seconds. It is over in most of the grains in 30 seconds and in all in a minute. The hila or fissures in the region of the hilum become very distinct, and the less resistant starch passes into a semifluid mass, which occupies the central part of the grain. The more resistant starch forms a band at the margin which is broad and dense at the sides and rather thin and not very dense at the ends. This band becomes thinner and less dense, and finally dissolves at the ends. The semifluid mass within flows out and is completely dissolved, followed by solution of the remaining portions of the band.

The reaction with *pyrogallic acid* begins in all the grains in 30 seconds and is over in 7 minutes. The hila or the fissures in the region of the hila become more distinct, and the less resistant starch is changed into a semifluid, swollen mass which occupies the central part of the grain. The more resistant starch forms a marginal band that is very broad and dense at the sides, and rather thin and not very dense at the ends. This starch also gradually becomes gelatinous. The gelatinized grains are large and retain some of the original form. The capsules are often wrinkled and crumpled.

Reaction with *ferric chloride* begins in some grains in 30 seconds and is over in 20 minutes. The reaction originates at one or both ends of the grain. The starch at these points becomes gelatinous and swells out irregularly, and the reaction proceeds over the whole grain until the opposite end or the center is reached, when portions of ungelatinized starch are often split by fissures into two or more pieces and are gelatinized independently of one another. This splitting off is probably due to the great strain on the ungelatinized parts of the grain caused by the swelling and gelatinization of the broken down portions. The gelatinized grains are large and do not retain much of their original form. The capsule is often much wrinkled and folded.

With *Purdy's solution* a few grains show some reaction in 3 minutes, and about half are gelatinized completely in 20 minutes. The reaction is incomplete at the end of an hour, and it has the same appearance as that with pyrogallic acid.

GENUS ARACHIS.

Arachis is a small genus with 7 known species, all but one of which are natives of Brazil. *A. hypogæa* is the best known and is now cultivated in many warm climates, especially in some of the southern United States, and commonly known as the peanut or ground-nut. The seeds are rich in a limpid oil and contain much starch. The specimen of the Virginia peanut which served as our source of starch is probably an agricultural variety of *A. hypogæa*, known as the Jumbo peanut.

STARCH OF ARACHIS HYPOGŒA (JUMBO PEANUT). (Plate 10, figs. 57 and 58. Chart 52.)

Histological Characteristics.—In *form* the grains are simple and usually isolated. Aggregates are present which consist of two or more components not pressed so firmly together as in many such masses observed in the starches from other sources, hence the separated components have not clearly marked pressure facets, but merely slight flattening here and there. The aggregates may be found as triplets or quadruplets, but more often they appear either in chains or irregular elongated masses. The most conspicuous forms of the isolated grains are spherical and ovoid. Rarely rounded-oval to elliptical grains are found, which somewhat resemble the more conspicuous grains of *Vicia*, *Phaseolus*, etc. Dome-shaped and slightly triangular grains with rounded angles and incidental forms are occasionally observed.

The *hilum* frequently appears as a clear spot, centric or nearly centric, with sometimes one or more fissures, or a rounded cavity, at this point. When two fissures are present they may form a cross; and if several, they are usually arranged as a stellate figure. The rounded-oval to elliptical forms usually have an elongated, central cleft, from which short, radiating fissures sometimes emerge, this arrangement resembling that of typical bean-type grains.

The *lamellæ* are usually not distinct. In some grains 6 to 8 rather fine, concentric rings were found.

The spherical grains vary in *size* from 6 to 18μ, the common size being 12μ. The rounded oval are commonly 10 by 12μ, and the elliptical forms commonly 8 by 12μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric and very distinct. The lines are rather thin and usually straight; the figure is in the form of a cross.

The degree of *polarization* is high, with some variation in the different grains.

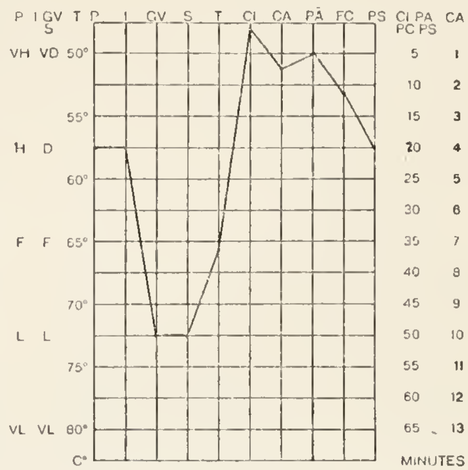
With *selenite* the quadrants are well defined, commonly equal in size and regular in shape. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather deep violet, which deepens rather quickly, becoming a deep purple in 5 minutes; with 0.125 per cent solution the grains color a very light reddish-violet, which deepens rather quickly into a fairly deep reddish-violet in 5 minutes. After heating in water until all the grains are gelatinized, the solution does not color, but the gelatinized grains become a deep reddish-purple on the addition of iodine. If the preparation is boiled for 2 minutes and then treated with iodine, the solution becomes a light bottle-green and the grain-residues assume either a light reddish-violet or old-rose tint. When an excess of iodine is added the grain-residues color a deep reddish-purple, and the capsules a deep old-rose to a wine color.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly at once and in 30 minutes are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 66.5°.

Chart No. 52.



Curve of Reaction-Intensities of Starch of Arachis hypogœa.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in practically all the grains in a minute. The reaction starts usually at one point on the margin, at which the starch darkens and swells somewhat. The rest of the marginal starch then becomes affected and the process spreads inward. When it nears the hilum a bubble often appears here, swells, then shrinks and disappears. The reaction appears to spread more rapidly from the point first affected than from other portions of the margin. The gelatinized grains are not very large and retain the original form of the grain. They appear to consist of a rather small, central, light area surrounded by a broad, dark marginal band.

The reaction with *chromic acid* begins at once and is over in 30 seconds. It is so rapid that the principal steps can not be clearly distinguished. It appears that the less resistant starch is converted into a semifluid mass in the interior of the grain, and the more resistant starch into a marginal band. Then there is formed a thin capsule which is dissolved at one point, the semifluid mass begins to flow out and dissolves, followed by solution of the remaining part of the capsule.

Reaction with *pyrogallic acid* begins in a minute and is over in 5 minutes. The hilum becomes very distinct and fine striæ are seen to radiate from the hilum in all directions throughout the grain. The less resistant starch forms a semifluid, swollen mass, which occupies the central part of the grain, while the more resistant starch forms a broad, dense, finely striated, marginal band, which shows the remains of the lamellæ in the form of two or three refractive and non-refractive parts. This band becomes, rather slowly, less dense and less broad. The gelatinized grains are fairly large and retain much of their original form. The capsule is thick and dense and not much wrinkled or folded.

With *ferric chloride* reaction begins in a few grains in 2 minutes and is over in 12 minutes. The process starts at one point on the margin, usually the distal end, where the starch swells out irregularly. From here the reaction spreads over the adjacent starch, and then over the whole grain until it reaches the vicinity of the hilum. At the hilum a bubble often forms which somewhat increases in size, but soon shrinks and finally disappears. Such of the starch as remains ungelatinized often splits into two or three pieces which separate and gelatinize independently of one another. The gelatinized grains are very large and do not retain much of their original form. The capsules are somewhat folded and crumpled.

The reaction with *Purdy's solution* begins in a few grains in 1½ minutes and all the grains are nearly completely gelatinized in 20 minutes. The reaction has the same characters as that with pyrogallic acid.

NOTES ON THE STARCHES OF LEGUMINOSÆ.

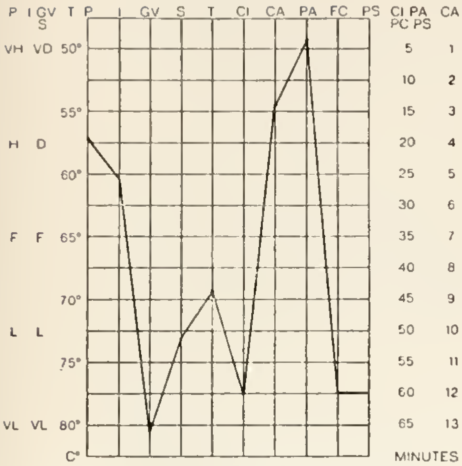
In *Vicia*, *Phaseolus*, *Mucuna*, *Dolichos*, *Lens*, *Lathyrus*, and *Pisum* (the wrinkled peas excepted) the starch-grains as a whole belong to a common type which may be designated the *bean type*, both because of the conspicuousness of this form of grain in these genera and of the common resemblance between the shape of the grain and the most familiar shapes of food beans. These grains are characterized especially by an ovoid to elliptical and kidney-shaped form, commonly having a deep, longitudinal fissuration which extends along a considerable length of the grain.

In gross general appearances the starches of *Vicia, Phaseolus, Lens,* and *Lathyrus* do not differ materially, but those of *Mucuna, Dolichos, Pisum, Arachis,* and *Wistaria* exhibit more or less distinctive peculiarities; and in the case of *Pisum, Arachis,* and *Wistaria* certain decided individualities. Comparing the photographs, the departure of the grains of these genera from those of the *Vicia-Phaseolus* type is especially noticeable in the marked tendency to smoothness of outline and to roundness; to the less conspicuous fissuration, especially as regards the longitudinal fissure; and to the more evident lamellation. Very much the same differences appear in *Dolichos.*

The starches of *Pisum* are, as stated under that head, divided into two very different groups, those of the wrinkled peas being of the rosette type, and those of the round and indent peas being of the bean type or *Vicia-Phaseolus* type. The starch of *Wistaria,* while having general resemblances in shape to the *Vicia-Phaseolus* type, is conspicuously lacking in the marked fissuration so distinct in the latter, and the grains are only from a fourth to a third as large. In *Arachis* a type is observed entirely different from those noted in the other *Leguminosæ.* From the foregoing it is obvious that there is no single type of grain characteristic of this family, and that to speak of a leguminous type of grain is absolutely vague and misleading.

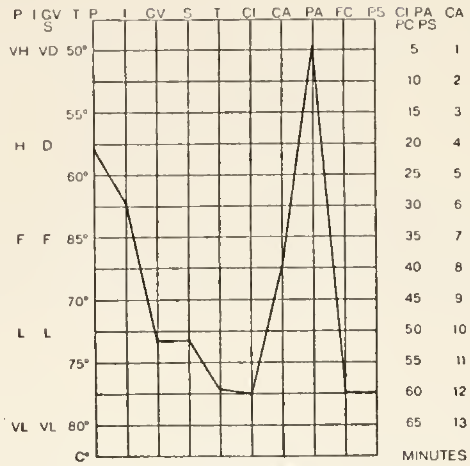
In polariscopic, color, temperature, and chemical reactions the different genera show specific peculiarities. It will be observed that there is throughout the members of the family a common type of reaction-curve, and that each genus is characterized by peculiar modifications of this curve. Striking variations will be noted in the case of each of the agents employed. Thus, in the degree of polarization, it is high to very high in *Lens,* high in *Vicia,* a trifle lower in *Phaseolus* and *Arachis,* below fair to fairly high in *Lathyrus* and also in the second group of *Pisum* and in *Wistaria,* fair in *Dolichos,* and low in the first group of *Pisum,* and so on, with the other records. It is of interest to note that the histological departures recorded in the starches of *Arachis* and *Wistaria* are accompanied by corresponding departures in the reaction curves. It is probable, considering the wide range of botanical peculiarities observed in the *Leguminosæ,* that a large variety of histological types of starches will be found which will show related peculiarities in their physical, physicochemical, and chemical properties.

Chart No. 53.



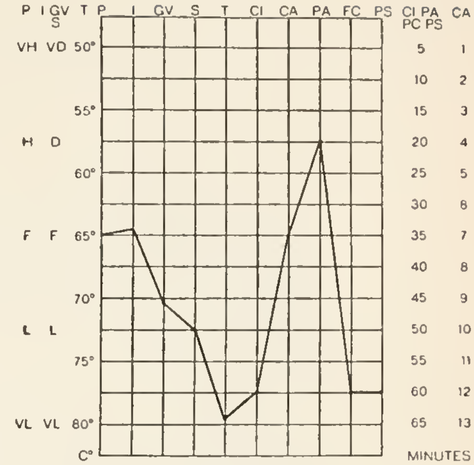
Composite Curve of Mean Reaction-Intensities of Starches of Vicia.

Chart No. 54.



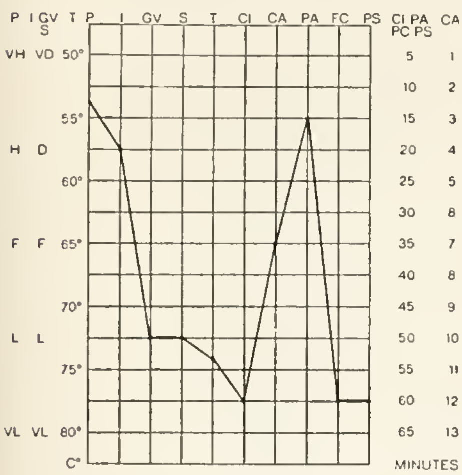
Composite Curve of Mean Reaction-Intensities of Starch of Phaseolus.

Chart No. 55.



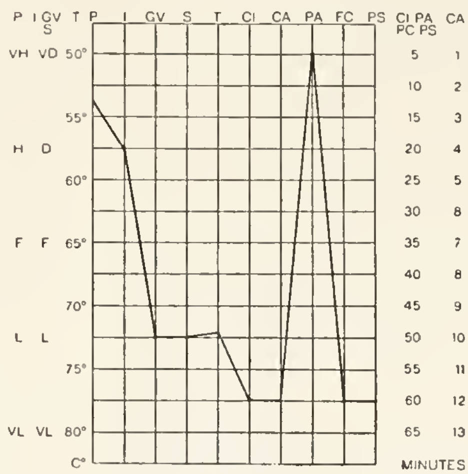
Curve of Reaction-Intensities of Starch of Dolichos.

Chart No. 56.



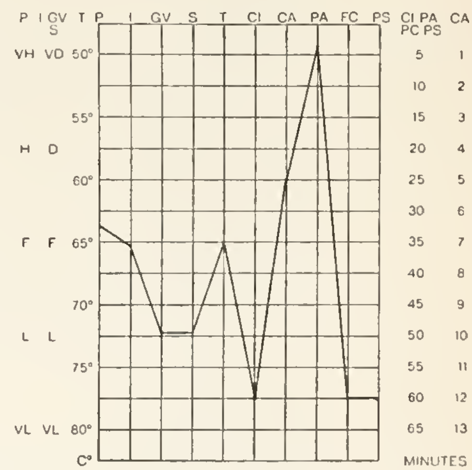
Curve of Reaction-Intensities of Starch of Mucuna.

Chart No. 57.



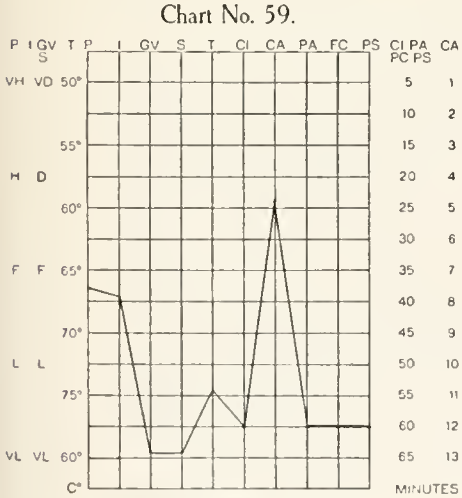
Curve of Reaction-Intensities of Starch of Lens.

Chart No. 58.



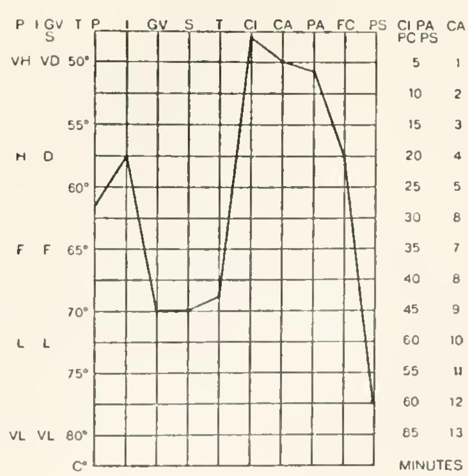
Composite Curve of Mean Reaction-Intensities of Starches of Lathyrus.

Chart No. 59.



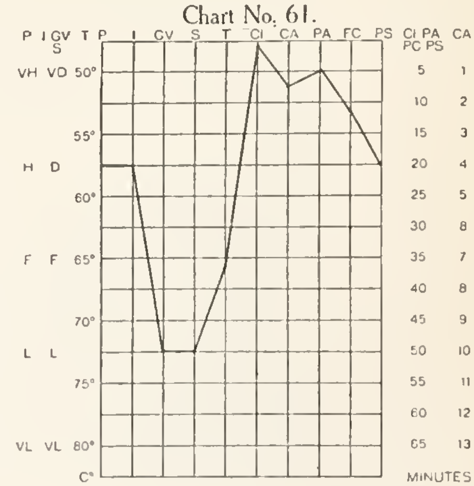
Composite Curve of Mean Reaction-Intensities of Starches of Pisum.

Chart No. 60.



Curve of Reaction-Intensities of Starch of Wistaria.

Chart No. 61.



Curva of Reaction-Inteosities of Starch of Arachis.

STARCHES OF POLYGONACEÆ.

Class, Dicotyledones. Order, Polygonales. Family, Polygonaceæ. Genus represented, Polygonum.

GENUS POLYGONUM.

The starch of only one representative of one genus of this family was studied. *Polygonum fagopyrum* Linn., usually designated *Fagopyrum esculentum* Mœnch., the common buckwheat of the agriculturist and of commerce, is a native of Central Asia, and cultivated chiefly in the northern and central parts of the United States. From the seeds is made a commercial flour rich in starch. The starches from two agricultural varieties, known as American and Japanese buckwheat, respectively, were examined.

STARCH OF POLYGONUM FAGOPYRUM VAR. (AMERICAN). (Plate 10, figs. 59 and 60. Chart 62.)

Histological Characteristics.—In *form* the grains are probably solely simple and for the most part isolated, and in part in aggregates of two or more components. Pressure facets are found on many of the grains. The conspicuous forms of the simple grains are polygonal, either with sharp or generally much-rounded angles, and round. The conspicuous forms of the aggregates are several grains arranged linearly, straight or curved, or in oval or irregularly shaped masses.

A cavity is usually found at the *hilum*, from which radiating fissures emerge. The hilum sometimes appears as a clear spot, centric or slightly eccentric in position.

The *lamellæ* are not visible.

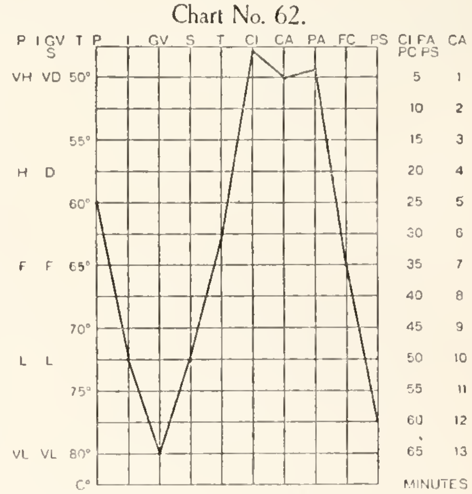
The grains vary in *size* from the smaller grains, which are 2μ, to the larger, which are 14μ. The common size is about 7μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, and distinct. The lines are rather fine and generally straight, but may be bent and rarely bisected. The figure is in the form of a cross.

The degree of *polarization* is fair to rather high, with frequent variation in the same aspect of a grain and also in different grains.

With *selenite* the quadrants are clearly defined, and in some grains of about equal size and regular in shape; but they mostly vary slightly in size and shape. The colors are generally pure.

Chart No. 62.



Curve of Reaction-Intensities of Starch of Polygonum fagopyrum var. (American).

Iodine Reactions.—With 0.25 per cent Lugol's solution most grains color a light violet, a few rather deeply, and the tint deepens slowly; with 0.125 per cent solution the grains assume a light reddish-violet tint, some rather deeper than others, and the color deepens within 5 minutes. After heating in water until all the grains are gelatinized, the solution colors a deep indigo-blue and the gelatinized grains a deep blue-violet on the addition of iodine. After boiling for 2 minutes, the solution colors a still deeper indigo-blue and the grain-residues either only very lightly or not at all. The capsules assume a deep reddish-purple or heliotrope tint when an excess of iodine is added.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly at once and in 30 minutes they are still only lightly colored.

Temperature Reaction.—The temperature of gelatinization is 63° to 64° C., mean 63.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once in all the grains. All but rare resistant grains are gelatinized in a minute, and all in 8 minutes. The reaction begins at the corners and edges of the facets, the starch at these points becoming dark and swelling slightly, and the process proceeds from these points all over the grain quite evenly. The gelatinized grains are not very large and retain much of their original form. They have a central, round, light space surrounded by a broad, marginal band of starch that is colored dark indigo.

Reaction with *chromic acid* begins at once and is over in a minute. The hilum becomes clear, and the less resistant starch, occupying the central part of the grain, swells evenly in all directions. The more resistant starch forms a fairly broad, dense band at the margin, which rapidly is transformed into a thin and transparent envelope or capsule. This capsule is dissolved at one point, and the inclosed semiliquid starch flows out and is rapidly dissolved, solution of the rest of the capsule following.

The reaction with *pyrogallic acid* begins in 15 to 30 seconds and is over in 3 minutes. The hilum becomes clear, and the less resistant starch is gelatinized and swells and occupies the central portion of the grain. The more resistant starch forms a broad, dense marginal band which becomes less broad and dense until it forms a rather thick but nearly transparent capsule. The gelatinized grains are large and retain some of their original form. The capsules are somewhat folded and wrinkled.

With *ferric chloride* reaction begins in a few grains in a minute. It is over in two-thirds of the grains in 10 minutes, in nearly all in 25 minutes, and in all in 35 minutes. The reaction begins at the corners and edges of the facets, and the starch at these points becomes gelatinous and swells out irregularly. The less resistant starch becomes gelatinized and occupies the central part of the grain, while the more resistant starch forms dense but not very broad masses at the margin, separated by the gelatinized starch of the corners and edges of the facets. Gradually the more resistant starch is gelatinized. The gelatinized grains are large and do not retain much of the original form. The capsules are often much wrinkled and crumpled.

The reaction with *Purdy's solution* starts in many grains in 30 seconds. Two-fifths are partially gelatinized in 20 minutes, with an incomplete reaction in an hour. The reaction appears to be the same qualitatively as that with pyrogallic acid.

STARCH OF POLYGONUM FAGOPYRUM VAR. (JAPANESE). (Plate 10, figs. 59 and 60. Chart 63.)

Histological Characteristics.—In *form* the conspicuous shapes and other features of the gross microscopical characters of the grains are identical with those of American buckwheat.

The *hilum* or cavity with radiating fissures in this region is practically identical with that of American buckwheat.

Lamellæ are not visible.

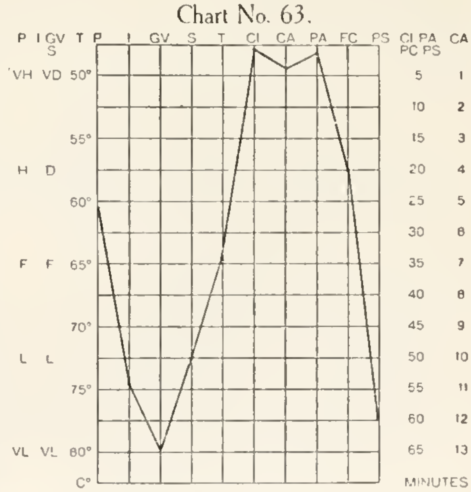
The grains vary in *size* from the smaller, which are 2μ, to the larger, which are 12μ. The common size is 8μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric and identical in its characters with that of American buckwheat.

The degree of *polarization* is fair to rather high. In the specimen studied there was a larger proportion of grains in which polarization is high than in American buckwheat.

With *selenite* the character of the quadrants and colors are identical with those already described for American buckwheat. The yellow appeared slightly brighter and purer in a greater proportion of the grains than in American buckwheat.

Chart No. 63.



Curve of Reaction-Intensities of Starch of Polygonum fagopyrum var. (Japanese).

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a light violet and darken very slowly. The color is lighter and slightly more reddish in tint than in American buckwheat; with 0.125 per cent solution the grains color slowly a light old-rose which deepens slightly in 5 minutes. The grains, with this weaker reagent, also show more of a reddish color than those of American buckwheat. After heating in water until all the grains are completely gelatinized, the solution colors a deep blue-violet and the gelatinized grains a rather deep reddish-violet on the addition of iodine. After boiling for 2 minutes, the solution colors a very deep reddish-blue, but the grain-residues do not color at all. When an excess of iodine is added the capsules color a deep red-violet to wine-red. There is more of a reddish tint in the Japanese than in the American buckwheat.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly at once and in 30 minutes they are still very lightly stained. The color is the same as that of American buckwheat.

Temperature Reaction.—The temperature of gelatinization is 64.5° to 65° C., mean 64.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once. All but rare resistant grains are gelatinized in a minute, and all in 5 minutes. It is the same qualitatively as that of the grains of American buckwheat.

The reaction with *chromic acid* begins at once and is over in 45 seconds. It is the same qualitatively as that of the grains of American buckwheat.

The reaction with *pyrogallic acid* begins in 15 seconds and is over in 1¾ minutes. It is the same qualitatively as that of the grains of American buckwheat.

With *ferric chloride* reaction begins in a few grains in a minute. It is over in nearly all in 10 minutes and in all in 20 minutes. It is the same qualitatively as that of the grains of American buckwheat.

Reaction with *Purdy's solution* begins in many grains in 30 seconds to 1 minute and is over in four-fifths in 15 minutes, with an incomplete reaction in an hour. It is the same qualitatively as that of the grains of American buckwheat.

Differentiation of Certain Starches of the Genus Polygonum.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

American: Probably solely simple, mostly isolated, isolated grains polygonal, sharp or generally much-rounded corners, round; aggregates rod or club-like, oval and irregular in shape.
Japanese: Same as in American buckwheat.

Hilum—Form, Number, and Position.

American: Form usually a cavity from which radiating fissures pass. Position centric or slightly eccentric.
Japanese: Form same as in American buckwheat. Position centric or slightly eccentric.

Lamellæ—General Characteristics.

American: Not visible.
Japanese: Not visible.

Size.

American: From 2 to 14μ, commonly 7μ.
Japanese: From 2 to 12μ, commonly 8μ.

POLARISCOPIC PROPERTIES.

Figure.

American: Centric or slightly eccentric, distinct, usually a cross, lines rather fine, generally straight.
Japanese: Same as in American buckwheat.

Degree of Polarization.

American: Fair to rather high.
Japanese: Fair to rather high, usually slightly higher than in American buckwheat.

Polarization with Selenite—Quadrants and Colors.

American: Quadrants clearly defined, commonly slightly irregular in shape and size. Colors generally pure.
Japanese: Quadrants same as in American buckwheat. Colors generally somewhat purer than in American buckwheat.

IODINE REACTIONS.

Intensity and Color.

American: Light; violet.
Japanese: Light, less than in American buckwheat; violet, more reddish than in American buckwheat.

STAINING REACTIONS.

With Gentian Violet.

American: Very light.
Japanese: Very light, same as in American buckwheat.

With Safranin.

American: Light.
Japanese: Light, same as in American buckwheat.

TEMPERATURE OF GELATINIZATION.

American: 63 to 64° C., mean 63.5°.
Japanese: 64.5 to 65° C., mean 64.75°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

American: Begins immediately; complete in all but rare resistant grains in a minute, and in all in 8 minutes.
Japanese: Begins immediately; complete in all but rare resistant grains in a minute, and in all in 5 minutes.

Reaction with Chromic Acid.

American: Begins at once; complete in a minute.
Japanese: Begins at once; complete in 45 seconds.

Reaction with Pyrogallic Acid.

American: Begins in 15 to 30 seconds; complete in 3 minutes.
Japanese: Begins in 15 seconds; complete in 1¾ minutes.

Reaction with Ferric Chloride.

American: Begins in a few in a minute; complete in all in 35 minutes.
Japanese: Begins in a few in a minute; complete in all in 20 minutes.

Reaction with Purdy's Solution.

American: Begins in many in 30 seconds; two-fifths partially gelatinized in 20 minutes, with an incomplete reaction in an hour in the grains as a whole.
Japanese: Begins in many in 30 to 60 seconds; four-fifths completely gelatinized in 15 minutes, with incomplete reaction in an hour in the grains as a whole.

NOTES ON THE STARCHES OF POLYGONUM.

The two buckwheat starches were obtained from agricultural varieties which differ very little. In general histological features the grains of the two specimens are not distinguishable from each other, and the differences noted in the degree of polarization and in the reactions with the reagents are slight and fall within the limits of error of experiment. However, that the two starches are not identical is suggested especially in the difference in the temperature of gelatinization (1.25°) and in the less sensitivity of the American form to all the chemical reagents.

STARCHES OF CUPULIFERÆ.

Class, Monocotyledones. Order, Fagales. Family, Cupuliferæ. Genera represented: Quercus, Castanea.

The *Cupuliferæ* include a number of important exogenous trees such as the oak, chestnut, and beech. The family embraces 10 genera and 368 recognized species.

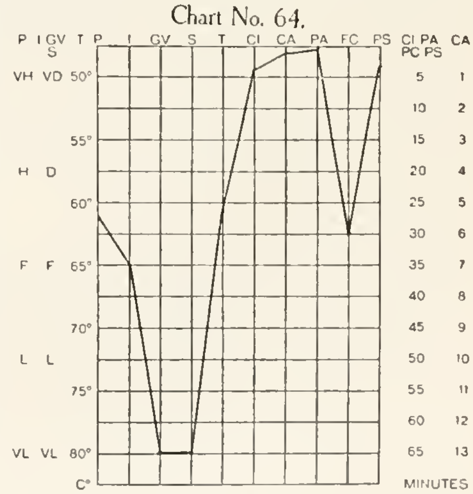
GENUS QUERCUS.

The oaks are widely distributed in the temperate and cool temperate regions of the Northern Hemisphere, in the mountainous parts of Mexico and Central America, and in the mountains of Central and Eastern Asia. They are absent south of the Mediterranean region, and also south of the equator in the New World. The genus includes about 300 species, about 40 of which are found in the United States—25 east of the Rocky Mountains. A number of hybrids have been recorded. The species have been divided into subgenera, but except *Q. densiflora* (peach oak of California) all the American and European species belong to the subgenus *Lepidobalanus*. The acorns, or fruits, of 5 species were used as sources of starches, as follows: *Q. alba* Linn., the white oak; *Q. muehlenbergi* Engelm. (*Q. castanea* Willd.; *Q. acuminata* Sarg.; *Q. prinus* var. *acuminata* Michx.), the yellow chestnut oak; *Q. prinus* Linn. (*Q. prinus* var. *monticola* Michx.; *Q. montana* Willd.), the chestnut oak or rock chestnut oak; *Q. rubra* Linn. (*Q. ambigua* Michx.), and the red oak, *Q. texana* Buckl., the Texan red oak or Spanish oak.

STARCH OF QUERCUS ALBA. (Plate 11, figs. 61 and 62. Chart 64.)

Histological Characteristics.—In *form* the grains are generally simple, and they are isolated, except some which occur in clumps, small aggregates, or compounds which usually consist of two components. A few of the isolated grains have clearly marked pressure facets. The conspicuous forms are ellipsoidal, somewhat bean-shaped, pyriform, ovoid, and lenticular. There are some triangular with rounded angles, hemispherical, sugar-loaf, nearly round, finger-shaped, and indefinite forms. The surface of the grains is frequently irregular, owing chiefly to wart-like excrescences at one or more points. These additional growths are generally located at either end of an ellipsoidal or nearly round grain, and are usually less resistant to reagents than the main portion of the grain.

Chart No. 64.



Curve of Reaction-Intensities of Starch of Quercus alba.

An elongated cleft, with or without radiating fissures, is most frequently found at the *hilum*. Occasionally in the ellipsoidal, pyriform, and nearly round grains the hilum appears as a clear, round eccentric spot, from which one longitudinal fissure often proceeds. There may also be present at the hilum in such grains a nearly round cavity, a cross, or a Y-shaped figure. The hilum may rarely be observed as a clear, round, or lenticular cavity, usually two-fifths to one-third eccentric.

The *lamellæ* are not visible in most of the grains, but when seen are rather coarse, complete rings which, even near the hilum, have the form of the margin of the grain. In grains of common size eight to ten have been counted. In some of the most irregular grains secondary sets of lamellæ, more indistinct than the primary lamellæ, may be observed.

The grains vary in *size* from the small, which are 4 by 3μ, to the larger, which are 32 by 14μ in length and breadth. The common size is 22 by 12μ.

Polariscopic Properties.—The *figure* is usually more or less eccentric. In most grains it is either in the form of a longitudinal line having bisected ends, or a cross having lines which intersect at right or oblique angles. The figure is distinct, and frequently irregular, and the lines are often bent or bisected.

The degree of *polarization* is fair to quite high. It varies considerably in the different grains and sometimes in the same aspect of a given grain.

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are fairly bright to quite bright. The yellow is commonly proportionately brighter than the blue, but more often varies in degree of brightness and purity, even in a given quadrant. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a blue-violet, which deepens fairly rapidly; with 0.125 per cent solution the grains color a very light blue-violet, which also deepens fairly rapidly. When the grains are heated in water until gelatinized, the solution colors a light indigo-blue and the grains a dark blue on the addition of iodine. When the grains are boiled for 2 minutes and then treated with iodine the solution is colored a deeper indigo-blue and the grain-residues a fairly deep, bright blue. With an excess of iodine, the grain-residues become deeper in color and sometimes have a slight reddish tint. The capsules usually color a light blue with a slight reddish tint, or rarely an old-rose color.

Staining Reactions.—With *gentian violet* the grains stain a very light violet immediately, and the color deepens slightly in 30 minutes. Some grains stain more deeply than others.

With *safranin* some of the grains show a very slight trace of pink immediately, and the color deepens slightly in 30 minutes. Considerable variation is found in the tint among the grains, some not staining at all.

Temperature Reaction.—The temperature of gelatinization is 60° to 61.5° C., mean 60.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a few grains at once. A few are gelatinized in 30 seconds, about one-half in a minute, practically all in 4 minutes, and all in 7 minutes. The entire grain is immediately colored a light reddish-violet, which gradually deepens to a light old-rose tint. Either a dark line or a ring appears at the region of the hilum, and in some grains a bubble is formed at this point. In the ellipsoidal, bean-shaped, and related forms, swelling and deepening of color usually begin at both ends and proceed towards the center, which is the last to become gelatinized. If excrescences are found upon the grains, gelatinization begins at these points, and when the entire grain is gelatinized these protuberances are lighter in tint. In the grains in which a hilum is demonstrable, a clear area forms around the dark ring at the hilum and also a delicate granular layer near the margin of the grain. In the pyriform grains, swelling and deepening of color start at the distal end, and are soon followed by the same changes at the proximal end, gelatinization then proceeding towards the center until the entire grain is involved. The gelatinized grains are deeply colored and uniformly swollen, and retain somewhat the shape of the untreated grain. The grains which have not become gelatinized have a golden-brown tint. When the gelatinized grains remain in the solution for 3 hours they become a bright indigo-blue.

The reaction with *chromic acid* begins immediately and all grains are dissolved in 25 seconds. The grains swell rapidly, gelatinization is almost instantaneous, the capsules burst, and all parts are dissolved. The reaction is so rapid that details of the process can not be determined.

With *pyrogallic acid* the grains begin to react immediately and all are gelatinized in 35 seconds. Both hilum and lamellæ become more distinct and fine striæ appear upon the latter. Swelling occurs at the cleft found in so many of the grains, and a bubble forms in it, which bubble after expanding rapidly is expelled, usually accompanied by a temporary invagination of the capsule at one point. From the large central cleft fine channels of gelatinization penetrate to all parts of the grain until all is changed. If an eccentric hilum is demonstrable in a grain, this part swells, and a longitudinal channel of gelatinization with delicate branches extends from it towards the distal end and gelatinization proceeds as already described. Separate centers of gelatinization form in the wart-like excrescences found in some grains, but finally merge with the body of the grain. The gelatinized grain is much swollen and somewhat distorted, but the general shape of the untreated grain is occasionally retained.

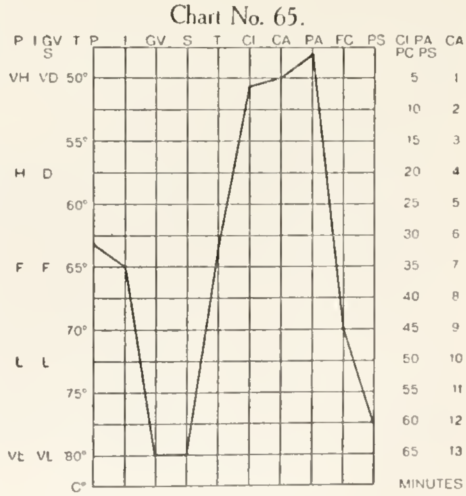
Reaction with *ferric chloride* begins in many grains in a minute. A number are gelatinized in 5 minutes; about one-half in 10 minutes; a gradual change in 15 minutes; all but a few scattered grains (one in several hundred) in 30 minutes; and all in an hour. The reaction begins at the margin, which becomes less opaque and hence resembles a dark border encircling a lighter mass. Later, either the hilum or both the hilum and the lamellæ become more distinct. A bubble which slowly expands and then collapses is often formed when either a very deep cleft or a cavity is present at the region of the hilum. Gelatinization and a rapid distension of the capsule now begins, usually at both ends of the bean-shaped and lenticular forms and at the distal end of the pyriform and other grains having a demonstrable, eccentric hilum. The central portion is the last to undergo gelatinization. Gradually, however, pieces are broken off from this more resistant starch and gelatinized, until the entire grain is gelatinized. The swollen grain is much distorted and therefore does not retain the shape of the untreated grain.

The reaction with *Purdy's solution* begins immediately. A few grains are gelatinized in 30 seconds, the majority in a minute, nine-tenths in 2 minutes, and all but a very few resistant forms (one in several hundred) in 3 minutes, most of the latter being gelatinized usually in 5 minutes, extremely few as late as 15 minutes. The cleft at the hilum, or the hilum, swells, and the lamellæ become sharply defined and striated. From the central cleft numerous delicate lines radiate, along the course of which gelatinization proceeds. When an eccentric hilum is demonstrable, a longitudinal refractive line with numerous branches extends from it towards the distal end of the grain, and the starch is gelatinized along this root-like fissure until most of the grain is gelatinized. If a grain has one or more excrescences, a focus of gelatinization occurs in each of these portions, as well as in the body of the grain, and a line of demarcation may remain between the separate sections of the grain, which sections subsequently become gelatinized. When the line of division does not gelatinize it may indicate the presence of a compound grain, even though separate hila were not demonstrable in the untreated grain. This separation is not so sharply marked as in doublets, because here a common lamellar covering incloses the divisions. The large grains with irregular outline gelatinize more rapidly than the others, and the contents of the capsule usually become completely gelatinized; while the grains in which the reaction is slower retain many refractive granules and often a few remnants of ungelatinized lamellæ. The gelatinized grain is large and somewhat distorted, but retains the general shape of the untreated grain.

STARCH OF QUERCUS MUEHLENBERGI. (Plate 11, figs. 63 and 64. Chart 65.)

Histological Characteristics.—In *form* nearly all of the grains are simple. Doublets and triplets and also compound grains, consisting usually of two components, are rarely observed. The simple grains are isolated, except a few which occur either in small aggregates or clumps. The conspicuous forms are the same as those noted for *Q. alba*, but ovoid, ellipsoidal, and pyriform shapes constitute a larger percentage of the grains. On the other hand, the grains with protuberances of characters similar to those noted under *Q. alba*, while present, are not so numerous, and hence the surface of the grains, as a whole, appears less irregular. Fewer aggregates are found than in *Q. alba*.

Chart No. 65.



Curve of Reaction-Intensities of Starch of Quercus muehlenbergi.

The *hilum* is often observed as a round, rarely lenticular, cavity, usually about one-third to two-fifths eccentric. From the hilum a longitudinal cleft frequently proceeds. This cleft is usually single and clear-cut, but occasionally ragged or double, and a few radial fissures may emerge from it. Just below the hilum a crescentic or a straight transverse fissure may be found, which with the longitudinal fissure already described forms a cross. In the bean-shaped grains a cleft similar in character to that noted under *Q. alba* is observed, but the central clefts of the grains are not so deep, and the hilum is more often demonstrable than in *Q. alba*.

The *lamellæ* are not demonstrable in all the grains, and when observable are less easily traced near the hilum than when near the periphery, on account of the cleft at the hilum. The lamellæ appear as rather coarse, concentric layers with an outline similar to that of the margin of the grain. The number counted on different grains varies from 6 to 10.

The *size* varies from the small, globular grains, which are 4 by 3μ, to the larger elongated forms, which are 30 by 19μ in length and breadth. The common size is 16 by 10μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and fairly clear-cut. Several grains show the peculiar bean type of figure noted in *Q. alba*. The lines of the figure are often straight and at oblique angles, but more often at right angles than in *Q. alba,* and the lines are not so often bent or bisected as in the *Q. alba.*

The degree of *polarization* is fair to quite high. It often varies in the same aspect of a grain. There is a smaller percentage of grains with quite high polarization than in *Q. alba*, and therefore, on the whole, somewhat lower than in *Q. alba.*

With *selenite* the quadrants are commonly well defined, slightly irregular in shape, and unequal in size. They are usually regular in shape and equal in size in the smaller grains, and are therefore more clearly defined than in the larger grains. The colors are about the same in brightness, variability, and purity as in *Q. alba.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a blue-violet; with 0.125 per cent solution they slowly color a light blue-violet. After heating in water until all are gelatinized and then adding iodine, the solution colors a deep blue and the gelatinized grains a bright blue. When boiled for 2 minutes and then treated with iodine, the solution colors very deeply and the grain-residues a bright blue. With an excess of iodine, the grain-residues color a deep blue with a reddish tint, and most of the capsules a blue-violet, while a few are more of an old-rose tint. The colors have slightly more of a reddish tint than in the grains of *Q. alba* so treated.

Staining Reactions.—With *gentian violet* some grains show a slight trace of violet immediately, and in 30 minutes the color has deepened slightly. Some grains stain more than others. The variations and the depth of tint are about the same as in *Q. alba.*

With *safranin* many grains stain a very light pink immediately, and in 30 minutes the color deepens slightly. Some grains stain more than others. The color is deeper at the central cleft and at the protuberances. The tint and the variations are about the same as in *Q. alba.*

Temperature Reaction.—The temperature of gelatinization is 62.5° to 64° C., mean 63.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains in 20 seconds. A few are gelatinized in 45 seconds, about five-sixths in 5 minutes, practically all in 7 minutes, and all in 15 minutes. The ungelatinized grains are of a deep golden-brown color, while the gelatinized grains are of a fairly bright reddish-blue. This blue is not quite so reddish a tint as in *Q. alba.* The reaction is qualitatively the same as in *Q. alba.*

Reaction with *chromic acid* begins at once. It is complete in the majority of the grains in 40 seconds and in all in 60 seconds. The hilum or the region of the cleft at this region swells, and the lamellæ become very distinct. One line passes from the hilum in the ovoid forms, while small lines pass out from the central cleft in the laterally extended grains. Gelatinization of the grain proceeds rapidly. The capsule is finally ruptured, with extension of the contents of the capsule and solution of both. The process appears to be qualitatively the same as in *Q. alba*, but it is much slower, so that certain details can be observed.

With *pyrogallic acid* reaction begins in about half at once and is complete in all the grains in 60 seconds. The process is qualitatively the same as in *Q. alba.*

The reaction with *ferric chloride* begins in a few grains in 45 seconds. In 5 minutes a few have begun to swell; in 10 minutes a very few are gelatinized; and in 15 minutes all the grains are in various stages of gelatinization. The reaction is complete in one-fifth of the grains in 30 minutes, and four-fifths are gelatinized and only a few scattered grains have resisted the reagent in 45 minutes. No further change occurs in an hour. The reaction is qualitatively the same as in *Q. alba.*

The reaction with *Purdy's solution* has begun in most grains in a minute. Only a very few (perhaps 1 in 500) are gelatinized in 5 minutes, about 1 in 100 in 10 minutes, about one-tenth in 15 minutes, about nine-tenths in 30 minutes, and all but a few scattered grains in an hour. The process is qualitatively the same as in *Q. alba*, but in most grains more lamellæ remain ungelatinized than those that are completely gelatinized.

STARCH OF QUERCUS PRINUS. (Plate 11, figs. 65 and 66. Chart 66.)

Histological Characteristics.—In *form* the grains are generally simple. A few doublets or compound grains, usually of two components, are occasionally present. The simple grains are isolated, except a few which occur in small aggregates and in clumps. The separate components of the aggregates have clearly marked pressure facets. The conspicuous forms, as well as the non-conspicuous, are the same as those noted for *Q. alba,* but the ellipsoidal, ovoid, and lenticular grains are more numerous than the somewhat bean-shaped grains. Grains with irregular surfaces due to the same cause as noted for *Q. alba* are present, but the percentage of grains with regular surfaces is higher in this species.

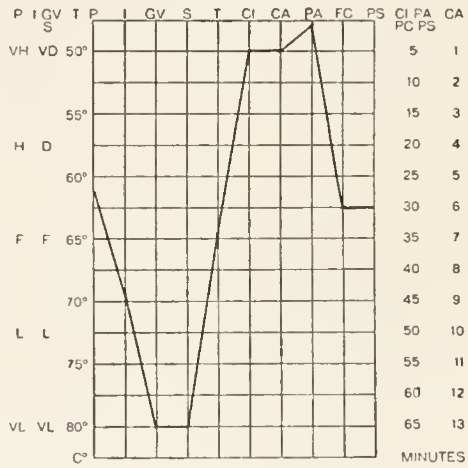
The elongated central cleft is marked in this species, as well as the eccentric *hilum* with one longitudinal fissure or other peculiarities at this region, already described for *Q. alba*. The clefts are, however, not so deep nor found in so large a proportion of grains as in *Q. alba*. The hilum when demonstrable is about one-third to two-fifths eccentric; rarely it is centric.

The *lamellæ* are less often demonstrable than in the grains of *Q. alba*, but occasionally grains are seen in which 8 can be counted. They are of similar structure to those of *Q. alba*.

The grains vary in *size* from the small, which are 4 by 3μ, to the larger, which are 24 by 14μ. The common size is 16 by 10μ.

Polariscopic Properties.—The *figure* is usually eccentric and fairly clear-cut. There are several grains which show the bean type of figure found in *Q. alba*, and a few in which the figure is centric or nearly centric. The lines generally intersect obliquely, and are not so frequently bent or bisected as in *Q. alba*.

Chart No. 66.



Curve of Reaction-Intensities of Starch of Quercus prinus.

The degree of *polarization* is fair to quite high. The percentage of grains in which the polarization is high is not so great as in *Q. alba*. Polarization, on the whole, is somewhat lower than in *Q. alba*.

With *selenite* the quadrants are usually well defined, slightly irregular in shape, and unequal in size. The colors are the same as those noted for *Q. alba*, but the percentage of grains in which the colors are bright and pure is not so high as in *Q. alba*. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather light violet, which deepens rather slowly; with 0.125 per cent solution the grains slowly take on a very light violet tint, which deepens slightly. The color of the grains when treated with these solutions is lighter and more reddish than in *Q. alba*. After heating in water until all the grains are completely gelatinized the solution colors light indigo-blue and the gelatinized grains a deep bluish-purple on the addition of iodine. If the preparation is then boiled for 2 minutes and afterwards treated with iodine, the solution colors a deep reddish-purple and the grain-residues a light bluish-violet. With an excess of iodine the grain-residues are colored a deep reddish-purple and the capsules a reddish-violet to deep old-rose. When treated with iodine the gelatinized grains and grain-residues have slightly more of a reddish tint than those of *Q. alba*.

Staining Reactions.—With *gentian violet* the grains do not stain immediately, but in 30 minutes have colored slightly. There is some variation in the depth of color of the different grains. The color is not quite so deep in the majority of the grains as in those of *Q. alba*.

With *safranin* the grains do not stain immediately, but in 30 minutes they have colored slightly. The larger grains are of about the same tint as those of *Q. alba*, but the smaller grains, which form the majority, do not stain quite so much as the grains of *Q. alba*.

Temperature Reaction.—The temperature of gelatinization is 64° to 65.8° C., mean 64.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains in 30 seconds. A few are gelatinized in a minute, about four-fifths in 3 minutes, practically all in 5 minutes, and all in within 23 minutes. The process is qualitatively the same as in *Q. alba*.

The reaction with *chromic acid* begins at once and most grains are dissolved in 35 seconds, while a very few resist the effects of the reagent for 60 seconds. The reaction is qualitatively the same as in *Q. alba*.

With *pyrogallic acid* the reaction begins at once and is complete in all grains in 45 seconds. The process is qualitatively the same as in *Q. alba*.

Reaction with *ferric chloride* begins in a few grains in a minute. A few are gelatinized in 5 minutes, about one-fifth in 10 minutes, about four-fifths in 15 minutes, all but a few scattered grains (one in several hundred) in 30 minutes, and all in an hour. The reaction is qualitatively the same as in *Q. alba*.

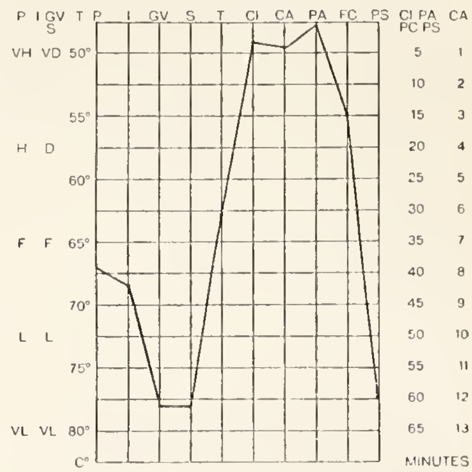
Reaction with *Purdy's solution* begins in a few grains immediately and all are in various stages of gelatinization in 5 minutes. There is a gradual change in 10 minutes. Gelatinization is complete in about nine-tenths in 15 minutes and in all in 30 minutes. The reaction is qualitatively the same as in *Q. alba*, but the process is not so complete. Not so many of the lamellæ become gelatinized as in the grains of *Q. muehlenbergi*, but the resemblance to this grain is closer than to *Q. alba*.

STARCH OF QUERCUS RUBRA. (Plate 12, fig. 67. Chart 67.)

Histological Characteristics.—In *form* nearly all of the grains are simple; the compound grains are usually of two components. The simple grains are isolated, except a few which occur in small aggregates and many in clumps. The conspicuous forms are the same as those of *Q. alba*, except that the ellipsoidal, ovoid, pyriform, and nearly round are relatively much more numerous. Grains with wart-like exerescences are noted, but, as a rule, the surfaces of the grains are much less irregular than those of *Q. alba*.

The *hilum* is usually one-third to two-fifths eccentric. From the hilum there proceeds in some grains a longitudinal cleft which becomes divided near the distal end into two or three divisions, resembling a 2- or 3-pronged fork. In other grains two fissures may start from the hilum or from a small transverse fissure just below the hilum. In the bean-shaped and also in some of the ellipsoidal grains a cleft like that noted under *Q. alba* is observed. In the round grains the hilum appears as a small centric, round cavity. In the pyriform grains a transverse or diagonal cleft is sometimes present at the hilum, and if the longitudinal cleft is single the two form a cross.

Chart No. 67.



Curve of Reaction-Intensities of Starch of Quercus rubra.

The *lamellæ* are not demonstrable.

The *size* varies from the smaller forms, which are 4 by 3μ, to the larger, which are 18 by 10μ in length and breadth. The common size is 12 by 7μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric and the bean type so often found in *Q. alba* is sometimes observed. The lines of the figure generally intersect obliquely and are more often straight than in *Q. alba*.

The degree of *polarization* is low to fairly high, frequently varying in the same aspect of a given grain; sometimes quite low at both ends and very often in one end it is very low or absent. This condition is probably caused by the forked cleft at the distal end.

With *selenite* one of the quadrants is frequently not well defined in the larger grains, but the appearance noted in *Q. alba* is sometimes observed. They are usually irregular in shape and unequal in size. The colors are fairly bright, but less so than in *Q. alba*. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution most grains color a very light red-violet, and most of them deepen in tint very little; with 0.125 per cent solution a few of the grains color either a very light red-violet or light old-rose, and the color deepens slightly and rather slowly.

When the grains are heated in water until all are gelatinized, the solution does not color at all on the addition of iodine, but the grains change to a deep reddish-purple. If the preparation is boiled for 2 minutes and then treated with iodine, the solution colors a deep bluish-violet, but most of the grain-residues do not color at all, while some become a light reddish-violet tint. With an excess of iodine all the grain-residues color a deep red-violet to purple, while the capsules assume an old-rose to a wine-color. The colors throughout the iodine reactions have more of a reddish tint than in *Q. alba*.

Staining Reactions.—With *gentian violet* the grains at once stain a very light violet and in 30 minutes the color has slightly deepened. The stain acts more upon the grain at the cleft than at the margin. There is considerable variation in the tint of the different grains. The depth of coloration is about the same as in *Q. alba*.

With *safranin* the grains stain very faintly at once and in 30 minutes they deepen slightly in color, particularly at the central cleft. There is considerable variation in the depth of tint in the different grains. The color is very light, but slightly deeper than in *Q. alba*.

Temperature Reaction.—The temperature of gelatinization is 62.5° to 63.5° C., mean 63°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once. A few grains are gelatinized in 30 seconds, about nine-tenths in 2 minutes, practically all in 3 minutes, and all in 5 minutes. The grains are much swollen and deeply colored, but retain the general shape of untreated grains. The reaction is qualitatively the same as in *Q. alba*.

The reaction with *chromic acid* begins immediately and all (except one in several hundred) are dissolved in 25 seconds. These few scattered grains may resist solution for 50 seconds. The reaction is qualitatively the same as for *Q. alba*.

With *pyrogallic acid* the reaction begins at once and is complete in 30 seconds. The gelatinized grains are so much swollen and wrinkled that they do not usually resemble the shape of the untreated grain. The reaction is qualitatively the same as in *Q. alba*.

The reaction with *ferric chloride* begins in a few grains in a minute and all are in various stages of gelatinization in 5 minutes. About half are gelatinized in 10 minutes and all but a few resistant grains (one in several hundred) in 15 minutes. The reaction is generally complete in the latter in 30 minutes. The gelatinized grain is much swollen, but often retains the general shape of the untreated grain. It is more regular in outline than in *Q. alba*. The reaction is qualitatively the same as in *Q. alba*, but during gelatinization small particles are not broken off with so much force from the larger ungelatinized mass as in *Q. alba*.

With *Purdy's solution* the hilum and central fissure swell slightly at once, but the subsequent change is very gradual during 15 minutes. In 30 minutes much of the central portion of only a very small percentage of the grains is gelatinized and there is little further progress in an hour. Gelatinization proceeds along the main cleft, which is divided at the distal end into two or three large branches. Radiating lines pass from the main fissure. Lamellæ unnoticeable in an untreated grain may be seen, but do not become very distinct. The reaction resembles that observed in the grains of *Q. texana*, but the lamellæ are not so well defined and gelatinization does not proceed so far. When protuberances are present a separate center of gelatinization is found in each. The gelatinized grains are swollen, but retain the shape of the untreated grain. The reaction is qualitatively the same as that noted for *Q. alba*, but does not proceed nearly so far.

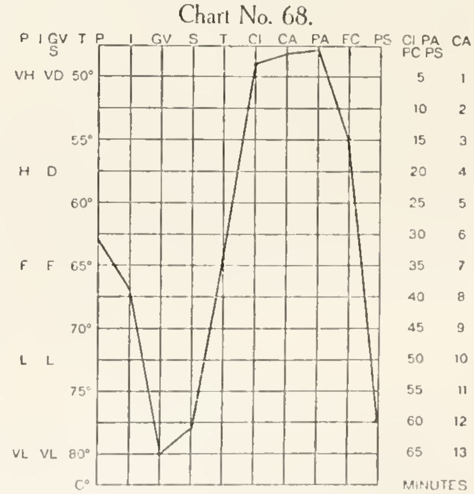
STARCH OF QUERCUS TEXANA. (Plate 12, fig. 68. Chart 68.)

Histological Characteristics.—In *form* the grains are usually simple; a few compounds present consist usually of two components. The grains are isolated, except a few found in small aggregates and many in clumps. The most conspicuous forms are ellipsoidal, ovoid, and pyriform. Other shapes, also noted in *Q. alba*, are present. The grains exhibit the same types of irregular surface as those noted for *Q. alba*.

The *hilum* is usually fissured, but occasionally it may be a round cavity, which is centric or usually eccentric, about one-third to two-fifths of the longitudinal axis. The longitudinal cleft which proceeds from the region of the hilum usually resembles a 2- or 3-pronged fork. If but one cleft starts from the hilum it usually soon divides into the two or three main branches. There is quite often a short, transverse fissure at the hilum or a little below it. The arrangement of the clefts is practically identical with that found in the grains of *Q. rubra*, but they are usually deeper and more often have radiating fissures. In the somewhat bean-shaped, and in the triangular grains, a single fissure similar to that of *Q. alba* is usually present.

The *lamellæ* are not generally demonstrable. Rarely 8 have been counted, which are seen to be identical in character to those of *Q. alba*.

Chart No. 68.



Curve of Reaction-Intensities of Starch of Quercus texana.

The *size* varies from the smaller, which are 4 by 3μ, to the larger elongated grains, which are 20 by 14μ, and the bean-shaped, which are 26 by 15μ in length and breadth. The common size is 12 by 7μ.

Polariscopic Properties.—The *figure* is usually eccentric, and the bean type seen in *Q. alba* is also found. The lines usually intersect obliquely and are more often bent or bisected than in *Q. rubra*, but not so frequently as in *Q. alba*.

The degree of *polarization* is fair to fairly high. It frequently varies in the same aspect of a given grain, one quadrant being much lower than the others. This difference may be caused by fissuration at the distal end. Polarization is slightly higher than in the grains of *Q. rubra*, but not so high as in *Q. alba*.

With *selenite* one of the quadrants is frequently not well defined, but the general appearances noted in *Q. alba* are present. They are usually irregular in shape and unequal in size. The colors are slightly brighter than in *Q. rubra*, but not so bright or so pure as in *Q. alba*. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution most grains color a light reddish-violet. In 5 minutes the color becomes fairly deep and in 10 minutes it is a very deep purple; with 0.125 per cent solution many grains color a very light red-violet, which deepens in 5 minutes and in 10 minutes becomes quite deep. Some of the grains in each preparation do not color. After heating in water until all are gelatinized, the solution does not color at all, but the grains assume a very deep blue-violet on the addition of iodine. When the solution is boiled for 2 minutes and then treated with iodine, the solution takes on a deep-violet color, but the grain-residues remain colorless. With an excess of iodine the solution changes to a deep bluish-purple, while the capsules color a deep rose-violet.

Staining Reactions.—With *gentian violet* the grains stain a very light violet at once and in 30 minutes have become fairly deeply colored. Some grains stain much more deeply than others. The coloration is about the same as in *Q. alba*.

With *safranin* the grains stain a light pink immediately and in 30 minutes they deepen slightly. Some of the grains stain much more deeply than others. The stain is deeper than in *Q. alba*. The color is slightly deeper than in *Q. rubra*.

Temperature Reaction.—The temperature of gelatinization is 64° to 64.5° C., mean 64.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once. A few are gelatinized in 40 seconds, practically all in 2 minutes, and all in 6 minutes. The color of the grains when observed after 3 hours is blue with a reddish tint. This more resembles the color of *Q. rubra* than of *Q. alba*. The reaction is qualitatively the same as in *Q. alba*.

Reaction with *chromic acid* begins at once and the grains are dissolved in 20 seconds. The reaction is qualitatively the same as in *Q. alba*.

The reaction with *pyrogallic acid* begins at once and is complete in all the grains in 28 seconds. The reaction is qualitatively the same as in *Q. alba*.

With *ferric chloride* reaction begins in a few grains in 45 seconds. Practically all are in various stages of gelatinization in 5 minutes, about two-thirds are gelatinized in 10 minutes, and all in 15 minutes, excepting a very few resistant grains (one in several hundreds) in which gelatinization is usually complete in 30 minutes. The gelatinized grain is much swollen, but often retains the shape of the untreated grain. It is more regular in outline than those of *Q. alba*. The reaction is qualitatively the same as that of *Q. alba*, but during the process particles are not broken off from the larger resistant mass of starch with so much force as in *Q. alba*.

The reaction with *Purdy's solution* begins at once in a few grains and practically all are in various stages of gelatinization in 5 minutes. Gradual changes occur, but even in an hour quite a broad border of resistant starch remains around the central gelatinized portion. The reaction is qualitatively the same as in *Q. alba*, but gelatinization is not so complete as in this species. It proceeds somewhat further than in *Q. rubra*.

Differentiation of Certain Starches of the Genus Quercus.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

Q. alba: Simple, few compound, isolated except a few small aggregates and clumps. Ellipsoidal, somewhat bean-shaped, ovoid, lenticular, and irregular of indefinite form.

Q. muehlenbergi: Same as in *Q. alba*, but fewer aggregates and irregular grains. A larger percentage of ovoid, ellipsoidal and pyriform.

Q. prinus: Same as in *Q. alba*, but fewer aggregates and irregular grains. A larger percentage of ellipsoidal, ovoid, and lenticular grains.

Q. rubra: Same as in *Q. alba*, except fewer aggregates and irregular grains, but more clumps; a larger percentage of ellipsoidal, ovoid, pyriform, and nearly round.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Conspicuous Forms.—Continued.

Q. texana: Same as in *Q. alba*, but fewer aggregates and the grains are not quite so irregular in outline. A larger percentage of ellipsoidal, ovoid, and pyriform.

Hilum—Form, Number, and Position.

Q. alba: Hilum usually deeply and extensively fissured; when not fissured, a clear round or lenticular spot. Position usually eccentric 0.4 to 0.3.

Q. muehlenbergi: Same as in *Q. alba*, but the hilum more often demonstrable and the fissure when present not so deep. Position usually eccentric 0.3 to 0.4.

Differentiation of Certain Starches of the Genus Quercus.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number and Position.—Continued.

Q. prinus: Same as in *Q. alba*, but the hilum more often demonstrable and the fissure when present not so deep. Position usually eccentric 0.3 to 0.4.

Q. rubra: Occasionally the same as in *Q. alba*, but hilum is more often demonstrable from which 1 longitudinal cleft with 2 to 3 pronged divisions, or 2 to 3 parallel longitudinal clefts proceed; a short transverse cleft through or just beneath the hilum sometimes present. Position usually eccentric 0.3 to 0.4.

Q. texana: Occasionally the same as *Q. alba*, but more often there are 2 to 3 parallel longitudinal fissures or one proceeding from the hilum, which divides into 2 or 3 pronged branches. A transverse cleft through or just beneath the hilum sometimes present. Position usually eccentric 0.3 to 0.4.

Lamellæ—General Characteristics and Number.

Q. alba: Not always distinct, when seen are rather coarse continuous rings, following the outline of the grain; secondary sets of lamellæ more indistinct than primary observed on most irregular grains. 8 to 10 on common-sized grains.

Q. muehlenbergi: Same as in *Q. alba*. 6 to 10 on common-sized grains.

Q. prinus: Same as in *Q. alba*, but demonstrable in smaller percentage of grains. 8 counted on common-sized grains.

Q. rubra: Not demonstrable.

Q. texana: Rarely demonstrable, when observed similar in character to those of *Q. alba*. 8 counted on the common-sized grains.

Size.

Q. alba: From 4 to 32μ, commonly 22μ.

Q. muehlenbergi: From 4 to 30μ, commonly 16μ.

Q. prinus: From 4 to 24μ, commonly 16μ.

Q. rubra: From 4 to 18μ, commonly 12μ.

Q. texana: From 4 to 20μ, very rarely 26μ, commonly 12μ.

POLARISCOPIC PROPERTIES.

Figure.

Q. alba: Sometimes centric, but usually eccentric, and commonly in the form of a cross or of the bean type; distinct, frequently irregular.

Q. muehlenbergi: Same as in *Q. alba*, but more regular, and fewer bean type.

Q. prinus: Same as in *Q. alba*, but more regular, and less of the bean type.

Q. rubra: Same as in *Q. alba*, but more regular, and the bean type is very rare.

Q. texana: Same as in *Q. alba*, but slightly more regular, and fewer of the bean type.

Degree of Polarization.

Q. alba: Fair to quite high.

Q. muehlenbergi: Fair to quite high, smaller percentage of grains in which they are quite high than in *Q. alba*.

Q. prinus: Fair to quite high; the percentage of grains in which they are quite high is not so great as in *Q. alba*.

Q. rubra: Low to fairly high, frequent variation in the same aspect of a given grain.

Q. texana: Fair to fairly high; frequent variation in the same aspect of a given grain.

Polarization with Selenite—Quadrants and Colors.

Q. alba: Quadrants usually well-defined, irregular in shape, unequal in size. Colors generally pure.

Q. muehlenbergi: Quadrants same as in *Q. alba*. Colors generally pure.

POLARISCOPIC PROPERTIES.—Continued.

Polarization with Selenite—Quadrants and Colors.—Con'd.

Q. prinus: Quadrants same as in *Q. alba*. Colors generally pure.

Q rubra: One of the quadrants is frequently not well-defined; occasionally the same as in *Q. alba*. Colors generally pure.

Q. texana: Quadrants same as in *Q. rubra*. Colors generally pure.

IODINE REACTIONS.

Intensity and Color.

Q. alba: Fair; blue-violet.

Q. muehlenbergi: Fair, the same as in *Q. alba;* blue-violet.

Q. prinus: Light, lighter than in *Q. alba;* violet, more reddish in tint and deepens more slowly than in *Q. alba*.

Q. rubra: Very light, much lighter than in *Q. alba;* red-violet.

Q. texana: Light, lighter than in *Q. alba;* red-violet.

STAINING REACTIONS.

With Gentian Violet.

Q. alba: Very light.

Q. muehlenbergi: Very light, the same as in *Q. alba*.

Q. prinus: Very light, less in the majority of the grains than in *Q. alba*.

Q. rubra: Very light, the same as in *Q. alba*.

Q. texana: Very light, the same as in *Q. alba*.

With Safranin.

Q. alba: Very light.

Q. muehlenbergi: Very light, about the same as in *Q. alba*.

Q. prinus: Very light, less than in the majority of the grains of *Q. alba*.

Q. rubra: Very light, slightly deeper than in *Q. alba*.

Q. texana: Light, slightly deeper than in *Q. alba*.

TEMPERATURE OF GELATINIZATION.

Q. alba: 60 to 61.5° C., mean 60.75°.

Q. muehlenbergi: 62.5 to 64° C., mean 63.75°.

Q. prinus: 64 to 65.8° C., mean 64.75°.

Q. rubra: 62.5 to 63.5° C., mean 63°.

Q. texana: 64 to 64.5° C., mean 64.25°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

Q. alba: Begins at once; complete in practically all in 4 minutes.

Q. muehlenbergi: Begins in 20 seconds; complete in practically all in 7 minutes.

Q. prinus: Begins in 30 seconds; complete in practically all in 5 minutes.

Q. rubra: Begins at once; complete in practically all in 3 minutes.

Q. texana: Begins at once; complete in practically all in 3 minutes.

Reaction with Chromic Acid.

Q. alba: Begins immediately; complete in 25 seconds.

Q. muehlenbergi: Begins immediately; complete in majority in 40 seconds, all in 60 seconds.

Q. prinus: Begins immediately; complete in majority in 35 seconds, all in 60 seconds.

Q. rubra: Begins immediately; complete in all but a rare resistant grain in 25 seconds, in all in 50 seconds.

Q. texana: Begins immediately; complete in all in 20 seconds.

Reaction with Pyrogallic Acid.

Q. alba: Begins immediately; complete in 25 seconds.

Q. muehlenbergi: Begins immediately in half of the grains; complete in 60 seconds.

Differentiation of Certain Starches of the Genus Quercus.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

Q. prinus: Begins immediately; complete in 45 seconds.
Q. rubra: Begins immediately; complete in 30 seconds.
Q. texana: Begins immediately; complete in 28 seconds.

Reaction with Ferric Chloride.

Q. alba: Begins in many in a minute; complete in all but rare resistant grains in 30 minutes, all in an hour.
Q. muehlenbergi: Begins in a few in 45 seconds; complete in all but rare resistant grain in 45 minutes.
Q. prinus: Begins in a few in a minute; complete in all but rare resistant grains in 30 minutes, all in 1 hour.
Q. rubra: Begins in a few in a minute; complete in all but rare resistant grains in 15 minutes; complete in these usually in 30 minutes.
Q. texana: Begins in a few in 45 seconds; complete in all but rare resistant grains in 15 minutes, complete in these in usually 30 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Purdy's Solution.

Q. alba: Begins immediately; complete in all but rare resistant grains in 3 minutes, usually complete in these in 5 minutes, rarely in 15 minutes.
Q. muehlenbergi: Begins in majority in a minute; complete in nine-tenths in 30 minutes, all but a few scattered grains in an hour.
Q. prinus: Begins in a few immediately; complete in 30 minutes.
Q. rubra: Begins in a few immediately; complete in the central portion in a small percentage of grains in 30 minutes, not so complete as in *Q. alba*. Incomplete in an hour.
Q. texana: Begins in a few immediately; complete in the central portion of a larger percentage of grains in 30 minutes than in *Q. rubra;* some resistant starch remaining in 60 minutes; not so complete as in *Q. alba.*

NOTES ON THE STARCHES OF QUERCUS.

Some minor differences are noted in the histological characteristics of the five oak starches. In the case of the reactions, except of those with gentian violet, the differences in each starch are diagnostic in relation to the others. The starches which correspond most closely in their reactions are those of *Q. rubra* and *Q. texana*, which are closely related species. *Q. rubra* has the lower degree of polarization; lower sensitivity to iodine, chromic acid, and Purdy's solution; and a lower temperature of gelatinization (1.25°). In the gentian violet, chloral hydrate-iodine, pyrogallic acid, and ferric chloride reactions they are practically identical.

GENUS CASTANEA.

Several species of *Castanea* are largely cultivated in certain parts of Europe, Asia, Northern Africa, and America, and from these and from the trees or shrubs growing wild, large quantities of edible fruit or nuts are gathered. In this country the cultural forms are referred to the common American sweet chestnut (*Castanea americana*); the European chestnut (*Castanea sativa*), which is also known as the Italian, Spanish, and French chestnut, the fruit of which is much larger, but less sweet and of inferior flavor; the Japanese chestnut (*Castanea crenata*), which has a large fruit, but of rather poor quality; and the chinkapin (*Castanea pumila; C. alnifolia*), the fruit of which is small. There are many cultural varieties of *Castanea*, and much has been done in the cultivation of selected forms, especially by grafting on species of either *Castanea* or *Quercus*—in the case of the latter, especially *Q. prinus* or the chestnut oak. Starches from four sources were studied: *C. americana* Raf. (*C. dentata* Bokh.), *C. sativa* var. *numbo, C. sativa* var., and *C. pumila* Mill.

STARCH OF CASTANEA AMERICANA. (Plate 12, figs. 69 and 70. Chart 69.)

Histological Characteristics.—In *form* the grains are usually simple, and are isolated, except some which occur in clumps and in small aggregates. There are a few compound grains of usually two or three components. Some of the isolated grains have well-marked pressure facets. The surface of the grains is frequently irregular, owing chiefly to wart-like protuberances at one or more points. These growths are generally located at either end of an ellipsoidal grain and appear less dense than the main portion of the grain. The conspicuous forms are ovoid, somewhat bean-shaped, ellipsoidal, club-shaped with pointed end, and pyriform. There are also triangular with rounded angles, lenticular, dome-shaped, napiform, pyriform with curved distal end, and irregular grains of indefinite shape.

The *hilum* is not usually demonstrable. Occasionally it may be observed as a clear, round spot, which may be centric, but is usually eccentric about two-fifths to about one-third of the longitudinal axis. Rarely a small irregular cavity is found at the hilum. A single longitudinal cleft, with or without radiating fissures, sometimes proceeds from the hilum. Either a short transverse or diagonal cleft is occasionally found, which may pass through or be located just beneath the distal margin of the hilum.

The *lamellæ* are rarely demonstrable, but when observed are rather coarse, complete rings which follow the outline of the grain. The lamellæ of the main body of the grain do not pass into the wart-like excrescences above referred to, and in which no lamellæ are demonstrable.

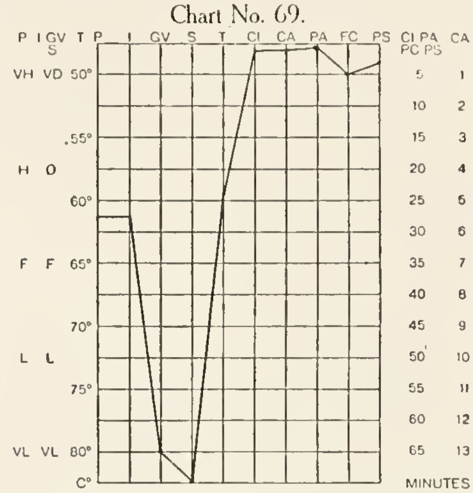
The grains vary in *size* from that of the smaller, which are 3 by 2μ, to the larger, which are usually 14 by 10μ, rarely 16 by 12μ in length and breadth. The common size is about 9 by 6μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric and not always distinct throughout. The lines intersect at an oblique angle, are frequently bent, and sometimes bisected. In some grains the figure is in the form of an elongated line having bisected ends of the bean type. Occasionally the figure is centric, and the lines intersect at right angles.

The degree of *polarization* is fair to high, frequently varying in the same aspect of a given grain, one quadrant often being lower than the other three.

With *selenite* the quadrants are, as a rule, fairly well defined, usually unequal in size, and irregular in shape. The colors are, on the whole, fairly pure; the blue is generally pure, but the yellow is often slightly impure.

Chart No. 69.



Curve of Reaction-Intensities of Starch of Castanea americana.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, which becomes very deep in 2 minutes; with 0.125 per cent solution the grains are colored a very light blue-violet which becomes quite deep in 2 minutes. After heating in water until the grains are completely gelatinized, the solution becomes a reddish-blue and the grains a deep blue with reddish tint on the addition of iodine. When the grains are boiled for 2 minutes and then treated with iodine, the solution and the grain-residues assume a deep blue with a reddish tint. With an excess of iodine the solution and grain-residues become deeper in color, and the capsules color a deep heliotrope to a wine-red.

Staining Reactions.—With *gentian violet* the grains do not stain at once, but in 30 minutes they are slightly colored.

With *safranin* the grains do not stain immediately and in 30 minutes there is only a trace of color in some grains.

Temperature Reactions.—The temperature of gelatinization is 58.5° to 60° C., mean 59.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in 20 seconds, the majority in 40 seconds, and all but rare resistant grains in a minute, gelatinization in these being complete within 1½ to 2 minutes. Occasionally either a dark spot or ring appears at the hilum and rarely either a dark line or slit-like structure in the central part of the grain. Gelatinization usually begins at the distal end and proceeds rapidly over the grain, accompanied by uniform swelling. The ring and slit-like structure become irregular in outline and are finally obscured as gelatinization and the accompanying deep-blue coloration advance towards this region. In the grains with excrescences, which frequently appear at either end, gelatinization starts at both ends and proceeds towards the middle until the entire grain is finally involved. The old-rose color so often observed in this reaction precedes the deep-blue coloration during gelatinization. The gelatinized grains are swollen, but retain the general shape of the untreated grain. They are of a deep reddish-blue color, usually with a lighter, elongated mesial line; and excrescences if present are also of lighter tint.

Reaction with *chromic acid* begins at once and all the grains are dissolved in 10 seconds, except very rare resistant grains, which may take 20 seconds. The grains swell rapidly, gelatinization is almost instantaneous, the capsule bursts, and all parts are dissolved. The reaction is so rapid that details of the process can not be determined.

The reaction with *pyrogallic acid* begins at once, and all but very rare resistant grains are gelatinized in 10 seconds, the latter being gelatinized in 15 to 20 seconds. The grains swell rapidly and gelatinization is almost instantaneous, so that it is impossible to ascertain the details of the process. The grains are completely gelatinized, with the exception of the outermost layers, which are much swollen and somewhat distorted, but retain the general shape of untreated grains.

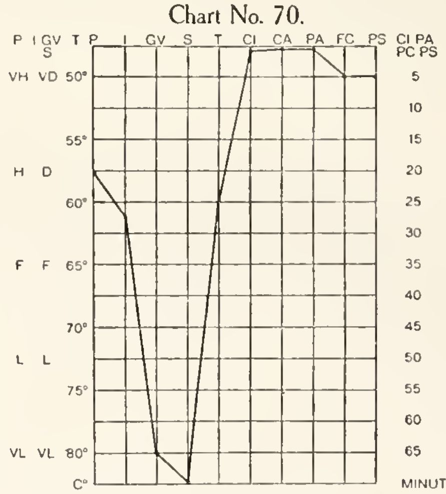
With *ferric chloride* the swelling begins in a few grains in 30 seconds. A small number are gelatinized in a minute, the majority in 2 minutes, and all but a few resistant grains in 5 minutes, which latter are nearly always completely gelatinized in 8 to 12 minutes; very rarely a grain may resist gelatinization for 28 minutes. A narrow translucent border is formed around the entire grain, which appears darker than the main body of the grain, and a dark spot is observed at the hilum. Gelatinization, accompanied by a rapid distension of the capsule, usually begins at the distal end, followed quickly by gelatinization at the proximal end, then spreading around the margin of the grain. The central part of the grain is the last to undergo gelatinization. When the process is near completion the most resistant starch is broken into rather large fragments which are finally gelatinized. These fragments do not fly asunder forcibly in grains in which gelatinization is rapid, while they do in the resistant grains. The gelatinized grains are so much swollen and distorted that they do not retain the shape of the untreated grain.

Reaction with *Purdy's solution* begins at once and a few grains are gelatinized in 20 seconds. About half are gelatinized in a minute, about four-fifths in 2 minutes, and all but a few resistant grains in 3 minutes, the latter perhaps taking 5 minutes, rarely 10. The hilum, if demonstrable, swells, and a single longitudinal cleft, which may have a few radial fissures, is formed, along which gelatinization proceeds. When the grain has one or more excrescences, a separate center of gelatinization is formed in each, and sometimes a partition persists between these and the main body of the grain after the reaction is complete. The grains are completely gelatinized, except the outermost layers, and are swollen, but the general shape of the untreated grain is retained.

STARCH OF CASTANEA SATIVA VAR. NUMBO. (Plate 12, figs. 71 and 72. Chart 70.)

Histological Characteristics.—In *form* the grains are usually simple and isolated, except some which occur in clumps and in small aggregates. There are a few compound grains, usually of two or three components. A few isolated grains have well-marked pressure facets. The irregularity of the surface and the location and structure of the protuberances are the same as in *C. americana.* The conspicuous forms are imperfect bean-shaped, ellipsoidal, ovoid, club-shaped with pointed distal end, and triangular with rounded angles. There are some pyriform, napiform, dome-shaped, lenticular, conical, finger-shaped, and irregular grains of indefinite form.

Chart No. 70.



Curve of Reaction-Intensities of Starch of Castanea sativa var. numbo.

The *hilum* is not usually demonstrable, but occasionally it may be observed as a round, fairly refractive spot, which is occasionally centric, but usually two-fifths to one-fifth eccentric of the longitudinal axis. A small irregular cavity, a diagonal, or a short transverse fissure is occasionally found at the hilum. A rather deep, central cleft is often noted in grains with excrescences at either end. A single longitudinal fissure frequently proceeds from the hilum. Fissures are more often present and are deeper than in the grains of *Castanea americana.*

The *lamellæ* are not very distinct, but are more often demonstrable than in grains of *C. americana.* They have the same structure and character as in *C. americana.* Occasionally 8 to 10 may be counted on the larger grains.

The grains vary in *size* from the smaller, which are 3 by 2μ, to the larger, which are 22 by 12μ, rarely 30 by 12μ, in length and breadth. The common size is 14 by 8μ in length and breadth.

Polariscopic Properties.—The *figures* are the same as in *C. americana.* The proportion of grains in which the figure is of the bean type, consisting of an elongated line with bisected ends, is greater than in *C. americana.*

The degree of *polarization* is fair to quite high, but sometimes varying in the same aspect of a given grain. The proportion of grains in which polarization is high is greater than in *C. americana.*

With *selenite* the quadrants are well defined and are more clear-cut than in *C. americana;* usually unequal in size and irregular in shape. The colors are generally pure; more often pure than in the grains of *C. americana.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, which deepens rapidly; with 0.125 per cent solution they color a very light blue-violet, which deepens rapidly. The tint in each case is about the same as in *C. americana*. After heating in water until all the grains are gelatinized and then treating with iodine, the solution colors a deep heliotrope and the grains a fairly deep blue with a reddish tint, slightly more of the red than in *C. americana*. When the grains are boiled for 2 minutes and then treated with iodine, the solution becomes a deep bluish-purple and the grain-residues a very light blue, some with reddish tint. When an excess of iodine is added, the grain-residues and the solution deepen in tint and the capsules color a deep heliotrope to a wine-red, more reddish than in *C. americana*.

Staining Reactions.—With *gentian violet* the grains show a very faint trace of violet at once and in 30 minutes they are very lightly stained. The coloration is about the same as in *C. americana*.

With *safranin* the grains do not stain immediately, and in 30 minutes there is simply a trace of the stain. The coloration is about the same as *C. americana*.

Temperature Reaction.—The temperature of gelatinization is 59° to 61° C., mean 60°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. Several grains are gelatinized in 10 seconds, the majority in 30 seconds, all but a few resistant grains in 45 seconds, and all in a minute. The reaction is qualitatively the same as in *C. americana*.

The reaction with *chromic acid* begins at once and practically all the grains are dissolved in 5 seconds, and all in 10 seconds. The reaction is qualitatively the same as in *C. americana*.

Reaction with *pyrogallic acid* begins immediately. The reaction is complete in practically all the grains in 10 seconds, and in all in 15 seconds. The reaction is qualitatively the same as in *C. americana*.

With *ferric chloride* reaction begins in a few grains in 30 seconds. About half are gelatinized in a minute, two-thirds in 2 minutes, nearly all in 3 minutes, and all but rare resistant grains in 5 minutes. The latter may take from 8 to 10, rarely 15, minutes for the completion of the reaction. The reaction is qualitatively the same as in *C. americana*.

The reaction with *Purdy's solution* begins immediately. A few grains are gelatinized in 20 seconds, the majority in 30 seconds, four-fifths in a minute, and all but rare resistant grains in 5 minutes. The reaction is usually complete in the latter in 8 minutes, but rarely takes 30 minutes. The grains in which reaction is slow are those of rather small size with a regular outline. The reaction is qualitatively the same as in *C. americana*.

STARCH OF CASTANEA SATIVA VAR. (Chart 71.)

The preparation was made from a large "Italian chestnut," which was not identified.

Histological Characteristics.—In *form* the grains are usually simple, and are isolated, except some which occur in clumps and a small number in aggregates. There are a few compound grains of few components. Some isolated grains have well-marked pressure facets. The irregularity of the surface and the locations and structure of the protuberances are identical with those of *C. americana*. The conspicuous forms are the same as those noted under *C. americana*, but a greater proportion of grains are large or have irregular outlines.

The *hilum* is not usually demonstrable. Occasionally an irregular cavity or elongated cleft may be distinguished at its position, and very rarely it is observed as a round spot, usually two-fifths to one-fifth eccentric of the longitudinal axis; it may be centric. A single longitudinal cleft with or without radiating fissures may proceed from the hilum. Sometimes the hilum may be pierced by a short transverse or diagonal cleft, or these fissures may be located slightly distal to the hilum.

The *lamellæ* are not usually demonstrable, but when observed are of similar structure to those noted under *C. americana*. Occasionally 6 to 8 lamellæ may be counted on the large grains.

The grains vary in *size* from the smaller, which are 4 by 3μ, to the larger, which are 22 by 12μ in length and breadth. The common size is 12 by 7μ in length and breadth.

Polariscopic Properties.—The *figure* is in all essential respects identical with that observed in *C. americana*.

The degree of *polarization* is fair to high. The proportion of grains in which it is high is greater than in *C. americana*.

With *selenite* the definition, size, and shape of the quadrants is identical with that noted for *C. americana*. The purity of the colors is the same as in *C. americana*.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet, which becomes very deep in 2 minutes; with 0.125 per cent solution the grains color a fairly deep blue-violet, which becomes quite deep in 2 minutes. After heating the grains in water until all are gelatinized, the solution becomes a deep blue and the grains a bright blue with a slightly reddish tint on the addition of iodine. The grains are brighter and lighter in tint and the solution a purer blue than in *C. americana*. When the grains are boiled for 2 minutes and then treated with iodine, the solution becomes a deep indigo-blue and the grain-residues a blue-violet color, lighter in tint than those of *C. americana*. When an excess of iodine is added most of the grain-residues become a deep heliotrope in color, but some of the capsules take on a wine-red of rather brighter tint than those of *C. americana*.

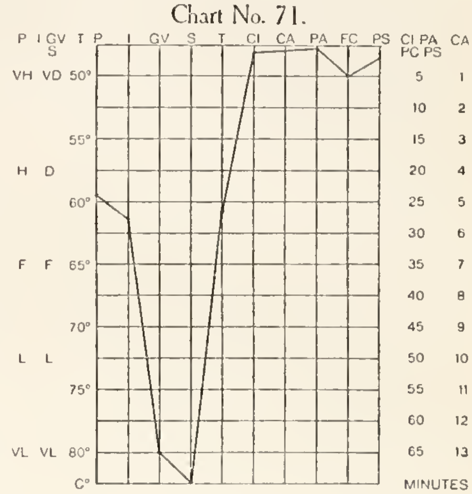
Staining Reactions.—With *gentian violet* and with *safranin* the color of the grains after 30 minutes is very light, about the same as that of *C. americana*.

Temperature Reaction.—The temperature of gelatinization is 60° to 62° C., mean 61°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins immediately. The majority of the grains are gelatinized in 30 seconds and all in a minute. The reaction is qualitatively the same as in *C. americana*, but the coloration of the grains which precedes the deep blue is not so reddish in tint, and the color of the gelatinized grains is a purer blue than in the grains of *C. americana*.

Reaction with *chromic acid* begins immediately and all but very rare resistant grains are dissolved in 10 seconds. In one of the latter the reaction took 30 seconds for completion. The reaction is qualitatively the same as in *C. americana*.

Chart No. 71.



Curve of Reaction-Intensities of Starch of Castanea sativa var.

The reaction with *pyrogallic acid* begins immediately. Most grains are gelatinized in 15 seconds and all in 20 seconds. The reaction is qualitatively the same as in *C. americana*.

With *ferric chloride* swelling begins in a few grains in 30 seconds. A small number are gelatinized in a minute, the majority in 2 minutes, and all but very few resistant grains in 5 minutes. The latter are generally gelatinized in 12 minutes, rarely not for 20 minutes. The reaction is qualitatively the same as in *C. americana*.

The reaction with *Purdy's solution* begins at once. A few are gelatinized in 20 seconds, the majority in 40 seconds, at least nine-tenths in a minute, and all but rare resistant grains in 2 minutes. Such resistant grains may not be gelatinized for 6 minutes, or rarely 10 minutes. The reaction is qualitatively the same as in *C. americana*.

STARCH OF CASTANEA PUMILA. (Plate 13, figs. 73 and 74. Chart 72.)

Histological Characteristics.—In *form* the grains are usually simple, and are isolated, except a few which occur in clumps or in aggregates. There are a few compound grains, generally of two or three components. A few isolated grains have clearly marked pressure facets. The irregularity of the surface and the locations and structure of the protuberances are the same as in *C. americana*. The conspicuous forms are ovoid, ellipsoidal, club-shaped with pointed distal end, somewhat bean-shaped, and nearly round. There are some triangular with rounded angles, lenticular, dome-shaped, hemispherical, heart-shaped, and irregular grains of indefinite form.

Either passing through or proceeding from the *hilum*, an elongated cleft is frequently found, with or without radiating fissures. Occasionally the hilum may be observed as a clear, round, or lenticular spot, usually eccentric about one-third to one-fourth of the longitudinal axis. A single longitudinal cleft frequently proceeds from the hilum, and sometimes a transverse cleft is found piercing it or located slightly distal to it. These two fissures may occasionally intersect each other so as to form a cross. The fissures are more frequently present and are deeper than those in the grains of *C. americana*.

The *lamellæ* are rarely demonstrable, and they are of similar structure to those noted under *C. americana*. On grains of fair size 7 may be counted.

The grains vary in *size* from the smaller, which are 3 by 2μ, to the larger, which are 18 by 10μ in length and breadth. The common size is 10 by 7μ in length and breadth.

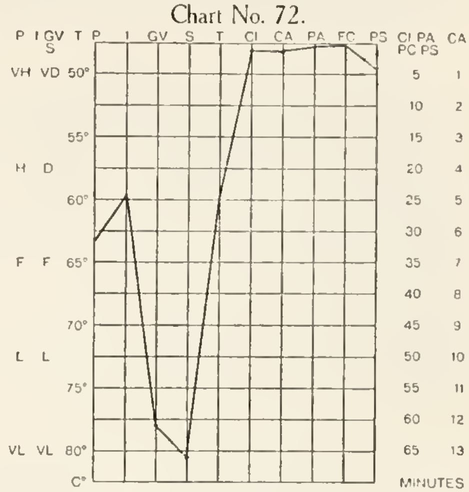
Polariscopic Properties.—The *figures* are the same as those noted for *C. americana*. The proportion of grains in which the figure is of the bean type, consisting of an elongated line with bisected ends, is rather higher than in *C. americana*.

The degree of *polarization* is fair to high. The proportion of grains in which polarization is high is smaller than in *C. americana*. The variation in the same aspect of a given grain is the same as in *C. americana*. On the whole, polarization is lower than in *C. americana*.

With *selenite* the quadrants are not so well defined as in *C. americana*, but otherwise essentially the same. The colors are pure in the larger number of grains, with considerable variation in the different grains and even in the same aspect of a given grain. The yellow of one quadrant may be impure in parts, but pure in the other three. The colors are not pure in as large a proportion of the grains as in those of *C. americana*.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather deep violet, which becomes very deep in 2 minutes; with 0.125 per cent solution the grains color a very light reddish-violet, which deepens gradually in 5 minutes. The color is a little deeper and of a more reddish tint than in *C. americana*. After heating in water until all the grains are gelatinized, the solution becomes of a heliotrope color and the grains a reddish blue to a heliotrope on the addition of iodine. If the grains are boiled for 2 minutes and then treated with iodine, the solution assumes a deep purplish-blue and the grain-residues a light red-violet. With an excess of iodine the capsules color an old-rose to wine-red. There is rather more red color in the solution, grain-residues, and capsules than in *C. americana*.

Chart No. 72.



Curve of Reaction-Intensities of Starch of Castanea pumila.

Staining Reactions.—With *gentian violet* and with *safranin* there is no reaction at once, except in a few grains in which the deep central cleft is slightly colored. In 30 minutes the grains are lightly colored, the tint being deeper at the cleft. The color is slightly deeper than in *C. americana*.

Temperature Reaction.—The temperature of gelatinization is 59° to 60.5° C., mean 59.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in 20 seconds, the majority in 30 seconds, and all in a minute except rare resistant grains in which the reaction is usually complete in 1½ minutes and rarely 3½ minutes. The slit-like structure which becomes irregular in outline during gelatinization is more frequently observed than in *C. americana*. The reaction is qualitatively the same as in *C. americana*.

Reaction with *chromic acid* begins at once and all the grains are dissolved in 15 seconds. The reaction is qualitatively the same as in *C. americana*.

The reaction with *pyrogallic acid* begins at once. Many grains are gelatinized in 5 seconds and all in 10 seconds. The reaction is qualitatively the same as in *C. americana*.

With *ferric chloride* swelling begins in a few grains in 20 seconds. A small number are gelatinized in a minute, about half in 2 minutes, the majority in 3 minutes, and all in 4 minutes, except a few resistant grains which may not be gelatinized for 10 to 27 minutes. The formation of a bubble at the hilum or of a slit-like structure in the central part of the grain, which enlarges and then collapses, is more frequently observed than in *C. americana*. The reaction is qualitatively the same as in *C. americana*.

With *Purdy's solution* reaction begins immediately. A few grains are gelatinized in 10 seconds, nearly all in 30 seconds, and all but a few resistant grains in a minute, the latter grains being completely gelatinized in 2 to 3 minutes. The reaction is qualitatively the same as in *C. americana*.

Differentiation of Certain Starches of the Genus Castanea.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

C. americana: Usually simple, few aggregates and compound grains, few pressure facets, surface irregular owing chiefly to wart-like protuberances. Ovoid, somewhat bean-shaped, ellipsoidal, club-shaped with pointed end, pyriform.

C. sativa var. *numbo:* Essentially the same as in *C. americana*.

C. sativa var.: Essentially the same as in *C. americana*, but greater proportion of larger grains and irregular grains.

C. pumila: Essentially the same as in *C. americana*.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.

C. americana: Form usually not demonstrable, clear, round spot; rarely an irregular cavity; single longitudinal or a transverse or diagonal fissure. Position usually eccentric about 0.4 to 0.3 of the longitudinal axis.

C. sativa var. *numbo:* Form same as in *C. americana*, but fissures more often present and deeper. Position usually eccentric about 0.4 to 0.2 of longitudinal axis.

Differentiation of Certain Starches of the Genus Castanea.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.—Continued.

C. sativa var.: Form same as in *C. sativa* var. *numbo*. Position the same as in *C. sativa* var. *numbo*.
C. pumila: Form same as in *C. sativa* var. *numbo*. Position usually eccentric about 0.3 to 0.25 of the longitudinal axis.

Lamellæ—General Characteristics and Number.

C. americana: Rarely demonstrable, rather coarse complete rings. Number not determined.
C. sativa var. *numbo:* Same as in *C. americana*, except more often demonstrable. 8 to 10 on the larger grains.
C. sativa var.: Same as in *C. americana*. 6 to 8 on the larger grains.
C. pumila: Same as in *C. sativa* var. *numbo*. 8 to 10 on the larger grains.

Size.

C. americana: From 3 to 16μ, commonly 9μ.
C. sativa var. *numbo:* From 3 to 30μ, commonly 14μ.
C. sativa var.: From 4 to 22μ, commonly 12μ.
C. pumila: From 3 to 18μ, commonly 16μ.

POLARISCOPIC PROPERTIES.

Figure.

C. americana: Usually eccentric, not always distinct, in some grains of bean type.
C. sativa var. *numbo:* Same as in *C. americana*, but bean-type figure more common.
C. sativa var.: Same as in *C. americana*.
C. pumila: Same as in *C. sativa* var. *numbo*.

Degree of Polarization.

C. americana: Fair to high.
C. sativa var. *numbo:* Fair to quite high, the proportion of grain in which polarization is high is greater than in *C. americana*.
C. sativa var.: Fair to high, higher on the whole than in *C. americana*.
C. pumila: Fair to high, the proportion of grains in which polarization is high is lower in *C. americana*.

Polarization with Selenite—Quadrants and Colors.

C. americana: Quadrants fairly well-defined, usually unequal in size, and irregular in shape. Colors fairly pure.
C. sativa var. *numbo:* Quadrants better defined and more clear-cut than in *C. americana;* usually unequal in size and often irregular in shape. Colors commonly pure.
C. sativa var.: Quadrants same as in *C. americana*. Colors fairly pure.
C. pumila: Quadrants less well defined than in *C. americana*, otherwise essentially the same. Colors less pure than in *C. americana*.

IODINE REACTIONS.

Intensity and Color.

C. americana: Fairly deep; blue-violet.
C. sativa var. *numbo:* Fairly deep, same as in *C. americana;* blue violet.
C. sativa var.: Deep, deeper than in *C. americana;* blue-violet.
C. pumila: Fairly deep, slightly deeper than in *C. americana;* blue-violet, more reddish than *C. americana*.

STAINING REACTIONS.

With Gentian Violet.

C. americana: Very light.
C. sativa var. *numbo:* Very light, same as in *C. americana*.
C. sativa var.: Very light, same as in *C. americana*.
C. pumila: Light, slightly deeper than in *C. americana*.

With Safranin.

C. americana: Faint.
C. sativa var. *numbo:* Faint, same as in *C. americana*.
C. sativa var.: Faint, same as in *C. americana*.
C. pumila: Very light, slightly more than in *C. americana*.

TEMPERATURE OF GELATINIZATION.

C. americana: 58.5 to 60° C., mean 57.25°.
C. sativa var. *numbo:* 59 to 61° C., mean 60°.
C. sativa var.: 60 to 62° C., mean 61°.
C. pumila: 59 to 60° C., mean 59.75°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

C. americana: Begins immediately; complete in practically all in 60 seconds.
C. sativa var. *numbo:* Begins immediately; complete in practically all in 45 seconds.
C. sativa var.: Begins immediately; complete in all in 60 seconds.
C. pumila: Begins immediately; complete in practically all in 60 seconds.

Reaction with Chromic Acid.

C. americana: Begins immediately; complete in practically all in 10 seconds.
C. sativa var. *numbo:* Begins immediately; complete in practically all in 5 seconds.
C. sativa var.: Begins immediately; complete in practically all in 10 seconds.
C. pumila: Begins immediately; complete in all in 15 seconds.

Reaction with Pyrogallic Acid.

C. americana: Begins immediately; complete in practically all in 10 seconds, and in all in 15 to 20 seconds.
C. sativa var. *numbo:* Begins immediately; complete in practically all in 10 seconds, and in all in 15 seconds.
C. sativa var.: Begins immediately; complete in most in 15 seconds, and in all in 20 seconds.
C. pumila: Begins immediately; complete in all in 10 seconds.

Reaction with Ferric Chloride.

C. americana: Begins in a few grains in 30 seconds; complete in practically all in 5 minutes.
C. sativa var. *numbo:* Begins in a few grains in 30 seconds; complete in practically all in 5 minutes.
C. sativa var.: Begins in a few in 30 seconds; complete in practically all in 5 minutes.
C. pumila: Begins in a few grains in 20 seconds; complete in practically all in 4 minutes.

Reaction with Purdy's Solution.

C. americana: Begins immediately; complete in practically all in 3 minutes.
C. sativa var. *numbo:* Begins immediately; complete in practically all in 5 minutes.
C. sativa var.: Begins immediately; complete in practically all in 2 minutes.
C. pumila: Begins immediately; complete in practically all in 1 minute.

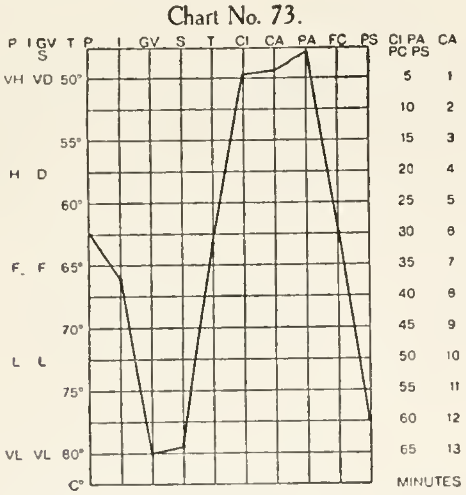
NOTES ON THE STARCHES OF CASTANEA.

Such differences as have been recorded in the histological characteristics of these starches are so trifling as to be practically useless in diagnosis. In the reactions the differences are in no case marked, thus indicating a very close botanical relationship. Excepting the starch of *Castanea sativa* var., which is of unknown source, it will be observed that there is close correspondence between these starches, and that *C. pumila* stands a little apart, a distinction that is to be expected upon the basis of the recognized botanical differences.

NOTES ON THE STARCHES OF CUPULIFERÆ. (Charts 73 and 74.)

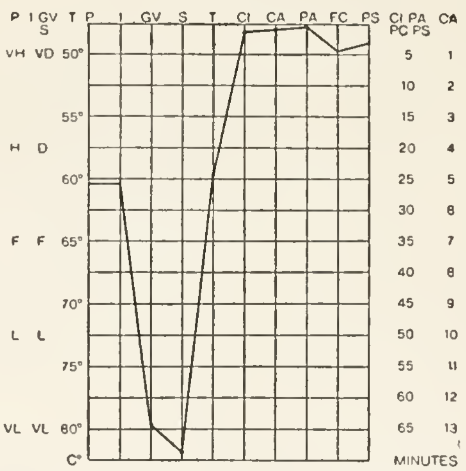
The starches of the two genera representing this family show manifest relationships in their various peculiarities. The histological likeness is quite apparent, but in *Quercus* are exhibited larger grains, less irregularity in form, a relatively less abundance of nipple-like processes, and more evident hilum and lamellæ. There are also close correspondences in the reactions, but the composite reaction curves of the two genera are sufficiently different to distinguish one from the other: In *Quercus* the average degree of polarization is lower, the sensitivity to iodine greater, the temperature of gelatinization higher, and the sensitivities to safranin, chloral hydrate-iodine, chromic acid, pyrogallic acid, ferric chloride, and Purdy's solution in most instances are different from those of *Castanea*. While, therefore, the histological differences are trifling, the reaction differences are in the aggregate marked.

Chart No. 73.



Composite Curve of Mean Reaction-Intensities of Starch of Quercus.

Chart No. 74.



Composite Curve of Mean Reaction-Intensities of Starch of Castanea.

STARCH OF SAPINDACEÆ.

Class, Dicotyledones. Order, Æsculinales. Family, Sapindaceæ. Genus represented, Æsculus.

GENUS ÆSCULUS.

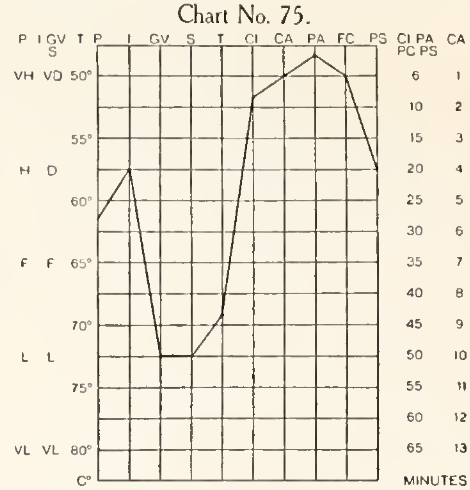
About a dozen species of the genus *Æsculus* are recorded, all said to be native to North America, Eastern Asia, and the Himalayas to Northern Greece. *Æsculus* includes the well-known horse chestnut or buckeye, which is cultivated extensively as a shade tree, and in some countries also for the fruit or seed, which is used for food for sheep and other animals. The native American species are represented chiefly by *Æ. octandra* Marsh (the sweet buckeye), *Æ. glabra* Willd. (the fetid buckeye), and *Æ. californica*, Nutt. The starch used was obtained from the fruit of *Æ. hippocastanum* Linn., the common horse chestnut, which is native of the region from the Himalayas to Northern Greece, but grown quite largely elsewhere.

STARCH OF ÆSCULUS HIPPOCASTANUM. (Plate 13, figs. 75 and 76. Chart 75.)

Histological Characteristics.—In *form* the grains are simple and isolated. The surface of the grains is somewhat irregular, the irregularities being due to slight rounded elevations and depressions and to small and large rounded protuberances from the margin. The distal end usually appears thinner than the rest of the grain and sometimes is not lamellated. The conspicuous forms are the elongated oval, having a narrow, pointed, distal end, ellipsoidal, pyriform, and spherical or nearly spherical. The grains are narrower at the distal than at the proximal end.

The *hilum* is a fairly distinct, rather small round spot, sometimes centric in the lenticular and spherical forms, but eccentric in most of these and in other forms. The eccentricity is commonly one-third to one-fifth of the longitudinal diameter and is usually about one-fourth. The hilum is sometimes fissured, the fissure usually being single and in the form of a straight but rather broad and irregular transverse cleft, or a transverse line having a double curve resembling the lines of the outstretched wings of a flying bird. Sometimes a longitudinal fissure extends from the hilum nearly to the distal margin.

Chart No. 75.



Curve of Reaction-Intensities of Starch of Æsculus hippocastanum.

The *lamellæ* are fairly distinct in the large grains, but indistinct in the medium to smaller grains; they are rather coarse, somewhat irregular, continuous bands, circular near the hilum, but elsewhere tending to follow the outline of the margin. They often vary much in size in different parts of the grain. There are about 20 on the larger grains.

The grains vary in *size* from the smaller, which are 1μ, to the larger, which are 32 by 16μ in length and breadth. The common size is 20 by 12μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric except in some lenticular and spherical forms. It is fairly distinct and usually fairly clear-cut. Frequently one or more lines composing it may not be visible on account of the low or absent polarization in some parts of the grain. The lines are generally curved and occasionally bisected.

The degree of *polarization* is fair, varying somewhat in different grains, and is higher in the same grain when viewed on end. It is low or absent in some parts of some grains.

With *selenite* the quadrants are generally well defined, irregular in form, and unequal in size. The colors, while not very bright, may be quite pure, though the yellow is often mixed with red.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are all colored a deep blue-violet; with 0.125 per cent solution they are colored fairly, but the color does not deepen rapidly.

After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains deeply on addition of iodine. After boiling for 2 minutes the solution colors very deeply and most of the grain-residues lightly. The capsules color pinkish-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fair to lightly stained.

With *safranin* the grains begin to stain at once and in 30 minutes are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 68.5° to 70° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in the small grains in 20 seconds and in the large grains in 45 seconds. All the small grains are gelatinized in a minute and all the large grains in 8 minutes. The reaction begins in all the grains at the pointed distal end, which grows dark but does not swell very much. Then the reaction progresses about the margin and over the rest of the surface into the interior. The grain does not swell very much until the hilum is reached, at which point a bubble is usually seen to be present. The bubble increases very greatly in size as the starch surrounding the hilum darkens and swells rapidly, and then decreases and finally disappears. The gelatinized grains are fairly large and retain much of their original form. They usually show a light center surrounded by a thick, dark band.

The reaction with *chromic acid* begins in 15 seconds and is over in a minute. The reaction begins at the distal end, which protrudes in the form of a large, thin-walled mass; then the grain becomes largely covered by fine striæ, which grow coarse, and the interior is broken up into coarse granules, while the margin is transformed into a fairly thick band, which is striated and shows remains of lamellæ. This band is discontinuous at the distal end. The granules melt down into a gelatinous mass and the marginal band becomes thinner and homogeneous in appearance as the whole grain swells. Then the capsule at the distal end dissolves, and the gelatinous starch in the interior flows out and is dissolved, and the marginal band is dissolved later from the distal end upward.

Reaction with *pyrogallic acid* in some grains begins in a few seconds, in all in 30 seconds, and is over in 2 minutes. It begins at the distal end, which swells greatly; then the starch about the hilum becomes gelatinous, the grain is marked by fine striæ, and the starch in the center of the area between the hilum and the distal end is broken up into granules, while the marginal portion forms a thick band, which is striated and marked by the remains of the lamellæ and is discontinuous at the distal end. The granules break down into a gelatinous mass, the grain swells, and the marginal band becomes fairly thin and homogeneous in appearance. The gelatinized grains are large and have a convoluted and twisted, thin-walled distal end and a smooth, thick-walled proximal end. They retain some of their original form.

With *ferric chloride* most of the smaller grains begin to react in 30 seconds, and some of the larger grains in 45 seconds. The reaction is over in practically all in 5 minutes. The distal end is the first to show change. It becomes gelatinous and swells out irregularly. If the grains are much pointed at the proximal end this also becomes gelatinized, swells out in the same way, and then the process advances from both ends to the central part, which frequently is the first part to split into several pieces which gelatinize separately. In grains not pointed at the proximal end the distal end is affected; then the process moves upward over the rest of the grain, and frequently before the starch around the hilum and at the proximal end is gelatinized it is split into several pieces which gelatinize later. The gelatinized grains are very large and much convoluted and irregular at the distal end, but smooth in the rest of the grain.

The reaction with *Purdy's solution* begins in most of the small grains and in some of the large grains in 30 seconds. Many small grains and some medium-sized grains are gelatinized in 3 minutes, and all of the small and large grains are nearly or completely gelatinized in 20 minutes.

NOTES ON THE STARCH OF ÆSCULUS HIPPOCASTANUM.

A relationship is commonly associated in the popular mind between the common chestnut and the horse chestnut, both on account of the similarity of the names and the gross general likeness of the seeds. It will be seen by an examination of the text and photographs that the starches of the seeds of these two genera are quite different. In histological characteristics the two kinds of starches could not be confounded, and in the reactions the differences are diagnostic, most noticeably in the temperature of gelatinization (9° difference).

STARCHES OF AROIDEÆ.

Class, Monocotyledones. Order, Arales. Family, Aroideæ. Genera represented: Arum, Arisæma, Dracunculus, Richardia, Dieffenbachia.

The *Aroideæ* constitute a large group of tuberous, herbaceous plants, mostly acaulescent, and including about 100 genera and 1000 species. We have studied starches from representatives of 5 of these genera. An acrid principle is present in various degrees of abundance or intensity throughout the family, and in some species it is so developed as to render the juice of parts of the plant more or less markedly poisonous.

GENUS ARUM.

The genus *Arum* is a recognized type of the family of which a number of members are grown under the common name of Calla, though they are not the true Callas, the latter constituting another genus. There are about 50 species, mostly natives of temperate and semitropical Asia. Preparations of starch were obtained from three sources: *Arum palæstinum* Boiss. (*A. sanctum* Hort.), the black calla or Solomon's lily; *A. cornutum*, a doubtful species; and *A. italicum* Miller, one of the most variable species.

STARCH OF ARUM PALÆSTINUM. (Plate 13, figs. 77 and 78. Chart 76.)

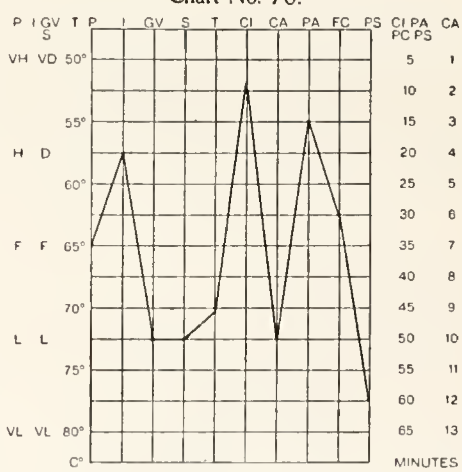
Histological Characteristics.—In *form* the grains are simple, mostly isolated and faceted. They occur rarely in small aggregates, more frequently in large clumps. The facets are very distinct and clear-cut, and somewhat concave. The most conspicuous forms appear to be the dome-shaped and hemispherical, with two or three, or even four, pressure facets at the distal end, triangular and spherical. When three or more facets exist they are grouped around a common center. Ovoid, with or without facets, quadrangular, and multiangular forms are seen, and the last are usually very irregular in shape. There are also grains, spherical or ovoid, having both ends flattened by facets.

The *hilum* is a small, fairly distinct, non-refractive spot, usually situated slightly eccentrically; rarely fissured, and if a fissure is present, it is neither deep nor wide. At times there is an appearance at the hilum of the existence of a smooth hole.

The *lamellæ* are concentric rings, not very distinct. Sometimes all follow the outline of the margin, and sometimes only those near the margin do so. One is, as a rule, much more prominent than the others, and it outlines a small area near by the hilum; only 8 on one grain could be counted with certainty.

The grains vary in *size* from 2 to 20μ; common size is 14μ.

Chart No. 76.



Curve of Reaction-Intensities of Starch of Arum palæstinum.

Polariscopic Properties.—The *figure* is distinct, clear-cut, and regular in shape, and generally slightly eccentric. The figure is altered in accord with changes to the shape of the grain. The lines may broaden out as they approach the margin, and become less distinct; or they may be of the same size and distinctness throughout their length.

The degree of *polarization* is fair; absent or very low in some of the grains, and in other grains absent only at the facets, where there is a depression. It is lower than in the other *Arum* starches.

With *selenite* the quadrants are well defined, and of nearly the same shape and equal in size in most grains. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color blue-violet readily and deeply; with 0.125 per cent solution they color less than in *A. cornutum.* After heating the preparation until all the grains were completely gelatinized, the solution is not colored at all on the addition of Lugol's solution. The gelatinized grains are colored deeply and much distorted and crumpled. After boiling the preparation for 2 minutes, the solution is colored deeply, but the grain-residues lightly or not at all upon the addition of iodine. On the addition of a slight excess of Lugol's solution the capsules color a violet.

Staining Reactions.—With *gentian violet* the staining begins in 5 minutes and in 30 minutes it is light.

With *safranin* the staining begins in 1½ minutes, but at the end of 30 minutes the grains are only lightly colored. With this stain the color of the grains is not as deep as that of *A. cornutum*, but deeper than that of *A. italicum.*

Temperature Reaction.—The temperature of gelatinization is 70° to 71° C., mean 70.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a minute and all the grains are darkened and the reaction over in 8 minutes. The hilum becomes prominent, but the lamellæ, except those especially distinct, are obscured. The grains are colored violet and begin to darken, especially at the edges and corners of the facets. The whole margin becomes dark, and this color spreads inward until the entire grain is colored. The grains swell somewhat during this process and become gelatinous. The gelatinized grains formed are not very large; they are rounded, and retain much of the original form. The color is uniformly a dark indigo, except for a clear, light, round space at or near the swollen hilum.

The reaction with *chromic acid* begins in 30 seconds and is over in 10 minutes. The hilum is very distinct, but the lamellæ not especially so. The hilum swells slightly, and fine striæ radiating from the hilum appear on all throughout the grain. These striæ become larger and more distinct, often in a stellate form, as the hilum continues to swell. The undissolved part of the grain is pushed out to the margin, and there is formed a marginal band consisting of two layers, the inner being a single layer of large, distinct, widely separated granules, and the outer a comparatively thin, finely striated band, which does not show the alternate refractive and non-refractive lines so plainly as in some of the starches of other genera; this band becomes thinner and clearer as the grain continues to swell, often growing much distorted by invaginations. Finally, the capsule dissolves at one point, allowing the inner granular matter to flow out and dissolve, followed by the solution of the capsule.

Reaction with *pyrogallic acid* begins slightly in 2 minutes and is over in 15 minutes. The hilum becomes prominent, but the lamellæ are not rendered more distinct. The hilum swells slightly and fine striæ appear, radiating from the hilum and becoming larger and more distinct. The non-refractive lines radiating from the hilum to the corners of the facets now become very clear. The hilum continues to swell slowly, the mass of the grain swelling at the same time. The more resistant starch at the margin forms a band of two layers, one being in the form of a single row of granules, the other a rather thin, homogeneous band which shows fine striæ and indistinct, alternate refractive and non-refractive lines. The gelatinized grains are fairly large, not much distorted, folded, or crumpled, and retain much of the original shape of the grain.

With *ferric chloride* reaction begins in 2 minutes and is over in 30 minutes. The hilum is quite distinct, but the lamellæ are invisible. The margin becomes clear and darker, but the inner portion of the grain appears lighter and opaque. The hilum begins to swell and two lines appear, which run to the corners of the facets. The hilum swells slowly and fine striæ arise throughout the substance of the grain. A band formed at the margin consists of an inner single row of coarse granules and an outer striated part formed of ungelatinized starch. This band becomes thinner, clearer, and quite homogeneous. Or the grain may gelatinize quickly and the hilum may swell without becoming very prominent. The gelatinized grains are not much distorted. When the process is slower, there is some sign of preliminary gelatinization of the margin, but this mode of dissolution is rare.

With *Purdy's solution* the reaction begins very slightly in 10 minutes. After 2 hours only about half the grains are at all affected and very few are completely gelatinized. The hilum and lamellæ become very distinct. Often the only change noted was the swelling of the hilum and the appearance of fine striæ throughout. As this process progresses, the inner portion of the grain is gelatinized, and the more resistant marginal portion forms a thick band, but the reaction does not go any further.

STARCH OF ARUM CORNUTUM. (Plate 14, figs. 79 and 80. Chart 77.)

Histological Characteristics.—In *form* the grains are simple and for the most part isolated; nearly all show one or more facets. Small aggregates of two or three or more grains are seen, and also rare larger aggregates. The pressure facets are not usually so sharply defined as in other *Arum* starches. The most conspicuous forms are the spherical and the ovoid, with one or more small, not very clearly defined facets; dome-shaped and hemispherical grains, with one, two, or three facets, or quite typically three at the base grouped triangularly about a common center. Polygonal forms are not uncommon, especially among the smaller grains, which usually are irregular in shape, owing to the differences in size, number, and position of the facets.

The *hilum* is a fairly distinct, round, non-refractive spot, eccentrically or nearly centrally placed. It is very rarely fissured, and if so the fissures are not deep or broad, and may be single lines placed transversely or diagonally, or consist of three lines variously arranged.

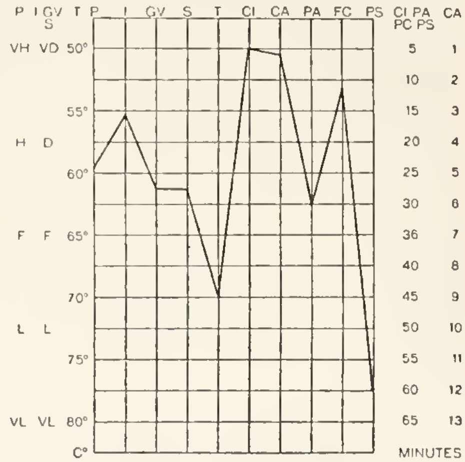
The *lamellæ* are very distinct, regular, concentric rings, which may or may not follow the outline of the margin; they follow it if the grain is of the dome-shaped type and the facets large. Some show an irregularity of outline which does not seem to depend on the form of the grain. Two are usually more distinct than the others, one rather near the hilum appears to outline a definite area about the hilum, and the other is about midway between this and the periphery. The number of the lamellæ varies between 10 and 16.

The grains vary in *size* from 2 to 24μ. The common size is 15μ.

Polariscopic Properties.—The *figure* is clear-cut, distinct, and regular in shape, usually slightly eccentric. The lines are generally of the same size and distinctness throughout their length. The figure is sometimes rendered peculiar by the facets, so that one line may appear to have two branches, etc. Lines indicating the positions of lamellæ could be distinguished on one or two of the larger grains. The figure is typically in the form of a cross.

The degree of *polarization* is fairly high. Inasmuch as the grains are of or closely approach the spherical form, there is not much variation according to the aspect viewed. Owing to the fact that there are concavities in the faceted surfaces, polarization is often low at these points.

Chart No. 77.



Curve of Reaction-Intensities of Starch of Arum cornutum.

With *selenite* the quadrants are well defined and usually of nearly the same shape and size. The colors are quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once and quite deeply. With 0.125 per cent solution they tint lightly at once, but the color deepens quickly. This starch is the most sensitive to iodine of the *Arum* starches. After heating the solution until the grains are completely gelatinized, the solution is colored slightly and some of the grains deeply and others lightly on the addition of iodine. Some of the colored capsules or portions of capsules are colored violet on adding more iodine. After boiling 2 minutes, the solution colors more deeply, but the grain-residues less deeply and some not at all, many being reduced to mere granular masses. All the uncolored capsules or portions of capsules are colored violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain in 2 minutes and after 30 minutes are stained fairly deeply to deeply.

With *safranin* the grains begin to stain in a minute, but at the end of 30 minutes are stained fairly deeply.

Temperature Reaction.—The temperature of gelatinization is 69.5° to 70.5° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds and all the grains are darkened and the reaction is practically over in 5 minutes. The hilum is often prominent as a dark spot. The lamellæ are not obscured. The grain is colored violet; then the margin begins to darken, especially about the corners of the facets, from here it spreads all around the margin, and then inward until the whole grain is dark. This is accompanied by very little and very gradual swelling. Quite commonly some of the marginal starch is gelatinized and protrudes, a reaction that appears to be characteristic of this species as compared with the other *Arums*. The capsules are uniformly dark, except for the lighter swollen hilum, and are not large or much distorted.

The reaction with *chromic acid* begins in 30 seconds and is over in 6 minutes. The hilum and lamellæ become prominent; fine striæ appear first about the hilum and then radiate throughout the grain, becoming more and more distinct, and the hilum is seen to swell. A clear inner space develops, which increases in size. The swelling is communicated to the entire grain, and the striæ open wider and become more distinct, and a band of two layers is formed at the margin of the large, clear, inner space. The inner layer of the band appears to be composed of one or two layers of granules formed by the widely separated striæ. The outer layer is more compact and presents the appearance of two or three alternate refractive and non-refractive layers crossed radially by fine striæ. The layers are very distinct in this starch. The grain continues to swell from the inside, the margin becomes thinner, clearer, and quite homogeneous. One part of the capsule protrudes and dissolves, permitting the contents of the capsule to stream out and be dissolved. The other parts of the capsule pass into solution slowly.

Reaction with *pyrogallic acid* begins in 30 seconds. After 30 minutes all the grains are affected and nearly all are fully gelatinized. In the reaction the hilum and lamellæ become prominent, fine striæ appear which radiate from the hilum, the hilum swells, the inner starch is converted into a gelatinous mass, and the more resistant marginal starch is formed into a band of two layers, the inner granular, the outer striated, but not so plainly marked by the refractive and non-refractive bands as in the reaction with chromic acid. This marginal starch, as the grain continues to swell, becomes smaller, clearer, and quite homogeneous. The gelatinized grains are fairly large and not much distorted, crumpled, or folded.

With *ferric chloride* reaction begins in a minute and is over in 12 minutes. The hilum becomes very prominent as a dark spot or bubble. Some of the coarser and more distinct lamellæ appear more clearly. The margin of the grain becomes clearer and darker, while the inner portion appears lighter and more opaque. In some of the more quickly reacting grains this clear appearance spreads over the whole grain, there is a little swelling, and the inner portion dissolves quickly; the margin is distinct, but very light and homogeneous. In the more slowly reacting grains the grain becomes divided by fine striæ and the inner portion dissolves and swells, causing general swelling. The undissolved portion at the margin forms a very broad, distinct ring marked with fine striæ and refractive and non-refractive bands. Only in the less sensitive grains can preliminary gelatinization of the margin be seen. A bubble forms at the hilum in some cases which gradually disappears as the grain swells. As the grains continue to enlarge the margin becomes thinner, lighter, and quite homogeneous, and invagination of one portion will often take place. The gelatinized grains are large and somewhat distorted by invagination, and are not much folded and crumpled, but retain much of the original shape of the grain.

The reaction with *Purdy's solution* begins very slightly in 30 seconds and is over in 15 minutes, about half of the grains being affected. The hilum and lamellæ, especially the latter, become very prominent. The hilum swells slightly and fine striæ appear which radiate from the hilum. As the hilum swells, the striæ become more distinct and concentric fissures appear in the lines of the more prominent lamellæ, thus forming apparently concentric rows of granules; while out towards the margin there is the usual appearance of fine striæ and refractive and non-refractive bands. As the grain continues to swell, this margin becomes thinner and homogeneous, until finally it is a thin, non-refractive line. The gelatinized grains are fairly large, and while some invagination may occur, especially at the faceted surfaces, they are not much crumpled or folded or otherwise distorted.

STARCH OF ARUM ITALICUM. (Plate 14, figs. 81 and 82. Chart 78.)

Histological Characteristics.—In *form* the grains are simple and for the most part isolated. They occur in part in small clumps or pseudo-aggregates, rarely in aggregates. The grains are usually marked with one or more pressure facets, usually very sharply defined and situated at the distal end of the grain. Facets may be on the sides also, but there is always some portion of the outside not so marked. There may be from one to five or six on a grain, and the presence of three at the distal end is not uncommon. The most conspicuous forms are the dome-shaped and hemispherical (marked by two or three facets), triangular, and spherical. There are a few quadrangular and irregularly polygonal forms, and some ovoid grains. They vary in shape according to the aspect viewed, because of differences in size, form, number, and position of the pressure facets.

The *hilum* is not distinct; it is a comparatively large round spot, usually very slightly eccentrically placed and always in or near the median line; lines extend on each side, continuing to the edges of the facets. The hilum is rarely distinctly fissured, and if so the fissure is generally regular, clean-cut, single, 3-armed, or stellate. There are no multiple hila.

The *lamellæ* are indistinct; only some near the hilum are visible. They are coarse, regular, concentric rings, invisible in many grains.

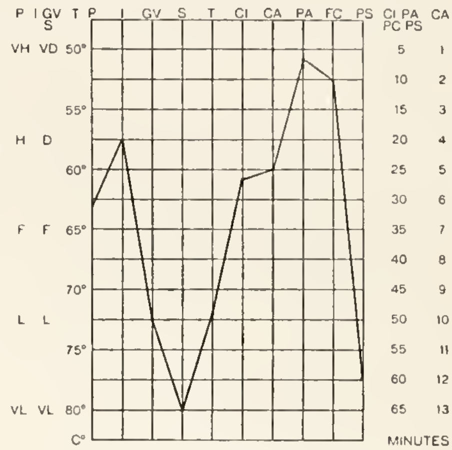
The grains vary in *size* from 2 to 16μ. The common size is 10μ.

Polariscopic Properties.—The *figure* is usually clean-cut, in the form of a cross; generally very slightly eccentric. The lines are broad and straight, tending to widen centrifugally.

The degree of *polarization* is fair, varying somewhat in different grains, being higher in the larger grains, and about the same in different aspects of the grains. It is higher than in *A. palæstinum.*

With *selenite* the quadrants are well defined, commonly regular in shape, and, as a rule, about equal in size. The colors are fairly pure.

Chart No. 78.



Curve of Reaction-Intensities of Starch of Arum italicum.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet. The depth of color is about the same as that of the grains of *Arum palæstinum.* Using 0.125 per cent solution the grains are colored lightly at first, the tint soon deepening, the reaction being the same as that of *A. palæstinum.* After heating until all the grains are completely gelatinized, the solution is colored deeply, but the grains not very deeply, upon the addition of iodine. After boiling for 2 minutes the solution is colored more deeply, the grain-residues faintly. All of the capsules contain some blue-reacting starch, and it is therefore often difficult to demonstrate the reaction of the capsule, but capsules devoid of blue-reacting starch become of a violet color with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly in 2 to 3 minutes, and after 30 minutes they are not much more stained. The color is the same as that in the grains of *A. palæstinum.*

With *safranin* the grains begin to stain very lightly in 30 seconds to a minute, but after 30 minutes the color has not deepened. The stain is lighter than that of *A. palæstinum.*

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in many grains in 30 to 60 seconds. About half are darkened in 5 minutes, all but a few in 15 minutes, and the reaction is over in practically all in 27 minutes. The hilum becomes more prominent, the edges and corners of the facets begin to darken and swell, the rest of the margin grows darker, and the process spreads inward over the whole grain. There is not much swelling connected with this reaction, and the line of demarcation between the swollen and unswollen portions is not marked. The gelatinized grains often show a central light space surrounded by a dark ring, and as they are not much swollen they retain much of the original form of the grain.

The reaction with *chromic acid* begins immediately and is over in 4 to 5 minutes. The hilum is not very prominent and it protrudes. The grain becomes divided by striæ which soon are enlarged into coarse fissures. The central, less resistant starch is changed into a gelatinous mass, and the outer, more resistant portion forms a ring at the margin, which at first is thick and coarsely striated, but later becomes thin and transparent. The ring or capsule dissolves at the proximal end, the contents pass out and are dissolved, and the capsule undergoes solution, the distal end being the last to disappear.

With *pyrogallic acid* there is a general reaction in 30 seconds. Most grains are gelatinized in 5 minutes and all in 7 minutes. The hilum becomes very prominent and then begins to swell. The grain is divided by fine striæ, and the less resistant portions pass into a gelatinous mass as the grain swells. The more resistant starch forms a finely striated ring at the margin, which ring becomes thinner and clearer as the grain swells. The gelatinized grains are fairly large and smooth and retain much of the original shape of the grain.

The reaction with *ferric chloride* begins in some grains in a minute; most are gelatinized in 5 minutes and all in 10 minutes. The reaction consists in the gelatinization and swelling of the less resistant central portion and the gathering of the more refractive portions at the margin in a more or less homogeneous ring. This ring grows thinner and transparent as gelatinization proceeds. The gelatinized grains are large and smooth and retain much of the original form of the grain.

The reaction with *Purdy's solution* begins in some grains at once and is general in 30 seconds. About half are gelatinized in 8 minutes and the others are in all stages of gelatinization. The reaction is similar to that with pyrogallic acid.

Differentiation of Certain Starches of the Genus Arum.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

A. palæstinum: Simple, mostly isolated. Dome-shaped and hemispherical, with two or three or more facets at distal end, triangular and spherical.
A. cornutum: Essentially the same as in *A. palæstinum* but the conspicuous forms are spherical, ovoid, dome-shaped, hemispherical, and triangular.
A. italicum: Essentially the same as in *A. palæstinum.*

Hilum—Form, Number, and Position.

A. palæstinum: Form fairly distinct, small, round, single; rarely fissured. Position usually slightly eccentric.
A. cornutum: Form same as in *A. palæstinum.* Position usually slightly eccentric.
A. italicum: Form not distinct, large round, single; rarely fissured. Position usually slightly eccentric.

Lamellæ—General Characteristics and Number.

A. palæstinum: Not very distinct, concentric rings; may or may not follow outline of margin, one prominent in region of hilum. 8 approximately on larger grains.
A. cornutum: Very distinct, coarse, concentric rings, may or may not follow outline of margin; two lamellæ usually very distinct; sometimes two sets of lamellæ. 10 to 16 on larger grains.
A. italicum: Indistinct; only some near hilum visible; coarse, regular, concentric rings. Number not determinable.

Size.

A. palæstinum: From 2 to 20μ, commonly 14μ.
A. cornutum: From 2 to 24μ, commonly 15μ.
A. italicum: From 2 to 16μ, commonly 10μ.

POLARISCOPIC PROPERTIES.

Figure.

A. palæstinum: Usually eccentric, clear-cut, regular in shape, in form of a cross.
A. cornutum: Same as in *A. palæstinum.*
A. italicum: Same as in *A. palæstinum.*

Degree of Polarization.

A. palæstinum: Fair.
A. cornutum: Fairly high.
A. italicum: Fair, higher than in *A. palæstinum,* and lower than in *A. cornutum.*

Polarization with Selenite—Quadrants and Colors.

A. palæstinum: Quadrants well-defined, and generally regular in size and shape. Colors not pure.
A. cornutum: Quadrants same as in *A. palæstinum.* Colors quite pure.
A. italicum: Quadrants same as in *A. palæstinum.* Colors fairly pure.

IODINE REACTIONS.

Intensity and Color.

A. palæstinum: Deep; blue-violet.
A. cornutum: Deep, deeper than in other *Arum* starches; blue-violet.

IODINE REACTIONS.—Continued.

Intensity and Color.—Continued.

A. italicum: Deep, the same as in *A. palæstinum;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

A. palæstinum: Light.
A. cornutum: Fairly deep to deep, much deeper than in *A. palæstinum.*
A. italicum: Light, same as in *A. palæstinum.*

With Safranin.

A. palæstinum: Light.
A. cornutum: Fairly deep, much deeper than in *A. palæstinum.*
A. italicum: Very light, less than in *A. palæstinum.*

TEMPERATURE OF GELATINIZATION.

A. palæstinum: 70 to 71° C., mean 70.5°.
A. cornutum: 69.5 to 70.5° C., mean 70°.
A. italicum: 71 to 73° C., mean 72°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

A. palæstinum: Begins in a minute; complete in 8 minutes.
A. cornutum: Begins in 30 seconds; complete in 5 minutes.
A. italicum: Begins in 30 to 60 seconds; complete in 27 minutes.

Reaction with Chromic Acid.

A. palæstinum: Begins in 30 seconds; complete in 10 minutes.
A. cornutum: Begins in 30 seconds; complete in 6 minutes.
A. italicum: Begins at once; complete in 5 minutes.

Reaction with Pyrogallic Acid.

A. palæstinum: Begins in 2 minutes; complete in 15 minutes.
A. cornutum: Begins in 30 seconds; complete in nearly all in 30 minutes.
A. italicum: Begins in 30 to 60 seconds; complete in 7 minutes.

Reaction with Ferric Chloride.

A. palæstinum: Begins in 2 minutes; complete in 30 minutes.
A. cornutum: Begins in a minute; complete in 12 minutes.
A. italicum: Begins in a minute; complete in 10 minutes.

Reaction with Purdy's Solution.

A. palæstinum: Begins in 10 minutes; half affected, a few completely gelatinized in 2 hours.
A. cornutum: Begins in 30 seconds; half affected and completely gelatinized in 15 minutes; no further reaction in 60 minutes.
A. italicum: Begins in 30 seconds; all are affected and half completely gelatinized in 8 minutes, the others partially gelatinized.

NOTES ON THE STARCHES OF ARUM.

The same type of starch-grain is exhibited by all of the *Arums,* and also by *Arisæma* and *Dracunculus,* which are closely related genera and formerly included among the former. The three starches are very closely in accord in their histological peculiarities. The differences in the degree of polarization are insignificant, but in the other reactions there are more or less significant variations, even with Purdy's solution, which acts very slowly. Each species can be readily distinguished from the others by peculiarities of the reactions.

GENUS ARISÆMA.

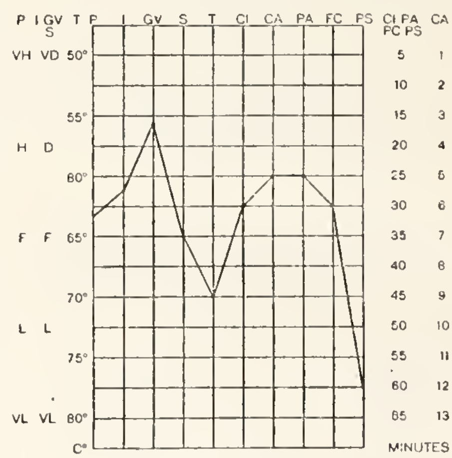
About 60 species of tuberous, herbaceous plants constitute this genus. Among the best known is *A. triphyllum* Torr., popularly known as the Jack-in-the-pulpit or Indian turnip. Starch was obtained from this species.

STARCH OF ARISÆMA TRIPHYLLUM. (Plate 14, figs. 83 and 84. Chart 79.)

Histological Characteristics.—In *form* the grains are simple and mostly isolated, they rarely occur in small aggregates and occasionally in clumps; all show pressure facets. The most conspicuous forms are the spherical and ovoid, marked with one or two small, rather poorly defined pressure facets; dome-shaped; hemispherical and triangular, all with pressure facets. There are also quadrangular and multiangular forms, the latter being uncommon. The dome-shaped and hemispherical forms often have three or four facets at the base, grouped about a common center. The facets on many grains are small and not definitely outlined; on others they are well defined and regular in shape. On end the grains usually appear round. The shape varies according to the position, number, and size of the facets.

The *hilum* is a very large, distinct, round, non-refractive spot, situated somewhat eccentrically; commonly fissured, the fissure being neither deep nor wide and usually a single transverse line; or there may be three lines arranged in an irregularly stellate fashion. The hilum may be double, and often appears to be in a well-defined area formed by one very distinct lamella.

Chart No. 79.



Curve of Reaction-Intensities of Starch of Arisæma triphyllum.

The *lamellæ* are very distinct, coarse, concentric rings which follow the outline of the margin. One or two are usually especially prominent, one outlining a space about the hilum as before stated, and the other being located about midway between the first and the margin of the grain. In a few grains there appear to be two sets of lamellæ which have no connection with each other, one consisting of a few very large, distinct lamellæ about the hilum, and the other of very fine indistinct lamellæ surrounding the first set. The lamellæ number from 8 to 16.

The grains vary in *size* from 3 to 28μ. The common size is 14μ.

Polariscopic Properties.—The *figure* is usually slightly eccentric, distinct, clear-cut, and in the form of a cross. The lines are broad, ragged, and of the same distinctness throughout their length, but may be broader near the margin. The figure is modified in a peculiar manner when the faceted end is seen, appearing as though there were more than one figure or as if the lines had branched.

The degree of *polarization* is fair. It is lower than that of *Arum cornutum*, but higher than in *A. palæstinum.* It is lowest at the faceted ends and highest when the grain is seen on end, and it also varies somewhat in different grains.

With *selenite* the quadrants are well marked, generally equal in size, and commonly regular in shape. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color readily and quite deeply a blue-violet; with 0.125 per cent solution they tint lightly, but the color deepens quickly. The coloration is less than with *A. palæstinum.* After heating the grains until they are completely gelatinized, the solution is not deeply colored on the addition of iodine, but the gelatinized grains color deeply. The grains are not much distorted or crumpled. After boiling 2 minutes, the solution is deeply colored, the grain-residues very little. With a slight excess of iodine the capsules become of a violet color.

Staining Reactions.—With *gentian violet* the grains begin to stain in 30 seconds. At the end of 30 minutes they are well stained. This starch stains the deepest of the four *Arum* starches studied.

With *safranin* the grains begin to stain in 30 seconds, but at the end of 30 minutes they are only fairly stained.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a minute. About half the grains are darkened in 5 minutes and nearly all are gelatinized in 30 minutes. The hilum becomes more distinct as a dark spot or fissure. The lamellæ appear as they do ordinarily. The whole grain is colored violet; then the faceted end begins to darken, with slight swelling. This process extends over the whole grain, advancing quickly along the margin on each side, and the entire grain finally becomes dark. There may be slight swelling after this. The gelatinized grains are not very large, and are uniformly dark, except a central, round, clear, lighter space representing the swollen hilum.

Reaction with *chromic acid* begins in 30 seconds and is practically over in 5 minutes. The hilum and lamellæ become very distinct. Fine striæ radiate from the hilum and become more and more distinct. The hilum swells, and subsequently the whole grain. The ungelatinized starch is pushed out to the margin, where it forms a ring having two layers. The inner layer consists of coarse granules, and the outer of striated refractive and non-refractive bands, which may or may not be distinct. The marginal part becomes thinner and lighter as the grain continues to swell, and finally invaginates at one or two places. One part of the capsule is dissolved, usually at one of the corners of the facets, the granular inner contents are poured out, and with the capsule quickly dissolve.

Reaction with *pyrogallic acid* begins in 30 seconds and is over in 25 minutes. The hilum and lamellæ become distinct. The grain is divided by fine striæ which radiate from the hilum. The hilum swells slowly at first, pushing out the ungelatinized starch to the margin. A very thick ring is thus formed, which has the commonly observed two layers, refractive and non-refractive, both very prominent. This ring becomes thinner and clearer, and the grain-wall or capsule frequently invaginates, often at the proximal end as this end swells. Finally, a large round or ovoid gelatinous mass forms, often retaining much of the original form and showing very little folding or crumpling.

With *ferric chloride* reaction begins in a minute and is over in 30 minutes; a few grains are not fully gelatinized even at the end of this period. The hilum is prominent as a dark spot or fissure. The lamellæ are not entirely obscured. The hilum swells, often fine striæ radiate from it, and there may be formed a characteristic banded, striated ring at the margin, though this band is not so distinct as it is with other reagents. If the reaction is slow there may be a preliminary gelatinization of the margin. The gelatinized grains are large and not much folded or crumpled, and retain much of the form of the original grain.

The reaction with *Purdy's solution* begins in 30 seconds. After an hour all the grains are affected, although very few are entirely gelatinized. The hilum and lamellæ become very distinct. Fine striæ appear which radiate from the hilum and become wider and therefore more distinct as the hilum swells. As the hilum swells, the inner portion of the grain is changed into a gelatinous mass. The more resistant starch at the margin forms a very distinct ring of two layers, the outer being distinctly striated and showing alternate refractive and non-refractive concentric bands. As the reaction proceeds, this ring becomes thin and clear. The swollen grains are large and not greatly folded, crumpled, or distorted. Often the reaction stops at some intermediate stage.

GENUS DRACUNCULUS.

The members of the genus are tuberous plants which are usually sold under the name *Arum dracunculus*, but the genus differs from the true *Arums* in certain morphological characteristics. Only two species are known, both native to the Mediterranean region. One of them, *D. vulgaris* Schott, is to some extent cultivated, notwithstanding its horribly ill-smelling flowers. From this species the starch was obtained.

STARCH OF DRACUNCULUS VULGARIS. (Plate 15, figs. 85 and 86. Chart 80.)

Histological Characteristics.—In *form* the grains are simple and usually isolated; all are marked with pressure facets, showing that in the plant they must have been in aggregate form. The facets are generally regular in shape and with sharply defined edges. They vary in number from one to four, rarely five or six. The most conspicuous forms are the ovoid, dome-shaped, hemispherical, and triangular; also polygonal, spherical, and various irregular forms. It is not uncommon for the dome-shaped and hemispherical forms to have three facets at base grouped about a common center. Rarely, spheres are seen with one or two small, indistinct facets on the surface. The grains vary in different aspects in accordance with the form, number, and arrangements of the facets; on end they usually appear round.

The *hilum* is a very distinct, light, round spot, generally in the median line and somewhat eccentric, usually deeply fissured. In many instances the fissures extend throughout the greater part of the grain. The 3-armed fissure is the most common. The main fissures frequently are subdivided. Occasionally there is a fissure consisting of a single line which is transverse or longitudinal.

The *lamellæ* are fairly distinct, rather fine, regular, concentric rings, some much coarser and more distinct than others; commonly one is especially distinct near the hilum. They are circular near the hilum, but those near the margin tend to follow its outline. They vary in number from 8 to 15.

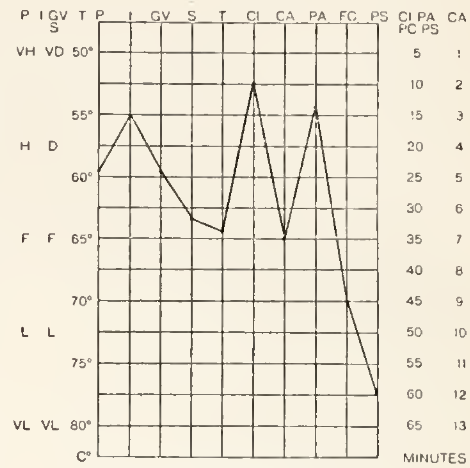
The grains vary in *size* from 4 to 36μ. The common size is 22μ.

Polariscopic Properties.—The *figure* is very distinct and generally slightly eccentric. The lines are broad and ragged and of about the same distinctness throughout their length, commonly tending to broaden as they approach the margin.

The degree of *polarization* is fairly high, higher when the grain is viewed from an end, and higher than in *Arum cornutum*.

With *selenite* the quadrants are fairly well defined, usually regular in shape, but unequal in size. The colors are as a rule pure.

Chart No. 80.



Curve of Reaction-Intensities of Starch of Dracunculus vulgaris.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once quite deeply a blue-violet; with 0.125 per cent solution they tint readily, the color deepening quickly. After heating in water until the grains are completely gelatinized, the solution is somewhat colored on the addition of iodine, while the gelatinized grains usually become deeply colored, some lightly. After boiling 2 minutes the solution is colored blue deeply, and the grain-residues a violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain in 2 minutes and at the end of 30 minutes are fairly deeply to deeply colored. This reaction is of the same intensity as that of *Arum cornutum*.

With *safranin* the grains stain very slightly in 2 minutes and after 30 minutes they are very slightly stained, but not so deeply as *Arum cornutum*.

Temperature Reaction.—The temperature of gelatinization is 63.5° to 65° C., mean 64.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a minute and almost all the grains are darkened in 10 minutes. A few grains are affected only at the corners of the facets. The hilum is distinct, especially if it be fissured. The lamellæ are somewhat obscured, not particularly so. The margin becomes slightly clearer, then darkens, generally first around the facets and then around other parts. The dark color spreads inward, often appearing to advance more along certain radial lines than others, until the whole grain is darkened, accompanied by a very slight swelling, especially of the corners of the facets, with no irregular protrusions. The gelatinized grains so formed are not very large and are of uniform color, except that some show a large, light, inner space representing the swollen hilum. Large light fissures often occupy the position of the fissures in the normal grain.

Reaction with *chromic acid* begins in 30 seconds and is over in 7 minutes. The hilum and lamellæ become distinct. The grain becomes traversed throughout by very fine striæ radiating from the hilum, which become more and more distinct as the hilum swells. Any fissures present at the hilum disappear. The inner portion of the grain is transformed into a gelatinous mass, and the more resistant outer starch forms a thick marginal ring with fine striations and alternate refractive and non-refractive bands. The grain becomes spherical and the marginal band gradually grows thinner, clearer, and quite homogeneous. This band or capsule now invaginates in several places, one part is dissolved and the granular contents are poured out and dissolved, followed by solution of the rest of the capsule.

With *pyrogallic acid* reaction begins in 1½ minutes and is over in 13 minutes. The hilum and lamellæ are distinct. Fine striæ radiate from the hilum as this part swells; as they grow more distinct the hilum swells rapidly, and a marginal band is formed which shows striæ and rather indistinct alternate refractive and non-refractive parts. Deep fissures at the hilum disappear as though they were merely invaginations from the outside that had become pushed out as the inner part of the grain swells. The marginal band gradually becomes thinner and clearer and appears in the form of a large capsule somewhat folded and distorted, but still retaining much of the original form. Rarely, the capsules are so much folded and creased that they resemble granular masses.

Reaction with *ferric chloride* begins in 2 minutes and is over in 45 minutes. The hilum becomes distinct, often as a dark spot or a fissure. The lamellæ are not apparent or indistinct. The margin becomes clear and darker, causing the inner portion to appear light and opaque by comparison. There is rarely slight gelatinization with saccular protrusion at certain points on the margin, especially if the grain does not react quickly. The hilum swells, or the substance within the grain dissolves and extrudes at this point. A marginal ring is formed which appears to be homogeneous; neither striæ nor refractive and non-refractive bands could be made out. The swollen grains are very large and obscure, not much distorted, unless there has been preliminary gelatinization of the margin, in which case they are very greatly distorted and show many sacculations.

The reaction with *Purdy's solution* begins very slightly in 2 minutes and is over in 30 minutes, but at least one-third of the total number of grains are not affected. The hilum and lamellæ become somewhat more distinct. The hilum swells slightly and the grain becomes divided by fine striæ, which become more distinct as the swelling of the hilum progresses. A marginal ring is formed consisting of two layers, the inner being composed of large granules and the outer of a striated band marked with concentric, refractive and non-refractive parts. This marginal ring soon becomes clear, thin, and homogeneous, and the grain is finally fully gelatinized. The gelatinized grains thus formed are fairly large, not much crumpled or wrinkled, and retain much of the original shape.

GENUS RICHARDIA.

The basis of this genus consists of a few well-marked species, natives of South Africa. Some species and several varieties are in common cultivation and are popularly known as callas, which, however, like the *Arum* callas, do not belong to the true monotypic genus *Calla*. Starches were prepared from the rhizomes of 3 well-known species: *R. elliotiana* Knoth. (*Calla elliotiana*, Hort.), the golden calla; *R. africana* Kunth., the common calla lily or Ethiopian lily, or Lily-of-the-Nile; and *R. albo-maculata* Hook., the spotted calla.

STARCH OF RICHARDIA ELLIOTIANA. (Plate 16, figs. 91 and 92. Chart 81.)

Histological Characteristics.—In *form* the grains are simple and usually isolated, with some aggregates of two, three, four, or more grains. The most conspicuous forms are polygonal, formed by a number of pressure facets; spherical and ovoid forms appear to be the fundamental types, but have been modified by mutual pressure, so as to be converted into pentagons, hexagons, and other polygonal forms; there are also dome-shaped and hemispherical, with one, two, or three or more small facets at the base; triangular; ovoid and spherical forms, with one or two small facets; and various indefinite forms. The facets are sharply defined. A given grain may have different shapes according to the aspect in which it is seen, owing to variations in the number, size, and distribution of the facets. For instance, on one end the dome-shaped and hemispherical grains appear spherical, and on the other end the surface is irregular, owing to the facets.

The *hilum* is a fairly distinct, small, round, non-refractive spot, centrally or slightly eccentrically placed, rarely marked by a transverse or a 3-armed fissure; but the figure appears as if it were beneath the surface of the grain and without communication with the outside. Double or multiple hila were not seen.

The *lamellæ* are only rarely distinct, when one or two may be seen especially large and prominent, one near the hilum and the other about midway between it and the margin. They are regular, concentric rings and do not follow the outline of the grain.

The grains vary in *size* from 1.4 to 18μ. The common size is 12μ.

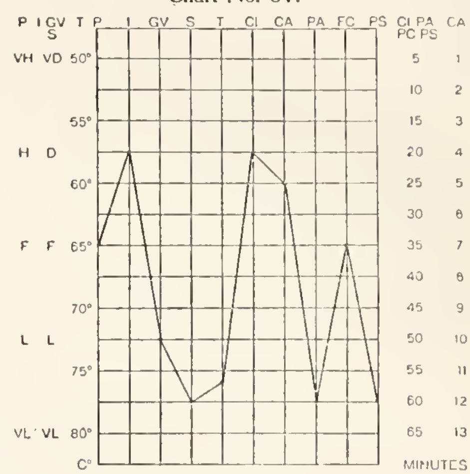
Polariscopic Properties.—The *figure* is well defined, centric or slightly eccentric, and in the form of a cross. The lines are of nearly the same size and distinctness throughout and rather sharply defined. Very rarely, owing to an elongation or other abnormality of the hilum, the figure appears as a solid line bisected at each end.

The degree of *polarization* is fair. Near some of the facets the grains appear isotropic, which is probably due to the depressions. It is higher when the grain is seen on end, and also in the larger grains.

With *selenite* the quadrants are well defined, regular in shape, usually equal or nearly equal in size. The colors are not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color immediately and deeply a blue-violet; with 0.125 per cent solution they tint immediately, the color deepening quickly until fairly dark. The tint of these grains is more blue than that of the grains of *R. africana* and *R. albo-maculata*. After heating the preparation until all the grains are completely gelatinized, the solution is colored somewhat and the grains in varying degrees upon the addition of iodine. With a slight excess of iodine the grains previously uncolored assume a pink-violet color. After boiling 2 minutes, the solution is colored more deeply, but the grain-residues much less than the solution, on the addition of iodine. With a slight excess of iodine the capsules are colored a pink-violet and many are much crumpled and folded, some disintegrated.

Chart No. 81.



Curve of Reaction-Intensities of Starch of *Richardia elliotiana*.

Staining Reactions.—With *gentian violet* and with *safranin* staining begins in about 30 seconds, the stain deepens very slowly, and in 30 minutes it is light.

Temperature Reaction.—The temperature of gelatinization is 75° to 77° C., mean 76°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds and is over in 20 minutes. The hilum becomes prominent as a dark spot or bubble, and the lamellæ are visible. The periphery often clears and becomes darker, while the inner part appears light and opaque. Small grains darken finally from the margin inward, the hilum swells, and the grain is slightly swollen, not much distorted, and uniformly dark, except in the center, where a large light space represents the swollen hilum. Larger grains swell slightly in one or two places on the periphery, often at the corners of the facets. Gelatinization proceeds over the whole grain, spreading along the margin on each side more rapidly than on the central part. The gelatinized grains are not very large and show a dark, thin, marginal band inclosing a large, light, clear space. Sometimes they are somewhat distorted.

Reaction with *chromic acid* begins in 30 seconds and is over in 5 minutes. The hilum becomes more prominent, and also some of the lamellæ. Fine striæ appear which radiate from the hilum and become more and more prominent. The hilum swells and the ungelatinized portions of the grain form a marginal ring of two layers, the inner being composed of large granules, and the outer of a finely striated ring composed of indistinct, alternate refractive and non-refractive bands. The grain continues to swell, and the ring or capsule gets thinner, clearer, and homogeneous-looking, until finally one point swells out and is dissolved, allowing the semifluid contents to escape. The remainder of the capsule then dissolves.

The reaction with *pyrogallic acid* begins in 2 minutes. After an hour about half of the grains are affected, but only half of these are entirely gelatinized. The hilum is prominent, and the lamellæ become less indistinct. There appear to be two methods of gelatinization. One by division of the grain into several pieces by fissures extending from one side to the other in irregular directions, and the independent gelatinization of these separate parts. This method produces a large, irregular, folded and sacculated capsule. The other method is by dissolution of the inner part of the grain, the swelling of the hilum, the appearance of fine striæ which gradually become more distinct, and the movement of the ungelatinized starch to the margin to form a ring consisting of two layers, the inner granular layer being small, as in the *Arum* starches. The gelatinized grains are fairly large and not much distorted, folded, or crumpled.

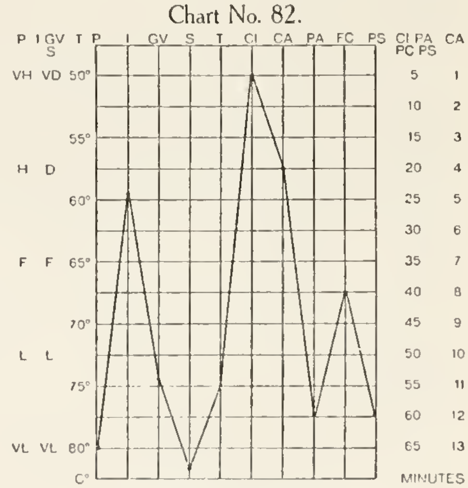
The reaction with *ferric chloride* begins in 2 minutes and is over in 35 minutes. The hilum and lamellæ are rendered quite distinct. The outer portions of the grains become clearer and darker. There is often gelatinization with protrusion at the corners and at the lines of union of the facets, and this may extend over a great part of the grain, followed by a swelling of the grain as a whole. Other grains swell by the dissolution and swelling of the less resistant starch of the inner part of the grain. The ungelatinized portions are pushed to the margin to form a homogeneous, one-layered ring, which does not show granules, bands, or fine striæ. This ring becomes in time clearer and thinner as the grain swells and forms a gelatinized capsule. The gelatinized grains are large and not much distorted, though there is sometimes an invagination or depression in the capsule.

With *Purdy's solution* the reaction begins with a few of the smaller grains in 1½ minutes, but after an hour there is no further reaction. The hilum and lamellæ are prominent. The lamellæ are not rendered so prominent as with pyrogallic acid, which is unusual. Some of the grains gelatinize quickly, with swelling of the hilum and the formation of a marginal ring, which rapidly becomes thin and homogeneous. Other grains are split by irregular fissures into several pieces, which gelatinize independently. This reaction is not completed in all the grains in which gelatinization begins.

STARCH OF RICHARDIA AFRICANA. (Plate 16, fig. 93. Chart 82.)

Histological Characteristics.—In *form* the grains are simple and isolated, except a few that occur in aggregates; they have from one to six or seven pressure facets, which are unequal in size and shape and irregular in their positions in different grains; some grains are entirely covered with facets. The polygonal forms are the most common and vary considerably in shape, owing to variations in number, size, and distribution of the facets; occasionally spherical, dome-shaped, hemispherical, triangular, ovoid (with one end flattened), and irregularly elliptical forms are seen (the irregularities being caused by irregular facets). Many grains, because of their marked angularities, have the appearance of crystals.

Chart No. 82.



Curve of Reaction-Intensities of Starch of Richardia africana.

The *hilum* is usually not visible. In several grains it appeared as a very small, non-refractive, round spot, centrically or slightly centrically placed. It was in no instance fissured.

The *lamellæ* can not be distinguished.

The grains vary in *size* from 1 to 10μ. The common size is 6μ.

Polariscopic Properties.—The grains are so small and the *polarization* so very low (almost *nil*), that it is impossible to determine anything satisfactory with regard to the figure or to the reactions with *selenite.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet somewhat less deeply than *R. elliotiana;* with 0.125 per cent solution they tint readily and the color deepens quickly. The shade is the same or slightly lighter than in *R. elliotiana*, but the color is more of a reddish-violet. After heating until the grains are completely gelatinized, the solution is fairly colored and the gelatinized grains very little on the addition of iodine. Most of the grains show a reddish-violet capsule on adding a very slight excess of iodine. After boiling 2 minutes the solution is colored deeply, but the grain-residues less deeply. Very few grain-residues contain any blue-reacting starch and all have reddish-violet capsules.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain within a minute, and after 30 minutes they are lightly colored, rather less so than *R. elliotiana.*

Temperature Reaction.—The temperature of gelatinization is 74° to 76° C., mean 75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 45 seconds and is over in 5 minutes. The hilum is occasionally more prominent. The lamellæ are visible. The corners of the facets darken and begin to swell, and the processes usually extend entirely around the margin and then inward. The grains do not swell as a whole until the hilum is affected by the reaction. The gelatinized grains are not very large and they have a dark marginal ring surrounding a lighter center. There is some protrusion at the corners of the facets, otherwise no distortion.

Reaction with *chromic acid* begins in 1½ minutes and is completed in 4 minutes. The hilum becomes more visible in many grains. Fissures frequently extend inward from the margin before the hilum begins to swell. The rest of the process is practically the same as that noted in the other *Richardia* starches. Fine striæ appear radiating from the hilum. The hilum swells, opening out in stellate form, and the ungelatinized portions are pushed peripherally to form a ring composed of but one layer, which ring grows thinner and clearer and dissolves at one point, opening out and allowing the gelatinized contents to flow out and dissolve. The rest of the ring or capsule disappears later.

With *pyrogallic acid* the reaction begins in a few grains in 10 minutes. After an hour about half of the grains are affected, but very few are fully gelatinized. The hilum becomes prominent, but the lamellæ remain invisible; fine striæ appear on the grain, and the hilum swells. The ungelatinized portions are pushed peripherally where they form two layers, an inner granular and an outer finely striated, which become thinner and clearer, but in almost every case remain divided. The gelatinized grains are not very large, and the capsules are distorted, folded, or crumpled. The grains outside the cover-slip react more completely, indicating a favorable influence of oxygen.

The reaction with *ferric chloride* begins in 2½ minutes and is over in 40 minutes. The hilum appears as a dark spot, and more prominent. It may now swell, causing a movement of the ungelatinized portions of the grain peripherally. Or, as the hilum swells, the grain may be divided into a number of entirely separate portions which swell independently. The gelatinized grains formed by the latter method are large, irregular, and distorted. All are difficult to see in the surrounding medium.

With *Purdy's solution* there were only slight evidences of any reaction after an hour. One or two grains showed fine striæ radiating from the hilum, one grain was completely gelatinized, and one divided by a longitudinal fissure into unequal parts. No other changes were noted.

STARCH OF RICHARDIA ALBO-MACULATA. (Plate 16, figs. 95 and 96. Chart 83.)

Histological Characteristics.—In *form* the grains are simple and are isolated, except a few in aggregates; nearly all have pressure facets, but usually not the large number exhibited by *R. elliotiana* and *R. africana*. The conspicuous forms are polygonal; some dome-shaped, hemispherical, triangular, ovoid, and spherical grains. The grains, as in the other *Richardia* starches, vary somewhat in form according to the aspect from which they are seen.

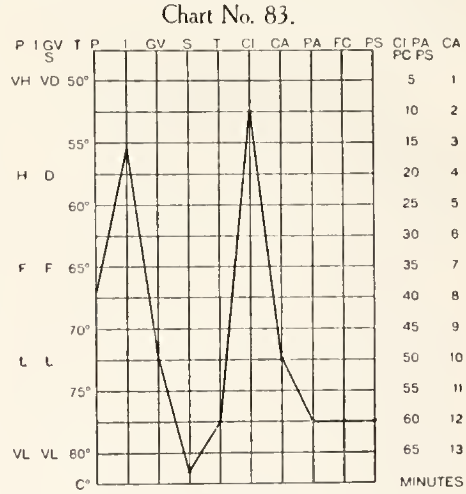
The *hilum* is usually invisible, but is a small, round, non-refractive spot, centrically or slightly eccentrically placed; it was never found fissured, and no multiple hila were seen.

The *lamellæ* are almost always invisible. In a few grains they appeared as regular, concentric rings, with no tendency to follow the faceted outlines of the margin. They are coarse, and one near the hilum is apt to be especially distinct. Not many appear on a grain.

The grains vary in *size* from 1 to 16μ. The common size is about 8μ.

Polariscopic Properties.—The *figure* is as a rule distinct, centric or slightly eccentric, in the form of a cross; its lines are about the same size and distinct throughout their length, not usually bent or distorted in any way.

Chart No. 83.



Curve of Reaction-Intensities of Starch of Richardia albo-maculata.

The degree of *polarization* is fair, probably less than that of the grains of *R. elliotiana*.

With *selenite* the quadrants are very well defined and commonly of about the same size and shape. The colors are not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deep blue-violet, deeper than *R. elliotiana;* with 0.125 per cent solution they tint readily and the color deepens rapidly, but not so deeply as *R. elliotiana*. The color is more of a red-violet than the color of *R. elliotiana*, but not so reddish as the color of *R. africana*. After heating until all are entirely gelatinized, the solution colors slightly and some of the grains color deeply and others lightly on the addition of the iodine. Those coloring lightly show a pinkish-violet capsule on the addition of slight excess of iodine. After boiling for 2 minutes, many gelatinized grains have lost all of their blue-reacting starch and the capsule is reduced to fragments or to amorphous granular masses. On the addition of iodine the solution is colored very deeply, the grain-residues and the fragments very slightly or not at all. When a slight excess of iodine is added, the capsules are colored a pinkish-violet. Occasionally some blue-reacting starch is contained in the capsule.

Staining Reactions.—With *gentian violet* the grains begin to stain immediately, but very slightly, and after 30 minutes the stain is light. All the grains are stained equally. The color is about the same as that in *R. elliotiana.*

With *safranin* the grains begin to stain very slightly within a minute. After 30 minutes they are very slightly stained, and less than *R. elliotiana.*

Temperature Reaction.—The temperature of gelatinization is 77° to 78° C., mean 77.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds in some grains and is over in all in 10 minutes. The hilum becomes prominent as a dark spot. The lamellæ are invisible. The grains are at first colored a light violet. One of the corners formed by facets now darkens and some irregular protrusion takes place here. This process spreads gradually over the whole grain, first involving the side on which it began, and from here spreading around the margin, the central portion being the last to be involved. Some smaller grains darken very rapidly all over and then swell. The gelatinized grains are not very large, and somewhat distorted in shape, the part first affected being more swollen than the rest; all show a dark, homogeneous, marginal ring inclosing a lighter, more or less circular area which represents the swollen hilum.

Reaction with *chromic acid* begins in 2 minutes and is complete in 10 minutes. The hilum and lamellæ become extremely prominent. Fine cracks or striæ appear radiating from the hilum. These grow more and more prominent and the hilum swells, or rather opens out, owing to an enlargement of some of the fissures previously formed. The immediate general result is a swollen grain consisting of an ungelatinized substance in the form of a peripheral ring that is divided into distinct parts and surrounds a mass of gelatinized starch. The outer portion of this ring is radially striated, but otherwise homogeneous in appearance; the inner portion, which is often separated from the outer by a very distinct clear space, consists of a row of coarse granules separated from one another by the lines of cleavage already noted. The grain continues to swell, the marginal ring becomes thinner and clearer until one part dissolves, the inner, faintly granular portion flows out and is dissolved, followed by solution of the rest of the ring or capsule.

With *pyrogallic acid* the reaction begins in 8 minutes, very few grains being affected. (Outside of the cover-slip all the grains were completely gelatinized in 20 minutes.) The hilum becomes distinct and the lamellæ are fairly prominent. The grain becomes divided by fine striæ which radiate from the hilum, the hilum swells, and the ungelatinized portions of the grain are moved peripherally to form a marginal ring consisting of two parts, an outer striated band marked by faint, alternate refractive and non-refractive rings, and an inner granular band. The outer band grows thinner and fainter as the grain continues to swell, and the inner band becomes mingled with the gelatinized starch within. The gelatinized grains so formed are fairly large in comparison with the original grains, and are not distorted, folded, or crumpled.

The reaction with *ferric chloride* begins in some grains in a minute and in all in 2 minutes. It is completed in 1¼ hours. The hilum is prominent as a dark spot; the lamellæ are invisible. Some grains react very rapidly. The hilum, and also the grain as a whole, undergoes swelling. Any intermediate stages are passed through so rapidly that they are not determinable. The result is a gelatinized grain having a thin, homogeneous capsule which is not folded or distorted. Other grains react slowly, first showing fine, radiating striæ, and then, as the hilum swells and the ungelatinized portions are pushed out to the margin, two layers are formed, as in the reactions to chromic acid and pyrogallic acid, but often not so plainly marked. The marginal ring becomes thinner, clearer, and quite homogeneous as the grain continues to swell. The gelatinized grains are large and rounded, not much folded, crumpled, or otherwise distorted.

The reaction with *Purdy's solution* begins in about 5 minutes in a very few grains. After 1½ hours only a very few grains are completely gelatinized; other grains are entirely unaffected. The hilum and lamellæ do not become especially prominent. The grains first show fine striæ radiating from the hilum; then the hilum swells and the ungelatinized portions of the grain push out to the margin, where they form a marginal ring of two parts, not very definitely separated—an inner row of large granules, and an outer, more or less homogeneous layer having fine striæ. These layers gradually become clearer and thinner as the grain swells, forming a capsule. The gelatinized grains are fairly large and not folded, crumpled, or otherwise much distorted.

Differentiation of Certain Starches of the Genus Richardia.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

R. elliotiana: Simple, usually isolated and with pressure facets. Polygonal, dome-shaped, hemispherical, triangular, ovoid, spherical.
R. africana: Essentially the same as in *R. elliotiana.*
R. albo-moculata: Essentially the same as in *R. elliotiana.*

Hilum—Form, Number, and Position.

R. elliotiana: Form small, fairly distinct, round spot; rarely fissured. Position centric or slightly eccentric.
R. africana: Form usually invisible and not fissured, otherwise the same as in *R. elliotiana.* Position centric or slightly eccentric.
R. albo-maculata: Form same as in *R. africana.* Position centric or slightly eccentric.

Lamellæ—General Characteristics and Number.

R. elliotiana: Not distinct, regular, concentric rings which do not follow the outline of the grain. Number not determined.
R. africana: Not visible.
R. albo-maculata: Not visible.

Size.

R. elliotiana: From 1.4 to 18μ, usually 12μ.
R. africana: From 1 to 10μ, usually 6μ.
R. albo-maculata: From 1 to 16μ, usually 8μ.

POLARISCOPIC PROPERTIES.

Figure.

R. elliotiana: Centric or slightly eccentric, well-defined, lines nearly the same size and distinctness throughout, figure in form of a cross.
R. africana: Practically *nil.*
R. albo-maculata: Same as in *R. elliotiana.*

Degree of Polarization.

R. elliotiana: Fair.
R. africana: Almost *nil.*
R. albo-maculata: Fair, probably lower than in *R. elliotiana.*

Polarization with Selenite—Quadrants and Colors.

R. elliotiana: Quadrants well-defined, regular in shape, equal or nearly equal in size. Colors not quite pure.
R. africana: Quadrants not determinable. Colors not determinable.
R. albo-maculata: Quadrants the same as in *R. elliotiana.* Colors not quite pure.

IODINE REACTIONS.

Intensity and Color.

R. elliotiana: Deep; blue-violet.
R. africana: Deep, less than in *R. elliotiana;* blue-violet.
R. albo-maculata: Deep, deeper than in *R. elliotiana;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

R. elliotiana: Light.
R. africana: Light, less than in *R. elliotiana.*
R. albo-maculata: Light, the same as in *R. elliotiana.*

With Safranin.

R. elliotiana: Very light.
R. africana: Very light, less than in *R. elliotiana.*
R. albo-maculata: Very light, less than in *R. elliotiana.*

TEMPERATURE OF GELATINIZATION.

R. elliotiana: 75 to 77° C., mean 76°.
R. africana: 74 to 76° C., mean 75°.
R. albo-maculata: 77 to 78° C., mean 77.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

R. elliotiana: Begins in 30 seconds; complete in 20 minutes.
R. africana: Begins in 45 seconds; complete in 5 minutes.
R. albo-maculata: Begins in 30 seconds; complete in 10 minutes.

Reaction with Chromic Acid.

R. elliotiana: Begins in 1½ minutes; complete in 5 minutes.
R. africana: Begins in 1½ minutes; complete in 4 minutes.
R. albo-maculata: Begins in 2 minutes; complete in 10 minutes.

Reaction with Pyrogallic Acid.

R. elliotiana: Begins in 2 minutes; about half are affected, and one-fourth completely gelatinized in an hour.
R. africana: Begins in a few in 10 minutes; about half are affected, and very few are completely gelatinized in an hour.
R. albo-maculata: Begins in 8 minutes; only a very few show any signs of reaction.

Reaction with Ferric Chloride.

R. elliotiana: Begins in 2 minutes; complete in 35 minutes.
R. africana: Begins in 2½ minutes; complete in 40 minutes.
R. albo-maculata: Begins in 2 minutes; complete in 75 minutes.

Reaction with Purdy's Solution.

R. elliotiana: Begins in 30 seconds, slight in a few grains; no further reaction.
R. africana: Begins in 1½ minutes, slight in 1 or 2 grains; no further reaction.
R. albo-maculata: Begins in 5 minutes, slight in a few grains; only a few grains are completely gelatinized in 1½ hours.

NOTES ON THE STARCHES OF RICHARDIA.

The starches of *Richardia* have the same general histological characteristics, and apart from obvious differences in size do not exhibit diagnostic differences. In the reactions, *R. elliotiana* and *R. albo-maculata* differ little in the degree of polarization, whereas in *R. africana* the reaction is very low. Little, and therefore unimportant, variations are recorded in the iodine, aniline, and Purdy solution reactions. In the temperature of gelatinization, *R. africana* falls 1° lower, and *R. albo-maculata* reaches 1.5° higher than in *R. elliotiana.* In the chloral hydrate-iodine, chromic acid, pyrogallic acid, and ferric chloride reactions the differences are more or less marked, so that no difficulty is experienced by means of the reaction-curves in reaching a diagnosis.

GENUS DIEFFENBACHIA.

Dieffenbachia is a genus of tropical and semitropical low perennials, native for the most part of Central and South America. They are in general cultivation as hot-house plants, chiefly because of their fine foliage. There are, according to different authors, from 6 to 12 distinct species. The juice of the plant is very acrid, causing smarting and tingling when applied to the skin, and even much greater irritation when in contact with the mucous membrane. *D. seguine* Schott is known as "dumb-cane" in the West Indies, because when the root is chewed the tongue swells, interfering with or preventing speech. Starches from four members of the genus, representing two species, were examined, and in each the starches of both pith and cortex were studied separately. The specimens include the following: *D. seguine* var. *nobilis* Engl. (*D. nobilis* Hort.), *D. seguine* var. *maculata* Lowe, *D. seguine* var. *irrorata* Engl. (*D. irrorata* Schott, *D. baumanni* Hort.), *D. illustris* Hort. (*D. late-maculata* Lind. and André).

STARCH OF PITH OF DIEFFENBACHIA SEGUINE VAR. NOBILIS.

(Plate 17, figs. 97 and 98. Chart 84.)

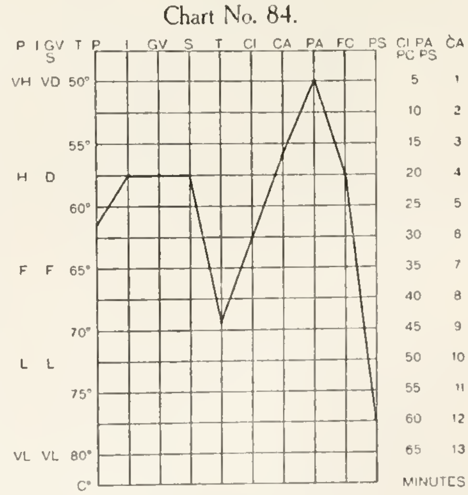
Histological Characteristics.—In *form* the grains are both simple and compound and show no tendency to form aggregates. The grains originally tend to long, elliptical forms, usually quite regular in outline, but become multiform because of secondary deposits. Plastids may often be seen adhering to some portion or portions of the grains. The forms are very numerous, but the most characteristic is an elongated or flattened ellipse, with one end tending to be round or broadly lanceolate and the other flattened; this may be modified by a bend in the middle of the grain, giving the grain somewhat the shape of a boomerang; or by a bend or protrusion at one end which causes it to assume a hook shape. T- and boot-shaped forms are present. The smaller grains are round, ovoid, oval, pyriform, and cylindrical with one end narrower than the other. The peculiar T- and boot-shaped and related forms, and the causes of their peculiarities, will be noted particularly in connection with *D. seguine* var. *maculata*. The grains of this species bear closer resemblances to *D. seguine* var. *irrorata* and *D. illustris* than to *D. seguine* var. *maculata*. On edge, the grains usually appear elliptical, but when seen from the end are round to oval.

The *hilum* is a relatively small, round, fairly distinct, non-refractive spot. It is eccentric from one-third to two-fifths of the longitudinal axis of the grain and situated usually in the broader end of the grain, and in or slightly to one side of the median line. Rarely the hilum is double. Fissuration is common, and the fissures are usually ragged and often deep.

The *lamellæ* are distinct, continuous, fine, regular or irregular circles, ellipses, segments of circles, etc. They vary in size, distinctness, and spacing in the same grain and in different grains. Those added last tend to follow the outline of the margin very closely, and many are somewhat wavy. They are flattened in the region distal to the hilum. The boot, T, and transition forms show independent sets of lamellæ which form the lateral projections, the latter being deposited by plastids after the primary set is completed. These secondary and tertiary sets are added at varying angles to the primary set. In well-developed forms the secondary sets are often the longest and usually coarser and more distinct than those of the primary set. The number of lamellæ varies from 15 on the small grains to 50 on the large grains. The average is about 35.

The grains vary in *size* from 5 to 60μ. The common size is 35μ. The largest grains may be from two to six times as long as broad, and about two-thirds as thick as broad.

Chart No. 84.



Curve of Reaction-Intensities of Starch of Dieffenbachia seguine var. nobilis (pith).

Polariscopic Properties.—The *figure* in the elongated grains is markedly eccentric. It is distinct and the lines are of about the same size and distinctness throughout their length, but may be bent and distorted. Usually but two of the four lines are visible for any length, the other two being very short. Various modifications are shown in part in the photographs.

The degree of *polarization* is fairly high, varying according to the aspect of the grain, being higher if the grain is viewed from the end or edge, and it varies in different grains.

With *selenite* the quadrants are well defined, but irregular in shape and size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet; with 0.125 per cent solution they color lightly. After heating until all the grains are completely gelatinized, the solution is colored slightly, but the gelatinized grains deeply, with iodine. The grains are swollen and somewhat distorted, but retain much of their original shape. After boiling 2 minutes, the solution is colored deeply, some of the grain-residues slightly and others not at all. The capsules are colored a red-violet.

Staining Reactions.—With *gentian violet* the grains begin to stain at once, some more deeply than others. The distal end of the grain stains more quickly and more deeply than the rest of the grain. At the end of 30 minutes the color is deep.

With *safranin* the grains begin to stain immediately, one as deeply as another. The distal end of the grain stains first and most deeply. After 30 minutes the grains are deeply stained.

Temperature Reaction.—The temperature of gelatinization is 68° to 70° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* most grains show the beginning of gelatinization in a minute. About half are gelatinized in 10 minutes and all in 30 minutes. The hilum becomes very distinct as a round dark spot or bubble. The lamellæ can be seen, but are not especially distinct. The periphery darkens at the proximal end, or less commonly at the hilum, and protrusion begins, the grain swelling more in the direction of its longitudinal than transverse axis. Both ends may begin to protrude simultaneously, or more frequently swelling may at first be entirely at the end. In the T and boot shapes swelling may occur from three points, all converging towards the center of the grain, which is affected last. Sometimes small processes will protrude at irregular points of the margin. The gelatinized grains are much elongated and somewhat broadened. Owing to the darkly colored starch being marked by light, transverse fissures, the grains have an appearance suggestive of annelid worms (Plate 19, figs. 113 and 114). The proximal end of the swollen grain is rounded and smooth, and incloses a large, light area representing the swollen hilum. The distal end is either squared or nodular, according to whether protrusion occurred from all points at once or successively. The grains retain to a great extent their original forms.

With *chromic acid* the grains begin to react in 15 seconds and all are dissolved in 3½ minutes. The hilum becomes more distinct, but not the lamellæ. A refractive line extends on each side of the hilum, marking off the inner portion of the grain from the margin and reaching the squared corners at the distal end of the grain. This end opens out fan-wise while becoming gelatinized and longitudinal fissures extend upward into the inner portion, which separates by transverse fissures and alters into coarse granules arranged in a somewhat lamellated fashion. The margin grows very distinct and consists of three or four well-marked striated bands, alternately light and dark. If there are two sets of lamellæ, one is separated from the other, the marginal portion of the grain including both sets. In the meanwhile the hilum swells, the distal end of the grain is dissolved, and the gelatinous inner portion gradually flows out and is dissolved, leaving the refractory marginal portion which dissolves last. At times the central part swells, and the margin on each side dissolves, the two ends dissolving later, the margin of the proximal end being the last of all to disappear.

The reaction with *pyrogallic acid* begins in some grains in 30 seconds and all are gelatinized in 5 minutes. The hilum becomes more distinct, but the lamellæ for the most part only slightly so. Two refractive lines radiate from the hilum to the squared corners at the distal end, outlining an inner space in which the lamellæ are very distinct. Coarse longitudinal striæ now extend from the distal end, which swells out fan-wise, and some transverse fissures are formed which divide the inner portion into coarse granules, arranged in lamellated fashion. The margin at the same time becomes more prominent and is marked by indistinct, alternate refractive and non-refractive bands having distinct fine striæ. Then the hilum begins to swell rapidly and the grain as a whole swells in all directions. The coarse granules in the interior dissolve very rapidly and the margin clears slowly until a gelatinized grain is formed which is very large and clear and with one end very much crumpled and nodular. A mass of granular starch persists at this end after other parts have cleared. The proximal end is smooth and rounded, inclosing a clear space. The gelatinized grain retains little of the original form of the grain.

The reaction with *ferric chloride* begins in 2 minutes. Some of the grains are gelatinized in 5 minutes and all in 20 minutes. The hilum becomes distinct as a dark spot or bubble. The lamellæ are not more distinct than usual. The margin becomes clearer, causing the inner portion to appear lighter and more opaque. The distal end begins to react with much irregular protrusion. Two refractive lines extend obliquely toward the distal end from the hilum, the hilum swells, and the rest of the grain becomes granular by the projection from the margin of irregular inter-crossing fissures. These changes are followed by general swelling of the grain and the disappearance of the granules. At times, and not uncommonly, the grain swells, beginning at the distal end, the hilum being the last to swell. If there are T or boot shapes, or modifications of these, swelling may begin at the distal end of the secondary deposits, then at the distal end of the primary part, and proceed towards the hilum from these two points. The gelatinized grains thus formed are much swollen and irregular in outline, often with three or four lobular projections on each side. The proximal end is usually smooth and rounded, not preserving much of the original form of the grain.

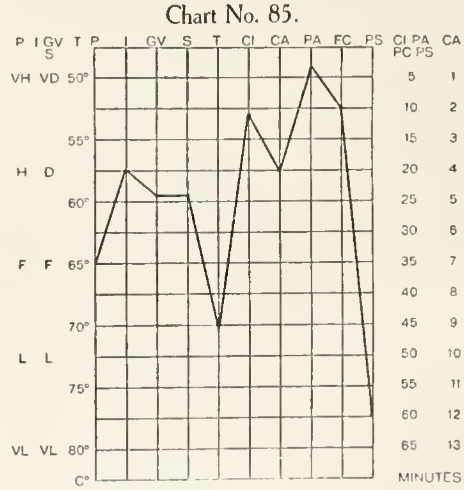
With *Purdy's solution* some grains show signs of swelling in a minute and the reaction is over in 45 minutes. All the grains are partially but none fully gelatinized. The hilum and lamellæ become very distinct and the grain is divided by many longitudinal and three or four transverse fissures which break up the inner portion into coarse granules arranged linearly. The distal end spreads out somewhat and the grain swells in the center, causing the lines of granules to break up until finally they become merely a fine, irregular granular mass. This process progressed to the hilum, which finally swells. The margin in some cases is separated from this inner portion by the extension of refractive lines from the hilum and is finely striated and sometimes banded. It can always be differentiated at the proximal end of the grain, especially immediately after the hilum has become swollen. The gelatinized grains thus formed are large and somewhat oval and retain but little of the original form. A granular mass may persist at the distal end. The proximal end is rounded and clear.

STARCH OF CORTEX OF DIEFFENBACHIA SEGUINE VAR. NOBILIS.

(Plate 17, figs. 99 and 100. Chart 85.)

Histological Characteristics.—In *form* the grains are both simple and compound, and isolated. There are no aggregates. The conspicuous forms are in general like those found in the pith, but narrower, with a much greater tendency to the cylindrical, and very few of the T-shaped, boot-shaped, and allied forms. The general differences between these grains and those of the pith are quite striking. The grains when seen on end appear to be spherical in form, and when on edge somewhat elliptical.

Chart No. 85.



Curve of Reaction-Intensities of Starch of Dieffenbachia seguine var. nobilis (cortex).

The *hilum* is a fairly distinct, small, round spot, eccentric one-sixth to one-eighth of the longitudinal axis, and in or near the median line. It is never fissured, and there are no multiple hila detectable even when secondary deposits exist.

The *lamellæ* are distinct, comparatively fine, regular or irregular segments of ellipses or circles, etc., usually squared at their distal ends, varying but slightly in size and distinctness in different grains, and not so fine, but more distinct, near the distal end of the grains than near the hilum. There are about 35 to 40 on the larger grains.

The grains vary in *size* from 4 to 49μ. The common size is 24μ.

Polariscopic Properties.—The *figure* is usually distinct and generally clear-cut. The lines may be regular, but are often much bent and otherwise distorted.

The degree of *polarization* is fair, not varying much in different grains. It is high when the grains are viewed on end. It is lower than in the pith starch of this plant.

With *selenite* the quadrants are well defined and usually irregular in shape and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color lightly and the color deepens quite readily. It is of the same intensity as that of the pith grains. After heating in water until all the grains are completely gelatinized, the solution colors slightly and the grains very deeply on addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly. On adding an excess of iodine the capsules color red-violet.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are deeply stained. The color is lighter than that of the pith starch.

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained, one grain as much as another. The color is not so deep as that of the pith starch.

Temperature Reaction.—The temperature of gelatinization is 68.5° to 70.5° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 15 seconds and in all in a minute. It is over in almost all in 8 minutes and in all in 12 minutes. The reaction is qualitatively the same as that of the pith grains.

The reaction with *chromic acid* begins in 30 seconds and is over in 4 minutes. It is the same qualitatively as that of the pith starch.

The reaction with *pyrogallic acid* begins in 15 to 30 seconds and is over in 3 minutes. It is the same qualitatively as that of the pith starch.

With *ferric chloride* the reaction begins in most grains in 30 seconds and is complete in 10 minutes. It is the same qualitatively as that of the pith-starch grains.

Reaction with *Purdy's solution* begins in most grains in 45 seconds. In 7 minutes many grains are partially gelatinized and the reaction is at an end in 30 minutes, when all the grains are partly gelatinized. It is the same qualitatively as that of the pith starch.

STARCH OF PITH OF DIEFFENBACHIA SEGUINE VAR. MACULATA.

(Plate 17, figs. 101 and 102. Chart 86.)

Histological Characteristics.—In *form* the grains are both simple and compound and show no tendency to form aggregates. They are very irregular in shape and show many forms, including round, ovoid, oval, pyriform, reniform, club-shaped, bottle-shaped, elongated elliptical with one end squared, boot-shaped, T-shaped, boomerang-shaped, and various other forms with nipple-like or knob-like projections. Transitional forms may be found between the elongated-elliptical and the T- and boot-shaped. Occasionally a T-shaped grain may be seen with a secondary or smaller projection from the side of the grain. When viewed from the side, the round, ovoid, oval, T-shaped, boot-shaped, and various irregularly shaped grains appear somewhat flattened; and from the end they usually appear oval, ovoid, or round. They show a greater tendency to secondary deposits and to be somewhat broader in type than the starch of the cortex, and also to be larger. The tendency to round, ovoid, and other short forms, and to freak forms such as the boot-shaped, etc., is decidedly more marked in this species than in the other *Dieffenbachia* examined.

The *hilum* is distinct and sometimes marked by a fissure, which may be divided at the ends into several radial fissures, and be crossed by a fissure which also may be divided at the ends. When not fissured, the hilum appears as a comparatively large, refractive spot. It is eccentric from two-fifths to one-fifth of the longitudinal axis of the grains. It may be in the median line or to one side.

The *lamellæ* are distinct, continuous, alternate refractive and non-refractive rings, ellipses or segments of rings and ellipses, which vary in size, spacing, and distinctness in the same grain and in different grains. Except those near the hilum, they tend to follow the irregularities of the margin and are often wavy even in grains having quite regular outlines. In the T- and boot-shaped and some of the transitional forms there are two or three sets of lamellæ, the secondary sets being formed by plastids after the primary set has been completed. Occasionally in the T forms the lamellæ of the secondary and tertiary sets are coarser and more widely spaced than those of the primary, both are finer than in *D. seguine* var. *nobilis*. The lamellæ vary in number from 12 in the very small grains to 66 in the large. The average for medium-sized grains is about 40.

The grains vary in *size* from 10 to 70μ, the common size being 40μ. They are ordinarily about one-fourth as broad as long and two-thirds as thick as broad.

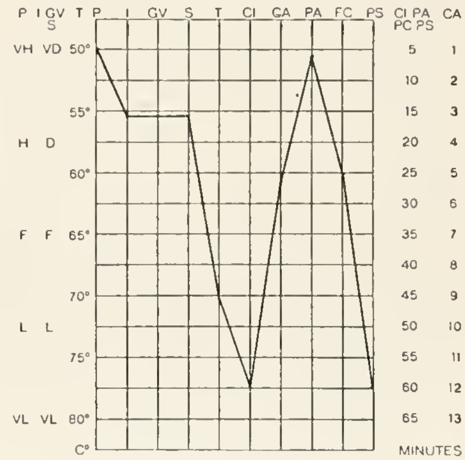
Polariscopic Properties.—The *figure*, excepting in the round, ovoid, and related forms, is very eccentric and much distorted by irregularities of the grain. The lines are broad and ragged and vary in width between the center of intersection and the margin of the grain. In the round, ovoid, and related forms, and when the grains are seen on end, the figure may have the form of a cross, or a more or less close approach to this form. As some of the grains, such as the T, boot, and allied forms, consist of two or more distinct parts, the figure may be peculiarly modified.

The degree of *polarization* is very high, much higher than in *D. seguine* var. *nobilis*, varying according to the aspect of the grain seen, and also in different grains.

With *selenite* the quadrants are well defined, irregular in shape, and of unequal size. In the grains with secondary and tertiary deposits the quadrants are of peculiar shapes according to the modifications in form. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution the grains are colored fairly deep. In both reactions the color is deeper than in the grains of *D. seguine* var. *nobilis*. After heating until the grains are completely gelatinized, the solution colors an indigo and the grains variably, some deeply and others lightly, with iodine. The grains are large, somewhat distorted, but retain to some extent their original shapes. After boiling for 2 minutes, the solution is colored more deeply, but the grain-residues not at all, or a very faint blue. With excess of iodine the capsules color red. Many of the grains are reduced to granular masses or are partly dissolved.

Chart No. 86.



Curve of Reaction-Intensities of Starch of Dieffenbachia seguine var. maculata (pith).

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain in a minute and after 30 minutes are stained deeply—more deeply than the grains of *D. seguine* var. *nobilis*.

Temperature Reaction.—The temperature of gelatinization is 70° to 71° C., mean 70.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* (plate 19, figs. 113 and 114) the reaction begins in 2 minutes. About half are darkened and gelatinized in 30 minutes, and all but one-sixth in an hour. The hilum becomes distinct as a black spot, or if fissured it appears in the form of irregular bubbles. The lamellæ become distinct. The grains have at first a light violet tint which deepens, the distal end becomes dark, and gelatinization proceeds from this point upward. Only occasionally does gelatinization begin at both ends. In the T-shaped, boot-shaped, and related forms the distal end of both primary and secondary sets of lamellæ darken and gelatinize. Occasionally the distal end of the secondary set alone, or with the proximal and the distal ends of the primary set, will darken and gelatinization will proceed from these points. There may be small protuberances from irregular points on the grain if the grain is slow in reacting. Most of the swollen grains present the alternate light and dark banded appearance noted in the other starches of the genus and retain much of the original shape of the grain. The hilum is marked by a clear, round spot surrounded by a narrow, clear, light ring. The round ovoid and related forms have not the striated appearance observed in other forms. When the reaction is complete the central parts of these grains are dark and traversed by fissures in one or two directions, while at the proximal end there is usually a round light space representing an area corresponding to the position of the hilum.

The reaction with *chromic acid* begins in 1½ minutes and is complete in 5½ minutes. The hilum and lamellæ become distinct. Longitudinal fissures extend in from the margin opposite the hilum and partly divide the main body of the grains. In the elliptical forms this part may be subdivided regularly by transverse fissures and thus the grain mass is arranged in rows of granules similar to the arrangement of the lamellæ. In the irregular forms the granules seem to have no fixed arrangement. The marginal parts are very distinctly marked with three or four finely striated bands. When the grains are compound the two portions are separated by the banded margin of the primary grain. The hilum swells together with other parts; the lower part of the grain is dissolved; then the inner granular portion; and finally, the marginal part near the hilum. Occasionally both ends dissolve, leaving the central portion, which passes into solution later; rarely the proximal end dissolves first.

With *pyrogallic acid* some grains are gelatinized in 1½ minutes and all in 7 minutes. The hilum and lamellæ become very distinct; the distal end swells slightly; and longitudinal fissures extend inward and transverse fissures appear, causing the inner portion to become granular. The granules are arranged in regular lines, corresponding with those of the lamellæ. The marginal parts become more distinct, finely striated, and indistinctly banded. The hilum swells greatly and the granules generally disappear, sometimes leaving a finely granular mass at the distal end of the grain. Later, the margin clears, or the distal end may swell, the granules at this part disappearing and the swelling extending upward. The hilum is the last part to swell, followed by clearing of the margin around the hilum. The gelatinized grains are very large, somewhat crumpled, and lobulated. The proximal end is smooth and rounded and the distal end crumpled and lobulated.

Reaction with *ferric chloride* begins in 2 to 5 minutes and is over in 25 minutes. The hilum becomes distinct as a dark spot or bubble, and the lamellæ disappear. The periphery of the grain becomes clear and darker, causing the inner part to appear light and opaque. In this lighter portion the lines of the lamellæ reappear. The distal end now becomes gelatinous and longitudinal striæ extend inward. In swelling, the gelatinized starch spreads out widely on all sides. If there are two sets of lamellæ this process usually begins at the distal end of the secondary set. Gelatinization proceeds and the inner portion becomes granular just above the swelling portion as the process advances up the grain. The hilum is finally included and in expanding extrudes the proximal margin, which is finely striated and shows indistinct bands. Occasionally the hilum swells first and the other part of the grain becomes gelatinized afterwards, the inner portion being coarsely granular and the periphery finely striated. The gelatinized grains are very large, commonly ovoid in form, and much folded and lobulated at the distal end. They retain little of the original form of the grain.

Reaction with *Purdy's solution* begins in some grains in 2 minutes and about half of the grains are only partially gelatinized in 1½ hours. Both hilum and lamellæ become very distinct. The inner part of the grain is divided by longitudinal and transverse fissures. The margin is distinct and striated. Swelling may begin at either end, or in the central portion of the grains, causing the formation ultimately of an oval mass. The granules formed attending the fissuration above referred to gradually disappear as the grain swells, followed by a clearing of the margin. The gelatinized grains are very large and somewhat folded, and retain but little of the original form.

STARCH OF CORTEX OF DIEFFENBACHIA SEGUINE VAR. MACULATA.

(Plate 18, figs. 103 and 104. Chart 87.)

Histological Characteristics.—In *form* the grains are both simple and compound, and are isolated. Like the pith starch the grains are irregular in shape and exhibit many forms, the multiplicity of which is due to lamellar deposits upon the original or primary grain. The conspicuous forms are round, ovoid, oval, elliptical, T-shaped, boot-shaped, boomerang-shaped, and transitional. Seen from the edge, the grains of the round and elliptical types appear of the same thickness as width, but those of irregular form and the T and boot shapes, etc., are somewhat flattened. From the end the grains appear round or oval. In preparing the cortex starch much of the pith was included, so that there is a considerable admixture of the latter starch. The pure cortex starch, like that of *D. seguine* var. *nobilis*, shows a marked tendency to the elliptical form and a consequently lessened tendency for the appearance of the round and freak types so conspicuous in the starch of the pith.

The *hilum* is a distinct, relatively large, round, non-refractive spot, less often fissured than even the pith starch. It is usually eccentric about two-fifths to one-fifth of the longitudinal axis of the elongated grains and commonly in the median line, generally at the larger end in grains of ovoid and related forms. It is never double.

The *lamellæ* are very distinct regular and irregular rings or ellipses or segments of circles or ellipses, commonly following the outlines of the margin, except those near the hilum, and occasionally wavy. The boot and T shapes and related forms have two or three sets, the additional sets being added to the primary set. The lamellæ vary in distinctness, size, and spacing in the same grain and in different grains, and where there are two or three sets those of the additional sets are usually larger, coarser, and more distinct. If the grains have one set of lamellæ, those near the margin are usually the more distinct. The number ranges from 15 on the small to 48 on the large grains, the average being about 30.

The *size* varies from 7 to 52μ. The common size is 27μ.

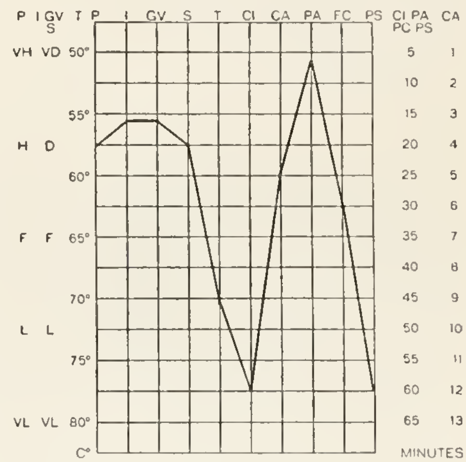
Polariscopic Properties.—The *figure* in the elongated forms is very eccentric and generally distinct and clear-cut. The lines are broad, ragged, and irregular, with the same general characteristics as in the pith starch. Owing to the peculiar optical effects produced by additions to the primary grain, as in the T and boot forms, the figure may be much modified. In the round and ovoid forms the figure is in the form of or an approach to a cross, as in the pith starch.

The degree of *polarization* is high, lower than in the pith starch, highest when the grain is viewed from the end or edge.

With *selenite* the quadrants are sharply defined, but vary in shape and size, as in other *Dieffenbachia* starches. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color quite readily. No differences could be noted between pith and cortex starches in this reaction. After heating until all the grains are completely gelatinized, the solution is colored indigo, while the grains stain deeply. The grains are large and somewhat crumpled, but retain some of the original form. After boiling for 2 minutes the solution is colored deeply and the grain-residues very lightly. With an excess of iodine the capsules become reddish or reddish-violet. They are not so readily reduced to granular masses as the grains of *D. seguine* var. *irrorata* or *D. illustris.*

Chart No. 87.



Curve of Reaction-Intensities of Starch of Dieffenbachia seguine var. maculata (cortex).

Staining Reactions.—With *gentian violet* the grains begin to stain in 2 minutes, but after 30 minutes are only deeply stained. The pith and cortex starches are colored about equally.

With *safranin* the grains begin to stain in a minute, some more deeply than others, and after 30 minutes are fairly deeply stained. The cortex starch stains less deeply than that of the pith.

Temperature Reaction.—The temperature of gelatinization is 70° to 71.2° C., mean 70.6°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 1½ minutes in all the grains and with three-fourths is over in an hour. The hilum becomes distinct as a dark spot or bubble. The lamellæ are not rendered more distinct. The margin opposite the hilum darkens and protrusion begins. If there are two sets of lamellæ, the distal end of each set may darken, or the hilum and the distal end may at the same time darken. Darkening and gelatinization spread over the whole grain from these points. The gelatinized grains thus formed are marked by transverse lines, giving the grain a resemblance to annelid worms, as before noted. The grains are not much distorted and are enlarged principally longitudinally. Some forms show a dark fissured mass in the central portion near and sometimes obscuring the swollen hilum.

The reaction with *chromic acid* begins in 30 to 60 seconds and all of the grains are dissolved in 5 minutes. Both hilum and lamellæ are rendered more distinct. The hilum swells somewhat and a refractive line appears on each side, sharply defining the inner area of the grain. The latter becomes divided into rows of granules by longitudinal fissures projected from the distal end in conjunction with transverse fissures which appear in the lines corresponding to the most prominent lamellæ. The margin becomes very well defined and very wide, and shows several distinct, finely striated bands. The hilum swells, the refractive lines at the side widen, and the grain begins to dissolve, usually from the distal end, which widens out. The granules disappear from the distal end up, followed by solution of the marginal part. Occasionally both ends dissolve, leaving the central portion, which disappears slowly.

Reaction begins with *pyrogallic acid* in 30 seconds and all the grains are gelatinized in 7 minutes. Both hilum and lamellæ become distinct, and longitudinal fissures extending from the distal end, together with transverse fissures, divide the inner part of the grain into a granular mass. The marginal part becomes denser and shows fine striations and obscure bands. Gelatinization begins at the distal end, and the grain becomes traversed by transverse fissures which give it the annelid appearance described under the chloral hydrate-iodine reaction. The hilum and the granules swell, the granular appearance vanishes, and the margin clears later. The gelatinized grains are very large and many are much crumpled and lobulated. Some approach a more or less oval form and are smooth.

Reaction begins with *ferric chloride* in 1½ minutes and the grains are all gelatinized in 30 minutes. The hilum becomes distinct as a dark spot or bubble. The lamellæ become indistinct. Gelatinization begins usually at the distal end; the marginal part becomes clearer and the inner portion opaque. The hilum often swells before other parts of the grain. The inner portion becomes faintly granular and separated by transverse fissures, corresponding to some of the lamellæ. Near the gelatinized parts faint longitudinal fissures appear. The marginal part becomes homogeneous, occasionally faintly striated. The grain swells slowly, becoming gelatinized from both ends, gelatinization beginning at the proximal end usually later than at distal end. The gelatinized grains thus formed are very large and somewhat folded and lobulated.

With *Purdy's solution* reaction begins faintly in 2 minutes in a few grains and after an hour half of the grains are partially gelatinized. Both hilum and lamellæ are rendered very distinct. Fissures extend inward from the margin at the distal end, at which point the grain swells into a gelatinous mass. Transverse fissures appear, which, together with the longitudinal fissures, divide the inner portion into rows of granules. Then the hilum may swell, followed by swelling of the distal end; or both hilum and distal end may begin to swell at the same time. The granular inner portion completely gelatinizes first, then the faintly striated marginal portion. The gelatinized grains are large, lobulated, and somewhat distorted.

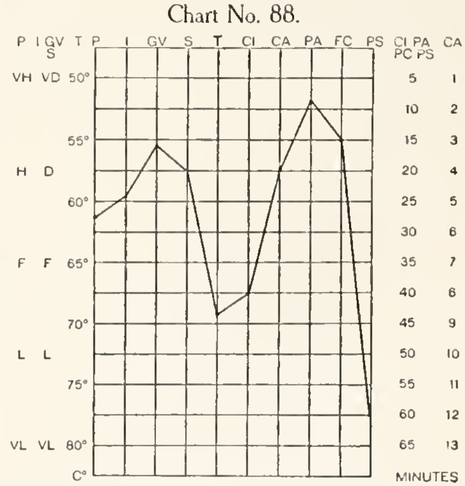
STARCH OF PITH OF DIEFFENBACHIA SEGUINE VAR. IRRORATA.

(Plate 18, figs. 105 and 106. Chart 88.)

Histological Characteristics.—In *form* the grains are both simple and compound, and isolated. The conspicuous forms are long ellipses, usually with both ends rounded, but sometimes the distal end flattened. In addition there are also narrow elliptical or fusiform grains with pointed ends, the latter being due to erosion. Occasionally an elliptical grain may be more or less hooked at one end. There are a few round, ovoid, oval, T-shaped, boot-shaped, boomerang-shaped, and related forms whose peculiarities of shape are due to secondary deposits of lamellæ. The lower proportion of grains having secondary deposits is very striking, and in this respect the grains are more like those of *D. seguine* var. *nobilis* than those of *D. seguine* var. *maculata* and *D. illustris.*

The *hilum* is a small, refractive spot, fairly distinct, and not fissured in any grain. It is eccentric in the elongated forms about two-fifths the longitudinal axis, and is generally in the median line. In grains having one end smaller than the other, the hilum is usually at the smaller end, contrary to what is commonly observed in *D. seguine* var. *maculata* and *D. seguine* var. *nobilis.*

Chart No. 88.



Curve of Reaction-Intensities of Starch of Dieffenbachia seguine var. irrorata (pith).

The *lamellæ* are distinct, regular or irregular circles or ellipses, or segments of circles or ellipses, often flattened and wavy. Only those about the hilum are circular and most of them are segments of curves. The lamellæ vary in size and spacing in the same grain and in different grains. In the boot shape and T shape and related shapes, there are two or three distinct sets of lamellæ, which may be more or less distorted. The number of lamellæ varies from 15 on the small to 48 on the large grains. The average is about 30.

The grains vary in *size* from 5 to 40μ. The common size is 27μ. The grains are commonly one-fourth to one-half as broad as they are long and about two-thirds as thick as broad.

Polariscopic Properties.—The *figure* in the elongated grains is very eccentric; it is distinct and fairly clear-cut. The lines are generally narrow and not clear-cut, often bent somewhat or otherwise distorted. As the grains are transitional between the elongated and round forms, the figure becomes less eccentric, so that in the few round forms it may be in the shape of a cross.

The degree of *polarization* is fairly high, but lower than *D. seguine* var. *nobilis,* varying in different grains and in different aspects of the same grain, highest when the grain is viewed from the end or edge.

With *selenite* the quadrants are well defined, variable in shape, and very unequal in size. The colors are fairly pure, but less pure than in *D. seguine* var. *nobilis.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they tint readily. In neither reaction is the color as deep as in the grains of *D. seguine* var. *nobilis.* After heating the grains until gelatinization has taken place, the solution is colored indigo-blue and all the grains very deeply. The grains are swollen, but retain much of the original form. After boiling for 2 minutes the solution is colored very deeply, but the grain-residues much less deeply. The latter are generally reduced to granular masses. If an excess of iodine is added, these granular masses as well as intact capsules are colored a deep pinkish-violet

Staining Reactions.—With *gentian violet* the grains begin to stain at once, staining with equal intensity. After 30 minutes the stain is deep. These grains stain deeper than those of *D. seguine* var. *nobilis.*

With *safranin* the grains tint slightly in 1½ minutes and after 30 minutes are deeply stained, more deeply than with gentian violet. There is no difference between the staining reaction of these grains and those of *D. seguine* var. *nobilis.*

Temperature Reaction.—The temperature of gelatinization is 68.5° to 69.5° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a minute; most are darkened and gelatinized in 20 minutes and all in 40 minutes. The hilum becomes very distinct as a dark spot or bubble. The lamellæ remain unchanged in point of distinctness. The margin grows clearer and darker, causing the inner part to appear light and opaque. All of the grains are tinted a light violet. The distal end of the grain becomes dark at the margin and protrusion begins. The smaller grains often darken all over and then swell. Gelatinization advances to the hilum, which swells, and the whole grain is converted into a gelatinous mass. Occasionally gelatinization begins at both ends of the grain and advances in all directions. The gelatinized grains then formed are proportionally much elongated, but not much widened; they present strikingly alternate light and dark segments, the dark segments appearing to consist of several rows of lamellæ. The proximal end presents a rounded, smooth margin inclosing a clear, light space that represents the swollen hilum. The grains have a dark indigo color; they are not much distorted and largely retain their original shape.

The grains begin to react with *chromic acid* in 30 seconds and are dissolved in 4 minutes. The hilum and lamellæ become more distinct. Two refractive lines radiate from the hilum, outlining an inner space which becomes so broken up by longitudinal and transverse fissures that it appears granular, the granules sometimes appearing to be arranged in regular rows corresponding to the rows of lamellæ. The margin becomes darker and more distinct, especially at the proximal end, where it is broader than elsewhere and shows fine striations. The hilum may swell and a portion of the margin near it dissolve, followed by the opening out, the extrusion of inner semiliquid starch, and then disappearance with other parts of the grain. The distal end may dissolve first, the proximal end dissolving last; or both ends may dissolve, leaving the central portion, which disappears later, the marginal parts going last. The lower end, if a chloroplastid adhere to it, usually separates and dissolves independently.

The grains begin to react with *pyrogallic acid* in a minute and are completely gelatinized in 8 minutes. Both hilum and lamellæ become very distinct, and two refractive lines extend from the hilum to the distal end of the grain, outlining an inner space. Longitudinal fissures extend in from the distal end and spread out somewhat as they reach upwards, dividing the inner portion into granules. Transverse fissures appear, and others in conjunction with the transverse fissures cause the grain to appear granular, the granules being arranged in rows corresponding to the lamellæ. The distal end in the meanwhile spreads out and becomes gelatinous. The hilum now swells enormously, and the granules referred to are gelatinized, leaving a finely striated margin which finally clears. The gelatinized grains are very large and more swollen longitudinally than transversely. The proximal end is smooth and rounded, and the distal end lobulated and much folded.

With *ferric chloride* the grains begin to swell in 2 minutes and all are gelatinized in 15 minutes. Both hilum and lamellæ are very distinct. The distal end of the grain becomes divided by fissures projected from the margin to the proximal end. The distal end swells, especially laterally, which swelling may proceed to the hilum, the last part to be gelatinized; or the hilum may swell when only a part of the distal end is gelatinized. The inner portion of the grain is often irregularly granular, and the margin shows fine striæ, especially near the hilum. Two kinds of gelatinized grains are formed according to the two modes of swelling: one triangular with a base corresponding to the distal end and the apex to the hilum, the other irregularly elliptical, lobulated, and folded.

Reaction with *Purdy's solution* begins in one-third of the grains in 2½ minutes and all are partially gelatinous in 1½ hours. Both hilum and lamellæ become very distinct. The distal end may begin to swell, or two refractive lines may start from the hilum, outlining an inner portion. Longitudinal fissures extend upward from the distal end, and these with transverse fissures separate the granules thus formed into rows corresponding to the lines of lamellæ. The longitudinal fissures at times may extend part way from the proximal end, leaving the distal portion unstriated. The inner granular portion passes into a gelatinous mass and the more resistant starch at the margin forms a wide, finely striated band marked by refractive and non-refractive lines. This band gradually becomes clearer and thinner until it is transformed into a thin envelope or capsule. The grains are large, generally more or less oval, and somewhat lobulated and folded.

STARCH OF CORTEX OF DIEFFENBACHIA SEGUINE VAR. IRRORATA.

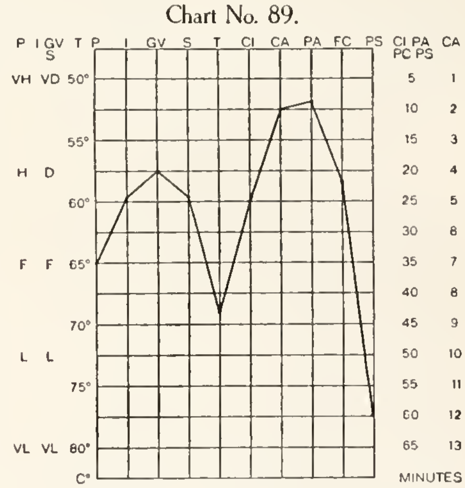
(Plate 18, figs. 107 and 108. Chart 89.)

Histological Characteristics.—In *form* the grains are both simple and compound, and they are isolated. The most conspicuous form is flattened elliptical, the distal end tending to be pointed. A chloroplastid may be made out, occasionally adhering to the grain at the distal end. In some of these forms both ends may be rounded and nearly equal in size, or both may be pointed, owing probably to the beginning of erosion; or the proximal end may be narrower than the distal end. Other elongated forms include short or broad, hook-shaped, T-shaped, boot-shaped, and various irregular shapes due mostly to secondary deposits of lamellæ. The proportion of grains of freakish shapes due to secondary lamellæ is notably less than in other starches of this genus, particularly in comparison with *D. seguine* var. *maculata*. From the end the elliptical grains appear round or oval, or occasionally somewhat prismatic. Usually they are not so thick as broad. The grains as a whole are smaller and less wide in proportion to length than in the pith starch.

The *hilum* is a fairly distinct, small, round, non-refractive spot, eccentric in the elliptical grains about two-fifths of the longitudinal axis of the grain, and situated in the median line. It was never seen to be fissured or to be double or multiple.

The *lamellæ* are fairly distinct, regular or irregular rings or ellipses, or segments of ellipses or rings, sometimes flattened at the distal end or wavy. The lamellæ around the hilum are circular, but beyond this they tend to follow the outline of margin of distal end. The T-shaped and other grains having secondary deposits show one or two additional sets, as in the case of grains of these types in other *Dieffenbachia* starches. They vary in size, distinctness, and spacing, those near the distal end being larger, further apart, and more distinct. The smaller grains have much finer and less distinct lamellæ than the larger grains, and the secondary lamellæ are coarser than the primary, varying from 10 on the small to 44 on the large grains; the average is about 30.

Chart No. 89.



Curve of Reaction-Intensities of Starch of Dieffenbachia seguine var. irrorata (cortex).

The *size* of the grains varies from 4 to 47μ. The common size is 27μ.

Polariscopic Properties.—The *figure* in the elongated grains is very eccentric and well defined, lines usually narrow and not clear-cut. In the few grains of the round or ovoid type the figure is centric or nearly centric, and in the form of or approaching that of a cross.

The *degree of polarization* is fair, distinctly lower than in the pith starch, highest when the grain is viewed from the end or edge, and varying distinctly in different grains.

With *selenite* the quadrants are usually fairly well defined, very unequal in size, and variable in shape. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet, the color being deepest at the margin; with 0.125 per cent solution they color readily. This starch is colored more deeply than the pith starch. After heating until all the grains are completely gelatinized, the solution is colored a weak indigo and the grains very deeply upon the addition of iodine. The grains are much enlarged and the capsules very much folded and lobular, some grains appearing as granular masses. After boiling for 2 minutes the solution is colored markedly and the grain-residues have a distinctly reddish appearance, even without using a great excess of iodine. Most grain-residues are in the form of granular masses which color red on the addition of excess of Lugol's solution.

Staining Reactions.—With *gentian violet* the grains begin to stain in 3 minutes and after 30 minutes are fairly deeply stained. The depth of coloration is less than with the pith starch.

With *safranin* the grains begin to stain at once and at the end of 30 minutes are deeply stained, but not so deeply as the pith starch.

Temperature Reaction.—The temperature of gelatinization is 68° to 69.5° C., mean 68.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a minute and all the grains are gelatinized in 25 minutes. The hilum becomes distinct as a black spot or bubble, but the lamellæ disappear. All the grains are tinted a slight violet. The distal end becomes dark and gelatinization begins at this point, with some irregular protrusion. The proximal end now darkens and gelatinization proceeds also from this point, the two areas ultimately meeting. Sometimes the grain darkens also at other points on the margin, but these rarely start to swell until they are reached by the areas of gelatinization which spread from the ends. Rarely gelatinization proceeds from only one end. The gelatinized grains are large, particularly in the longitudinal axis, and present a striking banded appearance, resembling that of an annelid worm, as already described.

Reaction with *chromic acid* begins in 15 seconds and all the grains are dissolved in 2 minutes. The hilum and lamellæ are rendered very distinct. Refractive lines extend from each side of the hilum, outlining an inner portion which becomes coarsely striated by longitudinal fissures starting from the distal end. The lamellæ are broken up by striæ into coarse granules and the margin appears finely striated. The hilum swells slightly and the grain passes into solution, the solution usually beginning at the distal end, which opens out, allowing the inner, semiliquid starch to flow out and dissolve. The proximal end is the last to disappear. Both ends may dissolve at the same time, or the grain may swell in the middle and dissolve, leaving the two ends to dissolve later. When plastids are attached to the grain they separate and disappear independently.

With *pyrogallic acid* reaction begins in 15 seconds and all the grains are swollen in 8 minutes. The hilum and lamellæ are rendered very indistinct, and from the hilum two refractive lines spread out fanwise toward the distal end, outlining an inner space. The hilum swells slightly and longitudinal fissures extend from the distal end of the grain, this end at the same time swelling somewhat. The fissures extend into the interior, and these with transverse fissures cause the inner portion of the grain to appear as granules arranged in rows, corresponding to the lines of the lamellæ, while at the same time the marginal part becomes denser and finely striated. The hilum continues to swell, the protrusion occurring at the distal end, the inner granular matter disappearing from this end upward; the margin clears later. The gelatinized grains so formed are very large, much crumpled, and lobulated at the distal end. This end is usually broader than the proximal end, which is smooth and rounded, and incloses the swollen hilum.

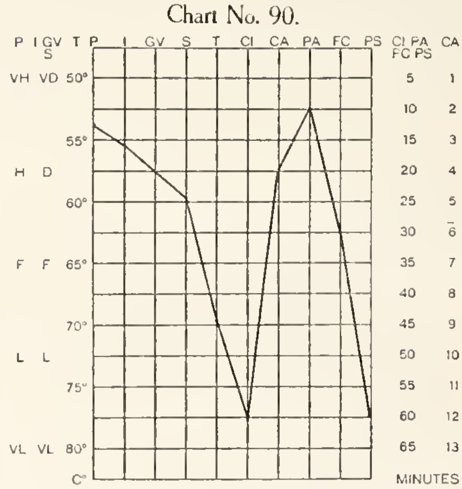
The reaction with *ferric chloride* begins in 1 to 3 minutes and all the grains are gelatinized in 22 minutes. The hilum becomes very distinct as a black spot or bubble. The lamellæ are at first indistinct. The distal end of the grain becomes gelatinous and begins to protrude, while the margin becomes clearer and darker, the inner portion appearing more opaque. The lamellæ become distinct in this central portion. The hilum swells slightly and two lines outline this central portion very distinctly. This inner part becomes fissured transversely and then longitudinally, with an appearance of granulation. The margin at the same time grows finely striated and denser, swelling gradually progressing from the distal end. The granules gradually dissolve, followed later by clearing of the margin. The hilum is usually the last to react, but occasionally swells greatly at the outstart of the reaction, coincidently with the swelling of the distal end of the grain, in which case the central part is the last to gelatinize. The gelatinized grains are very large, especially longitudinally, and much crumpled and lobulated.

The reaction with *Purdy's solution* begins in 2 minutes. At the end of 15 minutes all the grains are affected, but after 45 minutes only one-fifth are completely gelatinized, and at the end of an hour the reaction has not progressed further. The hilum and lamellæ are very distinct. The inner part of the grain becomes fissured by longitudinal fissures extending in from the distal end and by transverse fissures having the direction of the principal lamellæ, forming rows of granules. The outline of the grain appears wavy and irregular. The hilum swells slightly and refractive lines appear in each side, dividing the inner part from the margin, but these lines are not so prominent as with other reagents. Swelling proceeds inward from the distal end, the grain swells laterally and then becomes gelatinous, the granules disappearing and the margin clearing later. The gelatinized grains are large, crumpled, and lobulated.

STARCH OF PITH OF DIEFFENBACHIA ILLUSTRIS. (Plate 19, figs. 109 and 110. Chart 90.)

Histological Characteristics.—In *form* the grains are both simple and compound, and are almost always isolated. They are very irregular in shape, the fundamental type elliptical, with a marked tendency for lateral curvature, the degree of bending ranging from a slight curvature to 45° or more, thus giving rise to forms varying from elliptical to the boomerang-shaped. The proximal end may be the narrower or the broader, and the distal end is often flattened. There are some T-shaped, ovoid, oval, round, and various irregular forms. On the whole there is a greater variety of shapes than in other *Dieffenbachia* starches. The T-shaped, boot-shaped, boomerang-shaped, ovoid, and irregular grains are flattened, but the elliptical forms are round or nearly so, also often showing irregularities from every aspect; from the end they appear round, oval, or somewhat irregular.

Chart No. 90.



Curve of Reaction-Intensities of Starch of Dieffenbachia illustris (pith).

The *hilum* is a fairly distinct, small, non-refractive spot, occasionally showing a slight transverse fissure, usually eccentric about one-third to two-fifths of the longitudinal axis and placed to one side of the median line. Multiple hila were not noted.

The *lamellæ* are distinct rings, ellipses, or segments of rings or ellipses, which are probably continuous; in the elliptical grains they are usually flattened at the distal end, sometimes wavy. In boot and T shapes and in the irregular forms there are two or more sets of lamellæ, secondary sets being superposed on the primary. The lamellæ vary in distinctness, size, and spacing in the same grain, those making up the secondary and tertiary sets being wider and further apart. The sets differ also in distinctness, varying in number from 15 on the smaller grains to 48 on the larger, the average being about 30.

The grains vary in *size* from 7 to 60μ, the common size being about 35μ. They are commonly one-fourth to one-half as broad as long.

Polariscopic Properties.—The *figure* is very eccentric in the elongated grains and in the round forms slightly eccentric. The lines are distinct with ragged edges. In grains with secondary lamellæ the figure is very variable in form.

The degree of *polarization* is high, higher than in *D. seguine* var. *nobilis*, not so high as in *D. seguine* var. *maculata;* it varies in different grains and according to the position of the grain, and is highest when the grain is seen from the end.

With *selenite* the quadrants are well defined, but very irregular in shape and size. The colors are fairly pure, but better than in *D. seguine* var. *nobilis.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue violet; with 0.125 per cent solution they color lightly. The depth of color is in both reactions greater than in grains of *D. seguine* var. *nobilis.* After heating until all the grains are gelatinized the solution and the grains are very deeply colored with iodine. The gelatinized grains are somewhat crumpled, but many retain some of the original form. After boiling 2 minutes, the solution was colored very deeply and the grain-residues less deeply with iodine. With excess of iodine, the capsules are colored red and much crumpled, some being reduced to granular masses.

Staining Reactions.—With *gentian violet* the grains are slightly stained in 3 minutes, and staining is at an end in 20 minutes. The grains are deeply colored, about the same as with *D. seguine* var. *nobilis*, more than with *D. seguine* var. *maculata*.

With *safranin* the grains are slightly stained in a minute and after 30 minutes are deeply stained, less deeply than those of *D. seguine* var. *nobilis*.

Temperature Reaction.—The temperature of gelatinization is 69° to 70° C., mean 69.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 2 minutes and about three-fourths of the grains are completely gelatinized in 30 minutes. The hilum becomes distinct as a black spot or bubble, but the lamellæ do not change. The distal end begins to swell and rarely there is swelling at both ends. Gelatinization proceeds towards the hilum, some portions tending to swell more than others. In the T, boot, and other forms with two sets of lamellæ, swelling may begin at the distal end of both sets. In the elliptical grains when the hilum is reached it swells and the grain becomes a gelatinous mass with the characteristic arrangement of alternate light and dark bands, and of the annelid character referred to, with a rounded end inclosing the swollen hilum, which may be obscured by a dark fissured mass, the distal end being flattened. The gelatinized grains are modified in accordance with the form of the round grain.

Reaction with *chromic acid* begins in a minute and is complete in 4 minutes. Neither hilum nor lamellæ are changed at first. Soon the hilum swells slightly, longitudinal fissures extend in from the distal end, and transverse fissures appear later and in conjunction with the longitudinal lines break up the inner portion into granules which are arranged in rows corresponding to the lamellæ. The margin becomes distinctly banded and finely striated. The distal end is usually the first to dissolve, followed by solution of the inner granular portion, and then of other parts; or the hilum may swell, the granules dissolve, and then the marginal part; or the proximal end may dissolve first, or both ends at once, but the latter is rare. The grains always become very clear before dissolving, a condition not noted in any other of the *Dieffenbachia* starches.

With *pyrogallic acid* reaction begins in 30 seconds and all the grains are swollen in 10 minutes. Both hilum and lamellæ become very distinct, the hilum appearing as a dark spot or bubble. Longitudinal striæ appear at the distal end and extend upward and divide the inner portion, which later is broken, in conjunction with transverse fissures, into irregular rows of granules. The margin becomes finely striated and indistinctly banded. The hilum swells, the grain swelling chiefly longitudinally. The granules in the inner part gradually gelatinize, the margin clears, and a completely gelatinized grain is formed. Two conspicuous forms of gelatinized grains are thus produced, one being triangular, the other oval. Both kinds are crumpled and lobulated with a smooth portion at the proximal end.

The reaction with *ferric chloride* begins in 2 minutes and all the grains are gelatinized in 30 minutes. The hilum and lamellæ are distinct. The margin becomes clearer and darker, causing the inner portion to appear more opaque. Protrusion begins irregularly at the distal end of the grain, the hilum swells, and longitudinal fissures extend from the distal end, which, in conjunction with transverse fissures, breaks up the inner space into granules. The margin becomes finely striated and shows distinct bands. The granules gradually disappear as the grain swells, and the margin clears and becomes a thin and homogeneous capsule. Very rarely the reaction starts at both ends of the grain. The gelatinized grains are large, irregular, crumpled, and lobulated; often they are triangular, and occasionally ovoid or oval.

Reaction with *Purdy's solution* begins in 2 minutes, but after 1½ hours not more than one-fourth of the grains show any signs of being affected. The hilum and lamellæ become very distinct. The distal end swells, longitudinal fissures appear which extend upwards, the transverse fissures develop, the crossed fissures causing an appearance of rows of granules. The margin becomes striated and may show bands. Swelling proceeds from the distal end, and the granules disappear as the portion of the grain in which they lie becomes gelatinized. The margin clears at last and a gelatinous mass is formed. The gelatinized grains are large, crumpled, and lobulated, sometimes triangular, with the swollen hilum at the apex.

STARCH OF CORTEX OF DIEFFENBACHIA ILLUSTRIS. (Plate 19, figs. 111 and 112. Chart 91.)

Histological Characteristics.—In *form* the grains are both simple and compound, and are almost invariably isolated. The fundamental type is elliptical, usually with the proximal end narrower than the distal end, the latter often being flattened. There is a marked tendency, as in the pith starch, to a bending of the grain in its longitudinal axis, the curvature ranging from a slight deviation to more than 45°. There are T-shaped, boot-shaped, boomerang-shaped, and various irregular forms. Some of the smaller grains are irregularly oval, ovoid, or round. The elongated forms are as thick as broad, and on end appear round. The T, boot, oval, and irregularly rounded forms are flattened, and from the end appear oval to elliptical. Evidences of erosion are not uncommon. The grains usually are not only smaller than those of the pith starch, but there is, as in the cortex starch of *D. seguine* var. *nobilis*, a distinct tendency to a cylindrical form.

The *hilum* is a not very distinct, small, round, refractive spot, and not fissured. It is usually in the median line and commonly at the smaller end of the grain. It is eccentric generally about two-fifths of the longitudinal diameter. No multiple hila were noted.

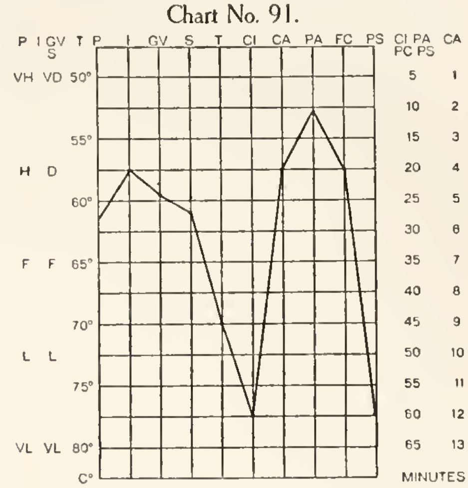
The *lamellæ* are fairly distinct, fine, regular or irregular rings or ellipses or segments of rings or ellipses, which, except near the hilum, tend to follow the outline of the grain. The distal ends of the ellipses are usually flattened and sometimes the lamellæ are wavy. They vary in size and spacing in different grains and even in the same grain. Those at the distal end are usually the largest. In the boot-shaped, T-shaped, and related forms are two sets of lamellæ, those of the secondary sets being the larger and more distinct. The average number of lamellæ is 26.

The grains vary in *size* from 5 to 50μ. The common size is 25μ. They are commonly from about one-third to one-fourth as broad as they are long.

Polariscopic Properties.—The *figure* is usually very eccentric in the elongated grains, and in the round forms slightly eccentric. The lines are narrower than in the pith starch, ragged, and usually more or less bent or wavy. In grains with secondary lamellæ the figure may be more or less modified in accordance with the peculiarities of form and structure.

The degree of *polarization* is fairly high. It is not so high as that of the pith starch. It is, as in other starches, highest when the grain is viewed from the end or edge, and also varies somewhat in different grains.

Chart No. 91.



Curve of Reaction-Intensities of Starch of Dieffenbachia illustris (cortex).

With *selenite* the quadrants are well defined, but very irregular in shape and size. The colors are only fairly pure, even less so than in the pith starch.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet; with 0.125 per cent solution they color lightly. The depth of color in both reactions is less than in the pith starch. After heating until all the grains are completely gelatinized the solution is colored a light indigo and the grains a very deep indigo with iodine. After boiling for 2 minutes the solution colors deeply, but the grain-residues lightly with iodine. With excess of iodine the capsules become a reddish-violet.

Staining Reactions.—With *gentian violet* the stain begins in a minute and after 30 minutes the grains are deeply colored. The reaction is less than with the pith starch.

With *safranin* in a minute the grains tint lightly and after 30 minutes they are fairly deeply stained, not so deeply as the pith starch.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a minute and is over in 30 minutes, about three-fourths of the grains being completely and the others partially gelatinized. The reaction is qualitatively the same as that of the pith starch.

Reaction with *chromic acid* begins in a minute and all the grains are dissolved in 4 minutes. This reaction is qualitatively the same as that of the pith starch.

The reaction with *pyrogallic acid* begins in a minute and all the grains are gelatinized in 11 minutes. This reaction is qualitatively the same as that of the pith starch.

With *ferric chloride* reaction begins in 30 seconds to a minute and all the grains are swollen in 20 minutes. This reaction is qualitatively the same as that of the pith starch.

With *Purdy's solution* the reaction begins in 1 to 1½ minutes, but after 1¼ hours only about one-fourth of the grains are gelatinized, and they only partially. This reaction is qualitatively the same as that of the pith starch.

Differentiation of Certain Starches of the Pith of the Genus Dieffenbachia.

Histological Characteristics.

Conspicuous Forms.

D. seguine var. *nobilis:* Simple and compound. Elongated ellipses with tendency to one broadly lanceolate end and one flattened end; boot-shaped, T-shaped, boomerang-shaped, and related forms due to secondary deposists of lamellæ; also round, ovoid, and oval forms, etc.

D. seguine var. *maculata:* Grains show great tendency to broadness and roundness, and to a far greater variety of forms that are due to the deposition of secondary deposits than in the case of the preceding starch. The T and boot shapes and related forms are relatively very numerous.

D. seguine var. *irrorata:* Same as *D. seguine* var. *nobilis,* except that there is less tendency to a pointing of the broadly lanceolate end and even a lower proportion of grains having secondary deposits of lamellæ, and hence of freakish forms.

D. illustris: Grains more like those of *D. seguine* var. *nobilis* and *D. seguine* var. *irrorata* than *D. seguine* var. *maculata.* Tendency to hooked forms very marked.

Hilum—Form, Number, and Position.

D. seguine var. *nobilis:* Form small, round, single, fissuration common and usually ragged, fairly distinct. Position eccentric in elongated grains about 0.3 to 0.4 of longitudinal axis of grain.

D. seguine var. *maculata:* Form comparatively large, round, single, sometimes fissured, distinct. Position eccentric 0.4 to 0.2 of longitudinal axis.

D. seguine var. *irrorata:* Form the same as in *D. seguine* var. *nobilis,* but not fissured. Position eccentric about 0.4 of longitudinal axis.

D. illustris: Form small, round, single, rarely fissured, fairly distinct. Position eccentric about 0.3 to 0.4 of longitudinal axis.

Lamellæ—General Characteristics and Number.

D. seguine var. *nobilis:* Distinct, continuous, fine, regular or irregular circles, ellipses, or segments of circles or ellipses; two sets in many grains, the secondary being coarser than the primary. About 35 on an average or medium-sized grain.

D. seguine var. *maculata:* Same as in *D. seguine* var. *nobilis,* except that both primary and secondary lamellæ are not so fine. About 40 on an average grain.

D. seguine var. *irrorata:* Same as in *D. seguine* var. *nobilis.* About 30 on an average grain.

D. illustris: Same as in *D. seguine* var. *nobilis.* About 30 on an average grain.

Size.

D. seguine var. *nobilis:* From 5 to 60μ, commonly 35μ.

D. seguine var. *maculata:* From 10 to 70μ, commonly 40μ.

D. seguine var. *irrorata:* From 5 to 40μ, commonly 27μ.

D. illustris: From 7 to 60μ, commonly 35μ.

Polariscopic Properties.

Figure.

D. seguine var. *nobilis:* Usually very eccentric, distinct, distorted; modified according to shape and structure of grain.

D. seguine var. *maculota:* Essentially the same as in *D. seguine* var. *nobilis.*

D. seguine var. *irrorata:* Essentially the same as in *D. seguine* var. *nobilis.*

D. illustris: Essentially the same as in *D. seguine* var. *nobilis.*

Degree of Polarization.

D. seguine var. *nobilis:* Fairly high.

D. seguine var. *maculata:* Very high, much higher than in *D. seguine* var. *nobilis.*

Polariscopic Properties.—Continued.

Degree of Polarization.—Continued.

D. seguine var. *irrorata:* Fairly high, but distinctly lower than in *D. seguine* var. *nobilis.*

D. illustris: High, higher than in *D. seguine* var. *nobilis.*

Polarization with Selenite—Quadrants and Colors.

D. seguine var. *nobilis:* Quadrants well-defined, irregular in shape and size. Colors fairly pure.

D. seguine var. *maculata:* Quadrants same as in *D. seguine* var. *nobilis.* Colors pure, purer than in *D. seguine* var. *nobilis.*

D. seguine var. *irrorata:* Quadrants same as in *D. seguine* var. *nobilis.* Colors fairly pure, but less pure than in *D. seguine* var. *nobilis.*

D. illustris: Quadrants same as in *D. seguine* var. *nobilis.* Fairly pure, better than in *D. seguine* var. *nobilis.*

Iodine Reactions.

Intensity and Color.

D. . eguine var. *nobilis:* Deep; blue-violet.

D. seguine var. *maculata:* Deep, deeper than in *D. seguine* var. *nobilis;* blue-violet.

D. seguine var. *irrorata:* Deep, not so deep as in *D. seguine* var. *nobilis;* blue-violet.

D. illustris: Deep, deeper than in *D. seguine* var. *nobilis;* blue-violet.

Staining Reactions.

With Gentian Violet.

D. seguine var. *nobilis:* Deep.

D. seguine var. *maculata:* Deep, deeper than in *D. seguine* var. *nobilis.*

D. seguine var. *irrorata:* Deep, deeper than in *D. seguine* var. *nobilis.*

D. illustris: Deep, same as in *D. seguine* var. *nobilis.*

With Safranin.

D. seguine var. *nobilis:* Deep.

D. seguine var. *maculata:* Deep, deeper than in *D. seguine* var. *nobilis.*

D. seguine var. *irrorata:* Deep, same as in *D. seguine* var. *nobilis.*

D. illustris: Deep, less than in *D. seguine* var. *nobilis.*

Temperature of Gelatinization.

D. seguine var. *nobilis:* 68 to 70° C., mean 69°.

D. seguine var. *maculata:* 70 to 71° C., mean 70.5°.

D. seguine var. *irrorata:* 68.5 to 69.5° C., mean 69°.

D. illustris: 69 to 70° C., mean 69.5°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

D. seguine var. *nobilis:* Begins in most of the grains in a minute; complete in half in 10 minutes, and in all in 30 minutes.

D. seguine var. *maculata:* Begins in 2 minutes; complete in five-sixths in an hour.

D. seguine var. *irrorata:* Begins in a minute; complete in 40 minutes.

D. illustris: Begins in 2 minutes; complete in three-fourths in 30 minutes.

Reaction with Chromic Acid.

D. seguine var. *nobilis:* Begins in 15 seconds; complete in 3½ minutes.

D. seguine var. *maculata:* Begins in 1½ minutes; complete in 5½ minutes.

D. seguine var. *irrorata:* Begins in 30 seconds; complete in 4 minutes.

D. illustris: Begins in a minute; complete in 4 minutes.

Differentiation of Certain Starches of the Pith of the Genus Dieffenbachia.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.

D. seguine var. *nobilis:* Begins in 30 seconds; complete in 5 minutes.
D. seguine var. *maculata:* Begins in 1½ minutes; complete in 7 minutes.
D. seguine var. *irrorata:* Begins in 1 minute; complete in 8 minutes.
D. illustris: Begins in 1½ minutes; complete in 10 minutes.

Reaction with Ferric Chloride.

D. seguine var. *nobilis:* Begins in 2 minutes; complete in all in 20 minutes.
D. seguine var. *maculata:* Begins in 2 to 5 minutes; complete in 25 minutes.
D. seguine var. *irrorata:* Begins in 2 minutes; complete in 15 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.—Continued.

D. illustris: Begins in 2 minutes; complete in 30 minutes.

Reaction with Purdy's Solution.

D. seguine var. *nobilis:* Begins in a minute; in 45 minutes all the grains are partially but none completely gelatinized; practically no further reaction in an hour.
D. seguine var. *maculata:* Begins in some in 2 minutes. In 1½ hours about half of the grains are partially gelatinized.
D. seguine var. *irrorata:* Begins in one-third in 2½ minutes. In 1½ hours all are partially gelatinous.
D. illustris: Begins in 2 minutes. In 1½ hours not more than about one-fourth of the grains show any signs of gelatinization.

Differentiation of Certain Starches of the Cortex of the Genus Dieffenbachia.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

D. seguine var. *nobilis:* Essentially the same as in pith starch, excepting that the grains are almost wholly of the cylindrical and elliptical types. Secondary lamellæ rare.
D. seguine var. *maculata:* Essentially the same as in pith starch, except a marked tendency to the elliptical form, and to less of the peculiar odd shapes due to secondary lamellæ.
D. seguine var. *irrorata:* Essentially the same as in pith starch, but with marked tendency to the elliptical form and to a lessening in the number of freakish forms due to secondary lamellæ.
D. illustris: Essentially the same as pith starch, but the grains are narrower, with much greater tendency to hook forms.

Hilum—Form, Number, and Position.

D. seguine var. *nobilis:* Form the same as in the pith, but not fissured. Position more eccentric than in pith starch.
D. seguine var. *maculata:* Form same as in the pith. Position eccentric, about the same as in pith starch.
D. seguine var. *irrorata:* Form same as in the pith. Position eccentric, about the same as in pith starch.
D. illustris: Form fairly distinct, small, round, not fissured. Position eccentric, about the same as in pith starch.

Lamellæ—General Characteristics and Number.

D. seguine var. *nobilis:* Same as in the pith, but finer. Number about the same as in pith starch.
D. seguine var. *maculata:* The same as in the pith. Number not so many, as a rule, as in pith starch.
D. seguine var. *irrorata:* Form same as in the pith. Number about the same as in pith starch.
D. illustris: Form about the same as in pith starch, but somewhat less distinct. Number about the same as in pith starch.

Size.

D. seguine var. *nobilis:* From 4 to 49μ, commonly 24μ.
D. seguine var. *maculata:* From 7 to 52μ, commonly 27μ.
D. seguine var. *irrorata:* From 4 to 47μ, commonly 27μ.
D. illustris: From 5 to 50μ, commonly 25μ.

POLARISCOPIC PROPERTIES.

Figure.

D. seguine var. *nobilis:* The same as in pith starch, but more eccentric.
D. seguine var. *maculata:* The same as in pith starch.
D. seguine var. *irrorata:* The same as in pith starch.
D. illustris: The same as in pith starch.

POLARISCOPIC PROPERTIES.—Continued.

Degree of Polarization.

D. seguine var. *nobilis:* Fair, lower than in pith starch.
D. seguine var. *maculata:* High, lower than in pith starch.
D. seguine var. *irrorata:* Fair, distinctly lower than in pith starch.
D. illustris: Fairly high, not so high as in pith starch.

Polarization with Selenite—Quadrants and Colors.

D. seguine var. *nobilis:* Quadrants same as in pith starch. Colors with lower purity than in pith starch.
D. seguine var. *maculata:* Quadrants same as in pith starch. Colors same as in pith starch.
D. seguine var. *irrorata:* Quadrants same as in pith starch. Colors same as in pith starch.
D. illustris: Quadrants same as in pith starch. Colors with lower purity than in pith starch.

IODINE REACTIONS.

Intensity and Color.

D. seguine var. *nobilis:* Deep, the same as in pith starch; blue-violet.
D. seguine var. *maculata:* Deep, the same as in pith starch; blue-violet.
D. seguine var. *irrorata:* Deep, deeper than in pith starch; blue-violet.
D. illustris: Deep, not so deep as in pith starch; blue-violet.

STAINING REACTIONS.

With Gentian Violet.

D. seguine var. *nobilis:* Deep, lighter than in pith starch.
D. seguine var. *maculata:* Deep, same as in pith starch.
D. seguine var. *irrorata:* Deep, same as in pith starch.
D. illustris: Deep, lighter than in pith starch.

With Safranin.

D. seguine var. *nobilis:* Fairly deep, not so deep as in pith starch.
D. seguine var. *maculata:* Fairly deep, not so deep as in pith starch.
D. seguine var. *irrorata:* Fairly deep, not so deep as in pith starch.
D. illustris: Fairly deep, not so deep as in pith starch.

TEMPERATURE OF GELATINIZATION.

D. seguine var. *nobilis:* 68.5 to 70.5° C., mean 69°.
D. seguine var. *maculata:* 70 to 71.2° C., mean 70.6°.
D. seguine var. *irrorata:* 68 to 69.5° C., mean 68.75°.
D. illustris: 69 to 71° C., mean 70°.

Differentiation of Certain Starches of the Cortex of the Genus Dieffenbachia.—Continued.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

D. seguine var. *nobilis:* Begins in a minute; complete in 12 minutes.
D. seguine var. *maculata:* Begins in $1\frac{1}{2}$ minutes; complete in three-fourths of the grains in an hour.
D. seguine var. *irrorata:* Begins in a minute; complete in 25 minutes.
D. illustris: Begins in a minute; complete in three-fourths of the grains in 30 minutes.

Reaction with Chromic Acid.

D. seguine var. *nobilis:* Begins in 30 seconds; complete in 4 minutes.
D. seguine var. *maculata:* Begins in 30 to 60 seconds; complete in 5 minutes.
D. seguine var. *irrorata:* Begins in 15 seconds; complete in 2 minutes.
D. illustris: Begins in a minute; complete in 4 minutes.

Reaction with Pyrogallic Acid.

D. seguine var. *nobilis:* Begins in 30 seconds; complete in 3 minutes.
D. seguine var. *maculata:* Begins in 30 seconds; complete in 7 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

D. seguine var. *irrorata:* Begins in 15 seconds; complete in 8 minutes.
D. illustris: Begins in a minute; complete in 11 minutes.

Reaction with Ferric Chloride.

D. seguine var. *nobilis:* Begins in 30 seconds; complete in 10 minutes.
D. seguine var. *maculata:* Begins in $1\frac{1}{2}$ minutes; complete in 30 minutes.
D. seguine var. *irrorata:* Begins in 1 to 3 minutes; complete in 22 minutes.
D. illustris: Begins in 30 to 60 seconds; complete in 20 minutes.

Reaction with Purdy's Solution.

D. seguine var. *nobilis:* Begins in 45 seconds; all the grains partially gelatinized in 30 minutes; incomplete in an hour.
D. seguine var. *maculata:* Begins in a few in 2 minutes; about half the grains partially gelatinized in an hour.
D. seguine var. *irrorata:* Begins in 2 minutes; complete in only one-fifth in 45 minutes; the rest are partially gelatinized; incomplete in an hour.
D. illustris: Begins in 1 to $1\frac{1}{2}$ minutes; about one-fourth partially gelatinized in $1\frac{1}{4}$ hours.

NOTES ON THE STARCHES OF DIEFFENBACHIA.

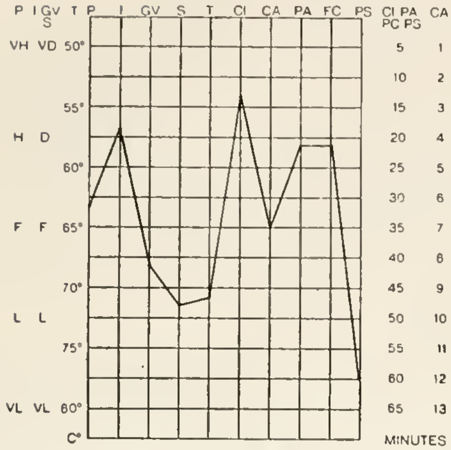
The fundamental or primary form of the starch-grains of *Dieffenbachia* is that of an elongated ellipse, this being subjected to various modifications, especially by the deposition of secondary lamellæ, so as to give rise to a considerable variety of shapes, some of them decidedly freakish. In comparing the starches of the pith and cortex, it will be noted in the former that irregularities in the forms are more conspicuous and that there is a greater tendency to larger grains in both width and length (and disproportionately wider), than in those of the cortex. Some differences are noted in the starches of the different varieties and species, *e.g.*, the tendency to the hook-like form in *D. illustris*, and the tendency to nodular deposits, particularly in *D. seguine*. In the reactions it is of especial interest to note that each of the specimens differs sufficiently to be distinguishable, and that while the pith and cortex starches of each variety very closely correspond they show differences that are more or less obvious. Thus, it will be seen that the pith starches compared with those of the cortex have in each case a higher polarization, and either about equal or generally less sensitivity to the reagents. With better methods differences would no doubt be brought out very distinctly.

NOTES ON THE STARCHES OF AROIDEÆ. (Charts 92–96A.)

The starches of the representatives of the five genera of *Aroideæ* studied (*Arum*, *Arisæma*, *Dracunculus*, *Richardia*, and *Dieffenbachia*) belong to two entirely different types—types that seemingly are so unlike as to suggest an absence of the family relationship set forth by the botanist. The characters possessed in common by the first four genera are obvious, and it is equally clear that *Dieffenbachia* must be set entirely apart. In general histological characters the starches of the members of the first four genera might readily be mistaken, one for the other, but none could be confounded with those of *Dieffenbachia*. While it might be difficult or impossible to differentiate the starches of these four genera by histological means, charts 92 to 95 show that the generic peculiarities are distinct; and by comparing further these charts with charts 96 and 96A, which exhibit the reactions of the pith and cortex of *Dieffenbachia* starches, there is observed a general correspondence as regards the type of curve, but the reaction-differences between the starches of the first four genera and those of *Dieffenbachia* are quite distinct. These data show that while the differences in histological characteristics of the two groups are seemingly irreconcilable, the physical, physicochemical, and chemical properties are akin.

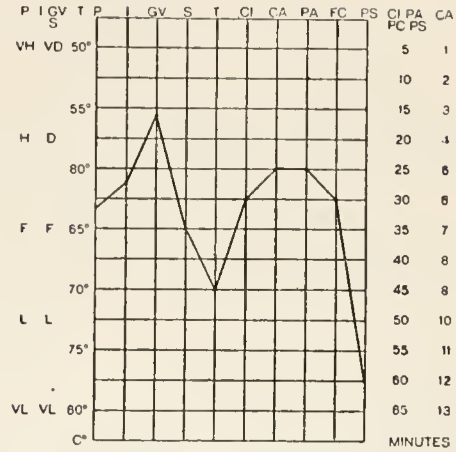
The marked differences presented by *Arum*, *Arisæma*, *Dracunculus*, and *Richardia* on the one hand, and *Dieffenbachia* on the other, led to a cursory examination of starches of several other genera of *Aroideæ*, including representatives of *Peltandra*, *Colocasia*, *Alocasia*, and *Amorphophallus*. *Peltandra* is represented by *P. undulata* Raf. (*P. virginica* Kunth.), and popularly known as the arrow arum. This starch closely coincides with the histological characters of the primary form of the *Dieffenbachia* grain (plate 15, figs. 87 and 88). It has a high degree of polarization, and the temperature of gelatinization is 73° to 75°C., mean 74°. Starch was prepared from the bulbs of *Colocasia* var. *esculenta* Schott (*Caladium esculenta* Schott), popularly known as the elephant's ear, and found to be in the form of extremely minute grains of the *Arum* type—grains too small for satisfactory study. A preparation from *Amorphophallus rivieri* Dur., a plant known as the devil's tongue or the snake palm, was also found to be in the form of small grains of the *Arum* type (plate 15, fig. 90). From *Alocasia putzeysi* N. E. Brown (*A. watsoniana* Hort.) a most peculiar kind of starch was obtained. The grains in the original or natural form appear to be spherical or nearly so, and tend to break apart into fragments which have sharp edges and angles (plate 15, fig. 89), and which, raw or boiled, become colored a wine-red with iodine. The degree of polarization was found to be quite variable, being quite high in the intact grains and in some pieces or parts of pieces, to very low in others. The interference figure was recorded as being somewhat eccentric, the lines intersecting in the spherical grains to form a cross. The temperature of gelatinization was 62° to 63° C., mean 62.5°.

Chart No. 92.



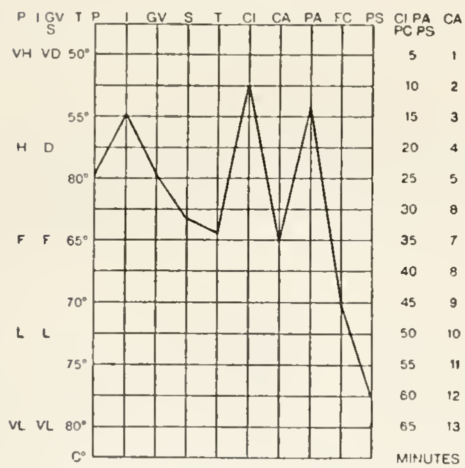
Composite Curve of Mean Reaction-Intensities of Starch of Arum.

Chart No. 93.



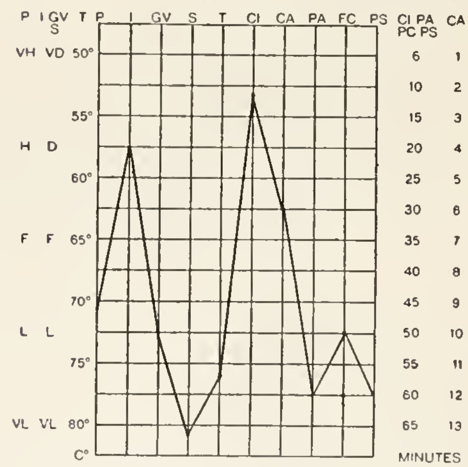
Curve of Reaction-Intensities of Starch of Arisæma.

Chart No. 94.



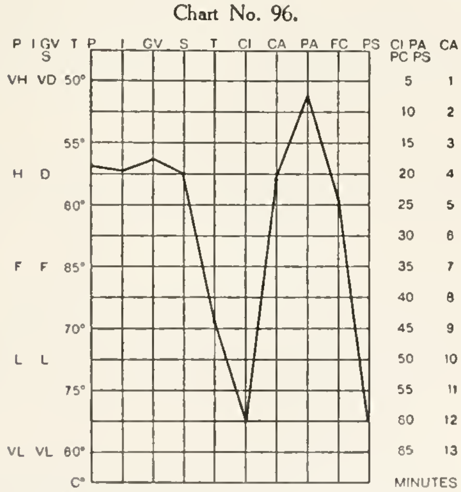
Curve of Reaction-Intensities of Starch of Dracunculus.

Chart No. 95.



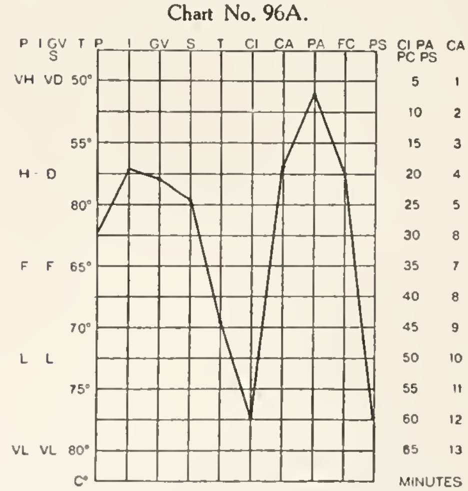
Composite Curve of Mean Reaction-Intensities of Starch of Richardia.

Chart No. 96.



Composite Curve of Mean Reaction-Intensities of Starch of Dieffenbachia (pith).

Chart No. 96A.



Composite Curve of Mean Reaction-Intensities of Starch of Dieffenbachia (cortex).

STARCHES OF LILIACEÆ.

Class, Monocotyledones. Order, Liliales. Family, Liliaceæ. Genera represented: Lilium, Fritillaria, Calochortus, Tulipa, Scilla, Chionodoxa, Puschkinia, Ornithogalum, Erythronium, Hyacinthus, Galtonia, Muscari, Brodiæa, Triteleia, Lachenalia.

The *Liliaceæ* include about 190 genera and 2,300 species, widely dispersed over the world; many of the genera furnish some of the most admired of our cultivated flowers. Representatives of 15 genera have been studied in this research.

GENUS LILIUM.

The genus *Lilium* is not only a member of a very large family, but is of itself very large as regards both species and varieties, and comprises many of the best-known and most beautiful garden plants. The lilies are native over almost all of the North Temperate Zone, and of Western Asia, Japan, South China, and Burma. The genus has been divided into 6 subgenera, of which number representatives of 4, including 15 specimens of species varieties, were studied, which are classified as follows:

Subgenus *Eulirion: L. candidum* Linn, *L. longiflorum* var. *giganteum* Hort., *L. longiflorum* var. *eximium* Nichol. (*L. eximium* Court, *L. harrisii* Carr.), *L. parryi* Wats., *L. rubellum* Baker.

Subgenus *Isolirion: L. philadelphicum* Linn.

Subgenus *Archlirion: L. tigrinum* var. *splendens* Leicht., *L. henryi* Baker, *L. auratum* Lindl., *L. speciosum* var. *album* Hort. (*L. lancifolium* var. *album*, *L. præcox* Hort.).

Subgenus *Martagon: L. martagon* Linn. (*L. dalmaticum* Vis.), *L. superbum* Linn.; *L. tenuifolium* Fisch; *L. pardalinum* Kellogg (*L. californicum* Domb.); *L. puberulum* Duchr. (*L. californicum* Hort., *L. humboldtii* Roez and Leicht, *L. bloomerianum* Kell.).

STARCH OF LILIUM CANDIDUM. (Plate 20, figs. 115 and 116. Chart 97.)

Histological Characteristics.—In *form* the grains are simple and almost always isolated. There are a few doublets and some of the grains have pressure facets. The surface of the grains is usually regular, and such irregularities as may be found are generally in the form of low, rounded projections of varying size, at or to one side of the proximal end. Irregularities may also be due to a less development of one side of the distal end than of the other, thus causing the grain to appear as if a slanting portion at this end had been cut off. There is some variety in the shapes of the grains, but not very marked. The conspicuous forms are the elongated ovoid, oval, elliptical with a somewhat flattened distal end, and triangular with rounded base and angles. There are, in addition, ovoid, quadrangular with rounded angles, clam-shell-shaped, pyriform, bottle-shaped, and round or nearly round. The small grains, of which there are comparatively few, are usually round or nearly round.

The *hilum* is a small, not very distinct, round, very eccentric spot. The range of eccentricity in the larger grains is from one-fifth to one-ninth—the latter in many of the grains. The hilum is often fissured, and the fissure is very short, narrow, clean-cut, and transverse, and has extending outwards and downwards towards the distal end on each side a refractive line or fissure beneath the surface of the grain.

The *lamellæ* are comparatively fine, fairly distinct ellipses, rings, or pseudo-quadrangles which are continuous near the hilum and apparently discontinuous at the equatorial and distal portions of the grain. They are usually regular, but sometimes show waviness and bending in some part of their course. They are, as a rule, not so fine but more distinct near the equator and the distal end than near the hilum, and there is often one especially large and distinct near the equator or the distal end. There are about 34 to 35 lamellæ on the larger grains.

The grains vary in *size* from the smaller, which are 8 by 6μ, to the largest elongated forms, which are 56 by 36μ in length and breadth; the largest broadened forms are 70 by 76μ. The common size is usually about 40 by 27μ.

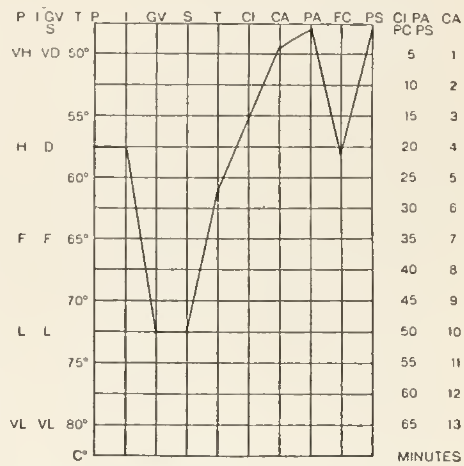
Polariscopic Properties.—The *figure* is very eccentric and distinct, but the lines are not clear-cut. The lines are usually broad, and broaden and become more diffused as they are nearer the margin of the grain. They often vary in width along their course, sometimes being bent and occasionally bisected or divided into branched lines. The angle of intersection of the lines also varies.

The degree of *polarization* is high, not varying much in different grains, but varying in different aspects of the same grain, being higher when the grain is viewed on end or on edge. In the same aspect of a grain it is usually not so high near the distal end as near the hilum.

With *selenite* the quadrants are not sharply defined and are somewhat irregular in shape and unequal in size. The colors are usually not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet, deeper at the margin and distal end than elsewhere; with 0.125 per cent solution they color fairly deeply, and the color deepens rapidly. After heating in water until all the grains are completely gelatinized, both the solution and the swollen grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues not at all or lightly. With an excess of iodine the capsules all color a red-violet.

Chart No. 97.



Curve of Reaction-Intensities of Starch of Lilium candidum.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and after 30 minutes they are stained rather light.

Temperature Reaction.—The temperature of gelatinization is 61.2° to 62.1° C., mean 61.65°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Almost all are gelatinized in 10 minutes and all in 15 minutes. The entire grain is immediately colored an old-rose. As the grain swells, either clouds or strands of darker color stream from the distal end towards the proximal end, at which a knob-like protuberance is formed that is stained a deep indigo-blue. A mass of substance so stained now appears at the distal end, and sometimes a thin layer of color also appears along the lateral margin. These two, with or without additional colored masses, now approach each other, pushing before them a thin, colorless envelope which forms a line of demarcation between the gelatinized and non-gelatinized parts. The central portion of the grain is the last to undergo gelatinization. Sometimes gelatinization is coincident at the proximal and distal ends, the latter end then being usually quite irregular in outline. In the broadly triangular or shell-shaped forms two protuberances frequently appear at the corners limiting the distal margin, then similar formations at the proximal end, and gelatinization advances from these points around the entire margin and towards the center, which is finally gelatinized. Sometimes a dark ring appears at the hilum, which breaks and forms a U, and is obscured as the colored, gelatinized part of the grain advances. At other times a transverse dark line appears at the hilum, which is drawn into a triangle and then obscured by the blue, proximal mass. The gelatinized grains are uniformly dark, except a light area which is probably the swollen hilum. Light, transverse lines at irregular intervals and two oblique lines extending from the position of the hilum towards the distal end may be observed. While the gelatinized grain is much enlarged and somewhat irregular in outline, it retains the general shape of the untreated grains.

Reaction with *chromic acid* begins at once and is complete in 50 seconds. The hilum becomes very distinct as a small light spot and two refractive lines pass from it towards the corners of the distal margin. The lamellæ at the distal margin are very distinct and finely striated. The proximal end swells rapidly, the clear space is enlarged at the hilum, and fine lines pass out from the two main lines mentioned above and also from the base of the gelatinized center of the grain. The entire grain is much enlarged and the outer layer at the proximal end becomes ruptured and allows the inner, gelatinized starch to flow out. The striated lamellæ at the distal margin are the last to be dissolved. During the process of solution a bubble is sometimes formed at the hilum, which precedes the formation of a channel of solution through the grain and finally collapses near the hilum end.

With *pyrogallic acid* the grains begin to react in 10 seconds and are fully gelatinized in a minute. Both hilum and lamellæ become very distinct. The hilum swells, and two refractive lines or channels appear and proceed from either side of the hilum towards the corners which limit the distal margin. The lamellæ between these lines are very conspicuous and finely striated. Delicate lines now pass from them and also from the base of the gelatinized area around the hilum; the proximal end swells rapidly, and in the ovoid forms it is much extended, while in the broadly triangular grains the path of gelatinization is frequently circuitous. In some grains the striated lamellæ at the lateral and distal margins are cut down at several points, so that a sharp, tooth-like lining appears within this outer coating. When gelatinization is complete a convoluted mass remains at the distal end, in which some refractive granules are sometimes found, while bounding the proximal end is the capsule and a delicately striated layer which may be slightly invaginated, or wrinkled, or have a slit through the middle. The gelatinized grains do not retain much of the form of the untreated grains. Some are pointed, while others are rounded at the proximal end. In a few grains the swelling is greater in the transverse than in the longitudinal axis.

With *ferric chloride* the grains begin to react in a minute. A few are gelatinized in 5 minutes, the majority in 10 minutes, and all in 21 minutes. At first neither the hilum nor the lamellæ are distinct. The marginal portion appears as a striated border which is less dense than the central part of the grain, and thus appears darker and less opaque than the latter. The hilum later becomes visible as a clear spot, or at this point a bubble or dark cleft may occasionally appear. The proximal end swells and a flowing movement of gelatinization takes place in which granular starch appears to pass through a cleft in the vicinity of the hilum, invagination usually occurring at this end, the capsule being greatly stretched but apparently not ruptured. Fine radiating lines extend from the corners of the central mass to the sides, and later from the base to the distal margin of the grain, and gelatinization progresses until all is broken down. The gelatinized grain is much swollen and does not retain much of the form of the untreated grain. In the broadly triangular grains the lines passing from the less resistant central part to the corners of the distal margin become larger until a crack results, and the flowing gelatinization movement takes place at these points as well as at the proximal end. Rarely there is an invagination at the distal end, and the lines joining this end with the central, more opaque mass become deepened, and gelatinization starts here.

Reaction with *Purdy's solution* begins at once in many grains. It is complete in several within 20 seconds and in all in 40 seconds. The hilum and lamellæ become very distinct. Gelatinization of the grain starts around the hilum and the proximal end swells. The outermost lamellar layer undergoes invagination after a short time. The lamellæ at the distal end become particularly conspicuous and delicately striated. Gelatinization progresses rapidly from the proximal end, and two distinct clear lines proceed obliquely towards the distal margin. From these two main lines fine lines are given off, and also a cluster of delicate lines pass from the base of the central, less resistant starch towards the distal margin. The entire grain appears to be permeated by delicate channels along which gelatinization is taking place, and thus the grain is soon broken down. The gelatinized grain is much enlarged, in most forms being greatly lengthened as well as broadened. Many of the broadly triangular grains undergo considerable extension laterally during the process of gelatinization. Sometimes a bubble appears at the hilum, as already noted during treatment with the other reagents, and it undergoes changes similar to those observed when the grain is treated with pyrogallic acid.

STARCH OF LILIUM LONGIFLORUM VAR. GIGANTEUM. (Plate 20, figs. 117 and 118. Chart 98.)

Histological Characteristics.—In *form* the grains are simple, isolated, and without pressure facets. They are usually regular in outline. There are some irregularities, caused by rounded, finger-like projections from the proximal end, and also by some large, rounded projections from other parts, which projections are often outlined from the main body of the grain by refractive lines which are probably indentations. The conspicuous forms are the broad and narrow triangular with curved base and rounded angles, clam-shell-shaped, and elliptical with both ends round and of the same size, and somewhat irregular elliptical with the distal end broadened and flattened. There are in addition ovoid, pyriform, mussel-shell-shaped, and rod-shaped grains. The small grains, of which there are very few, are round or nearly round.

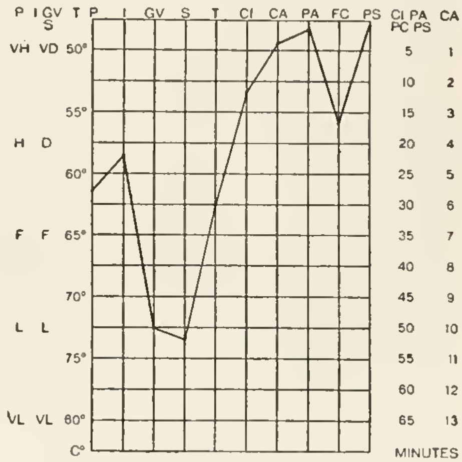
The *hilum* is a small, round or oval, not very distinct spot, with a range of eccentricity varying from one-sixth to one-ninth, usually one-sixth of the longitudinal axis. The hilum is sometimes marked by a cavity, or by a very short, narrow fissure, or less often a broad cleft from which a refractive line extends on each side towards the distal end.

The *lamellæ* are fairly distinct, usually regular circles or ellipses, or arcs of circles. They are fine and fairly distinct on about three-fourths of the grain, but usually coarse and very distinct near the distal end. There are sometimes one or two lamellæ near the equator of the grain, also coarse and very distinct. They vary somewhat in size and distinctness in different grains. There are about 35 to 40 lamellæ on the larger grains.

The grains vary in *size* from the small round forms, which are 8 by 8μ, to the larger elongated forms, which are 70 by 32μ, and the broad forms, which are 66 by 66μ in length and breadth. The common size is 40 by 22μ.

Polariscopic Properties.—The *figure* is very eccentric, distinct, but not clear-cut. The lines composing it may vary in width along their course, and they tend to become broader but less well defined as they approach the margin. They are sometimes bisected, but rarely further divided. They are also rarely bent or otherwise distorted, and they may be placed at varying angles from one another.

Chart No. 98.



Curve of Reaction-Intensities of Starch of Lilium longiflorum var. giganteum.

The degree of *polarization* is fairly high, not varying much in different grains, but varying in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is not so high as in *L. candidum.*

With *selenite* the quadrants are commonly fairly well defined, usually regular in shape and unequal in size. The colors are fairly pure, in many grains quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they all color fairly deeply, and the color deepens rapidly. It is not quite so deep as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply, but most of the grain-residues not at all, and some only lightly. The capsules are all colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After remaining in the solution for 30 minutes they are still only lightly stained, about the same as those of *L. candidum.*

With *safranin* the grains begin to stain at once. After remaining in the solution for 30 minutes they are still only lightly stained, and not quite so much as those of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 62.1° to 63° C., mean 62.55°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, the majority in 8 minutes, and all in 12 minutes. A dark ring or cleft is frequently formed at the hilum. A protuberance usually appears first at the proximal end, later at the distal end. The gelatinized grains are about as regular and the reaction is qualitatively the same as in *L. candidum.*

The grains begin to react at once with *chromic acid* and all are dissolved in 40 seconds. A bubble usually appears at the hilum. The reaction is qualitatively the same as in *L. candidum.*

Reaction with *pyrogallic acid* begins at once and all the grains are gelatinized in 45 seconds. A bubble sometimes appears at the proximal end. The gelatinized grains are more regular in outline than in *L. candidum,* the proximal end of more grains is rounded, and a sharp, serrated capsule is more frequently formed. A number of refractive granules remain in the gelatinized mass. The reaction is qualitatively the same as in *L. candidum.*

With *ferric chloride* the grains begin to react in 1½ minutes, few are gelatinized in 3 minutes, the majority in 9 minutes, and all in 17 minutes. The flowing gelatinization movement usually begins at the distal end and later appears at the proximal end. The reaction is qualitatively the same as in *L. candidum.*

The grains begin to react at once with *Purdy's solution* and all are gelatinized in 35 seconds. A bubble is frequently formed at the hilum, but disappears more quickly than in many forms of

Lilium. During gelatinization a brilliantly refractive lamella is frequently noted at about half the distance between the hilum and distal margin. The process is qualitatively the same as in the grains of *L. candidum.*

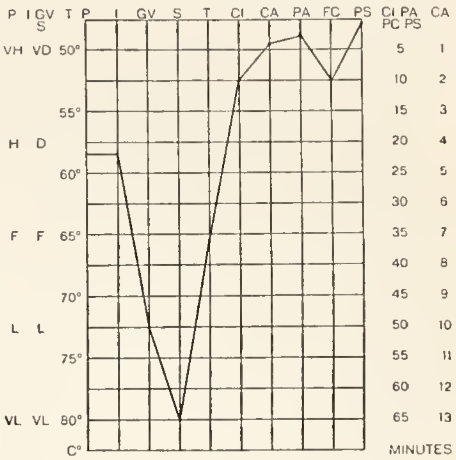
STARCH OF LILIUM LONGIFLORUM VAR. EXIMIUM. (Plate 20, figs. 119 and 120. Chart 99.)

Histological Characteristics.—In *form* the grains are simple; and except a few aggregates, chiefly doublets and triplets, they are isolated and rarely have pressure facets. The outline is usually fairly regular, but sometimes irregular, owing to rounded elevations and depressions in the surface of the grains and, occasionally, long, finger-like, rounded projections from the proximal end. Some grains have the appearance of having had one side of the distal end cut off in a slanting direction. The most conspicuous forms are the narrow and the broadened triangular with rounded base and angles, pyriform, elongated ovoid, and clam-shell-shaped to nearly round. There are also bottle-shaped, narrow elliptical often with one side bulging more than the other, quadrilateral, and a few mussel-shell-shaped.

The *hilum* is a rather indistinct, small, round, eccentric spot, its eccentricity nearly one-sixth to one-seventh, usually about one-sixth, of the longitudinal axis of the grains. The hilum is frequently fissured, the fissure being a small, narrow, straight, clean-cut transverse line, from which often two refractive lines proceed on each side outward and somewhat towards the distal end.

The *lamellæ* are fairly distinct, fine, regular circles, or ellipses, or segments of circles. They are continuous near the hilum, but appear discontinuous at the equator and at the distal end of the grain. They vary somewhat in different grains, and are not so fine but more distinct near the distal end than near the hilum. There are about 36 to 38 lamellæ on the larger grains.

Chart No. 99.



Curve of Reaction-Intensities of Starch of Lilium longiflorum var. eximium.

The grains vary in *size* from the smaller, which are 5 by 5μ, to the larger, elongated forms, which are 72 by 44μ, and the large, broadened forms, which are 70 by 66μ in length and breadth. The common size is 46 by 24μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. The lines of the figure are very broad, especially near the margin, and are not clearly defined. They are sometimes bisected, but occasionally bent, thus causing the figure to appear distorted, and they may be placed at varying angles to one another.

The degree of *polarization* is high, and higher when the grain is viewed on end or edge than on the flat. It varies somewhat in different grains, and is not so high as in *L. candidum.*

With *selenite* the quadrants are not very well defined, fairly regular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the colors deepen rapidly. It is not quite so deep as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues generally not at all or but lightly. The capsules are colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains stain very faintly at once. After remaining in solution for 30 minutes they are rather lightly stained. The depth of color is the same as that of *L. candidum.*

With *safranin* the grains stain very faintly at once. After remaining in this solution for 30 minutes they still stain very lightly. The color is less than that of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 65° to 66.2° C., mean 65.6°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once and all are gelatinized in 10 minutes. Protuberances appear first at the proximal end. The dark ring at the hilum described in *L. candidum* is more frequently observed than in that grain, but the process is qualitatively the same.

Reaction with *chromic acid* begins at once and is complete in 45 seconds. More bubbles appear at the hilum than in *L. candidum,* but the process is qualitatively the same.

With *pyrogallic acid* the grains begin to react in 20 seconds. A few small forms are gelatinized in 50 seconds and all the grains are gelatinized in 2½ minutes. The very small, round forms are completely gelatinized, but in the larger forms granules appear which remain in the gelatinous mass, and the layers at the distal end usually remain as a jointed, serrated lining in that region. The gelatinized grain is much swollen and more irregular in outline than in *L. candidum.* The process is qualitatively the same as in the latter.

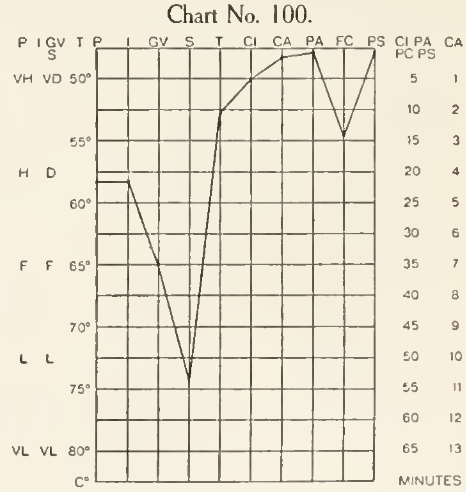
The grains begin to react in 30 seconds with *ferric chloride.* A few are gelatinized in 1½ minutes, the majority in 3½ minutes, and all in 10 minutes. A bubble appears frequently at the hilum, there is not so marked a contrast between the more transparent border and the central portion of the grain as in *L. candidum,* and the gelatinized grain is less irregular in outline, but the process is qualitatively the same.

Reaction with *Purdy's solution* begins at once. A few grains are gelatinized in 15 seconds, all in 30 seconds. The smaller grains are completely gelatinized, while the larger forms exhibit peculiarities similar to those noted in the reaction with pyrogallic acid. The points of difference between this grain and that of *L. candidum* are the more regular outline of the gelatinized grain, the more frequent appearance of bubbles at the proximal end, and the more common inversion of the outermost striated layer at this end during gelatinization, which inversion often persists after the reaction is completed. The process is qualitatively the same as in the grains of *L. candidum.*

STARCH OF LILIUM PARRYI. (Plate 21, figs. 121 and 122. Chart 100.)

Histological Characteristics.—In *form* the grains are simple, almost always isolated, and without pressure facets. The grains are sometimes irregular and varied in outline. The irregularities are due to lamellated and amorphous accretions at the sides and at times to the distal end; and also to a lack of development of one side of the distal end, causing it to be slanting. The conspicuous forms are the narrow elliptical, the pyriform, and bottle-shaped; also clam-shell-shaped, irregularly quadrilateral, elliptical with broadened and rather flattened distal ends, narrow ovoid, and some triangular with rounded angles and curved base. In general, the smaller grains are nearly round, ovoid, or rod-shaped.

Chart No. 100.



Curve of Reaction-Intensities of Starch of Lilium parryi.

The *hilum* is a distinct, rather small round or oval spot. It is eccentric, and the range of eccentricity is from one-fourth to one-seventh, usually one-fifth, of the longitudinal axis. The hilum is nearly always marked by a fairly deep cavity, from each side of which a refractive line often extends outwards and downwards towards the distal end; there is less frequently a short, narrow cleft at the hilum.

The *lamellæ* are not very distinct rather fine circles, or ellipses, or arcs of circles, etc., usually fairly regular, but sometimes showing waviness and other irregularities. As a rule, those near the distal end are not so fine, but more distinct than those near the hilum. There are sometimes two sets of lamellæ, the axis of one set forming an angle with the axis of the other. There are probably about 25 to 30 on the larger grains.

The grains vary in *size* from the smaller grains, which are 4 by 4μ, to the larger narrow elongated forms, which are 60 by 26μ, and the larger broader forms, which are 60 by 48μ in length and breadth. The common size is 32 by 19μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but usually not clear-cut; its lines are often bisected or further subdivided for at least a part of their length, as is common in this starch. They are also sometimes bent and otherwise distorted, and may be placed at varying angles, and they vary in width.

The degree of *polarization* is high, varying, but not much, in different grains, and highest when the grain is viewed on end or edge. It is very slightly less than that of the grains of *L. candidum.*

With *selenite* the quadrants are not well defined and are much broken up by the subdivisions of the lines of the interference figure. They are very irregular in shape and unequal in size. The colors are usually not pure, especially the yellow.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply, and the color deepens rapidly. It is not so deep as that of the grains of *L. candidum*. After heating in water until all the grains are completely gelatinized the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all, and a few very lightly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after remaining in the solution for 30 minutes they are fairly well stained, rather deeper than the grains of *L. candidum*.

With *safranin* the grains immediately begin to stain lightly, and after remaining in the solution for 30 minutes they are still slightly stained, not quite so much as the grains of *L. candidum*.

Temperature Reaction.—The temperature of gelatinization is 52° to 53.2° C., mean 52.6°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 1 minute, a majority in 3 minutes, and all in 5 minutes. A dark ring is usually found at the hilum and gelatinous projections are first formed at the distal end. The reaction is qualitatively the same as in the grains of *L. candidum*.

The grains begin to react at once with *chromic acid* and are dissolved in 15 seconds. Bubbles appear at the hilum. The reaction is qualitatively the same as in *L. candidum*.

With *pyrogallic acid* the grains begin to react at once and are completely gelatinized in 20 seconds. There is usually a bubble at the hilum, the proximal end is invaginated during the reaction, and the pathway of gelatinization is more or less twisted, instead of straight, as in *L. candidum*. The gelatinized grains are rather more convoluted at the distal end and more flattened at the proximal end than in *L. candidum*. The reaction is qualitatively the same as in the latter.

Reaction with *ferric chloride* begins in 30 seconds. A few grains are gelatinized in a minute, the majority in 3 minutes, and all in 14 minutes. The distal margin appears ragged, with many deep fissures passing through the striated border of the central mass. A flowing gelatinization movement takes place through these fissures. Sometimes this movement occurs almost coincidently at both ends, or at the proximal end to the corners limiting the distal margin. The outlines of the gelatinized grain are more regular than those of *L. candidum*. A bubble or deep fissure is usually present at the hilum. The reaction is qualitatively the same as in *L. candidum*.

The grains begin to react at once with *Purdy's solution*. Many are gelatinized in 15 seconds and all in 20 seconds. Bubbles generally appear at the hilum. The gelatinized grain is similar in form to that of *L. candidum*, but a larger number are rounded at the proximal end. The reaction is qualitatively the same as that of the grains in *L. candidum*.

STARCH OF LILIUM RUBELLUM. (Plate 21, figs. 123 and 124. Chart 101.)

Histological Characteristics.—In *form* the grains are simple and are isolated except for a few doublets and other small aggregates. Pressure facets are rare. The grains are somewhat irregular in outline at times, owing in part to unequal development, causing the surface to be somewhat elevated and depressed; and in part, although rarely, to lamellated additions to the sides. These additions are usually broad, and do not extend far out from the body of the grain. Many grains appear to have one side underdeveloped at the distal end, so that this end is oblique. The conspicuous forms are the elliptical with a broadened and sometimes flattened distal end, pyriform, and narrow and broad triangles with curved base and rounded angles; also ovoid, bottle-shaped, irregularly quadrilateral, and a few clam-shell-shaped and broadly lenticular forms. The smaller grains, of which there is a fair number, are round, nearly round, or elliptical.

The *hilum* is usually a distinct, small, and round or oval cavity, with a range of eccentricity from one-fifth to one-seventh, in most grains one-sixth of the longitudinal axis. It is sometimes marked by a short, narrow, clean-cut, and transverse fissure. From each side of the fissure or cavity two lines often extend outward and towards the distal end.

The *lamellæ* are usually distinct, rather fine, commonly regular circles, or ellipses, or arcs of circles, etc.; not so fine, but more distinct near the distal end than near the hilum, and in many grains fairly coarse near the distal end. A few grains have two sets, the axis of one forming an angle with the axis of the other. There are from 26 to 30 on the larger grains.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger, narrow, elongated forms, which are 64 by 48μ, and the broader forms, which are 60 by 58μ in length and breadth. The common size is 38 by 24μ.

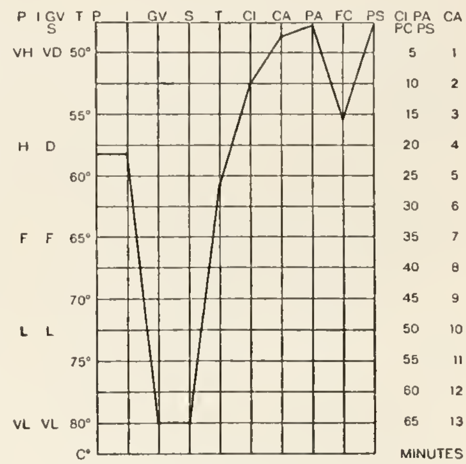
Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. Its lines are often bisected or further subdivided into three or more small lines for at least a part of their length. They are also often bent or otherwise distorted, variable in width, and sometimes placed at varying angles.

The degree of *polarization* is high, varying somewhat in different grains and in different aspects of the same grain; highest when the grain is viewed on end or edge. It is less than that of the grains of *L. candidum.*

With *selenite* the quadrants are not well defined, very irregular in shape, and unequal in size; colors usually not pure, the yellow having an admixture of red.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is less than that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply, but most of the grain-residues do not color at all, and others only lightly. The capsules color a red-violet with an excess of iodine.

Chart No. 101.



Curve of Reaction-Intensities of Starch of Lilium rubellum.

Staining Reactions.—With *gentian violet* the grains begin to stain at once, but there is very little change after they have remained in the solution for 30 minutes. They are very lightly stained, less than the grains of *L. candidum.*

With *safranin* the grains begin to stain at once, though very lightly, and there is practically no change after being in the solution for 30 minutes. They do not stain so much as the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 60.8° to 61.1° C., mean 60.95°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 2 minutes, the majority in 5 minutes, and all in 10 minutes. A protuberance appears more frequently first at the proximal end, and often later at the distal end or corners limiting the distal margin. The gelatinized grain is somewhat more irregular in outline than that of *L. candidum,* but the reaction is qualitatively the same.

Reaction with *chromic acid* begins at once. Many are dissolved in 20 seconds and all in 30 seconds. A bubble is occasionally formed at the hilum. The reaction is qualitatively the same as that of the grains of *L. candidum.*

With *pyrogallic acid* the grains begin to react at once and all are gelatinized in 25 seconds. A bubble frequently appears at the proximal end. More of the gelatinized grains are rounded at the proximal end than in *L. candidum,* and there is a greater variation in shape in some of the pointed forms having a central channel, and which appear rather more frequently than among the gelatinized grains of *L. candidum.*

The grains begin to react in a minute with *ferric chloride.* A few are gelatinized in 3 minutes, the majority in 7 minutes, and all in 16 minutes. The reaction is qualitatively the same as that of the grains of *L. candidum.*

Reaction with *Purdy's solution* begins at once and all the grains are gelatinized in 20 seconds. A bubble usually appears at the proximal end. The gelatinized grains vary much in form. More of them are rounded at the proximal end than in *L. candidum,* but the process is qualitatively the same.

STARCH OF LILIUM PHILADELPHICUM. (Plate 21, figs. 125 and 126. Chart 102.)

Histological Characteristics.—In *form* the grains are simple, isolated, and without pressure facets. They show inequalities in the surface in the form of elevations and depressions; there are long, slender, and rounded projections from the proximal end; and particularly large, lamellated additions, usually one but sometimes two in number, of varying size and shape, generally at the distal end or the sides of the grain. Many of the forms are distorted by these additions until they closely resemble irregularly shaped pebbles. Some grains are bent along the longitudinal axis. The conspicuous forms are the flattened elliptical with both ends rounded and blunt, and sometimes distorted by additions; rod-shaped, lenticular, clam-shell-shaped, and mussel-shell-shaped. There are also some triangular grains with rounded base and angles, pyriform, and a few ovoid and quadrilateral forms. The smaller grains are usually round or nearly round.

The *hilum* is a distinct, eccentric, small, round or oval cavity, with a range of eccentricity of from one-fourth to one-sixth, in most of the grains one-fifth, of the longitudinal axis; often with a small, narrow, and transverse fissure; the fissure and cavity may have two lines from each side proceeding outward and towards the distal end of the primary part of the grain.

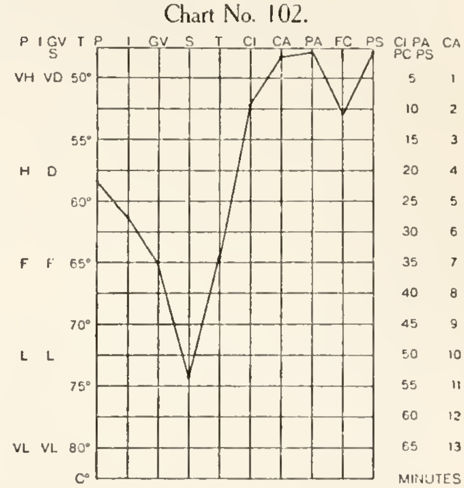
The *lamellæ* are not very distinct fine circles, ellipses, or segments of circles, etc., generally regular, but occasionally with a waviness of outline. Sometimes, at the sides or distal end of the grain, there are two or more sets of lamellæ, whose longitudinal axes form angles of varying degrees with that of the primary part of the grain, and which have apparently been formed at a different date from the latter. The lamellæ are not so fine, but are more distinct near the distal end than near the hilum. There are about 15 to 20 lamellæ on the larger grains. Some of the grains appear to be in the process of erosion.

The grains vary in *size;* the small grains are 4 by 4μ, the larger, elongated forms are 50 by 34μ, and the broadened forms are 40 by 40μ in length and breadth. The common size is 30 by 17μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and often clear-cut. The lines are sometimes not clearly defined and often placed at varying angles, bisected, and usually much curved, or sharply bent, thus causing the figure to be much distorted.

The degree of *polarization* is high, varying somewhat in different grains and in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is not so high as that of the grains of *L. candidum.*

Chart No. 102.



Curve of Reaction-Intensities of Starch of Lilium philadelphicum.

With *selenite* the quadrants are from fairly well defined to well defined, very irregular in shape and unequal in size. The colors are usually not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is much less than that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, while most of the grain-residues do not color at all, and the others only lightly. The capsules are all colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After being in solution for 30 minutes they stain fairly, somewhat more than the grains of *L. candidum.*

With *safranin* the grains begin to stain at once, although not so well as in *L. candidum.* After remaining in solution for 30 minutes they are rather lightly stained, not so much as the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 62.8° to 65° C., mean 63.9°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, many in 3 minutes, and all in 9 minutes. A dark ring frequently forms at the hilum, and irregular protuberances usually appear first at the distal end, and sometimes almost simultaneously from both ends. Where there are angles of irregularities on the grain, colored protuberances appear first at the points. The gelatinized grain is of varied and irregular shape. The reaction is qualitatively the same as that of the grains of *L. candidum.*

With *chromic acid* the grains begin to react at once and are completely dissolved in 20 seconds. Bubbles frequently appear at the hilum. The reaction is qualitatively the same as in *L. candidum.*

The grains begin to react at once with *pyrogallic acid* and all are gelatinized in 17 seconds. Bubbles frequently appear at the proximal end. The gelatinized grains are more rounded at the proximal end and more irregular than in *L. candidum*, but the reaction is qualitatively the same.

The reaction with *ferric chloride* begins in 30 seconds. A few grains are gelatinized in a minute, the majority in 4 minutes, and all in 11 minutes. Bubbles appear frequently at the proximal end and a flowing gelatinization movement usually first appears there, but sometimes begins simultaneously at both ends; or in the triangular forms this movement is very often first started at the corners limiting the distal margin. The reaction is qualitatively the same as that of the grains of *L. candidum*.

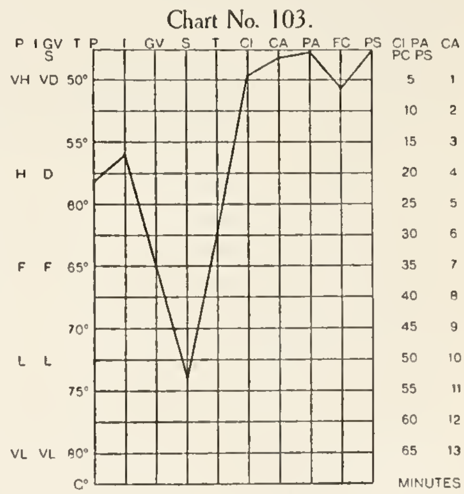
With *Purdy's solution* the grains begin to react at once. Many are gelatinized in 15 seconds and all in 23 seconds. Bubbles appear at the hilum in most grains. The outline of the gelatinized grains is very irregular. All the starch parts except the outermost layers of the smaller grains are gelatinized in this time, and in the larger grains there is a smaller convoluted mass at the distal end than in *L. candidum*. The process is qualitatively the same as in the latter.

STARCH OF LILIUM TIGRINUM VAR. SPLENDENS. (Plate 22, figs. 127 and 128. Chart 103.)

Histological Characteristics.—In *form* the grains are simple, isolated, and without pressure facets. The surface is usually irregular and varied. The irregularities are due to many inequalities in the form of elevations and depressions, and to some rather small, lamellated additions to the sides, or distal or proximal end. Sometimes a long, curved, finger-like, rounded protrusion appears at the proximal end. The conspicuous forms are flattened elliptical with the distal end somewhat broader than the proximal; narrow triangular with rounded angles and curved base; rod-shaped, which may be either bent, straight, or club-shaped. There are also pyriform, irregularly quadrilateral, clam-shell-shaped, mussel-shell-shaped, and nearly round grains. The smaller grains, which are not very numerous, are usually round, nearly round, or ovoid.

The *hilum* is a small, round, eccentric, not very distinct spot. The range of eccentricity is from one-fifth to one-sixth, usually one-sixth, of the longitudinal axis. The hilum is sometimes fissured, and the fissure is small, narrow, straight, clean-cut, and transverse; and two refractive lines sometimes extend from each end outward and towards the distal end.

The *lamellæ* are not very distinct, rather fine circles, ellipses, or irregularly formed rings or segments of circles, etc. They vary in size and distinctness in different grains; usually not so fine but more distinct near the distal end than near the hilum. They are often very irregular in form, and nearly all follow the outline of the margin. There are sometimes two or three sets of lamellæ. There are about 30 on the larger grains.



Curve of Reaction-Intensities of Starch of Lilium tigrinum var. splendens.

The grains vary in *size* from the small grains, which are 6 by 6μ, to the larger, which are 54 by 23μ in length and breadth. The common size of the elongated forms is 32 by 18μ in length and breadth. There are also many broadened forms, of which the common size is 30 by 28μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, distinct, and often clear-cut in the greatest part of its length; its lines are often very wavy, of varying width, and much curved, thus distorting the figure. They are placed at varying angles with one another.

The degree of *polarization* is high or fairly high, varying in different grains and in different aspects of the same grain. It is not so high as that of the grains of *L. candidum*.

With *selenite* the quadrants are not well defined, are very irregular in shape, and unequal in size. The colors are usually not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly deeply, and the color deepens rapidly. The color is deeper than that of the grains of *L. candidum*. After heating until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues are not colored at all or lightly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After being in the solution for 30 minutes they are fairly well stained, and more than in the case of the grains of *L. candidum.*

With *safranin* the grains begin to stain immediately. After remaining in solution for 30 minutes they are stained lightly, slightly less than the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 61.7° to 62.4° C., mean 62.05°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in 40 seconds, many in 2 minutes, and all in 4½ minutes. Protuberances appear simultaneously at both ends in the elongated grains, and in form the gelatinized grain is the same as in *L. candidum.* The reaction is qualitatively the same as in the grains of *L. candidum.*

The grains begin to react at once with *chromic acid* and all are dissolved in 15 seconds. No bubbles were observed at the hilum. The reaction is qualitatively practically the same as that in the grains of *L. candidum.*

With *pyrogallic acid* the grains begin to react at once and all are gelatinized in 35 seconds. The gelatinized grains of the small rounded forms are regular in outline; those of the others are quite irregular. The reaction is qualitatively the same as in the grains of *L. candidum.*

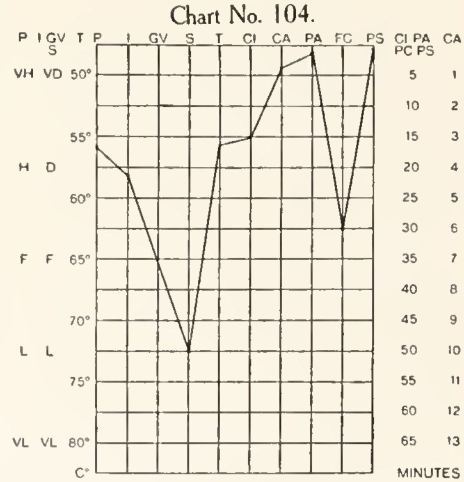
Reaction with *ferric chloride* begins at once. A few grains are gelatinized in 1½ minutes, the majority in 7 minutes, and all in 12 minutes. A flowing gelatinization movement begins in 30 seconds at the proximal end, or rarely simultaneously at both ends. The reaction is qualitatively the same as in *L. candidum.*

The grains begin to react at once with *Purdy's solution* and all are gelatinized in 20 seconds. In many of the grains bubbles appear at the hilum. The proximal end of the gelatinized grains is generally more rounded than in the grains of *L. candidum.* The reaction is qualitatively the same as in the grains of *L. candidum.*

STARCH OF LILIUM HENRYI. (Plate 22, figs. 129 and 130. Chart 104.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few in doublets and grains made up of clusters of small grains attached to the distal end of a large one. Sometimes single large pressure facets appear on the smaller grains, and a number of small irregular facets at the distal end of some of the larger grains. The surface of the grains is frequently irregular, owing to inequalities in the form of more or less knobby projections, to large and small lamellated additions to an otherwise completed grain, and to unequal development of the margin which causes one side of the distal end to project more than the other. The conspicuous forms are the narrow elliptical, the irregularly elliptical with one bulging side and the other somewhat flattened or a somewhat broadened distal end, and the triangular with curved base and rounded angles; also irregularly quadrilateral, rod-shaped, either bent or straight, nearly round, pyriform, clam-shell-shaped, broadly lenticular, and spindle-shaped grains. The comparatively few small grains are usually round, ovoid, or elliptical.

Chart No. 104.



Curve of Reaction-Intensities of Starch of Lilium henryi.

The *hilum* is a distinct round or elliptical spot, or deep cavity, with a range of eccentricity of from one-fifth to one-ninth of the longitudinal axis, usually one-fifth. It is sometimes marked by a small, straight or curved, transverse cleft, from each side of which a refractive line extends towards the distal end. Rarely a number of irregular fissures extend from the central cavity.

The *lamellæ* are distinct ellipses or circles, or rarely arcs of circles; usually rather coarse near the hilum, margin, and distal end, but fine at the equator of the grain. They appear to be discontinuous here, but are continuous near the margin, where they take the shape of the grain; often wavy in outline and irregular. Usually two or three very coarse and distinct ones are located at about one-third the distance between the hilum and the distal end and there may be one or two additional sets of lamellæ whose axes form angles with that of the main part of the grain. There are about 30 to 35 on the larger grains.

The small grains vary in *size* from 6 by 6μ, to the larger elongated forms, which are 90 by 42μ in length and breadth. The common size of the elongated forms is 40 by 26μ, and of the broader forms 40 by 35μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, usually not clear-cut. Its lines are generally broad and not clearly defined in some parts of their length; often bisected, or even further subdivided for at least a part of their length, and generally are also much bent and variable in width, and may be placed at varying angles to one another.

The degree of *polarization* is high, varying somewhat in different grains and in different aspects of the same grain, highest when the grain is viewed from end or edge. It is commonly somewhat higher than in the grains of *L. candidum.*

With *selenite* the quadrants are not well defined, very irregular in shape, and unequal in size. The colors not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep reddish-blue; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is not quite so deep as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all or lightly. The capsules color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After remaining in the solution for 30 minutes they are fairly well stained. The color exceeds that of the grains of *L. candidum.*

With *safranin* the grains begin to stain at once. After remaining in the solution for 30 minutes the stain is rather light to fair and about the same as the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 55.9° to 56.1° C., mean 56°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, the majority in 8 minutes, and all in 15 minutes. Protuberances usually first appear at the distal end in elongated forms, and at the corners limiting the distal margin of the broadly triangular forms. Either a dark-colored ring or fissure appears at the hilum at once. The gelatinized grains are slightly more irregular in outline than those of *L. candidum.* The reaction is qualitatively the same as in *L. candidum.*

With *chromic acid* the grains begin to react at once and are completely dissolved in 40 seconds. Bubbles are formed at the hilum. The reaction is qualitatively the same as in the grains of *L. candidum.*

Reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 20 seconds and all in a minute. Large bubbles are usually formed at the hilum. The reaction is qualitatively the same as the grains of *L. candidum.*

The reaction with *ferric chloride* begins in a minute. A few are gelatinized in 3 minutes, the majority in 11 minutes, and all in 30 minutes. The flowing gelatinization movement begins usually at the proximal end, but often starts simultaneously from both ends. In the broadly triangular and shell-shaped grains the flowing movement begins almost simultaneously at the proximal end and at the two corners of the distal margin. The reaction is qualitatively the same as that in the grains of *L. candidum.*

With *Purdy's solution* the grains begin to react immediately. Many are gelatinized in 15 seconds and all in 20 seconds. Bubbles appear at the hilum, and the proximal end is invaginated, and later swollen. The gelatinized grains are more rounded at the proximal end than most of those of *L. candidum.* The reaction is qualitatively the same as in the grains of *L. candidum.*

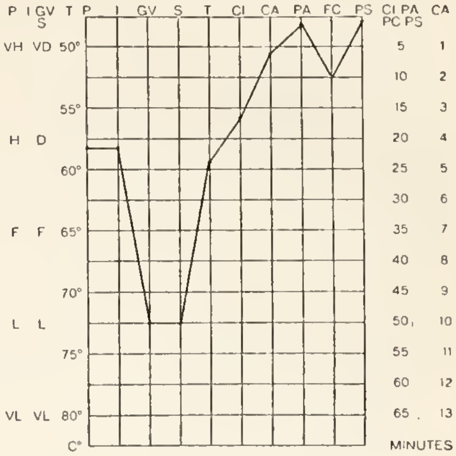
STARCH OF LILIUM AURATUM. (Plate 22, figs. 131 and 132. Chart 105.)

Histological Characteristics.—In *form* the grains are simple and are isolated, except a few doublets; a few show poorly defined pressure facets. The surface of the grains is often irregular, due to unequal development and to mutual pressure of the grains during growth, resulting in more or less angular depressions and elevations of the surface of the grain (especially at the sides and near the distal end) and in long, thick, straight or curved, or rounded projections from the proximal end. The conspicuous forms are narrow triangular to pyriform with rounded bases and angles, elongated ovoid, and narrow elliptical, often with a somewhat flattened distal end; also broadly triangular forms with rounded bases and angles, clam-shell-shaped, mussel-shell-shaped, oyster-shell-shaped, quadrilateral with rounded angles, and nearly round forms. The comparatively few small grains are usually round or elliptical.

The *hilum* is a small, rather indistinct, round, eccentric spot. Its range of eccentricity is from one-fifth to one-sixth, usually one-fifth. It may be marked by a small, single, straight, narrow, clean-cut, transverse fissure, with sometimes a refractive line extending outward toward the distal end from each side of the fissure.

The *lamellæ* are not very distinct fine lines that are continuous as circles or ellipses near the hilum, and appear to be discontinuous at the equator and distal end of the grain. They are usually fairly regular, but sometimes show bending and waviness in outline. They vary in size and distinctness in different grains, and are also generally not so fine but more distinct near the equator and the distal end of the grain than near the hilum. There appear to be about 30 on the larger grains, but this number is probably not accurate.

Chart No. 105.



Curve of Reaction-Intensities of Starch of Lilium auratum.

The grains vary in *size;* the smaller are 8 by 8μ; the largest narrow elongated forms are 80 by 44μ; the largest broad elongated forms are 60 by 48μ in length and breadth; the common size is 42 by 28μ.

Polariscopic Properties.—The *figure* is very eccentric, distinct, but often not clear-cut, since the lines become broader and less clearly defined as they proceed from the region of the hilum. They are often bisected and otherwise divided for some portion of their length, and are usually of irregular width, and bent, thus distorting the figure even to a greater extent than in the grains of *L. candidum.* The lines may be placed at varying angles.

The degree of *polarization* is high. It does not vary much in different grains, but is markedly higher when the grain is viewed on end or edge, and also varies in different parts of a given aspect of the same grain. It is slightly lower than that of the grains of *L. candidum.*

With *selenite* the quadrants are generally not well defined, often irregular in shape, and usually unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is not quite so deep as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues not at all or lightly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once. After remaining in solution for 30 minutes they are only stained rather lightly, the same as in the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 58° to 59.2° C., mean 58.6°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 2 minutes, the majority in 6 minutes, almost all in 10 minutes, and all in 17 minutes. Either a dark spot or line appears at the hilum. A protuberance frequently forms first at the proximal end, then at the distal margin, and sometimes at the corners limiting the distal margin of the broadly triangular grains. Gelatinization usually proceeds towards the center, more quickly from the proximal than the distal end. The outline of the gelatinized grain is more undulating than in the grains of *L. candidum*, but the reaction is the same qualitatively.

With *chromic acid* the grains begin to react at once and the reaction is complete in 70 seconds. A bubble is formed at the hilum more frequently than in *L. candidum.* The reaction is qualitatively the same as the grains of *L. candidum.*

Reaction with *pyrogallic acid* begins at once and all the grains are gelatinized in a minute. A bubble at the hilum appears more frequently than in *L. candidum.* During the process a band of refractive granules develop at about half the distance between the hilum and the distal margin, and sometimes a second one forms nearer the distal margin as gelatinization proceeds. The gelatinized grain often has a sharp, serrated lining at the distal margin, which sometimes extends partly up the sides. There are refractive granules in the gelatinized mass of the grain. The lateral walls are usually thinner and the proximal end more rounded than in the gelatinized grain of *L. candidum,* but the reaction is qualitatively the same.

The grains begin to react with *ferric chloride* in a minute. A few are gelatinized in 2 minutes, the majority in 10 minutes, and all in 22 minutes. The swelling more frequently occurs first at the distal end, then at the proximal end. In the broadly triangular forms the flowing gelatinization movement frequently begins at the two corners limiting the distal margin. The reaction is qualitatively the same as that of the grains of *L. candidum.*

With *Purdy's solution* the grains begin to react at once and all are gelatinized in 35 seconds. A bubble forms at the hilum more frequently than in *L. candidum.* A brilliantly refractive band frequently appears at about half the distance between the hilum and the distal margin. The reaction is qualitatively the same as that of the grains of *L. candidum.*

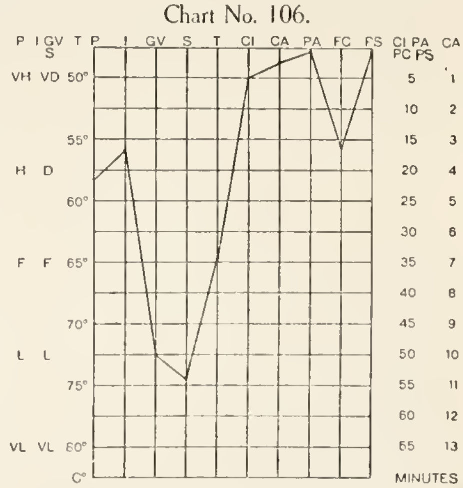
STARCH OF LILIUM SPECIOSUM VAR. ALBUM. (Plate 23, figs. 133 and 134. Chart 106.)

Histological Characteristics.—In *form* the grains are simple and for the most part isolated. There are very few small aggregates in the form of doublets, and a few pressure facets may be observed on some of the grains. The surface of the grains is usually quite regular, any slight irregularities which occur being due to an unequal development of the margin. The conspicuous forms are the narrowed to broad triangular with a curved base and rounded angles, and the elliptical that is regular in outline or with a broadened and somewhat flattened distal end; also, ovoid, clam-shell-shaped to nearly round, mussel-shell-shaped, and somewhat irregularly quadrilateral forms. The few small grains are usually round, oval, or elliptical.

The *hilum* is a distinct, small, round spot or cavity, with a range of eccentricity one-fifth to one-seventh, usually one-sixth, of the longitudinal axis. Besides the spot or cavity already noted, there may at times be a short, narrow, straight, transverse cleft, from each side of which a refractive line extends towards the distal end of the grain.

The *lamellæ* are distinct, fine, usually regular circles, ellipses, or arcs of circles, sometimes not so fine but more distinct near the distal end than near the hilum. There are at times two sets of lamellæ, one appearing later than the other, and forming an angle with a longitudinal axis of the primary grain. There are about 42 to 44 lamellæ on the larger grains.

Chart No. 106.



Curve of Reaction-Intensities of Starch of Lilium speciosum var. album.

The grains vary in *size;* the smaller are 4 by 4μ; the larger, narrow, elongated forms are 52 by 28μ; the elongated broader forms are 52 by 44μ in length and breadth. The common size is 34 by 22μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. Its lines are commonly somewhat broadened and less well defined in some part of their length; sometimes also bisected and even further subdivided; occasionally bent and the figure consequently distorted; and often placed at varying angles to one another.

The degree of *polarization* is high, not varying much in different grains, but varying in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is not quite so high as that of the grains of *L. candidum.*

With *selenite* the quadrants are not well defined, are usually regular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply, and the color deepens rapidly. It is deeper than that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and most of the grain-residues not at all or lightly. The capsules are all colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and after remaining in the solution for 30 minutes they are lightly stained, the same as the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 64.1° to 64.6° C., mean 64.35°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 30 seconds, the majority in 2 minutes, and all in 5 minutes. A protuberance usually appears first at the proximal end, followed by another at the distal margin, or by one at each corner limiting the distal margin. The reaction is qualitatively the same as that of the grains of *L. candidum.*

With *chromic acid* the grains begin to react at once and are completely gelatinized in 25 seconds. As a rule a bubble is not formed at the hilum. The reaction is qualitatively the same as that in the grains of *L. candidum.*

Reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 10 seconds and all in 20 seconds. A bubble sometimes occurs at the hilum. The gelatinized grains vary greatly in shape, some having the proximal end rounded, others pointed, as often found in those of *L. candidum;* while others are peculiar by being more swollen in the transverse than the longitudinal axis. The small rounded forms are usually completely gelatinized in the time stated, with the exception of the two outermost layers. The reaction is qualitatively the same as in the grains of *L. candidum.*

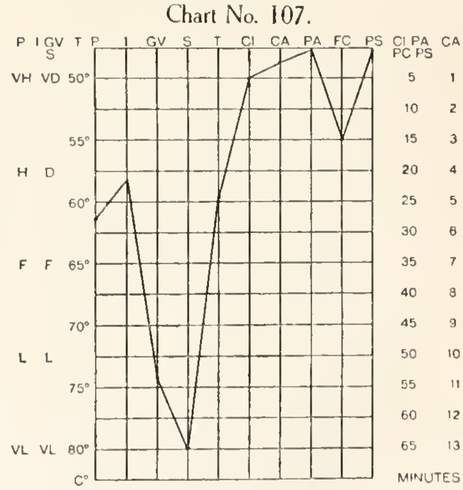
With *ferric chloride* the grains begin to react in 10 seconds. A few are completely gelatinized in 2 minutes, the majority in 8 minutes, and all in 17 minutes. The flowing gelatinization movement begins in 30 seconds at the distal margin, and progresses around the grain. The reaction is qualitatively the same as in the grains of *L. candidum.*

Reaction with *Purdy's solution* begins at once and the grains are completely gelatinized in 15 seconds. The reaction is qualitatively the same as in the grains of *L. candidum.*

STARCH OF LILIUM MARTAGON. (Plate 23, figs. 135 and 136. Chart 107.)

Histological Characteristics.—In *form* the grains are simple, and they are isolated, except a few that occur in small aggregates in the form of doublets and triplets. No pressure facets are noted on any of the grains. The surface of the grains tends to be somewhat irregular, the irregularities being due to knobby projections of the surface, to many fairly large, lamellated additions to the sides and ends, and also in a few cases to curved or straight, finger-like projections from the proximal end. The conspicuous forms are the elliptical with both ends rounded, or irregularly elliptical with distal end flattened or with one side curved and the other flat to bottle-shaped, and the rod-shaped, which may be either straight or bent; also lenticular, spindle-shaped, ovoid, irregularly quadrilateral, triangular, and round or nearly round. The smaller grains, of which there are few, are usually of the elliptical type.

Chart No. 107.



Curve of Reaction-Intensities of Starch of Lilium martagon.

The *hilum* is a fairly distinct, small round spot or cavity, with a range of eccentricity from one-fifth to one-tenth, usually about one-sixth, of the longitudinal axis. There is sometimes a short fissure at the hilum, from which two lines extend on each side towards the distal end.

The *lamellæ* are distinct and often rather coarse, but occasionally fine. They are circles, ellipses, or arcs of circles, those near the margin being very coarse, continuous, and with the curvature of the margin of the grain. There are often some irregularities of outlines of the lamellæ, and in many grains there are one or two additional sets of lamellæ whose axes form angles with the longitudinal axis of the main part of the grain. There are 15 to 20 on the larger grains.

The grains vary in *size;* the small grains are 12 by 8μ; the large, elongated forms are 60 by 30μ in length and breadth; the common size is 34 by 20μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and often clear-cut. At times some or all of its lines are broadened and not clearly outlined for at least part of their length. They are frequently bisected, and sometimes even further subdivided, and often somewhat bent and variable in width, and located at varying angles to one another.

The degree of *polarization* is fairly high. It varies in different aspects of a grain, being higher when the grains are viewed on end or edge. It is not so high as that of the grains of *L. candidum.*

With *selenite* the quadrants are fairly well or even quite well defined, and are irregular in shape and unequal in size. The colors are generally not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are all colored a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is not quite so deep as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues do not color or but very lightly. The capsules are all colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains stain very faintly at once. After remaining in the solution for 30 minutes they are only lightly stained. The color is less than that of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 58.5° to 59.7° C., mean 59.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, the majority in 3 minutes, and all in 5 minutes. Clouds of color move rapidly over the grain and a protuberance frequently occurs, first at the proximal end and then at the other end, or at the corners limiting the distal margin in case of the broadly triangular grains. The outline of the gelatinized grain is more irregular than in *L. candidum,* but the reaction is qualitatively the same.

The grains begin to react at once with *chromic acid* and all are dissolved in 25 seconds. The reaction is qualitatively the same as in the grains of *L. candidum.*

Reaction with *pyrogallic acid* begins immediately and all the grains are dissolved in 20 seconds. Bubbles are formed at the hilum. Most of the gelatinized grains are more rounded at the proximal margin than those in *L. candidum,* and the outermost lamellar layer is often folded or involuted at this region. Many of the fair-sized forms have a very small amount of starch remaining ungelatinized at the distal end. The reaction is qualitatively the same as in the grains of *L. candidum.*

With *ferric chloride* the grains begin to react in 40 seconds. A few are gelatinized in 1½ minutes, the majority in 12 minutes, and all in 15 minutes. There is usually a flowing gelatinization movement attended by swelling at both ends. It generally starts simultaneously at both ends, but sometimes first at one end, more frequently the proximal. A bubble or cleft appears at the hilum. The gelatinized grain is much distorted, and is more irregular than in *L. candidum,* but the reaction is qualitatively the same.

The grains begin to react at once with *Purdy's solution* and all are gelatinized in 25 seconds. Bubbles usually form at the hilum. The gelatinized grains are much varied in shape, but more are rounded at the proximal end than in *L. candidum.* The reaction is qualitatively the same as in the latter.

STARCH OF LILIUM SUPERBUM. (Plate 23, figs. 137 and 138. Chart 108.)

Histological Characteristics.—In *form* the grains are simple, almost wholly isolated, and without pressure facets. The surface is quite regular, with a few slight inequalities or rounded finger-like processes from the proximal end, which are often marked at the base by a refractive line, or of large, lamellated additions to the sides. The conspicuous forms are the ovoid and the narrow or broad triangular with rounded angles and curved base, which may be cut off slantingly at one side; also irregularly quadrilateral, clam-shell-shaped, rod-shaped, mussel-shell-shaped; elliptical with the distal end broadened and flattened, or with both ends of the same size; and rounded or rarely nearly round. The comparatively few small grains are usually round, nearly round, or elliptical in form.

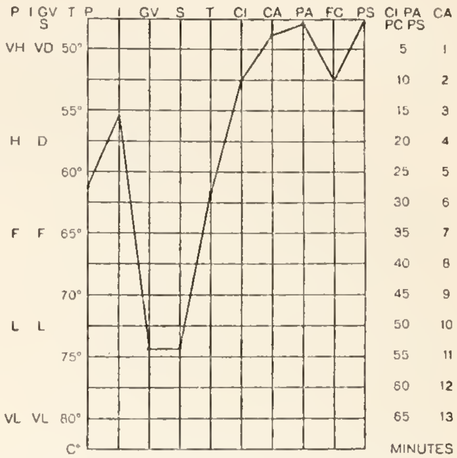
The *hilum* is a fairly distinct, small, round or elliptical cavity or spot, with a range of eccentricity of one-fourth to one-sixth, usually one-fifth, of the longitudinal axis. It is sometimes marked by a small, straight, transverse fissure. From both the cavity and the fissure two lines proceed on each side towards the distal end.

The *lamellæ* are indistinct, fine, regular circles or ellipses, or arcs of circles, usually not so coarse but more distinct near the distal end than near the hilum. There may be one or two sets of secondary lamellæ whose longitudinal axes form angles with that of the main part of the grain. On account of their indistinctness the number was not determined.

The grains vary in *size;* the smaller are 7 by 7μ; the larger, elongated forms are 60 by 40μ; the larger, broad forms are 44 by 60μ in length and breadth. The common size is 34 by 18μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. Its lines are rarely clearly defined and are often bisected or even further divided. They are also often bent and placed at varying angles, and sometimes are joined to one another by a distinct or hazy line that runs parallel to the direction of the lamellæ at about one-third to one-fourth of the distance from the hilum to the distal end.

Chart No. 108.



Curve of Reaction-Intensities of Starch of Lilium superbum.

The degree of *polarization,* as a rule, is fairly high, varying from high to low and also in different aspects of the grain, being highest when the grain is viewed on end or edge. It is not so high as that of the grains of *L. candidum.*

With *selenite* the quadrants are not well defined, are irregular in shape, and unequal in size. The colors are usually not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is deeper than that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the gelatinized grains fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residue not at all or very lightly. The capsules are colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once. After remaining in the solution for 30 minutes they are lightly stained, the color being less than that of the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 60.8° to 62.4° C., mean 61.6°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in a minute, the majority in 5 minutes, and all in 10 minutes. A dark ring frequently forms at the hilum. A protuberance often appears first at the proximal end, but sometimes first at the distal end, or at both ends simultaneously. The outline of the gelatinized grain is more irregular than that of the grains of *L. candidum,* but the reaction is qualitatively the same.

With *chromic acid* the grains begin to react at once. Many are dissolved in 20 seconds and all in 25 seconds. Bubbles usually appear at the proximal end. The reaction is qualitatively the same as in the grains of *L. candidum.*

Reaction with *pyrogallic acid* begins at once and all the grains are gelatinized in 35 seconds. A bubble usually appears at the hilum. The gelatinized grain is usually rounded at the proximal end, and in many grains this end does not elongate so much as in *L. candidum,* and the swelling extends more in the transverse than in the longitudinal axis. There are usually refractive granules in the gelatinized mass and lamellar layers; and sometimes the lateral margin forms a sharp, serrated lining at the distal end of the grain, which later becomes an amorphous mass. The reaction is qualitatively the same as in the grains of *L. candidum.*

The grains begin to react with *ferric chloride* in 30 seconds, a striated border appearing and a dark spot at the hilum. The flowing gelatinization movement begins in a minute, usually at the proximal end, rarely coincidently at both ends. A few grains are gelatinized in 2 minutes, the majority in 4 minutes, and all in 10 minutes. Bubbles frequently appear at the hilum, and there is an invagination of the proximal end during the reaction. The reaction is qualitatively the same as in the grains of *L. candidum.*

The reaction with *Purdy's solution* begins at once. Many grains are gelatinized in 20 seconds and all in 25 seconds. A bubble frequently appears at the hilum, and the outermost lamellar layer is invaginated at the proximal end. During gelatinization one lamella, located half way between the hilum and the distal margin, appears to be formed into brilliant, refractive granules. The reaction is qualitatively the same as in the grains of *L. candidum.*

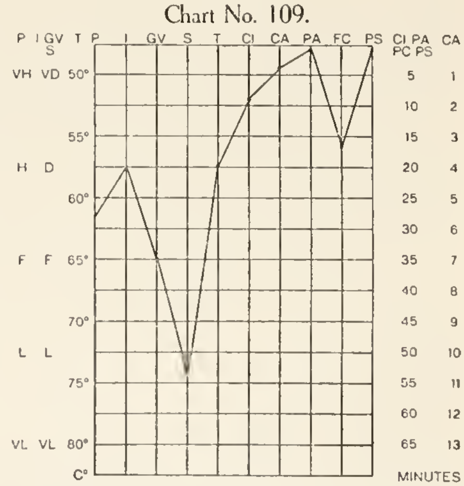
STARCH OF LILIUM TENUIFOLIUM. (Plate 24, figs. 139 and 140. Chart 109.)

Histological Characteristics.—In *form* the grains are simple, isolated, and without pressure facets. Owing to inequalities of development, which cause depressions or elevations, the surface of the grains is often irregular, and there is greater prominence of one side of the distal end or of one side of the grain than of the other. The conspicuous forms are the irregularly elliptical, which may have the distal end somewhat broadened or flattened, and often with one side bulging and the other flattened; and the regular and irregular, triangular, with a curved base and rounded angles, and often with one corner at the base cut off obliquely; also pyriform, quadrilateral, rod-shaped, and ovoid grains. The fairly numerous small grains are oval, elliptical, nearly round, or round.

The *hilum* is a distinct, rather small round spot or cavity, from which two lines often extend on each side towards the distal end. It has a range of eccentricity of from one-fourth to one-sixth, usually one-fifth, of the longitudinal axis. The hilum is rarely fissured.

The *lamellæ* are usually not very distinct, regular circles, ellipses, or arcs of ellipses or circles. They are fine near the hilum and for about two-thirds to three-fourths of the length of the grain, but become rather coarse and more distinct near the distal end. There are about 20 to 25 on the larger grains.

Chart No. 109.



Curve of Reaction-Intensities of Starch of Lilium tenuifolium.

The grains vary in *size* from the smaller, which are 4 by 4μ, to the larger elongated forms, which are 38 by 14μ, and the larger broadened forms, which are 42 by 44μ in length and breadth. The common size is 22 by 12μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and often clear-cut. The lines composing it are in some cases broadened in some part of their length. They are also occasionally bisected, frequently bent, and placed at varying angles to one another.

The degree of *polarization* is fairly high, varying somewhat in different grains and in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is less than that of the grains of *L. candidum.*

With *selenite* the quadrants are not sharply defined, are irregular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is the same as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all or lightly. The capsules are all colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after remaining in the solution for 30 minutes are fairly well stained. The color is more than that of the grains of *L. candidum.*

With *safranin* the grains begin to stain at once and after remaining in the solution for 30 minutes they are lightly stained, less than the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 56.6° to 58° C., mean 57.3°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 30 seconds, the majority in 5 minutes, and all in 8 minutes. Either a dark spot or ring usually appears at the hilum. One or more protuberances generally first appear at the proximal end and later at the other end. The outline of the gelatinized grain is undulating and more irregular than *L. candidum,* but the processes are qualitatively the same.

With *chromic acid* the grains begin to react at once. Many are completely dissolved in 20 seconds and all in 40 seconds. The reaction is qualitatively the same as in the grains of *L. candidum.*

The grains begin to react at once with *pyrogallic acid.* Many are gelatinized in 20 seconds and all in 30 seconds. A bubble usually appears at the hilum. The outline of the gelatinized grain is more rounded at the proximal end than in *L. candidum* and is more varied in shape and size. The reaction is qualitatively the same as in the grains of *L. candidum.*

Reaction with *ferric chloride* begins at once. A few grains are gelatinized in 2 minutes, the majority in 10 minutes, and all in 17 minutes. A flowing gelatinization movement starts in a few seconds from both ends simultaneously, or a movement from one end may slightly precede that from the other. There is usually a bubble formed at the hilum. Less of the ungelatinized starch remains at the distal end of the gelatinized grain than in *L. candidum,* but the reaction is qualitatively the same.

The grains begin to react at once with *Purdy's solution.* Many are gelatinized in 15 seconds and all in 25 seconds. A bubble usually appears at the hilum. The proximal end of the gelatinized grain is more rounded and there is less ungelatinized starch remaining at the distal end than in *L. candidum.* The reaction is qualitatively the same as in the latter.

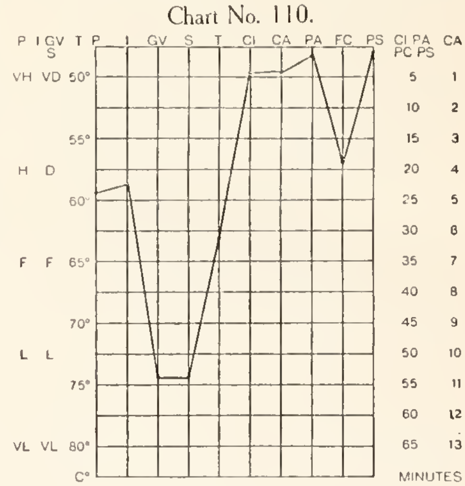
STARCH OF LILIUM PARDALINUM. (Plate 24, figs. 141 and 142. Chart 110.)

Histological Characteristics.—In *form* the grains are simple and generally isolated. There are no pressure facets. The surfaces are somewhat irregular, owing chiefly to inequalities causing many elevations, which may be smooth, knobby, or ridged; or to depressions in the surface, especially near the distal end. The conspicuous forms are pyriform, triangular with curved base and rounded angles, elliptical with or without a broadened distal end, clam-shell-shaped, and rod-shaped, which may be straight or bent; also irregularly quadrilateral, mussel-shell-shaped, and ovoid. The not very numerous small grains are usually oval or nearly round.

The *hilum* is sometimes a distinct, small round spot, with a range of eccentricity of from one-fifth to one-tenth, usually one-seventh, of the longitudinal axis. The hilum is often fissured, and there may be a narrow, clean-cut transverse or diagonal fissure; or two clean-cut fissures forming a cross, or a central cavity with several fissures proceeding from it.

The *lamellæ* are fairly distinct and usually fine. A few near the distal end are not so fine as the rest, and sometimes one fairly near the hilum and one near the equator appear to separate the finer lamellæ into three groups of varying breadth. The lamellæ are circles, ellipses, or arcs of circles, and frequently those near the margin may be seen to be continuous around the grains. They are generally fairly regular, but sometimes show waviness. There are 30 to 35 on the larger grains.

Chart No. 110.



Curve of Reaction-Intensities of Starch of Lilium pardalinum.

The grains vary in *size.* The smaller are 10 by 8μ; the larger broad forms are 80 by 88μ, and the larger elongated forms are 80 by 46μ in length and breadth. The common size is 44 by 40μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clearly defined; its lines are often bisected, and further divided into three or more lines for at least a part of their length. At times there is a more or less distinct line running parallel with the lamellæ and located at about one-third the distance from the hilum to the distal end. This line connects other lines of the figure. The normal lines are also often bent, variable in width, and placed at varying angles to one another.

The degree of *polarization* is fairly high to high, varying in different aspects and the same aspect of the same grain. There is sometimes an area of low polarization extending from the hilum to about one-third the distance to the distal end. Polarization is not so high as that of the grains of *L. candidum.*

With *selenite* the quadrants are not sharply defined, and they are irregular in shape and very unequal in size. The colors are usually not pure, the yellow especially being very much intermixed with red.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is not so deep as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution is colored deeply and the gelatinized grains fairly deeply on the addition of iodine. After boiling for 2 minutes, the solution is colored very deeply, and the grain-residues not at all or lightly. The capsules are all colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once, and after remaining in the solution for 30 minutes are only lightly stained, not so much as in the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 62.1° to 64.5° C., mean 63.3°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 1 minute, the majority in 4 minutes, and all in 7 minutes. A dark ring usually appears at the hilum and clouds of rose-purple color surge quickly over the grain. One or more protuberances are, as a rule, first formed at the distal margin, although later one is formed at the proximal end. The gelatinized grains generally have a much-scalloped outline and are thus more irregular than in *L. candidum.* The process is qualitatively the same as in the grains of *L. candidum.*

With *chromic acid* the grains begin to react at once and all are dissolved in 50 seconds. Bubbles are not often formed at the hilum. The reaction is qualitatively the same as in the grains of *L. candidum.*

Reaction with *pyrogallic acid* begins at once and all the grains are gelatinized in a minute. A bubble is not usually formed at the hilum. In some of the gelatinized grains refractive granules of ungelatinized starch are observed in the substance of the grain, together with a serrated lining or much-convoluted mass at the distal end and occasionally at the lateral margins. In the smallest grains the starch may be entirely gelatinized. The gelatinized grains are more varied in shape and more irregular than in *L. candidum,* but the reaction is qualitatively the same.

With *ferric chloride* the grains begin to react at once. A few are gelatinized in 3 minutes, the majority in 18 minutes, and all in 23 minutes. The flowing gelatinization movement begins frequently at the proximal end, but it may appear first at the corners limiting the distal margin or along that margin. The reaction is qualitatively the same as in the grains of *L. candidum.*

Reaction with *Purdy's solution* begins at once and all the grains are gelatinized in 30 minutes. The outlines of the gelatinized grains are more irregular than in *L. candidum.*

STARCH OF LILIUM PUBERULUM. (Plate 24, figs. 143 and 144. Chart 111.)

Histological Characteristics.—In *form* the grains are simple, almost wholly isolated, and without pressure facets. The surface is often very irregular, being knobbed either near the distal end or at various parts, or modified by amorphous or lamellated additions, especially to the sides or distal end. The conspicuous forms are elliptical with rather narrow proximal and somewhat broadened and flattened distal ends, rod-shaped, ovoid, and triangular with rounded angles and curved base; also clam-shell-shaped and lenticular. The smaller grains include chiefly oval, elliptical, and nearly round forms.

The *hilum,* when not fissured, is a small, indistinct round spot, with a range of eccentricity of one-sixth to one-tenth, usually about one-seventh, of the longitudinal axis. There may be 2 and sometimes 3 hila in a single grain, and often fissured; several deep fissures may proceed from a central cavity, or a single straight, rather short and narrow transverse line.

The *lamellæ* are distinct, rather fine, circles, ellipses, or arcs of circles, sometimes very irregular in shape, varying somewhat in different grains and generally not so fine, but more distinct near the distal end than near the hilum; but often there is not much distinction between the lamellæ of the two locations. There are sometimes one or two smaller sets of lamellæ added to the grains, about 36 on the larger grains.

The grains vary in *size;* the smaller are 10 by 10μ; the larger, narrow elongated grains are 70 by 42μ, and the larger, broader elongated forms are 76 by 60μ in length and breadth. The common size is 44 by 24μ.

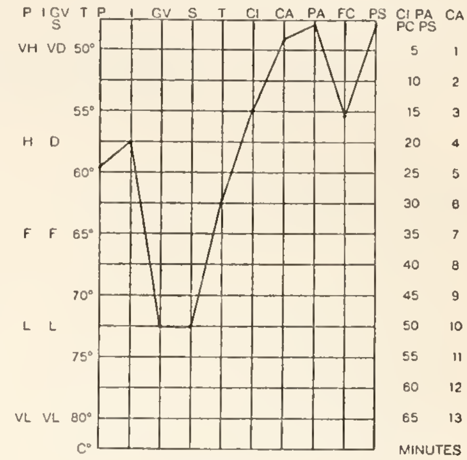
Polariscopic Properties.—The *figure* is eccentric, distinct, but usually not clear-cut in all of its parts. Its lines are sometimes bisected and even subdivided into three or more parts for part of their length, and are also often bent, otherwise distorted, and placed at varying angles to one another.

The *degree of polarization* is fairly high to high, varying in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is not so high as that of the grains of *L. candidum.*

With *selenite* the quadrants are usually not well defined, are irregular in shape, and unequal in size. The colors are usually not pure, especially the yellow.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is the same as that of the grains of *L. candidum.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all, or only lightly. The capsules all color a red-violet with an excess of iodine.

Chart No. 111.



Curve of Reaction-Intensities of Starch of Lilium puberulum.

Staining Reaction.—With *gentian violet* the grains begin to stain at once and after remaining in the solution for 30 minutes they are lightly stained, although slightly more than the grains of *L. candidum.*

With *safranin* the grains begin to stain at once and after remaining in the solution for 30 minutes they are only lightly stained, the same as in the grains of *L. candidum.*

Temperature Reaction.—The temperature of gelatinization is 62.1° to 62.2° C., mean 62.15°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 1 minute, the majority in 5 minutes, and all in 15 minutes. The dark ring at the hilum, heretofore noted, is seldom found. Protuberances usually appear first at the distal end of the elongated forms and at the corners limiting the distal margin of the broadly triangular grains. The outline of the gelatinized grain is very irregular and often much sacculated. The reaction is qualitatively the same as the grains observed in *L. candidum.*

The reaction with *chromic acid* begins at once and the grains are dissolved in 30 seconds. A bubble was not observed at the hilum. The reaction is qualitatively the same as that noted for *L. candidum.*

With *pyrogallic acid* the grains begin to react at once and all are gelatinized in a minute. The outline of the gelatinized grain is very irregular. In other respects the reaction is the same as that observed in *L. candidum.*

With *ferric chloride* the grains begin to react at once. A few are gelatinized in 3 minutes, the majority in 5 minutes, and all in 16 minutes. The reaction is the same as that observed in *L. candidum,* but gelatinization starts simultaneously at both ends in many grains, while others are first attacked at the distal margin. A rather larger proportion appears to react first at the proximal end than in *L. candidum.*

Reaction with *Purdy's solution* begins at once, and all the grains are gelatinized in 30 seconds. The reaction is the same as that noted under *L. candidum.*

Differentiation of Certain Starches of the Genus Lilium.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

L. candidum: Simple, few pressure facets, usually regular. Elongated ovoid, oval, elliptical with a flattened distal end, and triangular with rounded base and angles.

L. longiflorum var. *giganteum:* Same as in *L. candidum,* except no pressure facets, and more triangular and clam-shell-shaped forms, fewer ovoid.

L. longiflorum var. *eximium:* Same as in *L. candidum,* except more triangular pyriform and clam-shell-shaped to nearly round, fewer ovoid and elliptical.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Conspicuous Forms.—Continued.

L. parryi: Same as in *L. candidum,* except more irregular and more rod-shaped, pyriform, and bottle-shaped grains, and fewer ovoid.

L. rubellum: Same as in *L. candidum,* except more irregular, fewer ovoid, and more pyriform grains.

L. philadelphicum: Same as in *L. candidum,* except no pressure facets, more irregular, elliptical forms have both ends rounded and blunt, and there are more rod-shaped, lenticular, and mussel-shell-shaped grains.

Differentiation of Certain Starches of the Genus Lilium.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Conspicuous Forms.—Continued.

L. tigrinum var. *splendens:* Same as in *L. candidum*, except more irregular, more rod-shaped (curved or bent) and club-shaped. The triangular forms are narrower, and there are fewer ovoid grains.

L. henryi: Same as in *L. candidum*, except more irregular and fewer ovoid grains.

L. auratum: Same as in *L. candidum*, except more irregular and more narrow triangular and pyriform grains, and not quite so many ovoid forms.

L. speciosum var. *album:* Same as in *L. candidum*, except more broad and narrow triangular grains and irregular elliptical grains, and fewer ovoid.

L. martagon: Same as in *L. candidum*, except more irregular and more irregular elliptical, bottle-shaped, and rod-shaped, either straight or curved, and fewer ovoid.

L. superbum: Same as in *L. candidum*, except fewer elliptical grains.

L. tenuifolium: Same as in *L. candidum*, except more irregular and more irregularly elliptical and triangular and fewer ovoid.

L. pardalinum: Same as in *L. candidum*, except somewhat irregular and more pyriform, clam-shell-shaped, and curved or straight rod-shaped grains, and fewer ovoid grains.

L. puberulum: Same as in *L. candidum*, except often very irregular, may be double, and more rod-shaped grains, fewer ovoid and triangular.

Hilum—Form, Number, and Position.

L. candidum: Form single, small, not very distinct round spot, often fissured, fissure very short, narrow, clean-cut, and transverse. Position 0.2 to 0.11 of longitudinal axis, usually 0.11.

L. longiflorum var. *giganteum:* Form same as in *L. candidum*, but sometimes a cavity and less often fissured. Position 0.16 to 0.11 of longitudinal axis, usually 0.16.

L. longiflorum var. *eximium:* Form same as in *L. candidum*, but rarely if ever a cavity. Position 0.16 to 0.14 of longitudinal axis, usually 0.16.

L. parryi: Form same as in *L. candidum*, but more distinct, usually a cavity, not often fissured. Position 0.25 to 0.14 of longitudinal axis, usually 0.2.

L. rubellum: Form same as in *L. candidum*, but more distinct. Position eccentric 0.2 to 0.25 of longitudinal axis, usually 0.16.

L. philadelphicum: Form same as in *L. candidum*, but more distinct, always a cavity, often fissured. Position eccentric 0.25 to 0.16 of longitudinal axis, usually 0.20.

L. tigrinum var. *splendens:* Form same as in *L. candidum*, but less often fissured. Position eccentric from 0.20 to 0.16 of longitudinal axis, usually 0.16.

L. henryi: Form same as in *L. candidum*, but more distinct, sometimes a number of irregular fissures. Position 0.20 to 0.11 of longitudinal axis, usually 0.20.

L. auratum: Form same as in *L. candidum*. Position eccentric 0.20 to 0.16 of longitudinal axis, usually 0.20.

L. speciosum var. *album:* Form same as in *L. candidum*, but more distinct. Position eccentric 0.20 to 0.14 of longitudinal axis, usually 0.16.

L. martagon: Form same as in *L. candidum*, but fairly distinct. Position eccentric 0.20 to 0.10 of longitudinal axis, usually 0.16.

L. superbum: Form same as in *L. candidum*, but fairly distinct and sometimes oval in shape. Position eccentric 0.25 to 0.16 of longitudinal axis, usually 0.2.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.—Continued.

L. tenuifolium: Same as in *L. candidum*, but more distinct and rarely fissured. Position eccentric 0.25 to 0.16 of longitudinal axis, usually 0.2.

L. pardalinum: Same as in *L. candidum*, but fairly distinct and sometimes more than one fissure. Position eccentric 0.2 to 0.10 of longitudinal axis, usually 0.14.

L. puberulum: Same as in *L. candidum*, but sometimes 2 or even 3 hila in one grain; usually fissured by several deep fissures radiating from a central cavity or by a single, short, straight, transverse line. Position eccentric 0.16 to 0.10 of longitudinal axis, usually 0.14.

Lamellæ—General Characteristics and Number.

L. candidum: Fairly distinct, comparatively fine ellipses, rings, or arcs of circles, continuous and discontinuous, usually regular. 34 to 35 on larger grains.

L. longiflorum var. *giganteum:* Same as in *L. candidum*. 35 to 40 on larger grains.

L. longiflorum var. *eximium:* Same as in *L. candidum*. 36 to 38 on larger grains.

L. parryi: Same as in *L. candidum*, but not so distinct, sometimes 2 sets of lamellæ. 25 to 30 on larger grains.

L. rubellum: Same as in *L. candidum*, but slightly more distinct, rarely 2 sets of lamellæ. 26 to 30 on larger grains.

L. philadelphicum: Same as in *L. candidum*, but not so distinct and usually regular. Sometimes 2 or 3 sets whose longitudinal axis differs from that of the rest of grain. 15 to 20 on larger grains.

L. tigrinum var. *splendens:* Same as in *L. candidum*, but not so distinct, more irregular, sometimes small sets of 2 or 3 whose axes differ from that of rest of the grain. About 30 on larger grains.

L. henryi: Same as in *L. candidum*, but more distinct, not so fine, more irregular, and sometimes 2 or 3 small sets added to original grain. 30 to 35 on larger grains.

L. auratum: Same as in *L. candidum*, but not so distinct. Probably about 30 on larger grains.

L. speciosum var. *album:* Same as in *L. candidum*, but more distinct and sometimes 2 sets whose longitudinal axes do not coincide with the longitudinal axis of the grain. 42 to 44 on larger grains.

L. martagon: Same as in *L. candidum*, but more distinct, more irregular, and are continuous at the margin. Sometimes 1 or 2 additional sets. 15 to 20 on larger grains.

L. superbum: Same as in *L. candidum*, but not so distinct, 1 or 2 additional sets of lamellæ. Number not determined.

L. tenuifolium: Same as in *L. candidum*, but not so distinct. About 20 to 25 on larger grains.

L. pardalinum: Same as in *L. candidum*, but sometimes continuous around the margin. 30 to 35 on larger grains.

L. puberulum: Same as in *L. candidum*, but somewhat more distinct, more irregular, and may have 1 or 2 smaller sets added to main set. About 36 on larger grains.

Size.

L. candidum: From 8 to 70μ, commonly 40μ.

L. longiflorum var. *giganteum:* From 8 to 70μ, commonly 40μ.

L. longiflorum var. *eximium:* From 5 to 72μ, commonly 46μ.

L. parryi: From 4 to 60μ, commonly 32μ.

L. rubellum: From 4 to 64μ, commonly 38μ.

Differentiation of Certain Starches of the Genus Lilium.—Continued.

Histological Characteristics.—Continued.

Size.—Continued.

L. philadelphicum: From 4 to 50μ, commonly 30μ.
L. tigrinum var. *splendens:* From 6 to 54μ, commonly 32μ.
L. henryi: From 6 to 90μ, commonly 40μ.
L. auratum: From 8 to 80μ, commonly 42μ.
L. speciosum var. *album:* From 4 to 52μ, commonly 34μ.
L. martagon: From 12 to 60μ, commonly 34μ.
L. superbum: From 7 to 60μ, commonly 34μ.
L. tenuifolium: From 4 to 42μ, commonly 32μ.
L. pardalinum: From 10 to 80μ, commonly 44μ.
L. puberulum: From 10 to 76μ, commonly 44μ.

Polariscopic Properties.

Figure.

L. candidum: Very eccentric, distinct, not clear-cut; lines often bisected or further divided, bent, intersect at varying angles, vary in width.
L. longiflorum var. *giganteum:* Same as in *L. candidum*, but not so often bent.
L. longiflorum var. *eximium:* Same as in *L. candidum*.
L. parryi: Same as in *L. candidum*, but the lines more often bisected or further divided.
L. rubellum: Same as in *L. candidum*.
L. philadelphicum: Same as in *L. candidum*, but more apt to be clear-cut.
L. tigrinum var. *splendens:* Same as in *L. candidum*, but the lines not usually bisected.
L. henryi: Same as in *L. candidum*, but less clear-cut.
L. auratum: Same as in *L. candidum*.
L. speciosum var. *album:* Same as in *L. candidum*, but not so much bent.
L. martagon: Same as in *L. candidum*.
L. superbum: Same as in *L. candidum*.
L. tenuifolium: Same as in *L. candidum*, but not so often bisected.
L. pardalinum: Same as in *L. candidum*.
L. puberulum: Same as in *L. candidum*.

Degree of Polarization.

L. candidum: High.
L. longiflorum var. *giganteum:* Fairly high, not so high as in *L. candidum*.
L. longiflorum var. *eximium:* High, somewhat variable, less than in *L. candidum*.
L. parryi: High, varies somewhat, slightly less than in *L. candidum*.
L. rubellum: High, varies somewhat, less than in *L. candidum*.
L. philadelphicum: High, varies somewhat, less than in *L. candidum*.
L. tigrinum var. *splendens:* High to fairly high, less than in *L. candidum*.
L. henryi: High, varies somewhat, higher than in *L. candidum*.
L. auratum: High, slightly less than in *L. candidum*.
L. speciosum var. *album:* High, slightly less than in *L. candidum*.
L. martagon: Fairly high, less than in *L. candidum*.
L. superbum: Fairly high, variable, less than in *L. candidum*.
L. tenuifolium: Fairly high, somewhat variable, less than in *L. candidum*.
L. pardalinum: Fairly high to high, less than in *L. candidum*.
L. puberulum: Fairly high to high, less than in *L. candidum*.

Polarization with Selenite—Quadrants and Colors.

L. candidum: Quadrants not sharply defined, somewhat irregular in shape, and unequal in size. Colors usually not pure.
L. longiflorum var. *giganteum:* Quadrants fairly well defined, as a rule regular in shape, unequal in size. Colors pure or fairly pure.

Polariscopic Properties.—Continued.

Polarization with Selenite—Quadrants and Colors.—Cont'd.

L. longiflorum var. *eximium:* Quadrants the same as in *L. candidum*, except more regular. Colors not very pure.
L. parryi: Quadrants the same as in *L. candidum*, except more irregular. Colors usually not pure.
L. rubellum: Quadrants the same as in *L. candidum*, except more irregular. Colors usually not pure.
L. philadelphicum: Quadrants the same as in *L. candidum*, except more irregular and better defined. Colors usually not pure.
L. tigrinum var. *splendens:* Quadrants the same as in *L. candidum*. Colors usually not pure.
L. henryi: Quadrants the same as in *L. candidum*, except more irregular. Colors not pure.
L. auratum: Quadrants the same as in *L. candidum*, except more often irregular. Colors not pure.
L. speciosum var. *album:* Quadrants the same as in *L. candidum*, except more regular. Colors fairly pure.
L. martagon: Quadrants the same as in *L. candidum*, except better defined and more irregular. Colors usually not pure.
L. superbum: Quadrants the same as in *L. candidum*. Colors usually not pure.
L. tenuifolium: Quadrants the same as in *L. candidum*. Colors not pure.
L. pardalinum: Quadrants the same as in *L. candidum*, but more irregular. Colors usually not pure.
L. puberulum: Quadrants the same as in *L. candidum*, but more irregular. Colors usually not pure.

Iodine Reactions.

Intensity and Color.

L. candidum: Deep; violet-blue.
L. longiflorum var. *giganteum:* Deep, slightly less than in *L. candidum;* blue-violet.
L. longiflorum var. *eximium:* Deep, slightly less than in *L. candidum;* blue-violet.
L. parryi: Deep, less than in *L. candidum;* blue-violet.
L. rubellum: Deep, less than in *L. candidum;* blue-violet.
L. philadelphicum: Fairly deep, much less than in *L. candidum;* blue-violet.
L. tigrinum var. *splendens:* Deep, deeper than in *L. candidum;* blue-violet.
L. henryi: Deep, slightly less than in *L. candidum;* blue-violet.
L. auratum: Deep, slightly less than in *L. candidum;* blue-violet.
L. speciosum var. *album:* Deep, deeper than in *L. candidum;* blue-violet.
L. martagon: Deep, slightly less than in *L. candidum;* blue-violet.
L. superbum: Deep, deeper than in *L. candidum;* blue-violet.
L. tenuifolium: Deep, same as in *L. candidum;* blue-violet.
L. pardalinum: Deep, less than in *L. candidum;* blue-violet.
L. puberulum: Deep, same as in *L. candidum*, blue-violet.

Staining Reactions.

With Gentian Violet.

L. candidum: Light.
L. longiflorum var. *giganteum:* Light, same as in *L. candidum*.
L. longiflorum var. *eximium:* Light, the same as in *L. candidum*.
L. parryi: Fair, more than in *L. candidum*.
L. rubellum: Very light, less than in *L. candidum*.
L. philadelphicum: Fair, more than in *L. candidum*.
L. tigrinum var. *splendens:* Fair, more than in *L. candidum*.

Differentiation of Certain Starches of the Genus Lilium.—Continued.

Staining Reactions.—Continued.

With Gentian Violet.—Continued.

L. henryi: Fair, more than in *L. candidum.*
L. auratum: Light, the same as in *L. candidum.*
L. speciosum var. *album:* Light, the same as in *L. candidum.*
L. martagon: Light, less than in *L. candidum.*
L. superbum: Light, less than in *L. candidum.*
L. tenuifolium: Fair, more than in *L. candidum.*
L. pardalinum: Light, less than in *L. candidum.*
L. puberulum: Light, slightly more than in *L. candidum.*

With Safranin.

L. candidum: Light to fair.
L. longiflorum var. *giganteum:* Light, slightly less than in *L. candidum.*
L. longiflorum var. *eximium:* Very light, less than in *L. candidum.*
L. parryi: Light, slightly less than in *L. candidum.*
L. rubellum: Very light, much less than in *L. candidum.*
L. philadelphicum: Rather light, less than in *L. candidum.*
L. tigrinum var. *splendens:* Light, slightly less than in *L. candidum.*
L. henryi: Light to fair, the same as in *L. candidum.*
L. auratum: Light to fair, the same as in *L. candidum.*
L. speciosum var. *album:* Light, slightly less than in *L. candidum.*
L. martagon: Very light, less than in *L. candidum.*
L. superbum: Light, less than in *L. candidum.*
L. tenuifolium: Light, less than in *L. candidum.*
L. pardalinum: Light, less than in *L. candidum.*
L. puberulum: Light to fair, the same as in *L. candidum.*

Temperature of Gelatinization.

L. candidum: 61.2 to 62.1° C., mean 61.65°.
L. longiflorum var. *giganteum:* 62.1 to 63° C., mean 62.55°.
L. longiflorum var. *eximium:* 65 to 66.2° C., mean 65.6°.
L. parryi: 52 to 53.2° C., mean 52.6°.
L. rubellum: 60.8 to 61.1° C., mean 60.95°.
L. philadelphicum: 62.8 to 65° C., mean 63.9°.
L. tigrinum var. *splendens:* 61.7 to 62.4° C., mean 62.05°.
L. henryi: 55.9 to 56.1° C., mean 56.0°.
L. auratum: 58 to 59.2° C., mean 58.6°.
L. speciosum var. *album:* 64.1 to 64.6° C., mean 64.35°.
L. martagon: 58.5 to 59.7° C., mean 59.1°.
L. superbum: 60.8 to 62.4° C., mean 61.6°.
L. tenuifolium: 56.6 to 58° C., mean 57.3°.
L. pardalinum: 62.1 to 64.5° C., mean 63.3°.
L. puberulum: 62.1 to 62.2° C., mean 62.15°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

L. candidum: Begins at once; complete in all in 15 minutes.
L. longiflorum var. *giganteum:* Begins at once; complete in all in 12 minutes.
L. longiflorum var. *eximium:* Begins at once; complete in all in 10 minutes.
L. parryi: Begins at once; complete in all in 5 minutes.
L. rubellum: Begins at once; complete in all in 10 minutes.
L. philadelphicum: Begins at once; complete in all in 9 minutes.
L. tigrinum var. *splendens:* Begins at once; complete in all in 4½ minutes.
L. henryi: Begins at once; complete in all in 15 minutes.
L. auratum: Begins at once; complete in all in 17 minutes.
L. speciosum var. *album:* Begins at once; complete in all in 5 minutes.
L. martagon: Begins at once; complete in all in 5 minutes.
L. superbum: Begins at once; complete in all in 10 minutes.
L. tenuifolium: Begins at once; complete in all in 8 minutes.
L. pardalinum: Begins at once; complete in all in 4 minutes.
L. puberulum: Begins at once; complete in all in 15 minutes.

Effects of Various Reagents.—Continued.

Reaction with Chromic Acid.

L. candidum: Begins at once; complete in all in 50 seconds.
L. longiflorum var. *giganteum:* Begins at once; complete in all in 40 seconds.
L. longiflorum var. *eximium:* Begins at once; complete in all in 45 seconds.
L. parryi: Begins at once; complete in all in 15 seconds.
L. rubellum: Begins at once; complete in all in 30 seconds.
L. philadelphicum: Begins at once; complete in all in 20 seconds.
L. tigrinum var. *splendens:* Begins at once; complete in all in 15 seconds.
L. henryi: Begins at once; complete in all in 40 seconds.
L. auratum: Begins at once; complete in all in 70 seconds.
L. speciosum var. *album:* Begins at once; complete in all in 25 seconds.
L. martagon: Begins at once; complete in all in 25 seconds.
L. superbum: Begins at once; complete in all in 25 seconds.
L. tenuifolium: Begins at once; complete in all in 40 seconds.
L. pardalinum: Begins at once; complete in all in 50 seconds.
L. puberulum: Begins at once; complete in all in 30 seconds.

Reaction with Pyrogallic Acid.

L. candidum: Begins in 10 seconds; complete in all in 60 seconds.
L. longiflorum var. *giganteum:* Begins at once; complete in all in 45 seconds.
L. longiflorum var. *eximium:* Begins in 20 seconds; complete in all in 150 seconds.
L. parryi: Begins at once; complete in all in 20 seconds.
L. rubellum: Begins at once; complete in all in 25 seconds.
L. philadelphicum: Begins at once; complete in all in 17 seconds.
L. tigrinum var. *splendens:* Begins at once; complete in all in 35 seconds.
L. henryi: Begins at once; complete in all in 60 seconds.
L. auratum: Begins at once; complete in all in 60 seconds.
L. speciosum var. *album:* Begins at once; complete in all in 20 seconds.
L. martagon: Begins at once; complete in all in 20 seconds.
L. superbum: Begins at once; complete in all in 35 seconds.
L. tenuifolium: Begins at once; complete in all in 30 seconds.
L. pardalinum: Begins at once; complete in all in 60 seconds.
L. puberulum: Begins at once; complete in all in 60 seconds.

Reaction with Ferric Chloride.

L. candidum: Begins in 60 seconds; complete in all in 21 minutes.
L. longiflorum var. *giganteum:* Begins in 90 seconds; complete in all in 17 minutes.
L. longiflorum var. *eximium:* Begins in 30 seconds; complete in all in 10 minutes.
L. parryi: Begins in 30 seconds; complete in all in 14 minutes.
L. rubellum: Begins in 60 seconds; complete in all in 16 minutes.
L. philadelphicum: Begins in 30 seconds; complete in all in 11 minutes.
L. tigrinum var. *splendens:* Begins at once; complete in nearly all in 7 minutes.
L. henryi: Begins in 60 seconds; complete in all in 30 minutes.
L. auratum: Begins in 60 seconds; complete in all in 10 minutes.
L. speciosum var. *album:* Begins in 10 seconds; complete in all in 17 minutes.

Differentiation of Certain Starches of the Genus Lilium.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.—Continued.

L. martagon: Begins in 40 seconds; complete in all in 15 minutes.
L. superbum: Begins in 30 seconds; complete in all in 10 minutes.
L. tenuifolium: Begins at once; complete in all in 17 minutes.
L. pardalinum: Begins at once; complete in all in 18 minutes.
L. puberulum: Begins at once; complete in all in 16 minutes.

Reaction with Purdy's Solution.

L. candidum: Begins at once; complete in all in 40 seconds.
L. longiflorum var. *giganteum:* Begins at once; complete in all in 35 seconds.
L. longiflorum var. *eximium:* Begins at once; complete in all in 30 seconds.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Purdy's Solution.—Continued.

L. parryi: Begins at once; complete in all in 20 seconds.
L. rubellum: Begins at once; complete in all in 20 seconds.
L. philadelphicum: Begins at once; complete in all in 23 seconds.
L. tigrinum var. *splendens:* Begins at once; complete in all in 20 seconds.
L. henryi: Begins at once; complete in all in 20 seconds.
L. auratum: Begins at once; complete in all in 35 seconds.
L. speciosum var. *album:* Begins at once; complete in all in 15 seconds.
L. martagon: Begins at once; complete in all in 25 seconds.
L. superbum: Begins at once; complete in all in 25 seconds.
L. tenuifolium: Begins at once; complete in all in 25 seconds.
L. pardalinum: Begins at once; complete in all in 30 seconds.
L. puberulum: Begins at once; complete in all in 30 seconds.

NOTES ON THE STARCHES OF LILIUM.

Throughout the lilies there is a common type of grain with variations to be noted in the different starches; also some differences, rather indefinite, between the groups constituted by the subgenera. By reference to the photographs (plates 20 to 24) it will be found that the general appearances of the starches obtained from the members of the subgenus *Eulirion* have characteristics exceedingly alike, the main differences being in size and numerical distribution of the different conspicuous forms. In *L. philadelphicum,* the only member of the subgenus *Isolirion,* the grains are smaller, but the shape of the grain is distinctly more towards the type in which both ends are of the same form, in contradistinction to the grain of *Eulirion,* where one end tends to be larger than the other; and the hilum is more distinct, but the lamellæ generally less distinct. In the subgenus *Archlirion* there is a marked tendency to irregularity of shape, and particularly to grains that have the distal end flattened. The starch of *L. tigrinum* var. *splendens* differs very noticeably from those of other species of this subgenus. In the subgenus *Martagon* the histological peculiarities, on the whole, bear a much closer relationship to *Archlirion* than to *Eulirion* or *Isolirion.* In the polariscopic and other reactions, while all the starches exhibit specific differences here and there, they are not differences which are associated with the subgenera grouping—in other words, composite curves of the reactions of the members of the several subgenera would not differ in essential respects from one another. It may be that the division into subgenera, as quoted, is botanically artificial and not in accord with inherent peculiarities of the species. The starches of the different species differ, and in some of the reactions, especially in the temperature of gelatinization, the variations are more or less marked.

GENUS FRITILLARIA.

Fritillaria is a genus of liliaceous, bulbous plants, mostly natives of Europe and Asia, and to some extent of the Pacific slope of North America. Nearly all the Old World fritillaries resemble tulips in having tunicated bulbs, while those of the New World resemble the lilies in having scaly bulbs. Some are popularly known as lilies, and one of the best known native species (*F. meleagris*) is referred to popularly as the snakes-head lily or checkered lily, but its flowers are bell-shaped, while those of the lilies are funnel-shaped. The genus has been divided by Baker into 10 subgenera and includes about 40 species. In accordance with peculiarities of the bulbs, the genus has been classified in two groups. Starches from 8 specimens were examined, including the following:

Group I, having tunicated bulbs: *F. meleagris* Linn., *F. pyrenaica* Linn., *F. pudica* Spreng., *F. aurea* Schott., *F. armena* Boiss.

Group II, having scaly bulbs: *F. imperialis* var. *aurora* Hort., *F. liliacea* Lindl., *F. recurva* Benth.

STARCH OF FRITILLARIA MELEAGRIS. (Plate 25, figs. 145 and 146. Chart 112.)

Histological Characteristics.—In *form* the grains are almost solely simple and isolated, except a few in small aggregates. Very rare compound grains of few components are observed. The surface is usually regular, and such irregularities as occur take the form of small rounded projections or nipple-like processes from the sides or distal end, and are probably due to unequal development. The conspicuous forms are the elliptical, the rod-shaped (which is sometimes bent), the irregular elliptical (which has a broadened distal end), triangular (with curved base and rounded angles), and pyriform; also, ovoid, clam-shell-shaped, and quadrilateral with rounded angles.

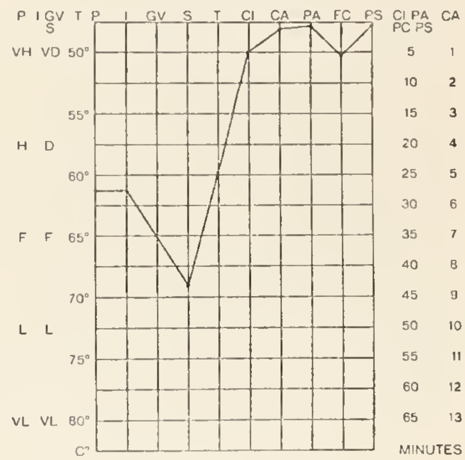
The *hilum* is a fairly distinct and large round spot or cavity. It is eccentric from one-fourth to one-sixth, usually about one-fifth, of the longitudinal axis of the grain. It is frequently fissured, the fissure being a straight, clean-cut line, usually very short.

The *lamellæ* are not very distinct fine circles or ellipses, or segments of circles, which generally follow the outline of the grain and are regular. They are not so fine, but fairly distinct for the most part near the hilum. The number was not determined.

The grains vary in *size*. The small grains are 10 by 8μ; the larger are narrow, elongated forms, 56 by 30μ; the broader, elongated forms are 55 by 38μ in length and breadth. The common sizes of the two latter forms are 34 by 21μ and 30 by 24μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. Some of its lines are broad and not clearly outlined for the greater part of their length; they are sometimes bisected and occasionally bent and otherwise distorted, and variable in width.

Chart No. 112.



Curve of Reaction-Intensities of Starch of Fritillaria meleagris.

The degree of *polarization* is fairly high, varying somewhat in different grains and materially in different aspects of the same grain, being highest when the grain is viewed on end or edge. In the same aspect of a grain it is often lower near the distal end.

With *selenite* the quadrants are generally not very well defined, are usually irregular in shape, and unequal in size. The colors are usually not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly, and the color deepens fairly rapidly. After heating in water until all the grains are completely gelatinized, the solution colors deeply and the gelatinized grains fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules all color a violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* the grains stain very faintly at once and in 30 minutes are fairly colored. The hilum and refractive lamellæ do not appear to be affected.

With *safranin* the grains stain very faintly at once and in 30 minutes are stained light to fair. A tint seems to be present in the hilum and refractive lamellæ which are unaffected by the gentian violet.

Temperature Reaction.—The temperature of gelatinization is 58.9° to 60.1° C., mean 59.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are gelatinized in 1½ minutes, the majority in 4 minutes, and all in 5 minutes. The entire grain is at once colored either a reddish violet or an old-rose, a border of deeper shade forming directly within the outer limiting layer; and either a dark transverse line or a ring appears near the hilum in many grains. Tinted, cloud-like masses in some grains stream from the distal end towards the proximal end; while in others a delicate, elongated, granular ring forms a short distance within the dark-blue border. The grain continues to swell, and one or more protuberances are formed at the distal end or at either corner of the distal margin, and a knob-like swelling now starts at the proximal end. From these masses gelatinization proceeds towards the center, pushing before them a thin, colorless mass which forms a line of demarcation between the gelatinized and non-gelatinized portions of the grain. Finally, the entire grain is gelatinized and appears much enlarged and somewhat irregular in outline, but retains the general shape of the untreated grain. Either a light, translucent area or a transverse line is frequently found at the hilum.

With *chromic acid* the grains begin to react immediately; many are dissolved in 10 seconds and all in 15 seconds. The hilum becomes very distinct and a bubble is usually formed here. The proximal end elongates very rapidly and ruptures, and the whole grain is quickly dissolved. The reaction is so rapid that it is impossible to describe it minutely.

With *pyrogallic acid* the grains begin to react at once. Many are gelatinized in 20 seconds and all in 35 seconds. Both hilum and lamellæ become distinct. The hilum, at which a bubble frequently appears, swells; the proximal end elongates; fine radiating lines pass from the gelatinized mass towards the distal and lateral margins; and the entire grain becomes gelatinized. As the grain swells the striated lamellæ at the lateral and distal margins may be cut down at several points almost to the capsule, forming a serrated lining which remains, especially at the distal end, when the reaction is complete. The gelatinized grain does not retain much of the form of the untreated grain.

The grains begin to react with *ferric chloride* in a minute. A few are gelatinized in 2 minutes, many in 4 minutes, and all in 11 minutes. At first neither the hilum nor the lamellæ are distinct; the marginal portion appears as a striated border, more transparent and darker in color than the central part. At the hilum either a dark transverse line or a bubble is formed, which increases in size and persists for some time, but finally disappears; and fine lines pass from the central mass towards the lateral and distal margins. Gelatinization and a rapid distension of the capsule frequently begin simultaneously at both ends; but in the broadly triangular and clam-shell-shaped grains it more often starts at the corners limiting the distal margin, followed quickly by swelling of the proximal end. The central portion of all grains is the last to become gelatinized. The gelatinized grain is much swollen, the outline of the distal and lateral parts is undulating, and the proximal end is more regular, rounded, and flattened, but occasionally at this point the next to the outer layer is invaginated. At the distal end the grain is irregularly folded and seamed.

Reaction with *Purdy's solution* begins at once. It is complete in many grains in 15 seconds and in all in 30 seconds. The hilum becomes distinct as a clear spot, or a bubble may appear at this point. Two clear lines pass obliquely from the hilum towards the corners of the distal margin, or one larger, central, root-like channel may proceed from the base of the swollen hilum towards the distal margin. The proximal end swells, and if there is a bubble at this point it increases in size, and just before it collapses there is an invagination of the outermost layer, either at the proximal end or at the side nearby. Fine lines pass from the two main lines, and many lines appear over the grain, until finally all the grain substance is gelatinized. In some grains a small mass of granulated substance or a few convoluted lamellæ may remain ungelatinized. The gelatinized grain is much swollen in both the longitudinal and transverse axes and retains very little of the shape of the untreated grain. Gelatinization is so rapid that the minute details can not be studied with satisfaction.

STARCH OF FRITILLARIA PYRENAICA. (Plate 25, figs. 147 and 148. Chart 113.)

Histological Characteristics.—In *form* the grains are almost wholly simple and isolated, except a few in small aggregates. Rare compound grains of few components are noted. No pressure facets were observed on the isolated grains. The surface is usually regular, with sometimes small protuberances and rarely an uneven, rather fluted surface at the distal end, due to pressure or irregularities of development. The conspicuous forms are the pyriform to bottle-shaped, the ovoid, the elliptical, and the triangular with curved base and rounded angles; also rod-shaped and nearly round grains. The smaller grains are usually nearly round, ovoid, or rod-shaped.

The *hilum* is an indistinct, rather small round spot. It is eccentric from one-fourth to one-sixth, usually one-fifth, of the longitudinal axis of most of the grains. The hilum is occasionally marked by a cavity, or by a fissure in the form of a narrow, short, transverse line.

The *lamellæ* are indistinct, fine, regular circles, ellipses, or arcs of circles, mostly of the same outline as the grain. Near the equator and distal end of the grain they are probably discontinuous and have the form of arcs of circles; they are usually not so fine, but more distinct, at the equator and distal third of the grains than elsewhere. The number was not determined.

The grains vary in *size;* the smaller are 10 by 10μ, the larger, narrow elongated grains are 54 by 26μ, and the broader elongated grains are 52 by 39μ in length and breadth. The common sizes of the last two forms are respectively 30 by 17μ, and 30 by 20μ in length and breadth.

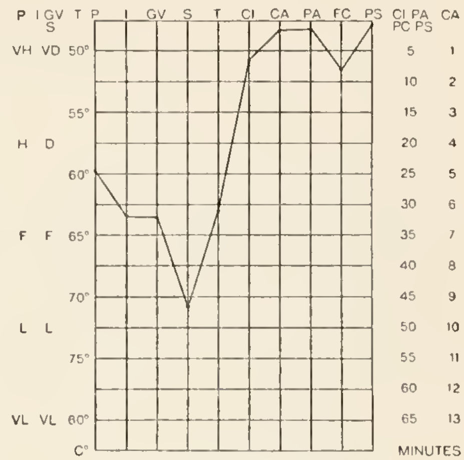
Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. The lines composing it often are broad and not clearly defined for the greater part of their length. They are usually straight, but sometimes bent, and they vary in width.

The degree of *polarization* is fairly high, varying somewhat in different grains and much in different aspects of the same grain, being highest when the grain is viewed on end or edge. In the same aspect of a grain it is often lower near the margin and distal end than near the hilum. It is slightly higher than that of the grains of *F. meleagris*.

With *selenite* the quadrants are not sharply defined, are usually regular in form and unequal in size. The colors are generally not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly. The color is slightly less than that of the grains of *F. meleagris.* After heating in water until all the grains are completely gelatinized, both the solution and the grains color fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and most of the grain-residues fairly. The capsules all color a violet on the addition of an excess of iodine.

Chart No. 113.



Curve of Reaction-Intensities of Starch of Fritillaria pyrenaica.

Staining Reactions.—With *gentian violet* the grains stain very slightly at once and in 30 minutes are fairly colored, some more than others. The color is slightly deeper than that of the grains of *F. meleagris.*

With *safranin* the grains stain very faintly at once and in 30 minutes are only lightly stained. The color is slightly less than that of the grains of *F. meleagris.*

Temperature Reaction.—The temperature of gelatinization is 62.5° to 63.8° C., mean 63.15°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Several are completely gelatinized in 70 seconds and all in 7 minutes. The gelatinized grains are much enlarged, but have the same general shape as the untreated grains. The process is qualitatively the same as in *F. meleagris.*

With *chromic acid* the grains begin to react at once. Many are dissolved in 10 seconds and all in 20 seconds. The process is the same qualitatively as that observed for *F. meleagris.*

The grains begin to react with *pyrogallic acid* at once and all are gelatinized in 1½ minutes. The gelatinized grains are much swollen, especially in the longitudinal axis, and do not retain much of the form of the untreated grain. The process is qualitatively the same as in *F. meleagris*, except that a bubble does not appear so frequently at the hilum and more grains have the serrated lining of the capsule at the distal margin.

Reaction with *ferric chloride* begins at once by the formation of a darker and transparent striated border, followed by irregular swelling in 30 seconds. A few grains are gelatinized in 2 minutes and all in 8 minutes. The process is qualitatively the same as in *F. meleagris.* The gelatinized grains are quite irregular in outline and many of them are flattened at the proximal end, as in *F. meleagris.*

With *Purdy's solution* the grains begin to react at once. Most of them are gelatinized in 20 seconds and all in 30 seconds. A bubble sometimes appears at the hilum. During the swelling process many grains are invaginated at the proximal end, and laterally extended, and finally rounded, as was often noted in *F. recurva.* The process is qualitatively the same as in *F. meleagris.*

STARCH OF FRITILLARIA PUDICA. (Plate 25, figs. 149 and 150. Chart 114.)

Histological Characteristics.—In *form* the grains are almost wholly simple and are isolated, except a few in small aggregates. Rare compound grains of few components are noted. Pressure facets appear rarely on the isolated grains and the small grains form numerous clumps. The surface of the grains is often irregular, owing to slight elevations and depressions and rather small, rounded protuberances and nipple-like processes. The specimen studied showed numerous grains which were extensively striated or even deeply fissured, longitudinally or transversely, especially at or near the hilum. Some grains were somewhat swollen, or ends were ragged, as though they were undergoing some process of dissolution. Only the unfissured or slightly fissured grains were therefore studied. The conspicuous forms are both broad and narrow, irregularly triangular with curved base and rounded angles, pyriform, irregularly quadrilateral, and elliptical; also a few irregular clam-shell shapes. Among the small grains many are nearly round or oval.

The *hilum* is a fairly small, round, distinct cavity with a refractive line extending from it on each side towards the distal end. It is eccentric except in the small, round grains, and the range of eccentricity is one-fourth to one-sixth, in most grains one-fourth, of the longitudinal axis. It is often fissured, and the fissure may be a single straight, short, transverse line; or there may be a very large number of irregular lines proceeding from a common center.

The *lamellæ* are indistinct, fine, either regular or irregular rings or ellipses or segments of circles. There are usually two or three or more lamellæ at the outer margin, which are coarse and distinct and probably formed at a different period from the rest of the grains. The number was not determined.

The grains vary in *size;* the smaller are 6 by 6μ; the larger are 64 by 54μ. The common sizes of the large broad and narrow grains are, respectively, 36 by 34μ and 32 by 22μ in length and breadth.

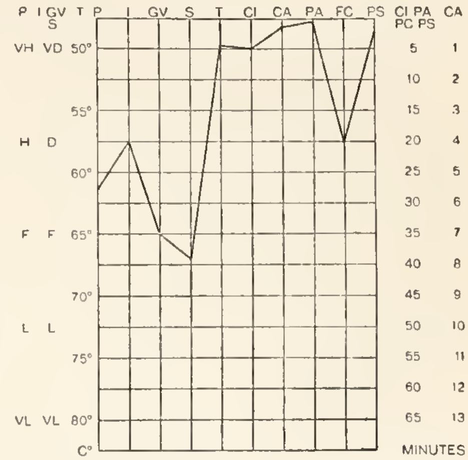
Polariscopic Properties.—The *figure* is eccentric, distinct, and usually not clear-cut; its lines are often broad and not clearly outlined for some part of their length; also often bisected or further subdivided, and may be bent and variously distorted, varying in width.

The degree of *polarization* is fair to fairly high, varying also in different aspects of a grain, being highest when the grain is viewed on end or edge; sometimes also in the same aspect of a grain, being higher near the hilum than near the margin or distal end, or the reverse. It is not usually quite so high as that of the grains of *F. meleagris.*

With *selenite* the quadrants are not well defined, are generally irregular in shape, and unequal in size. The colors are not usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rather rapidly. It is more than that of the grains of *F. meleagris.* After heating in water until all the grains are completely gelatinized, the solution and the gelatinized grains color somewhat deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. Many of the grains are entirely disintegrated. The capsules all color a violet with an excess of iodine.

Chart No. 114.



Curve of Reaction-Intensities of Starch of Fritillaria pudica.

Staining Reactions.—With *gentian violet* the grains are slightly stained at once, somewhat deeper than in *F. meleagris.* In 30 minutes they are fairly stained and the color is of the same depth as that of the grains of *F. meleagris.*

With *safranin* the grains are slightly stained at once, somewhat deeper than in *F. meleagris.* In 30 minutes they are stained light to fair, the same as that of the grains of *F. meleagris.*

Temperature Reaction.—The temperature of gelatinization is 49.1° to 50° C., mean 49.6°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are completely gelatinized in 30 seconds, half in 3 minutes, and all in 5 minutes. The reaction is qualitatively the same as that in *F. meleagris.*

The grains begin to react with *chromic acid* at once. Many are dissolved in 10 seconds and all in 15 seconds. The process is qualitatively the same as *F. meleagris.*

Reaction with *pyrogallic acid* begins immediately and gelatinization in all is complete in 20 seconds. The reaction is qualitatively the same as in *F. meleagris.*

With *ferric chloride* the grains begin to react in 30 seconds. Very few are gelatinized at once, about one-fifth in 5 minutes, and all in 20 minutes. The striated border noted in *F. meleagris* is very narrow or absent. A dark bubble or cleft appears in some grains at the hilum, as was occasionally found in *F. meleagris.* The gelatinized grains vary considerably in shape; some are extended more in the longitudinal and others more in the transverse axis. The reaction is qualitatively the same as that of *F. meleagris,* except that gelatinization and distension of the capsule usually begin simultaneously at several points on the surface of the grain.

Reaction with *Purdy's solution* begins immediately. It is complete in most grains in 10 seconds and in all in 15 seconds. The gelatinized grains vary in form, some being much distorted and having a convoluted mass at the distal end, while others are more regular in outline and have very little ungelatinized starch left at the distal end. Some of them are swollen more in the longitudinal than in the transverse axis, while in others the opposite is noted. The process is so very rapid that details can not be observed.

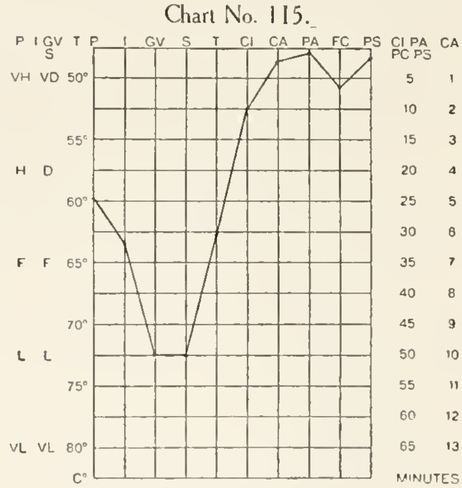
STARCH OF FRITILLARIA AUREA. (Plate 26, figs. 151 and 152. Chart 115.)

Histological Characteristics.—In *form* the grains are almost wholly simple and isolated, except a few in aggregates in the form of doublets and triplets. Compounds are noted rarely. Pressure facets are observed at the distal end of a few of the grains. The surface of the grains is, as a rule, more or less irregular. Some irregularities occur in the form of protuberances from the sides and ends, particularly the proximal end, and also some slighter irregularities. The conspicuous forms are the triangular with curved base and rounded angles, pyriform, and elliptical; also, rod-shaped, ovoid, nearly round, and clam-shell-shaped. The small grains, which are not numerous in this specimen, are usually rod-shaped, round, oval, or pyriform.

The *hilum* is a small, round, not very distinct spot or cavity, usually eccentric from one-third to one-fifth, in most grains one-fifth, of the longitudinal axis. Sometimes 2 hila appear in a single grain. In addition to the cavity, the hilum is sometimes fissured in a single line, rather long but straight, or doubly curved, one curve on each side of the central point.

The *lamellæ* are usually fairly distinct, fine, regular circles or segments of circles, varying in distinctness in different grains and in size and distinctness in different parts of the same grains, being not so fine but more distinct near the distal end than near the hilum. The number was not estimated.

Chart No. 115.



Curve of Reaction-Intensities of Starch of Fritillaria aurea.

The grains vary in *size;* the smaller are 6 by 6μ; the larger elongated are 52 by 40μ; the broader are 44 by 44μ in length and breadth. The common size is 34 by 32μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. Some of its lines are broadened and not clearly outlined for at least a part of their length; sometimes also bisected, and even further divided, frequently bent, and of variable width.

The degree of *polarization* is fairly high, varying somewhat in different grains and in different aspects of the same grain, being highest when the grain is viewed on end or edge. It varies also sometimes in different parts of the same aspect of a grain, often being not so high near the distal end as near the proximal end. It is higher than that of the grains of *F. meleagris.*

With *selenite* the quadrants are usually not very well defined, and are regular or irregular in shape and unequal in size. The colors are generally fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. It is less than that of the grains of *F. meleagris.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and most of the grain-residues fairly. The capsules all color a violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains stain very faintly at once and in 30 minutes they are still only slightly colored. The stain is not so much as that of the grains of *F. meleagris.*

Temperature Reaction.—The temperature of gelatinization is 61.5° to 64° C., mean 62.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Some are completely gelatinized in 1¼ minutes and all in 10 minutes. The reaction is qualitatively the same as the grains of *F. meleagris.* The knob-like protuberances at the proximal end more often appear sooner than similar formations at the corners limiting the distal margin, or at the distal margin, than in the grains of *F. meleagris.*

With *chromic acid* the grains begin to react at once. Some are dissolved in 15 seconds and all in 25 seconds. The reaction is qualitatively the same as in *F. meleagris.*

The grains begin to react with *pyrogallic acid* in 10 seconds. Many are gelatinized in 30 seconds and all in 40 seconds. The process is the same as in *F. meleagris*, but the appearance of bubbles at the hilum is less frequent and the gelatinized grain is more regular in outline.

Reaction with *ferric chloride* begins at once. A rapid distension of the capsule begins in 30 seconds. Several grains are gelatinized in 2 minutes, the majority in 5 minutes, and all in 7 minutes. The reaction is qualitatively the same as in *F. meleagris*, but the striated border becomes broader before distension of the capsule.

The reaction with *Purdy's solution* begins at once. Many grains are gelatinized in 30 seconds, almost all in a minute, and all in 2 minutes. The reaction is qualitatively the same as that of the grains of *F. meleagris*.

STARCH OF FRITILLARIA ARMENA. (Plate 26, figs. 153 and 154. Chart 116.)

Histological Characteristics.—In *form* the grains are almost wholly simple and with rare exceptions are isolated, with few pressure facets. Compounds and doublets are very rare. The surface is usually regular, and such irregularities as occur take the form of the greater prominence of one part of the margin than of the rest, and of very slight inequalities. The conspicuous forms are broad and narrow triangular with curved base and rounded angles, elliptical, and oval; also ovoid, pyriform, rod-shaped, nearly round, and clam-shell-shaped. The small grains, not very numerous in this species, are round, rod-shaped, oval, and pyriform.

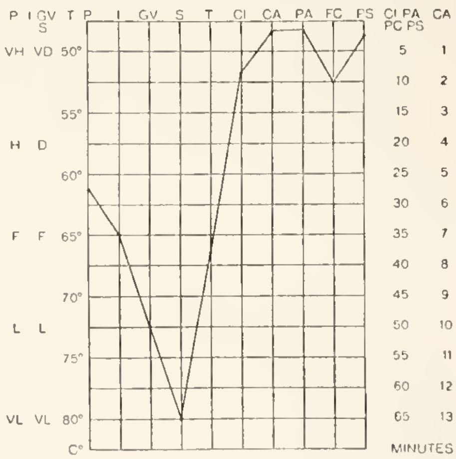
The *hilum* is a small, round, not very distinct spot, or rarely a cavity. It is eccentric one-fourth to one-sixth, in most grains one-fifth, of the longitudinal axis, with sometimes 2 hila in a single grain. The hilum is occasionally fissured in a single short, narrow, straight line, transverse or sometimes longitudinal.

The *lamellæ* are fine, indistinct circles, ellipses, or arcs of circles, nearly always regular, varying in size and distinctness in different grains, and usually are not so fine but more distinct near the distal end than near the hilum. The number was not determined.

The grains vary in *size;* the smaller are 8 by 8μ; the larger are 40 by 34μ in length and breadth; the common sizes measure respectively 28 by 24μ and 26 by 15μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, distinct, usually not clear-cut. Its lines are generally broad and not clearly defined in some part of their length, sometimes bisected and curved.

Chart No. 116.



Curve of Reaction-Intensities of Starch of Fritillaria armena.

The degree of *polarization* is fair to fairly high, varying in different aspects of the grain, highest when the grain is viewed on end or edge. It is not quite so high as that of the grains of *F. meleagris*.

With *selenite* the quadrants are not well defined, usually regular in shape, and unequal in size. The colors are generally fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fair blue-violet; with 0.125 per cent solution they color very lightly and the color does not deepen very rapidly. It is much less than that of the grains of *F. meleagris*. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and most of the grain-residues color fairly. The capsules all color a violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* and with *safranin* the grains stain faintly at once and in 30 minutes are but lightly stained, not so much as the grains of *F. meleagris*.

Temperature Reaction.—The temperature of gelatinization is 66.1° to 67.1° C., mean 66.6°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Some are gelatinized and stained deeply in 40 seconds, the majority in 4 minutes, and all in 8 minutes. The reaction is qualitatively the same as *F. meleagris*, but protuberances more often form first at the proximal end.

With *chromic acid* the grains begin to react at once and are completely dissolved in 20 seconds. The process is the same qualitatively as that observed in *F. meleagris*.

Reaction with *pyrogallic acid* begins in 20 seconds. Several of the grains are gelatinized in a minute and all in 1½ minutes. The reaction is qualitatively the same as in *F. meleagris*, but a bubble is not so frequently noted at the hilum. The gelatinized grains are quite regular in outline, many of them having at the base a serrated capsular coat.

The grains begin to react with *ferric chloride* at once by the formation of a dark striated border. Gelatinization begins in 1½ minutes. Many are gelatinized in 2½ minutes and all in 10 minutes. A transverse cleft or a bubble at the hilum is not so frequently observed as in *F. meleagris*, but the reaction is qualitatively the same.

With *Purdy's solution* some grains begin to react at once. Most of the grains are gelatinized in a minute and all in 2½ minutes. No bubble was observed at the hilum. There is a frequent invagination at the proximal end, or a drawing together of the sides during the process of gelatinization. The gelatinized grains are fairly regular in outline and rounded at the proximal end, varying much in shape and size. The process is qualitatively the same as the grains of *F. meleagris*.

STARCH OF FRITILLARIA IMPERIALIS VAR. AURORA. (Plate 26, figs. 155 and 156. Chart 117.)

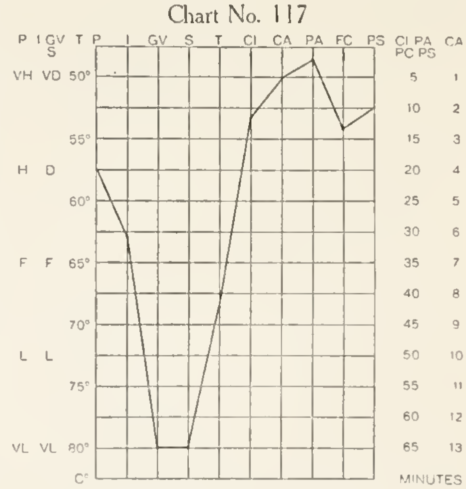
Histological Characteristics.—In *form* the grains are nearly always simple and are isolated, except a few in small aggregates. Rare compound grains of few components are seen and there are no pressure facets on the isolated grains. The surface is rarely irregular, irregularities being due almost solely to somewhat rounded projections, usually from the proximal end. The conspicuous forms are the broadly triangular with rounded angles and curved base, and clam-shell-shaped; also ovoid, nearly round, and broadly elliptical grains with a flattened distal end. The small grains are round, oval, and ovoid. There is a marked tendency to roundness in these grains.

The *hilum* is a small, round, indistinct spot, usually eccentric from one-fourth to one-fifth, commonly about one-fifth, of the longitudinal axis. The hilum may be fissured, usually is a single, straight narrow, or sometimes broad, longitudinal line. Sometimes a longitudinal line, with one or two diagonal lines, passes from a common center.

The *lamellæ* are fairly distinct, regular, usually fine circles or ellipses, or segments of circles, varying somewhat in size and distinctness in different grains, and not so fine, but more distinct, near the hilum than in other parts of the grain. There are about 28 on the larger grains.

The grains vary in *size*; the small are 4 by 4μ; the larger broad grains are 52 by 62μ; the broad but elongated forms are 60 by 46μ in length and breadth. The common sizes of the latter two forms are, respectively, 38 by 42μ and 30 by 20μ in length and breadth.

Chart No. 117



Curve of Reaction-Intensities of Starch of Fritillaria imperialis var. aurora.

Polariscopic Properties.—The *figure* is eccentric, distinct, and fairly clear-cut. Its lines become broader and somewhat less clearly outlined at some parts of their length, and are sometimes more or less bent.

The degree of *polarization* is high, not varying much in different grains, but varying somewhat in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is much higher than that of the grains of *F. meleagris*.

With *selenite* the quadrants are fairly well defined, regular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. It is less than that of the grains of *F. meleagris*. After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and most of the grain-residues fairly. The capsules all color a violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* and with *safranin* the grains stain very faintly at once and in 30 minutes are stained very lightly. The color is much less than that in *F. meleagris.*

Temperature Reaction.—The temperature of gelatinization is 68.2° to 68.6° C., mean 68.4°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. A few are completely gelatinized in 1½ minutes, about half in 5 minutes, the majority in 8 minutes, and all in 12 minutes. The process is qualitatively the same as in *F. meleagris*, but the hilum is not so distinct and swelling of the grain more often proceeds without the formation of protuberances, and the gelatinized grain is more regular in outline.

The grains begin to react with *chromic acid* at once. Some are dissolved in 30 seconds and all in a minute. The process is qualitatively the same with *F. meleagris*, but a bubble is not so frequently formed at the hilum.

Reaction with *pyrogallic acid* begins in 30 seconds and the process is complete in 2½ minutes. The hilum and lamellæ become very distinct and the hilum swells. The lamellæ towards the distal margin are striated and fine radiating lines pass from the central, clear portion towards the margin. Gelatinization continues gradually towards the distal margin until the entire grain is affected except the outer part, which has a serrated lining and frequently a few refractive granules embedded in gelatinized starch. In the ovoid grains two plume-like channels pass from the distal corners of the swollen hilum and a cluster of smaller channels extends from the base. No bubbles or transverse lines were observed at the hilum. The grain swells uniformly in every direction, so that the gelatinized grain is regular in outline and has practically the same shape as that of the untreated grain. The reaction appears to be qualitatively the same as in *F. meleagris*, but neither bubbles nor transverse lines were observed at the hilum, and the process is so much slower that the various steps of the reaction can be better studied.

With *ferric chloride* the grains begin to react in 3 minutes. Some are gelatinized in 5 minutes and all in 13 minutes. The striated border surrounding the central portion becomes quite broad before swelling begins. This border is much broader than in *F. meleagris.* The reaction is qualitatively the same as in *F. meleagris.* The gelatinized grains are more regular in outline than in the latter and also usually swollen more in the transverse than in the longitudinal axis.

Reaction with *Purdy's solution* begins at once. Many of the larger grains are gelatinized in 2 minutes, all of the larger grains in 5 minutes, and all of them in 10 minutes. Some of the small grains show little change in 30 minutes. The hilum becomes a very bright, refractive, round spot; the lamellæ grow more distinct and are striated in the broadly triangular forms, and the hilum then swells. Two coarse refractive lines, as well as numerous radiating lines, pass from the hilum towards the lateral and distal margins. The grains continue to swell in both the longitudinal and transverse axes until they are gelatinized, with the exception of a part of the capsule at the proximal end, together with remains of lamellæ at the distal margin, which later may form a serrated lining or be more irregularly arranged. The ovoid forms elongate at the proximal end, and from the swollen hilum one or two root-like, clear channels pass towards the distal margin, as described in *F. meleagris.* The gelatinized grain is much enlarged and is quite regular in outline. Several of the small grains after treatment with the solution for 30 minutes show no further change than a very clear, slightly swollen hilum and distinct striated lamellæ. The reaction is qualitatively the same as in *F. meleagris*, but a bubble was not observed at the hilum, the reaction is much slower, and the gelatinized grain is more regular in outline.

STARCH OF FRITILLARIA LILIACEA. (Plate 27, figs. 157 and 158. Chart 118.)

Histological Characteristics.—In *form* the grains are almost wholly simple and isolated, except a few small ones in doublets and triplets, and also a cluster of small grains at the distal end of one of the large ones. Compound grains are very rare. Occasionally pressure facets appear on the isolated grains, either one or two on a small grain, or a number of small facets at the distal end of a large grain. The surface of the grains is usually somewhat regular. There are few irregularities in the form of elevations and depressions, and especially a node-like protuberance of the proximal end. Many grains have a refractive line, probably representing a depression, which crosses transversely and forms a boundary between the rounded, knob-like proximal end and the body of the grain. The conspicuous forms are the broad and narrow triangular with curved base and rounded angles, ovoid, quadrilateral with rounded angles, pyriform, clam-shell-shaped, and elliptical; also rod-shaped, oval, and nearly round. The small grains are round, oval, or ovoid in form. The knob-like protrusion of the proximal end is very conspicuous in this species.

The *hilum* is a small, not very distinct round spot or cavity, often with a line proceeding from each side towards the distal end. It is eccentric one-fourth to one-sixth, generally about one-fifth, of the longitudinal axis. The hilum is sometimes fissured by a short, straight, narrow, transverse line.

The *lamellæ* are fine, not very distinct circles or ellipses, or irregular rings, or segments of circles. They are usually fairly regular and commonly more distinct but not so fine near the distal end than near the hilum, with often a very coarse and distinct lamella at about two-thirds or three-fourths the distance from the hilum to the distal end. The number was not determined.

The grains vary in *size;* the smaller are 8 by 8μ; the larger are 54 by 46μ and 52 by 52μ in length and breadth; the common sizes are 38 by 32μ or 30 by 20μ in length and breadth.

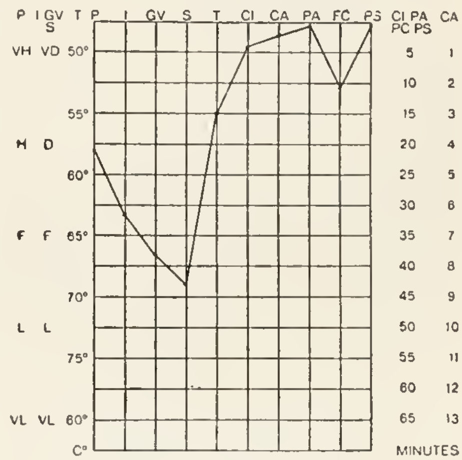
Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut, with one or all of its lines very much diffused along the greater part of their length, and one or more bisected or even further subdivided. They are often bent and variable in width.

The degree of *polarization* is fairly high, varying somewhat in different grains and in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is sometimes variable in different parts of the same aspect of a grain, often being lower near the margin and distal end than near the hilum. It is higher than that of the grains of *F. meleagris.*

With *selenite* the quadrants are not well defined, are irregular in form, and unequal in size. The colors are not usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. It is less than that of the grains of *F. meleagris.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and many of the grain-residues fairly or lightly. The capsules all color a violet with an excess of iodine.

Chart No. 118.



Curve of Reaction-Intensities of Starch of Fritillaria liliacea.

Staining Reactions.—With *gentian violet* the grains are faintly stained at once and in 30 minutes are stained light to fair, less than the grains of *F. meleagris.*

With *safranin* the grains are faintly stained at once and in 30 minutes are stained light to fair, the same as in the grains of *F. meleagris.*

Temperature Reaction.—The temperature of gelatinization is 54.8° to 55.4° C., mean 55.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Some are gelatinized in a minute and all in 4 minutes. The reaction is qualitatively the same as *F. meleagris.*

The grains begin to react with *chromic acid* at once. Some are dissolved in 15 seconds and all in 25 seconds. The process is qualitatively the same as in *F. meleagris.*

Reaction with *pyrogallic acid* begins at once and all the grains are completely gelatinized in 25 seconds. The reaction is qualitatively the same as in *F. meleagris.*

Reaction with *ferric chloride* begins at once by the formation of a dark, striated border. Swelling begins at different points in a minute in a few grains and a very few are gelatinized in 2 minutes. All the grains are in process of gelatinization in 2 minutes and all are gelatinized in 11 minutes. The reaction is qualitatively the same as in *F. meleagris,* but gelatinization begins more often first at the proximal end.

With *Purdy's solution* the grains react immediately. The reaction is complete in many of them in 10 seconds and in all in 20 seconds. The reaction is qualitatively the same as in *F. meleagris.*

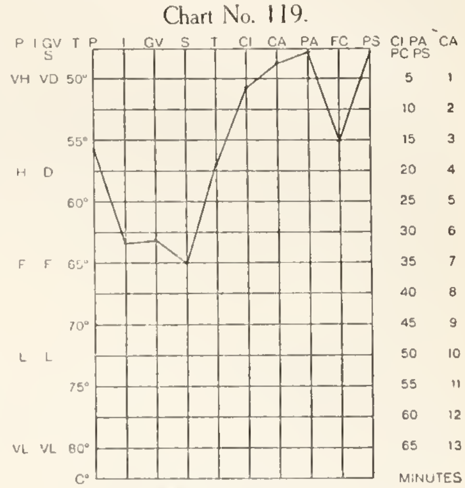
STARCH OF FRITILLARIA RECURVA. (Plate 27, figs. 159 and 160. Chart 119.)

Histological Characteristics.—In *form* the grains are usually simple and isolated, except a few that occur in small doublets and larger aggregates. Compound grains are occasionally seen. Pressure facets appear rarely on the isolated grains. The surface of the grains is usually somewhat irregular, owing sometimes to small protuberances, but generally to more or less widespread inequalities in the arrangement, size, and spacing of the lamellæ, which may therefore be set down chiefly to unequal development. The conspicuous forms are the irregularly elliptical with a flattened or rounded distal end, the irregularly oval, and the regularly or irregularly ovoid, also triangular forms with curved base and rounded angles, nearly pyriform, and round or nearly round, the last two forms being common among the small grains. The peculiarities of lamellation of this grain are very striking and distinctive from the starches of other fritillaries.

The *hilum* is a small, round, fairly distinct or indistinct spot. It is eccentric from one-fourth to one-seventh, commonly one-fifth, of the longitudinal axis in most of the grains. There may be two or more hila according to the number of components. The hilum is sometimes represented by a cavity, but usually has a short, narrow, single, and transverse fissure; or several short, ragged lines proceed from a common center; or a single, long, ragged line almost separates the proximal end from the rest of the grain.

The *lamellæ* are very distinct, usually rather fine, continuous, or discontinuous circles, ellipses, or lines that follow the outline of the grain. There are often small groups of discontinuous lamellæ whose longitudinal axis forms an angle with that of the main part of the grain, and these groups usually occur about two-thirds or more of the distance between the hilum and the distal end, varying greatly in size and distinctness in different grains and in the same grain, being also irregular, especially near the margin and distal end. Usually there are two or three continuous lamellæ encircling the whole grain near or at the margin. The lamellæ generally are divided into bands of fine lamellæ of varying breadth, separated from one another by one very coarse, distinct, refractive lamella. There are usually more of the latter near the distal end than near the hilum. There are 30 to 34 lamellæ on the larger grains, strikingly more conspicuous than in those of any other of the fritillaries examined.

Chart No. 119.



Curve of Reaction-Intensities of Starch of Fritillaria recurva.

The grains vary in *size;* the smaller are 6 by 6μ; the larger are 84 by 48μ; the common sizes are 44 by 30μ and 42 by 34μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. Its lines are usually broad and not well defined for the greater part of their length; they are sometimes bisected and rarely even further subdivided, and may be curved and distorted and of varying widths.

The degree of *polarization* is quite high, varying somewhat in different grains and in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is higher than that of the grains of *F. meleagris.*

With *selenite* the quadrants are usually not well defined, unequal in size, and irregular in shape. The colors may or may not be pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. It is less than that of the grains of *F. meleagris.* After heating in water until all the grains are completely gelatinized the solution and the gelatinized grains color fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues do not color at all and are usually disintegrated. The capsules all color a violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains stain slightly at once and in 30 minutes they are fairly stained. The color is more than that of the grains of *F. meleagris.*

Temperature Reaction.—The temperature of gelatinization is 57.9° to 59.5° C., mean 58.7°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react at once. Some are completely gelatinized in 1½ minutes and all in 12 minutes. The reaction is qualitatively the same as in *F. meleagris,* but knob-like protuberances appear more frequently first at the proximal end.

The reaction with *chromic acid* begins at once and is complete in all the grains in 30 seconds. The reaction is qualitatively the same as in *F. meleagris.*

The grains begin to react with *pyrogallic acid* at once. Many are gelatinized in 30 seconds and all in 50 seconds. A very large bubble usually appears at the hilum, which breaks into smaller bubbles towards the distal margin before entirely disappearing. One or two plume-like structures are formed from the base of the swollen hilum, and as the interior of the grain passes into gelatinization their pathway is often circuitous. The gelatinized grain usually has more remains of lamellæ at the proximal end than in *F. meleagris,* and they are thrown into folds similar to those at the distal margin, where they are much puckered and nodular. Some of these gelatinized grains are convoluted. The proximal end is generally much elongated and pointed. The gelatinized grains are much enlarged, the outline is undulating, and they do not retain much of the form of the untreated grain. The reaction is qualitatively the same as in *F. meleagris,* but is somewhat slower and not quite so complete, and the gelatinized grains are usually more irregular in outline.

With *ferric chloride* a few grains begin to react at once and all are in various stages of the reaction in a minute. A very few are gelatinized in 2 minutes, about one-fifth in 5 minutes, and practically all in 15 minutes; a few (possibly 1 in 100), are not wholly gelatinized in 20 minutes. The behavior of these grains varies considerably. In some the dark, striated border becomes rather broader than in *F. meleagris,* though not so broad as in *F. imperialis* var. *aurora,* and gelatinization begins at one point, while in others the striated border is narrower. In other forms there is only a narrow, dark border around the margin, and gelatinization with distension of the capsule begins simultaneously at several points. In some the wave of gelatinization begins flowing at both ends and otherwise resembles that in *F. meleagris.* A dark bubble or transverse cleft frequently appears, similar to that occasionally found in *F. meleagris.* The gelatinized grains are more varied in shape and more irregular in outline than those of *F. meleagris.*

Reaction with *Purdy's solution* begins at once. Most of the grains are gelatinized in 30 seconds and all in 45 seconds. The reaction is qualitatively the same as in *F. meleagris.*

Differentiation of Certain Starches of the Genus Fritillaria.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

F. meleagris: Simple, with few aggregates and rare compound grains, usually regular, small protuberances and nipple-like projections. Elliptical, rod-shaped, straight or bent, and irregular elliptical with broadened distal end, triangular with curved base and rounded angles, and pyriform.

F. pyrenaica: Essentially the same as in *F. meleagris,* but the conspicuous grains are pyriform to bottle-shaped, ovoid.

F. pudica: Essentially the same as in *F. meleagris,* but the surface is generally irregular and the conspicuous forms are irregularly broad and narrow triangular with curved base and rounded angles, pyriform, irregularly quadrilateral and elliptical.

F. aurea: Essentially the same as in *F. meleagris,* but the conspicuous forms are triangular with curved base and rounded angles, pyriform, and elliptical.

F. armena: Essentially the same as in *F. meleagris,* but the conspicuous forms are broad and narrow triangular with curved base and rounded angles, elliptical and oval.

F. imperialis var. *aurora:* Essentially the same as in *F. meleagris,* but the surface is rarely irregular and the conspicuous forms are broadly triangular with curved base and rounded angles and clam-shell-shaped, and a marked tendency to round forms.

F. liliacea: Essentially the same as in *F. meleagris,* but the conspicuous forms are broad and narrow triangular with curved base and rounded angles, ovoid, quadrilateral with rounded angles, pyriform, clam-shell-shaped, and elliptical. Knob-like protrusion of proximal end is very conspicuous.

F. recurva: Essentially the same as in *F. meleagris,* but irregular, and the conspicuous forms are irregularly elliptical with flattened or rounded distal end, irregularly oval, and regularly or irregularly ovoid. Lamellation quite peculiar and distinctive.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.

F. meleagris: Form fairly distinct, fairly large, round spot or cavity. Frequently fissured, fissure single, straight, clean-cut, transverse, usually short. Position eccentric 0.25 to 0.16, usually 0.20, of longitudinal axis.

F. pyrenaica: Form indistinct, rather small round spot, occasionally marked by a cavity or fissure. Fissure short, narrow transverse line. Position eccentric 0.25 to 0.16, usually 0.20, of longitudinal axis.

F. pudica: Form distinct, fairly small, round cavity, often fissured, fissure single, straight, short, transverse or a number of large irregular lines. 2 hila at times. Position eccentric 0.25 to 0.16, usually 0.25, of longitudinal axis.

F. aurea: Form not very distinct, small round spot or cavity. Sometimes fissured, fissure single, long straight or curved line. Sometimes 2 hila. Position eccentric 0.33 to 0.20, usually 0.20, of longitudinal axis.

F. armena: Form not very distinct, small round spot, rarely a cavity, occasionally fissured, fissure single, short, narrow, straight, transverse or longitudinal. Position eccentric 0.25 to 0.16, usually 0.20, of longitudinal axis.

F. imperialis var. *aurora:* Form indistinct, small, round spot. Often fissured, fissure short, narrow, or broad longitudinal line or longitudinal and diagonal lines. Position eccentric 0.25 to 0.20, usually 0.20, of longitudinal axis.

F. liliacea: Form not very distinct, small round spot or cavity, sometimes fissured, fissure single, short, straight transverse line. Position eccentric 0.25 to 0.16, usually 0.20, of longitudinal axis.

F. recurva: Form fairly distinct, small round or indistinct spot. Sometimes marked by a cavity or fissure. Fissure narrow, single, short transverse line or several short ragged lines. Sometimes 2 or more hila. Position eccentric 0.25 to 0.14, usually 0.20, of longitudinal axis.

Differentiation of Certain Starches of the Genus Fritillaria.—Continued.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.

F. meleagris: Not very distinct, fine ellipses or segments of circles or bands of the same shape as the grain, usually regular. Number not determined.
F. pyrenaica: Not distinct, fine, regular circles, ellipses, or rings of the same shape as the grain; some probably discontinuous. Number not determined.
F. pudica: Not very distinct, fine, regular, continuous, and discontinuous; continuous about the margin. Number not determined.
F. aurea: Usually fairly distinct, fine, regular, continuous, or discontinuous. Number not determined.
F. armena: Indistinct, fine, continuous, and discontinuous. Number not determined.
F. imperialis var. *aurora:* Fairly distinct, regular, usually fine, continuous, and discontinuous. 28 on larger grains.
F. liliacea: Not very distinct, fine, fairly regular, continuous, and discontinuous. Number not determined.
F. recurva: Very distinct, usually rather fine, often irregular, some groups composed of 2 or 3 lamellæ whose longitudinal axis does not correspond with that of the rest of the grain At the margin they are continuous. 30 to 34 on larger grains.

Size.

F. meleagris: From 10 to 56μ, commonly 34μ.
F. pyrenaica: From 10 to 54μ, commonly 30μ.
F. pudica: From 6 to 64μ, commonly 36μ.
F. aurea: From 6 to 52μ, commonly 34μ.
F. armena: From 8 to 40μ, commonly 28μ.
F. imperialis var. *aurora:* From 4 to 60μ, commonly 38μ.
F. liliacea: From 8 to 54μ, commonly 38μ.
F. recurva: From 6 to 84μ, commonly 44μ.

Polariscopic Properties.

Figure.

F. meleagris: Eccentric, distinct, not clear-cut, occasionally distorted.
F. pyrenaica: Eccentric, distinct, not clear-cut, usually regular.
F. pudica: Eccentric, distinct, usually not clear-cut, often irregular.
F. aurea: Eccentric, distinct, not clear-cut, frequently distorted.
F. armena: Eccentric, distinct, usually not clear-cut, sometimes distorted.
F. imperialis var. *aurora:* Eccentric, distinct, fairly clear-cut, usually regular.
F. liliacea: Eccentric, distinct, not clear-cut, usually irregular.
F. recurva: Eccentric, distinct, not clear-cut, sometimes irregular.

Degree of Polarization.

F. meleagris: Fairly hgih, somewhat variable.
F. pyrenaica: Fairly high, somewhat variable, higher than of grains of *F. meleagris.*
F. pudica: Fair to fairly high, variable, not quite so high as in *F. meleagris.*
F. aurea: Fairly high, somewhat variable, higher than in *F. meleagris.*
F. armena: Fair to fairly high, variable, not quite so high as in *F. meleagris.*
F. imperialis var. *aurora:* High, not variable, much higher than in *F. meleagris.*
F. liliacea: Fairly high, somewhat variable, higher than in *F. meleagris.*
F. recurva: Quite high, somewhat variable, higher than in *F. meleagris.*

Polariscopic Properties.—Continued.

Polarization with Selenite—Quadrants and Colors.

F. meleagris: Quadrants not well defined, usually irregular in shape, unequal in size. Color usually not pure.
F. pyrenaica: Quadrants not well defined, usually irregular, unequal in size. Colors usually not pure.
F. pudica: Quadrants not well defined, usually irregular, unequal in size. Colors not usually pure.
F. aurea: Quadrants not very well defined, regular or irregular, unequal in size. Colors usually fairly pure.
F. armena: Quadrants not well defined, usually regular, unequal in size. Colors usually fairly pure.
F. imperialis var. *aurora:* Quadrants fairly well defined, regular, unequal in size. Colors usually pure.
F. liliacea: Quadrants not well defined, irregular, unequal in size. Colors not usually pure.
F. recurva: Quadrants usually not well defined, irregular, unequal in size. Colors sometimes pure.

Iodine Reactions.

Intensity and Color.

F. meleagris: Fairly deep; blue-violet.
F. pyrenaica: Fairly deep, less than in *F. meleagris;* blue-violet.
F. pudica: Deep, deeper than in *F. meleagris;* blue-violet.
F. aurea: Fairly deep, less than in *F. meleagris;* blue-violet.
F. armena: Fair, much less than in *F. meleagris;* blue-violet.
F. imperialis var. *aurora:* Fairly deep, less than in *F. meleagris;* blue-violet.
F. liliacea: Fairly deep, less than in *F. meleagris;* blue-violet.
F. recurva: Fairly deep, less than in *F. meleagris;* blue-violet.

Staining Reactions.

With Gentian Violet.

F. meleagris: Fair.
F. pyrenaica: Fair, more than in *F. meleagris.*
F. pudica: Fair, the same as in *F. meleagris.*
F. aurea: Light, less than in *F. meleagris.*
F. armena: Light, less than in *F. meleagris.*
F. imperialis var. *aurora:* Very light, less than in *F. meleagris.*
F. liliacea: Light to fair, less than in *F. meleagris.*
F. recurva: Fair, more than in *F. meleagris.*

With Safranin.

F. meleagris: Light to fair.
F. pyrenaica: Light to fair, less than in *F. meleagris.*
F. pudica: Light to fair, the same as in *F. meleagris.*
F. aurea: Light, less than in *F. meleagris.*
F. armena: Very light, less than in *F. meleagris.*
F. imperialis var. *aurora:* Very light, less than in *F. meleagris.*
F. liliacea: Light to fair, the same as in *F. meleagris.*
F. recurva: Fair, more than in *F. meleagris.*

Temperature of Gelatinization.

F. meleagris: 58.9 to 60.1° C., mean 59.5°.
F. pyrenaica: 62.5 to 63.8° C., mean 63.15°.
F. pudica: 49.1 to 50° C., mean 49.6°.
F. aurea: 61.5 to 64° C., mean 62.75°.
F. armena: 66.1 to 67.10° C., mean 66.6°.
F. imperialis var. *aurora:* 68.2 to 68.6° C., mean 68.4°.
F. liliacea: 54.8 to 55.4° C., mean 55.1°.
F. recurva: 57.9 to 59.5° C., mean 58.7°.

Differentiation of Certain Starches of the Genus Fritillaria.—Continued.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

F. meleagris: Begins at once; complete in all in 5 minutes.
F. pyrenaica: Begins at once; complete in all in 7 minutes.
F. pudica: Begins at once; complete in all in 5 minutes.
F. aurea: Begins at once; complete in all in 10 minutes.
F. armena: Begins at once; complete in all in 8 minutes.
F. imperialis var. *aurora:* Begins at once; complete in all in 12 minutes.
F. liliacea: Begins at once; complete in all in 4 minutes.
F. recurva: Begins at once; complete in all in 12 minutes.

Reaction with Chromic Acid.

F. meleagris: Begins at once; complete in all in 15 seconds.
F. pyrenaica: Begins at once; complete in all in 20 seconds.
F. pudica: Begins at once; complete in all in 15 seconds.
F. aurea: Begins at once; complete in all in 25 seconds.
F. armena: Begins at once; complete in all in 20 seconds.
F. imperialis var. *aurora:* Begins at once; complete in all in 60 seconds.
F. liliacea: Begins at once; complete in all in 25 seconds.
F. recurva: Begins at once; complete in all in 30 seconds.

Reaction with Pyrogallic Acid.

F. meleagris: Begins at once; complete in all in 35 seconds.
F. pyrenaica: Begins at once; complete in all in 90 seconds.
F. pudica: Begins at once; complete in all in 20 seconds.
F. aurea: Begins in all in 10 seconds; complete in all in 40 seconds.
F. armena: Begins in all in 20 seconds; complete in all in 90 seconds.
F. imperialis var. *aurora:* Begins in all in 30 seconds; complete in all in 150 seconds.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

F. liliacea: Begins at once; complete in all in 25 seconds.
F. recurva: Begins at once; complete in all in 50 seconds.

Reaction with Ferric Chloride.

F. meleagris: Begins in all in 60 seconds; complete in all in 11 minutes.
F. pyrenaica: Begins in all in 30 seconds; complete in all in 8 minutes.
F. pudica: Begins in all in 30 seconds; complete in all in 20 minutes.
F. aurea: Begins in all grains in 30 seconds; complete in all in 7 minutes.
F. armena: Begins in all grains in 90 seconds; complete in all in 10 minutes.
F. imperialis var. *aurora:* Begins in all in 90 seconds; complete in all in 13 minutes.
F. liliacea: Begins in all grains in 60 seconds; complete in all in 11 minutes.
F. recurva: Begins in all grains in 60 seconds; complete in all in 15 minutes.

Reaction with Purdy's Solution.

F. meleagris: Begins at once; complete in all in 30 seconds.
F. pyrenaica: Begins at once; complete in all in 30 seconds.
F. pudica: Begins at once; complete in all in 2¼ minutes.
F. aurea: Begins at once; complete in all in 2 minutes.
F. armena: Begins in some grains at once; complete in all in 2½ minutes.
F. imperialis var. *aurora:* Begins at once; in 2 minutes many are gelatinized; complete in nearly all in 10 minutes.
F. liliacea: Begins at once; complete in all in 20 seconds.
F. recurva: Begins at once; complete in all in 45 seconds.

NOTES ON THE STARCHES OF FRITILLARIA.

The common type of grain found in the fritillary is not subjected to much modification in the different species, yet sufficiently in most instances to be serviceable in the differentiation of one species from another—modifications which, for instance, are noted in size, regularity of surface, and the characters of the hilum and lamellæ. In the polarization and other reactions, while there is manifestly a very close correspondence to a common type of reaction curve, the curve is so modified in the case of each specimen that one starch can readily be differentiated from the others. The differences in the reactions are noted particularly in the aniline, temperature, and chemical records, some of which are quite marked.

GENUS CALOCHORTUS.

The genus *Calochortus* is the western representative of *Tulipa*, and comprises about 30 species of cormous plants which are natives of North and Central Western America, chiefly of the United States and Mexico. They are closely related to *Tulipa* and *Fritillaria* and are in general garden cultivation in this country. They have been divided into two groups, including, respectively, the star and meadow tulips, and Mariposa tulips. Starches from 9 specimens were studied, as follows:

Group I, the star and meadow tulips: *C. albus* Dougl., *C. maweanus* var. *major* Hort., *C. benthami* Baker, and *C. lilacinus* Kellogg (*C. umbellatus* Wood).

Group II, the Mariposa tulips: *C. nitidus* Dougl., *C. howellii* Wats., *C. leichtlinii* Hook., *C. luteus* var. *oculatus* Wats. (*C. venustus* var. *oculatus* Hort.), and *C. splendens* Dougl.

STARCH OF CALOCHORTUS ALBUS. (Plate 28, figs. 163 and 164. Chart 120.)

Histological Characteristics.—In *form* the grains are simple and with rare exceptions isolated. There are no pressure facets. The surface of many grains is irregular, owing to uneven development of the margin and to some amorphous additions to the surface in the form of nipple-like processes or spicules. The conspicuous form is the ellipsoidal, with blunt ends. The distal end of a few of the grains may flare out in fan shape. Some of the grains show a tendency to the protrusion of the proximal end that will be referred to in the notes on *C. nitidus.** Other forms are the pure ovoid, ovoid approaching the spherical, quadrangular, some triangular, and some roughly lenticular grains. The grains, except some of the broader forms, are not flattened. Some fan-shaped grains show an inner core of lamellar structure, the rest being made up of amorphous material added later, forming the fan-like extensions.

The *hilum* is a fairly distinct, large, round cavity, and is eccentric one-fifth of the longitudinal axis of the grain, in the narrower end, and usually in or near the median line. In a few grains in which the longitudinal diameter is shorter than the transverse diameter the hilum is very near the center of the grain. It is never multiple and seldom fissured; the fissure is small and generally a clean-cut, transverse line, which may show a double curve or is rarely somewhat ragged.

The *lamellæ* are regular, rather fine, and fairly distinct, and follow closely the marginal outline of the primary part of the grain. Those about the hilum are usually less distinct than those elsewhere. There are about 16 to 20 lamellæ on the larger grains.

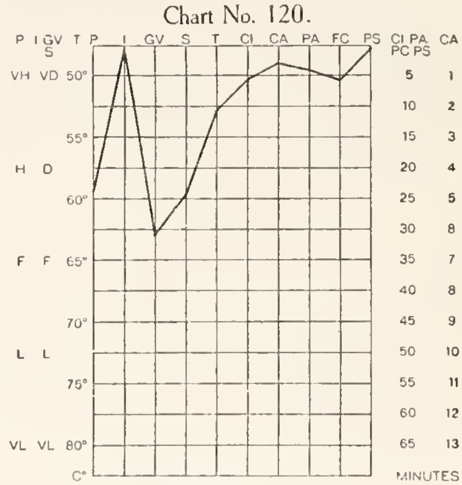
The grains vary in *size* from 4 to 40μ. The common size is 28μ.

Polariscopic Properties.—The *figure* is eccentric and clear-cut and distinct, usually even at the margin. Its lines are often somewhat broken up, bent, and otherwise distorted by inequalities in the surface of the grain, and they may be placed at varying angles to one another.

The degree of *polarization* is high, but not quite so high as in *C. nitidus.* It may be absent in certain regions of the grain and varies in different grains and also in different positions of the same grain.

With *selenite* the quadrants are clear-cut, often very irregular in shape, and always unequal in size. The colors are usually pure.

Chart No. 120.



Curve of Reaction-Intensities of Starch of Calochortus albus.

Iodine Reactions.—Using 0.25 per cent Lugol's solution, the grains are colored very deeply; with 0.125 per cent solution the grains color lightly at first, but the color deepens very quickly; slightly deeper than the shade assumed by the grains of *C. nitidus.* After heating, the grains are all completely gelatinized; the solution is colored very lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution is colored much more deeply, but the grain-residues much less. Most of the grain-residues consist of capsules which do not contain blue-reacting material or are disintegrated. If an excess of iodine is added, the capsules are colored violet.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after 30 minutes are fairly but somewhat unevenly colored. The color is slightly deeper than that of the grains of *C. nitidus.*

With *safranin* the grains begin to stain at once and after 30 minutes are deeply and fairly evenly stained. The color is slightly deeper than that assumed by the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 52° to 54° C., mean 53°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 45 seconds and is over in 6 minutes. The reaction is in all essential points identical with that of the grains of *C. nitidus.*

The reaction with *chromic acid* begins at once and is over in 30 seconds. The reaction is the same as that of the grains of *C. nitidus.*

The reaction with *pyrogallic acid* begins in 10 seconds and is over in 4 minutes. The reaction is the same as that of the grains of *C. nitidus.*

With *ferric chloride* the reaction begins in 30 seconds and is over in 6 minutes. It is the same as that observed in the grains of *C. nitidus.*

Reaction with *Purdy's solution* begins immediately and is over in 20 to 30 seconds. As far as could be determined, this reaction is the same as that of the grains of *C. nitidus.*

*_C. nitidus_ (page 516) was studied before the other specimens were received, and since it belongs to group II it is out of its proper place at the head of the list as the standard of comparison.

STARCH OF CALOCHORTUS MAWEANUS VAR. MAJOR. (Plate 28, figs. 165 and 166. Chart 121.)

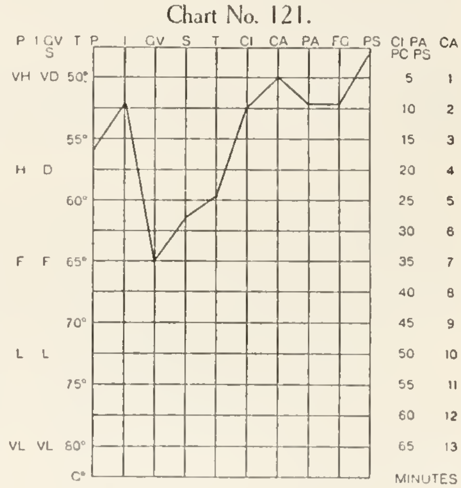
Histological Characteristics.—In *form* the grains are simple and usually isolated. There are no pressure facets. The surface is often somewhat irregular, owing to irregularities in the development and to amorphous additions to the primary part of the grain. The conspicuous form is elliptical, which is commonly quite regular. There are many round or almost round, fan-shaped, irregularly polygonal with rounded corners, very broad pyriform, and triangular with a rounded base. The grains are somewhat flattened, and some are narrower at one end than at the other.

The *hilum* is not very distinct and often shows two lines or fissures extending from it on each side. It is a small round spot, eccentric to about one-fifth of the longitudinal axis of the grain, located towards the smaller end, and usually in or near the median line. There are no double hila. If the hilum is fissured, the fissure is very small and does not communicate with the interior.

The *lamellæ* are not very distinct and are rather fine. They are often irregular owing to the unevenness in the surface of the grains. They appear to be arranged so that large, rather coarse lamellæ alternate with bands of others finer and less distinct. They are not so fine near the distal end and vary in size and distinctness in the different grains. There are 20 to 24 on the larger grains.

The grains vary in *size* from 4 to 46μ. The common size is 30μ. The common size of the elliptical grains is 32 by 24μ in length and width, and of the fan-shaped grains 30 by 26μ in length and width.

Chart No. 121.



Curve of Reaction-Intensities of Starch of Calochortus maweanus var. major.

Polariscopic Properties.—The *figure* is eccentric, distinct, and frequently clear-cut. Sometimes the lines are broader and less well defined, especially near the margin. They may be bent and distorted, and may be placed at varying angles to one another.

The degree of *polarization* is high, varying in different grains and in different positions of the same grain. It is somewhat higher than in the grains of *C. nitidus.*

With *selenite* the quadrants are usually well defined, are unequal in size, and often very irregular in shape. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deeply, some more than others; with 0.125 per cent solution they color lightly and the color deepens rapidly. The shade is lighter than that of the grains of *C. nitidus.* The color is blue-violet. After heating until the grains are completely gelatinous the solution colors lightly and the grains fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply and the grain-residues much less. The capsules all color red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are fairly well stained. The shade is about the same as that of the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 59° to 60° C., mean 59.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some of the smaller grains begin to react in 30 seconds and are gelatinized in 1½ minutes. All the grains begin to react in 45 to 60 seconds, about half are gelatinized in 4 minutes, and all in 10 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

Reaction with *chromic acid* begins immediately and is over in a minute. It is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *pyrogallic acid* begins in some grains at once and is general in 20 seconds. It is over in 8 minutes, but a very few of the grains are not completely gelatinized at this time. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *ferric chloride* some of the smaller grains begin to react in a minute and there is a general reaction in 2 minutes. About half are completely gelatinized in 4 minutes and all in 8 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *Purdy's solution* begins at once and is over in 30 seconds. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

STARCH OF CALOCHORTUS BENTHAMI. (Plate 28, figs. 167 and 168. Chart 122.)

Histological Characteristics.—In form the grains are simple and isolated, with few exceptions. There are no pressure facets. Many grains show amorphous additions which give a fan shape to an otherwise ellipsoidal grain. These deposits at times assume the character of nipple-like processes. In addition, some grains are irregular in outline, owing to the unequal development of the primary grain. There is a decided tendency for the proximal end to be protruded in nodular form. The conspicuous form is the ellipsoidal with blunt ends, both of which may be equal in size, or one may be much broader than the other. There are also pyriform, ovoid, irregularly quadrangular, and triangular grains. Most of the larger fan-shaped grains are formed by the addition of amorphous masses to the distal end of the primary ellipsoidal grain. The grains are somewhat flattened, and some are narrower at the proximal end than at the other.

The *hilum* is, as a rule, a distinct, medium-sized spot, situated eccentrically at about one-fifth of the longitudinal axis and in the median line. It is never double or multiple. It occasionally is marked by a clean-cut, transverse fissure.

The *lamellæ* are fairly distinct. They are rather fine, regular, continuous rings, which follow closely the outline of the margin. Those immediately surrounding the hilum, and at times those at the distal end, are the more distinct. They vary in size and distinctness in different grains. There are about 16 to 20 lamellæ on the larger grains.

The grains vary in *size* from 4 to 40μ. The common size is 32μ.

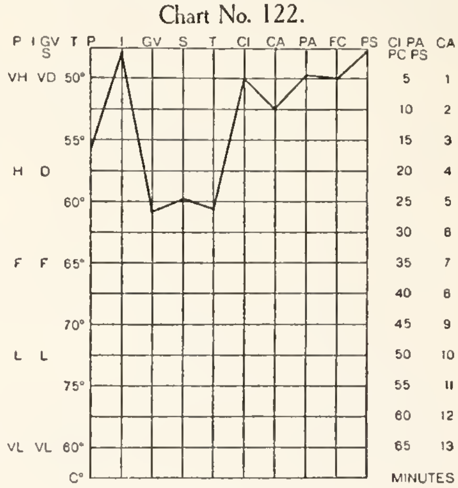
Polariscopic Properties.—The *figure* is eccentric, distinct, and clear-cut. Its lines are apt to become somewhat broader but less distinct as they approach the margin. They are also often bent and distorted and vary in width, and may be placed at varying angles to one another.

The degree of *polarization* is high, higher than that of the grains of *C. nitidus.* It varies somewhat, being very low in certain parts of the grains, especially at times near the margin. It varies also according to the portion of the grain.

With *selenite* the quadrants are clear-cut, very irregular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a very deep blue-violet; with 0.125 per cent solution the grains color well at once and the color deepens quickly. This color is deeper than that of the grains of *C. nitidus.* After heating until all the grains are completely gelatinized, the solution is colored lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution is colored much more deeply, but the grain-residues much less. Many of the capsules do not contain any blue-reacting starch. All the capsules color violet when an excess of iodine is added.

Chart No. 122.



Curve of Reaction-Intensities of Starch of Calochortus benthami.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and after 30 minutes they are deeply colored, some more than others. The color is deeper than that of the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 61° to 62° C., mean 61.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds and is over in 5 minutes. It is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *chromic acid* begins immediately and is over in 2 minutes. It is the same as that of the grains of *C. nitidus.*

With *pyrogallic acid* the reaction begins in 30 seconds and is over in 4 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *ferric chloride* the reaction begins in 15 seconds and is over in 5 minutes. It is qualitatively the same as that of the grains of *C. nitidus.*

With *Purdy's solution* the reaction begins in 10 seconds and is over in 30 seconds. It is qualitatively the same as the corresponding reaction in the grains of *C. nitidus.*

STARCH OF CALOCHORTUS LILACINUS. (Plate 29, figs. 169 and 170. Chart 123.)

Histological Characteristics.—In *form* the grains are simple and nearly always isolated and without pressure facets. Many show unevenness due to irregular development of the surface or to amorphous deposits. The conspicuous form is the elongated elliptical. There are also short elliptical, fan-shaped, pyriform, ovoid, round, a few diamond-shaped, and triangular with rounded corners. The grains are somewhat flattened and some are narrower at one end than at the other, in some the proximal and in others the distal end is the narrower.

The *hilum* is usually fairly distinct, small, eccentric about one-fifth, and usually in or near the median line. It is never double or multiple. It is commonly fissured, usually with a very small, single, transverse line. A few grains have irregular fissures extending from the hilum almost to the distal end.

The lamellæ are not distinct, but when seen they appear as rather fine, regular, continuous rings following the outline of the margin. Those near the distal end are not so fine as elsewhere, but in some cases they are more distinct than those near the hilum. The number could not be accurately determined.

The grains vary in *size* from 6 to 46μ. The common size is 28μ. The dimensions of an average elliptical grain are 28 by 16μ and of the broadened grains are 28 by 24μ in length and breadth.

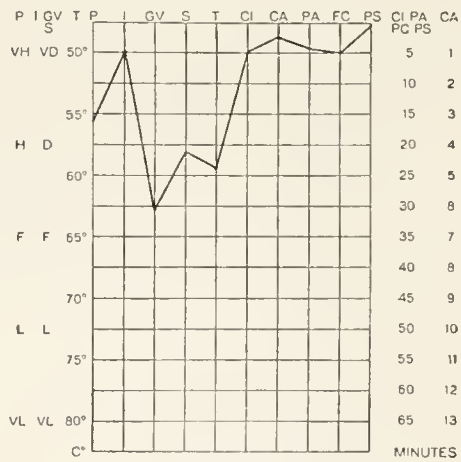
Polariscopic Properties.—The *figure* is eccentric, and, as a rule, clear-cut and distinct. In many grains, however, one or more of the lines are not so clearly defined as the others. The lines may be somewhat bent and otherwise distorted, varying in width, and be placed at varying angles to one another.

The degree of *polarization* is high, but varies somewhat in different grains and different aspects of the same grain. It is higher than that in the grains of *C. nitidus.*

With *selenite* the quadrants are well defined, are unequal in size, and irregular in shape. The colors are usually fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deeply a blue-violet at once; with 0.125 per cent solution they color at once and the color deepens rapidly. The shade is about the same as that of the grains of *C. nitidus.* After heating until the grains are completely gelatinized, the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply, the grain-residues much less, many not at all. Some grains are disintegrated. On the addition of a slight excess of iodine the grain-residues all show a red-violet capsule.

Chart No. 123.



Curve of Reaction-Intensities of Starch of Calochortus lilacinus.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly stained, all to an equal degree. The shade is deeper than that of the grains of *C. nitidus.*

With *safranin* the grains begin to stain at once and in 30 minutes they are deeply stained. The shade is deeper than that of the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 58° to 60° C., mean 59°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is a general reaction in 1½ minutes. About half the grains are gelatinized in 3 minutes and all in 5 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *chromic acid* begins at once and is over in 30 seconds. It is qualitatively the same as that of the grains of *C. nitidus.*

With *pyrogallic acid* there is a general reaction in 20 seconds and it is complete in practically all in 4 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *ferric chloride* some grains react in a minute and reaction is almost general in 2 minutes. Almost all the grains are gelatinized in 3 minutes and all in 5 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *Purdy's solution* begins at once and is over in a minute. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

STARCH OF CALOCHORTUS NITIDUS. (Plate 29, figs. 171 and 172. Chart 124.)

Histological Characteristics.—In *form* the grains are simple, isolated, and without pressure facets. The surface is commonly irregular, owing usually to the addition of large amorphous masses to the primary grain. There is frequently a nodular protuberance of the proximal end, formed by indentations in the margin at each side, and these indentations may be so deep that the grain has a trefoil shape. The tendency to this deformation of the grains is seen throughout *Calochortus*, but is most conspicuous in *C. nitidus* and *C. benthami.* There may be further modification by varying degrees of indentation and by a greater or less prominence (at the distal end) of lateral, fan-like extensions. The most conspicuous form is the fan-shaped with a knob-like protrusion of the proximal end. There are also blunt ellipsoidal grains which are either long and narrow, or short, round, ovoid, few pyriform, triangular, and mussel-shell forms. The grains are somewhat flattened, and most are narrower at the proximal end than at the other.

The *hilum* is sometimes distinct to very distinct, and comparatively large, but in some grains it is not apparent. When visible it is a round, non-refractive spot, eccentric to about one-fifth of the longitudinal axis of the grain and located usually in the smaller end of the grain, and in or near the median line. It rarely is fissured. Double hila were not observed.

The *lamellæ,* while indistinct, appear to be regular and continuous. At some distance from the hilum they follow the outline of the grain. They are rather fine and some are more distinct than others in the same grain and also in different grains. Those near the distal end are usually the more distinct. In some grains the smaller size and more clear-cut appearance of the lamellæ about the hilum, in contradistinction to the outer lamellæ, suggest that they were produced at different periods of growth. There are about 12 to 14 lamellæ on the larger grains.

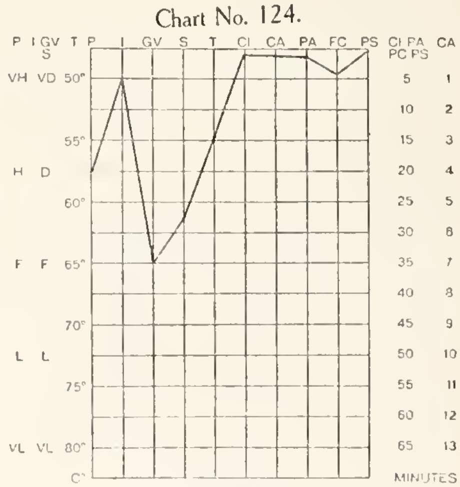
The grains vary in *size* from 3.5 to 30μ. The common size is 14μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, usually clear-cut, and often irregular. The lines of some grains are broader and less distinctly outlined at the margin than centrally. They are often bent and otherwise distorted, and placed at varying angles.

The degree of *polarization* is high, varying in different grains and in different aspects of the same grain, but usually about the same in a given aspect of a given grain.

With *selenite* the quadrants are generally sharply defined, irregular in shape, and unequal in size. The colors are fairly pure.

Chart No. 124.



Curve of Reaction-Intensities of Starch of Calochortus nitidus.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored very deeply blue-violet; with 0.125 per cent solution they color lightly at first and then deeply. After heating until all the grains are completely gelatinized, the solution is colored fairly well and the grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution is colored deeply, but the grain-residues much less deeply and many not at all. The capsules all color a pale violet when an excess of iodine is added, and the proximal portions often contain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and after 30 minutes they are fairly and evenly stained.

With *safranin* the grains begin to stain at once and after 30 minutes they are fairly deeply, but somewhat unevenly stained.

Temperature Reaction.—The temperature of gelatinization is 54° to 55.5° C., mean 54.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 15 seconds and is complete in 2 minutes. It usually begins at both ends, the distal end being affected first and becoming very dark and swollen, and then the proximal end. This process rapidly spreads to the central portion, which quickly swells. The swollen grains are at first uniformly dark, but after 30 minutes they show a light space at the proximal end and a dark, more or less homogeneous mass at the distal end. It is not unusual for this mass to be crossed by light fissures. The gelatinized grains are fairly large and quite regular in outline, and they retain somewhat the original form of the grain.

The reaction with *chromic acid* begins at once and is over in about 20 seconds. The process appears to consist in a rapid swelling of the hilum, and a movement of the inner substance of the grain to the distal end, where later it becomes gelatinous and swells in the form of a lobular, irregular mass. As the grain swells the proximal end invaginates and then dissolves, and the solution of other parts of the grain follows rapidly, the last part to dissolve being the lobulated distal end.

The reaction with *pyrogallic acid* begins immediately and is over in 2 minutes. The hilum becomes very prominent and then swells. The distal end becomes gelatinous and swells irregularly, causing it to be much folded and lobulated. The proximal inner portion of the grain passes into a gelatinous mass. The more resistant starch at the margin forms a homogeneous band which at first is quite broad. This band becomes thinner and transparent; the whole grain continues to swell, and a large, thin-walled gelatinous mass is formed that is smooth and rounded at the proximal end and very irregularly lobulated at the distal end.

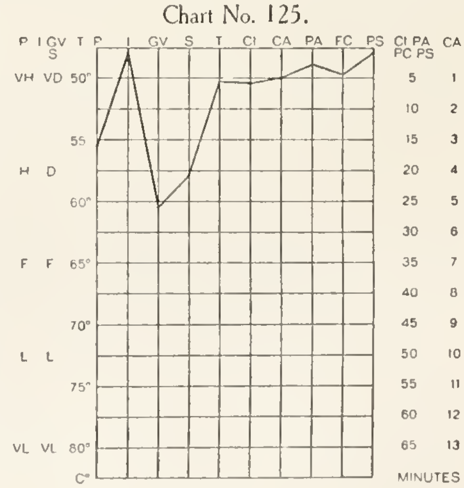
With *ferric chloride* the reaction begins in 30 seconds and is over in 4 minutes. The hilum becomes prominent. The grains are invaded at the distal end by small fissures, at which point the starch becomes gelatinous. This process proceeds from the distal end with great rapidity, causing much sacculation, until the edge of the more opaque portion surrounding the hilum is reached. Then the hilum swells suddenly upward, with enormous increase in size. The central, unswollen part of the grain becomes divided by fissures, followed by sudden partition, each part gelatinizing independently. There is thus formed a very large, clear, irregular mass that is much sacculated, especially at the distal end; the proximal end may be fairly smooth and rounded. The gelatinized grains are somewhat difficult to distinguish in the surrounding medium.

With *Purdy's solution* the reaction begins immediately and is over in 30 seconds or less. Both hilum and lamellæ become very distinct. The hilum swells and the distal end of the grain becomes gelatinized and swells out irregularly; the inner, ungelatinized part passes into a thin, gelatinous mass. The starch at the margin forms a fairly broad, homogeneous band, which rapidly becomes thinner and transparent as the grain continues to swell. The gelatinized grains are very large and smooth or somewhat folded and wrinkled at the proximal end, and very irregularly lobulated at the distal end.

STARCH OF CALOCHORTUS HOWELLII. (Plate 29, figs. 173 and 174. Chart 125.)

Histological Characteristics.—In *form* the grains are simple, and with rare exceptions they are isolated. They are without pressure facets. The surface of the grains is somewhat irregular, owing to the uneven development of different parts of the grain, and to secondary depositions. The most conspicuous form is the broad, short elliptical. There are also ellipsoidal forms having a very broad fan-like distal end; also ovoid, triangular, round, and polygonal with rounded corners. The grains are somewhat flattened, and some are narrower at one end than at the other.

Chart No. 125.



Curve of Reaction-Intensities of Starch of Calochortus howellii.

The *hilum* is generally very distinct. When not fissured it appears usually as a large, round, or transversely elongated cavity that communicates with the interior of the grain. It is eccentric about one-fifth of the longitudinal diameter of the grain and located usually in the smaller end. The grains often show two fissures or lines which extend from the hilum, one on each side. When the hilum is fissured the fissure is generally a short, straight, longitudinal line, or there may be two lines running obliquely on each side. There are no double or multiple hila.

The *lamellæ* are distinct, rather fine, continuous rings, not so fine but more distinct near the distal end. They follow the outline of the margin of the primary part of the grain and are somewhat irregular, owing to unevenness in the surface. They seem to be arranged so that one or two larger lamellæ alternate with groups of finer lamellæ. There are about 16 to 18 on the larger grains.

The grains vary in *size* from 5 to 40μ. The common size is 28μ. The elliptical grains are usually 28 by 19μ, and the broader grains are 30 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, distinct, and usually clear-cut. Occasionally the lines are dim and therefore not distinctly outlined. The lines may be bent, or otherwise distorted, and be placed at varying angles to one another.

The degree of *polarization* is high, varying greatly on different grains, and is lower in some parts of a given aspect of an individual grain than in others. It is a little higher, on the whole, than in the grains of *C. nitidus.*

With *selenite* the quadrants are well defined, unequal in size, and generally more or less irregular in shape. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once very deeply a blue-violet; with 0.125 per cent solution they color at once fairly and the color deepens rapidly. The shade is deeper than that of the grains of *C. nitidus.* After heating until the grains are completely gelatinized, both the solution and the grains color fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors more deeply, and the grain-residues but little or not at all. The capsules become colored violet upon the addition of a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are deeply stained, each grain as deeply as another. The shade is much deeper than that of the grains of *C. nitidus.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained. The color is deeper than that of the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 50° to 51° C., mean 50.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains begin to react in 30 seconds and the reaction is general in 1 to 1½ minutes. About half are fully darkened in 4 minutes, and the reaction is complete in 7 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *chromic acid* begins at once and is over in a minute. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *pyrogallic acid* there is a general reaction in 20 seconds and all the grains are completely gelatinized in 2½ minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *ferric chloride* begins in some grains in 30 seconds and is general in 2 minutes, and all the grains are fully gelatinized in 4 minutes. The reaction is the same qualitatively as that of the grains of *C. nitidus.*

Reaction with *Purdy's solution* begins at once and is over in 45 to 60 seconds. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

STARCH OF CALOCHORTUS LEICHTLINII. (Plate 30, figs. 175 and 176. Chart 126.)

Histological Characteristics.—In *form* the grains are simple, isolated, and without pressure facets. Their surface is varied and somewhat irregular, owing to the unequal development of different parts, and to secondary deposits. The conspicuous form is the short, broad elliptical, which approaches the ovoid; also ovoid, round, fan-shaped, pyriform, triangular, and irregularly polygonal with rounded corners. The grains are somewhat flattened and some are narrower at one end than at the other. These grains are the least irregular of all the calochorti starches.

The *hilum* is a not very distinct, small, round spot that is eccentric to about one-fifth of the longitudinal diameter of the grain, and located usually in or near the median line. It never was observed to be double, triple, or multiple, and it is rarely fissured. When fissured, the fissure is very small and indistinct, and is usually a single, straight, transverse line. There are sometimes two lines or fissures, one from each side of the hilum.

The *lamellæ* are indistinct, rather fine, continuous lines which usually follow the outline of the margin. They are not so fine near the distal end of the grain. The number could not be accurately determined.

The grains vary in *size* from 4 to 45μ. The common size is 28μ. The common dimensions of the elliptical grains are 28 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, distinct, and fairly clear-cut. Occasionally some lines are somewhat less clearly defined than others. The figure may be bent and otherwise distorted or bisected. The lines are placed at varying angles to one another.

The degree of *polarization* is high, varying somewhat in different grains and also in different aspects of the same grain. It is, as a rule, higher than that of the grains of *C. nitidus.*

With *selenite* the quadrants are usually well defined, unequal in size, and usually irregular in form. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once very deeply blue-violet; with 0.125 per cent solution they color immediately and the color deepens rapidly. The coloration is about the same as that of the grains of *C. nitidus.* After heating the grains until all are completely gelatinized the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors more deeply, but the grain-residues much less deeply. The capsules all color a red-violet with a slight excess of iodine, and all still retain much blue-reacting starch in the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are fairly stained. The color is deeper than that of the grains of *C. nitidus.*

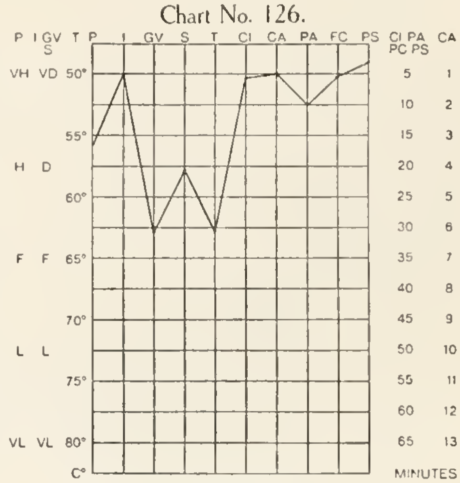
With *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained, some more than others. The color is deeper than that of the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 62° to 64° C., mean 63°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction is general in about 30 seconds although the smaller grains begin to react before this. About half are completely gelatinized in 2 minutes and all in 7 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *chromic acid* begins at once and is over in a minute. It is qualitatively the same as that of the grains of *C. nitidus.*

Chart No. 126.



Curve of Reaction-Intensities of Starch of Calochortus leichtlinii.

The reaction with *pyrogallic acid* is general in 30 seconds, and is entirely over in 10 minutes, but some grains are not completely gelatinized. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *ferric chloride* some grains begin to react in a minute and the reaction is general in 2½ minutes. Almost all are gelatinized in 5 minutes and all in 6 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *Purdy's solution* begins in 15 seconds and is over in 3 minutes, It is qualitatively the same as *C. nitidus.*

STARCH OF CALOCHORTUS LUTEUS VAR. OCULATUS. (Plate 30, figs. 177 and 178. Chart 127.)

Histological Characteristics.—In *form* the grains are simple, isolated, and without pressure facets. Their surfaces are varied and frequently very irregular, owing to uneven elevations and depressions and to amorphous additions which take the form of rounded protuberances and nipple processes. The conspicuous form is short elliptical, with many variations of fan-shaped, pyriform, irregularly quadrangular, ovoid, round, and triangular grains. In a few grains the transverse diameter is longer than the longitudinal, even much longer; such grains are also very irregular in outline.

The *hilum* is a fairly distinct, small spot, round or elliptical, and situated eccentrically about one-fifth of the longitudinal diameter and in or near the median line. It is never observed to be double or multiple. It may be fissured, in which case the fissure is usually a single, small, distinct, transverse line. Rarely the fissuration consists of two lines extending down from the hilum, one on each side.

The *lamellæ* are fairly distinct and regular, rather fine, continuous lines, which tend to follow the outline of the margin, with some irregularities due to inequalities of the surface. The projections from the surfaces of the grains are formed either by enlarged lamellæ that constitute a part of the primary grain, or by amorphous additions. The lamellæ near the distal end are not so fine but somewhat more distinct than those near the hilum. There are 18 to 20 on the larger grains.

The grains vary in *size* from 4 to 48μ. The common size is 32μ. The dimensions of elliptical grains are commonly 25 by 15μ, and those of the pyriform grains 34 by 26μ in length and breadth.

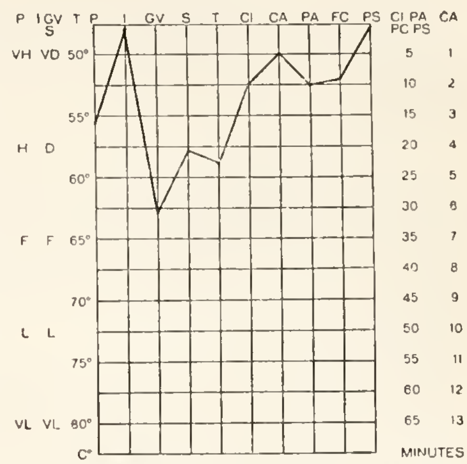
Polariscopic Properties.—The *figure* is eccentric, distinct, and generally clear-cut. The more irregular the grain the less well defined the figure. Sometimes one or more lines are less well defined than the others. The lines are often bent and otherwise distorted and placed at varying angles to one another.

The degree of *polarization* is high, varying in different grains and somewhat in different aspects of the same grain. It is, as a whole, higher than that of the grains of *C. nitidus.*

With *selenite* the quadrants are clearly outlined, unequal in size, and regular or irregular in shape, according to the degree of regularity of the outline of the grain. The colors in most cases are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deeply at once a blue-violet; with 0.125 per cent solution they color at once and the color deepens rapidly. The shade is slightly deeper than that of the grains of *C. nitidus.* After heating until all the grains are completely gelatinized the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply and the gelatinized grain-residues much less, or not at all. All the capsules color a red-violet with a slight excess of iodine, and most of them still retain some blue-reacting starch in the proximal end.

Chart No. 127.



Curve of Reaction-Intensities of Starch of Calochortus luteus var. oculatus.

Staining Reactions.—With *gentian violet* the grains begin to stain very slightly at once and in 30 minutes are deeply stained. The color is deeper in some than in others. It is deeper than in the grains of *C. nitidus.*

With *safranin* the grains begin to stain at once and in 30 minutes are deeply stained. The shade is deeper than that of the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 57.2° to 59° C., mean 58.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some of the smaller grains react in a minute and the reaction is general in 1½ minutes. About half are gelatinized in 3 minutes, all but a few in 7 minutes, and all in 10 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *chromic acid* begins at once and is over in a minute. It is qualitatively the same as that of the grains of *C. nitidus.*

With *pyrogallic acid* some of the smaller grains begin to react at once. The reaction is general in 20 seconds and is over in 10 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *ferric chloride* almost all the grains begin to react in 1½ minutes, most are gelatinized in 5 minutes, and all in 8 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

Reaction with *Purdy's solution* begins at once and is over in a minute. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

STARCH OF CALOCHORTUS SPLENDENS. (Plate 30, figs. 179 and 180. Chart 128.)

Histological Characteristics.—In *form* the grains are simple, with few exceptions isolated, and without pressure facets. The surface is irregular and varied owing to rounded projections from the margin, which in some instances are formed by amorphous additions, and in others by projecting overdeveloped lamellæ, which constitute a part of the primary grain. The conspicuous forms are the round pyriform and the short and broad elliptical, ovoid, fan-shaped, and irregularly quadrangular grains. The grains are somewhat flattened and some are narrower at one end, usually the proximal, than at the other.

The *hilum* is usually a distinct, comparatively small, round or elliptical spot, eccentric at about one-fifth the longitudinal diameter of the grain. It was never observed to be double or multiple. It may be fissured. The fissuration is usually in the form of a small, single, transverse line; but may consist of two lines slanting downward, one on each side from the hilum, or of several irregular fissures running in the direction of the longitudinal axis of the grain.

The *lamellæ* are indistinct, rather regular, fine, continuous rings, not so fine but more distinct near the distal end than near the hilum. They follow the outline of the margin and show marginal and other surface irregularities. The number could not be accurately determined.

The grains vary in *size* from 4 to 32μ. The common size is 20μ. The common dimensions of the pyriform grains are 22 by 17μ and of an elliptical grain 17 by 11μ in length and breadth.

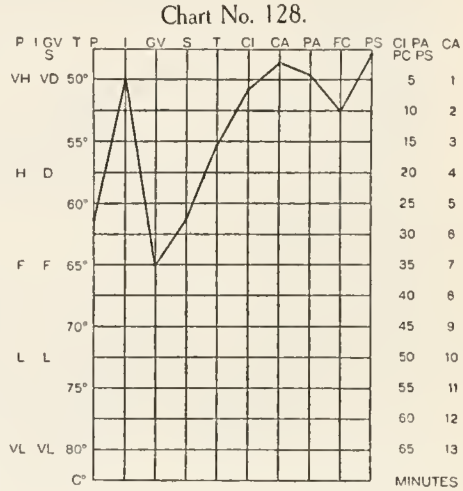
Polariscopic Properties.—The *figure* is eccentric, usually fairly clear-cut, but not always distinct. Occasionally one or more of the lines are broader and less clearly outlined than the rest of the figure. The lines may be bent or otherwise somewhat distorted and placed at varying angles to one another.

The degree of *polarization* is fairly high, varying in different grains and slightly in different aspects of the same grain. It is not so high as that of the grains of *C. nitidus.*

With *selenite* the quadrants are not well defined, are unequal in size and irregular in shape. The colors are usually fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains at once color a blue-violet very deeply; with 0.125 per cent solution they color at once and the color deepens rapidly. The shade is the same as that of the grains of *C. nitidus.* After heating until the grains are completely gelatinized the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply, but the grain-residues much less. All the capsules are colored a red-violet with a slight excess of iodine, and most of them contain some blue-reacting starch in the proximal end.

Chart No. 128.



Curve of Reaction-Intensities of Starch of Calochortus splendens.

Staining Reactions.—With *gentian violet* the grains stain very light at once and in 30 minutes are fairly stained. The shade is the same as that of the grains of *C. nitidus.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained. The shade is about the same as that of the grains of *C. nitidus.*

Temperature Reaction.—The temperature of gelatinization is 54.2° to 56° C., mean 55.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is a general reaction in 30 seconds. About half are gelatinized in 2 minutes and all in 7 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

The reaction with *chromic acid* begins at once and is over in 30 seconds. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *pyrogallic acid* some grains begin to react at once. The reaction is general in 20 seconds and is complete in 4 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

With *ferric chloride* many grains begin to react in 30 seconds and the reaction is general in 11 minutes. About half the total number are gelatinized in 1½ minutes and all in 10 minutes. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

Reaction with *Purdy's solution* begins at once and is over in 45 seconds. The reaction is qualitatively the same as that of the grains of *C. nitidus.*

Differentiation of Certain Starches of the Genus Calochortus.

Histological Characteristics.

Conspicuous Forms.

C. albus: Same as in *C. nitidus*, except more ellipsoidal grains with flattened ends, and with little tendency to nodular protrusion of the proximal end and the formation of fan-shaped grains.

C. maweanus var. *major:* Same as in *C. nitidus*, except a few multiple grains and aggregates and more elliptical and triangular, fewer fan-shaped and grains with nodular protrusion of proximal end.

C. benthami: Same as in *C. nitidus*, except some aggregates, fewer fan-shaped and more elliptical grains; tendency to nodular protrusion of proximal end marked.

C. lilacinus: Same as in *C. nitidus*, except few aggregates, fewer fan-shaped, and more elliptical.

C. nitidus: Simple, isolated, no pressure facets, irregular owing to unequal development and to amorphous additions. Fan-shaped with a rounded or nodular protrusion of proximal end, blunt ellipsoidal, ovoid, round, pyriform, triangular and mussel-shell shaped.

C. howellii: Same as in *C. nitidus*, except more ellipsoidal with blunted ends.

C. leichtlinii: Same as in *C. nitidus*, except a few aggregates, very few fan-shaped, many short, broad elliptical approaching ovoid; least irregular of all of the *Calochortus* starches.

C. luteus var. *oculatus:* Same as in *C. nitidus*, except a few aggregates, few fan-shaped, more short elliptical.

C. splendens: Same as in *C. nitidus*, except a few aggregates, few fan-shaped, many broad pyriform, and short, broad elliptical.

Hilum—Form, Number, and Position.

C. albus: Form same as in *C. nitidus*, except that always fairly distinct, rarely fissured, and fissure small, single, clear-cut. Position eccentric about 0.20 of longitudinal axis.

C. maweanus var. *major:* Form same as in *C. nitidus*, except that indistinct, small, sometimes fissured, fissures very small, single. Position eccentric about 0.20 of longitudinal axis.

C. benthami: Form same as in *C. nitidus*, except that always distinct, medium-sized, rarely fissured, fissure small, single, transverse. Position eccentric about 0.20 of longitudinal axis.

C. lilacinus: Form fairly distinct, small, always fissured, fissures very small, straight, single. Position eccentric about 0.20 of longitudinal axis.

C. nitidus: Form very distinct to indistinct, round, comparatively large spot, rarely fissured. Position eccentric about 0.20 of longitudinal axis.

C. howellii: Form the same as in *C. nitidus*, except that very distinct, sometimes an elliptical cavity, often fissured, fissures short, straight, single. Position eccentric about 0.20 of longitudinal axis.

C. leichtlinii: Form the same as in *C. nitidus*, except that not very distinct, round, rarely fissured, fissures very small, single, straight. Position eccentric about 0.20 of longitudinal axis.

C. luteus var. *oculatus:* Form fairly distinct, small, round, or elliptical, may be fissured, fissures small, straight, single. Position eccentric about 0.20 of longitudinal axis.

C. splendens: Form distinct, small, round or elliptical, may be fissured, fissures small, single, straight. Position eccentric about 0.20 of longitudinal axis.

Lamellæ—General Characteristics and Number.

C. albus: Same as in *C. nitidus*. 16 to 20 on larger grains.

C. maweanus var. *major:* Same as in *C. nitidus*, except that somewhat irregular. 20 to 24 on larger grains.

C. benthami: Same as in *C. nitidus*, except fairly distinct. 16 to 20 on larger grains.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.—Cont'd.

C. lilacinus: Same as in *C. nitidus*. Number not determined.

C. nitidus: Indistinct, rather fine, regular, and continuous. About 12 to 14 or larger grains.

C. howellii: Same as in *C. nitidus* except that distinct and somewhat irregular. 16 to 18 on larger grains.

C. leichtlinii: Same as in *C. nitidus*. Number not determined.

C. luteus var. *oculatus:* Same as in *C. nitidus*, but fairly distinct, and regular. 8 to 20 on larger grains.

C. splendens: Same as in *C. nitidus*. Number not determined.

Size.

C. albus: From 4 to 40μ, commonly 28μ.

C. maweanus var. *major:* From 4 to 46μ, commonly 30μ.

C. benthami: From 4 to 40μ, commonly 32μ.

C. lilacinus: From 6 to 46μ, commonly 28μ.

C. nitidus: From 3.5 to 30μ, commonly 14μ.

C. howellii: From 5 to 40μ, commonly 28μ.

C. leichtlinii: From 4 to 45μ, commonly 28μ.

C. luteus var. *oculatus:* From 4 to 48μ, commonly 32μ.

C. splendens: From 4 to 32μ, commonly 20μ.

Polariscopic Properties.

Figure.

C. albus: Same as in *C. nitidus*, except clear-cut.

C. maweanus var. *major:* Same as in *C. nitidus*, more often clear-cut.

C. benthami: Same as in *C. nitidus*, except clear-cut.

C. lilacinus: Same as in *C. nitidus*, except less often distorted.

C. nitidus: Eccentric, distinct, and usually clear-cut, often irregular.

C. howellii: Same as in *C. nitidus*.

C. leichtlinii: Same as in *C. nitidus*, except usually fairly clear-cut and not so irregular.

C. luteus var. *oculatus:* Same as in *C. nitidus*.

C. splendens: Same as in *C. nitidus*, except not always distinct, and fairly clear-cut.

Degree of Polarization.

C. albus: High, not so high as in *C. nitidus*.

C. maweanus var. *major:* High, somewhat higher than in *C. nitidus*. The same as *nitidus*.

C. benthami: High, higher than in *C. nitidus*.

C. lilacinus: High, higher than in *C. nitidus*.

C. nitidus: High.

C. howellii: High, slightly higher than in *C. nitidus*.

C. leichtlinii: High, higher than in *C. nitidus*.

C. luteus var. *oculatus:* High, slightly higher than in *C. nitidus*.

C. splendens: Fairly high, lower than in *C. nitidus*.

Polarization with Selenite—Quadrants and Colors.

C. albus: Quadrants same as in *C. nitidus*. Colors fairly pure, less than in *C. nitidus*.

C. maweanus var. *major:* Quadrants same as in *C. nitidus*, but usually not so well defined. Colors fairly pure.

C. benthami: Quadrants same as in *C. nitidus*. Colors fairly pure, better than in *C. nitidus*.

C. lilacinus: Quadrants same as in *C. nitidus*, but not so well defined. Colors fairly pure.

C. nitidus: Quadrants sharply defined, irregular in shape, and unequal in size. Colors fairly pure.

C. howellii: Quadrants same as in *C. nitidus*. Colors fairly pure.

C. leichtlinii: Quadrants same as in *C. nitidus*, but not quite so well defined. Colors fairly pure.

C. luteus var. *oculatus:* Quadrants same as in *C. nitidus*, but not so well defined. Colors fairly pure.

C. splendens: Quadrants same as in *C. nitidus*, but not so well defined. Colors fairly pure.

Differentiation of Certain Starches of the Genus Calochortus.—Continued.

IODINE REACTIONS.

Intensity and Color.

C. albus: Very deep, slightly deeper than in *C. nitidus;* blue-violet.
C. maweanus var. *major:* Very deep, slightly lighter than in *C. nitidus;* blue-violet.
C. benthami: Very deep, slightly deeper than in *C. nitidus;* blue-violet.
C. lilacinus: Very deep, about the same as in *C. nitidus;* blue-violet.
C. nitidus: Very deep; blue-violet.
C. howellii: Very deep, deeper than in *C. nitidus;* blue-violet.
C. leichtlinii: Very deep, about the same as in *C. nitidus;* blue-violet.
C. luteus var. *oculatus:* Very deep, slightly deeper than in *C. nitidus;* blue-violet.
C. splendens: Very deep, same as in *C. nitidus;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

C. albus: Fair, slightly deeper than in *C. nitidus.*
C. maweanus var. *major:* Fair, about the same as in *C. nitidus.*
C. benthami: Deep, deeper than in *C. nitidus.*
C. lilacinus: Fair, slightly deeper than in *C. nitidus.*
C. nitidus: Fair.
C. howellii: Deep, much deeper than in *C. nitidus.*
C. leichtlinii: Fair, deeper than in *C. nitidus.*
C. luteus var. *oculatus:* Deep, deeper than in *C. nitidus.*
C. splendens: Fair, same as in *C. nitidus.*

With Safranin.

C. albus: Deep, slightly deeper than in *C. nitidus.*
C. maweanus var. *major:* Fairly deep, about the same as in *C. nitidus.*
C. benthami: Fairly deep, slightly deeper than in *C. nitidus.*
C. lilacinus: Deep, deeper than in *C. nitidus.*
C. nitidus: Fairly deep.
C. howellii: Fairly deep, deeper than in *C. nitidus.*
C. leichtlinii: Fairly deep, deeper than in *C. nitidus.*
C. luteus var. *oculatus:* Deep, deeper than in *C. nitidus.*
C. splendens: Fairly deep, about the same as in *C. nitidus.*

TEMPERATURE OF GELATINIZATION.

C. albus: 52 to 54° C., mean 53°.
C. maweanus var. *major:* 59 to 60° C., mean 59.5°.
C. benthami: 61 to 62° C., mean 61.5°.
C. lilacinus: 58 to 60° C., mean 59°.
C. nitidus: 54 to 55.5° C., mean 54.75°.
C. howellii: 50 to 51° C., mean 50.5°.
C. leichtlinii: 62 to 64° C., mean 63°.
C. luteus var. *oculatus:* 57.2 to 59° C., mean 58.1°.
C. splendens: 54.2 to 56° C., mean 55.1°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

C. albus: Begins in 45 seconds; complete in 6 minutes.
C. maweanus var. *major:* Begins in 45 seconds; complete in 10 minutes.
C. benthami: Begins in 30 seconds; complete in 5 minutes.
C. lilacinus: Begins in 1½ minutes; complete in 5 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chloral Hydrate-Iodine.—Continued.

C. nitidus: Begins in 15 seconds; complete in 2 minutes.
C. howellii: Begins in a minute; complete in 7 minutes.
C. leichtlinii: Begins in 30 seconds; complete in 7 minutes.
C. luteus var. *oculatus:* Begins in 1½ minutes; complete in 10 minutes.
C. splendens: Begins in 30 seconds; complete in 7 minutes.

Reaction with Chromic Acid.

C. albus: Begins at once; complete in 30 seconds.
C. maweanus var. *major:* Begins at once; complete in a minute.
C. benthami: Begins at once; complete in 2 minutes.
C. lilacinus: Begins at once; complete in 30 seconds.
C. nitidus: Begins at once; complete in 20 seconds.
C howellii: Begins at once; complete in a minute.
C. leichtlinii: Begins at once; complete in a minute.
C. luteus var. *oculatus:* Begins at once; complete in a minute.
C. splendens: Begins at once; complete in 30 seconds.

Reaction with Pyrogallic Acid.

C. albus: Begins in 10 seconds; complete in 4 minutes.
C. maweanus var. *major:* Begins in 20 seconds; complete in most in 8 minutes.
C. benthami: Begins in 30 seconds; complete in 4 minutes.
C. lilacinus: Begins in 20 seconds; complete in 4 minutes.
C. nitidus: Begins at once; complete in 2 minutes.
C. howellii: Begins in 20 seconds; complete in 2½ minutes.
C. leichtlinii: Begins in 30 seconds; complete in most in 10 minutes.
C. luteus var. *oculatus:* Begins in 20 seconds; complete in 10 minutes.
C. splendens: Begins in 20 seconds; complete in 4 minutes.

Reaction with Ferric Chloride.

C. albus: Begins in 30 seconds; complete in 6 minutes.
C. maweanus var. *major:* Begins in 2 minutes; complete in 8 minutes.
C. benthami: Begins in 15 seconds; complete in 5 minutes.
C. lilacinus: Begins in 2 minutes; complete in 5 minutes.
C. nitidus: Begins in 30 seconds; complete in 4 minutes.
C. howellii: Begins in 2 minutes; complete in 4 minutes.
C. leichtlinii: Begins in 2½ minutes; complete in 6 minutes.
C. luteus var. *oculatus:* Begins in 1½ minutes; complete in 8 minutes.
C. splendens: Begins in 1½ minutes; complete in 10 minutes.

Reaction with Purdy's Solution.

C. albus: Begins at once; complete in 20 to 30 seconds.
C. maweanus var. *major:* Begins at once; complete in 30 seconds.
C. benthami: Begins in 10 seconds. Complete in 30 seconds.
C. lilacinus: Begins at once; complete in a minute.
C. nitidus: Begins at once; complete in 30 seconds.
C. howellii: Begins at once; complete in 45 to 60 seconds.
C. leichtlinii: Begins in 15 seconds; complete in 3 minutes.
C. luteus var. *oculatus:* Begins at once; complete in 1 minute.
C. splendens: Begins at once; complete in 45 seconds.

NOTES ON THE STARCHES OF CALOCHORTUS.

The starches of *Calochortus* in their histological characters exhibit differences in size, form, hilum, and lamellæ, especially in their size and lamellæ, and as regards the lamellæ in reference particularly to the secondary sets. In their reactions it will be noted that while the curves of the reaction-intensities are clearly of the same type, the departures from a given standard in the case of each starch are distinctive, the main deviations being seen in the temperature of gelatinization (the range being from 50.5° to 63°) and in the chloral hydrate-iodine, pyrogallic acid, and ferric chloride reactions.

GENUS TULIPA.

This large genus comprises over 80 species, a number of recognized botanical varieties, and perhaps materially over 2,000 garden varieties. Originally natives of Siberia, Asia Minor, China, and Japan, they have been naturalized in various European countries, especially those bordering the Mediterranean and Adriatic. They are widely and extensively cultivated in both the Old and New Worlds, notably in Holland, where there existed in 1636–7 a "tulipomania." At this time the tulip-bulb trade had grown to enormous proportions, the bulbs were a common article of speculation, and some of the rarer bulbs brought astonishing prices, in one instance as high as 13,000 florins. The garden varieties have had their origin directly or indirectly from *T. gesneriana* Linn., which is stated to have been cultivated in Turkey in 1554. The tulips have been classified by Stubenrauch, according to their botanical characters, into 8 groups. The starches of 12 species or varieties, representing 5 of the 8 groups, were examined, as follows:

Group I. *T. hageri* Held.
Group II. *T. sylvestris* Linn. and *T. greigi* Regel.
Group III. *T. billietiana* Jord. and Four., *T. didieri* Jord., *T. didieri* var. *mauriana*, and *T. didieri* var. *fransoniana*.
Group IV. *T. clusiana* Vent., *T. clusiana* var. *persica* Hort., *T. oculus-solis* St. Aman., and *T. præcox* Tenore.
Group V. *T. australis* Link.

The name *T. fransoniana* has been used synonymously with *T. didieri*, and on this account we have included it in the same group as the latter as being identical with or intimately related to it. *T. persica* has sometimes been used in commerce as a synonym of *T. patens*, etc., as above noted, and also to signify *Bæometra columellaris* Salisb. The former is a true tulip; the latter is a monotypic genus, native of South America and not a true tulip. Inasmuch as the starch obtained from our specimen agreed in its properties with the starches of other tulips, it was concluded that the source was one of the real tulips; and since *T. persica* has been used synonymously with *T. clausiana* the specimen has been so grouped. *Tulipa* is closely related to *Lilium*, *Fritillaria*, *Calochortus*, and *Erythronium*, all of which are included in this investigation. The relationship is evident in the fact that these 5 genera, including *Lloydia* and *Gagea*, have been grouped as constituting the tribe *Tulipeæ*.

STARCH OF TULIPA HAGERI. (Plate 31, figs. 181 and 182. Chart 129.)

Histological Characteristics.—In *form* the grains are simple and are isolated, except a few in the form of doublets. There are no pressure facets. The surface is usually quite regular. In many grains lateral depressions opposite the hilum give the proximal end of grain the appearance of protrusion. Slight lateral projections, chiefly nipple-like, are seen on some of the grains. The conspicuous forms are triangular with rounded angles and curved base, and pyriform in the larger grains; and slightly flattened elliptical, triangular, pyriform, ovoid, and round in the smaller grains. The grains are flattened, and when viewed on edge they are frequently found to be narrower at the distal end.

The *hilum* is a distinct, rather small, round, refractive spot with a range of eccentricity from one-fourth to one-sixth, usually one-fifth, of the longitudinal axis. A short fissure, which may be transverse or diagonal, is frequently present at the distal margin of the hilum.

The *lamellæ* are usually not demonstrable near the hilum, but occasionally are observed as complete rings, while at the sides and distal end they follow the outline of the grain and are probably incomplete. There are frequently several coarse and refractive lamellæ at varying distances from the hilum which are interspersed with groups of fine, less distinct lamellæ. The lamellæ are more often demonstrable in the area located about one-third to three-fourths of the distance between the hilum and distal margin. Rarely they can be counted over the greater part of the grain. An average of 44 has been counted on the larger grains.

The *size* of the smallest round grains is 5 by 5μ, and that of the largest grains 54 by 42μ in length and breadth. The common size of the larger grains is 36 by 30μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, except in some of the very small forms, and is fairly clear-cut. The lines of the figure are rather broad and generally straight, but tend to be much spread out, especially at the distal margin. Rarely they are either bent or bisected.

The degree of *polarization* is fairly high. It ranges from rather high in the large to fair in the small grains. There is some variation in the same aspect and also in different aspects of a grain.

With *sclenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The blue is quite pure, while the yellow is moderately pure.

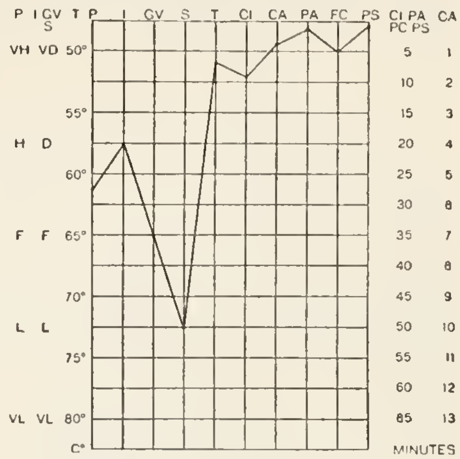
Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color quite well and the color deepens rapidly. After heating in water until all the grains are completely gelatinized, the solution colors rather deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the grain-residues rather lightly. The capsules all color a red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in about 30 seconds, and in 30 minutes they are *fairly* colored, some slightly more than others.

With *safranin* the grains begin to stain very lightly in about 30 seconds, and in 30 minutes they are lightly colored, some slightly more than others.

Temperature Reaction.—The temperature of gelatinization is 50.4° to 51.4° C., mean 50.9°.

Chart No. 129.



Curve of Reaction-Intensities of Starch of Tulipa hageri.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in many grains in 15 seconds and is over in 9 minutes. The reaction starts at the proximal end, which first darkens and then swells out in the form of a narrow, rounded projection, this being accompanied by the swelling of the hilum. At the hilum a bubble meanwhile forms, which increases and then decreases in size as the hilum swells. The distal end in the meanwhile usually darkens and then the sides of the grain, and the process of gelatinization and swelling moves inward from all sides, but more rapidly from the proximal end, until finally all of the grain is gelatinized. At times the distal end remains unaffected until the last. The swollen grains are fairly large, smooth, and not distorted; they retain much of the original form. They are of a uniform dark color, except at the proximal end, where there is a small, round, light space.

The reaction with *chromic acid* begins at once in most grains and is over in 45 seconds. It is impossible to determine accurately all the steps of the reaction, but in the main they are as follows: A bubble appears at the hilum and the grain becomes finely striated. The bubble increases in size as the hilum and the proximal end of the grain swell out into a long, rounded projection, and then decreases and disappears. Two lines or fissures extend from each side of the swollen grain towards the sides of the distal end, and the starch between them is divided by a number of longitudinal fissures into a granular mass which is pushed down to the distal end as the grain swells. The margin of the swollen proximal end is dissolved and the granular material within the capsule flows out and is dissolved and the remainder of the marginal starch at the sides and distal end dissolves later.

The reaction with *pyrogallic acid* begins in a very few seconds and is over in 1½ minutes. The hilum swells and a bubble appears which increases in size, enlarging principally in the direction of the distal end, and the proximal end becomes invaginated. Two lines or fissures extend from each side of the hilum towards the distal end, and the starch between them becomes divided by fine, longitudinal striæ or fissures. This part of the grain grows finely granular and collects at the distal end as the grain swells. The invaginated proximal end usually straightens out gradually as the grain swells. There is but little resistant starch at the margin, and what does appear there is soon gelatinized and appears as a thin, transparent capsule. The swollen grains are large, smooth, and not distorted at the proximal end, but wrinkled and sacculated at the distal end. They retain some of the original form of the grain.

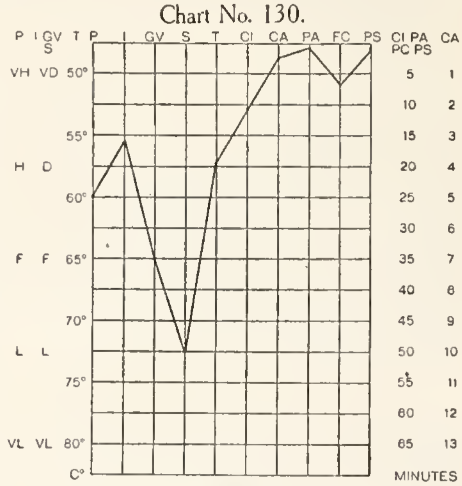
With *ferric chloride* the reaction begins in a few grains in a few seconds and in all in 5 seconds; it is over in nearly all in 3 minutes and in all in 5 minutes. The hilum swells, and also the starch at the proximal end, to form a long, rounded projection from the proximal end of the grain. A bubble formation at the hilum sometimes accompanies this. As the starch in the immediate vicinity of the reacting portion of the grain becomes affected, it is gelatinized and swells. The margin of the projection first formed is invaginated suddenly and deeply. This process of gelatinization and swelling moves on down the grain until all parts are affected, the distal end last. As the grain becomes fully swollen, the invaginated portion above referred to is pushed out. The swollen grains are very large and are irregular. They are smooth and rounded at the proximal end, and sacculated, wrinkled, and folded at the distal end.

The reaction with *Purdy's solution* begins in a few seconds and is over in a minute. It appears to be practically identical with that of pyrogallic acid. The main difference is that the bubble formation at the hilum does not occur so frequently with this reagent, and the resulting swollen grain is larger and retains less of the original form of the grain.

STARCH OF TULIPA SYLVESTRIS. (Plate 31, figs. 183 and 184. Chart 130.)

Histological Characteristics.—In *form* the grains are simple and with few exceptions isolated. No pressure facets were observed on the isolated grains. The surface is usually regular. A few grains have lateral depressions near the hilum; and rarely grains are seen with nipple-like processes at the sides near proximal end. The conspicuous forms among the large grains are triangular with curved base and rounded angles, somewhat clam-shell-shaped and elongated triangular with curved base and rounded angles varying to slightly pyriform. The conspicuous forms of the small grains are slightly flattened ellipsoidal, pyriform, ovoid, and round. The grains are flattened and when viewed on edge they are frequently seen to be narrower at the distal end. They are slightly less regular than those of *T. hageri.*

Chart No. 130.



Curve of Reaction-Intensities of Starch of Tulipa sylvestris.

The *hilum* is a fairly distinct refractive spot, which has a range of eccentricity from one-fourth to one-sixth of the longitudinal axis, in most grains one-fifth. A short transverse fissure at the distal margin of the hilum is occasionally present.

The majority of the *lamellæ* are fine but fairly distinct, and frequently grouped between a few disseminated, rather coarse and refractive ones; but occasionally grains are found in which the lamellæ are quite distinct and coarse throughout. In many of the grains one to three coarse, refractive lamellæ are particularly conspicuous at varying distances between the hilum and the distal end, frequently between one-half and two-thirds. In the larger grains an average of 42 lamellæ was counted.

The *size* of the smallest grains is 3 by 3μ; the largest broadened grains are 46 by 52μ; the larger elongated forms are 52 by 43μ in length and breadth. The common size of the broadened grains is 34 by 38μ, and of the elongated grains 30 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and fairly clear-cut. Its lines are generally thick and straight, but are expanded, especially at the distal margin. They are bent or bisected. It is the same as in the grains of *T. hageri.*

The degree of *polarization* is fairly high, without much variation in the different grains or in the same aspect of a given grain. It is higher than in *T. hageri.*

With *selenite* the quadrants are fairly well defined; they are regular in shape and unequal in size. The blue is quite pure, but the yellow is not pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is slightly deeper than that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly stained, some more than others. It is the same intensity as that of the grains of *T. hageri.*

With *safranin* the grains begin to stain at once and in 30 minutes are lightly stained, one as much as another. The intensity is the same as that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 56.5° to 57.8° C., mean 57.15°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in all the grains in 30 seconds. It is over in nearly all in 4 minutes and in all in 11 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *chromic acid* begins in a very few seconds and is over in 30 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

The reaction with *pyrogallic acid* begins in a few seconds and is over in a minute. It is the same qualitatively as that of the grains of *T. hageri.*

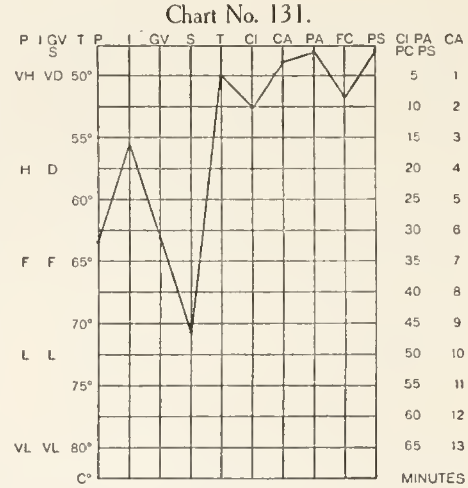
With *ferric chloride* reaction begins in a few grains in 15 seconds. It is over in nearly all in 4 minutes and in all in 7 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *Purdy's solution* begins in a few seconds and is over in 1¼ minutes. It is the same qualitatively as that of the grains of *T. hageri.*

STARCH OF TULIPA GREIGI. (Plate 31, figs. 185 and 186. Chart 131.)

Histological Characteristics.—In *form* the grains are simple and almost invariably isolated. Occasionally pressure facets were observed on small, isolated grains. The surface generally is regular; rarely there are irregular grains with lateral, nipple-like protuberances near or at the proximal end, as noted for *T. hageri.* The conspicuous forms in the large grains vary from the elongated triangular with curved base and rounded angles to somewhat pyriform, broadly triangular, and clam-shell-shaped. The smallest grains are generally pyriform, slightly flattened ellipsoidal, ovoid, and round. The grains are flattened, and when viewed on edge they are frequently seen to be narrower at the distal end.

Chart No. 131.



Curve of Reaction-Intensities of Starch of Tulipa greigi.

The *hilum* is a round refractive spot, with range of eccentricity from one-sixth to one-fifth, in most one-sixth, of the longitudinal axis. A short, transverse fissure through the distal margin of the hilum is often observed.

The *lamellæ* are not very distinct and frequently not demonstrable near the hilum, excepting one or two complete rings immediately surrounding it. Usually one, sometimes two or three, rather coarse, refractive lamellæ appear at varying distances from the hilum. They are often coarser and more distinct near the distal end than near the hilum. When demonstrable at the hilum they are concentric rings, but near the side and distal end they have the outline of the grain and are probably incomplete. The lamellæ are occasionally fairly distinct throughout the length of most of the grain and in such cases 40 to 46 of them have been counted.

The *size* of the smaller grains is 6 by 6μ; the larger, elongated forms are 55 by 40μ; the broadened grains 42 by 40μ in length and breadth. The common size of the elongated grains is 39 by 30μ and of the broadened grains 34 by 33μ in length and breadth.

Polariscopic Properties.—The *figure* is generally eccentric. It is usually distinct and fairly clear-cut, but varies considerably in this respect. The lines of the figure are straight, thick, and somewhat expanded at the distal and proximal margins. They are rarely bent or bisected. The figure is the same as in *T. hageri.*

The degree of *polarization* as fairly high. It varies considerably in different grains and in the same aspect of a given grain. It is not so high as *T. hageri.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The blue is quite pure, the yellow not pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is slightly more than that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution and the swollen grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. With a slight excess of iodine the capsules all color a red-violet.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly colored, some more than others. The color is deeper than that of the grains of *T. hageri.*

With *safranin* the grains begin to stain at once and in 30 minutes are lightly stained, one as much as another. The stain is deeper than with the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 49.6° to 51° C., mean 50.3°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 15 seconds. It is over in nearly all in 5 minutes and in all in 10 minutes. It is the same qualitatively as with *T. hageri.*

Reaction with *chromic acid* begins at once and is over in 30 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

The reaction with *pyrogallic acid* begins in a very few seconds, and is over in 45 seconds. It is the same qualitatively as with *T. hageri.*

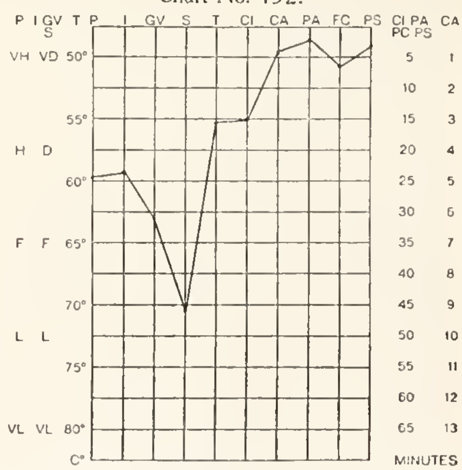
The reaction with *ferric chloride* begins in a few grains in 15 seconds. It is over in nearly all in 4 minutes and in all in 8 minutes. The reaction is the same qualitatively as with *T. hageri.*

With *Purdy's solution* reaction begins in a very few seconds and is over in 30 seconds. It is the same qualitatively as with *T. hageri.*

STARCH OF TULIPA BILLIETIANA. (Plate 32, figs. 187 and 188. Chart 132.)

Histological Characteristics.—In *form* the grains are simple and they are isolated, except a few small aggregates, usually in the form of doublets. No pressure facets are observed in the isolated grains. The surface of most grains is regular. Grains with slight lateral protuberances and nipple-like processes are more frequent than in *T. hageri.* There is occasionally an extension at the proximal end which rarely is finger-shaped and resembles *T. præcox* and *T. australis.* The conspicuous forms in the larger grains are flattened pyriform, flask-shaped, broadly triangular with curved base and rounded angles approaching both the clam-shell shape and the pyriform. The small grains are somewhat flattened elliptical, ovoid, pyriform, and round. The grains are flattened when viewed on edge, and frequently are narrower at the distal end. The grains are more often irregular in outline than in *T. hageri.*

Chart No. 132.



Curve of Reaction-Intensities of Starch of Tulipa billietiana.

The *hilum* is a small refractive spot with a range of eccentricity from one-fifth to one-seventh, usually one-sixth, of the longitudinal axis. A short transverse fissure is often found at the hilum.

Most of the *lamellæ* are fine and rather indistinct. When apparent they form complete rings around the hilum, and when near the sides and distal end have the shape of the outline of the grain and are probably incomplete at these points. One or more coarse, refractive lamellæ are always located at varying distances from the hilum. In the flattened pyriform forms one quite coarse, refractive lamella is usually situated at about two-thirds of the distance between the hilum and the distal end. From this lamella to the distal margin the grain is marked by lamellæ coarser than those near the hilum. On the clam-shell-shaped grains groups of fine lamellæ are interspersed with three or more coarse lamellæ placed at varying distances from the hilum. Occasionally from 44 to 48 lamellæ may be counted.

The *size* of the small, round forms is 6 by 6μ, the largest, elongated grains are 44 by 34μ in length and breadth. The common size of the larger grains is 36 by 28μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric. It is distinct and fairly clear-cut. Its lines are generally straight, but expanded near the proximal and distal margins; occasionally they are bent; and rarely bisected. The figure is the same as in *T. hageri.*

The degree of *polarization* is fairly high. It varies somewhat in different grains and in the same aspect of a given grain. There is less variation in the grains of this species than in those of *T. hageri.*

With *selenite* the quadrants are fairly well defined, ordinarily regular in shape, and unequal in size. The blue is pure, the yellow not quite pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not quite so deep as that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly. The capsules all color a red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes they are fairly stained, some more than others. The stain is slightly more than that of the grains of *T. hageri.*

Safranin.—The grains begin to stain very lightly at once, and in 30 minutes they are lightly stained, some more than others. The stain is slightly more than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 55.1° to 55.4° C., mean 55.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 15 seconds, in all in 30 seconds. It is complete in nearly all in 10 minutes and in all in 15 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

With *chromic acid* the reaction begins in a few seconds and is over in 45 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

The reaction with *pyrogallic acid* begins in some grains in a few seconds and is over in 2½ minutes. It is the same qualitatively as that of the grains of *T. hageri.*

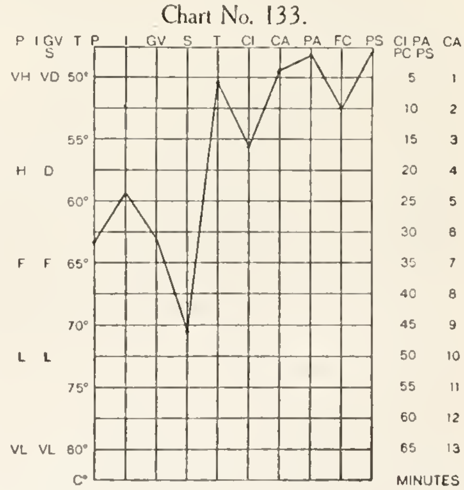
Reaction with *ferric chloride* begins in a few grains in 15 seconds. It is over in nearly all in 5 minutes and all in 7 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

The reaction with *Purdy's solution* begins in a few seconds and is over in 3 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

STARCH OF TULIPA DIDIERI. (Plate 32, figs. 189 and 190. Chart 133.)

Histological Characteristics.—In *form* the grains are simple and nearly always isolated. There are no pressure facets. The surface is usually regular. Some irregularities are caused by protuberances near or at the proximal end, of the kind noted under *T. hageri.* The conspicuous forms among the larger grains are triangular with rounded angles and base to clam-shell-shaped and pyriform. Among the large grains there are flattened pyriform approaching a bottle shape, and a few resembling the form of the Indian flint arrow-head. Among the smallest grains are slightly flattened ellipsoidal, pyriform, ovoid, and round. The grains are flattened, and when viewed on edge they are frequently seen to be narrower at the distal end. There is a larger proportion of grains with irregular outline than in *T. hageri.*

Chart No. 133.



Curve of Reaction-Intensities of Starch of Tulipa didieri.

The *hilum* is a distinct, round, refractive spot, with a range of eccentricity of one-fifth to one-eighth, usually one-sixth, of the long axis. A transverse fissure is often found at the hilum.

The *lamellæ* are mostly fine and indistinct, and when demonstrable they form complete rings around the hilum, and have the shape of the grain, appearing incomplete towards the sides and distal end. There is often a band of rather coarse, refractive lamellæ at about three-fourths of the distance between the hilum and the distal end, and the lamellæ for the last one-fourth of the distance between these points may be coarser and more refractive than those near the hilum. The larger forms apparently have about 27 or 30 lamellæ, but on account of the indistinctness the number can not be definitely determined.

The *size* of the small grains is 4 by 4μ; the larger, broadened grains are 42 by 44μ; the elongated grains are 50 by 42μ in length and breadth. The common size of the larger grains is 32 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, except in some of the very small grains. Its lines are thick and generally straight and expanded at the distal and proximal ends. Occasionally they may be bent and rarely are bisected. The figure is the same as that of *T. hageri.*

The degree of *polarization* is fairly high. There is considerable variation in the different grains and even in the same aspect of a given grain. It is not so high as in *T. hageri.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The blue is quite pure, but the yellow is not pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not quite so deep as that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the grain-residues lightly or not at all. With a slight excess of iodine all the capsules color a red-violet.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly stained, some slightly more than others. The stain is slightly deeper than that of the grains of *T. hageri.*

With *safranin* the grains begin to stain lightly at once and in 30 minutes are lightly stained, one as much as another. The color is deeper than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 50° to 51.5° C., mean 50.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds. It is over in most of them in 10 minutes and in all in 17 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *chromic acid* begins at once and is over in 45 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

With *pyrogallic acid* reaction begins in a few seconds and is over in a minute. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *ferric chloride* begins in a few grains in 15 seconds. It is over in nearly all in 6 minutes and in all in 10 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *Purdy's solution* begins at once and is over in 45 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

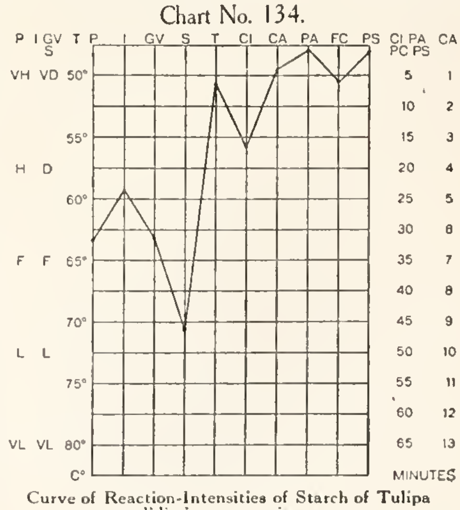
STARCH OF TULIPA DIDIERI VAR. MAURIANA. (Plate 32, figs. 191 and 192. Chart 134.)

Histological Characteristics.—In *form* the grains are simple and, almost without exception, isolated. There are no pressure facets. The surface is usually somewhat irregular, owing to an undulating margin and occasionally to nipple-like processes near the hilum. The conspicuous forms among the large grains are irregular ovoid, pyriform, flattened ellipsoidal, oval, and clam-shell-shaped. The smallest forms are oval, ovoid, ellipsoidal, and round. The grains are flattened, and when viewed on edge they are frequently seen to be narrower at the distal end. They are the most irregular of all the tulip starches.

The *hilum* is a round refractive spot, with a range of eccentricity of one-fifth to one-seventh, usually one-sixth, of the longitudinal diameter. A small transverse fissure is sometimes present at the hilum.

The *lamellæ* are usually fine and indistinct near the hilum, and there is often one coarse, refractive lamella at about three-fourths of the distance between the hilum and the distal end. The lamellæ are distinct and coarser in the quarter-section near the distal end than between the refractive lamella referred to and the hilum. Often there are two of these coarse, refractive lamellæ, one at about one-fourth and the other at three-fourths of the distance between the hilum and the distal margin. There is an alternation of coarse lamellæ with groups of fine lamellæ in the broadly triangular and also in the somewhat clam-shell-shaped grains. The lamellæ are not demonstrable throughout the entire grain, but occasionally 25 to 30 can be counted ou a grain.

Chart No. 134.



Curve of Reaction-Intensities of Starch of Tulipa didieri var. mauriana.

The *size* of the smallest grains is 6 by 6μ and of the largest 58 by 34μ. The common size is 36 by 24μ.

Polariscopic Properties.—The *figure* is usually eccentric. Its lines are thick and usually straight and somewhat expanded at the proximal and distal margins. Occasionally its lines are either bent or bisected, and have a greater tendency to distortion than in other *Tulipa*. The figure is the same as that of *T. hageri*.

The degree of *polarization* is fairly high. It varies somewhat in different grains and also in the same aspect of a given grain. It is not quite so high as in *T. hageri*.

With *selenite* the quadrants are fairly well defined, frequently irregular in shape, and unequal in size. The blue is quite pure, but the yellow is not pure, as in *T. hageri*.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is not so deep as that of the grains of *T. hageri*. After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules all color a red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are fairly stained. They stain more than the grains of *T. hageri*.

With *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained. The stain is deeper than in the grains of *T. hageri*.

Temperature Reaction.—The temperature of gelatinization is 50.2° to 51.7° C., mean 50.95°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in all the grains in 30 seconds. It is over in nearly all in 5 minutes and in all in 17 minutes. It is the same qualitatively as that of the grains of *T. hageri*.

With *chromic acid* reaction begins at once and is over in 50 seconds. It is the same qualitatively as that of the grains of *T. hageri*.

Reaction with *pyrogallic acid* begins in a few seconds and is over in 40 seconds. It is the same qualitatively as that of the grains of *T. hageri*.

The reaction with *ferric chloride* begins in a few grains in 15 seconds. It is over in nearly all in 4 minutes and in all in 6 minutes.

Reaction with *Purdy's solution* begins in a very few seconds and is over in a minute. It is the same qualitatively as that of the grains of *T. hageri*.

STARCH OF TULIPA DIDIERI VAR. FRANSONIANA. (Plate 33, figs. 193 and 194. Chart 135.)

Histological Characteristics.—In *form* the grains are simple, and, with the exception of some small aggregates, mostly in the form of triplets, they are isolated. Few pressure facets were noted on the isolated grains. The surface of most of the grains is regular. Irregularities are rare, and when found are usually caused by small protuberances at or near the proximal end, such as heretofore noted under other *Tulipa*. The conspicuous forms among the large grains are the broadly triangular with curved base and rounded angles to clam-shell shape, the narrow triangular to somewhat pyriform and rare flattened pyriform and Indian flint arrow-head shape. The smallest forms are slightly flattened oval, ovoid, pyriform and round. The grains are flattened and when viewed on edge they are frequently narrower at the distal end.

The *hilum* is a round, refractive spot, with a range of eccentricity from one-fourth to one-fifth, commonly one-fourth, of the longitudinal axis. A transverse cleft is frequently found at the hilum.

The *lamellæ* are usually fine and indistinct in the larger part of the grain. When distinct, those near the hilum form complete rings, but those nearer the margin assume the shape of the grain and appear to be incomplete. One quite coarse and refractive lamella is frequently found near the distal margin, between which point and the margin there is usually a band of quite fine lamellæ. Rarely the lamellæ may be observed throughout most of the grain, and about 30 have been recorded.

The *size* of the smaller grains is 6 by 6μ, of the larger grains 50 by 44μ, of the broadened grains 44 by 46μ, in length and breadth. The common size of the narrower grains is 36 by 30μ, of the broader grains 34 by 36μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric. It is distinct and fairly clear-cut. Its lines are thick and straight and are expanded near the distal and proximal margins. In rare cases the lines are either bent or bisected.

The degree of *polarization* is fairly high, but varies considerably in different grains and often in the same aspect of a given grain. It is scarcely as high as *T. hageri.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The blue is pure, but the yellow is not, as in the case of *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not so deep as that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules color a red-violet with a slight excess of iodine.

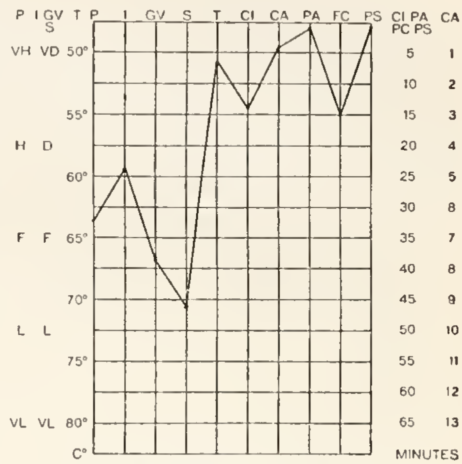
Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are fairly stained, some more than others. The stain is less than that of the grains of *T. hageri.*

With *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained. The color is deeper than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 50.1° to 52.2° C., mean 51.15°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in 30 seconds. It is over in nearly all in 8 minutes and in all in 14 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Chart No. 135.



Curve of Reaction-Intensities of Starch of Tulipa didieri var. fransoniana.

With *chromic acid* reaction begins at once and is over in 50 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *pyrogallic acid* begins in a very few seconds and in all in 15 seconds. It is over in 45 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *ferric chloride* begins in a very few grains in 30 seconds. It is over in nearly all in 5 minutes and in all in 15 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

With *Purdy's solution* reaction begins in a very few seconds and is over in 50 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

STARCH OF TULIPA CLUSIANA. (Plate 33, figs. 195 and 196. Chart 136.)

Histological Characteristics.—In *form* the grains are simple and, with the exception of a few doublets, are isolated. There are no pressure facets on the isolated grains. The surface of most grains is regular, but they are sometimes somewhat irregular owing to one or more nipple-like processes, either near or at the proximal end; or the proximal end may rarely be elongated into a finger-like process, the line of union with the body of the grain being indicated by a refractive line. The conspicuous forms among the larger grains are narrow to broad triangular with curved base and rounded angles, ovoid with distal end somewhat flattened, pyriform, and clam-shell-shaped. The smaller grains are flattened elliptical, pyriform, ovoid, and round. The grains are flattened and when viewed on edge they are frequently narrower at the distal end. The grains are more irregular than those of *T. hageri.*

The *hilum* is often not very distinct. It is a fairly refractive, round spot which usually has range of eccentricity from one-fifth to one-sixth, commonly one-sixth, of the longitudinal axis. A short transverse fissure may be found at the hilum.

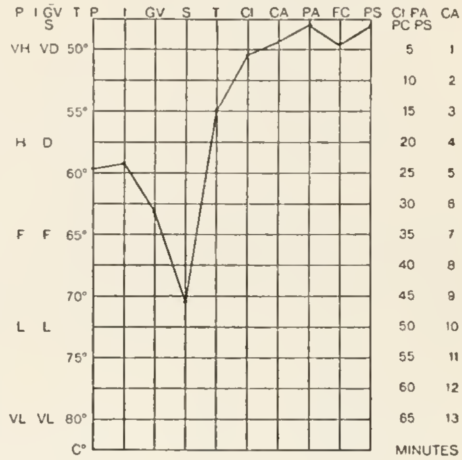
The *lamellæ* are generally fine and indistinct near the hilum, and fairly coarse and distinct near the lateral margins and distal end. In the clam-shell-shaped type the lamellæ are usually more distinct throughout most of the grain, 1 to 3 being more refractive and coarser than the others. The lamellæ, if demonstrable, are seen to form complete circles when located near the hilum, but assume the shape of the grains and appear incomplete when near the margin and distal end. There is usually one or two very refractive, coarse lamellæ at varying distances between the hilum and the distal end. The lamellæ are not clearly demonstrable over the entire grain, and as many as 38 to 40 lamellæ may be found on the larger grains.

The *size* of the smaller, round grains is 2 by 2μ; the larger, broader grains are 50 by 40μ; the narrower grains are 50 by 25μ in length and breadth. The common size of the narrow forms is 30 by 16μ and of the broader grains 34 by 30μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric. It is distinct and fairly clear-cut. The lines of the figure are rather thick, generally straight, and expanded at the distal and proximal margins. They are occasionally bent and rarely bisected. The figure is the same as in *T. hageri.*

The degree of *polarization* is fairly high. There is considerable variation in the different grains and in the same aspect of the same grain. It is higher than in the grains of *T. hageri.*

Chart No. 136.



Curve of Reaction-Intensities of Starch of Tulipa clusiana.

With *selenite* the quadrants are fairly well defined, usually regular in shape, and unequal in size. The blue is quite pure, and the yellow is fairly pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not quite so deep as that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors somewhat deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues very lightly or not at all. The capsules are all colored a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are stained fairly. The stain is slightly more than that of the grains of *T. hageri.*

With *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained. The stain is more than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 54° to 55.7° C., mean 54.85°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in all in 15 seconds. It is over in nearly all in 4 minutes and in all in 6 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *chromic acid* begins at once and is over in 40 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

The reaction with *pyrogallic acid* begins in a very few seconds and is over in 50 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

With *ferric chloride* reaction begins in a few grains in 15 seconds. It is over in nearly all in 3 minutes and in all in 4 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *Purdy's solution* begins in a very few seconds and is over in a minute. It is the same qualitatively as that of the grains of *T. hageri.*

STARCH OF TULIPA CLUSIANA VAR. PERSICA. (Plate 33, figs. 197 and 198. Chart 137.)

Histological Characteristics.—In *form* the grains are simple and isolated, except in case of a few doublets. There are no pressure facets. The surface is quite regular, more so than in *T. clusiana.* The conspicuous forms in the larger grains are triangular with rounded angles and curved base, somewhat clam-shell-shaped, and pyriform. The smaller grains are pyriform, oval, flattened ellipsoidal, and round. The grains are flattened, and when viewed on edge they frequently appear narrower at the distal end.

The *hilum* is a round, fairly refractive spot with a range of eccentricity from one-fourth to one-sixth, usually one-fifth, of the longitudinal axis. A short transverse fissure may be found at the hilum.

The *lamellæ* are mostly fine, but a few are quite coarse. When demonstrable near the hilum they form complete circles, but those near the margin and the distal end have the form of the outline of the grain and may be incomplete. In the large grains there are usually one to three or more refractive and coarser lamellæ which are found at varying points between the hilum and the distal margin. The lamellæ are not demonstrable throughout the entire grain, but occasionally 27 to 30 may be counted on larger grains.

The *size* of the smaller grains is 4 by 4μ, of the larger broader grains 48 by 50μ, of the elongated grains 42 by 38μ in length and breadth. The common size of the latter is 30 by 23μ in length and breadth.

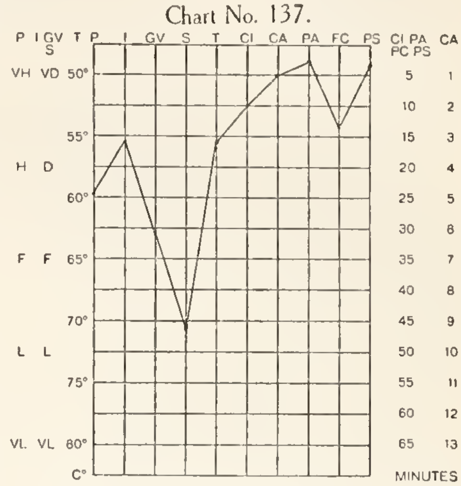
Polariscopic Properties.—The *figure* is usually eccentric. Its lines are rather thick and generally straight, but are diffused at the distal and proximal margins. They rarely appear bisected or bent.

The degree of *polarization* is fairly high, but varies in different grains and in the same aspect of a given grain. It is higher than in *T. hageri.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The blue is quite pure, but the yellow is not pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is slightly deeper than that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues rather lightly or not at all. The capsules all color a red-violet with a slight excess of iodine.

Chart No. 137.



Curve of Reaction-Intensities of Starch of Tulipa clusiana var. persica.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly almost immediately, and in 30 minutes they are fairly stained, some slightly more than others. The stain is slightly more than that of the grains of *T. hageri.*

With *safranin* the grains begin to stain very lightly almost immediately, and in 30 minutes they are lightly stained, some of them less than others. The stain is very slightly more than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 55.5° to 56.1° C., mean 55.8°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in a few seconds. Nearly all are gelatinized in 6 minutes and all in 10 minutes. The reaction is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *chromic acid* begins in some grains at once and in all in 15 seconds. It is over in a minute. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *pyrogallic acid* begins in some grains in 15 seconds and in all in 30 seconds. It is over in 2½ minutes. It is the same as that of the grains of *T. hageri,* except that there is very little bubble formation.

With *ferric chloride* reaction begins in a few grains in 30 seconds. Nearly all the grains are gelatinized in 10 minutes and all in 13 minutes. The reaction is the same qualitatively as that of the grains of *T. hageri.*

The reaction with *Purdy's solution* begins in 30 seconds and is over in 3 minutes. The reaction is the same qualitatively as that of the grains of *T. hageri.*

STARCH OF TULIPA OCULUS-SOLIS. (Plate 34, figs. 199 and 200. Chart 138.)

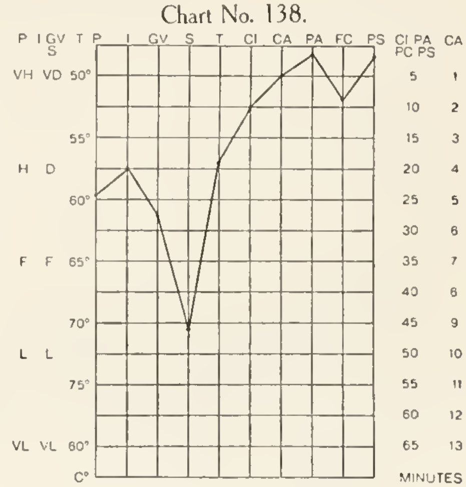
Histological Characteristics.—In *form* the grains are simple and with rare exceptions isolated. Doublets are very rare, and no pressure facets are observed. The surface is usually regular. When irregular they have nipple-like processes or rather broad, blunt protuberances generally at or near the proximal end. The conspicuous forms among the large grains are the elongated triangular and broadly triangular with curved base and rounded angles, pyriform, and clam-shell-shaped. The small grains are oval, somewhat ovoid with squared distal end, and round. The grains are flattened and when viewed on edge they are frequently seen to be narrower at the distal end. There is a larger proportion of irregular grains than in *T. hageri.*

The *hilum* is an indistinct, round spot, generally with a range of eccentricity from one-fourth to one-sixth, usually one-fifth, of the longitudinal diameter. It is ordinarily not fissured, and occasionally a small cavity may appear in it.

The *lamellæ* near the hilum are not usually demonstrable, but when observed they form complete rings, but near the margin and distal end they assume the shape of the outline of the grains, and are generally coarser and more distinct. Many grains have two or three more refractive, coarser lamellæ at varying points on the grain. On account of the indistinctness of the lamellæ their number can not be accurately determined throughout the grain, but rarely 30 to 32 are demonstrable.

The *size* of the small grains is 6 by 6μ, of the larger, broadened grains is 52 by 49μ, and of the elongated grains 60 by 42μ in length and breadth. The common size of the broadened grains is 34 by 36μ and of the elongated grains is 38 by 22μ in length and breadth.

Chart No. 138.



Curve of Reaction-Intensities of Starch of Tulipa oculus-solis.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and fairly clear-cut. Its lines are thick and usually straight, and expanded at the proximal and distal margins, rarely either bent or bisected. The figure is the same as in *T. hageri.*

The degree of polarization is fairly high, but varies in different grains and in the same aspect of a given grain. It is higher than in *T. hageri.*

With *selenite* the quadrants are fairly well defined and regular in shape, unequal in size. The blue is quite pure, the yellow not pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is the same as that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules all color a red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly deeply stained, some more than others. The color is deeper than that of the grains of *T. hageri.*

With *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained, some more than others. The color is deeper than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 56.2° to 58° C., mean 57.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in all in 30 seconds. It is over in nearly all the grains in 5 minutes and in all in 10 minutes. It is the same qualitatively as that of the grains of *T. hageri,* except that there is no bubble formation at the hilum.

With *chromic acid* reaction begins in a few seconds and is over in a minute. It is the same qualitatively as that of the grains of *T. hageri,* except that there is no bubble formation at the hilum.

Reaction with *pyrogallic acid* begins in a few seconds and is over in 1¼ minutes. It is the same qualitatively as that of the grains of *T. hageri,* except that there is no bubble formation at the hilum.

The reaction with *ferric chloride* begins in a few grains in 20 seconds. It is over in nearly all in 4 minutes and in all in 8 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

With *Purdy's solution* reaction begins in 20 seconds and is over in 1¾ minutes. It is the same qualitatively as that of the grains of *T. hageri,* except that there is no bubble formation at the hilum.

STARCH OF TULIPA PRÆCOX. (Plate 34, figs. 201 and 202. Chart 139.)

Histological Characteristics.—In *form* the grains are simple and with the exception of very few doublets are isolated. There are no pressure facets on the isolated grains. The surface of most grains is regular. Some grains have lateral or proximal nipple-like protuberances, and rarely the proximal end may be extended into a finger-like process, the longitudinal axis of which may or may not coincide with that of the main body of the grain. The conspicuous forms among the larger grains are triangular with curved base and rounded angles, pyriform, and a few broadly triangular forms which approach the clam-shell-shaped type. The smallest grains are usually elliptical, oval, ovoid, and round. The grains are flattened, and when viewed on edge they frequently appear narrower at the distal end. They are more regular than the grains of *T. hageri.*

The *hilum* is a round refractive spot with a range of eccentricity from one-fourth to one-sixth, usually one-fifth, of the longitudinal axis. A short transverse fissure may be found at the hilum.

The *lamellæ* are usually not demonstrable near the hilum and also close by the distal end. When observed, near the hilum they form complete circles, but those near the margin and distal end have the shape of the outline of the grain and are probably incomplete. One to three coarse, refractive lamellæ are frequently found on the large grains. There appear to be 38 to 40 lamellæ on the larger grains, but they are quite indistinct and not demonstrable throughout the entire grain, and therefore the number is uncertain.

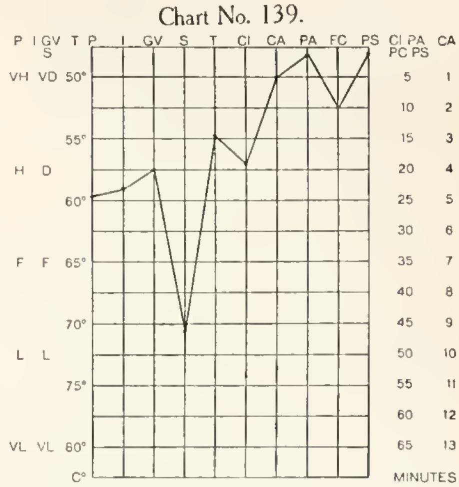
The *size* of the smaller grains is 6 by 6μ, and of the larger grains 60 by 48μ in length and breadth. The common size of the larger grains is 38 by 32μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and fairly clear-cut. The lines of the figure are rather thick and generally straight, but expanded at the proximal and distal margins. They are rarely either bent or bisected. The figure is the same as in *T. hageri.*

The degree of *polarization* is fairly high. It is somewhat variable in different grains and in the same aspect of a given grain. It is higher than in *T. hageri.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The blue is quite pure, but the yellow is not pure, as in *T. hageri.*

Chart No. 139.



Curve of Reaction-Intensities of Starch of Tulipa præcox.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is not so deep as that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are deeply stained, some much more than others. The stain is deeper than that of the grains of *T. hageri.*

With *safranin* the grains begin to stain at once and in 30 minutes are lightly stained, some slightly more than others. The stain is deeper than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 54° to 55.5° C., mean 54.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds, and in all in a minute. It is over in nearly all in 7 minutes and in all in 19 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *chromic acid* begins in a very few seconds and is over in a minute. It is the same qualitatively as that of the grains of *T. hageri.*

The reaction with *pyrogallic acid* begins in a very few seconds and is over in 1¼ minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *ferric chloride* begins in a few grains in 30 seconds. It is over in most in 6 minutes and in all in 10 minutes. It is qualitatively the same as that of the grains of *T. hageri.*

Reaction with *Purdy's solution* begins in a few seconds and is over in 1¼ minutes. The reaction is the same qualitatively as that of the grains of *T. hageri.*

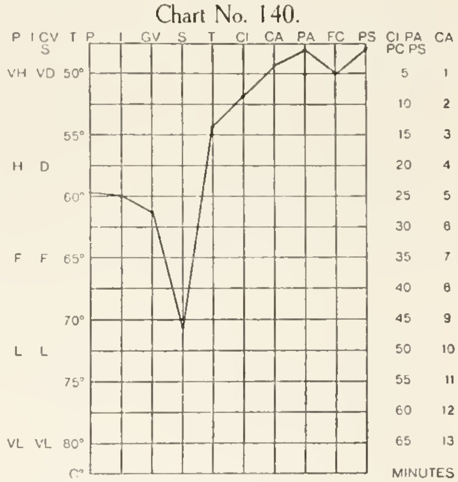
STARCH OF TULIPA AUSTRALIS. (Plate 34, figs. 203 and 204. Chart 140.)

Histological Characteristics.—In *form* the grains are simple and isolated, with rare exceptions. Small doublets are very rare, and there are no pressure facets. The surface of most grains is regular. Irregularities may be caused by nipple-like processes either at one or both sides of the proximal end, or rarely by the proximal end extending into a finger-like process, the axis of which may or may not coincide with the longitudinal axis of the grain. The conspicuous forms among the larger grains are triangular with curved base and rounded angles, somewhat clam-shell-shaped, and pyriform. Among the smallest grains the chief forms are elliptical, ovoid, oval, flattened elliptical, and round. The grains are flattened and when viewed on edge they frequently are seen to be narrower at the distal end. The proportion of irregular grains is larger than in *T. hageri.*

The *hilum* is a round fairly refractive spot with a range of eccentricity from one-fourth to one-sixth, commonly not quite one-fifth, of the longitudinal axis of the grain. The hilum is sometimes marked by a short transverse fissure.

The *lamellæ* are fine and rather indistinct, with the exception of a few coarse lamellæ which form a band located at a distance ranging from about one-third to two-thirds between the hilum and the distal end. There are sometimes on the large grains 3 disseminated, coarse, refractive lamellæ with groups of fine lamellæ between them. The lamellæ are not demonstrable throughout the grain, but 24 to 28 lamellæ can be made out on some grains.

Chart No. 140.



Curve of Reaction-Intensities of Starch of Tulipa australis.

The *size* of the small grains is 6 by 6μ, of the larger 52 by 44μ, of the broader 30 by 32μ in length and breadth. The common size is 34 by 30μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and fairly clear-cut. Its lines are rather thick and generally straight, and expanded at the margin and distal end. In some grains the lines are either bent or bisected.

The degree of *polarization* is fairly high. There is some variation in different grains, and even in the same grain. It is rather higher than in *T. hageri.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The blue is quite pure, but the yellow is not pure, as in *T. hageri.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not quite so deep as that of the grains of *T. hageri.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules color a red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly deeply stained, some slightly more than others, and deeper than in *T. hageri.*

With *safranin* the grains begin to stain at once and in 30 minutes are lightly colored. The stain is deeper than that of the grains of *T. hageri.*

Temperature Reaction.—The temperature of gelatinization is 52.7° to 54.8° C., mean 53.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in all the grains in 15 seconds. It is over in nearly all in 5 minutes and in all in 8 minutes. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *chromic acid* begins at once and is over in 40 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *pyrogallic acid* begins in a few seconds and is over in a minute. It is the same qualitatively as that of the grains of *T. hageri.*

Reaction with *ferric chloride* begins in a few grains in 15 seconds and is complete in all in 5 minutes. The reaction is the same qualitatively as that of the grains of *T. hageri.*

With *Purdy's solution* the reaction begins in a few seconds and is over in 45 seconds. It is the same qualitatively as that of the grains of *T. hageri.*

Differentiation of Certain Starches of the Genus Tulipa.

Histological Characteristics.

Conspicuous Forms.

T. hageri: Simple, few doublets, generally quite regular, irregularities due chiefly to slight lateral depressions at the proximal end and to slight lateral projections and nipple-like processes. Triangular with rounded angles and curved base and pyriform.
T. sylvestris: Same as in *T. hageri* with addition of somewhat clam-shell-shaped.
T. greigi: Same as in *T. hageri* with addition of somewhat clam-shell-shaped and flattened pyriform.
T. billietiana: Same as in *T. hageri* with addition of flattened pyriform and flask-shape.
T. didieri: Same as in *T. hageri* with addition of somewhat clam-shell-shaped, flattened pyriform, and Indian flint arrow-head-shaped.
T. didieri var. *mauriana:* Same as in *T. hageri* with addition of Indian flint arrow-head-shaped, and flattened pyriform.
T. didieri var. *fransoniana:* Same as in *T. hageri* with addition of somewhat clam-shell-shaped, flattened pyriform, and Indian flint arrow-head-shaped.
T. clusiana: Same as in *T. hageri* with addition of narrow triangular with curved base and rounded angles to ovoid with distal end flattened, and somewhat clam-shell-shaped.
T. clusiana var. *persica:* Same as in *T. hageri* with addition of somewhat clam-shell-shaped.
T. oculus-solis: Same as in *T. hageri* with addition of elongated triangular with curved base, somewhat clam-shell-shaped.
T. præcox: Same as in *T. hageri* with addition of somewhat clam-shell-shaped.
T. australis: Same as in *T. hageri* with addition of somewhat clam-shell-shaped.

Hilum—Form, Number, and Position.

T. hageri: Form distinct, rather small, round, single; sometimes a short transverse fissure present. Position eccentric about 0.25 to 0.16, usually 0.20, of the longitudinal axis.
T. sylvestris: Form the same as in *T. hageri.* Position eccentric about 0.25 to 0.16, usually 0.20, of the longitudinal axis.
T. greigi: Form the same as in *T. hageri.* Position eccentric about 0.20 to 0.16, usually 0.16, of the longitudinal axis.
T. billietiana: Form the same as in *T. hageri.* Position eccentric about 0.20 to 0.14, usually 0.16, of the longitudinal axis.
T. didieri: Form the same as in *T. hageri.* Position eccentric about 0.20 to 0.12, usually 0.16, of the longitudinal axis.
T. didieri var. *mauriana:* Form the same as in *T. hageri.* Position eccentric about 0.20 to 0.14, usually 0.16, of the longitudinal axis.
T. didieri var. *fransoniana:* Form the same as in *T. hageri.* Position eccentric about 0.25 to 0.20, usually 0.25, of the longitudinal axis.
T. clusiana: Form the same as in *T. hageri*, but often not so distinct. Position eccentric about 0.20 to 0.16, usually 0.16, of the longitudinal axis.
T. clusiana var. *persica:* Form the same as in *T. hageri.* Position eccentric about 0.25 to 0.16, usually 0.20, of the longitudinal axis.
T. oculus-solis: Form the same as in *T. hageri*, but not so distinct and less often fissured. Position eccentric about 0.25 to 0.16, usually 0.20, of the longitudinal axis.
T. præcox: Form the same as in *T. hageri.* Position eccentric about 0.25 to 0.16, usually 0.20, of the longitudinal axis.
T. australis: Form the same as in *T. hageri*, but hilum not so refractive. Position eccentric about 0.25 to 0.16, usually not quite 0.20, of the longitudinal axis.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.

T. hageri: Complete rings, when distinct, near the hilum, but usually not demonstrable at this point; when distal to hilum they follow the outline of the grain, and may be incomplete; frequently one or more coarse refractive lamellæ at varying distances from hilum, interspersed with groups of fine indistinct lamellæ. 44 counted on larger grains.
T. sylvestris: Same as in *T. hageri.* 42 on larger grains.
T. greigi: Same as in *T. hageri.* 46 on larger grains.
T. billietiana: Same as in *T. hageri*, but more often distinct in quarter section at distal margin. 44 to 48 on larger grains.
T. didieri: Same as in *T. hageri*, except more often distinct in quarter section near distal margin. 27 to 30 on larger grains.
T. didieri var. *mauriana:* Same as in *T. hageri*, except more often distinct in quarter section, near distal margin. 25 to 30 on larger grains.
T. didieri var. *fransoniana:* Same as in *T. hageri*, not quite so distinct. 30 on larger grains.
T. clusiana: Same as in *T. hageri.* 38 to 40 on larger grains.
T. clusiana var. *persica:* Same as in *T. hageri*, but not so distinct. 27 on larger grains.
T. oculus-solis: Same as in *T. hageri*, not quite so distinct. 30 to 32 on larger grains.
T. præcox: Same as in *T. hageri.* 38 to 40 on larger grains.
T. australis: Same as in *T. hageri*, not so distinct. 24 to 28 on larger grains.

Size.

T. hageri: From 5 to 54μ, commonly 36μ.
T. sylvestris: From 3 to 52μ, commonly 30μ.
T. greigi: From 6 to 55μ, commonly 39μ.
T. billietiana: From 6 to 44μ, commonly 36μ.
T. didieri: From 4 to 50μ, commonly 32μ.
T. didieri var. *mauriana:* From 6 to 58μ, commonly 36μ.
T. didieri var. *fransoniana:* From 6 to 50μ, commonly 36μ.
T. clusiana: From 2 to 50μ, commonly 30μ.
T. clusiana var. *persica:* From 4 to 48μ, commonly 30μ.
T. oculus-solis: From 6 to 60μ, commonly 38μ.
T. præcox: From 6 to 60μ, commonly 38μ.
T. australis: From 6 to 52μ, commonly 34μ.

Polariscopic Properties.

Figure.

T. hageri: Usually eccentric, generally distinct, fairly clear-cut, usually regular.
T. sylvestris: Same as in *T. hageri.*
T. greigi: Same as in *T. hageri.*
T. billietiana: Same as in *T. hageri.*
T. didieri: Same as in *T. hageri.*
T. didieri var. *mauriana:* Same as in *T. hageri.*
T. didieri var *fransoniana:* Same as in *T. hageri.*
T. clusiana: Same as in *T. hageri.*
T. clusiana var. *persica:* Same as in *T. hageri.*
T. oculus-solis: Same as in *T. hageri.*
T. præcox: Same as in *T. hageri.*
T. australis: Same as in *T. hageri.*

Degree of Polarization.

T. hageri: Fairly high.
T. sylvestris: Fairly high, higher than in *T. hageri.*
T. greigi: Fairly high, lower than in *T. hageri.*
T. billietiana: Fairly high, higher than in *T. hageri.*
T. didieri: Fairly high, lower than in *T. hageri.*
T. didieri var. *mauriana:* Fairly high, lower than in *T. hageri.*
T. didieri var. *fransoniana:* Fairly high, lower than in *T. hageri.*
T. clusiana: Fairly high, higher than in *T. hageri.*
T. clusiana var. *persica:* Fairly high, higher than in *T. hageri.*

Differentiation of Certain Starches of the Genus Tulipa.—Continued.

Polariscopic Properties.—Continued.

Degree of Polarization.—Continued.

T. oculus-solis: Fairly high, higher than in *T. hageri*
T. præcox: Fairly high, higher than in *T. hageri.*
T. australis: Fairly high, higher than in *T. hageri.*

Polarization with Selenite—Quadrants and Colors.

T. hageri: Quadrants fairly well defined, fairly regular in shape, unequal in size; blue pure, yellow slightly impure.
T. sylvestris: Quadrants and colors same as in *T. hageri.*
T. greigi: Quadrants and colors same as in *T. hageri.*
T. billietiana: Quadrants and colors same as in *T. hageri.*
T. didieri: Quadrants and colors same as in *T. hageri.*
T. didieri var. *mauriana:* Quadrants and colors same as in *T. hageri.*
T. didieri var. *fransoniana:* Quadrants and colors same as in *T. hageri.*
T. clusiana: Quadrants and colors same as in *T. hageri.*
T. clusiana var. *persica:* Quadrants and colors same as in *T. hageri.*
T. oculus-solis: Quadrants and colors same as in *T. hageri.*
T. præcox: Quadrants and colors same as in *T. hageri.*
T. australis: Quadrants and colors same as in *T. hageri.*

Iodine Reactions.

Intensity and Color.

T. hageri: Deep; blue-violet.
T. sylvestris: Deep, deeper than in *T. hageri;* blue-violet.
T. greigi: Deep, deeper than in *T. hageri;* blue-violet.
T. billietiana: Deep, less than in *T. hageri;* blue-violet.
T. didieri: Deep, less than in *T. hageri;* blue-violet.
T. didieri var. *mauriana:* Deep, less than in *T. hageri;* blue-violet.
T. didieri var. *fransoniana:* Deep, less than in *T. hageri;* blue-violet.
T. clusiana: Deep, less than in *T. hageri;* blue-violet.
T. clusiana var. *persica:* Deep, deeper thau in *T. hageri;* blue-violet.
T. oculus-solis: Deep, the same as in *T. hageri;* blue-violet.
T. præcox: Deep, less than in *T. hageri;* blue-violet.
T. australis: Deep, less than in *T. hageri;* blue-violet.

Staining Reactions.

With Gentian Violet.

T. hageri: Fair.
T. sylvestris: Fair, the same as in *T. hageri.*
T. greigi: Fair, deeper than in *T. hageri.*
T. billietiana: Fair, slightly deeper than in *T. hageri.*
T. didieri: Fair, deeper than in *T. hageri.*
T. didieri var. *mauriana:* Fair, deeper than in *T. hageri.*
T. didieri var. *fransoniana:* Fair, less than in *T. hageri.*
T. clusiana: Fair, deeper than in *T. hageri.*
T. clusiana var. *persica:* Fair, deeper than in *T. hageri.*
T. oculus-solis: Fairly deep.
T. præcox: Deep.
T. australis: Fairly deep.

With Safranin.

T. hageri: Light.
T. sylvestris: Light, same as in *T. hageri.*
T. greigi: Light, slightly deeper than in *T. hageri.*
T. billietiana: Light, slightly deeper than in *T. hageri.*
T. didieri: Light, slightly deeper than in *T. hageri.*
T. didieri var. *mauriana:* Light, slightly deeper than in *T. hageri.*
T. didieri var. *fransoniana:* Light, slightly deeper than in *T. hageri.*
T. clusiana: Light, slightly deeper than in *T. hageri.*
T. clusiana var. *persica:* Light, slightly deeper than in *T. hageri.*
T. oculus-solis: Light, slightly deeper than in *T. hageri.*
T. præcox: Light, slightly deeper than in *T. hageri.*
T. australis: Light, slightly deeper than in *T. hageri.*

Temperature of Gelatinization.

T. hageri: 50.4 to 51.4° C., mean 50.9°.
T. sylvestris: 56.5 to 57.8° C., mean 57.15°.
T. greigi: 49.6 to 51° C., mean 50.3°.
T. billietiana: 55.1 to 55.4° C., mean 55.25°.
T. didieri: 50 to 51.5° C., mean 50.75°.
T. didieri var. *mauriana:* 50.2 to 51.7° C., mean 50.95°.
T. didieri var. *fransoniana:* 50.1 to 52.2° C., mean 51.15°.
T. clusiana: 54 to 55.7° C., mean 54.85°.
T. clusiana var. *persica:* 55.5 to 56.1° C., mean 55.8°.
T. oculus-solis: 56.2 to 58° C., mean 57.1°.
T. præcox: 54 to 55.5° C., mean 54.75°.
T. australis: 52.7 to 54.8° C., mean 53.75°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

T. hageri: Begins in many in 15 seconds; complete in nearly all in 15 seconds and in all in 9 minutes.
T. sylvestris: Begins in all in 30 seconds; complete in nearly all in 4 minutes and in all in 11 minutes.
T. greigi: Begins in most in 15 seconds; complete in nearly all in 5 minutes and in all in 10 minutes.
T. billietiana: Begins in all in 30 seconds; complete in nearly all in 10 minutes and in all in 15 minutes.
T. didieri: Begins in most in 30 seconds; complete in nearly all in 10 minutes and in all in 17 minutes.
T. didieri var. *mauriana:* Begins in all in 30 seconds; complete in nearly all in 5 minutes and in all in 17 minutes.
T. didieri var. *fransoniana:* Begins in most in 30 seconds; complete in nearly all in 8 minutes and in all in 14 minutes.
T. clusiana: Begins in all in 15 seconds; complete in nearly all in 4 minutes and in all in 6 minutes.
T. clusiana var. *persica:* Begins in most in 15 seconds; complete in nearly all in 6 minutes and in all in 10 minutes.
T. oculus-solis: Begins in all in 30 seconds; complete in nearly all in 5 minutes and in all in 10 minutes.
T. præcox: Begins in most in 30 seconds; complete in nearly all in 7 minutes and in all in 19 minutes.
T. australis: Begins in all in 15 seconds; complete in nearly all in 5 minutes and in all in 8 minutes.

Reaction with Chromic Acid.

T. hageri: Begins in most at once; complete in all in 45 seconds.
T. sylvestris: Begins in all in a few seconds; complete in all in 30 seconds.
T. greigi: Begins in all at once; complete in all in 30 seconds.
T. billietiana: Begins in all in a few seconds; complete in all in 45 seconds.
T. didieri: Begins in all at once; complete in all in 45 seconds.
T. didieri var. *mauriana:* Begins in all at once; complete in all in 50 seconds.
T. didieri var. *fransoniana:* Begins in all at once; complete in all in 50 seconds.
T. clusiana: Begins in all at once; complete in all in 40 seconds.
T. clusiana var. *persica:* Begins in all in a few seconds; complete in all in 60 seconds.
T. oculus-solis: Begins in all in a few seconds; complete in all in 60 seconds.
T. præcox: Begins in all in a few seconds; complete in all in 60 seconds.
T. australis: Begins in all at once; complete in all in 40 seconds.

Reaction with Pyrogallic Acid.

T. hageri: Begins in all in a few seconds; complete in all in 90 seconds.
T. sylvestris: Begins in all in a few seconds; complete in all in 60 seconds.

Differentiation of Certain Starches of the Genus Tulipa.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

T. greigi: Begins in all in a few seconds; complete in all in 45 seconds.
T. billietiana: Begins in all in a few seconds; complete in all in 150 seconds.
T. didieri: Begins in all in a few seconds; complete in all in 60 seconds.
T. didieri var. *mauriana:* Begins in all in a few seconds; complete in all in 40 seconds.
T. didieri var. *fransoniana:* Begins in all in 15 seconds; complete in all in 45 seconds.
T. clusiana: Begins in all in a few seconds; complete in all in 50 seconds.
T. clusiana var. *persica:* Begins in all in 30 seconds; complete in all in 150 seconds.
T. oculus-solis: Begins in all in a few seconds; complete in all in 75 seconds.
T. præcox: Begins in all in a few seconds; complete in all in 75 seconds.
T. australis: Begins in all in a few seconds; complete in all in 60 seconds.

Reaction with Ferric Chloride.

T. hageri: Begins in a few in 15 seconds; complete in nearly all in 3 and in all in 5 minutes.
T. sylvestris: Begins in a few in 15 seconds; complete in nearly all in 4 and in all in 7 minutes.
T. greigi: Begins in a few in 15 seconds; complete in nearly all in 4 and in all in 8 minutes.
T. billietiana: Begins in a few in 15 seconds; complete in nearly all in 5 and in all in 7 minutes.
T. didieri: Begins in a few in 15 seconds; complete in nearly all in 6 and in all in 10 minutes.
T. didieri var. *mauriana:* Begins in a few in 15 seconds; complete in nearly all in 4 and in all in 6 minutes.
T. didieri var. *fransoniana:* Begins in a few in 30 seconds; complete in nearly all in 5 and in all in 15 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.—Continued.

T. clusiana: Begins in a few in 15 seconds; complete in nearly all in 3 and in all in 4 minutes.
T. clusiana var. *persica:* Begins in a few in 30 seconds; complete in nearly all in 10 and in all in 13 minutes.
T. oculus-solis: Begins in a few in 20 seconds; complete in nearly all in 4 and in all in 8 minutes.
T. præcox: Begins in a few in 30 seconds; complete in nearly all in 6 and in all in 10 minutes.
T. australis: Begins in a few in 15 seconds; complete in all in 5 minutes.

Reaction with Purdy's Solution.

T. hageri: Begins in all in a few seconds; complete in all in 60 seconds.
T. sylvestris: Begins in all in a few seconds; complete in all in 75 seconds.
T. greigi: Begins in all in a few seconds; complete in all in 30 seconds.
T. billietiana: Begins in all in a few seconds; complete in all in 180 seconds.
T. didieri: Begins in all at once; complete in all in 45 seconds.
T. didieri var. *mauriana:* Begins in all in a few seconds; complete in all in 60 seconds.
T. didieri var. *fransoniana:* Begins in all in a few seconds; complete in all in 50 seconds.
T. clusiana: Begins in all in a few seconds; complete in all in 60 seconds.
T. clusiana var. *persica:* Begins in all in 30 seconds; complete in all in 180 seconds.
T. oculus-solis: Begins in all in 20 seconds; complete in all in 105 seconds.
T. præcox: Begins in all in a few seconds; complete in all in 75 seconds.
T. australis: Begins in all in a few seconds; complete in all in 45 seconds.

NOTES ON THE STARCHES OF TULIPA.

The tulip starches differ so little in their general or gross histological features that it would be quite impossible, except in rare instances, to distinguish one from another by this means. In their reactions they exhibit close resemblances, yet the individual variations render diagnosis of each kind very easy. The most obvious differences are seen in the temperature records (the range of the temperatures of gelatinization being 50.3° to 57.15°) and in the reactions with the chemical reagents. The histological, physical, and chemical likenesses of *T. didieri* and its two varieties are worthy of particular note because of their showing the close correspondences between these and the botanical peculiarities. It will be seen that the only really marked difference is in the comparatively high temperature of gelatinization of *T. didieri* var. *fransoniana*, which is nearly 4° higher than the temperatures of the other two.

GENUS SCILLA.

This genus includes about 80 species of perennial bulbous plants that are widely distributed over the temperate districts of Europe, Asia, and Africa, and popularly known as squill, wild hyacinth, harebell, bluebell, sea onion, etc. *Scilla* is closely related to *Ornithogalum*, *Hyacinthus*, *Camassia*, *Chionodoxa*, and *Puschkinia*. *Chionodoxa* and *Scilla* have yielded hybrids which are known as Chionoscillas. The starches of *S. sibirica* Andr., *S. peruviana* Linn. (*S. ciliaris* Hort., *S. clusii* Parl.), and *S. bifolia* Linn. were studied. The first is the Siberian squill; the second is the Cuban lily or Peruvian jacinth or hyacinth; and the last is a species in common garden cultivation as an early flowering plant.

STARCH OF SCILLA SIBIRICA. (Plate 35, figs. 205 and 206. Chart 141.)

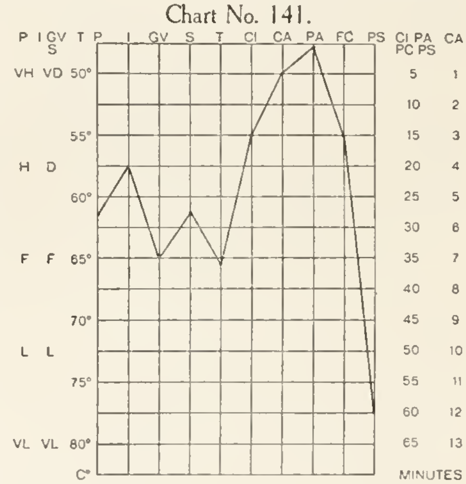
Histological Characteristics.—In *form* the grains are usually simple and mostly isolated. There are some small aggregates and compound grains of few components. Many isolated grains have either one pressure facet at the distal end, or one at the distal end and one at the side; but the facets are never clear-cut with well-defined edges. If the grain is compound the components are usually partially separated by fissures extending out to the rows of lamellæ encircling the component grains. The grains are rounded, except for some irregularities in the form of pressure facets and for small, irregular protuberances due to the unequal development of the surface. The conspicuous form is ovoid, which may be a pure ovoid or with the distal end flattened. There are also round, pyramidal, triangular, and dome-shaped. Most of these forms are modifications of the ovoid by pressure facets. The grains are not flattened in any diameter, except by pressure facets.

The *hilum* is distinct and comparatively large. It is usually eccentric, about one-fourth to one-third of the longitudinal diameter of the grain. In some grains it is centric. It may or may not be in the median line, usually it is round, except when marked by a fissure, but frequently it is elongated or lenticular. In the compound grains there are 2 or more hila in accordance with the number of grain-components, and in such cases each hilum has its separate set of lamellæ, the several sets as a rule being separated from one another by fissures. In other cases 2 hila may be placed very close together in a non-lamellated space, and such hila may be termed double. The hilum is often fissured, sometimes by a single line that may be straight or have a double curve in the transverse, diagonal, or longitudinal axis of the grain; or there may be three lines radiating from the hilum; or a cross; or an irregularly stellate arrangement of fissures. Most of the fissures are clean-cut and not ragged. There is in the case of compound grains quite a characteristic arrangement of two or more small crosses of the same size side by side.

The *lamellæ* are distinct. They are rather coarse, continuous, and regular; and coarser and more distinct near the hilum than near the margin. In compound grains each hilum is surrounded by about 2 or 3 lamellæ, the whole group of hila with their separate lamellæ being in turn inclosed by several continuous lamellæ. There are on an average 6 lamellæ on the simple, isolated grains and about 16 on the compound grains.

The grains vary in *size* from 3 to 28μ. The common size is 18μ.

Chart No. 141.



Curve of Reaction-Intensities of Starch of Scilla sibirica.

Polariscopic Properties.—The *figure* is usually eccentric, generally clear-cut, and distinct. In some grains one or more of the lines may be broader and less well defined than the others, which is due undoubtedly in some cases to differences in the degree of polarization of different parts of the grain. The longer lines are sometimes slightly bent or otherwise distorted, and they may vary much in width as well as in sharpness of outline.

The degree of *polarization* is fairly high. It may be low in some parts of the grains and it varies somewhat in different grains.

With *selenite* the quadrants are usually fairly well defined, some very well, and they are usually fairly regular in shape and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains at once color deeply a blue-violet; with 0.125 per cent solution the grains are colored lightly at once and become deeper slowly. After heating until all the grains are completely gelatinized, the solution and the gelatinized grains are colored deeply with iodine. Some of the grains do not color so deeply as the others. With an excess of iodine the grains show a violet capsule. After boiling for 2 minutes the solution is colored much more deeply, but the grain-residues much less. All of the capsules become of a violet color and are found to contain some blue-reacting material upon adding an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly in 30 seconds and after 30 minutes they are fairly colored.

With *safranin* the grains begin to stain very slightly in a minute. After 30 minutes they are fairly deeply stained.

Temperature Reaction.—The temperature of gelatinization is 65° to 67° C., mean 66°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react in 30 seconds. Almost all are gelatinized in 8 minutes and all in 15 minutes. The reaction usually begins at the distal end. The grain at this point becomes darker, then swells somewhat, with a little irregular protrusion. The process extends inward over the whole grain, more rapidly along the margin on each side than over the inner portion. There is a sharp line of demarcation between the gelatinized and the non-gelatinized parts. The process in some grains starts from both ends and advances from these points over the whole grain. The gelatinized grains are fairly large, somewhat distorted, and usually uniformly dark.

The reaction with *chromic acid* begins at once and is over in a minute. The hilum becomes very prominent and swells slightly, and the grain becomes covered by fine striæ. The inner portion is transformed into a gelatinous mass. The starch at the margin with some resistant starch of the inner portion forms a ring which is very distinctly striated and banded, more distinct at the distal end than at the proximal end of the grain. The ring becomes thinner and transparent as the grain continues to swell and finally ruptures at the proximal end, allowing the gelatinized starch within to flow out and dissolve, the ring or capsule itself later completely dissolving.

With *pyrogallic acid* most grains begin to react at once. All are fully gelatinized in 40 seconds. Both hilum and lamellæ are rendered very distinct. The hilum swells somewhat and the grain becomes covered by fine striæ. The inner portion is changed into a gelatinous mass. The starch at the margin forms a ring which is striated, but not always distinctly banded. If the swelling is very rapid, this ring may be divided at several places by very deep fissures which split it to the capsule. This cleavage, when the grain is fully gelatinized, gives rise to a number of small sacculations at the distal end. The gelatinized grains are large, somewhat folded and wrinkled, and often irregular at the distal end. They do not retain much of the original form of the grain.

With *ferric chloride* most grains begin to react in 1½ minutes. Nearly all are gelatinized in 10 minutes and all in 15 minutes. The hilum is rendered prominent, but not the lamellæ. The hilum begins to swell and the grain is divided by fine radial striæ. The inner portion is changed to a gelatinous mass. The marginal part forms a striated ring. This becomes thinner and more transparent as the grain continues to swell, until finally a large, thin-walled mass is formed. The gelatinized grains are large, fairly smooth, and somewhat distorted.

Reaction with *Purdy's solution* begins at once in many grains, and about two-fifths are completely gelatinized in 15 minutes, and nine-tenths in an hour. The hilum is very distinct, the lamellæ are visible, the hilum swells somewhat, and the grain becomes divided by fine striæ. The inner portion is transformed into a gelatinous mass as the grain swells. The marginal starch forms a ring which is thicker at the distal end, where it shows fine striæ and alternate refractive and non-refractive bands. This ring gradually becomes thinner and more transparent until a large, fairly smooth mass is formed. Some compound grains show a smaller mass within a larger one, showing that there is here present a primary grain which has later become enveloped by a secondary grain.

STARCH OF SCILLA PERUVIANA. (Plate 35, figs. 207 and 208. Chart 142.)

Histological Characteristics.—In *form* the grains are usually simple. There are some very irregular compound grains which may consist of a variable number of components; also a few aggregates composed either of grains of equal size, or of a large grain with several small grains adherent to the distal end. The surface is somewhat varied, owing to lamellated additions made after the original grain has been formed, or to protuberances caused by the unequal development. The conspicuous forms are rounded ovoid, or rounded elliptical with the larger proximal end and somewhat flattened distal end, or with both ends rounded; also round, ovoid, triangular, and quadrangular forms, with rounded corners, and some irregular or incidental forms found in other *Scillæ*. The grains are not flattened, and as a rule, when seen from the proximal end they appear spherical.

The *hilum* is generally very distinct, comparatively small, and situated eccentrically about one-fourth of the longitudinal axis of the grain. In some of the nearly round forms it is almost centrically placed. It is usually to one side of the median line. Two or more hila are often placed closely together, and in the compound grains each part has one or more hila. The hilum is usually markedly fissured, and the fissures may be single, transverse, diagonal, or longitudinal; a straight line, or a cross, or 3-armed, or irregularly stellate, and quite ragged.

The *lamellæ* are distinct, rather coarse lines, usually continuous, but which appear in compound grains to become discontinuous near the margin of the original grain at the point where the lamellated additions join it. They show no other irregularity in themselves, except that those of the original grain are of different shape from those of the completed grain. They vary in size and distinctness in different grains, but not much in the same grain. There are about 14 to 20 on the larger grains.

The grains vary in *size* from 6 to 46μ. The common size is 32μ. The dimensions of an average rounded ovoid grain are 32 by 26μ in length and breadth.

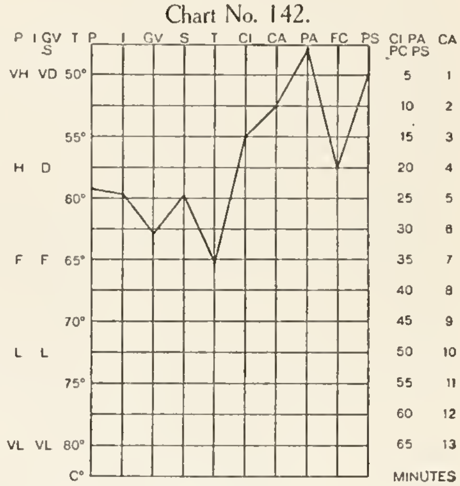
Polariscopic Properties.—The *figure* is usually eccentric, distinct, and generally clear-cut. Its rather broad lines become broader and less well defined in many grains, especially the longer lines, when nearing the margin. The lines may be bent and otherwise distorted, vary in width, and be placed at varying angles with each other.

The degree of *polarization* is high. It may be less towards the margin. It is much higher than that of the grains of *S. sibirica*. It does not vary greatly in different grains nor in different aspects of the same grain.

With *selenite* the quadrants are fairly clear-cut, usually unequal in size, and generally regular in form. The colors are fairly pure. As a rule the blue shows an admixture of yellow.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are deeply colored a blue-violet at once; with 0.125 per cent solution they color at once slightly and the color deepens slowly. The coloration is not so deep as that of the grains of *S. sibirica*. After heating until all the grains are completely gelatinized, the solution is colored lightly and the gelatinized grains very deeply with iodine. After boiling for 2 minutes the solution is colored very deeply, but the grain-residues lightly. With an excess of iodine the capsules take on a violet color.

Chart No. 142.



Curve of Reaction-Intensities of Starch of Scilla peruviana.

Staining Reactions.—With *gentian violet* the grains begin to stain at once, especially about the margin. After 30 minutes they are fairly stained, some more than others. The shade is slightly deeper than that of the grains of *S. sibirica*.

With *safranin* the grains begin to stain evenly at once. After 30 minutes they are fairly deeply colored, some more than others. The shade is nearly the same, but probably somewhat deeper, on the whole, than that of the grains of *S. sibirica*.

Temperature Reaction.—The temperature of gelatinization is 65° to 66° C., mean 65.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds. About half are darkened in 3½ minutes and all but a few are gelatinized in 15 minutes. The reaction proceeds without much swelling until the portion containing the hilum is involved. This reaction is qualitatively the same as that of the grains of *S. sibirica*.

With *chromic acid* some grains begin to react immediately. All are affected in 30 seconds, and the reaction is over in 2 minutes. The reaction is qualitatively the same as that of the grains of *S. sibirica*.

With *pyrogallic acid* there is a slight general reaction immediately. A few are partially gelatinized at once. Nearly all are gelatinized in 40 seconds and all in 65 seconds. The reaction is qualitatively the same as that of the grains of *S. sibirica*.

Reaction with *ferric chloride* begins in a few of the smaller grains in 30 seconds. About half of the grains are affected and fully gelatinized in 3½ minutes, two-thirds are gelatinized in 7 minutes, and all in 20 minutes. In many grains the reaction begins at projections on the margin. The reaction is the same qualitatively as the grains of *S. sibirica*.

With *Purdy's solution* there is a general reaction in 30 seconds. Most of the grains are completely gelatinized in 2 minutes, and all but rare resistant grains in 5 minutes. The reaction often begins by a splitting off of the secondary additions to the grain, after which it proceeds as in the grains of *S. sibirica*.

STARCH OF SCILLA BIFOLIA. (Plate 35, figs. 209 and 210. Chart 143.)

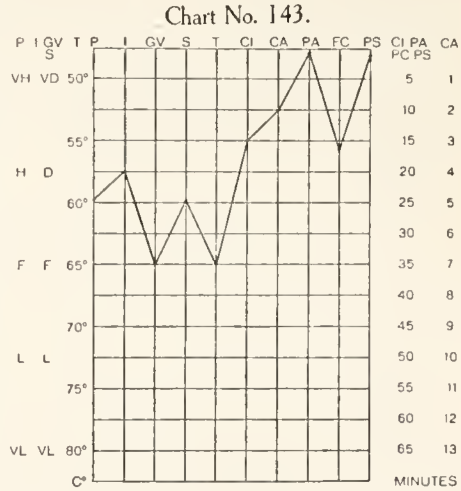
Histological Characteristics.—In *form* the grains are usually simple; there are a few double and a very few compound grains. No pressure facets were noted. The surface of the grains is rounded, but many are irregular. When on edge, some of them are seen to have a characteristic ridge extending along the long axis of the grain, and probably around the entire circumference. The surface of the grains, while rounded, is frequently somewhat irregular, owing to the unequal development. The conspicuous forms are ovoid to round, and irregular lenticular, some with almost pointed projections on one side; also oval, elliptical, triangular with rounded corners, and various irregular forms found in other *Scillæ.* The transverse diameter is longer than the longitudinal in many of these grains, particularly the lenticular and the triangular. The grains are commonly about two-thirds to three-fourths as thick as they are broad.

The *hilum* is usually very distinct and is a comparatively large, round, non-refractive spot which is eccentric commonly about one-fourth of the longitudinal axis of the grain. It may be in, near, or very much to one side of the median line. It is rarely fissured, and the fissure in such cases is very small and indistinct. It is often marked by a clean-cut, round, or somewhat elliptical cavity which appears to communicate with the interior of the grain. There is often about the hilum a well-marked area which appears to be raised above the surface of the rest of the grain and which does not always have the same shape as the margin of the grain. There may be in a single grain 2 or more hila which usually are placed linearly in the direction of the transverse axis. The compound grains show 2 or more hila, each surrounded by its own lamellæ.

The *lamellæ* are fairly distinct. They are rather coarse, continuous rings divisible into two systems, those comprising the raised area about the hilum and those comprising the remainder of the grain. Those of the first set are finer than those of the second. They vary in distinctness in different grains. There are about 10 to 12 on the larger grains.

The grains vary in *size* from 3 to 34μ. The common size is 22μ. The dimensions of an average ovoid grain are 20 by 24μ in width and length, and of the average triangular or lenticular grain are 24 by 16μ in width and length.

Chart No. 143.



Curve of Reaction-Intensities of Starch of Scilla bifolia.

Polariscopic Properties.—The *figure* is distinct, usually clear-cut, and eccentric. The lines may become somewhat broader but less distinctly outlined as they near the margin of the grain. They are somewhat bent and otherwise distorted in some of the grains, of variable width, and may be placed at varying angles.

The degree of *polarization* is fairly high. It varies in different grains and somewhat in different aspects of the same grain. It is about the same or slightly higher than that of the grains of *S. sibirica.*

With *selenite* the quadrants are fairly well defined, unequal in size, and usually irregular in shape. The colors are not pure, except when the grain is viewed from the top or side.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored at once a deep blue-violet; with 0.125 per cent solution the grains color lightly at first, and the color deepens rapidly. The shade is about the same as that of the grains of *S. sibirica.* After heating until all the grains are completely gelatinized, the solution is colored lightly and the gelatinized grains very deeply with iodine. After boiling for 2 minutes, the solution is colored deeply and the grain-residues very lightly. The capsules all have a violet color after the addition of a slight excess of iodine and most of them retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* some grains begin to stain at once and others in about a minute. After 30 minutes the grains are but fairly stained, some more than others. The shade is about the same as that of the grains of *S. sibirica.*

With *safranin* the grains begin to stain at once, but some stain more deeply than others. After 30 minutes they are fairly deeply colored, some more than others. The shade is slightly deeper than that of the grains of *S. sibirica.*

Temperature Reaction.—The temperature of gelatinization is 64° to 65.5° C., mean 64.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* about one-fourth of the grains begin to react in 30 seconds, and the reaction is almost general in 1½ minutes. About half are dark in 3 minutes and the reaction is complete in 15 minutes. This reaction is qualitatively the same as that of the grains of *S. sibirica.*

Reaction with *chromic acid* begins at once and is over in 2 minutes. This reaction is qualitatively the same as that of the grains of *S. sibirica.*

With *pyrogallic acid* there is a slight general reaction at once. In 30 seconds all are gelatinized. The reaction is qualitatively the same as that of the grains of *S. sibirica.*

With *ferric chloride* about half the grains begin to react in 30 minutes and all but a very few react in 3 minutes. Nearly all are gelatinized in 10 minutes and all are fully gelatinized in 17 minutes. In many of the grains the reaction starts at protuberances on the margin. The reaction is qualitatively the same as that of the grains of *S. sibirica.*

The reaction with *Purdy's solution* begins in most grains at once and almost all but rare resistant grains are completely gelatinized in 2 minutes. The last to gelatinize are the compound grains consisting of a small grain embedded in a large one. The outer part quickly becomes gelatinized, while the inner, smaller grain reacts comparatively slowly. The reaction is qualitatively the same as that of the grains of *S. sibirica.*

Differentiation of Certain Starches of the Genus Scilla.

Histological Characteristics.

Conspicuous Forms.

S. sibirica: Usually simple, mostly isolated, few compound grains, isolated grains somewhat irregular. Ovoid, ovoid with distal end flattened; round, triangular, pyramidal, dome-shaped.
S. peruviana: Essentially the same as in *S. sibirica*, except rounded ovoid and rounded ellipsoidal prominent.
S. bifolia: Essentially the same as in *S. sibirica*, except that the round and lenticular forms are very numerous.

Hilum—Form, Number, and Position.

S. sibirica: Form distinct, rather large, round or lenticular spot, often fissured. Position usually eccentric 0.25 to 0.33 of longitudinal axis.
S. peruviana: Form the same as in *S. sibirica*, except smaller; fissuration very marked. Position usually eccentric 0.25 of longitudinal axis.
S. bifolia: Form the same as in *S. sibirica*, but rarely fissured. Position usually eccentric 0.25 of longitudinal axis.

Lamellæ—General Characteristics and Number.

S. sibirica: Distinct, regular, continuous rather coarse. 2 sets in some grains. 6 on simple, 16 on compound grains.
S. peruviana: The same as in *S. sibirica*, but discontinuous in a portion of the grain. 14 to 20 on larger compound grains.
S. bifolia: The same as in *S. sibirica*, but not so distinct. 10 to 12 on larger grains.

Size.

S. sibirica: From 3 to 28μ, commonly 18μ.
S. peruviana: From 6 to 46μ, commonly 32μ.
S. bifolia: From 3 to 34μ, commonly 22μ.

Polariscopic Properties.

Figure.

S. sibirica: Usually eccentric, distinct, usually clear-cut, may be irregular.
S. peruviana: Same as in *S. sibirica.*
S. bifolia: Same as in *S. sibirica.*

Degree of Polarization.

S. sibirica: Fairly high.
S. peruviana: High, much higher than in *S. sibirica.*
S. bifolia: Fairly high, slightly higher than in *S. sibirica.*

Polarization with Selenite—Quadrants and Color.

S. sibirica: Quadrants fairly well defined, fairly regular in shape, usually unequal in size. Color fairly pure.
S. peruviana: Quadrants the same as in *S. sibirica.* Color quite pure.
S. bifolia: Quadrants the same as in *S. sibirica.* Color not pure.

Iodine Reactions.

Intensity and Color.

S. sibirica: Deep; blue-violet.
S. peruviana: Deep, not quite so deep as in *S. sibirica*; blue-violet.
S. bifolia: Deep, the same as in *S. sibirica;* blue-violet.

Staining Reactions.

With Gentian Violet.

S. sibirica: Fair.
S. peruviana: Fair, slightly deeper than in *S. sibirica.*
S. bifolia: Fair, the same as in *S. sibirica.*

With Safranin.

S. sibirica: Fairly deep.
S. peruviana: Fairly deep, slightly deeper than in *S. sibirica.*
S. bifolia: Fairly deep, the same or slightly deeper than in *S. sibirica.*

Temperature of Gelatinization.

S. sibirica: 65 to 67° C., mean 66°.
S. peruviana: 65 to 66° C., mean 65.5°.
S. bifolia: 64 to 65.5° C., mean 64.75°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

S. sibirica: Begins in 30 seconds; complete in 15 minutes.
S. peruviana: Begins in 30 seconds; complete in all but a few grains in 15 minutes.
S. bifolia: Begins in 1½ minutes; complete in all but a few grains in 15 minutes.

Reaction with Chromic Acid.

S. sibirica: Begins at once; complete in 1 minute.
S. peruviana: Begins at once; complete in 2 minutes.
S. bifolia: Begins at once; complete in 2 minutes.

Reaction with Pyrogallic Acid.

S. sibirica: Begins at once; complete in all in 40 seconds.
S. peruviana: Begins at once; complete in all in 65 seconds.
S. bifolia: Begins at once; complete in all in 30 seconds.

Reaction with Ferric Chloride.

S. sibirica: Begins in 1½ minutes; complete in 15 minutes.
S. peruviana: Begins in 30 seconds; complete in 20 minutes.
S. bifolia: Begins in 30 seconds; complete in 17 minutes.

Reaction with Purdy's Solution.

S. sibirica: Begins immediately; complete in seven-tenths in 30 minutes and in all but rare grains in 60 minutes.
S. peruviana: Begins immediately; complete in all but rare resistant grains in 5 minutes.
S. bifolia: Begins immediately; complete in all but rare resistant grains in 2 minutes.

NOTES ON THE STARCHES OF SCILLA.

The three starches examined, while showing the same gross microscopical characteristics, exhibit certain individualities which are of value on their differentiation. Thus, in *S. sibirica* and *S. bifolia* the grains, on the whole, are very much smaller than those of *S. peruviana*. In *S. peruviana* the grains are not only particularly noticeable because of the comparative size, but also because of the marked fissuration and lamellation. *S. bifolia*, in comparison with the other two, is particularly distinguished by the relative abundance of the elliptical type of grain and the tendency to greater irregularity of outline. The reactions show no important variations except with Purdy's solution. In temperatures of gelatinization the extreme difference is 1.25°. On the whole, *S. sibirica* and *S. bifolia* closely correspond in their reactions.

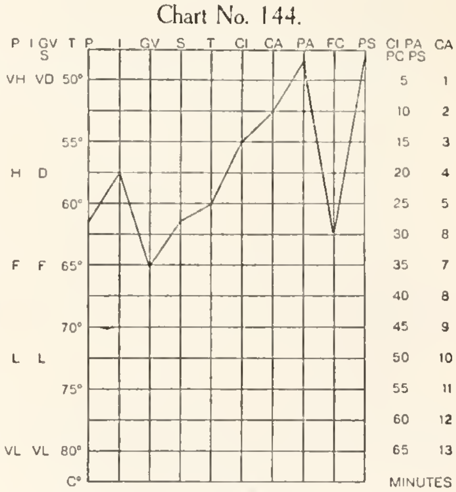
GENUS CHIONODOXA.

This very small genus of bulbous plants, all of which are natives of Crete and Asia Minor, is closely allied, as noted under *Scilla*, to a number of genera represented in this research. The starches from *C. luciliæ* Boiss., *C. tmolusi*, Hort., and *C. sardensis* Hort. were examined. *C. luciliæ* is popularly known as the glory-of-the-snow, and is probably the only true species of the three, the second and probably the third kind named being regarded as forms of the first.

STARCH OF CHIONODOXA LUCILIÆ. (Plate 36, figs. 211 and 212. Chart 144.)

Histological Characteristics.—In *form* the grains are almost wholly simple and are isolated, except a very few clumps. The smaller grains show some tendency to adhere to the larger ones. No pressure facets were observed. The surface of the grains is usually irregular, owing to unequal development of certain parts in the form of rounded protuberances and nipple-like projections, and in some cases to accretions added to a primary grain. The conspicuous forms are ovoid, bean-shaped or reniform, lenticular, and clam-shell type; also pyriform, round, elliptical, triangular, irregularly quadrangular, and various irregular forms. The grains are somewhat flattened, and when seen on edge appear narrower at the distal end than at the proximal.

Chart No. 144.



Curve of Reaction-Intensities of Starch of Chionodoxa luciliæ.

The *hilum* is a comparatively small, rather indistinct round spot, eccentric from one-fifth to two-fifths of the longitudinal axis of the grain and either in or to one side of the median line. There may be double or multiple hila. The hilum may be fissured, in which case the fissure usually takes the form of a well-marked, clear-cut cross; or a transverse fissure may appear that is either clean-cut or ragged; or a 3-armed fissure. Fissures may also partially separate dual or multiple hila from one another, and one or all of the hila may be fissured.

The *lamellæ* are fairly distinct, rather coarse, regular or irregular continuous rings which follow closely the outline of the margin, except when the latter is distorted by accretions. There are usually two sets, one composing an area about the hilum which is often quite prominent and sometimes appears to be raised, and the other extending between this and the margin. They are usually more distinct near the margin. There are 7 to 12 on a medium-sized grain.

The grains vary in *size* from 4 to 64μ. The common size is 34μ.

Polariscopic Properties.—The *figure* is usually eccentric and distinct, but as a rule not clear-cut, and quite irregular. Its lines are often much bent and distorted and almost always broader and less distinct at the margin.

The degree of *polarization* is fairly high, varying somewhat in the different grains and also in the same aspect of a given grain.

With *selenite* the quadrants are usually not clear-cut, are very irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a deep blue-violet; with 0.125 per cent solution they color quite deeply. After heating until the grains are all completely gelatinized, the solution is colored very lightly and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the grain-residues much less deeply. All the capsules contain some blue-reacting starch, and with an excess of iodine they become a light violet.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly in 30 seconds, and after 30 minutes are fairly stained, one grain as deeply as another.

Temperature Reaction.—The temperature of gelatinization is 59.4° to 60.6° C., mean 60°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute and almost all grains are gelatinized in 15 minutes. Both hilum and lamellæ are rendered distinct. The more prominent points on the reacting grain are the projections on the margin, which darken and sometimes swell to a marked degree around the whole margin, the swelling is very even, and the unswollen central part of the grain is thus surrounded by a dark band. The inner part of the grain then darkens gradually and when the hilum is reached the grain as a whole swells. The swollen grains are very large and show a very dark center surrounded by three or four concentric dark rings, sometimes broken irregularly, and separated from one another quite evenly by lighter spaces.

Reaction with *chromic acid* begins immediately and is over in 2 minutes. The hilum swells rapidly and the inner portion is transformed rapidly into a gelatinous mass, leaving a very thin marginal ring, which at first shows fine striæ and several alternately refractive and non-refractive concentric bands. This ring is soon altered into a very thin, homogeneous, transparent envelope which at the thinnest point, either at the proximal or distal end, invaginates and dissolves, the contents passing out and disappearing, followed by solution of the rest of the envelope. The grains swell to an enormous size before dissolving.

Reaction with *pyrogallic acid* begins in 10 seconds and is complete in nearly all the grains in 2 minutes. A very few are only partially gelatinized. Both hilum and lamellæ are rendered very distinct. The hilum begins to swell evenly and rapidly. The inner part of the grain is changed to a gelatinous mass. The starch at the margin forms a thin, homogeneous ring, which rapidly becomes thinner and transparent as the grain continues to swell. The swollen grains are large, somewhat folded, and crumpled, but retain much of the original shape.

Reaction with *ferric chloride* begins in 30 seconds and is over in 30 minutes. The hilum is very prominent, often appearing as a dark bubble. The grains begin to gelatinize usually at the distal end, with great and irregular protrusion; or gelatinization may begin at both ends. The process extends completely around the margin, so that a ring of gelatinized starch surrounds a non-gelatinized central portion. In the bean-shaped and reniform grains, however, the margin of the proximal end is not affected until the hilum itself swells. After the peripheral portion has become gelatinized, small pieces are broken, from time to time, from the non-gelatinized center, and gelatinize independently until this part of the grain is completely dissolved. The swollen grains are very large, greatly crumpled, lobulated, and distorted, and do not retain any of the original form.

The reaction with *Purdy's solution* begins immediately in some of the grains, and one-third are partially gelatinized and two-thirds completely gelatinized in 2 minutes. Both hilum and lamellæ become very distinct. The hilum swells and parts of the inner portion of the grain are dissolved, but some of the starch appears to be forced unchanged to the margin, forming a ring which shows fine striæ and several very distinct, alternate refractive and non-refractive bands. This ring becomes thinner and quite homogeneous and transparent as gelatinization proceeds and the grain swells, until it forms a thin-walled capsule. The swollen grains are large, but not very much folded, wrinkled, or distorted.

STARCH OF CHIONODOXA TMOLUSI. (Plate 36, figs. 213 and 214. Chart 145.)

Histological Characteristics.—In *form* the grains are almost wholly simple, and they are isolated with the exception of a few clumps. There are no pressure facets. The surface is often somewhat irregular owing to uneven development, rounded protuberances, and nipple-like processes, the latter being quite common. The conspicuous forms are ovoid, oval, lenticular, and clam-shell type; also triangular, pyriform, round, ellipsoidal, reniform or bean-shaped, and various irregular forms. The grains are usually not so thick as they are broad, and when seen on edge appear narrower at the distal than at the proximal end.

The *hilum* is rather small and usually not very distinct, but occasionally very prominent. It is eccentric about one-fifth to two-fifths of the longitudinal axis of the grain, and may or may not be in the median line. It often lies in a small, ovoid, round, or reniform area which appears to be raised above the surface of the rest of the grain, and which has not always the same shape as the grain. There may be 2 or more hila, which may be closely grouped or separated, each with its own 2 or 3 lamellæ. The hilum may be fissured, but the fissures are small, and generally take the form of a cross, a 3-armed figure, or a simple transverse line, usually small and clean-cut.

The *lamellæ* are not very distinct. They are coarse, rather regular, continuous lines which follow closely the outline of the grain; usually in two sets, those composing the raised area about the hilum and those composing the rest of the grain, but they do not appear to vary in character in different parts of the grain as in the other Chionodoxæ. There are about 5 to 7 on a grain of medium size.

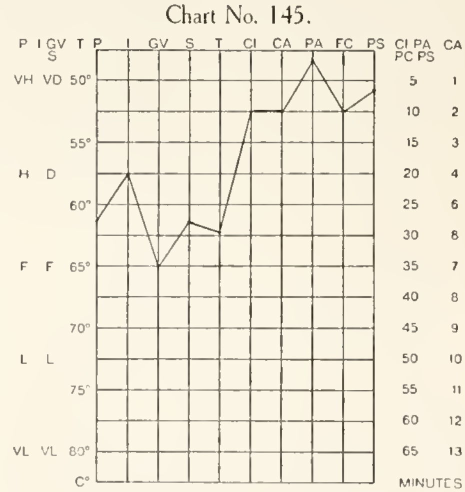
The grains vary in *size* from 3 to 32μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and generally clear-cut. The lines in some cases become broader and less distinct as they near the margin. They may be bent or otherwise distorted, and vary in width.

The degree of *polarization* is fairly high. It varies to a marked degree in different grains, and also in the same and in different aspects of a given grain. It is not so high as that of *C. luciliæ.*

With *selenite* the quadrants are, as a rule, clear-cut and well defined, but sometimes blurred. They are unequal in size and usually irregular in shape, but less irregular than in *C. luciliæ.* The colors are fairly pure as a rule.

Chart No. 145.



Curve of Reaction-Intensities of Starch of Chionodoxa tmolusi.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution the grains color quite deeply. The color is about the same in depth as that of the grains of *C. luciliæ.* After heating until all the grains are completely gelatinized, the solution is colored very lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution is colored very deeply, but the grain-residues much less deeply, when iodine is added. When an excess of iodine is used many of the capsules show an absence of blue-reacting starch, and all of them are colored violet with an excess of iodine. The grain-residues are mostly much swollen, crumpled, and distorted, and some are completely disintegrated.

Staining Reactions.—With *gentian violet* the grains stain very lightly in 30 seconds and after 30 minutes they are fairly well stained. The color is about the same as that of the grains of *C. luciliæ.*

With *safranin* the grains stain very lightly in 30 seconds, but in 30 minutes the color is fairly stained. The coloration is about the same, or slightly lighter, than that of the starch of *C. luciliæ.*

Temperature Reaction.—The temperature of gelatinization is 61.5° to 63.2° C., mean 62.35°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately and almost all the grains are gelatinized in 10 minutes. The reaction is the same as that of the grains of *C. luciliæ.*

Reaction with *chromic acid* begins at once and is over in 2 minutes. The reaction is the same qualitatively as that of the grains of *C. luciliæ.*

Reaction with *pyrogallic acid* begins in 15 seconds and is complete in 1½ minutes in nearly all the grains. A few are only partially gelatinized. The reaction is the same as that of the grains of *C. luciliæ.*

With *ferric chloride* the reaction begins in 30 seconds and is over in 10 minutes. The reaction is the same as that of the grains of *C. luciliæ.*

The reaction with *Purdy's solution* begins in some grains in 15 seconds; in nearly all it is complete in 7 minutes. A few small grains show an enlarged hilum, but no further evidence of reaction. It is the same qualitatively as that of the grains of *C. luciliæ.*

STARCH OF CHIONODOXA SARDENSIS. (Plate 36, figs. 215 and 216. Chart 146.)

Histological Characteristics.—In *form* the grains are almost wholly simple and they are isolated, with the exception of a few in clumps. Occasionally compound grains of two or more components are observed. There are no pressure facets. The surface is often somewhat uneven, owing to irregular rounded protuberances and nipple-like processes. The conspicuous forms are ovoid, oval, elliptical, and bean-shaped or reniform. There are also clam-shell and mussel-shell types, pyriform, ellipsoidal, lenticular, and various irregular forms. The grains when seen on edge appear somewhat flattened, and are narrower at the distal than the proximal end.

The *hilum* is very distinct, comparatively small, and eccentric from one-sixth to one-third of the longitudinal axis of the grain. It is usually situated on a small rounded, ovoid, or reniform area which is raised above the level of the rest of the grain. There may be 2 or more hila, and they are generally grouped irregularly. Usually the hilum is not fissured, but when it is the fissuration may be in the form of a small, transverse or longitudinal line, or 2- or 3-armed cross, or clean-cut or ragged, or divided by small secondary fissures.

The *lamellæ* are not very distinct, rather coarse, continuous rings, irregular or regular according to the outline of the margin. There are two sets, those located on the raised portion about the hilum and those outside of this area, those near the hilum being the more distinct. The lamella outlining the raised space is very prominent. There are about 6 to 7 on a grain of medium size.

The grains vary in *size* from 6 to 40μ. The common size is 22μ.

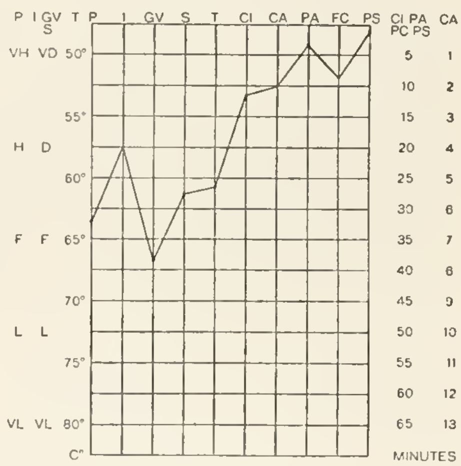
Polariscopic Properties.—The *figure* is distinct, and usually eccentric, and clear-cut. It is much more sharply defined than that in *C. luciliæ*, and the lines are less apt to be bent and otherwise distorted. The lines tend to become much broader and less well defined towards the margin, and they may vary much in width.

The degree of *polarization* is fairly high. It is about the same as in the grains of *C. luciliæ*. There is not much variation in the same and in different aspects of a given grain.

With *selenite* the quadrants are well defined, irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reaction.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet; with 0.125 per cent solution they are colored quite deeply and about the same in both cases as the grains of *C. luciliæ*. After heating until all the grains are fully gelatinized, the solution is colored lightly and the grains very deeply on the addition of iodine. After boiling 2 minutes the solution is much more deeply colored, but the grain-residues much less or not at all. With excess of iodine all the capsules take on a violet color. The capsules still retain blue-reacting starch in the proximal end.

Chart No. 146.



Curve of Reaction-Intensities of Starch of Chionodoxa sardensis.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain in 30 seconds, and after 30 minutes are fairly well stained. The color is less than that of the grains of *C. luciliæ*.

Temperature Reaction.—The temperature of gelatinization is 60.2° to 62° C., mean 61.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 20 seconds. In 4 minutes most and in 12 minutes all of the grains are gelatinized. The reaction is the same qualitatively as that of the grains of *C. luciliæ*.

Reaction with *chromic acid* begins at once. It is over in 2 minutes, except in some of the smaller grains, which do not dissolve within 6 to 7 minutes. The reaction is the same as that of the grains of *C. luciliæ*.

Reaction with *pyrogallic acid* begins in 20 seconds. All are affected and most of the grains are fully gelatinized in 3 minutes. The reaction is the same as that of the grains of *C. luciliæ*.

The reaction with *ferric chloride* begins in 20 seconds and is over in 8 minutes. It is the same as that of the grains of *C. luciliæ*.

With *Purdy's solution* the reaction begins at once. Most grains are gelatinized in a minute. A very few are refractory, and cease reacting after being partly gelatinized. There is apparently no further change during an hour. The reaction is the same qualitatively as that of the grains of *C. luciliæ*.

Differentiation of Certain Starches of the Genus Chionodoxa.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

C. luciliæ: Simple, rare compounds, no pressure facets, surface usually irregular owing to rounded protuberances and nipple-like processes and accretions, ovoid, reniform, lenticular, clam-shell-shaped.
C. tmolusi: Essentially the same as in *C. luciliæ*.
C. sardensis: Essentially the same as in *C. luciliæ*.

Hilum—Form, Number, and Position.

C. luciliæ: Form rather indistinct, comparatively small, round; occasionally multiple; may be fissured, usually in form of cross. Position eccentric about 0.20 to 0.40 of longitudinal axis.
C. tmolusi: Form essentially the same as in *C. luciliæ*, but hilum not so distinct. Position eccentric about 0.20 to 0.40 of longitudinal axis.
C. sardensis: Form essentially the same as in *C. luciliæ*, but hilum not so distinct. Position eccentric about 0.16 to 0.33 of longitudinal axis.

Lamellæ—General Characteristics and Number.

C. luciliæ: Fairly distinct, rather coarse, regular or irregular continuous, usually 2 sets. 7 to 12 on medium-sized grains.
C. tmolusi: Not very distinct, otherwise like *C. luciliæ*. 5 to 7 on medium-sized grains.
C. sardensis: Not very distinct, otherwise like *C. luciliæ*. 6 to 7 on medium-sized grains.

Size.

C. luciliæ: From 4 to 64μ, commonly 34μ.
C. tmolusi: From 3 to 32μ, commonly 20μ.
C. sardensis: From 6 to 40μ, commonly 22μ.

POLARISCOPIC PROPERTIES.

Figure.

C. luciliæ: Usually eccentric, distinct, usually not clear-cut, quite irregular.
C. tmolusi: Same as in *C. luciliæ*, except usually clear-cut and less irregular.
C. sardensis: Same as in *C. luciliæ*, except usually clear-cut and less irregular.

Degree of Polarization.

C. luciliæ: Fairly high, variable.
C. tmolusi: Fairly high, less variable than in *C. luciliæ*, but of same degree.
C. sardensis: Fairly high, much more variable and not so high as in *C. luciliæ*.

Polarization with Selenite—Quadrants and Colors.

C. luciliæ: Quadrants usually not clear-cut, very irregular in shape, unequal in size. Colors fairly pure.
C. tmolusi: Quadrants usually clear-cut, somewhat irregular, unequal in size. Colors fairly pure.
C. sardensis: Quadrants usually clear-cut, somewhat irregular, unequal in size. Colors fairly pure.

IODINE REACTIONS.

Intensity and Color.

C. luciliæ: Deep; blue-violet.
C. tmolusi: Deep, the same as *C. luciliæ;* blue-violet.
C. sardensis: Deep, the same as in *C. luciliæ;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

C. luciliæ: Fair.
C. tmolusi: Fair, about the same as in *C. luciliæ*.
C. sardensis: Fair, but less than in *C. luciliæ*.

With Safranin.

C. luciliæ: Fairly deep.
C. tmolusi: Fairly deep, the same or slightly lighter than in *C. luciliæ*.
C. sardensis: Fair, about the same as in *C. luciliæ*.

TEMPERATURE OF GELATINIZATION.

C. luciliæ: 59.4 to 60.6° C., mean 60°.
C. tmolusi: 61.5 to 63.2° C., mean 62.35°.
C. sardensis: 60.2 to 62° C., mean 61.1°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

C. luciliæ: Begins in a minute; complete in nearly all in 15 minutes.
C. tmolusi: Begins at once; complete in nearly all in 10 minutes.
C. sardensis: Begins in 20 seconds; complete in all in 12 minutes.

Reaction with Chromic Acid.

C. luciliæ: Begins at once; complete in all in 2 minutes.
C. tmolusi: Begins at once; complete in all in 2 minutes.
C. sardensis: Begins at once; complete in all in 2 minutes, except few small grains.

Reaction with Pyrogallic Acid.

C. luciliæ: Begins in 10 seconds; complete in most in 2 minutes.
C. tmolusi: Begins in 15 seconds; complete in nearly all in 1½ minutes.
C. sardensis: Begins in 20 seconds; complete in nearly all in 3 minutes, others partially gelatinized.

Reaction with Ferric Chloride.

C. luciliæ: Begins in 30 seconds; complete in all the grains in 30 minutes.
C. tmolusi: Begins in 30 seconds; complete in all in 10 minutes.
C. sardensis: Begins in 20 seconds; complete in all in 8 minutes.

Reaction with Purdy's Solution.

C. luciliæ: Begins at once in many grains; about one-third partially and two-thirds completely gelatinized in 2 minutes.
C. tmolusi: Begins in some in 15 seconds; complete in nearly all in 7 minutes.
C. sardensis: Begins at once; complete in most of the grains in a minute.

NOTES ON THE STARCHES OF CHIONODOXA.

In histological features the main differences in the three starches are in the different proportions of the several types of grains, differences in size, and in the distinctness and number of the lamellæ. How far these variations are constant is problematical. In their reactions there are very close correspondences throughout, the variations being noted particularly in the temperatures of gelatinization (60°, 62.35°, and 61.1°, respectively) and in the chemical reactions, except with chromic acid. Comparing the reactions of *C. luciliæ* with *C. tmolusi*, it will be observed that the former has a distinctly lower temperature of gelatinization, less sensitivity to chloral hydrate-iodine, pyrogallic acid, and ferric chloride, but greater sensitivity to Purdy's solution; and in comparison with *C. sardensis* it has a higher degree of polarization, less sensitiveness to iodine, a somewhat higher temperature of gelatinization, less sensitivity to chloral hydrate-iodine, ferric chloride, and Purdy's solution, and greater sensitivity to pyrogallic acid.

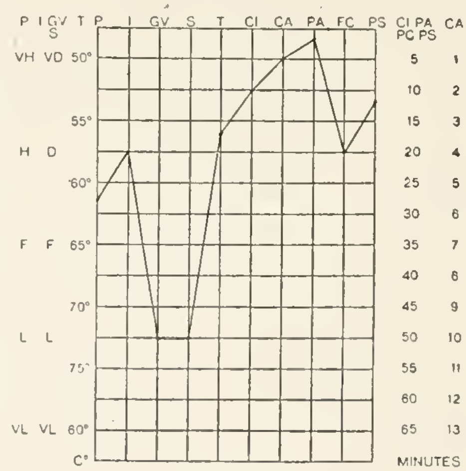
GENUS PUSCHKINIA.

This genus consists of only one or possibly two species of bulbous plants, native of Southern Asia. Its alliance with genera that are represented in this investigation has been referred to under *Scilla*. The only universally recognized species is *P. scilloides* Adams (*Adamsia scilloides* Willd.). The other and the questionable species is *P. libanotica* Zucc. (*P. sicula*), probably a variety, and designated *P. scilloides* var. *libanotica* by Boissier. Starches of both were studied.

STARCH OF PUSCHKINIA SCILLOIDES. (Plate 37, figs. 217 and 218. Chart 147.)

Histological Characteristics.—In *form* the grains are almost always simple and for the most part isolated. There are some compound grains, usually consisting of one large and two or three small components, the latter arranged at the sides and distal end of the large grain, and often partially separated by fissures, but held together by common lamellæ. There are many small aggregates, usually of two grains, one smaller than the other and adherent to the distal end of the larger grain. There are very few pressure facets on the isolated grains. The surface of the grains is somewhat irregular, due to irregular development or to secondary additions to the primary grain, often deposited on the distal end and sides, the longitudinal axis of which does not correspond with that of the primary part of the grain. In the compound grains, inequality in size of the components and variability of their positions with respect to one another also give rise to variations in surface. The conspicuous forms are ovoid and oval, which may have both ends rounded or the distal end squared and broader than the proximal end; triangular with rounded corners; also pyramidal, spherical, quadrilateral with rounded corners, and rarely lenticular, and pyriform. The grains when seen on edge are not flattened, but are not so thick at the distal end as at the proximal end.

Chart No. 147.



Curve of Reaction-Intensities of Starch of Puschkinia scilloides.

The *hilum* is a distinct, fairly large round spot, eccentric usually one-third to one-fourth of the longitudinal axis, and in or near the median line. Rarely in the smallest grains it is centric. Two or more hila are often linearly arranged in a single grain and may or may not be separated by fissures. The hilum is often fissured and the fissure may be narrow and short, broad and long, ragged or clear-cut; a single transverse or longitudinal fissure that is straight or curved on each side of the central point; or two fissures forming a cross; or three or more fissures springing from a central point. In some grains with more than one hilum one irregular fissure runs through all of the hila.

The *lamellæ* are fairly distinct, with usually continuous, coarse, irregular rings, as a rule discontinuous near distal end of the grains. They are generally coarser and more distinct near the hilum than near the distal end and vary in distinctness and size in different grains. There are 6 to 8 on the larger grains.

The grains vary in *size* from 4 to 26μ. The common size is 15μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and not entirely clear-cut, and generally somewhat irregular. Its lines are broad, usually broader but not so clearly outlined near the margin; sometimes slightly bent or otherwise distorted, and placed at varying angles to one another; the figure is often complicated, owing to the presence of several component grains of the aggregate or compound, in which case there may be one large and several small figures, or various modifications.

The degree of *polarization* is fairly high, varying in different grains, being low in some, high in others. It varies also in different aspects of the same grain, being highest when the grain is viewed on end or edge and commonly lower at margin of the distal end than near the hilum in the same aspect of a given grain.

With *selenite* the quadrants are fairly well defined, generally somewhat irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the swollen grains very deeply on addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly or not at all. The capsules color a reddish-violet on the addition of an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly at once and in 30 minutes are lightly colored.

Temperature Reaction.—The temperature of gelatinization is 55.8° to 56.9° C., mean 56.35°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds and is over in 10 minutes. The reaction starts at the distal end with darkening and considerable irregular protrusion, and the process advances until the whole grain is involved. There is always a sharp line of demarcation between the gelatinized and non-gelatinized parts of the grain. The gelatinized grains are fairly large, of a uniform dark color, and do not retain much of the original form of the grain.

Reaction with *chromic acid* begins in a few seconds and is over in a minute. The reaction starts at the hilum, where a bubble of gas or air forms, which increases and then decreases in size as the grain swells, and finally disappears. Meanwhile fine striæ appear radiating from the hilum in all directions, and the less resistant starch is rapidly gelatinized, accompanied by swelling of the whole grain. The more resistant starch forms a striated band at the margin which rapidly becomes thin and transparent, forming finally a capsule which dissolves at the proximal end, thus allowing the gelatinous material within to flow out and be dissolved. The rest of the capsule is rapidly dissolved after the escaped contents have disappeared.

Reaction with *pyrogallic acid* begins in 15 seconds and is over in 1½ minutes. It begins at the hilum, which swells somewhat, and a bubble appears which first increases then decreases in size and finally disappears. Fine striæ radiate from the hilum in all directions. The less resistant inner starch is gelatinized, and the more resistant outer starch forms a dense striated band at the margin, which as the grain swells becomes thin and transparent, especially at the distal end. The swollen grains are large, crumpled, and sacculated at the distal end and do not retain much of the original form of the grain.

With *ferric chloride* reaction begins in some grains in a minute and is over in 20 minutes. The reaction originates at the distal end, which is fissured internally in one or more places, and from these fissures gelatinized starch protrudes beneath the capsule. This process of gelatinization proceeds around the margin of the grain on each side and sometimes reaches the proximal end. Then it extends inward over the interior and denser portion of the grain, which is first split by fissures into small pieces that are separated from the main ungelatinized mass by wide bands of gelatinized starch and later are gelatinized themselves. The gelatinized grains are large, sacculated, crumpled, and distorted, and do not retain any of the original form of the grain.

Reaction with *Purdy's solution* begins at once. It is over in one-third of the grains in a minute, in three-fourths in 3 minutes, and in nearly all in 12 minutes. It appears to be qualitatively the same as that with pyrogallic acid.

STARCH OF PUSCHKINIA SCILLOIDES VAR. LIBANOTICA. (Plate 37, figs. 219 and 220. Chart 148.)

General Characteristics.—In *form* the grains are usually simple, and are isolated except a few in aggregates. Compound grains are not unusual and consist generally of one large grain with one or more smaller grains at its sides or distal end, the whole being surrounded by one, two, or more lamellæ. The components of such grains are frequently partially separated by fissures. There are a few aggregates, and these consist usually of a large grain having one or more small grains attached generally at the distal end, but sometimes at the side. A few of the grains have poorly defined pressure facets at the distal ends. The surface is rather irregular, due in the single grains to the additions of starch, usually lamellated, to the distal end and sides, the longitudinal axis of which additions does not correspond to that of the major part of the grain; and in the double grain to the irregularities in size and distribution of the component grains with respect to one another. The conspicuous forms are oval, ovoid, and triangular with flattened distal end and broad, rounded proximal end; also lenticular, quadrilateral with rounded angles, elliptical, and various irregular forms, some of which are very much deformed. The grains are not flattened, but when seen on edge the distal end is usually found to be much thinner than the proximal.

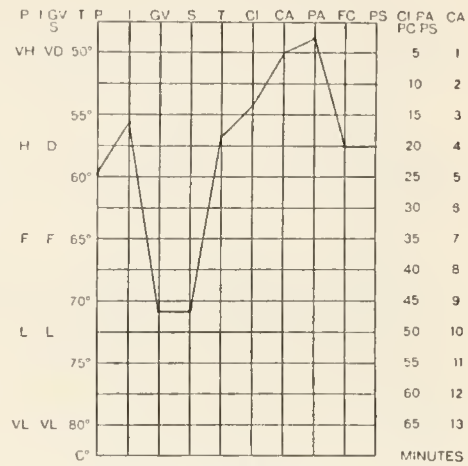
The *hilum* is a distinct, fairly large round spot, eccentric from about two-fifths to one-fourth of the longitudinal axis, and in or near the median line. In small round grains it may be eccentric. Two or more hila linearly are often arranged in a single grain or in a single component of a compound grain. The hilum is usually fissured, and there is either one long, rather narrow, clean-cut, straight line, longitudinal or transverse; or two long, straight lines forming a cross; or a group of small, ragged fissures radiating from a central point. In single grains with more than one hilum, a single fissure sometimes extends through the line of hila.

The *lamellæ* are fairly distinct, irregular, rather coarse continuous rings which follow the outline of the margin only when near it. They are more distinct, but not so coarse near the hilum as when near the margin, and vary in size and distinctness in different grains, and tend to be discontinuous at the distal end. There are 12 to 14 on the larger grains.

The grains vary in *size* from 3 to 30μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, not always clear-cut, and generally somewhat irregular. Its lines are broad, and usually broader but less clear-cut as they approach the margin, sometimes bent and otherwise distorted, and placed at varying angles to one another. Some grains have a complexity of figures caused by the presence of the several components of a compound grain, in which there is one large figure and one or more small ones or other modifications.

Chart No. 148.



Curve of Reaction-Intensities of Starch of Puschkinia scilloides var. libanotica.

The degree of *polarization* is fairly high, varying in different grains, being low in some to high in others. It varies also at times in different aspects of the same grain and is higher when the grain is on end or edge. It is slightly higher than that of the grains of *P. scilloides*.

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is slightly deeper than that of *P. scilloides*. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the swollen grains very deeply. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly or not at all. The capsules all color a reddish violet on the addition of an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly at once and in 30 minutes they are lightly stained, but more than the grains of *P. scilloides*.

Temperature Reaction.—The temperature of gelatinization is 55.6° to 57.8° C., mean 56.7°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 15 seconds and in all in 30 seconds. It is over in 13 minutes. It is the same qualitatively as that of the grains of *P. scilloides*.

Reaction with *chromic acid* begins in 15 seconds, and is over in a minute. It is the same qualitatively as that of the grains of *P. scilloides*.

Reaction with *pyrogallic acid* begins in 15 seconds and is complete in 2½ minutes. It is the same qualitatively as that of the grains of *P. scilloides*.

The reaction with *ferric chloride* begins in some grains in 45 seconds. It is over in four-fifths of the grains in 10 minutes and in all in 20 minutes. It is the same qualitatively as that of the grains of *P. scilloides*.

The reaction with *Purdy's solution* begins in 15 seconds and is over in 20 minutes. It is the same qualitatively as that of the grains of *P. scilloides*.

Differentiation of Certain Starches of the Genus Puschkinia.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

P. scilloides: Usually simple, a few compound grains usually consisting of 1, 2, or 3 components; many small aggregates of components similar to compound grains; surface somewhat irregular. Ovoid and oval with rounded ends or squared distal end and broader at proximal end; triangular with rounded corners. Few poorly defined pressure facets.

P. scilloides var. *libanotica:* Essentially the same as in *P. scilloides,* except a tendency to greater irregularity.

Hilum—Form, Number, and Position.

P. scilloides: Form distinct, fairly large, round; single or multiple; often fissured; fissure short or long, narrow or broad, ragged or clean-cut. Position eccentric, usually 0.33 to 0.25.

P. scilloides var. *libanotica:* Form essentially the same as in *P. scilloides.* Position eccentric, usually 0.40 to 0.25.

Lamellæ—General Characteristics and Number.

P. scilloides: Fairly distinct, usually continuous, coarse, irregular; usually discontinuous near distal end. 6 to 8 on larger grains.

P. scilloides var. *libanotica:* Essentially the same as in *P. scilloides.* 12 to 14 on larger grains.

Size.

P. scilloides: From 4 to 26μ, commonly 15μ.

P. scilloides var. *libanotica.* From 3 to 30μ, commonly 20μ.

POLARISCOPIC PROPERTIES.

Figure.

P. scilloides: Eccentric, distinct, not entirely clear-cut, generally somewhat irregular.

P. scilloides var. *libanotica:* Essentially the same as in *P. scilloides.*

Degree of Polarization.

P. scilloides: Fairly high.

P. scilloides var. *libanotica:* Fairly high, slightly higher than in *P. scilloides.*

Polarization with Selenite—Quadrants and Colors.

P. scilloides: Quadrants fairly well defined, generally somewhat irregular, unequal in size. Colors usually pure.

P. scilloides var. *libanotica:* Quadrants essentially the same as in *P. scilloides,* but more irregular in shape and more unequal in size. Colors pure.

IODINE REACTIONS.

Intensity and Color.

P. scilloides: Deep; blue-violet.

P. scilloides var. *libanotica:* Deep, slightly deeper than in *P. scilloides;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

P. scilloides: Light.

P. scilloides var. *libanotica:* Light, deeper than in *P. scilloides.*

With Safranin.

P. scilloides: Light.

P. scilloides var. *libanotica:* Light, deeper than in *P. scilloides.*

TEMPERATURE OF GELATINIZATION.

P. scilloides: 55.8 to 56.9° C., mean 56.35°.

P. scilloides var. *libanotica:* 55.6 to 57.8° C., mean 56.7°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

P. scilloides: Begins in 30 seconds; complete in 10 minutes.

P. scilloides var. *libanotica:* Begins in 30 seconds; complete in 13 minutes.

Reaction with Chromic Acid.

P. scilloides: Begins in a few seconds; complete in a minute.

P. scilloides var. *libanotica:* Begins in 15 seconds; complete in a minute.

Reaction with Pyrogallic Acid.

P. scilloides: Begins in 15 seconds; complete in 1½ minutes.

P. scilloides var. *libanotica:* Begins in 15 seconds; complete in 2½ minutes.

Reaction with Ferric Chloride.

P. scilloides: Begins in some in 60 seconds; complete in 20 minutes.

P. scilloides var. *libanotica:* Begins in some in 45 seconds; complete in 20 minutes.

Reaction with Purdy's Solution.

P. scilloides: Begins at once; complete in three-fourths of the grains in 3 minutes, and in nearly all in 12 minutes.

P. scilloides var. *libanotica:* Begins in 15 seconds; complete in all in 20 minutes.

NOTES ON THE STARCHES OF PUSCHKINIA.

The two *Puschkinia* starches are so alike in their histological characteristics and reactions that a certain diagnosis is doubtful. One of them came from a recognized species and the other from what is probably a variety of the same species, and as a consequence but little difference could be looked for. Such differences as were recorded are almost wholly within the limits of error. As the records stand, *P. scilloides* is distinguishable by the somewhat smaller grains, fewer lamellæ, lower polarization, less purity of colors with selenite, lower reaction-intensities with iodine and the anilines, lower temperature of gelatinization, greater sensitivity to chloral hydrate-iodine and pyrogallic acid, and less sensitivity to Purdy's solution. With weaker chemical reagents the differences would doubtless be accentuated.

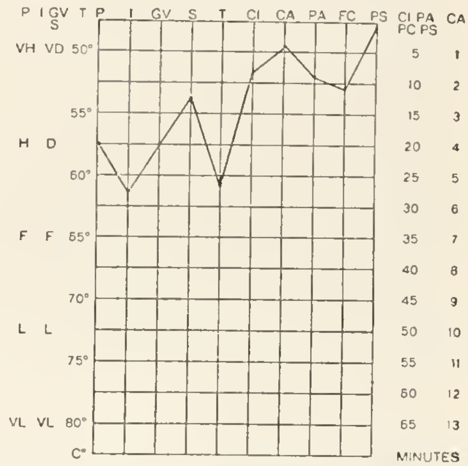
GENUS ORNITHOGALUM.

The genus *Ornithogalum*, which is one of the largest of the *Liliaceæ*, comprises about 100 species grouped among 7 subgenera. They are bulbous plants widely distributed over Europe, Africa, and the Orient. Some species have been introduced into America for garden cultivation, and some hardy kinds are found growing wild. *O. umbellatum* is popularly known as the star of Bethlehem. Two species and two varieties were studied as types of the genus: *O. nutans* Linn., *O. umbellatum* Linn., *O. narbonense* (*pyramidale*) Linn., and *O. thyrsoides* var. *aureum* Ait. (*O. aureum* Curt.).

STARCH OF ORNITHOGALUM NUTANS. (Plate 37, figs. 221 and 222. Chart 149.)

Histological Characteristics.—In *form* the grains are simple, and they are isolated, with the exception of rare doublets. There are no clumps and no pressure facets were observed on the isolated grains. The surface of some of the grains is somewhat irregular, owing to the addition of sets of lamellæ whose longitudinal axes do not coincide with the axis of the larger part of the grain. These sets of lamellæ were probably added at different periods of growth of the grain. As a rule, the grains are quite regular in outline. The conspicuous forms are the rounded ovoid and ovoid. The latter may have a narrow and squared distal end with a small depression in the middle of the squared portion. In addition, there are spherical, short elliptical, quadrangular with very rounded corners, and irregular forms. The grains are not flattened and are as thick as they are broad, and hence appear spherical when seen on end.

Chart No. 149.



Curve of Reaction-Intensities of Starch of Ornithogalum nutans.

The *hilum* is a fairly distinct, small to comparatively large, round or rarely lenticular spot, eccentric about one-third or more of the longitudinal axis, and in the median line. In small grains it may be centric. There are, rarely, 2 or more hila in a single grain. The hilum sometimes has a fissure, which is usually a small, single, clean-cut transverse or diagonal line; or there may be a cross or an irregularly stellate arrangement of small fissures.

The *lamellæ* are fairly distinct, usually regular, rather coarse rings. They are continuous, except those near the distal end, at which point there may be a set of discontinuous lamellæ, the longitudinal axis of which does not coincide with that of the body of the grain. They are usually coarser and more distinct near the margin and at the distal end than near the hilum. There are 10 to 13 lamellæ on the larger grains.

The grains vary in *size* from 6 to 38μ. The common size is 26μ.

Polariscopic Properties.—The *figure* is almost invariably eccentric, distinct, fairly clear-cut, and fairly regular. The lines are broad, and become broader, but less clearly outlined near the margin. They are usually straight and sometimes placed at equal angles to one another, and they are occasionally bisected.

The degree of *polarization* is high. It does not vary much in different grains, nor in different aspects of the same grain.

With *selenite* the quadrants are usually well defined, fairly regular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution and most of the grain-residues color deeply. Some of the capsules color violet with excess of iodine, the color of the others being obscured by the large amount of blue-reacting starch retained by them.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are deeply stained, some more than others.

With *safranin* the grains begin to stain deeply at once and in 30 minutes are very deeply stained, one as much as another.

Temperature Reaction.—The temperature of gelatinization is 60.5° to 62° C., mean 61.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds and is over in 8 minutes. The reaction begins at the distal end of the grain, which becomes dark violet, and this color spreads over the entire surface of the grain. The distal end soon changes in color to a very dark indigo and swells somewhat. This process extends upward around the margin and to the interior of the grain, until the whole grain is involved. The gelatinized grains so formed are fairly large, uniformly dark, and retain some of the original form.

Reaction with *chromic acid* begins in a very few seconds and is over in 45 seconds. The hilum swells, and a large bubble is formed which increases to a large size, then decreases and disappears. The inner portion of the grain is changed into a gelatinous mass, and the more resistant outer portion is formed into a thin, transparent envelope which as the grain swells becomes invaginated just over the point originally occupied by the hilum. The thin wall is dissolved at some point, and the inner gelatinous starch flows out and is dissolved. The capsule is dissolved, but not so rapidly as the extended gelatinous mass.

The reaction with *pyrogallic acid* begins in 15 seconds. The grains are nearly completely gelatinized in 8 minutes and all are fully disorganized in 30 minutes. The reaction begins at the hilum, which swells; the less resistant starch is changed into a gelatinous mass, the more resistant collects at the margin in the form of a broad, dense band, which sometimes is seen to be finely striated and which generally shows two or three indistinct, alternate, refractive and non-refractive rings; usually this band slowly becomes thinner and somewhat transparent, but in many grains it remains broad. The gelatinized grains are fairly large, generally smooth, and not much distorted.

With *ferric chloride* the reaction begins in some grains in 45 seconds and is over in 11 minutes. The reaction originates at the distal end, which is fissured internally, and from this fissure the gelatinized starch protrudes as a gelatinous mass covered by a gelatinized capsule. This process proceeds rather slowly towards the hilum, and when this point is reached an internal fissure extends downward to the gelatinized portion. The ungelatinized part of the grain is divided into two parts and these two into several pieces, which become widely separated by gelatinized starch, and then gelatinize themselves independently of one another. The gelatinized grains are very large, thin-walled, and irregular.

The reaction with *Purdy's solution* begins in 45 and is over in 60 seconds. It appears the same qualitatively as that with pyrogallic acid, but there is invagination of the capsules over the point formerly occupied by the hilum. The capsules are large, wrinkled, and sacculated at the distal end.

STARCH OF ORNITHOGALUM UMBELLATUM. (Plate 38, figs. 223 and 224. Chart 150.)

Histological Characteristics.—In *form* the grains are simple and with the exception of a few doublets and clumps they are isolated. No pressure facets were observed. The surface is rather irregular and somewhat varied, owing in part to a set of two or three lamellæ at or near the distal end, whose longitudinal axis does not agree with that of the larger part of the grain; and in part to irregularities in the development of the surface giving rise to small depressions in the margin, chiefly near the distal end. The conspicuous form is the ovoid with a squared end, and having in the center of this squared portion a deep but narrow depression; there are also spherical, irregularly elliptical, quadrangular with a rounded proximal end, a few triangular, and some irregular forms. The grains are not flattened and are of the same thickness as breadth, hence spherical when seen on end. The grains are slightly more irregular than those of *O. nutans*.

The *hilum* is a fairly distinct, small, round, or rarely lenticular spot. It is eccentric about one-third of the longitudinal axis and in the median line. Rarely it is centric. There are occasionally 2, and sometimes more, hila in a single grain. The hilum is often fissured, and there may be a narrow, short, straight, single, clean-cut, transverse or longitudinal fissure; less often there are two short, narrow, clean-cut fissures forming a cross.

The *lamellæ* are distinct, rather coarse, somewhat irregular, usually continuous rings; near the distal end they are probably discontinuous, and also more irregular, coarser, and more distinct than those near the hilum, often showing irregularities corresponding to depressions of the margin. They vary in distinctness and size in different grains. There are 8 to 14 on the larger grains.

The grains vary in *size* from 5 to 40μ. The common size is 21μ.

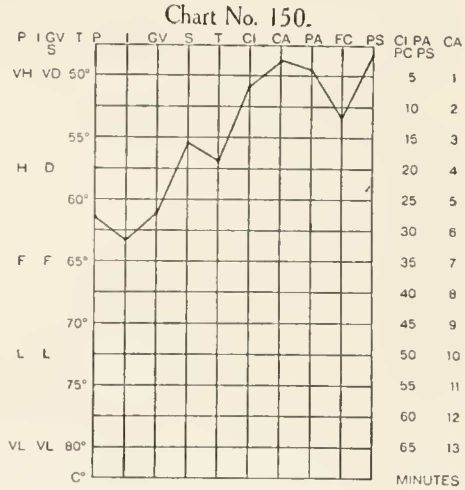
Polariscopic Properties.—The *figure* is eccentric, distinct, somewhat clear-cut, and fairly regular. Its lines are thick and become thicker and less well defined near the margin. They are usually not bent, are sometimes placed at equal distances from one another, and may be bisected.

The degree of *polarization* is fairly high. It is proportionately much higher in the larger grains, but does not vary much in different aspects of the same grain. It is not so high as that of the grains of *O. nutans*.

With *selenite* the quadrants are usually not very well defined, are fairly regular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. The color is less than that of the grains of *O. nutans*. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues rather lightly. On the addition of an excess of iodine all the capsules may be seen to be colored a reddish-violet. Most of them retain more or less blue-reacting starch.

Chart No. 150.



Curve of Reaction-Intensities of Starch of Ornithogalum umbellatum.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly deeply stained, not so deeply as those of *O. nutans*.

With *safranin* the grains begin to stain at once and in 30 minutes are deeply stained, not so deeply as those of *O. nutans*.

Temperature Reaction.—The temperature of gelatinization is 56.5° to 57° C., mean 56.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds. It is over in nearly all in 3 minutes and in all in 7 minutes. It is qualitatively the same as that of the grains of *O. nutans*.

Reaction with *chromic acid* begins in a very few seconds and is over in 30 seconds. The reaction is qualitatively the same as that of the grains of *O. nutans*.

The reaction with *pyrogallic acid* begins in 15 seconds. It is over in most grains in 2 minutes and in all in 4 minutes. The reaction is the same qualitatively as that of the grains of *O. nutans*.

With *ferric chloride* the reaction begins in a few grains in 15 seconds, and is over in 12 minutes. The reaction is qualitatively the same as that of the grains of *O. nutans*.

Reaction with *Purdy's solution* begins in a very few seconds and is over in 1¼ minutes. It is qualitatively the same as that of the grains of *O. nutans*.

STARCH OF ORNITHOGALUM NARBONENSE (PYRAMIDALE).

(Plate 38, figs. 225 and 226. Chart 151.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few doublets. No pressure facets were noted. The surface is quite irregular and somewhat varied, owing to irregular additions in the form of lamellated or amorphous accretions, chiefly to the distal end or to one or both sides near the distal end. These additions, and sometimes also the distal end of the original grain, are irregular, with many small depressions and slight elevations of the surface. The conspicuous form is the ovoid, with a pointed, squared, or irregular distal end; there are also many quadrangular grains with rounded proximal ends and irregularly squared distal ends; and fewer spherical, elliptical with ends of equal size or with a bulging proximal end, and triangular forms with rounded angles. There are many irregular forms. The grains are not flattened and are of the same thickness as breadth.

The *hilum* is a fairly distinct, small, round, or rarely lenticular spot. It is usually eccentric, about one-fourth, less often one-third, of the longitudinal axis, and in or to one side of the median line. There may be 2, or rarely more, hila in a single grain. The hilum is sometimes fissured. There is usually but one fissure, which is a short, narrow, clear-cut, transverse line, straight or with two curves; sometimes two fissures form a cross, or an irregularly stellate arrangement of a number of fissures.

The *lamellæ* are distinct, regular, coarse, continuous rings near the hilum, and probably discontinuous rings near the distal end. They are somewhat coarser but more distinct near the distal end than near the hilum and do not vary much in size and distinctness in different grains. There are about 8 to 12 on the larger grains.

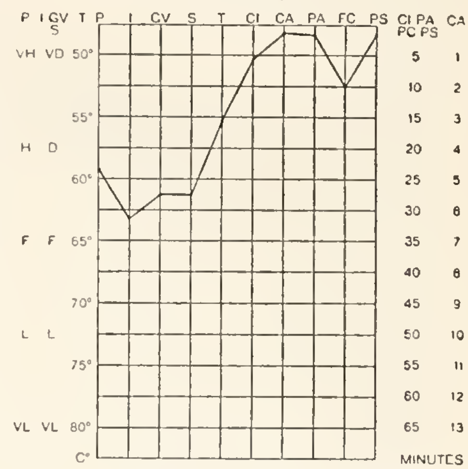
The grains vary in *size* from 5 to 40μ. The common size is 24μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, usually fairly clear-cut, and rather irregular. As a rule the lines are not thick, but they sometimes become thicker and less clear-cut at the margin. They are often bent and bisected, and sometimes placed at varying angles with one another. The lines are much more irregular than in *O. nutans* and *O. umbellatum.*

The degree of *polarization* is high. It does not vary much in different grains or in different aspects of the same grain, but is sometimes low in some parts near the margin of the same aspect of a given grain. It is not quite so high as in *O. nutans.*

With *selenite* the quadrants, as a rule, are fairly well defined, quite irregular in shape, and unequal in size. The colors are usually pure.

Chart No. 151.



Curve of Reaction-Intensities of Starch of Ornithogalum narbonense (pyramidale).

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens fairly rapidly. The color is slightly less than that of the grains of *O. nutans.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution is colored deeply and the grain-residues fairly. The capsules are colored reddish-violet when an excess of iodine is added, and most of them retain more or less blue-reacting starch.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained, but not so deeply as the grains of *O. nutans.*

Temperature Reaction.—The temperature of gelatinization is 55° to 56° C., mean 55.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds. It is over in most grains in 4 minutes and in all in 6 minutes. It is the same qualitatively as that of the grains of *O. nutans.*

Reaction with *chromic acid* begins at once and is over in 20 seconds. It is the same qualitatively as that of the grains of *O. nutans.*

Reaction with *pyrogallic acid* begins in 30 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *O. nutans.*

With *ferric chloride* reaction begins in some grains in 30 seconds and is over in 10 minutes. It is qualitatively the same as that of the grains of *O. nutans.*

The reaction with *Purdy's solution* begins at once. It is over in almost all the grains in 30 seconds and in all in 1½ minutes. It is the same qualitatively as that of the grains of *O. nutans.*

STARCH OF ORNITHOGALUM THYRSOIDES VAR. AUREUM.

(Plate 38, figs. 227 and 228. Chart 152).

Histological Characteristics.—In *form* the grains are simple. There are some doublets, multiples, and clumps. No pressure facets were observed. The surface of the grains is often quite irregular and somewhat varied, owing in minor part to a few irregular depressions, and in major part to lamellated additions (of varying size) to the sides or to the distal end. The longitudinal axes of these additions form angles with the longitudinal axes of the grains. The conspicuous forms are elongated ovoid to rounded ovoid; also spherical, quadrangular with rounded proximal end, triangular with rounded angles, and a few lenticular forms, and various irregular forms. These grains, like those of *O. narbonense* (*pyramidale*), are distinctly more irregular than those of *O. nutans* and *O. umbellatum.* The grains are not flattened and are as thick as they are wide.

The *hilum* is not very distinct, and is a small round spot. It is usually eccentric about one-fourth, less often one-third, of the longitudinal axis, and in or near the median line; sometimes 2 or more hila appear in a single grain. Occasionally the hilum is fissured, when there is usually but one short, narrow, clean-cut, transverse or diagonal fissure, straight or curved; or there may be two short, narrow, straight clean-cut fissures forming a cross.

The *lamellæ* are distinct, rather coarse, irregular rings, continuous near the hilum, but probably discontinuous near the distal end. They are coarser and more distinct near the distal end than near the hilum, and vary in size and distinctness in different grains. There are 12 to 14 on the larger grains.

The grains vary in *size* from 4 to 44μ. The common size is 27μ.

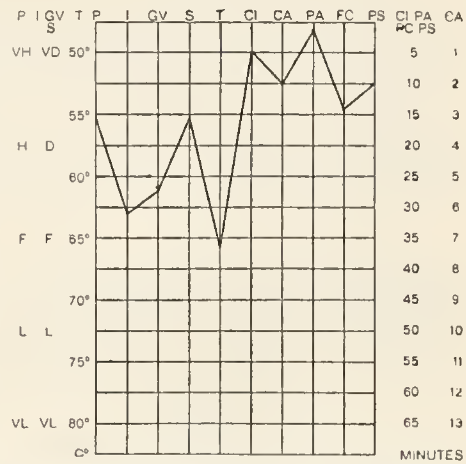
Polariscopic Properties.—The *figure* is eccentric, distinct, usually fairly clear-cut, and irregular. Its lines are rather thin, but often become thicker and less well defined near the margin, and often are very much bent and otherwise distorted, and sometimes bisected. They are at variable angles to each other.

The degree of *polarization* is high. It varies in different grains and in different parts of the same aspect of a grain. It is slightly higher than that of the grains of *O. nutans.*

With *selenite* the quadrants are fairly well defined, but usually very irregular in shape and unequal in size. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a fairly deep blue-violet; with 0.125 per cent solution they are colored rather lightly and the color does not deepen rapidly. The color is less than that of the grains of *O. nutans.* After heating in water until all of the grains are completely gelatinized, the solution colors rather lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly or not at all. With excess of iodine the capsules color a reddish-violet, and most of them retain more or less blue-reacting starch.

Chart No. 152.



Curve of Reaction-Intensities of Starch of Ornithogalum thyrsoides var. aureum.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are deeply stained. The color is not quite so deep as that of *O. nutans.*

Temperature Reaction.—The temperature of gelatinization is 65° to 67° C., mean 66°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 15 seconds and is over in 5 minutes. It is the same qualitatively as that of the grains of *O. nutans.*

Reaction with *chromic acid* begins in 15 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *O. nutans.*

The reaction with *pyrogallic acid* begins at once and gelatinization is complete in 1½ minutes. The reaction is qualitatively the same as that of the grains of *O. nutans.*

Reaction with *ferric chloride* begins in a few grains in 45 seconds and is over in 14 minutes. It is the same qualitatively as that of the grains of *O. nutans.*

With *Purdy's solution* the reaction begins in a few grains in a very few seconds and is over in a minute. In the rest of the grains it begins in a minute and is over in most of them in 4 minutes, and in all in 10 minutes. It is the same qualitatively as that of the grains of *O. nutans.*

Differentiation of Certain Starches of the Genus Ornithogalum.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

O. nutans: Simple, rare doublets, surface somewhat irregular, no pressure facets, secondary deposits of lamellæ. Rounded ovoid, and ovoid with a narrow squared distal end with a small depression.

O. umbellatum: Generally essentially the same as in *O. nutans* except slightly more irregularities of surface and greater conspicuousness of the ovoid grains with modified distal end.

O. narbonense (pyramidale): Essentially the same as in *O. umbellatum*, excepting a much greater irregularity of the grains.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Conspicuous Forms —Continued.

O. thyrsoides var. *aureum:* Essentially the same as in *O. nutans* except that the elongated ovoid are very prominent, and the surface of grains decidedly more irregular.

Hilum—Form, Number, and Position.

O. nutans: Form fairly distinct, small to comparatively large, round or rarely lenticular spot; usually single; sometimes fissured, fissure usually small, single, and clean-cut, or may be a cross or stellate arrangement. Position eccentric about 0.33 of the longitudinal axis or centric.

Differentiation of Certain Starches of the Genus Ornithogalum.—Continued.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.—Continued.

O. umbellatum: Form essentially the same as in *O. nutans.* Position eccentric about 0.33 of the longitudinal axis.
O. narbonense (pyramidale): Form essentially the same as in *O. nutans.* Position eccentric 0.25 to 0.33 of the longitudinal axis.
O. thyrsoides var. *aureum:* Form essentially the same as in *O. nutans.* Position eccentric 0.25, less often 0.33, of the longitudinal axis.

Lamellæ—General Characteristics and Number.

O. nutans: Fairly distinct, usually regular, rather coarse, continuous and discontinuous. 10 to 13 on larger grains.
O. umbellatum: Same as in *O. nutans.* 8 to 14 on larger grains.
O. narbonense (pyramidale): Same as in *O. nutans.* 8 to 12 on larger grains.
O. thyrsoides var. *aureum:* Same as in *O. nutans.* 12 to 14 on larger grains.

Size.

O. nutans: From 6 to 38μ, commonly 26μ.
O. umbellatum: From 5 to 40μ, commonly 21μ.
O. narbonense (pyramidale): From 5 to 40μ, commonly 24μ.
O. thyrsoides var. *aureum.* From 4 to 44μ, commonly 27μ.

Polariscopic Properties.

Figure.

O. nutans: Eccentric, distinct, fairly clear-cut, fairly regular.
O. umbellatum: Same as in *O. nutans.*
O. narbonense (pyramidale): Same as in *O. nutans*, except usually irregular.
O. thyrsoides var. *aureum:* Same as in *O. nutans*, except usually irregular.

Degree of Polarization.

O. nutans: High, slightly variable.
O. umbellatum: Fairly high, variable, lower than in *O. nutans.*
O. narbonense (pyramidale): High, slightly variable, not quite so high as in *O. nutans.*
O. thyrsoides var. *aureum:* High, variable, slightly higher than in *O. nutans.*

Polarization with Selenite—Quadrants and Colors.

O. nutans: Quadrants usually well-defined, fairly regular in shape, and unequal in size. Colors pure.
O. umbellatum: Quadrants usually not well defined, fairly regular in shape, and unequal in size. Colors pure.
O. narbonense (pyramidale): Quadrants the same as in *O. nutans*, but irregular. Colors usually pure.
O. thyrsoides var. *aureum:* Quadrants same as in *O. nutans*, but irregular. Colors usually pure.

Iodine Reactions.

Intensity and Color.

O. nutans: Fairly deep; blue-violet.
O. umbellatum: Fairly deep, less than in *O. nutans;* blue-violet.
O. narbonense (pyramidale): Fairly deep, slightly less than in *O. nutans;* blue-violet.
O. thyrsoides var. *aureum:* Fairly deep, less than in *O. nutans;* blue-violet.

Staining Reactions.

With Gentian Violet.

O. nutans: Deep.
O. umbellatum: Fairly deep, not so deep as in *O. nutans.*
O. narbonense (pyramidale): Fairly deep, not so deep as in *O. nutans.*
O. thyrsoides var. *aureum:* Deep, not quite so deep as in *O. nutans.*

With Safranin.

O. nutans: Very deep.
O. umbellatum: Deep, not so deep as in *O. nutans.*
O. narbonense (pyramidale): Fairly deep, not so deep as in *O. nutans.*
O. thyrsoides var. *aureum:* Deep, not quite so deep as in *O. nutans.*

Temperature of Gelatinization.

O. nutans: 60.5 to 62.0° C., mean 61.25°.
O. umbellatum: 56.5 to 57° C., mean 56.75°.
O. narbonense (pyramidale): 50.5 to 56° C., mean 55.5°.
O. thyrsoides var. *aureum:* 65 to 67° C., mean 66°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

O. nutans: Begins in 30 seconds; complete in 8 minutes.
O. umbellatum: Begins in 30 seconds; complete in 7 minutes.
O. narbonense (pyramidale): Begins in 30 seconds; complete in 6 minutes.
O. thyrsoides var. *aureum:* Begins in 15 seconds; complete in 5 minutes.

Reaction with Chromic Acid.

O. nutans: Begins in a few seconds; complete in 45 seconds.
O. umbellatum: Begins in a few seconds; complete in 30 seconds.
O. narbonense (pyramidale): Begins at once; complete in 20 seconds.
O. thyrsoides var. *aureum:* Begins in 15 seconds; complete in 2 minutes.

Reaction with Pyrogallic Acid.

O. nutans: Begins in 15 seconds; nearly all are completely gelatinized in 8 minutes.
O. umbellatum: Begins in 15 seconds; all are gelatinized in 4 minutes.
O. narbonense (pyramidale): Begins in 15 seconds; all are gelatinized in 2 minutes.
O. thyrsoides var. *aureum:* Begins at once; all are gelatinized in 1½ minutes.

Reaction with Ferric Chloride.

O. nutans: Begins in some in 45 seconds; complete in 11 minutes.
O. umbellatum: Begins in some in 45 seconds; complete in 12 minutes.
O. narbonense (pyramidale): Begins in some in 30 seconds; complete in 10 minutes.
O. thyrsoides var. *aureum:* Begins in some in 45 seconds; complete in 14 minutes.

Reaction with Purdy's Solution.

O. nutans: Begins in 15 seconds; complete in 1 minute.
O. umbellatum: Begins in a few seconds; complete in 1¼ minutes.
O. narbonense (pyramidale): Begins at once; complete in most in 30 seconds, in all in 1½ minutes.
O. thyrsoides var. *aureum:* Begins in some in a few seconds, and in all in 1 minute; complete in most grains in 4 minutes, in all in 10 minutes.

NOTES ON THE STARCHES OF ORNITHOGALUM.

The four starches of *Ornithogalum* are primarily divisible into two groups in accordance with the degree of regularity of the outline of the grains, the surface of the grains in *O. nutans* and *O. umbellatum* being, on the whole, quite regular in comparison with those of the other two; moreover, certain differences relating to the shapes in general are also of interest. A comparison of the interference figures and purity of colors with selenite shows a corresponding grouping. In their reactions, species differences are manifest, but there is not the grouping that has been pointed out. *O. umbellatum* and *O. narbonense* (*pyramidale*) correspond, on the whole, distinctly, and much closer than any other couple. The range of the temperatures of gelatinization is particularly noticeable, the lowest being 55.5° and the highest 66°, a difference of 10.5°. By means of the variations in the reactions each starch can without difficulty be distinguished from the others.

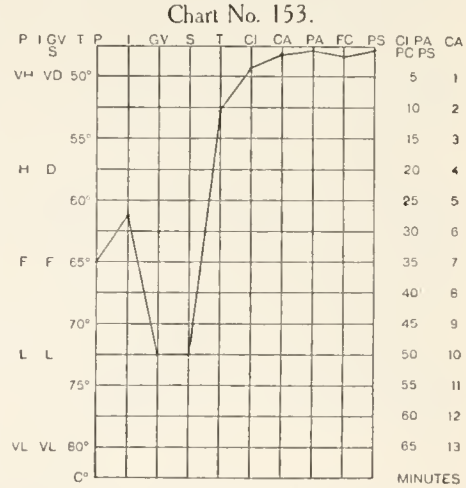
GENUS ERYTHRONIUM.

This genus consists of about 10 species, only one of which is European, the others being natives of Eastern and Western America. Erythroniums are popularly known as the dog-tooth violet or adder's tongue, and they bear nodding, lily-like flowers. Starches from 5 sources, divided into 2 groups, were examined: Group I, *E. dens-canis* Linn. and *E. dens-canis* var. *grandiflorum* Hort., this group including the European species and one of its varieties; Group II, *E. americanum* Smith (*E. angustatum* Raf., and *E. bracteatum* Boott), *E. grandiflorum* Pursh (*E. giganteum* Lindl.), *E. citrinum* Wats., and *E. californicum* Hort., representing three of the native American species. *E. americanum* is Eastern and the others are Western American.

STARCH OF ERYTHRONIUM DENS-CANIS. (Plate 39, figs. 229 and 230. Chart 153.)

Histological Characteristics.—In *form* the grains are simple. There are a few small doublets and a few clumps. There are pressure facets on some small grains. The surface is usually regular, and any irregularities may be observed chiefly as protuberances of the proximal end or sides, or one side of rounded triangular forms may be either more inclined or shorter than the other; or the distal margin may be expanded in these triangular grains, and an indentation appears a little to one side of the longitudinal axis and extends towards the hilum. The conspicuous forms are elliptical, ovoid, pyriform, and variations of the rounded triangular forms in the direction of clam-shell and oyster-shell shapes. In some of the triangular forms the base or distal end is almost pointed and the sides shortened so as to yield the flint arrow-head shape. The broad forms are flattened, and when viewed on edge the grains are flattened elliptical.

Chart No. 153.



Curve of Reaction-Intensities of Starch of Erythronium dens-canis.

The *hilum* is a refractive spot which is generally fissured by a small, irregular, transverse cleft, from which two short, curved fissures (resembling ox horns) frequently proceed; or in other instances branched, root-like fissures are located here. Two hila are occasionally found. There is a range of eccentricity of the hilum from one-fifth to one-fourth, usually one-fifth, of the longitudinal axis.

The *lamellæ* are fine and usually indistinct. They form complete rings around the hilum, but assume the shape of the grain near the margin and distal end, where they are not so fine but more distinct.

The grains vary considerably in *size*. The small, elongated grains measure 8 by 6μ in length and breadth; the larger, elongated types 40 by 36μ in length and breadth; and the broader, large forms 34 by 38μ in length and breadth. The common size is 26 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, except in a few of the smallest grains, quite distinct, and fairly clear-cut. Its lines are rather thick and generally straight, but somewhat expanded at the distal and proximal ends. Sometimes they are either bent or bisected.

The degree of *polarization* is fair. It varies in different grains as well as in the same aspect of a given grain.

With *selenite* the quadrants are fairly well defined, often irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly, but the color does not deepen rapidly. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, the grain-residues lightly or not at all. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain slightly at once and in 30 minutes they are lightly stained, some more than others.

Temperature Reaction.—The temperature of gelatinization is 51.4° to 53.9° C., mean 52.65°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 15 seconds and is over in 3 minutes. It begins at the distal end and at any prominences on the margin of the grain, at which points the grain becomes dark and swells out somewhat irregularly, progressing around both sides until it is near the hilum. Then the hilum swells, and the marginal starch at the proximal end is formed into a thick, rather long, rounded projection. This reaction spreads downward on each side and so meets the reaction of the sides and distal end. A dark, irregularly swollen band is thus formed which incloses a light and as yet ungelatinized central portion. This central part is rapidly gelatinized. The swollen grains are large, usually of a uniformly dark color, except at the proximal end, where there is a round, light space. They are somewhat distorted, but retain some of the original form of the grain.

Reaction with *chromic acid* begins at once and is over in 12 seconds. It is so rapid that it is impossible to clearly make out the steps, but it generally appears to take the following course: The hilum and the proximal end of the grain swell very greatly, the rest of the starch passes into a liquid or semiliquid mass, except a thin, transparent layer at the extreme margin, which forms a crumpled and distorted capsule, which is dissolved at one end, and the gelatinized contents flow out and are dissolved, followed by solution of the rest of the capsule.

Reaction with *pyrogallic acid* begins at once and is over in about 12 seconds. It is so rapid that the separate steps can not be satisfactorily determined. In the main it appears to consist of a rapid swelling of the hilum and proximal end, followed by the gelatinization of the rest of the grain, the swelling of the whole grain, and the formation of a thin, transparent layer of starch at the margin, into a distorted capsule crumpled and wrinkled at the distal end.

The reaction with *ferric chloride* begins in many grains in a few seconds and is over in 2 minutes. The reaction starts at the prominences on the sides and at the distal end, the starch here becoming gelatinous and swelling out irregularly, followed by swelling of the hilum and the proximal end. Then the inner starch is divided by internal fissures into several small pieces that widely separate from one another and then gelatinize. The gelatinized grains are very large, irregular, and do not retain much of the original form of the grains.

Reaction with *Purdy's solution* begins at once and is complete in 15 seconds. It is impossible to clearly distinguish all the steps, but in the essential features it appears to correspond qualitatively with the reaction with pyrogallic acid.

STARCH OF ERYTHRONIUM DENS-CANIS VAR. GRANDIFLORUM.

(Plate 39, figs. 231 and 232. Chart 154.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few clumps. No doublets or other aggregates were observed, although pressure facets were found on a few of the isolated grains. The surface is rather irregular and quite varied, the irregularities being due to the same causes as noted for *E. dens-canis*. In some grains the protuberances are long and finger-like. The conspicuous forms are elongated ovoid to club-shaped, oyster-shell-shaped, and flint arrow-head-shaped; also forms resembling the slipper animalcule, pyriform, round, and many that are indefinite.

The *hilum* is a distinct refractive spot having a range of eccentricity from one-fifth to one-sixth, usually one-sixth, of the longitudinal axis. There is generally a small cavity or a short fissure at the hilum, the fissure frequently being transverse, but sometimes diagonal. Two short, single fissures may radiate from the hilum or its position.

The *lamellæ* are rather distinct, complete, elliptical or circular rings around the hilum. Beyond the hilum they assume the form of the outline of the grain. They are usually more distinct near the distal end. The number is difficult to determine, but some grains appear to have 26.

The *size* of the small, round grains is 4 by 4μ, and of the narrow, elongated type of the larger grains 46 by 30μ in length and breadth. The common size is 30 by 12μ in length and breadth.

The size of the broader, elongated grains is 46 by 38μ in length and breadth, the common size being 28 by 24μ in length and breadth.

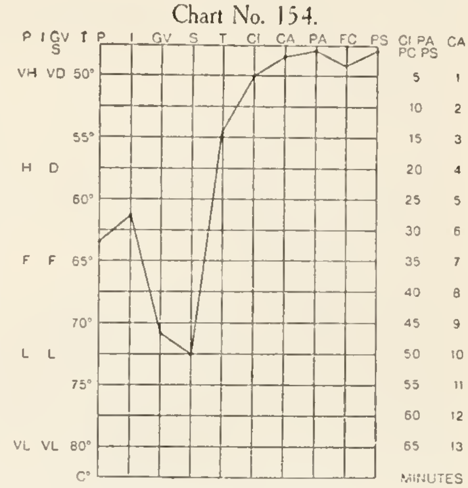
Polariscopic Properties.—The *figure* is eccentric, distinct, and fairly clear-cut. Its lines are rather thick, sometimes bent, and occasionally bisected.

The degree of *polarization* is fair. It varies somewhat in different grains and in the same aspect of a given grain. In many grains it is slightly higher and there is a greater variation than in *E. dens-canis.*

With *selenite* the quadrants are fairly well defined, very often irregular in shape and unequal in size. The blue is pure, the yellow not entirely so. The colors are brighter than in *E. dens-canis.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. It is the same as that of the grains of *E. dens-canis.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and many of the grain-residues lightly or not at all. The capsules all color a red-violet with a slight excess of iodine.

Chart No. 154.



Curve of Reaction-Intensities of Starch of Erythronium dens-canis var. grandiflorum.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes they are lightly stained. The color is slightly more than that of the grains of *E. dens-canis.*

With *safranin* the grains begin to stain lightly at once and in 30 minutes they are rather lightly stained. The color is the same as that of the grains of *E. dens-canis.*

Temperature Reaction.—The temperature of gelatinization is 53.2° to 55.1° C., mean 54.05°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in 45 seconds. It is over in nearly all in 3 minutes and in all in 5 minutes. The reaction is the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *chromic acid* begins at once and is over in 20 seconds. It is so rapid that the steps can not satisfactorily be made out, but is probably the same qualitatively as that of the grains of *E. dens-canis.*

With *pyrogallic acid* the reaction begins at once and is over in 25 seconds. It is very quick, and is probably the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *ferric chloride* begins in a few grains in a few seconds and is over in 3½ minutes. It is the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *Purdy's solution* begins at once and is over in 20 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

STARCH OF ERYTHRONIUM AMERICANUM. (Plate 39, figs. 233 and 234. Chart 155.)

Histological Characteristics.—In *form* the grains are simple, and isolated with the exception of a few in aggregates, mostly in the form of doublets and a few clumps. Pressure facets are occasionally observed on the isolated grains. The surface of most of the grains is regular. Irregularities are found which are due to the causes noted under *E. dens-canis.* The conspicuous forms are ovoid, rounded ovoid, pyriform, and triangular to clam-shell shape. Only few of the very minute forms are round. In addition to these noted there are some oyster-shell-shaped, pecten-shell-shaped, flint arrow-head-shaped, and various irregular grains. Very large oyster-shell-shaped forms similar to those rarely found in *E. grandiflorum* are also rare. The broadened grains are flattened.

The *hilum* is a bright, refractive spot similar to that in *E. dens-canis.* In the eccentric grains it has a range of one-fifth to one-fourth, usually one-fifth, of the longitudinal axis. There is sometimes a transverse cleft or a small, irregular cavity at the hilum, from which occasionally two short, almost straight fissures radiate. These fissures are sometimes diagonal and intersect each other, forming a cross.

The *lamellæ* are fairly distinct, fine, and usually form complete rings around the hilum; but farther out they have the form of the outline of the grain and are probably incomplete near the distal end. In some of the shell-shaped forms the lamellæ are coarser between the hilum to within two-thirds of the distance between hilum and distal end, and beyond this point they are not only finer but less distinct. In the pyriform and in some shell-shaped forms this arrangement is usually reversed. The best marked shell-shaped forms have 1 to 3 lamellæ that are particularly coarse and more refractive than the others.

The *size* of the small, elongated grains in length and breadth is 6 by 4μ; of the narrow, elongated size 42 by 33μ; the common size is 26 by 20μ; the broader, elongated grains 40 by 38μ. The common size is 28 by 26μ.

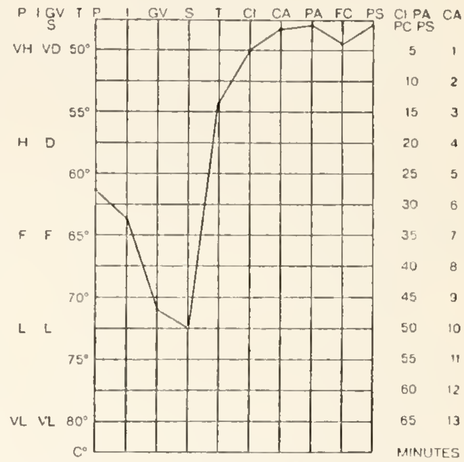
Polariscopic Properties.—The *figure* is eccentric, except in a few of the smallest grains, distinct, and fairly clear-cut. Its lines are rather broad and straight, but they expand somewhat at the proximal and distal margins. In rare cases they may be bent or bisected.

The degree of *polarization* is fair to rather high. It varies in different grains and in the same aspect of a given grain. It is higher than in *E. dens-canis.*

With *selenite* the quadrants are well defined, regular in shape, and unequal in size. The blue is pure, the yellow not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. The color is slightly less than that of the grains of *E. dens-canis.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, the grain-residues lightly or not at all. With a slight excess of iodine the capsules color a red-violet.

Chart No. 155.



Curve of Reaction-Intensities of Starch of Erythronium americanum.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes they are lightly stained, some more than others. The color is slightly more than that of the grains of *E. dens-canis.*

With *safranin* the grains begin to stain at once and in 30 minutes they are rather lightly stained. The color is the same as that of the grains of *E. dens-canis.*

Temperature Reaction.—The temperature of gelatinization is 52.9° to 54° C., mean 53.45°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in 15 seconds. It is usually over in some grains in 3 minutes and in all in 5 minutes. It is the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *chromic acid* begins at once and is over in 15 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *pyrogallic acid* begins in a few seconds and is over in 15 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

The reaction with *ferric chloride* begins in a few grains in 15 seconds and is over in 4 minutes. It is the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *Purdy's solution* begins in a few seconds and is over in 20 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

STARCH OF ERYTHRONIUM GRANDIFLORUM. (Plate 40, figs. 235 and 236. Chart 156.)

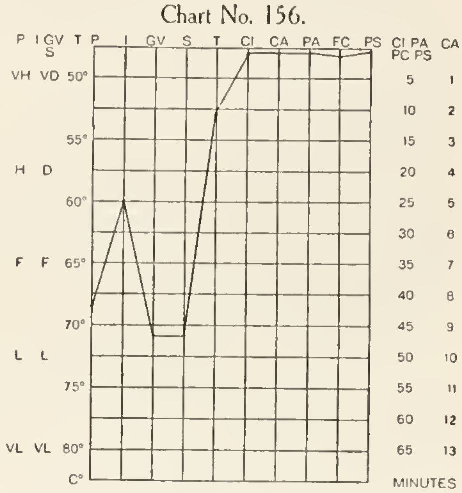
Histological Characteristics.—In *form* the grains are simple, and are isolated except a few that occur in aggregates, mostly in the form of doublets or triplets, and clumps. Pressure facets are occasionally found on the isolated grains. The grains vary more in form and size than in *E. dens-canis,* and the surface is on the whole more irregular. The variations in surface are chiefly due to protuberances near or at the hilum end; to the cutting off at various angles of the margin of forms belonging to the rounded triangular type; to the abrupt curving of one side of forms broadened at the distal end; and to an expansion of the distal margin with an indented line running towards the hilum and starting at one side of the longitudinal axis. The conspicuous forms are the elliptical, ovoid, pyriform, and variations of the rounded, triangular type to the clam-shell and oyster-shell shapes. Among the small grains there are more round or nearly round forms than in *E. dens-canis*, but most of the grains of this group are either ovoid or oval. The broad forms are flattened. Besides the forms noted, there are some flint arrow-head or pecten-shell-shaped grains.

The *hilum* is a refractive spot which is centric in the small, round forms, but eccentric about one-fifth, rarely one-fourth, in the elongated forms; usually with a transverse cleft or a small irregular cavity, from which rarely two curved fissures proceed. It is not as distinct and refractive as in *E. dens-canis*.

The *lamellæ* are usually indistinct. They form a complete ring around the hilum, but farther out assume the shape of the grain. Towards the distal end they are probably incomplete. They are more distinct in the clam-shell shape than in other forms.

The *size* in length and breadth of the small, elongated grains is 8 by 4μ; of the large, elongated grains 27 by 17μ; of the common size of the latter is 18 by 11μ; the size of the large broad forms is 33 by 33μ in the longest and transverse diameters. The common size of the large grains is 18 by 21μ in length and breadth.

Chart No. 156.



Curve of Reaction-Intensities of Starch of Erythronium grandiflorum.

Polariscopic Properties.—The *figure* is eccentric, except in a few of the smallest round grains. It is distinct and fairly clean-cut. Its lines are thick and usually straight, but expand somewhat toward the distal and proximal margins.

The degree of *polarization* is rather low to fair. There is some variation in the same aspect of a given grain. It is less than in *E. dens-canis*, and is the lowest of all of the erythroniums.

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are not quite pure. The blue is pure, but the yellow is not.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. It is slightly more than that of the grains of *E. dens-canis*. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and most of the grain-residues lightly or not at all. The capsules color a red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes they are lightly stained. The color is slightly more than that of the grains of *E. dens-canis*.

With *safranin* the grains begin to stain at once and in 30 minutes they are rather lightly stained. The color is more than that of the grains of *E. dens-canis*.

Temperature Reaction.—The temperature of gelatinization is 52.1° to 54° C., mean 53.05°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in a few seconds and is over in 1¼ minutes. It is the same qualitatively as that of the grains of *E. dens-canis*.

Reaction with *chromic acid* begins at once and is over in 10 seconds. It is so rapid that it is impossible to distinguish the separate steps.

The reaction with *pyrogallic acid* begins at once and is over in 10 seconds. It is so rapid that it is impossible to distinguish the separate steps.

Reaction with *ferric chloride* begins in many grains in a very few seconds and is over in 1¼ minutes. It is qualitatively the same as that of the grains of *E. dens-canis*.

With *Purdy's solution* the reaction begins at once and is over in 10 seconds. It is so rapid that it is impossible to distinguish the separate steps.

STARCH OF ERYTHRONIUM CITRINUM. (Plate 40, figs. 237 and 238. Chart 157.)

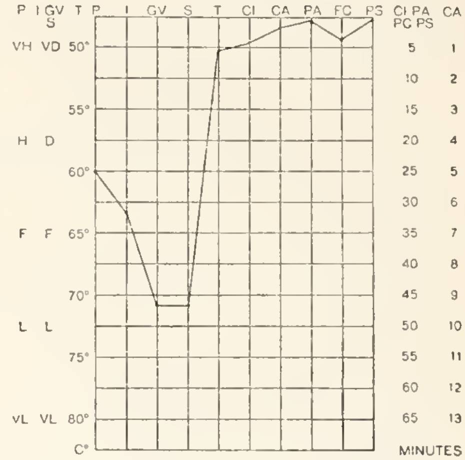
Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of a few in small aggregates, generally in the form of doublets and triplets, and a few clumps. Pressure facets are found on some of the isolated grains. The grains are varied in form, but the surfaces of a large number are fairly regular. Irregularities may be due to the cutting off of rounded corners, which become sharply angular; or the distal end may be cut off diagonally, so that one side of the grain is much longer than the other; or modifications may occur in other ways, as in *E. dens-canis.* The conspicuous forms are the ellipsoidal to club-shaped, ovoid, oval with distal end squared, and oyster-shell-shaped. There are a number of small, round grains, and small, flattened elliptical with rounded ends. Besides the above forms there are triangular, pyriform, clam-shell-shaped, and various irregular forms.

The *hilum* is a round refractive spot, centric in small round grains and eccentric in other forms, about one-fourth to one-fifth, more often one-fourth, of the longitudinal axis. There is often an irregular, small cavity, or a transverse cleft at the hilum. Two longitudinal, branched fissures proceeding from the hilum may be found in the elongated forms; or two short, ragged fissures may intersect each other diagonally, forming a cross; or two short fissures may curve outwards.

The *lamellæ* are indistinct in most grains. In the narrow triangular to oyster-shell type they are more distinct towards the distal end; while in the broader triangular to clam-shell shape they may be fairly distinct throughout; or a few coarser ones may appear midway between the hilum and the distal end.

The *size* of the small round grains is 4 by 4μ, and of the larger elongated forms 38 by 20μ in length and breadth. The common size of the latter is 28 by 16μ in length and breadth. The size of the broad grains is 38 by 42μ in length and breadth. The common size is 30 by 26μ in length and breadth.

Chart No. 157.



Curve of Reaction-Intensities of Starch of Erythronium citrinum.

Polariscopic Properties.—The *figure* is distinct and eccentric, except in some small grains, and fairly clear-cut. The lines are rather thick and frequently expand somewhat at the distal and proximal margins; they are often straight, but sometimes bent, and occasionally bisected.

The degree of *polarization* is fair to fairly high. It varies frequently in the same aspect of a given grain. There is a greater variation than in *E. dens-canis,* and in some of the grains it is higher than in the latter.

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are not quite pure, the blue being pure, but the yellow not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly and the color deepens slowly. The color is lighter than that of the grains of *E. dens-canis.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, the grain-residues rather lightly or not at all. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to color lightly at once and in 30 minutes they are lightly stained, some more than others. The color is slightly more than that of the grains of *E. dens-canis.*

With *safranin* the grains begin to color at once and in 30 minutes they are rather lightly colored. The color is slightly more than that of the grains of *E. dens-canis.*

Temperature Reaction.—The temperature of gelatinization is 49.1° to 51.8° C., mean 50.45°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in all the grains in 20 seconds and is over in 3¾ minutes. It is the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *chromic acid* begins at once and is over in 20 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

The reaction with *pyrogallic acid* begins at once and is over in 25 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

With *ferric chloride* the reaction begins in some grains in 15 seconds and is over in 3½ minutes. It is the same qualitatively as that of the grains of *E. dens-canis.*

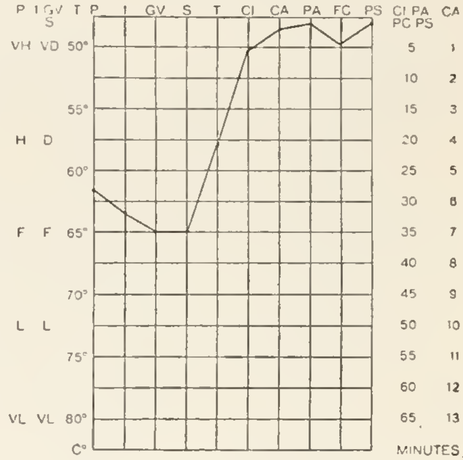
The reaction with *Purdy's solution* begins at once and is over in 10 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

STARCH OF ERYTHRONIUM CALIFORNICUM. (Plate 40, figs. 239 and 240. Chart 158.)

Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of some in doublets and in clumps. More small aggregates (usually in the form of doublets) and more clumps are found than was observed in *E. dens-canis.* Pressure facets are noted on some of the isolated grains. The surface is usually rather regular. Irregularities are due to the causes noted in *E. dens-canis.* The conspicuous forms are the oval elliptical, ovoid, pyriform, and irregular rounded triangular to irregular clam-shell and oyster-shell types. The broad forms are flattened.

The *hilum* is a small spot, not as refractive as in *E. dens-canis,* but about the same as *E. grandiflorum.* In the small round forms it is centric, and in the elongated grains, with a range of eccentricity from one-fourth to one-sixth, usually one-fourth, of the longitudinal axis. At the hilum there is generally a transverse fissure or a small irregular cavity from which, in many grains, two fissures pass out. In the broad forms these fissures are often curved and turn towards the proximal end like a pair of horns. In the elliptical grains they extend towards the distal end and are usually branched. A cluster of curved fissures at the hilum sometimes forms irregular figures.

Chart No. 158.



Curve of Reaction-Intensities of Starch of Erythronium californicum.

The *lamellæ* are indistinct as a rule, and when visible take the shape of the grain when very near the margin, and of the hilum when near it. They are usually more distinct near the margin and the distal end.

The *size* of the small round grains is 6 by 6μ, and of the large elongated forms is 42 by 32μ in length and breadth. The common size of the latter is 24 by 16μ in length and breadth; of the broader grains, 24 by 26μ.

Polariscopic Properties.—The *figure* is eccentric except in a few round forms. It is fairly clear-cut and distinct in some and rather indistinct in others. Its lines are fairly thick and straight and expand towards the proximal and distal ends, and they are sometimes hazy, often bent, or sometimes bisected.

The degree of *polarization* is rather low to fairly high, on the whole fair. There is often considerable variation in the same aspect of a given grain. There is a greater variation than in *E. dens-canis,* but on the whole it is higher.

With *selenite* the quadrants are usually quite well defined, irregular in shape, and unequal in size. The colors are not quite pure, the blue being pure, but the yellow not quite pure. They are purer than in *E. dens-canis.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. The color is slightly less than that of the grains of *E. dens-canis.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules all color a red-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes they are fairly stained. The color is much deeper than that of *E. dens-canis.*

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained. The color is much deeper than that of *E. dens-canis.*

Temperature Reaction.—The temperature of gelatinization is 57.2° to 58.6° C., mean 57.9°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds, and is over in 5½ minutes. It is the same qualitatively as that of the grains of *E. dens-canis.*

Reaction with *chromic acid* begins at once and is over in 25 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

The reaction with *pyrogallic acid* begins in a few seconds and is over in 50 seconds. It is probably the same qualitatively as that of the grains of *E. dens-canis.*

With *ferric chloride* the reaction begins in some grains in 15 seconds, and is over in 4½ minutes. It is the same qualitatively as that of the grains of *E. dens-canis.*

The reaction with *Purdy's solution* begins in a few seconds and is over in 50 seconds. It is the same qualitatively as that of the grains of *E. dens-canis.*

Differentiation of Certain Starches of the Genus Erythronium.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

E. dens-canis: Simple, few doublets, few grains with pressure facets; surface usually regular. Elliptical ovoid, pyriform, and rounded triangular, with variations towards clam-shell and oyster-shell shapes.

E. dens-canis var. *grandiflorum:* Simple, no doublets noted, few grains with pressure facets, surface rather irregular. Elongated ovoid to club-shape and oyster-shell shape.

E. americanum: Simple, few doublets, few grains with pressure facets, generally regular. Pyriform, ovoid, rounded ovoid, and triangular to clam-shell shape.

E. grandiflorum: Simple, doublets, and triplets, few grains with pressure facets, rather irregular. Elliptical, ovoid, pyriform, rounded triangular to clam-shell and oyster-shell shape. More round or nearly round forms than in *E. dens-canis.*

E. citrinum: Simple, some doublets and triplets, few grains with pressure facets, usually fairly regular. Ellipsoidal to club shape, ovoid, and oval with a squared distal end, oyster-shell shape.

E. californicum: Simple, more doublets than in *E. dens-canis,* some grains with pressure facets, surface rather regular. Oval-elliptical, ovoid, pyriform, irregular rounded triangular to irregular clam-shell and oyster-shell types. More round grains than in *E dens-canis.*

Hilum—Form, Number, and Position.

E. dens-canis: Distinct spot, usually marked by an irregular cavity or transverse cleft from which 2 short curved fissures proceed. 2 hila are sometimes found. Position eccentric 0.20 to 0.25, usually 0.20, of longitudinal axis.

E. dens-canis var. *grandiflorum:* Form same as in *E. dens-canis.* Position eccentric 0.16 to 0.20, usually 0.16, of longitudinal axis.

E. americanum: Form essentially the same as in *E. dens-canis.* Position eccentric 0.20 to 0.25, usually 0.20, of longitudinal axis.

E. grandiflorum: Form essentially the same as in *E. dens-canis,* but hilum not as distinct or as refractive. Position eccentric 0.20, rarely 0.25, of longitudinal axis.

E. citrinum: Form essentially the same as in *E. dens-canis.* Position eccentric 0.25 to 0.20, usually 0.25, of longitudinal axis.

E. californicum: Form essentially the same as in *E. dens-canis,* but the hilum is not so refractive. Position eccentric from 0.25 to 0.16, usually 0.25, of longitudinal axis.

Lamellæ—General Characteristics and Number.

E. dens-canis: Fine, usually indistinct, complete and incomplete, fairly regular, variable. Number not determined.

E. dens-canis var. *grandiflorum:* Essentially the same as in *E. dens-canis.* Probably about 26 on the larger grains.

E. americanum: Essentially the same as in *E. dens-canis.* Number not determined.

E. grandiflorum: Essentially the same as in *E. dens-canis.* Number not determined.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Lamellæ—General Characteristics and Number.—Cont'd.

E. citrinum: Essentially the same as in *E. dens-canis.* Number not determined.

E. californicum: Essentially the same as in *E. dens-canis.* Number not determined.

Size.

E. dens-canis: From 6 to 40μ, commonly 26μ.

E. dens-canis var. *grandiflorum:* From 4 to 46μ, commonly 28μ.

E. americanum: From 6 to 40μ, commonly 28μ.

E. grandiflorum: From 8 to 33μ, commonly 18μ.

E. citrinum: From 4 to 38μ, commonly 30μ.

E. californicum: From 6 to 42μ, commonly 24μ.

POLARISCOPIC PROPERTIES.

Figure.

E. dens-canis: Eccentric, distinct, fairly clear-cut, usually regular, but sometimes distorted.

E. dens-canis var. *grandiflorum:* Same as in *E. dens-canis* but less regular.

E. americanum: Same as in *E. dens-canis.*

E. grandiflorum: Same as in *E. dens-canis*

E. citrinum: Same as in *E. dens-canis.*

E. californicum: Same as in *E. dens-canis.*

Degree of Polarization.

E. dens-canis: Fair, somewhat variable.

E. dens-canis var. *grandiflorum:* Fair, slightly higher and more variable than in *E. dens-canis.*

E. americanum: Fair to fairly high, somewhat variable, slightly higher than in *E. dens-canis.*

E. grandiflorum: Low to fair, variable, lower than in *E. dens-canis.*

E. citrinum: Fair to fairly high, variable, higher than in *E. dens-canis.*

E. californicum: Rather low to fairly high, variable, on the whole higher than in *E. dens-canis.*

Polarization with Selenite—Quadrants and Colors.

E. dens-canis: Quadrants fairly well defined, often irregular, unequal in size. Colors not quite pure.

E. dens-canis var. *grandiflorum:* Quadrants the same as in *E. dens-canis.* Colors not quite pure.

E. americanum: Quadrants the same as in *E. dens-canis,* but more regular. Colors not quite pure.

E. grandiflorum: Quadrants the same as in *E. dens-canis,* but more regular. Colors not quite pure.

E. citrinum: Quadrants the same as in *E. dens-canis.* Colors not quite pure.

E. californicum: Quadrants the same as in *E. dens-canis.* Colors not quite pure, but better than in *E. dens-canis.*

IODINE REACTIONS.

Intensity and Color.

E. dens-canis: Fairly deep; blue-violet.

E. dens-canis var. *grandiflorum:* Fairly deep, the same as in *E. dens-canis;* blue-violet.

E. americanum: Fairly deep, slightly less than in *E. dens-canis;* blue-violet.

E. grandiflorum: Fairly deep, slightly more than in *E. dens-canis;* blue-violet.

Differentiation of Certain Starches of the Genus Erythronium.—Continued.

IODINE REACTIONS.—Continued.

Intensity and Color.—Continued.

E. citrinum: Fairly deep, less than in *E. dens-canis;* blue-violet.
E. californicum: Fairly deep, slightly less than in *E. dens-canis;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

E. dens-canis: Light.
E. dens-canis var. *grandiflorum:* Light, slightly more than in *E. dens-canis.*
E. americanum: Light, slightly more than in *E. dens-canis.*
E. grandiflorum: Light, slightly more than in *E. dens-canis.*
E. citrinum: Light, slightly more than in *E. dens-canis.*
E. californicum: Fair, much more than in *E. dens-canis.*

With Safranin.

E. dens-canis: Rather light.
E. dens-canis var. *grandiflorum:* Rather light, same as in *E. dens-canis.*
E. americanum: Rather light, same as in *E. dens-canis.*
E. grandiflorum: Rather light, more than in *E. dens-canis.*
E. citrinum: Rather light, slightly more than in *E. dens-canis.*
E. californicum: Fair, much more than in *E. dens-canis.*

TEMPERATURE OF GELATINIZATION.

E. dens-canis: 51.4 to 53.9° C., mean 52.65°.
E. dens-canis var. *grandiflorum:* 53.2 to 55.1° C., mean 54.05°.
E. americanum: 52.9 to 54° C., mean 53.45°.
E. grandiflorum: 52.1 to 54° C., mean 53.05°.
E. citrinum: 49.1 to 51.8° C., mean 50.45°.
E. californicum: 57.2 to 58.6° C., mean 57.9°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

E. dens-canis: Begins in all in 15 seconds; complete in all in 3 minutes.
E. dens-canis var. *grandiflorum:* Begins in most in 45 seconds; complete in all in 5 minutes.
E. americanum: Begins in most in 15 seconds; complete in all in 5 minutes.
E. grandiflorum: Begins in most in a few seconds; complete in all in 1¼ minutes.
E. citrinum: Begins in all in 20 seconds; complete in all in 3¾ minutes.
E. californicum: Begins in most in 30 seconds; complete in all in 5½ minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chromic Acid.

E. dens-canis: Begins at once; complete in all in 12 seconds.
E. dens-canis var. *grandiflorum:* Begins at once; complete in all in 20 seconds.
E. americanum: Begins at once; complete in all in 15 seconds.
E. grandiflorum: Begins at once; complete in less than 10 seconds.
E. citrinum: Begins at once; complete in all in 20 seconds.
E. californicum: Begins at once; complete in all in 25 seconds.

Reaction with Pyrogallic Acid.

E. dens-canis: Begins at once; complete in all in 12 seconds.
E. dens-canis var. *grandiflorum:* Begins at once; complete in all in 25 seconds.
E. americanum: Begins in a few seconds; complete in all in 30 seconds.
E. grandiflorum: Begins at once; complete in all in 10 seconds.
E. citrinum: Begins at once; complete in all in 25 seconds.
E. californicum: Begins in a few seconds; complete in all in 50 seconds.

Reaction with Ferric Chloride.

E. dens-canis: Begins in many in a few seconds; complete in all in 2 minutes.
E. dens-canis var. *grandiflorum:* Begins in a few in a few seconds; complete in all in 3½ minutes.
E. americanum: Begins in a few in 15 seconds; complete in all in 4 minutes.
E. grandiflorum: Begins in many in a few seconds; complete in all in 1¼ minutes.
E. citrinum: Begins in some in 15 seconds; complete in all in 3½ minutes.
E. californicum: Begins in many in 15 seconds; complete in all in 4½ minutes.

Reaction with Purdy's Solution.

E. dens-canis: Begins at once; complete in all in 15 seconds.
E. dens-canis var. *grandiflorum:* Begins at once; complete in all in 20 seconds.
E. americanum: Begins in a few seconds; complete in all in 20 seconds.
E. grandiflorum: Begins at once; complete in all within 10 seconds.
E. citrinum: Begins at once; complete in all in 10 seconds.
E. californicum: Begins in a few seconds; complete in all in 50 seconds.

NOTES ON THE STARCHES OF ERYTHRONIUM.

In histological features it will be observed that there are more or less marked variations in the different starches in relation to the characters of the outlines of the grains, the relative numbers of different types of grains, the peculiarities of the hilum, and fissuration and size, which, as a whole, are of diagnostic value. In their reactions the variations recorded in the responsivities with iodine, anilines, chromic acid, pyrogallic acid, and Purdy's solution are within narrow limits. The great sensitivity of all the starches to the chemical reagents makes the time of the reactions exceedingly short, all the reactions being complete within a few minutes. In the degree of polarization the range is from light to fair to fairly high; in the temperatures of gelatinization the range is from 50.45° to 57.9°; in the chloral hydrate-iodine reactions the limits are from 1¼ to 5½ minutes; in the ferric chloride reactions in 1¼ to 4½ minutes; and in the chromic acid, ferric chloride, and Purdy solutiom reactions within a minute. There is a close correspondence in the records of *E. dens-canis* and its variety *grandiflora*, and there appears to be a close relationship between these and *E. americanum*, which is in accord with botanical data. The former are European and the latter American.

GENUS HYACINTHUS.

Hyacinthus is a genus of bulbous plants which includes over 30 species and very many varieties, there being also hundreds of "named" garden forms. They are natives of Central Europe, Asia, and Africa. The common garden forms have had their origin in natives of the Mediterranean region. Quite a number of members of other genera of *Liliaceæ* are popularly known as hyacinths, as, for instance, certain species of *Scilla, Brodiæa, Muscari,* and *Camassia.* The water-hyacinth (*Eichhornia*) belongs to an entirely different family. The starches of three horticultural varieties were examined: *H. orientalis* var. *alba superbissima* Hort., which is probably a form of *H. orientalis* Linn.; and two kinds of the Roman hyacinths, the white and the Italian, both of which are probably forms of *H. orientalis* var. *albulus* Baker (*H. albulus* Jord., *H. romanus* Hort.).

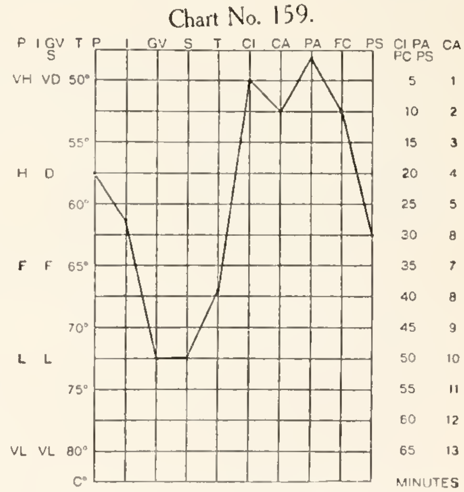
STARCH OF HYACINTHUS ORIENTALIS VAR. ALBA SUPERBISSIMA.

(Plate 41, figs. 241 and 242. Chart 159.)

Histological Characteristics.—In *form,* both simple and compound grains are present. Many aggregates are noted as doublets, triplets, or a larger number of components, the doublets often consisting of one large and one very small grain. Isolated grains with pressure facets are occasionally observed and there are a few small clumps. The surface of the simple grains is often irregular, owing chiefly to protuberances, some of which are in the form of secondary lamellæ, and some as rounded or nipple-like prominences. Protuberances are sometimes found on the compound grains. The conspicuous forms are ovoid, having a rounded proximal end and broadened and somewhat flattened at the distal end, ellipsoidal, nearly round, and pyriform. From this type transition forms to the clam-shell shape and mussel-shell shape, such as are found in *Muscari,* may be observed. There are also pyriform, conical, finger-shaped, triangular and quadrangular with rounded angles, dome-shaped, and various indefinite forms. When viewed on edge, many grains are seen to be narrower at the distal than at the proximal end.

The *hilum* is a large round or lenticular spot, eccentric about two-fifths to one-third, generally two-fifths, in all forms except the round. There are frequently 2 or more hila in a single grain. Very often fissures or cavities occur at the hilum. The fissuration may be noted as being in the form of a single transverse or longitudinal fissure, but usually both transverse and longitudinal fissures are present in the form of a cross or T. Irregular figures consisting of several short fissures, usually thorn-shaped or stellate, are also found. The fissures may be clean-cut or ragged. Fissures may be seen separating two hila in a single grain.

Chart No. 159.



Curve of Reaction-Intensities of Starch of Hyacinthus orientalis var. alba superbissima.

The *lamellæ* are quite coarse. They are distinct, complete rings near the hilum, and towards the margin and the distal end they tend to assume the form of the outlines of the grain and may be incomplete. There may be one but usually two very distinct lamellæ. In the latter case one is about one-third, the other about two-thirds of the distance from the hilum to the distal margin. There are about 12 to 14 lamellæ in the larger forms.

The grains vary in *size* from 3 to 34μ. The common size is 26 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric, except in the round forms. It is distinct and fairly clear-cut. Its lines are broad, somewhat broader towards the margin; they are usually straight, but may be bisected, bent, or otherwise distorted, the distortion probably being due to the presence of multiple component grains. Double figures are sometimes observed.

The degree of *polarization* is high. It varies in different grains, in different aspects of the same grain, and also in parts of the same aspect of a grain.

With *selenite* the quadrants are fairly well defined, usually somewhat irregular in shape, and unequal in size. The colors are mostly pure, though in quite a number the blue has a greenish tinge.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, which deepens rather slowly; with 0.125 per cent solution they color lightly at first and the color deepens rather slowly. After heating in water until all the grains are completely gelatinized, the solution colors a deep greenish-blue and the gelatinized grains a deep purplish-blue on the addition of iodine. After boiling for 2 minutes the solution colors very deeply an indigo-blue and the grain-residues a deep blue. The capsules all color a deep heliotrope to a wine-red with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once slightly and in 30 minutes they are fairly stained.

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained.

Temperature Reaction.—The temperature of gelatinization is 66° to 68° C., mean 67°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds. Practically all the grains are gelatinized in 5 minutes and all in 10 minutes. The reaction begins at the distal end and spreads around the margin, the more prominent portions of the latter becoming darker than the rest. These portions swell somewhat, and this process moves inward over the rest of the grain, the part about the hilum being the last to be affected. When the hilum is reached a bubble is often seen to form here, which increases in size, then becomes smaller, and finally disappears. The swollen grains are fairly large, of a uniform dark color, and retain some of their original shape.

The reaction with *chromic acid* begins at once. Some of the grains are dissolved in a minute, nearly all in 1½ minutes, and all in 2 minutes. The starch about the hilum becomes granular and gelatinous, and the part of the grain between the hilum and the distal end is divided by a number of longitudinal fissures and converted into an irregular mass; the rest of the grain shows a number of fine, radial striæ. The grain swells and a bubble appears at the hilum, which increases in size, then becomes smaller, and finally disappears. The granular mass in the interior of the grain becomes more and more gelatinous, and the more resistant starch is gathered at the margin in the form of a striated band or capsule, which shows two or three alternate refractive and non-refractive lines, apparently the remains of the lamellæ. This capsule becomes thin and transparent and is dissolved at the distal end or on one side. The gelatinous starch within the capsule flows out and is dissolved, the capsule dissolving later.

The reaction with *pyrogallic acid* begins immediately. Many grains are gelatinized in 10 seconds, almost all in 30 seconds, all but a few resistant grains in 40 seconds, and all in a minute. The starch about the hilum is transformed into a clear, semiliquid, gelatinized state; the grain becomes covered by fine striæ; and a bubble often appears at the hilum, which increases and then decreases in size, and finally disappears. The less resistant inner starch becomes gelatinous, attended by swelling of the whole grain, and the more resistant outer starch forms a thick, finely striated band at the margin, and this band or capsule becomes thinner and clearer and sometimes becomes invaginated just at the proximal end. The grains when fully swollen are large, the marginal band or capsule is rather thick, fairly transparent, and somewhat wrinkled and sacculated. They do not retain much of the original form of the grain.

With *ferric chloride* the reaction begins in some grains immediately. A few grains are gelatinized in a minute, the majority in 5 minutes, and nearly all in 10 minutes. The rare very resistant grains are not fully gelatinized until 15 to 20 minutes. The reaction begins at the distal end, which is fissured internally in one or two places, and the starch which is gelatinized at these points protrudes beneath the capsule. This process spreads to all parts of the distal end and nearby portions of the grain, and from here it extends upward and inward over the rest of the grain. A bubble in the meanwhile forms at the hilum, and as the reaction nears this point the bubble increases and then decreases in size and finally disappears. The portion of starch as yet ungelatinized is divided by fissures into two or three parts which become widely separated by bands of gelatinized starch, and then themselves become gelatinized independently of each other. The gelatinized grains are very large, sacculated, folded, and distorted. They do not retain much of the original form.

Reaction with *Purdy's solution* begins in some grains at once and in all in a minute. In 15 minutes all are partially gelatinized and in 30 minutes all are completely or nearly completely gelatinized. As far as the reaction goes, it appears to be the same qualitatively as that with pyrogallic acid.

STARCH OF HYACINTHUS ORIENTALIS VAR. ALBULUS (WHITE).

(Plate 41, figs. 243 and 244. Chart 160.)

Histological Characteristics.—In *form* both simple and compound grains are present. There are many aggregates, usually consisting of two to five components. Isolated grains with pressure facets are occasionally found, and a few small clumps are observed. The outline of the grain is occasionally irregular, which is chiefly due to the presence of secondary sets of lamellæ placed at varying angles to the primary set, and to one or more small rounded protuberances or nipple-like processes due to irregular development of the primary grain. The conspicuous forms are ovoid, often with squared and flattened distal end, almost clam-shell-shaped, pyriform, ellipsoidal, and nearly round. There are also ovoid with pointed distal end, imperfect rhomboidal, and dome-shaped grains. When viewed on edge some of the grains are narrower at the distal than the proximal end. There are more of the almost clam-shell-shaped grains than in *H. orientalis* var. *alba superbissima.*

The *hilum* may be observed as a distinct, round or lenticular, refractive spot which is usually two-fifths to one-third eccentric. In the round forms it is centric. The hilum is often fissured, and these fissures are of similar character and arrangement and occur in about as great a proportion of grains as in *H. orientalis* var. *alba superbissima.*

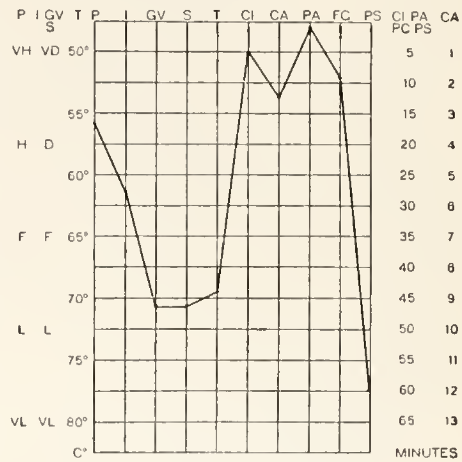
The *lamellæ* are of similar character and arrangement to those of *H. orientalis* var. *alba superbissima.* There are about 12 to 14 in the larger grains.

The grains vary in *size*; the smaller are 3 by 2μ, the larger are 46 by 30μ; the common size is 22 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric. The centric figure is less frequent than in *H. orientalis* var. *alba superbissima.* The lines are more often bent, and the double or multiple figure is not so clearly marked.

The degree of *polarization* is high. There is the variation among the grains noted for *H. orientalis* var. *alba superbissima,* but there is not so large a proportion in which polarization is very high. The variation in the same aspect of a given grain is the same as that noted for *H. orientalis* var. *alba superbissima.*

Chart No. 160.



Curve of Reaction-Intensities of Starch of Hyacinthus orientalis var. albulus (white).

With *selenite* the quadrants are fairly well defined, usually somewhat irregular in shape, and unequal in size. The quadrants are not quite so clean-cut, and in rather more grains they are irregular in shape and unequal in size than in *H. orientalis* var. *alba superbissima.* The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather deep blue-violet, which deepens gradually, the smaller grains becoming deeper than the larger ones. The color is about the same as in *H. orientalis* var. *alba superbissima.* With 0.125 per cent solution the grains color a light blue-violet which deepens rather rapidly. The tint is about the same as in *H. orientalis* var. *alba superbissima.* After heating in water until all the grains are gelatinized, the solution colors a deep blue and the grains a bright blue on the addition of iodine. The color of the solution is deeper and that of the grains a purer blue than in *H. orientalis* var. *alba superbissima.* If the grains are boiled for 2 minutes and then treated with iodine, the solution becomes a deep blue with a reddish tint and the grain-residues a light, pure blue. With an excess of iodine the capsules color a deep heliotrope to a wine red. There are not so many capsules of the latter color as in *H. orientalis* var. *alba superbissima.*

Staining Reactions.—With *gentian violet* the grains color slightly at once and in 30 minutes are fairly colored. The tint is slightly deeper than in *H. orientalis* var. *alba superbissima.*

With *safranin* the grains show a faint trace of color at once and in 30 minutes are fairly deep. The color is slightly deeper than in *H. orientalis* var. *alba superbissima.*

Temperature Reaction.—The temperature of gelatinization is 68° to 70° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in a minute, the majority in 3 minutes, and all but rare resistant grains in 5 minutes. The reaction is usually complete in the latter within 10 to 15 minutes, rarely 20 minutes. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

With *chromic acid* reaction begins at once. Some grains are dissolved in a minute, nearly all in 1½ minutes, and all in 2½ minutes. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

The reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 10 seconds, the majority in 30 seconds, and all in 45 seconds. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

Reaction with *ferric chloride* begins at once. A few grains are gelatinized in a minute, the majority in 3 minutes, about nine-tenths in 5 minutes, and all but rare resistant grains in 8 minutes. The reaction is complete in these in 15 to 17 minutes. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

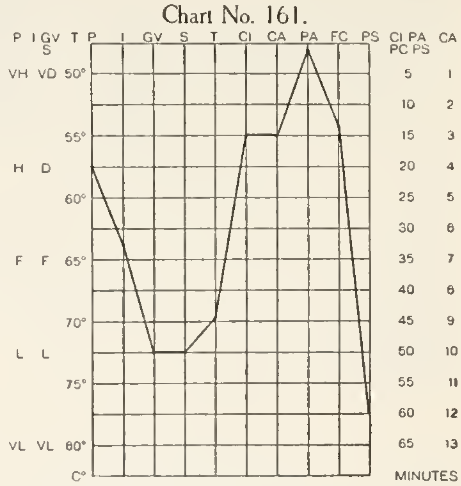
With *Purdy's solution* the reaction begins immediately and a few grains are gelatinized in 30 minutes. The larger grains are completely, and all the smaller partially, gelatinized in 15 minutes; and three-fourths are gelatinized in 30 minutes. There is practically no further progress in an hour. The medium-sized grains with regular outline are the most resistant. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

STARCH OF HYACINTHUS ORIENTALIS VAR. ALBULUS (ITALIAN).

(Plate 41, figs. 245 and 246. Chart 161.)

Histological Characteristics.—In *form* both simple and compound grains are present, with many aggregates consisting usually of from two to five components. Isolated grains with pressure facets are occasionally found, and a few small clumps are observed. The outline of the grain is occasionally irregular, which is chiefly due to the presence of a secondary set of lamellæ placed at varying angles to the primary set, and rarely to one or more protuberances, rounded or nipple-like, found on the surface. The conspicuous forms are ovoid, ovoid with squared distal end, nearly round, ellipsoidal, and pyriform. There are also grains with rounded proximal end and broadened, flattened distal end, some of which approach the clam-shell type, ovoid with pointed distal end, and dome-shaped. When viewed on edge some of the grains are narrower at the distal than the proximal end. There are not so many grains of the transition form to the clam-shell type, nor so many doublets consisting of one large grain and a minute rounded grain, as in *H. orientalis* var. *alba superbissima.*

Chart No. 161.



Curve of Reaction-Intensities of Starch of Hyacinthus orientalis var. albulus (Italian).

There is usually either a cleft or a small cavity at the *hilum.* Rarely the hilum may be observed as a round refractive spot. It is usually two-fifths to one-third eccentric. In the round forms it is centric. Sometimes 2 or more hila, without demonstrable lamellæ around each, may be observed in a single grain. The fissures are of the same character and arrangement as those noted for *H. orientalis* var. *alba superbissima,* but are found in more grains and the cruciate form is more often observed.

The *lamellæ* are usually quite coarse, and they are less coarse and distinct near the hilum than in other parts of the grain. When demonstrable near the hilum they are observed to form complete rings, but towards the distal end and the sides they follow the outline of the grain and are probably incomplete. One rather coarse, refractive lamella is frequently observed at varying distances from the hilum. There are 10 to 12 lamellæ in the larger grains.

The grains vary in *size;* the smaller are 4 by 3μ; the larger are 32 by 24μ in length and breadth. The common size is 20 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric. The arrangement and character of the lines is the same as in *H. orientalis* var. *alba superbissima,* except that the double and multiple figures are not so clearly marked and the lines are more frequently bent.

The degree of *polarization* is high. There is a variation in the different grains, as well as sometimes in the same aspect of a given grain. It is about the same as in *H. orientalis* var. *alba superbissima.*

With *selenite* the quadrants are fairly well defined, usually somewhat irregular in shape, and unequal in size. The quadrants are not quite so clear-cut, and in rather more grains they are irregular and unequal than in *H. orientalis* var. *alba superbissima.* The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet which deepens gradually, some grains becoming much deeper than others. The color is lighter and a little more reddish than the grains of *H. orientalis* var. *alba superbissima,* and there is also a much greater variation in the depth of tint of the different grains. With 0.125 per cent solution the grains color a light reddish-violet, which deepens gradually, some grains becoming much deeper than others. After heating in water until all the grains are gelatinized, the solution colors a fairly deep blue and the grains a purplish-blue on the addition of iodine. If the grains are boiled for 2 minutes and then treated with iodine, the solution becomes colored quite deeply and the grain-residues a fairly bright and pure blue. With an excess of iodine the capsules color a deep red-violet to a deep heliotrope, rarely a wine-red. The color is not quite so red as in *H. orientalis* var. *alba superbissima.*

Staining Reactions.—With *gentian violet* the grains color very slightly at once and in 30 minutes are fairly stained. The tint is about the same as in *H. orientalis* var. *alba superbissima.*

With *safranin* the grains show a faint trace of color at once and in 30 minutes are fairly deeply stained. The color is about the same as in *H. orientalis* var. *alba superbissima.*

Temperature Reaction.—The temperature of gelatinization is 69° to 70° C., mean 69.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in a minute, the majority in 5 minutes, about nine-tenths in 10 minutes, and all but rare resistant grains in 15 minutes. The reaction is complete in the latter usually in from 17 to 20 minutes, rarely as long as 24 minutes. The most resistant grains are the small ones with regular outline. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

Reaction with *chromic acid* begins at once. A few grains are gelatinized in 1¼ minutes, the majority in 2 minutes, and all in 3 minutes. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

The reaction with *pyrogallic acid* begins at once. Many are gelatinized in 30 seconds, and all in a minute. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

With *ferric chloride* the reaction begins immediately. A few grains are gelatinized in 1½ minutes, the majority in 5 minutes, about nine-tenths in 10 minutes, and all but rare resistant grains in 13 minutes. The reaction is complete in the latter in from 16 to 18 minutes, rarely as long as 25 minutes. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

Reaction with *Purdy's solution* begins immediately. A few grains are gelatinized in 30 seconds, all are partially gelatinized in 15 minutes, and about two-thirds are almost completely gelatinized in 30 minutes, while in the remainder the hilum is swollen and usually one or more delicate fissures proceed from it. The reaction is incomplete at the end of an hour. The medium-sized grains with regular outline are the most resistant. The reaction is qualitatively the same as in *H. orientalis* var. *alba superbissima.*

Differentiation of Certain Starches of the Genus Hyacinthus.

Histological Characteristics.

Conspicuous Forms.

H. orientalis var. *alba superbissima:* Simple and compound, pressure facets occasionally observed, surface often irregular owing to protuberances in the form of secondary lamellæ, and rounded and nipple-like prominences. Ovoid having a rounded proximal end and broadened somewhat flattened distal end, ellipsoidal, nearly round and pyriform.

H. orientalis var. *albulus* (white): Essentially the same as in *H. orientalis* var. *alba superbissima.* Clam-shell type more numerous.

H. orientalis var. *albulus* (Italian): Essentially the same as in *H. orientalis* var. *alba superbissima,* but of clam-shell type, and fewer doublets consisting of a large and a small grain.

Hilum—Form, Number, and Position.

H. orientalis var. *alba superbissima:* Form large, round or lenticular, often a cavity, often fissured; fissures single or cross or irregular, thorn-shaped or stellate. Position eccentric about 0.40 to 0.33, except in the round forms, in which it is centric.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.—Continued.

H. orientalis var. *albus* (white): Form the same as in *H. orientalis* var. *alba superbissima.* Position eccentric about 0.40 to 0.33, except in the round forms, where it is centric.

H. orientalis var. *albus* (Italian): Form the same as in *H. orientalis* var. *alba superbissima,* except fissuration and cruciate form more common. Position eccentric about 0.40 to 0.33, except in the round forms, where it is centric.

Lamellæ—General Characteristics and Number.

H. orientalis var. *alba superbissima:* Coarse distinct rings at hilum tend to have form of outline of grain and may be incomplete elsewhere; 1 or 2 lamellæ usually very distinct. About 12 to 14 on larger grains.

H. orientalis var. *albulus* (white): Same as in *H. orientalis* var. *alba superbissima.* About 12 to 14 on larger grains.

H. orientalis var. *albulus* (Italian): Quite coarse, otherwise essentially the same as in *H. orientalis* var. *alba superbissima.* About 10 to 12 on larger grains.

Differentiation of Certain Starches of the Genus Hyacinthus.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Size.

H. orientalis var. *alba superbissima:* From 3 to 34μ, commonly 26μ.
H. orientalis var. *albulus* (white): From 3 to 46μ, commonly 22μ.
H. orientalis var. *albulus* (Italian): From 4 to 32μ, commonly 20μ.

POLARISCOPIC PROPERTIES.

Figure.

H. orientalis var. *alba superbissima:* Eccentric, except in the ovoid forms, fairly clear-cut lines broad, usually straight. Double and multiple figures may be observed.
H. orientalis var. *albulus* (white): Essentially the same as in *H. orientalis* var. *alba superbissima,* but the centric figure is less frequent, the lines more often bent, and the double and multiple figures not so distinct.
H. orientalis var. *albulus* (Italian): Same as in *H. orientalis* var. *albulus* (white).

Degree of Polarization.

H. orientalis var. *alba superbissima:* High.
H. orientalis var. *albulus* (white): High, the same as in *H. orientalis* var. *alba superbissima,* but with larger proportion of grains in which polarization is very high.
H. orientalis var. *albulus* (Italian): High, about the same as in *H. orientalis* var. *alba superbissima.*

Polarization with Selenite—Quadrants and Colors.

H. orientalis var. *alba superbissima:* Quadrants fairly well defined, usually somewhat irregular in shape and unequal in size. Generally pure.
H. orientalis var. *albulus* (white): Quadrants fairly well defined, not quite so clear-cut and rather more irregular than in *H. orientalis* var. *alba superbissima.* Generally pure.
H. orientalis var. *albulus* (Italian): Quadrants essentially the same as in *H. orientalis* var. *albulus* (white). Generally pure.

IODINE REACTIONS.

Intensity and Color.

H. orientalis var. *alba superbissima:* Fairly deep; blue-violet.
H. orientalis var. *albulus* (white): Fairly deep, about the same as in *H. orientalis* var. *alba superbissima;* blue-violet.
H. orientalis var. *albulus* (Italian): Fairly deep, lighter and a little more reddish than *H. orientalis* var. *alba superbissima;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

H. orientalis var. *alba superbissima:* Light.
H. orientalis var. *albulus* (white): Light, slightly deeper than in *H. orientalis* var. *alba superbissima.*
H. orientalis var. *albulus* (Italian): Light, about the same as in *H. orientalis* var. *alba superbissima.*

STAINING REACTIONS.—Continued.

With Safranin.

H. orientalis var. *alba superbissima:* Light.
H. orientalis var *albulus* (white): Light, slightly deeper than in *H. orientalis* var. *alba superbissima.*
H. orientalis var. *albulus* (Italian): Light, about the same as in *H. orientalis* var. *alba superbissima.*

TEMPERATURE OF GELATINIZATION.

H. orientalis var. *alba superbissima:* 66 to 68° C., mean 67°.
H. orientalis var. *albulus* (white): 68 to 70° C., mean 69°.
H. orientalis var. *albulus* (Italian): 69 to 70° C., mean 69.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

H. orientalis var. *alba superbissima:* Begins in 30 seconds; complete in nearly all in 5 minutes.
H. orientalis var. *albulus* (white): Begins immediately; complete in nearly all in 5 minutes.
H. orientalis var. *albulus* (Italian): Begins immediately; complete in the majority in 5 minutes, and nearly all in 15 minutes.

Reaction with Chromic Acid.

H. orientalis var. *alba superbissima:* Begins at once; complete in nearly all in 1½ minutes, and in all in 2 minutes.
H. orientalis var. *albulus* (white): Begins at once; complete in nearly all in 1½ minutes, and in all in 2½ minutes.
H. orientalis var. *albulus* (Italian): Begins at once; complete in the majority in 2 minutes, and in all in 3 minutes.

Reaction with Pyrogallic Acid.

H. orientalis var. *alba superbissima:* Begins at once; complete in nearly all in 30 seconds, and in all in 60 seconds.
H. orientalis var. *albulus* (white): Begins at once; complete in a majority in 30 seconds, and in all in 45 seconds.
H. orientalis var. *albulus* (Italian): Begins at once; complete in many in 30 seconds, and in all in 60 seconds.

Reaction with Ferric Chloride.

H. orientalis var. *alba superbissima:* Begins at once; complete in nearly all in 10 minutes.
H. orientalis var. *albulus* (white): Begins at once; complete in nearly all in 8 minutes.
H. orientalis var. *albulus* (Italian): Begins at once; complete in nearly all in 13 minutes.

Reaction with Purdy's Solution.

H. orientalis var. *alba superbissima:* Begins at once; nearly complete in all in 30 minutes; incomplete in 1 hour.
H. orientalis var. *albulus* (white): Begins at once; complete or nearly complete in three-fourths in 30 minutes; incomplete in 1 hour.
H. orientalis var. *albulus* (Italian): Begins at once; complete or nearly complete in two-thirds in 30 minutes; incomplete in 1 hour.

NOTES ON THE STARCHES OF HYACINTHUS.

The starches examined were obtained from varieties or forms of the common hyacinth (*H. orientalis* Linn.), and are so alike in their histological properties that it would be very difficult or impossible to make a diagnosis upon this basis. They also closely agree in their reactions, yet vary sufficiently and individually to make possible the differentiation of one from another.

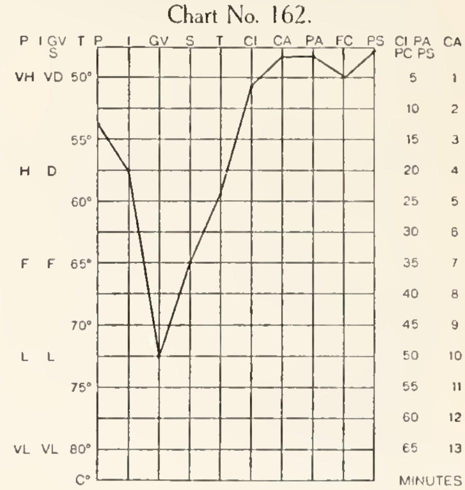
GENUS GALTONIA.

This genus consists of three species of hardy, bulbous plants, native of the Cape of Good Hope, and known as giant summer hyacinths. The genus differs from *Hyacinthus* chiefly by the larger number and the flattened character of the seeds. *G. candicans* Decne. (*Hyacinthus candicans* Baker), the best-known species, was used as the source of starch.

STARCH OF GALTONIA CANDICANS. (Plate 42, figs. 247 and 248. Chart 162.)

Histological Characteristics.—In *form* the grains are both simple and compound, the latter being double and multiple. There are a great many aggregates, and among them triplets and multiples are frequently observed. No pressure facets were found on the isolated grains. There are very few small clumps. The surface is often very irregular and quite varied, due in part to the presence of protuberances, rounded or nipple-like, either at the distal or proximal end, or both; and also in part to lamellated additions of varying sizes to the sides or at the distal end, these additions forming an angle with the longitudinal axis of the grain. Owing to the latter a primary oval grain is frequently transformed into a triangular form with rounded angles, or into some irregular form. Furthermore, sometimes there are irregular depressions on the margin of the grain. The multiple grains are often triangular with rounded angles, and may also have irregular depressions and projections; the triplets have usually a rounded triangular form. The conspicuous forms of the simple grains are rounded oval, ovoid, elongated ovoid, rounded oval at the proximal end and elongated and flattened at the distal end, pyriform, ellipsoidal, round, broadened, and elongated, mussel-shell-shaped, and various irregular forms.

Chart No. 162.



Curve of Reaction-Intensities of Starch of Galtonia candicans.

The *hilum* is a fairly large round or oval spot, centric in the round forms, and usually eccentric two-fifths to one-sixth, generally one-third, in the other forms. There are 2, and often more, hila in a single grain. The hilum usually is not fissured. Rarely one or more fissures are found which are often ragged; also occasionally an irregular cavity may be seen at the hilum.

The *lamellæ* are distinct, rather coarse, complete rings or ellipses around the hilum. They are finer, and probably incomplete, near the distal margin, towards which end they assume the shape of the grain and are often quite irregular. Some forms have an especially distinct lamella at about one-half or one-third of the distance between the hilum and distal end. There are 12 to 14 lamellæ in the larger grains.

The grains are 5 to 74μ in *size*. The common size is 39 by 26μ in length and breadth. The large round forms are about 34μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and fairly clear-cut. In some forms the lines are thick, generally more or less distorted by bends, variations in width, and bisection.

The degree of *polarization* is high. It is variable, ranging from very high in the largest forms to fair in the smallest grains. It often varies in the same aspect of a given grain.

With *selenite* the quadrants are fairly well defined, generally very irregular in shape, and unequal in size. In most of the grains the colors are bright and pure, but in some there is a greenish tinge.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep indigo; with 0.125 per cent solution they color fairly and the color deepens rapidly. After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. With an excess of iodine all the capsules color violet with a distinct tinge of red.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes they are lightly stained.

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 57.8° to 59.5° C., mean 58.65°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 15 seconds. Nearly all the grains are gelatinized in 3 minutes and all in 7 minutes. The distal end, or points on the margin distant from the hilum, grow dark and the color spreads all around the margin and over the inner area of the grain. Then the points at which the reaction began grow still darker as the starch gelatinizes and swells. This process proceeds inwardly over the grain until it reaches the hilum, where a bubble is seen to form, and to increase and then decrease in size, and finally disappear when the entire grain has become swollen and darkened. The swollen grains are rather large, uniformly dark in color, and retain some of the original form of the grain.

The reaction with *chromic acid* begins at once and is over in 20 seconds. It is so rapid that the different steps can not clearly be made out. The starch within the grain is changed into a gelatinous mass, and a bubble forms at the hilum, which first increases to a very large size, then decreases, and finally disappears. The grain swells to a great size, and an invagination then occurs, usually at the area at one time occupied by the hilum. The thin capsule is dissolved at the distal end, and the inner gelatinized starch flows out and is entirely dissolved, followed by solution of the remainder of the capsule.

Reaction with *pyrogallic acid* begins in a few seconds and is over in 2 minutes. The starch about the hilum is gelatinized, and the space between the hilum and the distal end becomes divided by a number of internal, longitudinal fissures into a granular mass which is pushed down to the distal end as the proximal end and central part of the grain increase in size. The resistant starch forms a broad striated band at the margin, and this is pushed in or invaginated at the proximal end. The granular mass at the distal end finally disappears and the marginal band becomes fairly thin and transparent. The swollen grains are large, folded, and sacculated at the distal end, and fairly smooth but invaginated at the proximal end. They do not retain much of the original form.

The reaction with *ferric chloride* begins in some grains in 30 seconds. It is complete in nearly all in 4 minutes, and in all in 5 minutes. The points on the margin most distant to the hilum begin to gelatinize with much swelling and consequent protrusion. This process spreads around the margin. It often begins at the margin of the proximal end before this point is reached by the reaction from the distal end or other points. The ungelatinized central portion becomes invaded by internal fissures, and often a bubble forms at the hilum which increases and then decreases in size, and finally disappears. Internal fissures cause the central part to be divided into several portions separated from one another by bands of gelatinous starch, and hence are forced apart and gelatinize independently of one another. The swollen grains are large, very irregular in outline, and do not retain any of their original outline.

With *Purdy's solution* the reaction begins in a very few seconds and is over in 25 seconds. It is the same qualitatively, but the gelatinized grains are larger and thinner-walled than in the reaction with pyrogallic acid.

GENUS MUSCARI.

The *Muscari*, grape, globe, or musk hyacinths, closely resemble the true hyacinths, the chief differences being in the former of smaller flower clusters, smaller individual flowers, and of the globose or urn shape of the flowers. There are about 40 species, all native of Europe, Western Asia, and Northern Africa. The common garden form of the grape hyacinth is *M. botryoides*, whose clusters of flowers resemble a bunch of grapes, as is indicated by the name of the species. The starches from 8 species were studied, including the following: *M. botryoides* Mill (*Hyacinthus botryoides*), *M. paradoxum* C. Koch, *M. micranthum* Baker, *M. commutatum* Guss, *M. comosum* Mill, *M. racemosum* Mill (*Hyacinthus racemosus* Hort.), *M. compactum* Baker, and *M. conicum* Baker.

STARCH OF MUSCARI BOTRYOIDES. (Plate 42, figs. 249 and 250. Chart 163.)

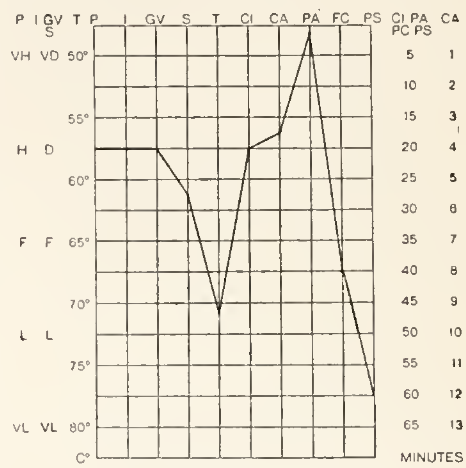
Histological Characteristics.—In *form* the grains are mostly simple and generally isolated. A few compound grains and aggregates are observed, both consisting usually of two components. Occasionally isolated grains with one or more pressure facets are observed. The surface is usually quite regular. Occasionally the grains have rounded or somewhat pointed protuberances, mostly at the distal end, sometimes lateral or proximal. As a rule, the point of union of these projections with the body of the grain is marked by a distinct fissure or linear depression. They appear to be in the nature of a small grain of the doublet in process of formation. The doublets usually consist of combinations of such large and small grains, or the two grains are occasionally of equal size.

The conspicuous forms are round, oval to ovoid, and transitional to clam-shell shape. When the large, ovoid grains are viewed on edge, some appear to be rounded wedge-shaped and others flattened ellipses, or somewhat lenticular.

The *hilum* is a distinct, fairly large, round or oval spot, centric in the round forms and eccentric about one-third to two-fifths of the longitudinal axis in the oval, ovoid, and mussel-shell-shaped forms. Sometimes it is double. The hilum is rarely fissured, and the fissure is short, transverse or longitudinal, clear-cut.

The *lamellæ* are fairly distinct, fine, regular, and complete. Those near the hilum are usually circular, but as they are located nearer the margin they assume the form of the outline of the grain. In the shell-shaped, ovoid, and oval grains the lamellæ are usually more distinct near the margin and at the distal end than near the hilum. A very few at the distal end of the shell-shaped forms appear to be incomplete. There are 10 to 14 on a single grain.

Chart No. 163.



Curve of Reaction-Intensities of Starch of Muscari botryoides.

The grains vary in *size* from 3 to 50μ. The common size is 20 by 28μ in length and breadth.

Polariscopic Properties.—The *figure* is slightly eccentric or centric, distinct, and fairly clear-cut. Its lines are rather thick and become thicker towards the margin. They are usually straight, but sometimes slightly bent, and occasionally bisected.

The degree of *polarization* is high. It varies somewhat in different parts of the same grain, and is higher when the grain is viewed on edge or end.

With *selenite* the quadrants are fairly well defined and are of about the same shape, but vary in size in some forms. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep violet-blue; with 0.125 per cent solution they color fairly and the color deepens rapidly. After heating in water until all the grains are completely gelatinized, the solution colors deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues deeply or fairly. The capsules color a reddish-violet on the addition of an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained.

Temperature Reaction.—The temperature of gelatinization is 70° to 72° C., mean 71°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 45 seconds, about three-fifths are gelatinized in 7 minutes, four-fifths in 15 minutes, and all in 20 minutes. The reaction begins at the margin of the distal end, which darkens and swells very slightly, and from this point the reaction spreads all around the margin and then inward until all of the grain is affected. The grain does not swell very much until the starch of the inner portion reacts, when it swells moderately. There did not appear to be any very sharp line of demarcation between the gelatinized and ungelatinized portions of the grain during the progress of the reaction. The swollen grains are fairly large, of a uniform dark color, and retain some of the original form.

Reaction with *chromic acid* begins in some grains at once, in all in 15 seconds, and it is over in 3½ minutes. The starch just above the hilum begins to pass into a gelatinous mass, and the rest of the grain becomes divided by fine striæ radiating from the hilum, which striæ, as the grain swells, become coarser and more distinct. The less resistant starch is gelatinized, while the more resistant forms a broad band at the margin, which is striated and uneven on its inner border and shows the remains of lamellæ, especially at the distal end. Outside of this striated band there is a thin, transparent envelope capsule which expands and becomes separated from the rest of the starch forming the band. This capsule is dissolved at one point and the mass of the grain with its striated band is partially extruded through this opening. The band also dissolves at one point, the gelatinized starch flows out and is completely dissolved, and the rest of the capsule and band also dissolve later.

The reaction with *pyrogallic acid* begins at once and gelatinization is complete in 1¼ minutes. The starch about the hilum is changed into a gelatinous mass, the lamellæ grow indistinct, and the grain becomes marked by fine striæ, which radiate in all directions from the hilum. The less resistant starch is gelatinized, while the more resistant forms a thick, finely striated, dense band at the margin, which slowly becomes thinner, less dense, and clearer as the grain swells, until it is a thin, transparent capsule. The completely swollen grains are large and do not retain much of their original form, and the capsules are folded, crumpled, and wrinkled.

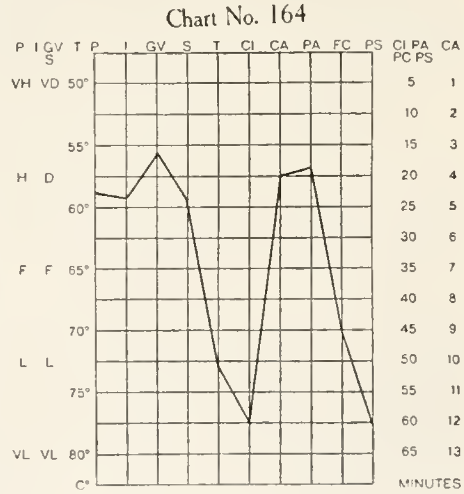
Reaction with *ferric chloride* begins in a few grains in a minute. About three-fourths are completely gelatinized in 11 minutes, nearly all in 27 minutes, and all in 40 minutes. The reaction begins at the distal end, which is internally fissured at one or two points, from which fissures gelatinized starch protrudes, forcing out the capsule. The fissures widen as more starch becomes gelatinized, and then the starch at the margin of this end is gelatinized. The reaction then spreads upward and inward, and often when it has extended about half of the distance between the hilum and the distal end the hilum swells rapidly, together with the proximal end, into a large, smooth projection. The small central portion of the grain that has remained ungelatinized is completely surrounded by gelatinized starch, but also becomes gelatinized. The capsules are very large, distorted, and wrinkled, and do not retain much of the original form of the grain.

With *Purdy's solution* the reaction begins in some grains in 30 seconds and in most grains in 2 minutes. About two-thirds of the grains are partially gelatinized in 8 minutes, and three-fourths in 20 minutes. The reaction appears to be the same qualitatively as that with pyrogallic acid.

STARCH OF MUSCARI PARADOXUM. (Plate 42, figs. 251 and 252. Chart 164.)

Histological Characteristics.—In *form* the grains are usually simple and for the most part isolated. There are a few compound grains and a number of small aggregates, consisting generally of one large grain with one or more small, adherent grains, one of which is frequently very minute. One or more pressure facets are occasionally found on the isolated grains. The outline of the grains is commonly irregular. The conspicuous forms are round, oval to ovoid, with transition forms to clam-shell-shaped grains; when viewed on edge they are flattened ellipses, or lenticular, or somewhat wedge-shaped. These grains vary more in outline, the hilum is usually fissured, and there is a greater tendency to the oval type than in *M. botryoides*.

Chart No. 164



Curve of Reaction-Intensities of Starch of Muscari paradoxum.

The *hilum* is a round or oval spot, centric on the round grains, and eccentric two-fifths to one-third of the longitudinal axis in the other forms; sometimes two or more hila occur in a single grain. The hilum is usually fissured; one transverse, one longitudinal, or two or more fissures may intersect each other, often forming a cross, but sometimes the arrangement is stellate or irregular. The fissures may be straight, curved, or ragged; they may appear without connection with the hila.

The *lamellæ* are rather distinct, coarse, complete rings or ellipses when located near the hilum. About three-fourths the distance from the hilum there is commonly a very distinct, coarse lamella. Those near the distal end are finer and less distinct, and probably discontinuous in the forms approaching the mussel-shell shape. Those near the distal end and margin take the form of the grain; they are also more irregular here than near the hilum. There are 6 to 10 lamellæ on a single grain.

The grains vary in *size* from 6 to 43μ. The common size is 24 by 29μ in length and breadth.

Polariscopic Properties.—The *figure* is either centric or slightly eccentric, usually distinct, but not clear-cut. The lines are generally straight and rather thick, becoming somewhat thicker towards the margin. They are occasionally bisected or slightly bent in the larger irregular forms.

The degree of *polarization* is high. It varies in the large grains from quite high to rather low, in the smallest grains being usually rather low. It varies in different parts of the same aspect of a given grain.

With *selenite* the quadrants in the smallest grains, and in some of the large, are fairly well defined, quite regular in shape, and equal in size. In other grains, especially the largest ones, they are frequently irregular in shape and unequal in size. In some forms the colors are pure, while in others they appear mixed.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly. The color is slightly less than that of the grains of *M. botryoides.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the swollen grains deeply on the addition of iodine. After boiling for 2 minutes, the solution colors deeply and the grain-residues deeply, lightly, or not at all. The capsules color a reddish-violet with a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are fairly deeply stained. The color is slightly deeper than that of *M. botryoides.*

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained. The color is deeper than that of *M. botryoides.*

Temperature Reaction.—The temperature of gelatinization is 72° to 74° C., mean 73°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in about half the grains in 45 seconds. About half of the grains are gelatinized in 15 minutes, three-fourths in 30 minutes, and four-fifths in 40 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *chromic acid* begins in all the grains in 30 seconds and is over in 4 minutes. It is the same qualitatively as that of the grains of *M. botryoides.*

Reaction with *pyrogallic acid* begins in some grains in 45 seconds and in all in 1½ minutes. About one-half are partially and one-half completely gelatinized in 7 minutes, and all are completely gelatinized in 18 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

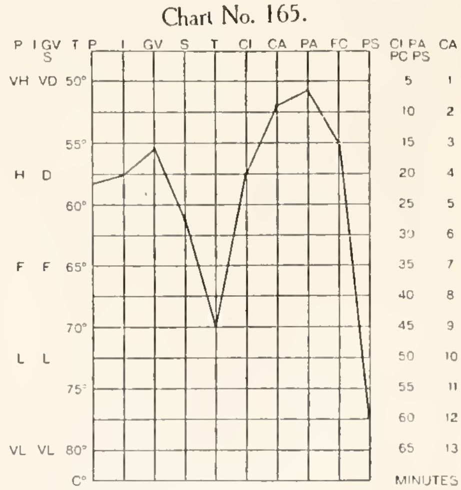
With *ferric chloride* the reaction begins in a few grains in a minute. It is over in four-fifths in 30 minutes, and in all in 45 minutes. It is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *Purdy's solution* begins in most grains in a minute and about one-fifth are partially gelatinized in 10 minutes without further important effect in an hour. The reaction is qualitatively the same as that of the grains of *M. botryoides.*

STARCH OF MUSCARI MICRANTHUM. (Plate 43, figs. 253 and 254. Chart 165.)

Histological Characteristics.—In *form* the grains are usually simple and for the most part isolated. There are a few compound grains in the form of doublets, and also a number of aggregates in the form of doublets, and also some clumps. As a rule, the surface of the grains is quite regular. The conspicuous forms are round, oval to ovoid, with some transitions from the ovoid with one margin flattened, to the triangular with rounded corners, and to the clam-shell-shaped grains. Some ovoid grains are squared at the distal end. The mussel-shell-shaped forms often show indentations at the distal margin. Isolated grains occasionally have one or more pressure facets. When on edge they are flattened ellipses, or somewhat lenticular, or wedge-shaped. The grains bear close general resemblances to those of *M. botryoides*, but are smaller, and comparatively frequently fissured.

Chart No. 165.



Curve of Reaction-Intensities of Starch of Muscari micranthum.

The *hilum* appears as a round or oval spot, centric in the rounded grains and eccentric in the other forms from one-fourth to four-ninths, commonly one-third, of the longitudinal axis. The hilum is sometimes fissured. The fissure may be a transverse or longitudinal straight or curved line; or two fissures may be present and form a cross; or fissures may radiate from the hilum, frequently three in number, or multiple fissures may form a stellate figure in the region of the hilum. Two hila may be seen separated by a short, transverse fissure. Crescent-shaped fissures may occasionally be noted, but apparently without connection with the hilum.

The *lamellæ* are rather fine, fairly distinct, complete rings near the hilum, more distinct but finer near the margin and distal end; usually regular, but sometimes irregular near the distal margin;

and usually one very prominent lamella about one-third the distance between the hilum and distal end. There are about 14 lamellæ on the larger grains.

The grains vary in *size* from 4 to 34μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and fairly clear-cut. Its lines are straight and rather thick, becoming somewhat thicker towards the margin.

The degree of *polarization* is high. It ranges from high in the large grains to fair in the smallest grains. It varies sometimes in the same aspect of a given grain.

With *selenite* the quadrants in the small grains are fairly well defined, quite regular in shape, and about equal size. In some of the large grains they are slightly irregular in shape, with variations in size. The colors are bright and pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens quickly. The color is not quite so deep as that of the grains of *M. botryoides.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues deeply, lightly, or not at all. The capsules all color a reddish-violet on the addition of an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly deeply stained, more than those of *M. botryoides.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained, the same as those of *M. botryoides.*

Temperature Reaction.—The temperature of gelatinization is 68.5° to 70° C., mean 69.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in many grains in 30 seconds. About half are gelatinized in 6 minutes, nearly all in 13 minutes, and all in 20 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *chromic acid* begins in all the grains in 30 seconds and is over in 1¾ minutes. It is the same qualitatively as that of the grains of *M. botryoides.*

Reaction with *pyrogallic acid* begins in most grains in 15 seconds. Nearly all are completely gelatinized and the rest partially gelatinized in 5 minutes and all are completely gelatinized in 7 minutes. The reaction is qualitatively the same as that of the grains of *M. botryoides.*

Reaction with *ferric chloride* begins in some grains in 30 seconds and is over in 15 minutes. It is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *Purdy's solution* begins in some grains in 15 seconds. About one-third are nearly completely gelatinized in 3½ minutes and half in 10 minutes. The reaction is qualitatively the same as that of the grains of *M. botryoides.*

STARCH OF MUSCARI CONICUM. (Plate 43, figs. 255 and 256. Chart 166.)

Histological Characteristics.—In *form* the grains are usually simple, and sometimes compound in the form of two components. The simple grains are isolated, with the exception of a few in small aggregates, mostly in the form of doublets, and very few clumps. Pressure facets are sometimes found on the isolated grains. The surface often shows slight irregularities due to occasional depressions at the distal end and to the protuberances sometimes found at different points on the margin. The conspicuous forms are round, oval to ovoid, and transitional forms to the clam-shell-shaped. When seen on edge the grains are lenticular, flattened elliptical, or rounded wedge-shaped. The resemblance to *M. botryoides* is quite close, but both the hila and the lamellæ are less conspicuous, the latter especially on the outer third of the grain; and there is a greater tendency to the oval type of grain.

The *hilum* is a rather distinct, round or oval spot, centric on the round forms, and eccentric two-fifths to one-third of the longitudinal axis in the large forms. It is rarely fissured, but there may be one short, transverse or longitudinal fissure, or a small, cross-shaped fissure.

The *lamellæ* are fairly distinct, rather coarse, complete rings or ellipses near the hilum, but having the shape of the margin when located near distal margin; in many they appear incomplete in the distal region. There are 1 to 3 very distinct lamellæ at varying distances, chiefly one-third and two-thirds from the hilum. Near the distal end and margin they are usually finer than those around the hilum and to within two-thirds or three-fourths of the distance between it and the distal end. There are about 13 on the larger grains.

The *size* of the grain varies from 6 to 40μ in length. The common size is 28 by 24μ in length and breadth.

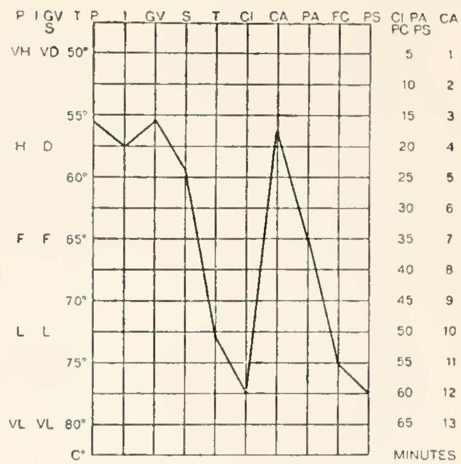
Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and usually fairly clear-cut. The lines are rather thick, and thicker towards the margin, and are generally straight, but occasionally bent or bisected.

The degree of *polarization* is high. It varies in different grains and in the same aspect of a grain. It is slightly higher than in *M. botryoides.*

With *selenite* the quadrants are fairly well defined and regular in shape in the small forms and in many of the large ones; but not infrequently irregular in shape and unequal in size in the large forms. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not so deep as that of the grains of *M. botryoides.* After heating in water until all the grains are completely gelatinized, both the solution and the grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues color deeply to lightly. The capsules all color a red-violet with an excess of iodine.

Chart No. 166.



Curve of Reaction-Intensities of Starch of Muscari conicum.

With *gentian violet* the grains begin to stain at once and in 30 minutes are deeply stained, more deeply than the grains of *M. botryoides.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained, more deeply than the grains of *M. botryoides.*

Temperature Reaction.—The temperature of gelatinization is 72° to 74° C., mean 73°.

Effects of Various Reagents.—With *chloral hydrate-iodine* all the grains begin to react in 30 minutes. About half of them are gelatinized in 22 minutes, two-thirds in 35 minutes, and three-fourths in 48 minutes. The reaction is qualitatively the same as that of the grains of *M. botryoides.*

Reaction with *chromic acid* begins in 15 seconds and is over in 3½ minutes. It is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *pyrogallic acid* begins in some grains in 30 seconds and in all in a minute. All are partially and one-fourth completely gelatinized in 8 minutes, four-fifths are completely gelatinized in 20 minutes, and all in 35 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

With *ferric chloride* the reaction begins in some grains in 45 seconds and in many in 1½ minutes. Nearly all are completely gelatinized in 45 minutes and all in 56 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *Purdy's solution* begins in some grains in 45 seconds and in all in 2 minutes. About one-fifth are completely gelatinized in 15 minutes, and half are gelatinized in 40 minutes without complete reaction in an hour in the others. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

STARCH OF MUSCARI COMMUTATUM. (Plate 43, figs. 257 and 258. Chart 167.)

Histological Characteristics.—In *form* the grains are usually simple. A few compound grains and aggregates in the form of doublets frequently occur, as well as clumps; and poorly marked pressure facets appear on some of the isolated grains. The surface is, on the whole, less regular than in *M. botryoides.* The conspicuous forms are round, rounded oval to ovoid, with a few somewhat clam-shell-shaped; when viewed on edge they are flattened ellipses, lenticular or somewhat wedge-shaped. These grains are distinctly smaller than *M. botryoides,* there is a greater tendency to spherical forms, and fissuration is common.

The *hilum* is sometimes seen as a round or oval spot; it is eccentric about four-ninths to one-third of the longitudinal axis in the oval, ovoid, and shell-shaped forms, and in or near the median line; it is centric or nearly centric in the round forms. The hilum is often marked by a transverse or longitudinal fissure, which may be straight or curved; or both transverse and longitudinal fissures may be present, forming a cross; or a number of fissures may radiate from the hilum, frequently three in number; two hila are found in some grains, between which a transverse fissure may often be seen.

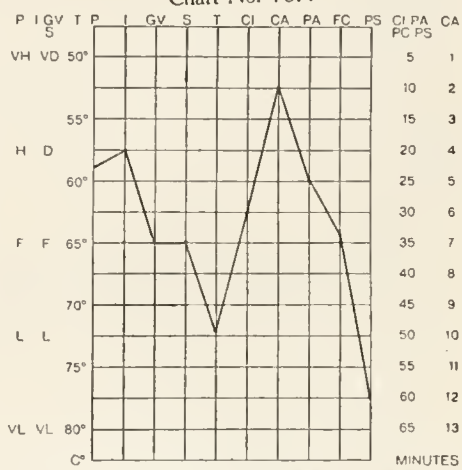
The *lamellæ* are rather indistinct, coarse, complete rings near the hilum, and more distinct and following the outline of the grain at the distal end and near the margin.

The grains vary in *size* from 4 to 34μ. The common size is about 19μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and usually clear-cut. Its lines are rather thick and generally straight.

The degree of *polarization* is high. It varies from high in the larger grains to fair in the smallest. In the largest grains it varies somewhat in different parts of the same grain, and is higher when viewed on edge and end. It is not so high as in *M. botryoides*.

Chart No. 167.



Curve of Reaction-Intensities of Starch of Muscari commutatum.

With *selenite* the quadrants are fairly well defined, regular in shape, and about equal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens quickly. The grains are not so deeply colored as those of *M. botryoides*. After heating in water until all the grains are gelatinized, the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly to lightly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly stained. The color is much less than that of the grains of *M. botryoides*.

With *safranin* the grains begin to stain at once and in 30 minutes are fairly stained. The color is somewhat lighter than that of the grains of *M. botryoides*.

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in many grains in a minute. About three-fourths are completely gelatinized in 8 minutes, nearly all in 17 minutes, and all in 30 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides*.

Reaction with *chromic acid* begins in some grains at once and in all in 15 seconds, and is over in 2 minutes. It is the same qualitatively as that of the grains of *M. botryoides*.

The reaction with *pyrogallic acid* begins in some grains in a few seconds and in all in 30 seconds. About one-fourth are completely and three-fourths partially gelatinized in 3 minutes, all nearly completely gelatinized in 8 minutes, and all completely gelatinized in 25 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides*.

The reaction with *ferric chloride* begins in a very few grains in a minute. About half are gelatinized in 8 minutes, nearly all in 27 minutes, and all in 33 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides*.

With *Purdy's solution* the reaction begins in some grains at once and in most of them in a minute. About one-third are partially gelatinized in 15 minutes, one-half in 25 minutes, and about three-fourths are partially and one-fifth completely in 60 minutes.

STARCH OF MUSCARI RACEMOSUM. (Plate 44, figs. 259 and 260. Chart 168.)

Histological Characteristics.—In *form* the grains are usually simple; rarely they are compound, consisting of two components. There are a few small aggregates, generally in the form of doublets, which consist of one large with one very small round or rounded triangular component; but occasionally the components are of equal size. Rarely triplets occur. Pressure facets are sometimes found on the isolated grain. A few clumps are present. The surface of the grains is usually quite regular. Irregularities may be due to protuberances which occasionally occur at various points.

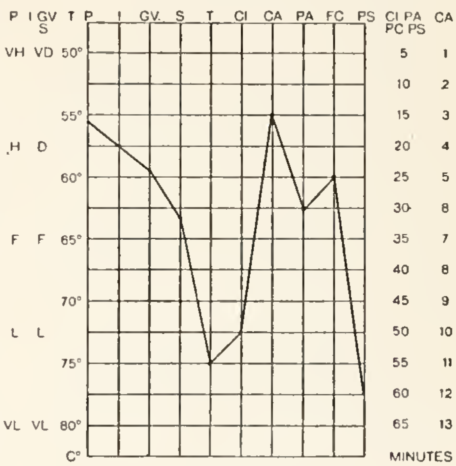
The conspicuous forms are round, oval, and ovoid, and transition forms to a few very large clam-shell-shaped forms. When viewed on edge they are lenticular, flattened elliptical, or rounded wedge-shaped. In comparison with *M. botryoides* this grain is much smaller, both hila and lamellæ are less conspicuous, and they have the appearance of a marked tendency to the spherical.

The *hilum* is seldom conspicuous, and may be seen as a round or oval spot, centric in the round forms, and eccentric two-fifths to one-third of the longitudinal axis in the larger forms; an eccentricity of one-third is rare. Two hila occur quite often in a single grain. Rarely the hilum is fissured, and an irregular cavity may be seen instead of the hilum. The fissure may be longitudinal or transverse; or occasionally a small cross or an irregular figure may be found.

The *lamellæ* are distinct, rather coarse, complete rings near the hilum and somewhat finer but very distinct near the distal and lateral margins. At these margins they may be more irregular and also incomplete. In many of the grains two very distinct, coarse lamellæ appear nearer the hilum than the distal end.

The *size* of the grain varies from 4 to 40μ. The common size is 19 by 20μ in length and breadth.

Chart No. 168.



Curve of Reaction-Intensities of Starch of Muscari racemosum.

Polariscopic Properties.—The *figure* is centric in the round forms and eccentric in the other forms. It is distinct and fairly clear-cut. Its lines are rather thick and become thicker towards the margin, and are rarely bent or bisected.

The degree of *polarization* is high. It varies slightly in different grains and in different aspects of the grain. It is slightly higher than in *M. botryoides*.

With *selenite* the quadrants are fairly well defined, usually regular in form, and about equal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep violet-blue; with 0.125 per cent solution they color fairly and the color deepens rapidly. The coloration is slightly less than that of the grains of *M. botryoides*. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues deeply to lightly. The capsules all color red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are deeply stained, but not quite so deeply as the grains of *M. botryoides*.

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained, but not quite so deeply as the grains of *M. botryoides*.

Temperature Reaction.—The temperature of gelatinization is 74.5° to 75° C., mean 74.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds. About half are gelatinized in 6 minutes, four-fifths in 15 minutes, nearly all in 30 minutes, and all in 50 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides*.

With *chromic acid* some of the grains begin to react in a very few seconds and all in 30 seconds, and the reaction is complete in 3 minutes. It is the same qualitatively as that of the grains of *M. botryoides*.

With *pyrogallic acid* some grains begin to react in 15 seconds and all in 45 seconds. All the grains are partially and about two-fifths nearly completely gelatinized in 5 minutes, two-thirds are completely gelatinized in 10 minutes, and all are completely gelatinized in 30 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides*.

Reaction with *ferric chloride* begins in some grains in 30 seconds. Nearly all the grains are gelatinized in 15 minutes and all in 25 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides*.

Reaction with *Purdy's solution* begins in one-sixth of the grains in a few seconds and they are gelatinized in a minute. All the grains begin to react in a minute and about half are completely gelatinized in 30 minutes, with little subsequent reaction in an hour.

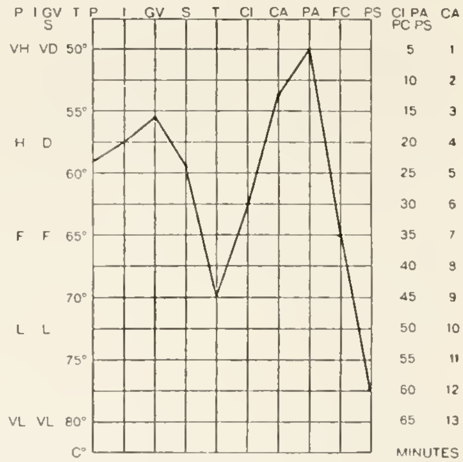
STARCH OF MUSCARI COMPACTUM. (Plate 44, figs. 261 and 262. Chart 169.)

Histological Characteristics.—In *form,* both simple and compound grains, and a few aggregates and clumps are observed. Some of the aggregates consist of one large grain and one very small, round grain; others consist of grains of equal size, and others of three or more grains may be seen. The surface is sometimes irregular, owing in some cases to small protuberances at different points. The conspicuous forms are round, oval, ovoid, and transitions to the clam-shell shape. When viewed on edge they are usually broadly lenticular or flattened elliptical. These grains bear close resemblance to those of *M. botryoides,* but both the hila and the lamella are less conspicuous, fissuration of the hilum is frequent, and there is a larger proportion of medium-sized grains.

The *hilum* is a small, round or oval spot, centric in the round forms, and eccentric from two-fifths to one-fourth, usually one-third, of the longitudinal axis in other forms. Double hila frequently occur. The hilum is often fissured, and the fissuration may be noted in the form of a single transverse or longitudinal fissure, or a cross, or a combination of fissures of irregular arrangement. The fissures are often ragged. Fissures may occur on either side of the hilum or between a double hila. An irregular cavity may be found at the hilum.

The *lamellæ* are distinct, rather coarse, complete rings near the hilum, but finer and of the same shape as the grain near the margin and distal end. They may be somewhat irregular at the latter point, and are probably incomplete in the clam-shell-shaped forms. One lamella near the hilum and one about the middle of the space between the hilum and the distal margin are often especially distinct. There are about 18 lamellæ in the larger forms.

Chart No. 169.



Curve of Reaction-Intensities of Starch of Muscari compactum.

The *size* of the grain varies from 4 to 44μ. The common size of the oval forms is 24 by 30μ in length and breadth, and of the large round forms 26 by 26μ in length and breadth.

Polariscopic Properties.—The *figure* is centric in the round grains and eccentric in other forms. It is distinct and fairly clear-cut. Its lines are rather thick and become thicker towards the margin, and are usually straight.

The degree of *polarization* is high. It varies slightly in different grains and sometimes in the same aspect of one grain. It is lower than in *M. botryoides.*

With *selenite* the quadrants are fairly well defined; they are as a whole regular in form and very often of about equal size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is not quite so deep as that of the grains of *M. botryoides.* After heating in water until all the grains are completely gelatinized, the solution and the grains color deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues fairly, lightly, or not at all. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are deeply stained. The color is slightly deeper than that of the grains of *M. botryoides.*

With *safranin* the grains begin to stain at once and in 30 minutes they are deeply stained. The color is deeper than that of the grains of *M. botryoides.*

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds. About half are gelatinized in 5 minutes, almost all in 12 minutes, and all in 30 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

Reaction with *chromic acid* begins in some grains at once and in all in 15 seconds, and is over in 2½ minutes. It is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *pyrogallic acid* begins in 30 seconds and is over in 5 minutes. It is the same qualitatively as that of *M. botryoides.*

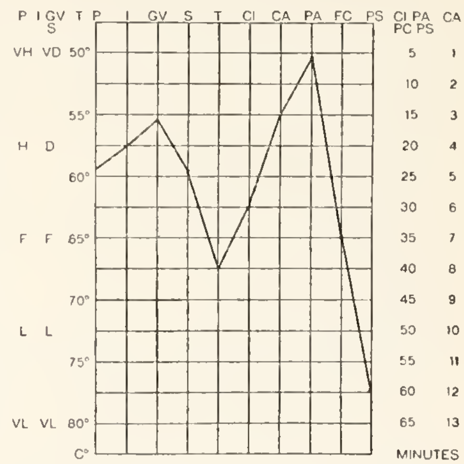
With *ferric chloride* the reaction begins in a few grains in 30 seconds. About two-thirds are completely gelatinized in 10 minutes, nearly all in 25 minutes, and all in 35 minutes. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

The reaction with *Purdy's solution* begins in about one-fifth of the grains at once and these are completely gelatinized in 30 seconds, and most of the grains are affected in 30 seconds. Half are completely and half partially gelatinized in 1½ hours.

STARCH OF MUSCARI COMOSUM. (Plate 44, figs. 263 and 264. Chart 170.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains, and a number of aggregates mostly consisting of a large grain and a small one and a few clumps. Pressure facets are found on some of the isolated grains. The surface is varied and commonly somewhat irregular. Besides slight unevenness of outline, more or less marked rounded protuberances and nipple-like projections at different points may sometimes exist. The conspicuous forms of the small grains are round, oval, and ovoid, and of the large grains oval, elliptical, and clam-shell-shaped, and transition forms from the ovoid to the last. When viewed on edge, they are flattened ellipses, or somewhat lenticular, or wedge-shaped. These grains show a greater tendency to the oval, elliptical, and clam-shell types than those of *M. botryoides;* fissuration of the hilum is the rule, not the exception.

Chart No. 170.



Curve of Reaction-Intensities of Starch of Muscari comosum.

The *hilum* is a distinct round or oval spot, centric in the small round grains and eccentric from two-fifths to one-fourth of the longitudinal axis in the large grains. Two or more hila sometimes occur on one grain. The hilum is generally fissured, especially on the large grains. These fissures may be longitudinal, or transverse, or two may form a cross. Sometimes from one aspect of the grain the fissure appears as a Y, while from another it is found to be a cross that is formed of one long arm passing through the hilum, and coinciding with the longitudinal axis, and having two lateral lines near one end and directed somewhat towards the proximal margin. Fissures forming stellate and irregular figures may be seen in place of the hilum, while fissures mostly crescent-shaped may also be noted in other parts of the grain.

The *lamellæ* are rather fine, fairly distinct, complete ellipses or rings near the hilum; they are more distinct but finer near the margin and the distal end. There is usually one prominent lamella about one-third the distance from the hilum. The lamellæ are usually regular, but sometimes irregular near the distal or lateral margins. There are about 14 or 15 in the larger grains.

The grains vary in *size* from 4 to 43μ. The common size is 24 by 28μ in length and breadth.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, but not clear-cut except in the smaller forms. Its lines are usually straight and rather thick, somewhat thicker towards the margin; they are occasionally bisected, and in the larger, irregular forms are bent or otherwise distorted.

The degree of *polarization* is high. In the large grains it is rather high to very high, and in the smallest grains it is fair. It varies in different parts of the same aspect of a given grain. It is, as a whole, not so high as in *M. botryoides.*

With *selenite* the quadrants in the smallest grains and also in some of the large ones are fairly well defined, quite regular in shape, and about equal in size. In other grains, especially the largest, they are irregular in shape and of unequal size. In some forms the colors are pure, while in many they are not.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not so deep as that of the grains of *M. botryoides.* After heating in water until all the grains are completely gelatinized, the solution colors deeply and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues deeply to lightly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are deeply stained, slightly more than *M. botryoides.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained, slightly more than *M. botryoides.*

Temperature Reaction.—The temperature of gelatinization is 67° to 69° C., mean 68°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in a minute. It is over in two-thirds in 8 minutes, in almost all in 17 minutes, and in all in 30 minutes. It is qualitatively the same as that of the grains of *M. botryoides.*

The reaction with *chromic acid* begins in some grains at once and in all in 30 seconds, and is over in 3 minutes. It is qualitatively the same as that of the grains of *M. botryoides.*

Reaction with *pyrogallic acid* begins in 30 seconds and is over in 6 minutes. It is the same qualitatively as that of the grains of *M. botryoides.*

Reaction with *ferric chloride* begins in a few grains in 1½ minutes. About four-fifths are gelatinized in 20 minutes and all in 35 minutes. The reaction is qualitatively the same as that of the grains of *M. botryoides.*

With *Purdy's solution* the reaction begins in most grains in 45 seconds. About half are partially gelatinized in 6 minutes, one-third are nearly and two-thirds completely gelatinized in 25 minutes. The reaction is not complete in an hour. The reaction is the same qualitatively as that of the grains of *M. botryoides.*

Differentiation of Certain Starches of the Genus Muscari.

Histological Characteristics.

Conspicuous Forms.

M. botryoides: Usually simple and isolated, compound grains and aggregates in the form of doublets, outline usually quite regular, occasionally protuberances mostly at distal end, occasionally one or more pressure facets. Round, oval to ovoid, and clam-shell-shaped.

M. paradoxum: Essentially the same as in *M. botryoides,* but with greater tendency to the oval type.

M. micranthum: Essentially the same as in *M. botryoides,* but smaller.

M. conicum: Essentially the same as in *M. botryoides,* but with greater tendency to the oval type.

M. commutatum: Essentially the same as in *M. botryoides,* but with a tendency to the spheroid and oval types and much smaller grains.

M. racemosum: Essentially the same as in *M. botryoides,* but with a marked tendency to the spherical form and much smaller grains.

M. compactum: Essentially the same as in *M. botryoides,* but a much larger proportion of medium-sized grains.

M. comosum: Essentially the same as in *M. botryoides,* but a markedly great tendency to oval, elliptical and clam-shell types.

Hilum—Form, Number, and Position.

M. botryoides: Form distinct, fairly large, round or oval; rarely fissured, fissure single, short, transverse or longitudinal. Position centric or eccentric 0.33 to 0.40 of longitudinal axis.

M. paradoxum: Form distinct, fairly large, round or oval. single, double or multiple; usually fissured, single transverse or longitudinal, straight or curved, or 2 or more ragged or clean-cut. Position centric or eccentric 0.40 to 0.33 of longitudinal axis.

M. micranthum: Form essentially the same as in *M. botryoides,* except that fissuration is less rare. Position centric or eccentric 0.25 to 0.44, usually 0.33, of longitudinal axis.

M. conicum: Form essentially the same as in *M. botryoides.* Position centric or eccentric 0.40 to 0.33 of longitudinal axis.

M. commutatum: Form essentially the same as in *M. botryoides,* but fissuration is frequent. Position centric, or eccentric 0.44 to 0.33 of longitudinal axis.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.—Continued.

M. racemosum: Form essentially the same as in *M. botryoides,* but the hilum is less often seen. Position centric, or eccentric 0.40 to 0.33 of longitudinal axis.

M. compactum: Form essentially the same as in *M. botryoides,* but fissuration is common. Position centric, or eccentric 0.40 to 0.25 of longitudinal axis.

M. comosum: Form essentially the same as in *M. botryoides,* but the hilum is generally fissured. Position centric, or eccentric 0.40 to 0.25 of longitudinal axis.

Lamellæ—General Characteristics and Number.

M. botryoides: Fairly distinct, fine, regular, usually complete circles or ellipses. 10 to 14 on larger grains.

M. paradoxum: Rather distinct, coarse, usually complete and regular rings or ellipses. 6 to 10 on larger grains.

M. micranthum: Fairly distinct, rather fine, complete, usually regular circles or ellipses. 14 on larger grains.

M. conicum: Fairly distinct, rather coarse, complete, usually regular circles or ellipses. 13 on larger grains.

M. commutatum: Rather indistinct, coarse, usually complete regular rings. Not determined.

M. racemosum: Distinct, rather coarse, usually complete, regular or irregular. 10 to 12 on larger grains.

M. compactum: Distinct, rather coarse, usually complete regular or irregular. 18 on larger grains.

M. comosum: Rather fine, fairly distinct, usually regular and usually complete circles or ellipses. 14 to 15 on larger grains.

Size.

M. botryoides: From 3 to 50μ, commonly 20μ.
M. paradoxum: From 6 to 34μ, commonly 24μ.
M. micranthum: From 4 to 34μ, commonly 20μ.
M. conicum: From 6 to 40μ, commonly 28μ.
M. commutatum: From 4 to 34μ, commonly 19μ.
M. racemosum: From 4 to 34μ, commonly 19μ.
M. compactum: From 4 to 42μ, commonly 24μ.
M. comosum: From 4 to 32μ, commonly 24μ.

Differentiation of Certain Starches of the Genus Muscari.—Continued.

POLARISCOPIC PROPERTIES.

Figure.

M. botryoides: Centric or eccentric, distinct, fairly clear-cut, usually regular.
M. paradoxum: Centric or eccentric, not clear-cut, usually regular.
M. micranthum: Centric or eccentric, distinct, fairly clear-cut, regular.
M. conicum: Centric or eccentric, distinct, fairly clear-cut, usually regular.
M. commutatum: Centric or eccentric, distinct, usually clear-cut, usually regular.
M. racemosum: Centric or eccentric, distinct, fairly clear-cut, usually regular.
M. compactum: Centric or eccentric, distinct, fairly clear-cut, usually regular.
M. comosum: Centric or eccentric, distinct, not clear-cut, usually regular.

Degree of Polarization.

M. botryoides: High.
M. paradoxum: High, variable, not so high as in *M. botryoides.*
M. micranthum: High, somewhat variable, not so high as in *M. botryoides.*
M. conicum: High, slightly higher than in *M. botryoides.*
M. commutatum: High, somewhat variable, not so high as in *M. botryoides.*
M. racemosum: High, slightly higher than in *M. botryoides.*
M. compactum: High, not quite so high as in *M. botryoides.*
M. comosum: High, variable, as a whole, not so high as in *M. botryoides.*

Polarization with Selenite—Quadrants and Colors.

M. botryoides: Quadrants fairly well defined, regular in shape. Colors pure.
M. paradoxum: Quadrants fairly well defined, regular. Colors often pure.
M. micranthum: Quadrants fairly well defined, quite regular. Colors pure.
M. conicum: Quadrants fairly well defined, frequently irregular. Colors usually pure.
M. commutatum: Quadrants fairly well defined, regular in shape. Colors pure.
M. racemosum: Quadrants fairly well defined, usually regular. Colors pure.
M. compactum: Quadrants fairly well defined, usually regular. Colors pure.
M. comosum: Quadrants fairly well defined, often irregular. Colors mostly impure.

IODINE REACTIONS.

Intensity and Color.

M. botryoides: Deep; blue-violet.
M. paradoxum: Deep, not so deep as in *M. botryoides;* blue-violet.
M. micranthum: Deep, same as in *M. paradoxum;* blue-violet.
M. conicum: Deep, same as in *M. paradoxum;* blue-violet.
M. commutatum: Deep, same as in *M. paradoxum;* blue-violet.
M. racemosum: Deep, same as in *M. paradoxum;* blue-violet.
M. compactum: Deep, same as in *M. paradoxum;* blue-violet.
M. comosum: Deep, same as in *M. paradoxum;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

M. botryoides: Deep.
M. paradoxum: Deep, slightly deeper than in *M. botryoides.*
M. micranthum: Deep, deeper than in *M. botryoides.*
M. conicum: Deep, deeper than in *M. botryoides.*
M. commutatum: Fair, much less deep than in *M. botryoides.*
M. racemosum: Deep, not quite so deep as in *M. botryoides.*
M. compactum: Deep, slightly deeper than in *M. botryoides.*
M. comosum: Deep, deeper than in *M. botryoides.*

With Safranin.

M. botryoides: Fairly deep.
M. paradoxum: Fairly deep, deeper than in *M. botryoides.*
M. micranthum: Fairly deep, the same as in *M. botryoides.*
M. conicum: Fairly deep, deeper than in *M. botryoides.*
M. commutatum: Fair, less deep than in *M. botryoides.*
M. racemosum: Fairly deep, not quite so deep as in *M. botryoides.*
M. compactum: Deep, deeper than in *M. botryoides.*
M. comosum: Fairly deep, slightly deeper than in *M. botryoides.*

TEMPERATURE OF GELATINIZATION.

M. botryoides: 70 to 72° C., mean 71°.
M. paradoxum: 72 to 74° C., mean 73°.
M. micranthum: 68.5 to 70° C., mean 69.25°.
M. conicum: 72 to 74° C., mean 73°.
M. commutatum: 71 to 73° C., mean 72°.
M. racemosum: 74.5 to 75° C., mean 74.75°.
M. compactum: 69 to 71° C., mean 69°.
M. comosum: 67 to 69° C., mean 68°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

M. botryoides: Begins in most in 45 seconds; complete in 20 minutes.
M. paradoxum: Begins in half in 45 seconds; complete in four-fifths in 40 minutes.
M. micranthum: Begins in many in 30 seconds; complete in 20 minutes.
M. conicum: Begins in all in 30 seconds; complete in three-fourths in 48 minutes.
M. commutatum: Begins in many in 60 seconds; complete in nearly all in 17 minutes, and in all in 30 minutes.
M. racemosum: Begins in most in 30 seconds; complete in nearly all in 30 minutes, all in 50 minutes.
M. compactum: Begins in most in 30 seconds; complete in 30 minutes.
M. comosum: Begins in most in 60 seconds; complete in all in 30 minutes.

Reaction with Chromic Acid.

M. botryoides: Begins in 15 seconds; complete in 3½ minutes.
M. paradoxum: Begins in 30 seconds; complete in 4 minutes.
M. micranthum: Begins in a few seconds; complete in 1¾ minutes.
M. conicum: Begins in 15 seconds; complete in 3½ minutes.
M. commutatum: Begins in 15 seconds; complete in 2 minutes.
M. racemosum: Begins in 30 seconds; complete in 3 minutes.
M. compactum: Begins in 30 seconds; complete in 2½ minutes.
M. comosum: Begins in 30 seconds; complete in 3 minutes.

Differentiation of Certain Starches of the Genus Muscari.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.

M. botryoides: Begins in all in 25 seconds; complete in 1¼ minutes.
M. paradoxum: Begins in all in 75 seconds; complete in 18 minutes.
M. micranthum: Begins in most of the grains in 15 seconds; complete in 7 minutes.
M. conicum: Begins in all in 60 seconds; complete in 35 minutes.
M. commutatum: Begins in all in 30 seconds; complete in 25 minutes.
M. racemosum: Begins in all in 45 seconds; complete in 30 minutes.
M. compactum: Begins in all in 30 seconds; complete in 5 minutes.
M. comosum: Begins in all in 30 seconds; complete in 6 minutes.

Reaction with Ferric Chloride.

M. botryoides: Begins in a few in 60 seconds; complete in 40 minutes.
M. paradoxum: Begins in a few in 60 seconds; complete in 45 minutes.
M. micranthum: Begins in a few in 30 seconds; complete in 15 minutes.
M. conicum: Begins in a few in 45 seconds; complete in 56 minutes.
M. commutatum: Begins in a few in 60 seconds; complete in 33 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.—Continued.

M. racemosum: Begins in a few in 30 seconds; complete in 25 minutes.
M. compactum: Begins in a few in 30 seconds; complete in 35 minutes.
M. comosum: Begins in a few in 1½ minutes; complete in 35 minutes.

Reaction with Purdy's Solution.

M. botryoides: Begins in most in 2 minutes; three-fourths are partially gelatinized in 25 minutes.
M. paradoxum: Begins in most in 1 minute; one-fifth are partially gelatinized in 10 minutes.
M. micranthum: Begins in some in 15 seconds; half are nearly completely gelatinized in 10 minutes.
M. conicum: Begins in some in 45 seconds; half are partially and half completely gelatinized in 40 minutes.
M. commutatum: Begins in most in 60 seconds; three-fourths are partially and one-fifth completely gelatinized in 60 minutes.
M. racemosum: Begins in all of the grains in 60 seconds; half are completely gelatinized in 30 minutes.
M. compactum: Begins in most of the grains in 30 seconds; half partially, half completely gelatinized in 90 minutes.
M. comosum: Begins in most of the grains in 45 seconds; two-thirds are partially gelatinized, one-third being nearly completely gelatinized in 25 minutes.

NOTES ON THE STARCHES OF MUSCARI.

These starches exhibit certain differences of diagnostic value in their gross histological characters, chiefly in the mean size, hilum, fissuration, and lamellæ. The size of the grains of *M. micranthum*, *M. commutatum*, and *M. racemosum* is, on the whole, less than in the other *Muscari* starches. Differences in fissuration between *M. botryoides*, *M. micranthum*, *M. conicum*, and *M. racemosum* as compared with other starches of this genus are quite striking; also in the lamellation, as regards both character and number. There are variations in reactions, ranging from practical identity (as in the iodine reactions) to well-marked differences (as in the reactions with the chemical reagents generally). The differences in the temperatures of gelatinization range within 68° and 74.75°, or 6.75°. Each starch can be readily distinguished from the others by means of variations in the reactions.

GENUS BRODIÆA.

Brodiæa is a genus of Western American (chiefly Californian) cormous plants which comprise about 30 species, including certain species heretofore classified as *Hookera*, *Milla*, or *Triteleia*. They have been divided by Purdy into four groups, based essentially upon peculiarities of the corms. In Group I the corm is flattened and fibrous coated, resembling that of crocus. Belonging to this group the following starches were studied: *B. peduncularis* Wats., *B. ixoides* var. *splendens* Hort., *B. candida* Baker, *B. lactea* Wats. (*Hesperoscordum lacteum*, *H. hyacinthinum*), and *B. laxa* Wats. The corm of Group II has a reddish, hairy coating, is not flattened, and bears many strong offsets. As representatives of this group there were examined: *B. coccinea* (*Brevoortia ida-maia* Wood, *B. coccinea*, Wats.), *B. grandiflora* Smith (*Hookera coronaria* Salisb.), *B. californica* Lindl. (*Hookera californica* Greene), *B. purdyi* Eastw., and *B. stellaris* Wats. Group III has long, bulbiferous corms and is represented in this research by *B. capitata* Benth. and *B. congesta* Smith. Group IV is characterized by bulbs like those of Group I, by dense umbels, and by the tube and the segments being of about the same length. No representative of this group was examined.

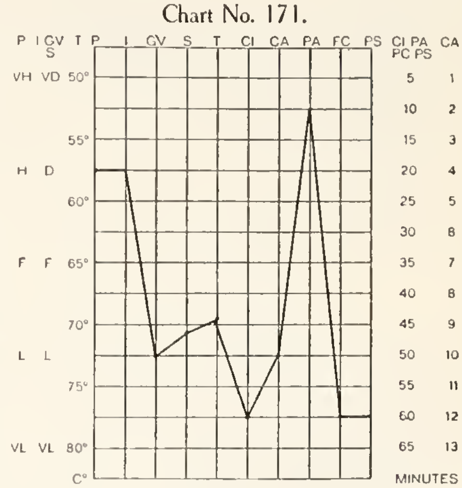
STARCH OF BRODIÆA PEDUNCULARIS. (Plate 45, figs. 265 and 266. Chart 171.)

Histological Characteristics.—In *form* the grains are simple, with occasional compound grains consisting of two components. The simple grains are isolated, with the exception of a few aggregates among the smaller grains, and a few among the large grains which have small grains attached, and a few clumps. The surface of the grains is usually irregular, owing chiefly to nipple-like processes and rounded protuberances formed by amorphous deposits. The conspicuous forms are ovoid, oval, and ellipsoidal; the latter may or may not have two ends of the same size; also there may be pyriform, triangular, ellipsoidal bent at or near the middle, thin and narrow lenticular, small round, and a few quadrangular or polygonal forms. When the grains are rolled over it is noticed that at any given diameter they are generally of about the same thickness, hence when seen on end are nearly round. Grains having large, irregular protuberances from the surface appear broader in the diameter of one aspect than of another.

The *hilum* is distinct, and when not fissured is a small round spot, eccentric about one-third of the longitudinal axis of the grain. It is usually in or near the median line and is rarely double or triple. When fissured, as is frequently the case, the fissuration may be superficial, or very deep and extensive, but it is often 3-armed and usually very ragged. The fissure may also be transverse, diagonal, ragged, or stellate. Rarely it is a true cross.

The *lamellæ* are fairly distinct, continuous, coarse rings which follow the outline of the margin, but show some irregularities independent of the marginal outline of the grain. They are coarser and more distinct in some grains than others. There is usually one on each grain that may be near the hilum or the margin that is especially distinct. There are about 8 to 10 lamellæ on the medium-sized grains. If there is more than one hilum, the two are inclosed in a common lamella, but there is an absence of lamellæ belonging to each hilum.

Chart No. 171.



Curve of Reaction-Intensities of Starch of Brodiæa peduncularis.

The grains vary in *size* from 2 to 60μ. The common size is 35μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and not always clear-cut. Its lines become broader but less sharp as they near the margin of the grain. They are often bent and otherwise distorted, and if there are very wide fissures the figure may be more or less modified.

The degree of *polarization* is high. Polarization is lacking in some grains at points about the margin. It varies in different grains and in different aspects of the same grain.

With *selenite* the quadrants are not, as a rule, well defined, and are irregular in shape and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet, which later deepens somewhat; with 0.125 per cent solution they are colored fairly and the color deepens quickly. After raising the temperature to a point at which all the grains are completely gelatinized, the grains are colored deeply and the solution fairly when iodine is added. In some of the less deeply colored grains the capsule is colored violet. After boiling for 2 minutes the solution colors very deeply, but the grain-residues much less deeply. Some blue-reacting contents of the capsules may remain in the proximal end of the capsule. At the distal end the capsules are crumpled and lobulated, and all are colored violet.

Staining Reactions.—With *gentian violet* the grains stain at once very lightly and even after 30 minutes they are lightly stained, some more than others.

With *safranin* the grains stain at once very lightly. After 30 minutes they are stained lightly, but rather more than with gentian violet, and some grains more than others.

Temperature Reaction.—The temperature of gelatinization is 68° to 69° C., mean 69.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a very few grains show slight reaction in 2 minutes. In 4 minutes about one-fourth to one-third begin to react, and some of those first affected are darkened completely at that time. In an hour one-third are completely gelatinized. There is no further change. The hilum becomes conspicuous as a dark bubble which soon disappears without swelling. The lamellæ are indistinct. The margin of the grain at the distal end becomes dark and then swells slightly and smoothly. Irregular spots on the sides, and sometimes at the hilum, become dark. All these foci swell somewhat and then become united, and the process passes inward over the whole grain. The swollen grains are fairly large and may be somewhat distorted. They usually show light fissures, where fissures pre-existed before gelatinization took place.

Reaction with *chromic acid* begins in some of the smaller grains in 30 seconds and is general in 3 to 4 minutes; all the grains are dissolved in 10 minutes. This reaction is slow and even; it does not start rapidly and then become slower, as is common with most starches. The hilum is very prominent. The lamellæ are fairly distinct, the hilum swells, the fissures widen, and the grain becomes covered with fine, radiating striæ. The inner portion is reduced to a granular, gelatinous mass. The peripherally located starch forms a ring which at first is thick and distinctly striated, with a ragged, inner border, which subsequently gradually becomes thinner and transparent as the grain swells, until a large, smooth, thin-walled, gelatinized grain is formed. This capsule dissolves at one end, and the inner mass flows out and disappears. The rest of the capsule dissolves rapidly.

The reaction with *pyrogallic acid* begins in some of the grains in 30 seconds and is general in 2 minutes. The grains are entirely gelatinized in 10 minutes. Both hilum and the lamellæ become very distinct. The hilum swells and the fissures widen and deepen. The grain is divided by fine, radiating fissures. The inner part of the grain is changed into a gelatinous mass. The marginal part forms a ring which at first is thick and opaque and shows fine striæ, and also concentric, alternate refractive and non-refractive bands. As the grain continues to swell, this ring becomes thinner and clearer and divided by internal fissures until a thin, transparent, gelatinous capsule forms. The swollen grains are large, and if the original grains are fissured they are somewhat lobulated and distorted; but if not fissured, they are smooth and retain much of the original shape of the grains.

Reaction with *ferric chloride* begins in a few grains in a minute and the reaction is over in them in 7 minutes. Other grains at this time are as yet unaffected, but in 9 to 10 minutes many begin to react. In 15 minutes about one-third are swollen; in 1¼ hours about two-thirds are gelatinized; and in 1½ hours all are gelatinized. The hilum becomes prominent, but the lamellæ are obscured. The reaction begins at projecting points on the distal end and sides, and proceeds over the grain until only a small portion about the hilum remains ungelatinized. This latter becomes split by many fissures, the pieces rapidly breaking apart and gelatinizing separately. The swollen grains are large, irregular, sacculated, and wrinkled. In some grains the hilum merely swells, and then the inner portion, followed by the marginal portion, is altered into a gelatinous mass. These gelatinized grains are not so large or so irregular or sacculated as those first described.

With *Purdy's solution* there is slight reaction in a few grains in 1½ minutes, but only a few are completely gelatinized and a few others show the beginning of gelatinization after an hour. Both hilum and lamellæ become very prominent. The hilum enlarges, and the grain is divided by fine, radial fissures. The inner part is transformed into a gelatinous mass, much of which appears to be forced to the base of the grain. The marginal part of the grain is differentiated into a thick, striated ring, which shows three or four concentric refractive and non-refractive bands. The ring later becomes a thin, transparent capsule. The gelatinized grains are large and somewhat wrinkled, but not lobulated.

STARCH OF BRODIÆA IXOIDES VAR. SPLENDENS. (Plate 45, figs. 267 and 268. Chart 172.)

Histological Characteristics.—In *form* the grains are simple with the exception of a few compounds; nearly all are isolated; there are few clumps, and no pressure facets. The surface may be irregular, owing not only to irregular development of the margin, but also to amorphous additions to the surface. The conspicuous forms are the elongated ovoid, broad ovoid, and long and short ellipsoidal. There are also round or nearly round, pyriform, irregularly triangular, and polygonal grains, and various irregular forms. The compound grains have very irregular shapes, and commonly are irregularly ellipsoidal. The grains are not flattened and are of the same or nearly the same thickness and width at any given transverse diameter. The distal end is usually narrower than the proximal.

The *hilum* is usually distinct when not fissured. It appears as a small round spot, and eccentric about one-third of the longitudinal axis of the grain, and commonly in the larger end of the grain. There may be two or more hila placed irregularly with respect to one another. The hilum is often fissured by a large or small, ragged or clear-cut, single, transverse or diagonal cleft; or a 3-armed, or a large irregular cruciate fissure.

The *lamellæ* are not very distinct. They appear to be rather coarse, regular, continuous rings, which follow the outline of the margin of the grain, but not of the amorphous additions; more distinct near the hilum. The average number on a grain could not be determined with any accuracy.

The grains vary in *size* from 3 to 38μ. The common size is 26μ. The common dimensions of large grains are 34 by 26μ in length and breadth.

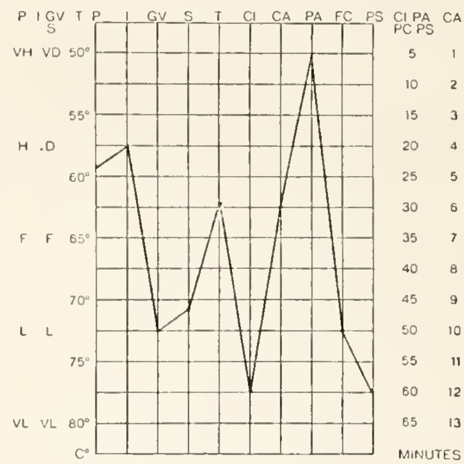
Polariscopic Properties.—The *figure* is eccentric, distinct, and usually clear-cut. Its lines tend to be of the same distinctness throughout, but may be bent or otherwise distorted. They are placed at varying angles to one another.

The degree of *polarization* is high. It varies greatly in different grains, being very high in some and extremely low in others. It is low at the distal ends of many of the grains, and it varies according to the aspect of the grain viewed. It is slightly lower than that of the grains of *B. peduncularis.*

With *selenite* the quadrants are fairly well defined, unequal in size, and generally irregular in shape. The colors in most cases are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet, some much more than others at first; with 0.125 per cent solution they color lightly at first, but the color deepens quickly, and some are more deeply colored than others. They are as deeply colored as those of *B. peduncularis.* After heating until all are completely gelatinized, the solution colors very lightly and the grains very deeply with iodine. After boiling for 2 minutes the solution colors more, but the grain-residues much less deeply. The capsules are colored a red-violet with very slight excess of iodine, and many still contain blue-reacting starch in the proximal end.

Chart No. 172.



Curve of Reaction-Intensities of Starch of Brodiæa ixoides var. splendens.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are lightly stained, some more than others. The shade is the same as that of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 61.5° to 62° C., mean 61.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains begin to react in 30 seconds. About half are darkened in 5 minutes, three-fourths in 15 minutes, and five-sixths in 25 minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

With *chromic acid* some grains begin to react in 30 seconds and most of them in a minute. The reaction is general in 2 minutes and over in 6 minutes, and is qualitatively the same as that of the grains of *B. peduncularis.*

Reaction with *pyrogallic acid* begins in a few grains at once and is general in 2 minutes. All the grains are completely gelatinized in 5 minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

Reaction with *ferric chloride* begins in a few grains at once and in about half in 1½ minutes. About three-fourths are fully gelatinized in 10 minutes, all but a very few in 25 minutes, and practically all in 50 minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

With *Purdy's solution* some few grains begin to react at once and the reaction is slight but general in 1½ minutes. Most of the small grains and a few of the medium-sized are nearly or completely gelatinized in 5 minutes. About half are partially or completely gelatinized in 15 minutes, but the reaction is incomplete in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

STARCH OF BRODIÆA CANDIDA. (Plate 45, figs. 269 and 270. Chart 173.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compounds; the smaller show some tendency to form doublets and triplets; the larger sometimes have several smaller grains adherent. The compound grains may be made up of two small grains surrounded by several layers of starch. There is a marked tendency among the grains to unite in large clumps. The grains are often distorted by nodular, spicular, or rounded processes, and it is not uncommon to see a perfectly formed primary grain, embedded or partially surrounded and thus distorted by irregular masses of amorphous matter. The most conspicuous forms are the long, pointed oval. There are broader and blunter, oval and ellipsoidal, and various modifications of them. The grains are not flattened in any diameter, and when turned over have the same dimensional characteristics as *B. peduncularis.*

The *hilum* is distinct, and when not fissured it is a round spot, situated eccentrically about one-third of the longitudinal axis of the grain, and usually in or near the median line. When it is fissured, as is usually the case, the fissure may be small, straight, or with a double curve, and clear-cut, transverse, or diagonal; or it may have three arms, or be irregularly stellate with one long arm extending in a longitudinal or diagonal direction. The hilum may be double, though rarely, but more than two were not observed.

The *lamellæ* are quite regular, fairly distinct, and coarse. They vary somewhat in different grains and are larger near the margin than near the hilum. They tend to closely follow the outline of the margin, but sometimes show irregularities. There are usually 6 to 10 lamellæ on a medium-sized grain.

The grains vary in *size* from 3 to 32μ. The common size is 16μ.

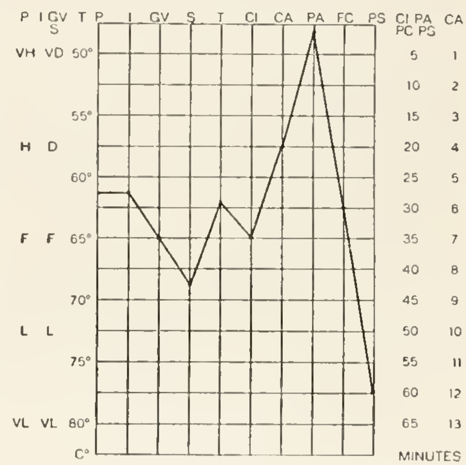
Polariscopic Properties.—The *figure* is distinct and fairly clear-cut. Its lines may become broader but less well defined at the margin and are often bent or otherwise distorted. Sometimes the lines do not intersect at the hilum.

The degree of *polarization* is fairly high. It is higher in certain aspects of the grain than in others, and varies in different grains. It is not so high as that of the grains of *B. peduncularis.*

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution the grains tint lightly at first and then the color deepens. The reaction is less than that of the grains of *B. peduncularis.* After heating until the grains are all completely gelatinized, the solution colors very faintly and the grains very deeply on the addition of iodine. The grains are much swollen and somewhat sacculated and distorted. After boiling for 2 minutes the solution is colored intensely, but the grain-residues less deeply than before, and some not at all. When a very slight excess of iodine is added the capsules color a red-violet. Most of the capsules contain more or less blue-reacting starch in the proximal end. The capsules are large and smooth at the proximal end, and sacculated, folded, and distorted at the distal end.

Chart No. 173.



Curve of Reaction-Intensities of Starch of Brodiæa candida.

Staining Reactions.—With *gentian violet* the grains stain very lightly at once and after 30 minutes are fairly well stained, more than those of *B. peduncularis.*

With *safranin* the grains stain very lightly at once, but after 30 minutes are only lightly stained, but more than the grains of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 61° to 63° C., mean 62°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains begin to react in a minute; most of them show some reaction and many are completely gelatinized in 5 minutes. All except one or two are completely gelatinized in 45 minutes. There is no further change. The process is in all respects qualitatively the same as that in the grains of *B. peduncularis.*

Reaction with *chromic acid* begins in many of the smaller grains immediately, is general in 30 seconds, and complete in 4 minutes. The process is identical with that in the grains of *B. peduncularis.*

Reaction with *pyrogallic acid* is general in 30 seconds and is over in 3 minutes. The process is identical with that of the grains of *B. peduncularis.*

The reaction with *ferric chloride* begins in many grains in a minute and is general in 2½ minutes. About five-sixths are completely gelatinized in 13 minutes, and the reaction is completed in 30 minutes. The process is the same as that of the grains of *B. peduncularis.*

With *Purdy's solution* the reaction begins at once in some smaller grains and is general in 30 seconds. None of the grains is fully gelatinized and very few are even partially gelatinized. The process seems to consist merely in the slight swelling of the hilum, unless also in some cases the innermost part of the grain may become gelatinous.

STARCH OF BRODIÆA LACTEA. (Plate 46, figs. 271 and 272. Chart 174.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compounds consisting of two or three components; some of the smaller form aggregates. There are no pressure facets on any of the isolated grains. There is some tendency to form in clumps. Rarely, 2 grains occur embedded in secondary deposits to form a large grain. A few grains have small, nipple-like and other processes and irregularities on the surface. The conspicuous form is the oval, with the narrow end rather pointed, and ovoid. In addition there are quadrangular, polygonal, nearly round, and a few pyriform grains. The grains are not flattened and they present practically the same diameter at any given diameter as they are turned over. When viewed on end they usually appear round.

The *hilum* is distinct, and when it is not fissured it appears as a small round spot, eccentric about one-third of the longitudinal axis of the grain, and usually in or near the median line. There may be double, or rarely triple, hila, each of which may or may not be surrounded by 2 or 3 lamellæ independent of the lamellæ of the others. Generally the hilum is fissured. The fissure is often very small and narrow, transverse or diagonal, but generally 3-armed; very rarely it is irregularly stellate. In some cases the hilum appears as a cavity with a fissure extending from it at one side. It is not rare for the body of the grain to be crossed by a number of small, irregular fissures.

The *lamellæ* are fairly distinct, coarse, continuous, and regular. They follow closely the outline of the margin, but occasionally one or two will show independent irregularities. They vary in size and distinctness in different grains, those near the hilum being more distinct than those near the margin. There are 8 to 10 lamellæ on a medium-sized grain.

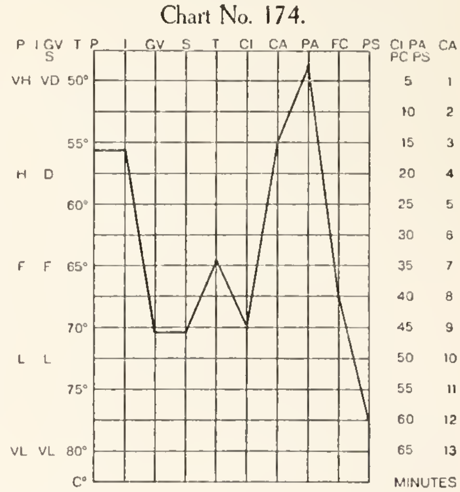
The grains vary in *size* from 2 to 32μ. The common size is 18μ.

Polariscopic Properties.—The *figure* is clear-cut and distinct. It is seldom bent or otherwise distorted. Its lines do not, as a rule, become broader and less well defined at the margin. Often the main peculiarity is the failure of the lines to meet at the hilum.

The degree of *polarization* is high. It is about the same in every part of the grain and does not vary much in different grains. It is slightly higher than that of the grains of *B. peduncularis.*

With *selenite* the quadrants are fairly clear-cut, unequal in size, and sometimes irregular in shape. The colors are pure and bright, but the yellow is often much encroached on by the red dividing lines.

Chart No. 174.



Curve of Reaction-Intensities of Starch of Brodiæa lactea.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains at once color a deep blue-violet; with 0.125 per cent solution they color fairly and then deepen slowly. The reaction is deeper than that of the grains of *B. peduncularis.* After heating until all the grains are completely gelatinized, the solution is colored lightly and the grains very deeply with iodine. The grains are much swollen and distorted, especially at the distal end. After boiling for 2 minutes the solution is deeply colored, but the grain-residues much less deeply. With the addition of a very slight excess of iodine the capsules color a violet, and the capsules generally contain some blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* the grains stain at once very lightly, but at the end of 30 minutes they are lightly colored, somewhat more than the grains of *B. peduncularis.*

With *safranin* the grains stain very lightly at once and after 30 minutes the color is light and about the same as the grains of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 64° to 65° C., mean 64.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few of the smaller grains react in a minute and about half are affected and a few gelatinized in 4 minutes. About three-fourths are affected in 10 minutes, about half being fully darkened, and all fully gelatinized in 45 minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

With *chromic acid* some grains begin to react in 20 seconds. The reaction is general in 1½ minutes and is over in 3 minutes. The reaction is the same qualitatively as that of the grains of *B. peduncularis.*

Reaction with *pyrogallic acid* begins in 30 seconds, and is over in 2½ minutes; it is practically the same as that of the grains of *B. peduncularis.*

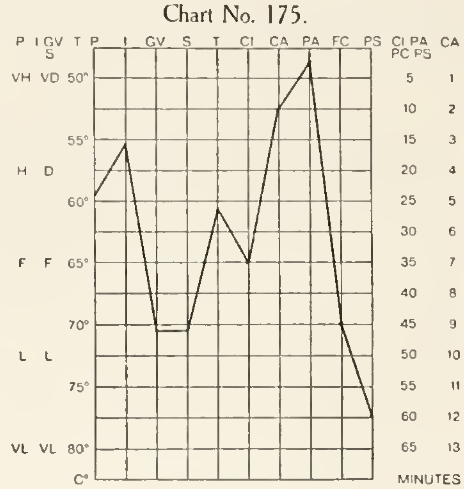
With *ferric chloride* there is some reaction in a minute. About half the grains are affected and many completely gelatinized in 5 minutes. All but a very few are gelatinized in 30 minutes, and all are gelatinized in 40 minutes. The reaction in these grains is practically identical with that of the grains of *B. peduncularis.*

With *Purdy's solution* there is a slight general reaction in a minute; two-thirds of the grains are partly gelatinized in 20 minutes; none fully gelatinized. There is no further change in an hour. The reaction is the same qualitatively as that of the grains of *B. peduncularis.*

STARCH OF BRODIÆA LAXA. (Plate 46, figs. 273 and 274. Chart 175.)

Histological Characteristics.—In *form* the grains are simple, except a few compounds which consist of two or three components. There are a few aggregates of the smaller grains, and one or more small grains may be seen fitting into a hollow or depression in a large grain, the exact lines of demarcation between the adherent grains being very hard to distinguish. Twin grains also occur which are united by some amorphous substance. Many grains show nipple-like processes or other irregularities of the surface. The conspicuous forms are the ovoid and oval; quadrangular, round, long and thin ellipsoidal, and broad or short ellipsoidal forms are commonly seen; rarely there are triangular and long and thin oval. The grains are not flattened in any diameter and therefore seem round when viewed on end.

Chart No. 175.



Curve of Reaction-Intensities of Starch of Brodiæa laxa.

The *hilum* is distinct and when not fissured it appears as a medium-sized round spot, eccentric about a third of the longitudinal axis of the grain, usually in or near the median line, rarely very much to one side. There may be 2 or more hila, in pairs or irregularly, and each may be surrounded by 2 or 3 lamellæ. The hilum is usually fissured. The fissures are commonly not deep or wide, and they are usually very irregular and ragged. They are commonly irregularly stellate, but 3- and 4-armed fissures are frequently seen. Rarely the fissure is single, transverse or diagonal, or with a double curve. It is not uncommon for a line of small, irregular fissures to extend from the hilum in the longitudinal axis of the grain.

The *lamellæ* are fairly distinct and very coarse, and more distinct near the margin than near the hilum. The difference in distinctness may be because those near the hilum are more or less obscured by the fissures. They are quite regular and tend to follow closely the line of the margin. Normally there are 6 to 8 lamellæ on a medium-sized grain.

The grains vary in *size* from 3 to 40μ. The common size is 26μ.

Polariscopic Properties.—The *figure* is usually clear-cut and distinct, even to the edge of the grain. Its lines are sometimes much bent and otherwise distorted, and do not always meet at the hilum.

The degree of *polarization* is high, not so high as that of the grains of *B. peduncularis.* It varies somewhat in different grains and in different aspects of the same grain.

With *selenite* the quadrants are usually clear-cut, irregular in shape, and unequal in size. The colors are generally pure and bright; sometimes the yellow has an admixture of red.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution the grains color deeply and the color deepens slowly. The color is somewhat deeper than that of the grains of *B. peduncularis.* After heating until the grains are completely gelatinized, the solution is colored slightly and the grains very deeply on the addition of iodine. The grains are much swollen and lobulated. After boiling for 2 minutes the solution is colored very deeply, but the grain-residues much less deeply or not at all. Most of the capsules contain some blue-reacting starch in the proximal end and all show a red-violet coloration when a slight excess of iodine is added.

Staining Reactions.—With *gentian violet* the grains begin to stain in 1½ minutes very lightly and after 30 minutes are only lightly stained. The color is deeper than that of the grains of *B. peduncularis.*

With *safranin* the grains begin to stain very lightly in a minute, but after 30 minutes are still very lightly stained. There is no difference in tint between these and the grains of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 60° to 62° C., mean 61°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds. Most of the grains are gelatinized in 20 minutes and practically all in 35 minutes. The reaction is qualitatively the same as that with the grains of *B. peduncularis.*

Reaction with *chromic acid* begins in 20 seconds and is over in 2 minutes. It is qualitatively the same as that of the grains of *B. peduncularis.*

With *pyrogallic acid* the reaction begins in 20 seconds and all the grains are completely gelatinized in 2½ minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

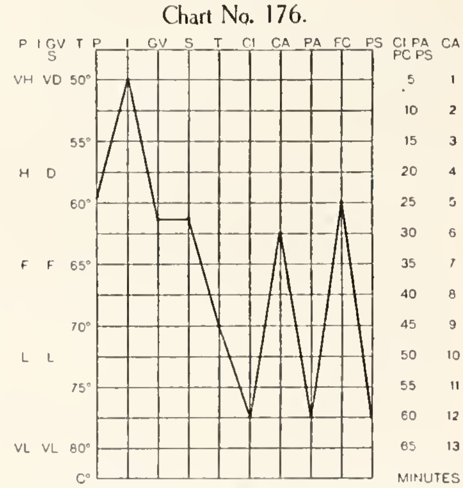
The reaction with *ferric chloride* begins in 45 seconds. All the grains are affected and three-fourths gelatinized in 22 minutes, and all are gelatinized in 45 minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

The reaction with *Purdy's solution* begins in the grains in 30 seconds. A few are completely and many partially gelatinized in 15 minutes, but the reaction is incomplete in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

STARCH OF BRODIÆA COCCINEA. (Plate 46, figs. 275 and 276. Chart 176.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compound, which latter more often consist of three than two components. There are a few aggregates of the smaller grains and a few clumps. The surface is, as a rule, irregular, many grains having rounded accretions or nipple-like processes projecting from the surface. The most conspicuous forms are short, broad ellipsoidal, verging into almost round and oval. Often grains are nearly round, but narrowed at the proximal end until they are somewhat triangular to pyriform. Ovoid forms are less common than in *B. peduncularis.* The grains are not flattened and are of much the same width and thickness at any given transverse diameter.

Chart No. 176.



Curve of Reaction-Intensities of Starch of Brodiæa coccinea.

The *hilum*, when not fissured, is a fairly distinct, medium-sized round spot, situated eccentrically about a third or less of the longitudinal axis of the grain, and in or near the median line. There may be 2 or more hila, often placed together in a non-lamellated space, and all or some may be fissured. When the hilum is fissured the fissure is usually not deep or broad, and it may be a short, straight, or curved transverse or diagonal line, or a 3-armed figure, or a cross. Occasionally the fissures are not clear-cut, but ragged and irregular. Rarely there is an irregular stellate group of fissures at the hilum.

The *lamellæ* are fairly distinct, regular, and coarse. Those about the hilum and in the central portion of the grain are usually the more distinct, and those near the margin are wider and coarser. They follow closely the outline of the margin, but not of the nipple-like processes or other projections from the surface. There are 10 to 15 lamellæ on medium-sized and large grains.

The grains vary in *size* from 4 to 34μ. The common size is 18μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not always clear-cut. Its lines often become broad and less distinctly outlined near the margin, and at times do not meet at the hilum. They are not often bent or otherwise distorted.

The degree of *polarization* is high, as a rule, but not quite so high as that of the grains of *B. peduncularis.* It may be absent in some parts of the grains, especially near the margin. It also varies somewhat in the different grains and is highest when the grains are viewed from the end.

With *selenite* the quadrants are fairly well defined, often irregular in shape, and unequal in size. In most cases the colors are pure and bright.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a deep blue-violet and the color is deeper than that of *B. peduncularis;* with 0.125 per cent solution the grains color fairly and the color grows deeper rapidly, slightly deeper than that of the grains of *B. peduncularis.* After heating until the grains are completely gelatinized, the solution is colored very faintly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution is colored much more deeply, but the grain-residues much less. On the addition of a slight excess of iodine the capsules are colored a reddish-violet. Most of the capsules contain some blue-reacting starch in the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain immediately, but very lightly. After 30 minutes most of the grains are fairly deeply stained, some more than others. The color is deeper than that of the grains of *B. peduncularis.*

With *safranin* the grains stain at once very lightly, but after 30 minutes they are fairly deeply stained, much more markedly than the majority of the grains of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is a slight reaction in some grains in a minute. About two-thirds are affected and some of them darkened throughout in 5 minutes. All are affected and three-fourths fully gelatinized in 15 minutes; all but 2 or 3 are fully gelatinized in 1½ hours. There is no further change. The reaction is practically identical with that of the grains of *B. peduncularis.*

Reaction with *chromic acid* begins immediately in some grains, is general in 1½ minutes, and over in 6 minutes. The reaction is practically identical with that of the grains of *B. peduncularis.*

With *pyrogallic acid* there is a slight reaction in a few grains in 30 seconds and most grains show some reaction in 5 minutes. Reaction is general in 10 minutes and has reached its limit in 25 minutes, but is incomplete in an hour. At this time the grains are in all stages from the beginning of swelling to a point nearly approaching or of complete gelatinization. The process is identical with that of the grains of *B. peduncularis.*

Some reaction with *ferric chloride* is seen in a few grains in 1½ minutes. About half are affected and some fully gelatinized in 5 minutes. About two-thirds are affected in 10 minutes, and almost all are completely gelatinized in 15 minutes. The reaction is over in all the grains in 25 minutes. The process is the same as that of the starch grains of *B. peduncularis.*

There is some reaction with *Purdy's solution* in a few grains in 1½ minutes, half are affected in 30 minutes and three-fourths in 50 minutes. None of the grains is entirely gelatinized, and many show merely an enlarged hilum and fine striæ radiating from it. There is no further change after an hour.

STARCH OF BRODIÆA GRANDIFLORA. (Plate 47, figs. 277 and 278. Chart 177.)

Histological Characteristics.—In *form* the grains are simple, with the exception if a few compounds consisting of two or three components. There were no aggregates of the smaller grains and but little tendency to form clumps. Large grains with a mass of smaller ones adherent to the base or sides are rarely seen. The surface of the grains is sometimes irregular, owing to spicular, nipple-like, and large projections. The conspicuous forms are oval, ovoid, and ellipsoidal; also long and elliptical, small round, triangular with flattened base and rounded apex, pyriform, a number of quadrangular grains, and various irregular forms. The grains are usually round when viewed on end.

When the *hilum* is not fissured, it appears as a fairly distinct, small, round spot, eccentric about one-third of the longitudinal axis of the grain and usually in or near the median line. There may be rarely 2 or even 3 hila, which are generally placed very close together, usually in a homogeneous, non-lamellated space, but in some cases each seems to have a few lamellæ. The hilum usually is fissured, but the fissures are not so common, so deep, or so wide as those in the grains of *B. peduncularis.* Generally the fissure is small, straight or double-curved, and transverse or diagonal; not uncommonly it has three lines, or is in the form of a cross; it may be clear-cut or ragged. Rarely the hilum is marked by an irregular, stellate fissure; in some grains it may not be fissured, but fissures may lie underneath it, or a fissure may extend through the hilum and the portion of the grain beneath.

The *lamellæ* are coarse and fairly distinct. One near the hilum is usually more distinct than the others. They follow the outline of the margin closely, but occasionally show irregularities not associated with the shape of the margin. There are usually 10 to 15 lamellæ on the larger grains.

The grains vary in *size* from 1 to 67μ. The common size is 36μ.

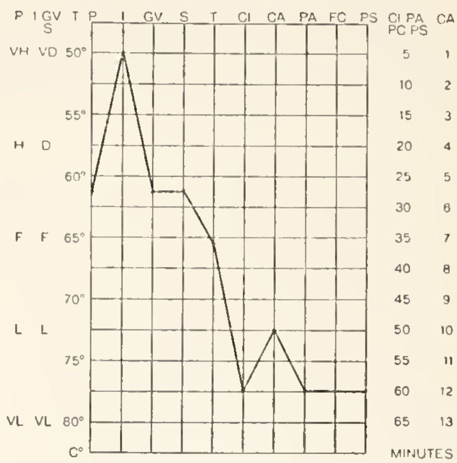
Polariscopic Properties.—The *figure* is distinct, but not always clear-cut, and is eccentric. Its lines are often blurred and indistinct, owing to fissures or irregularities in the grains; the lines do not always intersect at the hilum, but are connected at this point by a thin dark line.

The degree of *polarization* is fairly high. It varies somewhat in different grains and considerably in different aspects of the same grain. It is not so high as in the grains of *B. peduncularis.*

With *selenite* the quadrants are commonly not well defined, and are irregular in shape and unequal in size. The colors are not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains at first color deeply a blue-violet; somewhat deeper than those of *B. peduncularis;* with 0.125 per cent solution the grains are colored fairly. After heating until the grains are completely gelatinized, the solution is colored very lightly and the gelatinized grains very deeply with iodine. After boiling for 2 minutes the solution is colored very much deeper, but the grain-residues much less or not at all. The grain-residues are much swollen and lobulated at one end. The capsules are colored a red-violet when an excess of iodine is added, and some of them retain blue-reacting starch in the proximal end.

Chart No. 177.



Curve of Reaction-Intensities of Starch of Brodiæa grandiflora.

Staining Reactions.—With *gentian violet* the grains stain at once, but very lightly. After 30 minutes they are but lightly stained, slightly more than the grains of *B. peduncularis.* The individual grains are more evenly stained than those of *B. peduncularis.*

With *safranin* the grains stain at once, but very slightly. After 30 minutes the stain is quite deep and even, much more than of the grains of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 65° to 66.8° C., mean 65.9°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few of the smaller grains show some reaction in 3 minutes. A few of the larger show some changes, and practically all of the smaller, many of the latter being gelatinized in 5 minutes. About one-third of the larger grains are affected in 10 minutes; three-fourths of the total number are affected and most of them gelatinized after 1½ hours. There is no further change. The reaction is qualitatively the same as that with the grains of *B. peduncularis.*

Reaction with *chromic acid* begins in a minute and is over in 10 minutes. It is the same qualitatively as that of the grains of *B. peduncularis.*

With *pyrogallic acid* some grains react in 2 minutes. Almost all show signs of reaction and many are almost gelatinized in 5 minutes. The reaction reaches its limit, all being partially gelatinized, within 45 minutes, but none are completely gelatinized. Some show merely a beginning of reaction. There is no further change. The reaction is the same qualitatively as that of the grains of *B. peduncularis.*

With *ferric chloride* some of the smaller grains react in 2 minutes and one-third are affected in 5 minutes. About two-thirds of the total number are completely gelatinized in 25 minutes and all in 1½ hours. The reaction is the same qualitatively as that of the grains of *B. peduncularis.*

Reaction with *Purdy's solution* begins in 2 minutes very slightly. About one-fourth of the total number are affected in an hour, a few of which are almost completely gelatinized. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

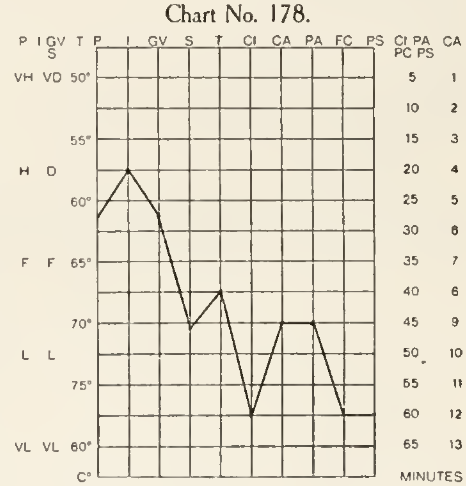
STARCH OF BRODIÆA CALIFORNICA. (Plate 47, figs. 279 and 280. Chart 178.)

Histological Characteristics.—In *form* the grains are simple. No compound grains or pressure facets were noted. The grains are isolated with few exceptions. The surface of the grains is on the whole quite regular. Irregularities are usually due to unequal development of various parts of the margin. Nipple-like processes are not common. The conspicuous forms are ovoid, oval, and ellipsoidal. The broader forms are not so thick as broad; and the distal end is apt to be narrower than the proximal, so that on edge the grains appear of an elongated, ovoid form.

The *hilum* is distinct and nearly always marked with fissures. It is eccentric about one-third of the longitudinal axis of the grain. There are probably compound grains with 2 or more hila which are likely obscured by fissures. The fissures are usually very deep and wide, less commonly they are small, single, transverse or diagonal lines, but usually the fissuration is in the form of a more or less clear-cut cross. There may be one fissure at the hilum and another rather irregular fissure between the hilum and the distal end. There are also at times irregularly stellate and 3-armed fissures. Fissuration is less marked than in *B. peduncularis.*

The *lamellæ* are fairly distinct, rather coarse, regular, continuous lines which follow the outline of the margin. Those near the hilum are more distinct than those at the distal end. They are arranged apparently so that a group of rather fine, indistinct lamellæ alternate with a single, coarse, and distinct lamella. The hilum is usually situated in a small, non-lamellated space. There are probably on the larger grains about 12 lamellæ, but the number could not be determined with accuracy.

Chart No. 178.



Curve of Reaction-Intensities of Starch of Brodiæa californica.

The grains vary in *size* from 5 to 57μ. The common size is 32μ. The common dimensions of a large, ovoid grain are 38 by 32μ in length and width.

Polariscopic Properties.—The *figure* is eccentric and distinct, not clear-cut. Two of the lines are often blurred and indistinct as they near the margin and slightly bent or otherwise distorted.

The degree of *polarization* is fairly high, except near the distal end and margin of some of the grains. It is somewhat less than that of the grains of *B. peduncularis.*

With *selenite* the quadrants are not well defined, are usually irregular in shape, and are unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once a deeply blue violet; with 0.125 per cent solution they color lightly at first, but the color soon deepens. Some grains are much more deeply colored than others. The shade is about the same as that of *B. peduncularis.* After heating until the grains are completely gelatinized, the solution colors fairly and the grains deeply with iodine. After boiling for 2 minutes the solution colors very deeply, the grain-residues very lightly or not at all. The capsules color a dark red-violet when a slight excess of iodine is added and many still contain some blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly deeply stained, some more deeply than others. All are colored more than the grains of *B. peduncularis.*

With *safranin* the grains begin to stain at once and in 30 minutes are lightly stained, some more than others. The color is the same as that of the grains of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 67° to 68° C., mean 67.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains show a reaction in 30 seconds. A few are darkened in 5 minutes and about one-third show some signs of reacting without much change in 10 minutes. A few more are darkened and there is a slight advance in the reaction in the other grains in 15 minutes. About one-fourth are darkened and some of the rest are affected in 30 minutes. About one-third are dark and a few more partially darkened and gelatinized in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

Reaction with *chromic acid* begins in a few grains in 30 seconds. About one-fourth are affected in 1½ minutes and two-thirds in 2½ minutes. At this time some of the grains have undergone complete solution. All the grains react within 3½ minutes and the reaction is over in 9 minutes. The process is qualitatively the same as that of the grains of *B. peduncularis.*

With *pyrogallic acid* a few react in 30 seconds and a few more in 1½ minutes. About one-fourth to one-third are almost completely gelatinized in 6 minutes, and the remainder are in all stages of reaction. About two-thirds are almost completely gelatinized in 20 minutes and all in 45 minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

A few grains begin to react with *ferric chloride* in 30 seconds, about one-fourth are gelatinous in 5 minutes, the rest are unaffected. About half are gelatinous or partially gelatinous in 10 minutes, two-thirds in 15 minutes, three-fourths in 30 minutes, and five-sixths in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

With *Purdy's solution* a few grains begin to react immediately. About one-fourth are affected in 2 minutes, and some of them, including a good many of the smaller grains, are completely gelatinized. About half are affected and some of these completely gelatinized in 10 minutes, and two-thirds are affected in 30 minutes, but the reaction is not complete in an hour. The reaction is the same qualitatively as that of the grains of *B. peduncularis.*

STARCH OF BRODIÆA PURDYI. (Plate 47, figs. 281 and 282. Chart 179.)

Histological Characteristics.—In *form* the grains are simple, except a few compounds consisting of two or three components that are often partially separated by fissures. Occasionally the smaller grains form small aggregates, and grains of all sizes are found to some extent in large clumps. The surface is, on the whole, fairly regular. There may be rounded projections of amorphous substance, and also nipple-like processes. The conspicuous forms are the ovoid to nearly round, oval, and ellipsoidal; also quadrangular with rounded corners, rarely pyriform, and many irregular forms. The grains are not quite so thick as broad.

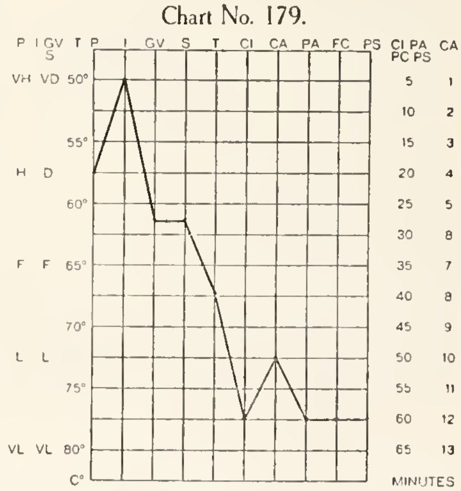
When the *hilum* is not fissured it appears as a not very distinct, fairly large, round spot, which commonly is eccentric about one-fourth of the longitudinal axis of the grain. Double or triple hila occur rarely, closely grouped in an amorphous, non-lamellated space. Usually the hilum is fissured and the fissures are commonly shallow and narrow. The fissure is often simple, diagonal or transverse, clear-cut or ragged. In some grains the hilum is not fissured, but the surface of the grain is slightly fissured between the hilum and the distal end.

The *lamellæ* are regular, coarse rings, but as a rule quite indistinct. Usually there is one distinct lamella near the hilum. The lamellæ follow closely the outline of the margin, but are not distinct enough to count.

The grains vary in *size* from 3 to 54μ. The common size is 26μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, but not clear-cut. Its lines are apt to become broadest but less sharp near the margin, and also occasionally in other parts of the grain. Sometimes a line will be bisected, and sometimes they are slightly bent or otherwise distorted.

Chart No. 179.



Curve of Reaction-Intensities of Starch of Brodiæa purdyi.

The degree of *polarization* is high. It is about the same as that of the grains of *B. peduncularis.* It is absent from some parts of some of the grains, and usually highest when the grain is viewed from the side or end. It varies somewhat in different grains.

With *selenite* the quadrants are not usually well defined, and are generally irregular in shape and unequal in size. The colors are fairly pure, especially the blue.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet, and the color gradually becomes deeper than in *B. peduncularis;* with 0.125 per cent solution the grains color fairly and somewhat more than those of *B. peduncularis.* After heating until the grains are completely gelatinized, the solution is colored fairly well and the grains very deeply with iodine. In some grains, which are less deeply stained, a violet outer layer appears at the distal end. After boiling for 2 minutes the solution is colored more deeply, but the grain-residues much less deeply. With a very slight excess of iodine all the capsules become violet. Most of the capsules still contain blue-reacting starch in their proximal ends.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after 30 minutes are fairly deeply stained, much more than *B. peduncularis.*

With *safranin* the grains stain immediately and after 30 minutes they are fairly deeply stained, much more than *B. peduncularis*. These grains are more evenly stained than those of the other *Brodiæa* starches.

Temperature Reaction.—The temperature of gelatinization is 66° to 68° C., mean 67°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains show signs of reaction in 2 minutes, about one-fifth in 5 minutes, about one-third in 10 minutes, and about two-thirds in 30 minutes. About three-fourths have fully reacted in 1½ hours, but the others are unaffected. There is no further change. The reaction is qualitatively the same as that of the grains of *B. peduncularis*.

Reaction with *chromic acid* begins in some grains in 30 seconds and is general in 1½ minutes. It is over in 10 minutes, and it agrees qualitatively in every respect with that of the grains of *B. peduncularis*.

There is reaction with *pyrogallic acid* in a few grains in a minute and it is general in 5 minutes. About one-third to one-half are partially gelatinized in 25 minutes, and the reaction has practically reached its limit in 35 minutes, at which time some of the grains show the beginning of reaction, while others are in all transitional stages between beginning and completion. There is no further change. The reaction is qualitatively the same as that of the grains of *B. peduncularis*.

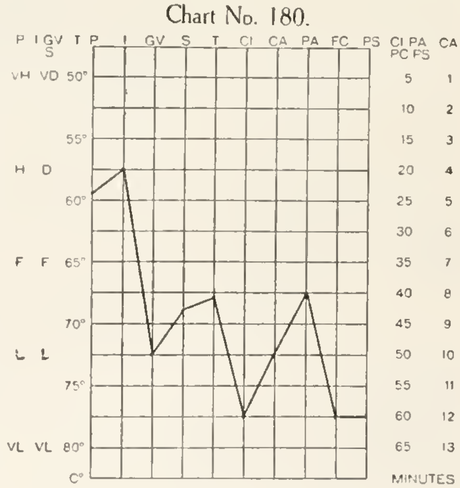
With *ferric chloride* some grains show a slight reaction in 1½ minutes. About one-fifth are affected in 5 minutes, half in 10 minutes, and two-thirds in 20 minutes. Practically all are completely gelatinized in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis*.

There is reaction with *Purdy's solution* in some grains in 5 minutes. About one-fourth show signs of reacting in an hour and about three-fourths in 1½ hours, but only a few are completely gelatinized within this time. There is no further change. The reaction, as far as it goes, is qualitatively the same as that of the grains of *B. peduncularis*.

STARCH OF BRODIÆA STELLARIS. (Plate 48, figs. 283 and 284. Chart 180.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compound grains. There are a few small aggregates among the smaller grains and also among some larger grains which have two or three small grains adherent to the surface. There are no pressure facets. The surface tends to be irregular, owing to irregularities of development, chiefly in the form of large or small nipple-like processes and rounded projections which give an uneven margin to an otherwise regular form. The conspicuous forms are the ovoid, oval, and ellipsoidal; also pyriform, elliptical and round, and many irregular forms. The grains, as a rule, are not so irregular in outline as those of *B. peduncularis*. Rarely grains occur with a mass of amorphous accretions, usually attached to the distal end.

Chart No. 180.



Curve of Reaction-Intensities of Starch of Brodiæa stellaris.

When the *hilum* is not fissured it is a fairly distinct, comparatively small round spot situated eccentrically about one-third of the longitudinal axis of the grain, usually in or near the median line. There are rarely 2 hila; a larger number was not observed. The hilum is generally fissured, but the fissures are not particularly broad or long. The common forms are simple transverse, 3-armed, or 4-armed. The lines may be straight or curved. Frequently the fissure presents a double curve. The fissures are, as a rule, clean-cut and not ragged.

The *lamellæ* are distinct and rather coarse, especially one or two near the margin. They are regular, continuous, and follow closely the outline of the margin except when the latter is distorted by irregular projections of an amorphous character. They sometimes show waviness and bending not related to the outline of the margin. There are 12 to 18 lamellæ on the medium-sized and large grains.

The grains vary in *size* from 2 to 40μ. The common size is 22μ.

Polariscopic Properties.—The *figure* is eccentric, usually clear-cut, and distinct. The lines occasionally become broader but less sharp near the margin. They may be slightly bent and otherwise distorted.

The degree of *polarization* is fairly high. It is apt to be higher when the grain is viewed from the end, and varies somewhat in different grains. As a whole, the grains are less polariscopic than those of *B. peduncularis.*

With *selenite* the quadrants, as a rule, are well defined, irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution the grains color fairly and the color deepens slowly. The color is the same as that of the grains of *B. peduncularis.* After heating until the grains are completely gelatinized, the solution is colored lightly and the grains deeply with iodine. A few capsules are colored violet at the distal end. After boiling for 2 minutes, the solution is colored much more deeply, but the grain-residues much less deeply or not at all. When a slight excess of iodine is used the capsules are colored a red-violet, and most of them still contain blue-reacting starch in the proximal end.

Staining Reactions.—With *gentian violet* the grains stain very slightly at once, but after 30 minutes are lightly colored, some more than others. The color is the same as that of the grains of *B. peduncularis.*

With *safranin* the grains stain very lightly at once and after 30 minutes are light colored. They are slightly more stained than those of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 67.2° to 69° C., mean 68.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some of the smaller grains begin to react in 2 minutes, and a majority of the grains show reaction in 5 minutes. About half are fully gelatinized in 30 minutes and about two-thirds are gelatinized in 1½ hours, but the others are unaffected. There is no further change. This reaction is qualitatively the same as that observed in the grains of *B. peduncularis.*

Reaction with *chromic acid* generally begins in 30 seconds and is over in 10 minutes. This reaction is qualitatively the same as that of the grains of *B. peduncularis.*

With *pyrogallic acid* some of the small grains begin to react in a minute, and the reaction is general in 2 minutes. About half are fully gelatinized in 14 minutes and almost all in 40 minutes. Some grains never completely gelatinize. There is no further change in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

Reaction with *ferric chloride* begins in some of the smaller grains in 3 minutes. About one-fourth of the grains are gelatinized in 8 minutes, but most of the others are not affected. Most grains are gelatinized in 25 minutes and all within 1½ hours. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

With *Purdy's solution* some of the smaller grains begin to react in a minute. A few more show enlargement of the hilum in 15 minutes. About one-third are affected, a few show partial gelatinization, and others a slight swelling of the hilum in 1½ hours. The reaction is the same as that of the grains of *B. peduncularis.*

STARCH OF BRODIÆA CAPITATA. (Plate 48, figs. 285 and 286. Chart 181.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compound grains which consist of a variable number of components; among the smaller grains there are frequently small aggregates, and some of the larger have one smaller grain adherent to the surface. The surface is quite regular, and there are comparatively few of the nipple-like processes so evident in certain species of *Brodiæa.* The conspicuous form is the ovoid to nearly round, oval, and ellipsoidal. The grains are of much the same width and thickness at any given diameter. When viewed from the end they appear spherical.

The *hilum* when not fissured is a not very distinct, comparatively large, round spot, situated eccentrically about one-third of the longitudinal axis of the grains, usually in the median line. Multiple hila are not uncommon, and there may be 1 to 4 or even more. The hila may be separated by small fissures, or closely grouped in a non-lamellated space, around which the lamellæ are seen. All, some, or none of the hila may be fissured. The single hilum is usually fissured, but the fissure is commonly not deep. Frequently there is but one transverse or diagonal fissure, which may be clear-cut and have a double curve. Ragged, 3-armed, and irregular stellate fissures are not uncommon.

The *lamellæ* are fairly distinct, regular, coarse, continuous rings, following the outline of the margin. Those near the distal end are usually coarser than those near the hilum. They vary in size and distinctness in different grains. There are 10 to 12 lamellæ on the larger grains.

The grains vary in *size* from 3 to 40μ. The common size is 24μ.

Polariscopic Properties.—The *figure* is eccentric, very distinct, not always clear-cut. The lines are thick and become thicker as they approach the margin. If there is a cavity or fissure at the hilum the lines of the figure may not meet at this point. In some cases one of the lines is seen to be bisected. This may occur when the line extends longitudinally along the middle of the grain.

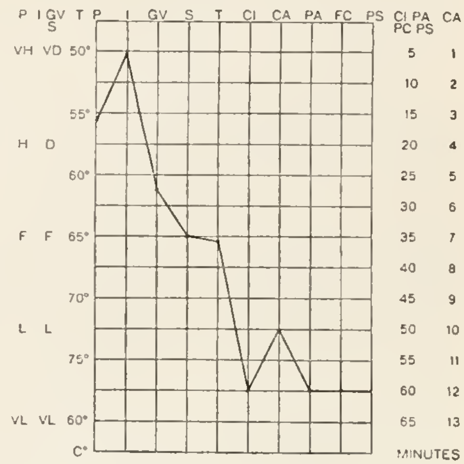
The degree of *polarization* is high, especially if the grain is viewed from the end; but in some of the grains it appears to be low or absent near and at the margin. It varies also in different grains. It is slightly higher than in the grains of *B. peduncularis.*

With *selenite* the quadrants are well defined, regular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution the grains tint fairly. The reactions are more than those of *B. peduncularis.* After heating until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine, and the grains are much swollen and distorted. After boiling for 2 minutes the solution is much more deeply colored, but the grain-residues much less, some not at all. On the addition of more iodine the capsules color a red-violet, and some blue-reacting starch may be seen, usually in the proximal end of the capsule. The distal end is empty, twisted, and crumpled.

Staining Reactions.—With *gentian violet* the grains stain at once fairly well and after 30 minutes are fairly deeply stained, yet not deeply. They are stained much deeper than the grains of *B. peduncularis.*

Chart No. 181.



Curve of Reaction-Intensities of Starch of Brodiæa capitata.

With *safranin* the grains stain at once lightly and after 30 minutes the color is fair. The grains are more markedly colored than those of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 65° to 66° C., mean 65.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some small grains in a minute and about half show some reaction in 10 minutes. Almost all are completely gelatinized in 50 minutes and all but 2 or 3 in 70 minutes. There is no further change. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

Reaction with *chromic acid* begins immediately in the smaller grains and in 30 seconds in the larger, and all the grains are completely dissolved in 10 minutes. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

The reaction with *pyrogallic acid* begins in a few grains in a minute and in all in 15 minutes. All the grains are partially gelatinized in 30 minutes, but the reaction is incomplete in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

With *ferric chloride* the reaction begins in the smaller grains in a minute, half the total number are affected in 10 minutes, and all are completely gelatinized in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

Reaction with *Purdy's solution* begins in some few grains in 45 seconds, all are affected in 7 minutes, and all partially gelatinized in an hour. The reaction is qualitatively the same as that of the grains of *B. peduncularis.*

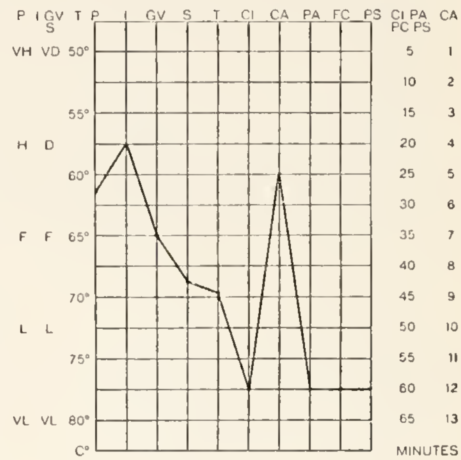
STARCH OF BRODIÆA CONGESTA. (Plate 48, figs. 287 and 288. Chart 182.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compounds which consist of two or more components. There are very few aggregates, even among the smaller grains, but there is a marked tendency to form large clumps. The surface of the grains is almost without exception very regular, showing the least irregularity of all the Brodiæas. The most conspicuous forms are the ovoid to round, oval, and ellipsoidal. The grains are not flattened in any transverse diameter, hence they are as thick as broad, and appear round when seen on end.

When not fissured, the *hilum* appears as a rather indistinct, large, round spot at the large end of the grain, usually in or near the median line, and eccentrically about one-third of the longitudinal axis. Double or triple hila occur, which may be partly separated from one another by fissures. The hilum is usually fissured, and the fissure may range from shallow and narrow to very deep and wide. It may be a simple transverse or diagonal line, with or without a single or double curve; or it may be 3-armed or 4-armed; or irregularly stellate; or ragged and irregular.

The *lamellæ*, as a rule, are not very distinct, are coarse and regular, and vary in distinctness in different grains. They follow closely the outline of the margin of the grain. Those near the distal end and marginal portions are apt to be coarser and more distinct than those near the hilum. The latter are obscured in almost every case by fissures. There are about 8 to 12 lamellæ on the larger grains.

Chart No. 182.



Curve of Reaction-Intensities of Starch of Brodiæa congesta.

The grains vary in *size* from 2 to 36μ. The common size is about 20μ.

Polariscopic Properties.—The *figure* is centric and usually clear-cut and distinct. Occasionally one or more of the lines may be broader and less sharp at the margin; rarely one or two are bent or otherwise distorted. In most cases the figure is very regular.

The degree of *polarization* is fairly high. It is sometimes low or absent at the distal end and marginal parts and varies also in different grains. It is not quite so high as in *B. peduncularis.*

With *selenite* the quadrants are usually clear-cut, unequal in size, and regular or irregular in shape. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution they color fairly and the color deepens slowly. The reaction is about the same as in the grains of *B. peduncularis.* After heating until the grains are completely gelatinized, the solution is colored lightly and the grains very deeply with iodine. The grains are much swollen, distorted, and lobulated. After boiling for 2 minutes the solution is colored much more deeply, but the grain-residues much less. With a very slight excess of iodine the capsules are colored a red-violet; some of the capsules contain blue-reacting starch in the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain at once very lightly, and after 30 minutes are fairly stained, but deeper than the grains of *B. peduncularis.*

With *safranin* the grains begin to stain at once, but the color is very faint. After 30 minutes they are lightly stained, slightly deeper than the grains of *B. peduncularis.*

Temperature Reaction.—The temperature of gelatinization is 68.5° to 70° C., mean 69.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is reaction in some of the smaller grains in 30 seconds, and in half in 5 minutes. About three-fourths are darkened in 30 minutes, and one-fifth are not affected even after an hour. The reaction is in all respects qualitatively the same as that in the grains of *B. peduncularis.*

Reaction with *chromic acid* begins in the small grains in 20 seconds, is general in 2½ minutes, and complete in 5 minutes. It is qualitatively identical with the reaction in the starch of *B. peduncularis.*

Reaction with *pyrogallic acid* begins in some grains in a minute, is general in 4 minutes, and is over in 30 minutes. None of the grains is ever fully gelatinized, but all reach about the same intermediate stage. The reaction is qualitatively the same as that in the starch of *B. peduncularis.*

The reaction with *ferric chloride* begins in some grains in 1½ minutes; about half are affected in 5 minutes, and two-thirds are completely gelatinized in 10 minutes. The reaction is complete in most of the grains in 30 minutes, and in all in an hour. It is qualitatively the same as that noted in the grains of *B. peduncularis.*

With *Purdy's solution* there is a reaction in some grains in 30 seconds, but only half show signs of reaction in 50 minutes. No further change was noted after the lapse of 2½ hours. None of the grains are completely gelatinized. This reaction is qualitatively the same as that in the grains of *B. peduncularis.*

Differentiation of Certain Starches of the Genus Brodiæa.

Histological Characteristics.

Conspicuous Forms.

B. peduncularis: Usually simple, rarely compound, few aggregates, surface usually irregular owing chiefly to nipple-like and rounded protuberances. Ovoid, oval, and ellipsoidal, with a tendency to pointing of the distal end.

B. ixoides var. *splendens:* Essentially the same as in *B. peduncularis,* except greater irregularity and tendency to pointing of the distal end.

B. candida: Essentially the same as in *B. peduncularis.*

B. lactea: Essentially the same as in *B. peduncularis.*

B. laxa: Essentially the same as in *B. peduncularis.*

B. coccinea: Essentially the same as in *B. peduncularis,* but the conspicuous form is the short, broad ellipsoidal, verging into almost round and oval.

B. grandiflora: Essentially the same as in *B. peduncularis,* but the surface is, as a rule, less irregular.

B. californica: Essentially the same as in *B. peduncularis,* but the surface is less irregular.

B. purdyi: Essentially the same as in *B. peduncularis,* but less irregular, the conspicuous forms tend more to the ovoid to almost round.

B. stellaris: Essentially the same as in *B. peduncularis.*

B. capitata: Essentially the same as in *B. peduncularis,* but with markedly fewer irregularities of surface, and there is a greater tendency towards roundness.

B. congesta: Essentially the same as in *B. peduncularis,* but much less irregularity of surface, these grains being the least irregular of all the Brodiæas, and in marked contrast with *B. ixoides* var. *splendens,* which is the most irregular.

Hilum—Form, Number, and Position.

B. peduncularis: Form distinct, small, round, double or multiple, usually fissured, fissures deep and extensive. Position eccentric about 0.33 of longitudinal axis.

B. ixoides var. *splendens:* Form distinct, small, round, may be double, usually fissured, fissures large and ragged. Position eccentric about 0.33 of longitudinal axis.

B. candida: Form distinct, small, round, rarely double, usually fissured, fissures small and clean-cut. Position eccentric about 0.33 of longitudinal axis.

B. lactea: Form distinct, small, round, may be double, usually fissured, fissure small and clean-cut. Position eccentric about 0.33 of longitudinal axis.

B. laxa: Form distinct, medium-sized, round, may be double, usually fissured, fissures small but irregular and ragged. Position eccentric about 0.33 of longitudinal axis.

B. coccinea: Form fairly distinct, medium-sized, round, single or multiple, usually fissured, fissure small and not deep or broad. Position eccentric about 0.33 or less of longitudinal axis.

B. grandiflora: Form distinct, small, round, usually single, may be multiple, usually fissured, fissure small and not deep or broad. Position eccentric about 0.33 of longitudinal axis.

B. californica: Form fairly distinct, small, round, always fissured, fissures usually very large, deep and wide, rarely small and shallow, probably multiple hila. Position eccentric about 0.33 of longitudinal axis.

B. purdyi: Form not very distinct, large, round, single, rarely multiple, usually fissured, fissures small and shallow. Position eccentric about 0.25 of longitudinal axis.

B. stellaris: Form fairly distinct, small, round, single, rarely double, usually fissured, fissures not deep or broad. Position eccentric about 0.33 of longitudinal axis.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.—Continued.

B. capitata: Form rather indistinct, large, round, single, may be multiple, usually fissured, fissures not deep but often ragged. Position eccentric about 0.33 of longitudinal axis.

B. congesta: Form rather indistinct, large, round, single, may be multiple, usually fissured, fissures small, or deep and wide, often ragged. Position eccentric about 0.33 of longitudinal axis.

Lamellæ—General Characteristics and Number.

B. peduncularis: Fairly distinct, continuous, coarse, sometimes irregular. 8 to 10 on medium-sized grains.

B. ixoides var. *splendens:* Not very distinct, rather coarse, continuous, no especial irregularities. Number not determined.

B. candida: Fairly distinct, coarse, usually regular, continuous. 6 to 10 on medium-sized grains.

B. lactea: Fairly distinct, coarse, continuous, usually regular. 8 to 10 on medium-sized grains.

B. laxa: Fairly distinct, very coarse, regular, continuous. 6 to 8 on medium-sized grains.

B. coccinea: Fairly distinct, regular, coarse, continuous. 10 to 15 on larger grains.

B. grandiflora: Fairly distinct, rather coarse, usually regular and continuous. About 10 to 15 on larger grains.

B. californica: Not very distinct, coarse, regular, continuous. About 12 on the larger grains.

B. purdyi: Indistinct, regular, coarse, continuous. Number not determined.

B. stellaris: Distinct, rather coarse, usually regular, continuous. 12 to 18 on larger grains.

B. capitata: Fairly distinct, regular, coarse, continuous. 10 to 12 on larger grains.

B. congesta: Not very distinct, coarse, regular, continuous. 8 to 12 on larger grains.

Size.

B. peduncularis: From 2 to 60μ, commonly 35μ.

B. ixoides var. *splendens:* From 3 to 38μ, commonly 26μ.

B. candida: From 3 to 32μ, commonly 16μ.

B. lactea: From 2 to 32μ, commonly 18μ.

B. laxa: From 3 to 40μ, commonly 26μ.

B. coccinea: From 4 to 34μ, commonly 18μ.

B. grandiflora: From 1 to 67μ, commonly 36μ.

B. californica: From 5 to 57μ, commonly 32μ.

B. purdyi: From 3 to 54μ, commonly 26μ.

B. stellaris: From 2 to 40μ, commonly 22μ.

B. capitata: From 3 to 40μ, commonly 24μ.

B. congesta: From 2 to 36μ, commonly 20μ.

Polariscopic Properties.

Figure.

B. peduncularis: Eccentric, distinct, not always clear-cut, often distorted.

B. ixoides var. *splendens:* Eccentric, distinct, usually clear-cut, may be distorted.

B. candida: Eccentric, distinct, fairly clear-cut, often distorted.

B. lactea: Eccentric, distinct, clear-cut, seldom distorted.

B. laxa: Eccentric, usually clear-cut, often distorted.

B. coccinea: Eccentric, distinct, not always clear-cut, usually regular.

B. grandiflora: Eccentric, distinct, not always clear-cut, nor regular.

B. californica: Eccentric, distinct, not clear-cut, often irregular.

B. purdyi: Eccentric, distinct, not clear-cut, sometimes irregular.

B. stellaris: Eccentric, distinct, usually clear-cut, may be irregular.

Differentiation of Certain Starches of the Genus Brodiæa.—Continued.

POLARISCOPIC PROPERTIES.—Continued.

Figure.—Continued.

B. capitata: Eccentric, very distinct, not always clear-cut, usually regular.
B. congesta: Eccentric, usually distinct, usually clear-cut, usually regular.

Degree of Polarization.

B. peduncularis: High.
B. ixoides var. *splendens:* High, but slightly lower than in *B. peduncularis.*
B. candida: Fairly high, lower than in *B. peduncularis.*
B. lactea: High, slightly higher than in *B. peduncularis.*
B. laxa: High, not so high as in *B. peduncularis.*
B. coccinea: High, not so high as in *B. peduncularis.*
B. grandiflora: Fairly high, lower than in *B. peduncularis.*
B. californica: Fairly high, lower than in *B. peduncularis.*
B. purdyi: High, about the same as in *B. peduncularis.*
B. stellaris: High, less than in *B. peduncularis.*
B. capitata: High, slightly higher than in *B. peduncularis.*
B. congesta: Fairly high, not so high as in *B. peduncularis.*

Polarization with Selenite—Quadrants and Colors.

B. peduncularis: Quadrants not well defined, irregular in shape, unequal in size. Colors pure.
B. ixoides var. *splendens:* Quadrants fairly well defined, usually irregular in shape, unequal in size. Colors usually not pure.
B. candida: Quadrants fairly well defined, irregular in shape, unequal in size. Colors not quite pure.
B. lactea: Quadrants well defined, sometimes irregular in shape, unequal in size. Colors pure.
B. laxa: Quadrants usually well defined, irregular in shape, unequal in size. Colors usually pure.
B. coccinea: Quadrants fairly well defined, often irregular in shape, unequal in size. Colors usually pure.
B. grandiflora: Quadrants usually not well defined, irregular in shape, unequal in size. Colors not pure.
B. californica: Quadrants not well defined, irregular in shape, unequal in size. Colors not pure.
B. purdyi: Quadrants usually not well defined, generally irregular in shape, unequal in size. Colors fairly pure.
B. stellaris: Quadrants usually well defined, irregular in shape, unequal in size. Colors usually pure.
B. capitata: Quadrants well defined, regular in shape, unequal in size. Colors pure.
B. congesta: Quadrants well defined, regular or irregular in shape, unequal in size. Colors fairly pure.

IODINE REACTIONS.

Intensity and Color.

B. peduncularis: Deep; blue-violet.
B. ixoides var. *splendens:* Deep, same as in *B. peduncularis;* blue-violet.
B. candida: Fairly deep, less than in *B. peduncularis;* blue-violet.
B. lactea: Deep, deeper than in *B. peduncularis;* blue-violet.
B. laxa: Deep, deeper than in *B. peduncularis;* blue-violet.
B. coccinea: Very deep, deeper than in *B. peduncularis;* blue-violet.
B. grandiflora: Very deep, deeper than in *B. peduncularis;* blue-violet.
B. californica: Deep, same as in *B. peduncularis;* blue-violet.
B. purdyi: Very deep, deeper than in *B. peduncularis;* blue-violet.
B. stellaris: Deep, same as in *B. peduncularis;* blue-violet.
B. capitata: Very deep, deeper than in *B. peduncularis;* blue-violet.
B. congesta: Deep, same as in *B. peduncularis;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

B. peduncularis: Light.
B. ixoides var. *splendens:* Light, same as in *B. peduncularis.*
B. candida: Fair, deeper than in *B. peduncularis.*
B. lactea: Light, deeper than in *B. peduncularis.*
B. laxa: Light, deeper than in *B. peduncularis.*
B. coccinea: Fairly deep, deeper than in *B. peduncularis.*
B. grandiflora: Light, slightly more than in *B. peduncularis.*
B. californica: Fairly deep, deeper than in *B. peduncularis.*
B. purdyi: Fairly deep, much deeper than in *B. peduncularis.*
B. stellaris: Light, same as in *B. peduncularis.*
B. capitata: Fairly deep, much deeper than in *B. peduncularis.*
B. congesta: Fair, deeper than in *B. peduncularis.*

With Safranin.

B. peduncularis: Light, but deeper than with gentian violet.
B. ixoides var. *splendens:* Light, same as in *B. peduncularis.*
B. candida: Light, but deeper than in *B. peduncularis.*
B. lactea: Light, same as in *B. peduncularis.*
B. laxa: Light, same as in *B. peduncularis.*
B. coccinea: Fairly deep, much deeper than in *B. peduncularis.*
B. grandiflora: Fairly deep, much deeper than in *B. peduncularis.*
B. californica: Light, the same as in *B. peduncularis.*
B. purdyi: Fairly deep, much deeper than in *B. peduncularis.*
B. stellaris: Light, slightly deeper than in *B. peduncularis.*
B. capitata: Fair, deeper than in *B. peduncularis.*
B. congesta: Light, slightly deeper than in *B. peduncularis.*

TEMPERATURE REACTION.

B. peduncularis: 68 to 69° C., mean 68.5°.
B. ixoides var. *splendens:* 65.5 to 62° C., mean 61.75°.
B. candida: 61 to 63° C., mean 62°.
B. lactea: 64 to 65° C., mean 64.5°.
B. laxa: 60 to 62° C., mean 61°.
B. coccinea: 69 to 71° C., mean 70°.
B. grandiflora: 65 to 66.8° C., mean 65.9°.
B. californica: 67 to 68° C., mean 67.5°.
B. purdyi: 66 to 68° C., mean 67°.
B. stellaris: 67.2 to 69° C., mean 68.1°.
B. capitata: 65 to 66° C., mean 65.5°.
B. congesta: 68.5 to 70° C., mean 69.25°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

B. peduncularis: Begins in one-third of grains in 4 minutes; complete in one-third in 30 minutes.
B. ixoides var. *splendens:* Begins in five-sixths of grains in 5 minutes; complete in five-sixths in 25 minutes.
B. candida: Begins in half of grains affected in 5 minutes; complete in all in 35 minutes.
B. lactea: Begins in all in 5 minutes; complete in all in 45 minutes.
B. laxa: Begins in all in 3 minutes; complete in all in 35 minutes.
B. coccinea: Begins in two-thirds in 5 minutes; complete in all but 2 or 3 in 90 minutes.
B. grandiflora: All the small grains, a few of the large (equaling about half the total number), in 5 minutes; complete in nearly three-fourths in 90 minutes.
B. californica: Begins in one-third in 5 minutes; complete in one-third in 60 minutes.

Differentiation of Certain Starches of the Genus Brodiæa.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chloral Hydrate-Iodine.—Continued.

B. purdyi: Begins in one-fifth in 5 minutes; complete in three-fourths in 90 minutes.
B. stellaris: Begins in two-thirds in 5 minutes; complete in two-thirds in 90 minutes.
B. capitata: Begins in half in 10 minutes; complete in all but 2 or 3 in 70 minutes.
B. congesta: Begins in half in 5 minutes; complete in three-fourths in 30 minutes.

Reaction with Chromic Acid.

B. peduncularis: General in 3 to 4 minutes; complete in all in 10 minutes.
B. ixoides var. *splendens:* General in 2 minutes; complete in all in 6 minutes.
B. candida: General in 30 seconds; complete in all in 4 minutes.
B. lactea: General in 1½ minutes; complete in all in 3 minutes.
B. laxa: General in 20 seconds; complete in all in 2 minutes.
B. coccinea: General in 1½ minutes; complete in 6 minutes.
B. grandiflora: General in 1 minute; complete in 10 minutes.
B. californica: General in 3½ minutes; complete in 9 minutes.
B. purdyi: General in 1½ minutes; complete in 10 minutes.
B. stellaris: General in 30 seconds; complete in 10 minutes.
B. capitata: General in 1 minute; complete in 10 minutes.
B. congesta: General in 2½ minutes; complete in 5 minutes.

Reaction with Pyrogallic Acid.

B. peduncularis: General in 2 minutes; complete in all in 10 minutes.
B. ixoides var. *splendens:* General in 2 minutes; complete in all in 5 minutes.
B. candida: General in 30 seconds; complete in all in 2 minutes.
B. lactea: General in 30 seconds; complete in all in 2½ minutes.
B. laxa: General in 20 seconds; complete in all in 2½ minutes.
B. coccinea: General in 10 minutes; most all partially gelatinized in 25 minutes; incomplete in an hour.
B. grandiflora: General in 5 minutes; most are partially gelatinized in 45 minutes; incomplete in an hour.
B. californica: General in 6 minutes; all completely gelatinized in 45 minutes.
B. purdyi: General in 5 minutes; most are partially gelatinized, some completely, in 35 minutes; incomplete in an hour.
B. stellaris: General in 2 minutes; almost all completely gelatinized in 40 minutes.
B. capitata: General in 15 minutes; all partially gelatinized in 30 minutes.
B. congesta: General in 4 minutes; all partially gelatinized in 30 minutes; incomplete in an hour.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.

B. peduncularis: Begins in many in 9 to 10 minutes; complete in all in 90 minutes.
B. ixoides var. *splendens:* Begins in half in 1½ minutes; complete in all in 50 minutes.
B. candida: General in 2½ minutes; complete in all in 30 minutes.
B. lactea: General in 7 minutes; complete in all in 40 minutes.
B. laxa: Begins in half in 5 minutes; complete in all in 45 minutes.
B. coccinea: Begins in half in 5 minutes; complete in all in 25 minutes.
B. grandiflora: Begins in one-third in 5 minutes; complete in all in 90 minutes.
B. californica: Begins in one-third in 5 minutes; complete in five-sixths in 60 minutes.
B. purdyi: Begins in one-fifth in 5 minutes; complete in all in 60 minutes.
B. stellaris: Begins in one-fourth in 8 minutes; complete in all in 90 minutes.
B. capitata: Begins in half in 10 minutes; complete in all in 60 minutes.
B. congesta: Begins in half in 5 minutes; complete in all in 60 minutes.

Reaction with Purdy's Solution.

B. peduncularis: Slight general reaction in 1½ minutes. In an hour a few are completely gelatinized, a few others are beginning to gelatinize.
B. ixoides var. *splendens:* Slight general reaction in 1½ minutes. About half partially or completely gelatinous in 15 minutes; incomplete in an hour.
B. candida: Slight general reaction in 30 seconds. All grains very slightly gelatinized in 10 minutes; incomplete in an hour.
B. lactea: Slight general reaction in a minute. About two-thirds are partially gelatinized in 20 minutes; incomplete in an hour.
B. laxa: Slight general reaction in a minute; a few are completely and many partially gelatinized in 15 minutes; incomplete in an hour.
B. coccinea: Slight reaction in a few grains in 1½ minutes; about three-fourths are affected, a few partially gelatinized, in 50 minutes.
B. grandiflora: Slight reaction in a few grains in 2 minutes; about one-fourth are affected, a few completely gelatinized, in 60 minutes.
B. californica: Slight reaction in one-fourth of the grains in 2 minutes; about two-thirds are affected in 30 minutes; incomplete in an hour.
B. purdyi: Slight reaction in a few grains in 5 minutes; about three-fourths are affected, some completely gelatinized in 90 minutes.
B. stellaris: Slight reaction in a few grains in a minute; about one-third are affected, some partially gelatinized in 90 minutes.
B. capitata: Begins in some grains in a minute; all are partially gelatinized in 60 minutes.
B. congesta: Begins in some grains in 30 seconds; about half are partially gelatinized in 50 minutes.

NOTES ON THE STARCHES OF BRODIÆA.

The variations shown by the *Brodiæa* starches in average size, relative abundance of different types, degree of irregularity of outline, in the hilum and in fissuration, and in the lamellæ are undoubtedly of usefulness in the recognition of the several species; but it does not seem probable that by the gross histological properties alone a positive differentiation could be made, although it might at times be apparent that the specimen did not come from a certain source, as, for instance, the starch of *B. ixoides* var. *splendens* could not have had its source in *B. californica.* In the reactions, the divergences in the case of each starch are usually within rather wide limits. The least differences, on the whole, are recorded in the degree of polarization. In the temperatures of gelatinization the range is from 61° to 70°, a difference of 9°. In the reactions with Purdy's solution all the starches were found to be resistant and gelatinization was incomplete at the end of an hour; but marked differences were noted in the intensities of the reactions in the interim, thus showing more or less marked variations in the sensitivities. The reaction-curves of the various *Brodiæa*, while exhibiting a common type, are sufficiently different to render the diagnosis of each species quite easy.

In reference to the three groups of *Brodiæa* it does not appear that there are any obvious gross histological peculiarities common to each group which would differentiate one from the others, but in the reactions the grouping is very evident and entirely in accord with that of the horticulturist. In the degree of polarization the reactions of the three groups average alike. In the iodine and gentian-violet reactions the first group shows, on the whole, distinctly less sensitivity than the second and third groups. In the safranin reactions the responses of the second group are, on the whole, better than those of the first and third. In the chloral hydrate-iodine reactions the sensitivity of the second group is, as a whole, distinctly lower than that of the first and second, and there is a similar indication in the chromic-acid reactions. In the pyrogallic-acid and ferric-chloride reactions the sensitivity of the first group is distinctly greater than in the second and third. In the reactions with Purdy's solution the order of sensitivity is first, third, and second groups. There are, therefore, positive distinctions as regards both species and groups.

GENUS TRITELEIA.

The Triteleias have been included by some botanists among *Milla* and *Brodiæa*, and by others regarded as a distinct genus. The species are South American and probably to be looked upon as the southern representatives of *Milla* and *Brodiæa* of North America. Because of certain peculiarities they may be grouped as a distinct genus. *T. uniflora* Lindl. (*Milla uniflora* Grah., *Brodiæa uniflora* Baker), popularly known as the spring star-flower, is a well-marked species and the only one under cultivation. From it starch was obtained.

STARCH OF TRITELEIA UNIFLORA. (Plate 49, figs. 289 and 290. Chart 183.)

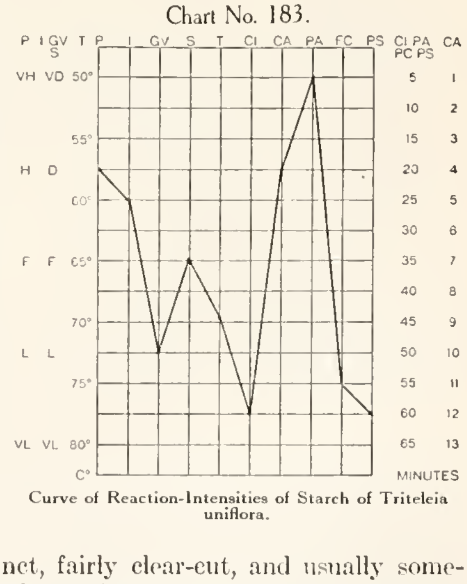
Histological Characteristics.—In *form* the grains are simple and nearly always isolated. They are usually marked at the distal end, and less often at one side, with pressure facets. Their surface is sometimes somewhat irregular, owing to pressure facets and irregularities in the development of different parts. The conspicuous form is the dome-shaped, which is often long, and the proximal end may be larger than the distal end, which is flattened. There are also hemispherical with flat or pyramidal bases, ovoid, oval, and spherical. The grains are of the same thickness as breadth, and therefore round when viewed on end.

The *hilum* is always fissured, and distinct. It is eccentric about one-third or less, often two-fifths, of the longitudinal axis, and is usually in the median line. There are no multiple hila. There may be one clean-cut, transverse, straight fissure, but usually two or more. If two, they are arranged so that three lines appear to radiate from a central cavity; if more, they are in an irregularly stellate form. The fissures are rarely ragged.

The *lamellæ* are fairly distinct, coarse, continuous rings, which usually follow the outline of the margin only when located near it; but in some grains this relationship is noted even when they are near the hilum. They are coarser near the margin, but more distinct near the hilum. There are 8 to 10 on the larger grains.

The grains vary in *size* from 4 to 26μ. The common size is 18μ.

Chart No. 183.



Curve of Reaction-Intensities of Starch of Triteleia uniflora.

Polariscopic Properties.—The *figure* is eccentric, distinct, fairly clear-cut, and usually somewhat irregular. Sometimes the lines are rather blurred, and may be bent or otherwise distorted.

The degree of *polarization* is high. It varies in different grains, being higher in the larger grains and in different aspects of the same grain. It is higher when the grain is viewed from the end or edge.

With *selenite* the quadrants are fairly well defined, usually somewhat irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly, and the color deepens slowly. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly to lightly. The capsules color a violet with excess of iodine, and most of them retain blue-reacting starch at their proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in 2 minutes and in 30 minutes are lightly stained, one as much as another.

With *safranin* the grains begin to stain, lightly in 1½ minutes, and in 30 minutes are fairly stained, one as much as another.

Temperature Reaction.—The temperature of gelatinization is 69.3° to 69.6° C., mean 69.45°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in 2 minutes. About half are gelatinized in 25 minutes and two-thirds in 45 minutes without much further reaction in an hour. The process starts at the distal end at the corners and edges of the facets. These points become dark and swell, and the reaction extends upward to the interior of the grain. There is a well-marked line of demarcation between the gelatinized and non-gelatinized portions. The gelatinized grains are fairly large and of a uniform dark color, and retain much of the original form.

Reaction with *chromic acid* begins in some grains in 15 seconds and in all in 45 seconds, and it is over in 4 minutes. The reaction starts at the hilum, which swells somewhat, and from it very fine, rather indistinct striæ radiate; a bubble forms at the hilum and increases and then decreases in size, finally disappearing. The less resistant portion of the grain is transformed into a gelatinous mass, while the more resistant part collects at the margin in the form of a rather thin, finely striated ring, sometimes indistinctly banded. This ring becomes thinner and transparent as the grain swells, especially at the proximal end. It is finally dissolved at one or two points. The inner, gelatinized starch flows out and dissolves, and then the remainder of the ring dissolves, but not rapidly, the distal end being the last to disappear.

The reaction with *pyrogallic acid* begins in all the grains in 30 seconds and is over in 5 minutes. The reaction originates at the hilum, which swells, and very fine striæ appear throughout the grain. A large bubble forms at the hilum and increases to a great size, then decreases, and finally disappears. The less resistant starch passes into a gelatinous mass, and the more resistant starch forms a rather thin, finely striated band at the margin. This band becomes thinner and transparent as the grain swells. The gelatinized grains are large, wrinkled, and folded, and do not retain the original form of the grain.

The reaction with *ferric chloride* begins in many grains in 2 minutes. About three-fourths are gelatinized in 15 minutes, four-fifths in 35 minutes, almost all in 55 minutes, and all in 1½ hours. The reaction starts at the distal end, at the corners and edges of the facets, which become gelatinous and swell. The process extends upward from here, and when it nears the portion of the grain near the hilum, this part is invaded by internal fissures dividing it into several portions separated by bands of gelatinized starch. These portions gelatinize independently of one another. In a few grains the process of gelatinization affects the whole margin before it reaches the interior of the grain. The gelatinized grains are very large, thin-walled, wrinkled, sacculated, and irregular in form, and do not retain any of the original form.

The reaction with *Purdy's solution* begins slightly in many grains in 45 seconds. About half are partially gelatinized in 15 minutes, about one-third almost completely gelatinized in 50 minutes, and one-half are partially and one-half completely gelatinized in 1¼ hours. The reaction appears to be the same qualitatively as that to pyrogallic acid.

GENUS LACHENALIA.

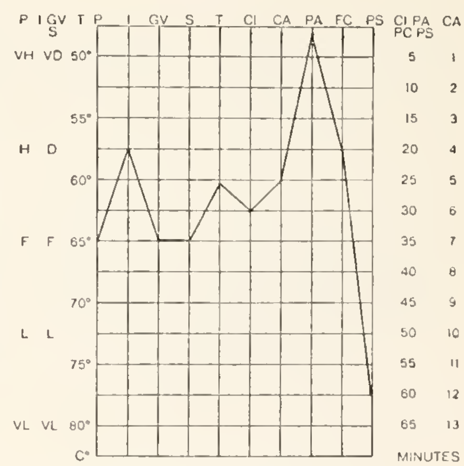
Lachenalia comprises 42 species, 9 of which are in cultivation. The members of this genus are natives of the region of the Cape of Good Hope, and popularly known as Cape cowslips. The starches from two sources were studied: *L. pendula* Ait. and *L. tricolor* var. *luteola* (*L. luteola* Jacq.).

STARCH OF LACHENALIA PENDULA. (Plate 49, figs. 291 and 292. Chart 184.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compounds consisting of two or more components. A few small aggregates of the smaller grains occur, with a great tendency to form clumps. The grains often present well-marked irregularities of the surfaces, such as large, nipple-like processes, or somewhat angular and rounded elevations, or slight depressions. Many grains have a flattened area at the distal end, and in some cases a narrow and shallow depression, which affects the form of some of the nearby lamellæ. The conspicuous form is the oval, which may be modified in various ways; for instance, by having commonly a rounded or flattened distal end, which has a cup-like depression, or by being long and slender or short and broad, or with a pointed or knob-like or much-bent distal end. There are also among the conspicuous grains round, ovoid, and pyriform. Among the smaller grains there are round and nearly round, pyriform, and oval forms. Any of these forms may be distorted by the irregularities of the surface, as above noted. When seen on end they appear round.

The *hilum* is usually very distinct. It is eccentric about one-fifth of the longitudinal axis of the grain and usually in or near the median line. Double or triple hila may be arranged somewhat irregularly. The hilum is generally a relatively large, round, non-refractive spot, but may appear ellipsoidal or lenticular, or as an irregular cavity communicating with the interior. It is rarely fissured, and if so the fissure is narrow, shallow, straight, clean-cut, transverse, or diagonal; or an irregular stellate arrangement. The multiple hila may or may not be separated by small fissures. The hilum is usually in the larger end of the grain.

Chart No. 184.



Curve of Reaction-Intensities of Starch of Lachenalia pendula.

The *lamellæ* are very distinct, fairly coarse, continuous rings, but often with variations caused by indentations or other irregularities of the surface of the grain. They are usually coarser and more distinct near the margin. There are 12 to 14 on the medium-sized grains.

The grains vary in *size* from 5 to 36μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is eccentric, clear-cut, distinct, and regular. Its lines are somewhat broadened at the margin; one is sometimes bisected, but they are usually straight. They intersect at right angles and thus form a cross.

The degree of *polarization* is fair. It is variable, being higher in some grains than in others, and varies also according to the aspect of the grain.

With *selenite* the quadrants are, as a rule, well defined, regular in shape, and somewhat unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet at once; with 0.125 per cent solution they color lightly, but the color deepens rapidly. After heating until the grains are completely gelatinized, the solution is colored lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution is colored much deeper, but the grain-residues much less deeply. The capsules are colored a pinkish-violet with a slight excess of iodine. The proximal part of the capsule may contain blue-reacting starch, and the capsule is much distorted, folded, and crumpled.

Staining Reactions.—With *gentian violet* and with *safranin* the grains stain at once lightly and after 30 minutes they are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 60.1° to 60.7° C., mean 60.4°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in many grains in a minute and all are completely gelatinized in 30 minutes. The hilum often becomes prominent, the lamellæ do not. The distal end is darkened, and the process spreads over the whole grain evenly and without much swelling until the entire grain is affected, after which there may be slight swelling. The swollen grains are not very large; they retain much of the original form and are uniformly dark in all parts.

Reaction with *chromic acid* begins in 15 seconds in the larger grains, most of which are dissolved in 2½ minutes; all the smaller are dissolved in 5 minutes. The hilum is prominent and the lamellæ are distinct. In the larger grains the hilum swells and the grain becomes covered with fine striæ. The inner portion is changed into a gelatinous mass, and the marginal part forms into a ring which is irregular on its inner edge, striated, and marked by alternate refractive and non-refractive bands. This ring becomes thinner and more transparent as the grain swells. The proximal end dissolves, the contents of the capsule flow out and dissolve, followed by solution of the rest of the capsule. The smaller grains begin to dissolve from the distal end before the hilum is affected, and the process advances up the grain by fissuration and the breaking down of the starch into granules, which granules are transformed into a gelatinous mass, followed by solution.

With *pyrogallic acid* the reaction begins at once and gelatinization is complete in 40 seconds. The process appeared to consist of a slow enlargement of the hilum without much change in the grain, except that fine striæ become evident throughout. Finally, a definite striated, banded ring is formed at the margin and this becomes gradually clearer and transparent. The swollen grains are not very large, are usually smooth, and not distorted, folded, or wrinkled.

Reaction with *ferric chloride* begins in 30 seconds to a minute and is over in 20 minutes. The hilum becomes prominent and swells, and the inner part of the grain is reduced to a gelatinous mass. The ring formed at the margin is striated, but not distinctly banded. It becomes thinner and clearer as the grain swells. The gelatinized grains are large, thin-walled, and not much distorted or lobulated. Some grains begin to gelatinize at the distal end and the process extends around the margin, followed by swelling of the hilum and subsequent changes the same as those previously described.

Reaction with *Purdy's solution* begins immediately in many grains. From one-fifth to one-fourth are fully gelatinized in 2 hours and the rest are only partially gelatinized. The reaction is the same as that with pyrogallic acid.

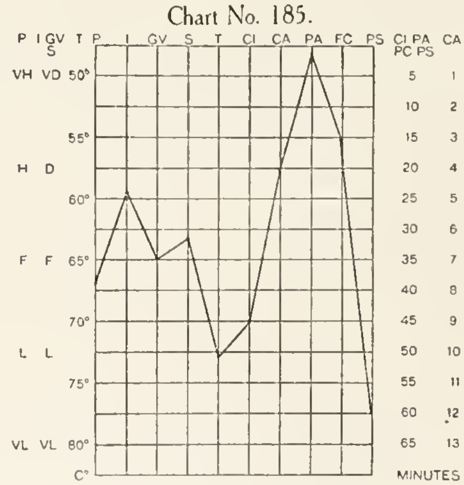
STARCH OF LACHENALIA TRICOLOR VAR. LUTEOLA. (Plate 49, figs. 293 and 294. Chart 185.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compound ones, which consist of two or more components. There are no aggregates, no well-defined pressure facets, and very few clumps. The grains are rounded and the surface tends to be quite regular, but a few irregularities are caused by the unequal development of different parts of the surface. There are very few of the nipple-like processes so common in *L. pendula*. The conspicuous form is the oval, with the distal and smaller end flattened. This form may be either short and broad or long and slender. There are also ovoid, round, pyriform, and ellipsoidal grains. Grains flattened at the distal end have a cup-like depression in this part. The grains when seen on end are round.

The *hilum* is a very distinct, relatively large, round, non-refractive spot, eccentric about one-fourth of the longitudinal axis of the grain, and usually in the median line. It is probably always a round cavity. It may be fissured in the form of a narrow, short, transverse or diagonal line; but fissuration is not common.

The *lamellæ* are usually fairly distinct, rather fine, regular, continuous rings, or segments of rings or ellipses, which follow the outline of the margin of the grain except near the hilum. The lamellæ near the cup-like depression, sometimes observed in the distal end, often show a corresponding curvature; those near the margin and distal end are larger, but not always more distinct than those near the hilum. The former often appear to be separated from the latter by a very distinct line, which may be either an elevation of the inner part of the grain or a distinct lamella. There are about 25 lamellæ on the medium-sized grains.

Chart No. 185.



Curve of Reaction-Intensities of Starch of Lachenalia tricolor var. luteola.

The grains vary in *size* from 5 to 30μ. The common size is 22μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, clear-cut, and regular. Its lines usually become broader and somewhat less distinctly outlined as they near the margin. The figure is very regular in shape, usually in the form of a cross having the lines at right angles.

The degree of *polarization* is fair, and does not vary very much in different grains nor in different aspects of the same grain. It is slightly lower than in *L. pendula*.

With *selenite* the quadrants are well defined, usually unequal in size, and fairly regular in shape. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains at once color deeply a blue-violet; with 0.125 per cent solution the grains color lightly at once and the color deepens quite rapidly. The shade is not so deep as that of the grains of *L. pendula*. After heating until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply and the grain-residues from fairly to not at all. All of the capsules color red-violet with a slight excess of iodine, and most of them contain much blue-reacting starch in the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in 2 minutes and in 30 minutes are fairly stained, some more or less than others. The shade is the same as that of the grains of *L. pendula*.

With *safranin* the grains begin to stain very lightly at once and in 30 minutes are fairly stained, one as much as another. The shade is slightly deeper than that of the grains of *L. pendula*.

Temperature Reaction.—The temperature of gelatinization is 72.9° to 74.2° C., mean 73.55°.

Effects of Various Reagents.—With *chloral hydrate-iodine* about three-fourths of the grains begin to react in 1 to 1½ minutes and all in 5 minutes. About one-third are gelatinized in 10 minutes, two-thirds in 20 minutes, and all in 45 minutes. The reaction is qualitatively the same as that of the grains of *L. pendula*.

With *chromic acid* the reaction begins in all the grains within 30 seconds and is over in 4 minutes. The reaction is qualitatively the same as that of the grains of *L. pendula*. There did not appear to be any noticeable difference in time-reactions of the large and the small grains, as was observed in *L. pendula*.

The reaction with *pyrogallic acid* begins at once, and gelatinization is complete in 55 seconds. The reaction is qualitatively the same as that of the grains of *L. pendula*.

With *ferric chloride* a few grains begin to react in a minute, about half in 3 minutes, most of them being small grains which are completely gelatinized, and three-fourths of all the grains are affected and most of them gelatinized in 5 minutes. The reaction is complete in 17 minutes. Qualitatively the reaction is the same as that of the grains of *L. pendula*.

With *Purdy's solution* there is some reaction in a few grains in 30 seconds, which becomes fairly general in 3 minutes. In 2 minutes grains which began to react in 30 seconds are completely or almost completely gelatinized; in 4 minutes some others of the smaller grains are also gelatinized, but most of them show merely a slight enlargement of the hilum. In 10 minutes about a third of the total number are partially gelatinized. There is very little change after this, some of the remaining two-thirds may swell somewhat, and some of the partially gelatinized grains may become completely gelatinized. The reaction is qualitatively the same as that of the grains of *L. pendula*.

Differentiation of Certain Starches of the Genus Lachenalia.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

L. pendula: Usually simple, few compound; surface irregular owing to nipple-like processes, secondary deposits, and depressions; flattening and cup-like depression of distal end common. Oval, round, ovoid, pyriform.

L. tricolor var. *luteola:* Essentially the same as in *L. pendula*, but less irregular and few nipple-like processes.

Hilum—Form, Number, and Position.

L. pendula: Form usually very distinct; relatively large, round, lenticular or ellipsoidal; sometimes a cavity; sometimes multiple; rarely fissured; fissures narrow, shallow, clear-cut. Position eccentric about 0.20 of longitudinal axis.

L. tricolor var. *luteola:* Form essentially the same as in *L. pendula*, except probably always round. Position eccentric about 0.25 of longitudinal axis.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Lamellæ—General Characteristics and Number.

L. pendula: Very distinct, fairly coarse, continuous, irregular. 12 to 14 on the medium-sized grains.

L. tricolor var. *luteola:* Fairly distinct, rather fine, continuous, or in segments. 25 on medium-sized grains.

Size.

L. pendula: From 5 to 36μ, commonly 20μ.

L. tricolar var. *luteola:* From 5 to 30μ, commonly 22μ.

POLARISCOPIC PROPERTIES.

Figure.

L. pendula: Eccentric, distinct, clear-cut, regular; figure a cross.

L. tricolor var. *luteola:* The same as in *L. pendula*.

Degree of Polarization.

L. pendula: Fair, variable.

L tricolor var. *luteola:* Fair, less variable, but slightly lower than in *L. pendula*.

Differentiation of Certain Starches of the Genus Lachenalia.—Continued.

POLARISCOPIC PROPERTIES.—Continued.

Polarization with Selenite—Quadrants and Colors.

L. pendula: Quadrants well defined, regular, somewhat unequal in size. Colors fairly pure.

L. tricolor var. *luteola:* Quadrants same as in *L. pendula*, but with less tendency to regularity and equality. Colors fairly pure.

IODINE REACTIONS.

Intensity and Color.

L. pendula: Deep; blue-violet.

L. tricolor var. *luteola:* Deep, but not so deep as in *L. pendula;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

L. pendula: Fair.

L. tricolor var. *luteola:* Fair, the same as in *L. pendula.*

With Safranin.

L. pendula: Fair.

L. tricolor var. *luteola:* Fair, but slightly deeper than in *L. pendula.*

TEMPERATURE OF GELATINIZATION.

L. pendula: 60.1 to 60.7° C., mean 60.4°.

L. tricolor var. *luteola:* 72.9 to 74.2° C., mean 73.55°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

L. pendula: Begins in many grains in a minute; complete in 30 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chloral Hydrate-Iodine.—Continued.

L. tricolor var. *luteola:* Begins in three-fourths in 60 to 90 seconds; complete in two-thirds in 20 minutes, and in all in 45 minutes.

Reaction with Chromic Acid.

L. pendula: Begins in large grains in 15 seconds; complete in most of the large grains in 2½ minutes, and in small and large grains in 5 minutes.

L. tricolor var. *luteola:* Begins in all within 30 seconds; complete in all in 4 minutes.

Reaction with Pyrogallic Acid.

L. pendula: Begins at once; complete in 40 seconds.

L. tricolor var. *luteola:* Begins at once; complete in 55 seconds.

Reaction with Ferric Chloride.

L. pendula: Begins in 30 to 60 seconds; complete in 20 minutes.

L. tricolor var. *luteola:* Begins in a few in a minute: nearly three-fourths gelatinized in 5 minutes, and all in 17 minutes.

Reaction with Purdy's Solution.

L. pendula: Begins in many at once; complete in one-fifth to one-fourth in 2 hours, the rest partially gelatinized.

L. tricolor var. *luteola:* General reaction in 3 minutes; about one-third partially gelatinized in 10 minutes. Very little further change in an hour.

NOTES ON THE STARCHES OF LACHENALIA.

The two starches of *Lachenalia* exhibit well-defined differences in their histological characters, especially as regards the hilum and lamellation. In the reactions they are very much alike except in the temperatures of gelatinization and in the reactions with chloral hydrate-iodine and Purdy's solution. In regard to the former the difference is 13.15°, which is very wide. In the reactions *L. tricolor* var. *luteola* is distinctly less sensitive to the former and more to the latter. In the other reactions differences are noted except with gentian violet, *L. tricolor* var. *luteola* having a lower degree of polarization, lower sensitivity to iodine and pyrogallic acid; and a higher sensitivity to safranin, chromic acid, and ferric chloride.

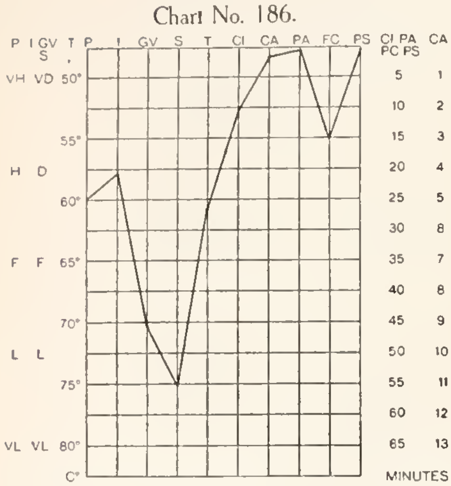
NOTES ON THE STARCHES OF LILIACEÆ. (Charts 186 to 200.)

The starches of all of the *Liliaceæ* examined belong to a common type, the gross histological characters of the grains being more or less modified in the different genera, but only in some instances to the extent of making it possible to state that this or that starch belongs to a given genus. The starches of *Lilium* and of the other members of the tulip tribe (*Lilium, Tulipa, Fritillaria, Calochortus, Erythronium—Lloydia* and *Gagea* not included in this research) are very much alike; the starch of *Galtonia* is less like the starches of *Hyacinthus*, with which genus it was identified, than with those of the tulip tribe; *Chionodoxa* and *Scilla* have certain characteristics in common; and there are certain gross features in *Puschkinia*, and so on in the other genera which suggest individualities which might be brought out satisfactorily by careful microscopic work. The general likeness of *Hyacinthus* and *Muscari* is very noticeable; and close resemblances are noted between the starches of *Brodiæa* and *Lachenalia*. In *Triteleia* the tendency to the occurrence of dome-shaped grains is very conspicuous, and particularizes this genus among the other genera.

In the reactions it is most interesting to note in the first place that among closely related genera, such as those included in the tulip tribe, there is a common type of reaction-curve; and also to compare this type of curve with that which is common to *Scilla* and *Chionodoxa*, and with that of *Hyacinthus* and *Muscari*, etc. In other words, it will be found that in each of the groups of closely related genera there is a common type of reaction-curve. It will also be seen upon comparing the various reaction-curves of different genera that each genus has a curve that differentiates it from the other genera.

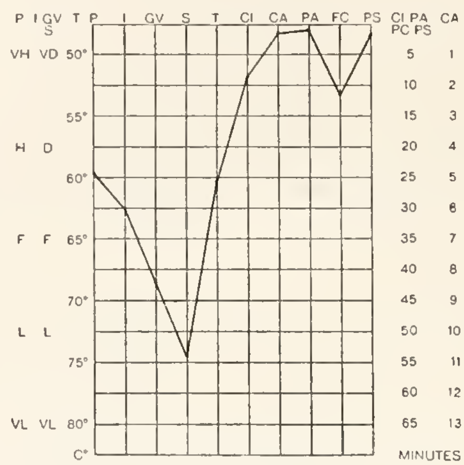
A feature worthy of note is the marked differences shown by different genera in the relative reaction-intensities. Upon this basis the several genera of *Liliaceæ* examined may be grouped in three or four classes having from high to low reaction intensities, or, in other words, having low to high resistances to chemical reagents. Thus, *Lilium, Fritillaria, Calochortus, Tulipa, Erythronium, Scilla, Chionodoxa, Ornithogalum, Puschkinia,* and *Galtonia* have, on the whole, high reaction-intensities; in *Hyacinthus* and *Lachenalia* there is a tendency to a lower standard; in *Muscari* and *Triteleia* still lower, and in *Brodiæa,* on the whole, the lowest of all. The differences in the resistance of the starches of *Brodiæa* to chemical reagents compared with those of *Tulipeæ,* for instance, is striking.

Chart No. 186.



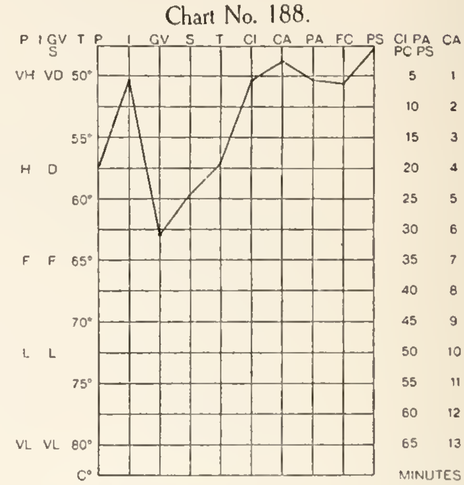
Composite Curve of Mean Reaction-Intensities of Starch of Lilium.

Chart No. 187.



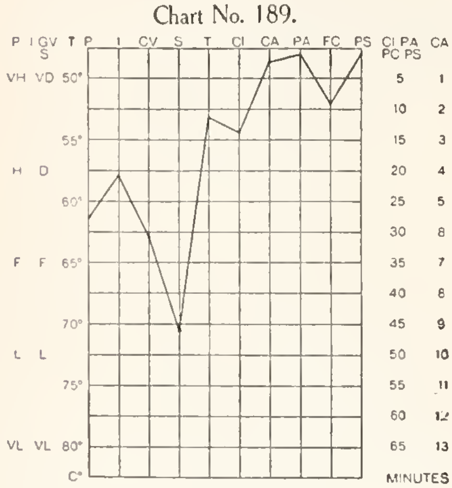
Composite Curve of Mean Reaction-Intensities of Starch of Fritillaria.

Chart No. 188.



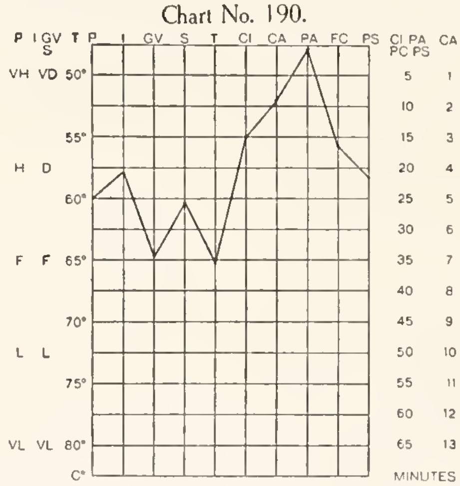
Composite Curve of Mean Reaction-Intensities of Starch of Calochortus.

Chart No. 189.



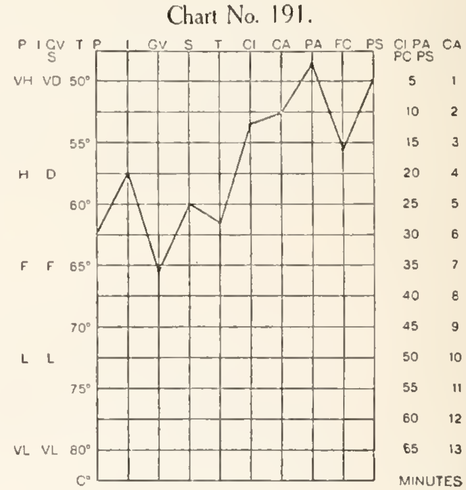
Composite Curve of Mean Reaction-Intensities of Starch of Tulipa.

Chart No. 190.



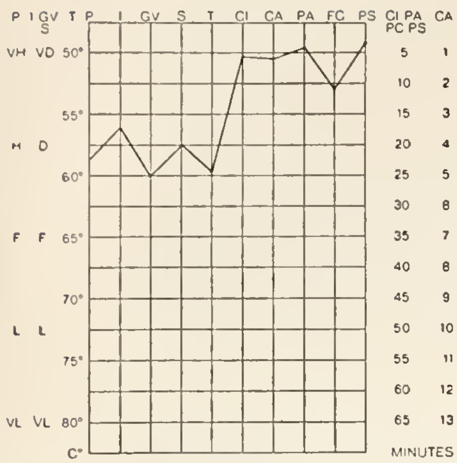
Composite Curve of Mean Reaction-Intensities of Starch of Scilla.

Chart No. 191.



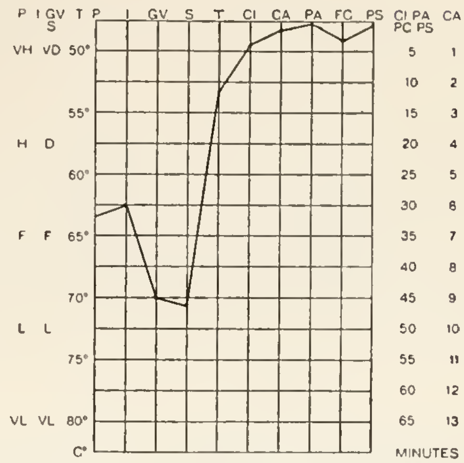
Composite Curve of Mean Reaction-Intensities of Starch of Chionodoxa.

Chart No. 192.



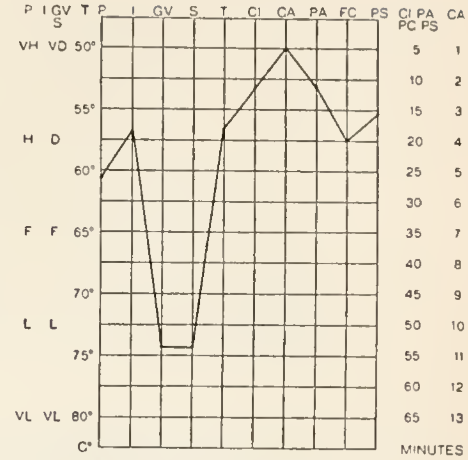
Composite Curve of Mean Reaction-Intensities of Starch of Ornithogalum.

Chart No. 193.



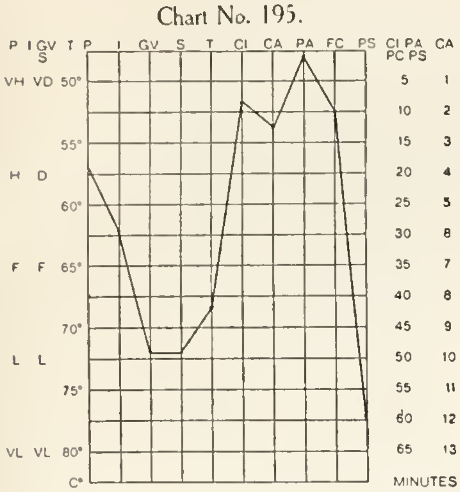
Composite Curve of Mean Reaction-Intensities of Starch of Erythronium.

Chart No. 194.



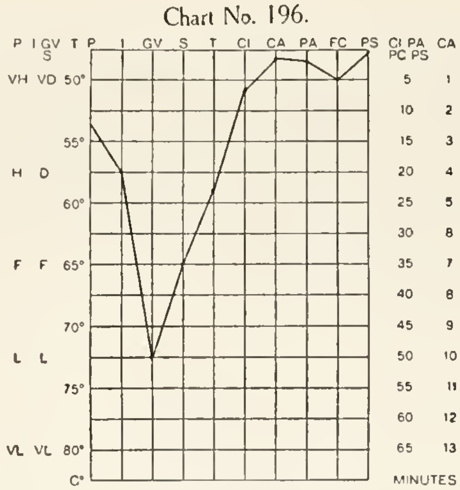
Composite Curve of Mean Reaction-Intensities of Starch of Puschkinia.

Chart No. 195.



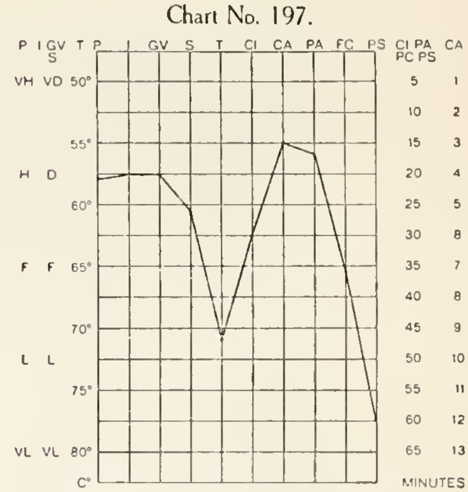
Composite Curve of Mean Reaction-Intensities of Starch of Hyacinthus.

Chart No. 196.



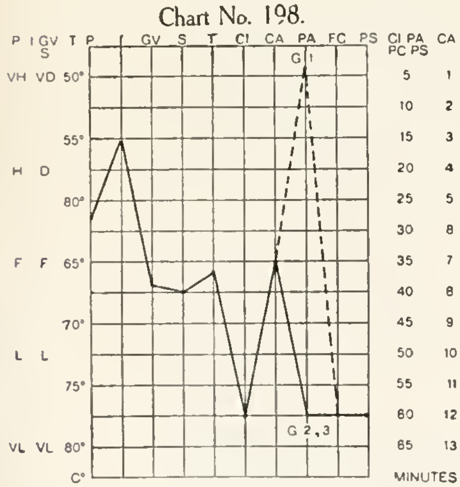
Curve of Reaction-Intensities of Starch of Galtonia.

Chart No. 197.



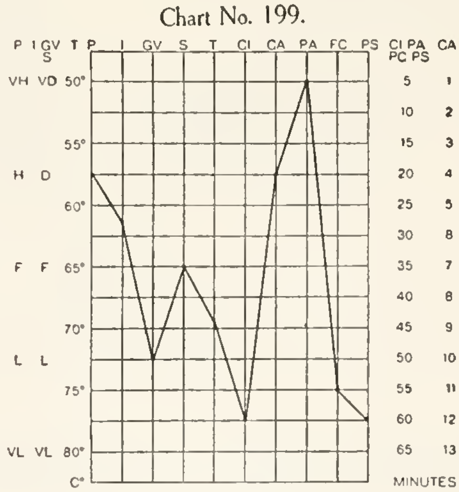
Composite Curve of Mean Reaction-Intensities of Starch of Muscari.

Chart No. 198.



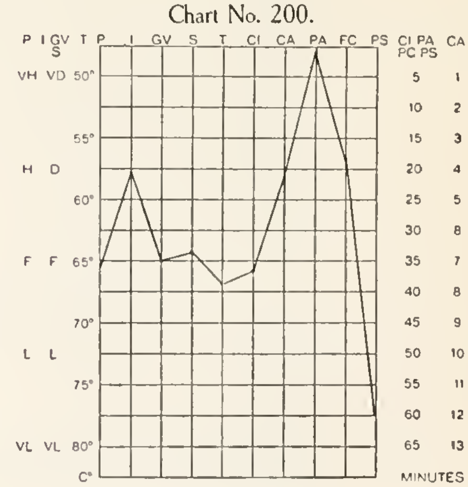
Composite Curve of Mean Reaction-Intensities of Starch of Brodiæa.

Chart No. 199.



Curve of Reaction-Intensities of Starch of Triteleia.

Chart No. 200.



Composite Curve of Mean Reaction-Intensities of Starch of Lachenalia.

STARCHES OF CONVALLARIACEÆ.

Class, Monocotyledones. Order, Liliales. Family, Convallariaceæ. Genera represented: Convallaria, Trillium.

Convallariaceæ is very closely allied to *Liliaceæ*, and by many botanists its members are classed among the latter. It includes less than a dozen genera and about 550 species, all of which are natives of North America, Europe, and Asia.

GENUS CONVALLARIA.

This genus includes but a single species, *Convallaria majalis* Linn., from which have arisen a number of varieties. The lily-of-the-valley is a native of the Southern Alleghenies and part of temperate Europe and Asia.

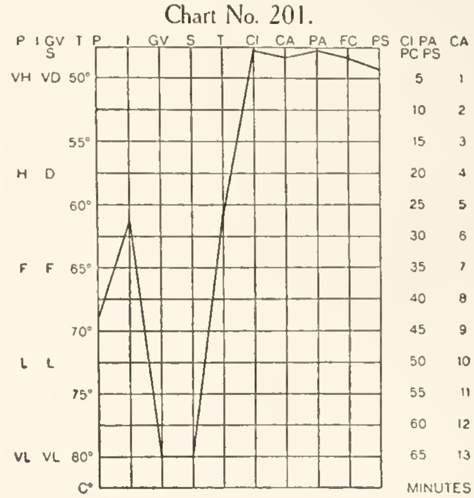
STARCH OF CONVALLARIA MAJALIS. (Plate 50, figs. 295 and 296. Chart 201.)

Histological Characteristics.—In *form* the grains are simple, with the exception of rare compound grains and a few small aggregates and clumps. Well-marked pressure facets are frequently found. The grains are either rather small or quite large, the former predominating. They are generally regular, but variations in the contour and in the length of the sides may occur, due to pressure. The conspicuous forms are nearly round to round, dome-shaped, ellipsoidal, ovoid, broadly triangular with curved base and rounded angles, bean-shaped, somewhat mussel-shell-shaped, and lenticular. The small grains are not flattened, but the large broadly triangular and somewhat mussel-shell-shaped are much less thick than broad, hence when seen on end the small grains are round and the large grains elliptical.

The *hilum* is a clear round spot, usually slightly to one-fourth eccentric of the longitudinal axis. The small grains are not fissured, but in the large, broad, triangular, and shell-shaped may be fissured by three clefts which form a Y-shaped figure; or one figure extends from each side of the hilum; or a group of clefts forming either a stellate or a thorn-shaped figure may be observed. In the large ovoid and bean-shaped grains generally one large fissure passes from the hilum towards the distal end.

The *lamellæ* are very indistinct, but occasionally they can be clearly observed on the larger grains, where they are not demonstrable near the hilum, but those which can be distinguished are fairly coarse and follow the outline of the grain. One of these lamellæ is often coarser and more refractive than the others.

Chart No. 201.



Curve of Reaction-Intensities of Starch of Convallaria majalis (small grains).

The grains vary in *size;* the smaller are 3 by 2μ; the larger are 44 by 26μ (ovoid) and 40 by 44μ (broadly triangular) in length and breadth. The common size is 8 by 7μ in length and breadth.

Polariscopic Properties.—The *figure* is usually slightly to quite eccentric. The lines in the smaller grains generally cross obliquely and are rather fine and straight, but in the larger they are coarse and cross each other obliquely; they may be straight, but are frequently bent and sometimes bisected.

The degree of *polarization* is fair. It is low to fair in the small grains, and high to very high in the large grains. Since the proportion of small grains is so much greater the mean degree of polarization is placed at fair. There is frequently a variation in the same aspect of a given grain.

With *selenite* the quadrants are well defined. In the smaller they are regular, but usually unequal in size; in the larger they are often irregular in shape and unequal in size. The colors of the small grains are dark, but appear to be pure, and in the larger bright but frequently impure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the smaller grains color a fairly deep blue-violet and the larger a red violet, the color in both deepening rather rapidly; with 0.125 per cent solution the small grains color a light blue-violet, the larger a light reddish-violet, the color in both deepening rather rapidly to a fairly deep tint. After heating in water until the grains are gelatinized, and then adding iodine, the solution colors a deep heliotrope and the grains a light reddish-violet to deep heliotrope. If the grains are boiled for 2 minutes and then treated with iodine, most of the small grain-residues are colored a violet to light red-violet, and some remain unstained, and the large grain-residues become a deep heliotrope, while the solution becomes a deep reddish-blue. With an excess of iodine the capsules of the smaller grains become a light reddish-violet to deep old-rose, those of the large ones a deep old-rose to a wine-red. The grain-residues color a very deep heliotrope.

Staining Reactions.—With *gentian violet* and with *safranin* a few grains color slightly at once and in 30 minutes they are very lightly stained, some more than others.

Temperature Reactions.—The temperature of gelatinization for the smaller grains is 60° to 62° C., mean 61°., for the majority of larger ones 71° to 72.5°., mean 71.75° C. Some of the large and medium-sized grains remain unaffected at 77° to 79° C.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. Many small grains are gelatinized in 15 seconds and all in 30 seconds; while the larger are gelatinized in 5 minutes and all in 15 minutes. The reaction is so rapid and the grains so small that the details frequently can not be studied. The large grains are quickly stained an old-rose color and the structure at the hilum swells and becomes sharply defined. The grains deepen in tint until they are a wine-red color, the blue coloration starts at the distal end, spreads around the margin, and then advances over the entire grain, accompanied with uniform swelling. The cleft or the cavity located at the hilum gradually decreases until it is obliterated. The most resistant grains have either a very large cavity or cleft at the hilum which swells and becomes of a metallic luster, persisting for many minutes, while the grain remains a deep wine-red color for a similar period, but finally the cavity or cleft disappears and the grain becomes deep blue in color. The gelatinized grains are much swollen, but retain the shape of the untreated grain.

Reaction with *chromic acid* begins immediately. The small grains are dissolved in 20 seconds, while the larger usually pass into solution in 2½ minutes, but some resistant grains take 6 minutes for solution. The reaction begins immediately and most of the grains are so small that the details can not be studied with accuracy. In the large grains the cleft or the cavity at the hilum swells; this is quickly followed by gelatinization of the central part of the grain, accompanied by the appearance of many refractive granules. The outer lamellæ become sharply defined and striated and the entire grain increases much in size. The capsule is ruptured either at the distal end or at the corners of this end. The gelatinized starch slowly flows from the capsule and is dissolved, followed by solution of the rest of the capsule.

The reaction with *pyrogallic acid* begins immediately. All the smaller grains are gelatinized in 30 seconds, many of the larger ones in a minute, and all but rare resistant grains in 3 minutes, the reaction being complete in the latter in 5 minutes. In the small grains the hilum swells and the entire grain is gelatinized so rapidly that the details can not be noted. In the large grains the clefts or the cavity at the hilum swells and branches of gelatinization pass from them towards the sides and distal end of the grain, and the lamellæ become more distinct and striated. Bubbles are given off from the deep clefts or cavity and gelatinization quickly follows. The reaction progresses more rapidly towards the sides and distal end of the grain, which parts are thrown into folds and distorted, while at the same time the proximal end retains the contour of the untreated grain.

Reaction with *ferric chloride* begins immediately. Some of the small grains are gelatinized in 30 seconds, nearly all in a minute, and all but rare resistant grains in 2 minutes, the latter requiring as long as 30 minutes. With the large ones the reaction begins in some in a minute and is complete in a few in 3 minutes. About one-third are gelatinized in 5 minutes, three-fifths in 15 minutes, and all but rare resistant grains in 30 to 60 minutes. In most of the small grains gelatinization spreads so rapidly over the entire grain that the details can not be satisfactorily made out. In the large grains the clefts or the cavities at the hilum swell rapidly and a bubble of air appears in them; a border is formed which has a lustrous appearance and is more transparent than the central part of the grain. In the ovoid forms gelatinization begins at the distal end, while in the broadly triangular or the somewhat mussel-shell-shaped grains it begins at one or both corners of the distal end. The reaction advances towards the proximal end, at which point the resistant starch is generally broken into rather large granules, which later are gelatinized. The gelatinized grains are swollen and distorted.

The reaction with *Purdy's solution* begins immediately. A few small grains are gelatinized in 30 seconds, a small number in a minute, about three-fifths in 2 minutes, and all but rare resistant grains in 3 minutes. A few large grains are gelatinized in 10 minutes and several in 30 minutes. The reaction is incomplete in an hour, and in most of the grains it has not proceeded further than the swelling of the hilum or fissures located at this point, the formation of branched fissures, and sharper definition and striation of the lamellæ. The hilum of the small grains swells, accompanied by gelatinization of the entire grain. The process is so rapid and the grains so small that the details of the reaction can not be accurately noted. The cleft or the cavity located at the hilum in the large grains swells and bubbles appear; branches are given off from the larger fissures which penetrate all parts of the grain. The lamellæ are rendered more distinct and become striated. As gelatinization proceeds the starch is often broken into large granules which gradually pass into gelatinization. In some of the broadly triangular grains gelatinization first takes place along the coarser and more refractive lamellæ, which thus forms a sharp line of demarcation between the outer and inner part of the grain. In such grains gelatinization frequently does not proceed in other parts of the grain beyond the initial steps noted. In both small and large gelatinized grains a heavy capsular wall remains, so that while they are swollen they retain the general shape of the untreated grain.

GENUS TRILLIUM.

This genus comprises about 18 species, a dozen of which are natives of North America. The American species are found from Canada and Nova Scotia to Florida, and as far westward as the middle west, and 2 species are represented in California and British Columbia. The Asiatic species are found from the Himalayas to Japan. The Trilliums are popularly known as wake robin, white wood lily, ground lily, and birthroot. Starches were obtained from *T. grandiflorum* Salisb. (*T. erythrocarpum*) of Eastern America; *T. ovatum* Pursh., the Pacific Coast representative of the former and much like it; and *T. sessile* var. *californicum* Wats. (*T.* var. *giganteum* Torr.). The first two are well-marked species.

STARCH OF TRILLIUM GRANDIFLORUM. (Plate 50, figs. 297 and 298. Chart 202.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a very few small aggregates and a few clumps that are readily separated. No pressure facets were observed on the isolated grains. The surface is usually smooth, but somewhat irregular in outline, owing to irregular development, causing many small depressions and elevations of the surface. The conspicuous forms are the oval to ovoid and round. There are also pyriform, elliptical, reniform, lenticular, and irregular shapes. The grains generally are not quite so thick as broad, and some of them are about two-thirds as thick as broad.

The *hilum* is not distinct in most grains, and when it can be seen it appears as a round or lenticular, large spot, usually eccentric about two-fifths or less of the longitudinal axis, and in or slightly to one side of the median line. It is occasionally fissured, the fissure being single, short, and indistinct.

The *lamellæ* are invisible.

The grains vary in *size* from 2 to 16μ. The common size is 12μ.

Polariscopic Properties.—The *figure* is usually eccentric, fairly distinct, and generally clear-cut. The lines are rather thick and in some grains they become thicker and less clearly outlined as they are nearer the margin. They are not bent.

The degree of *polarization* is fair. It varies in different grains, the larger being the more polariscopic, but it does not vary much in different aspects of the grains.

With *selenite* the quadrants are well defined, usually fairly regular in shape, but unequal in size. The colors are not pure.

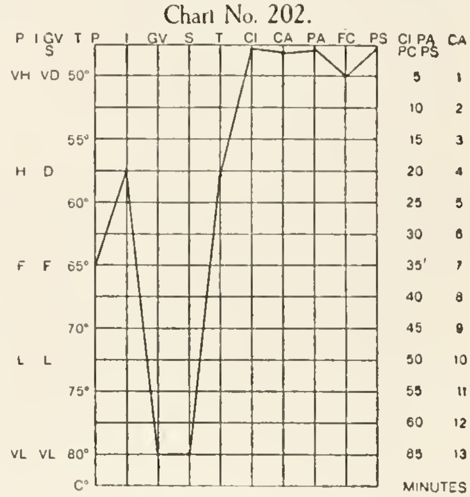
Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly deeply, and the color deepens rapidly. After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. With an excess of iodine the capsules color a light violet and some retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly in a minute and in 30 minutes they are still very lightly colored.

Temperature Reaction.—The temperature of gelatinization is 57° to 59° C., mean 58°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in nearly all in 45 seconds. The margin at the two ends becomes dark and swells slightly, and the reaction spreads rapidly from both points into the interior until the hilum is reached. The hilum swells very rapidly and the rest of the grain also swells considerably. A bubble can often be seen to form at the hilum, first increasing and then decreasing in size, and finally disappearing. The gelatinized grains are of a uniform dark color, usually fairly large, and retain some of the original form.

Chart No. 202.



Curve of Reaction-Intensities of Starch of Trillium grandiflorum.

Reaction with *chromic acid* begins at once and is over in 14 seconds. It is so rapid that it is impossible to distinguish the steps.

The reaction with *pyrogallic acid* begins at once and is over in 45 seconds. The hilum swells and a bubble appears at this point, which first increases and then decreases in size and finally disappears. The inner portion of the grain passes rapidly into a gelatinous mass and the whole grain swells. The marginal starch forms a thin, transparent capsule, which grows thinner as the grain continues to swell. The gelatinized grains are large, wrinkled, and folded, and do not retain any of their original form.

Reaction with *ferric chloride* begins in many grains in 15 seconds and is over in 5 minutes. Internal fissuration occurs at one or two points, and from these fissures gelatinized material protrudes beneath the capsule, and forces out the capsule. This process often extends all around the margin and then inward over the interior of the grain, and when the part of the grain immediately surrounding the hilum is reached a large fissure extends inwardly, giving rise to division of the intracapsular part of the grain into two parts, which in turn may be divided and subdivided. The pieces thus formed become separated by wide spaces of gelatinized starch, and are then gelatinized independently of one another. The gelatinized grains are large, irregular, folded, and variously distorted, and do not retain any of the original form of the grain.

Reaction with *Purdy's solution* begins at once and is over in 10 seconds. It is so rapid that it is impossible to detect the separate steps, but it is in all probability the same as that with pyrogallic acid.

STARCH OF TRILLIUM OVATUM. (Plate 50, fig. 299. Chart 203.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a very few small aggregates and clumps which are readily separated. No pressure facets were observed. The surface is usually smooth, but somewhat irregular, owing to irregularities in growth. The conspicuous forms are the oval to ovoid, and round. In addition there are elliptical, pyriform, reniform, lenticular, and irregular shapes. Some grains are two-thirds as thick as they are wide, and nearly all are less thick than broad. The lenticular grains are relatively much more abundant in this starch than in either of the others.

The *hilum* usually is not distinct, but when it can be seen it appears as a large round or lenticular spot, usually eccentric about two-fifths or less of the longitudinal axis, and in or slightly to one side of the median line. It is rarely fissured.

The *lamellæ* are invisible.

The grains vary in *size* from 1.5 to 10μ. The common size is 7μ.

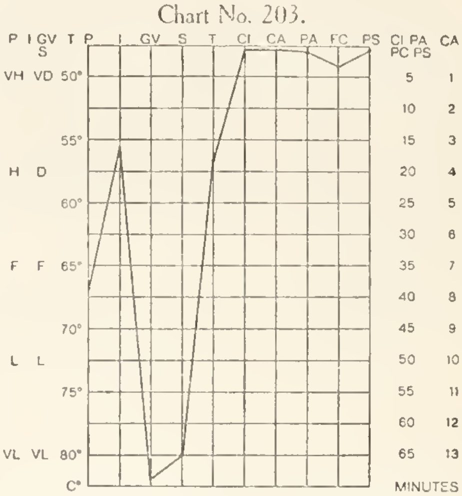
Polariscopic Properties.—The *figure* is usually eccentric, fairly distinct, and usually well defined. Its lines tend to be thick, often thicker as they near the margin; they are never bent.

The degree of *polarization* is fair. It varies in different grains, the large grains being more polariscopic than the small grains; but it does not vary much in different aspects of the same grain. It is slightly lower than that of the grains of *T. grandiflorum.*

With *selenite* the quadrants are well defined, usually fairly regular in shape, but unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. The color is slightly deeper than that of the grains of *T. grandiflorum.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues not at all or but slightly. The capsules color a light violet with an excess of iodine.

Chart No. 203.



Curve of Reaction-Intensities of Starch of Trillium ovatum.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly in a minute, and in 30 minutes they are still very lightly colored. The color is less than that of the grains of *T. grandiflorum.*

Temperature Reaction.—The temperature of gelatinization is 56° to 57.5° C., mean 56.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in 45 seconds. It is the same qualitatively as that of the grains of *T. grandiflorum.*

Reaction with *chromic acid* begins at once and is over in 11 seconds. It is so rapid that the individual steps can not be distinguished.

The reaction with *pyrogallic acid* begins at once and is over in a minute. It is qualitatively the same as that of the grains of *T. grandiflorum.*

Reaction with *ferric chloride* begins at once and is over in 3 minutes. It is the same qualitatively as that of the grains of *T. grandiflorum.*

Reaction with *Purdy's solution* begins at once and is over in 15 seconds. It is so rapid that the steps can not be made out.

STARCH OF TRILLIUM SESSILE VAR. CALIFORNICUM. (Plate 50, fig. 300. Chart 204.)

Histological Characteristics.—In *form* the grains are simple and isolated with the exception of a very few small aggregates and clumps that are usually easily broken up. No pressure facets were observed. The surface is generally smooth, but sometimes a little irregular in outline, owing to unequal development, causing small depressions and elevations, as in *T. grandiflorum.* The conspicuous forms are the oval to ovoid, and round. There are also elliptical, pyriform, reniform, lenticular, and various irregular forms. Some grains are about two-thirds as thick as they are broad, and most are less thick than broad.

The *hilum* is not usually distinct. It is a large round or lenticular spot, generally eccentric about two-fifths or less of the longitudinal axis of the grain, and in or near the median line. It is rarely fissured, the fissure being single, clean-cut, broad, and short or long.

The *lamellæ* are invisible.

The grains vary in *size* from 2 to 14μ. The common size is 8μ.

Polariscopic Properties.—The *figure* is usually eccentric, fairly distinct, and generally clear-cut. The lines are rather thick, and in some grains become thicker but not well defined as they near the margin. They are rarely bent.

The degree of *polarization* is fair. It varies in different grains, the larger grains being more polariscopic than the small, but not varying much in different aspects of the same grain. It is lower than that of the grains of *T. grandiflorum.*

With *sclenite* the quadrants are well defined, usually fairly regular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. The color is very slightly less than that of the grains of *T. grandiflorum.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. With an excess of iodine the capsules all color a light violet.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly in a minute and in 30 minutes they are very lightly stained. The shade is the same as that of *T. grandiflorum.*

Temperature Reaction.—The temperature of gelatinization is 54° to 56° C., mean 55°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in 45 seconds. It is the same qualitatively as that of the grains of *T. grandiflorum.*

Reaction with *chromic acid* begins at once and is over in 13 seconds. It is so rapid that the different steps can not be distinguished.

The reaction with *pyrogallic acid* begins at once and is over in 25 seconds. It is the same qualitatively as that of the grains of *T. grandiflorum.*

The reaction with *ferric chloride* begins in some grains in a very few seconds and is over in all in 6 minutes. It is the same qualitatively as that of the grains of *T. grandiflorum.*

Reaction with *Purdy's solution* begins at once and is complete in 22 seconds. It is so rapid that the separate steps can not be distinguished.

Differentiation of Certain Starches of the Genus Trillium.

Histological Characteristics.

Conspicuous Forms.

T. grandiflorum: Simple, isolated, very few small aggregates and clumps; no pressure facets; surface smooth but irregular in outline. Oval to ovoid and round.
T. ovatum: The same as in *T. grandiflorum*; lenticular much more abundant than in other two.
T. sessile var. *californicum:* The same as in *T. grandiflorum.*

Hilum—Form, Number, and Position.

T. grandiflorum: Form not distinct in most grains; large round or lenticular; single, occasionally fissured, fissure short, single, straight. Position usually eccentric about 0.40 or less of longitudinal axis.
T. ovatum: Form same as in *T. grandiflorum*, but elliptical grains relatively numerous. Position usually eccentric about 0.40 or less of longitudinal axis.
T. sessile var. *californicum:* Form same as in *T. grandiflorum.* Position usually eccentric about 0.40 or less of longitudinal axis.

Lamellæ—General Characteristics.

T. grandiflorum: Invisible.
T. ovatum: Invisible.
T. sessile var. *californicum:* Invisible.

Size.

T. grandiflorum: From 2 to 16μ, commonly 12μ.
T. ovatum: From 1.5 to 10μ, commonly 7μ.
T. sessile var. *californicum:* From 2 to 14μ, commonly 8μ.

Polariscopic Properties.

Figure.

T. grandiflorum: Usually eccentric, fairly distinct, usually clear-cut.
T. ovatum: Same as in *T. grandiflorum.*
T. sessile var. *californicum:* Same as in *T. grandiflorum.*

Polariscopic Properties.—Continued.

Degree of Polarization.

T. grandiflorum: Fair.
T. ovatum: Fair, slightly lower than in *T. grandiflorum.*
T. sessile var. *californicum:* Fair, slightly lower than in *T. grandiflorum.*

Polarization with Selenite—Quadrants and Colors.

T. grandiflorum: Quadrants well defined, usually fairly regular, unequal in size. Colors not pure.
T. ovatum: Quadrants the same as in *T. grandiflorum.* Colors not pure.
T. sessile var. *californicum:* Quadrants the same as in *T. grandiflorum.* Colors not pure.

Iodine Reactions.

Intensity and Color.

T. grandiflorum: Deep; bluish-violet.
T. ovatum: Deep, slightly deeper than in *T. grandiflorum;* bluish-violet.
T. sessile var. *californicum:* Deep, very slightly less deep than in *T. grandiflorum;* bluish-violet.

Staining Reactions.

With Gentian Violet.

T. grandiflorum: Very light.
T. ovatum: Very light, less than in *T. grandiflorum.*
T. sessile var. *californicum:* Very light, the same as in *T. grandiflorum.*

With Safranin.

T. grandiflorum: Very light.
T. ovatum: Very light, the same as in *T. grandiflorum.*
T. sessile var. *californicum:* Very light, the same as in *T. grandiflorum.*

Temperature of Gelatinization.

T. grandiflorum: 57 to 59° C., mean 58°.
T. ovatum: 56 to 57.5° C., mean 56.75°.
T. sessile var. *californicum:* 54 to 56° C., mean 55°.

Differentiation of Certain Starches of the Genus Trillium.—Continued.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

T. grandiflorum: Begins at once; complete in nearly all in 45 seconds.
T. ovatum: Begins at once; complete in 45 seconds.
T. sessile var. *californicum:* Begins at once; complete in 45 seconds.

Reaction with Chromic Acid.

T. grandiflorum: Begins at once; complete in 14 seconds.
T. ovatum: Begins at once; complete in 11 seconds.
T. sessile var. *californicum:* Begins at once; complete in 13 seconds.

Reaction with Pyrogallic Acid.

T. grandiflorum: Begins at once; complete in 45 seconds.
T. ovatum: Begins at once; complete in 60 seconds.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

T. sessile var. *californicum:* Begins at once; complete in 25 seconds.

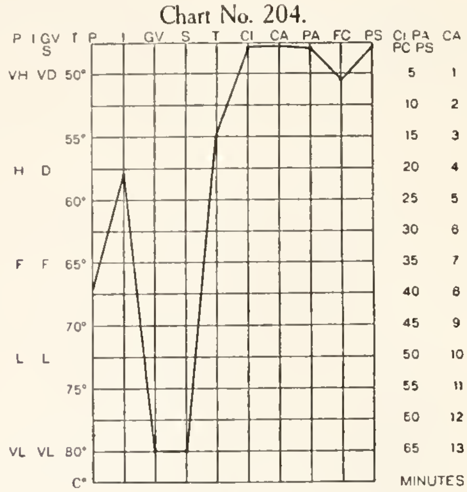
Reaction with Ferric Chloride.

T. grandiflorum: Begins in many in 15 seconds; complete in 5 minutes.
T. ovatum: Begins in many at once; complete in 3 minutes.
T. sessile var. *californicum:* Begins in some in a very few seconds; complete in 6 minutes.

Reaction with Purdy's Solution.

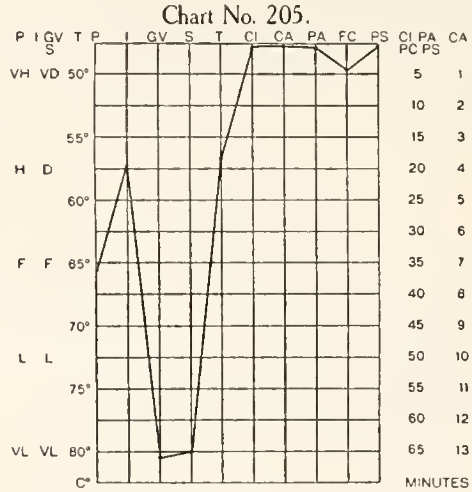
T. grandiflorum: Begins at once; complete in 10 seconds.
T. ovatum: Begins at once; complete in 15 seconds.
T. sessile var. *californicum:* Begins at once; complete in 22 seconds.

Chart No. 204.



Curve of Reaction-Intensities of Starch of Trillium sessile var. californicum.

Chart No. 205.



Composite Curve of Mean Reaction-Intensities of Starches of Trillium.

NOTES ON THE STARCHES OF TRILLIUM.

The *Trillium* starches are so alike in their histological characteristics that, apart from the relatively greater abundance of elliptical grains in *T. ovatum* and the larger average size of the grains of *T. grandiflorum*, they are practically indistinguishable, unless perhaps by very detailed study. In the reactions they vary within narrow limits, the most important differences being noted in the temperatures of gelatinization (58°, 56.75° and 55°, respectively), and in their sensitivities in relation to pyrogallic acid, ferric chloride, and Purdy's solution.

NOTES ON THE STARCHES OF CONVALLARIACEÆ. (Chart 205.)

There are very close resemblances between the small grains of *Convallaria* and the starches of *Trillium*. The very large grains of the former are comparatively few in number, and distinctly different histologically and polariscopically, and in their reaction intensities. The starch of *Convallaria* (small grains) has a lower degree of polarization and a lower reaction with iodine, and a higher temperature of gelatinization (61° and 56.58°, respectively, a difference of 4.42°), and more sensitivity to all of the chemical reagents. The reaction curves are very much alike, indicating a close botanical relationship between the two genera.

STARCHES OF COLCHICACEÆ.

Class, Monocotyledones. Order, Liliales. Family, Colchicaceæ. Genus represented, Colchicum.

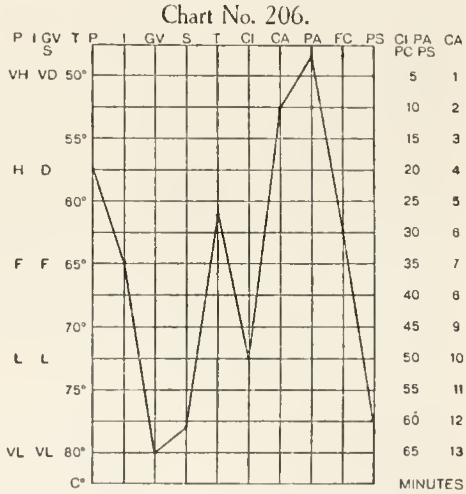
GENUS COLCHICUM.

This genus is native chiefly of the Mediterranean region and Southern Europe, and includes 30 species of bulbous crocus-like plants which are popularly known as meadow saffron or autumn crocus. The starch of *C. parkinsoni* Hook. was examined.

STARCH OF COLCHICUM PARKINSONI. (Plate 51, figs. 301 and 302. Chart 206.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compounds consisting of two components. There are a number of aggregates consisting of from two to five components, commonly two or three. The isolated grains are generally marked by one or more pressure facets at the distal end, usually one or two. There are a few clumps composed chiefly of small grains. The surface of nearly all the grains is divisible into two areas, one of which approaches the hemispherical, while the other is planar and variable in accordance with the size, number, and arrangement of the facets. The conspicuous forms are the dome-shaped to hemispherical, and spherical; also irregular triangular, quadrangular, and other angular forms arising through variations of the size, number, and arrangement of the pressure facets. The grains are not flattened, and therefore when seen on end they appear round.

Chart No. 206.



Curve of Reaction-Intensities of Starch of Colchicum parkinsoni.

The *hilum*, if not fissured, is a not very distinct, round, comparatively large spot, usually centric or nearly centric, but it may be eccentric as much as two-fifths to one-third of the longitudinal axis, and generally in the median line. There are no multiple hila. The hilum is usually fissured by from one or more fissures, which may appear as a single line, a cross, or three lines radiating from the center, or irregularly stellate.

The *lamellæ* are not very distinct, rather coarse, regular circles or ellipses, which do not follow the marginal outline unless located near the margin. There are 6 to 8 on the larger grains.

The grains vary in *size* from 5 to 28μ. The common size is 15μ.

Polariscopic Properties.—The *figure* is usually centric or nearly centric, distinct, but not clear-cut. It is generally placed so that two clear-cut lines run to the angles of the facets at the distal end; but the other two lines, which extend to the proximal end, are broader and not so clear-cut. The figure is regular or irregular, depending upon the shape of the grains. Double or triple figures are occasionally observed.

The degree of *polarization* is high. It varies in different grains, but not much in different aspects of the same grain. It is often higher at the distal than at the proximal end.

With *selenite* the quadrants are well defined, usually regular in shape, but as a rule unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color fairly a blue-violet; with 0.125 per cent solution they color very lightly and the color does not deepen rapidly. After heating in water until the grains are completely gelatinized, the solution colors fairly well and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules color a violet with excess of iodine and some of them retain blue-reacting starch at the proximal end. They are very much distorted, crumpled, and sacculated.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in a minute and in 30 minutes they are only very lightly stained.

With *safranin* the grains begin to stain very lightly in a minute and in 30 minutes they are lightly stained, some more than others. The grains color deeper with this stain than with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 60.5° to 62° C., mean 61.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in a minute. About one-half are gelatinized in 5 minutes, almost all in 20 minutes, and all in 50 minutes. The hilum, if not fissured, is visible, and if fissured it becomes very prominent. The edges and corners of the facets at the distal end grow dark and begin to swell slightly, and this process extends evenly upward over the whole grain, unaccompanied by very much swelling. There is usually a fairly sharp line of demarcation between the reacting and the non-reacting parts. The gelatinized grains are not very large, are uniformly dark in color, and retain much of the original form of the grain, the main difference between the form of the normal and altered grains being in the greater prominence of the corners of the facets of the latter.

Reaction with *chromic acid* begins in 15 seconds in most grains and in all in 30 seconds, and is over in 2 minutes. The hilum becomes prominent and begins to swell. Fine striæ develop and radiate from the hilum in all directions, and the inner portion of the grain is converted rapidly into a gelatinous mass, the whole grain swelling, the expansion being greater at the proximal than at the distal end. The marginal starch is formed into a thin, striated band which becomes thinner and transparent, and is finally dissolved at the proximal end, allowing the inner, granular starch to flow out and dissolve. Solution of the rest of the marginal band then follows.

The reaction with *pyrogallic acid* begins in 30 seconds and is over in 1½ to 2 minutes. The hilum, especially if fissured, becomes very prominent, and the lamellæ become visible in some of the grains. Then the hilum begins to swell and fine striæ appear, which radiate in all directions. The inner part of the grain is transformed into a gelatinous mass, and the marginal part is formed into a thin ring, which is striated and shows several alternate refractive and non-refractive bands. The proximal portion of the marginal band invaginates as the grain swells, and as swelling continues and as the marginal ring becomes thinner and more transparent, this invagination is pushed out. The gelatinized grains so formed are large and retain much of the original form, although they are irregular and creased.

Reaction with *ferric chloride* begins in 30 seconds in some grains and in 1½ minutes in most of them. About four-fifths are gelatinized in 12 minutes and all in 30 minutes. The hilum becomes very prominent as a dark bubble and then begins to swell. The bubble first increases and then decreases in size, and finally disappears. Fine striæ appear radiating from the hilum in all directions. The portion of the grain-substance just about the hilum is gelatinized, and the remaining part of the grain is completely divided by three or four internal or intracapsular fissures into parts, each of which in turn may be divided, these several portions gelatinizing independently of one another. The gelatinized grains do not retain any of the original form and usually are much folded and wrinkled.

The reaction with *Purdy's solution* begins in 30 minutes. About four-fifths are gelatinized in 17 minutes and all in an hour and 10 minutes. The reaction is the same qualitatively as that with pyrogallic acid.

STARCHES OF AMARYLLIDACEÆ.

Class, Monocotyledones. Order, Liliales. Family, Amaryllidaceæ. Genera represented: Amaryllis, Hippeastrum, Vallota, Crinum, Zephyranthes, Sprekelia, Hæmanthus, Hymenocallis, Leucoium, Galanthus, Alstrœmeria, Sternbergia, Narcissus.

The Amaryllidaceæ includes about 70 genera and 650 species. Starches of representatives of 13 genera were studied in this research.

GENUS AMARYLLIS.

The genus *Amaryllis* now includes only a single species, *A. belladonna* Linn., a native of the Cape of Good Hope and popularly known as the belladonna lily. The many other species heretofore included in this genus have been assigned to other genera—the Old World species to *Brunsvigia, Crinum, Hippeastrum, Licoris, Nerine, Sternbergia,* and *Vallota;* and the New World species to *Zephyranthes* and *Sprekelia.* The starch of a horticultural form known as *A. belladonna major* was used as the source of starch for this research.

STARCH OF AMARYLLIS BELLADONNA MAJOR. (Plate 51, figs. 303 and 304. Chart 207.)

Histological Characteristics.—In *form* the grains are usually simple, and they are isolated, with the exception of a few which occur in compound grains or in aggregates of few components, and rarely in small clumps. A few isolated grains are found with pressure facets. The surface is often irregular, generally due to the following causes: to a nipple-like or a rounded protuberance at the proximal end or at the side nearby; to a shifting of the longitudinal axis which results in a slight curving of either the proximal or the distal end; to secondary sets of lamellæ deposited at varying angles to the primary set; to the apparent inclosing of the primary set of lamellæ by a secondary set which may have a more undulating outline; to flattening of points on the surface, and to the saucer- or cup-shaped depression often found at the distal end or side of a large grain into which a small grain frequently fits very closely. The conspicuous forms are the elongated ovoid to oval and elliptical, with the broader distal end often somewhat squared, pyriform, oyster-shell-shaped, and club-shaped, the small club-shaped grains with quite pointed ends; also triangular with curved base and rounded angles, somewhat clam-shell-shaped, ellipsoidal, almost round, and imperfect boot-shaped. The grains are somewhat flattened, and those broadened at the distal end are seen to be narrowed at this end when viewed on edge. The small and medium-sized aggregates occur usually as doublets and triplets with components of about the same size. Large grains with one to four small adherent grains at the distal end or side nearby are sometimes found. Many of the grains show radicular grooves which may be lines of erosion.

The *hilum* is either a round or lenticular refractive spot which varies from slightly eccentric to usually about one-fifth or one-sixth of the longitudinal axis. Often a short transverse fissure, and sometimes a small cavity, is found at the hilum, and sometimes two short longitudinal fissures radiate from the sides of the hilum.

The *lamellæ* are not generally demonstrable throughout the entire grain. They are often less distinct directly around the hilum and also in a narrow border at the distal end. When near the hilum they sometimes appear as complete circles or ellipses, and often in passing from the hilum towards the margin the first demonstrable lamella has the general shape of the margin of the grain. Near the distal end the lamellæ always have the form of the margin of the grain and are probably incomplete. There are usually one to three coarse and quite refractive lamellæ which are interspersed with groups of finer and less distinct layers. One or more secondary sets of lamellæ are occasionally observed at varying angles to the first set; and sometimes a group of lamellæ of slightly different character incloses the primary set, a coarse, refractive lamella forming a line of demarcation between the two groups. On grains of large size from 52 to 58 lamellæ may be counted. Rarely a very large grain is found with 70 lamellæ.

The grains vary in *size;* the smaller are 5 by 3μ; the larger are 68 by 34μ in length and breadth; the common size is 42 by 20μ in length and breadth.

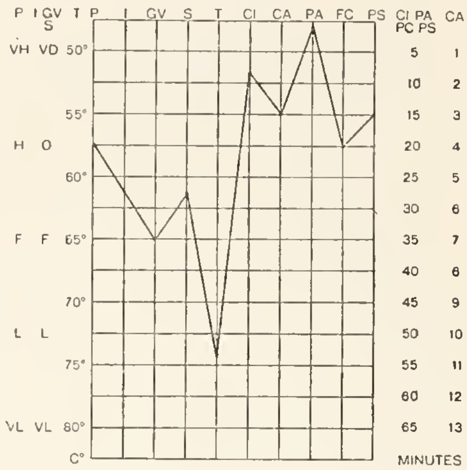
Polariscopic Properties.—The *figure* is eccentric. Its lines cross each other obliquely and are rather thin and broader at the margin. They are frequently bent and sometimes bisected. Double and multiple figures are found.

The degree of *polarization* is high. There is a variation in the grains, some of the larger ones having a very high polarization. Occasionally variations occur in the same aspect of a given grain.

With *selenite* the quadrants are sharply defined, unequal in size, and frequently irregular in shape. The colors are usually pure, but occasionally they have a greenish tint.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet which deepens rapidly; with 0.125 per cent solution they color a very light violet, which deepens rapidly. If the grains are heated in water until all are gelatinized and then treated with iodine, the solution becomes a fairly deep indigo-blue and the grains a somewhat lighter blue. When the preparation is boiled for 2 minutes and then treated with iodine the solution colors a very deep indigo-blue and the grain-residues a rather light, bright blue. With an excess of iodine the grain-residues color a very deep blue and the capsules either a deep reddish-violet or a deep heliotrope.

Chart No. 207.



Curve of Reaction-Intensities of Starch of Amaryllis belladonna major.

Staining Reactions.—With *gentian violet* the grains begin to color at once and in 30 minutes they are fairly stained.

With *safranin* the grains color lightly at once and in 30 minutes they are fairly deep in color, deeper than with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 73° to 75° C., mean 74°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once. A few grains are gelatinized in a minute, about five-sixths in 2 minutes, and all but a few resistant grains in 3 minutes. The reaction is complete in all in 8 minutes. The grains color a deep old-rose immediately, and a dark ring frequently appears at the hilum. Gelatinization usually begins at the proximal end, accompanied by the formation of a small rounded protuberance colored a deep blue. The same deep coloration now appears at the distal end and spreads around the margin. As the two areas of gelatinized starch increase in size and approach each other, the ring formed at the hilum end is forced slightly distalward and having enlarged, it collapses, one or more small bubbles being expelled. The process of gelatinization and coloring now advances rapidly from both ends towards the middle, a colorless line of demarcation between the gelatinized and ungelatinized starch being demonstrable during the process. The gelatinized grains are deeply colored with light areas at the hilum and fissures, and are much swollen, but retain the general shape of the untreated grain.

The reaction with *chromic acid* begins immediately. A few grains are dissolved in a minute, nearly all in 2 minutes, and all but rare resistant grains in 3 minutes. The reaction is complete in all in 4½ minutes. The hilum swells and the lamellæ become sharply defined and striated. A bubble frequently forms at the hilum, which quickly enlarges and collapses, followed by rapid swelling at the proximal end. Delicate, short, radiating fissures pass from the hilum towards the proximal end, and usually a fissure extends from each side of the hilum to the corners of the distal end, but sometimes there is but one central, longitudinal fissure. Delicate lateral fissures extend from these fissures, forming a feather-like figure, and gelatinization proceeds along the course of the fissures until the greater part of the grain is broken down. Numerous delicate fissures pass from this gelatinized part to the distal end of the grain. The outer lamellæ and the capsule at this point are far more resistant than the rest of the grain. During gelatinization of the lamellæ, refractive granules appear which persist in linear arrangement for a longer period at the distal end than at other parts, but are finally dissolved. The capsule at the proximal end ruptures, and about four-fifths of the grain usually passes out and into solution about a minute before the distal end is finally dissolved.

The reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 30 seconds and all in a minute, but the distal end of rare resistant grains in which the reaction is complete may not be gelatinized until 2 minutes. The hilum or the margins of the cleft located at this region swell, and the lamellæ become sharply defined and striated. As a rule, a longitudinal fissure extends from each side of the hilum to the corners of the distal end. At the hilum a bubble generally forms and enlarges, and as the proximal end gelatinizes and swells the bubble is driven slightly distalward and collapses, and the grain invaginates at the proximal end, and then protrudes after the disappearance of the bubble. Gelatinization proceeds rapidly along the course of the two radiating fissures or rarely a single central fissure, with their many lateral branches, until it reaches nearly to the distal end, which is much more resistant than the other part of the grain. Refractive granules, which are finally gelatinized, are sometimes observed as the lamellæ become gelatinized. The gelatinized grain is much swollen and usually rounded at the proximal end, but thrown into many folds at the distal end, so that it does not resemble in form the untreated grain.

Reaction with *ferric chloride* begins in a minute. A few grains are gelatinized in 2½ minutes, nearly all in 10 minutes, and all but rare resistant grains in 15 minutes. The reaction is complete in practically all in 20 minutes. A very exceptional grain may resist the reagent for 30 minutes. The hilum, or the cleft located at the hilum, becomes very distinct, and a transparent border is formed around a central opaque portion of the grain. In the border the lamellæ become sharply defined and striated, and the area gradually increases in width, followed by gradual complete gelatinization at the hilum. A bubble frequently appears at the hilum, and enlarges and collapses, and just as it collapses the proximal end or sides nearby are temporarily invaginated. A short, transverse fissure usually appears within the capsule at the region of the hilum, and gelatinization begins at this point, accompanied by rapid distension of the capsule. In grains with prominent corners or protuberances gelatinization begins simultaneously at these points and at the proximal end, or at the latter a little later. In many grains gelatinization proceeds gradually from the proximal to the distal end, which latter is the last to undergo the reaction. In some grains a transverse fissure similar to that observed at the hilum appears within the capsule near the distal end, followed by gelatinization and distension of capsule at the distal end. The two centers of gelatinization then advance towards each other, the central part of the grain being the last to undergo gelatinization. The most resistant starch is generally broken into fairly large granules which later are gelatinized separately.

With *Purdy's solution* the reaction begins immediately. A few small grains are gelatinized in 30 seconds and about two-thirds of the grains are completely gelatinized in 2 minutes. All of the remaining one-third are gelatinized, except a small cap-like portion at the distal end of each grain, which is much more resistant than other parts of the grain, and this disappears except in rare resistant grains in 10 minutes. The reaction is usually complete in all of the grains in 15 minutes; rarely a resistant grain lasts for 30 minutes. At the hilum a bubble is usually formed which enlarges, then collapses, followed by rapid gelatinization of the grain and distension of the capsule at the proximal end. Gelatinization proceeds rapidly until all but a small, cap-like portion is reached at the distal end which is generally much more resistant than the other part of the grain. Rarely gelatinization starts at the distal end a little later than at the proximal end, and the two areas of gelatinization advance towards the middle of the grain. The center of gelatinization at the distal end may be in a secondary set of lamellæ which sometimes appears to inclose the primary set. The stages of the reaction are similar to those noted for pyrogallic acid.

GENUS HIPPEASTRUM.

This genus includes 40 to 50 species of bulbous plants, natives of tropical America. The genus is closely allied to certain other members of *Amaryllidaceæ* studied in this research (see page 625), and most of them are cultivated under the name of *Amaryllis*. They are popularly known as the knight's star lily, equestrian star, and as other forms of lilies. Starches from two species and one horticultural variety were studied as types of the genus: *H. vittatum* Herb., the most common species in cultivation in our gardens, is a native of Peru; *H. equestre* Herb., known as the Barbados lily, is a native of Mexico, Chile, and Brazil; and *H. aulicum* var. *robustum* Hort., is from a parent species that is a native of Brazil and known as the lily-of-the-palace.

STARCH OF HIPPEASTRUM VITTATUM. (Plate 52, figs. 307 and 308. Chart 208.)

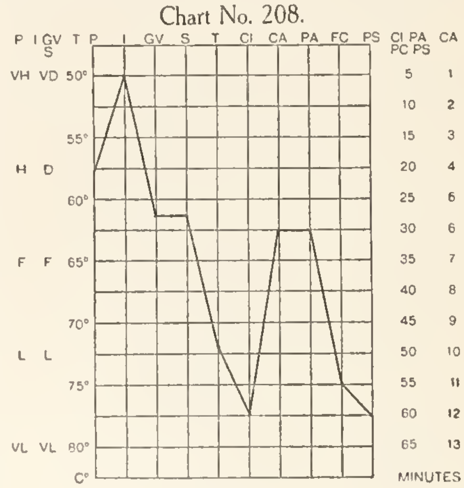
Histological Characteristics.—In *form* the grains are usually simple. Compound grains and aggregates, each generally in the form of two components, are occasionally observed. Some of the latter consist of a large grain with a small grain, which appears in the form of a large, nodular projection. No pressure facets were seen on the isolated grains, and no clumps were noted. The surface of the grains is somewhat irregular owing to irregularities in development, chiefly in the form of an addition at different periods of two or three or more discontinuous lamellæ, to nipple-like processes. The conspicuous forms are the spherical ovoid, ovoid with a pointed distal end, and triangular and quadrangular and polygonal whose corners are very much rounded. There are in addition spherical, lenticular, oval, elliptical, reniform, and some irregular forms. The grains are rarely flattened, and therefore usually of the same thickness as width, and on end they commonly appear spherical. Some of the large grains are from two-fifths to one-half as thick as broad.

The *hilum* is a distinct, fairly large, round or rarely lenticular spot, which is eccentric sometimes two-fifths, usually about one-third, of the longitudinal axis, and often to one side of the median line. There are sometimes two or more hila in a single grain. The hilum is often fissured, and the fissure usually is short, narrow, and single, but ragged; or it may be deep and broad, but never very long; or there may be cross-fissures.

The *lamellæ* are distinct and fairly coarse. Near the hilum they are continuous rings, often irregular in shape; while at the margin several sets of discontinuous lamellæ frequently occur, whose longitudinal axes form angles of varying degrees with the longitudinal axis of the grain. The lamellæ near the margin are, as a rule, coarser and more distinct than those near the hilum, and there is usually one very distinct lamella which probably outlines the margin of the grain before the secondary depositions. There are 10 to 12 lamellæ on the larger grains.

The grains vary in *size* from 5 to 50μ. The common size is 24μ.

Chart No. 208.



Curve of Reaction-Intensities of Starch of Hippeastrum vittatum.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, sometimes clear-cut, and irregular. The lines are thick and may be thicker and not well defined in some portions, especially as they near the margin. They are often slightly bent and otherwise distorted, and may be placed at varying angles to one another. A double figure is sometimes observed.

The degree of *polarization* is high. It varies somewhat in different grains and in different aspects of the same grain and sometimes in different parts of the same aspect of a grain. It is highest when the grain is viewed on end.

With *selenite* the quadrants are not, as a rule, sharply defined, are irregular in shape, and unequal in size. The colors are bright and usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very deep indigo, and with 0.125 per cent solution they color fairly at once and the color deepens quickly. After heating in water until all the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues very lightly, most of them not at all. With excess of iodine the capsules color a red-violet. Many of the capsules are partially or wholly disintegrated.

Staining Reactions.—With *gentian violet* the reaction begins very slightly at once and in 30 minutes the grains are fairly deeply stained, one as much as another.

With *safranin* the reaction begins at once and in 30 minutes they are fairly deeply stained, one grain as much as another.

Temperature Reaction.—Temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 30 seconds, some grains gelatinizing almost at once. All are affected in 1½ minutes, about two-thirds are gelatinized in 15 minutes, and all but very few grains in an hour. The reaction, except in those grains which gelatinize very rapidly, begins at the margin of the distal end, which becomes dark but does not swell. This color spreads over the surface of the grain, but remains deeper at the distal end, and this deeper color advances slowly upward over the whole surface. When the starch in the interior is affected there occurs slight swelling of the whole grain. The gelatinized grains are not very large, are of a uniform dark color, and retain some of the original form of the grain.

The reaction with *chromic acid* begins in some grains in 15 seconds, in all in a minute, and is over in 6 minutes. The reaction starts about the hilum, which swells, and the grain becomes covered by radial striæ, which grow coarser as the grain increases in size. The less resistant starch in the interior of the grain is changed into a gelatinous mass, while the more resistant exterior starch forms a thick, coarsely striated, marginal ring consisting of alternate refractive and non-refractive bands. In some grains there is not only a complete marginal ring, but one or two or more concentric segments of rings at the distal end. The grains continue to swell until they are very large, and the marginal ring becomes thin and transparent and is finally dissolved at some point, usually near the proximal end. The inner, gelatinized starch flows out and is dissolved, followed by solution of the rest of the marginal ring or capsule.

With *pyrogallic acid* reaction begins in some grains in 30 seconds and in all in a minute. About three-fourths of the grains are gelatinized in 7 minutes and almost all in 30 minutes. The hilum begins to swell, and a bubble is formed there which increases, then decreases in size, and finally disappears. The grain is marked by coarse striæ, and the less resistant starch is converted slowly into a gelatinous mass which occupies the cavity made at the hilum, which mass, by swelling, pushes the more resistant starch to the margin, where a thick, coarsely striated ring is formed that shows alternate refractive and non-refractive bands. This ring becomes somewhat thinner and transparent as the grain swells. The swollen grains are large, distorted, wrinkled, and crumpled, and do not retain the original form of the grain.

Reaction with *ferric chloride* begins in a few grains in a minute. It is over in half the grains in 12 minutes, in nearly all in 25 minutes, and in all in 55 minutes. The reaction begins in the small grains at the hilum, which swells, and the grain becomes covered by fine radial striæ. The interior of the grain is converted into a gelatinous mass, leaving a broad, dense, finely striated ring at the periphery, which becomes thin and transparent. In the larger grains the reaction begins at the distal end, which is first fissured and then becomes gelatinous, and this gelatinization proceeds upward over the rest of the grain. The resulting gelatinized grains are large, wrinkled, and somewhat distorted.

The reaction with *Purdy's solution* begins in some grains in a minute and in most grains in 2 minutes. About one-fifth are partially gelatinized in 10 minutes, a third are partially and a few completely gelatinized in 40 minutes, and one-third are completely gelatinized in 1½ hours. The reaction is qualitatively the same as that with pyrogallic acid.

STARCH OF HIPPEASTRUM EQUESTRE. (Plate 52, figs. 309 and 310. Chart 209.)

Histological Characteristics.—In *form* the grains are usually simple, compound grains are not common, and there are a few small aggregates. No pressure facets are observed on the grains. There were no clumps. The surface tends to be somewhat irregular, owing to the unequal development, and but rarely to lamellated depositions at different periods of growth and nipple-like processes. The conspicuous forms are the ovoid, which may be broad and almost spherical, or narrow and with a pointed distal end; elliptical with rounded ends of about equal size; triangular and quadrangular grains with rounded corners, reniform, spherical, lenticular, and pyriform grains. The grains are rarely flattened, and therefore nearly always as thick as they are broad. Some of the large grains are about two-fifths to a half as thick as broad.

The *hilum* is a distinct, fairly large, round or lenticular spot, usually eccentric about one-third to two-fifths of the longitudinal axis, and in or to one side of the median line. There may be 2 or more hila in a single grain. The hilum is often fissured, and the fissure is usually single, short, and narrow, but ragged and irregular. There may be two clear-cut fissures arranged as a cross.

The *lamellæ* are fairly distinct, rather coarse, irregular, continuous or discontinuous rings which are usually coarser and more distinct near the margin than near the hilum. They vary very much in distinctness in different grains. There is often one very distinct lamella separating the less coarse lamellæ about the hilum from the coarser ones beyond, and it may represent the outline of a primary grain. There are 6 to 8 lamellæ on the larger grains.

The grains vary in *size* from 4 to 35μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, sometimes not clear-cut, and irregular. The lines are thick and thicker marginally, and often slightly bent and otherwise distorted, and placed at varying angles to one another.

The degree of *polarization* is fairly high. It varies in different grains, in different aspects of the same grain, and in different parts of the same aspect of a given grain. It is not so high as that of the grains of *H. vittatum.*

With *selenite* the quadrants are not, as a rule, sharply defined and are irregular in shape and unequal in size. The colors are not so bright as in *H. vittatum,* and usually not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very deep indigo; and with 0.125 per cent solution they color fairly well at once and the color deepens rapidly. The color is slightly deeper than that of the grains of *H. vittatum.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply, but most of the grain-residues not at all. With an excess of iodine the capsules color a red-violet. Many of the capsules are disintegrated.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes are fairly deeply stained. The color is less than that of the grains of *H. vittatum.*

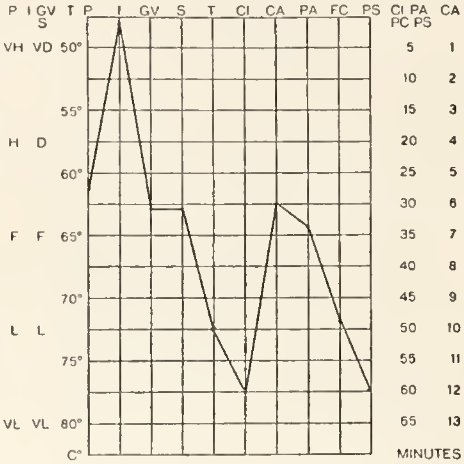
With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained. The color is less than that of the grains of *H. vittatum.*

Temperature Reaction.—The temperature of gelatinization is 72° to 73° C., mean 72.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in a minute. About one-third of the grains are gelatinized in 10 minutes, three-fourths in 17 minutes, and four-fifths in 45 minutes. The reaction is not complete in an hour. The reaction is qualitatively the same as that of the grains of *H. vittatum.*

The reaction with *chromic acid* begins in some grains in 15 seconds, in all in 45 seconds, and is over in 6 minutes. It is qualitatively the same as that of the grains of *H. vittatum.*

Chart No. 209.



Curve of Reaction-Intensities of Starch of Hippeastrum equestre.

Reaction with *pyrogallic acid* begins in some grains in 15 seconds and in all in 45 seconds. About three-fourths are completely gelatinized in 3 minutes, almost all in 20 minutes, and all in 33 minutes. The reaction is qualitatively the same as that of the grains of *H. vittatum.*

The reaction with *ferric chloride* begins in a few grains in a minute. It is complete in three-fourths in 18 minutes, in almost all in 30 minutes, and all in 48 minutes. It is qualitatively the same as that of the grains of *H. vittatum.*

Reaction with *Purdy's solution* begins in some grains in 30 seconds and in most grains in 15 seconds. About a third are partially gelatinized in 15 minutes, and half are partially and a few completely gelatinized in 35 minutes, and one-fourth are completely gelatinized in 1¼ hours. The reaction is the same qualitatively as that of the grains of *H. vittatum.*

STARCH OF HIPPEASTRUM AULICUM VAR. ROBUSTUM. (Plate 52, figs. 311 and 312. Chart 210.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compounds and a few aggregates. No pressure facets were observed on the isolated grains. There are no clumps. The surface is somewhat irregular owing to unequal development and to the addition at different periods of growth of groups of two or three or more discontinuous lamellæ whose longitudinal axes are at an angle to the longitudinal axis of the grain. At times two or more grains appear to have been pressed together and both inclosed in several lamellæ. Large doublets are occasionally seen. The conspicuous forms are the spherical ovoid, which is narrower at the distal than at the proximal end, and quadrilateral and triangular grains, whose corners are very much rounded off; also spherical, slender elliptical, triangular, lenticular, pyriform, and some irregular forms. The grains are usually as thick as they are broad, but some of the larger are from two-fifths to one-half as thick as broad.

The *hilum* is a distinct, rather large spot, usually round, but sometimes lenticular. It may be centric, but is usually eccentric about one-third to two-fifths of the longitudinal axis, and in or to one side of the median line. There may be 2 or rarely more hila in one grain. The hilum is often marked by a round cavity or a fissure, which is usually a single, narrow, short line, commonly ragged and irregular. It is sometimes broad and ragged, 3-armed, or variously irregular.

The *lamellæ* are very distinct, rather coarse, irregular, continuous rings, except near the margin, where there may be one or more groups of discontinuous lamellæ. They are usually coarser and more distinct near the margin than near the hilum, and vary in size and distinctness in different grains. There are about 10 to 12 on the larger grains.

The grains vary in *size* from 6 to 40μ. The common size is 22μ.

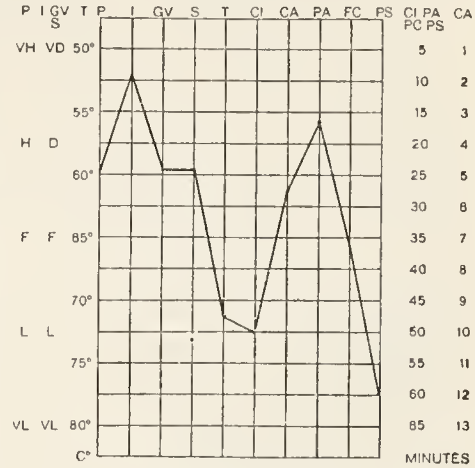
Polariscopic Properties.—The *figure* is usually eccentric, distinct, sometimes clear-cut, and irregular. Its lines are generally thick, and broader and not so well defined in some parts of their length as in others, especially near the margin of the grain. The lines are sometimes bent and otherwise distorted, and often placed at varying angles to one another. Double figures are occasionally observed.

The degree of *polarization* is high. It varies in different grains, in different aspects of the same grain, and in different parts of the same aspect of a given grain. It is not so high as that of the grains of *H. vittatum.*

With *selenite* the quadrants are, as a rule, not well defined, and are irregular in shape and unequal in size. The colors are usually not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very deep indigo, and with 0.125 per cent solution they color fairly and the color deepens rapidly. It is not quite so deep as that of the grains of *H. vittatum.* After heating in water until all the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and most of the grain-residues not at all. With an excess of iodine the capsules color a red-violet; some of them are disintegrated.

Chart No. 210.



Curve of Reaction-Intensities of Starch of Hippeastrum aulicum var. robustum.

Staining Reactions.—With *gentian violet* the grains begin to stain very slightly at once and in 30 minutes are colored fairly deeply, more than the grains of *H. vittatum.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained, deeper than the grains of *H. vittatum.*

Temperature Reaction.—The temperature of gelatinization is 71.5° to 72° C., mean 71.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 1½ minutes. About half are gelatinized in 12 minutes, three-fourths in 27 minutes, and almost all in 50 minutes. The reaction is the same qualitatively as that of the grains of *H. vittatum.*

Reaction with *chromic acid* begins in some grains in 30 seconds, in all in 1¼ minutes, and is over in 5½ minutes. It is the same qualitatively as that of the grains of *H. vittatum.*

The reaction with *pyrogallic acid* begins in all the grains in a minute. Almost all are completely gelatinized in 12 minutes and all in 17 minutes. The reaction is qualitatively the same as that of the grains of *H. vittatum.*

The reaction with *ferric chloride* begins in a few grains in 1½ minutes. About four-fifths are gelatinized in 12 minutes, almost all in 25 minutes, and all in 37 minutes. The reaction is qualitatively the same as that of the grains of *H. vittatum.*

Reaction with *Purdy's solution* begins in many grains in 2 minutes. About one-fourth are partially and a few completely gelatinized in 20 minutes. About one-third are gelatinized in 30 minutes and one-half in an hour. The reaction is the same qualitatively as that of the grains of *H. vittatum.*

Differentiation of Certain Starches of the Genus Hippeastrum.

Histological Characteristics.

Conspicuous Forms.

H. vittatum: Usually simple; some compounds and doublets; surface somewhat irregular owing chiefly to secondary lamellæ and nipple-like processes. Spherical-ovoid, ovoid with pointed distal end, triangular, quadrangular, and polygonal with rounded corners.

H. equestre: Essentially the same as in *H. vittatum*, excepting comparative rareness of secondary depositions and nipple-like processes.

H. aulicum var. *robustum:* Essentially the same as in *H. vittatum.*

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.

H. vittatum: Form distinct, fairly large, round or rarely lenticular; single or multiple; sometimes fissured, fissures usually short, narrow, single, ragged. Position usually eccentric about 0.33 or 0.40 of longitudinal axis.

H. equestre: Form essentially the same as in *H. vittatum.* Position usually eccentric about 0.33 to 0.40 of longitudinal axis.

H. aulicum var. *robustum:* Form essentially the same as in *H. vittatum.* Position usually eccentric about 0.33 to 0.40 of longitudinal axis.

Differentiation of Certain Starches of the Genus Hippeastrum.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Lamellæ—General Characteristics and Number.

H. vittatum: Distinct, fairly coarse, continuous or discontinuous, irregular. 10 to 12 on larger grains.
H. equestre: Fairly distinct, rather coarse, irregular, continuous or discontinuous. 6 to 8 on larger grains.
H. aulicum var. *robustum:* Very distinct, rather coarse, irregular, continuous or discontinuous. 10 to 12 on larger grains.

Size.

H. vittatum: From 5 to 50μ, commonly 24μ.
H. equestre: From 4 to 35μ, commonly 20μ.
H. aulicum var. *robustum:* From 6 to 40μ, commonly 22μ.

POLARISCOPIC PROPERTIES.

Figure.

H. vittatum: Usually eccentric, distinct, usually not clear-cut, irregular.
H. equestre: Essentially the same as in *H. vittatum.*
H. aulicum var *robustum:* Essentially the same as in *H. vittatum.*

Degree of Polarization.

H. vittatum: High.
H. equestre: Fairly high.
H. aulicum: var. *robustum:* High, but not so high as in *H. vittatum.*

Polarization with Selenite—Quadrants and Colors.

H. vittatum: Quadrants usually not well-defined, irregular in shape, unequal in size. Colors usually pure.
H. equestre: Quadrants the same as in *H. vittatum.* Colors not quite pure.
H. aulicum var. *robustum:* Quadrants the same as in *H. vittatum.* Colors not quite pure.

IODINE REACTIONS.

Intensity and Color.

H. vittatum: Very deep; indigo.
H. equestre: Very deep, slightly deeper than in *H. vittatum;* indigo.
H. aulicum var. *robustum:* Very deep, less than in *H. vittatum;* indigo.

STAINING REACTIONS.

With Gentian Violet.

H. vittatum: Fairly deep.
H. equestre: Fairly deep, less than in *H. vittatum.*
H. aulicum var. *robustum:* Fairly deep, more than in *H. vittatum.*

STAINING REACTIONS.—Continued.

With Safranin.

H. vittatum: Fairly deep.
H. equestre: Fairly deep, less than in *H. vittatum.*
H. aulicum var. *robustum:* Fairly deep, deeper than in *H. vittatum.*

TEMPERATURE OF GELATINIZATION.

H. vittatum: 71 to 73° C., mean 72°.
H. equestre: 72 to 73° C., mean 72.5°.
H. aulicum var. *robustum:* 71.5 to 72° C., mean 71.75°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

H. vittatum: Begins in all in 1½ minutes; complete in two-thirds in 15 minutes and in nearly all in 60 minutes.
H. equestre: Begins in most in a minute; complete in four-fifths in 45 minutes, but incomplete in 60 minutes.
H. aulicum var. *robustum:* Begins in most in 1½ minutes; complete in almost all in 50 minutes.

Reaction with Chromic Acid.

H. vittatum: Begins in all in a minute; complete in 6 minutes.
H. equestre: Begins in all in 45 seconds; complete in 6 minutes.
H. aulicum var. *robustum:* Begins in all in 1¼ minutes; complete in 5½ minutes.

Reaction with Pyrogallic Acid.

H. vittatum: Begins in all in a minute; complete in almost all in 30 minutes.
H. equestre: Begins in all in 45 seconds; complete in all in 33 minutes.
H. aulicum var. *robustum:* Begins in all in a minute; complete in all in 17 minutes.

Reaction with Ferric Chloride.

H. vittatum: Begins in a few in a minute; complete in all in 55 minutes.
H. equestre: Begins in a few in a minute; complete in all in 48 minutes.
H. aulicum var. *robustum:* Begins in a few in 1½ minutes; complete in all in 37 minutes.

Reaction with Purdy's Solution.

H. vittatum: Begins in most in 2 minutes; complete in one-third in 1½ hours.
H. equestre: Begins in most in 1¼ minutes; complete in half in 1¼ hours.
H. aulicum var. *robustum:* Begins in most in 2 minutes; complete in half in an hour.

NOTES ON THE STARCHES OF HIPPEASTRUM.

The three starches of *Hippeastrum* do not exhibit any marked gross histological characteristics which might be useful in diagnosis excepting possibly in the rareness of secondary depositions and in nipple-like processes in *H. equestre.* On the other hand, the reaction curves, while having striking general resemblances, are far from being identical, and are in fact sufficiently different to permit of the distinction of one starch from another. In all the reactions there are definite differences, but the least marked are in the temperatures of gelatinization (there being less than 1° variation), and in the reactions with chloral hydrate-iodine, ferric chloride, and Purdy's solution. On the whole, the grains are moderately resistant to heat and chemical reagents. The high responsivity to iodine and the fairly high reaction with the aniline dyes are particularly noticeable.

GENUS VALLOTA.

This genus, like *Amaryllis*, has but a single species, *Vallota purpurea* Herb. It is the South African representative of the American *Hippeastrum*, and is cultivated under the name of the Scarborough lily. It is closely related to *Cyrtanthus*, another South African genus, and it has been suggested that *Vallota* be classified as a subgenus of *Cyrtanthus*.

STARCH OF VALLOTA PURPUREA. (Plate 51, figs. 305 and 306. Chart 211).

Histological Characteristics.—In *form* the grains are usually simple. There are occasionally compounds and aggregates consisting of two or three components. Rarely pressure facets are seen on the isolated grains. There are no clumps. The surface of the grains is usually somewhat irregular, owing chiefly to inequalities in the development of the various parts. There are sometimes seen two or three grains of unequal size, generally arranged in linear fashion, which have been pressed together and then later inclosed by several lamellæ. The conspicuous forms are spherical ovoid to spherical, spherical forms with very slight irregularities, ovoid, quadrilateral and triangular with very much rounded angles. There are also elliptical, elliptical with a broad, squared distal end, dome-shaped, oval, round, and various irregular forms. The grains are not flattened and therefore are as thick as broad.

The *hilum* is a distinct, rather large, round or rarely elliptical spot, eccentric from two-fifths to one-fourth, usually about one-third, of the longitudinal axis, and in or to one side of the median line. There may be 2, 3, or 4 hila linearly arranged, usually parallel to the transverse axis of the grain. The hilum may have a fissure, which is usually single, transverse or diagonal, straight or singly curved, often bisected or ragged at the ends. There is also sometimes a stellate or irregular arrangement of fissures at the hilum.

The *lamellæ* are distinct, rather fine, often irregular circles or ellipses or arcs of circles which may or may not be continuous. Those near the hilum do not always correspond in shape to the outline of the margin. Those near the margin often appear to have been added at a different time from those near the hilum, and their longitudinal axis often does not coincide with that of those near the hilum. The former are not so fine as those near the hilum, but are distinct and do not vary much in distinctness in different grains. There are 12 to 14 lamellæ on the larger grains.

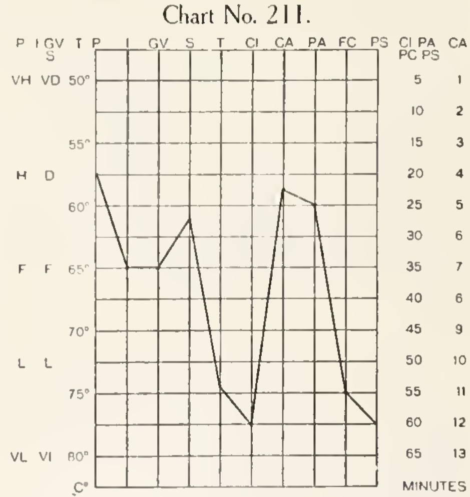
The grains vary in *size* from 3 to 30μ. The common size is 18μ.

Polariscopic Properties.—The *figure* is usually markedly eccentric, distinct, but not clear-cut. Its lines are broad and tend to become broader and poorly defined as they near the margin; they are sometimes somewhat bent and otherwise distorted; and often they are placed at varying angles to one another, causing the figure to be irregular.

The degree of *polarization* is high. It varies somewhat in different grains, but not much in different aspects of the same grain. It is sometimes lower near the margin of the same aspect of a grain than near the hilum.

With *selenite* the quadrants are not well defined, are irregular in shape, and unequal in size. The colors are usually pure.

Chart No. 211.



Curve of Reaction-Intensities of Starch of Vallota purpurea.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fair blue-violet and the color deepens quite rapidly; with 0.125 per cent solution they color lightly, but the color deepens fairly rapidly. After heating in water until the grains are completely gelatinized, the solution colors lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply, but the grain-residues generally lightly or not at all. With an excess of iodine the capsules color a red-violet and about half of them retain more or less blue-reacting starch, especially at the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain in 2 minutes and in 30 minutes are fairly stained, one as much as another.

With *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained, one as much as another.

Temperature Reaction.—The temperature of gelatinization is 73.5° to 75° C., mean 74.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 30 seconds. About half are gelatinized in 15 minutes, four-fifths in 50 minutes, and almost all in 1¼ hours. The reaction begins at the distal end, which becomes dark. Usually this coloration then extends around the entire margin, and over the whole surface of the grain, unaccompanied by swelling; but sometimes it extends upward and inward from the distal end only, then the process proceeds inward from all points on the surface until the whole grain is involved, and as it proceeds inward there is slight swelling of the grain. The gelatinized grains are not very large, are of a uniform dark color, and retain much of the original form.

Reaction with *chromic acid* begins in most grains in 30 seconds, in all in a minute, and is over in 4½ minutes. It originates at the hilum, which begins to swell, and a small bubble forms which slightly increases in size, then decreases, and then disappears. The hilum and the rest of the grain swell, and fine striæ appear radiating in all directions from the hilum. The less resistant central starch is gelatinized and the more resistant outer starch collects at the margin in the form of a thick, finely striated ring, which becomes progressively thinner and transparent. Finally, the proximal end of the ring or capsule, which is thinner than the rest, is dissolved, and the gelatinized starch flows out and into solution, followed by solution of the remainder of the marginal ring or capsule.

Reaction with *pyrogallic acid* begins in most grains in a minute. In 5 minutes all are partially and some are completely gelatinized, and all are completely gelatinized in 25 minutes. The reaction begins as a swelling of the hilum and by the appearance of very fine striæ which radiate in all directions from the hilum. As the hilum and other parts continue to swell the less resistant central starch is transformed to a gelatinous mass, and the more resistant outer starch is gathered at the margin in the form of a thick, homogeneous-looking, smooth ring or capsule. The ring becomes thinner and transparent as swelling continues and for some time after the swelling has ceased. The gelatinized grains are large, folded, and wrinkled, and do not retain much of the original shape.

The reaction with *ferric chloride* begins in a few grains in 1¾ minutes. About two-thirds are gelatinized in 15 minutes, nearly all in 37 minutes, and all in 55 minutes. The reaction begins at the hilum, where a small bubble forms. The hilum swells and the bubble increases in size up to a certain point, then decreases, and finally disappears; but the hilum continues to swell and so does the grain, as a whole. The inner part of the grain now appears to pass into a gelatinous mass, and the marginal portion is formed into a thick, homogeneous ring which rapidly becomes thinner and transparent and capsular, and invaginates in two or three places as swelling continues. The gelatinized grains are large and smooth, but do not retain much of the original shape.

With *Purdy's solution* there is a slight reaction in some grains in 1½ minutes. About half of the grains are partially gelatinized in 15 minutes and two-thirds in 25 minutes. The reaction is the same qualitatively as that of the grains with pyrogallic acid.

GENUS CRINUM.

The genus *Crinum* includes about 60 species of bulbous tropical and subtropical plants which have a wide geographical distribution. The Asiatic poison bulb, which is used by natives of the East as an emetic in cases of poisoning, is from *C. asiaticum*. Fully half of the species are in cultivation and a number of hybrids have been recorded. The close relationship of *Crinum* to *Amaryllis* has been noted under the latter. The starches of two species were examined, including *C. fimbriatulum* Baker and *C. americanum* Linn., the Florida swamp lily.

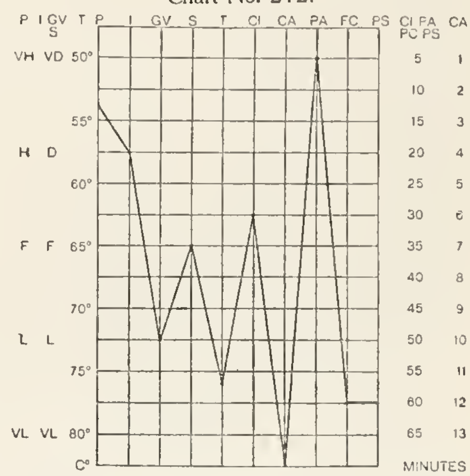
STARCH OF CRINUM FIMBRIATULUM. (Plate 53, figs. 313 and 314. Chart 212.)

Histological Characteristics.—In *form* the grains are almost wholly simple, and are isolated, with the exception of a few in small aggregates, which frequently consist of one large component with one or two rather small ones at the distal end or rarely at the side near the distal end. Pressure facets are occasionally found on the isolated grains. A few compound grains are present. The grains are often irregular, owing chiefly to the following causes: to a slight shifting of the longitudinal axis of the lamellæ during their deposition, rarely causing those of later formation to be placed at right angles to the primary set; the presence of one or more small, rounded protuberances; to slight inequalities of the surface; and to a slightly concave depression sometimes found at the distal end. The conspicuous forms are elongated ovoid, often with a squared, a concave, or a diagonal distal end; ovoid, pyriform, ellipsoidal, and nearly round; also triangular with curved base and rounded angles, mussel-shell-shaped, finger-shaped, quadrangular with rounded angles, and irregular diamond-shaped with proximal end more rounded than the distal end. The grains are usually not flattened.

The *hilum* may be a clear round or lenticular spot, eccentric about one-third to one-sixth of the longitudinal axis. It is usually fissured; the fissures are frequently in the form of a crescent-shaped transverse cleft, but sometimes intersect to form a cross or a dragon-fly figure.

The *lamellæ* are not usually demonstrable near the hilum, but if apparent they form either fine circular or oval rings at the hilum or mostly follow the outline of the grain when located distally. There is often one more coarse and refractive lamella forming a boundary between the primary and secondary sets of lamellæ, and sometimes the more regular grains show two or three such lamellæ at varying distances from the hilum. The lamellæ are generally more distinct in the distal end over about one-third of the grain, but occasionally may be observed as fine lines over most of the grain. In such grains 24 to 26 are often counted, rarely 33 to 42.

Chart No. 212.



Curve of Reaction-Intensities of Starch of Crinum fimbriatulum.

The grains vary in *size;* the smaller are 3 by 2μ; the larger are 58 by 38μ in length and breadth. The common size is about 44 by 28μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric and distinct. The lines are rather thin and intersect obliquely. They may be straight, but are often bent and sometimes bisected. Double figures indicating the presence of compound grains and aggregates are observed.

The degree of *polarization* is high to very high, with variation in the same aspect of a given grain.

With *selenite* the quadrants are distinct and fairly clear-cut, but are unequal in size and generally irregular in shape. The colors usually are not pure, having a greenish tint.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet which deepens rapidly; with 0.125 per cent solution the grains color a light blue-violet, some lighter than others, which deepens gradually. After heating in water until the grains are gelatinized and then adding iodine the solution colors a deep indigo-blue and the grains a fairly deep bright blue. If the grains are boiled for 2 minutes and then treated with iodine, the grain-residues become a light to fairly deep blue and the solution a very deep blue. With an excess of iodine the grain-residues become a light blue, some with reddish tint, and the capsules a red-violet to heliotrope.

Staining Reactions.—With *gentian violet* the grains begin to color immediately and in 30 minutes are lightly stained.

With *safranin* the grains begin to color immediately and in 30 minutes are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 75° to 77° C., mean 76°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. Some small grains are gelatinized in a minute. A small number, including large and small grains, are gelatinized in 5 minutes, about six-sevenths in 10 minutes, nine-tenths in 15 minutes, and all but rare resistant grains (one in many hundred) in 30 minutes. No further change occurred in an hour. The grains immediately color an old-rose, which quickly deepens to a wine-red color. The hilum or the clefts become very distinct and much swollen, and a bubble appears. Gelatinization accompanied by a dark-bluish color starts at the distal end or at the corners of this margin when the grains are of a broadened form at the distal end, spreads around the margin, and then gradually over the entire grain, accompanied by uniform swelling. When the clefts at the hilum are much swollen, they appear to exert a repellent force upon the advance of gelatinization, which process, after reaching a point near this structure, remains stationary for many minutes. The bubble finally collapses as a whole or disappears in a series of small bubbles, and the region at this point becomes gelatinized. The gelatinized grain is swollen and deeply colored, but retains the shape of the untreated grain.

Reaction with *chromic acid* begins in a few grains in 45 seconds. A small number are dissolved in 5 minutes, more than half in 8 minutes, nearly all in 10 minutes, and practically all in 14 minutes. The lamellæ and hilum or clefts become more clearly defined, and a bubble appears which enlarges greatly. From the region of the hilum usually one large plume-like fissure (two in the broadened forms) extends toward the distal end. During gelatinization many refractive granules appear which remain for several minutes embedded in the more soluble starch. The grain continues to swell, and the capsule is ruptured either at the distal end or at the corners limiting this margin. The gelatinized starch with any resistant granules flows out slowly, the sides and proximal end of the capsule gradually dissolving, followed by the solution of the remaining part of the grain.

The reaction with *pyrogallic acid* begins in a few grains in 30 seconds. A small number are gelatinized in a minute, more than half in 2½ minutes, nearly all in 3½ minutes, and practically all in 5 minutes. Rare resistant grains are seen, in which the reaction is complete, with the very rare exception of the lamellæ at the proximal end, when there is a very large, persistent bubble at the hilum in 6 minutes. The lamellæ become more sharply defined and striated, while the hilum or the clefts swell and a bubble appears, which after increasing much in size, may collapse suddenly or disappear through the gradual expulsion of small bubbles. From the region of the hilum one large, plume-like fissure (or two in the grains with broadened distal end) proceeds towards the distal end, which is gelatinized much sooner than the proximal end and the sides nearby. During gelatinization a number of refractive granules appear which usually become gelatinized. In the most resistant grains the bubble at the region of the hilum increases greatly in size and is very persistent, remaining several minutes after gelatinization of the distal end. The collapse of this bubble is generally accompanied by temporary invagination of the capsule at the distal end and by the lamellæ at the proximal end and sides nearby being cut down into a serrated lining with refractive edges. These most resistant lamellæ are gradually gelatinized. The gelatinized grain is swollen and much distorted at the distal end, but is usually regular in outline at the proximal end.

With *ferric chloride* a few grains begin to swell in 2 minutes, a small number are gelatinized in 5 minutes, about one-fifth in 15 minutes, about two-thirds in 30 minutes, and about nine-tenths in 60 minutes. The hilum or clefts swell and become lustrous, owing to the presence of a large bubble. A border, in which the lamellæ are at first more distinct and later become quite lustrous, is formed around the grain. Internal fissures appear in this border, either at the distal end or the corner limiting this margin, and gelatinization begins, accompanied by a distension of the capsule at one or more points at the distal end. The reaction now proceeds gradually towards the proximal end until it reaches the clefts; the bubble or bubbles are then expelled and the starch breaks into refractive granules which are finally gelatinized. In grains with a regular border and very small, circular cavity at the hilum the lustrous border gradually increases in width, more rapidly at the distal margin than at the proximal end and sides nearby; it advances over the grain until the hilum is reached; the small bubble then swells and suddenly collapses, followed by rapid gelatinization of the grain, the starch at the proximal end proving the most resistant. The gelatinized grains are much swollen and somewhat distorted, but retain the general shape of the untreated grain.

The reaction with *Purdy's solution* begins in a few grains in a minute. A few are gelatinized in 5 minutes, but there appears to be little if any further progress in an hour. The hilum, clefts, and lamellæ become very distinct, and a single plume-like fissure passes from the hilum to the distal end, where gelatinization is more rapid than at the proximal end. During gelatinization a number of small refractive granules appear along the course of the plume-like fissure or channel, the outer lamellæ of the proximal end remaining unaffected or finally breaking into two or more large fragments, which may gradually become gelatinized.

STARCH OF CRINUM AMERICANUM. (Plate 53, figs. 315 and 316. Chart 213.)

Histological Characteristics.—In *form* the grains are usually simple and are isolated, except a few which occur in small aggregates. Pressure facets are occasionally found on the isolated grains; compound grains are rare. The grains are usually regular. The conspicuous forms are ovoid, pyriform, ellipsoidal, elongated ovoid with squared or concave distal end, and nearly round. There are also a few triangular grains with curved base and rounded angles, some of which approach the mussel-shell-shaped grains. The grains are much more regular than those of *C. fimbriatulum*, and a smaller number of both compound grains and aggregates are observed; when the latter are present they are of the same character as those of *C. fimbriatulum.*

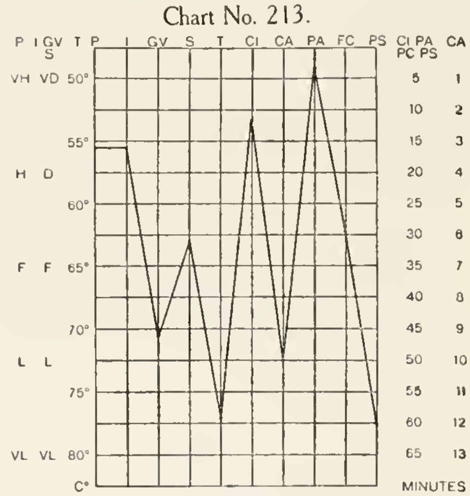
The *hilum* is a round or lenticular clear spot, eccentric about one-third to one-fourth of the longitudinal axis. It is not usually fissured, but sometimes one short fissure passes from each side of the hilum, or there may be a short, transverse, crescentic fissure.

The *lamellæ* are frequently not demonstrable near the hilum, but when observed they form fine circular or oval rings; toward the distal end they follow the outline of the grain. There is often one, sometimes three, refractive and coarser lamellæ placed at varying distances from the hilum. On the large grains frequently 24 to 26 lamellæ, rarely 42, may be counted. The lamellæ are of the same character and arrangement as those in *C. fimbriatulum,* but can be determined over a greater part of many more grains than in that species.

The grains vary in *size;* the smaller are 3 by 2μ; the larger are 44 by 30μ in length and breadth. The common size is 24 by 14μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric. Its lines intersect obliquely and are fine and usually straight, with slight broadening at the margin; occasionally bent and rarely bisected. Double figures are rare. The figure is much more regular than in *C. fimbriatulum.*

Chart No. 213.



Curve of Reaction-Intensities of Starch of Crinum americanum.

The degree of *polarization* is high to very high. The proportion of grains in which the polarization is very high is less than in *C. fimbriatulum,* so that the degree of polarization is somewhat lower.

With *selenite* the quadrants are distinct, clean-cut, and unequal in size, but usually regular in shape. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet, some deeper than others, the color deepening rapidly. The tint is at first slightly lighter than in *C. fimbriatulum,* but it deepens more rapidly. With 0.125 per cent solution the grains color a very light blue-violet, some deeper than others, but slightly lighter than in *C. fimbriatulum,* yet deepening rather more quickly than in *C. fimbriatulum.* After heating in water until all the grains are gelatinized and then adding iodine, the solution colors a deep indigo-blue and the grains a fairly deep bright-blue, both about the same as in *C. fimbriatulum.* If the grains are boiled for 2 minutes and then treated with iodine, the grain-residues do not color or become a very light to a fairly deep blue and the solution a very deep blue. The grain-residues are slightly lighter in color than in *C. fimbriatulum.* With an excess of iodine the grain-residues color a deep dull-blue, some with reddish tint, and the capsules a deep old-rose to wine-red. The grain-residues and capsules are deeper in tint and the capsules are redder than in *C. fimbriatulum.*

Staining Reactions.—With *gentian violet* the grains begin to color slightly at once and in 30 minutes are lightly stained. The color is slightly deeper than in *C. fimbriatulum.*

With *safranin* the grains begin to color slightly at once and in 30 minutes are fairly stained. The tint is slightly deeper than in *C. fimbriatulum.*

Temperature Reaction.—The temperature of gelatinization is 76° to 78° C., mean 77°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins immediately. Many small grains and a few of the larger are gelatinized in 30 seconds, about half in 5 minutes, about nine-tenths in 10 minutes, all but rare resistant grains in 12 minutes, in which the reaction is usually complete in 20 minutes, rarely 30 minutes. The gelatinized grains are uniformly swollen and resemble the shape of the untreated grain. The reaction is qualitatively the same as in *C. fimbriatulum,* except that a small dark area is generally found at the hilum instead of the large, swollen structures containing bubbles present in that species.

Reaction with *chromic acid* begins in a few grains in 45 seconds. A small number are dissolved in 5 minutes, nearly all in 8 minutes, and all in 10 minutes. The reaction is qualitatively the same as in *C. fimbriatulum,* except that usually a small bubble or none is formed at the hilum.

Reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 30 seconds, more than half in 1½ minutes, nearly all in 2½ minutes, all but rare resistant grains in 3 minutes, and all in 4 minutes. The reaction is qualitatively the same as in *C. fimbriatulum*, except that the bubble at the hilum is rarely so large or so persistent as in that species.

With *ferric chloride* the grains begin to swell in a minute. About half are gelatinized in 5 minutes, about five-eighths in 15 minutes, and all but rare resistant grains in 30 minutes, in which the reaction is complete in 60 minutes. The reaction is qualitatively the same as the second method noted for *C. fimbriatulum.*

Reaction with *Purdy's solution* begins in a minute. A few grains are gelatinized in 5 minutes, very slight progress is noted at 30 minutes, and about one-tenth are gelatinized in 60 minutes. The reaction is qualitatively the same as in *C. fimbriatulum.*

Differentiation of Certain Starches of the Genus Crinum.

Histological Characteristics.

Conspicuous Forms.

C. fimbriatulum: Usually simple, few aggregates and compounds, occasional pressure facets, often irregular. Elongated ovoid, often with squared, concave, or diagonal distal end; ovoid, pyriform, ellipsoidal and nearly round.

C. americanum: Essentially the same as in *C. fimbriatulum*, but a smaller number of compounds and aggregates.

Hilum—Form, Number, and Position.

C. fimbriatulum: Form clear, round or lenticular spot; usually fissured, fissuration crescentic, a cross, or dragon-fly shape. Position eccentric about 0.33 to 0.16 of longitudinal axis.

C. americanum: Form the same as in *C. fimbriatulum*, but not usually fissured. Position eccentric about 0.33 to 0.25 of longitudinal axis.

Lamellæ—General Characteristics and Number.

C. fimbriatulum: Fine circular or oval rings about hilum, but follow outline of grain when distal; usually not demonstrable near hilum. Often one or more coarse refractive lamellæ. 24 to 26.

C. americanum: Essentially the same as in *C. fimbriatulum*, but can be seen over a larger part of a larger number of grains. 24 to 26.

Size.

C. fimbriatulum: From 3 to 58μ, commonly 44 by 28μ.

C. americanum: From 3 to 44μ, commonly 24 by 14μ.

Polariscopic Properties.

Figure.

C. fimbriatulum: Eccentric, distinct; lines rather thin, usually straight, intersect obliquely, often bent, and sometimes bisected.

C. americanum: The same as in *C. fimbriatulum*, but the figure is less irregular.

Degree of Polarization.

C. fimbriatulum: High to very high.

C. americanum: High to very high, but somewhat lower, on the whole, than in *C. fimbriatulum.*

Polarization with Selenite—Quadrants and Colors.

C. fimbriatulum: Quadrants distinct, fairly clear-cut, unequal in size, generally irregular in shape. Colors usually not pure.

C. americanum: Quadrants the same as in *C. fimbriatulum*, but regular in shape. Colors generally pure.

Iodine Reactions.

Intensity and Color.

C. fimbriatulum: Deep; blue-violet.

C. americanum: Deep, deeper than in *C. fimbriatulum;* blue-violet.

Staining Reactions.

With Gentian Violet.

C. fimbriatulum: Light.

C. americanum: Light, deeper than in *C. fimbriatulum.*

With Safranin.

C. fimbriatulum: Fair.

C. americanum: Fair, slightly deeper than in *C. fimbriatulum.*

Temperature of Gelatinization.

C. fimbriatulum: 75 to 77° C., mean 76°.

C. americanum: 76 to 78° C., mean 77°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

C. fimbriatulum: Begins immediately; complete in practically all in 30 minutes.

C. americanum: Begins immediately; complete in practically all in 12 minutes.

Reaction with Chromic Acid.

C. fimbriatulum: Begins in a few in 45 seconds; complete in practically all in 14 minutes.

C. americanum: Begins in a few in 45 seconds; complete in all in 10 minutes.

Reaction with Pyrogallic Acid.

C. fimbriatulum: Begins in a few in 30 seconds; complete in practically all in 5 minutes.

C. americanum: Begins in a few immediately; complete in practically all in 3 minutes.

Reaction with Ferric Chloride.

C. fimbriatulum: Begins in a few in 2 minutes; complete in nine-tenths in 60 minutes.

C. americanum: Begins in a minute; complete in practically all in 30 minutes.

Reaction with Purdy's Solution.

C. fimbriatulum: Begins in a few in a minute; a few are gelatinized in 5 minutes; very little progress in an hour.

C. americanum: Begins in a minute; a few are gelatinized in 5 minutes, and about one-tenth in an hour.

NOTES ON THE STARCHES OF CRINUM.

These starches exhibit some minor gross histological differences, such, for instance, as in *C. americanum* the less number of compound grains and aggregates, the less fissuration of the hilum, the more visible lamellæ, and the smaller grains. The two starches differ in every one of the reactions, although to a negligible degree with Purdy's solution. Excepting the polarization and temperature reactions, *C. americanum* is the more responsive with every reagent.

GENUS ZEPHYRANTHES.

Zephyranthes, the small amaryllis, zephyr lily, fairy lily, or swamp lily, according to Baker includes 34 species, which may be grouped into 3 subgenera. They are natives of the warmer parts of America, especially from Texas south. The starches from two species were studied; *Z. candida* Herb. and *Z. rosea* Lindl.

STARCH OF ZEPHYRANTHES CANDIDA. (Plate 54, figs. 319 and 320. Chart 214.)

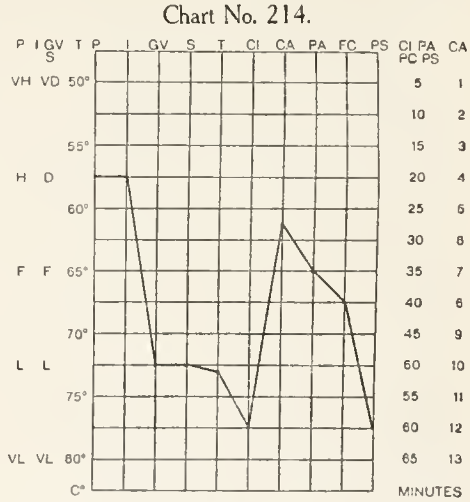
Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few small aggregates. Pressure facets were seen on some of the isolated grains. There are no clumps. The surface is rather irregular, owing to the unequal development of the surface, chiefly in the form of nipple-like processes and round protuberances and depressions of varying size. The conspicuous forms are the ovoid to spherical and oval to elliptical. There are also triangular, hemispherical, reniform, pyriform, and various irregular forms. The grains are, as a rule, about one-half to two-thirds as thick as they are broad. They vary in shape in different aspects, according to the size and position of the projections and depressions of their surfaces.

The *hilum* is a fairly distinct, small, round, or rather large lenticular spot, usually eccentric about one-third of the longitudinal axis; centric in some grains with the lenticular hila. There are often double and sometimes multiple hila. The hilum is frequently fissured, and there may be one fissure, small or large, rather ragged and irregular and running transversely; or two irregular large fissures forming a cross; or a number of ragged fissures arranged in an irregularly stellate fashion. In the case of multiple hila there is usually a row of such irregularly stellate fissures, one set marking each hilum.

The *lamellæ* are fairly distinct, rather coarse, continuous rings; fairly regular in form near the hilum, but very irregular near the margin, and sometimes discontinuous as they follow the marginal outline. They are much coarser and more distinct near the hilum than near the margin and vary in distinctness in different grains. There are about 8 to 10 lamellæ on the larger grains.

The grains vary in *size* from 4 to 38μ. The common size is 24μ.

Chart No. 214.



Curve of Reaction-Intensities of Starch of Zephyranthes candida.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, irregular, and rarely clear-cut. Its lines are often blurred, bent, and otherwise distorted, and are placed at varying angles with one another. It usually consists of four converging lines forming an X-shaped figure.

The degree of *polarization* is high. It varies somewhat in different grains and in different aspects of the same grain (being higher when the grain is viewed on end or edge); also in different parts of the same aspect of a given grain. An area centrally located, sometimes quite large, is isotropic, so that in some instances only marginal parts of the grain are illuminated.

With *selenite* the quadrants are not well defined, are irregular in form, and unequal in size. The colors are usually quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rather rapidly. After heating in water until the grains are completely gelatinized, the solution colors fairly and most of the grains deeply or lightly on the addition of iodine. The capsules of the grains that color lightly become a red-violet color when a slight excess of iodine is present. After boiling for 2 minutes the solution colors deeply and most of the grain-residues not at all or lightly. With an excess of iodine the capsules color a red-violet and a few of them contain blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes are lightly stained, one as much as another.

With *safranin* the grains begin to stain at once and in 30 minutes are rather lightly colored, one as much as another.

Temperature Reaction.—The temperature of gelatinization is 72° to 74° C., mean 73°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 2 minutes. It is complete in one-third in 25 minutes and in three-fourths in 50 minutes. The reaction begins usually at the distal end; or if the grain has a longer transverse than longitudinal diameter, it starts at the extremities of the transverse diameter, from which it usually proceeds all along the margin, which becomes dark but does not swell, and then inward over the entire grain, the whole grain swelling slightly. Occasionally the reaction originates at the extremities of the transverse diameter, and then extends inward from both sides until the whole grain is involved without first affecting the margin as a whole. The gelatinized grains are not very large, are of a uniform dark color, and retain much of the original form.

Reaction with *chromic acid* begins in most grains in 30 seconds and in all in a minute, and is over in 5½ minutes. The reaction begins at the hilum, which swells slightly. Fine striæ appear throughout the grain, at first distinguishable at the margin and later in the space about the swollen hilum. The inner portion of the grain is converted into a gelatinous mass, and the marginal part forms a thick ring which is distinctly striated and sometimes shows alternate refractive and unrefractive rings of a lamellar arrangement. The grain increases in size in all directions, and the marginal ring becomes very thin and transparent, and finally one point is dissolved, the inclosed semifluid mass flows out and is dissolved, and the remaining part of the marginal ring dissolves very soon afterward.

The reaction with *pyrogallic acid* begins in most grains in a minute and in all in 1½ minutes. About three-fourths are partially and one-fourth completely gelatinized in 4 minutes, and all are completely gelatinized in 35 minutes. The reaction begins at the hilum, which swells slightly, and fine striæ appear radiating throughout the grain. The inner part of the grain immediately surrounding the hilum is transformed into a gelatinous mass and the remaining portion forms a very thick, striated, marginal ring, which slowly becomes thinner and transparent as the grain swells slowly. The gelatinized grains are large, somewhat wrinkled and sacculated, and do not retain the original form.

Reaction with *ferric chloride* begins in a few grains in a minute. About three-fourths are completely gelatinized in 15 minutes, almost all in 30 minutes, and all in 40 minutes. The reaction begins at the hilum in the small grains, but at the distal end in the larger grains. In the small grains the hilum swells somewhat, fine striæ appear throughout the grain, the more resistant starch forms a thick marginal ring, which is distinctly striated, and this ring becomes thin and transparent as the grain swells and incloses a mass of gelatinized starch. The gelatinized grains so formed are large and comparatively smooth and free from distortions. In the large grains the distal end becomes fissured within the capsules in two or three places, and from these fissures the gelatinized starch exudes, forcing out the capsule. This process of gelatinization involves the entire mass at the distal end, and then moves proximally. In the meantime the same process often starts at the proximal end, and from these two points the reaction proceeds over the whole grain. When the reaction reaches a more resistant portion about the hilum this part becomes divided by a fissure, and these two in turn into two, the four pieces gelatinizing independently of one another. The gelatinized grains so formed are large, wrinkled, and distorted.

With *Purdy's solution* the reaction begins in many grains in a minute and a few are partially gelatinized in 5 minutes. About half are partially and a few are completely gelatinized in 15 minutes and one-fourth are completely gelatinized in 30 minutes. The reaction is qualitatively the same as that with pyrogallic acid.

STARCH OF ZEPHYRANTHES ROSEA. (Plate 54, figs. 321 and 322. Chart 215.)

Histological Characteristics.—In *form* the grains are simple and are isolated, except a few aggregates in the form of doublets. Pressure facets are rarely seen. There are no clumps. The surface is smooth but somewhat irregular, owing to the unequal development resulting in small rounded or angular projections and slight depressions. The conspicuous forms are the ovoid to spherical and oval to elliptical. There are also quadrangular with rounded angles, lenticular, triangular, and pyriform. The grains are about one-half to two-thirds as thick as they are broad.

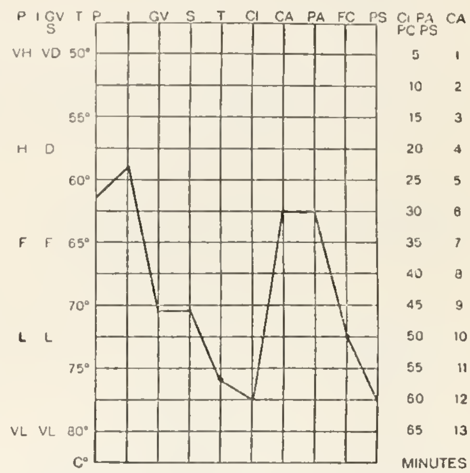
The *hilum* is not distinct. It is a small, round or rarely lenticular spot, usually eccentric one-third to two-fifths of the longitudinal axis. There are rarely double hila. The hilum is seldom fissured, and the fissure is usually single, narrow, shallow, and short, and may be clean-cut or ragged.

The *lamellæ* are generally very indistinct. In the few grains in which they could be detected they were seen only near the hilum. They appeared as fairly coarse, regular, continuous rings, circular to elliptical. Their number could not be determined satisfactorily.

The grains vary in *size* from 4 to 40μ. The common size is 26μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, irregular, and not clear-cut. Its lines are usually blurred, often somewhat bent or otherwise distorted, and placed at varying angles to one another. Large areas, especially centrally, may be dark.

Chart No. 215.



Curve of Reaction-Intensities of Starch of Zephyranthes rosea.

The degree of *polarization* is fairly high. It varies much in different grains (being low in some grains and high in others), also in different aspects of the same grain and in different parts of the same aspect of a grain. It is not so high as that of the grains of *Z. candida.*

With *selenite* the quadrants are not well defined, are irregular in shape, and unequal in size. The colors are, on the whole, fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens rather rapidly. The color is not so deep as that of the grains of *Z. candida.* After heating in water until the grains are completely gelatinized, both the solution and the grains color fairly deeply on the addition of iodine. With a slight excess of iodine the capsules color a red-violet. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly or not at all. The capsules color a red-violet with a slight excess of iodine. Some of the capsules retain blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain lightly at once and in 30 minutes are lightly stained. The color is a little deeper than that of the grains of *Z. candida.*

Temperature Reaction.—The temperature of gelatinization is 75° to 77° C., mean 76°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 2½ minutes. About one-third are gelatinized in 20 minutes, two-thirds in 26 minutes, and four-fifths in 1¼ hours. The reaction is the same qualitatively as that of the grains of *Z. candida.*

Reaction with *chromic acid* begins in all the grains in 1¼ minutes and is over in 6 minutes. It is qualitatively the same as that of the grains of *Z. candida.*

The reaction with *pyrogallic acid* begins in all the grains in 1½ minutes, and two-thirds are partially and one-third completely gelatinized in 7 minutes. About two-thirds are completely gelatinized in 12 minutes, four-fifths in 25 minutes, and nearly all in 30 minutes. The reaction is qualitatively the same as that of the grains of *Z. candida.*

The reaction with *ferric chloride* begins in a few grains in a minute. About two-thirds are gelatinized in 18 minutes and all in 50 minutes. The reaction is the same qualitatively as that of the grains of *Z. candida.*

With *Purdy's solution* the reaction begins in most grains in 1¼ minutes, yet very few are even partially gelatinized at the end of 30 minutes. The reaction is the same qualitatively as that of the grains of *Z. candida.*

Differentiation of Certain Starches of the Genus Zephyranthes.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

Z. candida: Simple, few aggregates; surface irregular, due to unequal development. Ovoid to spherical, oval to elliptical.
Z. rosea: Essentially the same as in *Z. candida.*

Hilum—Form, Number, and Position.

Z. candida: Form fairly distinct, small, round or rather lenticular spot; usually single, but often double, rarely multiple; often fissured, fissures small or large, ragged, single or multiple. Position usually eccentric about 0.33 to 0.40 of longitudinal axis.
Z. rosea: Form not distinct; small, round, rarely lenticular spot; rarely double; seldom fissured, fissures single, narrow and short, clean-cut or ragged. Position usually eccentric 0.33 to 0.40 of longitudinal axis.

Lamellæ—General Characteristics and Number.

Z. candida: Fairly distinct, rather coarse, continuous, fairly regular near hilum, irregular near the margin. 8 to 10 on larger grains.
Z. rosea: Very indistinct, fairly coarse, regular, continuous. Number not determined.

Size.

Z. candida: From 4 to 38μ, commonly 24μ.
Z. rosea: From 4 to 40μ, commonly 26μ.

POLARISCOPIC PROPERTIES.

Figure.

Z. candida: Usually eccentric, distinct, not clear-cut, irregular.
Z. rosea: Same as in *Z. candida.*

Degree of Polarization.

Z. candida: High, varies somewhat.
Z. rosea: Fairly high, less than in *Z. candida.*

Polarization with Selenite—Quadrants and Colors.

Z. candida: Quadrants not well defined, irregular in form, unequal in size. Colors usually quite pure.
Z. rosea: Quadrants the same as in *Z. candida.* Colors fairly pure.

IODINE REACTIONS.

Intensity and Color.

Z. candida: Deep; blue-violet.
Z. rosea: Deep, not so deep as in *Z. candida;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

Z. candida: Light.
Z. rosea: Light, a little deeper than in *Z. candida.*

With Safranin.

Z. candida: Light.
Z. rosea: Light, a little deeper than in *Z. candida.*

TEMPERATURE OF GELATINIZATION.

Z. candida: 72 to 74° C., mean 73°.
Z. rosea: 75 to 77° C., mean 76°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

Z. candida: Begins in most in 2 minutes; complete in three-fourths in 50 minutes.
Z. rosea: Begins in most in 2½ minutes; complete in four-fifths in 75 minutes.

Reaction with Chromic Acid.

Z. candida: Begins in all in a minute; complete in 5½ minutes.
Z. rosea: Begins in all in 1¼ minutes; complete in 6 minutes.

Reaction with Pyrogallic Acid.

Z. candida: Begins in all in 1½ minutes; complete in 35 minutes.
Z. rosea: Begins in all in 1½ minutes; complete in almost all in 30 minutes.

Reaction with Ferric Chloride.

Z. candida: Begins in a few in a minute; complete in 40 minutes.
Z. rosea: Begins in a few in a minute; complete in 50 minutes.

Reaction with Purdy's Solution.

Z. candida: Begins in many in a minute; many partially and one-fourth completely gelatinized in 30 minutes.
Z. rosea: Begins in most in 1¼ minutes; a very few are partially gelatinized in 30 minutes.

NOTES ON THE STARCHES OF ZEPHYRANTHES.

In histological characteristics the main difference between the two starches is in the degree of distinctness of the hilum and lamellæ. Their reaction intensities differ in every case. The reaction of *Z. candida* is greater in polarization and with heat, iodine, chloral hydrate-iodine, chromic acid, ferric chloride, and Purdy's solution; and less with the anilines and pyrogallic acid. The difference in the temperature of gelatinization is 3°. On the whole, the grains are quite resistant to the various reagents except iodine.

GENUS SPREKELIA.

The genus *Sprekelia,* like *Amaryllis* and *Vallota,* includes but a single species, *S. formosissima* Herb. (*Amaryllis formosissima* Linn). It is a native of Mexico and is commonly known as the Jacobæa lily.

STARCH OF SPREKELIA FORMOSISSIMA. (Plate 53, figs. 317 and 318. Chart 216.)

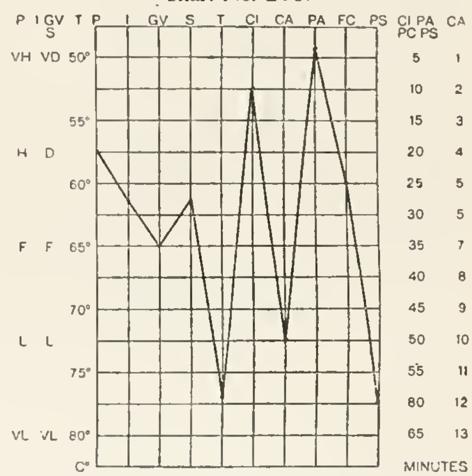
Histological Characteristics.—In *form* the grains are usually simple and isolated. Compound grains and aggregates, consisting of generally two components, and clumps are occasionally observed. Some isolated grains have pressure facets. The surface is quite smooth but often irregular, due chiefly to the following causes: a slightly undulating outline; a protuberance at either side of the hilum; either a finger- or a nipple-shaped projection at the proximal end; additional sets of lamellæ placed at varying angles to the primary set or inclosing the primary set. The conspicuous forms are elongated ovoid to nearly round, and oval to ellipsoidal, which are sometimes slightly flattened at one or more points. There are also pyriform, broadly triangular with curved base and rounded angles approaching the clam-shell-shaped, dome-shaped, club-shaped, finger-shaped, lenticular, and almost quadrangular grains. The aggregates commonly occur as doublets of small or medium-sized components of about equal size, but sometimes they consist of one small component.

The *hilum* may be observed as either a clear, round or lenticular spot which is eccentric, ranging from slightly to one-fourth eccentric of the longitudinal axis. A small cavity from which two short fissures radiate is frequently found at the hilum. The hilum is often fissured either by a transverse cleft, by two clefts which form a cross, by a thorn-shaped cleft, or by a group of fissures forming a stellate figure.

The *lamellæ* are usually not demonstrable throughout the entire grain. One and sometimes two rather coarse and refractive lamellæ frequently appear to divide the lamellæ into groups of slightly different character. The lamellæ are generally not distinguishable directly around the hilum. Toward the distal end they follow the outline of the grain. The number can not be satisfactorily determined.

The grains vary in *size;* the smaller are 4 by 3μ; the larger are 42 by 28μ in length and breadth. The common size is 26 by 20μ in length and breadth. There are laterally extended grains, the larger of which are 28 by 38μ in length and breadth. The common size of these is 20 by 28μ in length and breadth.

Chart No. 216.



Curve of Reaction-Intensities of Starch of Sprekelia formosissima.

Polariscopic Properties.—The *figure* may be slightly to quite eccentric, of the leguminous type, or centric. Its lines are rather fine and are sometimes straight, but often bent or bisected. Double figures are also observed.

The degree of *polarization* is high. The grains vary from fair to very high, with the average high, often with a variation in the same and different aspect of a given grain.

With *selenite* the quadrants are fairly well defined and usually irregular in shape and unequal in size. The blue is more often pure, although in some grains it has a greenish and in others a purplish tint. The yellow is frequently not pure throughout the entire quadrants.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep reddish-violet at once, which deepens rapidly; with 0.125 per cent solution they color a light red-violet, which deepens gradually. When the grains are heated in water until all are gelatinized, the solution colors a deep indigo-blue and the grains a light blue, some with reddish tint, on the addition of iodine. When the preparation is boiled for 2 minutes and then treated with iodine the solution becomes a very deep indigo-blue and the grain-residues a fairly deep, bright blue. When an excess of iodine is added the grain-residues become deep blue, many with a reddish tint, and the capsules a deep red-violet to wine-red.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are fairly well colored.

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly deep in color, deeper than with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 76° to 78° C., mean 77°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins immediately. A few grains are gelatinized in a minute, nearly all in 5 minutes, and all but rare resistant grains in 10 minutes, in which latter the reaction may take 30 minutes for completion. The grains color a light red-violet at once, which deepens rather quickly to a deep old-rose and later to wine-red. Either a dark ring or an irregular structure appears at the hilum, and gelatinization accompanied by a dark reddish-purple coloration begins around the margin, spreading gradually towards the center, accompanied by uniform swelling. During this process the ring or irregular structure at the hilum enlarges and finally breaks. In the most resistant grains this structure persists for a long time. The gelatinized grains are uniformly swollen and colored a deep reddish-purple.

Reaction with *chromic acid* begins in 30 seconds. A few grains are dissolved in 2 minutes, nearly all in 7 minutes, and all in 10 minutes. The hilum or structures located here swell, the lamellæ become sharply defined and striated. Usually an internal longitudinal fissure with lateral branches extends from the hilum towards the distal end. As the lamellæ are gelatinized great masses of refractive granules remain embedded for some time in the gelatinized starch. Finally, the capsule breaks at one or more points, and the semigelatinized starch pours out and becomes completely dissolved. At the hilum a bubble is often formed which enlarges and then collapses, followed frequently by the gelatinization of the lamellæ and the appearance of many refractive granules without the formation of the longitudinal, branched fissure. In some of the grains a border forms which gradually clears and becomes ruptured, separating from the main body of the grain, and dissolves. The main body of the grain passes into solution as above described much more slowly than the border. This border is probably constituted of a secondary set of lamellæ which incloses the primary set.

With *pyrogallic acid* reaction begins immediately. A few are gelatinized in a minute, nearly all in 2 minutes, and all but a few resistant grains in 3 minutes. The reaction is complete in the latter in 4 minutes. At the hilum a bubble often forms, which enlarges and then collapses, followed by rapid gelatinization of the proximal end of the grain. Usually a branched, internal, longitudinal fissure extends from the hilum, along the course of which gelatinization proceeds. The lamellæ are generally quickly gelatinized, but in the grains in which the process is slow many refractive granules appear which persist for some time, but are finally gelatinized. The gelatinized grains are much swollen and distorted.

Reaction with *ferric chloride* begins immediately. A few grains are gelatinized in 2 minutes, about one-fifth in 5 minutes, nearly all in 15 minutes, and all but rare resistant grains in 25 minutes, some of the latter not being gelatinized even in an hour. Either the hilum or cleft at this region swells and a bubble usually forms there. A border, in which the lamellæ become more distinct and striated, forms around the grain. Gelatinization, accompanied by rapid distension of the capsule, begins usually at the distal end, but sometimes at the corners limiting the distal margin. Frequently gelatinization proceeds gradually towards the proximal end until the bubble at this point collapses, followed by the formation of internal radiating fissures and the breaking of the resistant starch into rather coarse granules which are finally gelatinized. In other grains gelatinization starts at the proximal end very soon after the process begins at the distal end, and the central portion of the grain is the more resistant. The grains which resist the reagent the longest are those in which the bubble at the hilum persists for a considerable period.

The reaction with *Purdy's solution* begins in a few grains in a minute; a few of the smaller grains are gelatinized in 2 minutes, about one-tenth in 15 minutes, very little progress occurs in 30 minutes, and only a few of the larger grains are gelatinized in an hour. The hilum or fissures located here swell slightly and sometimes a bubble is formed; the lamellæ become more distinct and striated in some of the grains, although in the majority they are still not clearly demonstrable. A single internal, root-like fissure is formed in the elongated grains, and one from either side of the hilum in the broadened forms. Gelatinization proceeds along the course of these fissures and as the lamellæ are broken down, refractive granules remain first in rows, are later embedded in the less resistant starch, and finally gelatinize. Only a few grains are affected beyond the first stages, which are characterized by swelling of the hilum, fissuration, and increased prominence of the lamellæ. The smaller sizes constitute the greater proportion of these gelatinized grains, although many of these remain unaffected. The few grains gelatinized are swollen, but retain the general shape of the untreated grain.

GENUS HÆMANTHUS.

The genus *Hæmanthus* includes over 35 species of African bulbous plants, most of which are from the Cape district. They are popularly known as the blood lily or blood plant, both generic and English names being founded on the red color of the flowers. They are also known as the Cape tulip. The bulbs of some species, notably *H. toxicarius*, are poisonous, and this plant is stated to be the source of an arrow-head poison of the Hottentots. Starch was obtained from *H. katherinæ* Baker, a well-marked species.

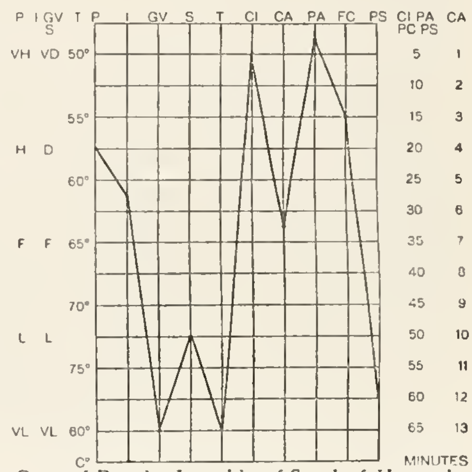
STARCH OF HÆMANTHUS KATHERINÆ. (Plate 54, figs. 323 and 324. Chart 217.)

Histological Characteristics.—In *form* the grains are usually simple, and are isolated except a small number which occur in small aggregates. There are a few compound grains of few components. The grains are frequently irregular, chiefly because of the deposition of a secondary set of lamellæ placed at varying angles to the primary set; to a slight shifting of the longitudinal axis of the lamellæ with a resultant curvation at one end of the grain; or to protuberances at different points on the grain which vary in form from small nipple-like to finger-shaped processes. The conspicuous forms are ellipsoidal, ovoid, elongated ovoid, bean-shaped, triangular with rounded angles, pyriform, and lenticular; also club-shaped, napiform, rod-shaped with curved ends, imperfect quadrangular, T-shaped, boot-shaped, and indefinite shapes.

The *hilum* is usually very indistinct, but when clearly made out it is a round or oval spot which varies from centric to quite eccentric, ranging usually from about five-elevenths to one-seventh of the longitudinal axis. The hilum is, as a rule, not fissured, and a small cavity is occasionally observed.

The *lamellæ* are very indistinct and are not demonstrable throughout the entire grain. Those which can be determined follow the outline of the main body of the grain. Occasionally 8 to 10 rather coarse lamellæ may be counted.

Chart No. 217.



Curve of Reaction-Intensities of Starch of Hæmanthus katherinæ.

The *size* varies; the smaller are 4 by 3μ; the larger are 36 by 20μ in length and breadth. The common size is about 22 by 14μ in length and breadth.

Polariscopic Properties.—The *figure* is centric to quite eccentric, and also bean type. The lines vary from rather fine to quite broad, and frequently cross each other obliquely, and also may be arranged to form a mesial line with bisected ends (bean type), or to intersect mostly at right or nearly right angles; they are often bent. Double figures both of the compound and the aggregate type are observed.

The degree of *polarization* is high, with considerable variation in the different grains, the range being from fair to quite high, with the great majority high. Variation is also frequent in the same aspect of a given grain.

With *selenite* the quadrants are fairly well defined, usually unequal in size, and irregular in shape. The colors may be pure, but are often not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, which deepens rapidly; with 0.125 per cent solution they become a very light violet, which deepens rather rapidly. After heating in water until the grains are gelatinized and then adding iodine the solution colors a rather deep indigo-blue and the gelatinized grains a bright, fairly deep blue, a few with reddish tint. If the grains are boiled for 2 minutes and then treated with iodine the grain-residues become a rather light blue with a reddish tint, the capsules a fairly deep reddish-violet, and the solution a very deep blue. With an excess of iodine the grain-residues become a deeper blue with redder tint and the capsules a deep old-rose to a wine-red.

Staining Reactions.—With *gentian violet* the grains begin to color slightly at once and in 30 minutes are very lightly stained.

With *safranin* the grains begin to color slightly at once and in 30 minutes are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 79° to 81° C., mean 80°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in 30 seconds, more than half in 2 minutes, nearly all in 3 minutes, all but rare resistant grains in 5 minutes, in which latter the reaction is usually complete in 8 minutes, rarely not until 14 minutes. The grains at once color a deep old-rose, which deepens to a wine-red in many grains. The hilum becomes distinct in some grains. Gelatinization accompanied with the deep-bluish color begins either at the distal end or in the protuberances and spreads around the margin, then advances towards the hilum, which region is the last to undergo gelatinization. The gelatinized grains are uniformly swollen and deeply colored.

The reaction with *chromic acid* begins immediately. A few grains are dissolved in 2 minutes, more than half in 3 minutes, nearly all in 4 minutes, all but resistant portions of a few grains in 5 minutes, and all in 6½ minutes. The hilum swells and either one large, ragged, mesial cleft extends towards the distal end, or one from either end of the slightly eccentric or centric hilum which is often found in ellipsoidal grains; and large branches pass to any prominent corners or protuberances on the grain. The central part is quickly disorganized, with the appearance of a mass of refractive granules embedded in the gelatinized starch. The outer lamellæ, which are sharply defined and striated, resist the reaction a few minutes longer, but as the starch continues to gelatinize, the distended capsule is ruptured, usually at the distal end or at a prominent corner or protuberance. The gelatinized starch with embedded granules flows slowly through the opening and passes into solution, the rest of the grain being soon dissolved.

With *pyrogallic acid* the reaction begins immediately. A few grains are gelatinized in 15 seconds, more than half in a minute, nearly all in 2 minutes, and all but rare resistant grains in 2½ minutes, in which the reaction is usually complete in 3½ minutes, rarely not until 5½ minutes. The hilum swells and occasionally a bubble appears, which swells rapidly and then collapses. From this area one, and sometimes two clefts pass towards the distal end. The central part of the grain is quickly disorganized, followed by the appearance of a mass of refractive granules embedded in the more gelatinizable starch. The outer lamellæ are sharply defined and striated, and resist the reaction longer, but are finally broken down with the appearance of regularly arranged refractive granules. The refractive granules are finally gelatinized, those of the sides and proximal end being the most resistant. The gelatinized grain is much swollen and distorted.

The reaction with *ferric chloride* begins immediately. A few grains are gelatinized in a minute, about half in 5 minutes, about seven-eighths (or more) in 10 minutes, and all but rare resistant grains in 15 minutes, in which latter the reaction is usually complete in 20 minutes, rarely not until 30 minutes. The hilum becomes distinct in some grains and a small bubble may appear, which is often quite persistent. A border of less dense starch is formed around the grain, which soon becomes broader at the distal end. Gelatinization accompanied by distension of the capsule usually begins either at the distal end or at any prominent angles or protuberances, and advances gradually towards the hilum. Small, crescent-shaped, internal clefts in the less dense border precede the breaking down of the lamellæ; and finally, when this border has closed around the hilum, gelatinization spreads rapidly over this region, with the exception of the outer lamellæ of the proximal end and sides nearby, in which parts the reaction gradually becomes complete. Following the expulsion of a very persistent small bubble at the hilum, a cleft is formed which separates the starch of this region into fragments which gradually become soluble. The gelatinized grains are swollen, but retain the general shape of the untreated grain.

Reaction with *Purdy's solution* begins in a few grains immediately. A very small number are gelatinized in 5 minutes, and the reaction is so low that only a few scattered grains are gelatinized at the end of 60 minutes. The hilum swells, and occasionally a rather persistent, small bubble appears at this point. In grains with an eccentric hilum, a root-like cleft is formed which extends from this region towards the distal end. The outer lamellæ become distinct and striated. The central and distal portions of the grain gelatinize, followed by the breaking of the more resistant starch at the proximal end and sides nearby into larger fragments, which may gradually gelatinize or remain unaffected at the end of 60 minutes. In nearly round grains the hilum swells and delicate radial fissures form, one of which soon becomes more prominent, and gelatinization proceeds rapidly along its course towards the distal end. The gelatinized grains are swollen, but retain the general shape of untreated grain.

GENUS HYMENOCALLIS.

Hymenocallis and *Pancratium* are closely related. The names are frequently used synonymously, and considerable confusion has existed owing to the repeated shifting of species from one genus to the other. *Hymenocallis* is a New World genus (excepting an African species, *H. senegambica*); *Pancratium* is an Old World genus. The former includes about 30 species of bulbous plants, popularly known as the spider lily, spirit lily, and sea daffodil. Starches from two species were studied: *H. undulata* Herb. (*Pancratium undulatum*), a native of Venezuela, and *H. calathina* Nichols (*Pancratium calathinum* Ker., *Ismene calathina* Herb.), a native of Peru and Bolivia.

STARCH OF HYMENOCALLIS UNDULATA. (Plate 55, figs. 325 and 326. Chart 218.)

Histological Characteristics.—In *form* the grains are usually simple and isolated, except a small number which occur in small aggregates. Compound grains of few components are not common. The grains are often irregular, as the result chiefly of the following causes: concave depressions at varying points on the surface, a rounded protuberance near the proximal end, a protuberance at either side of the distal end of an ovoid grain, slight shifting of the longitudinal axis of the lamellæ; or rarely to a secondary deposit of lamellæ placed at right angles to the primary set. The conspicuous forms are ovoid, ellipsoidal, nearly round, dome-shaped, ellipsoidal with squared distal end, and bean-shaped; also rounded triangular and quadrangular, lenticular, bell-jar-shaped, finger-shaped, mussel-shell-shaped, and polygonal grains.

There is usually either a small rounded cavity or a cleft at the *hilum*, but the hilum may be observed as a clear, round, or elliptical spot which may be centric, but is usually eccentric, frequently eccentric about two-fifths, rarely one-third to one-sixth, of the longitudinal axis. The clefts frequently appear diagonal to the longitudinal axis of the grain, which position is probably caused by the slight shifting of the axis of the lamellæ. Often one short transverse or diagonal cleft passes just distal to the hilum or may intersect it. When two or more clefts are found they may be so arranged as to form a cross, or a Y-shaped or flying-bird figure.

The *lamellæ* are not distinct and are less clearly demonstrable near the hilum. On the large grains one distinct and quite refractive lamella is usually found located at varying distances from the hilum. On large grains occasionally 8 to 14 rather coarse to fairly fine lamellæ may be counted, which follow the outline of the grain.

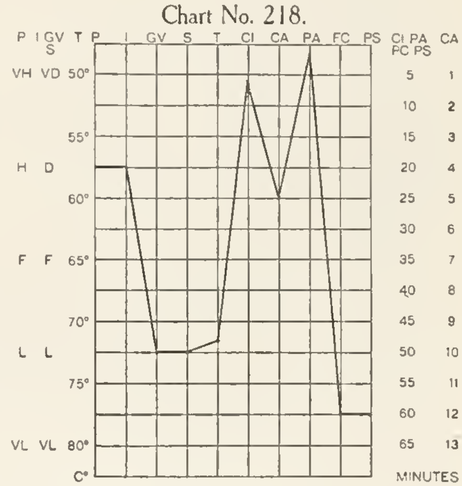
The grains vary in *size;* the smaller are 3 by 2μ; the larger elongated grains are 38 by 20μ, and the broadened forms are 32 by 40μ in length and breadth. The common size is about 24 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* may be eccentric, centric, or of the bean type. Its lines are rather broad and may intersect obliquely or at varying angles, but sometimes they are in the form of a single, elongated, mesial line with bisected ends, of the bean type; they may be straight, but are often bent.

The degree of *polarization* is high. The grains vary from high to very high, but the proportion of the latter is not great. There may also be some variation in the same aspect of a given grain.

With *selenite* the quadrants are well defined and sometimes regular in shape and equal in size, but more often they are irregular in shape and unequal in size. The colors are generally pure, but sometimes either the yellow is not pure throughout the entire quadrants, or both the blue and the yellow may have a greenish tint.

Chart No. 218.



Curve of Reaction-Intensities of Starch of Hymenocallis undulata.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather deep blue-violet, which deepens rapidly; with 0.125 per cent they color a light blue-violet which deepens rapidly. After heating the grains in water until all are gelatinized and then adding iodine, the solution colors a deep indigo-blue and the grains a light to fairly deep bright blue. If the gelatinized grains are boiled for 2 minutes and then treated with iodine, the grain-residues become a fairly deep blue, many with a reddish tint, the capsules a deep reddish violet to heliotrope and the solution a very deep blue. With an excess of iodine the grain-residues color a deep, dull blue, many with a reddish tint, and the capsules a deep heliotrope to a wine-red color.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to color slightly at once and in 30 minutes they are slightly colored.

Temperature Reaction.—The temperature of gelatinization is 70° to 72° C., mean 71°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. About one-third are gelatinized in a minute, about two-thirds in 2 minutes, nearly all in 5 minutes, and all but a few resistant grains in 7 minutes, in which latter the reaction is usually complete in 15 minutes, rarely 20 minutes. The grains immediately take on an old-rose color, which usually deepens quickly to wine-red color. The hilum or the clefts at this region swell, and a small bubble appears. Gelatinization accompanied by a deep blue coloration begins at the distal end, spreads around the margin of the grain, and then advances towards the region of the hilum, which is the last part of the grain to react. When grains have pressure facets, or sharp corners, gelatinization begins at these points and then proceeds as before stated. The gelatinized grain is uniformly swollen and deeply colored.

The reaction with *chromic acid* begins immediately. A few grains are dissolved in 30 seconds, more than half in 2 minutes, nearly all in 4 minutes, and all but the more resistant parts of a few grains in 5 minutes, which are usually dissolved in 6 minutes, rarely not until 9 minutes. The lamellæ become quite distinct and striated, the clefts at the hilum swell, and a bubble appears, which enlarges gradually and then is expelled, followed quickly by gelatinization of this area. Usually either one longitudinal branched cleft, or many delicate radial fissures, according to the shape of the grain, pass from this gelatinized area towards the sides and distal end, and the lamellæ (except the outermost ones) become soluble, accompanied by the appearance of irregularly embedded, refractive granules, which gradually pass into solution. The outermost lamellæ, which are sharply defined and striated, are comparatively resistant, but are finally dissolved. The grain continues to swell until the capsule is ruptured either at the distal end or at any sharp corners which limit this margin, and the entire grain gradually passes into solution. Grains in which the bubble at the hilum becomes greatly enlarged are invaginated either at the proximal end or the sides nearby during its expulsion, and the starch surrounding the gelatinized area is often cut into a sharp, serrated lining, with brilliant refractive points.

Reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 15 seconds, more than half in 30 seconds, nearly all in 1½ minutes, and all but rare resistant grains in 2 minutes, in which the reaction is complete in 3 minutes. The lamellæ become distinct and striated, and the clefts at the hilum swell, accompanied by the appearance of a bubble which is greatly enlarged and then expelled. As the bubble disappears, usually a proximal or lateral invagination of the grain occurs, followed by a recovery. The starch is quickly gelatinized, except the outermost lamellæ, in the greater part of which the reaction is later complete. The gelatinized grains are much swollen and distorted.

The reaction with *ferric chloride* begins in a few grains in 30 seconds. A small number are gelatinized in 2 minutes, about one-third in 5 minutes, about three-fourths in 15 minutes, about nine-tenths in 30 minutes, and all but rare resistant (one in many hundred) grains in 60 minutes. The clefts at the hilum swell, and a small bubble appears which usually does not greatly enlarge. A lustrous border is formed around the grain, in which the lamellæ are more sharply defined than in other parts of the grain. Gelatinization usually begins at the distal end or at any sharp corners, and soon spreads around the grain. The lustrous border increases in width, and when it reaches the region of the hilum the bubble collapses, followed by the breaking of the most resistant starch into usually two, sometimes more, large fragments, which gradually become gelatinized. The gelatinized grain is much swollen and distorted.

Reaction with *Purdy's solution* begins in a few grains at once. A few of the smaller grains are gelatinized in 30 seconds, about one-seventh in 5 minutes, and about three-fifths in 15 minutes; there is slight progress in 30 minutes, and about seven-tenths are gelatinized in 60 minutes. The clefts at the hilum swell, a bubble sometimes appears, and the outer lamellæ become sharply defined and striated. There appears a large mesial cleft, from which delicate fissures radiate, and gelatinization proceeds along the course of this cleft, frequently cutting the lamellæ into a sharp, serrated lining having brilliant points. In some grains this lining is gradually gelatinized, but it persists in others. Irregularly arranged, refractive granules usually appear, but are gradually gelatinized in most of the grains. The gelatinized grain is swollen, but is bounded by a firm, fairly thick wall, and retains the general shape of the untreated grain.

STARCH OF HYMENOCALLIS CALATHINA. (Plate 55, figs. 327 and 328. Chart 219.)

Histological Characteristics.—In *form* the grains are usually simple, and isolated with the exception of a small number which occur in small aggregates. There are a few compound grains of few components. Irregular grains of similar character to those noted for *H. undulata* are found, but are not so numerous nor so marked as in that species. The conspicuous forms are nearly round, ellipsoidal, ovoid, dome-shaped, ellipsoidal with squared distal end, and somewhat bean-shaped; also rounded triangular and quadrangular, lenticular, and polygonal. The forms are similar to those found in *H. undulata*, but are more rounded or broader and less irregular.

There is usually either a small, rounded cavity or a cleft at the *hilum*, but the hilum may be observed as a clear round or elliptical spot, centric or eccentric, frequently about four-ninths, rarely one-fourth, of the longitudinal axis. The clefts are similar to those noted for *H. undulata*.

The *lamellæ* are not always demonstrable, especially near the hilum, but are distinct in a greater number of grains than in *H. undulata.* When observed near the hilum they are in the form of circular or oval rings, but most of the lamellæ follow closely the outline of the grain. One quite refractive lamella is often seen at varying distances from the hilum, and sometimes there is a band of very fine, indistinct lamellæ at the margin of the grain. On the large grains frequently 16, rarely 20 to 22, lamellæ can be counted. The lamellæ are more distinct, but of the same general character as in *H. undulata.*

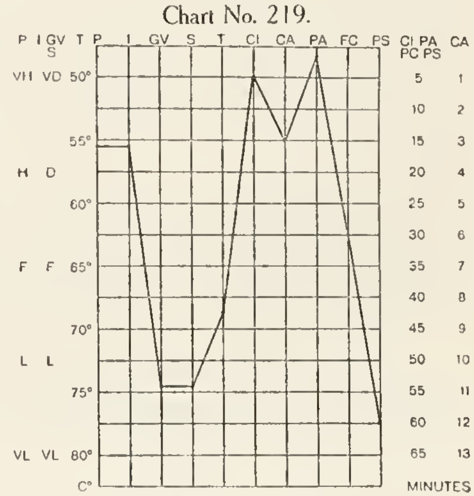
The grains vary in *size;* the smaller are 4 by 3μ; the larger, elongated ones are 36 by 38μ, and the broadened forms are 36 by 44μ in length and breadth. The common size is about 24 by 22μ in length and breadth.

Polariscopic Properties.—The *figure* is centric, eccentric, or of the bean type; more often centric or nearly centric than in *H. undulata;* and while the lines are of similar character and arrangement with those of that species they are more often straight.

The degree of *polarization* is high, rather higher than in *H. undulata.* The same variation is found among the different grains, but the proportion in which the polarization is very high is greater than in *H. undulata.* There is less variation in the same aspect of a given grain than in *H. undulata.*

With *selenite* the quadrants are well defined, and many are regular in shape and equal in size. The number of grains in which they are regular is greater than in *H. undulata.* The colors are generally pure, but sometimes have a greenish tinge, or the margin of the yellow quadrant may be orange in tint. The colors are more often pure than in *H. undulata.*

Chart No. 219.



Curve of Reaction-Intensities of Starch of Hymenocallis calathina.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather deep blue-violet, which deepens rapidly, the tint being a little deeper and bluer than in *H. undulata.* With 0.125 per cent solution they become a light blue-violet, about the same as in *H. undulata,* which deepens rapidly. After heating in water until all the grains are gelatinized and then adding iodine, the solution becomes of a deep indigo-blue color and the grains of a light reddish violet to a dull, fairly deep blue, many with a reddish tint. The grains are deeper, redder, and duller in tint than in *H. undulata.* If the gelatinized grains are boiled for 2 minutes and then treated with iodine, the solution colors very deeply and the grain-residues a light to fairly deep blue, some with reddish tint, lighter than those of *H. undulata,* and the capsules a light reddish violet. With an excess of iodine the grain-residues color a dull, fairly deep blue with a reddish tint and the capsules a deep old-rose to a wine-red. The tint is slightly lighter but rather redder than in *H. undulata.*

Staining Reactions.—With *gentian violet* the grains begin to color slightly at once and in 30 minutes are lightly stained—slightly lighter than in *H. undulata.*

With *safranin* the grains begin to color at once and in 30 minutes are lightly colored—slightly lighter than in *H. undulata.*

Temperature Reaction.—The temperature of gelatinization is 68° to 69° C., mean 68.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in 30 seconds, about two-fifths in a minute, about four-fifths in 2 minutes, nearly all in 3 minutes, and all but rare resistant grains in 5 minutes. In the latter the reaction is usually complete in 14 minutes, rarely not until 17 minutes; it is qualitatively the same as in *H. undulata.*

Reaction with *chromic acid* begins immediately. A few grains are dissolved in 30 seconds, more than half in a minute, nearly all in 1½ minutes, all but rare resistant grains in 2 minutes, and all in 3 minutes. The reaction is qualitatively the same as in *H. undulata.*

The reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 15 seconds, more than half in 30 seconds, nearly all in a minute, and all but rare resistant grains in 1½ minutes. In the latter the reaction is usually complete in 2 minutes, rarely 2½ minutes; it is qualitatively the same as in *H. undulata.*

Reaction with *ferric chloride* begins in a few grains in 30 seconds. A small number are gelatinized in 2 minutes, about two-fifths in 5 minutes, about four-fifths in 15 minutes, and all but rare resistant grains in 30 minutes; the latter (one in many hundred) are ungelatinized in 60 minutes. The reaction is qualitatively the same as in *H. undulata.*

The reaction with *Purdy's solution* begins in a few grains immediately. A small number are gelatinized in 30 seconds, about one-fourth in 5 minutes, and about three-fifths in 15 minutes. There is slight progress in 30 minutes, and about four-fifths are gelatinized in 60 minutes. The reaction is qualitatively the same as in *H. undulata.*

Differentiation of Certain Starches of the Genus Hymenocallis.

HISTOLOGICAL CHARACTERSITICS.

Conspicuous Forms.

H. undulata: Usually simple, few compounds and aggregates, often irregular in outline. Ovoid, ellipsoidal, nearly round, dome-shaped, ellipsoidal with squared distal end, and bean-shaped.
H. calathina: Essentially the same as in *H. undulata,* except less irregular, more rounded, and broader.

Hilum—Form, Number, and Position.

H. undulata: Form usually a small rounded cavity or cleft at hilum; hilum may appear as a clear, round or elliptical spot. Position centric or eccentric; eccentric frequently about 0.40, rarely 0.33 to 0.16 of the longitudinal axis.
H. calathina: Form the same as in *H. undulata.* Position centric or eccentric; eccentric frequently about 0.44, rarely 0.25, of the longitudinal axis.

Lamellæ—General Characteristics and Number.

H. undulata: Not distinct, coarse to fairly fine. 8 to 14.
H. calathina: Less indistinct than in *H. undulata.* 20 to 22.

Size.

H. undulata: From 3 to 40μ, commonly 24 by 16μ.
H. calathina: From 4 to 44μ, commonly 24 by 22μ.

POLARISCOPIC PROPERTIES.

Figure.

H. undulata: Centric, eccentric, or bean type; lines rather broad, straight, bent, or bisected.
H. calathina: The same as in *H. undulata,* but more often straight.

Degree of Polarization.

H. undulata: High, varies from high to very high.
H. calathina: High, varies from high to very high, rather higher than in *H. undulata.*

Polarization with Selenite—Quadrants and Colors.

H. undulata: Quadrants well defined, usually irregular in shape and unequal in size. Colors generally pure.
H. calathina: Quadrants the same as in *H. undulata,* but more grains with quadrants of regular shape. Colors generally pure, more often pure than in *H. undulata.*

IODINE REACTIONS.

Intensity and Color.

H. undulata: Deep; blue-violet.
H. calathina: Deep, little deeper than in *H. undulata;* blue-violet, more blue than in *H. undulata.*

STAINING REACTIONS.

With Gentian Violet.

H. undulata: Light.
H. calathina: Light, lighter than in *H. undulata.*

With Safranin.

H. undulata: Light.
H. calathina: Light, lighter than in *H. undulata.*

TEMPERATURE OF GELATINIZATION.

H. undulata: 70 to 72° C., mean 71°.
H. calathina: 68 to 69° C., mean 68.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

H. undulata: Begins immediately; complete in practically all in 7 minutes.
H. calathina: Begins immediately; complete in practically all in 5 minutes.

Reaction with Chromic Acid.

H. undulata: Begins immediately; complete in practically all in 5 minutes.
H. calathina: Begins immediately; complete in all in 3 minutes.

Reaction with Pyrogallic Acid.

H. undulata: Begins immediately; complete in practically all in 2 minutes.
H. calathina: Begins immediately; complete in practically all in 1½ minutes.

Reaction with Ferric Chloride.

H. undulata: Begins in a few in 30 seconds; complete in nine-tenths in 30 minutes, and in practically all in 60 minutes.
H. calathina: Begins in a few in 30 seconds; complete in practically all in 30 minutes.

Reaction with Purdy's Solution.

H. undulata: Begins in a few at once; complete in seven-tenths in 60 minutes.
H. calathina: Begins in a few at once; complete in eight-tenths in 60 minutes.

NOTES ON THE STARCHES OF HYMENOCALLIS.

The two starches differ but little in their histological characters, the grains of *H. undulata* being somewhat more irregular and not so rounded and broad, the hilum less eccentric, and the lamellæ more distinct. In the reaction intensities the records are very close, the most noticeable difference being in the temperature of gelatinization, amounting to 2.5°. *H. undulata* exhibits the lower degree of polarization, the lower iodine reaction, the higher aniline reactions, the higher temperature of gelatinization, and the less sensitivity to all the chemical reagents.

GENUS LEUCOIUM.

Leucoium, or *Leucojum*, includes 8 species of bulbous plants, natives of Central and Southern Europe and the region of the Mediterranean, and popularly known as the snowflake. Starches from 2 species were examined: *L. æstivum* Linn., the summer snowflake, and *L. vernum*, the spring snowflake.

STARCH OF LEUCOIUM ÆSTIVUM. (Plate 55, figs. 329 and 330. Chart 220.)

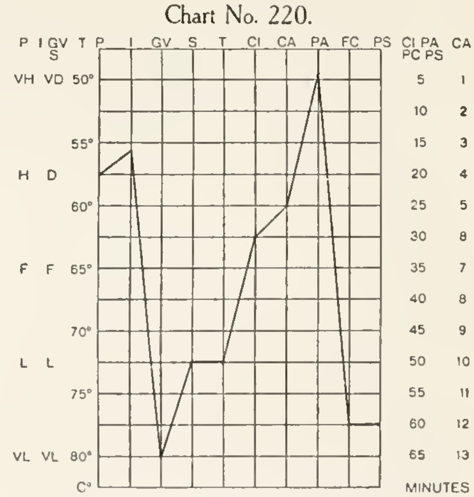
Histological Characteristics.—In *form* the grains are almost wholly simple and are isolated, except a small number which occur in small aggregates and in clumps of small grains. Both the compound grains and the aggregates often consist of linearly arranged, rather small components which number 2 to 6, rarely as many as 13. Pressure facets are occasionally found on the isolated grains. The grains, as a rule, are somewhat irregular, irregularities being due chiefly to an abrupt depression at one side of the proximal end, so that the contours of the two sides are different; to a protuberance at or near the proximal end; or to slightly concave depressions (probably in some instances a point of attachment for small grains) at varying points on the surface of a large grain. The conspicuous forms are the irregular ovoid, nearly round, oval, elliptical, bean-shaped, mussel-shell-shaped to clam-shell-shaped, pyriform, and lenticular. The grains are usually flattened, and when seen on edge are narrower at the distal than at the proximal end.

The *hilum* is eccentric about one-third to one-fourth of the longitudinal axis. It may appear as a clear round or lenticular spot, but usually it is fissured. In the broadened grains the clefts are generally so arranged as to form a Y, T, or cross, or thorn-shaped figure. The clefts are deep, and frequently ragged.

The *lamellæ* are not very distinct, except one that is very refractive and located at varying distances from the hilum. They are less clearly demonstrable around the hilum and also sometimes near the distal end, and in grains with an unfissured hilum they may be observed directly around the hilum, as fine circular rings, but a short distance out they follow the outline of the grain. On the medium-sized and large grains 24 can often be counted, rarely 30 to 36.

The grains vary in *size;* the small ones are 3 by 2μ; the large, broadened forms are 44 by 50μ, and the elongated forms are 60 by 56μ in length and breadth. The common size is about 30 by 38μ in length and breadth.

Chart No. 220.



Curve of Reaction-Intensities of Starch of Leucoium æstivum.

Polariscopic Properties.—The *figure* is usually eccentric and fairly distinct. Its lines are rather broad and intersect obliquely; they may be straight, but are frequently bent or bisected. Double and multiple figures, both of the compound and aggregate type, are found.

The degree of polarization is high, ranging from fair to very high. Variation is frequent in the same aspect of a given grain.

With *selenite* the quadrants are fairly clear-cut, usually irregular in shape, and unequal in size. The blue is generally pure, the yellow not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather deep violet with a reddish tint, some deeper than others, the color deepening rapidly; with 0.125 per cent solution the grains are colored a rather light violet with a reddish tint, the color deepening rapidly. After heating the grains in water until they are completely gelatinized and then adding iodine, the solution colors a deep indigo-blue and the grains a rather light bright blue, some darker than others. If the grains are then boiled for 2 minutes and treated with iodine, the solution colors a very deep blue and the grain-residues a light to fairly deep blue, while the capsules take on a violet color. With an excess of iodine the grain-residues color a deeper blue, many with a reddish tint, and the capsules become a deep heliotrope to a dull wine-red color.

Staining Reactions.—With *gentian violet* the grains begin immediately to stain very slightly and in 30 minutes are very lightly colored.

With *safranin* the grains begin to stain slightly at once and in 30 minutes are lightly colored.

Temperature Reaction.—The temperature of gelatinization is 72° to 73° C., mean 72.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins immediately. Many of the smaller and a few larger grains are gelatinized in 2 minutes, about half in 5 minutes, five-eighths in 15 minutes, and nearly all in 30 minutes. Rare resistant grains may react for over 60 minutes. The grains immediately color a light reddish-violet which deepens to an old-rose. The hilum and clefts become very distinct, swell, and darken in color, while a bubble frequently appears in the hilum or clefts. Gelatinization accompanied by a deep bluish tint begins at the distal end, or sometimes in the broadly triangular grains, at the corners limiting the distal margin. The process spreads around the entire margin and then gradually advances toward the hilum and clefts from which the bubbles are expelled, and the entire grain becomes a deep blue with a lighter area at the hilum. The most resistant grains retain the bubble at the hilum for many minutes and take on a deep wine-red color, and finally when gelatinized they have a deep reddish-purple instead of the usually bluish color. The gelatinized grain is uniformly swollen and thus retains the general shape of the untreated grain.

Reaction with *chromic acid* begins immediately. A few grains are dissolved in a minute and nearly all in 5 minutes. The more resistant grains usually pass into solution in 8 minutes, but rarely the reaction takes 10 minutes. The hilum and the clefts swell, and frequently small bubbles are gradually given off from these parts, leaving a clear space with ragged, refractive edges retaining the general shape of the cavity or clefts. Gelatinization rapidly follows, and a mass of irregularly arranged, refractive granules appears embedded in the more soluble starch, and bordered by the more resistant outer lamellæ, which retain their regular outline. These lamellæ are sharply defined and striated, and as they become disorganized, refractive granules appear in linear arrangement. The granules become gelatinized, the grain continues to swell, and finally the capsule breaks either at one point of the distal end or at the corners limiting the distal margin. The extruded contents of the capsule and remainder of the capsule then dissolve.

The reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 30 seconds, nearly all in 3 minutes, all but rare resistant grains in 4 minutes, and all in 5½ minutes. The hilum and clefts swell and a bubble, which greatly enlarges, usually appears here. In some grains previous to general gelatinization small bubbles are given off successively as the cleft gradually lessens in width, while in other grains a large bubble is expelled which moves to the distal end, where it remains for a while, and when it collapses there is frequently an invagination at the proximal end accompanied by rapid outward movement and gelatinization of the area. The outer, more resistant lamellæ are sharply defined and striated, and either numerous delicate fissures pass from the gelatinized area towards the distal end of the grain, or the large internal clefts extend through the grain. The grain gradually enlarges, accompanied by the appearance of irregularly arranged, refractive granules, which remain for a time embedded in the more soluble starch, but later are usually gelatinized. The gelatinized grains are much swollen and distorted.

Reaction with *ferric chloride* begins in a few grains in a minute. A small number are gelatinized in 5 minutes, about one-fourth in 15 minutes, three-fourths in 30 minutes, and six-sevenths in 60 minutes. The hilum and the clefts become very distinct and a bubble appears which expands, and in the most resistant grains remains for several minutes; and as gelatinization occurs the bubble finally disappears either by the sudden collapsing of the entire bubble or by the expulsion of a succession of small bubbles. A border forms around the grain which consists of sharply defined and striated lamellæ. Gelatinization begins at the distal end, accompanied by rapid distention of the capsule, and proceeds gradually towards the proximal end. When at least two-thirds of the grain is gelatinized, the more resistant starch around the hilum breaks into large granules which fly apart and gelatinize. In large grains with sharp corners limiting the distal end, the border becomes broader at these points and gelatinization begins here and proceeds towards the center. The gelatinized grain is much swollen and distorted.

Reaction with *Purdy's solution* begins in a few grains in 30 seconds. A small number are gelatinized in 5 minutes, but in 60 minutes there is little further progress, only a few scattered grains having been gelatinized. The hilum and clefts become swollen and very distinct, and the lamellæ are more sharply defined and striated. The reaction in most of the grains does not proceed beyond this point. In a few grains delicate radiating fissures pass from the hilum, or delicate branches pass from the clefts, and the starch around these parts is gradually gelatinized. During the process a mass of small, refractive granules appear embedded in the more soluble starch, and the latter is often bordered by a layer of regularly arranged granules and four or five ungelatinized lamellæ. Most of these granules soon become gelatinized, but frequently a few are found when examined even after an hour. In some of the grains delicate fissures do not form at the region of the hilum, but the clefts deepen and break the starch into a few large granules which gradually gelatinize. The gelatinized grains are somewhat swollen, but retain the general shape of the untreated grain.

STARCH OF LEUCOIUM VERNUM. (Plate 56, figs. 331 and 332. Chart 221.)

Histological Characteristics.—In *form* the grains are almost wholly simple and are isolated, except a few which occur in small aggregates and clumps. Pressure facets are occasionally observed. There are a few compound grains. The general characteristics of the forms of the grains are the same as those found in *L. æstivum.*

The *hilum* is usually eccentric about one-third to one-fourth of the longitudinal axis. It may be observed as a clear round or lenticular spot, but generally it is fissured. The arrangement and character of the clefts is the same as that noted for *L. æstivum.*

The *lamellæ* are not distinct, except one that is very refractive and located at varying distance from the hilum. They are not usually demonstrable near the hilum and also frequently at the distal end. In many of the medium-sized grains 28 lamellæ can be counted. The lamellæ are of the same character and shape as those noted for *L. æstivum,* but on the whole less indistinct.

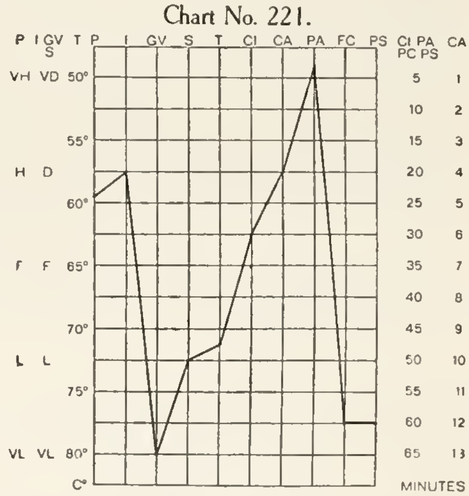
The grains vary in *size;* the smaller are 4 by 2μ; the larger, broadened forms are 46 by 50μ, and the elongated are 60 by 46μ in length and breadth. The grains of common size are about 30 by 36μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric. Its lines are of the same character and arrangement as in *L. æstivum.* Double and multiple figures, the same as those of *L. æstivum,* are observed.

The degree of *polarization* is high, but slightly lower than in *L. æstivum.* It ranges from fair to very high. The variation in the same aspect of a grain is the same as in *L. æstivum.*

With *selenite* the character of the quadrants and the colors are the same as in *L. æstivum.*

Chart No. 221.



Curve of Reaction-Intensities of Starch of Leucoium vernum.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather deep violet with a reddish tint, the colors deepening rather rapidly. The tint is slightly redder, and slightly less, and it does not deepen quite so rapidly as in *L. æstivum.* With 0.125 per cent solution they color a rather light violet, slightly deeper than in *L. æstivum.* After heating the grains in water until all are completely gelatinized and then adding iodine, the solution becomes a deep indigo-blue and the grains a fairly deep blue. If the grains are boiled for 2 minutes and then treated with iodine, the solution colors a very deep blue, and the grain-residues generally a light blue, on the whole lighter than in *L. æstivum.* The capsules are colored a light reddish-violet. With an excess of iodine the capsules become old-rose to wine-red. The tint is slightly redder and brighter than in *L. æstivum.*

Staining Reactions.—With *gentian violet* the grains color very slightly at once and in 30 minutes are very lightly colored. The tint is about the same as in *L. æstivum.*

With *safranin* the grains begin to stain slightly at once and in 30 minutes are lightly colored. The tint is about the same as in *L. æstivum.*

Temperature Reaction.—The temperature of gelatinization is 71° to 72° C., mean 71.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. Many of the smaller grains and a few of the larger are gelatinized in 2 minutes, about three-fifths in 5 minutes, four-fifths in 15 minutes, and nearly all in 30 minutes. Rare resistant grains may last 60 minutes. The reaction is qualitatively the same as in *L. æstivum.*

Reaction with *chromic acid* begins immediately. A few grains are dissolved in a minute and nearly all in 4 minutes. The most resistant grains are usually dissolved in from 7 to 9 minutes. The reaction is qualitatively the same as in *L. æstivum.*

With *pyrogallic acid* the reaction begins immediately. A few grains are gelatinized in 30 seconds, nearly all in 3 minutes, all but rare resistant grains in 4 minutes, and all in 5 minutes. The reaction is qualitatively the same as in *L. æstivum.*

Reaction with *ferric chloride* begins in a few grains in a minute. A small number are gelatinized in 5 minutes, about one-third in 15 minutes, three-fifths in 30 minutes, and four-fifths in 60 minutes. The reaction is qualitatively the same as in *L. æstivum.*

The reaction with *Purdy's solution* begins in a few grains in 30 seconds. A small number are gelatinized in 5 minutes, with very slight progress occurring in 60 minutes. About one-twelfth are gelatinized in this time, the proportion being larger than in *L. æstivum.* The reaction is qualitatively the same as in *L. æstivum.*

Differentiation of Certain Starches of the Genus Leucoium.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

L. æstivum: Usually simple, few aggregates and compounds, few pressure facets; somewhat irregular. Irregular ovoid, nearly round, oval, elliptical, bean-shaped, mussel-shell-shaped and clam-shell-shaped, pyriform, and lenticular. Flattened when seen on edge, narrower at distal than at proximal end.
L. vernum: Essentially the same as in *L. æstivum.*

Hilum—Form, Number, and Position.

L. æstivum: Form clear, round or lenticular spot, usually fissured, clefts deep and frequently ragged. Position about 0.33 to 0.25 eccentric of longitudinal axis.
L. vernum: Form essentially the same as in *L. æstivum.* Position the same as in *L. æstivum.*

Lamellæ—General Characteristics and Number.

L. æstivum: Not distinct, usually one very distinct; fine circles around hilum, but farther out follow the contour of grain. 24.
L. vernum: Essentially the same as in *L. æstivum,* but rather less indistinct, as a whole. 28.

Size.

L. æstivum: From 2 to 60μ, commonly 30 by 38μ.
L. vernum: From 2 to 60μ, commonly 30 by 36μ.

POLARISCOPIC PROPERTIES.

Figure.

L. æstivum: Usually eccentric, fairly distinct, lines broad and intersect obliquely, may be bent or bisected.
L. vernum: The same as in *L. æstivum.*

Degree of Polarization.

L. æstivum: High, range from fair to very high.
L. vernum: High, ranges from fair to very high, slightly lower than in *L. æstivum.*

Polarization with Selenite—Quadrants and Colors.

L. æstivum: Quadrants fairly clear-cut, usually irregular in shape, unequal in size. Colors, blue pure, yellow not quite pure.
L. vernum: Quadrants the same as in *L. æstivum.* Colors the same as in *L. æstivum.*

IODINE REACTIONS.

Intensity and Color.

L. æstivum: Rather deep; violet with reddish tint.
L. vernum: Rather deep, slightly less than in *L. æstivum.* Color slightly redder than in *L. æstivum.*

STAINING REACTIONS.

With Gentian Violet.

L. æstivum: Very light.
L. vernum: Very light, the same as in *L. æstivum.*

With Safranin.

L. æstivum: Light.
L. vernum: Light, the same as in *L. æstivum.*

TEMPERATURE OF GELATINIZATION.

L æstivum: 72 to 73° C., mean 72.5°.
L. vernum: 71 to 72° C., mean 71.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

L. æstivum: Begins immediately; complete in five-eighths in 15 minutes and in nearly all in 30 minutes.
L. vernum: Begins immediately; complete in three-fifths in 15 minutes, and in nearly all in 30 minutes.

Reaction with Chromic Acid.

L. æstivum: Begins immediately; complete in nearly all in 5 minutes.
L. vernum: Begins immediately; complete in nearly all in 4 minutes.

Reaction with Pyrogallic Acid.

L. æstivum: Begins immediately; complete in nearly all in 4 minutes.
L. vernum: Begins immediately; complete in nearly all in 3 minutes.

Reaction with Ferric Chloride.

L. æstivum: Begins in a few in a minute; complete in three-fourths in 30 minutes and in six-sevenths in 60 minutes.
L. vernum: Begins in a few in a minute; complete in three-fifths in 30 minutes and in four-fifths in 60 minutes.

Reaction with Purdy's Solution.

L. æstivum: Begins in a few in 30 seconds; little reaction in 60 minutes.
L. vernum: Begins in a few in 30 seconds; little reaction in 60 minutes.

NOTES ON THE STARCHES OF LEUCOIUM.

The *Leucoium* starches are closely alike, and apart from the slight variations in the distinctness and number of the lamellæ no differences of note were recorded. They also agree closely in their reactions. *L. æstivum* has the higher degree of polarization, the higher reaction with iodine, the higher temperature of gelatinization (1° difference), and somewhat less sensitivity to chromic acid and pyrogallic acid. The differences throughout are slight, which is in accord with the closeness of the species botanically.

GENUS GALANTHUS.

Galanthus is a small genus of about a dozen species, all natives of Central and Southern Europe and the Caucasus, and popularly referred to as the snowdrops. Two species representing the main species-types of the genus were studied: *G. nivalis* Linn., the common snowdrop, and *G. elwesii,* Hook., the giant snowdrop. The former is found from the Pyrenees to the Caucasus, and the latter in the mountains of Asia Minor.

STARCH OF GALANTHUS NIVALIS. (Plate 56, figs. 333 and 334. Chart 222.)

Histological Characteristics.—In *form* the grains are usually simple, with occasional compounds and small aggregates. Poorly defined pressure facets may sometimes be seen on the isolated grains. The smaller grains often occur in clumps. The surface sometimes has irregular projections, blunt to nipple-like, and also depressions. The conspicuous forms are spherical, ovoid (which may vary from short to ellipsoidal), triangular, lenticular, oval, quadrangular with much rounded corners, some clam-shell type, and some irregular forms. The grains are about one-half to two-thirds as thick as broad and tend to be somewhat triangular to wedge-shaped when seen on edge, the distal end being narrower than the proximal end.

The *hilum* is distinct, and eccentric from one-fifth to two-thirds of the longitudinal axis. When not fissured it is usually a comparatively small round spot or hole; rarely it is elongated or lenticular. It may be double or rarely triple. It is usually fissured. The fissuration may be in the form of a cleft that is neither deep nor wide, transverse or diagonal with a double downward curve, 3-armed, irregularly stellate, clean-cut or ragged. Sometimes there is a fissure at the hilum and another towards the distal end.

The *lamellæ* are very distinct, rather fine, continuous rings; they may be irregular and not always follow the outline of the margin; they are more distinct near the hilum, especially one lamella; they vary in distinctness in different grains. If there are double hila, each has usually its own set, which as they become more distally located fuse with the lamellæ of other hila. There are about 20 to 26 lamellæ on the larger grains.

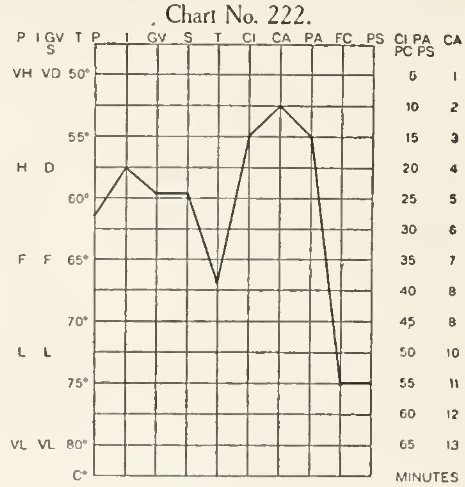
The grains vary in *size* from 7 to 46μ. The common size is 34μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, fairly regular, and fairly clear-cut. Its lines are always broad, and may become less distinctly outlined near the margin; also slightly bent and otherwise distorted. Double figures are sometimes observed.

The degree of *polarization* is fairly high. It sometimes is less at the distal end than at the proximal end, and it is higher in certain positions of the same grain. It varies somewhat in different grains.

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and usually of unequal size. The colors are fairly pure.

Chart No. 222.



Curve of Reaction-Intensities of Starch of Galanthus nivalis.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored immediately a deep blue-violet, some more than others; with 0.125 per cent solution they tint fairly lightly, some more than others, and the color deepens rapidly. After heating in water until the grains are completely gelatinized, the solution is colored lightly and the grains to variable depths on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply, but the grain-residues much less. All of the capsules contain some blue-reacting starch, and with an excess of iodine all show a blue-violet coloration.

Staining Reactions.—With *gentian violet* the grains stain at once fairly well and in 30 minutes some are stained fairly deeply to deep.

With *safranin* the grains stain at once very lightly and after 30 minutes some are colored fairly deep to deep. The depth of color is about the same as that of the gentian violet.

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 66.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains begin to react immediately. About three-fourths are gelatinized in 5 minutes, and gelatinization is complete in practically all in 15 minutes. Very rare resistant grains may not be gelatinized until the lapse of 45 minutes. The hilum is prominent and the lamellæ are not obscured. The margin becomes clearer and darker. The more prominent projections and the distal end begin to darken and swell, the swelling being smooth and regular; in some grains the reaction begins at both ends. From whatever point it starts the reaction spreads over the whole grain, progressing usually around the margin much faster than on the inner parts, so that often there will be a swollen, somewhat irregular, gelatinous ring surrounding an ungelatinized central portion. The line of demarcation between the gelatinized and the ungelatinized parts of the grains is very well marked. The whole grain is finally involved. The swelling during this process is considerable and somewhat irregular. The gelatinized grains are fairly large, of a uniform dark color, and somewhat irregular in outline.

The reaction with *chromic acid* begins in 20 seconds and is over in 2 minutes. Both hilum and lamellæ are distinct. The hilum swells somewhat and fine striæ appear throughout the grain. The whole inner part is changed and swells into a gelatinous mass which has a thin capsule that becomes thinner and more transparent and finally dissolves at one place. The inner gelatinous mass flows out and is dissolved, followed by solution of the capsule.

Reaction with *pyrogallic acid* begins in 2 minutes. In 6 minutes most and in 45 minutes all of the grains are gelatinized. Both hilum and lamellæ are prominent, and the hilum swells somewhat. The grain becomes covered by fine striæ, which are especially distinct near the hilum. The inner portion of the grain is often broken up into large granules, which are transformed into a gelatinous mass as the grain swells. The marginal ring is thin and striated, and shows concentric, refractive and non-refractive bands. It is ragged and irregular on the inside. This ring gradually becomes thin and transparent as the grains swells. The swollen grains are large, crumpled, and wrinkled. The process is very slow at first, but very rapid when once fairly started.

With *ferric chloride* there is a reaction in some grains in 2 minutes; about four-fifths are gelatinized in 20 minutes and all in an hour. The hilum may or may not be distinct. The lamellæ are not entirely obscured. The hilum swells. The inner portion of the grain usually is changed into a gelatinous mass, while the marginal ring becomes thin. Sometimes the process begins at the margin at the distal end, or at the proximal end, or at both ends, with much protrusion. The process extends over the grain until it reaches the inner portion contiguous to the hilum; this part is split by many irregular fissures. The pieces suddenly part and are gelatinized independently. The gelatinized grains are very large, very much distorted, and sacculated.

The reaction with *Purdy's solution* begins in 30 seconds. Some grains react rapidly, others slowly, but all are partially gelatinized; many are entirely gelatinized in 25 minutes. The reaction is complete in three-fourths in an hour; qualitatively it is the same as that with pyrogallic acid.

STARCH OF GALANTHUS ELWESII. (Plate 56, figs. 335 and 336. Chart 223.)

Histological Characteristics.—In *form* the grains are usually simple. Occasionally they are compound and in aggregates, generally of two equal-sized components. The surface oftens tends to be irregular because of projections and depressions of varying sizes. The conspicuous forms are ovoid, spherical, lenticular, elliptical, and clam-shell-shaped. The last show two slight depressions in the margin at the proximal end on either side of a central projection which is variable in size. There are also triangular, pyriform, and irregular shapes. The grains are somewhat flattened, and triangular to wedge-shaped when seen on edge, the distal end being thinner than the proximal end. As a rule, they are about one-half to two-thirds as thick as broad.

The *hilum* is commonly quite distinct. If not fissured, it is a large, round spot or hole, eccentric usually one-third to two-fifths of the longitudinal axis and in or near the median line. Triple or multiple hila may be present, irregularly arranged, often in a non-lamellated space. The hilum is usually fissured, and the fissuration may be in the form of a deep or very superficial cleft, simple, clean-cut or ragged, transverse or diagonal, a cross or 3-armed; or of an irregularly stellate form. The fissuration is more marked than in *G. nivalis*.

The *lamellæ* are fairly distinct, fine, continuous rings, regular or irregular, more distinct near the hilum, usually one especially distinct which outlines or limits the length of the fissure of the hilum. When two or more hila exist, each has a number of separate lamellæ which become fused with lamellæ of other hila. There are about 18 to 20 lamellæ on the large grains.

The grains vary in *size* from 12 to 44μ. The common size is 28μ.

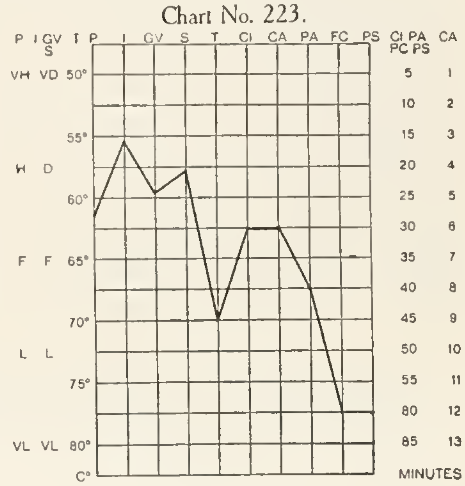
Polariscopic Properties.—The *figure* is eccentric, distinct, but not always clear-cut. Its lines are broad, usually broader and less distinctly defined as they near the margin; they are frequently bent and otherwise distorted.

The degree of *polarization* is fairly high. It is lower at the distal end of some grains than at the proximal end, and varies much in different grains. Large portions of a grain may be dark. It is the same as that of the grains of *G. nivalis*, but the lines and the dark areas are more pronounced.

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored at once a deep blue-violet, some more than others; with 0.125 per cent solution the grains color fairly lightly, some more than others, and the color deepens rapidly. It is slightly deeper than that of the grains of *G. nivalis*. After heating in water until all the grains are completely gelatinized, the solution is colored lightly and the grains usually very deeply on the addition of iodine. Some grains, which do not stain so deeply as others, show a violet capsule upon the addition of an excess of iodine. After boiling for 2 minutes the solution is colored much more deeply, but the grain-residues much less or not at all. With an excess of iodine the capsules become violet or reddish-violet.

Chart No. 223.



Curve of Reaction-Intensities of Starch of Galanthus elwesii.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after 30 minutes are colored fairly deep to deep. The color is the same as that of the grains of *G. nivalis*.

With *safranin* the grains begin to stain immediately very lightly and after 30 minutes are colored fairly deep to deep. The color is slightly deeper that that of the grains of *G. nivalis*.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. About half are gelatinized in 5 minutes and gelatinization is complete in all except very rare resistant grains in 30 minutes. The latter may not be fully gelatinized until 60 minutes. The reaction is qualitatively the same as that of the grains of *G. nivalis*.

The reaction with *chromic acid* begins in 20 seconds and is over in 6 minutes. The reaction is qualitatively the same as that of the grains of *G. nivalis*.

Reaction with *pyrogallic acid* begins in some grains in 3½ minutes and is general in 7 minutes. About one-fourth are gelatinized in 25 minutes, and two-thirds are fully and one-third partially gelatinized after 45 minutes. The reaction is qualitatively the same as that of the grains of *G. nivalis*.

With *ferric chloride* some of the grains begin to react in 1¼ minutes; about one-third are affected in 7 minutes, half are gelatinized in 15 minutes, and all except a few are completely gelatinized in an hour and 20 minutes. The reaction is qualitatively the same as that of the grains of *G. nivalis*.

With *Purdy's solution* some of the grains react in 30 seconds, and all are affected and one-fourth fully gelatinized in 30 minutes. About half are gelatinized in an hour and about three-fourths are fully gelatinized in 1½ hours. There is little further change. The reaction is qualitatively the same as that of the grains of *G. nivalis*.

Differentiation of Certain Starches of the Genus Galanthus.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

G. nivalis: Usually simple, occasional compounds and aggregates, some poorly defined pressure facets, surface sometimes irregular owing to unequal development. Spherical, ovoid, ellipsoidal, triangular, lenticular, quadrangular.
G. elwesii: Essentially the same as in *G. nivalis.*

Hilum—Form, Number, and Position.

G. nivalis: Form distinct, usually single, small, round, rarely elongated, may be double. Usually fissured, fissures usually neither deep nor very wide, single or 2 or more. Position eccentric 0.20 to 0.40 of longitudinal axis.
G. elwesii: Form essentially the same as in *G. nivalis;* fissuration more marked. Position eccentric 0.33 to 0.40 of longitudinal axis.

Lamellæ—General Characteristics and Number.

G. nivalis: Very distinct, rather fine, continuous, may be irregular. 20 to 26 on larger grains.
G. elwesii: Fairly distinct, fine, continuous, may be irregular. 18 to 20 on larger grains.

Size.

G. nivalis: From 7 to 46μ, commonly 34μ.
G. elwesii: From 12 to 44μ, commonly 28μ.

POLARISCOPIC PROPERTIES.

Figure.

G. nivalis: Eccentric, distinct, fairly clear-cut, lines broad, may be slightly bent and otherwise distorted, fairly regular.
G. elwesii: The same as in *G. nivalis*, except lines broader and dark areas more pronounced.

Degree of Polarization.

G. nivalis: Fairly high.
G. elwesii: Fairly high, same as in *G. nivalis*, but dark areas more pronounced.

Polarization with Selenite—Quadrants and Colors.

G. nivalis: Quadrants fairly well defined, fairly regular in form, unequal in size. Colors fairly pure.
G. elwesii: Quadrants the same as in *G. nivalis.* Colors fairly pure.

IODINE REACTIONS.

Intensity and Colors.

G. nivalis: Deep; blue-violet.
G. elwesii: Deep; slightly deeper than in *G. nivalis;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

G. nivalis: Fairly deep to deep.
G. elwesii: Fairly deep to deep, the same as in *G. nivalis.*

With Safranin.

G. nivalis: Fairly deep to deep.
G. elwesii: Fairly deep to deep, slightly deeper than in *G. nivalis.*

TEMPERATURE OF GELATINIZATION.

G. nivalis: 66 to 67° C., mean 66.5°.
G. elwesii: 69 to 71° C., mean 70°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

G. nivalis: Begins immediately; complete in practically all in 15 minutes.
G. elwesii: Begins immediately; complete in practically all in 30 minutes.

Reaction with Chromic Acid.

G. nivalis: Begins in all in 20 seconds; complete in 2 minutes.
G. elwesii: Begins in all in 20 seconds; complete in 6 minutes.

Reaction with Pyrogallic Acid.

G. nivalis: Begins in 2 minutes; complete in 45 minutes.
G. elwesii: Begins in 3½ minutes; complete in two-thirds and partial in one-third in 45 minutes.

Reaction with Ferric Chloride.

G. nivalis: Begins in some in 2 minutes; complete in 60 minutes.
G. elwesii: Begins in some in 1½ minutes; complete in 80 minutes.

Reaction with Purdy's Solution.

G. nivalis: Begins in some in 30 seconds; complete in three-fourths in 1 hour.
G. elwesii: Begins in some in 30 seconds; complete in three-fourths in 1½ hours.

NOTES ON THE STARCHES OF GALANTHUS.

The grains of *G. nivalis* are less deeply fissured, somewhat larger, and the lamellæ more distinct than in those of *G. elwesii*, otherwise the starches are essentially the same in their gross histological characters. In their reactions they are close, but differ sufficiently to make possible the differentiation of one from the other. The most noticeable differences are noted in the temperature of gelatinization (difference 3.5°), and in the chemical reactions. They are essentially the same in the degree of polarization and in the reaction with gentian violet, but *G. nivalis* has the less reaction with iodine and safranin, and the higher sensitivity in relation to all of the chemical reagents.

GENUS ALSTRŒMERIA.

This genus of tuberous-rooted plants is composed of natives of South America, some of which have a special commercial importance because of their tubers yielding the Talcahuano arrowroot (see *Maranta*). Starches from three sources were studied: *A. ligtu* Linn., a native of Chile; *A. brasiliensis* Spreng., a native of Brazil; *A. aurantiaca* (*aurea*) Don., a native of Chile. The first preparation was obtained from the Materia Medica Museum of the University of Pennsylvania, in which it was deposited about 50 years ago, at which time the specimen was received by Dr. Carson, then professor of materia medica and therapeutics, and recorded as being derived from *A. ligtu.*

STARCH OF ALSTRŒMERIA LIGTU. (Plate 57, figs. 337 and 338. Chart 224.)

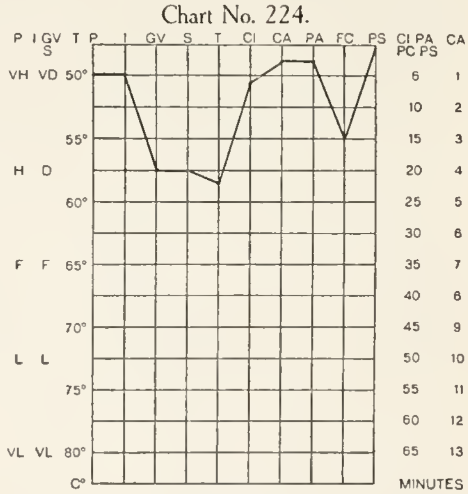
Histological Characteristics.—In *form* the grains are commonly either compound or aggregates, and made up of two, three, or more components. The lines of union of the component grains are usually indistinct, but in some they are often shown in the form of one or more distinct fissures or linear depressions which partly separate the grains from each other; sometimes there is merely a more or less obscure marking. When simple grains can be made out, they are spherical to ovoid in shape and rarely have pressure facets. Those with pressure facets are dome-shaped to hemispherical. The compound grains are ovoid, and oval to elliptical. Occasionally a compound grain will have small grains adhering to the surface. The components of a compound grain may be arranged linearly, or in two rows, or in irregular masses somewhat resembling a mulberry.

The *hilum* is not distinct. It is a small, round, non-refractive spot. There are often double, triple, or multiple hila. In the simple grains the hilum is usually centric or nearly centric and it may be eccentric as much as two-fifths of the longitudinal axis. The hila in the compound grains usually lie close to the median line or may be irregularly arranged. In the single grains the hilum is situated in a space which sometimes is very distinctly outlined, giving the hilum the appearance of being very large and distinct. It is sometimes marked by a fissure which usually is neither large nor deep, and which may be single and placed generally in a transverse or longitudinal direction. There may be two fissures crossing one another.

The *lamellæ* are not very distinct. When they can be fairly clearly seen they appear to be rather coarse, concentric rings. There are sometimes small lamellæ about each hilum. The outermost rows of the compound grains encircle the grains, as a whole, following the outline of the margin. The number of lamellæ could not be estimated with exactness; from 4 to 9 were counted.

The grains vary in *size* from 8 to 70μ, the common size of the simple grains being about 30μ. The compound grains vary from 40 to 70μ, the common size being about 55μ.

Chart No. 224.



Curve of Reaction-Intensities of Starch of Alstrœmeria ligtu.

Polariscopic Properties.—The *figure* in the simple grains is usually nearly centric. In the compounds and aggregates it is eccentric and multiple. It is distinct but not clear-cut. The lines are broad and widen near the margin. The multiple figures have a curious criss-cross form, and double and multiple figures are extremely numerous.

The degree of *polarization* is very high. The simple grains and the doublets appear to have a somewhat higher degree of polarization than the compounds of 3 or more components. It varies in aggregates according to the position of the grain.

With *selenite* the quadrants are generally fairly well defined, usually very irregular in shape, and unequal in size, except in the simple spherical grains. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a very deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. After heating in water until the grains are completely gelatinized, the solution is not colored, but the grains are colored very deeply, with iodine. After boiling for 2 minutes the grains are much disintegrated and the residues react very lightly, but the solution colors very deeply. With an excess of iodine the capsules become a violet color.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly in 30 seconds, and in 30 minutes are stained deeply and evenly.

With *safranin* the reaction begins at once. Some grains are at first much more deeply stained than others, but in 30 minutes they are deeply and evenly colored.

Temperature Reaction.—The temperature of gelatinization is 58° to 59° C., mean 58.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 45 seconds and is over in 7 minutes. In all grains the hila become distinct as dark spots, but the lamellæ are invisible. The grains are darkened around the margin, and the lines of separation between the component grains of the aggregates are in this process made very distinct by light lines. The component grains swell at the margin, and the grain as a whole gradually becomes gelatinized. The grains which constitute an aggregate swell to variable degrees, and when all are gelatinized the mass resembles a mulberry in form. In the linear aggregates and compounds the components at both ends react, thus presenting the appearance of bipolar swelling. The gelatinized grains are not much larger than the original grains and appear to consist of two parts, an outer wall which is light in color and shows folds and creases, and an inner part which is dark and irregularly fissured.

Reaction with *chromic acid* begins in a few seconds and is over in 30 seconds. The hilum becomes very distinct; it appears as a light, refractive spot when not fissured and as a dark bubble when fissured. As the hilum swells the bubble disappears. The hila in all aggregates and compounds apparently swell at the same time. All of the component grains swell enormously and rapidly; the margin of the grain becomes very distinct as a striated and distinctly banded ring. The whole grain becomes clearer, and finally one point on the margin is dissolved, followed rapidly by solution of other parts. The aggregates often open centrally to form a ring of swollen grains which finally disappear.

The reaction with *pyrogallic acid* begins in 20 seconds and is over in 2½ minutes. The hilum becomes very distinct and also the lines showing the boundaries of the component grains of compounds; but the lamellæ are invisible. The hilum swells rapidly and considerably, pushing out the walls of the grain into a thick, finely striated, and indistinctly banded ring. After the reaction is complete the aggregates and compounds often have a mulberry-like appearance, composed of separate, clear, gelatinized grains, not much folded or crumpled. The individual component grains are usually spherical or slightly oval, and not much distorted.

The reaction with *ferric chloride* begins in 30 seconds and all the grains are gelatinized in 15 minutes. The hilum is distinct as a black spot or bubble. The marginal part of the single grain becomes clear and darker, causing the central part to appear lighter and opaque. Portions of the margin begin to gelatinize and to protrude irregularly, and this process extends all the way around the margin. The hilum suddenly swells, pushing out parts of the grain in all directions. A dense band is formed at the margin which quickly clears, and with the formation is a large, crumpled and folded gelatinized grain. In the compounds and aggregates the component parts swell unevenly, and the gelatinized grains are lobulated, folded, and crumpled. Often the central portions of some of the grains remain ungelatinized.

Reaction with *Purdy's solution* begins at once and is over in 30 seconds. The hilum becomes very distinct, either as a refractive spot or a dark bubble. The lamellæ are fairly distinct. The hilum swells enormously, pushing the substance of the grain out peripherally, the margin becoming striated and occasionally banded. The gelatinized grains formed from the simple grains are large, round, or oval, and not crumpled or folded; but those formed from compounds and aggregates are usually in the form of large, lobulated, mulberry-like masses.

STARCH OF ALSTRŒMERIA BRASILIENSIS. (Plate 57, figs. 339 and 340. Chart 225.)

Histological Characteristics.—In *form* the grains are usually simple, with a very few compound grains. Neither aggregates nor grains with pressure facets were observed, nor clumps. The surface of the grains is quite regular, the projections and depressions being quite small. The conspicuous forms are the ovoid, spherical, and oval to elliptical. The grains are not flattened, and appear round when seen on end.

The *hilum* is a fairly distinct, small, round spot, eccentric from two-fifths to one-sixth, usually one-fifth, of the longitudinal axis of the grain, and in or much to one side of the median line. The hilum may be double or multiple, and the multiple hila are usually arranged irregularly in a small, non-lamellated space. The hilum may be fissured, and the fissure is usually small but deep, transverse or diagonal, clean-cut or ragged; or there may be two or more fissures variously arranged. Fissuration in these grains is not conspicuous, as also in *A. ligtu*, and in marked contrast with the decidedly fissured grains of *A. aurantiaca* (*aurea*).

The *lamellæ* are, as a rule, not very distinct, and are rather fine, regular circles or segments of circles, which are probably continuous and which some distance from the hilum tend to follow closely the outline of the margin of the grain. They are finer, more distinct, and circular near the hilum. There are 18 to 24 on the larger grains.

The grains vary in *size* from 10 to 48μ. The common size is 30μ.

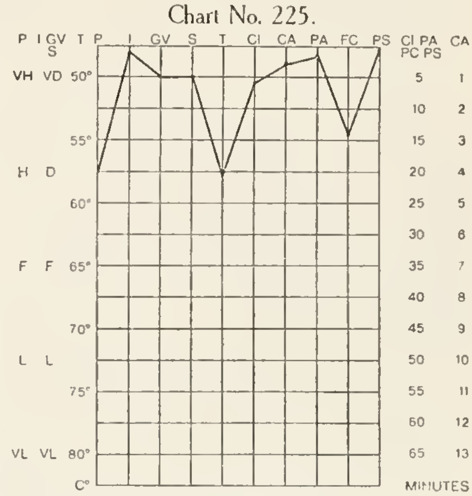
Polariscopic Properties.—The *figure* is generally markedly eccentric, distinct, and as a rule fairly clear-cut. In most grains the lines become wider and less sharply defined as they near the margin, and they may be somewhat bent and otherwise distorted, and often placed at varying angles to one another. Multiple and double figures are rare.

The degree of *polarization* is high and does not vary greatly in different grains or in different aspects of the same grain. It is not so high as that of the grains of *A. ligtu.*

With *selenite* the quadrants are usually fairly well defined, irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. The color is deeper than in the grains of *A. ligtu.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. When an excess of iodine is added the capsules color a pinkish-violet. Very few of the capsules still contain blue-reacting starch, and they are collapsed, broken, and twisted.

Chart No. 225.



Curve of Reaction-Intensities of Starch of Alstrœmeria brasiliensis.

Staining Reactions.—With *gentian violet* the grains begin to stain at once, and in 30 minutes are very deeply stained, some more than others. They are much more deeply stained than the grains of *A. ligtu.*

With *safranin* the grains begin to stain at once and in 30 minutes are very deeply stained, some more than others. They are more deeply stained than the grains of *A. ligtu.*

Temperature Reaction.—The temperature of gelatinization is 57° to 58.5° C., mean 57.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds and is over in 6 minutes. It is qualitatively the same as that of corresponding grains of *A. ligtu.*

Reaction with *chromic acid* begins in a few seconds and is over in 30 seconds. It is qualitatively the same as in corresponding grains of *A. ligtu.*

The reaction with *pyrogallic acid* begins in 15 seconds and is over in all but a very few grains in 2 minutes. It is qualitatively the same as in corresponding grains of *A. ligtu.*

With *ferric chloride* the reaction begins in a few grains in a minute and is over in all the grains in 14 minutes. It is the same qualitatively as in corresponding grains of *A. ligtu.*

The reaction with *Purdy's solution* begins at once and is over in 30 seconds. It is qualitatively the same as in corresponding grains of *A. ligtu.*

STARCH OF ALSTRŒMERIA AURANTIACA (AUREA). (Plate 57, figs. 341 and 342. Chart 226.)

Histological Characteristics.—In *form* the grains are usually simple, with a few compound grains and aggregates. Single, large pressure facets were observed in a few isolated grains. Sometimes a small grain appears to be embedded in a large one. The surface of the grains tends to be quite regular. The conspicuous forms are the ovoid to spherical, and oval. The grains are not flattened, and appear spherical when seen on end.

The *hilum* is nearly always fissured, and the fissuration is very deep, wide, ragged, and usually stellate. There may be but one fissure placed obliquely, transversely, or longitudinally, but there are usually two or more large, deep fissures very irregularly arranged; or a great number of fine fissures radiating from the hilum, almost to the margin of the grain. There may be double and multiple hila, linearly arranged, one or all of which may be fissured. If the hilum is not fissured it is a somewhat indistinct, rather large round spot. It is usually eccentric about two-fifths to one-third of the longitudinal axis of the grain, and in the median line.

The *lamellæ* are fairly distinct, rather coarse, regular rings which, except those near the hilum, tend to follow the outline of the margin of the grain. They are usually continuous ellipses, but may appear to be segments of ellipses, which, however, are probably continuous. They are fine, but generally more distinct near the hilum. There are about 12 to 14 on the larger grains.

The grains vary in *size* from 18 to 69μ. The common size is 40μ.

Polariscopic Properties.—The *figure* is somewhat eccentric, distinct, regular, and fairly clear-cut, though the lines become less well defined as they near the margin. The lines may be very broad, somewhat bent or otherwise distorted in some part of their course. Double and multiple figures are occasionally seen.

The degree of *polarization* is very high. In some grains polarization colors are shown. It does not vary much in different grains or in different aspects of the same grain. It is slightly higher than that of the grains of *A. ligtu.*

With *selenite* the quadrants are not sharply defined, are fairly regular in shape, but unequal in size. The colors are not quite pure.

Iodine reactions.—With 0.25 per cent Lugol's solution the grains color a very deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. The color is not so deep as in the grains of *A. ligtu.* After heating in water until the grains are completely gelatinized, the solution colors deeply and the grains fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors more deeply, but most of the grain-residues not at all. With excess of iodine the capsules color a blue-violet and very few of them contain blue-reacting starch. They are collapsed, broken, and twisted.

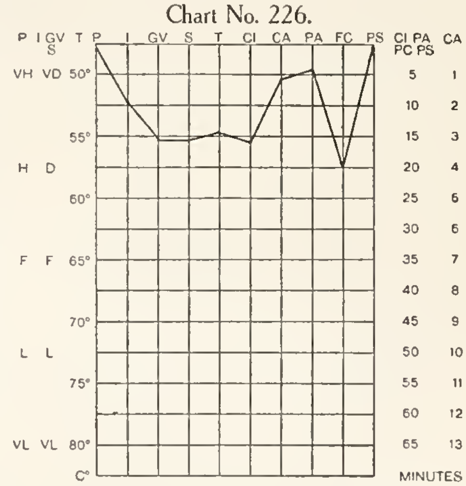
Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are deeply stained, some more than others. The color is slightly deeper than the grains of *A. ligtu.*

With *safranin* the grains begin to stain at once and in 30 minutes are deeply stained, one as deeply as another. The color is slightly deeper than in the grains of *A. ligtu.*

Temperature Reaction.—The temperature of gelatinization is 53.5° to 56° C., mean 54.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction is general in 30 seconds. About four-fifths are gelatinized in 9 minutes and all in 17 minutes. It is the same qualitatively as in corresponding grains of *A. ligtu.*

Chart No. 226.



Curve of Reaction-Intensities of Starch of Alstrœmeria aurantiaca (aurea).

The reaction with *chromic acid* begins in 15 seconds and is over in 1¼ minutes. It is the same qualitatively as in corresponding grains of *A. ligtu.*

The reaction with *pyrogallic acid* is general in 30 seconds and is over in 4 minutes. It is the same qualitatively as in corresponding grains of *A. ligtu.*

Reaction with *ferric chloride* begins in some grains in 30 seconds. About four-fifths are gelatinized in 10 minutes and all in 20 minutes. Qualitatively the reaction is the same as in corresponding grains of *A. ligtu.*

The reaction with *Purdy's solution* begins in a very few seconds and is over in 30 seconds. It is qualitatively the same as in corresponding grains of *A. ligtu.*

Differentiation of Certain Starches of the Genus Alstrœmeria.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

A. ligtu: Usually compound or aggregates of 2, 3, or more components. Ovoid, oval to elliptical. Simple grains spherical to ovoid, dome-shaped to hemispherical.

A. brasiliensis: Usually simple, few compounds, no aggregates, or pressure facets of isolated grains. Ovoid, spherical, oval to elliptical.

A. aurantiaca (aurea): Usually simple, few compounds and aggregates, occasional grains with single pressure facets. Ovoid to spherical, and oval.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.

A. ligtu: Form not distinct, small, round, often multiple; sometimes fissured, fissures not large nor deep. Position centric to eccentric about 0.40 of longitudinal axis.

A. brasiliensis: Form fairly distinct, small, round spot; usually single, may be multiple; may be fissured, fissures small but deep, and ragged. Position centric to eccentric about 0.40 to 0.16 of the longitudinal axis; more eccentric, as a whole, than in the other species.

Differentiation of Certain Starches of the Genus Alstrœmeria.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.—Continued.

A. aurantiaca (aurea): Form rather distinct, rather large round spot; may be multiple; nearly always fissured, fissure or fissures large, deep, irregular and ragged, or a great number of fine radiating fissures. Position centric to eccentric about 0.40 to 0.33 of the longitudinal axis.

Lamellæ—General Characteristics and Number.

A. ligtu: Not very distinct, rather coarse, regular, concentric rings. 4 to 9 on larger grains, probably more.
A. brasiliensis: Not very distinct, rather fine, regular circles or segments of circles. 18 to 24 on larger grains.
A. aurantiaca (aurea): Fairly distinct, rather coarse, regular rings or ellipses or segments of ellipses. 18 to 24 on larger grains.

Size.

A. ligtu: From 8 to 70μ, commonly 30μ (simple).
A. brasiliensis: From 10 to 48μ, commonly 30μ (simple).
A. aurantiaca (aurea): From 18 to 69μ, commonly 40μ (simple).

POLARISCOPIC PROPERTIES.

Figure.

A. ligtu: Eccentric, distinct, not always clear-cut, often distorted and double multiple.
A. brasiliensis: Usually very eccentric, distinct, usually clear-cut, at times somewhat distorted, rarely double or multiple figures.
A. aurantiaca (aurea): Somewhat eccentric, fairly clear-cut, fairly regular, occasionally double or multiple figures.

Degree of Polarization.

A. ligtu: Very high.
A. brasiliensis: High, not so high as in *A. ligtu.*
A. aurantiaca (aurea): Very high, slightly higher than in *A. ligtu.*

Polarization with Selenite—Quadrants and Colors.

A. ligtu: Quadrants usually fairly well defined, usually very irregular in shape, and unequal in size. Colors fairly pure.
A. brasiliensis: Quadrants usually well defined, irregular in shape, and unequal in size. Colors fairly pure.
A. aurantiaca (aurea): Quadrants not well defined, fairly regular in shape, but unequal in size. Colors fairly pure.

IODINE REACTIONS.

Intensity and Color.

A. ligtu: Very deep; blue-violet.
A. brasiliensis: Very deep, deeper than in *A. ligtu;* blue-violet.
A. aurantiaca (aurea): Very deep, less deep than in *A. ligtu;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

A. ligtu: Deep.
A. brasiliensis: Very deep, much deeper than in *A. ligtu.*
A. aurantiaca (aurea): Deep, slightly deeper than in *A. ligtu.*

With Safranin.

A ligtu: Deep.
A. brasiliensis: Very deep, much deeper than in *A. ligtu.*
A. aurantiaca (aurea): Deep, slightly deeper than in *A. ligtu.*

TEMPERATURE OF GELATINIZATION.

A. ligtu: 58 to 59° C., mean 58.5°.
A. brasiliensis: 57 to 58.5° C., mean 57.75°.
A. aurantiaca (aurea): 53.5 to 56° C., mean 54.75°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

A. ligtu: Begins in 45 seconds; complete in 7 minutes.
A. brasiliensis: Begins in 30 seconds; complete in 6 minutes.
A. aurantiaca (aurea): Begins in 30 seconds; complete in four-fifths in 9 minutes, and in all in 17 minutes.

Reaction with Chromic Acid.

A. ligtu: Begins in a few seconds; complete in 30 seconds.
A. brasiliensis: Begins in a few seconds; complete in 30 seconds.
A. aurantiaca (aurea): Begins in 15 seconds; complete in 1¼ minutes.

Reaction with Pyrogallic Acid.

A. ligtu: Begins in 20 seconds; complete in 2½ minutes.
A. brasiliensis: Begins in 15 seconds; complete in 2 minutes.
A. aurantiaca (aurea): Begins in 30 seconds; complete in 4 minutes.

Reaction with Ferric Chloride.

A. ligtu: Begins in a few in 30 seconds; complete in 15 minutes.
A. brasiliensis: Begins in a few in 60 seconds; complete in 14 minutes.
A. aurantiaca (aurea): Begins in a few in 30 seconds; complete in 20 minutes.

Reaction with Purdy's Solution.

A. ligtu: Begins at once; complete in 30 seconds.
A. brasiliensis: Begins at once; complete in 30 seconds.
A. aurantiaca (aurea): Begins in a very few seconds; complete in 30 seconds.

NOTES ON THE STARCHES OF ALSTRŒMERIA.

The most noticeable differences in the appearances of the *Alstrœmeria* starches are in relation to the abundance of compound grains in *A. ligtu;* the very conspicuous fissuration of *A. aurantiaca* (*aurea*); the differences in the distinctness, coarseness, and fineness of the lamellæ, and in the sizes of the grains. The differences in the interference figures are very conspicuous, owing to relative numbers of compound and single grains in the two starches. In the reactions, differences of importance are noted in almost every record, and the sensitivity of the starches to the various reagents is very marked. On the whole, the starch of *A. brasiliensis* is the most sensitive. *A. ligtu* in comparison with *A. aurantiaca* (*aurea*) is less responsive in the color and heat reactions, but more responsive, on the whole, with the chemical reagents.

GENUS STERNBERGIA.

Sternbergia includes only four species of bulbous plants, natives of Eastern Europe to Asia Minor. Starch was obtained from *S. lutea* Ker-Gawl. (*Amaryllis lutea* Linn.), a native of the Mediterranean region of Europe, and of Asia, and popularly known as the star-flower and winter daffodil.

STARCH OF STERNBERGIA LUTEA. (Plate 58, figs. 343 and 344. Chart 227.)

Histological Characteristics.—In *form* the grains are usually simple, with very few compounds and a few aggregates. No pressure facets were observed on the isolated grains, and no clumps. The surface of the grains is usually very irregular, owing to unequal development, which results in numerous more or less nodular elevations and depressions. The conspicuous forms are ovoid, oval, round, ellipsoidal, reniform, and various irregular shapes. Many grains are as thick as broad, but some of the larger are about one-half to two-thirds as thick as broad.

The *hilum* is a distinct, rather small, round or lenticular spot, usually eccentric about two-fifths of the longitudinal axis, and in or to one side of the median line. Sometimes two or more hila occur in a single grain. The hilum is sometimes fissured, and there may be either a single clean-cut, short, transverse, diagonal or longitudinal fissure; or two short, narrow, clean-cut fissures forming a cross.

The *lamellæ* are distinct, rather coarse, continuous, irregular rings, which tend even when near the hilum to follow more or less closely the outline of the margin. They are usually coarser and more distinct near the margin than near the hilum. They vary in size and distinctness in different grains and in different parts of the same grain. There are 6 to 8 on the larger grains.

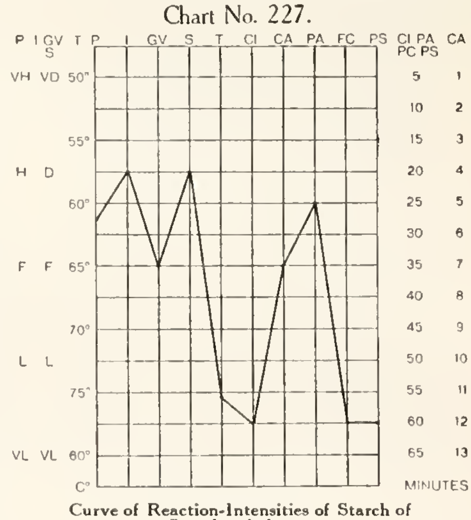
The grains vary in *size* from 6 to 50μ. The common size is 34μ.

Polariscopic Properties.—The *figure* is usually eccentric, fairly distinct, irregular, and seldom clear-cut. The lines are often bent or otherwise distorted, or bisected, and placed at widely varying angles to one another. Double figures are seen occasionally.

The degree of *polarization* is fairly high. It varies somewhat in different grains, in different aspects of the same grain, and in different parts of the same aspect of a grain.

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are never pure.

Chart No. 227.



Curve of Reaction-Intensities of Starch of Sternbergia lutea.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color rather lightly at first and the color quickly deepens. After heating in water until the grains are completely gelatinized, the solution colors lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly or commonly not at all. The capsules color a red-violet with excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes are fairly stained, one grain as much as another.

With *safranin* the grains begin to stain at once and in 30 minutes are deeply stained, one grain as much as another.

Temperature Reaction.—The temperature of gelatinization is 75° to 76° C., mean 75.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 1¼ minutes. About half are gelatinized in 18 minutes, three-fourths in 50 minutes, and four-fifths in 70 minutes. The reaction begins at the sides, which become dark. Then the starch at both distal and proximal ends grows darker and swells somewhat, and from these two points this process of swelling and coloring extends inward until the entire grain is affected. The gelatinized grains are not very large and are of uniform dark color. They are somewhat distorted, but retain some of the original form.

The reaction with *chromic acid* begins in 1¼ minutes and is over in 7 minutes. The grain becomes covered by fine striæ which grow larger, and a bubble is formed at the hilum, which swells, then decreases in size, and then disappears. The whole of the inner part of the grain out to the margin now passes into a gelatinous mass, and a band of the more resistant non-gelatinized starch forms at the margin. As this process proceeds, the grain swells and the thin gelatinous capsule that is formed is dissolved, usually at the proximal end, and the inclosed gelatinized starch escapes and is dissolved, followed by solution of the capsule.

With *pyrogallic acid* the reaction begins in some grains in 2 minutes. About one-third are partially and two-thirds completely gelatinized in 14 minutes and all are completely gelatinized in 25 minutes. The reaction begins with a slight swelling of the hilum and the appearance of fine striæ which radiate throughout the grain. The whole grain is now changed into a gelatinous mass without any sharp division of the inner gelatinous substance and the thick marginal ring. As the process goes on the grain swells, and finally a large, distorted, and folded, thin-walled gelatinous mass is formed.

The reaction with *ferric chloride* begins in a few grains in 2 minutes. About three-fourths are completely gelatinized in 20 minutes and all in 65 minutes. The reaction generally begins at the distal end, where the starch becomes gelatinous and swells. The reaction progresses around the margin of the grain, the starch near the margin often becoming first divided from that of the interior of the grain by a line of ungelatinized starch, which line later gelatinizes. When the whole of the marginal starch is gelatinized the process moves inward. The ungelatinized starch is invaded by fissures, dividing it into several, irregular pieces, which are moved apart by the gelatinization of the substance between, and later themselves gelatinize. The gelatinized grains are very large, wrinkled, folded, and distorted, and do not retain much of the original form.

Reaction with *Purdy's solution* begins in some grains in 1½ minutes. About one-fourth are partially gelatinized in 15 minutes, one-half in 30 minutes, and only one-third of the grains are completely gelatinized in 1¾ hours. The reaction is the same qualitatively as that to pyrogallic acid.

GENUS NARCISSUS.

Baker states that this genus includes 16 species, but according to horticulturists there are thrice this many. The number of garden forms is very large. Most of the narcissi are natives of southwestern Europe and the Mediterranean region. Starches from 13 sources were studied: *N. horsfieldii* Burb., a form referred to the *Pseudo-narcissus* Linn., or common daffodil; *N. maximus* Hort., a form also referred to the *Pseudo-narcissus; N. bulbocodium* Linn., the hoop-petticoat daffodil; *N. bulbocodium* var. *conspicua* Hort.; *N. bulbocodium* var. *monophyllus* Baker (*N. monophyllus* Moore; *N. clusii* Dunal); *N. incomparabilis* Mill.; *N. odorus* Linn.; *N. poeticus* Linn., the pheasant's eye narcissus; *N. biflorus* Curt., the primrose peerless narcissus; *N. jonquilla* Linn., the jonquil; *N. jonquilla* var. *rugulosus* Hort.; *N. jonquilla* var. *campernelli rugulosus* Hort.; and *N. tazetta* var. *orientalis* Hort., the Chinese sacred lily.

According to Baily's classification these narcissi are grouped as follows:

I. Magnicoronati or large-crowned—*N. horsfieldii, N. maximus, N. bulbocodium* and its varieties.

II. Mediocoronati or medium-crowned—*N. incomparabilis* and *N. odorus.*

III. Parvicoronati or small-crowned—*N. poeticus, N. biflorus, N. jonquilla* and its varieties, and *N. tazetta* var. *orientalis.*

STARCH OF NARCISSUS HORSFIELDII. (Plate 58, figs. 345 and 346. Chart 228.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains and a few small aggregates. The surface of the grains is somewhat irregular, owing to unequal development, with a tendency to nipple-like projections and shallow depressions. The conspicuous forms are irregularly ovoid, oval to elliptical; other forms are also lenticular, quadrilateral with rounded corners, irregularly rounded, pyriform, bottle- or gourd-shaped. The broader forms are about half as thick as wide, and the narrower forms have about the same thickness as width.

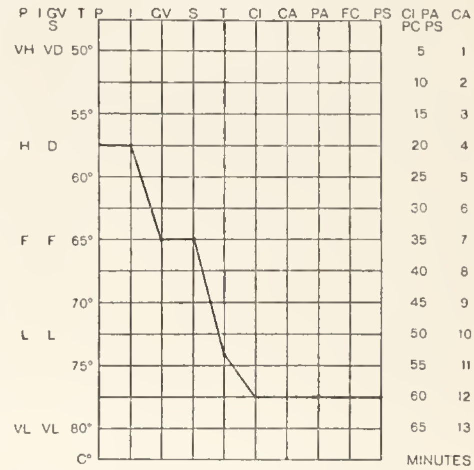
The *hilum* is small and fairly distinct. It may be eccentric, but is usually eccentric about two-fifths to one-fourth of the longitudinal axis. It is fissured, the fissure generally being small, transverse or diagonal, and clean-cut or ragged. It may be 3-armed or irregularly stellate. The hilum is often double or multiple, and usually arranged linearly in a non-lamellated space. The hila may be separated from one another by small fissures, and one or all may be fissured. Sometimes there is a long, curved, irregular fissure extending through the line of hila. The hilum is also not infrequently of an elongated or lenticular form.

The *lamellæ* are distinct. They are rather fine, continuous rings, and tend to follow the outline of the margin, which is often very irregular. One lamella near the hilum is usually more distinct than the others. Those centrally located are almost always more distinct than those near the margin. There are about 12 to 14 on the larger grains.

The grains vary in *size* from 3 to 48μ. The common size is 32μ.

Polariscopic Properties.—The *figure* is usually eccentric, and not clear-cut, but distinct. One or more of the lines are often quite broad, and sometimes not sharply defined. There is often some slight bending or other distortion of the lines.

Chart No. 228.



Curve of Reaction-Intensities of Starch of Narcissus horsfieldii.

The degree of *polarization* is high, varying greatly in different grains; it is low or absent in some parts of the grains, and in some grains only small marginal areas are illuminated.

With *selenite* the quadrants are usually not well defined, are irregular in shape, and unequal in size. The colors are sometimes pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a bluish-violet; with 0.125 per cent solution the grains tint lightly and the color does not deepen very rapidly. After heating in water until the grains are gelatinized, the solution is colored deeply and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution is colored much more deeply, but the grain-residues much less. All of the capsules contain some blue-reacting starch. With an excess of iodine the capsules are colored a pinkish-violet.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once very lightly, and after 30 minutes are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 73° to 75° C., mean 74°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains react in 2½ minutes, and the reaction is general in 4 minutes. About one-fourth are darkened in 15 minutes, and all are affected and four-fifths gelatinized in an hour. There was little further change. The hilum usually becomes prominent. The margin grows clearer and darker, and then irregular points on the margin become very dark. This process may extend all around the margin or be confined to the two ends of the grain or to irregular points on the side. It subsequently extends inward evenly and without great swelling. The line of demarcation between the gelatinized and non-gelatinized parts is fairly distinct. The gelatinized grains are not very large and are usually of a uniform color.

With *chromic acid* there is some reaction in 30 seconds, it is general in 1½ minutes, and is over in 14 minutes. The hilum becomes distinct and then swells, and the grain is marked by fine striæ. The inner portion is changed into a thin, gelatinous mass, and the starch at the margin is formed into a saccular ring which is divided by coarse radial striæ and presents a ragged border on the inside. This ring or capsule grows thinner and clearer, and one part dissolves, followed by an opening and the extrusion and solution of the contents, and the solution of the capsule.

With *pyrogallic acid* there is a very slight general reaction in 4 minutes. About one-fourth of the grains are almost completely gelatinized in 25 minutes and about two-thirds are fully gelatinized in an hour. The hilum becomes distinct, but the lamellæ are not especially so. The hilum swells somewhat and the grain is divided by fine striæ. The inner portion is transformed into a gelatinous mass, while the margin becomes a thick, striated band which is very ragged on the inside. This band or capsule becomes thinner, clearer, and quite homogeneous-looking as the grain swells. The gelatinized grains are fairly large and somewhat wrinkled, but otherwise not greatly distorted.

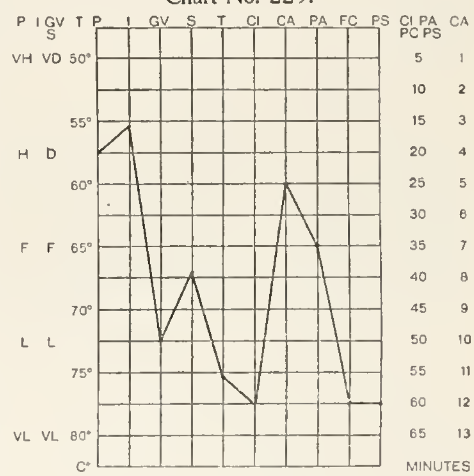
With *ferric chloride* there is a reaction in a few grains in 3 minutes and most of the grains react in 10 minutes. A few are completely gelatinized in 10 minutes, about one-third in 15 minutes, and the reaction is complete in 1½ hours. The hilum becomes prominent and swells somewhat in the form of a gelatinous projection in most cases. This process may spread into the grain to a certain point, and then the rest of the grain becomes divided by fissures. The pieces suddenly part and gelatinize separately. The gelatinized grains are large and irregular, much sacculated and folded, and bear little resemblance to the original grain.

Reaction with *Purdy's solution* begins in some grains in 1 to 1½ minutes. Almost all are affected and a few are completely gelatinized after an hour, and one-fourth gelatinized in 2 hours. There was no further change. The reaction is qualitatively the same as that with pyrogallic acid.

STARCH OF NARCISSUS MAXIMUS. (Plate 58, figs. 347 and 348. Chart 229.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compounds and aggregates. Occasionally grains are observed having poorly defined pressure facets. The surface of the grains is often very irregular, owing chiefly to unequal development in the form of rounded protuberances or nipple-like projections. Sometimes there are additions which completely surround the original grain. The conspicuous forms are the ovoid, which is usually slender and pointed at the distal end, oval to elliptical, lenticular, and nearly spherical. There are also quadrilateral, triangular, pyriform, and various irregular forms. The quadrilateral and triangular forms and related forms are about half as thick as they are wide, but the rounded forms are about as thick as broad.

Chart No. 229.



Curve of Reaction-Intensities of Starch of Narcissus maximus.

The *hilum* is a small, not very distinct, round spot, usually eccentric about one-third to one-fourth of the longitudinal axis of the grain, and in or to one side of the median line. It is frequently fissured, and the fissure is usually small, clean-cut, transverse, straight or with a double curve; rarely there are two lines forming a cross.

The *lamellæ* are not very distinct and are often invisible. When they can be seen they appear as rather fine, fairly regular, continuous rings which tend to follow the outline of the margin. There are from 8 to 12 on the larger grains.

The grains vary in *size* from 4 to 42μ. The common size is 26μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and usually not clear-cut, as one or more of the lines are often less clearly defined in some part of their length. The lines are often bent, otherwise distorted, and sometimes bisected.

The degree of *polarization* is high. It varies greatly in different grains and somewhat in different aspects of the same grain, and very much in different parts of the same aspect of a grain. It is the same as that of the grains of *N. horsfieldii.*

With *selenite* the quadrants are usually not well defined, are very irregular in shape, and unequal in size. The colors are sometimes pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet, some more than others; with 0.125 per cent solution the grains color fairly, slightly more than the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution colors lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the grain-residues fairly. The capsules color a red-violet on the addition of an excess of iodine, and most of them contain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in a minute, and in 30 minutes they are lightly stained. The color is much less than that of *N. horsfieldii.*

With *safranin* the grains begin to stain very lightly at once, and in 30 minutes they are fairly stained. The color is slightly less than that of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 74.5° to 76° C., mean 75.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains in 30 seconds and is general in 3 minutes. About one-fifth are gelatinized in 30 minutes, one-third in 45 minutes, one-half in an hour, and two-thirds in 1¼ hours. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *chromic acid* the reaction begins in 1½ minutes and is over in 5 minutes. It is the same qualitatively as that of the grains of *N. horsfieldii.*

With *pyrogallic acid* the reaction begins in 2½ minutes. About one-third are gelatinized in 15 minutes, one-half in 22 minutes, two-thirds in 27 minutes, and all in 38 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *ferric chloride* the reaction begins in a few grains in 4 minutes. About one-third are gelatinized in 15 minutes, one-half in 20 minutes, five-sixths in 27 minutes, and all in 7 hours. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *Purdy's solution* there is a slight reaction in 2½ minutes, and a very few are completely or partially gelatinized in 12 minutes. The reaction is incomplete in an hour. It is qualitatively the same as that of the grains of *N. horsfieldii.*

STARCH OF NARCISSUS BULBOCODIUM. (Plate 59, figs. 349 and 350. Chart 230.)

Histological Characteristics.—In *form* the grains are usually simple. There are some compound grains and aggregates which usually consist of two components. Occasionally grains are seen which are marked with well-defined pressure facets. The surface of the grains is often quite smooth, but rounded protuberances and nipple-like processes are not uncommon. The conspicuous forms are the ovoid to oval and elliptical, one end being less wide than the other, the former usually being the distal end. There are also spherical, bean-shaped, pyriform, triangular, and irregularly quadrilateral, hemispherical, and irregular forms. Some of the broader forms are about half as thick as they are broad, but the majority are of about the same thickness as width.

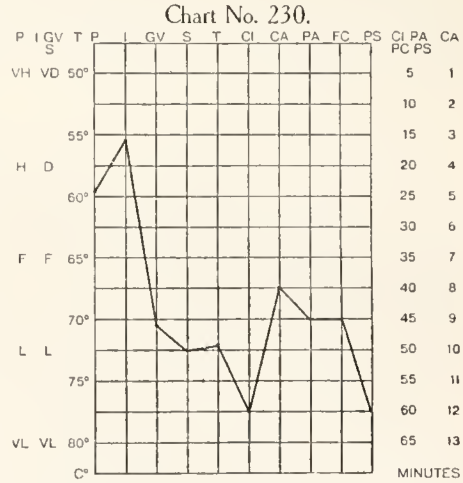
The *hilum* is comparatively small and not very distinct. It is round, usually eccentric about two-fifths to one-third of the longitudinal axis, and in or not far from the median line. Rarely the hilum is lenticular or elliptical in shape. There may be double or multiple hila grouped together, usually linearly, in a non-lamellated space. Commonly one long fissure, often with branches at each hilum, runs through the line of hila and extends into the grain beyond on each side. Often the single hilum has a small, irregular, transverse or diagonal fissure.

The *lamellæ* are not distinct. They are comparatively coarse, continuous rings. If multiple hila exist in one grain the lamellæ often show irregularities corresponding to those of the form of the hilum space. They are less distinct but more regular and tend to follow the outline of the margin when they are near the margin. There are usually 6 to 10 on the larger grains.

The grains vary in *size* from 5 to 54μ. The common size is 32μ.

Polariscopic Properties.—The *figure* is usually eccentric, sometimes distinct and generally not clear-cut. Some or all of the lines may become broader and less distinctly defined as they near the margin. The lines are frequently somewhat bent or otherwise distorted.

Chart No. 230.



Curve of Reaction-Intensities of Starch of Narcissus bulbocodium.

The degree of *polarization* is high. It is low in some of the grains, and especially at the distal end or centrally. It always varies with the position of the grain. Large areas may sometimes be seen which are dark. The grains are slightly less polariscopic than those of *N. horsfieldii.*

With *selenite* the quadrants are usually well defined, very irregular in shape, and unequal in size. The colors are generally very pure.

Iodine Reaction.—With 0.25 per cent Lugol's solution the grains are colored deeply at once a blue-violet; with 0.125 per cent solution they color lightly and the shade deepens slowly. The color is slightly deeper than that of the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution is colored lightly and the grains very deeply upon the addition of iodine. Some of the grains which contain little blue-reacting starch are of a dark-violet color. After boiling for 2 minutes the solution is colored more deeply, but the grain-residues much less. Most of the latter contain blue-reacting starch, and all have a pinkish-violet colored capsule.

Staining Reactions.—With *gentian violet* the grains begin to stain at once very slightly and after 30 minutes they are lightly stained. The color is less than that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain at once, but after 30 minutes they are lightly stained. The color is less than that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is a reaction in most of the grains in 3 minutes. About one-fourth are darkened and probably gelatinized in 8 minutes, and one-half are completely gelatinized in 55 minutes. Of the remaining half, some are partially gelatinized, but others are entirely unaffected. There was no further change. The reaction is qualitatively the same as that in the grains of *N. horsfieldii.*

With *chromic acid* there is some reaction in 30 seconds, it is general in a minute, and over in 8 minutes. The reaction is the same as that of the grains of *N. horsfieldii.*

With *pyrogallic acid* a few of the grains react in a minute and all are affected, about one-fourth being completely gelatinized in 10 minutes. The reaction is complete in 45 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

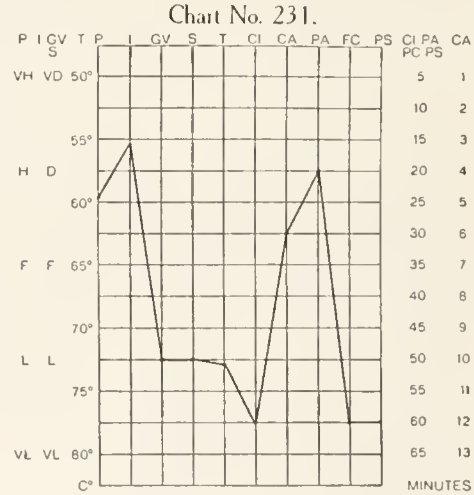
With *ferric chloride* there is a reaction in some of the grains in 1½ minutes. About one-third are gelatinized in 10 minutes, three-fourths in 25 minutes, and all in 50 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *Purdy's solution* there is a slight reaction in 3 minutes. A few are gelatinized and a few more are slightly affected in 1½ hours. There was no further change. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

STARCH OF NARCISSUS BULBOCODIUM VAR. CONSPICUA. (Plate 59, figs. 351 and 352. Chart 231.)

Histological Characteristics.—In *form* the grains usually are simple. There are few compound grains and aggregates. Pressure facets were rarely observed on the isolated grains. The surface is often irregular, owing chiefly to the unequal development of their surfaces in the form of rounded protrusions or nipple-like processes. Sometimes an addition is made so that the grain is completely inclosed by a lamellated deposit. The conspicuous forms are the ovoid to oval and elliptical, which often are not so wide at the distal end as at the proximal end. There are also spherical, hemispherical, quadrilateral, triangular, and various odd forms. The triangular, quadrilateral, and other broad forms are about half as thick as they are broad, but the other forms as a whole are of the same thickness as width.

Chart No. 231.



Curve of Reaction-Intensities of Starch of Narcissus bulbocodium var. conspicua.

The *hilum* is a small, not very distinct, round or lenticular spot, usually eccentric about two-fifths to one-third of the longitudinal axis of the grain and in or to one side of the median line. It is often fissured, and the fissure is usually small, but ragged and irregular. Not only the hilum but parts of the grain between it and the distal end may be fissured.

The *lamellæ* are rather indistinct, but can usually be seen as rather coarse, regular rings which tend to follow the outline of the margin of the grain. There are about 6 to 8 on the larger grains.

The grains vary in *size* from 4 to 40μ. The common size is 24μ.

Polariscopic Properties.—The *figure* is usually eccentric, sometimes distinct, and generally not clear-cut. One or more of the lines are broader and less sharply defined in some parts than in others, and sometimes they are also somewhat bent or otherwise distorted.

The degree of *polarization* is high. It varies in different grains, in different aspects of the same grain, and in different parts of the same aspect of a grain. In some grains large areas are dark. It is slightly less than that of the grains of *N. horsfieldii.*

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are usually very pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens slowly. They are more deeply colored than the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply and the grain-residues much less. The capsules are colored a red-violet on the addition of an excess of iodine and most of them still contain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in 2 minutes and in 30 minutes are lightly stained. The reaction is less than that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain very lightly at once and in 30 minutes are lightly stained. The reaction is less than that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 72° to 73.5° C., mean 72.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 3 minutes. About one-third of the grains are gelatinized in 30 minutes and half in 45 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *chromic acid* begins in a minute and is over in 6 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

Reaction with *pyrogallic acid* begins in 2 minutes. About one-fourth of the grains are gelatinized in 7 minutes, three-fourths in 10 minutes, and all in 20 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

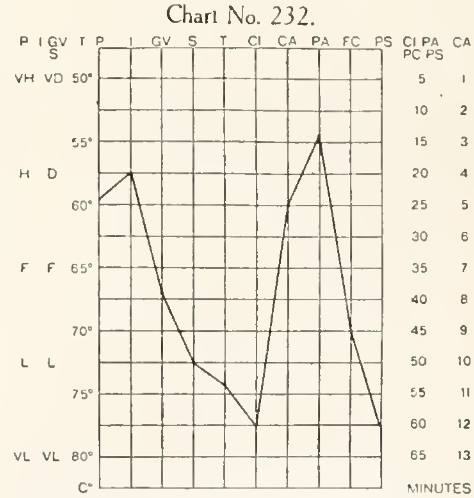
Reaction with *ferric chloride* begins in a few grains in 3 minutes, about half are gelatinized in 25 minutes, and all in 1¼ hours. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *Purdy's solution* begins very slightly in 2 minutes and only a few are even partially gelatinized in 10 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

STARCH OF NARCISSUS BULBOCODIUM VAR. MONOPHYLLUS. (Plate 59, figs. 353 and 354. Chart 232.)

Histological Characteristics.—In *form* the grains are usually simple. There are rarely compound grains and aggregates, and pressure facets are seldom observed. The surface of the grains tends to be somewhat irregular, owing chiefly to nodular or nipple-like additions which vary in size. In some grains deposits in the form of two or three lamellæ entirely surround the grain. The conspicuous forms are the ovoid, and oval to elliptical, the distal end usually being the narrower. There are also irregularly quadrilateral forms with rounded angles, spherical forms, triangular forms with rounded angles, and various irregular shapes. The quadrilateral and triangular and other broad forms are from one-half to three-fourths as thick as they are broad; the other forms, as a whole, are of about the same thickness as width.

Chart No. 232.



Curve of Reaction-Intensities of Starch of Narcissus bulbocodium var. monophyllus.

The *hilum* is a small, not very distinct, round or lenticular spot, usually eccentric from one-third to two-fifths of the longitudinal axis of the grain, in or to one side of the median line, and generally fissured. The fissure may be small, and there may be a single transverse or diagonal line; or there is an irregularly stellate arrangement of fissures. There are sometimes double hila.

The *lamellæ* are not very distinct, but when they can be seen they appear as rather coarse, regular, continuous rings which tend to follow the outline of the margin of the grain. There are about 5 to 7 on the larger grains.

The grains vary in *size* from 3 to 42μ. The common size is 22μ.

Polariscopic Properties.—The *figure* is eccentric, distinct, and often clear-cut. In many grains one or more of the lines become broader and less well defined in some part of their length. Sometimes they are somewhat bent or otherwise distorted.

The degree of *polarization* is high. It varies in different grains, in different aspects of the same grain, and often in different parts of the same aspect of a grain. It is not quite so high as that of the grains of *N. horsfieldii*.

With *selenite* the quadrants are usually well defined, are irregular in shape, and unequal in size. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet, some more than others; with 0.125 per cent solution they color fairly and the color deepens slowly. The coloration is of the same depth as that of the grains of *N. horsfieldii*. After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues much less deeply. With an excess of iodine the capsules become a red-violet, and most of them contain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain at once very lightly and after 30 minutes are fairly stained, some more than others. The color is slightly less than that of the grains of *N. horsfieldii*.

With *safranin* the grains begin to stain at once very lightly and after 30 minutes are lightly stained, some slightly more than others. The color is less than that of the grains of *N. horsfieldii*.

Temperature Reaction.—The temperature of gelatinization is 73° to 75° C., mean 74°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 45 seconds and is fairly general in 3 minutes. About one-fourth are gelatinized in 11 minutes, one-third in 20 minutes, and three-fourths in 45 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii*.

Reaction with *chromic acid* begins in 45 seconds and is over in 5 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii*.

The reaction with *pyrogallic acid* is nearly general in 45 seconds. About three-fourths are gelatinized in 10 minutes and all in 13 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii*.

The reaction with *ferric chloride* begins in a few grains in 2 minutes. About half are gelatinized in 10 minutes, three-fourths in 22 minutes, and practically all in 45 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii*.

Reaction with *Purdy's solution* begins slightly in 2 minutes. A few are partially gelatinized in 8 minutes, one-fifth in 20 minutes, and one-third in 45 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii*.

STARCH OF NARCISSUS INCOMPARABILIS. (Plate 60, figs. 355 and 356. Chart 233.)

Histological Characteristics.—In *form* the grains are usually simple. Occasionally compound grains and aggregates are seen. Pressure facets are rarely noted. The surface of the grains is irregular, owing to unequal development, which is sometimes in the form of rounded protrusions or nipple-like processes. The conspicuous forms are the ovoid to oval and elliptical; also spherical, triangular with rounded angles, lenticular, reniform, irregularly quadrangular, polygonal, rod-like, and various irregular shapes. The triangular, quadrangular, reniform, and the broader forms are one-half to three-fourths as thick as they are broad; and the other forms, as a whole, are of the same thickness as breadth.

The *hilum* is a not very distinct, small, round or lenticular spot. It is eccentric about two-fifths of the longitudinal axis of the grain. It is commonly fissured, and the fissure may be a small, ragged, transverse line, or a cross, or 3-armed figure.

The *lamellæ* are, as a rule, invisible, but when they can be seen they appear as rather coarse, regular, continuous rings tending to follow the irregularities of the margin. The number could not be determined.

The grains vary in *size* from 2 to 42μ. The common size is 28μ.

Polariscopic Properties.—The *figure* is usually eccentric and, as a rule, not clear-cut. In some grains its lines are wider and not clearly outlined and are often somewhat bent and otherwise distorted.

The degree of *polarization* is high. It varies greatly in different grains, in different aspects of the same grain, and in different parts of the same aspect. It is lower than that of the grains of *N. horsfieldii*.

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens slowly. The color is the same as that of the grains of *N. horsfieldii.* After heating in water until all the grains are completely gelatinized, the solution colors fairly deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the grain-residues less. With an excess of iodine the capsules color violet, and most of them contain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain in 3 minutes and in 30 minutes they are but lightly stained. The coloration is less than that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain very lightly in a minute and in 30 minutes they are lightly stained. The reaction is less than that of the grains of *N. horsfieldii.*

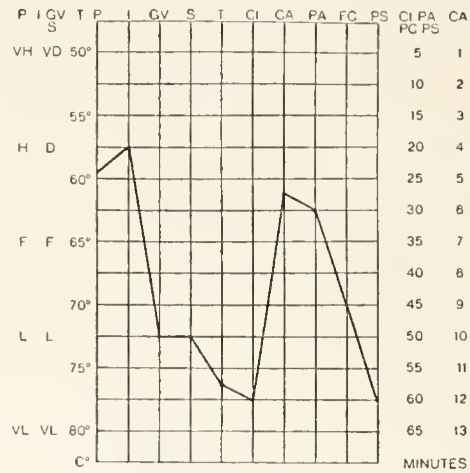
Temperature Reaction.—The temperature of gelatinization is 75.5° to 77° C., mean 76.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some grains in a minute and in most of the grains in 3 minutes. About one-fifth are gelatinized in 15 minutes, one-fourth in 30 minutes, one-half in 55 minutes, and two-thirds in 1¼ hours. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

Reaction with *chromic acid* begins in 45 seconds and is over in 5½ minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *pyrogallic acid* begins in some grains in 30 seconds and is general in 3 minutes. Some are completely gelatinized in 10 minutes, one-third in 15 minutes, one-half in 20 minutes, and nearly all in 30 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

Chart No. 233.



Curve of Reaction-Intensities of Starch of Narcissus incomparabilis.

The reaction with *ferric chloride* begins in some grains in 4 minutes. Most of the grains are completely gelatinized in 30 minutes and all in 45 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *Purdy's solution* there is a slight reaction in a few grains in 1½ minutes, and these become partially gelatinized in 20 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

STARCH OF NARCISSUS ODORUS. (Plate 60, figs. 357 and 358. Chart 234.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains and aggregates, usually of two components. Grains with pressure facets were rare. The surface of the grains is often irregular, owing to small projections and depressions. The conspicuous forms are ovoid to oval and elliptical. There are spherical, triangular, irregularly pyriform, dome-shaped, hemispherical, and various irregular forms. Broad grains are commonly about half as thick as they are broad, but the narrow grains are about as thick as wide.

The *hilum* is usually a small, not very distinct round spot, eccentric about two-fifths to one-third of the longitudinal axis, seldom double or multiple. It is also occasionally elongated or lenticular in form. It is rarely fissured, and the fissuration is in the form of a single line, or a small cross, and clear-cut; or very rarely it is irregularly stellate.

The *lamellæ* are not distinct; on many grains they are invisible. When they can be made out they appear as irregular, continuous rings much more distinct near the hilum, and rather fine in comparison with the lamellæ of other narcissi. There are about 10 to 12 on the larger grains.

The grains vary in *size* from 3 to 38μ. The common size is 22μ.

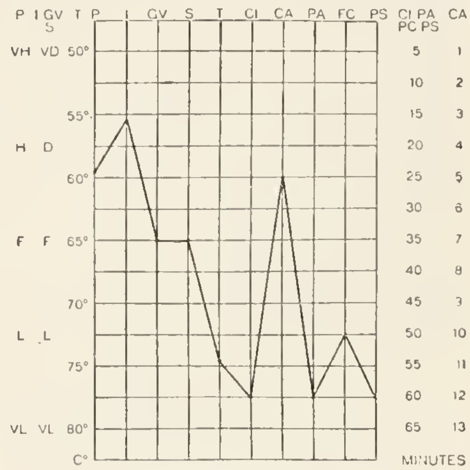
Polariscopic Properties.—The *figure* is usually eccentric and distinct, generally not clear-cut, but in many grains the lines are blurred and indistinct, and often bent or otherwise distorted.

The degree of *polarization* is fairly high. It varies much in different grains, in different aspects of the same grain, and may be very low or almost absent in large areas of the same aspect of a given grain. It is less variable and slightly less in degree than in the grains of *N. horsfieldii.*

With *selenite* the quadrants are very poorly defined in most grains, and are irregular in shape and unequal in size. The colors are sometimes pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet; with 0.125 per cent solution they tint lightly and the color deepens slowly. The color is somewhat deeper than that of the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution and grains color deeply, some grains more than others. The grains which do not stain so deeply take on a violet color when a slight excess of iodine is added. After boiling for 2 minutes the solution stains more deeply, but the grain-residues less. Most of the capsules retain some blue-reacting starch and all are colored a pinkish-violet.

Chart No. 234.



Curve of Reaction-Intensities of Starch of Narcissus odorus.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and are fairly stained after 30 minutes. The depth of color is the same as that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain very lightly in 2 minutes and in 30 minutes are fairly stained. The depth of color is the same as that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 74° to 75° C., mean 74.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains react in 2½ minutes and the reaction is general in 3½ minutes. All are gelatinized, with the exception of a few near the edges of the cover-slip, in 2 hours. There was no further change. The reaction is qualitatively the same as that observed of the grains of *N. horsfieldii.*

With *chromic acid* some of the grains react in 30 seconds, the reaction is general in a minute, and complete in 5 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

There is a reaction with *pyrogallic acid* in many grains in 2 minutes. A few are gelatinized in 30 seconds, and at this time all the grains are more or less affected. About three-fourths are fully gelatinized in 45 minutes and the others are in all stages of reaction. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

There is a reaction with *ferric chloride* of a few grains in 4 minutes. A few are completely gelatinized and many others show some reaction in 3½ minutes. All the grains are completely gelatinized in 45 minutes. The reaction is qualitatively the same as that of *N. horsfieldii.*

With *Purdy's solution* there is a slight reaction in some grains in 15 minutes. One was fully gelatinized and a few others showed a slight enlargement of the hilum and fine striæ radiating throughout the grain in 45 minutes. There was no further change. The reaction is qualitatively the same as that of *N. horsfieldii.*

STARCH OF NARCISSUS POETICUS. (Plate 60, figs. 359 and 360. Chart 235.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains and aggregates. Grains with pressure facets are rare. The surface of the grains is usually very irregular, owing to unequal development, especially to nipple-like processes. The conspicuous forms are the ovoid, oval, and elliptical. There are also spherical, triangular, irregularly pyriform, rod-like, lenticular, and very irregular forms. The grains if broad are about half as thick as they are wide, while the narrow forms are of the same thickness as width.

The *hilum* is a distinct round or lenticular spot and nearly always fissured. It is usually eccentric from two-fifths to one-third of the longitudinal axis. There are often double or multiple hila, which are usually traversed by a long, irregular fissure having many side branches at each hilum. In the case of the single hilum the fissures may be large or small, simple, transverse, diagonal, or longitudinal, clean-cut or ragged, or the combination may be 3-armed in the form of a cross, or irregularly stellate.

The *lamellæ* are not very distinct, but usually can be seen. Near the hilum, where they are seen with less difficulty, they appear as coarse, regular, continuous rings which do not follow the outline of the margin. As far as could be determined, there are about 5 to 6 on the larger grains.

The grains vary in *size* from 3 to 44μ. The common size is 28μ.

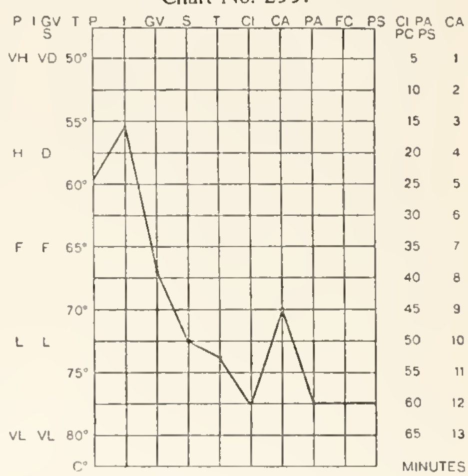
Polariscopic Properties.—The *figure* is usually not clear-cut, but commonly distinct. One or two lines may be very broad and indistinct, and they are often much bent or otherwise distorted, often especially at the margin of the grain.

The degree of *polarization* is high. It is very variable in different grains, and varies in different aspects of the same grain. It may be absent in some parts and very low in certain other parts of the same grain. It is lower than in the grains of *N. horsfieldii.*

With *selenite* the quadrants are not as a rule sharply defined and are very irregular in shape and unequal in size. The colors are sometimes pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply a blue-violet; with 0.125 per cent solution they tint lightly and the color deepens slowly. The color is slightly deeper than that in the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution is colored deeply and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution is colored much deeper, but the grain-residues much less deeply. All the capsules contain some blue-reacting starch. With an excess of iodine the capsules are colored blue.

Chart No. 235.



Curve of Reaction-Intensities of Starch of Narcissus poeticus.

Staining Reactions.—With *gentian violet* the grains stain at once lightly and after 30 minutes are fairly stained. The color is slightly less than that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain very lightly in 30 seconds, and in 30 minutes are slightly stained. The color is less than that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 72.5° to 74° C., mean 73.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is a reaction in many grains in 4 minutes. About three-fourths of the grains are gelatinized in an hour. The remaining one-fourth are, as a rule, unaffected. There was no further change. The reaction is qualitatively the same as that in the grains of *N. horsfieldii.*

With *chromic acid* there is a general reaction in a minute which is over in 9 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

There is a general reaction with *pyrogallic acid* in 2 minutes and in 35 minutes about half are fully gelatinized. The other half of the grains are affected and in all stages of reaction. There was no further change. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *ferric chloride* a number of grains begin to react in 3 minutes and all are not affected, but about one-fifth are fully gelatinized in 10 minutes. All are reacting and almost all completely gelatinized in 45 minutes, and the reaction is complete in 1¼ hours. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

Reaction with *Purdy's solution* begins in a few grains in 2 minutes, but at the end of an hour only a few more were affected and only one or two were completely gelatinized. There was no further change. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

STARCH OF NARCISSUS BIFLORUS. (Plate 61, figs. 361 and 362. Chart 236.)

Histological Characteristics.—In *form* the grains are usually simple. There are very few compound grains and aggregates. Pressure facets are very rare. The surface of the grains is generally irregular, owing to additions in the form of rounded protrusions and nipple-like projections. The conspicuous forms are the ovoid to the oval and elliptical. There are some spherical, irregular quadrangular forms with rounded angles, lenticular, triangular, and various irregular forms. The triangular and quadrangular forms are about three-fourths as thick as they are broad, and the ovoid and other forms generally are as thick as they are broad.

The *hilum*, when not fissured, is an indistinct, small, round or rarely lenticular spot, usually eccentric about one-third to two-fifths of the longitudinal axis, and either in or slightly to one side of the median line. It is almost invariably fissured, and the fissuration may be in the form of a single straight or double curved transverse line, or a 3-armed figure, or a cross, or large and very irregular and ragged. There may be double and even multiple hila.

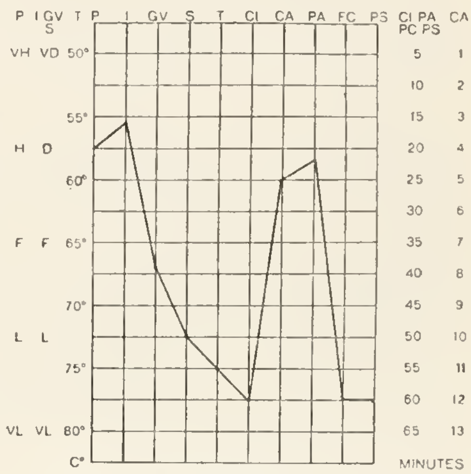
The *lamellæ* are commonly invisible, and when they can be seen they appear as fairly regular, coarse rings which tend to follow the outline of the margin. The number could not be determined.

The grains vary in *size* from 3 to 40μ. The common size is 26μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and generally not sharply defined. One or two of its lines may be broadened and not clear-cut in some parts of their length, and they may be bent and otherwise distorted.

The degree of *polarization* is high. It varies greatly in different grains, also in different aspects of the same grain and in the same aspect of a given grain. It is about the same as that of the grains of *N. horsfieldii.*

Chart No. 236.



Curve of Reaction-Intensities of Starch of Narcissus biflorus.

With *selenite* the quadrants are not, as a rule, sharply defined, and are irregular in shape and unequal in size. The colors are sometimes pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly and the color deepens slowly. The grains are colored more deeply than those of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors more deeply and the grain-residues less. The capsules color violet with an excess of iodine, and all of them retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain in 3 minutes and in 30 minutes are fairly stained, some more than others. The color is somewhat less than that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain in 3 minutes, and in 30 minutes are lightly stained, but every one of the same shade. The color is less than that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 74° to 76° C., mean 75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in 3 minutes. About one-fourth are completely gelatinized in 15 minutes, one-third in 25 minutes, one-half in 35 minutes, and two-thirds in 50 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *chromic acid* begins in some grains in 30 seconds, in all in a minute, and is over in 5 minutes. It is the same qualitatively as that of the grains of *N. horsfieldii.*

Reaction with *pyrogallic acid* begins in all the grains in 2½ minutes. About one-fourth are completely gelatinized in 8 minutes, one-half in 11 minutes, two-thirds in 15 minutes, and all in 22 minutes. The reaction is the same qualitatively as that of the grains of *N. horsfieldii.*

The reaction with *ferric chloride* begins in a few in 3 minutes. About one-fourth are gelatinized in 22 minutes, one-half in 28 minutes, nearly all in 50 minutes, and all in an hour. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *Purdy's solution* there is a slight reaction in a few grains in 15 minutes. The reaction is the same qualitatively as that of *N. horsfieldii.*

STARCH OF NARCISSUS JONQUILLA. (Plate 61, figs. 363 and 364. Chart 237.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains and aggregates. Pressure facets are rare. In some instances it is impossible to determine whether the grains are compound or simple grains with multiple hila. The surface of the grains is often irregular, owing chiefly to rounded protrusions and nipple-like processes. The conspicuous forms are ovoid to oval and elliptical, irregularly quadrilateral and triangular. There are also lenticular, pyriform having a narrow part which is often very small, polygonal forms, hemispherical, wedge-shaped, and various irregular forms. The broad grains are commonly about half as thick as wide, and narrower towards the distal end. The narrow grains are of about the same thickness as width, and when seen on edge appear as elongated ovoid grains.

The *hilum* is not very distinct, and is rather small and round. It is usually eccentric about two-fifths to one-fifth of the longitudinal axis. It may be double or multiple. It is sometimes fissured, but the fissure is seldom deep or wide, and it may be simple, transverse, or diagonal, or 3-armed, or a cross; it may be clear-cut; it infrequently is irregularly stellate.

The *lamellæ* are not very distinct, but are more distinct near the hilum than near the margin. When they can be seen they appear as continuous, coarse, fairly regular rings, which tend to follow the outline of the margin. The number was not determined.

The grains vary in *size* from 3 to 34μ. The common size is 20μ.

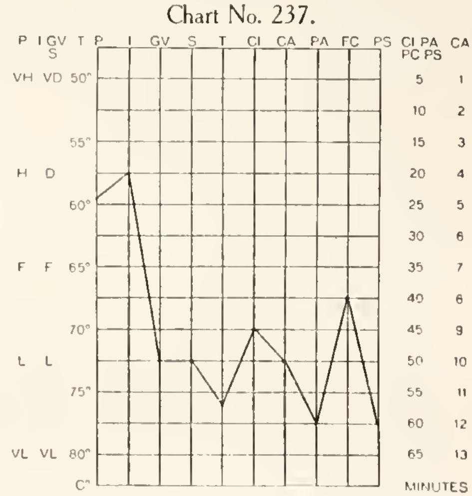
Polariscopic Properties.—The *figure* is usually eccentric and generally not very distinct or clear-cut. Its lines are often somewhat bent and otherwise distorted.

The degree of *polarization* is high; very variable in different grains, with the position of the grain, and in different parts of the same aspect of a given grain. It is not so high as that of the grains of *N. horsfieldii.*

With *selenite* the quadrants are as a rule not sharply defined, irregular in shape, and unequal in size. The colors are sometimes pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a deep blue-violet; with 0.125 per cent solution they tint very lightly and the color does not deepen rapidly. The depth of color is about the same as that of the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution is colored deeply and the grains mostly very deeply on the addition of iodine. Some grains which do not color so deeply as the rest have a violet color. After boiling for 2 minutes the solution is colored more deeply, but the grain-residues much less. Most of the capsules still contain some blue-reacting starch. When an excess of iodine is used all of them have a dark-violet color.

Chart No. 237.



Curve of Reaction-Intensities of Starch of Narcissus jonquilla.

Staining Reactions.—With *gentian violet* the grains stain at once, but very lightly, and after 30 minutes are still lightly stained. The color is less than that of the grains of *N. horsfieldii.*

With *safranin* the grains stain very slightly at once and after 30 minutes the stain is light. This reaction is less than that to gentian violet and the color is less than that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 75° to 77° C., mean 76°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is some reaction in a few grains in a minute and the majority begin to react in 3 minutes. All are affected and one-half are gelatinized in 15 minutes, and all excepting a very few are gelatinized in 45 minutes. There was practically no further change. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *chromic acid* begins in a minute and is over in 10 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

There is a slight reaction with *pyrogallic acid* in a few grains in 2 minutes and it is general in 10 minutes. A few grains are completely gelatinized in 20 minutes and half are gelatinized in an hour. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *ferric chloride* a few grains are gelatinized and a few others show the beginning of a reaction in 4 minutes, and most of the grains begin to react in 6 minutes. About three-fourths are gelatinized in 20 minutes and all in 40 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

There is a slight reaction with *Purdy's solution* in a few grains in 15 minutes, but after 2 hours there was no further change.

STARCH OF NARCISSUS JONQUILLA VAR. RUGULOSUS. (Plate 61, figs. 365 and 366. Chart 238.)

Histological Characteristics.—In *form* the grains are simple. A few occur in aggregates. Poorly defined pressure facets are rarely seen. The surface is generally irregular, owing to inequalities of development. In some cases the grains often have an outer coating of starch, which is not lamellated, except when the primary grain is very small. The conspicuous forms are the ovoid to oval and elliptical; also lenticular, irregularly quadrilateral and triangular with rounded corners, reniform, and almost spherical. The quadrilateral and reniform and some of the broad ovoid forms are from one-half to three-fourths as thick as they are broad.

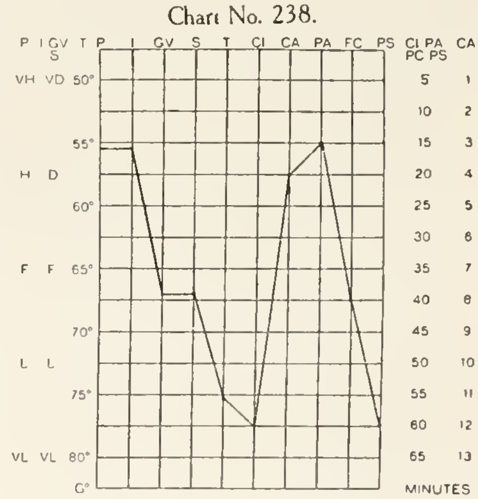
The *hilum* is a small, not very distinct, round or lenticular spot, usually eccentric about one-third of the longitudinal axis of the grain and in or to one side of the median line. It is generally fissured, and the fissuration is usually in the form of a single, small, and clean-cut, straight, transverse line. It may be as a cross or a variable arrangement, especially in an irregularly stellate fashion. No multiple hila were observed.

The *lamellæ* are usually indistinct, but when they can be seen they appear as rather coarse, continuous, regular rings which follow the outline of the margin. There are about 6 to 10 on the larger grains.

The grains vary in *size* from 4 to 50μ. The common size is 28μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and often clear-cut, but one or more of its lines may become broader and less well defined in some part of their course. The lines are also sometimes bent and otherwise distorted.

Chart No. 238.



Curve of Reaction-Intensities of Starch of Narcissus jonquilla var. rugulosus.

The degree of *polarization* is high. It varies somewhat in different grains, in different aspects of the same grain, and often very greatly in different parts of the same aspect of a grain. It is slightly higher than that of the grains of *N. horsfieldii.*

With *selenite* the quadrants are usually well defined, generally irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly. The color is slightly deeper than that of the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues not very deeply. The capsules all color a red-violet with an excess of iodine and most of them retain blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain very slightly in a minute and in 30 minutes are fairly stained. The color is not quite so deep as that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain very lightly at once and in 30 minutes are fairly stained. The color is not quite so deep as that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 74.5° to 76° C., mean 75.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 2½ minutes. About one-fourth of the grains are gelatinized in 10 minutes, one-half in 15 minutes, three-fourths in 23 minutes, and five-sixths in 15 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *chromic acid* begins in 45 seconds and is over in 4 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

Reaction with *pyrogallic acid* begins in 45 seconds and is over in 15 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *ferric chloride* begins in a few grains in 1½ minutes. About three-fourths are gelatinized in 10 minutes and all in 40 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

Reaction with *Purdy's solution* begins in many grains in 30 seconds and most of them are partially gelatinized in 3 minutes. About half are completely gelatinized in 20 minutes and two-thirds in 30 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

STARCH OF NARCISSUS JONQUILLA VAR. CAMPERNELLI RUGULOSUS.

(Plate 62, figs. 367 and 368. Chart 239.)

Histological Characteristics.—In *form* the grains are simple. There are a few aggregates. Pressure facets are rarely observed. The surface of the grains is somewhat irregular, owing to irregularities of development rather than additions to their surfaces, but grains are occasionally seen inclosed in a layer of starch of variable thickness. The conspicuous forms are the ovoid to oval, irregularly quadrilateral and triangular with very much rounded angles. In addition there are spherical, hemispherical, pyriform, lenticular, reniform, and many irregular shapes. The quadrilateral, reniform, and triangular grains are about one-half to three-fourths as thick as they are broad, and the ovoid and other rounded forms are commonly about as thick as broad.

The *hilum* is a fairly small, not very distinct, round spot, usually eccentric about one-fourth to one-third of the longitudinal axis of the grain and on or to one side of the median line. It is often fissured and the fissures are usually small and clear-cut. There may be one transverse line, straight or with a double curve, or two irregular, ragged fissures radiating from the hilum, or a stellate arrangement. No multiple hila were observed.

The *lamellæ* are usually invisible, but when they can be seen they appear as fairly regular, coarse, continuous rings which follow closely the outline of the margin of the grain. The number could not be determined.

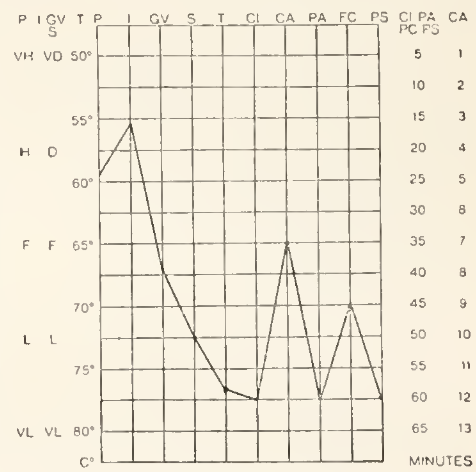
The grains vary in *size* from 3.5 to 44μ. The common size is 24μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and often clear-cut, but frequently one or more of the lines become broader and less well defined in some parts of their length. The lines are also often somewhat bent or otherwise distorted.

The *degree of polarization* is high. It varies much in different grains, in different aspects of the same grain, and often very much in different parts of the same aspect of a grain. It is about the same as that of the grains of *N. horsfieldii.*

With *selenite* the quadrants are usually not well defined, irregular in shape, and unequal in size. The colors are often pure.

Chart No. 239.



Curve of Reaction-Intensities of Starch of Narcissus jonquilla var. campernelli rugulosus.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens slowly. It is slightly deeper than that of the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains deeply on the addition of iodine. The capsules color a red-violet with an excess of iodine and most of them retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain in 2 minutes and in 30 minutes are but fairly stained. The color is very slightly less than that of the grains of *N. horsfieldii.*

With *safranin* the grains begin to stain in a minute and in 30 minutes they are but lightly stained. The color is less than that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 76° to 77° C., mean 76.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 1½ minutes and is over in a few in 3 minutes. It is nearly general in 5 minutes and in 10 minutes a few more are completely or partially gelatinized. About one-fourth are completely gelatinized in 35 minutes, one-third in 1¼ hours, and two-fifths in 1¾ hours. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

The reaction with *chromic acid* begins in a few grains in 45 seconds, in all in 1¼ minutes, and is over in 7 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

Reaction with *pyrogallic acid* begins in many grains in 1½ minutes and in 10 minutes a few are completely and most of the rest partially gelatinized. About four-fifths are completely gelatinized in 27 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *ferric chloride* a few grains react in 4 minutes. About one-third are gelatinized in 20 minutes, three-fourths in 25 minutes, and practically all in 45 minutes. The reaction is the same qualitatively as that of the grains of *N. horsfieldii.*

With *Purdy's solution* all the grains show a slight reaction in 20 minutes, but no further change. In so far as the reaction goes it is qualitatively the same as that of the grains of *N. horsfieldii.*

STARCH OF NARCISSUS TAZETTA VAR. ORIENTALIS. (Plate 62, figs. 369 and 370. Chart 240.)

Histological Characteristics.—In *form* the grains are simple. Rarely they occur in small aggregates. Pressure facets were very rarely observed. The surface of the grains is often very irregular, owing to unequal development and to secondary starchy deposits occurring in the form of projections, especially in the form of nipple-like processes. The conspicuous forms are the ovoid to oval and lenticular; also spherical, triangular, and quadrangular with rounded angles, pyriform, and various irregular shapes. The triangular, quadrangular, and pyriform grains are generally about one-half to three-fourths as thick as broad, but the ovoid and other rounded forms are commonly about as thick as broad.

The *hilum* is, as a rule, very indistinct. It is a small, round or rarely lenticular spot, usually eccentric from one-fifth to two-fifths of the longitudinal axis, and commonly to one side of the median line. It is often fissured, and the fissuration is usually in the form of a very small, transverse line, but sometimes longitudinal, large, ragged, or irregular.

The *lamellæ* are generally invisible, but sometimes appear as coarse, regular, continuous rings, which tend to follow closely the marginal outline. The number was not determined.

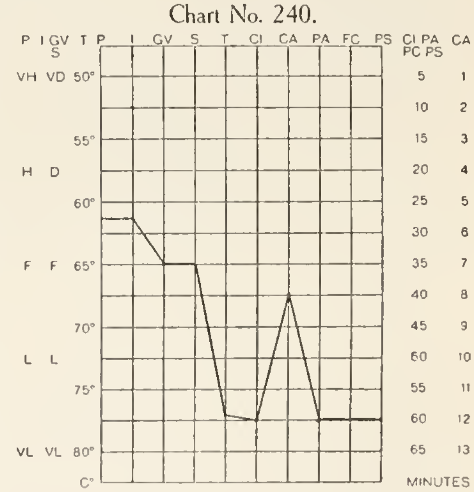
The grains vary in *size* from 4 to 54μ. The common size is 34μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and sometimes clear-cut, but its lines often broaden and are not clearly defined in some part of their length, also somewhat bent and otherwise distorted.

The degree of *polarization* is high. It varies in different grains, in different aspects of the same grain, and in different parts of the same aspect of a grain. It is higher than that of the grains of *N. horsfieldii.*

With *selenite* the quadrants are usually well defined, generally irregular in shape, and unequal in size. The colors are usually not pure.

Chart No. 240.



Curve of Reaction-Intensities of Starch of Narcissus tazetta var. orientalis.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly and the color deepens slowly. It is lighter than that of the grains of *N. horsfieldii.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues much less. The capsules are colored a red-violet with an excess of iodine and most of them retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are fairly stained. The color is the same as that of the grains of *N. horsfieldii.*

Temperature Reaction.—The temperature of gelatinization is 76° to 78° C., mean 77°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in many grains in a minute. About one-fifth are gelatinized in 30 minutes and one-fourth in an hour. The reaction is the same qualitatively as that of the grains of *N. horsfieldii.*

The reaction with *chromic acid* begins in 1½ minutes and is over in 8 minutes. It is qualitatively the same as that of the grains of *N. horsfieldii.*

Reaction with *pyrogallic acid* is slight but general in 2½ minutes. About one-fifth of the grains are completely gelatinized in 16 minutes, one-half in 20 minutes, and two-thirds in 25 minutes. The reaction is qualitatively the same as that of the grains of *N. horsfieldii.*

With *ferric chloride* the reaction begins in a very few grains in 3 minutes. It is complete in half the grains in 18 minutes and in all in an hour. It is the same qualitatively as that of the grains of *N. horsfieldii.*

There was no reaction with *Purdy's solution.*

Differentiation of Certain Starches of the Genus Narcissus.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

N. horsfieldii: Usually simple, rarely compounds and aggregates, rarely pressure facets, surface somewhat irregular. Ovoid to oval and elliptical.

N. maximus: Usually simple, few compounds and aggregates, few pressure facets, surface often very irregular. Ovoid to oval and elliptical, lenticular and nearly spherical.

N. bulbocodium: Usually simple, some compounds and aggregates, some well-defined pressure facets, aggregates generally fairly regular. Ovoid to oval and elliptical.

N. bulbocodium var. *conspicua:* Usually simple, few compounds and aggregates, rarely pressure facets, often irregular. Ovoid to oval and elliptical.

N. bulbocodium var. *monophyllus:* Usually simple, rare compounds and aggregates, rarely pressure facets, somewhat irregular. Ovoid to oval and elliptical.

N. incomparabilis: Usually simple, rarely compounds and aggregates, rarely pressure facets, surface irregular. Ovoid to oval and elliptical.

N. odorus: Usually simple, a few compounds and aggregates, rarely no pressure facets, surface often irregular. Ovoid to oval and elliptical.

N. poeticus: Usually simple, few compounds and aggregates, pressure facets rare, surface very irregular. Ovoid to oval and elliptical.

N. biflorus: Usually simple, rarely compounds and aggregates, pressure facets rare, surface sometimes irregular. Ovoid to oval and elliptical.

N. jonquilla: Usually simple, few compounds and aggregates, pressure facets rare, surface often irregular. Ovoid to oval and elliptical, irregularly quadrilateral and triangular.

N. jonquilla var. *rugulosus:* Usually simple, few aggregates, rarely poorly defined pressure facets, surface irregular. Ovoid to oval and elliptical, irregularly quadrilateral and triangular.

N. jonquilla var. *campernelli rugulosus:* Usually simple, few small aggregates, rarely pressure facets, surface somewhat irregular. Ovoid to oval, irregularly quadrilateral and triangular.

N. tazetta var. *orientalis:* Simple, few small aggregates, rarely pressure facets, surface somewhat irregular. Ovoid to oval, irregularly quadrilateral and triangular.

Hilum—Form, Number, and Position.

N. horsfieldii: Form fairly distinct, small, round or lenticular; single or multiple; often fissured, fissure usually small, clean-cut or ragged. Position usually eccentric, about 0.4 to 0.25 of longitudinal axis.

N. maximus: Form not very distinct, small, round; often fissured, fissure usually small and clean-cut. Position usually eccentric, about 0.33 to 0.25 of longitudinal axis.

N. bulbocodium: Form not very distinct, comparatively small, round, lenticular or ellipsoidal, may be multiple; often fissured, commonly one long fissure often with branches. Position usually eccentric, about 0.4 to 0.33 of longitudinal axis.

N. bulbocodium var. *conspicua:* Form not very distinct, small, round or lenticular; often fissured, fissure usually small, ragged and irregular. Position usually eccentric, about 0.4 to 0.33 of longitudinal axis.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.—Continued.

N. bulbocodium var. *monophyllus:* Form not very distinct, small, round or lenticular; usually fissured, fissure usually small and irregular. Position usually eccentric, about 0.4 to 0.33 of longitudinal axis.

N. incomparabilis: Form not very distinct, small, round or lenticular; usually fissured, fissure usually small and ragged. Position usually eccentric, about 0.4 of longitudinal axis.

N. odorus: Form not very distinct, small, round or lenticular; rarely fissured; fissure usually small and clear-cut. Position usually eccentric, about 0.4 to 0.33 of longitudinal axis.

N. poeticus: Form single and multiple; distinct as a round or lenticular spot; nearly always fissured, fissures large or small, clear-cut or ragged. Position usually eccentric, about 0.4 to 0.33 of longitudinal axis.

N. biflorus: Form indistinct, small, round or rarely multiple; almost invariably fissured, fissuration varied. Position usually eccentric, about 0.4 to 0.33 of longitudinal axis.

N. jonquilla: Form not very distinct, rather small, single or multiple, round; sometimes fissured, fissure usually small, variable. Position usually eccentric, about 0.4 to 0.2 of longitudinal axis.

N. jonquilla var. *rugulosus:* Form not very distinct, small, round or lenticular; usually fissured, fissure usually small and clean-cut. Position usually eccentric, about 0.33 of longitudinal axis.

N. jonquilla var. *compernelli rugulosus:* Form not very distinct, small, round; often fissured, fissures usually small and usually clean-cut. Position usually eccentric, about 0.33 to 0.25 of longitudinal axis.

N. tazetta var. *orientalis:* Form usually very indistinct, small, round to rarely lenticular; often fissured, fissure usually very small. Position usually eccentric, about 0.4 to 0.2 of longitudinal axis.

Lamellæ—General Characteristics and Number.

N. horsfieldii: Distinct, rather fine, often irregular, continuous rings. 12 to 14 on the larger grains.

N. maximus: Not very distinct, rather fine, fairly regular, continuous rings. 8 to 12 on the larger grains.

N. bulbocodium: Not distinct, comparatively coarse, fairly regular, continuous rings. 6 to 10 on the larger grains.

N. bulbocodium var. *conspicua:* Rather indistinct, coarse, regular, continuous rings. 6 to 8 on the larger grains.

N. bulbocodium var. *monophyllus:* Not very distinct, coarse, regular, continuous. 5 to 7 on the larger grains.

N. incomparabilis: As a rule. invisible, coarse, regular, continuous rings. Number not determined.

N. odorus: Not distinct, irregular, continuous rings, rather fine. 10 to 12 on the larger grains.

N. poeticus: Not very distinct, coarse, regular, continuous rings. 5 to 6 on the larger grains.

N. biflorus: Commonly invisible, fairly regular, coarse, continuous rings. Number not determined.

N. jonquilla: Not very distinct, coarse, fairly regular, continuous, coarse rings. Number not determined.

N. jonquilla var. *rugulosus:* Usually indistinct, regular, rather coarse, continuous rings. 6 to 10 on the larger grains.

Differentiation of Certain Starches of the Genus Narcissus.—Continued.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.—Cont'd.

N. jonquilla var. *campernelli rugulosus:* Usually invisible, fairly regular, coarse, continuous rings. Number not determined.

N. tazetta var. *orientalis:* Usually invisible, coarse, regular, continuous rings. Number not determined.

Size.

N. horsfieldii: From 3 to 48μ, usually 32μ.
N. maximus: From 4 to 42μ, usually 26μ.
N. bulbocodium: From 5 to 54μ, usually 32μ.
N. bulbocodium var. *conspicua:* From 4 to 40μ, usually 24μ.
N. bulbocodium var. *monophyllus:* From 3 to 42μ, usually 22μ.
N. incomparabilis: From 2 to 42μ, usually 28μ.
N. odorus: From 3 to 40μ, usually 24μ.
N. poeticus: From 3 to 44μ, usually 28μ.
N. biflorus: From 3 to 40μ, usually 26μ.
N. jonquilla: From 3 to 34μ, usually 20μ.
N. jonquilla var. *rugulosus:* From 4 to 50μ, usually 28μ.
N. jonquilla var. *campernelli rugulosus:* From 3.5 to 44μ, usually 24μ.
N. tazetta var. *orientalis:* From 4 to 54μ, usually 34μ.

Polariscopic Properties.

Figure.

N. horsfieldii: Usually eccentric, distinct, usually not clear-cut, often distorted.
N. maximus: Essentially the same as in *N. horsfieldii.*
N. bulbocodium: Essentially the same as in *N. horsfieldii.*
N. bulbocodium var. *conspicua:* Essentially the same as in *N. horsfieldii.*
N. bulbocodium var. *monophyllus:* Essentially the same as in *N. horsfieldii.*
N. incomparabilis: Essentially the same as in *N. horsfieldii.*
N. odorus: Essentially the same as in *N. horsfieldii.*
N. poeticus: Essentially the same as in *N. horsfieldii.*
N. biflorus: Essentially the same as in *N. horsfieldii.*
N. jonquilla: Essentially the same as in *N. horsfieldii.*
N. jonquilla var. *rugulosus:* Essentially the same as in *N. horsfieldii.*
N. jonquilla var. *campernelli rugulosus:* Essentially the same as in *N. horsfieldii.*
N. tazetta var. *orientalis:* Essentially the same as in *N. horsfieldii.*

Degree of Polarization.

N. horsfieldii: High, very variable.
N. maximus: High, very variable, the same as in *N. horsfieldii.*
N. bulbocodium: High, variable, not so high as in *N. horsfieldii.*
N. bulbocodium var. *conspicua:* High, not very variable and slightly less than in *N. horsfieldii.*
N. bulbocodium var. *monophyllus:* High, variable, not quite so high as in *N. horsfieldii.*
N. incomparabilis: High, very variable, not so high as in *N. horsfieldii.*
N. odorus: High, less variable and not so high as in *N. horsfieldii.*
N. poeticus: High, variable, not so high as in *N. horsfieldii.*
N. biflorus: High, very variable, the same as in *N. horsfieldii.*
N. jonquilla: High, very variable, not so high as in *N. horsfieldii.*
N. jonquilla var. *rugulosus:* High, somewhat variable, slightly higher than in *N. horsfieldii.*
N. jonquilla var. *campernelli rugulosus:* High, very variable, not so high as in *N. horsfieldii.*
N. tazetta var. *orientalis:* High, very variable, slightly lower than in *N. horsfieldii.*

Polariscopic Properties.—Continued.

Polarization with Selenite—Quadrants and Colors.

N. horsfieldii: Quadrants usually not well defined, irregular in shape and unequal in size. Colors sometimes pure.
N. maximus: Quadrants the same as in *N. horsfieldii.* Colors sometimes pure.
N. bulbocodium: Quadrants usually well defined, irregular in shape and unequal in size. Colors usually very pure.
N. bulbocodium var. *conspicua:* Quadrants usually well defined, irregular in shape and unequal in size. Colors usually very pure.
N. bulbocodium var. *monophyllus:* Quadrants usually well defined, irregular in shape and unequal in size. Colors usually pure.
N. incomparabilis: Quadrants usually well defined, irregular in shape and unequal in size. Colors usually pure.
N. odorus: Quadrants usually poorly defined, irregular in shape and unequal in size. Colors sometimes pure.
N. poeticus: Quadrants usually not well defined, irregular in shape and unequal in size. Colors sometimes pure.
N. biflorus: Quadrants usually not well defined, irregular in shape and unequal in size. Colors sometimes pure.
N. jonquilla: Quadrants usually not well defined, irregular in shape, and unequal in size. Colors sometimes pure.
N. jonquilla var. *rugulosus:* Quadrants usually well defined, generally irregular in shape and unequal in size. Colors usually pure.
N. jonquilla var. *campernelli rugulosus:* Quadrants usually not well defined, irregular in shape and unequal in size. Colors often pure.
N. tazetta var. *orientalis:* Quadrants usually well defined, irregular in shape and unequal in size. Colors usually not pure.

Iodine Reactions.

Intensity and Color.

N. horsfieldii: Deep; blue-violet.
N. maximus: Deep, slightly deeper than in *N. horsfieldii;* blue-violet.
N. bulbocodium: Deep, slightly deeper than in *N. horsfieldii;* blue-violet.
N. bulbocodium var. *conspicua:* Deep, slightly deeper than in *N. horsfieldii;* blue-violet.
N. bulbocodium var. *monophyllus:* Deep, the same as in *N. horsfieldii;* blue-violet.
N. incomparabilis: Deep, the same as in *N. horsfieldii;* blue-violet.
N. odorus: Deep, slightly deeper than in *N. horsfieldii;* blue-violet.
N. poeticus: Deep, slightly deeper than in *N. horsfieldii;* blue-violet.
N. biflorus: Deep, deeper than in *N. horsfieldii;* blue-violet.
N. jonquilla: Deep, the same as in *N. horsfieldii;* blue-violet.
N. jonquilla var. *rugulosus:* Deep, slightly deeper than in *N. horsfieldii;* blue-violet.
N. jonquilla var. *campernelli rugulosus:* Deep, slightly deeper than in *N. horsfieldii;* blue-violet.
N. tazetta var. *orientalis:* Fairly deep, less than in *N. horsfieldii;* blue-violet.

Staining Reactions.

With Gentian Violet.

N. horsfieldii: Fair.
N. maximus: Light, much less than in *N. horsfieldii.*
N. bulbocodium: Light, slightly less thau in *N. horsfieldii.*
N. bulbocodium var. *conspicua:* Light, less than in *N. horsfieldii.*

Differentiation of Certain Starches of the Genus Narcissus.—Continued.

STAINING REACTIONS.—Continued.

With Gentian Violet.—Continued.

N. bulbocodium var. *monophyllus:* Fair, slightly less than in *N. horsfieldii.*
N. incomparabilis: Light, less than in *N. horsfieldii.*
N. odorus: Fair, the same as in *N. horsfieldii.*
N. poeticus: Fair, slightly less than in *N. horsfieldii.*
N. biflorus: Fair, somewhat less than in *N. horsfieldii.*
N. jonquilla: Light, less than in *N. horsfieldii.*
N. jonquilla var. *rugulosus:* Fair, slightly less than in *N. horsfieldii.*
N. jonquilla var. *campernelli rugulosus:* Fair, slightly less than in *N. horsfieldii.*
N. tazetta var. *orientalis:* Fair, the same as in *N. horsfieldii.*

With Safranin.

N. horsfieldii: Fair.
N. maximus: Fair, slightly less than in *N. horsfieldii.*
N. bulbocodium: Light, less than in *N. horsfieldii.*
N. bulbocodium var. *conspicua:* Light, less than in *N. horsfieldii.*
N. bulbocodium var. *monophyllus:* Light, less than in *N. horsfieldii.*
N. incomparabilis: Light, less than in *N. horsfieldii.*
N. odorus: Fair, the same as in *N. horsfieldii.*
N. poeticus: Light, less than in *N. horsfieldii.*
N. biflorus: Light, less than in *N. horsfieldii.*
N. jonquilla: Light, less than in *N. horsfieldii.*
N. jonquilla var. *rugulosus:* Fair, slightly less than in *N. horsfieldii.*
N. jonquilla var. *campernelli rugulosus:* Light, less than in *N. horsfieldii.*
N. tazetta var. *orientalis:* Fair, the same as in *N. horsfieldii.*

TEMPERATURE OF GELATINIZATION.

N. horsfieldii: 73 to 75° C., mean 74°.
N. maximus: 74.5 to 76° C., mean 75.25°.
N. bulbocodium: 71 to 73° C., mean 72°.
N. bulbocodium var. *conspicua:* 72 to 73.5° C., mean 72.75°.
N. bulbocodium var. *monophyllus:* 73 to 75° C., mean 74°.
N. incomparabilis: 75.5 to 77° C., mean 76.25°.
N. odorus: 74 to 75° C., mean 74.5°.
N. poeticus: 72.5 to 74° C., mean 73.25°.
N. biflorus: 74 to 76° C., mean 75°.
N. jonquilla: 75 to 77° C., mean 76°.
N. jonquilla var. *rugulosus:* 74.5 to 76° C., mean 75.25°.
N. jonquilla var. *campernelli rugulosus:* 76 to 77° C., mean 76.5°.
N. tazetta var. *orientalis:* 76 to 78° C., mean 77°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

N. horsfieldii: Begins in most in 4 minutes; complete in four-fifths in 60 minutes.
N. maximus: Begins in most in 3 minutes; complete in two-thirds in 75 minutes.
N. bulbocodium: Begins in most in 3 minutes; complete in half in 55 minutes.
N. bulbocodium var. *conspicua:* Begins in most in 3 minutes; complete in half in 45 minutes.
N. bulbocodium var. *monophyllus:* Begins in most in 3 minutes; complete in three-fourths in 45 minutes.
N. incomparabilis: Begins in most in 3 minutes; complete in two-thirds in 75 minutes.
N. odorus: Begins in most in 3½ minutes; complete in 120 minutes.
N. poeticus: Begins in most in 4 minutes; complete in three-fourths in 60 minutes.
N. biflorus: Begins in most in 3 minutes; complete in two-thirds in 50 minutes.
N. jonquilla: Begins in most in 3 minutes; complete in all but a few in 45 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chloral Hydrate-Iodine.—Continued.

N. jonquilla var. *rugulosus:* Begins in most in 2½ minutes; complete in five-sixths in 15 minutes.
N. jonquilla var. *campernelli rugulosus:* Begins in most in 5 minutes; complete in two-fifths in 105 minutes.
N. tazetta var. *orientalis:* Begins in many in 1 minute; complete in one-fourth in 60 minutes.

Reaction with Chromic Acid.

N. horsfieldii: Begins in 1½ minutes; complete in 14 minutes.
N. maximus: Begins in 1½ minutes; complete in 5 minutes.
N. bulbocodium: Begins in 1 minute; complete in 8 minutes.
N. bulbocodium var. *conspicua:* Begins in 1 minute; complete in 6 minutes.
N. bulbocodium var. *monophyllus:* Begins in 45 seconds; complete in 5 minutes.
N. incomparabilis: Begins in 45 seconds; complete in 5½ minutes.
N. odorus: Begins in 1 minute; complete in 5 minutes.
N. poeticus: Begins in 1 minute; complete in 9 minutes.
N. biflorus: Begins in 1 minute; complete in 5 minutes.
N. jonquilla: Begins in 1 minute; complete in 10 minutes.
N. jonquilla var. *rugulosus:* Begins in 45 seconds; complete in 4 minutes.
N. jonquilla var. *campernelli rugulosus:* Begins in 1¼ minutes, complete in 7 minutes.
N. tazetta var. *orientalis:* Begins in 1½ minutes; complete in 8 minutes.

Reaction with Pyrogallic Acid.

N. horsfieldii: Begins in 4 minutes; complete in two-thirds in 60 minutes.
N. maximus: Begins in 2½ minutes; complete in 35 minutes.
N. bulbocodium: Begins in 1 minute; complete in 45 minutes.
N. bulbocodium var. *conspicua:* Begins in 2 minutes; complete in 20 minutes.
N. bulbocodium var. *monophyllus:* Begins in 45 seconds; complete in 13 minutes.
N. incomparabilis: Begins in 3 minutes; complete in all but a few in 30 minutes.
N. odorus: Begins in many in 2 minutes; about one-fourth partially and three-fourths completely gelatinized in 45 minutes.
N. poeticus: Begins in 2 minutes; complete in half in 35 minutes.
N. biflorus: Begins in 2½ minutes; complete in all in 22 minutes.
N. jonquilla: Begins in many in 2 minutes; about half are partially and half completely gelatinized in 60 minutes.
N. jonquilla var. *rugulosus:* Begins in 45 seconds; complete in 15 minutes.
N. jonquilla var. *campernelli rugulosus:* Begins in many in 1½ minutes; about four-fifths are completely gelatinized in 27 minutes.
N. tazetta var. *orientalis:* Begins in 2½ minutes; complete in two-thirds in 25 minutes.

Reaction with Ferric Chloride.

N. horsfieldii: Begins in a few in 2 minutes; complete in 1½ hours.
N. maximus: Begins in a few in 4 minutes; complete in an hour.
N. bulbocodium: Begins in a few in 1½ minutes; complete in 50 minutes.

Differentiation of Certain Starches of the Genus Narcissus.—Continued.

EFFECTS OF VARIOUS REAGENTS—Continued.

Reaction with Ferric Chloride.—Continued.

N. bulbocodium var. *conspicua:* Begins in a few in 3 minutes; complete in $1\frac{1}{4}$ hours.
N. bulbocodium var. *monophyllus:* Begins in a few in 2 minutes; complete in 45 minutes.
N. incomparabilis: Begins in a few in 4 minutes; complete in 45 minutes.
N. odorus: Begins in a few in 4 minutes; complete in 45 minutes.
N. poeticus: Begins in a few in 3 minutes; complete in $1\frac{1}{4}$ hours.
N. biflorus: Begins in a few in 3 minutes; complete in an hour.
N. jonquilla: Begins in a few in 4 minutes; complete in 40 minutes.
N. jonquilla var. *rugulosus:* Begins in a few in $1\frac{1}{2}$ minutes; complete in 40 minutes.
N. jonquilla var. *campernelli rugulosus:* Begins in a few in 4 minutes; complete in 45 minutes.
N. tazetta var. *orientalis:* Begins in a few in 3 minutes; complete in an hour.

Reaction with Purdy's Solution.

N. horsfieldii: Begins in a few in $1\frac{1}{2}$ minutes; complete in one-fourth in 2 hours; the rest are partially gelatinized.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Purdy's Solution.—Continued.

N. maximus: Begins in a few in $2\frac{1}{2}$ minutes; a few are completely and others partially gelatinized in 12 minutes.
N. bulbocodium: Begins in a few in 3 minutes; a few gelatinized and others slightly swollen in $1\frac{1}{2}$ hours.
N. bulbocodium var. *conspicua:* Begins in a few in 2 minutes; a few are partially gelatinized in 10 minutes.
N. bulbocodium var. *monophyllus:* Begins in a few in 2 minutes; complete in one-third in 45 minutes.
N. incomparabilis: Begins in a few in $1\frac{1}{2}$ minutes; a few are partially gelatinized in 20 minutes.
N. odorus: Begins in a few in 15 minutes; slight swelling of a few, a gelatinization of one, in 45 minutes.
N. poeticus: Begins in a few in 2 minutes; 1 or 2 completely and a few partially gelatinized in an hour.
N. biflorus: Begins in a few in 15 minutes; no further change.
N. jonquilla: Begins in a few in 15 minutes; no further change.
N. jonquilla var. *rugulosus:* Begins in many in 30 seconds; complete in two-thirds in 30 minutes.
N. jonquilla var. *campernelli rugulosus:* Begins in a few in 20 minutes; no further change.
N. tazetta var. *orientalis:* No reaction.

NOTES ON THE STARCHES OF NARCISSUS.

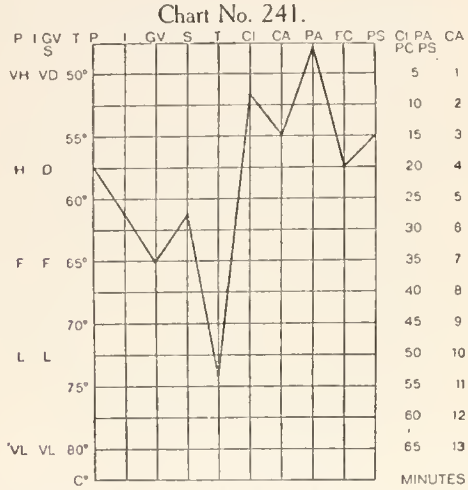
The *Narcissus* starches have in common a certain likeness, but there are many noticeable variations, as will be seen by reference to the plates. While the variations may not be sufficiently marked in any case to point definitely to any given species, they are often of such a character as to justify the conclusion that the specimen of starch did not come from a given plant—in other words, a negative diagnosis. The differences are noted particularly in the character of the fissuration, the relative regularity or irregularity of the outlines of the grains, and the differences in the character of the lamellæ and in the sizes of the grains. Thus, one would not be likely to confound the starches of *N. odorus* and *N. jonquilla* with either *N. poeticus* or *N. biflorus;* nor would it be likely that the grains of *N. jonquilla rugulosis* would be mistaken for those of *N. jonquilla.* The variability in the abundance of nipple-like processes in the different starches is very noticeable, but to what extent these differences are constant is problematical. Such processes are very common among starches of various families. In some of the narcissi starches these processes are conspicuous by their abundance, and in others they may be few, or conspicuous by their absence. In their histological peculiarities there does not appear to be any grouping of these starches such as that given in the table. In the reactions with certain agents the variations are within narrow limits, while with others they are more or less wide. In the degree of polarization, and in the reactions with iodine, the anilines, and heat they differ little. In the temperatures of gelatinization the difference is 5°. In the chemical reactions the starches of narcissi usually show marked resistance, except in the chromic acid reaction, which is moderate. The reaction-curves fall for the most part below the equator, and, on the whole, very much below.

NOTES ON THE STARCHES OF AMARYLLIDACEÆ. (Charts 241 to 253.)

There is running throughout these starches what appears to be a common type of grain which is more or less modified in the different genera; but the modifications are sometimes quite as marked in the different members of a genus as in the different genera. There are certain variable characteristics which are very conspicuous, as, for instance, in the sizes of the grains and in the degree of irregularity of outline, the conspicuousness and position of the hilum, the characters of the fissuration, and the relative prevalence of nipple-like processes. These differences are often exhibited very satisfactorily by the photographs. A comparison of the photographs taken by polarized light will show not only species differences, but also generic peculiarities which in some cases are very striking.

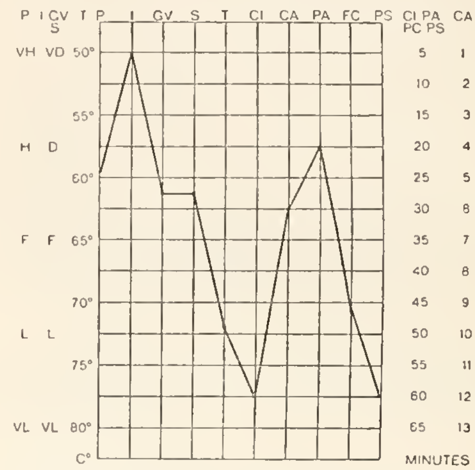
The reaction-curves of the different genera show more or less marked and characteristic differences, and it will be seen in comparing the curves of the various genera with those of *Amaryllis* that the division of the genus as heretofore constituted into a number of distinct genera, as noted under *Amaryllis*, is in entire accord with the peculiarities exhibited by the reactions. The reaction-curve of *Alstrœmeria* differs so essentially from the other curves as to sugggst that this genus is misclassed; and there are so many variations in the types of curves as to indicate that the *Amaryllidaceæ* may soon be divided by the systematic botanist into a number of families.

Chart No. 241.



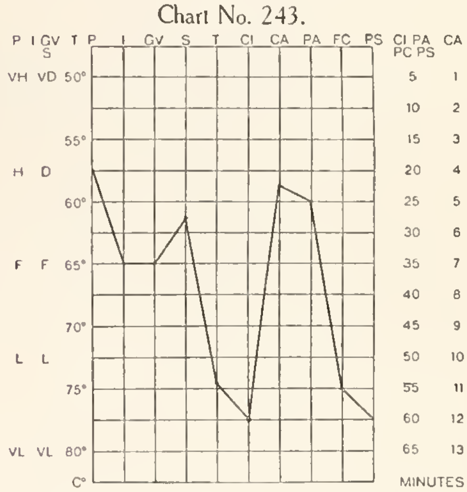
Curve of Reaction-Intensities of Starch of Amaryllis.

Chart No. 242.



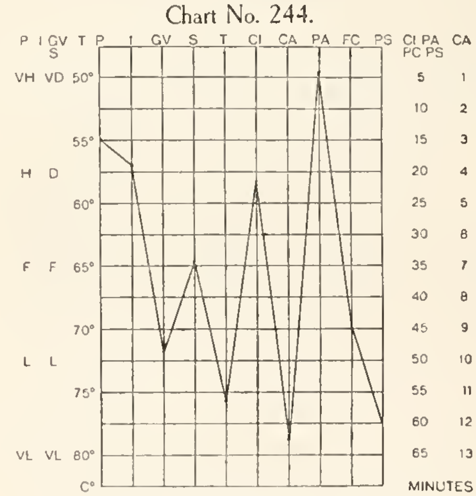
Composite Curve of Mean Reaction-Intensities of Starch of Hippeastrum.

Chart No. 243.



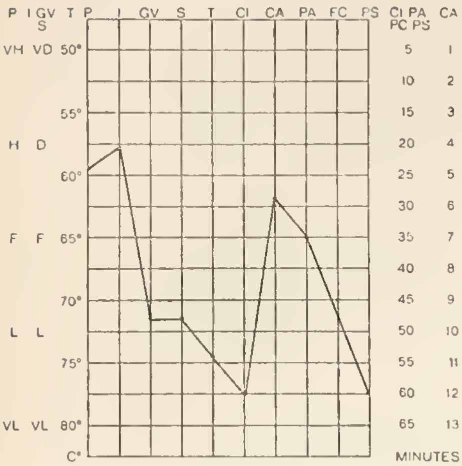
Curve of Reaction-Intensities of Starch of Vallota.

Chart No. 244.



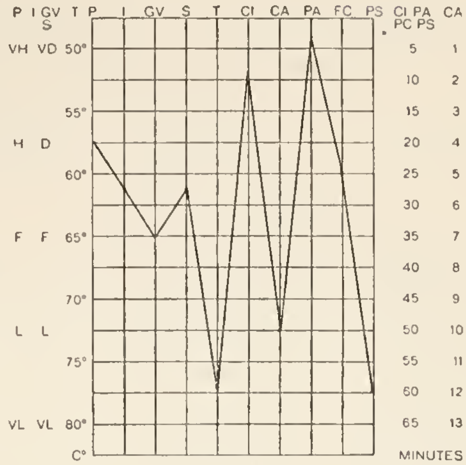
Composite Curve of Mean Reaction-Intensities of Starch of Crinum.

Chart No. 245.



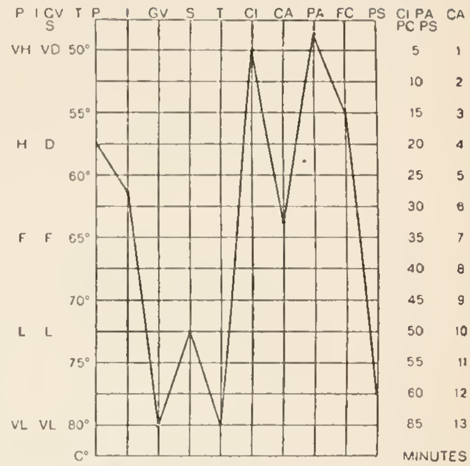
Composite Curve of Mean Reaction-Intensities of Starch of Zephyranthes.

Chart No. 246.



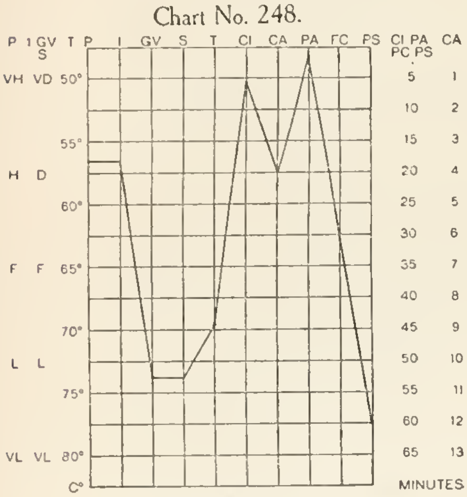
Curve of Reaction-Intensities of Starch of Sprekelia.

Chart No. 247.



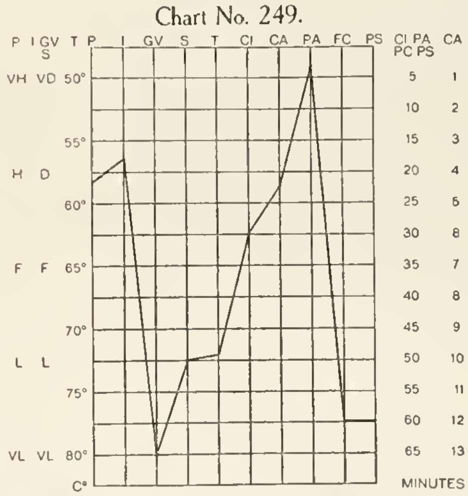
Curve of Reaction-Intensities of Starch of Hæmanthus.

Chart No. 248.



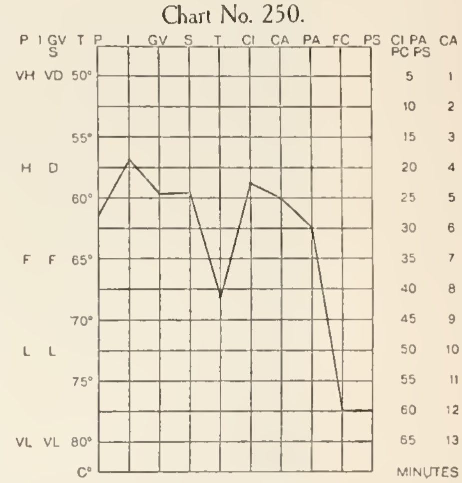
Composite Curve of Mean Reaction-Intensities of Starch of Hymenocallis.

Chart No. 249.



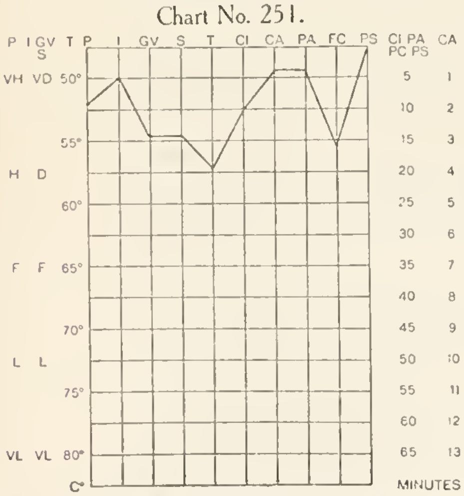
Composite Curve of Mean Reaction-Intensities of Starch of Leucoium.

Chart No. 250.



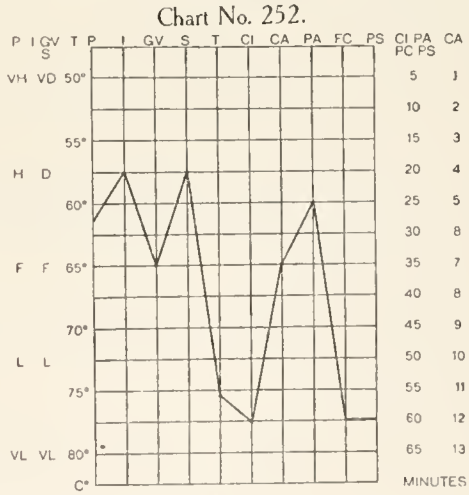
Composite Curve of Mean Reaction-Intensities of Starch of Galanthus.

Chart No. 251.



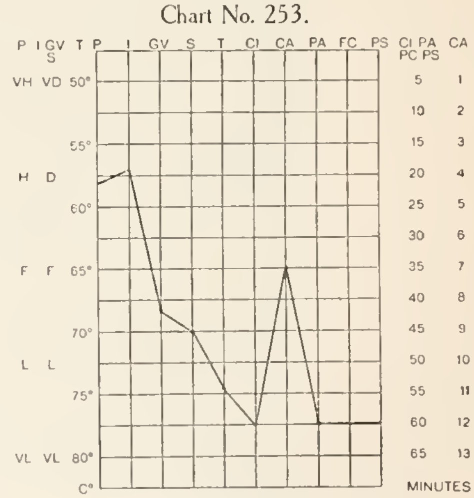
Composite Curve of Mean Reaction-Intensities of Starch of Alstrœmeria.

Chart No. 252.



Curve of Reaction-Intensities of Starch of Sternbergia.

Chart No. 253.



Composite Curve of Mean Reaction-Intensities of Starch of Narcissus.

STARCHES OF TACCACEÆ.

Class, Monocotyledones. Order, Liliales. Family, Taccaceæ. Genus represented, Tacca.

This family is closely allied to *Amaryllidaceæ*, and includes only the genera *Tacca* and *Schizocapsa*. *Tacca* is typical of the family, and comprises about 9 species; *Schizocapsa* is a monotypic genus.

GENUS TACCA.

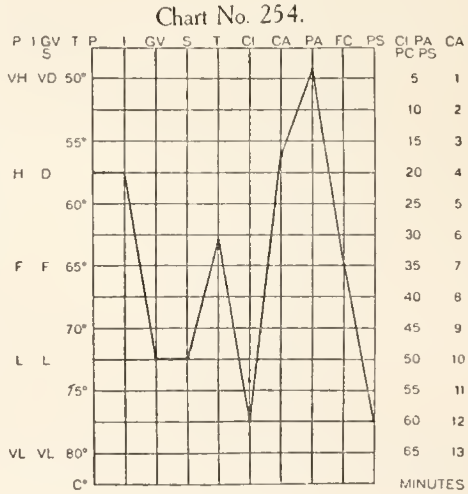
Tacca is a genus of tropical plants, some of which are cultivated for their rhizomes, which are rich in starch, containing as much as 30 per cent. Of the 9 species, 2 are natives of tropical America, and the others of Asia, Africa, the Indian Archipelago, and the Pacific Islands. The starch from one source was studied, *T. pinnatifida* Jack. (*T. oceanica* Nutt.). The starch is commercially known as Williams's arrow-root, South Sea arrow-root, and Fiji arrow-root.

STARCH OF TACCA PINNATIFIDA. (Plate 62, figs. 371 and 372. Chart 254.)

Histological Characteristics.—In *form* the grains are simple and almost isolated, with the exception of a few which occur in aggregates that consist of two or rarely of three or more components. Nearly all have one or more, commonly two, pressure facets. The surface is rounded and very even, except near the pressure facets, where often the appearance of swelling suggests secondary deposits or partial gelatinization. The conspicuous forms are the dome-shaped with from one to three facets at the base, spherical to oval, and polygonal. Some of the dome-shaped type are more or less elongated, sometimes appearing like a half of a flattened ellipse. A spherical grain may be seen with a single pressure facet. In the aggregates consisting of two grains, the grains are commonly unequal in size. The grains are not flattened, and when seen from the proximal end appear spherical; but from the distal end they appear circular and irregular on the top on account of the facets.

The *hilum* when not fissured is a large, round, refractive spot, usually eccentric about two-fifths of its longitudinal diameter and in the median line. It is generally marked by a deep, transverse fissure, showing at times a single and at others a double curve. It is often subdivided by numerous fissures, and often there is a 3-armed figure, and rarely a stellate arrangement of small fissures.

Chart No. 254.



Curve of Reaction-Intensities of Starch of Tacca pinnatifida.

The *lamellæ* are fairly distinct, relatively coarse, widely spaced, regular, usually concentric rings. They vary in size, spacing, and distinctness even in the same grain, those centrally located being the coarser and more distinct than those near the margin. They are for the most part circular and follow the outline of the margin only when very near it. There is an average of 10 to 14 lamellæ on medium-sized grains.

The grains vary in *size* from 6 to 28μ. The common size is 18μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and clear-cut. The four lines are distinctly visible throughout and tend to become somewhat broader or narrower towards the margin of the grain, and are sometimes bent or otherwise distorted. Two lines usually cross the grain obliquely to the corners of the facets.

The degree of *polarization* is high. It is higher from the end than from any other aspect of the grain, but occasionally it is very low at the faceted end, due to the hollowed spaces of the facets. It does not vary much in different grains.

With *selenite* the quadrants are well defined, usually irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a reddish-blue; with 0.125 per cent solution they are only slightly colored at first, but deepen rapidly. After heating in water until the grains are fully gelatinized, the solution and some of the grains are colored deeply with iodine, but some of the grains do not react. The gelatinized grains are smooth and rounded and somewhat lobulated at one end. If excess of iodine be added, the grains which previously had not reacted exhibit voilet-colored capsules.

Staining Reactions.—With *gentian violet* reaction begins in 3 minutes, but after 30 minutes the grains are only lightly stained.

With *safranin* reaction begins in 2 minutes, but after 30 minutes the grains are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 62° to 64° C., mean 63°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins slightly in 1½ minutes, and is complete in four-fifths in 20 minutes. The reaction is incomplete in an hour. The hilum becomes very distinct as a dark spot or bubble, but the lamellæ disappear. The angles of the facets become dark, and gelatinization begins at these parts without much swelling and spreads up over the whole grain. Later, the lines of junction of the facets and the angles swell out more than the rest of the grain so that the facets appear to be concave. Rarely there is swelling at both ends. Those grains which swell slowly often show an irregular swelling or protrusion of the whole margin surrounding a central ungelatinized portion, which latter finally becomes gelatinized. The gelatinized grains have a dark blue marginal ring, inclosing a lighter space which represents the altered hilum.

Reaction with *chromic acid* begins in 30 seconds and is over in 3½ minutes. The hilum is distinct, but the lamellæ are not more so than in the normal grain. The body of the grain becomes marked throughout by fine striæ radiating from the hilum. The hilum swells in common with other central parts of the grain, pushing the substance of the grain out to the margin, which is comparatively thick and finely striated, but without refractive bands. The margin becomes thinner and clearer and finally dissolves at one point; the contents flow out and gradually disappear, the capsule then dissolves, the portion opposite the point where the dissolution first occurred disappearing last.

With *pyrogallic acid* the reaction begins in 30 seconds and is over in 3½ minutes. The hilum is distinct as a dark bubble, but the lamellæ are not especially distinct. The hilum swells upward greatly, the substance of the body of grain in the meantime becoming divided by fine striæ. The inner part is transformed into a gelatinous mass, and the more resistant outer part forms a thick, finely striated ring which gradually becomes thinner and clearer, and a large gelatinized grain is formed, which is much crumpled and folded, particularly at the faceted end. The edges of the facets may swell out more than the rest of the grain. The swollen grains retain but little of the original form.

The reaction with *ferric chloride* begins in some grains in 2½ minutes and is over in 35 minutes. The hilum becomes distinct as a dark bubble, but the lamellæ disappear. The marginal part of the grain becomes clearer and darker, the inner portion appearing light and opaque. Gelatinization with some irregular lobular protrusion begins from the corners and lines of junction of the facets. The hilum swells greatly before this process has gone very far, and some of the substance of the grain moves marginally, the margin appearing finely striated. The margin finally clears and a gelatinized grain is formed. The grains are large, clear, and much lobulated and distorted.

Reaction with *Purdy's solution* begins in 2½ minutes. About half are fully swollen and most of the remaining half are not affected after an hour. The hilum becomes very distinct as a dark spot or bubble. The lamellæ are also very distinct. The hilum swells rapidly, the body of the grain, which previously had been divided by fine striæ, is pushed out to form a distinct, broad ring which shows finely striated, refractive, and non-refractive bands. This ring gradually clears. The swollen grains are large and clear, and are not much crumpled or distorted.

STARCHES OF IRIDACEÆ.

Class, Monocotyledones. Order, Liliales. Family, Iridaceæ. Genera represented: Iris, Moræa, Homeria, Tigridia, Gladiolus, Watsonia, Tritonia, Freesia, Antholyza, Crocus, Romulea, Cypella, Marica, Gelasine, Sparaxis, Ixia, Babiana.

The *Iridaceæ* or *Irideæ* includes 57 genera and about 700 species, natives chiefly of the Mediterranean region and South Africa, and to some extent of Australia, Asia, and America. Representatives of 17 genera were studied.

GENUS IRIS.

There are over 170 species of *Iris*, over 100 of which and a very large number of garden varieties are in cultivation. They are natives of the north temperate region of Asia, Europe, and North America; and also of Africa north of the Atlas Mountains, the southern representatives in the latter country being classified as Moræas. Four recognized horticultural groups include: (1) the German irises, the best known of which are *I. germanica*, the fleur-de-lis or blue flag; and *I. florentina*, the source of the orris-root of commerce; (2) the Japanese irises, including a large number of garden forms which are referable to *I. lævigata*; (3) the dwarf irises, referable to *I. pumila*, *I. verna*, and *I. cristata*; (4) the *Oncocyclus* irises, in certain respects distinctly differentiated from the other groups. These plants are also classified into two series, which are distinguished, respectively, by a short, thick root-stock or creeping rhizome, or by a bulbous root-stock. Hasselbring includes in the first series the subgenera *Apogon*, *Pardanthopsis*, *Evansia*, *Pseudovansia*, *Pogoniris*, *Regelia*, and *Oncocyclus;* and in the second series, *Xiphion*, *Gynandiris*, and *Juno*. Starches from thirteen sources were studied, which are distributed among the two series and the ten subgenera as follows: Series 1, subgenera *Pogoniris* and *Regelia: Iris florentina* Linn., *I. pallida* var. *speciosa* Hort., and *I. pumila* var. *cyanea* Hort.; subgenus *Oncocylus: I. bismarckiana* Hort. and *I. iberica* Hoff. Series 2, subgenus *Xiphion: I. xiphium* var. *grand tresorier* Hort., *I. xiphium* var. *wilhelmine* Hort., *I. xiphium* var. *lusitanica* Hort., *I. tingitana* Boiss. and Reut (*I. reticulata* M. Biev.), and *I. histrio* Reichb. f. (*Xiphium histrio* Hook. f.); subgenus *Juno: I. alata* Poir. (*I. scorpoides* Desf.) and *I. caucasica* Hoffm.

STARCH OF IRIS FLORENTINA. (Plate 63, figs. 373 and 374. Chart 255.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains, small aggregates, grains with pressure facets, and clumps consisting of very minute grains. The surface is often irregular. The irregularity of the simple grain is generally due to rounded protuberances, more frequently located near the hilum, or to a secondary deposit of starch in such a way that the longitudinal axis of one or more sets of lamellæ is placed at varying angles, commonly at right angles, to the same axis of the primary grain; and also by a cup-shaped depression at the distal end of the primary set of lamellæ, as well as frequently of the secondary set. The conspicuous forms of the simple grain are the elongated ovoid with a squared, hollowed distal end, and the oval and finger-shaped with a similar distal end; also a cone-shaped grain with rounded apex is occasionally present; and as results of secondary deposits upon the primary grain various forms, such as boot-shaped, bow-shaped, T-shaped, L-shaped, and laterally curved club-shaped are found. The conspicuous forms of both the compound and aggregate grains are heart-shaped with blunt apex, and knob-shaped. These grains are formed by the union of oval or rounded grains, the proximal ends being either closely fitted or flaring from each other. There may or may not be a secondary deposit of lamellæ common to both grains. Both compound and aggregate grains are also found composed of one small grain attached to the distal end of a large grain, and other forms of doublets and occasionally triplets arranged triangularly or linearly. The grains are not flattened.

The *hilum* appears as a distinct, clear, round spot, centric in the small, round forms and eccentric one-third to one-sixth, usually one-fourth, of the longitudinal axis in the elongated larger forms. Either a cavity or a cleft may appear at the hilum. These clefts are usually transverse, cross-shaped, or stellate. One delicate, short, longitudinal fissure generally runs from each side of the hilum.

The *lamellæ* are rather coarse, but generally not very distinct; often they can not be observed near the hilum, but sometimes they appear here as complete rings. Beyond this region they assume the shape and irregularity of the grain, and are probably incomplete near the distal end. One or more secondary sets of lamellæ are frequently observed at varying angles to the primary set.

The grains vary in *size;* the smaller are 6 by 4μ; the larger are 30 by 16μ in length and breadth. The common size is 18 by 10μ in length and breadth.

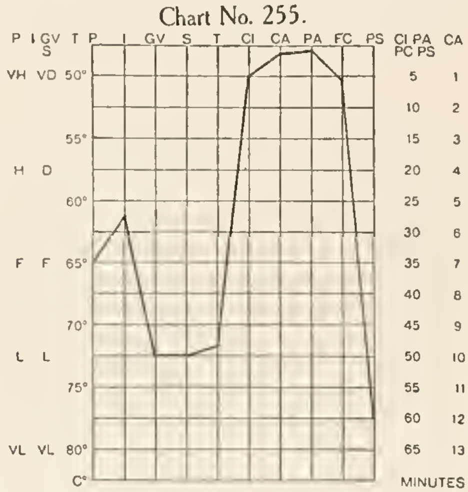
Polariscopic Properties.—The *figure* is usually eccentric and distinct in most of the grains. Its lines are rather fine, often bent, sometimes bisected. It is fairly clear-cut, distinct, but generally irregular.

The degree of *polarization* is fair. It varies somewhat in the different grains and in the same aspect of a given grain.

With *selenite* the quadrants are fairly well defined, generally irregular in shape, and unequal in size. The colors are generally pure, the blue being quite pure, but the yellow sometimes not.

Iodine Reactions.—with 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with 0.125 per cent solution they color rather lightly at first, and the color does not deepen rapidly. After heating in water until the grains are completely gelatinized the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues do not color at all. The capsules color a deep red-violet to wine-red with an excess of iodine.

Chart No. 255.



Curve of Reaction-Intensities of Starch of Iris florentina.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes they are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 71° to 72° C., mean 71.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains begin to react in 30 seconds, and all are gelatinized in 5 minutes. The reaction begins at the distal end of the simple grains and also at the free edges of any of those portions which have probably been added last. These points become dark and swell slightly, and usually the starch at the proximal end becomes dark and swells slightly. The process now advances inward from these two points over the rest of the grain, but there is not much swelling until the starch of the greater part of the grain becomes dark. There is usually a line of demarcation between the gelatinized and the non-gelatinized portions of the grain. The gelatinized grains are fairly large, of a uniform dark color, and retain much of their original form.

The reaction with *chromic acid* begins in 5 seconds and is complete in 25 seconds. It is so rapid that it is impossible to distinguish all the steps, but in general it appears to consist in the gelatinization of the inner part of the grain in that portion between the hilum and the distal end, and also of all the starch at the distal end. These parts of the grain become granular and pass into a semifluid mass, and the whole grain swells, only a thin layer remaining at the distal end. The margin, except at the distal end, is formed of a fairly thick, striated band which shows the remains of some lamellæ. This band becomes thinner and homogeneous, and finally the layer at the distal end is dissolved, opens out, and the gelatinous starch within flows out and dissolves.

Reaction with *pyrogallic acid* begins in 10 seconds and is over in a minute. The hilum swells somewhat and two lines appear, one on each side of the hilum, which run towards the distal end. Between these two lines the starch becomes granular and then gelatinous, and the grain swells, especially in the direction of the longitudinal axis. The more resistant starch forms a band at the margin which is thicker at the proximal than at the distal end, and shows striæ and the remains of the lamellæ. This band becomes thinner and homogeneous in appearance as the grain swells and is especially thin at the distal end. The gelatinized grains are large, much twisted, folded, and convoluted at the distal ends and retain some of their original shape at the proximal end.

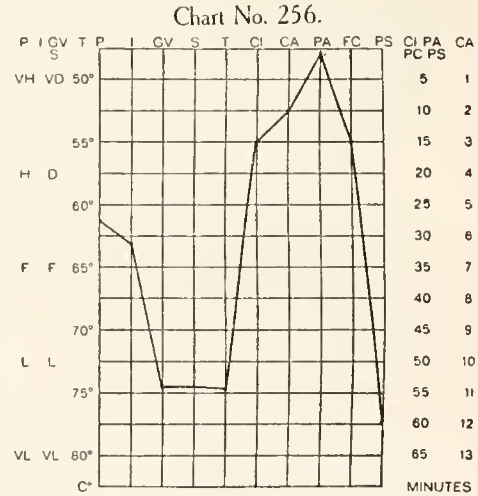
The reaction with *ferric chloride* begins in many grains in 30 seconds and is over in 6 minutes. The reaction begins at the distal end. The starch at the squared corners becomes gelatinized and spreads out laterally, and later all the starch at the distal end becomes gelatinized and swells irregularly. The starch at the proximal end also often becomes gelatinous and swells, and the process advances inward from the two ends over the rest of the grain. In the other grains it simply advanced upward and inward over the whole grain. The gelatinized grains are very large and thick-walled, and the capsule is often folded and crumpled, and the grains distorted.

The reaction with *Purdy's solution* begins in most grains in 30 seconds, and in all in a minute. About half of the grains are partially gelatinized in 5 minutes, two-thirds in 10 minutes, nine-tenths in 15 minutes, and completely in practically all in 30 minutes, except a small amount of starch at the proximal end. The hilum or clefts at this region swell and two delicate fissures, if not already present, form and extend obliquely from the hilum to the corners limiting the distal margin. The lamellæ between these two fissures become clearly defined; the grains gelatinize at the distal end and the capsule spreads out laterally; gelatinization advances from the distal end towards the proximal between the two fissures already noted, accompanied by swelling. In the grains with secondary sets of lamellæ a separate center of gelatinization is formed from that of the main body of the grain. The gelatinized grains are swollen and sometimes refractive granules are embedded in the more soluble starch. They retain the general shape of the untreated grain.

STARCH OF IRIS PALLIDA VAR. SPECIOSA. (Plate 63, figs. 375 and 376. Chart 256.)

Histological Characteristics.—In *form* the grains are usually simple and isolated. A few have pressure facets. A number of grains are found in small aggregates and in compound grains of few components, and a few clumps are present which consist usually of minute grains. The surface of the grains is often irregular, owing to the same causes noted under *I. florentina.* The conspicuous forms of the simple grains are the elongated ovoid, with a squared, hollowed distal end, oval ellipsoidal, pure ovoid, pyriform, and nearly round. There are also dome-shaped with a well-marked pressure facet, cone-shaped with rounded apex, spatula-shaped, and finger-shaped. As a result of secondary deposits upon the primary grain, various shapes are found such as noted for *I. florentina.* The compound grains and aggregates are also of similar character to those described for *I. florentina.* The grains are not so irregular in outline, and a larger proportion of the shortened, broader forms are found than in *I. florentina.*

Chart No. 256.



Curve of Reaction-Intensities of Starch of Iris pallida var. speciosa.

The *hilum* is observed as either a distinct round or elliptical spot, which is usually eccentric, the range of eccentricity being generally from one-fourth to one-eighth of the longitudinal axis. The hilum is not as a rule fissured. Occasionally either a diagonal or a transverse cleft may pass through it. One short, delicate, longitudinal fissure sometimes runs obliquely from each side of the hilum. The hilum is less often fissured and not so refractive when fissured as in *I. florentina.*

The *lamellæ* are not generally demonstrable throughout the entire grain. Often they can not be observed at the hilum, but occasionally they appear at this part as indistinct, rather coarse, complete rings. Beyond this region they tend to assume the shape and irregularity of the grain, and are probably incomplete near the distal end. One or more secondary sets of lamellæ are observed at varying angles to the first set. Rarely 20 lamellæ may be counted on the larger grains.

The grains vary in *size;* the smaller are 4 by 3μ; the larger are 32 by 14μ in length and breadth. The common size is 16 by 12μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric. The proportion of grains of medium size in which it is centric is much greater than in *I. florentina.* It is commonly clear-cut, and its lines are similar in character to those described for *I. florentina,* but more often straight.

The degree of *polarization* is fair to high. The same variations are found as noted for *I. florentina.* Polarization is higher than in *I. florentina.*

With *selenite* the quadrants are fairly well defined, but not quite so irregular in shape and so unequal in size as in *I. florentina,* and the colors are more often pure than in *I. florentina.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color fairly deep reddish-violet which deepens rapidly; with 0.125 per cent solution they are colored a very light violet which also deepens rapidly. The color is lighter and has more of a reddish tint than the grains of *I. florentina.* After heating in water until the grains are completely gelatinized, the solution becomes a deep indigo-blue and the grains a lighter blue on the addition of iodine. The grains are both lighter and brighter in tint than those of *I. florentina.* When the grains are boiled for 2 minutes and then treated with iodine, the solution colors a deep reddish-blue and the gelatinized grains a rather light blue, sometimes with a reddish tint. With an excess of iodine the grain-residues color a deep reddish-blue and the capsules a deep reddish heliotrope. The solution has more, and the grains and capsules less, of a reddish tint than *I. florentina.*

Staining Reactions.—With *gentian violet* the grains exhibit a very faint trace of violet at once and in 30 minutes are very lightly colored. The color is considerably lighter than in the grains of *I. florentina.*

With *safranin* the grains exhibit a very faint trace of pink immediately and in 30 minutes are lightly stained. The color is less than in the grains of *I. florentina*, but the difference is not so great as in the case of gentian violet.

Temperature Reaction.—The temperature of gelatinization is 74° to 75° C., mean 74.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains in 30 seconds. It is complete in about half in 5 minutes, in the majority in 7 minutes, in nine-tenths in 10 minutes, and in all but a few resistant grains in 15 minutes, in which the reaction may not be completed for 20 to 25 minutes. The reaction is qualitatively the same as in *I. florentina.*

With *chromic acid* the grains begin to swell in 20 seconds. A few are dissolved in 40 seconds, the majority in a minute, and all in 2 minutes. Refractive granules are frequently observed during gelatinization of the grains, but the entire grain is finally dissolved. The reaction is qualitatively the same as in *I. florentina.*

Reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 20 seconds, the majority in 40 seconds, all but a few resistant grains in a minute, and all in 1½ minutes. The reaction is qualitatively the same as in *I. florentina.*

With *ferric chloride* a few grains begin to swell in 30 seconds. A small number are gelatinized in 2 minutes, about one-third in 5 minutes, nine-tenths in 10 minutes, and all but a few resistant grains in 15 minutes. A small portion of the starch at the proximal end is occasionally not gelatinized, while in *I. florentina* the gelatinization is generally complete. The reaction is qualitatively the same as in *I. florentina.*

The reaction with *Purdy's solution* begins in a few grains in 30 seconds. A small number are gelatinized in 5 minutes, and about one-tenth in 15 minutes, but after this time, up to 30 minutes, there is very little progress. The hilum is swollen in the grains not gelatinized and a longitudinal fissure usually extends obliquely from each side of it, between which the lamellæ have become more distinct. During gelatinization the grains do not frequently spread out laterally, bell-shape, at the distal end, as in *I. florentina*, but gelatinization gradually advances towards the proximal end between the two longitudinal fissures already noted and is accompanied by less distortion of the grain. The reaction is qualitatively the same as in *I. florentina.*

STARCH OF IRIS PUMILA VAR. CYANEA. (Plate 63, figs. 377 and 378. Chart 257.)

Histological Characteristics.—In *form* the grains are usually simple and isolated, and a few have pressure facets; a number are found in the form of small aggregates, compound grains of few components, and in clumps, the latter consisting generally of minute grains. The surface of the grains is often irregular, owing to the same causes noted under *I. florentina.* The conspicuous forms of the simple grains are the finger-shaped with hollow distal end, elongated ovoid with similar distal end, irregular ellipsoidal, and pyriform; also dome-shaped, spatula-shaped, round grains of medium size, cone-shaped with rounded apex, and irregular grains of definite shape. As a result of secondary deposits upon the primary grains, various shapes are found among the grains, such as noted under *I. florentina.* The compound grains and aggregates are also of similar character to those described under *I. florentina.* The grains are mostly elongated and are more irregular in outline than those of *I. florentina.*

The *hilum* is observed as a distinct round or elliptical spot, usually one-sixth to one-tenth eccentric of the longitudinal axis. It is not generally so refractive nor so often fissured as in *I. floren-*

tina. Sometimes either a short transverse or diagonal fissure is found at the hilum, and occasionally one delicate longitudinal fissure runs obliquely from each side of the hilum.

The *lamellæ* are usually fine and indistinct. When demonstrable they form complete rings around the hilum, but beyond this region they assume the shape of the margin of the grain and are probably incomplete. One or more secondary sets of lamellæ are frequently found at varying angles to the primary set. On the large grains 28 to 32 lamellæ have been counted.

The grains vary in *size;* the smaller are 3 by 2μ; the larger are 40 by 14μ in length and breadth. The common size is 30 by 13μ in length and breadth.

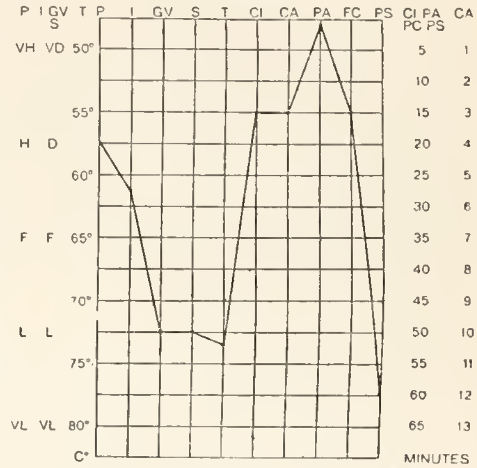
Polariscopic Properties.—The *figure* is usually eccentric. It is generally clear-cut, and the lines are of similar character to those noted for *I. florentina,* but more often bent or bisected.

The degree of polarization is high. There is a variation in the grains, in some of which polarization is very high. The same variation is noted as in *I. florentina* in the one aspect of a given grain. The degree of polarization is distinctly higher than in *I. florentina.*

With *selenite* the quadrants are well defined, unequal in size, and more often irregular in shape than in the grains of *I. florentina.* The colors are generally pure, about the same as in those of *I. florentina.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet, which deepens rather rapidly; with 0.125 per cent solution they color a very light violet which deepens rather rapidly. The reaction is of about the same intensity as in *I. florentina.* After heating in water until the grains are gelatinized, the solution colors a deep greenish-blue and the grains a deep blue with a reddish tint on the addition of iodine. If the grains are boiled for 2 minutes and then treated with iodine, the solution colors a deep indigo-blue and the grain-residues a deep purple. With an excess of iodine the capsules color a deep old-rose to wine-red. The gelatinized grains and the capsules have more of a reddish tint than in *I. florentina.*

Chart No. 257.



Curve of Reaction-Intensities of Starch of Iris pumila var. cyanea.

Staining Reactions.—With *gentian violet* the grains show a faint trace of violet immediately and in 30 minutes are lightly stained. The tint is about the same as in *I. florentina.*

With *safranin* the grains stain faintly at once and in 30 minutes are lightly colored. The tint is about the same as in *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 72.5° to 74° C., mean 73.2°.

Effects of Various Reagents.—With *chloral hydrate-iodine* a few grains begin to react in 30 seconds. About half are gelatinized and there is reaction in practically all in 5 minutes; about nine-tenths are gelatinized in 10 minutes, and all in 15 minutes, excepting the rare resistant grains, which may not be completely gelatinized for 25 to 40 minutes. The reaction is qualitatively the same as in *I. florentina.*

The reaction with *chromic acid* begins immediately. A few are dissolved in 20 seconds, the majority in 40 seconds, and nearly all in 1½ miuutes, excepting rare resistant grains in which reaction takes 3 minutes for completion. The reaction is qualitatively the same as in *I. florentina.*

Reaction with *pyrogallic* acid begins at once. Many are gelatinized in 20 seconds; the majority in 40 seconds and all but a few resistant grains in a minute, and it is complete in the latter in 2 minutes. The reaction is qualitatively the same as in *I. florentina.*

With *ferric chloride* a few grains begin to swell in 30 seconds. A small number are gelatinized in 2 minutes, about half in 5 minutes, nine-tenths in 10 minutes, and nearly all in 15 minutes, with the exception of a small amount of starch at the proximal end, which is not gelatinized even in 30 minutes. The reaction is qualitatively the same as in *I. florentina.*

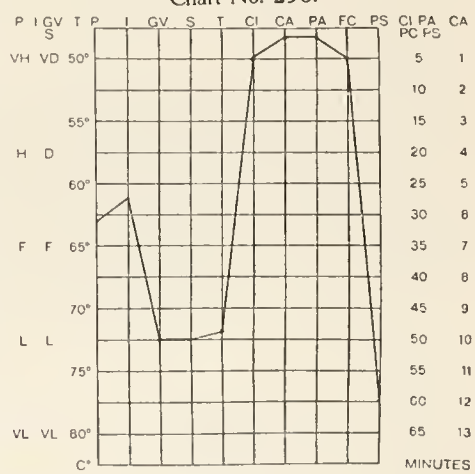
The reaction with *Purdy's solution* begins in a few grains in 30 seconds. A small number are gelatinized in 2 minutes and very gradual progress occurs in 5 minutes. About one-tenth are gelatinized and there is partial gelatinization of about one-half in 10 minutes. About one-fifth are gelatinized and two-thirds are partially gelatinized in 15 minutes. The reaction is qualitatively the same as in *I. florentina.*

STARCH OF IRIS BISMARCKIANA. (Plate 64, figs. 379 and 380. Chart 258.)

Histological Characteristics.—In *form* the grains are mostly simple. There are some compound grains, aggregates which are usually in the form of doublets or triplets, separated-grains with pressure facets, and clumps chiefly consisting of very small grains. The surface of the grains is often irregular, the irregularities of both the simple and the compound grains being due to the same causes as noted under *I. florentina.* The conspicuous forms are with some exceptions the same as those observed in *I. florentina,* but the grains give the impression of more broadness in relation to length, and the conical grain with rounded apex is more frequently found. Among the compound grains a broadly lenticular grain with rounded ends is frequently found besides the forms noted in *I. florentina.* The small, globular grains sometimes attached to a very large grain are more often at the side than fitting into the distal end, as observed in *I. florentina,* and the depression at this end is not so deep as in *I. florentina.* The grains of *I. bismarckiana* more closely resemble those of *I. iberica* than *I. florentina.*

The *hilum* is a fairly distinct, refractive, round or lenticular spot, centric in the small round grains, and eccentric one-fourth to one-seventh, usually one-sixth, of the longitudinal axis in the larger elongated grains; 4 hila are sometimes present in a single grain. In place of the hilum there is often a rounded cavity which is not often fissured.

Chart No. 258.



Curve of Reaction-Intensities of Starch of Iris bismarckiana.

The *lamellæ* are fairly distinct and may form complete rings around the hilum. Beyond this area they have the form of the outline of the grain, and show any irregularities that may appear in it. The number on grains of fair size varies from 10 to 16.

The grains vary in *size;* the smaller are 4 by 4μ; the larger are 26 by 14μ in length and breadth. The common size is 18 by 12μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric and distinct. Its lines are rather fine and often bent, bisected, or otherwise distorted. It is fairly clear-cut, but more irregular than in *I. florentina.*

The degree of *polarization* is fair to fairly high, with frequent variations in the same aspect of a given grain. It is slightly higher than in *I. florentina.*

With *selenite* the quadrants are generally fairly well defined, but usually irregular in shape and unequal in size. The colors are fairly pure, the blue being quite pure, but the yellow is often not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep violet; with 0.125 per cent solution they color lightly at first and the color does not deepen rapidly. It is about the same as that of the grains of *I. florentina.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. The capsules all color a deep red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained. The stain is the same as that of the grains of *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 15 seconds and is over in 4 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *chromic acid* begins in a few seconds and is over in 35 seconds. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *pyrogallic acid* begins in 7 seconds and is over in 70 seconds. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *ferric chloride* begins in 15 seconds and is over in 5 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *Purdy's solution* begins in 30 seconds. Two-thirds are nearly completely gelatinized in 2 minutes and four-fifths are gelatinized in 10 minutes. The reaction is the same qualitatively as that of the grains of *I. florentina.*

STARCH OF IRIS IBERICA. (Plate 64, figs. 381 and 382. Chart 259.)

Histological Characteristics.—In *form* the grains are mostly simple. There are some compound grains, aggregates usually in the form of doublets, separated grains with pressure facets, and clumps consisting of very small grains. The surface is often irregular, owing to the causes noted in the grains of *I. florentina.* The conspicuous forms are similar to those observed in *I. florentina,* but the simple grains are neither so elongated nor so slender, and are more regular, because secondary sets of lamellæ are not so frequent. Among the compound grains a broadly lenticular form with rounded ends is frequently present, besides the forms noted for *I. florentina.* The resemblances as a whole to *I. bismarckiana* are closer than to *I. florentina.*

The *hilum* is a distinct refractive spot, centric in the small, round grains, and eccentric in the larger grains from one-fifth to one-seventh, usually one-fifth, of the longitudinal axis. Two hila without a line of separation are sometimes found in a simple grain. Two short longitudinal fissures frequently run from the hilum. A cavity may appear at the hilum, but usually there is an absence of clefts.

The *lamellæ* are not distinct. It is impossible to determine with any definiteness either their character or number.

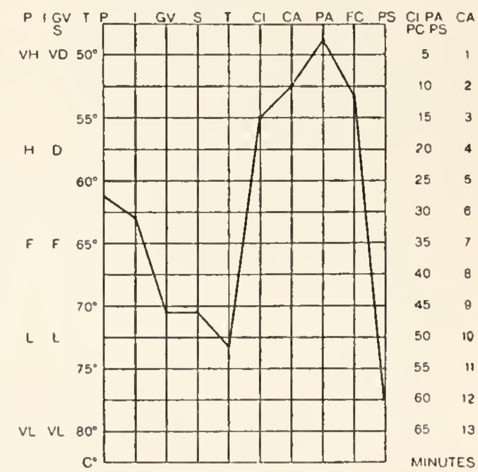
There is a variation in *size;* the smaller are 4 by 4μ; the larger measure 28 by 16μ in length and breadth. The common size is 18 by 10μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric and distinct. Its lines are rather fine and sometimes straight, but often bent or bisected. It is fairly clear-cut, and regular in more of the grain than in *I. florentina.*

The degree of *polarization* is fairly high. There is some variation in the different grains and occasionally in the same aspect of a given grain. It is higher than in *I. florentina.*

With *selenite* the quadrants are usually unequal in size and vary somewhat in shape. The colors are pure, purer than in *I. florentina.*

Chart No. 259.



Curve of Reaction-Intensities of Starch of Iris iberica.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all begin to color a fairly deep violet; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. The color is less than that of the grains of *I. florentina.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. The capsules all color a deep red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are lightly stained. The stain is slightly more than that of the grains of *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 72.2° to 74° C., mean 73.1°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a few grains in 30 seconds and in most in a minute. One-third are gelatinized in 3 minutes and all in 15 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *chromic acid* begins in 15 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *pyrogallic acid* begins in 20 seconds and is over in 2½ minutes. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *ferric chloride* begins in some grains in a minute and is over in 12 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

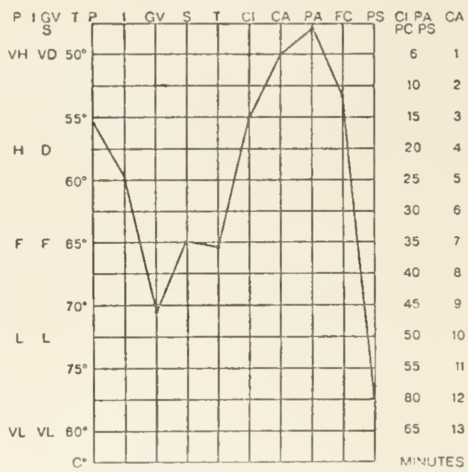
With *Purdy's solution* a few of the grains begin to react in 1½ to 2 minutes, and a few are partially gelatinized in 15 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

STARCH OF IRIS XIPHIUM VAR. GRAND TRESORIER. (Plate 64, figs. 383 and 384. Chart 260.)

Histological Characteristics.—In *form* the grains are usually simple. Compound grains, aggregates, separated-grains with pressure facets, and a few small clumps are present, as in *I. florentina.* The surface is sometimes irregular, owing to the causes noted under *I. florentina.* The conspicuous forms in the simple grains are cone-shaped with rounded apex, ovoid with squared distal end, and clam-shell-shaped; also quite perfect ovoid, laterally curved club-shaped, and oval forms. The compound grains and aggregates are similar to those observed in *I. florentina,* except that a minute globular grain is more frequently found at the lines of union of the component of compounds and aggregates. The grains are broader in proportion to length and more irregular in outline than those of *I. florentina.*

The *hilum* is a distinct, round, clear spot, centric in the small globular forms and eccentric two-fifths to one-third, usually two-fifths, of the longitudinal axis in the larger grains. Either a cavity of the same shape as the hilum or irregular ragged clefts may be located at the hilum. The clefts are more often arranged in a double, branched, root-like form, an irregular cross, or resembling the outline of the flying bird or dragon-fly. In the last-named shapes the clefts are usually diagonal to the longitudinal axis.

Chart No. 260.



Curve of Reaction-Intensities of Starch of Iris xiphium var. Grand Tresorier.

The *lamellæ* are very indistinct and the number on a grain can not be determined. Those occasionally visible are rather coarse.

The *size* of the average round form is 4 by 4μ, and of the elongated forms from 6 by 3μ to 36 by 24μ in length and breadth. The common size is 24 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric and distinct. The lines are rather thick and sometimes broaden at the margin of the grain. They may be straight, but are more often bent, and occasionally bisected. The figure is fairly clear-cut, and rather more distinct and regular than in *I. florentina.*

The degree of *polarization* is rather high to quite high. There is some variation in the different grains and occasionally in the same aspect of a given grain. It is distinctly higher than in *I. florentina.*

With *selenite* the quadrants are generally somewhat irregular in shape and unequal in size. The colors are generally pure, the yellow sometimes being not quite pure. They are purer than in *I. florentina.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they all color lightly at once and the color does not deepen rapidly. It is slightly more than that of the grains of *I. florentina.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains all begin to stain at once and in 30 minutes are lightly stained, more than the grains of *I. florentina.*

With *safranin* the grains begin to stain at once and in 30 minutes they are fairly stained, more than the grains of *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 65° to 66° C., mean 65.5°.

Effects of Various Reagents.—With *choral hydrate-iodine* the reaction begins in 45 seconds, is over in two-thirds of the grains in 8 minutes, and in practically all in 15 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *chromic acid* begins in some grains at once, in all in 15 seconds, and is over in a minute. It is the same qualitatively as that of the grains of *I. florentina.*

With *pyrogallic acid* the reaction begins in some grains at once, in all in 15 seconds, and is over in 45 seconds. It is the same qualitatively as that of the grains of *I. florentina.*

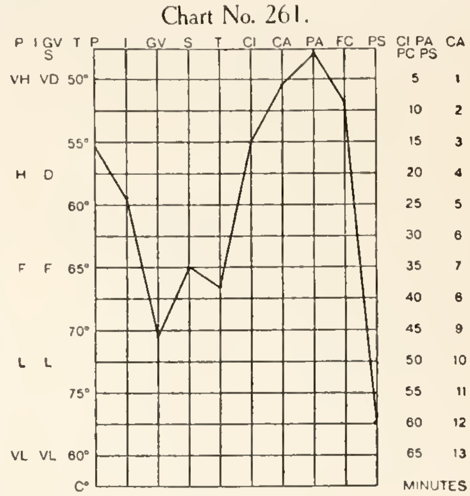
The reaction with *ferrric chloride* begins in a few grains in 30 seconds and is over in all in 12 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *Purdy's solution* begins in a few grains in a minute, and in 5 minutes a few are nearly completely gelatinized. All show signs of reacting and about one-fifth are nearly completely gelatinized in 25 minutes. The reaction is qualitatively the same as that of the grains of *I. florentina.*

STARCH OF IRIS XIPHIUM VAR. WILHELMINE. (Plate 65, figs. 385 and 386. Chart 261.)

Histological Characteristics.—In *form* the grains are usually simple. Compound grains, aggregates, separated-grains with pressure facets, and a few pseudo aggregates (chiefly collections of minute grains) are present as in *I. florentina.* The surface of the grains is occasionally irregular, owing to the same causes as noted under *I. florentina.* The secondary set of lamellæ is more frequently formed at the proximal end in this species. The conspicuous forms of the simple grains are the ovoid with a square distal end, oval, broadly triangular with curved base and rounded angles, pyriform, and a number of small, globular grains. The conspicuous forms of the compound grains are irregular oval to heart-shaped. Those of the aggregates are one minute globular grain closely fitted into a cavity of one large grain, and two grains of equal size with a small globular grain fitted in the depression at their point of union. The broadly triangular forms are somewhat flattened. The grains are much broader in proportion to the length and more regular than in *I. florentina.*

Chart No. 261.



Curve of Reaction-Intensities of Starch of Iris xiphium var. Wilhelmine.

The *hilum* is a distinct, clear, refractive spot, centric in the small globular forms and eccentric two-fifths to one-third, usually two-fifths, of the longitudinal axis in the larger grains. More than one hilum may be found in a grain. There is usually at the hilum either a deep cavity or ragged clefts, so arranged as to form a diagonal cross approaching the figure of a flying bird or dragon-fly when seen from below.

The *lamellæ* are usually invisible, but occasionally a few can be observed which generally are fairly coarse. One or two distinct lamellæ, either at about a third or half the distance between the hilum and distal end, may sometimes be observed. In small globular forms the lamellæ form complete rings around the hilum; but in grains in which the hilum is deeply fissured the lamellæ are not visible near this part and those observed usually assume the shape of the grain.

The grains vary in *size;* the smaller are 4 by 4μ; the larger are 34 by 22μ and 34 by 28μ in length and breadth. The common sizes are 26 by 20μ and 26 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is generally eccentric and quite distinct. Its lines are rather thick and usually straight with broadening towards the margin, but are occasionally bent. It is fairly regular and rather more clear-cut than that of *I. florentina.*

The degree of *polarization* is high to quite high, often varying in the same aspect of a given grain. It is distinctly higher than in *I. florentina.*

With *selenite* the quadrants are well defined and generally irregular in shape and unequal in size. The colors are commonly pure, but the yellow in some grains is not quite pure. The colors are rather purer than in *I. florentina.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep blue-violet; with 0.125 per cent solution they color fairly and the color is deeper than that of the grains of *I. florentina.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. The capsules all color a red-violet with an excess of iodine.

Staining Reaction.—With *gentian violet* the grains begin to stain at once and in 30 minutes are lightly colored, and the tint is deeper than that of the grains of *I. florentina.*

With *safranin* the grains begin to color at once and in 30 minutes are fairly stained and the tint is deeper than that of the grains of *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 66.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in 30 seconds. It is over in three-fourths of the grains in 10 minutes and in all in 15 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *chromic acid* begins in a few grains at once and in all in 15 seconds. It is over in 70 seconds. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *pyrogallic acid* begins in all the grains in 15 seconds and is over in a minute. It is qualitatively the same as that of the grains of *I. florentina.*

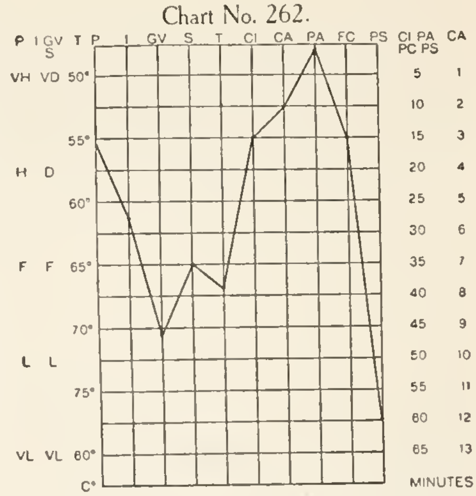
Reaction with *ferric chloride* begins in a few grains in 45 seconds. It is over in nearly all in 8 minutes and in all in 12 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *Purdy's solution* begins in most grains in 45 seconds, some are partially gelatinized in 5 minutes, and about half are nearly completely gelatinized in 30 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

STARCH OF IRIS XIPHIUM VAR. LUSITANICA. (Plate 65, figs. 387 and 388. Chart 262.)

Histological Characteristics.—In *form* the grains are generally simple. Compound grains, aggregates, separated-grains with pressure facets, and a few clumps consisting of minute globular grains are present as in *I. florentina;* the surface is sometimes irregular. The irregularities are generally due to a broadening of the proximal end; or to a curving of the distal end caused by the addition of a secondary set of lamellæ; or to rounded protuberances, which more often appear at or near the proximal end. The conspicuous forms of the simple grains are cone-shaped with rounded apex, ovoid, broadly triangular to clam-shell-shaped, and oval with squared end. In addition there are large oval and curved club-shaped grains. The compound grains are often irregular oval to broadly lenticular. The aggregates consist either of equal-sized components, or of one large grain with one very small, globular one. The separated-grains are usually dome-shaped. The grains are much broader in relation to length and more regular in shape than those of *I. florentina,* and the cup-shaped depression at the termination of the sets of lamellæ is not usually observed. The broadly triangular to clam-shell-shaped forms are somewhat flattened.

Chart No. 262.



Curve of Reaction-Intensities of Starch of Iris xiphium var. Lusitanica.

The *hilum* may appear as a clear, distinct, refractive spot which is centric in small, round forms, but in the elongated grains is eccentric very slightly or from two-fifths to one-third, usually two-fifths, of the longitudinal axis. There is usually either a cavity or a cleft at the hilum. There may be either one transverse or diagonal cleft, or two or more clefts which generally form a cross, or a figure like that of a flying bird, or of a root-like form. They resemble those noted for *I. xiphium* var. *Grand Tresorier.*

The *lamellæ* not distinct and the number can not be determined with certainty. When distinctly visible they are rather coarse. One quite coarse, distinct lamella is frequently observed, either at one-third or one-fourth of the distance from the hilum.

The grains vary in *size;* the smaller are 3 by 3μ; the larger are 38 by 36μ and 32 by 20μ in length and breadth. The common sizes are 24 by 18μ and 26 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is generally eccentric and quite distinct. The lines of the figure are rather thick and generally are straight and broaden towards the margin. The figure is fairly clear-cut and more distinct and regular than in *I. florentina.*

The degree of *polarization* is rather high to quite high. There are variations in the different grains as well as sometimes in the same aspect of a given grain. It is distinctly higher than in *I. florentina.*

With *selenite* the quadrants are fairly well defined, generally slightly irregular in shape, and unequal in size. The colors are generally pure, but the yellow is sometimes not pure throughout the entire quadrant. The colors are purer than in *I. florentina.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all begin to color a fairly deep blue-violet; with 0.125 per cent solution they color lightly, and the color is the same as that of the grains of *I. florentina*. After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. The capsules color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains all begin to stain at once and in 30 minutes are lightly stained, but more than the grains of *I. florentina*.

With *safranin* the grains all begin to stain at once and in 30 minutes are fairly stained, but more than the grains of *I. florentina*.

Temperature Reaction.—The temperature of gelatinization is 66.5° to 67.5° C., mean 67°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds. It is over in two-thirds of the grains in 10 minutes and in nearly all in 15 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

The reaction with *chromic acid* begins in 15 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

With *pyrogallic acid* the reaction begins in 15 seconds and is over in a minute. It is the same qualitatively as that of the grains of *I. florentina*.

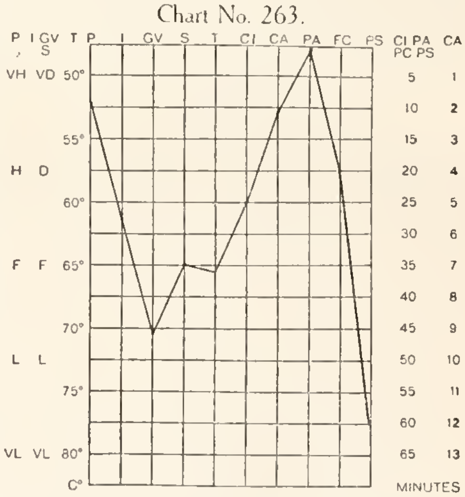
The reaction with *ferric chloride* begins in some grains in 15 seconds. It is over in four-fifths of the grains in 10 minutes and in practically all in 15 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

Reaction with *Purdy's solution* begins in 30 seconds and a few are partially gelatinized in 10 minutes.

STARCH OF IRIS TINGITANA. (Plate 65, figs. 389 and 390. Chart 263.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains, aggregates, and separated-grains with pressure facets; clumps were not observed. The surface of the grains is occasionally irregular, owing chiefly to rounded protuberances or secondary sets of lamellæ. The conspicuous forms among the simple grains are the broadly triangular with rounded angles to clam-shell-shaped, and cone-shaped with rounded apex; also a few ovoid and also finger-shaped grains with squared end and a hollowed depression. The conspicuous forms among the compound grains are broadly lenticular and irregularly oval. The aggregates usually appear as doublets, or as triplets in linear arrangement, or with one or more minute grains firmly attached to a large one. The separated-grains have well-marked pressure facets and are generally dome-shaped with either squared or pointed base, or are polygonal. The grains are more uniform in shape and much broader in relation to length than in *I. florentina*, and more closely resemble *I. xiphium* var. *lusitanica*. The broadly triangular to clam-shell-shaped grains are somewhat flattened.

Chart No. 263.



Curve of Reaction-Intensities of Starch of Iris tingitana.

The *hilum* is a clear, distinct, refractive spot, centric in the small round forms, and eccentric two-fifths to one-fourth, usually one-third, of the longitudinal axis in other forms. There is commonly either a cavity or cleft at the hilum. The clefts are often ragged and branched root-like, and frequently form a diagonal cross approaching the flying-bird type previously referred to.

The *lamellæ* in the larger forms are rather distinct, but often are not visible on a part of the grain, and two particularly refractive lamellæ are frequently observed about one-third to two-thirds of the distance from the hilum. The lamellæ in all the grains but the round forms, at a short distance from the hilum, have the shape of the grain and are not very coarse. In round forms 9 lamellæ forming a band around the margin can be counted, in the medium-sized grains there are 14 to 19 distinct lamellæ, and in the large ovoid forms there may be as many as 38.

The grains vary in *size;* the smaller are 4 by 4μ, the larger are 46 by 34μ and 50 by 28μ in length and breadth. The common sizes are 30 by 22μ and 32 by 29μ in length and breadth.

Polariscopic Properties.—The *figure* is generally eccentric and quite distinct. Its lines are rather thick and generally straight with broadening towards the margin, and occasionally are bisected. It is fairly clear-cut, and more distinct and regular than in *I. florentina.*

The degree of *polarization* is high to very high, sometimes varying in the same aspect of a given grain. It is decidedly higher than in *I. florentina.*

With *selenite* the quadrants are well defined, often slightly irregular in shape, and unequal in size. The colors are generally pure, but the yellow is sometimes not quite pure. They are purer than in *I. florentina.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep violet-blue; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. It is the same as that of the grains of *I. florentina.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues do not color at all. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes are lightly stained, slightly more than the grains of *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 65° to 66° C., mean 65.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds. One-half of the grains are gelatinized in 10 minutes, three-fourths in 15 minutes, and practically all in 25 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *chromic acid* begins in some grains in a few seconds and in all the rest in 20 seconds, and it is over in 2¼ minutes. It is the same qualitatively as that of the grains of *I. florentina,* except that the capsule is quite as likely to be dissolved first at the proximal as at the distal end.

Reaction with *pyrogallic acid* begins in all the grains in 15 seconds and is over in a minute. It is the same qualitatively as that of the grains of *I. florentina,* except that a bubble is practically always formed at the hilum, and that when this bubble decreases in size it leads to an invagination of the capsule at the proximal end, to be followed by the reverse movement.

The reaction with *ferric chloride* begins in a few grains in 30 to 45 seconds. It is over in four-fifths of the grains in 10 minutes and in all in 20 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *Purdy's solution* begins in all the grains in 30 seconds and a few are nearly completely gelatinized in 5 minutes. One-third are nearly completely gelatinized in 15 minutes, and three-fifths of the remaining two-thirds are partially gelatinized.

STARCH OF IRIS RETICULATA. (Plate 66, figs. 391 and 392. Chart 264.)

Histological Characteristics.—In *form* the grains are usually simple. There are some compound grains, aggregates, and separated-grains with pressure facets; clumps composed chiefly of minute globular grains are also observed. The surface of the grains is often irregular. The margin of the grain frequently is undulating; there are irregularities due to secondary deposits, and rounded protuberances as in *I. florentina.* The conspicuous forms are the cone-shaped with rounded apex, pyriform with a squared end, minute and fair-sized globular, and oval with or without a squared end; also a few elongated, slender grains similar to those observed in *I. florentina.* Among the compound grains there is an irregular oval form, as well as forms similar to those of *I. florentina.* The aggregates frequently consist of one large with one or more minute, globular grains; and occasionally of grains of equal or nearly equal size. The grains are broader in proportion to length and less irregular than those of *I. florentina.*

The *hilum* may be observed as a clear, distinct, round, refractive spot, centric in the round forms, and in most of the grains eccentric from slightly to two-fifths to one-third, usually two-fifths, of the longitudinal axis. Either a cavity or a cleft commonly is to be seen at the hilum. The clefts are generally ragged and irregular; sometimes two are so arranged as to form a cross.

The *lamellæ* are rather fine but distinct. They form complete, regular rings around the hilum, but farther out have the shape of the outline of the grain, and are probably not complete near the distal margin. There are 22 lamellæ on the grains of fair size.

The grains vary in *size;* the smaller are 11 by 4μ; the larger are 46 by 36μ and 40 by 24μ in length and breadth. The common sizes are 30 by 22μ and 32 by 26μ in length and breadth.

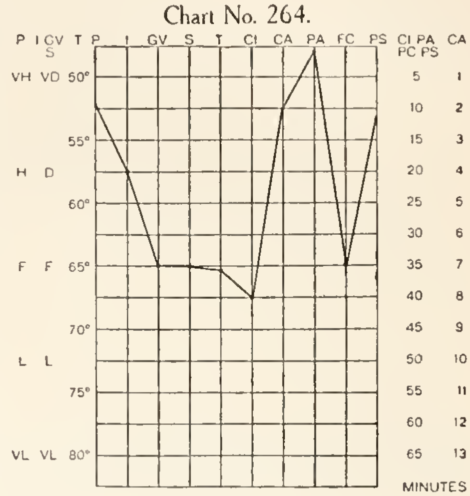
Polariscopic Properties.—The *figure* is generally eccentric and distinct. The lines of the figure are rather thick and often straight, with slight broadening at the margin of the grain; sometimes bisected. The figure is fairly clear-cut, and more distinct and regular than in *I. florentina*.

The degree of *polarization* is high to very high, sometimes varying in one aspect of the same grain. It is markedly higher than in *I. florentina*.

With *selenite* the quadrants are usually irregular in shape and size. The colors are generally pure, purer than in *I. florentina*, but the yellow is occasionally not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all begin to color a deep violet-blue; with 0.125 per cent solution they color fairly and the color deepens fairly rapidly. It is more than that of the grains of *I. florentina*. After heating in water until the grains are completely gelatinized, the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. The capsules all color reddish-violet with an excess of iodine.

Chart No. 264.



Curve of Reaction-Intensities of Starch of Iris reticulata.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes they are fairly stained, distinctly more than the grains of *I. florentina*.

Temperature Reaction.—The temperature of gelatinization is 64.5° to 66° C., mean 65.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a few grains in as many seconds and in all in a minute. It is complete in two-thirds of the grains in 17 minutes, in four-fifths in 25 minutes, and in all in 40 minutes. It is qualitatively the same as that of the grains of *I. florentina*.

The reaction with *chromic acid* begins in most grains in 15 seconds, in the rest in 30 seconds, and is over in 2 minutes. It is the same qualitatively as that of the grains of *I. florentina*, except that in these grains a bubble usually forms at the hilum, which increases and then decreases in size, accompanied by invagination at the proximal end followed by the opposite movement, and then the bubble disappears. Also the outer coating may be dissolved at either the proximal or the distal end, whereas in *I. florentina* the solution occurs at the latter.

The reaction with *pyrogallic acid* begins in 15 seconds and is over in a minute. It is the same qualitatively as that of the grains of *I. florentina*, except that a large bubble forms at the hilum of every grain.

Reaction with *ferric chloride* begins in some grains in 30 seconds, is complete in nearly all in 25 minutes, and in all in 35 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

Reaction with *Purdy's solution* begins in some grains at once and in all in 45 seconds, three-fourths of the grains are nearly completely gelatinized and the others are partially gelatinized in 4 minutes, and all are nearly completely gelatinized in 12 minutes. The reaction is the same qualitatively as that of the grains of *I. florentina*.

STARCH OF IRIS HISTRIO. (Plate 66, figs. 393 and 394. Chart 265.)

Histological Characteristics.—In *form* the grains are usually simple. Compound grains, aggregates, separated-grains which are chiefly dome-shaped or polygonal with well-marked pressure facets, and a very few clumps are present. The surface is sometimes irregular. Many grains have an irregular undulating margin as well as the rounded protuberances and secondary deposits of lamellæ similar to those noted in the grains of *I. florentina*. The secondary sets of lamellæ frequently appear at either side of the distal end of an oval, rounded grain. The conspicuous forms are cone-shaped with rounded apex, broadly triangular with rounded angles to clam-shell and oyster-shell shapes, and ovoid with squared end. Among the compound grains are found the broadly lenticular with rounded ends, the irregular oval, and the knob shape noted for *I. florentina*. The aggregates consist of a large grain with one or more small grains, although there are doublets, triplets, and even multiples made up of components of equal or about equal size. The grains are broader in relation to length and rather more regular in form than those of *I. florentina.* The aggregates and the fissures at the hilum bear a greater similarity to the grains of *I. xiphium* var. *Grand Tresorier* than to *I. florentina.*

The *hilum* may appear as a clear, distinct, refractive spot, centric in small, round forms, and eccentric two-fifths to one-third, usually two-fifths, of the longitudinal axis in most of the grains. There are sometimes two or more hila without a line of division in the simple grains. Either a cavity or a cleft is usually found at the hilum. The clefts frequently are ragged and appear either in the form of a cross, or of the flying-bird or dragon-fly type, or as a branched, root-like structure.

The *lamellæ* are not very distinct, and the number can not be definitely decided; those visible appear to be rather coarse. In some grains the lamellæ were indistinct for one-third of the distance from the hilum, and for the remainder of the grain 10 rather coarse and fairly distinct lamellæ were counted. In other grains 8 coarse lamellæ were counted between the hilum and three-fourths of the distance, and then a band located in the last one-fourth consisting of 5 fine lamellæ.

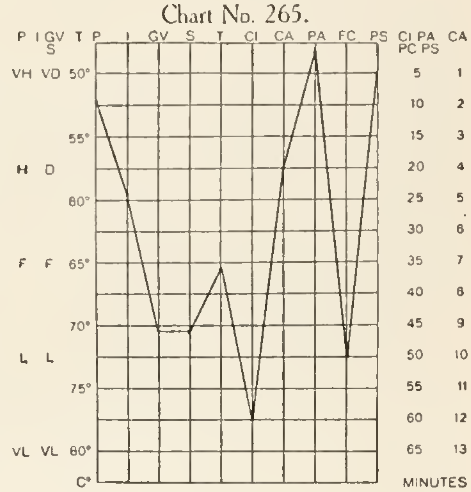
The grains vary in *size;* the smaller are 3 by 3μ; the larger are 36 by 49μ and 36 by 28μ in length and breadth. The common sizes are 24 by 30μ and 28 by 22μ in length and breadth.

Polariscopic Properties.—The *figure* is generally eccentric and very distinct. Its lines are rather thick and may be straight with broadening at the margin, but are either bent or bisected in the greater number of grains. It is fairly clear-cut, and more distinct than in *I. florentina.*

The degree of *polarization* is high to very high, with some variation in the same aspect of a given grain. Polarization is markedly higher than in *I. florentina.*

With *selenite* the quadrants are well defined in some grains and regular in shape and equal in size, while in many grains they are not clearly defined, and are irregular in shape and unequal in size. The colors are generally purer than in *I. florentina.* In several grains the yellow was not quite pure and occasionally the same is noted for blue.

Chart No. 265.



Curve of Reaction-Intensities of Starch of Iris histrio.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep violet-blue; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues do not color at all. The capsules all color a reddish-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes they are lightly stained, but slightly more than the grains of *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 65° to 66° C., mean 65.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 15 seconds. It is over in one-third in 10 minutes, one-half in 17 minutes, in three-fourths in 40 minutes, and in all in 60 minutes. There is a thin coating or outer layer of the grains which is affected first, otherwise the reaction is qualitatively the same as that of the grains of *I. florentina.*

The reaction with *chromic acid* begins in some grains in 15 seconds, in all within 30 seconds, and is over in 4 minutes. It is qualitatively the same as that of the grains of *I. florentina,* but the distal end does not appear to be much more sensitive to the reagent than the proximal end or the sides.

With *pyrogallic acid* some grains begin to react in 15 seconds and all in 30 seconds, and it is over in 1¾ minutes. It is qualitatively the same as that of the grains of *I. florentina.*

The reaction with *ferric chloride* begins in many grains in a minute. Three-fourths of the grains are completely gelatinized in 25 minutes and practically all in 50 minutes. It is qualitatively the same as that of the grains of *I. florentina.*

Reaction with *Purdy's solution* begins in many grains in 45 seconds, and all are nearly completely gelatinized in 5 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

STARCH OF IRIS ALATA. (Plate 66, figs. 395 and 396. Chart 266.)

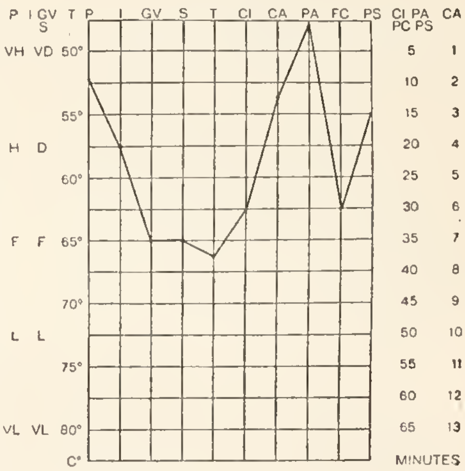
Histological Characteristics.—In *form* the grains are usually simple. Compound grains frequently occur. There are also aggregates, separated-grains with pressure facets, and clumps consisting mainly of very small grains. The surface is often irregular, the irregularities being due to the same causes noted in *I. florentina.* The conspicuous forms of the simple grains are elongated ovoid with squared distal end, pyriform with squared distal end, oval with broadened distal end which approaches the fresh-water mussel-shell-shaped, and numerous small globular grains. Slender, finger-shaped forms similar to those of *I. florentina* are rare. The compound grains are frequently either irregular ovoid, or there is one large grain with one or two minute globular grains at the distal end. The irregular lenticular and the knob-shaped are rare. The aggregates consist usually of one large grain having attached one or more small grains, or of two grains of equal size together with minute globular grains at the point of union. The grains are much broader in relation to length, and both compound grains and aggregates are more numerous than in *I. florentina.* The grains are not flattened.

The *hilum* is a clear, distinct, round, refractive spot. In the elongated grains it is eccentric two-fifths to one-fourth, usually one-third, of the longitudinal axis; 2 or 3 hila may be observed in one grain. In place of the hilum either a cavity or clefts of various forms may be seen, the most common forms being one or two short, transverse clefts with a diagonal cleft crossing them; one diagonal cleft with one transverse cleft; and several short ones forming a stellate figure. Two longitudinal fissures frequently proceed from the hilum or cleft at this point.

The *lamellæ* are rather coarse and fairly distinct. They sometimes form complete regular rings around the hilum, while in some grains they have at this part the form of the margin of the grain. The lamellæ are frequently indistinct for one-third of the distance from the hilum, while for the remaining distance they are well marked and rather coarse. There are often 9 coarse lamellæ in the round grains of fair size, while 25 are sometimes visible in the grains of elongated oval with squared-end form.

The grains vary in *size;* the smaller are 4 by 4μ; the larger are 48 by 36μ and 50 by 32μ in length and breadth. The common sizes are 32 by 22μ and 30 by 29μ in length and breadth.

Chart No. 266.



Curve of Reaction-Intensities of Starch of Iris alata.

Polariscopic Properties.—The *figure* is usually eccentric and quite distinct. Its lines are generally straight and fairly thick, broadening towards the margin of the grain; they may be bent or bisected. The figure is fairly clear-cut and more distinct and less irregular than in *I. florentina.*

The degree of *polarization* is high to very high. Occasionally it varies in the same aspect of a given grain. It is distinctly higher than in *I. florentina.*

With *selenite* the quadrants are well defined, often regular in shape, and equal in size. The colors are generally purer than in *I. florentina.* The yellow is occasionally not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep indigo-blue; with 0.125 per cent solution they color fairly and the color deepens fairly rapidly. It is deeper than that of the grains of *I. florentina.* After heating in water until the grains are completely gelatinized, the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues do not color at all. The capsules all color a reddish-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes they are fairly stained, and distinctly more than the grains of *I. florentina.*

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 66.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds. It is over in three-fifths in 15 minutes, and in nearly all in 30 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *chromic acid* begins in 20 seconds and is over in 2½ minutes. It is the same qualitatively as that of the grains of *I. florentina.*

Reaction with *pyrogallic acid* begins in 15 seconds and is over in 1½ minutes. It is the same qualitatively as that of the grains of *I. florentina.*

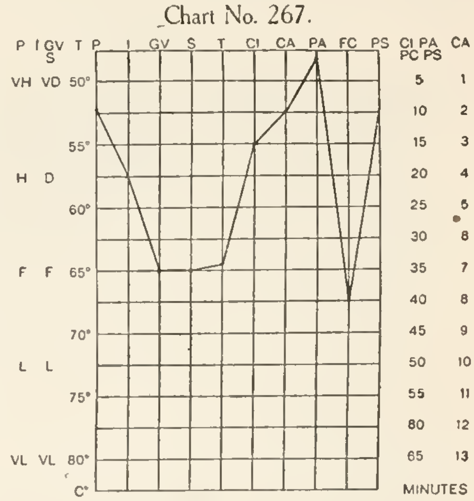
The reaction with *ferric chloride* begins in a minute. It is over in half in 10 minutes, in nearly all in 17 minutes, and in all in 30 minutes. It is the same qualitatively as that of the grains of *I. florentina.*

The reaction with *Purdy's solution* begins in 15 seconds. Two-fifths of the grains are nearly completely gelatinized and the remaining three-fifths are partially gelatinized in 15 minutes. The reaction is the same qualitatively as that of the grains of *I. florentina.*

STARCH OF IRIS CAUCASICA. (Plate 67, figs. 397 and 398. Chart 267.)

Histological Characteristics.—In *form* the grains are usually simple. Compound grains frequently occur. There are aggregates, separated-grains with pressure facets, and a few clumps consisting chiefly of collections of minute grains. The surface of the grains is often irregular. The irregularity is more frequently caused by small, rounded protuberances occurring at different points on the margin of the grain. The causes of the irregularities noted under *I. florentina* are also found, although the cup-shaped depression either at the end of the main grain or in the secondary growth is not often observed. The conspicuous forms among the simple grains are irregular ovoid, elongated oval with squared distal end, and round with squared distal end. Occasionally grains are globular or conical with a rounded apex. The broadly lenticular with rounded ends is frequently found among the compound grains, as well as the irregular ovoid and the double grain with the secondary growth already noted under *I. florentina.* The aggregate grains often appear in the form of one large grain having one or more small ones at the side; or as three grains placed in a row. The grains are not flattened, although irregular depressions may be found on the surface. The grains are wider in proportion to length, but the cup-shaped depression at the distal end is not so marked as in *I. florentina.*

Chart No. 267.



Curve of Reaction-Intensities of Starch of Iris caucasica.

The *hilum* may appear as a clear, distinct, round or oval spot, centric in the globular forms, and slightly eccentric to one-third, usually two-fifths, of the longitudinal axis in the majority of the grains. There are sometimes 3, 4, or as many as 7 hila in one grain. Either a cavity or clefts of different forms are frequently located at the hilum. The clefts are more often diagonal, sometimes two in the shape of a cross, and sometimes branched and root-like. Two short longitudinal lines frequently pass from the hilum.

The *lamellæ* in many grains are not distinct throughout the entire grain. They sometimes form complete, regular rings or ellipses near the hilum and frequently have the shape of the outline, even within a short distance of the hilum. There are about 20 rather coarse lamellæ on the large grains.

The grains vary in *size;* the elongated grains are from 9 by 6μ to 49 by 34μ in length and breadth; and the broader grains are 26 by 40μ in length and breadth. The common size is 26 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric and distinct. The lines are rather thick and often straight with broadening at the margin of the grain. They may be bent or bisected. The figure is fairly clear-cut, more distinct, and less irregular than in the grains of *I. florentina.*

The degree of *polarization* is high to very high, frequently varying in the same aspect of a given grain. It is distinctly higher than in *I. florentina.*

With *selenite* the quadrants are fairly well defined. The colors are quite pure in most of the grains, and on the whole purer than in *I. florentina.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep indigo-blue; with 0.125 per cent solution they color fairly, and the color deepens rather rapidly. It is more than that of the grains of *I. florentina*. After heating in water until the grains are completely gelatinized, the solution and the gelatinized grains color deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but most of the grain-residues not at all. The capsules all color a reddish-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes they are fairly stained, and more than the grains of *I. florentina*.

Temperature Reaction.—The temperature of gelatinization is 64° to 65° C., mean 64.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds. It is over in one-half in 10 minutes and in nearly all in 15 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

The reaction with *chromic acid* begins in some grains in 15 seconds, in all in 45 seconds, and is over in 2 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

The reaction with *pyrogallic acid* begins in 10 to 15 seconds and is over in 1½ minutes. It is the same qualitatively as that of the grains of *I. florentina*.

With *ferric chloride* the grains begin to react in many grains in 30 to 45 seconds. The reaction is over in half of the grains in 15 minutes, in nearly all in 30 minutes, and in all in 40 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

With *Purdy's solution* the reaction begins in many grains in 20 seconds. Most of the grains are nearly completely gelatinized in 5 minutes and all are completely gelatinized in 8 minutes. It is the same qualitatively as that of the grains of *I. florentina*.

Differentiation of the Starches of the Genus Iris.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

I. florentina: Usually simple. Some compound, small aggregates, grains with few pressure facets. Often irregular with rounded protuberances and secondary deposits of starch. Cup-shaped depressions at the distal end of primary sets of lamellæ, and frequently of secondary sets. Elongated ovoid with squared, hollowed, distal end; oval, finger-shaped, and conical with rounded apex. Both compound and aggregate grains consisting of a large grain with a small grain fitting into its distal end.

I. pallida var. *speciosa:* Essentially the same as in *I. florentina*, but not so irregular in outline, and shortened and broader forms are proportionately more numerous.

I. pumila var. *cyanea:* Essentially the same as in *I. florentina*, but more irregular, and the grains are mostly elongated.

I. bismarckiana: The same as in *I. florentina*, but the grains tend to be broader in proportion to length; conical grains with rounded apex are more numerous; small grains attached to large grains often at the side instead of at distal end; depression at end not so deep; compound, broadly lenticular frequently found.

I. iberica: The same as in *I. bismarckiana*.

I. xiphium var. *Grand Tresorier:* Cone-shaped with rounded apex, ovoid with squared distal end, and clam-shell-shaped. Compound grains similar to *I. florentina*, except minute globular grains more frequently found at lines of union of components, more regular in outline, and broader in proportion to length. Otherwise same as in *I. florentina*.

I. xiphium var. *Wilhelmine:* Ovoid with squared distal end, oval, broadly triangular with curved base and rounded angles, pyriform, and small globular. Grains broader in proportion to length than in *I. florentina*. Otherwise the same as in *I. florentina*.

I. xiphium var. *lusitanica:* Cone-shaped with rounded apex, ovoid, broadly triangular to clam-shell-shaped, oval with squared end, broader in relation to length. Otherwise essentially the same as in *I. florentina*.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Conspicuous Forms.—Continued.

I. tingitana: Broadly triangular with rounded angles to clam-shell-shaped, cone-shaped with rounded apex. More uniform in shape and much broader in relation to length than in *I. florentina*. They bear closer resemblance to *I. xiphium* var. *lusitanica* than to *I. florentina*.

I. reticulata: Cone-shaped with rounded apex, pyriform with squared ends, globular, good-sized, and minute, oval with or without squared end; irregular oval. Less irregular and broader in proportion to length than in *I. florentina*. Otherwise essentially the same as in *I. florentina*.

I. histrio: Cone-shaped with rounded apex, broadly triangular with rounded angles to clam-shell and oyster-shell shapes, ovoid with squared end. Less irregular, and broader in proportion to length than in *I. florentina*. Otherwise essentially the same as in *I. florentina*.

I. alata: Elongated ovoid with squared distal end; pyriform with squared distal end, oval with broadened distal end, and numerous small globular grains. Compound grains and aggregates more numerous, and grains are broader in relation to length than in *I. florentina*, but otherwise essentially the same.

I. caucasica: Irregular ovoid, elongated oval with squared distal end, and round with squared distal end. Cup-shaped depressions at distal end not so marked as in *I. florentina*. Otherwise about the same as in *I. florentina*.

Hilum—Form, Number, and Position.

I. florentina: Form distinct round spot or cavity; may be fissured; single short, straight transverse cleft, or cross or stellate fissures. Position usually eccentric 0.33 to 0.16, commonly 0.25, of longitudinal axis.

I. pallida var. *speciosa:* Form distinct round or elliptical spot; occasionally fissured diagonally or transversely; less often fissured than in *I. florentina*, and unfissured hilum less refractive. Position usually eccentric about 0.25 to 0.12 of longitudinal axis.

Differentiation of the Starches of the Genus Iris.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.—Continued.

I. pumila var. *cyanea:* Form the same as in *I. pallida* var. *speciosa.* Position usually eccentric about 0.16 to 0.10 of longitudinal axis.

I. bismarckiana: Form fairly distinct round or lenticular spot, or cavity sometimes. 4 hila may be present. Hilum seldom fissured. Position usually eccentric 0.25 to 0.14, commonly 0.16, of longitudinal axis.

I. iberica: Form distinct round spot or cavity; sometimes 2 hila; usually not cleft. Position eccentric usually from 0.20 to 0.14, commonly 0.20, of longitudinal axis.

I. xiphium var. *Grand Tresorier:* Form distinct round spot or cavity, often deeply and irregularly cleft; clefts in form of double-branched roots, irregular cross, flying-bird or dragon-fly type. Position usually eccentric, 0.40 to 0.33, commonly 0.40, of longitudinal axis.

I. xiphium var. *Wilhelmine:* Form distinct round spot or deep cavity, often cleft; clefts deep, ragged, irregular, forming a diagonal cross, flying-bird, or dragon-fly type, or a branched, root-like figure. Position usually eccentric 0.40 to 0.33, commonly 0.40, of longitudinal axis.

I. xiphium var. *lusitanica:* Form distinct round spot or cavity, often cleft either by a straight transverse or diagonal or 2 or more forming a cross or flying-bird type. Position usually eccentric 0.40 to 0.33, commonly 0.40, of longitudinal axis.

I. tingitana: Form distinct round spot or cavity, often fissured; clefts often ragged and form a branched root-like figure, or a diagonal or transverse cross, or flying-bird type. Position usually eccentric 0.40 to 0.25, commonly 0.33, of longitudinal axis.

I. reticulata: Form distinct round spot or cavity, often fissured; clefts irregular and ragged, but sometimes form a cross. Position usually eccentric slightly or 0.40 to 0.33, commonly 0.40, of longitudinal axis.

I. histrio: Form distinct, round spot or cavity; sometimes 2 hila. Often fissured, clefts usually ragged and in form of a cross, flying-bird, or dragon-fly type, or a branching root-like form. Position usually eccentric 0.40 to 0.33, commonly 0.40, of longitudinal axis.

I. alata: Form distinct round spot or cavity; sometimes 3 hila; may be fissured; clefts usually arranged in twos or threes, or in irregular stellate fashion. Position usually eccentric 0.40 to 0.25, commonly 0.33, of longitudinal axis.

I. caucasica: Form distinct round or oval spot or cavity. Sometimes 4 or more hila. Often fissured; clefts commonly diagonal; sometimes a cross or root-like arrangement. Position usually eccentric slightly to 0.33, commonly 0.40, of longitudinal axis.

Lamellæ—General Characteristics and Number.

I. florentina: Rather coarse, generally not very distinct, complete and incomplete, 2 sets sometimes, rings around hilum, outer lamellæ follow outlines of grains. 13 to 21 on larger grains.

I. pallida var. *speciosa:* Indistinct, rather coarse complete rings near hilum; distally irregular and probably incomplete. Rarely 20 on larger grains.

I. pumila var. *cyanea:* Indistinct, usually fine complete rings near hilum; distally irregular and probably incomplete. 28 to 32 on larger grains.

I. bismarckiana: Fairly distinct, rings around hilum or otherwise the same as in *I. florentina.* 10 to 16 on larger grains.

I. iberica: Not distinct, impossible to determine character. Number not determined.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Lamellæ—General Characteristics and Number.—Cont'd.

I. xiphium var. *Grand Tresorier:* Not distinct, a few very coarse lamellæ visible. Number not determined.

I. xiphium var. *Wilhelmine:* Usually visible, some coarse lamellæ occasionally seen which have the shape of the outline of the grain. Number not determined.

I xiphium var. *lusitanica:* Not distinct, some coarse lamellæ visible. Number not determined.

I. tingitana: Often invisible, when seen rather coarse, and have the form of the grain. When can be counted, 14 to 19 on medium-sized grains; 38 on larger.

I. reticulata: Rather fine, distinct, complete regular rings at hilum, probably incomplete, and follow margin of grain when distal to hilum. 22 on fair-sized grains.

I. histrio: Indistinct, one-third distance from hilum; coarse and follow shape of grain when distal to hilum. Number not satisfactorily determined.

I. alata: Fairly distinct, rather coarse complete regular rings around hilum; often indistinct for one-third of the distance from hilum, but distinct beyond. 25 on larger grains.

I. caucasica: Often not distinct throughout, sometimes coarse complete regular rings or ellipses near the hilum, probably have the shape of the grains when located at and beyond the hilum. 20 on larger grains.

Size.

I. florentina: From 6 to 30μ, commonly 18μ.
I. pallida var. *speciosa:* From 4 to 32μ, commonly 16μ.
I. pumila var. *cyanea:* From 3 to 40μ, commonly 30μ.
I. bismarckiana: From 4 to 26μ, commonly 18μ.
I. iberica: From 4 to 28μ, commonly 18μ.
I. xiphium var. *Grand Tresorier:* From 4 to 36μ, commonly 24μ.
I. xiphium var. *Wilhelmine:* From 4 to 34μ, commonly 26μ.
I. xiphium var. *lusitanica:* From 3 to 38μ, commonly 24μ.
I. tingitana: From 4 to 50μ, commonly 30μ.
I. reticulata: From 4 to 46μ, commonly 30μ.
I. histrio: From 3 to 36μ, commonly 36μ.
I. alata: From 4 to 50μ, commonly 33μ.
I. caucasica: From 9 to 49μ, commonly 26μ.

POLARISCOPIC PROPERTIES.

Figure.

I. florentina: Eccentric, distinct, usually irregular; lines fine, often bent, sometimes bisected.

I. pallida var. *speciosa:* Same as in *I. florentina,* but centric figure more frequent and lines more often straight.

I. pumila var. *cyanea:* Same as in *I. florentina,* but the lines more often bent.

I. bismarckiana: Same as in *I. florentina,* but figure more irregular.

I. iberica: Same as in *I. florentina,* but figure less irregular.

I. xiphium var. *Grand Tresorier:* The same as in *I. florentina,* but less irregular and more clean-cut.

I. xiphium var. *Wilhelmine:* Same as in *I. xiphium* var. *Grand Tresorier.*

I. xiphium var. *lusitanica:* Same as in *I. xiphium* var. *Grand Tresorier.*

I. tingitana: Same as in *I. florentina,* but more distinct and regular.

I. reticulata: Same as in *I. florentina,* but more distinct and regular.

I. histrio: Same as in *I. florentina,* but more distinct.

I. alata: Same as in *I. florentina,* but more distinct and less irregular.

I. caucasica: Same as in *I. florentina,* but more distinct and less irregular.

Differentiation of the Starches of the Genus Iris.—Continued.

POLARISCOPIC PROPERTIES.—Continued.

Degree of Polarization.

I. florentina: Fair.
I. pallida var. *speciosa:* Fair to high, higher than in *I. florentina.*
I. pumila var. *cyanea:* High, distinctly higher than in *I. florentina.*
I. bismarckiana: Fair to fairly high, slightly higher than in *I. florentina.*
I. iberica: Fairly high, more than in *I. florentina.*
I. xiphium var. *Grand Tresorier:* Rather high to quite high, distinctly higher than in *I. florentina.*
I. xiphium var. *Wilhelmine:* High to quite high, distinctly higher than in *I. florentina.*
I. xiphium var. *lusitanica:* Rather high to quite high, distinctly higher than in *I. florentina.*
I. tingitana: High to very high, decidedly higher than in *I. florentina.*
I. reticulata: High to very high, decidedly higher than in *I. florentina.*
I. histrio: High to very high, decidedly higher than in *I. florentina.*
I. alata: High to very high, decidedly higher than in *I. florentina.*
I. caucasica: High to very high, decidedly higher than in *I. florentina.*

Polarization with Selenite—Quadrants and Colors.

I. florentina: Quadrants fairly well defined, generally irregular, unequal in size. Colors generally pure.
I. pallida var. *speciosa:* Quadrants essentially the same as in *I. florentina*, but not quite so irregular or unequal. Colors more often pure than in *I. florentina.*
I. pumila var. *cyanea:* Quadrants essentially the same as in *I. florentina*, except more irregularity. Colors generally pure.
I. bismarckiana: Quadrants and colors essentially the same as in *I. florentina.*
I. iberica: Quadrants and colors essentially the same as in *I. florentina.*
I. xiphium var. *Grand Tresorier:* Quadrants and colors essentially the same as in *I. florentina.*
I. xiphium var. *Wilhelmine:* Quadrants and colors essentially the same as in *I. florentina.*
I. xiphium var. *lusitanica:* Quadrants and colors essentially the same as in *I. florentina.*
I. tingitana: Quadrants and colors essentially the same as in *I. florentina.*
I. reticulata: Quadrants and colors essentially the same as in *I. florentina.*
I. histrio: Quadrants and colors essentially the same as in *I. florentina.*
I. alata: Quadrants and colors essentially the same as in *I. florentina.*
I. caucasica: Quadrants and colors essentially the same as in *I. florentina.*

IODINE REACTIONS.

Intensity and Color.

I. florentina: Fairly deep; violet.
I. pallida var. *speciosa:* Fairly deep, less than in *I. florentina;* violet.
I. pumila var. *cyanea:* Fairly deep, the same as in *I. florentina;* violet.
I. bismarckiana: Fairly deep, the same as in *I. florentina;* violet.
I. iberica: Fairly deep, less than in *I. florentina;* violet.
I. xiphium var. *Grand Tresorier:* Fairly deep, slightly more than in *I. florentina;* blue-violet.
I. xiphium var. *Wilhelmine:* Fairly deep, more than in *I. florentina;* blue-violet.

IODINE REACTIONS.—Continued.

Intensity and Color.—Continued.

I. xiphium var. *lusitanica:* Fairly deep, the same as in *I. florentina;* blue-violet.
I. tingitana: Fairly deep, the same as in *I. florentina;* violet-blue.
I. reticulata: Deep, more than in *I. florentina;* violet-blue.
I. histrio: Fairly deep, slightly more than in *I. florentina;* violet-blue.
I. alata: Deep, more than in *I. florentina;* indigo-blue.
I. caucasica: Deep, more than in *I. florentina;* indigo-blue.

STAINING REACTIONS.

With Gentian Violet.

I. florentina: Light.
I. pallida var. *speciosa:* Light, less than in *I. florentina.*
I. pumila var. *cyanea:* Light, the same as in *I. florentina.*
I. bismarckiana: Light, the same as in *I. florentina.*
I. iberica: Light, slightly more than in *I. florentina.*
I. xiphium var. *Grand Tresorier:* Light, more than in *I. florentina.*
I. xiphium var. *Wilhelmine:* Light, more than in *I. florentina.*
I. xiphium var. *lusitanica:* Light, more than in *I. florentina.*
I. tingitana: Light, slightly more than in *I. florentina.*
I. reticulata: Fair, more than in *I. florentina.*
I. histrio: Light, more than in *I. florentina.*
I. alata: Fair, distinctly more than in *I. florentina.*
I. caucasica: Fair, distinctly more than in *I. florentina.*

With Safranin.

I. florentina: Light.
I. pallida var. *speciosa:* Light, less than in *I. florentina.*
I. pumila var. *cyanea:* Light, the same as in *I. florentina.*
I. bismarckiana: Light, the same as in *I. florentina.*
I. iberica: Light, but slightly more than in *I. florentina.*
I. xiphium var. *Grand Tresorier:* Fair, distinctly more than in *I. florentina.*
I. xiphium var. *Wilhelmine:* Fair, distinctly more than in *I. florentina.*
I. xiphium var. *lusitanica:* Fair, distinctly more than in *I. florentina.*
I. tingitana: Light, more than in *I. florentina.*
I. reticulata: Fair, distinctly more than in *I. florentina.*
I. histrio: Light, slightly more than in *I. florentina.*
I. alata: Fair, distinctly more than in *I. florentina.*
I. caucasica: Fair, distinctly more than in *I. florentina.*

TEMPERATURE OF GELATINIZATION.

I. florentina: 71 to 72° C., mean 71.5°.
I. pallida var. *speciosa:* 74 to 75° C., mean 74.5°.
I. pumila var. *cyanea:* 72.5 to 74° C., mean 73.25°.
I. bismarckiana: 71 to 73° C., mean 72°.
I. iberica: 72.2 to 74° C., mean 73.1°.
I. xiphium var. *Grand Tresorier:* 65 to 66° C., mean 65.5°.
I. xiphium var. *Wilhelmine:* 66 to 67° C., mean 66.5°.
I. xiphium var. *lusitanica:* 66.5 to 67.5° C., mean 67°.
I. tingitana: 65 to 66° C., mean 65.5°.
I. reticulata: 64.5 to 66° C., mean 65.25°.
I. histrio: 65 to 66° C., mean 65.5°.
I. alata: 66 to 67° C., mean 66.5°.
I. caucasica: 64 to 65° C., mean 64.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

I. florentina: Begins in all in 30 seconds; complete in all in 5 minutes.
I. pallida var. *speciosa:* Begins in a few in 30 seconds; complete in practically all in 15 minutes.
I. pumila var. *cyanea:* Begins in a few in 30 seconds; complete in practically all in 15 minutes.
I. bismarckiana: Begins in a few in 30 seconds; complete in all in 5 minutes.

Differentiation of the Starches of the Genus Iris.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chloral Hydrate-Iodine.—Continued.

I. iberica: Begins in most in 60 seconds; complete in one-third in 3 minutes, and in all in 15 minutes.
I. xiphium var. *Grand Tresorier:* Begins in all in 45 seconds; complete in two-thirds in 8 minutes, and in all in 15 minutes.
I. xiphium var. *Wilhelmine:* Begins in most in 30 seconds; complete in three-fourths in 10 minutes, and in all in 15 minutes.
I. xiphium var. *lusitanica:* Begins in all in 30 seconds; complete in two-thirds in 10 minutes, and in nearly all in 15 minutes.
I. tingitana: Begins in most in 30 seconds; complete in half in 10 minutes, and in practically all in 25 minutes.
I. reticulata: Begins in all in 50 seconds; complete in two-thirds in 17 minutes, in four-fifths in 25 minutes, and in all in 40 minutes.
I. histrio: Begins in all in 15 seconds; complete in one-third in 10 minutes, in three-fourths in 40 minutes, and in all in 60 minutes.
I. alata: Begins in most in 30 seconds; complete in three-fifths in 15 minutes, and in nearly all in 30 minutes.
I. caucasica: Begins in most in 30 seconds; complete in half in 10 minutes, and in nearly all in 15 minutes.

Reaction with Chromic Acid.

I. florentina: Begins in all in 5 seconds; complete in all in 25 seconds.
I. pallida var. *speciosa:* Begins in all in 20 seconds; complete in 2 minutes.
I. pumila var. *cyanea:* Begins in a few in 20 seconds; complete in 3 minutes.
I. bismarckiana: Begins in a few seconds; complete in all in 35 seconds.
I. iberica: Begins in a few in 15 seconds; complete in all in 2 minutes.
I. xiphium var. *Grand Tresorier:* Begins in all in 15 seconds; complete in all in a minute.
I. xiphium var. *Wilhelmine:* Begins in all in 15 seconds; complete in all in 70 seconds.
I. xiphium var. *lusitanica:* Begins in all in 15 seconds; complete in all in 2 minutes.
I. tingitana: Begins in all in 20 seconds; complete in all in 2¼ minutes.
I. reticulata: Begins in all in 30 seconds; complete in all in 2 minutes.
I. histrio: Begins in all in 30 seconds; complete in all in 4 minutes.
I. alata: Begins in all in 20 seconds; complete in all in 2½ minutes.
I. caucasica: Begins in all in 45 seconds; complete in all in 2 minutes.

Reaction with Pyrogallic Acid.

I. florentina: Begins in 10 seconds; complete in all in a minute.
I. pallida var. *speciosa:* Begins at once; complete in practically all in a minute.
I. pumila var. *cyanea:* Begins at once; complete in practically all in a minute.
I. bismarckiana: Begins in all in 7 seconds; complete in all in 70 seconds.
I. iberica: Begins in all in 20 seconds; complete in all in 2½ minutes.
I. xiphium var. *Grand Tresorier:* Begins in all in 15 seconds; complete in all in 45 seconds.
I. xiphium var. *Wilhelmine:* Begins in all in 15 seconds; complete in all in a minute.
I. xiphium var. *lusitanica:* Begins in all in 15 seconds; complete in all in a minute.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

I. tingitana: Begins in all in 15 seconds; complete in all in a minute.
I. reticulata: Begins in all in 15 seconds: complete in all in a minute.
I. histrio: Begins in all in 30 seconds; complete in all in 1¾ minutes.
I. alata: Begins in all in 15 seconds; complete in all in 1½ minutes.
I. caucasica: Begins in all in 10 to 15 seconds; complete in all in 1½ minutes.

Reaction with Ferric Chloride.

I. florentina: Begins in many in 30 seconds; complete in all in 6 minutes.
I. pallida var. *speciosa:* Begins in many in 30 seconds; complete in practically all in 15 minutes.
I. pumila var. *cyanea:* Begins in many in 30 seconds; complete in practically all in 15 minutes.
I. bismarckiana: Begins in many in 15 seconds; complete in all in 5 minutes.
I. iberica: Begins in some in 60 seconds; complete in all in 12 minutes.
I. xiphium var. *Grand Tresorier:* Begins in a few in 30 seconds; complete in all in 12 minutes.
I. xiphium var. *Wilhelmine:* Begins in a few in 45 seconds; complete in all in 8 minutes.
I. xiphium var. *lusitanica:* Begins in some in 30 seconds; complete in all in 15 minutes.
I. tingitana: Begins in a few in 30 to 45 seconds; complete in all in 20 minutes.
I. reticulata: Begins in some in 30 seconds; complete in nearly all in 25 minutes, and all in 35 minutes.
I. histrio: Begins in many in 60 seconds; complete in three-fourths in 25 minutes, and in all in 50 minutes.
I. alata: Begins in many in 60 seconds; complete in all in 30 minutes.
I. caucasica: Begins in many in 30 to 45 seconds; complete in nearly all in 30 minutes and in all in 40 minutes.

Reaction with Purdy's Solution.

I. florentina: Begins in all in 60 seconds; about two-thirds partially gelatinized in 10 minutes.
I. pallida var. *speciosa:* Begins in a few in 30 seconds; about one-tenth gelatinized in 15 minutes; very little progress in 30 minutes.
I. pumila var. *cyanea:* Begins in a few in 30 seconds; about two-thirds partially and one-fifth fully gelatinized in 15 minutes.
I. bismarckiana: Begins in all in 30 seconds; about four-fifths nearly completely gelatinized in 10 minutes.
I. iberica: Begins in a few in 90 to 120 seconds; a few partially gelatinized in 15 minutes.
I. xiphium var. *Grand Tresorier:* Begins in a few in 60 seconds; one-fifth nearly completely gelatinized in 25 minutes.
I. xiphium var. *Wilhelmine:* Begins in most in 45 seconds; half nearly completely gelatinized in 30 minutes.
I. xiphium var. *lusitanica:* Begins in all in 30 seconds; a few partially gelatinized in ten minutes.
I. tingitana: Begins in all in 30 seconds; one-third nearly completely gelatinized in 15 minutes.
I. reticulata: Begins in all in 45 seconds; all nearly completely gelatinized in 12 minutes.
I. histrio: Begins in many in 45 seconds; all nearly completely gelatinized in 5 minutes.
I. alata: Begins in all in 15 seconds; two-fifths nearly completely and three-fifths partially gelatinized in 15 minutes.
I. caucasica: Begins in many in 20 seconds; all nearly completely gelatinized in 8 minutes.

NOTES ON THE STARCHES OF IRIS.

Upon the basis of general microscopical characters, these starches appear as two types, one of which is represented by *I. florentina*, *I. pallida speciosa*, *I. pumila* var. *cyanea*, *I. bismarckiana*, and *I. iberica;* and the other by *I. xiphium*, *I. tingitana*, *I. reticulata*, *I. histrio*, *I. alata*, and *I. caucasica*. The first type includes the starches of members of the subgenera *Pogoniris*, *Regelia*, and *Oncocyclus;* and the second, those of the subgenera *Xiphion* and *Juno*. Even among the starches of each of these types differences have been recorded in size, regularity or irregularity of outline, fissuration, and lamellation, that are more or less distinctive, as, for instance, as seen in comparing *I. florentina*, *I. pumila* var. *cyanea*, and *I. caucasica* with the starches of the other irises. There are also in the reactions more or less marked groupings that are in entire accord with the classification of the botanist. Thus, in *Pogoniris*, *Regelia*, and *Oncocyclus* the distinctly lower degree of polarization, the less reactivity with safranin, the uniformly higher temperature of gelatinization (an average difference of 6.87°) as compared with the members of the other subgenera, is very noticeable. The three starches of the varieties of *Xiphium* are, on the whole, very close in their reactions; in fact, so close that there can be no mistake about their close botanical relationship. Likewise the starches of the other three members of the subgenus are closely in accord, but by no means so close as in the case of the xiphiums; and their curves differ sufficiently from those of the xiphiums to permit of their differentiation as groups, the differences being noted particularly in the chloral hydrate-iodine, ferric chloride, and Purdy's solution reactions. There is a very close relationship between the members of the subgenus *Juno*, and between these and the group consisting of *I. tingitana*, *I. reticulata*, and *I. histrio*, than to any other group. It seems likely that by means of a larger number of reagents and some modifications in the methods that groupings would be brought out that may be strictly in accord with those of Baker; but those of different botanists are not in accord, and it seems that the classification of the entire genus demands considerable revision.

GENUS MORÆA.

Moræa is a genus of bulbous plants closely related to *Iris*, most of them being popularly known as irises. About 60 species are recorded, three-fourths of which are from South Africa, while the others are natives of Tropical Africa, Australia, and Madagascar. They are the southern representative of the true irises of the north. Starch from one species was studied, *M. tristis* Ker. (*Iris tristis*).

STARCH OF MORÆA TRISTIS. (Plate 67, figs. 399 and 400. Chart 268.)

Histological Characteristics.—In *form* the grains are, as a rule, simple, with occasional compound grains consisting of two components. There are very few clumps. The smaller grains appear to have been in aggregates at one time, as almost all show one or two pressure facets and other distortion from pressure. Some of the larger grains have irregular accretions on their surfaces, so that the form of the original grain may be more or less masked; the outlines tend to be quite irregular. The conspicuous forms are ovoid, either elongated or short and broad. There are also short ellipsoidal, irregularly rounded or quadrilateral, trefoil, rounded triangular, and womb-shaped to pyriform. The small grains comprise round, many sugar-loaf, ovoid, and irregularly polygonal. The larger grains do not appear to be flattened. There is a larger proportion of small grains in this starch in comparison with the number found in starches generally.

The *hilum* is distinct and comparatively small or of medium size. It is eccentric, so that if the grain is broader than it is long, as many of them are, it lies in the shorter diameter of the grain; it may be double. It is often marked by a small fissure, not deep, and the fissuration may be in the form of a single straight transverse or diagonal line, and usually ragged; sometimes double, triple, or irregularly stellate.

The *lamellæ* are not distinct. When they can be seen they appear as coarse, continuous rings or segments of rings; often irregular, owing in part to irregularities of the surface, but not always following the outline of the margin. Usually those added last are the most distinct. A broad, non-lamellated space often surrounds the hilum and is bounded by a fairly distinct lamella, within which space the fissures are confined. There are probably 6 to 8 lamellæ on a medium-sized grain.

The grains vary in *size* from 3 to 30μ; the common size is 20μ. The elongated grains average about 20 by 14μ, and the rounded quadrilateral about 22 by 24μ in length and breadth.

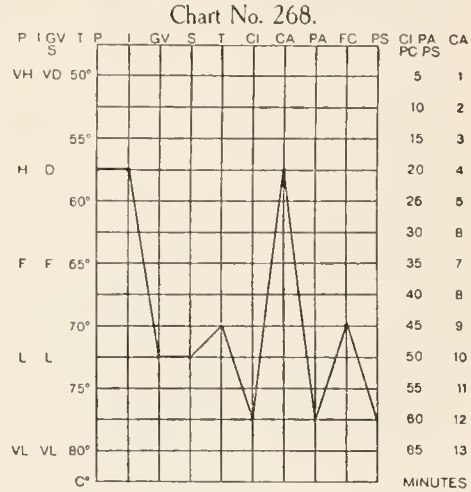
Polariscopic Properties.—The *figure* is eccentric, clear-cut, and distinct in every part, but with many distortions and peculiarities caused by the accretions on the surface of the grain. Portions of a secondary figure sometimes appear in such cases, and sometimes the central part of the figure is made up of a large dark spot of irregular form.

The degree of *polarization* is high. It varies with the position of the grain, in different grains, and notably in different parts of the same grain. It is usually higher over the irregular accretions on the surfaces.

With *selenite* the quadrants are clear-cut, often very irregular in shape, and rarely equal in size. The colors in some are pure, but in others not.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply at once and the color deepens rapidly; with 0.125 per cent solution they color at once almost as deeply as with a 0.25 per cent solution. After heating in water until the grains are completely gelatinized, the solution is colored faintly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply, but the grain-residues much less. With slight excess of iodine the grain-residues show a dark, blue-violet-colored wall. Practically all the capsules retain more or less blue-reacting starch.

Chart No. 268.



Curve of Reaction-Intensities of Starch of Moræa tristis.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly at once, but after 30 minutes they are only lightly stained.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in the smaller grains in 1½ minutes. Some become gelatinized in 5 minutes, about three-fourths in 45 minutes, and all in 1½ to 2 hours. The reaction begins at the proximal end, which darkens and swells somewhat, and the process extends over the grain. The line of demarcation between the gelatinized and non-gelatinized portions is fairly well marked. The swollen grains are not very large, but uniformly dark and somewhat irregular in form.

With *chromic acid* some grains react in 20 seconds. The reaction is general in a minute and is over in 4 minutes. The hilum becomes very prominent and then swells, and the grain becomes covered by fine striæ. The inner part passes into a gelatinous mass, while the outer forms a rather thin ring, ragged on the inner side, which becomes thinner and transparent and finally dissolves at one end, when the inner gelatinized starch flows out and is dissolved, followed by the solution of other parts.

With *pyrogallic acid* a slight reaction occurs in some grains in 2 minutes; all are affected and about one-fifth partially gelatinized in 8 minutes, and half are partially gelatinized in 45 minutes. The hilum is very prominent, the lamellæ fairly so. The hilum swells, the grain becomes covered by fine striæ, and the inner portion is changed into a gelatinous mass. The marginal ring is rather thin, very distinctly striated, and ragged on the inner side. It grows fairly thin and transparent as the grain swells. The grains are never completely gelatinized.

The reaction with *ferric chloride* begins in some grains in 6 minutes. About half are gelatinous in 20 minutes, almost all in 30 minutes, and all are gelatinized in 45 minutes. The hilum becomes prominent and swells, and the inner part is altered into a gelatinous mass. The margin grows thin, very distinctly striated, and very ragged on the inner edge. This ring becomes thinner and transparent as the grain swells. The swollen grains are large, transparent, somewhat folded and wrinkled, but are generally smooth and not greatly distorted.

With *Purdy's solution* some grains are affected in 5 minutes and all are affected and a few almost completely gelatinized in 30 minutes. This reaction, as far as it goes, is practically identical with that to pyrogallic acid.

GENUS HOMERIA.

The genus *Homeria* comprises 6 species of bulbous plants, natives of the Cape of Good Hope. The genus, with others represented in this research, is allied to *Iris*, *Moræa*, and *Tigridia*. The starch of only one species, *H. collina* Vent. (*Moræa collina* Thunb.), was available for study.

STARCH OF HOMERIA COLLINA. (Plate 67, figs. 401 and 402. Chart 269.)

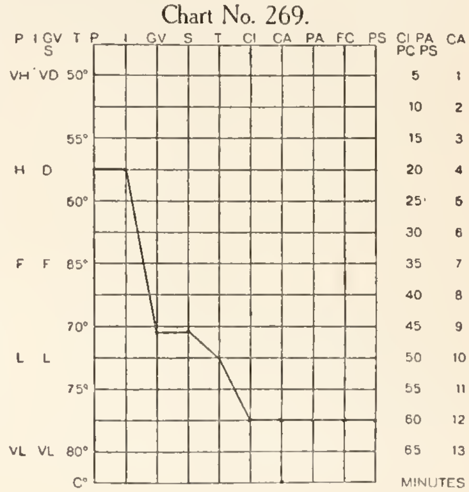
Histological Characteristics.—In *form* the grains are usually simple, with occasional compound grains consisting of two components. There are some clumps. The smaller grains often form doublets or triplets linearly arranged, and there is a tendency for small grains to adhere to the large grain. The smaller grains are also very variable in form, some are narrow, but most of them are more or less markedly irregular in outline. Pressure facets on the single grains are rare. The surface is usually very irregular, owing to uneven amorphous accretions on the surface and to irregularities in development of the primary grains. Nodular projections are not uncommon. The conspicuous forms are the elongated ovoid, lenticular, reniform, pure ovoid, triangular with marked corners, womb-shaped, and irregularly quadrilateral or polyhedral with rounded corners; also a few pyriform. The grains are not flattened in any diameter.

The *hilum* is eccentric and quite distinct. It may be in or to one side of the median line, and when not fissured it is a comparatively large round spot. There may be 2 hila. It is very often fissured, but the fissure is not especially deep or wide, and usually is irregular or ragged. It sometimes appears as though there had been originally two fissures which started from two centers and later coalesced.

The *lamellæ* are not distinct. When they could be seen they appeared to be coarse, irregular, continuous rings or segments of rings. They are often irregular, but do not follow the irregularities of the margin of the grain. Usually one very distinct lamella outlines a smooth, non-lamellated space surrounding the hilum. There are about 6 to 8 lamellæ on a medium-sized grain.

The grains vary in *size* from 2 to 42μ. The common size is 28μ. The elongated ovoid and lenticular grains have average dimensions of 38 by 20μ, and the quadrilateral about 36 by 30μ in length and breadth. There is a larger proportion of small grains in this starch in comparison with the number found in starches generally.

Chart No. 269.



Curve of Reaction-Intensities of Starch of Homeria collina.

Polariscopic Properties.—The *figure* is eccentric, and is, as a rule, clear-cut and distinct. The lines in some of the larger grains are bent and otherwise distorted, with here and there peculiar duplications of parts of the figure, owing probably to the amorphous concretions on the surface. The central part of the figure is sometimes a large, irregular, dark spot.

The degree of *polarization* is high. It varies in different parts of the same grain and also in different grains.

With *selenite* the quadrants are, as a rule, clear-cut and well defined, often very irregular in shape and unequal in size. The colors are pure in most grains.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored deeply at once; with 0.125 per cent solution they tint deeply, almost as deep as that with a 0.25 per cent solution. After heating until the grains are completely gelatinized, the solution is colored deeply and the swollen grains very deeply on the addition of iodine. Some of the grains which color less deeply than others exhibit a violet-colored capsule when an excess of iodine is used. After boiling for 2 minutes the solution is colored very deeply, but the grain-residues less deeply. Most of the capsules retain some blue-reacting starch. With an excess of iodine all the capsules are of a red-violet color.

Staining Reactions.—With *gentian violet* in 15 minutes the grains show some slight stain and in 30 minutes the color is very little deeper. The color is deeper than in *Moræa tristis.*

With *safranin* there is a slight coloration in 7 minutes, but in 30 minutes the tint is very little deeper than at first. The stain is deeper, however, than that with gentian violet and deeper than in *M. tristis.*

Temperature Reaction.—The temperature of gelatinization is 72° to 73° C., mean 72.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains show a reaction in 10 minutes. Most of the smaller grains are gelatinized in 20 minutes, but at this time most of the larger grains are unaffected. A few of the larger grains are gelatinized in 45 minutes, and about one-third are gelatinized in 4 hours, while others are unaltered. The hilum becomes distinct, and the distal end and the most prominent parts of the margin become dark. This process extends over the grain, with some swelling, usually very regular. There is a very sharp line of demarcation between the gelatinized and ungelatinized portions of the grain. The whole grain is finally darkened. The swollen grains formed are not very large and are generally smooth and somewhat irregular, but retain much of the original form of the grain and are of an even color throughout.

With *chromic acid* there is a slight reaction in a few grains in $1\frac{1}{2}$ minutes; it is in general in $2\frac{1}{2}$ minutes, and over in 15 minutes. The hilum becomes very prominent and the grain is covered with striæ; its inner portion is altered into a gelatinous mass. The substance at the margin forms a thin ring (very distinctly striated and ragged on the inner edge), which becomes thinner and more transparent and is finally dissolved at one point, from which the inner gelatinized mass flows out and is dissolved, followed by solution of the other parts.

The reaction with *pyrogallic acid* begins very slowly, and there is only a slight reaction in some grains in 10 minutes. It is general in 15 minutes, and all are partially gelatinized in an hour. A few are completely gelatinized in 85 minutes. The reaction consists, as with chromic acid, in the appearance of fine striæ throughout the grain, the dissolution of the inner part of the grains, and the formation of a comparatively thin, distinctly striated, marginal ring that is very ragged on the inner side. This ring becomes clearer and thinner as the grain swells until it forms merely a thin, transparent film. The gelatinized grains are fairly large and somewhat wrinkled, but are generally smooth and not greatly distorted and retain much of the original form of the grain.

With *ferric chloride* a few grains react and some are fully gelatinized in 5 minutes. One-half are affected, including all the smaller (most of which are fully gelatinized), in 25 minutes. About five-sixths are fully gelatinized, but the others are affected, in an hour. The reaction consists in the dissolution of the inner portion of the grain, preceded by the appearance of fine striæ throughout, the swelling of the grain, and the formation of a thin, ragged, striated marginal ring, which gradually becomes very thin and transparent. The swollen grains are fairly large, somewhat wrinkled and distorted, but usually retaining somewhat the original shape of the grain.

With *Purdy's solution* one or two grains show some reaction in 45 minutes. There is no further change. Similarities in the properties of the starches of *Moræa* and *Homeria* are very apparent.

GENUS TIGRIDIA.

This genus includes about 8 or 10 species of bulbous plants, natives of Mexico, Central America, Peru, and Chili. It was for many years identified with *Ferraria*, a South African genus, and even at present the typical species, *T. pavonia*, is referred to in Mexico as *Ferraria tigridia*. Tigridias are popularly known as the Mexican tiger-flower, or tiger-iris, or shell-flower. The starches of *T. pavonia* var. *grandiflora alba* Hort. and *T. pavonia* var. *conchiflora* Hort. (*T. conchiflora* Sweet) were studied.

STARCH OF TIGRIDIA PAVONIA VAR. GRANDIFLORA ALBA. (Plate 68, figs. 403 and 404. Chart 270.)

Histological Characteristics.—In *form* the grains are simple. There are a few aggregates and no pressure facets were observed. Irregularities are frequent, owing to the unequal development of the surfaces and margins, chiefly in the form of nodular or nipple-like protrusions. Depressions of the margin near the proximal end often give this part of the grain an appearance of protrusion. The small grains are of variable shapes, chiefly rounded, ovoid, elliptical, triangular, and polygonal. They are very numerous in comparison with the number found in most starches. The conspicuous forms are the lima-bean-shaped, reniform, oval, and ovoid; also rounded and lenticular-shaped and various modifications of the foregoing. The grains are somewhat flattened and about one-half to two-thirds as thick as they are broad.

In the larger grains the *hilum* is deeply and irregularly fissured, and in the grains of medium size it appears as a distinct, comparatively large, round spot. It is eccentric from two-fifths to one-fourth, usually about one-third, of the longitudinal axis. There are commonly many deep but narrow and irregular fissures of varied arrangement. In many grains fissures radiate from two or more centers, and in some the substance of the grain between the hilum and the distal end is fissured irregularly, which may mean a number of hila, but it is impossible to definitely determine this.

The *lamellæ* are not distinct circles, ellipses, or arcs of circles. When they can be distinctly made out they appear rather coarse near the hilum, and fine as they are located nearer the margin and distal end. They are quite regular and from the equator to the distal margin follow the outline of the grain. The number can not be accurately determined.

The grains vary in *size;* the smaller are 5 by 5μ; the larger are 30 by 40μ in length and breadth. The common sizes are 20 by 30μ in length and breadth, and 24 by 26μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric and usually obscure. A large portion of the central part of the grain is entirely dark, so that in most grains only the outer parts of the quadrants are illuminated. In the few grains in which the figure is clearly defined the lines are broad, but usually not sharp.

The degree of *polarization* varies from very low in most grains to fair in a few. It varies greatly in different aspects of the same grain, being fairly high when the grain is viewed on end or edge. In the broad aspect of a grain it is usually entirely lacking about the hilum, and a very large area, almost the entire grain, may be absolutely dark.

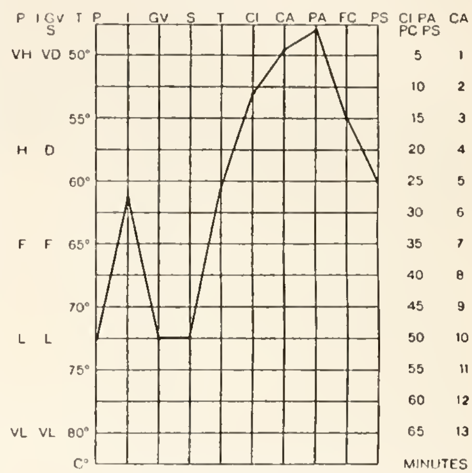
With *selenite* the quadrants are as a rule not defined; they vary in shape and are unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all begin to color a fairly deep indigo; with 0.125 per cent solution they all color fairly and the color deepens gradually. After heating in water until the grains are completely gelatinized, the solution colors fairly and the gelatinized grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly. The capsules all color a pale violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes are rather lightly stained.

Temperature Reaction.—The temperature of gelatinization is 60° to 62° C., mean 61°.

Chart No. 270.



Curve of Reaction-Intensities of Starch of Tigridia pavonia var. grandiflora alba.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in all in a minute. It is over in four-fifths of the grains in 7 minutes and in all in 12 minutes. The margin at the distal end swells slightly and becomes dark, and this process extends to the depressions at each side of the proximal end and then moves upward and inward, later including the whole margin. The process spreads centrally until it reaches the hilum. The fissures at the hilum usually widen greatly, and appear to divide the starch which has not yet gelatinized into two or more pieces, and these gelatinize later. The gelatinized grains are fairly large and of a uniform dark indigo, except for the light lines which occupy the position of the lines of the figures.

The reaction with *chromic acid* begins in a few seconds and is over in 50 seconds. The starch about the hilum begins to be converted into a gelatinous mass, and rather coarse striæ appear throughout the grain. At the hilum a bubble forms which first increases and then decreases in size, as the grain swells, and finally disappears. The whole interior of the grain now passes into a gelatinous mass, leaving only a thin capsule, and the grain swells greatly. The capsule is dissolved in one or two places near the distal end, and the inner gelatinized starch flows out and is completely dissolved, the capsule dissolving later.

Reaction with *pyrogallic acid* begins in a few seconds and is over in 55 seconds. It is so rapid that the successive steps can not be satisfactorily determined. The starch about the hilum gelatinizes, followed by gelatinization of the rest of the grain, except several bright refractive spots, which remain in the neighborhood of the proximal end, but finally disappear. The gelatinized grains are much distorted, folded, and sacculated, particularly at the distal end. Their appearance suggests that most of the gelatinized contents had escaped into the surrounding liquid.

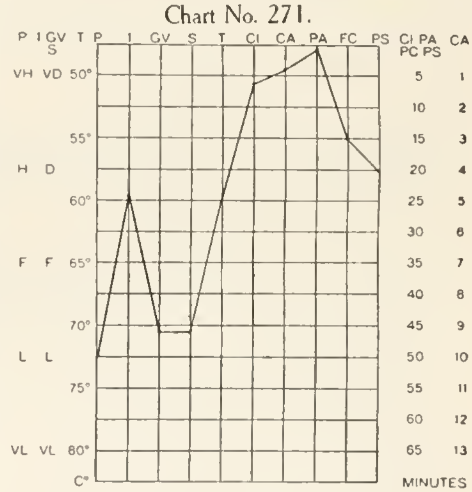
Reaction with *ferric chloride* begins in a few grains in 45 seconds. It is over in nearly all in 15 minutes and in all in 25 minutes. The reaction begins at the distal end, which becomes slightly fissured at two or three places, from which fissures there is a protrusion of gelatinous material inclosed in the gelatinized capsule. This process continues until all of the distal end and also many places on the margin are gelatinized. Then at two or three points on the proximal end the starch swells out in short, finger-like projections. The process now moves inward until all the starch is gelatinized except that immediately surrounding the hilum or the fissures at the hilum. These fissures now begin to grow wider and separate the starch here into several pieces which gelatinize independently of one another. The resulting gelatinized grain is very large, and the capsule is usually much twisted, sacculated, and otherwise distorted.

The reaction with *Purdy's solution* begins in some grains in 40 seconds. About four-fifths are partially gelatinized in 5 minutes and all are completely gelatinized in 25 minutes. The reaction begins by the breaking up of the starch between the hilum and the distal end into granules, which granules gradually pass into a gelatinous mass, leaving a very thin capsule except at the proximal end, where there is a thick, striated strip of starch which finally becomes thin and transparent. The gelatinized grain is large and the capsule is somewhat folded and sacculated, but not so much so as is the case in the reaction with pyrogallic acid.

STARCH OF TIGRIDIA PAVONIA VAR. CONCHIFLORA. (Plate 68, figs. 405 and 406. Chart 271.)

Histological Characteristics.—In *form* the grains are simple. There are a few aggregates and clumps. No pressure facets were observed on the grains. The surface of the grains is generally somewhat irregular, owing to variations in the development of parts of the margin, sometimes in the form of nodular or nipple-like protrusions. Depressions of the margin at each side of the hilum, giving the proximal end the appearance of a protuberance, are not rare. The small grains are numerous and of various shapes, chiefly rounded, elliptical, and polygonal. The conspicuous forms are the lima-bean-shaped, reniform, oval, and ovoid. There are also spindle-shaped grains, some having the longitudinal axis shorter than the transverse axis; also some irregularly shaped grains of various forms. The grains are somewhat flattened and about one-third to one-half as thick as they are broad.

Chart No. 271.



Curve of Reaction-Intensities of Starch of Tigridia pavonia var. conchiflora.

The *hilum* is usually fissured, and when not it appears as a distinct, comparatively large round spot. It is eccentric from a degree varying from very slight to one-third, usually two-fifths, of the longitudinal axis. The fissure usually takes the form of three or four narrow but rather irregular lines radiating from a common center or from a straight transverse line. Stellate or variable arrangements of irregular fissures also occur.

The *lamellæ* are not distinct, fine, regular arcs of circles, or continuous ellipses about the hilum, or bands of the same shape as the outline of the grain. Those near the hilum are not so fine but more distinct than those near the margin of the grain. The number could not be accurately determined.

The grains vary in *size* from 8 by 8μ to 26 by 34μ in length and breadth. The common size is 20 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric and usually very obscure. A large area of the central part of the grain in some cases, practically the whole of the grain, is dark. In a few grains (probably grains on edge or end) the figure is fairly clear-cut and the lines fairly regular.

The degree of *polarization* extends from very low to fair, varying much in different aspects of the same grain, and is from fair to high when the grain is viewed on end or edge. In the broad aspect of a grain polarization is often absent in a central area of variable size, sometimes about as large as the grain. It is lower, on the whole, than that of *T. pavonia* var. *grandiflora alba.*

With *selenite* the quadrants are generally not defined and are very irregular in form and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fairly deep indigo; with 0.125 per cent solution they color fairly, the color deepens gradually, and is deeper than that of the grains of *T. pavonia* var. *grandiflora alba.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the gelatinized grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply, but the grain-residues lightly. The capsules all color a pale violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains all begin to stain at once and in 30 minutes they are lightly stained. The color is deeper than that of *T. pavonia* var. *grandiflora alba.*

Temperature Reaction.—The temperature of gelatinization is 59° to 61° C., mean 60°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in all in a minute and is over in all in 7 minutes. It is the same qualitatively as that of the grains of *T. pavonia* var. *grandiflora alba.*

With *chromic acid* the grains begin to react in a few seconds and reaction is over in 45 seconds. It is the same qualitatively as that of the grains of *T. pavonia* var. *grandiflora alba.*

Reaction with *pyrogallic acid* begins in a few seconds and is over in 50 seconds. It is the same qualitatively as that of the grains of *T. pavonia* var. *grandiflora alba.*

With *ferric chloride* a few grains begin to react in 45 seconds and reaction is over in all in 15 minutes. It is the same qualitatively as that of the grains of *T. pavonia* var. *grandiflora alba.*

Reaction with *Purdy's solution* begins in some grains in 45 seconds. About four-fifths of the grains are partially gelatinized in 8 minutes and all are completely gelatinized in 20 minutes. The reaction is qualitatively the same as that of the grains of *T. pavonia* var. *grandiflora alba.*

Differentiation of Certain Starches of the Genus Tigridia.

Histological Characteristics.

Conspicuous Forms.

T. pavonia var. *grandiflora alba:* Usually simple, a few small aggregates, no pressure facets; surface regular. Lima-bean-shaped, reniform, oval, and ovoid.

T. pavonia var. *conchiflora:* Essentially the same as in *T. pavonia* var. *grandiflora alba.*

Hilum—Form, Number, and Position.

T. pavonia var. *grandiflora alba:* Form distinct large round spot, or deeply and irregularly fissured. Position eccentric 0.40 to 0.25, usually 0.33, of longitudinal axis.

T. pavonia var. *conchiflora:* Form essentially the same as in *T. pavonia* var. *grandiflora alba.* Position eccentric from very slight to 0.33, usually 0.40, of longitudinal axis.

Lamellæ—General Characteristics and Number.

T. pavonia var. *grandiflora alba:* Not distinct; circles, ellipses or arcs of circles; fine or rather coarse; quite regular. Number not determined.

T. pavonia var. *conchiflora:* The same as in *T pavonia* var. *grandiflora alba.* Number not determined.

Size.

T. pavonia var. *grandiflora alba:* From 5 to 40μ, commonly 30μ.

T. pavonia var. *conchiflora:* From 8 to 34μ, commonly 24μ.

Polariscopic Properties.

Figure.

T. pavonia var. *grandiflora alba:* Eccentric, not distinct nor clear-cut, central part of grain dark.

T. pavonia var. *conchiflora:* The same as in *T. pavonia* var. *grandiflora alba.*

Degree of Polarization.

T. pavonia var. *grandiflora alba:* Very low to fair, very variable.

T. pavonia var. *conchiflora:* Very low to fair, very variable; on the whole, lower than in *T. pavonia* var. *grandiflora alba.*

Polarization with Selenite—Quadrants and Colors.

T. pavonia var. *grandiflora alba:* Quadrants poorly defined, irregular in shape, unequal in size. Colors not pure.

T. pavonia var. *conchiflora:* Quadrants the same as in *T. pavonia* var. *grandiflora alba.* Colors not pure.

Iodine Reactions.

Intensity and Color.

T. pavonia var. *grandiflora alba:* Fairly deep; indigo.

T. pavonia var. *conchiflora:* Fairly deep, deeper than in *T. pavonia* var. *grandiflora alba;* indigo.

Staining Reactions.

With Gentian Violet.

T. pavonia var. *grandiflora alba:* Rather light.

T. pavonia var. *conchiflora:* Rather light, slightly more than in *T. pavonia* var. *grandiflora alba.*

With Safranin.

T. pavonia var. *grandiflora alba:* Rather light.

T. pavonia var. *conchiflora:* Rather light, slightly more than in *T. pavonia* var. *grandiflora alba.*

Temperature of Gelatinization.

T. pavonia var. *grandiflora alba:* 60 to 62° C., mean 61°.

T. pavonia var. *conchiflora:* 59 to 61° C., mean 60°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

T. pavonia var. *grandiflora alba:* Begins in all in a minute; complete in four-fifths in 7 minutes, and in all in 12 minutes.

T. pavonia var. *conchiflora:* Begins in all in a minute; complete in all in 7 minutes.

Reaction with Chromic Acid.

T. pavonia var. *grandiflora alba:* Begins in a few seconds; complete in all in 50 seconds.

T. pavonia var. *conchiflora:* Begins in a few seconds; complete in all in 45 seconds.

Reaction with Pyrogallic Acid.

T. pavonia var. *grandiflora alba:* Begins in a few seconds; complete in all in 55 seconds.

T. pavona var. *conchiflora:* Begins in a few seconds; complete in all in 50 seconds.

Reaction with Ferric Chloride.

T. pavonia var. *grandiflora alba:* Begins in a few in 45 seconds; complete in nearly all in 15 minutes.

T. pavonia var. *conchiflora:* Begins in a few in 45 seconds; complete in all in 15 minutes.

Reaction with Purdy's Solution.

T. pavonia var. *grandiflora alba:* Begins in some in 40 seconds; complete in all in 25 minutes.

T. pavonia var. *conchiflora:* Begins in some in 45 seconds; complete in all in 20 minutes.

NOTES ON THE STARCHES OF TIGRIDIA.

The two varieties of *Tigridia pavonia* are very nearly alike in all respects, the main differences being in the histological properties in size, in the reactions, in the degree of polarization, and in the temperature of gelatinization. All the differences are within the normal limits of error of experiment and observation.

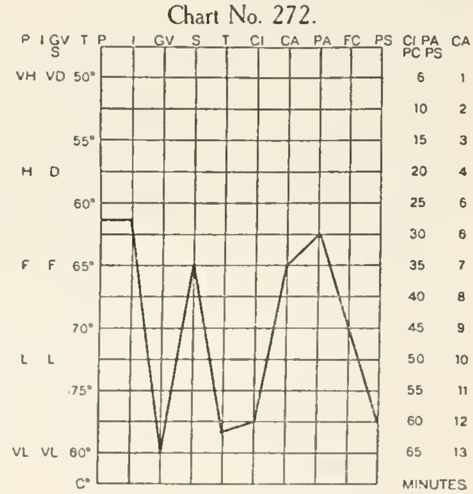
GENUS GLADIOLUS.

This genus of iridaceous, cormous or bulbous plants includes about 140 species, mostly natives of Cape Colony and Natal. About 15 species are natives of the Mediterranean region, and a few have been found in the mountains of tropical Africa. Most of the cultivated forms are species or hybrids referable to the South African group and represented chiefly by *G. cardinalis*, *G. floribundus*, *G. psittacinus*, and *G. blandus*. The European group is represented chiefly by *G. byzantinus* and *G. communis*. Starches from 4 species were examined, including *G. byzantinus* Miller, *G. primulinus* Baker, *G. cardinalis* var. (Blushing Bride), and *G. floribundus* Jacq. *G. byzantinus* is a Mediterranean species; *G. primulinus* is from Victoria Falls, South Africa, and according to Baker resembles *G. psittacinus*, *G. dracocephalus*, and *G. quartinianus*; and both *G. cardinalis* and *G. floribundus* are South African.

STARCH OF GLADIOLUS BYZANTINUS. (Plate 68, figs. 407 and 408. Chart 272.)

Histological Characteristics.—In *form* the grains are simple and mostly isolated. They frequently occur in aggregates of two or three or more grains of equal or unequal size, and such aggregates may be spherical. Nearly all the isolated grains are marked at the distal end or at other parts by one or more well-defined pressure facets, usually three or four. The surface of the grains is quite regular, but shapes vary, owing to differences in the number, size, and arrangement of the pressure facets. The conspicuous forms are hemispherical with a 2-, 3-, or 4-faceted base, the rounded end being the proximal; also spherical aggregates consisting of two or three grains, and forms which vary in accordance with the peculiarities of the pressure facets. The grains are not flattened, and on end they usually appear spherical.

Chart No. 272.



Curve of Reaction-Intensities of Starch of Gladiolus byzantinus.

The *hilum* is usually not distinct, but when it can be seen it appears as a comparatively large round spot, centric or eccentric up to about two-fifths of the longitudinal axis and in the median line. It is never fissured, though two lines may sometimes appear to extend from it to the corners of the facets, but this appearance is probably due to a depression at the facet. There are no multiple hila.

The *lamellæ* are indistinct, regular, coarse rings, having the form of the outline of the margin; slightly more distinct in some grains than in others, but do not vary much in distinctness in the same grain. There are about 6 on the larger grains.

The grains vary in *size* from 3 to 26μ. The common size is 16μ.

Polariscopic Properties.—The *figure* is centric or somewhat eccentric. The two lines extending to the corners of the facets are clear-cut, the other two are not. Often all the lines are broad and not clean-cut and widen towards the margin. The lines are straight, but of varying lengths, and are generally placed at varying distances from one another.

The degree of *polarization* is fairly high. It varies much in different grains (being low in some and high in others) and also in various parts of the same aspect of a grain, usually being low near the facets, and it also varies in different aspects of a grain.

With *selenite* the quadrants are generally well defined, irregular in shape, and unequal in size. The colors are often pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet which deepens rapidly; with 0.125 per cent solution they color lightly, but the color deepens rapidly. After heating in water until the grains are completely gelatinized, the solution is colored fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution is colored deeply and the grain-residues fairly. On the addition of an excess of iodine the capsules color a red-violet, and most of them are seen to retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain very faintly in 2 minutes and in 30 minutes they are very lightly stained.

With *safranin* the grains begin to stain very lightly at once and in 30 minutes they are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 78° to 79° C., mean 78.5°

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 2 minutes; about one-fifth are gelatinized in 20 minutes, one-half in 35 minutes, and three-fourths in 1¼ hours. The reaction begins at the corners and edges of the facets at the distal end, which darken and swell slowly and slightly; this process usually extends about the entire margin of the grain and then inward over the whole interior of the grain. The line of demarcation between the gelatinized and the ungelatinized portions is never very marked. The gelatinized grains are not large, are of uniform dark color, and retain much of the original form of the grain.

The reaction with *chromic acid* begins in a minute and is over in 7 minutes. The hilum swells and from it fine striæ radiate in all directions. The inner portion of the grain is converted into a gelatinous mass, the whole grain swells, and the fine striæ become coarse and very distinct. The resistant marginal starch forms a band or ring of granules which surrounds the inner, gelatinous mass, becomes thinner and transparent, and is finally dissolved at one point, usually the corners of one of the facets; gelatinized starch flows out and is dissolved and the remainder of the band slowly passes into solution.

Reaction with *pyrogallic acid* begins in many grains in a minute; all are partially gelatinized in 8 minutes, two-thirds completely in 18 minutes, and nearly all in 30 minutes. The reaction begins at the hilum, which swells slightly, and fine striæ radiate from this point. The inner portion is then changed into a gelatinous mass and the marginal area forms a band very distinctly striated. The grains swell slowly and to a great size, and the marginal band grows thinner and transparent until it becomes a very thin, homogeneous envelope. The gelatinized grains are large, but not much distorted, wrinkled, or folded, and retain much of the original form.

With *ferric chloride* the reaction begins in a few grains in a minute. About two-thirds are gelatinized in 15 minutes and all in 45 minutes. The reaction usually consists in swelling of the hilum, followed by progressive gelatinization from the interior outwards. This process is accompanied by a steady, slow swelling; but in some grains the corners of the facets at the distal end become gelatinous and swell before the process begins in other parts, after which the reaction is the same as that described above. The gelatinized grains are large, not distorted, wrinkled, or crumpled, and retain much of the original form of the grain.

Reaction with *Purdy's solution* begins slightly in a very few grains in a minute. There is no further change.

STARCH OF GLADIOLUS PRIMULINUS. (Plate 69, figs. 409 and 410. Chart 273.)

Histological Characteristics.—In *form* the grains are simple and isolated. There are no aggregates and few clumps. Most of the grains are marked by one or more pressure facets. The surface of the grains is regular but varied in form, owing to variation in the number, form, and arrangement of the facets. Small grains, chiefly round or polygonal, are very abundant. The conspicuous forms are polygonal and much varied, owing to the peculiarities of the pressure facets; also spherical, hemispherical, and sugar-loaf forms and their modifications. The grains are not flattened, and owing to the abundance and other properties of the pressure facets appear of different shapes when observed from different aspect.

The *hilum* is a fairly distinct, comparatively large round spot, centric usually. It is never fissured and no multiple hila were observed.

The *lamellæ* are invisible.

The grains vary in *size* from 2 to 14μ. The common size is 10μ.

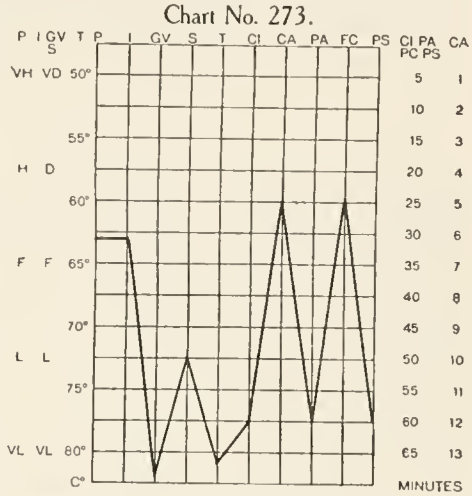
Polariscopic Properties.—The *figure* is usually centric, distinct, and clear-cut. Sometimes one or more of its lines are broader and not so clear-cut as the others. The lines are not bent or otherwise distorted, but are sometimes placed at varying distances from one another.

The degree of *polarization* is fair. It does not vary much in different grains of the same size, nor in varying positions of the same grains. It is not so high as that of the grains of *G. byzantinus.*

With *selenite* the quadrants are, as a rule, fairly well defined, regular in shape, and nearly equal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet; with 0.125 per cent solution they color lightly and the color deepens slowly. The color is less than that of the grains of *G. byzantinus.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues usually lightly. On addition of an excess of iodine the capsules take on a red-violet color and many are seen to retain some blue-reacting starch.

Chart No. 273.



Curve of Reaction-Intensities of Starch of Gladiolus primulinus.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in 2 minutes and in 30 minutes the color has not changed. It is lighter than that of the grains of *G. byzantinus.*

With *safranin* the grains begin to stain lightly in a minute and after 30 minutes the color has not changed. It is distinctly lighter than that of the grains of *G. byzantinus.*

Temperature Reaction.—The temperature of gelatinization is 80° to 82° C., mean 81°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 30 seconds and in most grains in 2 minutes. About half are gelatinized in 10 minutes, two-thirds in an hour, and three-fourths in 1¾ hours. It is the same qualitatively as in the grains of *G. byzantinus.*

The reaction with *chromic acid* begins in 2 minutes and is over in 5 minutes. It is the same qualitatively as that of the grains of *G. byzantinus.*

Reaction with *pyrogallic acid* begins slightly in a few grains in 2 minutes. In 15 minutes a few of the grains are partially gelatinized, in 22 minutes all are partially gelatinized, and in 35 minutes some are completely gelatinized. The reaction is the same qualitatively as that of the grains of *G. byzantinus.*

With *ferric chloride* the reaction begins in a few grains in 1½ minutes and is over in 25 minutes. It is qualitatively the same as that of the grains of *G. byzantinus.*

There is no reaction with Purdy's solution.

STARCH OF GLADIOLUS CARDINALIS VAR. (BLUSHING BRIDE).

(Plate 69, figs. 411 and 412. Chart 274.)

Histological Characteristics.—In *form* the grains are simple, except a very few compounds, consisting of two or three components which have become covered with two or three common lamellæ. The grains usually occur in aggregates of two or three grains of equal size, which are so firmly adherent that few of them become separated; hence, grains with pressure facets are rare. The grains constituting the aggregates are regular in outline, but varied in form in accordance with the number, size, and arrangement of the grains. The conspicuous forms among the isolated grains are the ovoid with much rounded ends, spherical, and rounded triangular; those among the aggregates are the triangular, the elliptical, and the ovoid. The last is formed by one large grain having what appears to be one or two very small grains inserted in the distal end. The forms of the component grains of the aggregates are somewhat hemispherical with two or three or more facets at the distal end, and hemispherical and sugar-loaf forms with one facet at the distal end. The grains are not flattened, and in one aspect they appear spherical.

The *hilum* is a fairly distinct, comparatively large, round spot, centric or eccentric about two-fifths of the longitudinal axis and in the median line. It is never fissured. Rarely there are double hila in a single component. Fissures, depressions, or lines may be seen which define the regions of union of components of aggregates.

The *lamellæ* are not distinct, and appear as regular, coarse rings which tend to follow the marginal outline. They do not vary much in size and distinctness in different grains, nor in different parts of the same grain. There are from 6 to 8 on the larger grains.

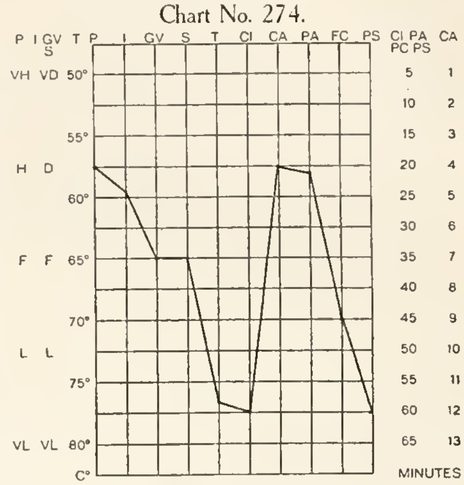
The isolated grains vary in *size* from 3 to 26μ. The common size is 10μ. The aggregates vary in size from 7 to 37μ. The common size is 30μ.

Polariscopic Properties.—The figure is centric or slightly eccentric, distinct, but not always clear-cut. Its lines usually are broad, and become broader and less clear-cut near the margin. They are usually straight and placed at equal distances from one another. The double or triple figure is often very apparent in the case of aggregates and compounds of two or three components.

The degree of *polarization* is high and does not vary much in different grains and only slightly in different aspects of the same grain. It is distinctly higher than that of the grains of *G. byzantinus.*

With *selenite* the quadrants are well defined, regular in shape, and usually equal in size. The colors are pure.

Chart No. 274.



Curve of Reaction-Intensities of Starch of Gladiolus cardinalis var. (Blushiog Bride).

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet; with 0.125 per cent solution they color lightly, but the color deepens quickly, and is slightly deeper than that of the grains of *G. byzantinus.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes both the solution and the grain-residues color deeply. On the addition of an excess of iodine very few capsules are colored a red-violet; others appear blue, owing to the presence within of much blue-reacting starch, which marks the color of the capsule.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once, and in 30 minutes they are fairly stained. The stain is deeper than that of *G. byzantinus.*

With *safranin* the grains begin to stain lightly at once and in 30 minutes they are fairly colored. The color is about the same as that of *G. byzantinus.*

Temperature Reaction.—The temperature of gelatinization is 80° to 81° C., mean 80.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in many grains in 1½ minutes. Many of the smaller grains are gelatinized in 4 minutes. About one-third of the entire number of grains are gelatinized in 11 minutes, two-thirds in 17 minutes, and three-fourths in 40 minutes. The reaction is qualitatively the same as that of the grains of *G. byzantinus.*

The reaction with *chromic acid* begins in all the grains in 45 seconds and is over in 4 minutes. It is the same qualitatively as that of the grains of *G. byzantinus.*

Reaction with *pyrogallic acid* begins in a minute, all the grains are partially gelatinized in 10 minutes, and almost all are completely gelatinized in 22 minutes. The reaction is the same qualitatively as that of the grains of *G. byzantinus.*

The reaction with *ferric chloride* begins in some grains in a minute. About two-thirds are gelatinized in 15 minutes, almost all in 35 minutes, and all in 45 minutes. The reaction is the same qualitatively as that of the grains of *G. byzantinus.*

With *Purdy's solution* there is a slight reaction in many grains in a minute. About half of the total number are somewhat swollen in 15 minutes and all are beginning to be gelatinized in 45 minutes. The reaction is the same qualitatively as that of the grains of *G. byzantinus.*

STARCH OF GLADIOLUS FLORIBUNDUS. (Plate 69, figs. 413 and 414. Chart 275.)

Histological Characteristics.—In *form* the grains are simple and isolated. Most of them are marked at the distal end with one or more pressure facets and the grains tend somewhat to occur in clumps, but no aggregates were noted. Small grains, generally globular or polygonal, are abundant. The surface of the grains is regular but varied, owing to differences in size, number, and arrangement of the facets. The conspicuous forms are spherical, almost spherical with one small facet at the distal end, and somewhat quadrilateral with three basal facets and a rounded side which is the proximal end; also dome-shaped, hemispherical with a pyramidal base or with a variable number of facets, ovoid with one facet at the distal end, and various polygonal and other modifications. The grains are not flattened, and on end usually appear spherical.

The *hilum* is a fairly distinct, comparatively large round spot, centric, or eccentric to about two-fifths or more of the longitudinal axis of the grain, and in the median line. The hilum is never fissured and no multiple hila were observed.

The *lamellæ* are invisible.

The grains vary in *size* from 2 to 12μ. The common size is 8μ.

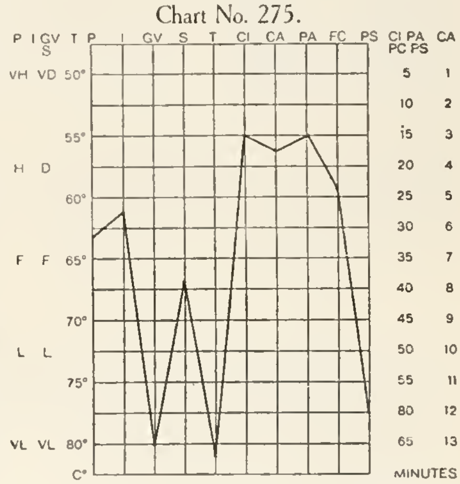
Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and clear-cut. Its lines are not bent or distorted in any way and tend to be placed at equal distances from one another.

The degree of *polarization* is fairly high. It does not vary much in different grains, or in different aspects of the same grain, or in different parts of the same aspect of a given grain. It is on the whole not quite so high as in the grains of *G. byzantinus.*

With *selenite* the quadrants are, as a rule, well defined, regular in shape, and nearly equal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet; with 0.125 per cent solution they color lightly, but the color soon deepens. It is of the same intensity as that of the grains of *G. byzantinus.* After heating in water until the grains are completely gelatinized, both the solution and the grains color fairly on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues rather lightly. All the capsules color violet when an excess of iodine is added and most of them retain some blue-reacting starch.

Chart No. 275.



Curve of Reaction-Intensities of Starch of Gladiolus floribundus.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in a minute and in 30 minutes they are but very lightly stained. The color is slightly less than that of *G. byzantinus.*

With *safranin* the grains begin to stain lightly at once and in 30 minutes they are fairly colored. The color is slightly less than that of the grains of *G. byzantinus.*

Temperature Reaction.—The temperature of gelatinization is 76° to 77° C., mean 76.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in many grains in a minute. Nearly all are gelatinized in 8 minutes and all in 15 minutes. The reaction is qualitatively the same as that of the grains of *G. byzantinus.*

The reaction with *chromic acid* begins in 30 seconds and is over in 3½ minutes. It is the same qualitatively as that of the grains of *G. byzantinus.*

Reaction with *pyrogallic acid* begins in a minute. All are partially gelatinized in 3 minutes and completely in 15 minutes. The reaction is qualitatively the same as that of the grains of *G. byzantinus.*

With *ferric chloride* the reaction begins in a few grains in a minute. About one-half are gelatinized in 4 minutes and all in 23 minutes. The reaction is qualitatively the same as that of the grains of *G. byzantinus.*

The reaction with *Purdy's solution* begins in a few grains in a minute. In 20 minutes about half the grains are partially and the others beginning to be gelatinized. The reaction is qualitatively the same as that of the grains of *G. byzantinus.*

Differentiation of Certain Starches of the Genus Gladiolus.

Histological Characteristics.

Conspicuous Forms.

G. byzantinus: Simple, many small aggregates of 2, 3, or more components; nearly all isolated grains have pressure facets; surface regular but varied owing to facets. Hemispherical with a 2-, 3-, or 4-faceted base.

G. primulinus: Essentially the same as in *G. byzantinus,* except in absence of aggregates and the conspicuous forms are polygonal, which are much varied.

Histological Characteristics.—Continued.

Conspicuous Forms.—Continued.

G. cardinalis var. (*Blushing Bride*): Essentially the same as in *G. byzantinus,* but the conspicuous forms are ovoid with much rounded ends, spherical, and rounded triangular.

G. floribundus: Essentially the same as in *G. byzantinus,* except in absence of aggregates and that the conspicuous forms are spherical or almost spherical with one small facet at distal end, and somewhat quadrilateral with 3 basal facets and rounded side.

Differentiation of Certain Starches of the Genus Gladiolus.—Continued.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.

G. byzantinus: Form usually not distinct, comparatively large, single round spot, not fissured. Position centric or eccentric to about 0.40 of the longitudinal axis.
G. primulinus: Form fairly distinct, large, round spot, single, never fissured. Position usually centric.
G. cardinalis var. (*Blushing Bride*): Form fairly distinct, comparatively large, round spot, single, never fissured, rarely double. Position centric or eccentric to about 0.40 of the longitudinal axis.
G. floribundus: Form fairly distinct, large, round spot, single, never fissured. Position centric or eccentric to about 0.40 or more of the longitudinal axis.

Lamellæ—General Characteristics and Number.

G. byzantinus: Not distinct, regular, coarse rings following outline of margin. 6 on larger grains.
G. primulinus: Invisible.
G. cardinalis var. (*Blushing Bride*): Not very distinct, regular, coarse rings. 6 to 8 on larger grains.
G. floribundus: Invisible.

Size.

G. byzantinus: From 3 to 26μ, commonly 16μ.
G. primulinus: From 2 to 14μ, commonly 10μ.
G. cardinalis var. (*Blushing Bride*): From 3 to 37μ, commonly 30μ.
G. floribundus: From 2 to 12μ, commonly 8μ.

Polariscopic Properties.

Figure.

G. byzantinus: Centric or somewhat eccentric, distinct, not entirely clear-cut, slight irregularities.
G. primulinus: Essentially the same as in *G. byzantinus*, but the form is usually centric.
G. cardinalis var. (*Blushing Bride*): Essentially the same as in *G. byzantinus*, double and triple figures common.
G. floribundus: Essentially the same as in *G. byzantinus*.

Degree of Polarization.

G. byzantinus: Fairly high, very variable.
G. primulinus: Fair, not very variable, lower than in *G. byzantinus*.
G. cardinalis var. (*Blushing Bride*): High, not very variable, higher than in *G. byzantinus*.
G. floribundus: Fairly high, not very variable, not quite so high as in *G. byzantinus*.

Polarization with Selenite—Quadrants and Colors.

G. byzantinus: Quadrants generally well defined, irregular in shape, unequal in size. Colors often pure.
G. primulinus: Quadrants usually fairly well defined, regular, and nearly equal in size. Colors fairly pure.
G. cardinalis var. (*Blushing Bride*): Quadrants well defined, regular, nearly equal in size. Colors fairly pure.
G. floribundus: Quadrants usually well defined, regular, nearly equal in size. Colors fairly pure.

Iodine Reactions.

Intensity and Color.

G. byzantinus: Fairly deep; violet.
G. primulinus: Fairly deep, but less than in *G. byzantinus;* violet.
G. cardinalis var. (*Blushing Bride*): Fairly deep, slightly deeper than in *G. byzantinus;* violet.
G. floribundus: Fairly deep, the same as in *G. byzantinus;* violet.

Staining Reactions.

With Gentian Violet.

G. byzantinus: Very light.
G. primulinus: Very light, lighter than in *G. byzantinus.*
G. cardinalis var. (*Blushing Bride*): Fair, deeper than in *G. byzantinus.*
G. floribundus: Very light, lighter than in *G. byzantinus.*

With Safranin.

G. byzantinus: Fair.
G. primulinus: Light, distinctly less than in *G. byzantinus.*
G. cardinalis var. (*Blushing Bride*): Fair, about the same as in *G. byzantinus.*
G. floribundus: Fair, but slightly less than in *G. byzantinus.*

Temperature of Gelatinization.

G. byzantinus: 78 to 79° C., mean 78.5°.
G. primulinus: 80 to 82° C., mean 81°.
G. cardinalis var. (*Blushing Bride*): 80 to 81° C., mean 80.5°.
G. floribundus: 76 to 77° C., mean 76.5°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

G. byzantinus: Begins in most grains in 2 minutes; complete in three-fourths in 75 minutes.
G. primulinus: Begins in some grains in 30 seconds; complete in three-fourths in 105 minutes.
G. cardinalis var. (*Blushing Bride*): Begins in many grains in 1½ minutes; complete in three-fourths in 40 minutes.
G. floribundus: Begins in many grains in a minute; complete in all in 15 minutes.

Reaction with Chromic Acid.

G. byzantinus: Begins in a minute; complete in 7 minutes.
G. primulinus: Begins in 2 minutes; complete in 5 minutes.
G. cardinalis var. (*Blushing Bride*): Begins in 45 seconds; complete in 4 minutes.
G. floribundus: Begins in 30 seconds; complete in 3½ minutes.

Reaction with Pyrogallic Acid.

G. byzantinus: Begins in many grains in a minute; complete in nearly all in 30 minutes.
G. primulinus: Begins slightly in a few in 2 minutes; some completely gelatinized in 35 minutes, others partially.
G. cardinalis var. (*Blushing Bride*): Begins in all the grains in a minute; complete in all in 22 minutes.
G. floribundus: Begins in a minute; complete in all in 15 minutes.

Reaction with Ferric Chloride.

G. byzantinus: Begins in a few grains in a minute; complete in all in 45 minutes.
G. primulinus: Begins in a few grains in a minute; complete in all in 25 minutes.
G. cardinalis var. (*Blushing Bride*): Begins in a few grains in a minute; complete in all in 45 minutes.
G. floribundus: Begins in a few grains in a minute; complete in all in 23 minutes.

Reaction with Purdy's Solution.

G. byzantinus: Begins in a few grains in a minute; no further change.
G. primulinus: No reaction.
G. cardinalis var. (*Blushing Bride*): Slight in many grains in a minute; all the grains are beginning to be gelatinized in 45 minutes.
G. floribundus: Begins in a few grains in a minute; about half of the grains are partially gelatinized, and the rest beginning to be gelatinized, in 20 minutes.

NOTES ON THE STARCHES OF GLADIOLUS.

These starches show more or less conspicuous differences in their gross histology, *G. primulinus* and *G. floribundus* being notably smaller than *G. byzantinus*, *G. cardinalis* var. (Blushing Bride), and variations occur particularly in form and lamellation in the several starches. In the reactions the differences permit of ready diagnosis; every reaction shows more or less noticeable differences, the sum of which in the case of each starch is definitely diagnostic.

GENUS WATSONIA.

The genus *Watsonia* includes 16 species of bulbous plants, natives of the Cape of Good Hope, except a single species that is native to Madagascar. This genus in its essential botanical characters is closely akin to *Gladiolus*. Starches from 3 sources were examined, including 2 species and 1 variety: *W. humilis* Mill., *W. iridifolia* var. *o'brieni* (*W. alba* Hort., *W. o'brieni* Mast., *W. iridifolia* var. *alba* Rob., *W. meriana* var. *alba* Hort.), and *W. meriana* Mill.

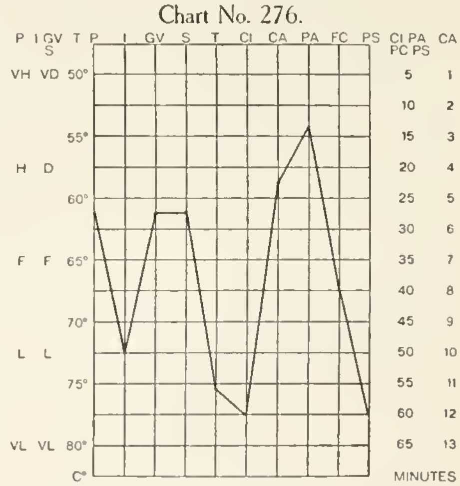
STARCH OF WATSONIA HUMILIS. (Plate 70, figs. 415 and 416. Chart 276.)

Histological Characteristics.—In *form* the grains are simple, and except the small ones are almost wholly in the form of aggregates consisting of two or more components, usually two or three, the lines of union commonly being indicated by fissures. In some cases the aggregates have the appearance of a combination inclosed by a common layer of starch, thus making a compound grain. Owing to the tendency of the aggregates to remain adherent, isolated grains having pressure facets are not common. The conspicuous forms of the aggregates are the ovoid and spherical, with transitional forms; also some ellipsoidal forms, mostly made up of two grains of unequal size. The grains are not flattened, hence when seen on end they appear to be spherical. In comparison with starches generally there is a very large proportion of small grains which are spherical, oval, and polygonal.

The *hilum* is large and generally very distinct, usually somewhat eccentric, and often appears to be a cavity extending to the inner part of the grain. It usually is round, elongated in a few cases, and sometimes fissured. The fissuration may be observed as a simple, clear-cut, transverse line, or irregularly stellate. Lines, or fissures, deep or shallow, frequently exist at the lines of union of the grains composing the aggregates. There may be 2 or 3 hila, depending upon the number of component grains.

The *lamellæ* are usually fairly distinct. They are rather coarse, commonly regular, continuous concentric rings, and those nearer the hilum are generally the most distinct. Some of the lamellæ, at parts distal to the hilum, are curved so that they may not correspond with the form of the marginal outline. In such cases a part of the aggregate has presumably broken away and later has been covered with secondary layers of starch. Otherwise the lamellæ follow regularly the outline of the margin. There are about 8 to 9 lamellæ on the larger grains.

Chart No. 276.



Curve of Reaction-Intensities of Starch of Watsonia humilis.

The single grains vary in *size* from 1.5 to 20μ. The aggregates are as large as 28μ. The common size of the doublets is 16μ.

Polariscopic Properties.—The *figure* is distinct, fairly clear-cut, and fairly regular. Some of the grains may show lines which become broader, yet distinctly defined at the margin. In many grains the central part of the figure is a large, dark area of irregular outline, and in a few only marginal parts of the grains are observed.

The degree of *polarization* is fairly high. It varies very much in different grains, but not greatly in different aspects of the same grain.

With *selenite* the quadrants are generally not clear-cut, are usually irregular in shape, and somewhat unequal in size. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a light violet and the color deepens very slowly; with 0.125 per cent solution they tint very lightly and the color deepens but little. After heating until the grains are completely gelatinized, the solution stains fairly well and the grains very deeply on the addition of iodine. Grains not so deeply stained as others show a violet capsule upon the addition of a slight excess of iodine. After boiling 2 minutes the solution stains much more deeply, but the grain-residues much less. With excess of iodine many capsules become a violet color and most of them contain blue-reacting starch. Some grains are completely disintegrated.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and the color is fairly deep, but after 30 minutes the reaction is not much better than at first.

Temperature Reaction.—The temperature of gelatinization is 75° to 76° C., mean 75.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some of the smaller and medium-sized grains in 5 minutes, in others within 8 minutes, and all are darkened in 20 minutes; the larger grains are not affected. The hilum becomes very distinct, but the lamellæ are invisible. The whole periphery darkens and the process extends inward from the margin without any swelling. There is not a very sharp line of demarcation between the gelatinized and the non-gelatinized parts. After the grain is darkened it swells slightly. The gelatinized grains formed are about twice as large as the original grains and often show a light center with a dark marginal ring; they are not distorted, and retain much of the original form.

The reaction with *chromic acid* begins in a minute and is over in 4½ minutes. The hilum becomes very distinct, but not the lamellæ. The hilum swells somewhat, the grain becomes striated, and the inner part is converted into a gelatinous mass. The starch at the periphery forms a very distinctly striated ring, ragged on the inner edge, and marked by alternate refractive and non-refractive bands; this ring grows thinner as the grain swells and finally invaginates on one side, continues to grow thinner and transparent, and finally disappears.

Reaction with *pyrogallic acid* begins in 1½ minutes and is over in 13 minutes. The hilum is prominent, but the lamellæ are not. The grain becomes covered by very coarse radiating striæ. The inner part of the grain melts down slowly and evenly. The grain swells as the process progresses. The starch at the margin forms a ring which is very distinctly striated and shows alternate refractive and non-refractive bands. The process did not go beyond this point.

With *ferric chloride* a few grains begin to react in 1½ minutes. About three-fourths are affected in 30 minutes and all are completely gelatinized in 40 minutes. The hilum is distinct and swells somewhat, and the grain becomes covered with fine striæ which grow coarser as the process goes on. The inner portion passes into a gelatinous mass. The starch at the margin forms a striated ring with a ragged, inner edge. This becomes thinner and transparent as the grain swells, until finally a large, thin-walled, gelatinized grain is formed. These grains are large, somewhat infolded, but in general retain the original forms of the grains.

There is a very slight reaction with *Purdy's solution* in some grains in 5 minutes, but no further change. The hilum and lamellæ are both very distinct. The hilum swells somewhat and the grain becomes covered by fine striæ. A part of the inner starch may become gelatinous, but there is little or no further reaction.

STARCH OF WATSONIA IRIDIFOLIA VAR. O'BRIENI. (Plate 70, figs. 417 and 418. Chart 277.)

Histological Characteristics.—In *form* the grains are simple, and many are to be seen in aggregates consisting of two or three components, usually two. A few isolated grains have pressure facets, as a rule one or two, usually one. The small grains are nothing like so numerous as in *W. humilis*. The conspicuous aggregates are oval to elliptical and rounded to angular. Among the isolated grains are noted spherical, dome-shaped, distorted spherical, hemispherical, and polygonal. The grains are not flattened in any diameter, and appear spherical when seen on end.

The *hilum* is generally very distinct. It is large and usually round, and in aggregates may be double, triple, or multiple, according to the number of components. It is generally somewhat eccentric and located in or slightly to one side of the median line, and has the appearance of a cavity. It may be fissured, and the fissuration may be ragged, or be in the form simply of a transverse curved line, or be 3-armed. Lines or fissures indicating the location of union of components of aggregates are common.

The *lamellæ* are usually fairly distinct; they are coarse, regular, continuous rings and may be distorted near the margin, which as a rule they tend to follow. In some aggregates the lamellæ near the hilum show the outlines of pressure facets, these parts seeming to have been covered with secondary layers of starch so that the outlines of the grain have become entirely different from the original. There are about 6 to 8 lamellæ on the larger grains, and those near the hilum are the more distinct.

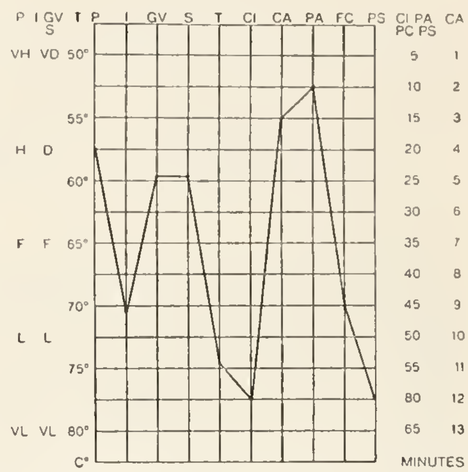
The isolated grains vary in *size* from 2 to 18μ and the aggregates up to 30μ. The common size of the isolated grains is 10μ and of the doublets 20μ.

Polariscopic Properties.—The *figure* is generally clear-cut, distinct, and fairly regular. Its lines may become somewhat broader, but less defined at the margin of the grain, and may be slightly bent or otherwise distorted. Where there are two or more hila, two or more figures may be observed. There is usually an absence of the large, dark central area referred to in *W. humilis.*

The degree of *polarization* is high; as a whole, somewhat higher than that in the grains of *W. humilis.* It varies somewhat in different grains, but not greatly in different aspects of the same grain.

With *selenite* the quadrants are, as a rule, clear-cut, fairly regular in shape, and fairly equal in size. The colors are pure.

Chart No. 277.



Curve of Reaction-Intensities of Starch of Watsonia iridifolia var. o'brieni.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored lightly, but the color is deeper than that of *W. humilis;* with 0.125 per cent solution the grains color lightly and do not deepen readily, but the color is deeper than that of the grains of *W. humilis.* After heating until the grains are completely gelatinized, the solution is fairly colored and the grains very deeply with iodine. After boiling for 2 minutes both the solution and the grain-residues are very deeply colored. If an excess of iodine is added, some of the more lightly colored grains show a violet capsule.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain fairly deeply at once, but after 30 minutes the tint is not much deeper. It is the same as that of *W. humilis.*

Temperature Reaction.—The temperature of gelatinization is 74° to 75° C., mean 74.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* there is reaction in some of the smaller grains in a minute; many medium-sized grains are affected in 5 minutes; almost all the small and the medium-sized grains are darkened, but only very few of the larger grains are affected in 15 minutes. There is practically no further change. The reaction is practically identical qualitatively with that of the grains of *W. humilis.*

The reaction with *chromic acid* begins in many grains in a minute and is over in 3 minutes. It is practically identical qualitatively with that of the grains of *W. humilis.*

With *pyrogallic acid* there is a slight general reaction in 2 minutes and all the grains are completely gelatinized in 10 minutes. The reaction is qualitatively the same as that in the grains of *W. humilis.*

There is a reaction with *ferric chloride* in some grains in 2½ minutes. All are affected and most of them partially gelatinized in 30 minutes, and all are gelatinized in 45 minutes. The reaction is practically identical qualitatively with that of *W. humilis.*

There is with *Purdy's solution* a slight reaction of a few grains in 5 minutes. A few more may afterwards be affected and there may be a slight increase in the signs of swelling, but otherwise there is no further change.

STARCH OF WATSONIA MERIANA. (Plate 70, figs. 419 and 420. Chart 278.)

Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of most or all of the larger grains, which consist of two or more components. The very small grains are numerous, but not nearly so abundant relatively as in *W. humilis.* The surface is quite regular, and there are very few isolated grains having pressure facets. The conspicuous forms are the oval to ovoid, to spherical or nearly spherical. There are a few rounded, triangular, pyriform, and hemispherical grains. The very small grains are mostly spherical or polygonal. The larger grains are not flattened and appear spherical on end.

The *hilum* is distinct. When not fissured it is a comparatively large round spot, or a hollow space centrally or somewhat eccentrically situated, and usually in the median line. It often is fissured, and the fissuration may be a small, transverse, ragged line, 3-armed or stellate. Lines or fissures at the junctions of the components of aggregates are quite common.

The *lamellæ* are indistinct, and when distinguishable they appear as coarse, regular, concentric rings, sometimes divided into segments by the fissures. They tend to follow closely the outline of the margin. There are probably 5 to 6 on the larger grains.

The small grains vary in *size* from 3 to 20μ, and the doublets to 34μ. The common size of the double grains is 22 by 18μ in length and breadth.

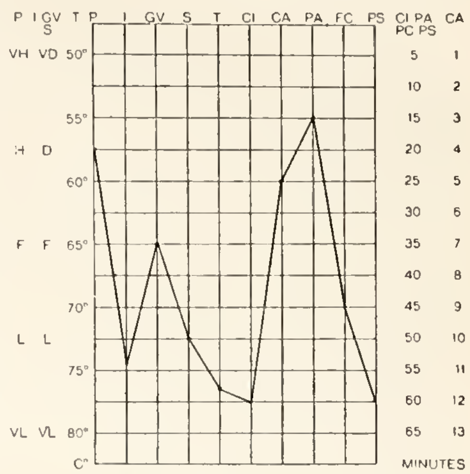
Polariscopic Properties.—The *figure* is usually eccentric, distinct, and generally clear-cut. Sometimes its lines become broader and less distinctly outlined near the margin. Double and multiple aggregates show corresponding figures. The lines are sometimes slightly bent, but as a rule the figure is regular.

The degree of *polarization* is high, slightly higher than that of the grains of *W. humilis.* It varies somewhat in different grains, but not much with the position of the grains. A dark central area tends to be much less marked in this species than in *W. humilis,* but more marked than in *W. iridifolia* var *o'brieni.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and fairly equal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very light violet and the color deepens very slowly; with 0.125 per cent solution the grains are scarcely colored at all, and the reaction is less than that of the grains of *W. humilis.* After heating until the grains are completely gelatinized, both the solution and the grains color deeply. On the addition of iodine and after boiling 2 minutes the solution colors more deeply and the grain-residues less. Most of the capsules contain some blue-reacting starch and they color a red-violet with slight excess of iodine.

Chart No. 278.



Curve of Reaction-Intensities of Starch of Watsonia meriana.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after 30 minutes are fairly stained. The color is not so deep as that of the grains of *W. humilis.*

With *safranin* the grains begin to stain at once and after 30 minutes are lightly stained. The color is not so deep as that of the grains of *W. humilis.*

Temperature Reaction.—The temperature of gelatinization is 75.5° to 77° C., mean 76.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some of the very small grains in 3 minutes and they are gelatinized in 5 minutes. Some medium-sized grains begin to react within this time. All the small grains are gelatinized in 13 minutes and a few of the medium-sized grains are gelatinized in 20 minutes. The larger grains, with few exceptions, remain unaffected. The reaction is qualitatively the same as that of the grains of *W. humilis.*

The reaction with *chromic acid* begins in the small grains in 30 seconds, and in the large grains in a minute, and is over in all in 5 minutes. It is the same qualitatively as that of the grains of *W. humilis.*

Reaction with *pyrogallic acid* begins in some small grains in 30 seconds and in all the grains in 1½ to 2 minutes. All are completely gelatinized in 15 minutes. This reaction is qualitatively the same as that of the grains of *W. humilis.*

With *ferric chloride* a few of the smaller grains begin to react in 2 minutes. In 15 minutes all the small grains are gelatinized and half of the larger ones are affected and many completely gelatinized. About three-fourths of all the grains are gelatinized in 25 minutes, and four-fifths in 35 minutes. All are affected in 45 minutes, and in 1½ hours all are completely gelatinized, except a very few near the edges of the cover-slip. This reaction is qualitatively the same as that of the grains of *W. humilis.*

With *Purdy's solution* about half the grains are slightly affected in 3 minutes and all in 15 minutes. There is no further change. This reaction is qualitatively the same as that of the grains of *W. humilis.*

Differentiation of Certain Starches of the Genus Watsonia.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

W. humilis: Simple, except small grains almost wholly in the form of aggregates of 2 or more components, probably some compound grains, very few isolated grains with pressure facets. Aggregates ovoid and spherical, with transitional forms, small grains exceptionally abundant.

W. iridifolia var. *o'brieni:* Essentially the same as in *W. humilis*, but the conspicuous aggregates are ovoid to elliptical and rounded triangular. Small grains fairly numerous.

W. meriana: Essentially the same as in *W. humilis*, but the conspicuous aggregates are the oval to ovoid, to spherical or nearly spherical. Small grains not nearly so numerous.

Hilum—Form, Number, and Position.

W. humilis: Form large, usually very distinct, usually round, may be a cavity, may be fissured. Position usually slightly eccentric.

W. iridifolia var. *o'brieni:* Form essentially the same as in *W. humilis.* Position usually slightly eccentric.

W. meriana: Form essentially the same as in *W. humilis.* Position usually eccentric.

Lamellæ—General Characteristics and Number.

W. humilis: Fairly distinct, rather coarse, usually regular, continuous concentric rings, more distinct near the hilum. 8 to 9 on larger grains.

W. iridifolia var. *o'brieni:* Essentially the same as in *W. humilis.* 6 to 8 on larger grains.

W. meriana: Essentially the same as in *W. humilis*, but less distinct. 5 to 6 on larger grains.

Size.

W. humilis: Single 1.5 to 28μ; doublets 16μ.

W. iridifolia var. *o'brieni:* Single 2 to 30μ; doublets 20μ.

W. meriana: Single 3 to 34μ; doublets 22μ.

POLARISCOPIC PROPERTIES.

Figure.

W. humilis: Usually somewhat eccentric, distinct and generally clear-cut, fairly regular; large dark area common.

W. iridifolia var. *o'brieni:* Essentially the same as in *W. humilis*, but usually absence of large dark area.

W. meriana: Essentially the same as in *W. humilis*, but dark area less marked.

Degree of Polarization.

W. humilis: Fairly high, varies much in different grains.

W. iridifolia var. *o'brieni:* High, varies somewhat, higher than in *W. humilis.*

W. meriana: High, varies somewhat, higher than in *W. humilis.*

Polarization with Selenite—Quadrants and Colors.

W. humilis: Quadrants usually not clear-cut, generally irregular, somewhat unequal in size. Colors generally pure.

W. iridifolia var. *o'brieni:* Quadrants usually clear-cut, fairly regular and fairly equal in size. Colors pure.

W. meriana: Quadrants fairly clear-cut, fairly regular, fairly equal in size. Colors pure.

IODINE REACTIONS.

Intensity and Color.

W. humilis: Light; violet.

W. iridifolia var. *o'brieni:* Light, slightly deeper than in *W. humilis;* violet.

W. meriana: Light, lighter than in *W. humilis;* violet.

STAINING REACTIONS.

With Gentian Violet.

W. humilis: Fairly deep.

W. iridifolia var. *o'brieni:* Fairly deep, little deeper than in *W. humilis.*

W. meriana: Fair, not so deep as in *W. humilis.*

With Safranin.

W. humilis: Fairly deep.

W. iridifolia var. *o'brieni:* Fairly deep, little deeper than in *W. humilis.*

W. meriana: Light, not so deep as in *W. humilis.*

TEMPERATURE OF GELATINIZATION.

W. humilis: 75 to 76° C., mean 75.5°.

W. iridifolia var. *o'brieni:* 74 to 75° C., mean 74.5°.

W. meriana: 75.5 to 77° C., mean 76.25°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

W. humilis: Begins in the smaller grains in 5 minutes; complete in small and medium-sized grains in 20 minutes. Larger grains unaffected.

W. iridifolia var. *o'brieni:* Begins in all small and medium-sized grains in 5 minutes; all the small and medium-sized grains complete in 15 minutes. Very few of larger grains at all affected.

W. meriana: Begins in all small and in a few medium-sized grains in 5 minutes; complete in all the small and in a few medium-sized grains in 20 minutes; very few large grains at all affected.

Reaction with Chromic Acid.

W. humilis: Begins in a minute; complete in 4½ minutes.

W. iridifolia var. *o'brieni:* Begins in a minute; complete in 3 minutes.

W. meriana: Begins in 30 to 60 seconds; complete in 5 minutes.

Reaction with Pyrogallic Acid.

W. humilis: Begins in 1½ minutes; complete in 13 minutes.

W. iridifolia var. *o'brieni:* Begins in 2 minutes; complete in 10 minutes.

W. meriana: Begins in 1½ to 2 minutes; complete in 15 minutes.

Reaction with Ferric Chloride.

W. humilis: Begins in some in 1½ minutes; complete in 40 minutes.

W. iridifolia var. *o'brieni:* Begins in some in 2½ minutes; complete in 45 minutes.

W. meriana: Begins in some in 2 minutes; complete in 45 minutes.

Reaction with Purdy's Solution.

W. humilis: Begins in some in 5 minutes; no further change.

W. iridifolia var. *o'brieni:* Slight reaction in some in 5 minutes; slight swelling of affected grains; no further change.

W. meriana: Slight reaction in one-fourth in 15 minutes; no further change.

NOTES ON THE STARCHES OF WATSONIA.

Such differences as have been recorded in the gross histological characters of these starches are of a minor nature and probably entirely incidental, and therefore likely of no real diagnostic value. The reactions have a very close correspondence, the most noticeable differences being in the dark area in the polarization figure, and the aniline reactions, the reactions of *W. meriana* falling below the other two, but the variations are unimportant.

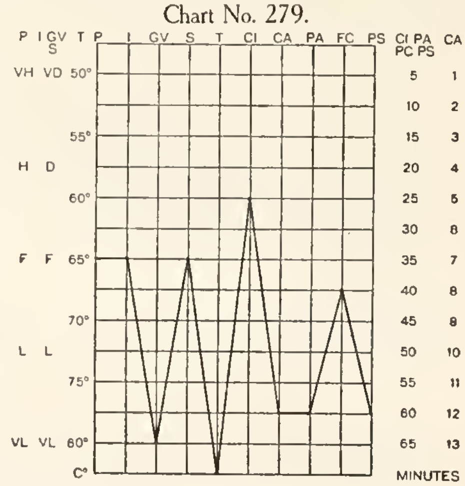
GENUS TRITONIA (MONTBRETIA).

Tritonia includes over 30 species of South African bulbous plants, only a few of which are in general cultivation. The older generic name is *Montbretia*, and tritonias are commonly known by this name. The starches of 3 species, 2 varieties, and a hybrid were studied: *T. crocata* Ker-Gawl. (*Ixia crocata*), *T. crocata* var. *lilacina* Hort., *T. crocata* var. *rosca* Hort., *T. securigera* Ker-Gawl., *T. pottsii* Benth. (*Montbretia pottsii* Baker) and the hybrid *T. crocosmæflora* Lemoine (*T. pottsii* × *crocosmia aurea*).

STARCH OF TRITONIA CROCATA. (Plate 71, figs. 421 and 422. Chart 279.)

Histological Characteristics.—In *form* the grains are mostly or solely simple and isolated, with the exception of numerous aggregates (possibly some compounds), in the form of doublets and triplets. There are a number of doublets which consist of one large grain into which a small grain of variable size is partially embedded, giving the large grain the appearance of a nodular protrusion. There are a few clumps consisting of smaller grains. A few grains have pressure facets, and the facets may be shallow depressions, and hexagonal or honeycomb-like; the surface is, as a rule, rounded and regular. The most conspicuous forms of the isolated grains are spherical, and transitional shapes between this and ovoid and elliptical. The aggregates are most commonly triplets of rounded triangular form, some doublets consisting of grains of approximately the same size and from oval to flattened ovoid in form, and the large grains with small grains partially embedded and of a broad, oval form. The grains are not flattened in any diameter, and hence as thick as wide.

Chart No. 279.



Curve of Reaction-Intensities of Starch of Tritonia crocata.

The *hilum* is indistinct, but when brought out by a reagent, such as Purdy's solution, it is seen to be a small round spot that is centric or very slightly eccentrically placed. Rarely it is slightly fissured. There may be 2 or 3 or more hila according to the number of component grains, and 2 or 3 hila may be observed in a simple grain.

The *lamellæ* are very indistinct unless rendered quite evident by Purdy's solution or other reagent. They then appear as fairly fine, regular, continuous rings. If there is more than one hilum, each has usually its own set of lamellæ, which fuse at a short distance from the hilum or are inclosed by another set. In some cases the multiple hila are set close together in a homogeneous, non-lamellated space, outlined by very distinct lamellæ. There are about 10 lamellæ on a large grain.

The grains vary in *size* from 3 to 26μ. The common size is 18μ.

Polariscopic Properties.—The *figure* is centric, or slightly eccentric, distinct, but not as a rule clear-cut. The lines are rather broad, without bending or other distortion. The figure may be double or triple, in accordance with the number of hila.

The degree of *polarization* is fair, with little variation in different grains or in different aspects of the same grain.

With *selenite* the quadrants are not as a rule sharply defined, but they tend to be regular in shape and equal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored fairly a blue-violet at once and deepen rapidly; with 0.125 per cent solution they color lightly. After heating in water until the grains are completely gelatinized, the solution is colored lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution and most of the grain-residues are colored deeply. A few of the capsules which contain but little blue-reacting starch become a violet color upon the addition of an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in 2 minutes, but after 30 minutes the color has not noticeably deepened.

With *safranin* the grains begin to stain light at once and in 30 minutes are fairly colored.

Temperature Reaction.—The temperature of gelatinization is 82° to 83° C., mean 82.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in the smaller grains in 30 seconds, and in many of the larger grains in 2 minutes, by which time some of the smaller grains are completely gelatinized. About two-thirds of the larger grains are gelatinized in 8 minutes and all are gelatinized in 25 minutes. Neither hilum nor lamellæ are distinct. The grains first color a very dark violet. Then the entire margin becomes a deep indigo color, and this process extends inward over the entire grain. The swollen grains are not large, are of a uniform dark color, and retain much of the original form of the grain.

The reaction with *chromic acid* begins in a few grains in 30 seconds. It is general in 1½ minutes and all are dissolved in 20 minutes. The hilum becomes distinct, but not the lamellæ. The inner part of the grain is converted into a gelatinous mass. The outer part forms a thick, striated ring which later divides into two parts, an outer which is thin and may be folded and distorted, and an inner which is thicker and shows fine striæ and concentric bands. The outer part is dissolved at the proximal end, and the space between the outer and inner parts increases until they are often completely separated. The inner part, which has grown much thinner, also dissolves at the proximal end, and the gelatinized starch of the interior flows out and dissolves, followed by solution of the remaining part of the ring.

The reaction with *pyrogallic acid* begins in 15 minutes, but is very slight. After 30 minutes there is not much change, and after 45 minutes only a few grains are completely gelatinized. The hilum becomes distinct, and some of the lamellæ may be made out. The hilum swells, and fine striæ appear running throughout the grain. The inner portion passes into a gelatinous mass, and the margin is formed into a thick, finely striated ring, which gradually becomes clear and thinner. The gelatinized grains are not very large, not folded or wrinkled, and retain much of the original form of the grain.

With *ferric chloride* about one-fourth of the grains show some reaction in 4 minutes and all are partially gelatinized in 10 minutes. The reaction is practically completed in 40 minutes, it being incomplete in very few grains. The hilum at first is not distinct, but later becomes so. The lamellæ are invisible. The hilum swells, and fine radial striæ appear throughout the grain. The inner part is converted readily into a gelatinous mass. The outer part first forms a finely striated ring, which becomes thinner and clearer as the grain swells. The swollen grains are fairly large, rounded, and not wrinkled or folded.

With *Purdy's solution* a number of grains become gelatinous at once. The reaction is general in nearly all in 2 minutes; it reaches its limit in 16 minutes in about one-fourth of the grains, and in about three-fourths in 45 minutes. It is very similar to that with pyrogallic acid, and is not complete in all the grains in an hour.

STARCH OF TRITONIA CROCATA VAR. LILACINA. (Plate 71, figs. 423 and 424. Chart 280.)

Histological Characteristics.—In *form* the grains are mostly or solely simple and isolated, with the exception of aggregates or compounds in the form of doublets and triplets, rarely the latter. The doublets usually consist of components of unequal size and most of them are made up of one large grain with a small grain partially embedded, giving this part of the grain the appearance of protuberances. Grains having pressure facets are uncommon, and the facets may be very shallow depressions and hexagonal, like the honeycomb. There are some clumps made up of the smaller medium-sized grains. The surface of the grains is rounded and tends to be quite regular in outline. The most conspicuous forms of isolated grains are spherical, and transitional forms appear between them and the ovoid. There are rarely ellipsoidal and triangular forms representing doublets and triplets, and the doublets consisting of a combination of a large and a small grain are broadly ovoid. These grains very closely resemble those of *T. crocata*; they are rounded in all aspects and appear to be of the same diameter as width.

The *hilum* is indistinct unless it is brought out with Purdy's solution or other reagent. Then it appears to be a small round spot, centric or slightly eccentric. It may be double, triple, or quadruple. They may be arranged regularly at equal distances from one another, or irregularly, so that one is at a greater or less distance than the others. It is sometimes fissured slightly. Apparently the hilum is always situated in a homogeneous smooth space which is without lamellation.

The *lamellæ* are very indistinct, but may be brought out by Purdy's solution; yet even with this medium they were not very well defined. They appear as regular rings, which are rather coarse, none being more prominent than the others. There are about 7 on a medium-sized grain.

The grains vary in *size* from 3 to 26μ. The common size is 18μ.

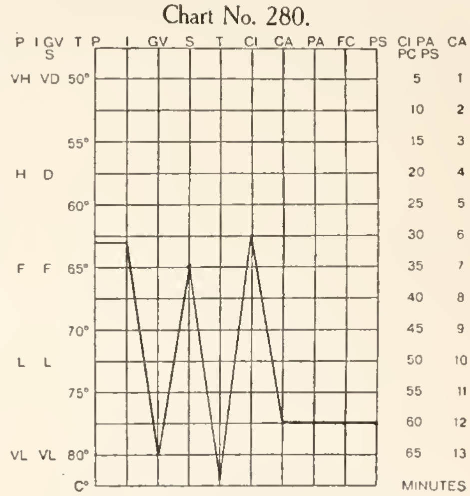
Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, but not, as a rule, clear-cut. There is no marked bending or other distortion of the lines. Double or triple figures are rare.

The degree of *polarization* is fair, with little variation in different grains and in different aspects of a given grain. It is probably very slightly higher than in *Tritonia crocata.*

With *selenite* the quadrants are not sharply defined, but tend to be regular in shape and size. The yellow is prone to be encroached upon by the red dividing lines. Apart from this the colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored fairly a blue-violet, but more than those of *T. crocata;* with 0.125 per cent solution they color lightly, but slightly more than those of *T. crocata*. After heating until the grains are completely gelatinized, the solution is colored faintly and the grains very deeply with iodine. Capsules containing very little blue-reacting starch have a violet color. After boiling for 2 minutes the solution is more deeply colored, but the grain-residues less deeply. Many capsules have a blue-violet color, while others are blue with a reddish tinge.

Chart No. 280.



Curve of Reaction-Intensities of Starch of Tritonia crocata var. lilacina.

Staining Reactions.—With *gentian violet* the grains stain very lightly at once, but after 30 minutes the color is very light. It is about the same as that of *T. crocata.*

With *safranin* the grains stain lightly at once and after 30 minutes are fairly stained, about the same as *T. crocata.* This reaction is deeper than that with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 81° to 82.5° C., mean 81.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction occurs in many grains in a minute. All are affected and some are completely gelatinized in 3 minutes and all in 30 minutes. The hilum is not very distinct, but the lamellæ are invisible. The grains are colored violet. The margin becomes dark and this process diffuses inwardly over the whole grain, after which the grain swells. The gelatinized grains are not large and they retain much of the original form of the grain. They are of an even dark color throughout.

The reaction with *chromic acid* begins in most grains in 30 seconds and is practically over in 30 minutes. The hilum becomes distinct and then swells. The grain is divided by fine radial striæ. The inner part passes into a gelatinous mass. The marginal part forms a thick, finely striated ring, which later is divided into a thin, transparent outer layer and a thicker inner layer. The outer layer dissolves at the proximal end and the two layers separate. The inner dissolves at one point, followed by solution of other parts and complete disappearance of the grain.

With *pyrogallic acid* there is some reaction in a few grains in 30 seconds and very slight general reaction in 10 minutes. In 45 minutes some of those which began to react in 30 seconds are only partially gelatinized; in others there is slight swelling. The reaction consists in the swelling of the hilum, breaking down of the interior of the grain into a gelatinous mass, and the formation of a marginal ring which grows clearer and narrower, but which never, except in those grains outside or near the edge of the cover-slip, becomes very thin or transparent. The gelatinized grains are not large, and they retain much of the original form of the grains.

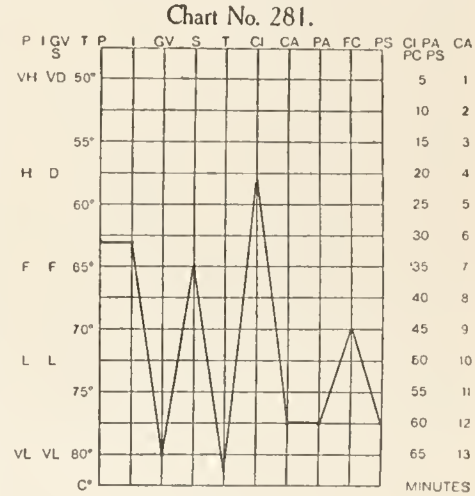
A rapid reaction occurs with *ferric chloride* in a few grains in 30 seconds, the reaction is general in 6 minutes, and reaches its limits in an hour, though the grains are not completely gelatinized. The reaction consists in the solution of the inner part of the grain and the formation of an outer ring, which grows thinner and more transparent as the grain continues to swell. The swollen grains are large, usually smooth, and rounded, and rarely show any folds, wrinkles, or sacculations.

Some grains react immediately with *Purdy's solution*, the reaction is general in 4 minutes, and about half are gelatinized in 35 minutes. In 2 hours practically all are completely gelatinized. The reaction is, as usual, first a simple breaking down of the inner part into a gelatinous mass, followed by much slower change in the marginal portion, which becomes a thin, transparent capsule. The swollen grains are fairly large, rounded, and smooth.

STARCH OF TRITONIA CROCATA VAR. ROSEA. (Plate 71, figs. 425 and 426. Chart 281.)

Histological Characteristics.—In *form* the grains are mostly or solely simple and are isolated, with the exception of numerous aggregates or compounds, chiefly in the form of doublets. Each of the latter may be made up of components of equal to very unequal size, and many of them consist of one large component with one that is small and having the appearance of being partially embedded. There are some clumps, especially among the medium and small sizes, and there are many grains with pressure facets, particularly of the hemispherical type, and some of the markings are hexagonal like the honeycomb. The surface of the grains is rounded and tends to be quite regular. The outline is usually modified in the doublets and triplets by more or less marked depressions at the lines of union of the component grains. The conspicuous forms of the isolated grains are the spherical and transitional forms between these and the ovoid. The doublets are mostly ellipsoidal and ovoid, while the triplets are rounded triangular. The grains are not flattened in any diameter and therefore are of the same thickness as breadth. These grains, in comparison with *T. crocata*, contain a relatively large number of doublets and relatively few small grains, and give the impression of being on the whole larger.

Chart No. 281.



Curve of Reaction-Intensities of Starch of Tritonia crocata var. rosea.

The *hilum* is generally indistinct, but when the grains are acted upon by Purdy's solution it appears as a small, round spot which is centric or slightly eccentric. It is rarely fissured. A single grain may show 2 or 3 hila according to the number of components. Each hilum may be surrounded by a separate set of lamellæ, and in others the hila are set close together in a common, non-lamellated space, bordered by one very distinct lamella.

The *lamellæ* are very indistinct unless they are intensified by Purdy's solution or other reagent. They appear as regular, comparatively coarse, continuous rings. There are three sets in some of the doublets, one surrounding each hilum, and a third surrounding the whole inner mass. There are about 8 on a large grain.

The grains vary in *size* from 4 to 27μ. The common size is 17μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, but as a rule not clear-cut. The figures may be single or double, according to the number of components. The lines are rather broad, and there is no bending or other distortion of the figure.

The degree of *polarization* is fair. There is not much variation in different grains or in different aspects of the same grain. It is probably slightly higher than in *T. crocata*.

With *selenite* the quadrants are not usually well defined, but tend to be regular in shape and equal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored fairly and more deeply than those of *T. crocata*, but with 0.125 per cent solution there was no difference. The color is blue-violet. After heating until the grains are completely gelatinized, the solution is colored fairly and the grains very deeply with iodine. After boiling for 2 minutes the solution is colored much deeper, but the grain-residues somewhat lighter. In a few cases the grains exhibited a pinkish-violet capsule when the color was not obscured by the intensity of the blue of the contained starch.

Staining Reactions.—With *gentian violet* the grains stain immediately, but very slightly. After 30 minutes they are still very slightly stained, about the same as in *T. crocata*.

With *safranin* the grains stain immediately but lightly. After 30 minutes they are fairly stained. The color is about the same as that of the grains of *T. crocata*, but is deeper than with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 80° to 82° C., mean 81°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 45 seconds in many of the smaller grains and it is general in 2 minutes. About four-fifths of the entire number of grains are darkened and apparently completely gelatinized in 10 minutes. The reaction is complete in all the grains in 22 minutes. The hilum may or may not become distinct, and the lamellæ are entirely obscured. The grains are colored a deep violet. The margin usually becomes very dark at all points and the reaction spreads inward over all, the violet color deepening first. There is no sharp line of demarcation between the gelatinized and non-gelatinized portions. The grains swell somewhat after they are completely darkened. The gelatinized grains are not large; they retain much of the original form of the grain and they are of a uniform dark color.

There is a general reaction with *chromic acid* in 30 seconds, and it is over in 15 minutes. The hilum at first is not very distinct, but later becomes distinct. The lamellæ, as a rule, are invisible. The hilum swells somewhat, and the grain becomes divided by fine, radial striæ which grow wider and coarser as the hilum enlarges. The interior of the grain is converted rapidly. The more resistant starch at the margin, at first, forms one thick band which is finely striated. Later, as the grain continues to swell, this band is divided into two parts, the outer being rather thin and homogeneous and somewhat folded and wrinkled, while the inner part is thicker and shows fine striæ and a ragged inner edge. As the reaction proceeds the space separating the two parts increases, especially at the distal end. The proximal end of the outer layer is dissolved, and the inner layer with its gelatinous contents is extruded partly or completely through the opening. The proximal end of this inner ring is now dissolved, and the gelatinous material within flows out and undergoes complete solution. The two rings dissolve later.

With *pyrogallic acid* there is a slight reaction in some grains in 1½ minutes and a very slight general reaction in 10 minutes. One or two are completely gelatinized in 25 minutes. There is no further change after an hour. About the edges of the cover-slip the reaction is rapid and complete. The hilum is prominent. The lamellæ may be distinguished. The hilum swells somewhat, and radial striæ appear throughout the grain. The inner portion is altered into a gelatinous mass. The marginal part forms a ring which exhibits fine striæ. This ring gradually becomes smaller and more homogeneous, but is never quite reduced to the film which forms the margin of a completely gelatinized grain. The gelatinized grains are not very large, not folded, wrinkled, or sacculated, and they retain much of the original form of the grain.

Most grains begin to react in 2½ minutes with *ferric chloride*, and all show some reaction in 7 minutes. The reaction is over in 45 minutes, although the grains are only partially gelatinized. The hilum, which at first is obscure, becomes distinct as it begins to enlarge. The grain is divided by fine radial striæ. The inner part is changed into a gelatinous mass. The marginal part forms a finely striated ring, which grows thinner and quite homogeneous, but never becomes the thin, transparent capsule of a completely gelatinized grain. The grains are fairly large, rounded, and smooth, and occasionally one is seen which shows sacculations or other irregularities at the base.

With *Purdy's solution* some grains show a reaction in 30 seconds. A few begin to react in 5 minutes. The reaction is general in 12 minutes. About half are completely gelatinized in 45 minutes and about four-fifths in 1 hour and 45 minutes. The lamellæ and hilum are both distinct. The hilum swells, fine striæ appear radiating throughout the grain, and the reaction proceeds by the breaking down of the inner portion into a gelatinous mass and the formation of the marginal portion into a finely striated ring, which becomes gradually very thin and transparent. The gelatinized grains are fairly large, usually rounded and smooth, and retain much of the original form.

STARCH OF TRITONIA SECURIGERA. (Plate 72, figs. 427 and 428. Chart 282.)

Histological Characteristics.—In *form* the grains are mostly or solely simple, and are isolated, with the exception of a few aggregates (or compounds) in the form of doublets and triplets. Some doublets consist of components varying from equal to very unequal size, and a few of them consist of a large grain with what appears to be a small grain partially embedded. There are some grains with pressure facets, and in some of them the facets are hexagonal, of a honeycomb appearance. The surface of the grains is rounded and tends to be regular in outline. The most common, conspicuous forms of isolated grains are spherical to ovoid, chiefly the former. There are also rounded ovoid, to ellipsoidal, pyriform, sugar-loaf, and hemispherical. Among the aggregates the doublets range from ovoid to oval and elliptical. The grains are not flattened and appear to be as thick as broad. The spherical forms are more conspicuous with fewer aggregates than in the case of *T. crocata*.

The *hilum* is a rather large, fairly distinct round spot, and may be double or triple in a simple grain. With doublets and triplets 2 or 3 hila may be seen. The single are centric or only slightly eccentric. If there are 2 or more each may have its own set of lamellæ, which in some cases becomes fused; or the hila may be close together in a clear, homogeneous, non-lamellated space and surrounded by rather coarse, distinct lamellæ. Fissuration was not observed.

The *lamellæ* are rather indistinct. If Purdy's solution be used they become quite apparent as rather coarse, regular, continuous rings of equal coarseness and equal distinctness. There are about 4 or 5 on one grain, and usually 2 or 3 about each hilum if there are more than one hilum and each hilum has a separate set of lamellæ.

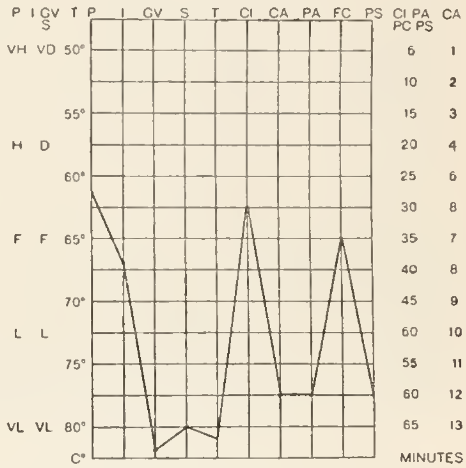
The grains vary in *size* from 2 to 30μ. The common size is 18μ.

Polariscopic Properties.—The *figure* is eccentric to slightly eccentric, but as a rule clear-cut. The lines become broader, but not sharply defined, as they extend to the margin of the grain. There are double or triple figures caused by the presence of two or more component grains.

The degree of *polarization* is fairly high. It varies somewhat in different grains, but not much in different aspects of the same grain. It is distinctly higher than in *T. crocata*.

With *selenite* the quadrants are not as a rule well defined; they tend to be regular in shape but often unequal in size. If there are two or more hila an indistinct mass of lines and colors appears in the center of the grain, outside of which are the regular large quadrants. The colors are fairly pure.

Chart No. 282.



Curve of Reaction-Intensities of Starch of Tritonia securigera.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored fairly, not so deeply as those of *T. crocata;* with 0.125 per cent solution they are colored lightly and the color is blue-violet. After heating until the grains are completely gelatinized, the solution is colored very lightly and the grains very deeply when iodine is added. After boiling for 2 minutes the solution will color more deeply, but the grain-residues less deeply. Some of the grains exhibit a violet-colored capsule, but generally this color is obscured by a large amount of blue-reacting starch remaining within the capsule.

Staining Reactions.—With *gentian violet* the grains stain very lightly at once and after 30 minutes they are still very lightly colored, lighter than that of *T. crocata.*

With *safranin* the grains begin to stain immediately very lightly and after 30 minutes they are still very lightly colored. The stain is much lighter than that of *T. crocata.*

Temperature Reaction.—The temperature of gelatinization is 80° to 82° C., mean 81°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some injured grains begin to react immediately and some smaller grains in a minute. The reaction is practically general in 2 minutes. All the small grains and about one-fourth of the large ones are dark in 7 minutes, about four-fifths in 17 minutes, and all in 30 minutes. The hila are usually distinct, but the lamellæ are obscured. The grains become very dark around the entire margin and the coloration spreads inward evenly over the whole grain. There is no sharp line of demarcation between the affected and unaffected parts of the grain, and not much swelling until the whole grain is dark. The gelatinized grains so formed are not very large, have a dark-blue color, and retain much of the original form.

The reaction with *chromic acid* begins in some grains in 30 seconds, it is general in a minute, and over in 18 minutes. The hilum is very distinct, but the lamellæ are not. The hilum swells somewhat and fine striæ appear, radiating from it throughout the grain. These striæ widen as the hilum continues to swell. The inner portion of the grain gradually becomes gelatinous. The more resistant starch at the margin forms a thick ring which gradually becomes thinner. Later the ring is divided into two distinct parts, the outer portion becomes very thin, transparent, wrinkled, and folded, while the inner portion remains thick and retains a rounded form. The upper part of the outer layer dissolves and the inner layer with its contained gelatinous material is extruded partly or completely. Usually, however, before the two portions are completely separated the top of the inner layer also is dissolved, the inclosed gelatinized starch flows out and is dissolved, and then the outer and inner rings slowly dissolve.

Reaction with *pyrogallic acid* occurs immediately in a few grains, probably the injured ones; it becomes general in 7 minutes, although it is very slight. In 17 minutes about one-sixth are fully or partially gelatinized, but in 45 minutes there is not much further change. The hilum is very prominent. Some of the lamellæ may be distinguished. The hilum swells and fine striæ appear radiating throughout the grain. The inner portion becomes gelatinous and the more resistant starch at the margin forms a ring, which is at first thick and finely striated, but later becomes thin and homogeneous until it forms merely the transparent wall of a gelatinous grain. The gelatinized grains are fairly large, rounded in outline, and not much crumpled or folded. They retain much of the original form of the grain.

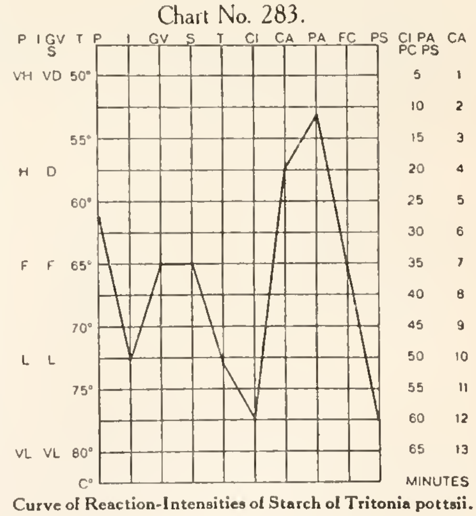
A few grains react at once with *ferric chloride* and some of the smaller, intact grains in 1½ to 2 minutes. The reaction is general in 5 minutes. All are partially gelatinized in 13 minutes, and the reaction is complete in 35 minutes. The hilum becomes distinct, but the lamellæ are obscure. The hilum swells, and the grain becomes divided by fine striæ. As the hilum continues to enlarge and the central part of the grain becomes gelatinous, the more resistant marginal starch forms a radially striated ring, which becomes thinner and clearer as the grain continues to swell, until finally it is a thin, homogeneous envelope inclosing transparent, gelatinized starch. The gelatinized grains are fairly large, but not much wrinkled, folded, or sacculated. They retain much of the original form of the grain.

A number of grains react at once with *Purdy's solution.* The reaction is general in 2 minutes, and about one-third are partially or completely gelatinized in 8 minutes. In 30 minutes about half are gelatinized and in 80 minutes about four-fifths are completely gelatinized. The hilum and lamellæ are both very distinct. The hilum swells. The grain becomes divided by fine striæ. The inner part becomes gelatinous, and the outer part of more resistant starch forms a band which shows striæ and three or four alternate refractive and non-refractive concentric rings. This band becomes thinner and clearer as the grain continues to swell, until it is reduced to a thin wall. The gelatinized grains are not very large; some are folded and distorted, but most of them retain much of the original form.

STARCH OF TRITONIA POTTSII. (Plate 72, figs. 429 and 430. Chart 283.)

Histological Characteristics.—In *form* the grains are simple and isolated. Many are marked with one, two, or rarely more well or poorly defined pressure facets at the distal end. There are some clumps. The surface of the grains is rounded and tends to be quite regular. The conspicuous forms are the hemispherical, ovoid, rounded ovoid, and spherical; also triangular and other polygonal forms arise through peculiarities of the pressure facets. The ovoid and spherical grains are not flattened and when on end appear to be spherical. The preparation was not very clean, more or less foreign matter being adherent to the grains. The general appearance of these grains differs appreciably from that of *T. crocata* and *T. securigera*, but resembles closely that of *T. crocosmæflora*.

Chart No. 283.



Curve of Reaction-Intensities of Starch of Tritonia pottsii.

The *hilum* is a fairly distinct, small round spot, usually eccentric about two-fifths to one-third of the longitudinal axis, and in the median line. Rarely it is centric. It is often fissured, and the fissures may be shallow or deep, short or long. There is usually either a single, straight, transverse or diagonally placed fissure, or three fissures of varying length, generally placed in the diagonal axes of the grain, and there is rarely a small, irregularly stellate arrangement of fissures. There are occasionally 2 hila in one grain.

The *lamellæ* are not as a rule distinct and are rather coarse, regular continuous rings which usually follow the outline of the margin of the grain. They are larger and more distinct near the hilum than near the margin and do not vary much in different grains. There are usually 10 to 12 on the larger grains.

The grains vary in *size* from 3 to 32μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, but not clear-cut. Its lines are generally broad and not clearly defined, and may be bent or otherwise distorted.

The degree of *polarization* is fairly high. It varies greatly in different grains and in different parts of the same aspect of a given grain.

With *selenite* the quadrants are fairly well defined, and tend to be irregular in shape and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color lightly a violet tinged with blue and the color deepens fairly rapidly; with 0.125 per cent solution they color very lightly and the color deepens slowly. The color is less than in *T. crocata.* After heating in water until the grains are gelatinized, the solution colors fairly and the grains deeply. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly. The capsules color violet with a slight excess of iodine and most of them retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are fairly stained. The color is deeper than in *T. crocata.*

Temperature Reaction.—The temperature of gelatinization is 72° to 73° C., mean 72.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in many grains in a minute; about half are gelatinized in 12 minutes, two-thirds in 22 minutes, four-fifths in 35 minutes, and almost all in 1¼ hours. The reaction is qualitatively the same as that of the grains of *T. crocata.*

Reaction with *chromic acid* begins in 30 seconds and is over in 4 minutes. It is qualitatively the same as that of the grains of *T. crocata.*

The reaction with *pyrogallic acid* begins in 45 seconds and is over in 12 minutes. It is the same qualitatively as that of the grains of *T. crocata.*

The reaction with *ferric chloride* begins in some grains in 1¼ minutes. About two-thirds are gelatinized in 11 minutes, almost all in 20 minutes, and all in 37 minutes. The reaction is the same qualitatively as that of the grains of *T. crocata.*

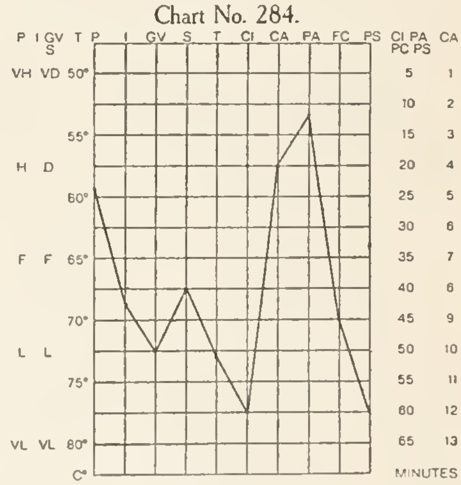
The reaction with *Purdy's solution* begins slightly in a few grains in 1½ minutes, all show some reaction and a few are partially gelatinized in 30 minutes, and all are partially and a few nearly completely gelatinized in 1¼ hours. The reaction is qualitatively the same as that of the grains of *T. crocata.*

STARCH OF TRITONIA CROCOSMÆFLORA. (Plate 72, figs. 431 and 432. Chart 284.)

Histological Characteristics.—In *form* the grains are simple and are isolated, except a few aggregates of two or more components. Most of the larger grains are marked by one or two, sometimes three or more, pressure facets; there are some clumps. The surface of the grains is rounded and tends to be quite regular. The conspicuous forms are hemispherical and spherical to oval, with some triangular and other polygonal forms, which vary in shape in accordance with the number, size, and arrangement of the pressure facets. The grains are not flattened and appear spherical on end. Their general appearance is like those of *T. pottsii*, but like the latter differs materially from those of the other tritonias.

The *hilum* is a distinct, small, round spot, usually eccentric about two-fifths of the longitudinal axis and in the median line. It is often fissured, and there is usually a single shallow, short, straight or curved fissure, usually transverse, sometimes diagonal or longitudinal. There is sometimes an irregularly stellate arrangement of short fissures. Rarely there are double hila.

Chart No. 284.



Curve of Reaction-Intensities of Starch of Tritonia crocosmæflora.

The *lamellæ* are not as a rule distinct. They appear to be continuous, regular, rather coarse rings which usually follow the outline of the margin. They do not vary much in size and distinctness in different grains, but are usually coarser and more distinct near the hilum than near the margin. There are 8 to 10 on the larger grains.

The grains vary in *size* from 2 to 34μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is usually eccentric and distinct, but not always clear-cut. Its lines are usually thick and not sharp and often become thicker and less clear-cut as they approach the margin. They are occasionally bent or otherwise distorted.

The degree of *polarization* is fairly high. It varies considerably in different grains and in different aspects of the same grain. It is slightly higher than in *T. pottsii* and distinctly higher than in *T. crocata*.

With *selenite* the quadrants are fairly well defined and tend to be irregular in shape and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color fairly a blue-violet; with 0.125 per cent solution they color lightly and the color deepens slowly. The color is deeper than in *T. pottsii*, but about the same as *T. crocata*. After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. Some that are not so deeply colored have a violet capsule. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly. The capsules all have a violet color and most of them retain more or less blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are lightly stained. The color is less than in *T. pottsii*, but slightly deeper than in *T. crocota*.

With *safranin* the grains begin to stain at once and in 30 minutes are fairly well stained. The color is slightly less than in *T. pottsii* and *T. crocata*.

Temperature Reaction.—The temperature of gelatinization is 72° to 74° C., mean 73°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 1½ minutes. About one-fourth are gelatinized in 15 minutes, two-thirds in 30 minutes, and three-fourths in an hour. The reaction begins at the distal end of the grain and at the corners and angles of the facets if these are present. The points at which the process starts become dark and swell slightly, and from them it extends inwards until all the grain is gelatinized. The gelatinized grains are not very large, are of a uniform dark color, and retain much of the original form of the grain. The main difference between the gelatinized and the ungelatinized grains, apart from size, is that in the former the corners and angles of the facets are more prominent.

The reaction with *chromic acid* begins in most of the grains in 45 seconds, in all in a minute, and is over in 4 minutes. The hilum swells slightly, fine striæ appear radiating throughout the grain, and a bubble appears at the hilum. The bubble swells as the hilum swells, up to a certain point, then it begins to shrink and finally disappear. The inner portion of the grain is transformed into a coarsely granular, gelatinized mass, the granules later becoming broken up and dissolved. The marginal material forms a thick, coarsely striated band, which later is seen to be composed of a row of coarse granules. This band becomes thinner and transparent as the grain swells, especially at the proximal end, where it is finally dissolved. The inner, gelatinous material flows out and is dissolved, and the remaining portion of the marginal band subsequently slowly dissolves.

Reaction with *pyrogallic acid* begins in most grains in a minute and in all in 1½ minutes. All are partially and half completely gelatinized in 7 minutes, and all are completely gelatinized in 12 minutes. The reaction begins around the hilum, which swells slightly; then fine striæ are seen radiating from the hilum in all directions throughout the grain; and a bubble of gas or air appears above the hilum, which at first swells as the grain swells, then decreases in size, and finally disappears. The grain continues to swell and the inner portion is gelatinized, while the marginal part forms a thick, finely striated ring, which becomes thinner and transparent. The gelatinized grains are large, folded, wrinkled, and sacculated, and do not retain the original form of the grain.

The reaction with *ferric chloride* begins in a few grains in 2 minutes. About half are completely gelatinized in 12 minutes, four-fifths in 27 minutes, practically all in 45 minutes, and all in 1¼ hours. The reaction usually begins at the hilum and consists in the formation of a bubble, which first swells, then shrinks, and then disappears. The inner portion of the grain is rendered into a gelatinous mass, and there is formed at the margin a thick band having a more or less homogeneous appearance. This band gradually grows thinner and transparent as the grain swells. In many grains, however, the corners and edges of the facets become gelatinized and swell before the rest of the grain is affected, but thereafter the process is the same as described. The gelatinized grains are large, much folded, wrinkled, and crumpled, and retain little of the original form.

With *Purdy's solution* the reaction begins very slightly in many grains in 2 minutes. In 15 minutes one or two of the grains are partially gelatinized, and in 1½ hours all the grains are slightly and a few nearly completely gelatinized.

Differentiation of Certain Starches of the Genus Tritonia.

Histological Characteristics.

Conspicuous Forms.

T. crocata: Mostly or solely simple, numerous aggregates or compounds in form of doublets and triplets, many doublets consist of a large grain having a small grain partially embedded, rounded and regular. Few grains with pressure facets. Spherical and transitional forms between them and ovoid and elliptical. Doublets oval to flattened ovoid and broad ovoid. Spherical when seen on end.

T. crocata var. *lilacina:* Essentially the same as in *T. crocata.*

T. crocata var. *rosea:* Essentially the same as in *T. crocata,* excepting a relatively large number of doublets and a less number of small grains.

T. securigera: Essentially the same as in *T. crocata,* except that the spherical forms are more conspicuous, and fewer aggregates.

T. pottsii: Simple, many grains with pressure facets; rounded and fairly regular, hemispherical, ovoid, rounded ovoid and spherical. Differ materially in general resemblances from *T. crocata,* but closely resemble *T. crocosmæflora.*

T. crocosmæflora: Essentially the same as *T. pottsii.*

Hilum—Form, Number, and Position.

T. crocata: Form indistinct, small, round, rarely slightly fissured, sometimes multiple. Position centric or slightly eccentric.

T. crocata var. *lilacina:* Form essentially the same as *T. crocata.* Position centric or slightly eccentric.

T. crocata var. *rosea:* Form essentially the same as in *T. crocata.* Position centric or slightly eccentric.

T. securigera: Form fairly distinct, large, no fissures, sometimes multiple. Position centric or slightly eccentric.

T. pottsii: Form fairly distinct, small, round, single or occasionally double, often fissured, a single short fissure or 3 fissures or stellate. Position usually eccentric about two-fifths to one-third of the longitudinal axis.

T. crocosmæflora: Form distinct, small, round, single, rarely double, often a single shallow and short fissure, or stellate. Position usually eccentric about two-fifths of the longitudinal axis.

Lamellæ—General Characteristics and Number.

T. crocata: Very indistinct, fairly fine, regular, continuous rings; about 10 on the larger grains.

T. crocata var. *lilacina:* Very indistinct, rather coarse, regular, continuous rings; about 7 on the larger grains.

T. crocata var. *rosea:* Very indistinct, regular, comparatively coarse, continuous rings; about 8 on the larger grains.

T. securigera: Rather indistinct, rather coarse, regular, continuous rings; about 4 to 5 on the larger grains.

T. pottsii: Not as a rule distinct; rather coarse, regular, continuous rings; 10 to 12 on the larger grains.

T. crocosmæflora: Essentially the same as in *T. pottsii;* 8 to 10 on the larger grains.

Size.

T. crocata: From 3 to 26μ, commonly 18μ.

T. crocata var. *lilacina:* From 3 to 26μ, commonly 18μ.

T. crocata var. *rosea:* From 4 to 27μ, commonly 17μ.

T. securigera: From 2 to 30μ, commonly 18μ.

T. pottsii: From 3 to 32μ, commonly 20μ.

T. crocosmæflora: From 2 to 34μ, commonly 20μ.

Polariscopic Properties.

Figure.

T. crocata: Centric or slightly eccentric, not as a rule, clear-cut, lines straight.

T. crocata var. *lilacina:* Essentially the same as in *T. crocata.*

Polariscopic Properties.—Continued.

Figure.—Continued.

T. crocata var. *rosea:* Essentially the same as in *T. crocata.*

T. securigera: Essentially the same as in *T. crocata.*

T. pottsii: Usually eccentric, not clear-cut, lines may be bent or otherwise distorted.

T. crocosmæflora: Essentially the same as in *T. pottsii.*

Degree of Polarization.

T. crocata: Fair, not much variation.

T. crocata var. *lilacina:* Fair, probably slightly higher than in *T. crocata.*

T. crocata var. *rosea:* Fair, probably slightly higher than in *T. crocata.*

T. securigera: Fairly high, variable, distinctly higher than in *T. crocata.*

T. pottsii: Fairly high, variable, distinctly higher than in *T. crocata.*

T. crocosmæflora: The same as in *T. pottsii,* except more variable and slightly higher.

Polarization with Selenite—Quadrants and Colors.

T. crocata: Quadrants, as a rule, not sharply defined, tend to be regular in shape, and equal in size. Colors fairly pure.

T. crocata var. *lilacina:* Quadrants essentially the same as in *T. crocata.* Colors fairly pure.

T. crocata var. *rosea:* Quadrants essentially the same as in *T. crocata.* Colors fairly pure.

T. securigera: Quadrants essentially the same as in *T. crocata,* but greater tendency to inequality in size. Colors fairly pure.

T. pottsii: Quadrants fairly well defined, tend to be irregular in shape and unequal in size. Colors fairly pure.

T. crocosmæflora: Quadrants the same as in *T. pottsii.* Colors fairly pure.

Iodine Reactions.

Intensity and Color.

T. crocata: Fair; blue-violet.

T. crocata var. *lilacina:* Fair, slightly more than in *T. crocata;* blue-violet.

T. crocata var. *rosea:* Fair, slightly more than in *T. crocata;* blue-violet.

T. securigera: Fair, but not so much as in *T. crocata;* blue-violet.

T. pottsii: Light, less than in *T. crocata;* blue-violet.

T. crocosmæflora: Fair, more than in *T. pottsii,* but less than in *T. crocata;* blue-violet.

Staining Reactions.

With Gentian Violet.

T. crocata: Very lightly.

T. crocata var. *lilacina:* Very lightly, about the same as in *T. crocata.*

T. crocata var. *rosea:* Very lightly, about the same as in *T. crocata.*

T. securigera: Very light, lighter than in *T. crocata.*

T. pottsii: Fair, deeper than in *T. crocata.*

T. crocosmæflora: Light, less than in *T. pottsii,* but more than in *T. crocata.*

With Safranin.

T. crocata: Fair.

T. crocata var. *lilacina:* Fair, about the same as in *T. crocata.*

T. crocata var. *rosea:* Fair, about the same as in *T. crocata.*

T. securigera: Very light, much less than in *T. crocata.*

T. pottsii: Fair, about the same as in *T. crocata.*

T. crocosmæflora: Fair, less than in *T. pottsii* and *T. crocata.*

Differentiation of Certain Starches of the Genus Tritonia.—Continued.

TEMPERATURE OF GELATINIZATION.

T. crocata: 82 to 83° C., mean 82.5°.
T. crocata var. *lilacina:* 81 to 82.5° C., mean 81.75°.
T. crocata var. *rosea:* 81 to 82° C., mean 81.5°.
T. securigera: 80 to 82° C., mean 81°.
T. pottsii: 72 to 73° C., mean 72.5°.
T. crocosmœflora: 72 to 74° C., mean 73°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

T. crocata: Begins in half to 2 minutes; complete in 25 minutes.
T. crocata var. *lilacina:* Begins in 1 to 3 minutes; complete in 30 minutes.
T. crocata var. *rosea:* Begins in three-fourths to 2 minutes; complete in 22 minutes.
T. securigera: Begins in 1 to 2 minutes; complete in 30 minutes.
T. pottsii: Begins in many in a minute; complete in four-fifths in 35 minutes, and in almost all in 1¼ hours.
T. crocosmœflora: Begins in most in 1½ minutes; complete in three-fourths in 1 hour.

Reaction with Chromic Acid.

T. crocata: Begins in 30 to 90 seconds; complete in 20 minutes.
T. crocata var. *lilacina:* Begins in 30 seconds; complete in 30 minutes.
T. crocata var. *rosea:* Begins in 30 seconds; complete in 15 minutes.
T. securigera: Begins in 30 to 60 seconds; complete in 18 minutes.
T. pottsii: Begins in 30 seconds; complete in 4 minutes.
T. crocosmœflora: Begins in most in 45 seconds; complete in 4 minutes.

Reaction with Pyrogallic Acid.

T. crocata: Very slight general reaction in 15 minutes; a very few grains are completely gelatinized in 45 minutes.
T. crocata var. *lilacina:* Very slight general reaction in 10 minutes; a few grains are partially gelatinized in 45 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

T. crocata var. *rosea:* Very slight general reaction in 10 minutes; slight general reaction in 10 minutes; 1 or 2 completely gelatinized in 25 minutes.
T. securigera: Very slight general reaction in 7 minutes; one-sixth fully or partially gelatinized in 17 minutes.
T. pottsii: Begins in all in 45 seconds; complete in 12 minutes.
T. crocosmœflora: Begins in most in 60 seconds; complete in 12 minutes.

Reaction with Ferric Chloride.

T. crocata: Begins in some in 4 minutes; practically complete in 40 minutes.
T. crocata var. *lilacina:* Begins in all in 6 minutes; not complete in 60 minutes.
T. crocata var. *rosea:* Begins in all in 7 minutes; not complete in 45 minutes.
T. securigera: Begins in all in 5 minutes; complete in 35 minutes.
T. pottsii: Begins in some in 1¼ minutes; complete in almost all in 20, and in all in 37 minutes.
T. crocosmœflora: Begins in a few in 1¼ minutes; complete in practically all in 45 minutes and in all in 75 minutes.

Reaction with Purdy's Solution.

T. crocata: Begins in all in 2 minutes; complete in three-fourths in 45 minutes; incomplete in a few in 60 minutes.
T. crocata var. *lilacina:* Begins in all in 4 minutes; complete in all in 2 hours.
T. crocata var. *rosea:* Begins in all in 12 minutes; complete in four-fifths in 1¾ hours.
T. securigera: Begins in all in 2 minutes; complete in four-fifths in 1⅓ hours.
T. pottsii: Slightly in a few in 1½ minutes; all are partially gelatinized and a few nearly completely gelatinized in 1½ hours.
T. crocosmœflora: Slightly many in 2 minutes; all are partially and a few nearly completely gelatinized in 1½ hours.

NOTES ON THE STARCHES OF TRITONIA.

Comparing these starches it will be observed that on the basis of the gross histological characters the specimens may be divided into three groups which consist of *T. crocata* and its two varieties, *T. securigera*, and *T. pottsii* and *T. crocosmœflora*, respectively. This is in accord with botanical peculiarities. The same grouping holds good for the reactions, differences being quite marked in almost every reaction. It is of particular interest to note the marked differences in the temperatures of gelatinization of *T. crocata* and its varieties and *T. securigera* as compared with those of *T. pottsii* and its hybrid, a difference of 8.7°; and also that while *T. crocata* and its varieties and *T. securigera* correspond in their temperatures of gelatinization they differ appreciably in their reactions. *T. pottsii* and its hybrid appear to stand distinctly apart from the other members of the genus in the peculiarities of their starches, yet there is the same type of reaction-curve.

GENUS FREESIA

The Freesias are bulbous plants, natives of the neighborhood of the Cape of Good Hope and closely allied with *Tritonia* and *Gladiolus*. Less than a half a dozen species and a few varieties are in common cultivation. It seems probable that *F. refracta* is the parent stock of the genus. Starches from 2 varieties of 1 species were examined: *F. refracta* var. *alba* and *F. refracta* var. *leichtlinii.*

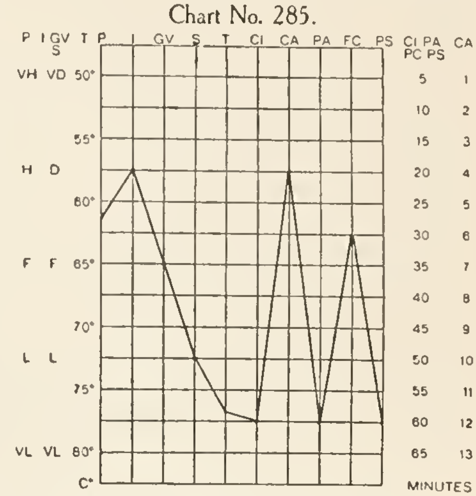
STARCH OF FREESIA REFRACTA VAR. ALBA. (Plate 73, figs. 433 and 434. Chart 285.)

Histological Characteristics.—In *form* the grains are simple and occur isolated or as aggregates consisting of two, three, four, or more components. On all the isolated grains pressure facets are found that have been parts of aggregates. The surface tends to be rounded and smooth. The conspicuous form is the hemispherical with one, two, or three facets at the base; also spherical to almost spherical, ovoid, and polygonal, a few of the latter having small facets all over the surface. The grains are not flattened and appear spherical when viewed on end.

The *hilum* is usually centric and a fairly distinct, relatively large, non-refractive spot, always in the median line. Rarely the hilum is fissured, and if so the fissuration is either in the form of a cross or a 3-armed figure. Double hila may be seen in a single grain, and 2 or more may be observed in aggregates.

The *lamellæ* are rather indistinct, regular, fine, concentric rings, following the shape of the margin of the grain, even when near the hilum. When the lamellæ were distinct enough to be counted it was estimated that the number was about 10 to 12 on a medium-sized grain. They become more distinct near the margin and one situated midway between the hilum and the margin was prominent in most of the grains.

Chart No. 285.



Curve of Reaction-Intensities of Starch of Freesia refracta var. alba.

The grains vary in *size* from 2 to 18μ. The common size is 12μ.

Polariscopic Properties.—The *figure* is usually centric. It is distinct and fairly clear-cut, but the lines are somewhat wider at the margin and are sometimes bent or otherwise distorted.

The degree of *polarization* is fairly high. It varies somewhat in different grains and in the same aspect of a given grain. It is higher at the proximal than the distal end.

With *selenite* the quadrants are sharply defined, fairly regular in shape, but unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet; with 0.125 per cent solution they tint slightly. After heating in water until the grains are completely gelatinized, the solution is colored a deep indigo and the grains lightly to deeply, or not at all, upon the addition of iodine. The gelatinized grains are folded and distorted, but do not lose all of their original shape. After boiling for 2 minutes the solution colors more deeply and the grain-residues much less deeply. With an excess of iodine the capsule stains violet.

Staining Reactions.—With *gentian violet* the grains begin to stain in 3 minutes and after 30 minutes are fairly stained.

With *safranin* the grains begin to stain in a minute and in 30 minutes are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 76° to 77.5° C., mean 76.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds in the smaller grains and is general in 2 minutes. The reaction is over in three-fourths of the grains in 30 minutes, but the reaction is incomplete in an hour. The hilum becomes much more distinct as a dark spot and the whole grain is colored a light violet. Two lines or fissures often appear in the hemispherical forms which run from the hilum to the corners of the facets. The margin becomes dark at one or two points, generally at the sharp corners of the facets, and there may be slight protrusion from these points. Then the reaction spreads upward and inward over the whole grain, and when it reaches the hilum this part swells, accompanied by swelling of the whole grain. The gelatinized grains do not become very large and do not lose their original contour. They have usually a dark indigo-colored, marginal ring surrounding a lighter, round, central space.

The reaction with *chromic acid* begins in a minute and is over in 4 minutes. The hilum becomes very distinct and a line extends from it on each side to the corners of the facet at the base of the grain. The hilum swells, and these lines open out to form a triangular space which divides the grain into two portions, the inner becoming coarsely granular, and the outer or marginal becoming finely striated and marked with two or three refractive and non-refractive rings. One corner of the marginal ring now dissolves and opens out, allowing the coarsely granular inner portion to flow out. The exuded starch passes into solution, followed by solution of the more resistant marginal part.

With *pyrogallic acid* some grains begin to react in 2 minutes. All are affected in 30 minutes and half are entirely gelatinized. The hilum and lamellæ become more distinct, and a line or fissure extends from each side of the hilum to the corners of the facets. Fine striæ appear radiating from the hilum throughout the grain, the hilum begins to swell, and the lines radiating from it open out at the same time. The inner parts pass into a gelatinous mass, while the marginal portions form a finely striated ring which shows in some parts refractive and non-refractive bands. This ring grows thinner and clearer. The gelatinized grains thus formed are swollen to about 1.5 times or twice the size of the original and are not much folded or crumpled, but retain somewhat the original form of the grain.

The reaction with *ferric chloride* begins in some of the smaller grains in 2 minutes and is complete in 30 minutes. The hilum becomes very distinct, but the lamellæ entirely disappear. In those grains in which the reaction is rapid the whole grain becomes very clear, the inner portion is changed into a gelatinous mass, and the entire grain swells slowly until a relatively large mass is formed which retains in general the original shape of the grain. In the grains that react more slowly lines are seen running from the hilum to the corners of the facets; the marginal portion becomes clearer and darker; and the lamellæ reappear in this marginal part. The grain now begins to swell, the inner part being converted into a gelatinous mass, which is inclosed by a striated marginal ring, which becomes thinner and more transparent. The gelatinized grains are large and smooth, and retain somewhat the original form of the grain.

The reaction with *Purdy's solution* begins in some grains in 1½ minutes and is complete in half the total number in 45 minutes. The hilum and lamellæ become more distinct and two lines extend from the hilum to the corners made of the facets. The inner part of the grain is transformed into a gelatinous mass, and the more resistant marginal part forms a ring which is striated and shows concentric refractive and non-refractive bands. Just inside the outer marginal ring there is often a darker, somewhat striated, and fissured ring. Further changes consist in the gradual clearing and thinning of both marginal rings to form a gelatinous capsule. The gelatinized grains thus formed retain much of the original form of the grain.

STARCH OF FREESIA REFRACTA VAR. LEICHTLINII. (Plate 73, figs. 435 and 436. Chart 286.)

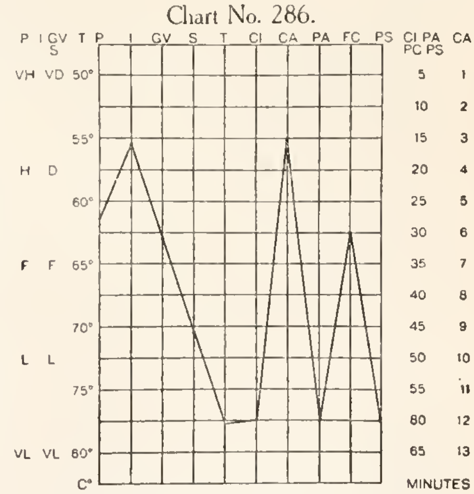
Histological Characteristics.—In *form* the grains are simple and occur isolated or in aggregates of two or more components, which may be of equal or unequal size. All the isolated grains that have been parts of aggregates are marked by pressure facets. The surface tends to roundness and smoothness. The conspicuous forms are hemispherical with one to three facets at the distal end; also spherical or nearly spherical, ovoid, and polygonal. A few grains may be seen marked over the entire surface with pressure facets. The grains are not flattened, and on end they appear spherical in shape.

The *hilum* is a fairly distinct, relatively large, non-refractive spot, usually centrically placed and in the median line. There may be double hila, and 2 or more may be noted in aggregates. The hilum is rarely fissured, and if so the fissuration is slight and of variable form.

The *lamellæ* are indistinct, and when they can be clearly seen they appear as fine, regular, concentric rings which follow the outline of the margin of the grain, being more distinct as they are near the margin. One about the center of the space between the hilum and the margin is commonly very distinct. They appear to average about 10 to 12 to a medium-sized grain.

The grains vary in *size* from 2 to 19μ. The common size is about 10μ.

Chart No. 286.



Curve of Reaction-Intensities of Starch of Freesia refracta var. leichtlinii.

Polariscopic Properties.—The *figure* is usually centric, distinct, and fairly well defined, but the lines are generally somewhat broader near the margin and sometimes bent.

The degree of *polarization* is fairly high, varying somewhat in different grains and in different aspects of the same grain. It is higher at the proximal than at the distal end.

With *selenite* the quadrants are sharply defined, fairly regular in shape, but unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they tint lightly at first, but deeper than the grains of *Freesia refracta* var. *alba*. After heating in water until the grains are completely gelatinized the solution colors deep indigo with iodine, while the grains are in general lightly colored. The swollen grains are rounded but not much distorted. After boiling for 2 minutes the solution colors much more deeply, but the grain-residues, as a rule, do not color. With excess of iodine the capsules are colored red-violet. The grains are much distorted and many have been reduced to crumpled, granular masses.

Staining Reactions.—With *gentian violet* the grains begin to stain in 3 minutes and after 30 minutes are fairly stained, slightly deeper than the grains of *F. refracta* var. *alba*.

With *safranin* the grains begin to stain in 2 minutes and after 30 minutes are fairly stained, more deeply than the grains of *F. refracta* var. *alba*.

Temperature Reaction.—The temperature of gelatinization is 76.5° to 78° C., mean 77.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 2½ minutes in two-thirds of the grains and is practically over in all in 30 minutes. It is qualitatively the same as that of the grains of *F. refracta* var. *alba*.

With *chromic acid* some grains are dissolved in 1½ minutes and all in 3 minutes. The reaction is qualitatively the same as that of the grains of *F. refracta* var. *alba*.

The reaction with *pyrogallic acid* begins in 2 minutes, and all the grains are partially and half completely gelatinized in 20 minutes. This reaction is qualitatively the same as that of the grains of *F. refracta* var. *alba*.

The reaction with *ferric chloride* begins in some grains in 2½ minutes and is complete in 30 minutes. It is qualitatively the same as that of the grains of *F. refracta* var. *alba*.

Reaction with *Purdy's solution* begins in some grains in 2½ minutes and is over in half the grains in 30 minutes. It is qualitatively the same as that of the grains of *F. refracta* var. *alba*.

Differentiation of Certain Starches of the Genus Freesia.

Histological Characteristics.

Conspicuous Forms.

F. refracta var. *alba:* Simple, isolated and in aggregates of 2 or more components, isolated grains have pressure facets. Hemispherical with 1 to 3 facets at base.

F. refracta var. *leichtlinii:* Same as in *F. refracta* var. *alba*.

Hilum—Form, Number, and Position.

F. refracta var. *alba:* Form fairly distinct, relatively large round spot; may be double, rarely fissured. Position usually centric.

F. refracta var. *leichtlinii:* Form same as in *F. refracta* var. *alba*. Position usually centric.

Lamellæ—General Characteristics and Number.

F. refracta var. *alba:* Rather indistinct, fine, regular, concentric rings. 10 to 12 on medium-sized grains.

F. refracta var. *leichtlinii:* The same as in *F. refracta* var. *alba*. 10 to 12 on medium-sized grains.

Size.

F. refracta var. *alba:* From 2 to 18μ, commonly 12μ.

F. refracta var. *leichtlinii:* From 2 to 19μ, commonly 10μ.

Polariscopic Properties.

Figure.

F. refracta var. *alba:* Usually centric, distinct, fairly clear-cut, regular.

F. refracta var. *leichtlinii:* Same as in *F. refracta* var. *alba*.

Degree of Polarization.

F. refracta var. *alba:* Fairly high, somewhat variable.

F. refracta var. *leichtlinii:* Same as in *F. refracta* var. *alba*.

Polariscopic Properties.—Continued.

Polarization with Selenite—Quadrants and Colors.

F. refracta var. *alba:* Quadrants sharply defined, fairly regular, unequal in size. Colors fairly pure.

F. refracta var. *leichtlinii:* Quadrants the same as in *F. refracta* var. *alba*. Colors fairly pure.

Iodine Reactions.

Intensity and Color.

F. refracta var. *alba:* Deep; blue-violet.

F. refracta var. *leichtlinii:* Deep, more than in *F. refracta* var. *alba;* blue-violet.

Staining Reactions.

With Gentian Violet.

F. refracta var. *alba:* Fair.

F. refracta var. *leichtlinii:* Fair, slightly deeper than in *F. refracta* var. *alba*.

With Safranin.

F. refracta var. *alba:* Light.

F. refracta var. *leichtlinii:* Light, slightly deeper than in *F. refracta* var. *alba*.

Temperature of Gelatinization.

F. refracta var. *alba:* 76 to 77.5° C., mean 76.75°.

F. refracta var. *leichtlinii:* 76.5 to 78° C., mean 77.25°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

F. refracta var. *alba:* Begins in 30 seconds, general in 2 minutes; complete in three-fourths of the grains in 30 minutes; remaining one-fourth not affected.

F. refracta var. *leichtlinii:* Begins in 2½ minutes in two-thirds of the grains; complete in most in 30 minutes; not fully complete in an hour.

Differentiation of Certain Starches of the Genus Freesia.—Continued.

Effects of Various Reagents.—Continued.

Reaction with Chromic Acid.

F. refracta var. *alba:* Begins in a minute; complete in 4 minutes.
F. refracta var. *leichtlinii:* Begins in 1½ minutes; complete in 3 minutes.

Reaction with Pyrogallic Acid.

F. refracta var. *alba:* Begins in some in 2 minutes; all partially and one-half completely gelatinized in 30 minutes.
F. refracta var. *leichtlinii:* Begins in 2 minutes; all partially and one-half completely gelatinized in 20 minutes.

Effects of Various Reagents.—Continued.

Reaction with Ferric Chloride.

F. refracta var. *alba:* Begins in some in 2 minutes; complete in 30 minutes.
F. refracta var. *leichtlinii:* Begins in some in 2½ minutes; complete in 30 minutes.

Reaction with Purdy's Solution.

F. refracta var. *alba:* Begins in some in 1½ minutes; complete in half in 45 minutes.
F. refracta var. *leichtlinii:* Begins in some in 2½ minutes; complete in half in 30 minutes.

NOTES ON THE STARCHES OF FREESIA.

The two starches examined, being from two varieties of the same species, are very much alike in all respects, but it seems from the slight differences in the reactions that one could with reasonable certainty be distinguished from the other.

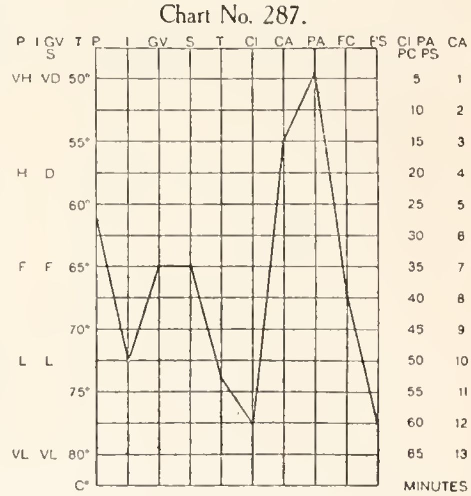
GENUS ANTHOLYZA.

This genus includes about 20 species of cormous plants, natives of the Cape of Good Hope and tropical Africa. Some of them were introduced into cultivation about the middle of the eighteenth century, and they are popularly known as African corn flag. The starches from *A. crocosmoides* and *A. paniculata* were studied as types of the genus.

STARCH OF ANTHOLYZA CROCOSMOIDES. (Plate 73, figs. 437 and 438. Chart 287.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a few aggregates in the form of doublets, triplets, and very rare quadruplets and quintuplets, and a few clumps. Practically all of the isolated grains are marked by one or more pressure facets at the distal end; these are usually large and sharply defined, but some large grains have a number of small, often poorly defined facets at the distal end. The surface is usually regular, but in some cases one side of the distal end is more prominent than the other, especially if there are two or more facets of unequal size present. The conspicuous forms are the spherical, hemispherical, and rounded ovoid. The hemispherical forms have from one to three or more pressure facets at the base. The aggregates are almost invariably in the form of doublets and triplets, the former being elliptical and the latter rounded triangular, the junctions of the components being indicated by linear depressions or fissures. Among the smaller grains polygonal forms are common. The grains are not flattened, and when seen on end appear spherical. There was considerable foreign matter in the preparation which could not be removed.

Chart No. 287.



Curve of Reaction-Intensities of Starch of Antholyza crocosmoides.

The *hilum* is a rather large round spot or cavity which is generally distinct. It is usually eccentric about two-fifths or less of the longitudinal axis and in some small grains it is centric. It is sometimes fissured by a short, straight, transverse fissure, or by three short, straight fissures proceeding from a central cavity; or, rarely, by a number of short, irregular fissures.

The *lamellæ* are usually indistinct, but when they can clearly be seen they appear as rather coarse, regular, complete rings with the form of the outline of the grains, except near the hilum, where they are circular. The number was not satisfactorily determined, but there are probably 5 to 7 on the larger grains.

The grains vary in *size;* the smaller, round grains are 0.75μ; the larger are 24 by 28μ to 18 by 18μ in length and breadth. The common sizes are 12 by 10μ and 10 by 10μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and generally clear-cut. At times its lines are less clearly defined in some portions of their length and tend to become broader peripherally, especially close to the margin; they are sometimes curved or otherwise distorted. Two or more figures may be seen on the surfaces of the facets and in the case of aggregates.

The degree of *polarization* is fairly high, varying somewhat in different grains, but not very much in different aspects of the same grain. In the same aspect of a grain it is sometimes lower at the facets than in any other part.

With *selenite* the quadrants are, as a rule, well defined, irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a light blue-violet; with 0.125 per cent solution they do not color perceptibly until after about 1 to 1½ minutes, then very lightly, and the color deepens gradually. After heating in water until the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues fairly deeply. In some of the grains, when an excess of iodine is added, violet-colored capsules can be seen.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they stain fairly, a few more than others.

Temperature Reaction.—The temperature of gelatinization is 73° to 75° C., mean 74°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in many grains in 30 seconds. All of the small and most of the medium-sized grains, constituting two-thirds of the total number, are gelatinized in 5 minutes, four-fifths are affected in 10 minutes, gelatinization incomplete in an hour. The whole grain is colored deep violet; swelling begins at the distal end; then the corners and edges of the facets grow very dark as they swell, and this process proceeds up along the sides and inward, but not so rapidly as along the margin. The hilum is finally reached and swells, and then the starch at the proximal end is gelatinized. The gelatinized grains are fairly large and retain much of the original form of the grains, with usually a round, light space in the interior surrounded by a rim of dark material. Some of the grains do not react at all or not fully, as they are observed usually to have a fissure or cavity at the hilum.

Reaction with *chromic acid* begins in most grains in 15 seconds and in all in 30 seconds, and is over in 3 minutes. The hilum begins to enlarge and fine striæ appear which radiate in all directions from the hilum. The grain swells, and the central part becomes clear and is probably occupied by a gelatinous semifluid mass. The more resistant starch is seen at the margin, where it forms at first a thick, striated ring which shows two or three alternate refractive and non-refractive bands. This ring grows progressively thinner as the grains continue to swell until it is very thin and transparent. It is then dissolved at one point, either at the corner of facets or near the proximal end. The gelatinized starch flows out and is dissolved, and the outer, thin capsule dissolves later.

The reaction with *pyrogallic acid* begins in all the grains in 30 seconds. The hilum enlarges, lines or fissures extend from it to the corners of the facets, and fine striæ appear radiating in all directions throughout the grain. The inner part now becomes filled with a semiliquid mass of starch and the more resistant starch at the margin forms into a thick ring as the grain swells. This ring is striated and marked by two or three alternate refractive and non-refractive bands. As the grain continues to enlarge, the ring becomes somewhat thinner and quite transparent, but never grows very thin. The swollen grains are large and somewhat distorted and folded, but retain much of their original forms.

The reaction with *ferric chloride* begins in some grains in 2 minutes; about one-third, including most of the small ones, are completely gelatinized in 15 minutes, and all in 40 minutes. The reaction begins with the increase in size of the hilum. Lines or fissures extend from the hilum to the corners of the facets, and these increase in size as the hilum swells. The grain swells and the interior becomes filled with a semiliquid mass. The process of gelatinization often takes place much more rapidly in one direction than in others, so that the grain at first swells more in this one direction. Later, the same process takes place universally. The more resistant starch forms a very thick, faintly striated band at the periphery. This slowly grows thinner and clearer until it is very thin and transparent. The swollen grains are large and somewhat distorted.

With *Purdy's solution* there is in 4 minutes a slight reaction in a few grains, which consists of little enlargement of the grain, the gelatinization of a small amount of starch which causes the hilum to appear larger, and the appearance of fine striæ which radiate from the hilum. There was no further change of importance.

STARCH OF ANTHOLYZA PANICULATA. (Plate 74, figs. 439 and 440. Chart 288.)

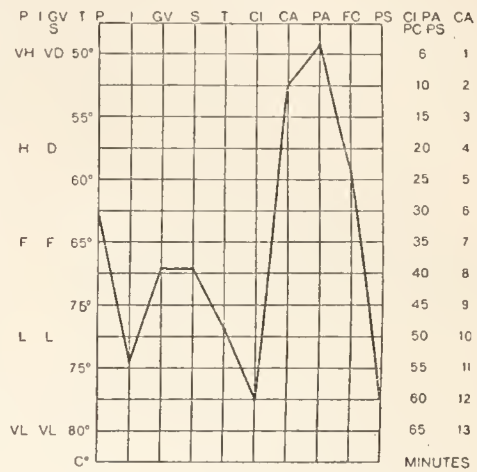
Histological Characteristics.—In *form* the grains are simple, and are isolated except very few aggregates of two or three components. The isolated grains are usually marked by one to three pressure facets, commonly one or two. These facets are generally large and sharply defined, often irregular in shape; there are many clumps and much foreign matter is present. The surface of the grains is usually regular, but some irregularity may be due to a greater prominence of one side of the distal end than of the other. The conspicuous forms are the spherical, hemispherical, and rounded ovoid; the hemispherical forms have from one to three or more facets at the base or distal end. There are also the elliptical and rounded triangular forms of the doublets and triplets. Some of the medium-sized and small grains are polygonal, owing to multiple pressure facets. The grains are not flattened, and appear spherical when seen on end.

The *hilum* is not very large. It is a fairly distinct round spot or cavity, usually eccentric about two-fifths or less of the longitudinal axis; sometimes marked by a rather short, straight, transverse fissure.

The *lamellæ* are fairly distinct, usually coarse, and regular continuous rings when near the hilum, but when near the margin they may be irregular and discontinuous rings. They are coarser and more distinct near the hilum than near the margin of the grain. There are 10 to 12 on the larger grains.

The grains vary in *size* from 0.75 to 30 by 17μ in length and breadth. The common size is 20 by 16μ in length and breadth.

Chart No. 288.



Curve of Reaction-Intensities of Starch of Antholyza paniculata.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, and generally clear-cut. At times its lines become less clearly defined in some portions of their length. They are sometimes curved and otherwise distorted and as a rule are broader near the margin of the grains. In the faceted grains another figure or parts of a figure may be seen on the faceted surface, and in the doublets or triplets a corresponding number of figures may be seen.

The degree of *polarization* is fairly high. It varies much in different grains, but not much in different aspects of the same grain. In the same aspect of a grain it is sometimes lower at the facets than in other parts. It is not so high as in *A. crocosmoides.*

With *selenite* the quadrants are generally fairly well defined, irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a light blue-violet; with 0.125 per cent solution they do not color for 1½ minutes and then lightly. The color is even lighter than that of the grains of *A. crocosmoides.* After heating in water until the grains are completely gelatinized, the solution colors deeply and the swollen grains very deeply. After boiling for 2 minutes the solution colors very deeply and the grain-residues fairly. On the addition of an excess of iodine most of the capsules color violet.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes stain fairly, some more than the rest. The stain is less than that of *A. crocosmoides.*

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 30 seconds and in most in 1½ minutes. About four-fifths are affected in 10 minutes. The reaction is incomplete in an hour and is the same qualitatively as that of the grains of *A. crocosmoides.*

The reaction with *chromic acid* begins in some grains in 30 seconds and in all within 45 seconds, and is over in all in 2 minutes. It is the same qualitatively as that of the grains of *A. crocosmoides.*

Reaction with *pyrogallic acid* has begun in all the grains in 45 seconds and is over in 3½ minutes. It is the same qualitatively as that of the grains of *A. crocosmoides.*

The reaction with *ferric chloride* begins in some grains in 2 minutes and is over in all in 23 minutes. It is the same qualitatively as that of the grains of *A. crocosmoides.*

With *Purdy's solution* there is a slight reaction in some grains in 3 minutes, without further important change. It is the same qualitatively as that of the grains of *A. crocosmoides*.

Differentiation of Certain Starches of the Genus Antholyza.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

A. crocosmoides: Simple, few aggregates, chiefly in the form of doublets and triplets, isolated grains usually have 1 or 2 pressure facets. Spherical, hemispherical, and ovoid.
A. paniculata: Essentially the same as in *A. crocosmoides*.

Hilum—Form, Number, and Position.

A. crocosmoides: Rather large, generally distinct round spot or cavity; sometimes fissured, fissures usually short, straight, and transverse. Usually eccentric two-fifths or less of longitudinal axis.
A. paniculata: Not very large, fairly distinct spot or cavity, sometimes fissured, fissures usually short, straight, transverse. Position usually eccentric two-fifths or less of longitudinal axis.

Lamellæ—General Characteristics and Number.

A. crocosmoides: Usually indistinct, rather coarse, regular, complete, having form of outline of grain, except near the hilum, where they are circular. Number not accurately determined, probably 5 to 7.
A. paniculata: Fairly distinct, usually coarse, regular, usually continuous, of the same shape as outline of grain except near the hilum. 10 to 12 on larger grains.

Size.

A. crocosmoides: From 0.75 to 24μ, commonly 10μ.
A. paniculata: From 0.75 to 30μ, commonly 20μ.

POLARISCOPIC PROPERTIES.

Figure.

A. crocosmoides: Usually eccentric, distinct, usually clear-cut, lines sometimes bent and otherwise distorted.
A. paniculata: Same as in *A. crocosmoides*.

Degree of Polarization.

A. crocosmoides: Fairly high, variable.
A. paniculata: Fairly high, more variable and not so high as in *A. crocosmoides*.

Polarization with Selenite—Quadrants and Colors.

A. crocosmoides: Quadrants, as a rule, well defined, irregular in shape, and unequal in size. Colors usually pure.
A. paniculata: Quadrants the same as in *A. crocosmoides*. Colors usually pure.

IODINE REACTIONS.

Intensity and Color.

A. crocosmoides: Light; blue-violet.
A. paniculata: Light, less than in *A. crocosmoides*; blue-violet.

STAINING REACTIONS.

With Gentian Violet.

A. crocosmoides: Fair.
A. paniculata: Fair, less than in *A. crocosmoides*.

With Safranin.

A. crocosmoides: Fair.
A. paniculata: Fair, less than in *A. crocosmoides*.

TEMPERATURE REACTION.

A. crocosmoides: 73 to 75° C., mean 74°.
A. paniculata: 71 to 73° C., mean 72°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

A. crocosmoides: Begins in many in 30 seconds; four-fifths affected in 10 minutes; incomplete in an hour.
A. paniculata: Begins in some in 30 seconds; four-fifths affected in 10 minutes; incomplete in an hour.

Reaction with Chromic Acid.

A. crocosmoides: Begins in most in 15 seconds; complete in all in 3 minutes.
A. paniculata: Begins in some in 30 seconds; complete in all in 2 minutes.

Reaction with Pyrogallic Acid.

A. crocosmoides: Begins in all in 30 seconds; complete in all in 4 minutes.
A. paniculata: Begins in all in 45 seconds; complete in all in 3½ minutes.

Reaction with Ferric Chloride.

A. crocosmoides: Begins in some grains in 2 minutes; complete in all in 40 minutes.
A. paniculata: Begins in some grains in 2 minutes; complete in all in 23 minutes.

Reaction with Purdy's Solution.

A. crocosmoides: There is a slight reaction in 4 minutes; no further reaction of importance.
A. paniculata: There is a slight reaction in some of the grains in 3 minutes. No further reaction of importance.

NOTES ON THE STARCHES OF ANTHOLYZA.

The histological characters of these starches vary sufficiently to be of some usefulness in differentiation. The reactions are in close correspondence, the greatest difference being noted in the temperature of gelatinization (2°). The variations are slight and usually within the limits of error.

GENUS CROCUS.

The genus *Crocus* includes about 70 species of cormous herbs, natives of Southern Europe and Southwestern Asia, especially of the region of Greece and Asia Minor. The horticulturist classes them into the spring-flowering and autumn-flowering forms, and to the latter belongs *C. sativus* Linn., the common saffron crocus. Three garden forms included in the first class were used as sources of starch. These are *C. susianus*, Ker. (Cloth-of-Gold crocus), *C. versicolor* Ker. (Cloth-of-Silver crocus, striped) and *C.* var. (Baron von Brunow, deep blue).

STARCH OF CROCUS SUSIANUS (CLOTH-OF-GOLD). (Plate 74, figs. 441 and 442. Chart 289.)

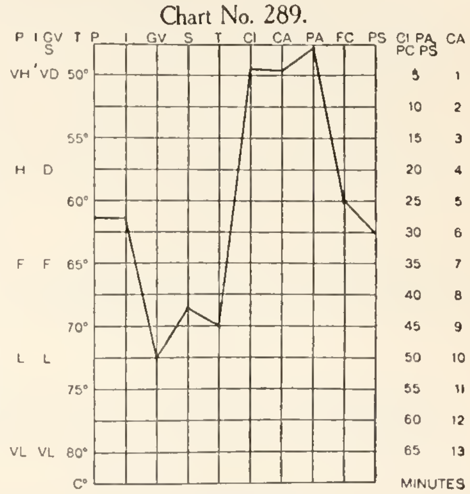
Histological Characteristics.—In *form* the grains are simple. They are partly isolated and partly either in aggregates which consist of two or more components or in clumps consisting of many grains. Well-marked pressure facets are very common. The surface of many grains is irregular, owing to depressions and ridges. The conspicuous forms are polygonal, dome-shaped with either a flattened or pointed distal end, and round or nearly round; also ellipsoidal with slightly flattened distal end, bell-jar-shaped, sugar-loaf, and imperfect rhomboidal grains. The aggregates may consist of components of approximately equal size; but frequently very small grains fit closely at the point of union of two or more large grains; and there are also doublets, which consist of one large and one very small component.

The *hilum* is often observed as a round or lenticular refractive spot, usually either slightly eccentric or centric, but it may be eccentric to about one-third of the longitudinal axis. Frequently a short transverse cleft (sometimes oblique) is found at the hilum. In the dome-shaped grains one longitudinal fissure frequently runs from the sides of a small cavity at the hilum. In the rounded forms with slightly pointed distal end, one longitudinal fissure may proceed from the hilum or this fissure may intersect a transverse fissure and a cross. Occasionally either a Y-shaped or thorn-like cleft is present.

The *lamellæ* are not demonstrable.

The grains vary in *size;* the smaller are 3 by 2μ; the larger are 22 by 18μ in length and breadth; the common size is 12 by 11μ in length and breadth. The larger grains and those of common size are usually separated parts of aggregates, but occasionally round or nearly round grains which have never formed part of the aggregate are found, the larger of which are 16 by 16μ to 18 by 17μ in length and breadth; the common size of these is 12 by 12μ in length and breadth.

Chart No. 289.



Curve of Reaction-Intensities of Starch of Crocus susianus (Cloth-of-Gold).

Polariscopic Properties.—The *figure* is usually either slightly eccentric or centric. Its lines are sometimes rather thick, straight, and cross each other at right angles, but more often they are not distinct throughout the entire figure and frequently are bent or bisected. Sometimes two or more figures are closely connected, denoting the presence of aggregates.

The degree of *polarization* is fair to high. There is a considerable variation in the differeut grains and also in any one aspect of a given grain. The polarization in two or three quadrants is frequently quite high, while the remaining one or two will be very low.

With *selenite* the quadrants are usually not well defined, but occasionally they are quite clean-cut. They are generally irregular in shape and unequal in size. The blue is more often pure, but is impure in many grains, while the yellow is usually not pure throughout the entire quadrant. The degree of purity sometimes differs in different quadrants of a given grain.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, which becomes quite deep in a minute; with 0.125 per cent solution they color a very light violet which deepens rapidly. After heating in water until the grains are gelatinized, the solution colors a deep indigo-blue and the grains a lighter but deep indigo-blue on the addition of iodine. If the solution is boiled for 2 minutes and then treated with iodine, the solution colors more deeply and most of the grain-residues either a very light blue or not at all, while a few are bright indigo-blue. With an excess of iodine the gelatinized grain-residues become a deep purple and the capsules usually a deep heliotrope and occasionally wine-red.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are lightly stained; some, usually the smaller, color more than others.

With *safranin* the grains color very slightly immediately and in 30 minutes are stained light to fair, some more deeply than others.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in 30 seconds, about half in a minute, about nine-tenths in 2 minutes, and all but rare resistant grains in 3 minutes. The reaction is complete in the latter in 5½ minutes. The grains color a light red-violet immediately, and either a dark ring or irregular looped structure is occasionally formed at the hilum. Gelatinization begins at the pressure facets and a dark rim of color appears here, which spreads first around the margin of the grain or along ridges on the surface when such are present. Occasionally small protuberances are formed at the corners of the grains during gelatinization. Gelatinization begins uniformly around the surface of round grains and spreads towards the center. In the more resistant grains an old-rose tint precedes the deep-blue coloring, which indicates the occurrence of gelatinization. The gelatinized grains are much swollen, but retain the shape of the untreated grain.

The reaction begins at once with *chromic acid.* A few grains are dissolved in 20 seconds, a majority in 30 seconds, all but rare resistant grains in 45 seconds, and all in 75 seconds. Lamellæ not seen in the normal grain become distinct, the hilum swells, and two or more radiating fissures proceed from it. The interior of the capsule is quickly dissolved, the grain swells, and finally the capsule is ruptured at one or more points and the entire grain is dissolved.

Reaction begins with *pyrogallic acid* immediately. A few grains are gelatinized in 10 seconds and all in 30 seconds. The hilum swells, fissures radiate from it to the corners of the grain, and gelatinization proceeds so rapidly that the details can not be satisfactorily determined. Occasionally a bubble forms at the hilum, which appears temporarily to retard the reaction; it then enlarges and finally collapses, followed by rapid gelatinization of the grain. In the round grains the hilum swells and numerous fine radiating fissures proceed from it.

The reaction with *ferric chloride* begins in a few grains in 30 seconds; several are gelatinized in a minute, practically all are in various stages in 3 minutes, the majority are gelatinized in 5 minutes, and all but a few resistant grains in 10 minutes. The reaction is complete usually in 18 minutes, rarely 25 minutes. The hilum, or cleft located at this point, swells, and a bubble often collects there. Gelatinization now begins at the facets, the process spreads quickly around the margin of the grain, the starch in the center being the most resistant. This less soluble starch is broken forcibly into fragments, which are finally gelatinized. The most resistant grains are the forms with regular outline, in which either the cavity or cleft at the hilum gradually enlarges until finally collapse occurs and a succession of bubbles is expelled, followed by the rapid gelatinization of the grain. The grains are swollen, but retain the general shape of the untreated grain.

Reaction begins immediately with *Purdy's solution.* A few rather small grains are gelatinized in a minute, and all are in various stages of dissolution in 5 minutes. About one-third are gelatinized in 10 minutes, more than half in 15 minutes, and all in 30 minutes, except a few of the round or the dome-shaped type. The hilum swells and fissures radiate from it to the corners of the grain. A bubble is rarely formed at the hilum. The starch lining the capsule becomes delicately striated and rarely evidence of lamellæ may be observed. Gelatinization usually proceeds around the hilum and along the fissures, accompanied by uniform swelling of the grain. Occasionally the starch at the proximal end is gelatinized rather rapidly, accompanied by a distension of the capsule, and a center of gelatinization then begins at the facets located at the distal end, with similar swelling. Gelatinization advances from these two centers towards each other, from the proximal with the greater rapidity, until the whole grain is involved. In the round grains the hilum swells, the previously unseen lamellæ become fairly distinct and striated, and gelatinization proceeds slowly until the reaction is complete. A narrow border of resistant starch is not completely gelatinized. The gelatinized grains are swollen, but retain the shape of the untreated grains.

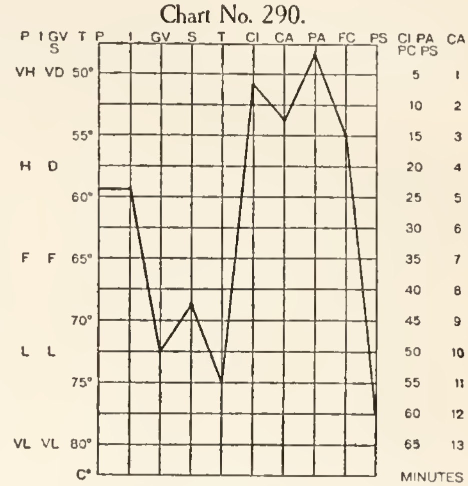
STARCH OF CROCUS VERSICOLOR (CLOTH-OF-SILVER). (Plate 74, figs. 443 and 444. Chart 290.)

Histological Characteristics.—In *form* the grains are simple, partly isolated, and partly either in aggregates which consist of two or more components or in clumps consisting of many grains. Well-marked pressure facets are found on most of the isolated grains. The irregularities of some grains are due to the same causes as those noted for *C. susianus* (Cloth-of-Gold). The conspicuous forms are the polygonal, dome-shaped with either a flattened or pointed distal end, and round or nearly round. Compared with *C. susianus* (Cloth-of-Gold) the proportion of dome-shaped, round and nearly round, and ellipsoidal grains is much greater; the grains are more regular in outline than those of *C. susianus* (Cloth-of-Gold); the aggregates are of similar character to those of *C. susianus* (Cloth-of-Gold), but the proportion of doublets and triplets is much greater.

The *hilum* is frequently observed as a round or lenticular spot, usually centric or from slightly to one-third eccentric of the longitudinal axis. The fissures and cavity found sometimes at the hilum are similar to those noted for *C. susianus* (Cloth-of-Gold) and the hilum is more often demonstrable, and when present the fissures or cavities are deeper.

The *lamellæ* are not usually demonstrable. Occasionally they can be observed, and they generally appear as complete rings near the hilum, but tend to follow the outline of the margin throughout the greater part of the grain. In the dome-shaped grains the lamellæ near the hilum also usually have the form of the margin of the grain. One coarse and refractive lamella is often found at varying distances between the hilum and the distal end. In round forms this lamella is usually at the equator. On grains of fair size, 8 to 10 lamellæ can occasionally be counted.

Chart No. 290.



Curve of Reaction-Intensities of Starch of Crocus versicolor (Cloth-of-Silver).

The grains vary in *size;* the smaller ones are 3 by 2μ; the larger are 24 by 23μ in length and breadth; the common size is 16 by 14μ in length and breadth. A number of round grains may reach the size of 20μ. The common size is 12μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric. It is of similar character to that noted for *C. susianus* (Cloth-of-Gold), but is more often regular and distinct throughout the entire grain. Double or multiple figures are also observed.

The degree of *polarization* is fair to high. There is a greater variation in the different grains than in *C. susianus* (Cloth-of-Gold), and the proportion of grains in which the polarization is high is much greater. The same variation in one aspect of a given grain is observed, but such grains are less often found than in *C. susianus* (Cloth-of-Gold).

With *selenite* the quadrants are frequently well defined. They are clean-cut in a much greater proportion of grains than in *C. susianus* (Cloth-of-Gold). The quadrants are usually somewhat irregular in shape and unequal in size; but there are more grains in which they are regular and equal than in *C. susianus* (Cloth-of-Gold). The same degree of purity of the colors and variation in the different quadrants is observed as that noted for *C. susianus* (Cloth-of-Gold), but the colors are pure in a greater proportion of the grains.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep violet with a reddish tint, which becomes quite deep in 2 minutes; with 0.125 per cent solution the grains color a very light reddish violet, some deeper than others, which becomes fairly deep in 2 minutes. The grains are slightly redder in tint, color more unevenly, and deepen in tint more slowly than in *C. susianus* (Cloth-of-Gold). After heating in water until the grains are gelatinized, the solution colors a deep indigo-blue and the grains from a light indigo-blue to quite a light blue with a reddish tint on the addition of iodine. The solution is deeper in color and the grains lighter and some not so pure a blue as in *C. susianus* (Cloth-of-Gold). If the grains are boiled for 2 minutes and then treated with iodine the grain-residues color a light blue-violet to rather deep indigo-blue and the solution very deep blue. There is a greater range of tint in the gelatinized grains and the solution is deeper than in *C. susianus* (Cloth-of-Gold). With an excess of iodine the grain-residues color a lighter yet quite deep purple, and the capsules a lighter heliotrope to a wine-red.

Staining Reactions.—With *gentian violet* when viewed in masses the grains show a slight trace of color at once and in 30 minutes are lightly colored, about the same as in *C. susianus* (Cloth-of-Gold).

With *safranin* the grains color very slightly immediately and in 30 minutes are lightly to fairly stained. The color is about the same as in *C. susianus* (Cloth-of-Gold).

Temperature Reaction.—The temperature of gelatinization is 75° to 76°C., mean 75.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in a minute, the majority in 5 minutes, and all but rare resistant grains in 7 minutes. The reaction is complete in the latter in 12 to 17 minutes. The larger round grains and others with regular outline are the most resistant. A dark ring or an irregular, looped structure appears at the hilum in a much larger proportion of grains than in *C. susianus* (Cloth-of-Gold). The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

The reaction begins at once with *chromic acid.* A few grains are dissolved in 45 seconds, the majority in 2 minutes, all but rare resistant grains in 2½ minutes, and in all in 4 minutes. The grains with regular outline are the most resistant. The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

The reaction begins immediately with *pyrogallic acid.* A few grains are gelatinized in 20 seconds, the majority in 40 seconds, and all in 1½ minutes. A bubble is formed at the hilum much more often than in *C. susianus* (Cloth-of-Gold), and the gelatinized grains are more regular in outline. The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

The reaction with *ferric chloride* begins in a few grains in a minute. A small number are gelatinized in 2 minutes, practically all are in various stages of gelatinization and about one-third are gelatinized in 5 minutes, the majority are gelatinized in 7 minutes, and all but rare resistant grains in 15 minutes. The reaction is complete in all in 45 minutes. Bubbles collect at the hilum in a greater proportion of grains than in *C. susianus* (Cloth-of-Gold). The most resistant grains are those with regular outline and also those in which the cavity or cleft at the hilum swells very much, from which bubbles are later expelled. In such grains the marginal border broadens, the lamellæ become distinct and striated, and the starch is finally gelatinized without the distension of the capsule at one or more points. The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

The reaction begins at once with *Purdy's solution.* A few of the smaller grains are gelatinized in 2 minutes, and all are in various stages of the process in 5 minutes. About one-fifth are gelatinized in 10 minutes, but there is little if any further progress at the end of 15 minutes. Gelatinization has only proceeded as far as that in the grains of *C. susianus* (Cloth-of-Gold) in a very small proportion of the grains, probably about one-fourth, at the end of 30 minutes. The hilum is swollen, radiating fissures are formed, and the lamellæ become distinct and striated. The reaction is qualitatively the same as in *C. susianus* (Cloth-of Gold).

STARCH OF CROCUS VAR. (BARON VON BRUNOW). (Plate 75, figs. 445 and 446. Chart 291.)

Histological Characteristics.—In *form* the grains are simple. They are partly isolated, partly in aggregates which consist of two or more components, and partly in clumps of many grains. Well-marked pressure facets are found on most of the isolated grains. The irregularity frequently observed on the surface of the grains is due to the causes noted in *C. susianus* (Cloth-of-Gold). The conspicuous forms are polygonal, dome-shaped with flattened or pointed end, and round or nearly round. Compared with *C. susianus* (Cloth-of-Gold), the proportion of dome-shaped and curvilinear grains is greater and the grains are more regular in outline. They are more irregular than *C. versicolor* (Cloth-of-Silver). The aggregates are similar to those of *C. susianus* (Cloth-of-Gold), but there are more doublets, triplets, and quadruplets consisting of components of regular shape and of equal size.

The *hilum* is frequently observed as a round or lenticular spot, usually eccentric from slightly to one-third of the longitudinal axis. The hilum is more often demonstrable and either the fissures or cavity when present are deeper than in *C. susianus* (Cloth-of-Gold).

The *lamellæ* are not usually demonstrable and the number can not be determined, since they are not obvious throughout the grain.

The grains vary in *size;* the smaller are 3 by 2μ; the larger are 18 by 16μ in length and breadth. The common size is 13 by 12μ in length and breadth. There are a number of large round or nearly round grains which may be 18μ, the common size being 12μ.

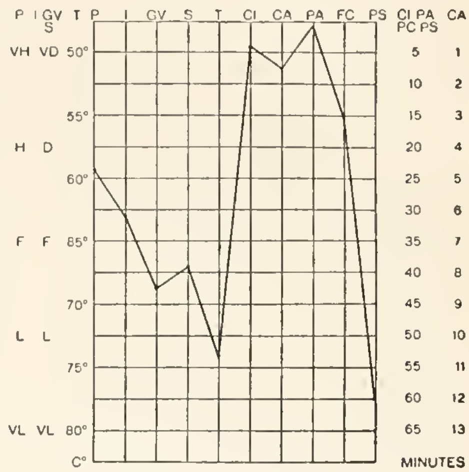
Polariscopic Properties.—The *figure* is usually either slightly eccentric or centric. It is essentially of the same character as that noted in *C. susianus* (Cloth-of-Gold), but more often distinct and regular throughout the entire grain, though more irregular and less often distinct than in *C. versicolor* (Cloth-of-Silver). Double and multiple figures are also observed.

The degree of *polarization* is fair to high. The same variation is found in the different grains and in one aspect of a given grain as noted for *C. susianus* (Cloth-of-Gold), and there are more grains in which polarization is high throughout the grain, but not so many as in *C. versicolor* (Cloth-of-Silver).

With *selenite* the quadrants are frequently not well defined, but they are clean-cut in a greater proportion of grains than in *C. susianus* (Cloth-of-Gold). They are generally irregular in shape and unequal in size, but the proportion of grains in which they are regular and equal is greater than in *C. susianus* (Cloth-of-Gold), but the degree of purity of the colors and the variation in the different quadrants are the same.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep to light reddish-violet, the fairly deeply colored grains become quite deeply colored in 1½ minutes, while the lightly colored grains deepen very slightly even in 5 minutes. If the grains are repeatedly treated for 10 minutes by drawing the solution at intervals under the cover-glass, a number of grains still remain with only a slight trace of color, but there is nothing in the microscopic structure, as far as could be discerned, to indicate the cause for this resistance to iodine. A very thin layer of starch was used in this reaction. With 0.125 per cent solution about half the grains color a very light red-violet, which in 3 minutes deepens slightly. Even when treated for 15 minutes with the same solution, quite a number of the grains are barely colored, while others vary from a light red-violet to a deep heliotrope. The grains color much more unevenly, less deeply on the whole, and much redder in tint than in *C. susianus* (Cloth-of-Gold).

Chart No. 291.



Curve of Reaction-Intensities of Starch of Crocus var. (Baron von Brunow).

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are lightly to fairly stained, the color being deeper at the facets. There is a greater variation in the depth of tint in the different grains, and some are stained deeper than in *C. susianus* (Cloth-of-Gold).

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 74°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in 40 seconds, nearly all in 3 minutes, and all but rare resistant grains in 4 minutes. The reaction is complete in 11 minutes. The isolated grains, as well as aggregates of regular outline, are the most resistant. The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

The reaction begins at once with *chromic acid.* A few grains are gelatinized in 30 seconds, nearly all in 45 seconds, all but rare resistant grains in 1½ minutes, and all in 2½ minutes. The most resistant grains are those with regular outline. The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

Reaction begins at once with *pyrogallic acid.* A few grains are gelatinized in 15 seconds, nearly all in 30 seconds, and all in 50 seconds. The gelatinized grains are swollen and somewhat distorted, but retain the general shape of the untreated grain. The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

The reaction begins at once with *ferric chloride.* A few grains are gelatinized in 1½ minutes and practically all are in the process in 5 minutes. About nine-tenths are gelatinized in 10 minutes and all but rare resistant grains in 15 minutes. The reaction is complete in 18 minutes. The reaction is qualitatively the same as *C. susianus* (Cloth-of-Gold).

The reaction begins immediately with *Purdy's solution.* A few grains are gelatinized in 1½ minutes and all are in various stages of the reaction in 5 minutes. About half are gelatinized in 15 minutes and two-thirds in 30 minutes. The grains with regular outline are the more resistant to the reagent. The reaction is qualitatively the same as in *C. susianus* (Cloth-of-Gold).

Differentiation of Certain Starches of the Genus Crocus.

Histological Characteristics.

Conspicuous Forms.

C. susianus (*Cloth-of-Gold*): Simple, aggregates, well-marked pressure facets very common, surface of many of the grains irregular. Conspicuous forms polygonal, dome-shaped with flattened or pointed distal end, round or nearly round.

Histological Characteristics.—Continued.

Conspicuous Forms.—Continued.

C. versicolor (*Cloth-of-Silver*): Essentially the same as in *C. susianus* (Cloth-of-Gold), but the proportion of dome-shaped, round, nearly round, and ellipsoidal grains is much greater; the grains more regular in outline; and the proportion of doublets and triplets greater.

Differentiation of Certain Starches of the Genus Crocus.—Continued.

Histological Characteristics.—Continued.

Conspicuous Forms.—Continued.

C. var (*Baron von Brunow*): Essentially the same as in C. *susianus*, but the proportion of dome-shaped and curvilinear grains is greater, the surface more regular, and more doublets and triplets and quadruplets of components of equal size.

Hilum—Form, Number, and Position.

C. *susianus* (*Cloth-of-Gold*): Form round or lenticular; frequently a short transverse or oblique cleft at hilum. In dome-shaped grains frequently a longitudinal fissure from sides of small cavity; rounded forms may be a cross or a longitudinal fissure. Occasionally Y-shaped or thorn-like. Position slightly eccentric or centric; may be eccentric to 0.33 of longitudinal axis.

C. *versicolor* (*Cloth-of-Silver*): The same as in C. *susianus* (Cloth-of-Gold), except the hilum is more often demonstrable, and the fissures or cavities are deeper. Position the same as in C. *susianus* (Cloth-of-Gold).

C. var. (*Baron von Brunow*): Essentially the same as in C. *versicolor* (Cloth-of-Silver). Position the same as in C. *susianus* (Cloth-of-Gold).

Lamellæ—General Characteristics and Number.

C. *susianus* (*Cloth-of-Gold*): Not demonstrable.

C. *versicolor* (*Cloth-of-Silver*): Not usually demonstrable; usually rings around hilum, tend to follow outline of grain. 8 to 10 on grains of fair size.

C. var. (*Baron von Brunow*): Not usually demonstrable.

Size.

C. *susianus* (*Cloth-of-Gold*): From 3 to 22μ, commonly 12μ.

C. *versicolor* (*Cloth-of-Silver*): 3 to 24μ, commonly 16μ.

C. var. (*Baron von Brunow*): 3 to 18μ, commonly 13μ.

Polariscopic Properties.

Figure.

C. *susianus* (*Cloth-of-Gold*): Usually slightly eccentric, lines usually not distinct through the entire figure and frequently bent or bisected. Sometimes 2 or more figures.

C. *versicolor* (*Cloth-of-Silver*): Same as in C. *susianus* (Cloth-of-Gold), but more often regular and distinct throughout.

C. var. (*Baron von Brunow*): Same as in C. *versicolor* (Cloth-of-Silver).

Degree of Polarization.

C. *susianus* (*Cloth-of-Gold*): Fair to high.

C. *versicolor* (*Cloth-of-Silver*): Fair to very high, higher on the whole than in C. *susianus* (Cloth-of-Gold).

C. var. (*Baron von Brunow*): Fair to high, higher on the whole than in C. *susianus* (Cloth-of-Gold), but less than in C. *versicolor* (Cloth-of-Silver).

Polarization with Selenite—Quadrants and Colors.

C. *susianus* (*Cloth-of-Gold*): Quadrants usually not well-defined, irregular in shape, and unequal in size. Colors usually impure.

C. *versicolor* (*Cloth-of-Silver*): Quadrants the same as in C. *susianus* (Cloth-of-Gold), except that the quadrants are clear-cut, regular, and equal in a greater portion of the grains. Colors usually impure.

C. var. (*Baron von Brunow*): Quadrants the same as in C. *versicolor* (Cloth-of-Silver). Colors usually impure.

Iodine Reactions.

Intensity and Color.

C. *susianus* (*Cloth-of-Gold*): Fairly deep; blue-violet.

C. *versicolor* (*Cloth-of-Silver*): Fairly deep, but deeper than in C. *susianus* (Cloth-of-Gold); violet with reddish tint.

Iodine Reactions.—Continued.

Intensity and Color.—Continued.

C. var. (*Baron von Brunow*): Fairly deep to light, less deeply on the whole than in C. *susianus* (Cloth-of-Gold); violet deep to light, redder than in C. *susianus* (Cloth-of-Gold).

Staining Reactions.

With Gentian Violet.

C. *susianus* (*Cloth-of-Gold*): Light.

C. *versicolor* (*Cloth-of-Silver*): Light, about the same as in C. *susianus* (Cloth-of-Gold).

C. var. (*Baron von Brunow*): Light to fair, on the whole deeper than in C. *susianus* (Cloth-of-Gold).

With Safranin.

C. *susianus* (*Cloth-of-Gold*): Light to fair.

C. *versicolor* (*Cloth-of-Silver*): Light to fair, about the same as in C. *susianus* (Cloth-of-Gold).

C. var. (*Baron von Brunow*): Light to fair, on the whole deeper than in C. *susianus* (Cloth-of-Gold).

Temperature of Gelatinization.

C. *susianus* (*Cloth-of-Gold*): 69 to 71° C., mean 70°.

C. *versicolor* (*Cloth-of-Silver*): 75 to 76° C., mean 75°.

C. var. (*Baron von Brunow*): 71 to 73° C., mean 74°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

C. *susianus* (*Cloth-of-Gold*): Begins immediately; complete in practically all in 3 minutes, and in all in 5½ minutes.

C. *versicolor* (*Cloth-of-Silver*): Begins immediately; complete in practically all in 7 minutes, and in all in 17 minutes.

C. var. (*Baron von Brunow*): Begins immediately; complete in practically all in 4 minutes, and in all in 11 minutes.

Reaction with Chromic Acid.

C. *susianus* (*Cloth-of-Gold*): Begins immediately; complete in practically all in 45 seconds, and in all in 75 seconds.

C. *versicolor* (*Cloth-of-Silver*): Begins immediately; complete in practically all in 2½ minutes, and in all in 4 minutes.

C. var. (*Baron von Brunow*): Begins immediately; complete in practically all in 1½ minutes, and in all in 2½ minutes.

Reaction with Pyrogallic Acid.

C. *susianus* (*Cloth-of-Gold*): Begins immediately; complete in 30 seconds.

C. *versicolor* (*Cloth-of-Silver*): Begins immediately; complete in all in 1½ minutes.

C. var. (*Baron von Brunow*): Begins immediately; complete in 50 seconds.

Reaction with Ferric Chloride.

C. *susianus* (*Cloth-of-Gold*): Begins in a few in 30 seconds; complete in practically all in 10 minutes and in all in 25 minutes.

C. *versicolor* (*Cloth-of-Silver*): Begins in a few in 60 seconds; complete in nearly all in 15 minutes, and in all in 45 minutes.

C. var. (*Baron von Brunow*): Begins immediately; complete in practically all in 15 minutes, and in all in 18 minutes.

Reaction with Purdy's Solution.

C. *susianus* (*Cloth-of-Gold*): Begins immediately; complete in practically all in 30 minutes.

C. *versicolor* (*Cloth-of-Silver*): Begins immediately; complete in about one-fourth in 30 minutes.

C. var. (*Baron von Brunow*): Begins immediately; complete in about two-thirds in 30 minutes.

NOTES ON THE STARCHES OF CROCUS.

There are some minor differences in these starches in regard especially to the relative number of different forms of grains, the hilum, and the lamellæ, which are useful in distinguishing one from the other. In general, *C. susianus* and *C.* var. (Baron von Brunow) have the closest likeness of any two. In the reactions, the starches are very much alike, the main differences being noted in the temperatures of gelatinization (5°), and in the reactions with chloral hydrate-iodine and ferric chloride.

GENUS ROMULEA.

The genus *Romulea* includes about 33 species of cormous plants that are closely allied to *Crocus*, and which are natives of the Mediterranean region and of Western and Southern Africa. *Romulea rosea* var. *speciosa* Baker (*Tricnonema speciosum* Ker.) was the only specimen available to us as a source of starch.

STARCH OF ROMULEA ROSEA VAR. SPECIOSA. (Plate 75, figs. 447 and 448. Chart 292.)

Histological Characteristics.—In *form* the grains are simple, and are isolated except a few aggregates which are usually in the form of doublets or triplets. Nearly all the isolated grains are marked by one to three pressure facets. There are a few clumps. The surface is usually smooth and regular. The conspicuous forms are the hemispherical to dome-shaped with one to three facets at the base, the spherical, and the ovoid; also some polygonal forms that owe their shape to multiple pressure facets. The grains are not flattened and on end they appear spherical.

The *hilum* is a distinct, comparatively large spot, usually slightly eccentric and in the median line. In some grains there appears to be a cavity at the hilum. The hilum is rarely fissured. Double and triple hila may occur.

The *lamellæ* are rather coarse, usually indistinct, regular, and continuous, and follow the marginal outline closely. There is one lamella which is near the hilum and one or two near the margin, which are coarser than the rest and very distinct. Seldom more than 6 can be counted on a single grain.

The grains vary in *size* from 3 to 25μ. The common size is about 15μ.

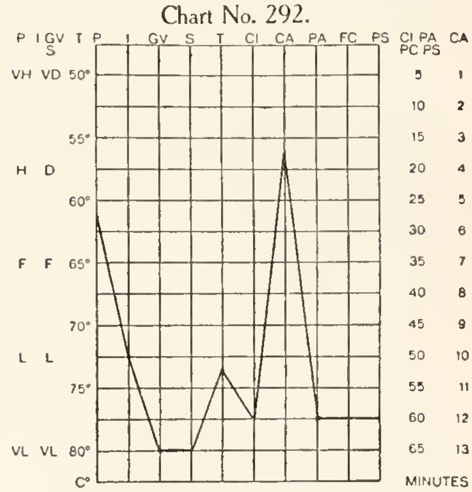
Polariscopic Properties.—The *figure* is usually eccentric, distinct, and fairly clear-cut It is modified by the surfaces of the facets. Its lines are rather broad, tending to become broader marginally, and are sometimes bent.

The degree of *polarization* is fairly high. It varies somewhat in different grains and in different aspects of a given grain.

With *selenite* the quadrants are well defined, usually clear-cut, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a very light violet-blue and the tint deepens slowly, becoming fairly deep after some time; with 0.125 per cent solution the grains color very faintly and the tint deepens slowly. After heating in water until all the grains are gelatinized the solution colors fairly and most of the gelatinized grains deeply. After boiling for 2 minutes the solution is colored very deeply and the grain-residues lightly. The capsule is colored violet with an excess of iodine and most of them contain some blue-reacting substance.

Chart No. 292.



Curve of Reaction-Intensities of Starch of Romulea rosea var. speciosa.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to color slightly at once and at the end of 30 minutes they are very lightly stained.

Temperature Reaction.—The temperature of gelatinization is 73° to 74° C., mean 73.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a very few grains in 1¾ minutes and is general in 4 minutes; about one-fourth, including all the small grains and a very few of the large grains, are gelatinized in 25 minutes, and about half of the larger grains are gelatinized in 1 hour 35 minutes. The reaction begins at the corners and edges of the facets, and the starch here stains a deep indigo and swells slightly. From these points the process spreads slowly inward over the rest of the grain, accompanied by very slight swelling. The gelatinized grains are not very large and retain much of their original form.

Reaction with *chromic acid* begins in some grains in 15 to 30 seconds and is over in 3½ minutes. The less resistant starch melts down into a semifluid mass occupying the center of the grain and the more resistant starch forms a striated marginal band, which is broad at first but grows thin and transparent, especially at the corners of the facets. Usually the resulting thin capsule is dissolved at these points and the semiliquid central mass flows out and is fully dissolved, and the rest of the capsule is also dissolved slowly.

The reaction with *pyrogallic acid* is general in 15 minutes, and about half of the grains are fully gelatinized and the rest are partially gelatinized in 40 minutes. The hilum and lamellæ grow more prominent and the grain becomes covered by fine striæ radiating in all directions from the hilum. The less resistant starch melts down into a gelatinous mass occupying the central portion of the grain and causing the grain to swell. The more resistant starch forms a fairly broad, dense, striated, marginal band, which becomes gradually thin and transparent in the fully gelatinized grains; these grains are fairly large and retain some of their original form, and the capsules are sometimes slightly wrinkled and folded.

With *ferric chloride* a very few grains begin to react in 2 minutes and one-third are affected; a few are completely gelatinized in 13 minutes, three-fifths are completely gelatinized in 27 minutes, and practically all in an hour. The reaction begins at the corners and edges of the facets. The starch at these points becomes gelatinous and swells out irregularly, distending the capsule. From these points the reaction spreads until all the starch at the base is involved, and then it spreads inward over the rest of the grain. In some cases the less resistant material collects in the central part of the grain in a gelatinous mass, causing the grain to swell and the more resistant starch forms a dense marginal band which becomes gradually thin and transparent. The gelatinized grains are large and retain some of their original form. The capsules are often wrinkled and folded.

The reaction with *Purdy's solution* begins in a few grains in 30 seconds, and in an hour a scattered few show complete gelatinization and the rest show various stages of partial gelatinization. The reaction presents the same appearance as that to pyrogallic acid.

GENUS CYPELLA.

This genus includes 8 species of bulbous plants, natives of Southern Brazil, Uruguay, and Argentina. *C. herberti* is the only species in common cultivation in this country and from it was obtained a specimen of starch representative of the genus.

STARCH OF CYPELLA HERBERTI. (Plate 75, figs. 449 and 450. Chart 293.)

Histological Characteristics.—In *form* there are both simple and compound grains, a few clumps but no aggregates; no pressure facets. The surface of the grains is rounded and tends to be somewhat irregular in outline. The conspicuous forms are the reniform to rounded reniform, with a slight protrusion from the straightened edge, which is the proximal end; also lenticular, elliptical to almost round, and rounded triangular. The grains are somewhat flattened, the reniform grains being about half as thick as long.

The *hilum* is always fissured, generally very deeply. It is very eccentric, and commonly in or near the median line. It is sometimes double or multiple; and there may be two or more hila in the compound grains. The fissures are usually very wide and deep and take the form of a very ragged cross placed longitudinally or diagonally, and may include all the hila. In other cases there is an irregularly stellate fissure, or when there are two or more hila there may be a corresponding number of irregularly stellate fissures.

The *lamellæ* are generally not very distinct; when seen, they appear as coarse, regular, continuous lines. They tend to follow the outline of the margin, but otherwise do not appear to have irregularities. Near the hilum they are somewhat obscured by the deep fissures. There are probably about 6 to 8 on a medium-sized grain.

The grains vary in *size* from 4 to 48μ. The common size is 30μ.

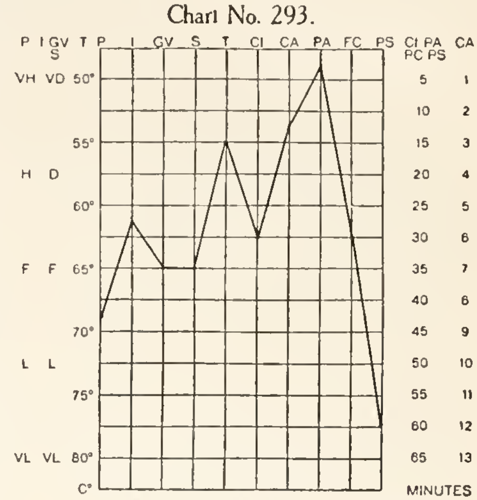
Polariscopic Properties.—The *figure* is eccentric, fairly distinct, but not clear-cut, owing to the broad diffused lines. One of its lines may be bisected, and rarely the lines may be bent.

The degree of *polarization* is low to fair in most grains, and decidedly variable in different grains and in different aspects of the same grain.

With *selenite* the quadrants are not well defined, usually irregular in shape, and always unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored at once fairly deeply; with 0.125 per cent solution the coloration occurs immediately and deepens until it is nearly as deep as that with the 0.25 per cent solution. After heating until all the grains are completely gelatinized, the solution is colored lightly and the gelatinized grains deeply on the addition of iodine; these grains (which are less deeply colored than others) have a pinkish capsule after the addition of an excess of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly. Most of the capsules contain some blue-reacting starch. When an excess of iodine is added, some of the grain-residues have a violet-colored capsule, some a blue-violet, and others a pinkish-violet.

Chart No. 293.



Curve of Reaction-Intensities of Starch of Cypella herberti.

Staining Reactions.—With *gentian violet* the grains begin to stain immediately and after 30 minutes the color is fair.

With *safranin* the grains begin to stain immediately and after 30 minutes they are fairly well stained.

Temperature Reaction.—The temperature of gelatinization is 54.5° to 56.5° C., mean 55°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some of the smaller grains begin to react in 30 seconds and in 2½ minutes the reaction is general. All are darkened and the reaction is over in 30 minutes. In the reniform grains the reaction begins with swelling at the base and spreads around the margin until it reaches the two prominences at the side of the proximal end of the grain. In the meanwhile the reaction spreads over all of the inner part of the grain until only a small, wedge-shaped portion is left about the hilum at the proximal end, and this soon also becomes included. The gelatinized grains are fairly large and their distal ends show a concentric arrangement of rather irregular dark bands separated by light fissures. The proximal portions generally appear as more or less homogeneous dark masses divided by irregular fissures, in the same manner that the original grain was fissured. They retain much of the original form of the grain.

There is reaction with *chromic acid* in many grains in 20 seconds and it is over in all in 2½ minutes. The reaction appears to consist in a rapid breaking down of the whole substance of the grain, beginning at the portion just beneath the hilum and extending towards the proximal end and outward to the sides. The grain becomes a large, gelatinous mass consisting of a very thin homogeneous capsule inclosing a finely granular mass. The capsule is dissolved at one point and the granular inclosed mass flows out and is dissolved, followed by solution of the capsule.

With *pyrogallic acid* there is a general reaction in 30 seconds and it is over in 2½ minutes. The reaction consists in a general breaking down of the grain into a finely granular mass, accompanied by enormous swelling. This reaction begins in the portion between the distal end and the hilum, and extends downward and outward, the part just above the hilum remaining unaffected at first, but is pushed up to form a thick, marginal portion as the grain swells. Then the margin gradually becomes thinner and transparent. The gelatinized grains are very large, much folded, and invaginated, and they do not retain much of the original form of the grains.

The reaction with *ferric chloride* begins in 1½ minutes. Most grains are gelatinized in 15 minutes and all in 30 minutes. The margin up to the prominences at each side of the proximal end becomes gelatinous. The process starts at the distal end of the grain and spreads upward. After these prominences are reached the process spreads inward and at the same time a very small part of the proximal end is involved, and finally there is formed an irregularly gelatinous, peripheral portion surrounding, or almost surrounding, a non-gelatinized center. The center becomes invaded by small fissures which divide it into small parts which separate and gelatinize independently. The gelatinized grains are very large, somewhat irregular, and sacculated. They do not retain any of the original form of the grain.

There is a reaction with *Purdy's solution* in some grains in 3 minutes; some grains are unaffected, some are only partially gelatinized, but nearly all are completely gelatinized in 1½ hours. This reaction is the same qualitatively as that to pyrogallic acid.

GENUS MARICA.

This is a tropical American genus of 11 species, stated to be more closely allied to *Cypella* than to any other genus of the *Iridaceæ*. The starch from *M. gracilis* Herb. was studied as a type of the genus.

STARCH OF MARICA GRACILIS. (Plate 76, figs. 451 and 452. Chart 294.)

Histological Characteristics.—In *form* the grains are simple and isolated. There are a few clumps. Pressure facets are not seen on any grains. The surface is smooth, but the margin is irregular, owing to irregularities in the development of the surface, especially the margin at the proximal end. The conspicuous form is the reniform, the concave edge corresponding to the proximal end. This concavity is sometimes marked with a protuberance; sometimes this end is straight or curved outward, with or without a protuberance. There is quite a variety of forms ranging from rod-like to elliptical, oval and ovoid, oval with pointed ends, sugar-loaf, pyriform, etc. The grains are flattened and about one-third as thick as broad. On end or edge they are of a flattened elliptical form.

The *hilum* is not distinct and is a small round spot, eccentric one-sixth to one-ninth of the longitudinal axis of the grain and in or to one side of the median line. It is sometimes fissured, and the fissure is single in the longitudinal or diagonal axis, short or long, narrow and clean-cut.

The *lamellæ* are fairly distinct, regular, fine, probably arcs of circles, which follow the outline of the margin of the distal end; not so fine, but more distinct near the distal end. They do not vary much in different grains. There are 16 to 18 on the larger grains.

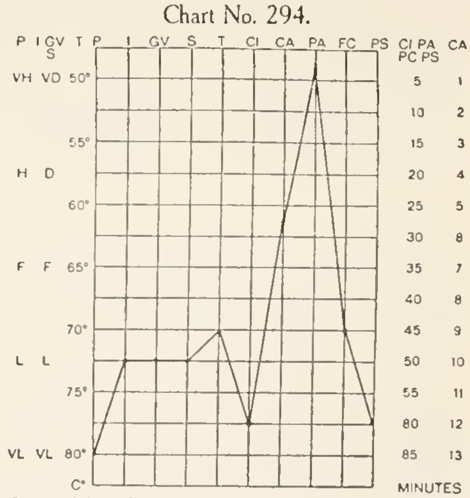
The grains vary in *size* from 5 to 52μ. The common size is 39μ.

Polariscopic Properties.—The *figure* is eccentric and usually very obscure unless the grain is viewed on end or edge, in which cases it is both distinct and clear-cut, and the lines are not bent nor otherwise distorted. Ordinarily its lines are very broad and diffused and merge into one another.

The degree of *polarization* is very low. It is usually absent over the greater part of the surface, especially centrally. When the grain is viewed on end or edge polarization is high.

With *selenite* the quadrants are usually fused. The colors are impure. If the grain is on end or edge, the quadrants are well defined, fairly regular in shape, and unequal in size. The colors are not pure.

Chart No. 294.



Curve of Reaction-Intensities of Starch of Marica gracilis.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color lightly at first and the color deepens slowly until it is a fairly deep indigo; with 0.125 per cent solution they begin to color faintly in about 1½ minutes, but the color deepens but little. After heating in water until the grains are completely gelatinized, the solution colors deeply and the grains fairly deeply on the addition of iodine. After heating for 2 minutes, the solution colors very deeply and the grain-residues lightly. With an excess of iodine the capsules all color violet.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are lightly stained, one as much as another.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some grains in 2 minutes and in many in 3 minutes. It is over in four-fifths of the grains in 20 minutes and in all in 1½ hours. The reaction usually begins with darkening and swelling of the margin at the distal end and extends around the margin to the projections marking the extremities of the proximal end. The reaction then progresses inward and upward over the grain until it is all darkened and somewhat swollen. There is always a sharp line of demarcation between the gelatinized and non-gelatinized portions. Often there is a cap at the distal end which gelatinizes before the rest of the grain is affected. In some grains the reaction begins at the distal end and at the same time at the projections at either extremity at the proximal end, and from these points inward over the whole grain. The gelatinized grains are fairly large and of a uniform dark color, and retain some of the original form.

The reaction with *chromic acid* begins in 30 seconds and is over in 5½ minutes. The reaction begins with the appearance of coarse striæ throughout the grain. The starch from the hilum to the distal margin is converted into a granular, gelatinous mass inclosed in a thin capsule, and the grain swells, leaving a narrow, striated line of resistant starch along the proximal margin. The thin capsule is now dissolved at the sides, or at the distal end, and the gelatinized starch flows out and is dissolved. The resistant starch at the proximal end dissolves at the same time, but not so rapidly as the rest of the grain.

With *pyrogallic acid* the reaction begins in 45 seconds and is over in 3½ minutes. The reaction begins with the appearance of fine striæ throughout, followed by a swelling of the grain caused by conversion of the entire grain-substance between the hilum and the sides and distal margin into a finely granular, gelatinous mass. The granules disappear, leaving a small, thin, finely striated line of resistant starch at the proximal end, which, after the rest of the grain is completely gelatinized, becomes thinner and transparent. The gelatinized grains are large and are thrown into lamella-like folds between the proximal and the distal ends, and retain much of the original form of the grain.

The reaction with *ferric chloride* begins in some grains in 2½ minutes. About half are completely gelatinized in 12 minutes, four-fifths in 20 minutes, and all in 45 minutes. The grain becomes invaded by fissures at the distal end, at the sides, and at the projections at the proximal end, from which fissures, gelatinized starch oozes, forcing out the capsular covering. The process spreads over nearby portions of the margin, and then slowly inward over the rest of the grain, the proximal end being the last to be affected. The swollen grains are large, very much wrinkled, folded, and sacculated, and retain some of the original form of the grain.

The reaction with *Purdy's solution* begins in a few grains in 4 minutes. In 45 minutes half of the grains are partially and a few nearly completely gelatinized. The reaction appears the same qualitatively as that to pyrogallic acid.

GENUS GELASINE.

Gelasine is a genus of South American bulbous plants which includes only 2 species. *G. azurea*, the only representative available as a source of starch, is a native of Argentina and is to a limited extent in garden cultivation.

STARCH OF GELASINE AZUREA. (Plate 76, figs. 453 and 454. Chart 295.)

Histological Characteristics.—In *form* the grains are simple with the exception of rare compounds which consist of two components. The simple grains are isolated and there are no pressure facets. There are a few clumps. The surface is, as a rule, well rounded and smooth, but there is slight irregularity of outline owing to unequal development of the marginal portions. The conspicuous forms are the reniform and elliptical to ovoid; also spherical, hemispherical, lenticular, triangular, etc. The part of the margin corresponding to the concavity of the reniform shapes may be straight or curved outward, and is not infrequently marked by a small protuberance. This part is the proximal end; the distal end is very convex. The grains are slightly flattened and about one-half to one-third as thick as they are broad, and the longitudinal axis of the grain is in most cases in the short diameter.

The *hilum* is a quite distinct, small round spot, very eccentric, and usually in or near the median line. The hilum is seldom fissured. There may be, rarely, 2 hila, and they may be separated by a small fissure. The fissuration may be in the form of a single longitudinal or diagonal line, or 2- or 3-armed. In all cases it is clear-cut and not ragged.

The *lamellæ* are fairly distinct, comparatively coarse, regular, continuous rings. They follow closely the outline of the margin and exhibit no other irregularities. They are usually more distinct near the hilum than near the margin. There are from 14 to 18 on the larger grains.

The grains vary in *size* from 3 to 36μ. The common size is 24μ

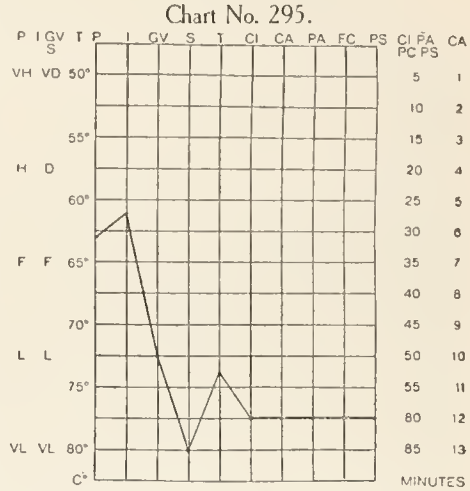
Polariscopic Properties.—The *figure* is eccentric, distinct, and fairly clear-cut. Its lines tend to be somewhat broad, and often broader and dimmer in some parts of their length. They are not infrequently bent somewhat.

The degree of *polarization* is fair to fairly high. It is very low or absent in some parts of the grains and varies somewhat in different grains. It is high when the grain is viewed from the end or sides.

With *selenite* the quadrants are well defined, somewhat irregular in shape, and unequal in size. The colors are not pure, except when the grains are viewed from the end or sides.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored at once and fairly deeply; with 0.125 per cent solution they color lightly at first, but the color deepens quickly. After heating until the grains are completely gelatinized, the solution is colored lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution is colored deeply and the grain-residues lightly. Almost all the capsules retain blue-reacting starch, and all have a violet color after being subjected to an excess of iodine.

Chart No. 295.



Curve of Reaction-Intensities of Starch of Gelasine azurea.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once, but in 30 minutes the color is not much deeper than at first.

With *safranin* the grains begin to stain very lightly in a minute and after 30 minutes the stain is still very light.

Temperature Reaction.—The temperature of gelatinization is 73° to 74° C., mean 73.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 1½ minutes, about three-fourths are fully darkened and swollen in 30 minutes, and five-sixths in an hour. There is no further change. The reaction may begin at the margin, at the distal end, at one side, or at the proximal end. It then spreads along the margin only as far as the two prominences on the sides of the proximal end, and then inward over the whole grain. This process is usually accompanied by some swelling. There is a fairly sharp line of demarcation between the gelatinized and non-gelatinized parts of the grain. The hilum is often unaffected until all other parts of the grain are altered. The gelatinized grains are fairly large, but not much distorted, and they retain somewhat their original shape. They are usually uniformly a dark blue.

With *chromic acid* the grains begin to react in 20 seconds and the reaction is practically over in 12 minutes. The hilum begins to swell somewhat. The grain becomes divided by fine radial striæ, which later grow very coarse. The inner portion passes into a gelatinous mass. There is formed at the margin a striated ring, ragged on the inner edge, and showing at first very distinct, concentric, alternate refractive and non-refractive bands. This ring becomes thinner, transparent, and quite homogeneous as the grain swells. The end finally dissolves, allowing the inner, granular gelatinized starch to exude and to pass into solution. Other parts of the capsule dissolve slowly.

With *pyrogallic acid* some grains show slight reaction in 3 minutes. About five-sixths are affected and a few are fully gelatinized in 60 minutes. Both hilum and lamellæ are distinct. The hilum swells and the grain becomes divided by fine radial striæ. The inner portion is changed into a gelatinous mass. A striated ring is formed at the margin, the inner part of which is very ragged. As the grain swells this ring becomes thinner and more transparent. The gelatinized grains so formed are fairly large and somewhat infolded and wrinkled, but they retain somewhat the original form of the grain.

With *ferric chloride* a few of the smaller grains react in 2½ minutes. About half are affected and fully or partially gelatinized in 10 minutes, and three-fourths are gelatinized in 45 minutes. There is not much further change. The reaction consists in the swelling of the hilum, the appearance of fine striæ which radiate throughout the grain, and the conversion of the inner portion into a gelatinous mass. The material at the margin forms into a ring which is distinctly striated. As the grain swells this ring becomes thinner and transparent. The gelatinized grains are very large, somewhat folded, and wrinkled.

A few grains react in 10 seconds with *Purdy's solution*, but after 45 minutes only a few are even partially gelatinized. There is no further change. The great majority never react. This reaction is similar in character to that with pyrogallic acid.

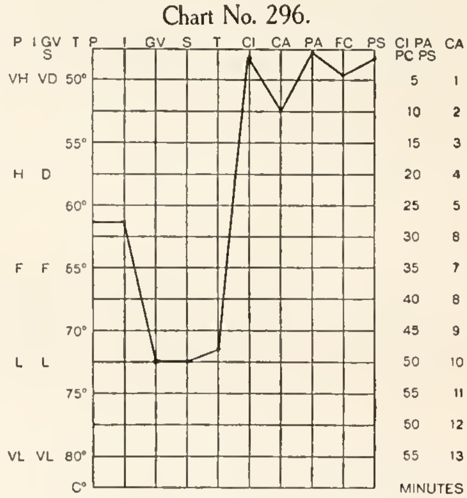
GENUS SPARAXIS.

Sparaxis is a genus of less than half a dozen species of bulbous plants, closely related to *Ixia*. It is a native of South Africa, and popularly known as the wand flower, or rarely as the harlequin flower. There are a number of garden varieties, chiefly in the form of hybrids, which for the most part are referable to 3 species: *S. bulbifera* Ker., *S. tricolor* Ker., and *S. grandiflora* Ker. All of these are also known as corresponding Ixias. Starches from two garden forms were prepared: *S. grandiflora alba* and *S.* var. (Albertine).

STARCH OF SPARAXIS GRANDIFLORA ALBA. (Plate 76, figs. 455 and 456. Chart 296.)

Histological Characteristics.—In *form* the grains are almost wholly simple. There are a few compound grains consisting of few components. The simple grains are either isolated, in aggregates of few components, or in clumps. Most of the isolated grains have sharply defined pressure facets. The surface of the grains is sometimes irregular, owing chiefly to the flattening of one or more points on the curved surface, or to the occasional presence of ridges found principally upon the rounded forms. The conspicuous forms are dome-shaped, which sometimes have a pointed base, hemispherical, round, and nearly round. There are also a few ovoid, pyriform, imperfect quadrangular that are rounded with broadened and flattened distal end, broadly triangular with curved base and rounded angles, and ellipsoidal with sometimes a slightly broadened and flattened distal end. The aggregates are more often doublets of ellipsoidal or almost spherical form; but triplets, quadruplets, and even quintuplets with components arranged compactly are frequently observed. Aggregates with components in linear arrangement are also occasionally present.

Chart No. 296.



Curve of Reaction-Intensities of Starch of Sparaxis grandiflora alba.

The *hilum* may be noted as a clear round spot, centric or eccentric to about one-third to one-fourth of the longitudinal axis. A small, irregular cavity, from which two short fissures usually proceed, is often found in the dome-shaped grains. A cavity with two or more fissures is present in the rare pyriform and broadly triangular grains.

The *lamellæ* are usually indistinct, but occasionally 7 fairly coarse, complete rings may be counted in the round grains; 8 or 9 in the dome-shaped grains. The lamellæ immediately around the hilum are usually circular in outline, but the remaining ones tend to have the form of the outline of the grain. On fair-sized dome-shaped grains 8 fairly coarse lamellæ can sometimes be distinguished.

The grains vary in *size;* the smaller are 3 by 2μ; the larger dome-shaped grains are 16 by 14μ in length and breadth. There are a number of isolated, round grains, the larger of which are 16 by 16μ. The common size of the dome-shaped grains is 12 by 10μ, and of the round grains 12 by 12μ in length and breadth. A few ellipsoidal grains are usually 20 by 16μ, but rarely may be 30 by 24μ in length and breadth.

Polariscopic Properties.—The *figure* is slightly eccentric, centric, and quite eccentric. Its lines are frequently not distinct throughout, and are often either bent or bisected. Double figures indicating the presence either of aggregates or compound grains, essentially the former, are fairly frequent.

The degree of *polarization* is fair to high. There is a variation in the different grains, as well as in the same aspect of a given grain. One or two quadrants may be much lower than others.

With *selenite* the quadrants are usually not clearly defined, and are generally irregular in shape and unequal in size. There is often a variation in the purity of the colors in a given grain; they may be impure in one or more quadrants and pure in others. The yellow is more often impure than the blue, which latter is pure in the greater number of grains.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color immediately a fairly deep blue-violet, which deepens rather rapidly; with 0.125 per cent solution they color a light blue-violet, which deepens rather rapidly. After heating in water until the grains are gelatinized and then treating with iodine, the solution colors a greenish-blue, most of the grains a deep purplish-blue, and the rare, large, ellipsoidal grains a deep reddish-violet. When the solution is boiled for 2 minutes and then treated with iodine, the solution becomes a deep indigo-blue and the grain-residues a light blue. With an excess of iodine the solution becomes a greenish-blue and the grain-residues a deep reddish-purple, while the capsules are colored a deep heliotrope to a wine red.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are lightly stained.

With *safranin* the grains begin to stain at once and in 30 minutes are lightly colored. Even the rare ellipsoidal and pyriform grains stain lightly, although a little deeper than the others.

Temperature Reaction.—The temperature of gelatinization is 71° to 72° C., mean 71.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins immediately. A few are gelatinized in 30 seconds, nearly all in a minute, and all but a few resistant grains in 2 minutes. The reaction is complete in the latter in 8 minutes. The entire grain is colored an old-rose. Either a dark spot, a ring, or an irregular looped structure usually appears at the hilum. Gelatinization begins at the edges of the pressure facets, which are indicated by a dark blue rim on the dome-shaped grains; this process spreads around the margin of the grain and then towards the center, until the entire grain is gelatinized. In round grains gelatinization begins uniformly on all parts of the surface and proceeds towards the center. Both the dark ring and the looped structure gradually become much enlarged during gelatinization, but finally collapse, and clouds of the dark-blue color then flow over the entire grain and the reaction is complete. The grains with regular outline and those in which the structures at the hilum swell considerably are most resistant to the reagent. The gelatinized grains are swollen, but retain the general shape of the untreated grain.

The reaction begins immediately with *chromic acid.* A few are dissolved in 30 seconds, nearly all in a minute, and all but rare resistant grains in 2 minutes. The reaction is complete in these in 5½ minutes. The hilum swells and thick fissures radiate from it towards the corners of the dome-shaped and somewhat quadrangular grains; the lamellæ become fairly distinct and are striated, and all but the thick, slowly reacting capsule is quickly gelatinized. The capsule is quite resistant, but as the grain swells it is finally ruptured, usually at the facets when present, and the entire grain passes into solution. In the round grains the process is the same, excepting that the rather thick, radiating fissures are not formed.

The reaction begins immediately with *pyrogallic acid.* A few grains are gelatinized in 15 seconds and all but a few resistant grains in 30 seconds. The reaction is complete in the latter in 60 seconds. The hilum swells and fissures proceed from it towards the corners of the faceted grains. In the round forms the process is similar, but the reaction is usually slower and the lamellæ can often be more clearly distinguished. The gelatinized grains retain the general shape of the untreated grain, but are much swollen and somewhat distorted at the facets. They are bounded by a fairly thick outer layer in which the remains of 2 lamellæ may sometimes be distinguished.

The reaction begins immediately with *ferric chloride.* A few grains are gelatinized in 30 seconds, nearly all in 1½ minutes, and all but a few resistant grains in 4 minutes. The reaction is complete in the latter in 12 minutes. The hilum swells and a bubble often forms there. A border which is more transparent forms around the grain. Later the lamellæ in this area become more clearly defined. Gelatinization usually begins at the facets, followed by a rapid distension of the capsule at these points. This process sometimes spreads around the whole surface of the grain, the central portion being the last to undergo gelatinization. In some grains the hilum swells and gelatinization begins in the center and advances gradually towards the surface. This form of gelatinization is found chiefly in the round grains. The gelatinized grains are much swollen and somewhat distorted at the facets, but retain the general shape of the untreated grain.

With *Purdy's solution* the reaction begins immediately. A few are gelatinized in 30 seconds, nearly all in a minute, and all but rare resistant grains in 2 minutes; many of the latter are not affected beyond the first steps of the reaction, even in 30 minutes. The hilum swells and two or more radiating fissures proceed from it towards the corners of the grain, and the lamellæ become more distinct and are striated. Gelatinization follows the course of the fissures until all the starch becomes soluble except 2 or 3 of the outermost lamellæ and the capsule. In the round grains the hilum swells, the lamellæ become sharply defined and striated, delicate fissures radiate from the hilum, and gelatinization proceeds, accompanied with uniform swelling. The small and medium-sized grains with regular outline are the most resistant. The gelatinized grains are swollen, but retain the general shape of the untreated grain.

STARCH OF SPARAXIS VAR. (ALBERTINE). (Plate 77, figs. 457 and 458. Chart 297.)

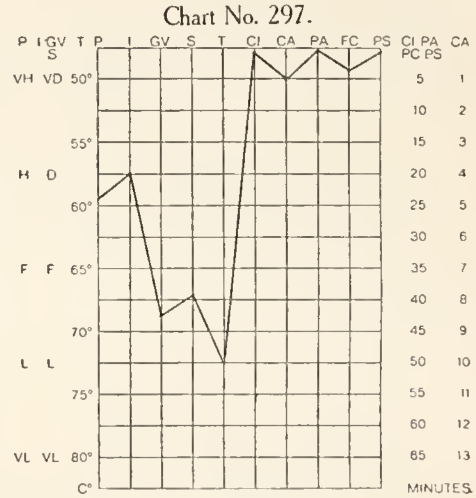
Histological Characteristics.—In *form* the grains are almost wholly simple. Compound grains consisting of few components are present in small numbers. The simple grains are found as isolated grains, usually with sharply defined pressure facets, in aggregates of few components, and in clumps. Irregularities of the grains are sometimes found which are attributable to the same causes as noted for *S. grandiflora alba.* The conspicuous forms are dome-shaped (sometimes with a pointed base), hemisphercial, and round or nearly round; also ovoid, pyriform, imperfect quadrangular, triangular, ellipsoidal, etc., as in *S. grandiflora alba.* There is in this starch a larger proportion of rather large, ovoid, pyriform, and broadly triangular forms than in *S. grandiflora alba.*

The *hilum* is sometimes distinct as a small, clear, round spot, centric or eccentric to about one-third to one-fifth of the longitudinal axis. A small cavity, from which two short fissures usually proceed, is often found in the dome-shaped grains. A cavity at the hilum with two or more radiating fissures is usually present in the rather large pyriform and broadly triangular grains.

The *lamellæ* are not often demonstrable. They are not quite so distinct in as large a proportion of grains as in *S. grandiflora alba*, but when observed are of the same character and number.

The *size* varies; the smaller grains are 3 by 2μ; the larger dome-shaped are 19 by 18μ in length and breadth. A number of rather large, round, isolated grains are 20 by 20μ in length and breadth. The common size of the dome-shaped grains is 14 by 13μ and of the round grains 13 by 13μ in length and breadth. A few ellipsoidal grains are usually about 24 by 18μ, but rarely 32 by 26μ.

Chart No. 297.



Curve of Reaction-Intensities of Starch of Sparaxis var. (Albertine).

Polariscopic Properties.—The *figure* is centric or eccentric. Its lines are similar to those of *S. grandiflora alba*, but are more often distinct throughout the entire length. In a large proportion of grains the figure is quite eccentric.

The degree of *polarization* is fair to high. There is the same variation in the different grains as noted for *S. grandiflora alba*, as well as in the same aspect of a given grain. The proportion of grains in which the polarization is high is greater than in *S. grandiflora alba*, and there is a smaller number of grains in which it varies in the same aspect of the grain.

With *selenite* the quadrants are often not clearly defined and they are in much larger proportion in *S. grandiflora alba.* They are often irregular in shape and unequal in size, but a greater proportion are larger than in *S. grandiflora alba.* The purity of the colors is about the same as in *S. grandiflora alba.*

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue with a reddish tint which deepens very rapidly. The tint is much deeper and changes more quickly than in *S. grandiflora alba.* With 0.125 per cent solution the grains color a deep blue-violet which deepens rapidly; it is deeper than in *S. grandiflora alba.* After heating in water until all the grains are gelatinized and then treating with iodine, the solution colors a greenish-blue and most of the grains a deep purplish-blue, and the rare, rather large, ellipsoidal grains color a deep reddish-violet. The color of solution and grains is about the same as *S. grandiflora alba.* The solution if boiled for 2 minutes and then treated with iodine colors a deep indigo-blue and the grain-residues a bright, lighter blue, some with reddish tint, a deeper blue than *S. grandiflora alba.* With an excess of iodine the solution becomes a deeper blue, the grain-residues a deep purple, and the capsules a deep heliotrope to a deep old-rose and a wine-red. There are more capsules with redder tint than in *S. grandiflora alba.*

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are lightly to fairly colored. The tint is deeper than in *S. grandiflora alba.*

With *safranin* the grains begin to stain at once, and in 30 minutes are light to fairly deep in color. The tint is distinctly deeper than in *S. grandiflora alba.*

Temperature Reaction.—The temperature of gelatinization is 72° to 73° C., mean 72.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins immediately. A few grains are gelatinized in 30 seconds and all but a few resistant grains in a minute. The reaction is usually complete in the latter in 3½ minutes. Rarely a broadly triangular grain with curved base and rounded angles is observed, in which gelatinization does not reach completion in 18 minutes. The grains generally swell uniformly during the reaction, but in the broadly triangular form a small, rounded protuberance appears at the proximal end. The reaction is qualitatively the same as in *S. grandiflora alba.*

The reaction begins immediately with *chromic acid.* A few grains are dissolved in 15 seconds, nearly all in 30 seconds, and all but rare resistant grains in a minute. The reaction is complete in the latter in 1¾ minutes. It is qualitatively the same as in *S. grandiflora alba.*

The reaction begins immediately with *pyrogallic acid.* A few are gelatinized in 15 seconds, and all but a few resistant grains in 25 seconds. The reaction is complete in the latter in 45 seconds. It is qualitatively the same as in *S. grandiflora alba.*

With *ferric chloride* the reaction begins immediately. A few grains are gelatinized in 30 seconds, nearly all in a minute, and all but rare resistant grains in 3 minutes. The reaction is usually complete in the latter within 10 minutes, but very rarely a broadly triangular grain resists the reagent for 25 minutes. The reaction is qualitatively the same as in *S. grandiflora alba.*

The reaction begins at once with *Purdy's solution.* A few grains are gelatinized in 15 seconds, nearly all in 45 seconds, and all but rare resistant grains in a minute. The reaction is usually complete in the latter in 10 minutes. A much smaller number of grains in which the reaction has only proceeded as far as the first stages is found in this starch than in *S. grandiflora alba.* The reaction is qualitatively the same as in *S. grandiflora alba.*

Differentiation of Certain Starches of the Genus Sparaxis.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

S. grandiflora alba: Almost wholly single, few compound grains, some aggregates or clumps, isolated grains usually have sharply defined pressure facets, surface sometimes irregular. Dome-shaped with sometimes a pointed base, hemispherical, round and nearly round.

S. var. (*Albertine*): Essentially the same as in *S. grandiflora alba,* but with a large proportion of large ovoid, pyriform, and broadly triangular grains.

Hilum—Form, Number, and Position.

S. grandiflora alba: Form clear, round spot, or irregular cavity, 2 or more short fissures. Position centric, or eccentric to about 0.33 or 0.25 of the longitudinal axis.

S. var. (*Albertine*): Form essentially the same as in *S. grandiflora alba.* Position centric, or eccentric to about 0.33 to 0.2 of the longitudinal axis.

Lamellæ—General Characteristics and Number.

S. grandiflora alba: Usually indistinct, but occasionally fairly coarse complete rings or having the form of the outline of the grain. About 7 to 9 on round and dome-shaped grains.

S var. (*Albertine*): Essentially the same as in *S. grandiflora alba,* but less often demonstrable. The same as in *S. grandiflora alba.*

Size.

S. grandiflora alba: From 3 to 30μ, commonly 12μ.

S. var. (*Albertine*): From 3 to 32μ, commonly 13μ.

POLARISCOPIC PROPERTIES.

Figure.

S. grandiflora alba: Centric or eccentric, lines frequently not distinct throughout, often either bent or bisected. Double figures fairly frequent.

POLARISCOPIC PROPERTIES.—Continued.

Figure.—Continued.

S. var. (*Albertine*): The same as in *S. grandiflora alba,* except that the lines are more often distinct throughout their length, and figure more often eccentric.

Degree of Polarization.

S. grandiflora alba: Fair to high. Variable in different grains and in a given aspect of a grain.

S. var. (*Albertine*): Fair to high. On the whole higher, and less variable in a given aspect of a grain.

Polarization with Selenite—Quadrants and Colors.

S. grandiflora alba: Quadrants usually clearly defined, generally irregular in shape and unequal in size. Colors not pure.

S. var. (*Albertine*): Quadrants the same as in *S. grandiflora alba,* but on the whole less irregular. Colors not pure.

IODINE REACTIONS.

Intensity and Color.

S. grandiflora alba: Fairly deep; blue-violet.

S. var. (*Albertine*): Deep, much deeper than in *S. grandiflora alba;* blue with reddish tint.

STAINING REACTIONS.

With Gentian Violet.

S. grandiflora alba: Light.

S. var. (*Albertine*): Light to fair, deeper than in *S. grandiflora alba.*

With Safranin.

S. grandiflora alba: Light.

S. var. (*Albertine*): Light to fairly deep, distinctly deeper than in *S. grandiflora alba.*

TEMPERATURE OF GELATINIZATION.

S. grandiflora alba: 71 to 72° C., mean 71.5°.

S. var. (*Albertine*): 72 to 73° C., mean 72.5°.

Differentiation of Certain Starches of the Genus Sparaxis.—Continued.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

S. grandiflora alba: Begins immediately; complete in practically all in 2 minutes and in all in 8 minutes.
S. var. (*Albertine*): Begins immediately; complete in practically all in a minute and in all in 3½ minutes.

Reaction with Chromic Acid.

S. grandiflora alba: Begins immediately; complete in practically all in 2 minutes and in all in 5½ minutes.
S. var. (*Albertine*): Begins immediately; complete in practically all in a minute and in all in 1¾ minutes.

Reaction with Pyrogallic Acid.

S. grandiflora alba: Begins immediately; complete in practically all in 30 seconds and in all in 60 seconds.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Pyrogallic Acid.—Continued.

S. var. (*Albertine*): Begins immediately; complete in practically all in 25 seconds and in all in 45 seconds.

Reaction with Ferric Chloride.

S. grandiflora alba: Begins immediately; complete in practically all in 4 minutes and in all in 12 minutes.
S. var. (*Albertine*): Begins immediately; complete in practically all in 3 minutes and in all in 10 minutes.

Reaction with Purdy's Solution.

S. grandiflora alba: Begins immediately; complete in practically all in 2 minutes, but not complete even at the end of 30 minutes.
S. var. (*Albertine*): Begins immediately; complete in practically all in a minute and in all in 10 minutes.

NOTES ON THE STARCHES OF SPARAXIS.

These starches differ unessentially in histological features, and the same is true in regard to their reactions. Comparing *S. grandiflora alba* with *S.* var. (Albertine), it will be found that the former exhibits a lower degree of polarization, lower reactivity with iodine and the anilines, lower temperature of gelatinization, and lower sensitivity throughout with the chemical reagents. The differences are, however, usually not marked, and the starches are probably from closely related plants.

GENUS IXIA.

Ixias are bulbous plants, native of the Cape of Good Hope aud largely cultivated, in the form chiefly of hundreds of horticultural varieties. About 23 species are known. The ixias hybridize so freely that not only are the varieties numerous, but continually being added to; and they are so mixed by interbreeding that reference of horticultural varieties to the exact parent-species is seldom possible. The starches from two species and one garden variety of unknown parentage were studied: *I. speciosa* Andr. (*I. craterioides* Ker.), *I. viridiflora* Lam., and *I.* var. (Emma).

STARCH OF IXIA SPECIOSA. (Plate 77, figs. 459 and 460. Chart 298.)

Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of many aggregates, in the form of doublets and triplets of equal or unequal sized components. Practically all the isolated grains have one or more, usually two or three, pressure facets at their distal ends. The surface of the grains tends to be rounded and quite regular. The conspicuous forms are the hemispherical with usually one to three facets at the base or distal end, spherical, and spherical to oval and elliptical; there are also a number of polygonal grains. Among the small grains are many spherical grains and others ranging from this form to rod-like, and also polygonal. The grains are not flattened and are of the same thickness as width, and hence spherical when seen on end.

The *hilum* is a comparatively large, round, distinct spot, usually slightly eccentric and commonly in the median line. It is rarely fissured, and the fissure is a short, narrow, straight, transverse line. The doublets and triplets often have lines or fissures at the places of union of the component grains, and two or more hila may be observed on a single grain.

The *lamellæ* are fairly distinct, rather coarse, regular, continuous rings, usually of the same form as the margin of the grain when distal from the hilum. There are about 4 to 6 on the larger grains.

The grains vary in *size;* the smaller are 2μ, the larger hemispherical type 18 by 15μ in length and breadth. The common size of the larger grains is 12 by 10μ in length and breadth.

Polariscopic Properties.—The *figure* is usually somewhat eccentric, fairly distinct, and generally clear-cut. Sometimes one or more of its lines are broader than the others and not quite clearly defined. The center of the figure is sometimes a rather large, dark area. Two or more fissures may be seen on the doublets and triplets, and the figure may be modified by the facets.

The degree of *polarization* is fair, varying somewhat in different grains but not much in different aspects of the same grain.

With *selenite* the quadrants are fairly well defined, generally regular in shape, and of unequal size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens slowly. After heating in water until the grains are completely gelatinized, the solution colors lightly and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly or not at all. The capsules color violet with an excess of iodine.

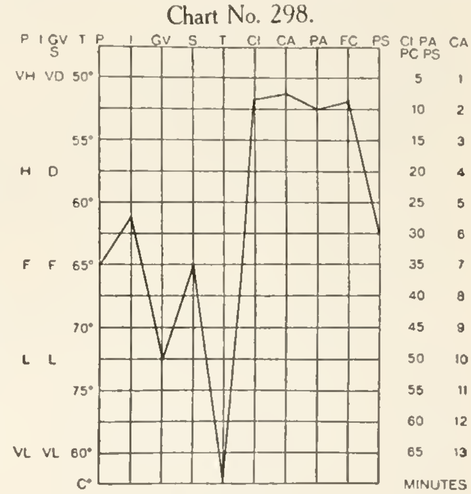
Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes are only lightly stained.

With *safranin* the grains begin to stain at once and in 30 minutes are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 83° to 85° C., mean 84°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in all the grains in 20 seconds and is over in 8 minutes. The grains color violet and then a dark indigo-blue along the lines which border the facets, and this darkened portion swells slightly. This process now proceeds about the margin of the grain and then inwards. It progresses more rapidly into the interior of the grain from the distal end. When the hilum is reached the whole grain rapidly increases in size and all the starch becomes of a dark indigo color. Later the swollen grains are seen to consist of a round, light inner space surrounded by a thick, dark border. The gelatinized grains are not very large and retain much of their original form.

Chart No. 298.



Curve of Reaction-Intensities of Starch of Ixia speciosa.

The reaction with *chromic acid* begins in 5 seconds and is over in 1½ minutes. The grains become covered with fine striæ which radiate from the hilum. The hilum rapidly increases in size, and the rest of the grain swells until all the less resistant starch has been gelatinized and the more resistant material is gathered at the margin in a fairly thick, striated band. This band becomes thinner and transparent, and is finally dissolved at one point, usually one of the corners of the facets. The gelatinized starch flows out and is dissolved, followed by solution of the rest of the capsule.

The reaction with *pyrogallic acid* begins in 30 seconds and is over in 10 minutes. The hilum enlarges and fine striæ appear which radiate from the hilum in all directions throughout the grain. The less resistant starch in the central part of the grain passes into a gelatinous condition, and the grain swells. The more resistant starch forms a thick, striated, marginal band, which becomes somewhat thinner and clearer and may be seen to be divided into a very thin inner portion and a thick outer portion. The gelatinized grains are large, smooth, and retain much of their original form.

The reaction with *ferric chloride* begins in many grains in 30 seconds and is over in 8 minutes. The grains begin to gelatinize, usually at the corners of the facets, where the starch protrudes in the form of small, irregular projections. This process spreads over the entire distal end of the grains and then upward and inward. When the hilum is reached the surrounding starch is converted into a gelatinous mass and the whole grain swells The more resistant material is gathered at the sides and proximal end, where it becomes gelatinized, leaving only a thin, transparent capsule continuous with that formed at the distal end. The swollen grains are large, somewhat irregular at the distal ends, and do not retain much of the original form.

With *Purdy's solution* most grains show some reaction in 1½ minutes. In 5 minutes about one-third, including many large grains, are nearly completely gelatinized. In 10 minutes about half and in 30 minutes all are nearly completely gelatinized. This reagent produces the same changes, as far as appearances go, as pyrogallic acid.

STARCH OF IXIA VIRIDIFLORA. (Plate 77, figs. 461 and 462. Chart 299.)

Histological Characteristics.—In *form* the grains are simple and are isolated, except many aggregates in the form of doublets, triplets, and quadruplets of equal or unequal size. Nearly all the isolated grains have pressure facets, commonly from one to three, at the distal end. The surface tends to be smooth and regular. The conspicuous forms are the hemispherical with one to three pressure facets at the base, spherical, and spherical to ovoid. There are many grains of polygonal and other forms among the smaller grains. The doublets are elliptical and the triplets rounded triangular. The grains are of the same thickness as width and appear to be spherical when seen on end.

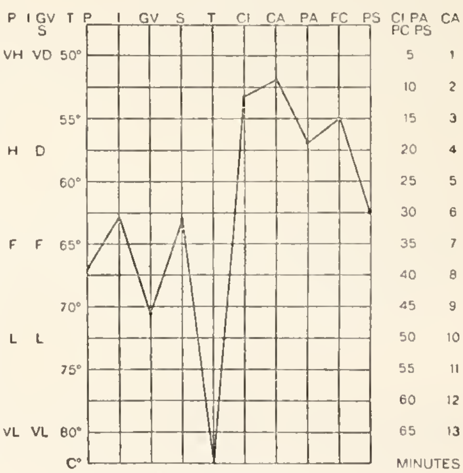
The *hilum* is a comparatively large, round, fairly distinct spot, usually situated slightly eccentrically and in the median line, rarely fissured. The lines of union between the components of doublets and triplets are marked by depressions or fissures.

The *lamellæ* are fairly distinct, rather coarse, regular, continuous rings, usually the shape of the margin of the grain. There are 5 to 6 on the larger grains.

The grains vary in *size;* the smaller are 2μ; the larger are 17 by 15μ in length and breadth. The common size is 12 by 10μ in length and breadth.

Polariscopic Properties.—The *figure* is usually slightly eccentric, fairly distinct, and generally clear-cut. One or more of its lines sometimes become broadened and not clearly defined. The center may be represented by a large dark area.

Chart No. 299.



Curve of Reaction-Intensities of Starch of Ixia viridiflora.

The degree of *polarization* is fair, varying somewhat in different grains and in different aspects of the same grain. It is lower than that of the grains of *I. speciosa.*

With *selenite* the quadrants are fairly well defined, unequal in size, and generally regular in shape. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color rather lightly and the color deepens slowly. It is not quite so deep as that of the grains of *I. speciosa.* After heating in water until the grains are completely gelatinized, the solution colors lightly and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly to not at all. The capsule colors violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once very lightly, and in 30 minutes are lightly stained. The color is deeper than that of the grains of *I. speciosa.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly stained. The color is deeper than that of the grains of *I. speciosa.*

Temperature Reaction.—The temperature of gelatinization is 82° to 84° C., mean 83°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 30 minutes, and in all in a minute. It is over in most of the grains in 6 minutes and in all in 12 minutes. It is qualitatively the same as that of the grains of *I. speciosa.*

The reaction with *chromic acid* begins in 15 seconds and is over in 1¾ minutes. It is the same qualitatively as that of the grains of *I. speciosa.*

The reaction with *pyrogallic acid* begins in 45 seconds and is over in 18 minutes. It is the same qualitatively as that of the grains of *I. speciosa.*

The reaction with *ferric chloride* begins in many grains in 45 seconds and is over in 15 minutes. It is the same qualitatively as that of the grains of *I. speciosa.*

Reaction with *Purdy's solution* begins in some grains in 3 minutes; in 10 minutes a few and in 30 minutes all are nearly completely gelatinized. The reaction is the same qualitatively as that of the grains of *I. speciosa.*

STARCH OF IXIA VAR. (EMMA). (Plate 78, figs. 463 and 464. Chart 300.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a number of aggregates, usually in the form of doublets or triplets. Most of the isolated grains are marked by one or more, generally one or two, pressure facets at the distal end. The surface is usually quite smooth and regular. The conspicuous forms are the hemispherical with one to three pressure facets at the base or distal end, and the spherical; also the ovoid and oval to elliptical. The smaller grains are of similar forms. The doublets are oval to elliptical and the triplets roundly triangular. The grains are of the same thickness as breadth, and appear to be spherical when viewed on end.

The *hilum* is a fairly distinct, comparatively large round spot, usually slightly eccentrically situated and in or slightly to one side of the median line. There is sometimes a round cavity at the hilum, and the hilum is seldom fissured. Lines, fissures, or depressions commonly mark the place of union of the components of aggregates.

The *lamellæ* are rather indistinct, rather coarse, regular continuous rings which have the shape of the grain, except those immediately surrounding the hilum. The number could not be accurately determined, but there appeared to be about 5 or 6 on the larger grains.

The grains vary in *size;* the smaller are 2μ, the larger 20 by 16μ in length and breadth. The common size is 14 by 12μ in length and breadth.

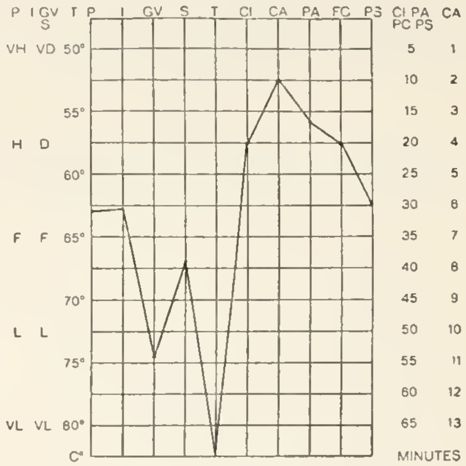
Polariscopic Properties.—The *figure* is usually somewhat eccentric, distinct, and generally clear-cut. In some grains commonly one, sometimes more, of the lines are broad and not clearly outlined.

The degree of *polarization* is fair, varying somewhat in different grains and in the same aspect of a grain. It is sometimes lower at the distal end near the facets than elsewhere. It is slightly higher than that of the grains of *I. speciosa.*

With *selenite* the quadrants are fairly well defined, generally regular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly and the color deepens slowly. The color is less than that of the grains of *I. speciosa.* After heating in water until the grains are completely gelatinized, the solution colors lightly and the swollen grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly to not at all. The capsules color violet with an excess of iodine.

Chart No. 300.



Curve of Reaction-Intensities of Starch of Ixia var. (Emma).

Staining Reactions.—With *gentian violet* the grains begin to stain at once very lightly and in 30 minutes are lightly stained, but slightly less than the grains of *I. speciosa.*

With *safranin* the grains begin to stain at once and in 30 minutes are fairly stained, but less than those of *I. speciosa.*

Temperature Reaction.—The temperature of gelatinization is 84° to 85° C., mean 84.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 45 seconds. It is over in two-thirds of the grains in 5 minutes and nearly all are gelatinized in 20 minutes. The reaction is the same qualitatively as that of the grains of *I. speciosa.*

Reaction with *chromic acid* begins in 15 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *I. speciosa.*

The reaction with *pyrogallic acid* begins in all the grains in a minute and is over in 17 minutes. It is the same qualitatively as that of the grains of *I. speciosa.*

Reaction with *ferric chloride* begins in most grains in 45 seconds and is over in 20 minutes. It is the same qualitatively as that of the grains of *I. speciosa.*

With *Purdy's solution* reaction begins in a few grains in 2 minutes, very few are partially gelatinized in 5 minutes, and all are nearly completely gelatinized in 30 minutes.

Differentiation of Certain Starches of the Genus Ixia.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

I. speciosa: Simple, many aggregates, usually in the form of doublets and triplets, 1 to 3 or more pressure facets on isolated grains. Hemispherical with 1 to 3 pressure facets at base, spherical, spherical to oval and elliptical.
I. viridiflora: Essentially the same as in *I. speciosa.*
I. var. (*Emma*): Essentially the same as in *I. speciosa.*

Hilum—Form, Number, and Position.

I. speciosa: Form comparatively large, round, distinct, rarely fissured, fissures single, short, transverse. Position usually slightly eccentric.
I. viridiflora: Form essentially the same as in *I. speciosa.* Position usually slightly eccentric.
I. var. (*Emma*): Form essentially the same as in *I. speciosa.* Position usually slightly eccentric.

Lamellæ—General Characteristics and Number.

I. speciosa: Fairly distinct, rather coarse, regular continuous rings of same shape as the grain when distal to the hilum. About 4 to 6 on larger grains.
I. viridiflora: Essentially the same as in *I. speciosa.* About 5 to 6 on the larger grains.
I. var. (*Emma*): Essentially the same as in *I. speciosa.* About 5 to 6 on the larger grains.

Size.

I. speciosa: From 2 to 18μ, commonly 12μ.
I. viridiflora: From 2 to 17μ, commonly 12μ.
I. var. (*Emma*): From 2 to 20μ, commonly 14μ.

POLARISCOPIC PROPERTIES.

Figure.

I. speciosa: Usually eccentric, fairly distinct, usually clear-cut.
I. viridiflora: The same as in *I. speciosa.*
I. var. (*Emmo*): The same as in *I. speciosa.*

Degree of Polarization.

I. speciosa: Fair, somewhat variable.
I. viridiflora: Fair, somewhat variable, lower than in *I. speciosa.*
I. var. (*Emma*): Fair, somewhat variable, slightly higher than in *I. speciosa.*

Polarization with Selenite—Quadrants and Colors.

I. speciosa: Quadrants fairly well defined, generally regular, unequal in size. Colors pure.
I. viridiflora: Quadrants the same as in *I. speciosa.* Colors pure.
I. var. (*Emma*): Quadrants the same as in *I. speciosa.* Colors pure.

IODINE REACTIONS.

Intensity and Color.

I. speciosa: Fairly deep; blue-violet.
I. viridiflora: Fairly deep, less than in *I. speciosa;* blue-violet.
I. var. (*Emma*): Fairly deep, less than in *I. speciosa;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

I. speciosa: Light.
I. viridiflora: Light, more than in *I. speciosa.*
I. var. (*Emma*): Light, slightly less than in *I. speciosa.*

With Safranin.

I. speciosa: Fair.
I. viridiflora: Fair, more than in *I. speciosa.*
I. var. (*Emma*): Fair, less than in *I. speciosa.*

TEMPERATURE OF GELATINIZATION.

I. speciosa: 83 to 85° C., mean 84°.
I. viridiflora: 82 to 84° C., mean 83°.
I. var. (*Emma*): 84 to 85° C., mean 84.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

I. speciosa: Begins in all in 20 seconds; complete in all in 8 minutes.
I. viridiflora: Begins in some in 30 seconds; complete in 12 minutes.
I. var. (*Emma*): Begins in most in 45 seconds; complete in nearly all in 20 minutes.

Reaction with Chromic Acid.

I. speciosa: Begins in all in 5 seconds; complete in all in 1½ minutes.
I. viridiflora: Begins in all in 15 seconds; complete in all in 1¾ minutes.
I. var. (*Emma:*) Begins in all the grains in 15 seconds; complete in all in 2 minutes.

Reaction with Pyrogallic Acid.

I. speciosa: Begins in all in 30 seconds; complete in all in 10 minutes.
I. viridiflora: Begins in all in 45 seconds; complete in all in 18 minutes.
I. var. (*Emma*): Begins in all in 60 seconds; complete in all in 17 minutes.

Reaction with Ferric Chloride.

I. speciosa: Begins in many in 30 seconds; complete in all in 8 minutes.
I. viridiflora: Begins in many in 45 seconds; complete in all in 15 minutes.
I. var. (*Emma*): Begins in most in 45 seconds; complete in all in 20 minutes.

Reaction with Purdy's Solution.

I. speciosa: Begins in most in 1½ minutes; nearly complete in all in 30 minutes.
I. viridiflora: Begins in some in 3 minutes; nearly complete in all in 30 minutes.
I. var. (*Emma*): Begins in a few grains in 2 minutes; nearly complete in all in 30 minutes.

NOTES ON THE STARCHES OF IXIA.

The three *Ixia* starches show no essential histological differences, and the correspondence between their reactions is close. However, *I. speciosa* could with readiness be distinguished from the other two, which latter could also be diagnosed, one from the other.

GENUS BABIANA.

The babianas are natives of South Africa and number about 50 species. Very few species but quite a number of horticultural varieties are in cultivation. The starchy corms are eaten by baboons, hence the name of the genus; and the same part when roasted resembles chestnuts prepared in the same way, and are used as food by the Hottentots. Starches of two horticultural varieties of unknown parentage were used as sources of starch: *B.* var. (*Violacea*) and *B.* var. (*Athraction*).

STARCH OF BABIANA VAR. (VIOLACEA). (Plate 78, figs. 465 and 466. Chart 301.)

Histological Characteristics.—In *form* the grains are simple and isolated, with the exception of a number of aggregates, in the form of doublets and triplets which may consist of components of equal or unequal size. The isolated grains have usually from one to three pressure facets at the distal end. The surface of the grains is smooth and quite regular. In some grains secondary deposits appear to have been added to the facets and adjacent parts. The conspicuous forms are the hemispherical with usually two to three facets at the base, and spherical; also forms ranging from the spherical to oval and elliptical, and various polygonal forms due to multiple facets. The doublets are usually elliptical or oval and the triplets are rounded triangular. The grains are not flattened, and when seen on end are spherical.

The *hilum* varies from indistinct to fairly distinct, and is a comparatively large round spot, rarely a cavity, and usually very slightly eccentrically situated. The hilum is rarely fissured. In some grains there are two lines extending from each side of this cavity to the corners of the facets. There are sometimes 2 hila in a single isolated grain.

The *lamellæ* are as a rule not distinct, and are rather coarse, regular, continuous rings having near the margin the form of the outline of the grain. The number could not be accurately estimated, but there are probably about 5 to 6 on the larger grains.

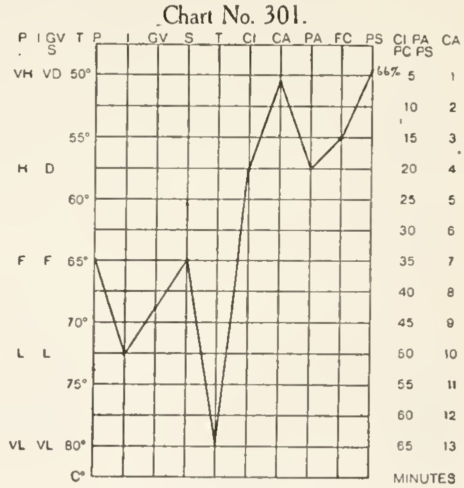
The grains vary in *size;* the smaller are 3 by 3μ; the larger are 20 by 20μ and 18 by 20μ in length and breadth. The common size is usually 14 by 14μ.

Polariscopic Properties.—The *figure* is usually slightly eccentric, distinct, and clear-cut, sometimes very sharply clear-cut and regular. The lines may be broad or narrow, and may not be clearly defined. They are generally straight.

The degree of *polarization* is low to high, usually fair. It varies in different grains and in different aspects of the same grain.

With *selenite* the quadrants are usually well defined and regular in shape, but usually unequal in size. The colors are fairly pure.

Chart No. 301.



Curve of Reaction-Intensities of Starch of Babiana var. (Violacea).

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather light bluish-violet and the color deepens rapidly; with 0.125 per cent solution they color lightly and the color deepens fairly rapidly. After heating in water until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues fairly. When an excess of iodine is added the capsules become violet.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in 1½ minutes and in 30 minutes some are stained lightly and others fairly well.

With *safranin* the grains begin to stain at once lightly and in 30 minutes are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 79° to 81° C., mean 80°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds. It is over in four-fifths of the grains in 7½ minutes and in all in 20 minutes. The grains stain a light violet, and then the corners and edges of the facets darken and swell slightly. From these points this process extends around the margin and inwards. It advances more rapidly inwards from the distal end. When the hilum is reached the whole grain swells, but not to a great size. The gelatinized grains are not very large, they retain much of their original form, and are usually of a uniform dark-blue color.

Reaction with *chromic acid* begins in 5 seconds and is over in 1¼ minutes. The hilum swells, or appears to swell, and fine striæ radiate from this point in all directions. The less resistant starch is converted into a semifluid, gelatinous mass in the central portion of the grain, and the grain swells. The more resistant starch forms a thick, coarsely striated, marginal band, which progressively grows thin and transparent as the grain swells. One portion is dissolved, usually at one corner or edge of a facet, and the semifluid mass in the interior flows out and is dissolved, and the remainder of the marginal band dissolves later.

The reaction with *pyrogallic acid* begins in 30 seconds and is over in 20 minutes. The hilum appears to enlarge, and fine but distinct striæ radiate from the hilum in all directions. The less resistant starch is transformed into a semifluid mass in the interior of the grain, and the more resistant starch forms a thick, finely striated, marginal band, which as the grain swells grows clearer and somewhat thinner and transparent. The gelatinized grains are large, not very much distorted, and retain much of their original form.

With *ferric chloride* the reaction begins in many grains in 45 seconds and is over in 15 minutes. It begins at the distal end, where the corners and edges of the facets become gelatinous and swell out irregularly. Sometimes this process is followed by gelatinization and swelling of the marginal part of the proximal end. The process now spreads over the rest of the grain, and when the hilum is reached the whole grain swells greatly. The swollen grains are large, greatly folded and sacculated, and do not retain much of the original form of the grain.

The reaction with *Purdy's solution* begins in many grains in 15 seconds, and in all in 40 seconds. It is over in about two-thirds of the total number, including most of the smaller grains, in 4 minutes. It is qualitatively the same as that to pyrogallic acid.

STARCH OF BABIANA VAR. (ATHRACTION). (Plate 78, figs. 467 and 468. Chart 302.)

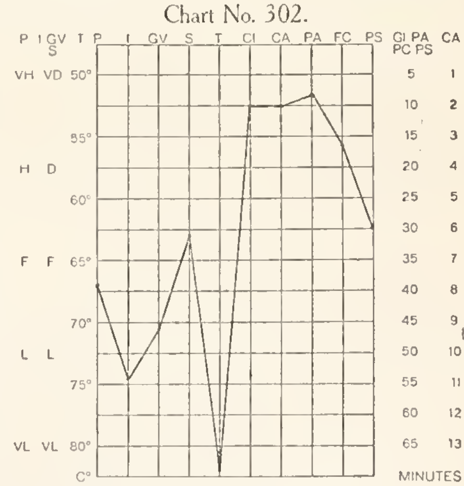
Histological Characteristics.—In *form* the grains are simple. They are isolated, with the exception of a few aggregates, usually in the form of doublets and triplets. The isolated grains have from one to four pressure facets at the distal end. The surface of the grains is smooth and quite regular. The conspicuous forms are the hemispherical with usually one to three pressure facets at the base, and spherical; also ovoid to oval and elliptical, and some polygonal forms. The doublets range from elliptical to oval, and the triplets are usually rounded triangular. The grains are not flattened and appear to be spherical when seen on end.

The *hilum* is a fairly distinct and usually a comparatively large round spot, commonly slightly eccentric; occasionally marked by a small round cavity and rarely slightly fissured. Two or more hila are rarely observed on an isolated grain. In some grains there are two lines extending from each side of the cavity or cleft to the angles made at the facets.

Lamellæ indistinct and, when seen, appear regular, rather coarse, and continuous. Number not determined.

The grains vary in *size;* the smaller are 2 by 2μ; the larger are 19 by 14μ and 14 by 18μ in length and breadth. The common size is about 12μ.

Chart No. 302.



Curve of Reaction-Intensities of Starch of Babiana var. (Athraction).

Polariscopic Properties.—The *figure* is usually slightly eccentric, distinct, clear-cut, and regular; its lines are generally straight and clearly defined.

The degree of *polarization* is low to fairly high, usually fair. It varies in different grains and in different aspects of a grain. It is lower than in *B.* var. (*Violacea*).

With *selenite* the quadrants are usually well defined, fairly regular in shape, and commonly unequal in size. The colors are, as a rule, pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather light blue-violet and the color deepens rapidly; with 0.125 per cent solution the grains color lightly and the color deepens fairly rapidly. It is less than that of the grains of *B.* var. (*Violacea*). After heating in water until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues fairly. The capsules all color violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly in 1 to 2 minutes and in 30 minutes are colored lightly. Color deeper than that of grains of *B.* var. (*Violacea*).

With *safranin* the grains begin to stain lightly at once and in 30 minutes are fairly colored, slightly deeper than the grains of *B.* var. (*Violacea*).

Temperature Reaction.—The temperature of gelatinization is 81° to 83° C., mean 82°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 seconds and is over in nearly all in 10 minutes. It is the same qualitatively as that of the grains of *B.* var. (*Violacea*).

Reaction with *chromic acid* begins in 15 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *B.* var. (*Violacea*).

The reaction with *pyrogallic acid* begins in 15 seconds, and all are nearly completely gelatinized in 8 minutes. The reaction is the same qualitatively as that of the grains of *B.* var. (*Violacea*).

The reaction with *ferric chloride* begins in some grains in a minute and is over in 17 minutes. It is the same qualitatively as that of the grains of *B.* var. (*Violacea*).

Reaction with *Purdy's solution* begins in a few grains in 2 minutes, a few are partially gelatinized in 12 minutes, and nearly all are partially gelatinized in 30 minutes. The reaction is the same qualitatively as that of the grains of *B.* var. (*Violacea*).

Differentiation of Certain Starches of the Genus Babiana.

Histological Characteristics.

Conspicuous Forms.

B. var. (*Violacea*): Simple, isolated except a number of aggregates chiefly in the form of doublets and triplets, isolated grains faceted, surface rounded and smooth, often 2 lines from hilum to facets. Hemispherical with usually 1 to 3 pressure facets at base, and spherical.

B. var. (*Athraction*): Same as in *B.* var. (*Violacea*).

Hilum—Form, Number, and Position.

B. var. (*Violacea*): Form indistinct to fairly distinct, comparatively large round spot or sometimes a cavity; rarely fissured; occasionally 2 hila. Position usually very slightly eccentric.

B. var. (*Athraction*): Form fairly distinct, otherwise the same as in *B.* var. (*Violacea*). Position usually very slightly eccentric.

Lamellæ—General Characteristics and Number.

B. var. (*Violacea*): Not as a rule distinct, rather coarse, regular, continuous, of the shape of the grain near the margin. Probably 5 to 6.

B. var. (*Athraction*): Less distinct than in *B.* var. (*Violacea*), otherwise the same. Number not estimated.

Size.

B. var. (*Violacea*): From 3 to 20μ, commonly 14μ.

B. var. (*Athraction*): From 2 to 19μ, commonly 12μ.

Polariscopic Properties.

Figure.

B. var. (*Violacea*): Usually slightly eccentric, distinct, clear-cut and regular.

B. var. (*Athraction*): The same as in *B.* var. (*Violacea*).

Degree of Polarization.

B. var. (*Violacea*): Low to high, usually fair.

B. var. (*Athraction*): Low to fairly high, less than in *B.* var. (*Violacea*).

Polarization with Selenite—Quadrants and Colors.

B. var. (*Violacea*): Quadrants usually well defined, regular in shape, and unequal in size. Colors usually pure.

B. var. (*Athraction*): Quadrants the same as in *B.* var. (*Violacea*). Colors usually pure.

Iodine Reactions.

Intensity and Color.

B. var. (*Violacea*): Rather light; blue-violet.

B. var. (*Athraction*): Rather light, less than in *B.* var. (*Violacea*); blue-violet.

Staining Reactions.

With Gentian Violet.

B. var. (*Violacea*): Light to fair.

B. var. (*Athraction*): Light, less than in *B.* var. (*Violacea*).

With Safranin.

B. var. (*Violacea*): Fair.

B. var. (*Athraction*): Fair, slightly deeper than in *B.* var. (*Violacea*).

Temperature of Gelatinization.

B. var. (*Violacea*): 79 to 81° C., mean 80°.

B. var. (*Athraction*): 81 to 83° C., mean 82°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

B. var. (*Violacea*): Begins in 30 seconds; complete in four-fifths in 7½ minutes, and in all in 20 minutes.

B. var. (*Athraction*): Begins in 30 seconds; complete in nearly all in 10 minutes, no further change.

Reaction with Chromic Acid.

B. var. (*Violacea*): Begins in all in 5 seconds; complete in all in 1¼ minutes.

B. var. (*Athraction*): Begins in all in 15 seconds; complete in all in 2 minutes.

Reaction with Pyrogallic Acid.

B. var. (*Violacea*): Begins in all in 30 seconds; complete in all in 20 minutes.

B. var. (*Athraction*): Begins in all in 30 seconds; nearly complete in all in 8 minutes.

Reaction with Ferric Chloride.

B. var. (*Violacea*): Begins in many in 45 seconds; complete in all in 15 minutes.

B. var. (*Athraction*): Begins in some in 60 seconds; complete in all in 17 minutes.

Reaction with Purdy's Solution.

B. var. (*Violacea*): Begins in many in 15 seconds; complete in two-thirds in 4 minutes.

B. var. (*Athraction*): Begins in a few in 120 seconds; nearly all partially gelatinized in 30 minutes.

NOTES ON THE STARCHES OF BABIANA.

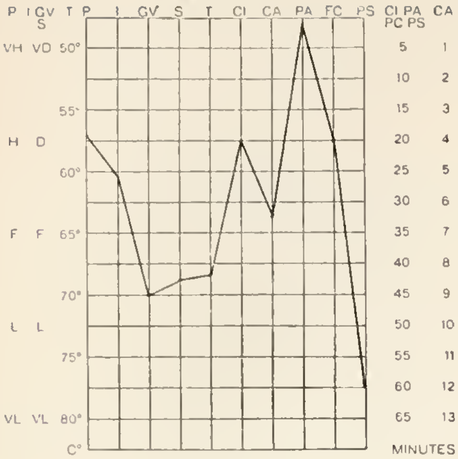
The gross histological differences in these starches are of a very minor character and probably of no real value in diagnosis. The starches differ, however, in every reaction, *B.* var. (*Violacea*) having a higher degree of polarization, a higher reactivity with iodine and gentian violet, a lower reactivity with safranin, a lower temperature of gelatinization, a lower sensitivity to chloral hydrate-iodine and pyrogallic acid, and a higher sensitivity to chromic acid, ferric chloride, and Purdy's solution.

NOTES ON THE STARCHES OF IRIDACEÆ. (Charts 303 to 319.)

From an examination of the descriptions and the plates it will be seen that the starches from *Iridaceæ* include a number of distinct types characterized by their conspicuous forms. Among the irises there are two distinct types, as already referred to under *Iris*. The starches of *Moræa* and *Homeria* appear to be essentially modifications of one of the *Iris* types, and the same might be said of the starch of *Tigridia*, but in the latter instance the departure is more marked. *Iris, Moræa, Homeria*, and *Tigridia* are closely allied genera. Another distinct type is observed in *Gladiolus*, and which is represented in more or less modified form in *Watsonia, Tritonia, Freesia, Antholyza, Crocus, Romulea, Sparaxis, Ixia*, and *Babiana*. Finally, another type is apparent in *Marica* and *Gelasine*, the form of the grains in one of them being, it appears, a modification of that of the other.

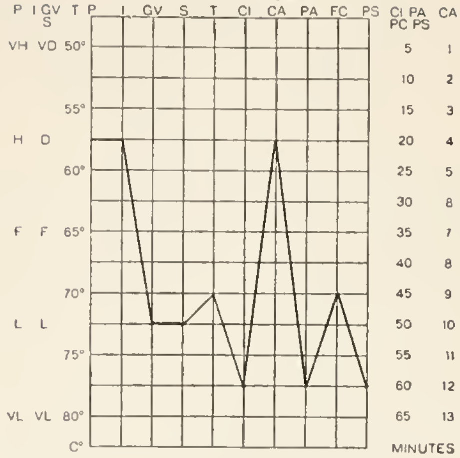
In a comparison of the reaction-curves of the representatives of these genera, it will be noticed that there are more or less marked generic differences throughout the members of the family, but there is no grouping of the genera curves that corresponds with the grouping based on the histological characters. The reactions of each genus represented are definitely distinctive of the genus, and it will be noted that while in some instances there is a closeness of the curves in closely related genera, in others there is not. Thus, botanically, *Iris, Moræa, Homeria*, and *Tigridia* are closely allied genera, but while there are likenesses in the histology of their starches the reaction-curves do not show corresponding closeness. *Gladiolus* and *Watsonia* are botanically closely related, the starches are histologically alike, and the reaction-curves are of the same type, one being a modification of the other. *Tritonia* and *Freesia* are closely allied in botanical characteristics, and allied in turn with *Gladiolus* and *Watsonia*. The starch-grains are very much alike, and the correspondence in the reaction-curves is distinct. In *Antholyza* and *Crocus* not only are the starches of the same histological type, but the reaction-curves have the same fundamental characters. *Romulea* is closely allied to *Crocus*, but while the starches are of the same histological type the reaction-curves show distinctive differences, the starch of the former being distinctly more resistant, but the differences in the curves may be quantitative rather than qualitative. *Marica* and *Cypella* are allied genera, and this is indicated both in the histology and the reactions of the starches. *Sparaxis, Ixia*, and *Babiana* are all closely allied South African genera, and have the same type of grains and the same type of reaction-curve. (See Prefatory Notes.)

Chart No. 303.



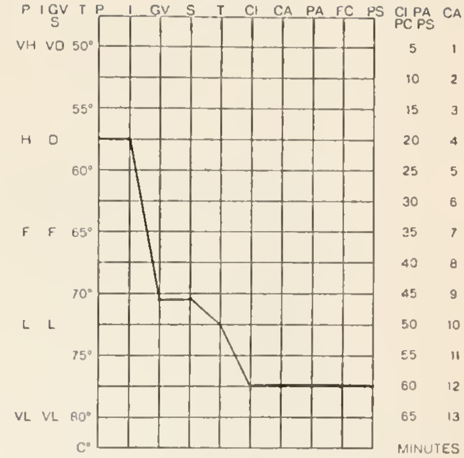
Composite Curve of Mean Reaction-Intensities of Starch of Iris.

Chart No. 304.



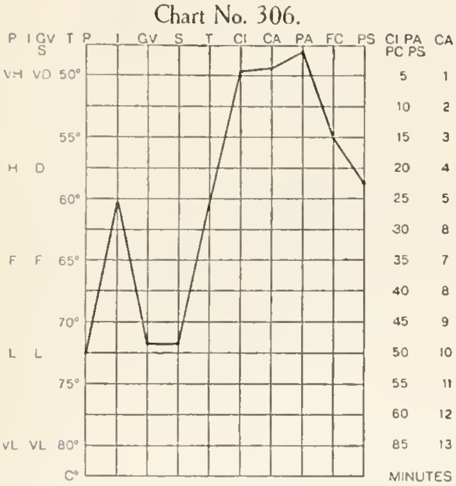
Curve of Reaction-Intensities of Starch of Moræa.

Chart No. 305.



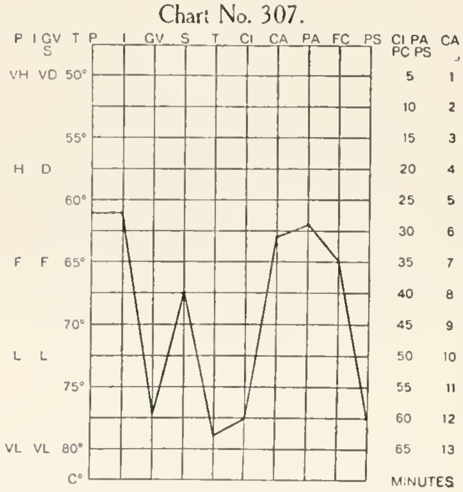
Curve of Reaction-Intensities of Starch of Homeria.

Chart No. 306.



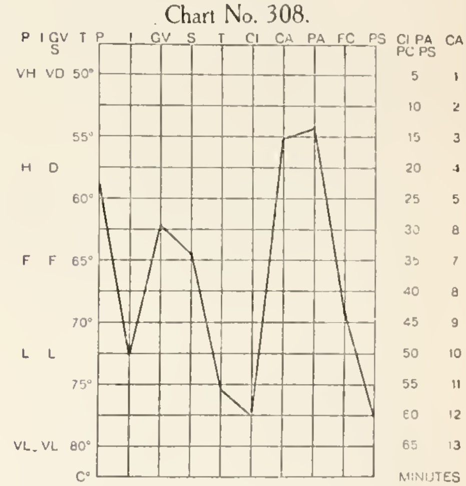
Composite Curve of Mean Reaction-Intensities of Starch of Tigridia.

Chart No. 307.



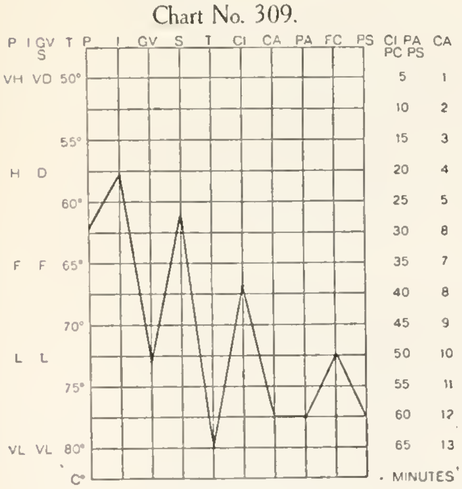
Composite Curve of Mean Reaction-Intensities of Starch of Gladiolus.

Chart No. 308.



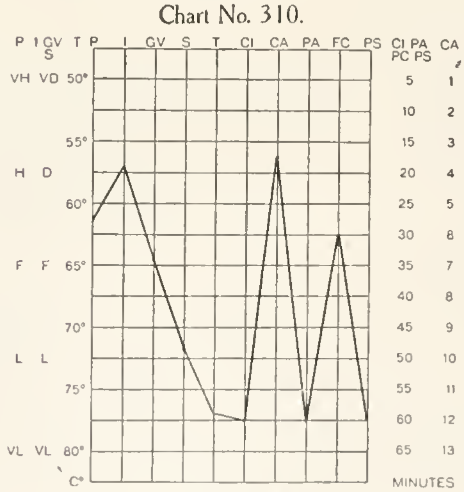
Composite Curve of Mean Reaction-Intensities of Starch of Watsonia.

Chart No. 309.



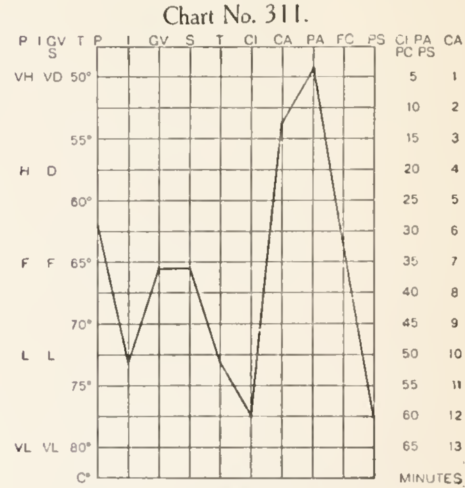
Composite Curve of Mean Reaction-Intensities of Starch of Tritonia.

Chart No. 310.



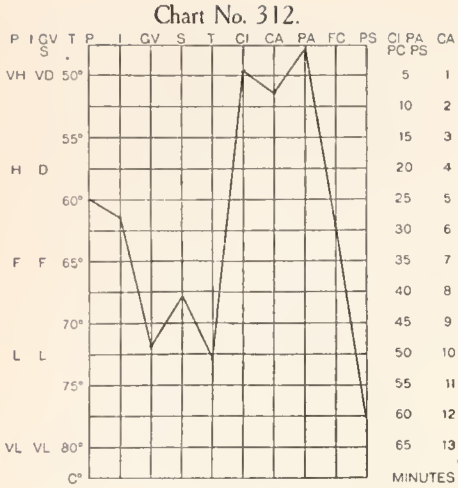
Composite Curve of Mean Reaction-Intensities of Starch of Freesia.

Chart No. 311.



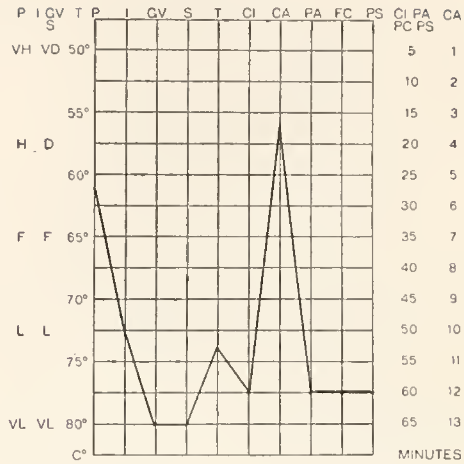
Composite Curve of Mean Reaction-Intensities of Starch of Antholyza.

Chart No. 312.



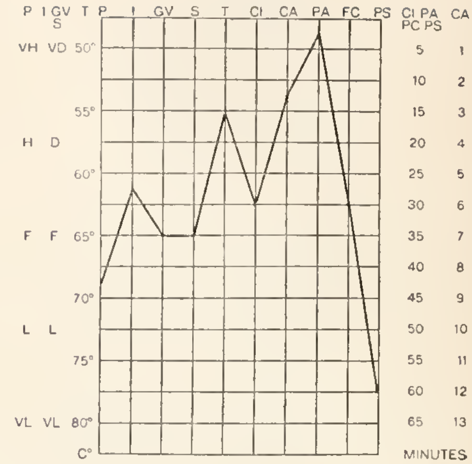
Composite Curve of Mean Reaction-Intensities of Starch of Crocus.

Chart No. 313.



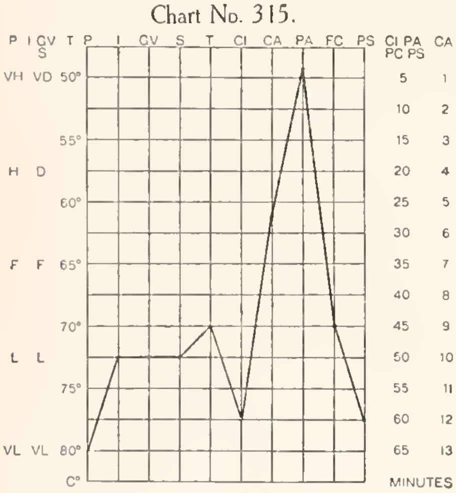
Curve of Reaction-Intensities of Starch of Romulea.

Chart No. 314.



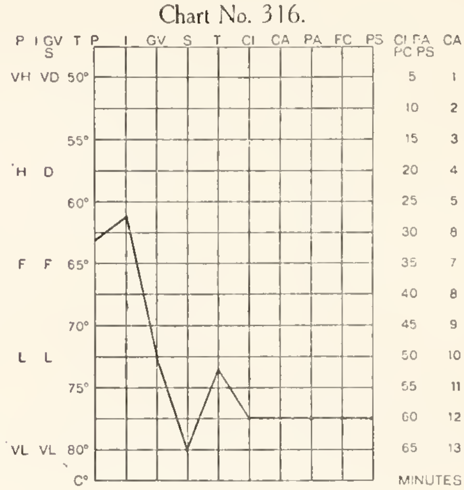
Curve of Reaction-Intensities of Starch of Cypella.

Chart No. 315.



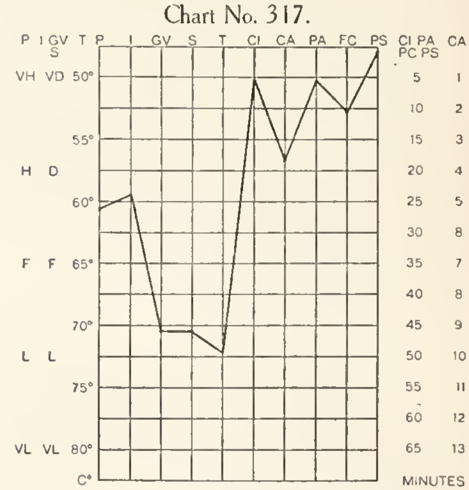
Curve of Reaction-Intensities of Starch of Marica.

Chart No. 316.



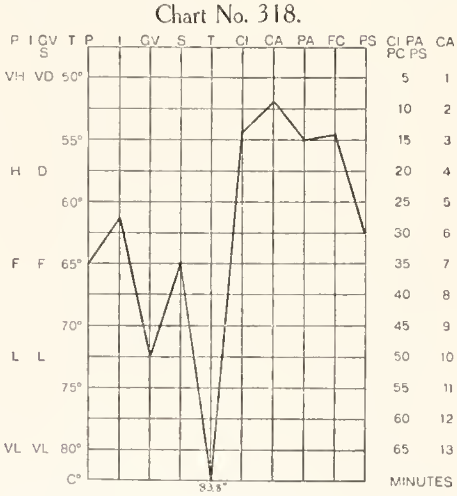
Curve of Reaction-Intensities of Starch of Gelasine.

Chart No. 317.



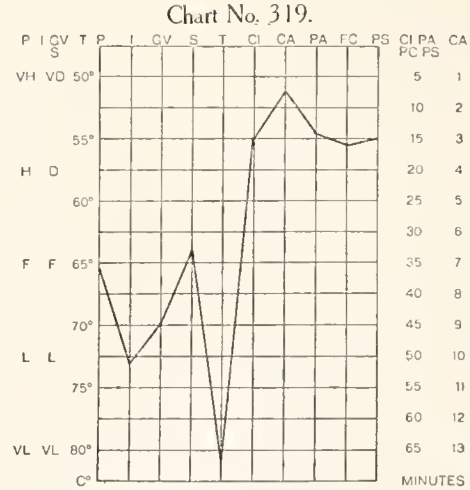
Composite Curve of Mean Reaction-Intensities of Starch of Sparaxis.

Chart No. 318.



Composite Curve of Mean Reaction-Intensities of Starch of Ixia.

Chart No. 319.



Composite Curve of Mean Reaction-Intensities of Starch of Babiana.

STARCHES OF MUSACEÆ.

Class, Monocotyledones. Order, Scitaminales. Family, Musaceæ.
Genus represented, Musa.

GENUS MUSA.

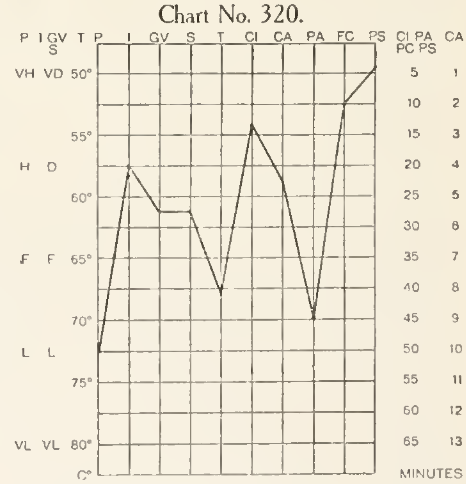
The genus *Musa*, one of the four genera of *Musaceæ*, which includes about 50 species, comprises about 20 species of tropical plants that are widely distributed, especially in the tropical regions of the Old World. Some of the species or varieties are extensively cultivated, chiefly for the fruit or for the fiber that is obtained from the tree-like stems, one species (*M. textilis*) being the source of Manila hemp. Starches from 3 species were studied, including *M. cavendishii* Lamb. (*M. sinensis* Sagot, *M. chinensis* Sweet), the Chinese dwarf banana, and known in the central parts of America as the dwarf Jamaica banana; *M. sapientum* Linn., the common banana; and *M. ensete* Gmel., the Abyssinian banana. The first is a native of Southern China, the second is a native of India and the East Indian Islands, and the third a native of Abyssinia. There are at least a half dozen varieties of *M. sapientum*, the most important being *M. sapientum* var. *paradisiaca* Hort. (*M. paradisiaca* Linn.), which is commonly known as the plantain banana, cooking banana, or Adam's fig; and most of the banana fruit of commerce in this country is of this variety. It is grown extensively for its fruit, which is used as a food directly or in the form of " banana starch," the latter being obtained from the unripe fruit. As the fruit ripens the starch disappears. *M. cavendishii* is extensively cultivated in the Southern States and West Indies, chiefly for its fruit. *M. ensete* is the largest of the species, and is cultivated chiefly as a decorative plant.

STARCH OF MUSA CAVENDISHII OBTAINED FROM THE STALK.

(Plate 79, figs. 469 and 470. Chart 320.)

Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of a few clumps. No pressure facets were observed. The surface of the grains is flattened and the margin tends to be irregular, owing to depressions and rounded projections, and to nipple-like processes. The edges of some grains are serrated and appear as though they had been eroded. The conspicuous forms are the mussel-shell, clam-shell, and oyster-shell shapes. There are also ovoid, circular, oval, elliptical, spindle, and various irregular forms. The grains are very much flattened, and when viewed from the end or edge are of a long, slender, and more or less irregular spindle form.

Chart No. 320.



Curve of Reaction-Intensities of Starch of Musa cavendishii (stalk).

The *hilum* is a very small, round, non-refractive, not very distinct spot, generally situated very eccentrically, commonly at the base of a more or less distinct projection from the end, usually in the median line or only slightly to one side. It is never fissured, and grains with double hila were not seen.

The *lamellæ* are distinct and are in the form of fine rings around the hilum and segments of rings beyond, which follow the outline of the distal margin. Those at the distal end are not so fine but more distinct than the others, and they also vary in distinctness in different grains. In fairly large grains the number is usually from 35 to 45.

The grains vary in *size* from 8 to 80μ. The common size is about 40μ.

Polariscopic Properties.—The *figure* is usually very eccentric, fairly distinct, but not clear-cut. Usually two of its lines are visible which generally become very broad and dim toward the margin; the lines may be bent or otherwise distorted, and often obscured in some part by variations in the degree of polarization. The figure is distinct and clear-cut when the grain is viewed on edge or end.

The degree of *polarization* is low. Polarization is often absent or very low in large areas of the grain, which may be due in part at least to thinness of the substance at these points. Polarization is high when the grain is seen on edge or end and when overlapping of the grain occurs.

With *selenite* the quadrants are not well defined, very unequal in size, and irregular in shape. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color immediately and very deeply a bluish-violet; with 0.125 per cent solution they color immediately, and the color deepens quickly. After heating in water until the grains are completely gelatinized, the solution colors lightly but the grains deeply on the addition of iodine. If much iodine is added a violet-colored capsule appears in some grains. After boiling for 2 minutes the solution is colored somewhat more deeply, but the grain-residues slightly; with an excess of iodine the capsules are colored a blue-violet.

Staining Reactions.—With *gentian violet* staining begins in 30 seconds, but after 30 minutes the grains are fairly deeply stained, some more than others.

With *safranin* staining begins immediately, but at the end of 30 minutes the grains are only fairly deeply stained, some more than others. This reaction is much less than that with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 67° to 68.5° C., mean 67.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in a minute; in all in 3 minutes. Most grains darken in 5 minutes and all are darkened in 13 minutes. The hilum is prominent and the lamellæ are not obscured. If the grain is eroded, as is the case with some in the preparation studied, there is swelling and protrusion from the various irregular points about the margin. Swelling and protrusion usually begins at one or two points at the distal end. These join and the process extends gradually upward over the whole grain. At times both proximal and distal ends swell, followed by swelling of other parts of the grain; or very frequently the process extends upward around the margin from the distal end and stops on each side of the hilum, until the other parts of the grain are gelatinized, and then the hilum swells; or the entire margin may be gelatinized so that there is a ring of gelatinous material about the ungelatinized central part of the grain. The gelatinized grains are small and show two or three or four long, finger-like projections at the proximal end, and a number of dark lines or folds more or less completely separated by light spaces at the distal end, arranged like the lamellæ.

The reaction with *chromic acid* begins in 30 seconds and is over in 4½ minutes. The grain is divided by fine fissures, which rapidly grow coarse and more distinct. The hilum swells out in the form of a long, narrow projection from the end of the grain. The proximal end is dissolved and opens out. The rest of the grain becomes divided into rows of granules following the lines of the lamellæ, and these in turn are divided at the distal end into concentric crescents, one of which rarely separates and is dissolved independently. The rest of the grain dissolves slowly, the upper portion just beneath the swollen hilum, where the largest granules are, being the last to dissolve.

With *pyrogallic acid* the reaction begins in 30 seconds and is over in 45 minutes. The hilum and lamellæ are both distinct. The hilum swells slightly and two lines appear, one on each side, which are like the hilum in appearance and widen out as the hilum swells. The hilum continues to increase in size, or rather the inner portion of the grain is broken down into a finely granular, gelatinous mass. A slight line of resistant starch persists for a time at the margin, but soon clears away. The grain swells slowly and evenly. There are often formed two or three rows of coarse granules, the granules near the hilum being gelatinized last. When the reaction is complete the gelatinized grains are large, somewhat folded and otherwise distorted.

With *ferric chloride* the reaction begins in 2½ minutes and is over in 10 minutes. The hilum and lamellæ are distinct and the margin becomes clear. Various points, especially at the distal end, begin to gelatinize, and the process spreads towards the proximal end over the whole grain, the swelling proceeding in succession from row to row. The hilum protrudes as a long, finger-like projection, and usually before this process is complete similar protrusions occur at two or three nearby points. The gelatinized grains formed during the process show an irregular, sacculated appearance at the proximal end and a somewhat irregular margin with the inner portion laid in folds which follow the lines of lamellæ.

The reaction with *Purdy's solution* begins immediately and is over in 4 minutes. A few grains are probably not completely gelatinized even at the end of an hour or more. The hilum and lamellæ are made very distinct. The hilum swells somewhat, often without any saccular protrusion. The inner portion of the grain is divided into rows of granules by fine striæ and by transverse fissures which follow the lines of the more prominent, non-refractive lamellæ. These granules are converted into a clear, gelatinous, finely granular mass as the grain swells slowly and evenly. The gelatinized grain is large and shows folds in the lower part corresponding to the lines of lamellæ. It may or may not show saccular projections from the proximal end. Another method of reaction is one in which the two ends gelatinize first, then the central part.

STARCH OF MUSA CAVENDISHII OBTAINED FROM THE GREEN FRUIT.

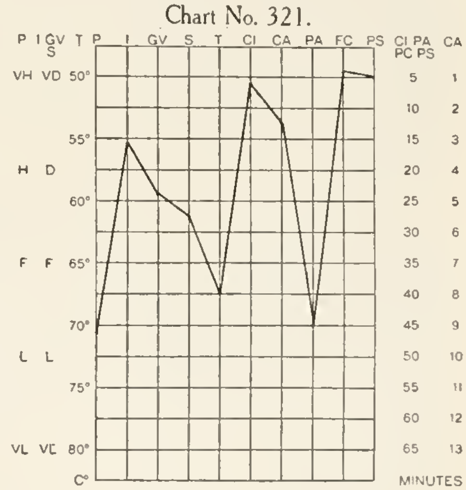
(Plate 79, figs. 471 and 472. Chart 321.)

Histological Characteristics.—In *form* the grains are simple, and they are isolated with the exception of a few clumps. No pressure facets were observed. Grains are much flattened and the margin is generally more or less irregular, owing in part to depressions and rounded protuberances and nipple-like projections, as in the case of the stalk starch. The conspicuous forms are the ovoid to the clam-shell-shaped. There are also rounded triangular, straight or bent, elongated elliptical, elliptical, rod-like, pyriform, and various irregular forms. The grains when seen from the end or edge appear as more or less irregular, elongated ellipses.

The *hilum* is not very distinct. It is a comparatively small, round, non-refractive spot, situated generally very eccentrically, and may be in, but usually to one side, of the median line. It is never fissured, and it may be elongated in a transverse direction. Several grains with double hila were observed.

The *lamellæ* are very distinct, fine rings about the hilum and rather irregular arcs of circles beyond. They are often wavy, or otherwise irregular in outline, owing to the deviations of the surface. Those near the distal end are more distinct and not so fine as those near the hilum. The average number on fairly large grains is from 30 to 45.

Chart No. 321.



Curve of Reaction-Intensities of Starch of Musa cavendishii (green fruit).

The grains vary in *size* from 6 to 70μ. The common size is 35μ.

Polariscopic Properties.—The *figure* is usually very eccentric, fairly distinct, and not well defined. Its lines are apt to be very broad and dim, and may be somewhat bent or otherwise distorted. If the grain is viewed from the end or edge the figure is very clear-cut and distinct.

The degree of *polarization* is low, but distinctly higher than that of the starch of the stalk. It is absent at some points, and very low throughout in some grains, which may be accounted for in part by the thinness of the grains. It is quite high when grains are viewed from the end or edge; in other words, in accordance with the thickness of the starch.

With *selenite* the quadrants are not well defined, very unequal in size, and irregular in shape.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color immediately and deeply a bluish-violet; with 0.125 per cent solution they color lightly immediately, but the color deepens rapidly. The color in both these reactions is deeper than that shown by the stalk-starch. After heating in water until all the grains are completely gelatinized, the solution is slightly colored on the addition of iodine and some grains are colored deeply and others lightly. Some of the latter show a violet-colored capsule. After boiling for 2 minutes the solution is much more deeply colored but the grain-residues much less deeply. With a very slight excess of iodine the capsules are seen to be colored a blue-violet and are much wrinkled and crumpled, but none are disintegrated.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After 30 minutes the color is fairly deep, deeper than that shown by the stalk-starch.

With *safranin* staining begins at once rather lightly, but after 30 minutes it is fairly uniform. There is no difference in the staining of the fruit-starch and the stalk-starch.

Temperature Reaction.—The temperature of gelatinization is 66.5° to 68.5° C., mean 67.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in a minute. All are darkened in 6 minutes. The hilum becomes more prominent. The lamellæ after a preliminary clearing are not entirely obscured. Irregular points on the margin begin to darken, usually at the distal end of sides. The points become joined, as the process spreads, and the hilum is approached. The process may stop on one side of the hilum and then spread inward until the whole grain is affected; or the hilum may swell out at the same time the margin begins to darken; or the hilum may not swell until the process is spreading over the margin, so that the inner portion of the grain, which later becomes affected, may be entirely surrounded by a swollen irregular, gelatinous ring. The gelatinized grains so formed are fairly large, often much sacculated, especially about the hilum, which with two or three adjacent points swell out into a long, irregular, finger-like projection. At the distal end the grain shows concentric dark lines, more or less completely separated by light spaces after the fashion of the arrangement of the lamellæ. The grains may also be irregular and sacculated all around the margin.

The reaction with *chromic acid* begins in 15 seconds and is over in 2½ minutes. The hilum swells out very rapidly in the form of a long, finger-like projection which may or may not be dissolved at one point and open out. The rest of the grain is seen to be crossed by fine radial striæ, which become more and more distinct. The distal end of the grain is divided into a number of concentric crescents, each consisting of not more than 2 lamellæ. These crescents are usually separated serially, then break up into pieces which dissolve, and finally, the reaction reaches the upper part of the grain, which has been divided into large granules by the radial striæ and transverse fissures following the lines of the most prominent, non-refractive lamellæ. These granules dissolve one by one until the grain has disappeared.

Reaction with *pyrogallic acid* begins in a minute and is over in 45 minutes. The hilum and lamellæ become more distinct. The hilum swells slightly and two non-refractive lines extend out on each side, towards the distal end, and widen as the hilum swells. The grain now becomes divided irregularly by many irregular fissures running through the substance in all directions and also by regularly fine, radial striæ. The central part is now converted into a granular mass, the process extending toward the distal end from the hilum. There is thus formed a large, gelatinized grain that is much lobulated, folded, and crumpled, and which does not retain any of the original form of the grain.

The reaction with *ferric chloride* begins in 1½ minutes and is over in 4 minutes. The hilum is prominent and the lamellæ are not obscured. The reaction begins with gelatinization and swelling at one or two points on the margin on one side, followed by the same process at one or two points on the opposite side, or at either end. Other parts of the margin become clear and darker and the process may proceed around it with great swelling and irregular protrusion. The inner portion later becomes divided by fissures and the parts so formed separate quickly and gelatinize independently, accompanied by great and sudden expansion of the whole grain and subsequent invagination and unfolding of one side. Or the process may proceed from the proximal towards the distal end, in which case the grain is marked with folds which follow the lines of the principal lamellæ. The proximal end shows many long, narrow sacculations. A less common method of reaction is the swelling and gelatinization of the hilum and distal end, the central portion being the last to be affected. The gelatinized grains thus formed are essentially like those formed from the starch of the root.

The reaction with *Purdy's solution* begins in 15 seconds and is over in 5 minutes. The hilum and lamellæ are rendered very prominent. Usually the hilum and distal end begin to gelatinize coincidently. The central portion is radially striated and is divided into rows of granules, corresponding to the lamellæ, by transverse fissures which follow the lines of the non-refractive lamellæ. This is followed by the rapid transformation of the granules into a gelatinous mass, accompanied by great swelling of the whole grain. The grains so formed are very large and retain very little of the original form.

STARCH OF MUSA SAPIENTUM OBTAINED FROM THE STALK.

(Plate 79, figs. 473 and 474. Chart 322.)

Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of a few clumps. There are no pressure facets. The outlines of the grains are usually quite irregular, owing to rounded projections and nipple-like processes. The conspicuous forms are the irregularly ovoid, clam-shell-shaped, oyster-shell-shaped, and mussel-shell-shaped, and oval to spindle-shaped. These different forms are modified in various ways, so as to give a most varied assortment of shapes. The grains are very flat, and when seen on edge or end usually appear to be of a narrow, spindle form. Some of the irregularities appear to be due to additions after the grain was nearly fully formed.

The *hilum* is a not very distinct, comparatively small, round, non-refractive spot. It is usually situated very eccentrically, sometimes almost at the extreme proximal end, and in or to one side of the median line. Some elongated, ellipsoidal hila occur, but neither multiple hila nor fissures are seen.

The *lamellæ* are very distinct. They are comparatively fine circles immediately around the hilum. Segments of circles beyond show generally a marked tendency to follow the irregularities of the distal margin; those at the distal end are coarser and more distinct than those near the hilum. The number varies in medium-sized and large grains from 48 to 70.

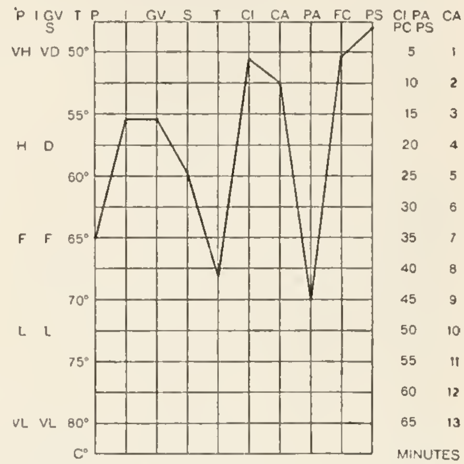
The grains vary in *size* from 9 to 70μ. The common size is 46μ.

Polariscopic Properties.—The *figure* is unusually very eccentric, but neither distinct nor clear-cut; its four lines are generally broad but of unequal width and length. There is commonly more or less bending and distortion due to variations in width and to irregularities of the grains.

The degree of *polarization* is from low to very high in different parts of the grains; as an average fair; on the whole, higher than that of the stalk-starch of *M. cavendishii.* There is also not so much variation in the same aspect of a given grain on account of irregularities, hollows, and ridges on the surface as in the latter. It is high when the grain is seen from the end or edge, and when there is an overlapping of parts of grains.

With *selenite* the quadrants are fairly well defined, but they tend to vary very much in shape and size. The colors are not pure.

Chart No. 322.



Curve of Reaction-Intensities of Starch of Musa sapientum.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color immediately and deeply a bluish-violet, more deeply than that of *M. cavendishii.* With 0.125 per cent solution the grains color immediately but lightly and the color deepens quickly until it is somewhat deeper than that of the stalk-starch of *M. cavendishii.* After heating in water until the grains are completely gelatinized, the solution colors lightly and the grains for the most part deeply on the addition of iodine. The grains are much folded, sacculated, and distorted. Those which do not color deeply show a violet-colored capsule when excess of iodine is added. After boiling for 2 minutes, the solution colors much more deeply and the grain-residues much less. With slight excess of iodine the capsule is colored a blue-violet, and much distorted and crumpled; some contain blue-reacting starch.

Staining Reactions.—With *gentian violet* staining begins immediately rather lightly; deeper, however, than that with the stalk-starch of *M. cavendishii.* After 30 minutes the stain is quite deep, especially about the margin and at the distal end. It is much deeper than the stalk-starch of *M. cavendishii.*

With *safranin* staining begins immediately, but after 30 minutes the stain is fairly deep, although rather deeper than the stalk-starch of *M. cavendishii.* The individual grains are stained evenly, but some grains are stained deeper than others.

Temperature Reaction.—The temperature of gelatinization is 67° to 69° C., mean 68°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute. Most of the grains are darkened in 3 minutes and all in 7 minutes. The hilum is distinct as a dark spot, but the lamellæ are indistinct. The margin darkens at irregular points, usually at the distal end or sides. Frequently the hilum protrudes from the proximal end of the grain at the very beginning of the reaction. The process of swelling and protrusion extends from these points all around the margin, so that an irregular, gelatinized mass surrounds an ungelatinized inner portion, which later is gelatinized. The gelatinized grains so formed are large and very irregular. The distal end shows more or less irregular, broken, concentric, dark semicircles, which are separated by less dark spaces. The upper part shows a dark mass crossed by light fissures. A light-colored saccular protrusion from the distal end of the gelatinized grain represents the swollen grain.

Reaction with *chromic acid* begins in 30 seconds and is over in 2 minutes. The hilum is prominent and the lamellæ are unchanged. The grain becomes divided by fine radial striæ and at the same time the hilum protrudes as a small projection from the end of the grain, accompanied often by two or three swellings at nearby points. The whole grain then swells quickly with the formation of a large, thin-walled, gelatinized mass, and at times a collection of coarsely granular material at the distal end. Finally the capsule of the gelatinized grain becomes dissolved at one point, and the inner, granular, gelatinous mass flows out and is dissolved, solution of the capsule following later.

In other grains the hilum swells and the capsule is dissolved at the proximal end, allowing any broken-down starch to escape. Solution of the rest of the grain follows slowly, the starch apparently being first divided by fine fissures, then broken off and gelatinized, and in this form flowing out into the reagent in which it is dissolved. Rarely concentric crescents separate serially from the distal end, along the lines of the most prominent lamellæ, and dissolve independently.

The reaction with *pyrogallic acid* begins in a minute and is over in 45 minutes. The hilum and lamellæ are very distinct. The hilum begins to swell slowly at first, this accompanied by the appearance of two non-refractive lines, which extend out on each side towards the distal end of the grain. As the hilum swells, these lines appear to open out and become broader. The next step is the dissolution of the rest of the substance of the grain. No one part seens to be affected before another, bnt all melt gradually into a finely granular mass, which later clears and becomes quite homogeneous. As this change goes on, the entire grain swells and is converted into a large, sacculated, folded, and invaginated ovoid mass.

Reaction with *ferric chloride* begins in a minute and is over in 6 minutes. The reaction starts at the margin at one point or at two points, usually at two points opposite one another, and these begin to gelatinize, accompanied with great protrusion, the process extending around the margin, usually towards the proximal end first. The hilum swells out into a long, saccular projection, and many points on the surrounding margin likewise protrude. Finally, the rest of the margin is similarly affected, so that the ungelatinized central portion is completely surrounded by a gelatinous margin with long, irregular projections. This central part becomes divided into several portions by fissures. These portions are separated quickly and dissolve independently of one another. The gelatinized grains are very irregular in outline and often reduced to a large, shapeless, granular mass.

With *Purdy's solution* the reaction begins at once and is over in 1½ minutes. The reaction is so quick that it is difficult or impossible to distinguish clearly the separate steps. It appears to begin usually by enormous swelling of the hilum, followed by rapid gelatinization and swelling of other parts of the grain; or both ends of the grain may gelatinize and swell. The upper portion of the central parts of the grain becomes divided into granules by fine, radial striæ which extend from the now swollen hilum, and also by fissures which appear along the lines of the most prominent lamellæ. This ungelatinized portion quickly swells in every direction and a large, gelatinized grain is formed. The gelatinized grains may exhibit a number of sacculations; or may be merely unfolded and wrinkled; or may show a series of folds following the lines of the lamellæ. Sometimes there is a long, finger-like projection at the distal end.

STARCH OF MUSA ENSETE. (Plate 80, figs. 475 and 476. Chart 323.)

Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of clumps and a few aggregates in the form of doublets. Rarely grains show two or three hila, which appear to have one non-refractive lamella around each, but all inclosed by the outer common lamellæ. There are no pressure facets on the isolated grains. Many of the grains are very irregular in outline, owing to depressions, rounded protuberances, and nipple-like processes. The conspicuous forms are the mussel-shell-shaped, clam-shell and oyster-shell types; also elongated ovoid, elongated oval, rounded triangular, elliptical, straight or bent spindle form, and various irregular forms. The grains are flattened, and when seen on edge or end they are irregular ellipses or spindles, sometimes somewhat pyriform.

The *hilum* is a round or oval, not very distinct, usually non-refractive spot, eccentric about one-sixth to one-fourth, usually one-sixth, of the longitudinal axis. There are sometimes 2 or 3 hila. Occasionally there may be either an arched fissure or an irregular, small cavity at the position of the hilum.

The *lamellæ* are quite distinct, and they are finer but not so distinct in the immediate vicinity of the hilum. In some grains they are quite coarse at the distal margin, in others fine. There are frequently 3 to 5 very coarse and distinct refractive lamellæ. The lamellæ in the elongated ovoid forms may form complete rings about the hilum, but beyond this region they generally assume the form of the outline of the grain and are more or less irregular throughout. They also vary in the coarseness. In some of the larger projections of the grain separate systems of lamellæ seem to have been added after the formation of the main part of the grain. The number is about 48 to 54 on the long slender forms, to 28 to 40 on the broad shell-shaped.

The *size* of the small grains is 10 by 8μ in length and breadth; of the larger elongated grains 44 by 22μ, and of the broad, large grains 30 by 50μ. The common size of the elongated grains is 24 by 14μ, and of the broad grains 26 by 30μ in length and breadth.

Polariscopic Properties.—The *figure* is usually very eccentric, fairly distinct, but not clear-cut. Its lines are from moderately thin to broad, and may be straight, but often bent, or bisected, or distorted because of variations in their width. The figure is better defined when the grain is on edge or end.

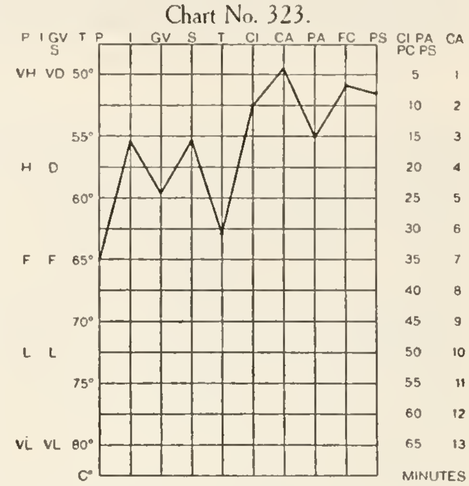
The degree of *polarization* is fair, varying somewhat in different grains and sometimes much in different parts of the same aspect of a grain. It is distinctly higher than in *M. cavendishii* (stalk), and on the whole not so variable.

With *selenite* the quadrants are not clearly defined, are irregular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep blue-violet; with 0.125 per cent solution they color lightly and the color deepens fairly rapidly. It is slightly deeper than that of the grains of *M. cavendishii* (stalk). After heating in water until all the grains are completely gelatinized, the solution colors deeply and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly deeply stained, some more than others. The stain is slightly deeper than that of the grains of *M. cavendishii* (stalk).

Chart No. 323.



Curve of Reaction-Intensities of Starch of Musa ensete.

With *safranin* the grains begin to stain at once and in 30 minutes are deeply stained, some more than others. The color is deeper than that of the grains of *M. cavendishii* (stalk).

Temperature Reaction.—The temperature of gelatinization is 62° to 64° C., mean 63°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds, and all are darkened in 10 minutes. It is the same qualitatively as that of the grains of *M. cavendishii* (stalk).

The reaction with *chromic acid* begins in most grains at once, and in the rest in a few seconds, and is over in 50 seconds. As far as could be determined, it is the same qualitatively as that of the grains of *M. cavendishii* (stalk).

Reaction with *pyrogallic acid* begins in some grains in a few seconds and in all in 15 seconds. Nearly all the grains are completely gelatinized, and the rest nearly completely gelatinized in 5 minutes; and all are gelatinized in 15 minutes. The reaction is the same qualitatively as that of the grains of *M. cavendishii* (stalk).

The reaction with *ferric chloride* begins in a few grains in 20 seconds. Nearly all are gelatinized in 4 minutes and all in 7 minutes. The reaction is the same qualitatively as that of the grains of *M. cavendishii* (stalk).

The reaction with *Purdy's solution* begins in many grains in 15 seconds and in all in 30 seconds. Nearly all are completely gelatinized in 2½ minutes and all in 8 minutes. The reaction is qualitatively the same as that of the grains of *M. cavendishii* (stalk).

Differentiation of Certain Starches of the Genus Musa.

Histological Characteristics.

Conspicuous Forms.

M. cavendishii (stalk): Simple, no pressure facets, flattened, margin irregular owing to depressions, rounded projections, and nipple-like processes. Mussel-shell-shaped and clam-shell-shaped.

M. cavendishii (green fruit): Essentially the same as in the foregoing, except that the mussel-shell-shaped is less prominent.

M. sapientum: Essentially the same as in *M. cavendishii* (stalk), except that the irregular ovoid is the most prominent form.

M. ensete: Essentially the same as in *M. cavendishii* (stalk).

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.

M. cavendishii (stalk): Form small, round, non-refractive, distinct spot. Not fissured; no double or multiple hila noted. Position usually very eccentric.

M. cavendishii (green fruit): Form the same as in the foregoing, except less distinct, and several grains with double hila observed. Position usually very eccentric.

M. sapientum: Form the same as in *M. cavendishii* (stalk), except less distinct. Position usually very eccentric.

M. ensete: Form the same as in *M. cavendishii* (stalk), except less distinct, and occasional double or triple hila. Position usually very eccentric.

Differentiation of Certain Starches of the Genus Musa.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Lamellæ—General Characteristics and Number.

M. cavendishii (stalk): Distinct, fine rings or segments of rings, tend to be wavy and irregular. 35 to 45 on the fairly large grains.
M. cavendishii (green fruit): Same as in the foregoing, but more distinct. 30 to 45 on the larger grains.
M. sapientum: The same as in *M. cavendishii* (stalk), but more distinct. 48 to 70.
M. ensete: The same as in *M. cavendishii* (stalk). 48 to 54.

Size.

M. cavendishii (stalk): From 8 to 80μ, commonly 40μ.
M. cavendishii (green fruit): From 8 to 70μ, commonly 35μ.
M. sapientum: From 9 to 70μ, commonly 46μ.
M. ensete: From 10 to 44μ, commonly 26μ.

POLARISCOPIC PROPERTIES.

Figure.

M. cavendishii (stalk): Usually very eccentric, distinct, not clear-cut, usually irregular.
M. cavendishii (green fruit): Same as the foregoing.
M. sapientum: Same as in *M. cavendishii* (stalk).
M. ensete: Same as in *M. cavendishii* (stalk).

Degree of Polarization.

M. cavendishii (stalk): Low.
M. cavendishii (green fruit): Low, but distinctly higher than in *M. cavendishii* (stalk).
M. sapientum: Fair, higher than in *M. cavendishii.*
M. ensete: Fair, higher than in *M. cavendishii.*

Polarization with Selenite—Quadrants and Colors.

M. cavendishii (stalk): Quadrants not well defined, irregular in shape, and unequal in size. Colors not pure.
M. cavendishii (green fruit): Quadrants same as in *M. cavendishii* (stalk). Colors not pure.
M. sapientum: Quadrants same as in *M. cavendishii* (stalk). Colors not pure.
M. ensete: Quadrants same as in *M. cavendishii* (stalk). Colors not pure.

IODINE REACTIONS.

Intensity and Colors.

M. cavendishii (stalk): Deep; blue-violet.
M. cavendishii (green fruit): Deep, deeper than the foregoing; blue-violet.
M. sapientum: Deep, deeper than in *M. cavendishii;* blue-violet.
M. ensete: Deep, slightly deeper than *M. cavendishii* (stalk); blue-violet.

STAINING REACTIONS.

With Gentian Violet.

M. cavendishii (stalk): Fairly deep.
M. cavendishii (green fruit): Fairly deep, deeper than the foregoing.
M. sapientum: Quite deep, much deeper than in *M. cavendishii* (stalk).
M. ensete: Fairly deep, slightly deeper than in *M. cavendishii* (stalk).

STAINING REACTIONS.—Continued.

With Safranin.

M. cavendishii (stalk): Fairly deep.
M. cavendishii (green fruit): Fairly deep, the same as the foregoing.
M. sapientum: Fairly deep, rather deeper than in *M. cavendishii* (stalk).
M. ensete: Deep, deeper than in *M. cavendishii* (stalk)

TEMPERATURE OF GELATINIZATION.

M. cavendishii (stalk): 67 to 68.5° C., mean 67.75°.
M. cavendishii (green fruit): 66.5 to 68.5° C., mean 67.5°.
M. sapientum: 67 to 69° C., mean 68°.
M. ensete: 62 to 64° C., mean 63°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

M. cavendishii (stalk): Begins in most in 60 seconds. All darkened in 13 minutes.
M. cavendishii (green fruit): Begins in most in 60 seconds. All darkened in 6 minutes.
M. sapientum: Begins in 60 seconds. All darkened in 7 minutes.
M. ensete: Begins in most in 30 seconds. All darkened in 10 minutes.

Reaction with Chromic Acid.

M. cavendishii (stalk): Begins in 30 seconds; complete in 4½ minutes.
M. cavendishii (green fruit): Begins in 15 seconds; complete in 2½ minutes.
M. sapientum: Begins in 30 seconds; complete in 2 minutes.
M. ensete: Begins in most at once; complete in 50 seconds.

Reaction with Pyrogallic Acid.

M. cavendishii (stalk): Begins in 30 seconds; complete in 45 minutes.
M. cavendishii (green fruit): Begins in 60 seconds; complete in 45 minutes.
M. sapientum: Begins in 60 seconds; complete in 45 seconds.
M. ensete: Begins in all in 15 seconds; complete in all in 15 minutes.

Reaction with Ferric Chloride.

M. cavendishii (stalk): Begins in 2½ minutes; complete in 10 minutes.
M. cavendishii (green fruit): Begins in 1½ minutes; complete in 4 minutes.
M. sapientum: Begins in 60 seconds; complete in 6 minutes.
M. ensete: Begins in a few in 20 seconds; complete in 7 minutes.

Reaction with Purdy's Solution.

M. cavendishii (stalk): Begins at once; complete in 4 minutes.
M. cavendishii (green fruit): Begins in 15 seconds; complete in 5 minutes.
M. sapientum: Begins at once; complete in 1½ minutes.
M. ensete: Begins in many in 15 seconds; nearly complete in 2½ minutes, and complete in all in 8 minutes.

NOTES ON THE STARCHES OF MUSA.

The *Musa* starches differ in very minor degree in their gross histology; but in their reactions not only is each species readily differentiated from the others, but also, in case of *M. cavendishii*, the starch of the stalk from that of the green fruit. It is a curious coincidence that the starches of the fruit of *M. cavendishii* and of the stalk of *M. sapientum* are in closer correspondence than the two stalk starches. *M. cavendishii* and *M. sapientum,* in accord with botanical data, are in closer agreement than either with *M. ensete.*

STARCHES OF ZINGIBERACEÆ.

Class, Monocotyledones. Order, Scitaminales. Family, Zingiberaceæ.
Genera represented: Zingiber, Hedychium, Curcuma.

The family *Zingiberaceæ* includes 23 genera and about 315 species, chiefly tropical, and mostly natives of Indian China.

GENUS ZINGIBER.

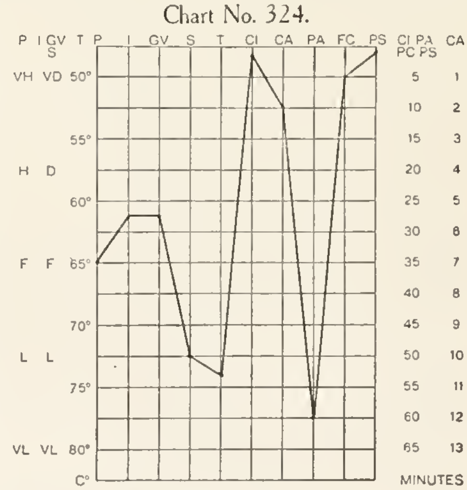
There are about 30 species o^c^ *Zingiber.* Ginger is extensively cultivated throughout tropical Asia, and also in many other tropical countries, particularly in Jamaica and nearby regions. The rhizome of *Zingiber officinale* Rosc. is the officinal ginger of the materia medica. The most esteemed form is Jamaica ginger, which is probably a variety of *Zingiber officinale,* the rhizomes of which are designated commercially black or white in accordance with whether the dark integument is intact or has been scraped off. Starches from four sources were examined, as follows: (1) *Z. officinale* Rosc., the preparation being obtained directly from the rhizome from the Botanical Gardens of the University of Pennsylvania; (2) a preparation made from ground ginger sold commercially as Jamaica ginger; (3) another preparation made from the white rhizomes sold as Jamaica ginger; and (4) another preparation obtained from rhizomes in the materia medica collection of the University of Pennsylvania, marked Cochin ginger, which has been bottled for a period of perhaps over 50 years, and is regarded as a variety of *Z. officinale.*

STARCH OF ZINGIBER OFFICINALE. (Plate 80, figs. 477 and 478. Chart 324.)

The starch was prepared from the fresh rhizome obtained from the Botanical Gardens of the University of Pennsylvania.

Histological Characteristics.—In *form* the grains are simple with the exception of rare compound grains consisting of two components. There are a few clumps, no aggregates, and no pressure facets. The surface tends somewhat to irregularity, due chiefly to small, rounded protuberances and nipple-like projections, the latter especially at the proximal end. The margin of the grain, particularly of the proximal end, may be undulating owing to erosions. The most conspicuous form is a flattened ovoid with a tendency for the whole grain, particularly the proximal end, to be more or less curved along the longitudinal axis. The proximal end is usually more or less pointed, and sometimes this projection is very marked, particularly in grains that have undergone erosion. This end may be so modified as to form a very acute or a very obtuse angle, or all transitional angles. Some of the grains are dome-shaped, triangular, oval, almost square, and in some there is an approach to the clam-shell type. The grains are distinctly flattened, being usually about one-third as thick as broad. In this specimen many grains showed more or less marked erosion at the proximal end.

Chart No. 324.



Curve of Reaction-Intensities of Starch of Zingiber officinale.

The *hilum* is not usually visible, chiefly because of its smallness and its extremely eccentric location, it being situated at the apex of the small point that projects from the proximal end. When it can be seen it is a small round spot, never fissured. Double hila are rare.

The *lamellæ* are very distinct, fine, and regular, and arranged in regular series running transversely to the longitudinal axis as arcs of circles which are in all probability parts of continuous rings. Near the hilum are two usually coarser and more distinct than the others. Occasionally those near the distal end are larger and coarser than those in the middle of the grain, and there are more or less variations in different parts. On a large grain the common number is about 57.

The grains vary in *size* from 7.5 to 64μ. The common size is about 44 by 22μ in length and breadth.

Polariscopic Properties.—The *figure* is extremely eccentric, very distinct, but not sharply defined. Its lines are apt to be broad, of nearly uniform width, but not clear-cut. As a rule only one or two lines are seen. When only one is present it follows closely the longitudinal axis of the grain; but when there are two they are marginal, the part of the grain corresponding to the longitudinal axis being bright.

The degree of *polarization* is fair. It varies according to the position of the grain. It is highest when the grains are observed on end or edge. It varies in different grains, is almost absent in eroded parts, and is higher when grains are overlapped.

With *selenite* the quadrants are fairly well defined. Usually only one or two quadrants are visible, sometimes one and parts of two, and rarely parts of four. The quadrants tend to be quite regular in shape, but are usually unequal in size. The colors are generally fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color fairly deeply a blue-violet; with 0.125 per cent solution the color is light at first, but deepens fairly rapidly. After heating until the grains are completely gelatinized, the solution reacts very lightly and the grains deeply on the addition of iodine. After boiling for 2 minutes, the solution is much more deeply colored, but the grain-residues only slightly. With an excess of iodine, some grains react a dark blue with a violet-colored capsule; others show but little of the blue-reacting substance and a violet-colored capsule.

Staining Reactions.—With *gentian violet* the grains begin to stain at once, but the distal end is much more deeply stained than the rest and a very sharp line of demarcation usually exists between the two parts. After 30 minutes they are fairly deeply stained.

With *safranin* the grains begin to stain at once rather lightly, but even after 30 minutes they are lightly colored, the distal end more deeply than the proximal, although there is not so much difference as when gentian violet is used.

Temperature Reaction.—The temperature of gelatinization is 73.3° to 74.4° C., mean 73.85°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds and is over in 2 minutes. The hilum and lamellæ are obscured. The distal end becomes dark and begins to swell somewhat smoothly, appearing like a cap fitted on the end of the grain. This cap is probably freshly deposited starch. The grains now become dark throughout the distal end, and irregular points on the periphery darken, and swelling and gelatinization proceed from the distal end along the margin of these points, usually along only one side, continuing around the proximal end before extending upward along the other side. When the process has progressed all around the margin, the central portion is invaded and the outer part of the grain becomes a capsule, which contains a mass of gelatinized starch. The gelatinized grains show a smooth, rounded distal end, separated from the swollen cap previously noted. The grain is swollen, and many fine lamellæ are seen, such as would appear in an ungelatinized grain. At the distal end there may be one or more elongated sacculations, and rarely the whole margin may show these irregular protrusions.

The reaction with *chromic acid* begins in 20 seconds and is over in 2 minutes. The hilum swells quickly and protrudes from the end of the grain, the upper part undergoing solution. The lamellæ are very distinct. The cap-like part at the distal end of the grain separates from the rest, becomes as a rule finely granular and swells, and finally is dissolved—sometimes in a manner similar to thatof the major part of the grain. The lamellæ appear to be detached one by one, but there is no definite separation of crescents as in certain starches. This process continues until the grain is entirely dissolved.

With *pyrogallic acid* in 2 minutes there is a reaction in a few grains, and in 30 minutes all show some reaction. After 45 minutes there is practically no further change; the preparation is dried at this time. The hilum and lamellæ are both very clear. The hilum swells slightly and the portion of the grain around it becomes rapidly striated. A line of demarcation in the form of a gradually widening, clear space appears between the cap-like end and the body of the grain, and small fissures extend upward into the grain from the distal end. The main part of the grain appears to be gradually transformed into a gelatinous mass, the inner part going first, the outer appearing as a very distinct, homogeneous wall, which becomes gradually thinner and clearer. The gelatinized grains are fairly large, crumpled, and wrinkled.

Reaction with *ferric chloride* begins in a few grains in 45 seconds and is completed in 5 minutes. The hilum and lamellæ are not visible. The hilum and near-by parts swell greatly with irregular protrusion. In some grains one or two irregular points in the margin also swell. This process extends all around the margin and is characterized by great irregularities. It now extends inward slowly, and sometimes the inner, ungelatinized portion is divided by fissures into separate pieces which swell separately. The gelatinized grains so formed are very large, greatly distorted, folded, crumpled, and sacculated.

With *Purdy's solution* the reaction begins immediately and is over in 1½ minutes. The hilum and one or two contiguous points protrude, fine striæ radiate from the hilum throughout the grain, and the entire substance of the grain is changed gradually into a gelatinous mass. The gelatinized grains are large, ovoid in shape, and often very smooth. Rarely, the two ends of the grain begin to react first, and then the central portion.

STARCH OF ZINGIBER OFFICINALE VAR. JAMAICA No. 1. (Plate 80, figs. 479 and 480. Chart 325.)

The starch was prepared from the ground white rhizomes bought in the open market and sold as Jamaica ginger.

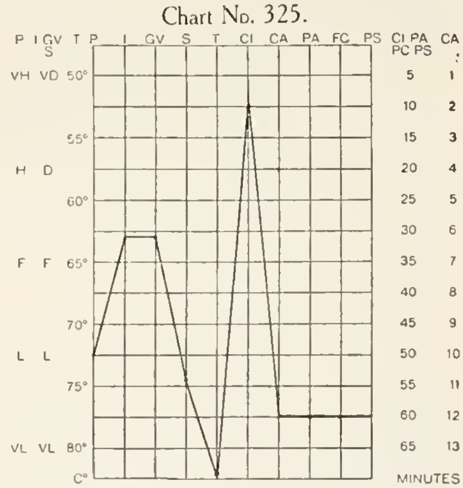
Histological Characteristics.—In *form* the grains are usually simple. There are rare compound grains consisting of two or three components; also a few aggregates and clumps, but no pressure facets. The surface of the grains is smooth and there is not much irregularity of outline. The margin may be marked by small, rounded protuberances, depressions, or nipple-like projections. The most conspicuous forms are the short, broad, ovoid, and oval; also flattened ovoid and oval, nearly circular, approaching the clam-shell type, sugar-loaf, rounded, triangular, and rounded quadrilateral. There is a tendency to a nipple-like protrusion at the proximal end of many grains. The grains are so much flattened that top and bottom sides are almost parallel, and the thickness is about one-fourth of the breadth. There is more or less amorphous foreign matter adherent to some grains.

The *hilum* is not distinct, but usually visible and quite eccentric. It is a small, round spot with two non-refractive lines or fissures which extend outward and downward from it on the sides. Occasionally the hilum shows a small transverse or a 3-armed fissure, not wide or deep or prominent. There are apparently no double hila.

The *lamellæ* are fairly distinct, fine, regular, apparently continuous segments of rings, not showing any irregularities; rarely several may be more prominent than the others. They were not distinct enough in any grain to determine the number accurately.

The grains vary in *size* from 5 to 45μ. The common size is 30μ.

Chart No. 325.



Curve of Reaction-Intensities of Starch of Zingiber officinale var. Jamaica No. 1.

Polariscopic Properties.—The *figure* is very eccentric, distinct, but not clearly defined. Its lines are broad and not sharply defined, and tend to become somewhat wider and less sharply defined as the margin is approached. Two marginal lines are usually the only part of the figure seen; occasionally three or four lines are observed. There may be bending and other irregularity of the figure, due to depressions or elevations on the surface of the grain and to the addition of later deposits of starch at the base of some of the grains, which causes the appearance of a cross-bar connecting the two long lines about two-thirds of the distance from the hilum to the margin.

The degree of *polarization* is low, much lower than in *Z. officinale*. The distal end is apt to be more polariscopic than other parts. Polarization varies with the position of the grain, being much higher when the grain is viewed from the end or side.

With *selenite* the quadrants are not clearly defined, fairly regular in shape, but unequal in size. The colors are not pure, both yellow and blue appearing to be mixed with much red.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, but less than *Z. officinale;* with 0.125 per cent solution the grains tint very lightly and the color deepens slowly, but at no time does it become so deep as that of *Z. officinale*. After heating in water until the grains are completely gelatinized, the solution is colored very lightly and the grains generally deeply. A few grains are colored lightly and these have a violet-colored capsule. After boiling for 2 minutes, the solution is colored much more deeply, the grain-residues somewhat less, and most of them have a violet-colored capsule.

Staining Reactions.—With *gentian violet* the reaction begins immediately rather lightly, and after 30 minutes the stain is fairly deep, deeper in some grains than in others; not so deep as the grains of *Z. officinale.*

With *safranin* staining begins immediately, but very faintly, and even after 30 minutes the grains are lightly stained. There is slightly less coloration than in *Z. officinale.*

Temperature Reaction.—The temperature of gelatinization is 81.7° to 82.8° C., mean 82.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains begin to react in a minute and reaction is complete in 10 minutes. There is no further change within 6 hours. The hilum is usually very distinct as a small, dark spot or bubble. The lamellæ are visible. In the grains that react, the distal end becomes very dark and swells. The hilum swells and protrudes from the top of the grain as a small, rounded knob. From both ends the process of gelatinization extends over the whole grain. Occasionally one of the ends is affected at first. The gelatinized grains are fairly large and appear more or less homogeneous, though they may show some irregular, light cracks or fissures in the central parts.

Reaction with *chromic acid* begins in 1½ minutes and is completed in 20 minutes. The hilum becomes very distinct, but the lamellæ are invisible. The central portions of the grain, extending from the hilum to the distal end, become divided irregularly by many small fissures which gradually widen until this part is transformed into an irregular, granular mass. The more resistant starch at the margin forms a wall, which is especially thick at the sides of the grain and is usually quite homogeneous, though it may be crossed irregularly by striæ. The distal end is dissolved and the granular starch pours out and is dissolved; the proximal end disappears; and, finally, the resistant starch at the sides goes into solution.

The reaction with *pyrogallic acid* begins in a few grains in 2 minutes, but after 20 minutes a few grains are partially gelatinized, and one or two are completely gelatinized. (The preparation dried in about 45 minutes.) The hilum is always distinct and the lamellæ are distinct throughout the grain. The grain is altered into a gelatinous mass, beginning at the hilum. The more resistant starch at the margin forms at first a homogeneous wall, through which are seen wedge-shaped fissures. This wall or capsule gradually becomes clear and thinner, but apparently never entirely disappears. The gelatinized grains so formed are large, irregular in outline, somewhat sacculated, wrinkled, and involuted.

The reaction with *ferric chloride* begins in 2½ minutes and is practically over in 1¼ hours. (A few grains near the edge of the cover-slip apparently never become completely gelatinized.) The hilum is prominent as a dark spot or bubble. The lamellæ are invisible. In general, the reaction appears to consist of the homogeneous dissolution and swelling of the entire grain, without the formation in most cases of a definite capsule. In some grains the inner portion from the hilum to the distal end is divided by irregular fissures, becomes granular, and forms a well-marked capsule, which later disappears. The gelatinized grains formed by these processes, which are not very different fundamentally, are large, folded, crumpled, and shapeless.

After 2 hours there is no reaction with *Purdy's solution.*

STARCH OF ZINGIBER OFFICINALE VAR. JAMAICA No. 2. (Plate 80, figs. 479 and 480. Chart 326.)

The starch was prepared from white rhizomes bought in the open market as Jamaica ginger.

Histological Characteristics.—In *form* the grains are simple. No compound grains, aggregates, or pressure facets were noted, but there are many clumps. The grains tend to be quite regular in outline, though some of them have a small, pointed projection at the top of the grain. The most conspicuous grains are ovoid, somewhat narrowed at the proximal end; also short, elliptical forms, oval, rounded triangular, rounded quadrangular, circular, and a few approaching the clam-shell type. The grains are about one-fourth as thick as broad and usually appear as narrow, flattened, elongated ellipses when seen on edge.

The *hilum* is a medium-sized spot, fairly distinct, round and non-refractive. It is very eccentric, but not at the very edge of the grain, as in *Z. officinale,* and it is usually in or near the median line. There is often a non-refractive line on each side, extending out towards the distal end. It is not fissured and there are no double or multiple hila.

The *lamellæ* are not usually visible. When they can be seen they are very faint and appear to be regular, fine arcs of circles, commonly quite uniform in size and distinctness. Rarely one or two were coarser and more distinct than the others. They are so faint that it is impossible to count them with any accuracy.

The grains vary in *size* from 4 to 42μ. The common size is about 28μ.

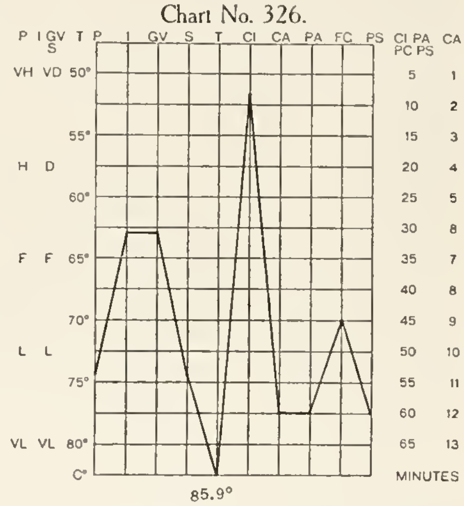
Polariscopic Properties.—The *figure* is distinct, but not clearly defined. Its lines are usually thick and the edges are dim. The lines are not bent or otherwise distorted.

The degree of *polarization* is low. It is lower in *Z. officinale* and *Z. officinale* var. *jamaica* No. 1. When the grains are viewed from the edge or from the end they appear highly polariscopic.

With *selenite* the quadrants are not especially well defined, are unequal in size, regular in shape. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color immediately a fairly deep blue-violet, not so deep as *Z. officinale* and about the same as *Z. officinale* var. *jamaica* No. 2; with 0.125 per cent solution they tint lightly at once and the tint deepens slowly. After heating in water until the grains are completely gelatinized, the solution is somewhat colored and the grains fairly deeply by the addition of iodine. Some show a violet capsule. After boiling for 2 minutes the grain-residues are less deeply colored, but the solution much more deeply. All the grains show a violet capsule, and there are capsules which do not retain any blue-reacting starch.

Chart No. 326.



Curve of Reaction-Intensities of Starch of Zingiber officinale var. Jamaica No. 2.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after 30 minutes are all fairly deep, some more than others. The coloration is lighter than in *Z. officinale.*

With *safranin* the grains begin to stain lightly in a minute, but slowly, so that at the end of 30 minutes they are only lightly stained. The color is less than that of *Z. officinale.*

Temperature Reaction.—The temperature of gelatinization is 85.5° to 86.3° C., mean 85.9°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in most grains in 45 seconds and is complete in all in 8 minutes. The hilum is very distinct as a dark bubble or spot. The lamellæ are invisible. The margin, as in most other starch-grains, becomes darker and clearer. Irregular points at the distal end and sides of the grain now darken and protrude. The hilum at this time frequently swells out into a small knob. From these points the process extends over the whole grain, smoothly and without any more swelling at one point than at another. There is in the grains occasionally a perpendicular fissure which extends from the swollen hilum almost to the distal end of the grains. The grains are uniformly dark and show resemblance to the original form of the grain.

The reaction with *chromic acid* begins in 2 minutes and is over in 13 minutes. The hilum becomes very prominent, and the lamellæ may be made out dimly. As the hilum swells slightly, fine striæ appear which radiate throughout the grain, growing coarse and more distinct. In the majority of the grains the whole interior now changes into a gelatinous, finely granular mass inclosed in a thin capsule, which dissolves at one point and opens out, thus allowing the gelatinized starch of the inside to flow out and dissolve. The remaining portion of the capsule dissolves slowly. In a few grains the hilum swells out quickly before other parts of the grain react in any way, and following its solution the rest of the grain disappears, the gelatinous starch flowing out of the opening at the hilum.

Reaction with *pyrogallic acid* begins in some grains in 3 minutes and about half the number are partially gelatinized in 35 minutes. The hilum is prominent and some fine lamellæ may be seen. The hilum swells somewhat and fine striæ appear radiating throughout the grain. The entire grain now appears to be transformed into a finely granular, gelatinous mass which gradually expands, forming a large mass with a thin capsule. This capsule does not show many folds, lines, or wrinkles.

The reaction with *ferric chloride* begins in a few grains in 3 minutes. It is general in about 15 minutes, when about one-fourth are completely gelatinized. The reaction is over in 45 minutes.

The hilum is very distinct as a dark spot or bubble. A line of irregular fissures extends down the middle of the grain from the hilum to the base, and as the grain swells the inner portion is converted into a gelatinous, finely granular mass. Reaction occurs most rapidly at and near the distal end. The gelatinized grains so formed are usually large, smooth, rounded, sometimes irregular, sacculated, and wrinkled. Many retain some of the original form of the grain.

With *Purdy's solution* there is some reaction in many grains within 15 minutes and after 3 hours most of the grains are swollen, but none completely gelatinized. The hilum is very distinct and the lamellæ may be made out. The hilum swells somewhat, and there is splitting and fissuring of the grain and generally swelling.

STARCH OF ZINGIBER OFFICINALE VAR. COCHIN. (Plate 81, figs. 481 and 482. Chart 327.)

The starch was prepared from rhizomes deposited in the Materia Medica Museum of the Medical School of the University of Pennsylvania. It is a very old specimen, having been in the museum for probably 50 years or more.

Histological Characteristics.—In *form* the grains are usually simple, with a few compound grains, many clumps, no aggregates, and no pressure facets. The surface is quite smooth and tends to be quite regular. Nipple-like processes are common. The most conspicuous form is the flattened ovoid, which often has a small, pointed projection at the proximal end; also oval, elliptical, circular, and various irregular shapes, a few of which approach the clam-shell type. The grains are much flattened, and are about one-third as thick as broad. On edge they appear as long, flattened, narrow ellipses.

The *hilum* is rarely visible and it appears as a small, round, non-refractive spot situated very eccentrically, almost at the edge. It shows in some grains two non-refractive lines which extend outward and downward from it, one on each side, but it is not fissured. It is usually in the median line and it may occasionally be double.

The *lamellæ* are very indistinct, and when seen they appear as fine, regular arcs of circles, probably continuous; the hilum is so eccentric that it is difficult to determine whether they are continuous or not. There are probably very many on one grain, some more prominent than others. The projections and mammary processes from the surface of the grains are included in the structure of the original grain.

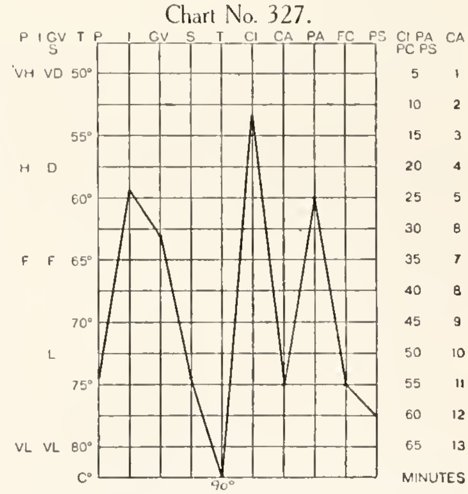
The grains vary in *size* from 5 to 40μ. The common size is 28μ.

Polariscopic Properties.—The *figure* is very eccentric, fairly distinct, though its lines are rather broad and margins dim. Only one or two lines are usually seen. If one line, it is in or near the median line, but if there are two they are placed marginally. Parts of other lines may also be seen in some grains.

The degree of *polarization* is low, lower than that of *Z. officinale* and about the same as that of *Z. officinale* var. *jamaica* No. 2. There is not much difference in different grains. When the grains are viewed from the end or edge it is high.

With *selenite* the quadrants are not well defined, are fairly regular in shape, and unequal in size. Usually but two quadrants are visible, or one with parts of two.

Chart No. 327.



Curve of Reaction-Intensities of Starch of Zingiber officinale var. Cochin.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains react readily and become a fairly deep blue-violet; with 0.125 per cent solution the grains color very lightly. The reaction is somewhat deeper than in *Z. officinale.* After heating in water until the grains are completely gelatinized, the solution is colored fairly well and the grain fairly deeply on the addition of iodine. Many of the grains have a violet-colored wall. After boiling 2 minutes the solution is colored very deeply and the grain-residues very lightly or not at all. When an excess of iodine is added the capsules appear violet-colored.

Staining Reactions.—With *gentian violet* the grains begin to stain in less than a minute and after 30 minutes the stain is fairly deep, not quite so deep as that of the grains of *Z. officinale.*

With *safranin* the grains begin to stain in a minute. After 30 minutes they are lightly stained, slightly less than in *Z. officinale.*

Temperature Reaction.—The temperature of gelatinization is 89.5° to 90.5° C., mean 90°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some of the injured grains in 30 seconds and these are completely darkened, though not fully swollen, in 3 minutes. The reaction begins in the intact grains in 2½ minutes and is complete in all in 10 minutes. The hilum is prominent as a dark spot. The grain becomes clearer and darker around the margin, the lower portion darkens and swells somewhat and the process extends upward over the other parts of the grain. It usually spreads more rapidly up the margin than over the central portion. Sometimes the distal end becomes dark and the hilum swells at the same time. The reaction then extends over the grain from these two points. After the grains are darkened, they swell, and irregular fissures appear. There is usually a very light space of varying shape at the proximal end, representing the swollen hilum. After 2 or 3 hours the grain often shows a transverse fissure which nearly separates the grain into 2 parts.

Reaction with *chromic acid* begins in 2 minutes and is complete in 11 minutes. The hilum is very distinct and also some of the lamellæ. Two non-refractive lines extend outward and downward on either side of the hilum, thus outlining an inner, fan-shaped area, which becomes divided into granules by many fine fissures which are very wide at the proximal end. The whole mass becomes gelatinized. The marginal starch above the hilum is more resistant and appears as a broad, quite homogeneous band. The gelatinized grain so formed is now dissolved at one point, usually the distal end. The gelatinous starch inside flows out and is dissolved. The more resistant, marginal starch in the region of the hilum dissolves more slowly and finally the entire grain has disappeared.

The reaction with *pyrogallic acid* begins in about 5 minutes in those grains which are not underneath the cover-slip, and all of these are completely gelatinized in 20 to 25 minutes. Those underneath the cover-slip do not react. The hilum is prominent, and the lamellæ may be made out in some grains. The inner part of the grain may either be changed into a gelatiuous mass or it may be divided by a perpendicular irregular fissure and the grain be broken up into granules which become a gelatinous mass, the result beiug the same as that of the first method. The gelatinized grains so formed are thin-walled, large, somewhat irregular, but rounded in outline and without much wrinkling and folding.

With *ferric chloride* the reaction begins in a few in 3 minutes and is complete in all in 55 minutes. The hilum is prominent, but the lamellæ can not be seen. The whole interior of the grain is changed into a gelatinous, granular mass and swells out, forming a large, irregular, thin-walled mass, which is at first smooth and rounded; later the capsule becomes wrinkled and folded. In some grains a number of irregular fissures may extend from the hilum to the distal end, along the longitudinal axis, and subsequent to this the inner portion of the grain becomes a gelatinous mass, with swelling, and the final formation of a large gelatinized grain.

There is no reaction to *Purdy's solution* after 2 hours.

Differentiation of Certain Starches of the Genus Zingiber.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

Z. officinale: Usually simple, rarely compound, no aggregates, no pressure facets, surface somewhat irregular owing to small rounded protuberances and nipple-like projections, the latter especially at proximal end, flattened, flattened ovoid, curved longitudinally, especially the proximal end, proximal end usually pointed.

Z. officinale var. *Jamaica No. 1:* Essentially the same as in *Z. officinale,* except that the conspicuous grains are short, broad ovoid and oval.

Z. officinale var. *Jamaica No. 2:* Essentially the same as in *Z. officinale* var. *Jamaica No. 1.*

Z. officinale var. *Cochin:* Essentially the same as *Z. officinale* var. *Jamaica No. 1.*

Hilum—Form, Number, and Position.

Z. officinale: Form not usually visible, small round spot, never fissured. No double hila. Position extremely eccentric.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Hilum—Form, Number, and Position.—Continued.

Z. officinale var. *Jamaica No. 1:* Form not distinct, small round spot, occasionally slightly fissured, no double hila. Position very eccentric.

Z. officinale var. *Jamaica No. 2:* Form fairly distinct, medium-sized round spot, not fissured, no double hila. Position very eccentric.

Z. officinale var. *Cochin:* Form rarely visible, small round spot, not fissured, occasionally double hila. Position very eccentric.

Lamellæ—General Characteristics and Number.

Z. officinale: Very distinct, fine, regular. About 57.

Z. officinale var. *Jamaica No. 1:* Fairly distinct, fine, regular. Not determined.

Z. officinale var. *Jamaica No. 2:* Usually not visible; fine, regular. Number not determined.

Z. officinale var. *Cochin:* Very indistinct, fine, regular. Number not determined.

Differentiation of Certain Starches of the Genus Zingiber.—Continued.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Size.

Z. officinale: From 7.5 to 64μ, commonly 44μ.
Z. officinale var. *Jamaica No. 1:* From 5 to 45μ, commonly 30μ.
Z. officinale var. *Jamaica No. 2:* From 4 to 42μ, commonly 28μ.
Z. officinale var. *Cochin:* From 5 to 40μ, commonly 28μ.

POLARISCOPIC PROPERTIES.

Figure.

Z. officinale: Extremely eccentric, very distinct and not sharply defined. Usually only 1 or 2 of the 4 lines of the figure are visible.
Z. officinale var. *Jamaica No. 1:* Essentially the same as in *Z. officinale,* but less eccentric.
Z. officinale var. *Jamaica No. 2:* Essentially the same as in *Z. officinale,* but less eccentric.
Z. officinale var. *Cochin:* Essentially the same as in *Z. officinale,* but less eccentric.

Degree of Polarization.

Z. officinale: Fair.
Z. officinale var. *Jamaica No. 1:* Low.
Z. officinale var. *Jamaica No. 2:* Low, lower than in *Z. officinale* var. *Jamaica No. 1.*
Z. officinale var. *Cochin:* Low, the same as in *Z. officinale* var. *Jamaica No. 2.*

With Selenite.

No marked differences.

IODINE REACTIONS.

Intensity and Color.

Z. officinale: Fairly deep; blue-violet.
Z. officinale var. *Jamaica No. 1:* Fairly deep, less than in *Z. officinale;* blue-violet.
Z. officinale var. *Jamaica No. 2:* Fairly deep, less than in *Z. officinale* var. *Jamaica No. 1;* blue-violet.
Z. officinale var. *Cochin:* Fairly deep, deeper than in *Z. officinale;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

Z. officinale: Fairly deep.
Z. officinale var. *Jamaica No. 1:* Fairly deep, but less than in *Z. officinale.*
Z. officinale var. *Jamaica No. 2:* Fairly deep, but less than in *Z. officinale.*
Z. officinale var. *Cochin:* Fairly deep, but less than in *Z. officinale.*

With Safranin.

Z. officinale: Light.
Z. officinale var. *Jamaica No. 1:* Light, slightly less than in *Z. officinale.*
Z. officinale var. *Jamaica No. 2:* Light, less than in *Z. officinale.*

STAINING REACTIONS.—Continued.

With Safranin.—Continued.

Z. officinale var. *Cochin:* Light, slightly less than in *Z. officinale.*

TEMPERATURE OF GELATINIZATION.

Z. officinale: 73.3 to 74.4° C., mean 73.85°.
Z. officinale var. *Jamaica No. 1:* 81.7 to 82.8° C., mean 82.25°.
Z. officinale var. *Jamaica No. 2:* 85.5 to 86.3° C., mean 85.9°.
Z. officinale var. *Cochin:* 89.5 to 90.5° C., mean 90°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

Z. officinale: Begins in most in 30 seconds; complete in all in 2 minutes.
Z. officinale var. *Jamaica No. 1:* Begins in 1 minute; complete in all in 10 minutes.
Z. officinale var. *Jamaica No. 2:* Begins in most in 45 seconds; complete in all in 8 minutes.
Z. officinale var. *Cochin:* Begins in 2½ minutes; complete in all in 10 minutes.

Reaction with Chromic Acid.

Z. officinale: Begins in 20 seconds; complete in 2 minutes.
Z. officinale var. *Jamaica No. 1:* Begins in 1½ minutes; complete in 20 minutes.
Z. officinale var. *Jamaica No. 2:* Begins in 2 minutes; complete in 13 minutes.
Z. officinale var. *Cochin:* Begins in 2 minutes; complete in 11 minutes.

Reaction with Pyrogallic Acid.

Z. officinale: Begins in most in 2 minutes; all partially gelatinized in 35 minutes.
Z. officinale var. *Jamaica No. 1:* Begins in a few in 2 minutes; a few partially gelatinized in 20 minutes.
Z. officinale var. *Jamaica No. 2:* Begins in some in 3 minutes; about half partially gelatinized in 35 minutes.
Z. officinale var. *Cochin:* No reaction.

Reaction with Ferric Chloride.

Z. officinale: Begins in 45 seconds; complete in 5 minutes.
Z. officinale var. *Jamaica No. 1:* Begins in 2½ minutes; partially complete in 1¼ hours.
Z. officinale var. *Jamaica No. 2:* Begins in 3 minutes; complete in 45 minutes.
Z. officinale var. *Cochin:* Begins in a few in 3 minutes; complete in 55 minutes.

Reaction with Purdy's Solution.

Z. officinale: Begins at once; complete in 1½ minutes.
Z. officinale var. *Jamaica No. 1:* No reaction after 2 hours.
Z. officinale var. *Jamaica No. 2:* Begins in some in 15 minutes; most are affected after 3 hours.
Z. officinale var. *Cochin:* No reaction after 2 hours.

NOTES ON THE STARCHES OF ZINGIBER.

The starch of *Z. officinale* differs in histology and in reactions from the specimens of Jamaica ginger which are marketed as *Z. officinale;* and both of these in turn from *Z. officinale* var. *Cochin.* The true *Z. officinale* is particularly distinguished by the conspicuousness of the nipple-like proximal end, the distinct lamellæ, and average greater size. Cochin ginger bears a closer resemblance to *Z. officinale* than to the Jamaica gingers. In their reactions *Z. officinale* likewise stands apart, and the Jamaica and Cochin gingers have relationships which, on the whole, are in accord with those of their histology. The high temperature of gelatinization of the Jamaica and Cochin gingers is notable (82.25°, 85.9°, and 90°), especially of the latter, which is the highest record of any starch yet examined. The comparatively great resistance shown by the Jamaica and Cochin gingers in comparison with *Z. officinale* in the reactions with the chemical reagents is very marked.

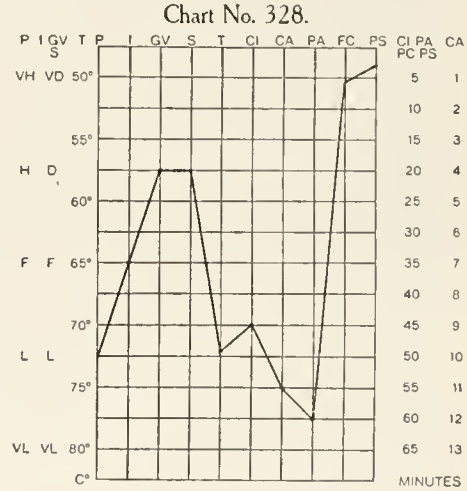
GENUS HEDYCHIUM.

This genus includes about 25 species of rhizomatous plants, natives of tropical Asia, many of them being found in India. Some are in cultivation, chiefly as green-house plants, and are popularly known as the garland flower, the butterfly lily, and the ginger lily. Starches from 2 species, both natives of India, were studied: *H. coronarium* Kœnig and *H. gardnerianum* Roscoe. The starch of the latter we were not able to free entirely from foreign matter.

STARCH OF HEDYCHIUM CORONARIUM. (Plate 81, figs. 483 and 484. Chart 328.)

Histological Characteristics.—In *form* the grains are simple, with the exception of rare compound grains of two components. There are no aggregates and no pressure facets, and there are few clumps. The surface is rounded, and tends to an irregularity of outline, owing chiefly to nipple-like projections, especially at the proximal end. The conspicuous form is that of a flattened ellipse with the pointed proximal end which is usually bent laterally; also triangular, spindle-shaped, pyriform, nearly circular, approaching the clam-shell type, and various irregular forms. The grains generally tend to be more or less bent along the longitudinal axis, especially the proximal end; many exhibit the effects of erosion of the proximal end, which may be very limited or extend to or beyond the middle. The grains are distinctly flattened, being about one-fourth as thick as broad. When on edge they are very slender and spindle-shaped, and often curved and irregular.

Chart No. 328.



Curve of Reaction-Intensities of Starch of Hedychium coronarium.

The *hilum* is always invisible in the simple grains, probably because it is situated at the extreme tip of the pointed projection of the end of the grain. In some of the rare compound grains a small, round, indistinct hilum may be seen in the median line in each of the two parts of the grain. The hilum in these grains is extremely eccentric.

The *lamellæ* are distinct, fine, regular arcs of circles, probably continuous. They follow closely the outline of the distal end. They vary much in distinctness, those at the distal end generally appearing to be the most distinct and the coarsest. There are about 58 to 60 on the larger grains.

The grains vary in *size* from 8 to 62μ. The dimensions of the most conspicuous grains average about 48 by 20μ. The common length is about 42μ.

Polariscopic Properties.—The figure is extremely eccentric, fairly distinct, but not clear-cut. Usually only one line of the figure is seen, occasionally two. The lines are broad and not sharply defined, and in some grains are joined by a cross-line at about two-thirds of the distance from the hilum to the distal end.

The degree of *polarization* is low. It varies in different grains and even in different parts of the same grain, and according to the aspect of the grain. When the grains are viewed on end or on edge, polarization is quite high.

With *selenite* the quadrants are not well defined, are irregular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once a bluish-violet fairly well; with 0.125 per cent solution the grains color lightly at first, and then slowly deeper. After heating in water until the grains are completely gelatinized, the solution colors deeply and the grains deeply to very deeply on the addition of iodine. After boiling for 2 minutes, the solution colors much more deeply and the grain-residues somewhat less. The grains are much swollen and distorted, and with an excess of iodine many of the more lightly colored show a dark-violet capsule.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and after 30 minutes are deeply stained.

Temperature Reaction.—The temperature of gelatinization is 71.5° to 73.1° C., mean 72.3°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 30 seconds; most are darkened in 5 minutes, and all in 10 minutes, and the reaction is complete in 45 minutes. They begin to darken at the distal end and at the ends of any projections from the surface. The hilum swells out as a little knob, and this becomes joined with other like swellings, so that the whole margin becomes swollen and dark. The process usually extends along one side more rapidly than the other. There is not often a very sharp line of demarcation between the swollen and unswollen portions. The unswollen central part of the grain is quickly involved, but the swelling as a whole is not great. The gelatinized grains when first formed are fairly large and somewhat distorted, owing to the enlargement, twisting, and bending of the various projections from the margin, and of a uniform dark color. After a little time the lower portion separates partially from the rest of the grain and is seen to have a somewhat lamellated structure.

With *chromic acid* the grains begin to react in 15 seconds, and reaction is over in 11 minutes. The hilum protrudes from the top, and the grain shows on its surface long, irregular indentations which later become irregular fissures. The lower end of the grain becomes fissured and granular, and separates off bodily from the upper part, soon dissolving entirely; the remaining part divides into rows of coarse granules in part by the irregular fissures before mentioned, and also by the other fissures which extend transversely in the direction of the principal lamellæ. The parts separated by the latter fissures do not appear to separate serially from the grain, but the whole grain becomes gradually thinner and more transparent until it disappears entirely.

With *pyrogallic acid* a few grains begin to react in 1½ minutes; there is practically no further change after an hour, except in the grains outside the cover-slip. The hilum (when it can be seen at all) and the lamellæ become very prominent. The hila of grains outside the cover-slip may swell somewhat, such exposed grains all becoming gelatinized in a very short time. In such grains the process appears to consist in the swelling of the hilum, the invasion of the distal part of the grain by many irregular fissures, and the gelatinization and swelling of this part. The gelatinized grains are large and irregular in outline. The distal end shows a number of concentric folds arranged somewhat like the lamellæ. The grains under the cover-slip show no change after 25 minutes except that they become clearer and more transparent; the lamellæ more distinct; and the distal end of the grain often partly separated from the rest, as if it were a cap adherent to the grain but not an integral part of it.

Reaction with *ferric chloride* is general in 30 seconds and complete in 6 minutes. The hilum and one or two points nearby swell in long, finger-like projections. The rest of the grain, having been divided by irregular longitudinal striæ and transverse fissures into granules, is converted into a granular mass, with great swelling and much distortion. The distal end often separates, or partially separates, from the main body and appears to gelatinize independently. The gelatinized grains are very large, much distorted, folded, and bent. The lower portion shows lamella-like rows of folds of the capsule.

The reaction begins at once with *Purdy's solution* and is over in 3 minutes. The hilum and one or two contiguous points protrude. The grain becomes divided by fine radiating striæ and the entire substance is changed into a gelatinous mass, inclosed by a thin, transparent capsule. The gelatinized grains are large and ovoid in shape, and the capsule or outer part is smooth.

STARCH OF HEDYCHIUM GARDNERIANUM. (Plate 81, figs. 485 and 486. Chart 329.)

Histological Characteristics.—In *form* the grains are simple with the exception of rare compound grains consisting of two components. There are no aggregates or pressure facets, and little tendency to form clumps. The surface is rounded, with a marked tendency to irregularities of the margin, due chiefly to nipple-like projections, especially from the proximal end. The grains are quite varied in form, very much more than in *H. coronarium.* The conspicuous forms belong to the clam-shell type and the flattened, elliptical type with a pointed proximal end; also ovoid, pyriform, triangular, spindle form, and various irregular forms. The grains are much flattened, and on an average are from one-fifth to one-fourth as thick as wide. When seen on edge they are spindle-shaped.

The *hilum* is generally not visible, due probably to its extreme eccentricity. In some double grains a faint, very eccentric hilum may be discerned in each of the components, which is very small and round, and situated in the median line. The hilum is never fissured.

The *lamellæ* are fairly distinct, regular, fine arcs of circles which are probably continuous and follow closely the outline of the distal end. Those nearer the distal end are usually coarser and more distinct than those near the hilum. There are about 30 lamellæ on the larger grains.

The grains vary in *size* from 5 to 42μ. The dimensions of the clam-shell-shaped grains are on an average 26 by 17μ in length and breadth, and those of the elliptical grains 36 by 28μ in length and breadth. In the two forms the long and short diameters are reversed in relation to the longitudinal and transverse diameters. The common size is about 28μ.

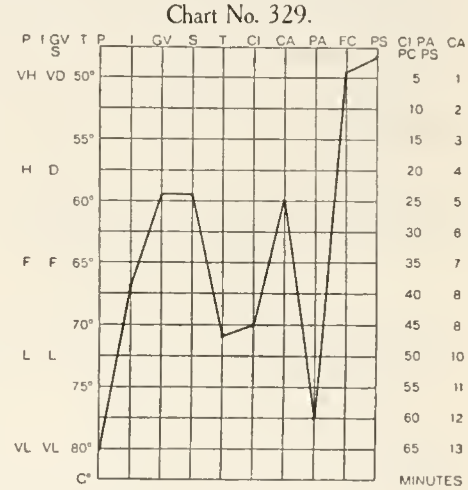
Polariscopic Properties.—The *figure* is extremely eccentric, not distinct, and not clear-cut. Usually only one and sometimes two lines are visible and they are usually broad and blurred, especially when near the margin, and sometimes bent and distorted. Rarely a grain is observed in which all four lines of the figure are seen.

The degree of *polarization* is very low, much lower than in the grains of *H. coronarium.* It appears very high in the grains on end or edge, but does not vary much in different grains nor in a given aspect of a grain.

With *selenite* the quadrants are not well defined, are variable in shape and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a blue-violet fairly well, but not so deeply as the grains of *H. coronarium;* with 0.125 per cent solution the grains react lightly at once and the color deepens somewhat. After heating in water until the grains are completely gelatinized, the solution colors rather lightly and the grains very deeply with iodine. After boiling for 2 minutes the solution colors much more deeply and the grain-residues less deeply. When an excess of iodine is added most of the capsules show a dark-violet coloration. The color is lighter than in *H. coronarium.*

Chart No. 329.



Curve of Reaction-Intensities of Starch of Hedychium gardnerianum.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and after 30 minutes are deeply stained. The color is slightly less than that of *H. coronarium.*

Temperature Reaction.—The temperature of gelatinization is 70.2° to 72.1° C., mean 71.15°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction starts in most grains in 15 to 30 seconds; all are darkened in 3 minutes and the reaction is complete in 45 minutes. The nipple-like projections and the distal end darken and swell. These parts become joined about the margin by progressive action, so that there is formed a somewhat swollen gelatinous ring inclosing a non-gelatinized center, which latter finally becomes involved in the reaction. There is usually a sharp line of demarcation between the swollen and the unswollen portions. The whole grain then swells until a fairly large, uniformly dark, gelatinous mass is formed, which is somewhat distorted owing to the swelling and bending of the nipple-like projections; otherwise the gelatinized grain retains much of the original form.

With *chromic acid* the reaction begins at once in most grains and is completed in 5 minutes. The hilum becomes prominent and then swells. The portion of the grain between the hilum at the distal end is divided by irregular fissures, then passes into a gelatinous mass. The grains continue to swell, the capsule at the proximal end dissolves, the inner granular material flows out and is dissolved, and then the rest of the capsule disappears.

There is reaction with *pyrogallic acid* in one-fifth in a minute, but it apparently consists in only a gradual fading of the lamellæ, an increasing transparency of the grain, and occasionally a slight swelling of the hilum and body of the grain. In about 25 minutes these grains show some swelling and a partial gelatinization of the body of the grain.

Reaction with *ferric chloride* is general in 30 seconds, and is over in 4 minutes. The reaction consists in the swelling of the hilum and its protrusion as a more or less irregular projection from the proximal end of the grain, usually accompanied by one or two similar protrusions from nearby points. The body of the grain becomes divided by irregular fissures into granules which are transformed into a gelatinous mass, and the whole grain swells. The gelatinized grains so formed are large, lobulated, and irregular at the top, and folded in irregular lamella-like folds at the base. They retain but little of the original form of the grain.

The reaction with *Purdy's solution* begins immediately and is over in 1½ minutes. The hilum protrudes, the inner portion is converted rapidly into a gelatinous mass, and the grain swells. The gelatinized grains so formed are smooth, as a rule, and retain some of the original form.

Differentiation of Certain Starches of the Genus Hedychium.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

H. coronarium: Usually simple, rare compounds, surface may be irregular owing chiefly to nipple-like projections, flattened. Flattened ellipses with pointed proximal end which commonly is curved.
H. gardnerianum: Essentially the same as in *H. coronarium*, but conspicuous forms belong to the clam-shell type and flattened elliptical type.

Hilum—Form, Number, and Position.

H. coronarium: Form invisible in simple grains; small, round, single, and indistinct in compound grains; not fissured. Position extremely eccentric.
H. gardnerianum: Form the same as in *H. coronarium*. Position extremely eccentric.

Lamellæ—General Characteristics and Number.

H. coronarium: Distinct, fine, regular arcs of circles. 58 to 60.
H. gardnerianum: Fairly distinct, fine, regular arcs of circles. 30.

Size.

H. coronarium: From 8 to 62μ, commonly 42μ.
H. gardnerianum: From 5 to 42μ, commonly 28μ.

POLARISCOPIC PROPERTIES.

Figure.

H. coronarium: Extremely eccentric, fairly distinct, not clear-cut.
H. gardnerianum: Extremely eccentric, not distinct or clear-cut.

Degree of Polarization.

H. coronarium: Low.
H. gardnerianum: Very low, lower than in *H. coronarium*.

Polarization with Selenite—Quadrants and Colors.

H. coronarium: Quadrants not well defined, irregular in shape, and unequal in size. Colors not pure.
H. gardnerianum: Quadrants the same as in *H. coronarium*. Colors not pure.

IODINE REACTIONS.

Intensity and Color.

H. coronarium: Fair; blue-violet.
H. gardnerianum: Fair, less than in *H. coronarium;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

H. coronarium: Deep.
H. gardnerianum: Deep, slightly less than in *H. coronarium*.

With Safranin.

H. coronarium: Deep.
H. gardnerianum: Deep, but less than in *H. coronarium*.

TEMPERATURE OF GELATINIZATION.

H. coronarium: 71.5 to 73.1° C., mean 72.3°.
H. gardnerianum: 70.2 to 72.1° C., mean 71.15°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

H. coronarium: Begins in most in 30 seconds; complete in 45 minutes.
H. gardnerianum: Begins in most in 15 to 30 seconds; complete in 45 minutes.

Reaction with Chromic Acid.

H. coronarium: Begins in 15 seconds; complete in 11 minutes.
H. gardnerianum: Begins at once; complete in 5 minutes.

Reaction with Pyrogallic Acid.

H. coronarium: Begins in a few in 90 seconds; very slight reaction in 25 minutes.
H. gardnerianum: Begins in one-fifth in 60 seconds; about one-fifth are only partially gelatinized in 25 minutes.

Reaction with Ferric Chloride.

H. coronarium: General in 30 seconds; complete in 6 minutes.
H. gardnerianum: General in 30 seconds; complete in 4 minutes.

Reaction with Purdy's Solution.

H. coronarium: Begins at once; complete in 3 minutes.
H. gardnerianum: Begins at once; complete in 1½ minutes.

NOTES ON THE STARCHES OF HEDYCHIUM.

The specimens of these starches are not very favorable for histological comparison, because that of *H. gardnerianum* contains not only an abundance of eroded grains, but also much foreign matter that could not be removed. The chief differences appear to be in the tendency of the latter to a relative abundance of the clam-shell type, to a smaller size of grain, to less distinct lamellation, and to a less tendency to the formation of a nipple-like proximal end. In their reactions they differ sufficiently to be distinguished, *H. gardnerianum* having the lower degree of polarization, lower reactivity with iodine and the anilines, lower temperature of gelatinization, and higher sensitivity to chromic acid, ferric chloride, and Purdy's solution.

GENUS CURCUMA.

The genus *Curcuma* includes a few species of tuberous-rooted, herbaceous perennials that are essentially tropical. They are to some extent cultivated as green-house plants, and some are of more or less commercial importance. *C. angustifolio*, *C. leucorrhiza*, and *C. rubescens* are the chief sources of a form of East Indian arrowroot (see *Marantaceæ*, page 813); *C. longa* yields turmeric, which is of importance especially as a dye-stuff and as a condiment; *C. amada* is the source of mango ginger; *C. zedoaria* and *C. aromatica* furnish the East Indian drug known as zedoary, which is used in medicine and in the preparation of incense, the latter species also yielding a turmeric-like article of commerce. Starches from two sources were examined: *C. longa* Linn. and *C. petiolata* Roxb.

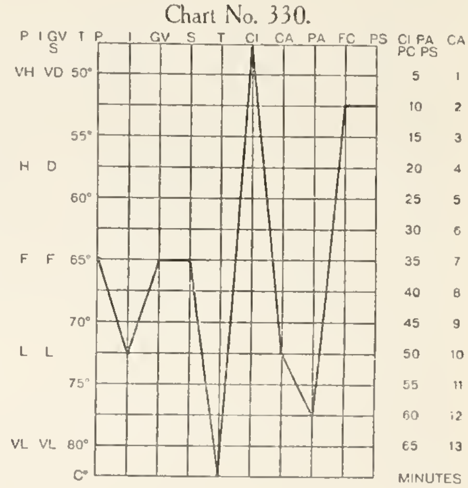
STARCH OF CURCUMA LONGA. (Plate 82, figs. 487 and 488. Chart 330.)

Histological Characteristics.—In *form* the grains are simple, and are isolated with the exception of a few in clumps. The grains are frequently irregular, owing chiefly to the following causes: to small protuberances which are usually found at the proximal end or side nearby; to an indentation at one side of the hilum; and to a slight deflexion at the proximal end and to small extensions of the corners forming the curved margin of the dista. end. The conspicuous forms are ovoid, often with flattened sides and somewhat abruptly pointed proximal end; triangular with curved base; pyriform, often with flattened sides; shield-shaped, somewhat mussel-shell-shaped, and imperfect quadrilateral. The grains are much flattened and usually of narrow elliptical form when viewed on edge.

The *hilum* is very indistinct and occasionally may be observed as a round or lenticular spot, very eccentric according to the length of the grain, usually eccentric one-eighth to one-fifteenth of the longitudinal axis.

The *lamellæ* are usually not clearly demonstrable, especially near the hilum. When observed they vary from rather fine to fairly coarse layers, which follow the outline of the distal margin and are probably incomplete. On grains of large size 32 may be counted, rarely 40.

Chart No. 330.



Curve of Reaction-Intensities of Starch of Curcuma longa.

The grains vary in *size;* the smaller are 10 by 6μ; the larger are 42 by 16μ in length and breadth. The common size is about 24 by 18μ in length and breadth.

Polariscopic Properties.—The *figure* is very eccentric and usually indistinct where the lines intersect. Its lines are rather broad and frequently bent.

The degree of *polarization* is fair, varying in the same aspect of a given grain. At the proximal end polarization is absent or very low, but fair in from two-thirds to four-fifths of grain.

With *selenite* the quadrants are not clearly defined and the one at the proximal end can rarely be distinguished. They are irregular in shape and unequal in size. The colors are usually not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains become a light, dull reddish-violet, some deeper than others, the color deepening rapidly in some grains and gradually in others. With 0.125 per cent solution the grains soon color a dull, light reddish-violet or gray (ashes-of-roses), deepening rapidly in most grains. After heating in water until all the grains are gelatinized, and then adding iodine, the solution becomes a deep indigo-blue and the grains a fairly deep, rather dull blue, some having a reddish tint. If the gelatinized grains are boiled for 2 minutes and then treated with iodine, most of the grain-residues become a very light blue, with a few scattered ones of fairly deep tint, and the solution colors more deeply. With an excess of iodine the grain-residues become a deep, dull blue with reddish tint and the capsules a light to rather deep heliotrope color.

Staining Reactions.—With *gentian violet* the grains do not color at once, but in 30 minutes are fairly stained. The starch contained much yellow coloring matter (turmeric), which affected the tint of the aniline reaction.

With *safranin* the grains do not color at once, but in 30 minutes are fairly stained. The yellow coloration of the starch affects the tint of the reaction.

Temperature Reaction.—The temperature of gelatinization is 82° to 83° C., mean 82.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in 10 seconds, nearly all in 20 seconds, and all in 30 seconds. The grains immediately color an old-rose and the hilum becomes more distinct. Gelatinization accompanied by a deep bluish coloration starts at the distal end or at any prominent projections. The deep color spreads around the margin and then advances rapidly towards the center from the distal margin until the entire grain is gelatinized. The gelatinized grain is deeply colored, uniformly swollen, and retains the general shape of the untreated grain.

The reaction begins immediately with *chromic acid.* A few grains are dissolved in 2 minutes, more than half in 5 minutes, nearly all in 6 minutes, all but rare resistant grains in 8 minutes, and all in 10 minutes. The hilum swells and the starch encircling it is quickly gelatinized. A large, plume-like fissure or channel extends from this area, and the lamellæ distal to the hilum become sharply defined and striated. The capsule at the proximal end is soon ruptured and quickly dissolved, but gelatinization proceeds very gradually along the course of the branched fissure towards the distal end accompanied by the appearance of numerous refractive granules, which remain for a while embedded in the soluble starch; finally, the entire grain is dissolved.

Reaction with *pyrogallic acid* begins in a few grains in 30 seconds. A small number are gelatinized in 3 minutes, practically all are partially gelatinized in 15 minutes, nearly all in 30 minutes, with but slight signs of any progress from this time to the end of an hour. The hilum swells, the lamellæ towards the distal end become more distinct, and usually a delicate short fissure passes from each side of the hilum, but sometimes one longitudinal branched fissure extends towards the distal end. Gelatinization begins around the hilum and the starch at the proximal end quickly becomes gelatinized, accompanied by a slight distension of the capsule. The reaction then proceeds either between the two short, radiating fissures, or along the course of the single, branched fissure until about one-half to three-fifths of the grain is gelatinized. In the grains with a large, single, branched fissure the lamellæ are cut down into a serrate lining of the capsule. The gelatinized grains are swollen but retain the shape of the untreated grain.

The reaction with *ferric chloride* begins in 30 seconds. A few grains are gelatinized in 2 minutes, more than half in 3 minutes, about four-fifths in 4 minutes, and all but the central part of a few resistant grains in 5½ minutes, in which gelatinization is complete in 10 minutes. A narrow border, which more sharply defines the lamellæ, forms around the grain. Gelatinization usually begins at the proximal end, accompanied by rapid distension of the capsule, and quickly followed by swelling at any prominent projections. Gelatinization proceeds for about the proximal third of the grain towards the distal end, where the border of the more transparent lamellæ has gradually broadened. The starch at this margin now breaks into larger fragments, which quickly gelatinize. The lamellæ of the central part of the grain are the most resistant, but finally break into granules which are broken down and the entire grain becomes gelatinized. The gelatinized grain is much swollen and distorted.

Reaction with *Purdy's solution* begins in a few grains in 30 seconds. A small number are gelatinized in 2 minutes, more than half in 3 minutes, nearly all in 5 minutes, and all but a few resistant grains in 6 minutes, in which latter the reaction is complete in 10 minutes. The lamellæ become more distinct and striated, and the hilum swells. Gelatinization usually begins at the hilum, although if there are very prominent protuberances swelling may start first and be more rapid in them. The reaction usually proceeds towards the distal end, with a gradual breaking down of the lamellæ until the entire grain is gelatinized. Sometimes one longitudinal, somewhat oblique fissure may be observed proceeding from the hilum, from which occasionally large branches may form, so that the lamellæ are cut into a deep serrate lining of the capsule during gelatinization. The gelatinized grains are swollen and somewhat distorted, but have a general resemblance to the untreated grain.

STARCH OF CURCUMA PETIOLATA. (Plate 82, figs. 489 and 490. Chart 331.)

Histological Characteristics.—In *form* the grains are simple and are isolated, with the exception of a few in clumps. The grains are often irregular owing to the same causes as noted under *C. longa.* The conspicuous forms are the same as in *C. longa*, but there are more irregular grains; the protuberances are more prominent, those at the proximal end ranging from nipple-like to finger-shaped, and those at the corners limiting the curved distal margin being longer and sometimes curved towards the proximal end.

The *hilum* is very indistinct, but rather more often visible than in *C. longa*, and always very eccentric; thus the range varies with the length of the grain. It is usually eccentric from about one-sixth to one-nineteenth of the longitudinal axis.

The *lamellæ* are usually not clearly demonstrable near the hilum, but occasionally in this region a few fine circular rings may be observed. Most of the lamellæ follow the outline of the distal margin and are probably incomplete. On grains of large size from 35 to 50 lamellæ may be counted. The lamellæ are rather more distinct and can be counted over the entire surface in a larger number of grains than in *C. longa*.

The *size* of the grains varies; the smaller are 9 by 6μ; the larger are 50 by 16μ in length and breadth. The common size is about 28 by 20μ in length and breadth.

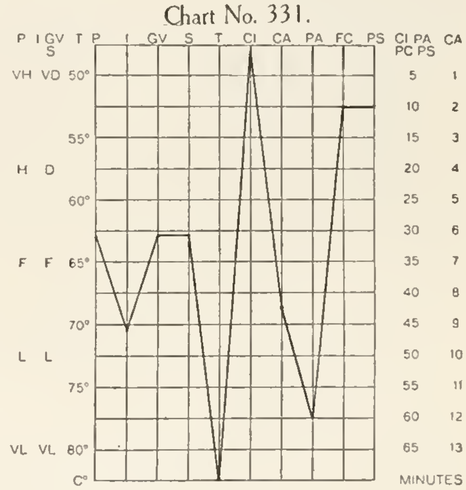
Polariscopic Properties.—The *figure* is very eccentric and usually indistinct at the point where lines intersect. The arrangement and character of the lines are the same as in *C. longa*, but more often bent.

The degree of *polarization* is fair, a little higher than in *C. longa*, but the same variations are observed.

With *selenite* the quadrants are not clearly defined and are even more irregular than in *C. longa*. The colors are generally not quite pure, although the blue is more often pure than in *C. longa*.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a rather light reddish-violet, which deepens gradually in most grains and quickly in others. The tint is deeper but brighter than in *C. longa* and deepens more gradually. With 0.125 per cent solution the grains soon color a light reddish-violet which deepens rather rapidly. The tint is deeper at first than *C. longa*, but does not darken so much as in that species. After heating in water until all the grains are gelatinized and then adding iodine, the solution becomes a deep blue and the grains either a deep blue with reddish tint or a deep blue-violet. The solution is rather deeper in color than in *C. longa*, and the grains are brighter and of a rather more reddish tint than in that species. If the gelatinized grains are boiled for 2 minutes and then treated with iodine, the solution colors very deeply and the grains become a very light to fairly deep bright blue, slightly deeper than in *C. longa*. With an excess of iodine the grains color a very deep blue with reddish tint and the capsules a light heliotrope to wine-red. The tint is redder and brighter than in *C. longa*.

Chart No. 331.



Curve of Reaction-Intensities of Starch of Curcuma petiolata.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to color slightly at once and in 30 minutes they are fairly colored. They are slightly deeper in tint and of a different shade than in *C. longa*, in which the color is probably affected by the yellow coloring matter in the starch.

Temperature Reaction.—The temperature of gelatinization is 82° to 83° C., mean 82.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A small number of grains are gelatinized in 15 seconds, nearly all in 30 seconds, all in 40 seconds. The reaction is qualitatively the same as in *C. longa*.

Reaction begins at once with *chromic acid*. A few grains are dissolved in 2 minutes, more than half in 5 minutes, nearly all in 6 minutes, and all in 8½ minutes. The reaction is qualitatively the same as in *C. longa*.

With *pyrogallic acid* reaction begins in a few grains in 30 seconds, a small number are gelatinized in 5 minutes, and practically all are partially or completely gelatinized in 15 minutes. Most grains are from one-third to two-fifths gelatinized in 30 minutes, and there is slight progress during the remainder of the hour. The reaction is qualitatively the same as in *C. longa*.

The reaction with *ferric chloride* begins in a few grains in a minute. A small number are gelatinized in 2 minutes, more than half in 3 minutes, about four-fifths in 5 minutes, nearly all in 6 minutes, and all but a few resistant grains in 7 minutes, in which latter the reaction is usually complete in 10 minutes. It is qualitatively the same as in *C. longa*.

Reaction with *Purdy's solution* begins in a few grains in a minute. A small number are gelatinized in 3 minutes, nearly all in 5 minutes, all but a few resistant grains in 6 minutes, in which latter it is complete in 10 minutes. The reaction is qualitatively the same as in *C. longa*.

Differentiation of Certain Starches of the Genus Curcuma.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

C. longa: Simple, isolated, frequently irregular; ovoid, often with flattened sides and somewhat abruptly pointed proximal end; triangular with curved base; pyriform, often with flattened sides, shield-shaped, mussel-shell-shaped, and imperfect quadrilateral when viewed on end, usually narrow elliptical.
C. petiolata: Same as in *C. longa*, but more irregular; protuberances more prominent, corners limiting distal end longer; sometimes curved towards the proximal end.

Hilum—Form, Number, and Position.

C. longa: Form very indistinct, round or lenticular spot. Position eccentric usually about 0.12 to 0.07 of longitudinal axis.
C. petiolata: Form rather more often visible than in *C. longa*. Position eccentric usually about 0.16 to 0.05 of longitudinal axis.

Lamellæ—General Characteristics and Number.

C. longa: Usually not clearly demonstrable, especially near the hilum, rather fine to fairly coarse, follow outline of distal margin, probably incomplete. 32 to 40 on larger grains.
C. petiolata: Rather more distinct, and can be counted over the whole surface in a larger number of grains than in *C. longa*. 35 to 50 on fair to large grains.

Size.

C. longa: From 10 to 42μ, commonly 24 by 18μ.
C. petiolata: From 9 to 50μ, commonly 28 by 20μ.

POLARISCOPIC PROPERTIES.

Figure.

C. longa: Very eccentric, usually indistinct in area in which the lines intersect; lines rather broad and frequently bent.
C. petiolata: Lines more often bent than in *C. longa*.

Degree of Polarization.

C. longa: Fair. Very low or absent at proximal end.
C. petiolata: Fair. A little higher than in *C. longa*, otherwise the same.

Polarization with Selenite—Quadrants and Colors.

C. longa: Quadrants not clearly defined, one at proximal end rarely seen, irregular in shape, unequal in size. Colors not quite pure.

POLARISCOPIC PROPERTIES.—Continued.

Polarization with Selenite—Quadrants and Colors.—Cont'd.

C. petiolata: Quadrants same as in *C. longa* except more irregular. Colors not quite pure, blue, more often pure than in *C. longa*.

IODINE REACTIONS.

Intensity and Color.

C. longa: Light; dull red-violet.
C. petiolata: Light, deeper than in *C. longa;* brighter than in *C. longa*.

STAINING REACTIONS.

With Gentian Violet.

C. longa: Fair.
C. petiolata: Fair, slightly deeper than in *C. longa*.

With Safranin.

C. longa: Fair.
C. petiolata: Fair, slightly deeper than in *C. longa*.

TEMPERATURE OF GELATINIZATION.

C. longa: 82 to 83° C., mean 82.5°.
C. petiolata: 82 to 83° C., mean 82.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

C. longa: Begins at once; complete in 30 seconds.
C. petiolata: Begins at once; complete in 40 seconds.

Reaction with Chromic Acid.

C. longa: Begins at once; complete in 10 minutes.
C. petiolata: Begins at once; complete in all in 8½ minutes.

Reaction with Pyrogallic Acid.

C. longa: Begins in a few in 30 seconds; in nearly all in 30 minutes; incomplete in 60 minutes.
C. petiolata: Begins in a few in 30 seconds; most are from one-third to two-fifths gelatinized in 30 minutes; incomplete in an hour.

Reaction with Ferric Chloride.

C. longa: Begins in 30 seconds; complete in 10 minutes.
C. petiolata: Begins in a few in 60 seconds; complete in 10 minutes.

Reaction with Purdy's Solution.

C. longa: Begins in a few in 30 seconds; complete in 10 minutes.
C. petiolata: Begins in a few in 60 seconds; complete in 10 minutes.

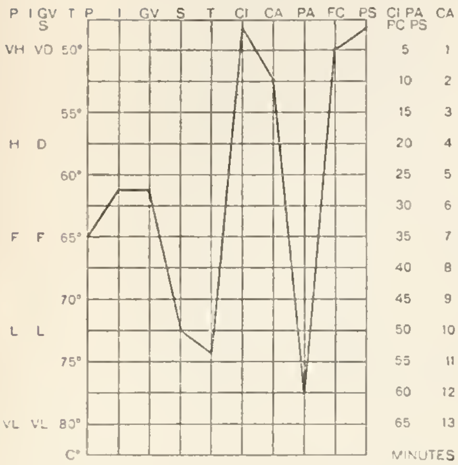
NOTES ON THE STARCHES OF CURCUMA.

The *Curcuma* starches show important histological differences, as instanced in *C. petiolata*, having grains more irregular and prominences more marked; the corners limiting the distal end larger and sometimes curved towards the proximal end; the hilum more often visible; the lamellæ rather more distinct; and the grains slightly larger, as a whole. In their reactions they show distinct differences, except in the case of heat, ferric chloride, and Purdy's solution. The variations are quite important.

NOTES ON THE STARCHES OF ZINGIBERACEÆ. (Charts 332 to 334.)

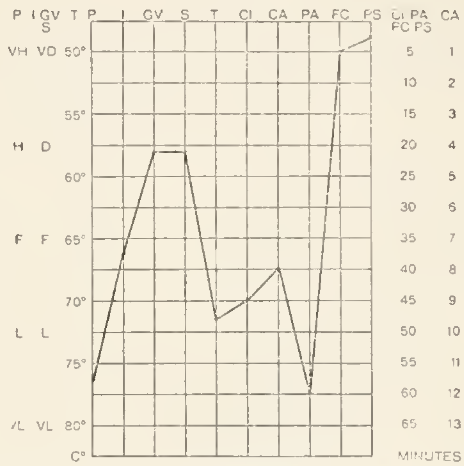
Leaving out of consideration the starches of the varieties of *Z. officinale*, it will be observed that the starches of all three genera are in very close correspondence in their histological characteristics. Those of *Z. officinale* and *H. coronarium* are very much alike, the chief differences being in *H. coronarium* in the more marked lamellation; more marked tendency to a decidedly pointed proximal end; the distinct tendency to a hooked proximal end, and to a nodular projection from one side of the grain. In *H. coronarium* polarization is lower; and there are more or less marked differences in the reactions. In *Curcuma*, while there is the same type of grain, the grains are more closely allied to *Zingiber* than to *Hedychium* and the tendency to a broadening of the distal end is very noticeable, in which respect they bear close resemblances to *H. gardnerianum*. In comparing the composite reaction-curves, it will be seen that each genus has a type different from the others, and that the curve of *Curcuma* is nearer related to that of *Zingiber* than *Hedychium*. It is of especial interest to note that the temperatures of gelatinization of *Z. officinale* and the two *Hedychium* starches are very close, that the temperatures of *Curcuma* are about 10° higher; and that the temperatures of gelatinization of the varieties of *Zingiber* are from 10° to 15° higher. The Jamaica and Cochin ginger starches, judging from their histological and reaction differences, as compared with the official ginger, were doubtless obtained from mongrel plants.

Chart No. 332.



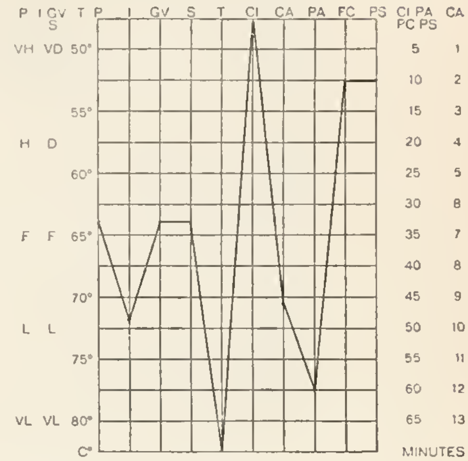
Curve of Reaction-Intensities of Starch of Zingiber.

Chart No. 333.



Composite Curve of Mean Reaction-Intensities of Starch of Hedychium.

Chart No. 334.



Composite Curve of Mean Reaction-Intensities of Starch of Curcuma.

STARCHES OF CANNACEÆ.

Class, Monocotyledones. Order, Scitaminales. Family, Cannaceæ. Genus, Canna.

GENUS CANNA.

The cannas, popularly known as the Indian shot plant, because of the small, round, shot-like seeds, are ornamental, herbaceous plants that are natives of the tropics and semi-tropics of both hemispheres and now cultivated extensively in a number of countries as foliage plants and for other economic purposes. There are a number of tribes or types, species, varieties, and horticultural forms, and during comparatively recent years the evolution of the latter by hybridization, by crossing hybrids, etc., and by selection and cultivation has gone on to so great a degree that a very large number of forms are offered by the trade. It is quite impossible in most cases to properly refer these forms to either the actual, immediate, or remote parentage. The tuberous roots are rich in starch, and in some countries the canna is cultivated especially for this substance, or for the roots, which are eaten as a vegetable. The well-known arrowroot, *Tous-les-mois* (see *Marantaceæ*, page 813), is attributed to *Canna edulis*, a native of tropical America. The starches of the cannas are in the form of exceptionally large, markedly lamellated grains, which render them especially useful for the study of starch-properties. Starches from ten sources were examined, including the following: *C. warszewiczii* Dietr., a native of Costa Rica, is a well-marked species, and one of only two of this list that are recognized as such; *C. roscoeana* Bouche is referred to *C. lutea* Miller; *C. musæfolia* we have not been able to indentify; *C. edulis* Ker. (*C. esculenta* Lodd.), a well-defined species, is a native of tropical America; *C.* var. (*Königen Charlotte*), *C.* var. (*President Carnot*), *C.* var. (*L. E. Bally*), *C.* var. (*Mrs. Kate Grey*), *C.* var. (*Jean Tissot*), and *C.* var. (*J. D. Eisele*) are cultural forms and probably hybrids of some kind and of varied source.

STARCH OF CANNA WARSZEWICZII. (Plate 82, figs. 491 and 492. Chart 335.)

Histological Characteristics.—In *form* the grains are usually simple and isolated. A few compound grains consisting of two components are present, characterized by two hila and a more or less well-defined depression or fissure at the line of union of the two grains. There are no pressure facets. There is some irregularity of outline which tends to be most conspicuous in the region of the hilum. The most conspicuous forms are the broad ovoid and clam-shell type. The peculiar formation of the latter seems to be the result of a tendency to the formation of lateral depressions at each side of the hilum, which is associated with a shortening of the long diameter of the large, ovoid grains. In some ovoid grains the depression is unilateral and others bilateral, thus giving rise to the appearance of an extrusion of the part of the grain on which the hilum is located. Between the best-defined, broad ovoid, and clam-shell types of grains there are all transitional forms—oval, reniform, pyriform, cylindrical, circular, quadrangular, triangular, and irregular. Viewed on edge, the grains are seen to be flattened, elliptical, or ellipsoidal, and one end may be thicker than the other, rendering them somewhat prismatic.

The *hilum* is a small, distinct, circular, eccentric spot, near or on the margin, and slightly to the right or left of the longitudinal axis. Occasionally the hilum is elongated instead of circular, and a grain of an elongated, flattened form is noted rarely, which has the hilum centrally located. Fissuration is sometimes noted in the region of the hilum, and similar fissures may be seen in other parts of the same or other grains. In the conspicuous grains 2 hila are present; in some apparently single grains 3 or 4 hila are linearly arranged.

The *lamellæ* are very distinct, generally coarser and more distinct near the hilum than near the distal margin and more distinct in some grains than in others. They are coarse, regular rings about the hilum, and arcs of circles beyond which are probably continuous and follow very closely the outlines of parts of the grain distal to the hilum. They are arranged so that 1 or 2 very large, coarse lamellæ alternate with a group of very fine, rather indistinct lamellæ. On a large grain the average number is 48 to 50.

The grains vary in *size* from 15 to 70μ. The common size is about 50μ. The large, ovoid grains range from about 45 by 30μ to 72 by 60μ in length and breadth, and the clam-shell type from 40 by 40μ to 50 by 40μ in length and breadth. In some of the latter the longitudinal diameter is shorter than the transverse diameter.

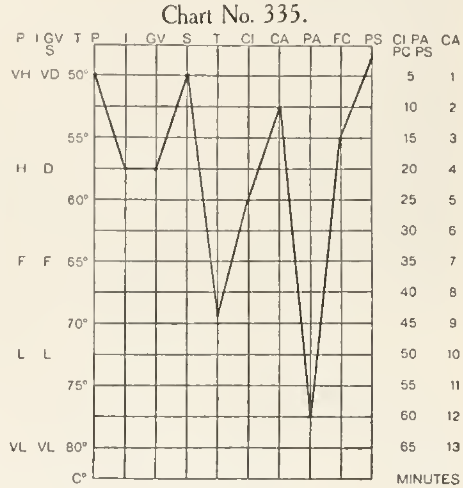
Polariscopic Properties.—The *figure* is very distinct and generally clear-cut. Its lines are rather broad, becoming slightly broader and less clear-cut near the margin. Usually two lines are for the most part visible and cross the grain diagonally; sometimes there are only one and small parts of others, in which case the single line corresponds with the longitudinal axis of the grain. The lines are usually regular, but placed at varying angles to one another.

The degree of *polarization* is very high; when seen on edge or end it is higher than in other aspects and does not vary materially in different grains or in different parts of the same aspect of a given grain. Polarization colors appear in most grains.

With *selenite* the quadrants are fairly well defined, fairly regular in form, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deeply a blue-violet, the marginal part being more deeply colored than the rest of the grain; with 0.125 per cent solution the grains color readily, but the tint deepens rapidly. After heating in water until all the grains are completely gelatinized, the solution becomes a deep indigo color and the grains a very light indigo upon the addition of iodine. After boiling for 2 minutes the solution colors even more deeply and the grain-residues light or not at all. The capsules all color a red-violet with a slight excess of iodine.

Chart No. 335.



Curve of Reaction-Intensities of Starch of Canna warszewiczii.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After 30 minutes they are deeply stained, some more than others, and the margins more than the inner portion.

With *safranin* the grains begin to stain deeply at once. After 30 minutes they are very deeply stained. This coloration is more intense than with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 68° to 70° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains begin to react in a minute and all are darkened in 25 minutes. The hilum and lamellæ become indistinct. The prominent points on the margin grow dark and begin to protrude and the reaction extends along the margin from one point to another. The protrusion from the margin may surround the grain entirely, inclosing a central, unswollen portion which swells later. In some grains the hilum and one or two adjacent points may swell out first, then the distal end, and finally the central portion. After the whole grain is darkened, swelling continues for some time. The resulting gelatinized grains are fairly large, the proximal portion is lobular, and the distal rounded. The part between the hilum and the distal margin shows a number of irregular concentric bands of darkened starch, which are partially or completely separated by light fissures. (See plate 86, figs. 511 to 516.)

With *chromic acid* the reaction begins in 30 seconds, and is over in 2 minutes. The hilum and lamellæ become more distinct. The hilum swells, and fine striæ appear which radiate from the hilum throughout the grain. Fissures take the place of the most prominent of these striæ and extend deeply throughout the grain. The upper margin of the proximal end of the grain is dissolved, then the rest of the grain swells and dissolves in a very typical manner. The fine striæ which have obscured the lamellæ disappear from a crescentic zone at the distal end and the lamellæ reappear, and then the zone separated from the rest of the grain is dissolved; another such zone forms and separates, and then a third is formed, but this rarely separates. The rest of the grain, which consists of rows of large granules, becomes clearer and more transparent and finally dissolves also. (See plate 87, figs. 519 to 522.)

With *pyrogallic acid* the grains begin to react in a minute and about one-sixth of the total number are gelatinized in 20 minutes, the rest being in all stages of the reaction, from a slight swelling of the hilum to partial gelatinization. There is no further change. The hilum swells slightly, and fine striæ appear which radiate from the hilum through the grain, 4 or 5 of which develop into very deep fissures which split the grain into pyramids with bases on the distal margin and apexes directed towards the hilum. As the grain continues to swell these parts are repeatedly subdivided and become more gelatinous until finally they disappear in the form of a homogeneous, gelatinous mass. The gelatinized grains resulting from this reaction are large, irregularly lobulated at the proximal end, and folded in an irregularly lamellated fashion at the distal end.

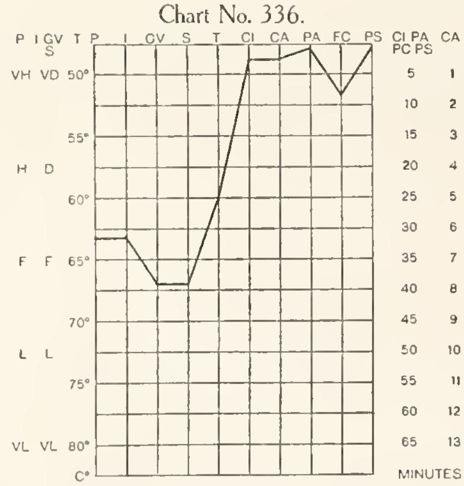
The grains begin to react in 2 minutes with *ferric chloride.* About half are gelatinized in 5 minutes and all in 15 minutes. The hilum and lamellæ become indistinct, and the margin becomes darker and clearer than the rest of the grain. A small fissure appears in the neighborhood of the hilum, and one or two secondary fissures may develop near this which widen greatly, permitting of swelling and protrusion from one or more points on the margin, distending the capsule. Striæ radiating from the hilum may also develop. Following this there may be more or less irregular fissuring and swelling of the whole grain. In some grains the margin reacts more rapidly than the inner portion, which latter is therefore surrounded by an irregular, gelatinous ring. The reaction now moves inward, and small portions of the grain-substance are broken off and gelatinized separately until the whole grain is ultimately completely gelatinized. The gelatinized grains are very large and irregular, folded and nodular at the proximal end, and rounded and lamellated at the distal end.

The reaction with *Purdy's solution* begins in a few seconds and is complete in 2 minutes. The hilum and lamellæ become more distinct. The hilum and one or two nearby points swell rapidly and protrude, forming two or three irregular, finger-like projections. The grain becomes covered by fine striæ which radiate from the hilum. Four or five of these striæ become very deep fissures which, as the grain swells, open out, dividing the grain-substance into pyramids with their bases at the distal margin and the apexes towards the proximal end. These parts are repeatedly subdivided again and finally are converted into a homogeneous gelatinous mass. In the grains that react very rapidly this process does not appear. The hilum swells out and the rest of the grain-substance passes rapidly into a gelatinous mass. The gelatinous grains are very large, lobulated and irregular at the proximal end, and folded in lamellar fashion at the distal end.

STARCH OF CANNA ROSCOEANA. (Plate 83, figs. 493 and 494. Chart 336.)

Histological Characteristics —In *form* the grains are simple. No compound grains or aggregates were observed and no pressure facets were detected on any grains. The surface of the grains tends to be quite regular, and when irregularities of outline are noted they are usually at the proximal end and in the form of unilateral or bilateral depressions. The most conspicuous forms are the broad ovoid and clam-shell type. This form varies also in relative length and breadth and in the relative size of the two ends. The clam-shell type is not so well formed as in *C. warszewiczii.* There are also reniform, long triangular, quadrilateral, and various incidental forms. Seen from the side, the grains are elliptical or ellipsoidal, and frequently one end is thicker than the other, giving them a prismatic form.

Chart No. 336.



Curve of Reaction-Intensities of Starch of Canna roscoeana.

The *hilum* is a relatively small, not very distinct, round, refractive spot, situated very eccentrically. In the ovoid, triangular, and related forms it is usually in the median line and at the narrow end. In the other forms it may be to one side of the median line. Rarely it is marked by a fissure.

The *lamellæ* are very distinct, alternately light and dark, continuous, concentric rings or arcs of circles which are very regular. In some cases the outer lamellæ follow some irregularities in the margin. The hilum is their common center. They vary greatly in distinctness in the same grain, and somewhat in different grains. They are slightly coarser and more distinct than in *C. warszewiczii.* There are about 45 on the larger grains.

The grains vary in *size* from 13 to 88μ. The common size is 60μ. Some of the larger ovoid grains measure 88 by 55μ, and some of the larger clam-shell or reniform grains measure 35 by 55μ in length and breadth.

Polariscopic Properties.—The *figure* is very eccentric and clear-cut. The lines are very broad and do not vary much in breadth. Usually only one or two lines are visible throughout their course. If one, it is in or near the longitudinal axis; if two, they run obliquely from the hilum. The lines are not distorted and are placed at less varying angles to one another than in *C. warszewiczii.*

The degree of *polarization* is very high. Polarization colors may be seen in some grains. It is higher and the colors are more visible when the grains are viewed on end or edge, and higher than in the grains of *C. warszewiczii.*

With *selenite* the quadrants are fairly well defined, fairly regular in form, unequal in size. The colors are very pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color blue-violet very deeply; with 0.125 per cent solution the grains color at once and the color deepens rapidly. The color is deeper than that of *C. warszewiczii.* After heating in water until the grains are completely gelatinized, the solution becomes a deep indigo color and the color of the grains varies from deep indigo to a very faint tint upon the addition of iodine. After boiling for 2 minutes, the solution is colored very deeply and the grain-residues very little. With a slight excess of iodine all the capsules are of a red-violet color.

Staining Reactions.—With *gentian violet* the grains begin to stain at once, the margins being first affected, and in 30 minutes they are deeply stained, a few more deeply than the rest. The stain is about the same as that of *C. warszewiczii.*

With *safranin* the grains begin to stain deeply at once, and in 30 minutes are very deeply stained, some much more than others. The stain is not so deep as that of the grains of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 69° to 70° C., mean 69.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react in a minute; about half are swollen in 5 minutes and the reaction is complete in 15 minutes. The hilum and the lamellæ are rendered indistinct. Then the hilum grows prominent as a black spot. In the meantime, the grains become colored a light violet, the distal end staining more deeply than the other. The inner portion of the grain becomes lighter and the margin darker, the dark coloration of the latter extending to the projections in the regions of the hilum, which begin to protrude, followed by protrusion of other nearby portions. The hilum may now either darken and swell suddenly, or gradually be included in the general swelling. The final result of the coloring and swelling is the formation of masses characterized by an unswollen violet-colored center surrounded by a gelatinized indigo-blue mass. As the reaction proceeds, the central portion swells in common with the rest of the mass and becomes a deep blue, and darker than the surrounding parts.

The grains begin to react in 30 minutes with *chromic acid,* and the reaction is complete in 3 minutes. Both hilum and lamellæ become more distinct. Then, as the hilum begins to swell, fine striæ radiate from this point and the lamellæ are obscured. The proximal end of the grain is dissolved, leaving a clear, open space. At the distal end lamellation again becomes distinct and more and more marked until there occurs a splitting off serially of several concentric portions. The main body of the grain in the meantime becomes clearer and finally disappears. If the first crescent does not separate, the whole grain will after a time open out from the proximal end and dissolve.

With *pyrogallic acid* swelling of the grain begins in 2 minutes. One or two grains are entirely swollen and the rest are in all stages of the reaction in 16 minutes, but the reaction does not progress any further. The hilum swells slightly and protrudes. Two fissures on either side of the hilum partially divide the grain, then many fine striæ appear which radiate from the hilum, and deep fissuration occurs in four or five directions attended by great swelling of the hilum; or vertical fissuration may occur more or less irregularly without great swelling of the hilum, the parts so defined swelling independently of one another, forming a very large, irregularly lobulated mass. This form of swelling seems to be peculiar to the large ovoid grains. The gelatinized clam-shell and reniform grains have a lamellated, somewhat rounded form, except at the point corresponding to the location of the hilum, where the mass is clear and not so much crumpled and protruding.

The reaction with *ferric chloride* begins in 1½ minutes and is complete in 10 minutes. It is similar qualitatively to that of *C. warszewiczii.*

Reaction with *Purdy's solution* begins in 15 seconds and is complete in almost all the grains in 1½ minutes and in all in 5 minutes. It is qualitatively the same as that of the grains of *C. warszewiczii.*

STARCH OF CANNA MUSÆFOLIA. (Plate 83, figs. 495 and 496. Chart 337.)

Histological Characteristics.—In *form* the grains are usually simple, with a few compound grains consisting of two or three components. There are no aggregates or grains with pressure facets. The grains are rounded but somewhat irregular in outline, especially near the hilum. The conspicuous form is the broad ovoid with the proximal end usually narrowed, and the clam-shell type. They resemble quite closely the grains of *C. roscoeana*. There are also reniform, pyriform, triangular and quadrangular with rounded angles, and various irregular forms. Some of the longer grains are bent about the longitudinal axis. The grains are distinctly flattened, being about one-fourth as deep as wide. When seen on edge they may have a spindle form or be prismatic.

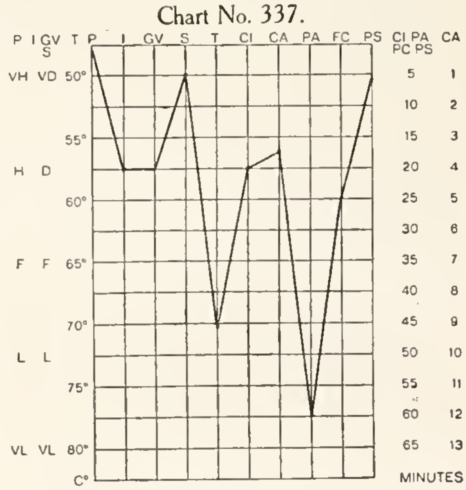
The *hilum* appears as a small, round, very distinct, very eccentric spot, in or near the median line. Occasionally the hilum is lenticular and more rarely it is centric. Multiple linearly arranged hila occur rarely. Fissuration is uncommon.

The *lamellæ* are very distinct coarse circles or regular arcs of circles which are probably continuous and follow closely the outline of the grain most distal to the hilum. As a rule, those nearest the hilum are the coarsest and most distinct and vary much on different parts of the same grain. On different grains they vary in distinctness and coarseness. The lamellæ are more distinct and slightly coarser than in *C. warszewiczii*. There are about 60 on the larger grains.

The grains vary in *size* from 15 to 82μ. The common size is 55μ.

Polariscopic Properties.—The *figure* is very eccentric, distinct, and usually clear-cut aud regular. The lines are broad, but usually of the same size and distinctness throughout their length. One or two may be visible throughout their length; if one, it lies in the longitudinal axis of the grain; if two, they cross the grain diagonally from the hilum.

Chart No. 337.



Curve of Reaction-Intensities of Starch of Canna musæfolia.

The degree of *polarization* is very high, slightly higher than that of the grains of *C. warszewiczii*. Polarization colors are seen in many grains. It is highest when the grain is on edge or end, and it does not vary greatly in different grains.

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deeply a blue-violet; and with 0.125 per cent solution they color readily and the tint deepens rapidly, the margins coloring more intensely than the rest of the grain. The reaction is of the same intensity as that of *C. warszewiczii*. After heating in water until the grains are all completely gelatinized, the solution colors a deep indigo and the grains a very light indigo on the addition of iodine. After boiling for 2 minutes the solution colors even more deeply and the grains not at all or very lightly. With a slight excess of iodine the capsules color a red-violet.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and after 30 minutes are deeply stained, some more than others. Most of them show deeply staining oval marks on their surfaces. The shade is about the same as that of the grains of *C. warszewiczii.*

With *safranin* the grains begin to stain at once and after 30 minutes are very deeply stained. They are of about the same color as those of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 70° to 71° C., mean 70.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute and is over in half the grains in 7 minutes and in all in 20 minutes. It is qualitatively the same as that of *C. warszewiczii.*

Reaction with *chromic acid* begins in 30 seconds and is over in 3½ minutes. It is qualitatively the same as that of the grains of *C. warszewiczii.*

The reaction with *pyrogallic acid* begins in 1½ minutes. In 15 minutes a few grains are fully gelatinized, while about one-fifth are partially gelatinous and the remainder merely show the beginning of reaction.

With *ferric chloride* the reaction begins in 1½ minutes and is over in 25 minutes. It is the same qualitatively as in *C. warszewiczii.*

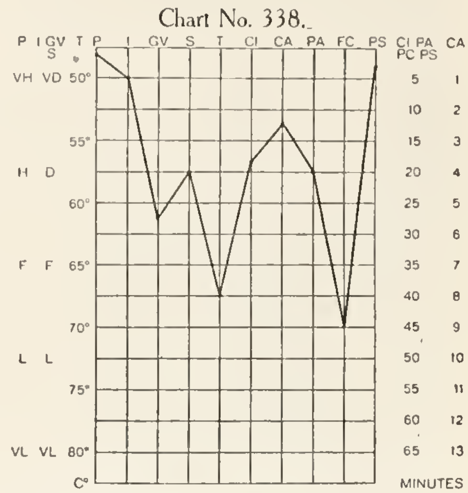
Reaction with *Purdy's solution* begins in 15 seconds and is over in the majority of grains in 2½ minutes and in all in 6 minutes. It is qualitatively the same as in *C. warszewiczii.*

STARCH OF CANNA EDULIS. (Plate 83, figs. 497 and 498. Chart 338.)

Histological Characteristics.—In *form* the grains are simple with the exception of very rare compounds in the form of two components. There are no aggregates or clumps and no pressure facets. The surface of the grains tends to be quite smooth, the chief irregularities being in the form usually of two depressions at the proximal end, causing the extreme end to be somewhat protrusive. The most conspicuous form is the broad ovoid; there are also oval, clam-shell type, reniform, pyriform, irregularly triangular and quadrangular with rounded angles, nearly round forms, elliptical, and various irregular forms. The broad ovoid grains are usually two-thirds to three-fourths as broad as long. From the sides the grains are flat and one-fourth to one-third as thick as broad, and have the shape of a long ellipse with one end sometimes thicker than the other. On end the grains are flattened and of an ellipsoidal form.

The *hilum* is a very eccentric, not very distinct, small, round, non-refractive spot, usually in the median line, occasionally slightly to one side. It is never fissured, and is occasionally double.

The *lamellæ* are very distinct, and are coarse regular rings or arcs of circles which are probably continuous. Those in the mesial part of the grain and at the distal end are usually the coarser and more distinct. Occasionally one or two near the hilum are very large and tend to follow the outline of the margin, those most distal to the hilum may be wavy in outline, otherwise they show no irregularities. If there are two hila in one grain, there are two sets of lamellæ, one corresponding to each hilum, but they merge into one another a short distance from the hila. The lamellæ are a little less distinct and finer than in *C. warszewiczii.* The number varies from 25 on the smaller grains to 85 on the larger; the common number is about 55.



Curve of Reaction-Intensities of Starch of Canna edulis.

The grains vary in *size* from 15 to 120μ. The common size is 60μ.

Polariscopic Properties.—The *figure* is very eccentric, very well defined except at the margin where the lines become broadened and somewhat hazy, and occasionally broken up and striated with fine, white striæ. Its lines are broad and usually two of the four lines are observed throughout their length running obliquely from the hilum.

The degree of *polarization* is very high, about the same as that of *C. roscoeana.* Polarization colors may be seen in some grains and are always visible when the grain is on end or edge. It is higher than in the grains of *C. warszewiczii,* about the same as *C. roscoeana.*

With *selenite* the quadrants are fairly sharply defined, fairly regular in shape, and unequal in size. The colors are very pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color more deeply a blue-violet, much deeper than *C. warszewiczii* and even deeper than *C. roscoeana;* with 0.125 per cent solution they color readily. After heating in water until the grains are completely gelatinized, the solution colored a light indigo and the grains a deep indigo with iodine. After boiling for 2 minutes the solution becomes a deep indigo color, but most of the grain-residues do not color at all. The capsules, when excess of iodine is added, become a dark red-violet; they are generally much disintegrated or reduced to granular masses.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are deeply and evenly stained. The color is less than in the grains of *C. warszewiczii.*

With *safranin* the grains begin to stain at once and after 30 minutes are fairly evenly and deeply stained. The coloration is less than *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 67° to 68° C., mean 67.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 1½ minutes. Most grains are entirely gelatinized in 10 minutes and all in 18 minutes. The hilum and lamellæ disappear. The margin becomes clearer and darker, which by contrast causes the inner portion of the grain to appear lighter and opaque. The one or two shoulder-like projections near the proximal end, or projections elsewhere, become dark and swollen, and the changes are followed by the darkening and swelling of other parts. The hilum and one or two nearby marginal points protrude as very long projections, the hilum swelling first and the reaction extending to the margin. The result of this is the formation of a ring of indigo-colored, gelatinized starch surrounding a violet-tinted, ungelatinized central mass which later is gradually included in the process. The gelatinized grains are large, irregularly rounded, and show a number of irregular bands of dark material separated by fissural lines in the distal portion. The marginal portion often breaks away in long strips from the rest of the grain, while in the central part a dark mass remains which is often fissured in one or two directions. At the proximal end there are often narrow projections.

Reaction with *chromic acid* begins in 15 seconds and is over in 2½ minutes. The hilum and lamellæ are distinct. A line extends out transversely on each side of the hilum. The hilum swells greatly, and the inner portion of the grain becomes divided by fine cross-fissures into a number of granules. The margin at the hilum is dissolved and the capsule opens out. One or rarely two large crescents containing several lamellæ now appear at the distal end of the grain and may separate and dissolve separately. Often they do not separate, but gradually become clear and finally disappear with the rest of the grain, the inner granular portion disappearing last.

The reaction with *pyrogallic acid* begins in 30 seconds and ends in 20 minutes. The hilum and lamellæ are distinct. A refractive line extends from each side of the hilum, the hilum swells, and three or four deep fissures radiate through the substance of the grain, open out as the hilum continues swelling, and the grain is thus divided into small pyramids which become divided and repeatedly subdivided as the grain swells, and finally pass into a granular gelatinous mass. The gelatinized grains are large and rounded or reniform in shape. At the proximal end there is a clear space representing the swollen hilum, and at the distal end a series of concentric folds, which may be lobulated and much distorted.

Reaction with *ferric chloride* begins in 4 minutes and is over in 45 minutes. The hilum and lamellæ disappear. The margin of the grain becomes clear and dark and a few lamellæ reappear within it. The clearing and darkening spread inward and involve the central portion of the grain. Swelling with great protrusion begins at either one or both of the projections of the proximal end. A small crack or fissure appears in the margin at the point at which protrusion occurs, distending a gelatinized capsule. From this point the grain may proceed to swell in one of two ways: Either a ring of gelatinization extends from the two points already mentioned around the margin, which is followed by swelling and great protrusion of the hilum, leaving a central unswollen portion which becomes divided by fissures into several pieces which subsequently gelatinize; or the hilum may swell first and gelatinization proceed distally with fissuring throughout the grain, the distal end being affected last. Occasionally the grain may begin to swell at both ends and at indifferent points on the margin. The gelatinized grains are large and very much folded, crumpled, and distorted. The proximal end is characterized by two or three long, finger-like projections, and the distal end by a crumpled, irregular mass.

The reaction with *Purdy's solution* begins in 15 seconds. Most grains are gelatinized in 1½ minutes and all in 3 minutes. The hilum and lamellæ become very distinct and a refractive line extends on each side from the hilum, and the hilum swells slowly and then very rapidly. As the swelling extends distally over the whole grain, the grain dissolves rapidly or slowly, as the case may be Usually there is no fissuration or only very fine fissures appear, or occasionally there may be deep fissures which radiate from the swollen hilum and open out as the grain swells, thus dividing the substance of the grain into four or five pyramidal parts. No longitudinal fissuring of the grain occurs. The gelatinized grains are large, somewhat ovoid, or round; they show a clear space with little projection outward at the proximal end, representing the swollen hilum and a rounded portion below, with either concentric rows or folds and sacculations.

STARCH OF CANNA VAR. (KÖNIGEN CHARLOTTE). (Plate 84, figs. 499 and 500. Chart 339.)

Histological Characteristics.—In *form* the grains are simple with the exception of rare compounds. There are no aggregates, clumps, or pressure facets. The surface is usually quite regular except for rounded or nipple-like protuberances at the side or at either end of the grain. The primary grain is sometimes completely surrounded by a secondary system of lamellæ. The conspicuous forms are the flattened ovoid; also oval, pyriform, elliptical, nearly spherical, irregularly quadrilateral and triangular with rounded corners, a few clam-shell type forms, and various irregular forms. The grains are usually much flattened and from one-fourth to one-half as thick as they are broad, and from one-third to three-fourths as broad as long. Seen on edge they are elliptical and may be narrower at one end than at the other.

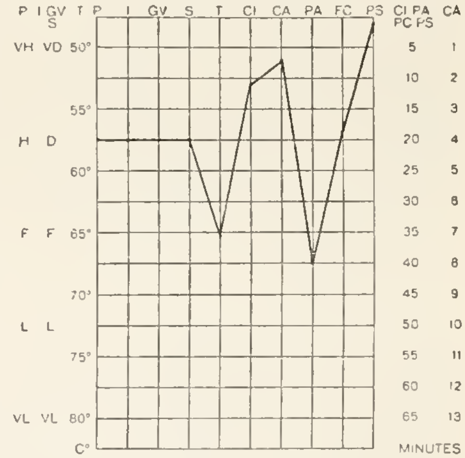
The *hilum* is often invisible on account of its extreme eccentricity. When it can be seen it is a very small, fairly distinct, round spot. It is usually single, but may be multiple, and it is never fissured. It varies in position from the extreme margin to one-sixth to one-ninth of the longitudinal axis, and is in or near the median line.

The *lamellæ* are very distinct, fine, fairly regular circles near the hilum, or arcs of circles beyond the hilum which are probably continuous. They are arranged so that groups of fine lamellæ alternate with coarse ones. They are not usually so fine and not so distinct at the distal end. They generally follow closely the outline of the distal margin, but are sometimes wavy and irregular. There are from 65 to 70 on the large grains.

The grains vary in *size* from 8 to 90μ. The common size is 46μ.

Polariscopic Properties.—The *figure* is very eccentric, very distinct, but not usually clear-cut. The lines are generally broad and only one or two are visible throughout their length; their margins are hazy and often somewhat bent and otherwise distorted. Two lines are sometimes connected by a third cross-line at about two-thirds the distance from the hilum to the distal end. When one long line is present it is usually in the longitudinal axis, and when there are two lines they are diagonal.

Chart No. 339.



Curve of Reaction-Intensities of Starch of Canna var (Konigen Charlotte).

The degree of *polarization* is high as a rule. It varies in different grains, in different aspects of the same grain, and in the same aspect of a grain. It is not so high as that of the grains of *C. warszewiczii.*

With *selenite* the quadrants are usually fairly well defined, fairly regular in shape, and unequal in size. The colors are not always pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once a deep violet-blue; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is not so deep as that of the grains of *C. warszewiczii.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly or not at all. With an excess of iodine the capsules become a violet color. Some capsules retain blue-reacting starch in the proximal end.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are deeply stained, some more than others. The color is the same as that of the grains of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 64.5° to 66° C., mean 65.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds and is over in 11 minutes. It is qualitatively the same as that of *C. warszewiczii.*

The reaction with *chromic acid* begins in 15 seconds and is over in 1½ minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

Reaction with *pyrogallic acid* begins in a minute and half are fully gelatinized in 10 minutes, about three-fourths are gelatinized in 15 minutes, and all in 40 minutes. The reaction is qualitatively the same as that of the grains of *C. warszewiczii.*

With *ferric chloride* the reaction begins in a few grains in a minute. Most grains are gelatinized in 7 minutes and all in 18 minutes. The reaction is qualitatively the same as that of the grains of *C. warszewiczii.*

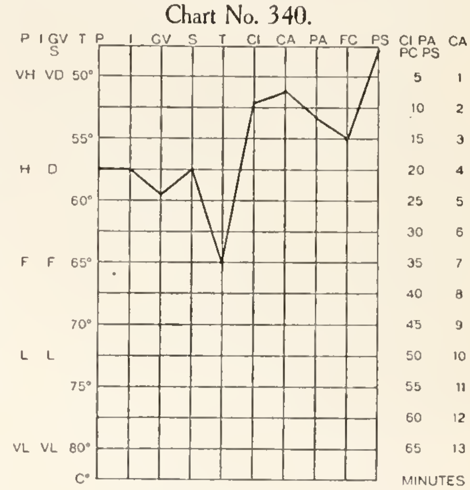
Reaction with *Purdy's solution* begins in a few seconds and is over in 1¼ minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

STARCH OF CANNA VAR. (PRESIDENT CARNOT). (Plate 84, figs. 501 and 502. Chart 340.)

Histological Characteristics.—In *form* the grains are simple, except rare compound grains consisting of two components. There are no aggregates, clumps, or pressure facets. The surface shows a marked tendency to irregularity, owing in part to a curving of the grains, but chiefly to rounded protuberances and nipple-like projections. The conspicuous forms are flattened, irregular ovoid, also broad ovoid, oval, pointed oval, flattened oval, irregularly quadrilateral, pyriform, bent or straight lenticular, triangular with rounded angles, clam-shell type and mussel-shell type. The grains are flattened and from one-fourth to one-half as thick as they are broad, and about one-half to three-fourths or more as broad as long.

The *hilum* is sometimes invisible, owing to its extreme eccentricity; when not so eccentric, it appears as a small, distinct, round or rarely elliptical spot, which may be located as far inward as one-sixth to one-ninth of the longitudinal axis, and in or to one side of the median line. There are occasionally 2 hila, and rarely more than 2 may be present and arranged linearly. The hila may or may not be separated from one another by a depression or a fine fissure, but the hilum itself is never fissured.

Chart No. 340.



Curve of Reaction-Intensities of Starch of Canna var. (President Carnot).

The *lamellæ* are very distinct, fine, regular or irregular circles, or arcs of circles which are probably continuous. Except those immediately surrounding the hilum, they tend to follow the outline of the distal end, but are often wavy and otherwise irregular. They are frequently arranged so that bands of varying numbers of fine lamellæ are grouped by scattered large, coarse lamellæ. The lamellæ vary somewhat in size and distinctness in the different grains and also in the same grain, being usually not so fine but more distinct near the distal end. There are sometimes two systems of lamellæ. There are about 70 lamellæ on the larger grains.

The grains vary in *size* from 6 to 76μ. The common size is 50μ.

Polariscopic Properties.—The *figure* is very eccentric, distinct, and sometimes clear-cut. One or two arms may be seen throughout their length, and they are often broadened and not clearly outlined in some part of their length, and they may be bent or otherwise much distorted or bisected. If one long line is present it is usually located longitudinally; but if two are present they are usually oblique.

The degree of *polarization* is high. It varies somewhat in the different grains and very much in different aspects of the same grain, being highest when the grain is viewed on end, and occasionally it varies in different parts of the same aspect of a grain. It is not so high as in the grains of *C. warszewiczii.*

With *selenite* the quadrants may be well or poorly defined, and are fairly regular in shape and unequal in size. The colors are usually not quite pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep bluish-violet, some more than others; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is deeper than that of the grains of *C. warszewiczii.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains fairly deeply on the addition of iodine. After boiling for 2 minutes the solution colors more deeply and the grain-residues lightly or not at all. The capsules all color a red-violet when an excess of iodine is added, and some of them retain some blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are deeply stained, some more than others, not so deeply as those of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 64° to 66° C., mean 65°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute and is over in 9 minutes. It is the same qualitatively as that of the grains of *C. warszewiczii,* except that in the beginning the grains are colored a much deeper violet.

The reaction with *chromic acid* begins in 15 seconds and is over in 1½ minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

Reaction with *pyrogallic acid* begins in 45 seconds. Most grains are gelatinized in 6 minutes and all in 12 minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

With *ferric chloride* a few grains begin to react in 45 seconds. Nearly all are gelatinized in 9 minutes and all in 15 minutes. The reaction is qualitatively the same as has been recorded in the grains of *C. warszewiczii.*

The reaction with *Purdy's solution* begins at once and is over in 40 seconds. It is the same qualitatively as that of the grains of *C. warszewiczii.*

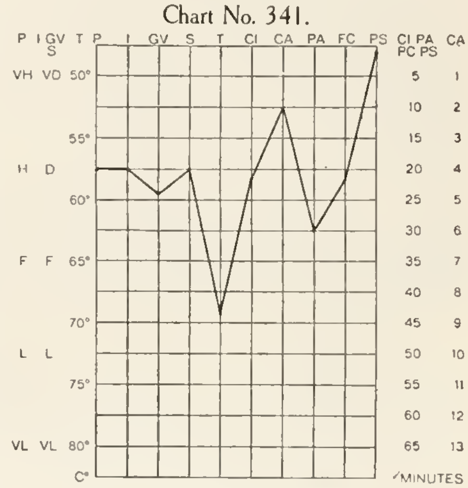
STARCH OF CANNA VAR. (L. E. BALLY). (Plate 84, figs. 503 and 504. Chart 341.)

Histological Characteristics.—In *form* the grains are simple, with the exception of very few compounds. There are no aggregates, clumps, or pressure facets. The surface of the grains tends to be quite regular excepting for slight depressions at the sides of the proximal end. The conspicuous forms are the flattened, broad ovoid. There are also flattened oval, oval, pyriform, lenticular, triangular and quadrangular with rounded angles, poorly formed clam-shell type, and various irregular forms. The grains are all flattened and about one-fourth to one-half as thick as wide, and the larger grains are from three-fourths to as broad as long.

The *hilum* is a very eccentric and fairly distinct small, round, or rarely lenticular spot. Eccentricity usually ranges from the extreme margin to from one-sixth to one-ninth of the longitudinal axis of the grain. The hilum lies in or to one side of the median line. It is never fissured. There may be 2 or more hila linearly arranged.

The *lamellæ* are distinct, fine circles about the hilum or segments of circles, beyond which they are probably continuous. They usually follow closely the outline of the distal end, but sometimes show waviness and other irregularities not in accordance with the marginal outline. They are usually so arranged that a band of fine lamellæ alternate with one large, coarse lamella. They are not so fine but more distinct in some grains than in others and are commonly coarser though not necessarily more distinct near the distal end. There are generally from 60 to 70 lamellæ on the larger grains.

Chart No. 341.



Curve of Reaction-Intensities of Starch of Canna var. (L. E. Bally).

The grains vary in *size* from 6 to 70μ. The common size is 35μ.

Polariscopic Properties.—The *figure* is very eccentric, very distinct, but commonly not clear-cut and broad. Usually one or two of its lines are visible throughout their length and become somewhat broader and hazy near the margin of the grain. They may be somewhat bent or otherwise distorted.

The degree of *polarization* is high. It varies greatly in different grains, in different positions of the same grain, and also sometimes in different parts of the same aspect of a grain. It is not so high as that of the grains of *C. warszewiczii.*

With *selenite* the quadrants are fairly well defined, unequal in size, and fairly regular in shape. The colors are usually not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep violet-blue; with 0.125 per cent solution they color fairly and the color deepens quickly, some more than others. The color is slightly deeper than that of the grains of *C. warszewiczii.* After heating the grains in water until they are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes, the solution colors deeply and the grain-residues lightly or not at all. The capsules color a red-violet with excess of iodine and many of them retain blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are deeply stained, some more than others. The color is not quite so deep as that of the grains of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 68° to 70° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute and is over in 22 minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

The reaction with *chromic acid* begins in 15 seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

With *pyrogallic acid* the reaction begins in a minute. About half the grains are gelatinized in 10 minutes, and all nearly completely in 30 minutes. The reaction is qualitatively the same as that of the grains of *C. warszewiczii.*

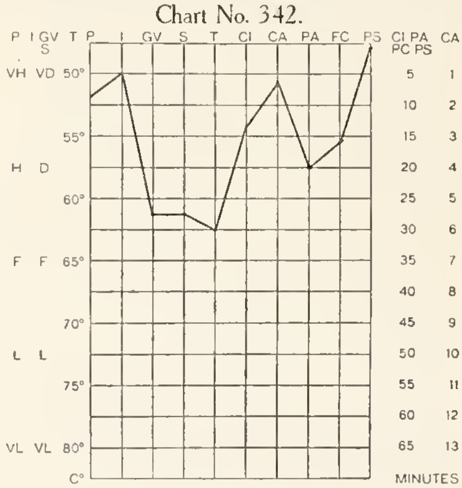
Reaction with *ferric chloride* begins in a few grains in 1½ minutes, most grains are gelatinized in 10 minutes, and all in 22 minutes. The reaction is qualitatively the same as that of the grains of *C. warszewiczii.*

The reaction with *Purdy's solution* begins at once and is over in a minute. It is the same qualitatively as that of the grains of *C. warszewiczii.*

STARCH OF CANNA VAR. (MRS. KATE GREY). (Plate 85, figs. 505 and 506. Chart 342.)

Histological Characteristics.—In *form* the grains are simple with the exception of a few compounds of two or three components. There are no aggregates, clumps, or pressure facets. The surface is usually fairly regular. Irregularities are due chiefly to small rounded protuberances and nipple-like projections. The conspicuous forms are the narrow to broad flattened ovoid; also quadrangular forms with rounded angles, oval, pyriform, almost round, elliptical, triangular with rounded angles, some approximations to the clam-shell type, and various indefinite forms. The grains are flattened and are about one-fourth to one-half as thick as broad, and commonly about one-half to seven-eighths as broad as long. Seen on edge they are somewhat elliptical and one end is usually narrower than the other.

Chart No. 342.



Curve of Reaction-Intensities of Starch of Canna var. (Mrs. Kate Grey).

The *hilum* is a fairly distinct, small, round or lenticular spot, usually eccentric from the extreme margin to about one-sixth to one-ninth of the longitudinal axis of the grain and in or near the median line. It is occasionally fissured, the fissure being in the form of a very small, shallow, transverse line. There may be 2 or rarely more hila arranged linearly.

The *lamellæ* are distinct, usually fine, fairly regular circles around the hilum, or segments of circles beyond, which are probably continuous. They occasionally show waviness and other irregularities, but, as a rule, follow in their form the outline of the distal end. They do not vary greatly in different grains and are generally arranged so that bands of varying numbers of fine lamellæ alternate with one coarse, very distinct lamella. In the same grain they are generally not so fine, but are distinct at the distal end. There are about 65 on the larger grains.

The grains vary in *size* from 7 to 68μ. The common size is 40μ.

Polariscopic Properties.—The *figure* is very eccentric, distinct, and sometimes clear-cut. The lines are usually broad and not sharply cut. One or two may be seen along the length of the grain. They vary in width and may be bent. If one long line is present it is usually in the longitudinal axis, but if two, they are diagonal. Sometimes the two lines are connected by a third transverse line located about midway between the hilum and the distal end.

The degree of *polarization* is very high. It varies somewhat but not greatly in different grains and much in different aspects of the same grain, being highest when the grain is viewed on end or edge. It is not quite so high as in the grains of *C. warszewiczii.*

With *selenite* the quadrants are fairly well defined, and are fairly regular in shape and unequal in size. The colors usually are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color at once a violet-blue; with 0.125 per cent solution they color fairly and the color deepens quickly. The color is deeper than that of the grains of *C. warszewiczii.* After heating in water until the grains are completely gelatinized, the solution colors fairly deeply and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors more deeply and the grain-residues less deeply. The capsules color a violet with excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes are fairly deeply stained, some more than others. The color is not so deep as that of the grains of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 62° to 63° C., mean 62.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute and is over in 13 minutes. It is qualitatively the same as that of the grains of *C. warszewiczii,* except that the grains are colored a much deeper violet at the beginning of the reaction.

Reaction with *chromic acid* begins in a very few seconds and is over in 1¼ minutes. It is qualitatively about the same as that of the grains of *C. warszewiczii,* the main point of difference being that with these grains a serial separation of crescents from the distal end does not often occur.

With *pyrogallic acid* the reaction begins in 30 seconds. Nearly all are completely gelatinized in 10 minutes and all are fully gelatinized in 20 minutes. The reaction is the same qualitatively as that of the grains of *C. warszewiczii.*

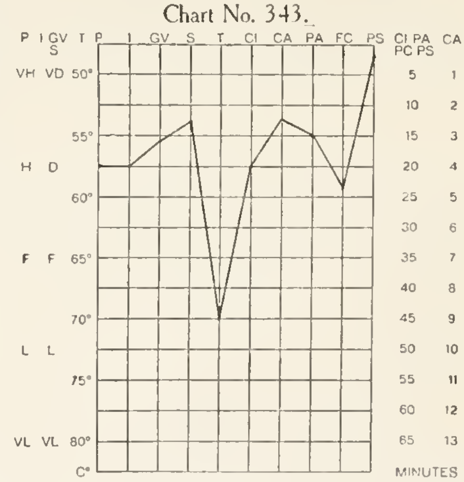
The reaction with *ferric chloride* begins in some grains in a minute and in nearly all in 2 minutes. Almost all are gelatinized in 10 minutes and all in 16 minutes. The reaction is qualitatively the same as that of the grains of *C. warszewiczii.*

Reaction with *Purdy's solution* begins at once and is over in 30 seconds. It is qualitatively the same as that of the grains of *C. warszewiczii.*

STARCH OF CANNA VAR. (JEAN TISSOT). (Plate 85, figs. 507 and 508. Chart 343.)

Histological Characteristics.—In *form* the grains are simple with the exception of a few compound grains consisting of two components. There are no aggregates, few clumps, and no pressure facets. The surface of the grains is fairly regular. In these, as in other *Canna* grains, small, rounded protuberances and nipple-like projections render the margin of some grains irregular. The conspicuous forms are the broad ovoid, also flattened ovoid, flattened elliptical, lenticular, oval, pyriform, triangular and quadrilateral with rounded angles, clam-shell type, and various irregular forms. The grains are all flattened so that they are about one-fourth as thick as they are broad, and on end or edge appear as thin flattened ellipses. They range from about half to as broad as long.

Chart No. 343.



Curve of Reaction-Intensities of Starch of Canna var. (Jean Tissot).

The *hilum* is often invisible owing to its extreme marginal location. When visible it is a distinct, small, round, or rarely lenticular spot. It is usually eccentric from the extreme margin to about one-sixth to one-ninth of the longitudinal axis, and in or near the median line. It is rarely double and rarely fissured. If a fissure is present it is a very small, single, transverse or diagonal line.

The *lamellæ* are very distinct, fine, fairly regular circles around the hilum, or segments of circles beyond, which are probably continuous. They usually follow the outline of the distal margin, but occasionally show an irregular waviness not in accordance with the outline of the grain. Those nearer the distal end are often not so fine, though not more distinct, than those near the hilum, and are coarser and more distinct in one grain than in another. There are about 60 lamellæ on the larger grains.

The grains vary in *size* from 5 to 60μ. The common size is 40μ.

Polariscopic Properties.—The *figure* is very eccentric, very distinct, but not clear-cut. The lines are broad, and usually one or two are visible throughout the length of the grain. If there is one such line, it is in or close to the longitudinal axis, but if two lines they are diagonally placed. The lines are sometimes connected by a transverse line at about half the distance between the hilum and distal end, and also often vary in width or are bent.

The degree of *polarization* is high. It is variable in different grains, being comparatively low in some grains to very high in others. It also varies in different aspects of the same grain and in different parts of the same aspect of a grain. It is not so high as that of the grains of *C. warszewiczii.*

With *selenite* the quadrants are fairly well defined, fairly regular in shape, and very unequal in size. The colors are usually not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep violet-blue; with 0.125 per cent solution they color fairly well and the color deepens rapidly. The color is slightly deeper than that of the grains of *C. warszewiczii.* After heating in water until the grains are completely gelatinized, the solution colors lightly and the grains fairly deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues lightly or not at all. The capsules color a pinkish-violet with an excess of iodine; some retain blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes are deeply stained, some more than others. The color is the same as that of the grains of *C. warszewiezii.*

With *safranin* the grains begin to stain at once and in 30 minutes are deeply stained, some more than others. The color is slightly less than that of the grains of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 45 seconds. It is complete in nearly all in 10 minutes and in all in 20 minutes. It is qualitatively the same as that of the grains of *C. warszewiczii.*

The reaction with *chromic acid* begins in 15 seconds and is over in 2½ minutes. It is qualitatively the same as that of the grains of *C. warszewiczii.*

The reaction with *pyrogallic acid* begins in a minute. All are partially and one-third completely gelatinized in 10 minutes, and about half are completely and the rest nearly completely gelatinized in 15 minutes. The reaction is qualitatively the same as that recorded of the grains of *C. warszewiczii.*

Reaction with *ferric chloride* begins in some grains in a minute and is general in 2½ minutes. Nearly all are gelatinized in 10 minutes and all in 23 minutes. The reaction is qualitatively the same as that of the grains of *C. warszewiczii.*

The reaction with *Purdy's solution* begins in a very few seconds and is over in 2 minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

STARCH OF CANNA VAR. (J. D. EISELE). (Plate 85, figs. 509 and 510. Chart 344.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compounds which consist of two components. There are no aggregates, few clumps, and no pressure facets. The surface of the grains is usually quite regular. There is slight irregularity of the margin at the proximal end, owing to one- and two-sided slight depressions or to nodular or nipple-like projections. The most conspicuous form is the broad to flattened ovoid; also oval, elliptical, lenticular, pyriform, triangular and quadrangular with rounded angles, almost round, clam-shell type, and indefinite forms. The grains are much flattened and about one-fourth to one-half as thick as broad. Usually the largest grains are one-half to three-fourths as broad as long.

The *hilum* is sometimes invisible on account of an extreme marginal position. When seen it is a fairly distinct, small, round spot, eccentric from the extreme margin to about one-sixth to one-ninth of the longitudinal axis and in or near the median line. It is rarely fissured. The fissure is a short, shallow, single, transverse line. There may be 2 or rarely more hila linearly arranged and sometimes separated by fissures.

The *lamellæ* are very distinct, fairly regular circles in the region of the hilum, or arcs of circles beyond, which are probably continuous. The arcs usually follow the outline of the distal margin but sometimes are wavy and otherwise irregular. They are generally arranged so that bands of varying numbers of fine, not very distinct lamellæ alternate with one or two very coarse, distinct lamellæ. They vary in size and distinctness in the different grains and even in the same grain are not so fine but usually more distinct near the distal end. There are about 55 on the larger grains.

The grains vary in *size* from 6 to 78μ. The common size is 44μ.

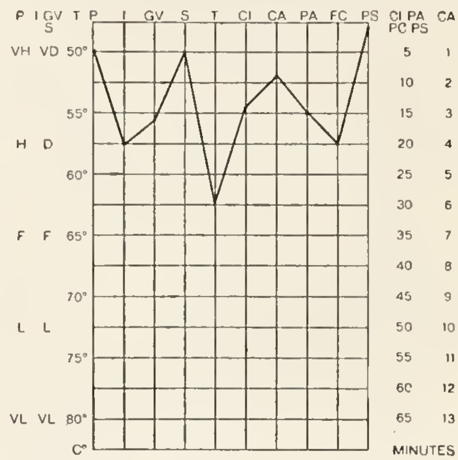
Polariscopic Properties.—The *figure* is very eccentric, very distinct, but usually not clear-cut. One or two long lines may be seen; if one line, it is usually in or near the longitudinal axis; if two lines, they are oblique. Two lines may be connected by a transverse line at about two-thirds of the distance from the hilum to the distal end. The lines are also often bent and vary in width.

The degree of *polarization* is very high. It varies in different grains and in different aspects of the same grain, and somewhat in different parts of the same aspect of a grain. It is the same as that of the grains of *C. warszewiczii.*

With *selenite* the quadrants are usually fairly well defined, fairly regular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep violet-blue; with 0.125 per cent solution they color fairly and the color deepens rapidly. The color is slightly deeper than that of the grains of *C. warszewiczii.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains fairly deeply. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. With an excess of iodine the capsules color a red-violet or violet. Many capsules contain blue-reacting starch in the proximal end.

Chart No. 344.



Curve of Reaction-Intensities of Starch of Canna var. (J. D. Eisele).

Staining Reactions.—With *gentian violet* the grains begin to color at once and in 30 minutes are deeply stained, some more than others. The color is deeper than that of the grains of *C. warszewiczii.*

With *safranin* the grains begin to color at once and in 30 minutes are deeply stained, some more than others. The color is the same as that of the grains of *C. warszewiczii.*

Temperature Reaction.—The temperature of gelatinization is 62° to 63° C., mean 62.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute. It is over in most grains in 7 minutes and in all in 14 minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

Reaction with *chromic acid* begins in 15 seconds and is over in 1¾ minutes. It is the same qualitatively as that of the grains of *C. warszewiczii.*

The reaction with *pyrogallic acid* begins in most grains in 30 seconds. About three-fourths are gelatinized in 6 minutes and practically all in 15 minutes. The reaction is the same qualitatively as that of the grains of *C. warszewiczii.*

With *ferric chloride* the reaction begins in a few grains in 1½ minutes and in almost all in 3 minutes; most grains are gelatinized in 12 minutes and all in 20 minutes. The reaction is the same qualitatively as that of the grains of *C. warszewiczii.*

The reaction with *Purdy's solution* begins at once and it is over in 45 seconds. It is the same qualitatively as that of the grains of *C. warszewiczii.*

Differentiation of Certain Starches of the Genus Canna.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

C. warszewiczii: Usually simple, few compound, no pressure facets, some irregularity of surface, flattened; broad ovoid and clam-shell type.

C. roscoeana: Essentially the same as in *C. warszewiczii,* but with less irregularity of surface and apparent absence of compound grains, not so well formed clam-shell type, and less abundance of irregular forms.

C. musæfolia: Essentially the same as in *C. warszewiczii,* but less irregular; they resemble more closely *C. roscoeana.*

C. edulis: Essentially the same as in *C. warszewiczii,* but with less irregularity, while the most conspicuous form is the broad ovoid.

C. var. (*Königen Charlotte*): Essentially the same as in *C. warszewiczii,* but with less irregularity, while the most conspicuous form is the flattened ovoid.

C. var. (*President Carnot*): Essentially the same as in *C. warszewiczii,* but the most conspicuous form is the flattened, irregular ovoid.

C. var. (*L. E. Bally*): Essentially the same as in *C. warszewiczii,* but less irregular, while the most conspicuous form is the flattened ovoid.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Conspicuous Forms.—Continued.

C. var. (*Mrs. Kate Grey*): Essentially the same as in *C. warszewiczii,* but the conspicuous form is the narrow to broad flattened ovoid.

C. var. (*Jean Tissot*): Essentially the same as in *C. warszewiczii,* but the conspicuous form is the broad ovoid.

C. var. (*J. D. Eisele*): Essentially the same as in *C. warszewiczii,* but the conspicuous form is the broad to flattened ovoid.

Hilum—Form, Number, and Position.

C. warszewiczii: Form small, distinct, single, round or elliptical, may be multiple; fissuration not common. Position usually very eccentric.

C. roscoeana: Form small, not very distinct, single round; fissuration not common. Position usually very eccentric.

C. musæfolia: Form small, very distinct, single, round or lenticular, may be multiple; fissuration uncommon. Position usually very eccentric.

Differentiation of Certain Starches of the Genus Canna.—Continued.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.—Continued.

C. edulis: Form small, not very distinct, single, round, occasionally double; no fissures. Position usually very eccentric.

C. var. (*Königen Charlotte*): Form very small, fairly distinct, round, single, may be multiple, never fissured. Position usually very eccentric, from extreme margin to 0.16 to 0.11 of longitudinal axis.

C. var. (*President Carnot*): Form small, distinct, round or rarely elliptical, never fissured, usually single, may be multiple. Position usually very eccentric, from extreme margin to 0.16 to 0.11 of longitudinal axis.

C. var. (*L. E. Bally*): Form fairly distinct, small, round or rarely lenticular, single or rarely multiple, never fissured. Position usually very eccentric, from extreme margin to 0.16 to 0.11 of longitudinal axis.

C. var. (*Mrs. Kate Grey*): Form fairly distinct, small, round or lenticular, single or may be double, occasionally fissured, fissures small and shallow. Position usually very eccentric, from extreme margin to 0.16 to 0.11 of longitudinal axis.

C. var. (*Jean Tissot*): Form distinct, small, round or rarely lenticular, single or rarely multiple, rarely fissured, fissures small and shallow. Position usually eccentric from extreme margin to 0.16 to 0.11 of longitudinal axis.

C. var. (*J. D. Eisele*): Form fairly distinct, small, round, single or rarely multiple, rarely fissured, fissures small and shallow. Position usually eccentric, from extreme margin to 0.16 to 0.11 of longitudinal axis.

Lamellæ—General Characteristics and Number.

C. warszewiczii: Very distinct, regular, fairly coarse circles or arcs of circles. About 48 to 50 on larger grains.

C. roscoeana: Very distinct, regular, coarse circles or arcs of circles. More distinct and slightly coarser than those of *C. warszewiczii.* About 45 on larger grains.

C. musæfolia: Very distinct, regular, coarse circles or arcs of circles. More distinct and slightly coarser than those of *C. warszewiczii.* About 60 on larger grains.

C. edulis: Very distinct, regular, coarse circles or arcs of circles. A little finer than those of *C. warszewiczii.* About 85 on larger grains.

C. var. (*Königen Charlotte*): Very distinct, fairly regular, fine circles or arcs of circles, sometimes wavy, not so fine and not so distinct near the distal end. About 65 to 70 on larger grains.

C. var. (*President Carnot*): Very distinct, fine, fairly regular circles or arcs of circles, sometimes wavy, not so fine and more distinct at the distal end. About 70 on larger grains.

C. var. (*L. E. Bally*): Distinct, fine, fairly regular circles or arcs of circles, sometimes wavy, not so fine but of the same distinctness at distal as at proximal end. About 60 to 70 on larger grains.

C. var. (*Mrs. Kate Grey*): Distinct, fine, fairly regular circles or arcs of circles, wavy, not so fine and more distinct at distal end. About 65 on larger grains.

C. var. (*Jean Tissot*): Very distinct, fine, fairly regular circles or arcs of circles, occasionally wavy, not so fine but of the same distinctness at the distal end. About 60 on larger grains.

C. var. (*J. D. Eisele*): Very distinct, fine, fairly regular circles or arcs of circles, sometimes wavy, not so fine and more distinct near the distal end. About 55 on larger grains.

Size.

C. warszewiczii: From 15 to 70μ, commonly 50μ.

C. roscoeana: From 13 to 88μ, commonly 60μ.

C. musæfolia: From 15 to 82μ, commonly 55μ.

C. edulis: From 15 to 120μ, commonly 60μ.

Histological Characteristics.—Continued.

Size.—Continued.

C. var. (*Königen Charlotte*): From 8 to 90μ, commonly 45μ.

C. var. (*President Carnot*): From 6 to 76μ, commonly 50μ.

C. var. (*L. E. Bally*): From 6 to 70μ, commonly 35μ.

C. var. (*Mrs. Kate Grey*): From 7 to 68μ, commonly 40μ.

C. var. (*Jean Tissot*): From 5 to 60μ, commonly 40μ.

C. var. (*J. D. Eisele*): From 6 to 78μ, commonly 44μ.

Polariscopic Properties.

Figure.

C. warszewiczii: Very eccentric, very distinct, usually clear-cut, sometimes irregular, lines rather broad, usually only 1 or 2 lines visible for whole length, if 1 line it is longitudinal, and if 2 lines they are oblique. Lines often bent or otherwise distorted, or occasionally bisected.

C. roscoeana: Essentially the same as in *C. warszewiczii.*

C. musæfolia: Essentially the same as in *C. warszewiczii.*

C. edulis: Essentially the same as in *C. worszewiczii.*

C. var. (*Königen Charlotte*): Essentially the same as in *C. warszewiczii.*

C. var. (*President Carnot*): Essentially the same as in *C. warszewiczii.*

C. var. (*L. E. Bally*): Essentially the same as in *C. worszewiczii.*

C. var. (*Mrs. Kate Grey*): Essentially the same as in *C. warszewiczii.*

C. var. (*Jean Tissot*): Essentially the same as in *C. warszewiczii.*

C. var. (*J. D. Eisele*): Essentially the same as in *C. warszewiczii.*

Degree of Polarization.

C. warszewiczii: Very high.

C. roscoeana: Very high, higher than in *C. warszewiczii.*

C. musæfolia: Very high, slightly higher than in *C. warszewiczii.*

C. edulis: Very high, higher than in *C. warszewiczii.*

C. var. (*Königen Charlotte*): High, not so high as in *C. warszewiczii.*

C. var. (*President Carnot*): High, not so high as in *C. warszewiczii.*

C. var. (*L. E. Bally*): High, not so high as in *C. warszewiczii.*

C. var. (*Mrs. Kate Grey*): Very high, not quite so high as in *C. warszewiczii.*

C. var. (*Jean Tissot*): High, not so high as in *C. warszewiczii.*

C. var. (*J. D. Eisele*): Very high, the same as in *C. warszewiczii.*

Polarization with Selenite—Quadrants and Colors.

C. warszewiczii: Quadrants fairly well defined, fairly regular in form, unequal in size. Colors usually pure.

C. roscoeana: Quadrants the same as in *C. warszewiczii.* Colors very pure.

C. musæfolia: Quadrants the same as in *C. warszewiczii.* Colors pure.

C. edulis: Quadrants the same as in *C. warszewiczii.* Colors very pure.

C. var. (*Königen Charlotte*): Quadrants the same as in *C. warszewiczii.* Colors usually pure.

C. var. (*President Carnot*): Quadrants the same as in *C. warszewiczii.* Colors usually pure.

C. var. (*L. E. Bally*): Quadrants the same as in *C. warszewiczii.* Colors usually not pure.

C. var. (*Mrs. Kate Grey*): Quadrants the same as in *C. warszewiczii.* Colors usually not pure.

C. var. (*Jean Tissot*): Quadrants the same as in *C. warszewiczii.* Colors usually not pure.

C. var. (*J. D. Eisele*): Quadrants the same as in *C. warszewiczii.* Colors usually pure.

Differentiation of Certain Starches of the Genus Canna.—Continued.

Iodine Reactions.

Intensity and Color.

C. warszewiczii: Deep; blue-violet.
C. roscoeana: Very deep, deeper than in *C. warszewiczii;* blue-violet.
C. musæfolia: Deep, the same as in *C. warszewiczii;* blue-violet.
C. edulis: Very deep, much deeper than in *C. warszewiczii;* blue-violet.
C. var. (*Königen Charlotte*): Deep, not so deep as in *C. warszewiczii;* blue-violet.
C. var. (*President Carnot*): Deep, deeper than in *C. warszewiczii;* blue-violet.
C. var. (*L. E. Bally*): Deep, slightly deeper than in *C. warszewiczii;* blue-violet.
C. var. (*Mrs. Kate Grey*): Very deep, deeper than in *C. warszewiczii;* blue-violet.
C. var. (*Jean Tissot*): Deep, slightly deeper than in *C. warszewiczii;* blue-violet.
C. var. (*J. D. Eisele*): Deep, slightly deeper than in *C. warszewiczii;* blue-violet.

Staining Reactions.

With Gentian Violet.

C. warszewiczii: Deep.
C. roscoeana: Deep, the same as in *C. warszewiczii.*
C. musæfolia: Deep, the same as in *C. warszewiczii.*
C. edulis: Fairly deep, not so deep as in *C. warszewiczii.*
C. var. (*Königen Charlotte*): Deep, the same as in *C. warszewiczii.*
C. var. (*President Carnot*): Deep, not so deep as in *C. warszewiczii.*
C. var. (*L. E. Bally*): Deep, not quite so deep as in *C. warszewiczii.*
C. var. (*Mrs. Kate Grey*): Fairly deep, not so deep as in *C. warszewiczii.*
C. var. (*Jean Tissot*): Deep, deeper than in *C. warszewiczii.*
C. var. (*J. D. Eisele*): Deep, deeper than in *C. warszewiczii.*

With Safranin.

C. warszewiczii: Very deep.
C. roscoeana: Deep, not so deep as in *C. warszewiczii.*
C. musæfolia: Very deep, the same as in *C. warszewiczii.*
C. edulis: Deep, not so deep as in *C. warszewiczii.*
C. var. (*Königen Charlotte*): Deep, not so deep as in *C. warszewiczii.*
C. var. (*President Carnot*): Deep, not so deep as in *C. warszewiczii.*
C. var. (*L. E. Bally*): Deep, not so deep as in *C. warszewiczii.*
C. var. (*Mrs. Kate Grey*): Fairly deep, not so deep as in *C. warszewiczii.*
C. var. (*Jean Tissot*): Deep, slightly less than in *C. warszewiczii.*
C. var. (*J. D. Eisele*): Very deep, the same as in *C. warszewiczii.*

Temperature of Gelatinization.

C. warszewiczii: 68 to 70° C., mean 69°.
C. roscoeana: 69 to 70° C., mean 69.5°.
C. musæfolia: 70 to 71° C., mean 70.5°.
C. edulis: 67 to 68° C., mean 67.5°.
C. var. (*Königen Charlotte*): 64.5 to 66° C., mean 65.25°.
C. var. (*President Carnot*): 64 to 66° C., mean 65°.
C. var. (*L. E. Bally*): 68 to 70° C., mean 69°.
C. var. (*Mrs. Kate Grey*): 62 to 63° C., mean 62.5°.
C. var. (*Jean Tissot*): 69 to 71° C., mean 70°.
C. var. (*J. D. Eisele*): 62 to 63° C., mean 62.5°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

C. warszewiczii: Begins in a minute; complete in 25 minutes.
C. roscoeana: Begins in a minute; complete in 15 minutes.
C. musæfolia: Begins in a minute; complete in 20 minutes.
C. edulis: Begins in 1½ minutes; complete in most in 10 minutes, and in all in 18 minutes.
C. var. (*Königen Charlotte*): Begins in 30 seconds; complete in 11 minutes.
C. var. (*President Carnot*): Begins in a minute; complete in 9 minutes.
C. var. (*L. E. Bally*): Begins in a minute; complete in 22 minutes.
C. var. (*Mrs. Kate Grey*): Begins in a minute; complete in 13 minutes.
C. var. (*Jean Tissot*): Begins in 45 seconds; complete in nearly all in 10 minutes, and in all in 20 minutes.
C. var. (*J. D. Eisele*): Begins in a minute; complete in most in 7 minutes, and in all in 14 minutes.

Reaction with Chromic Acid.

C. warszewiczii: Begins in 30 seconds; complete in 2 minutes.
C. roscoeana: Begins in 30 seconds; complete in 3 minutes.
C. musæfolia: Begins in 30 seconds; complete in 3½ minutes.
C. edulis: Begins in 15 seconds; complete in 2½ minutes.
C. var. (*Königen Charlotte*): Begins in 15 seconds; complete in 1½ minutes.
C. var. (*President Carnot*): Begins in 15 seconds; complete in 1½ minutes.
C. var. (*L. E. Bally*): Begins in 15 seconds; complete in 2 minutes.
C. var. (*Mrs. Kate Grey*): Begins in a few seconds; complete in 1¼ minutes.
C. var. (*Jean Tissot*): Begins in 15 seconds; complete in 2½ minutes.
C. var. (*J. D. Eisele*): Begins in 15 seconds; complete in 1¾ minutes.

Reaction with Pyrogallic Acid.

C. warszewiczii: Begins in a minute; complete in one-sixth in 20 minutes.
C. roscoeana: Begins in 2 minutes; complete in 1 or 2 and all reacting in 16 minutes.
C. musæfolia: Begins in 1½ minutes; complete in a few grains and one-fifth partially gelatinized in 15 minutes.
C. edulis: Begins in 30 seconds; complete in 20 minutes.
C. var. (*Königen Charlotte*): Begins in a minute; complete in three-fourths in 15 minutes, and in all in 40 minutes.
C. var. (*President Carnot*): Begins in 45 seconds; complete in most in 6 minutes, and in all in 12 minutes.
C. var. (*L. E. Bally*): Begins in a minute; complete in one-half in 10 minutes, and nearly complete in all in 30 minutes.
C. var. (*Mrs. Kate Grey*): Begins in 30 seconds; complete in nearly all in 10 minutes, and in all in 20 minutes.
C. var. (*Jean Tissot*): Begins in a minute; about one-half are completely and the rest nearly completely gelatinized in 15 minutes.
C. var. (*J. D. Eisele*): Begins in 30 seconds; complete in three-fourths in 6 minutes, and in practically all in 15 minutes.

Reaction with Ferric Chloride.

C. warszewiczii: Begins in 2 minutes; complete in 15 minutes.
C. roscoeana: Begins in 1½ minutes; complete in 10 minutes.

Differentiation of Certain Starches of the Genus Canna.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.—Continued.

C. musæfolia: Begins in 1½ minutes; complete in 25 minutes.
C. edulis: Begins in 4 minutes; complete in 45 minutes.
C. var. (*Königen Charlotte*): Begins in a minute; complete in most in 7 minutes, and in all in 18 minutes.
C. var. (*President Carnot*): Begins in 45 seconds; complete in most in 9 minutes, and in all in 15 minutes.
C. var. (*L. E. Bally*): Begins in 1½ minutes; complete in most in 10 minutes, and in all in 22 minutes.
C. var. (*Mrs. Kate Grey*): Begins in a minute; complete in most all in 10 minutes, and in all in 16 minutes.
C. var. (*Jean Tissot*): Begins in a minute; complete in nearly all in 10 minutes, and in all in 23 minutes.
C. var. (*J. D. Eisele*): Begins in 1½ minutes; complete in most in 12 minutes, and in all in 20 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Purdy's Solution.

C. warszewiczii: Begins in a few seconds; complete in 2 minutes.
C. roscoeana: Begins in 15 seconds; complete in 5 minutes.
C. musæfolia: Begins in 15 seconds; complete in 6 minutes.
C. edulis: Begins in 15 seconds; complete in 3 minutes.
C. var. (*Königen Charlotte*): Begins in a few seconds; complete in 1¼ minutes.
C. var. (*President Carnot*): Begins at once; complete in 40 seconds.
C. var. (*L. E. Bally*): Begins at once; complete in a minute.
C. var. (*Mrs. Kate Grey*): Begins at once; complete in 30 seconds.
C. var. (*Jean Tissot*): Begins in a very few seconds; complete in 2 minutes.
C. var. (*J. D. Eisele*): Begins at once; complete in 45 seconds.

NOTES ON THE STARCHES OF CANNA.

There are variations, mostly of a minor character, in the forms, sizes, hila, and lamellæ, which are useful in the differentiation of the several starches. In their reactions, the differences are sufficient, but not, on the whole, marked, to enable the distinction of one from another; and it will be noted upon a comparison of the reaction-curves that there is a general correspondence in the curves of the first four specimens (four species), and also of the curves of the six horticultural varieties that follow.

STARCHES OF MARANTACEÆ.

Class, Monocotyledones. Order, Scitaminales. Family, Marantaceæ. Genera represented: Maranta, Calathea, Stromanthe.

The *Marantaceæ* include about 12 genera and 150 species of herbaceous plants, all natives of the tropics, mostly of America. The genera represented in this research are very closely allied, and most of the cultivated forms of *Maranta* belong to other genera of the family, especially to *Calathea* and *Stromanthe.*

GENUS MARANTA.

This genus includes about a dozen herbaceous tropical plants which are natives of Central and Southern America. *Maranta, Calathea, Stromanthe, Phrynium,* and *Thalia* are closely allied, and many of the *Calathea* and *Stromanthe* are marketed as Marantas. Starches from four recognized species of *Maranta* were studied, including *M. arundinacea* Linn., *M. massangeana* E. Morr. (*Calathea massangeana* Hort.), *M. leuconeura* E. Morr., *M. kerchoveana* E. Morr., *M. kerchovei* Hort. (*Calathea kerchoveana* Hort.), and *M. musaica* Hort. In addition to these, two forms of commercial arrowroot obtained from leading English importers, and stated to be from *M. arundinacea,* were studied. The supply of *Maranta* arrowroot to the trade originally came from Bermuda, hence the name Bermuda arrowroot; but now the supply seems to be from St. Vincent.

The true Marantas include very few species. They are cultivated chiefly as foliage plants and as a source of arrowroot. Arrowroot is a generic name, originally applied to starches obtained from the rhizomes of a number of members of this genus, especially from *M. arundinacea,* but it soon became a commercial term that has been attached to a number of starches from various species of different genera, families, and orders. The word had its origin in the application by the Indians of Jamaica of the crushed rhizome to poisoned-arrow wounds to extract the poison. The nutritive value of this starch was recognized by Hughes in 1751, and it is due to this property that arrowroot became an article of commerce and of importance as an article of diet of the sick.

The true arrowroot was originally obtained solely from *M. arundinacea,* which was taken from the island of Dominica to Barbados, and later to Jamaica, and since then cultivated in various parts of the West Indies, East Indies, Ceylon, Africa, Southeastern United States, and other countries. The same or different kinds of arrowroot are often distinguished in commerce merely by the names of the countries in which they are produced. Next in importance to *M. arundinacea* as a source of true arrowroot is *M. indica* Tussac, regarded as a distinct species, but only a variety. Its chief differences from *M. arundinacea* are in its having leaves that are smooth on both sides and pointed, and in the color of the seeds.

Wickström concluded that *M. arundinacea* and *M. indica* are identical, and Flückiger (Pharmakognosie des Pflanzenreiches, 1881, 220) states that the differences are so slight that the latter can not be regarded as a distinct species. Flückiger records that the starches are identical, but Hanausek (Microscopy of Technical Products, Trans. by Winton, 1907, 43) described certain minor differences. In comparing the starches of *M. arundinacea* and *M. indica,* and a starch from an uncertain source which was described by von Höhnel (Die Stärke und die Mahlproducte, 1882, 31) as a West Indian product, Hanausek found that the grains of *M. indica* are characterized by their pronounced wavy, angular outlines; those of the von Höhnel starch by their rounded form; and those of *M. arundinacea* by intermediate characteristics. Pariera (Materia Medica and Therapeutics, edited by Joseph Carson, 1854, 226), one of the earliest authorities to describe West Indian arrowroot, refers to it as white, colorless, and tasteless, and in the form either of a light opaque white powder or of small, pulverulent masses. The grains are convex, more or less elliptical, and moderately uniform in size. The shape is more or less irregular, but often oblong, or usually somewhat ovate oblong, frequently triangular, or oyster-shaped or mussel-shaped. In some of the samples, after having been digested in water, one or rarely two mammillary processes are seen projecting from the surface of some of the particles. In some specimens these processes appeared like short spines. The rings are very distinct, though fine. The hilum is usually very distinct, and generally located towards one end of the grain; normally it is circular, but frequently cracked in a linear, stellate manner. Forms resembling Bermuda arrowroot are known as Montserrat and St. Vincent arrowroots. The grains of the former are stated to be larger and to have a larger number of narrow fissures; while those of the latter not only show a larger number having fissures than in the Bermuda variety, but also form larger masses or clumps of grains, and the starch is not so white. Nägeli's description, recorded a few years later, will be found on page 224.

The starch *Maranta arundinacea* is described by Wiesner, a very recent authority, as being in the form of simple grains, and that when viewed from the side they are oval, rounded triangular, or deltoid-shaped with obtuse angles; and in transverse section, circular or somewhat flattened. The size of the grain is very variable, so that the average can not be expressed by one number, but by the range. The longest diameter of the starch-grain varies between 13 and 70μ, the average being between 27 and 54μ. Lamellæ can always be traced but are never strongly marked. The hilum may lie in the center, but more frequently is about one-sixth eccentric and then located nearer the broad or the narrow end. There is usually a transverse cleft, filled with air, proceeding from the hilum, this cleft being usually in the form of a double curve.

East Indian arrowroot comes from two entirely different sources, one in the rhizomes of *M. arundinacea* and the other in the roots of several species of *Curcuma* (*Zingiberaceæ*), especially *C. angustifolia*, *C. leucorrhiza*, and *C. rubescens*. The *Curcuma* starches are also known as tikor, Bombay, Malabar, and Tellicherry arrowroot, and also as white and buff-colored tikor. The white tikor, according to Pariera (*loc. cit.*, page 238), differs from the buff-colored by the absence of various impurities, indicating that both have a common source of origin, the difference being due to different degrees of care in the preparation. White tikor is described as being in the form of a fine, white powder, transparent, flattened disks (about 0.0003 inch in thickness, the largest being about 0.0027 inch long and 0.00129 inch broad), ovate, oblong ovate, with a very short neck or nipple-like projection at the extremity at which the hilum is located. The hilum is very small, circular, not very distinct, and placed at the narrow end of the grain. The lamellæ are apparent on both the flat surfaces and the edges, and are numerous, close, and very fine. (See *Curcuma*, page 790.)

Portland arrowroot or Portland sago, made in the island of Portland, is obtained from the corms of *Arum maculatum* (*Aroideæ*) and is described by Pariera (*loc. cit.*, 158) as being in the form of exceedingly small (average size, 0.00022 inch in diameter), circular, muller-shaped, or polygonal grains, having angularities which appear to be due to compression. The hilum is circular and apparently lies in a small depression and it cracks in a linear or stellate manner. Tavoo starch is said to come from *Arum esculentum*. (See *Arum*, page 440.)

Queensland arrowroot is prepared from the rhizomes of various Cannas (*Cannaceæ*). The grains are stated to belong to the same type as the true arrowroots and are described by Hanausek (*loc. cit.*, page 46) as being simple, rarely in semi-aggregates, flattened, broadly ovate, or reniform, or even fiddle-shaped, drawn out at the end into a short point. An eccentric hilum is always evident, and the starch is characterized by the large grains which vary in size up to 130μ in length. *Tous-les-mois*, a well-known arrowroot of the English and French, was for a time thought to be derived from *Canna coccinea*, but Pariera (*loc. cit.*, page 227) states that the probable source (since confirmed) is *C. edulis*, a plant known on the western coast of South America as achira. He records the grains as being very large (in this respect exceeding those of all other starches), somewhat egg-shaped, oval or oblong, but generally more or less ovate. The hilum is very distinct, circular, and usually placed at the narrow extremity of the grain; very rarely it is double, and once it was seen to be triple. The rings are fine, numerous, concentric, and regular, but somewhat irregularly spaced. The hilum and the body of the grain are frequently cracked. (See *Cannaceæ*, page 796.)

Two entirely different kinds of arrowroot come from Guiana. One form known as Guiana arrowroot, or yam starch, is made from several species of *Dioscorea* (*Dioscoreaceæ*), especially *D. sativa* and *D. alata*. These grains are described by Hanausek (*loc. cit.*, page 47) as being simple, flattened, irregularly ovate, elliptical, or club-shaped, with a more or less distinct point at which the hilum is located. The large grains are 14 by 80μ, usually 30 by 45μ long. The other starch is derived from the fruit of the banana, chiefly from *Musa sapientum* and *M. paradisiaca*, which latter is probably not a distinct species but merely a variety of *M. sapientum*. Hanausek (*loc. cit.*, page 47) states that the simple starch-grains are elongated, ovate, pear-shaped, and rod-shaped, with an eccentric hilum, distinct rings, and 30μ to 76μ long. (See *Musaceæ*, page 771.)

Brazilian arrowroot, variously known as cassava, manioc, mandioca, and tapioca, is obtained from the tuberous roots of several species of *Manihot*, chiefly from *Manihot utilissima*, *M. aipi*, and *M. carthaginensis* (*Euphorbiaceæ*). *M. utilissima* yields the bitter cassava and *M. aipi* the sweet cassava. Pariera (*loc cit.*, page 383) states that this starch consists of single grains which in the living plant were united in groups or compound grains, each being composed of two, three, or four grains. Most are muller-shaped, and therefore were united in the plant in groups of two each. When seen endwise they appear circular or globular. Some are truncated, egg-shaped grains with one or two facets at the truncation. The hilum is circular and surrounded with rings, and bursts in a stellate manner (see *Manihot*, page 876). Another form of Brazilian arrowroot and from an entirely different kind of plant is the starch of the common sweet potato, *Batatus edulis* or *Ipomœa batatus* (*Convolvulaceæ*). This starch is described by Hanausek (*loc. cit.*, page 46) as being a fine powder consisting either of aggregates or of grains separated from aggregates, the individual grains being hemispherical, sugar-loaf-shaped, club-shaped, and polygonal, the larger measuring 20 to 50μ. The hilum is eccentric, mostly with radiating clefts, and the lamellæ are distinct. (See *Batatus edulis*, page 884.)

Tahiti arrowroot comes chiefly from the Hawaiian Islands, and for a time was stated to be obtained from *Tacca oceanica*, but it has since been shown that this plant is identical with *T. pinnatifida* (see *Taccaceæ*, page 686). From this plant a starch is also prepared in the East Indian province of Arracen. Pariera (*loc. cit.*, page 221) records it as a white powder with a slight musty odor. The grains are circular, muller-shaped, or polyhedral. Some muller-shaped forms are slightly narrowed at the base, and the base instead of being flat appears to be hollowed out. The hilum is small and circular and is cracked in a linear or stellate manner. The lamellæ are few and not very distinct, and the prevalent size is 0.008 by 0.00007 inch. (See *Tacca*, page 686.)

A starch from Chili which is sold under the name of Talcahuano arrowroot is made from the tuberous root of several species of *Alstrœmeria*, chiefly probably *A. ligtu*. (See *Alstrœmeria*, page 658.)

Colocasia (*Aroideæ*) also yields a starch that has been marketed as an arrowroot.

Under the name of koonti, or coontie, is sold an arrowroot prepared in Florida and in Bahama and West Indian islands from the rhizomes of several species of *Zamia* (*Cycadaceæ*). The Florida species are chiefly *Z. floridana* and *Z. pumila*, which are usually referred to *Z. integrifolia*, the latter being West Indian. Arrowroot is prepared from the seeds of *Dioon* (*Cycadaceæ*). (See *Dioon*, page 896.)

A Chinese arrowroot is made from the root-stocks of *Nelumbo speciosa* (*Nymphœaceæ*), from which species was also obtained the Pythagorean bean or sacred bean of the ancients. (See *Nelumbo*, page 849.)

A so-called English arrowroot was claimed to be a true or a pseudo potato starch, but Nägeli (Die Stärkekörner, etc., *loc. cit.*) found that it is a variety of Jamaica or West Indian arrowroot. He describes the grains as being oval, elongated coniform, three- or four-cornered, and most of them more or less irregular. The diameter corresponding to the hilum is from two-thirds to twice the length of the transverse diameter. The hilum end is the thicker and narrower. The lamellæ are fine and fairly distinct, the outer lamellæ often forming a separate system. Most grains are unfissured; occasionally in place of the hilum there is a very short, longitudinal, or transverse fissure, or there may be short radiating fissures. The fissures may form a three-armed figure, or an oblique cross, but seldom a true cross.

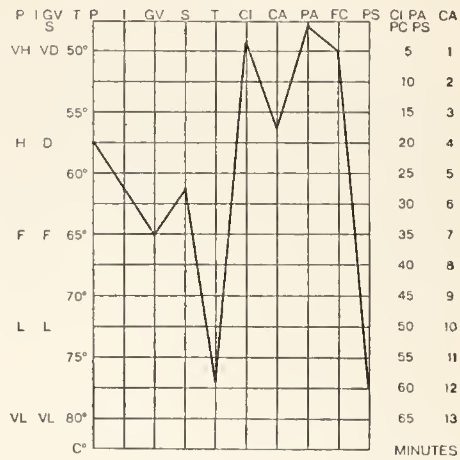
It will be observed from the foregoing that the arrowroots of commerce have been obtained from various species, varieties, and forms which represent eleven families, including, *Marantaceæ*, *Zingeberaceæ*, *Aroideæ*, *Cannaceæ*, *Dioscoraceæ*, *Musaceæ*, *Euphorbiaceæ*, *Convolvulaceæ*, *Amaryllidaceæ*, *Nymphaceæ*, and *Cycadaceæ;* seven orders, including *Scitaminales*, *Arales*, *Liliales*, *Geraniales*, *Cycadales*, *Polemoniales*, and *Ranales;* and three classes, *Monocotyledones*, *Dicotyledones*, and *Gymnospermæ*. Doubtless a careful search into the literature of the true and false arrowroots would show other sources. The importance that has fallaciously been attributed to arrowroots as an article of diet in the sick room because chiefly of their assumed greater digestibility than starches generally has been referred to elsewhere (see Part I, page 194).

STARCH OF MARANTA ARUNDINACEA. (Plate 88, figs. 523 and 524. Chart 345.)

Histological Characteristics.—In *form* the grains are almost wholly simple and isolated, with the exception of a small number which rarely occur in small aggregates (doublets). There are a few compound grains. Pressure facets are very seldom observed. More of the grains are regular, irregularities being chiefly the result either of protuberances or depressions in the surface of the grain. The protuberances are more often located either near or at the proximal end. They may be present at the corners of the distal margin of triangular grains and at the distal end of ellipsoidal or other elongated types. These protuberances may vary from rounded, pointed, and nipple-like to rather large cone-shaped, the latter type always being located at the proximal end. A depression at one side of the hilum is often found in the mussel-shell-shaped grain, and a concave indentation resembling a pressure facet is occasionally present at or near the distal end of such grains. The conspicuous forms are ovoid, ellipsoidal, pyriform, triangular with curved base and rounded angles, nearly round, mussel-shell-shaped, and ellipsoidal with a mesial elevation of one side. There are also imperfect quadrangular with rounded angles, club-shaped, lenticular, and finger-shaped grains. The grains are somewhat flattened, and when viewed on edge they are usually ovoid in shape, with the narrower end towards the distal end.

The *hilum* may be observed as a clear, round, or lenticular spot, generally eccentric, the range of eccentricity being from four-ninths to one-fourth, usually one-third to one-fourth. The variation is caused by the presence of additional lamellæ at the proximal end. Either a small, rounded cavity or one or more fissures are often observed at the hilum. In the broadened grains the fissures frequently form a Y-shaped figure, while in the elongated forms either one short, transverse cleft, one crescent-shaped cleft, or two slightly curved, small fissures so arranged as to resemble a soaring bird are often found. In ellipsoidal grains with one side slightly elevated mesially, the hilum is laterally located at this elevated point.

Chart No. 345.



Curve of Reaction-Intensities of Starch of Maranta arundinacea.

The *lamellæ* are demonstrable on most grains and are fine, less fine near the hilum than towards the distal end, at which margin in the shell-shaped grains there is often a band of very delicate or indistinct lamellæ. They form complete, circular rings near the hilum, but at other regions of the grain they closely follow the margin and are probably incomplete. On the larger grains 28 to 32 lamellæ may be counted. Occasionally when the protuberance on the grain is large, a depression is noted between the main body of the grain and this deposit, which indicates that the lamellæ of such a protuberance may be a secondary set of lamellæ.

The grains vary in *size;* the smaller are 3 by 2μ, the larger, 36 by 20μ in length and breadth. The common size is about 24 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is quite eccentric to slightly eccentric, and occasionally centric. Its lines are distinct, fine, and usually cross each other obliquely. They are generally straight, but are sometimes bent, and rarely bisected.

The degree of *polarization* is high, with slight variation in different grains, a few being very high. Occasionally there are variations in the same aspect of a given grain.

With *selenite* the quadrants are clearly defined and clean-cut, usually unequal in size, and sometimes irregular in shape. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet at once, which deepens gradually, some becoming much deeper than others; with 0.125 per cent solution the grains color a rather light blue-violet which deepens in most grains rather rapidly. After heating in water until the grains are gelatinized and then adding iodine, the grains become a dull, quite deep blue, some with reddish tint, and the solution a rather deep indigo-blue. If the gelatinized grains are boiled for 2 minutes and then treated with iodine, the solution colors a very deep indigo-blue and the grain-residues a light blue, some with reddish tint, and the capsules a reddish-violet. With an excess of iodine the capsules color an old-rose to a deep heliotrope.

Staining Reactions.—With *gentian violet* the grains begin to color slightly at once and in 30 minutes are fairly colored.

With *safranin* the grains begin to color slightly at once and in 30 minutes are fairly deep in tint, rather deeper than with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 76° to 78° C., mean 77°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in a minute, nearly all in 2 minutes, all but a few resistant grains in 3 minutes, in which the reaction is usually complete in 6 minutes, rarely not until 7 minutes. The grains color an old-rose at once, and the hilum appears as a dark spot, ring, or lines. Gelatinization accompanied by a dark bluish color begins at the distal end, or at any prominent corners or protuberances on the grain, quickly spreads around the margin and then advances more rapidly from the distal margin towards the hilum than from other points, the region of the hilum being the last to undergo the reaction. The grain is deeply colored, uniformly and slightly swollen, but retains the general shape of the untreated grain.

Reaction with *chromic acid* begins immediately. Several grains are dissolved in a minute, nearly all in 2 minutes, and all but parts of a few resistant grains in 3½ minutes, in which the reaction is usually complete in 4½, rarely 5½, minutes. The structures at the hilum swell and a bubble appears which enlarges and then collapses, followed in most grains by a rapid disorganization of the surrounding region, accompanied by the appearance of an irregular mass of refractive granules embedded in the gelatinized starch. The outer lamellæ are sharply defined and striated, and as they become broken down the refractive granules appear first in linear arrangement; the grain continues to enlarge and finally the capsule is ruptured. The rupture occurs at the distal end of the narrow forms, or usually at one corner of the distal margin in the broadened triangular and shell-shaped grains; which corner during the reaction becomes prominent and extended laterally. The entire grain now passes into solution, the capsule of the proximal end and sides nearby usually being the most resistant. An exception occurs to this method, when a large, cone-shaped extension is present at the proximal end, the capsule then being ruptured first at this point, but the other steps of the reaction are the same, except that from the slightly eccentric hilum, fissures extend towards both the proximal and the distal ends. During the process of gelatinization in the more resistant grains, two or three parallel, branched fissures in the narrower forms, and a cluster of fissures with two, sometimes three, more prominent ones in the broader forms can be observed extending from the hilum towards the distal end; the steps of the process are the same as those described above.

The reaction with *pyrogallic acid* begins immediately. Several of the grains are gelatinized in 10 seconds, nearly all in 30 seconds, and all in 45 seconds. The structures at the hilum swell and a bubble appears which quickly enlarges and then suddenly collapses by the rapid gelatinization of the grain with the exception of the outermost lamellæ, which are soon gelatinized. The reaction is so rapid that the various steps are difficult to determine, but in the less reactive grains, two or three large, branched fissures extend distalwards from the hilum, along which gelatinization proceeds with a faint trace of granules embedded in the more soluble starch until the process is complete. The gelatinized grain is much swollen and the capsule is thrown into folds at the distal end, but retains the general contour at the proximal end, so that it resembles the untreated grain.

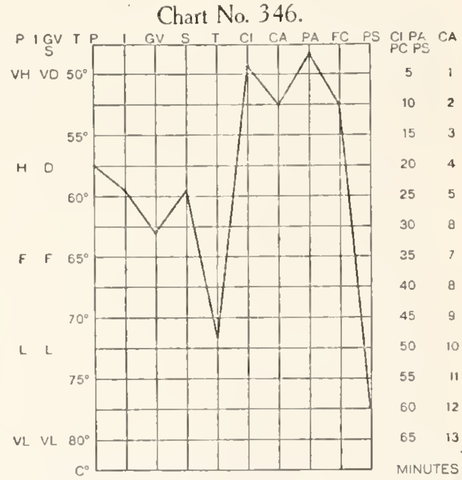
The reaction with *ferric chloride* begins in a few grains immediately. A small number are gelatinized in a minute, about three-fourths in 2 minutes, about seven-eighths in 4 minutes, and all but rare resistant grains in 5 minutes, in which latter the reaction is usually complete in 8 minutes, rarely 10 minutes. The structures at the hilum become very distinct, then a bubble usually appears at this point, and a lustrous border forms around the grain. This border increases in width, more rapidly generally at the distal end, and gelatinization begins at the hilum in the narrower forms, but at the corners of the distal margin in the broadened forms, accompanied in each type by the rapid distension of the capsule. Gelatinization in the latter case proceeds towards the proximal end accompanied by irregularly arranged, refractive granules embedded in the more soluble starch; finally, as the reaction approaches the region of the hilum, the bubble rapidly enlarges, then collapses, followed by the fissuration of this more resistant starch into rather large, irregular masses which gradually become gelatinous. In many grains, the lustrous border gradually closes around the hilum, the lamellæ in this border becoming more sharply defined; the bubble at the hilum swells rapidly, collapses, and gelatinization quickly spreads over the grain, with the exception of the outer lamellæ of the proximal end and sides nearby, which gradually become gelatinous. In grains in which this process is less rapid, gelatinization is frequently accompanied by the appearance of fissures extending inward from the distal end and outward from the region of the hilum. Exceptions of these two general types of gelatinization are found in those grains which have large protuberances and in elongated ellipsoidal grains having the hilum located in the middle of one side. In the grains with a large, cone-shaped protuberance at the proximal end, gelatinization with distension of the capsule begins at this end, followed rather rapidly from the distal end, the starch of the region surrounding the hilum being the most resistant. In the elongated, ellipsoidal grains above noted, gelatinization begins simultaneously at both ends. The gelatinized grains are much swollen but retain the general shapes of the untreated grain.

Reaction with *Purdy's solution* begins in a few grains in 30 seconds. About one-fortieth are gelatinized in 5 minutes, about one-twentieth in 15 minutes, about one-sixteenth in 30 minutes, and about one-eighth in 60 minutes. The hilum swells, but generally no bubble appears; the fissures are similar in character and arrangement to those described for the resistant grains when treated with pyrogallic acid, but are much deeper and more clear-cut. The lamellæ are sharply defined and striated, and during their disorganization refractive granules appear, which are less resistant and irregularly massed around the hilum and center of the grain, but linearly arranged near the distal margin and also at the proximal end, when they appear at this point. Gelatinization proceeds more rapidly from the hilum to the distal end between two coarser, radiating fissures, between which there is a cluster of delicate fissures. Or the starch at the proximal end and sides nearby, usually being the most resistant, often remains as a homogeneous, solid border in the otherwise gelatinized grain, but sometimes it breaks into fairly large, irregular fragments which may persist or gradually gelatinize; or this border may become differentiated into sharply defined and striated lamellæ, which, if they become disorganized, result in the appearance of linearly arranged, refractive granules. The gelatinized grains are swollen, but retain the general shape of the untreated grain, and there is usually either a trace of a few lamellæ or some refractive granules present.

STARCH OF MARANTA ARUNDINACEA VAR. No. 1. (Plate 88, figs. 525 and 526. Chart 346.)

Histological Characteristics.—In *form* the grains are simple, excepting some rare compounds consisting of two components; there appears no tendency to form aggregates or clumps, and pressure facets are rare. The surface of the grains tends to be more or less irregular, owing to rounded protuberances, nipple-like processes, and spicules, which are most commonly found at the distal end of the grains. The most conspicuous forms are ovoid to oval and elliptical, clam-shell-shaped, mussel-shell-shaped, triangular with rounded angles, and spherical; also pyriform, quadrangular with rounded angles, elongated dome-shaped, and various regular forms. The proximal may be the broader or narrower end, but when the grain is seen on edge the distal end is the narrower. When viewed on end the grain is ovoid to spherical at the proximal end, and narrow and irregularly elliptical at the distal end. The ovoid to the oval and elliptical forms are commonly from about one-half to two-thirds as broad as long, but the shell-shaped and allied forms may be broader than long.

Chart No. 346.



Curve of Reaction-Intensities of Starch of Maranta arundinacea var. No. 1.

The *hilum* is a small, round, non-refractive spot, usually eccentric about one-sixth to one-fourth of the longitudinal axis. It may be in or somewhat to one side of the median line. It is sometimes marked by a short, but deep, transverse fissure having a double curve, and the fissure may be divided at the ends into several smaller fissures; or it may be crossed by another fissure to form a 2-armed figure. Compound grains with 2 hila are seen, and the line of junction of the component grains may be indicated by a linear depression or a fissure.

The *lamellæ* are continuous circles or arcs of circles, which are often irregular as they follow the outline of the margin. They are not usually very distinct and are rather coarse. They vary in size and spacing in the same grain and in different grains, and those added last are often the largest and most distinct. They may be wavy in outline without reference to the form of the margin of the grain, and vary in number, averaging about 23 on the larger grains.

The grains vary in *size* from 11 to 54μ. The common size is 20μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, clear-cut, and irregular. Its lines are usually well defined, comparatively narrow, and approaching the same size and distinctness throughout, with a tendency to widening at the margin. Usually four lines appear and may be somewhat bent or otherwise distorted and placed at varying distance from one another, and the longer lines may cross the grain diagonally, longitudinally, or transversely.

The degree of *polarization* is high. It is higher if the grain is viewed on edge or end, and it varies somewhat in different grains and in some grains in the same aspect of a given grain. Polarization is about the same as in *M. arundinacea*, but the variations are greater.

With *selenite* the quadrants are well defined, irregular in shape, and unequal in size. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, a little deeper than *M. arundinacea;* with 0.125 per cent solution they tint lightly at first and the color deepens slowly, but more rapidly than in *M. arundinacea.* After heating the solution until the grains are completely gelatinized, the grains are deeply colored with iodine, but the solution is colored lightly, if at all. After boiling for 2 minutes, the grain-residues color less and the solution very markedly. On the addition of an excess of iodine the capsules are colored violet, while the contents of the grain-residues representing the greater part of the grain are of an indigo color.

Staining Reactions.—With *gentian violet* the grains begin to stain slightly at once and after 30 minutes are fairly stained. The individual grains are evenly colored, but some grains more deeply than others. The color is a little deeper than in *M. arundinacea.*

With *safranin* the grains begin to tint at once and in 30 minutes are fairly deeply stained, slightly deeper than in *M. arundinacea.*

Temperature Reaction.—The temperature of gelatinization is 71° to 72° C., mean 71.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once. A few grains are gelatinized in 45 seconds, nearly all in 2 minutes, all but a few resistant grains in 3½ minutes, and all in 10 minutes. The hilum becomes very distinct as a small black spot or bubble. The lamellæ are rendered invisible. The distal end and the tips of the spicules and nipple-like processes, whenever they appear, may become dark, and gelatinization begins at these parts with swelling and protrusion, which is especially marked at the distal end. The process extends sometimes half way around the margin. Occasionally swelling occurs at both ends. Usually after a time the grains swell out enormously at the distal end and sides, leaving a triangular portion, including the hilum, that remains for a time ungelatinized; later this portion is also included in the process. The gelatinized grains are large, but do not exhibit much distortion of the original shape. They often show alternate light and dark bands at the distal end and in the body of the grain. These bands may not be entirely separated, and proximally there is a clear, smooth, round space representing the swollen hilum. In some cases the interior of the grain is very dark and shows merely irregular fissures.

The reaction with *chromic acid* begins in two-thirds of the grains in 15 seconds, is over in practically all in 2 minutes, and in all in 5½ minutes. The hilum and sometimes the lamellæ become prominent. Two refractive lines now appear to extend from the hilum, one on each side, to the distal end of the grain, outlining an oval, inner space, which becomes divided by fine, longitudinal striæ or fissures which extend from the hilum. The hilum now swells enormously and, as it enlarges, the striated, inner portion of the grain is pushed before it towards the distal end. The margin becomes distinct and much thicker at the distal than the proximal end, and shows fine or coarse striations according as the grain reacts quickly or slowly. The marginal part of the grain is in the form of a capsule and becomes dissolved at one point at the proximal end where it is thin, and the inner part of the grain flows out and is dissolved, followed by solution of the remaining part of the capsule. In a few cases a formation of crescents occurs as in certain other starches.

Reaction with *pyrogallic acid* begins at once. Most of the grains are gelatinized in 30 seconds and all in 65 to 105 seconds. After a bubble appears at the hilum, the hilum and lamellæ become very distinct. The hilum swells slightly, and at times refractive lines extend from each side to the distal end and fine striæ radiate from the hilum through the grain. The hilum now swells greatly and the bubble is moved to one side and then disappears. The inner part of the grain is pushed by the swelling process towards the distal end, which becomes granular. The margin is broad and very distinct, is finely striated, and shows two or three bands. This banded appearance eventually clears away, as does also the granular mass at the distal end. The swollen grains so formed are large and ovoid and retain somewhat the original shape of the grain. The proximal end is rounded; the distal is crumpled and irregular.

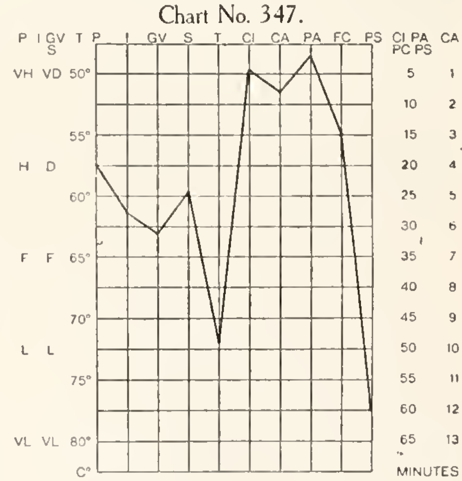
With *ferric chloride* reaction begins in two-thirds of the grains in 2 minutes, about seven-tenths are gelatinized in 5 minutes, and practically all in 10 minutes. The reaction is complete in all in 20 to 35 minutes. The hilum is prominent as a dark bubble, the lamellæ disappear, the margin becomes clear and darker, and the inner portion of the grain appears light and opaque. The distal end becomes gelatinized and has irregular protrusions. In grains in which the transverse diameter is the longest (triangular and certain related forms), the two poles of this diameter become gelatinized first, then the hilum swells enormously just before or just as this process of gelatinization reaches it, and the bubble which appears at the hilum during the first part of the reaction now becomes very large and then disappears. The gelatinized grains are very large, round, and smooth at the proximal end, and crumpled, lobulated, and folded at the distal end. The margin is at first distinct and shows indistinctly striated bands; later it becomes thin and clear.

Reaction with *Purdy's solution* begins immediately and almost all of the grains are swollen in 2 minutes; about four-fifths are gelatinized in 5 minutes and nearly all in 30 minutes; no further progress occurs in an hour. The hilum and lamellæ become distinct and fine striæ radiate from the hilum throughout the inner portion of the grain. The hilum swells rapidly, pushing the striated part before it to the distal end, where it collects as a granular mass. Some of the gelatinized part of the grain is formed into a marginal band which is very distinctly marked with fine striations. If the hilum is fissured and the reaction slow, the grain may be divided by deep fissures, which open out in a stellate fashion as the hilum swells. The gelatinized grains are large, ovoid to elliptical. The proximal end is smooth and rounded, while the distal is crumpled, lobulated, and distorted.

STARCH OF MARANTA ARUNDINACEA VAR. No. 2. (Plate 88, figs. 527 and 528. Chart 347.)

Histological Characteristics.—In *form* the grains are simple, with the exception of a few compounds in the form of two or three components. There is no tendency to form aggregates or clumps, and pressure facets are rare. The surface of the grains tends to be irregular, owing to rounded protuberances and spicular or nipple-like projections, which are most frequently found at the distal end of the grain. The conspicuous forms are ovoid to oval and elliptical, clam-shell- and mussel-shell-shaped, pyriform, triangular, spherical, and dome-shaped; also various irregular forms. The proximal end may be the narrower or broader end. The grains are from about half to a third as thick as wide, and commonly from one-third to three-fourths as broad as long. When observed on end the proximal end is ovoid to spherical or elliptical, while the distal end is oval to elliptical, the distal end being flattened more than the proximal. In the ovoid to elliptical forms the longitudinal axis is longer than the transverse, while in some of the clam-shell and related types the reverse is often the case.

Chart No. 347.



Curve of Reaction-Intensities of Starch of Maranta arundinacea var. No. 2.

The *hilum* is a distinct, relatively large, round, refractive spot. Double hila are common, and three hila may be seen arranged triangularly. It is usually eccentric about one-sixth to one-fourth of the longitudinal axis and in or slightly to one side of the median line. It is often fissured, and the fissuration is commonly in the form of a short, deep, transverse or longitudinal fissure, whose ends often branch into a number of small fissures; or there may be an irregular or stellate arrangement of small fissures.

The *lamellæ* are not very distinct. They vary greatly in distinctness and size in different grains, and somewhat in the same grain. They are circles or arcs of circles, and those more distal to the hilum tend to follow the outlines of the margin. In grains with double hila, two sets of lamellæ corresponding to the hila are noted, but a short distance from the hila they are merged into one another. Their number varies from 16 on the small to 38 on the large grains. The average is 22.

The grains vary in *size* from 7 to 45μ. The common size is 28μ.

Polariscopic Properties.—The *figure* is usually eccentric and distinct. Its lines are very clearly defined and some tend to widen materially as they are nearer the margin of the grain. They are so arranged usually that one corresponds with the longitudinal axis of the grain; in some grains they divide the field obliquely.

The degree of *polarization* is high, about the same as that of *Maranta arundinacea*, but with greater variation. It varies a little in different grains, in different aspects of a given grain, and occasionally in the same aspect of a grain.

With *selenite* the quadrants are very well defined, irregular in shape, and unequal in size. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet, the same depth of color but more blue than in *M. arundinacea;* with 0.125 per cent solution they tint lightly, the color deepens slowly, but more rapidly than in *M. arundinacea.* When heated in water until complete gelatinization has occurred the solution is colored a deep indigo on the addition of iodine; the gelatinized grains are colored deeply to lightly, mostly the latter. The gelatinized grains are smooth, rounded, and nodular, and granular at the distal end. After boiling for 2 minutes the solution is much more intensely colored and the grain-residues but little or not at all. With an excess of iodine all the capsules take on a red-violet color and are folded and twisted.

Staining Reactions.—With *gentian violet* the grains begin to stain slightly at once and after 30 minutes they are fairly colored, slightly deeper than in *M. arundinacea.*

With *safranin* staining begins immediately and after 30 minutes the grains are fairly deeply stained, slightly deeper than in *M. arundinacea.*

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* some grains show the beginning of a reaction at once. A few are gelatinized in 45 seconds, more than half in 1½ minutes, nearly all in 2 minutes, and all but rare resistant grains in 4½ minutes, in which latter the reaction may not be complete until 15 minutes. The lamellæ become indistinct, but the hilum grows more distinct as a black spot, or is fissured. All the grains take on a light violet tint, the margin becomes clearer and forms a clear ring which spreads inward, causing the central portion to assume a lighter, more refractive appearance. The lamellæ reappear in the marginal clear space, this being accompanied by the development of dark points on the margin, especially on the nodular projections and at the distal end. Protrusion and gelatinization begin at these points and then proceed gradually towards the hilum. The grain as a whole in the meantime becomes colored a dark violet. Gelatinization may begin at opposite ends of the grain at the same time and proceed centrally, gradually approaching the hilum, which finally swells.

Reaction with *chromic acid* begins in two-thirds of the grains in 15 seconds and in the remaining one-third in 45 seconds. Nearly all are dissolved in 1½ minutes and all in 4 minutes. The lamellæ are indistinct, but the hilum becomes distinct and swells, accompanied by the formation of fine, radiating striæ throughout the grain. Coarse striæ or folds appear at the distal end of the grain. The margin dissolves at a point above the swollen hilum, and the space formed by the swollen hilum opens out. One faintly lamellated, finely striated crescent usually forms at the distal end of the grain, which generally does not split off, but if it does, a second much fainter one forms. After the widening out of the swollen hilum, the grain gradually becomes clearer and finally dissolves. When the hilum is fissured, the fissures widen and deepen, and extend through the grain. One portion of the margin now dissolves and the fissures widen, followed by the solution of the grain.

With *pyrogallic acid* evidences of swelling appear in most grains at once. Several are gelatinized in 10 seconds, nearly all in 35 seconds, all but rare resistant grains in 50 seconds, and all within 2 minutes. There is no further change. The hilum and lamellæ become very distinct. The hilum swells and highly refractive lines, probably fissures in the interior of the grain, extend on each side to the margin. The hilum gradually becomes larger and fine striæ appear in the grain. Later coarse striæ or folds develop at the distal end. The hilum gradually enlarges, and the lamellated substance of the grain is pushed out to the margin until a large, gelatinized grain is formed which exhibits a clear inner space that is surrounded by a dark margin having still darker striated bands and a granular mass at the distal end. In grains in which the hilum is centric, granular masses are formed at two parts of the grain. If the hilum is fissured, the fissures widen, but there are no essential differences in the type of swelling. The fully gelatinized grains are large, clear, oval, and somewhat folded.

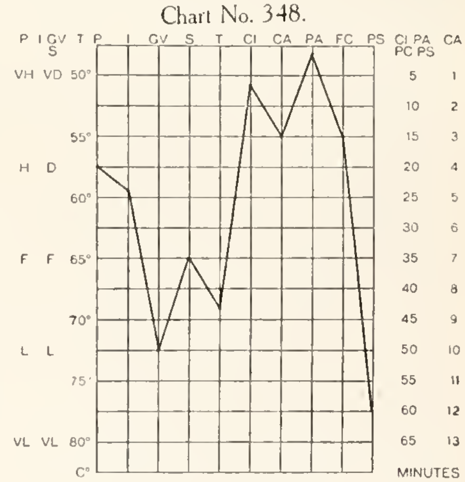
With *ferric chloride* a beginning of a reaction is seen in some grains at once. A few are gelatinized in a minute, about four-fifths in 5 minutes, nearly all in 10 minutes, all but rare resistant grains in 15 minutes, and all in 25 to 30 minutes. The lamellæ disappear and the hilum becomes distinct as a black spot. There is often a protrusion or gelatinization of the margin at the nodules or nipple-like processes of the grain or from the distal end. The rest of the margin becomes clear and shows lamellation, and a ring is formed which widens as it spreads inward, lessening the area of the inner, lighter portion. The swelling is slight until a bubble is formed at the hilum. This is followed by great swelling and the disappearance of the bubble. By this swelling a clear inner space is formed, surrounded by a darker portion that exhibits striated rings, and granular masses are present where protrusion first took place from the margin. The gelatinized grains gradually become clear and are finally quite transparent. They are very large, oval, and somewhat folded and crumpled.

Swelling begins in 30 seconds or less with *Purdy's solution*. A few grains are gelatinized in a minute, about one-fourth in 5 minutes, about two-thirds in 30 minutes, and four-fifths in 60 minutes. The hilum and lamellæ become more distinct. Two refractive lines extend from the hilum to the margin, and the grain becomes finely striated. The hilum and the grain swell very rapidly, forming a smooth, gelatinized grain which has a distal end with a lobulated outline, and a collection of granular starch. The margin is darker than other parts of the grain, and shows one or three finely striated darker bands, which gradually disappear, as does the granular mass at the lobulated distal end. There is no essential difference in the gelatinization of grains with fissured hilum. The gelatinized grains finally formed are very large and of a regular, rounded, ovoid outline.

STARCH OF MARANTA MASSANGEANA. (Plate 89, figs. 529 and 530. Chart 348.)

Histological Characteristics.—In *form* the grains are simple and consist of isolated ones which were the components of small aggregates, with the exception of a small number which have never existed as aggregates and a few small aggregates. No compound grains were observed. Pressure facets are found on most of the grains. The grains are generally regular, but a slight concave indentation, possibly a pressure facet, may be found at one side of the distal margin of the larger, rounded grains which have a broadened and somewhat thinned distal margin. The conspicuous forms are dome-shaped with squared or pointed base, round, and polygonal. There are also a few ellipsoidal and rounded with broadened and somewhat thinned distal end which approach the triangular with rounded angles. Scattered among the numerous separated grains are much larger ones which are gelatinized and so distorted that their structure can not be studied. The grains are more regular than those of *M. arundinacea*, differ generally in shape, and in the frequent presence of pressure facets.

Chart No. 348.



Curve of Reaction-Intensities of Starch of Maranta massangeana.

The *hilum* is a round, clear, refractive spot, centric to slightly eccentric about two-fifths to five-twelfths of the longitudinal axis. The hilum is usually not fissured. Clefts which form either a stellate, a Y-shaped, or a soaring-bird figure are sometimes present.

The *lamellæ* are demonstrable, and in the round forms of large size from 12 to 16 rather fine, complete, circular rings may be counted. In the dome-shaped type the lamellæ, even those immediately around the hilum, usually have the form of the grain. There are 8 to 10 lamellæ on the large, dome-shaped grains. They are more often demonstrable throughout the entire grain than in *M. arundinacea*.

The grains vary in *size;* the smaller are 4 by 3μ; the larger, dome-shaped grains are 24 by 20μ, and the large, round forms are 26 by 26μ in length and breadth. The common size of the dome-shaped grains is about 18 by 16μ and of the round grains about 16 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is centric to slightly eccentric, rarely quite eccentric, distinct, and clear-cut. Its lines are rather fine and usually straight; they often cross at right angles, but sometimes obliquely. The figure is more regular than in *M. arundinacea*.

The degree of *polarization* is high. The average is about the same as in *M. arundinacea.* There is a greater variation among the grains; in some it is lower, yet it is high in a larger proportion of grains than in *M. arundinacea.* A variation in the same aspect of a given grain is much more frequently observed than in those of *M. arundinacea.*

With *selenite* the quadrants are clearly defined and clean-cut, about the same as in *M. arundinacea.* They are commonly slightly unequal in size and irregular in shape, but less so than in *M. arundinacea.* The colors are generally pure, the degree of purity being a little less than in *M. arundinacea.*

Iodine Reactions.—With 0.25 per cent Lugol's solution most grains color a fairly deep blue-violet, some a reddish-violet, which deepens rather rapidly, more quickly than in *M. arundinacea;* with 0.125 per cent solution they soon color a rather light blue-violet, a little deeper but somewhat redder than in *M. arundinacea,* which deepens rather rapidly. After heating in water until the grains are gelatinized and then adding iodine, the solution becomes a deep indigo-blue, and the gelatinized grains a dull, rather deep blue, some with a reddish tint to reddish-violet. The solution is deeper and the grains rather lighter in color than in *M. arundinacea.* If the gelatinized grains are boiled for 2 minutes and then treated with iodine, the solution becomes a very deep blue, while the grain-residues either do not color or become a very light blue, some with reddish tint, much lighter than in *M. arundinacea.* With an excess of iodine the capsules color a deep old-rose to wine-red, deeper and redder than in *M. arundinacea.*

Staining Reactions.—With *gentian violet* the grains begin to color lightly at once and in 30 minutes are lightly colored, lighter than in *M. arundinacea.*

With *safranin* the grains begin to color slightly at once and in 30 minutes are fairly colored, lighter than in *M. arundinacea.*

Temperature Reactions.—The temperature of gelatinization is 68° to 70° C., mean 69°. This temperature refers to the separated and round grains, since the rare, scattered grains which apparently bear a resemblance to *M. arundinacea* are either entirely or partially gelatinized before subjecting to heat.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in a minute, about half in 2 minutes, nearly all in 4 minutes, and all but a few resistant grains in 7 minutes, in which latter the reaction is usually complete in 10 minutes, rarely in 15 minutes. The grains color an old-rose at once, which deepens in many to a wine-red before the appearance of the bluish color which accompanies gelatinization. The hilum becomes very distinct either as a dark dot, a ring, or a lustrous structure. Gelatinization starts at the distal end of the dome-shaped grains, accompanied by a narrow line of bluish color which spreads quickly to the sides and proximal end, and then advances more rapidly towards the hilum from these latter points than from the distal end until the entire grain is gelatinized. In the round forms, which are the most resistant of all the grains, gelatinization begins at indifferent parts of the margin, accompanied by a narrow border of bluish color that closes in around the structure at the hilum, which is frequently large and metallic in appearance. The hilum gradually shrinks and becomes dark as gelatinization approaches it, usually more rapidly from one pole than the other, until the entire grain is gelatinized and deeply colored. The gelatinized grains are uniformly swollen, are slightly larger, and retain the general shape of the untreated grain. The reaction is qualitatively the same as in *M. arundinacea,* but the structure at the hilum is more prominent and the grains color a purer old-rose and more often become wine-red previous to gelatinization.

Reaction with *chromic acid* begins immediately. A few grains are dissolved in 30 seconds, nearly all in 2 minutes, all but parts of resistant grains in 3 minutes, and all in 3½ minutes. The reaction is qualitatively the same as in *M. arundinacea,* except that the capsule more often either breaks at both corners of the distal margin of dome-shaped grains, followed by the solution of the sides and proximal end; or first ruptures at the proximal end, the lamellæ and capsule of the distal margin in each case being the last to undergo solution. In very resistant grains the solution of the entire grain is very uniform, and occasionally the capsule at the distal margin is the first part to be ruptured.

Reaction begins immediately with *pyrogallic acid.* A few of the grains are gelatinized in 10 seconds, nearly all in 30 seconds, all but rare resistant grains in 45 seconds, and all in 60 seconds. The reaction is qualitatively the same as in *M. arundinacea,* but as the shapes of the grains are so different, the arrangement of the fissures is not the same, one extending from each end of the hilum to the corners of the distal margin of dome-shaped grains, and delicate radiating ones from the hilum of the round grains. The gelatinized grains are swollen and somewhat distorted, but bear a general resemblance to the untreated grain.

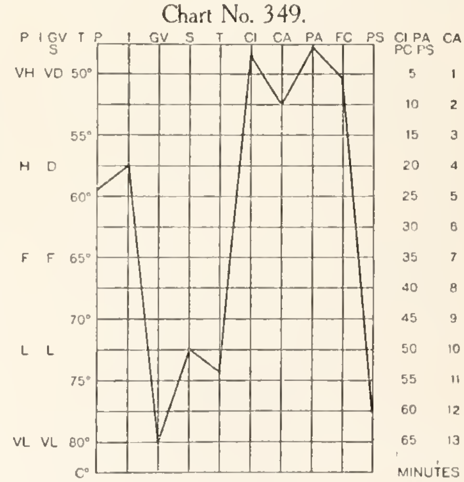
The reaction begins immediately with *ferric chloride.* A few grains are gelatinized in a minute, about one-third in 2 minutes, about two-thirds in 5 minutes, about seven-eighths in 10 minutes, and all but rare resistant grains in 15 minutes, in which the reaction is usually complete in 25 minutes, rarely 32 minutes. The reaction is qualitatively the same as in *M. arundinacea.* The gelatinization of the grains more often follows the second type described for *M. arundinacea,* the chief point of difference in this reaction being that the border which forms around the grain advances towards the hilum more rapidly from the sides and proximal end than from the distal margin. In dome-shaped grains with pointed distal margin, gelatinization with distension of the capsule often starts at the central, sharp corner of this margin. The gelatinized grains are much swollen and somewhat distorted, but retain the general shape of the untreated grain.

The reaction with *Purdy's solution* begins in a few grains in a minute. Only a very few scattered grains are gelatinized in 5 minutes, not more than about one-fiftieth in 15 minutes, very slight progress in 30 minutes, and about one-tenth gelatinized in 60 minutes. The reaction is qualitatively the same as in *M. arundinacea,* except that: (1) since the grains differ so in shape, the arrangement of the fissures is not the same, but similar, deeper, and more clear-cut than those described in the reaction with pyrogallic acid; (2) gelatinization in the dome-shaped grains with squared base proceeds more rapidly towards the corners at the distal margin and the proximal end than in the central part of the distal margin. Rare ovoid grains appear in which gelatinization has progressed further towards the distal end than the proximal, but it is not complete. The gelatinized grains are swollen, but retain the shape of the untreated grain.

STARCH OF MARANTA LEUCONEURA. (Plate 89, fig. 531. Chart 349.)

Histological Characteristics.—In *form* the grains are usually simple, chiefly isolated ones which have been the components of small aggregates. There are rare compound grains of few components and a very few small aggregates. Most grains have pressure facets. The grains are usually regular, but occasionally a small protuberance is observed near the proximal end in the large grains. The conspicuous forms are dome-shaped with either squared or pointed base, round, and polygonal; also few large, ovoid, pyriform, clam-shell-shaped, oyster-shell-shaped, and club-shaped. The smaller grains (which form the largest number) are more regular than those of *M. arundinacca* and differ generally in shape and in the frequent appearance of pressure facets. The smaller are not flattened, the larger are usually ovoid in shape when viewed on edge.

Chart No. 349.



Curve of Reaction-Intensities of Starch of Maranta leuconeura.

The *hilum* is a clear, round spot, usually centric, slightly eccentric, or rarely quite eccentric. The eccentricity may range from six-thirteenths to one-sixth of the longitudinal axis. The hilum is usually not fissured, but occasionally a small transverse fissure is observed in the large grains. The hilum is less frequently fissured and usually less eccentric than in *M. arundinacea.*

The *lamellæ* are not demonstrable in the small, dome-shaped, and round grains. They are distinct in the rather large ovoid, triangular, and shell-shaped grains, forming delicate circular rings around the hilum and following the outline of the grain nearer the distal end. Large ovoid grains have 32 delicate lamellæ, and on the rounded triangular and clam-shell-shaped grains 20 to 26 have been counted. The lamellæ are demonstrable on a much smaller number of grains than in *M. arundinacea,* but are similar in character to those found on the grains of that species.

The grains vary in *size;* the smaller are 2 by 2μ; the larger dome-shaped are 13 by 12μ; the larger, round grains are 14 by 14μ, in length and breadth. The common size for the dome-shaped grains is 10 by 8μ, and of the round 10 by 10μ in length and breadth. The larger of the scattered ovoid grains are 30 by 16μ, and of the shell-shaped 28 by 24μ in length and breadth. The common size is about 22 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is usually centric to slightly eccentric, rarely quite eccentric. Its lines are distinct, usually straight, and rather fine, and cross each other at right angles, rarely obliquely, and they may be bent. Compared with *M. arundinacea* the lines generally cross each other at a different angle and are much less often bent.

The degree of *polarization* is high, but slightly lower than in *M. arundinacea.* The same variation is found in the different grains, but the proportion in which polarization is very high is much smaller. A similar variation is found in the same aspect of a given grain as that of *M. arundinacea.*

With *selenite* the quadrants are distinct and clean-cut, and generally equal in size and regular in shape. The colors are generally pure. The quadrants are as clean-cut and the purity of the colors the same as in *M. arundinacea,* but they are commonly nearer equal in size and more regular in shape.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep dull blue to reddish-violet (about the same for both large and small grains), which deepens rapidly. The tint is deeper, duller, and more reddish in some grains, and deepens more rapidly and with less variation in intensity than in *M. arundinacea.* After heating in water until the grains are gelatinized and then adding iodine, the solution becomes blue, somewhat lighter than in *M. arundinacea,* and the large grains a lighter, somewhat brighter blue than those of *M. arundinacea;* and some of the small grains a light blue, many with reddish tint to red-violet. The blue is lighter, and those with reddish tint are somewhat redder than in *M. arundinacea.* If the gelatinized grains are boiled for 2 minutes and then treated with iodine, the solution colors a very deep blue and the grain-residues of the small grains a light old-rose, those of the large grains a deep blue with reddish tint to red-violet. With an excess of iodine the capsules color a deep old-rose to a wine-red; the color is deeper and redder than in *M. arundinacea.*

Staining Reactions.—With *gentian violet* the grains begin to color slightly at once and in 30 minutes are very lightly stained, the large scattered grains a little deeper than the others, but all distinctly lighter than in *M. arundinacea.*

With *safranin* the grains begin to color slightly at once and in 30 minutes are lightly colored, the larger ones somewhat deeper than the others, but all distinctly lighter than in *M. arundinacea.*

Temperature Reaction.—The temperature of gelatinization for the small grains is 73° to 75° C., mean 74°. Several scattered, large grains are gelatinized at 78° to 80° C., mean 79°; but others are unaffected at this temperature. The scarcity of material in this preparation and the effect of very high temperature upon the smaller grains in the solution prevented carrying it further. In view of the resistance of these large, scattered grains to some of the chemical reagents, it is probable that the majority are not gelatinized until a higher temperature is reached than the above.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in 30 seconds, nearly all in 1½ minutes, all but a few resistant in 2 minutes, and these latter usually in 4 to rarely 11 minutes. The most resistant grains are the rather large, mussel-shell-shaped type; some of these large grains, however, are gelatinized in 2 minutes, and since they are very few it is difficult to form conclusions as to their rate of gelatinization. The reaction is qualitatively the same as in *M. arundinacea* with the following exceptions: First, the grains color a deeper old-rose at once; second, in the few large grains under observation the last region of the grain to become gelatinized is distal to the hilum, and thus nearer the center of the grain. The gelatinized grain is uniformly swollen and thus retains the shape of the untreated grain.

Reaction begins at once with *chromic acid.* Several grains are gelatinized in a minute, nearly all in 1½ minutes, and all but rare resistant grains in 2 minutes, in which the reaction is usually completed in 4½, rarely 6½ minutes. The most resistant grains are the scattered shell-shaped, triangular, and ovoid forms. The reaction is qualitatively the same as in *M. arundinacea* with the following exceptions: First, no bubble was observed at the hilum and the refractive granules which appear at the region surrounding it during gelatinization are more brilliant. Second, since most grains differ so much in shape the arrangements of the fissures are very often not the same; one radiating fissure passes from each side of the hilum to the corners of the distal margin of dome-shaped grains, the capsule ruptures at one of these points and the sides and proximal end are dissolved before the distal margin. Third, in the few large grains under observation, no bubble was found at the hilum and the capsule ruptured at one side near the proximal end, the lamellæ were more sharply defined, and when disorganized the refractive granules were more brilliant.

The reaction with *pyrogallic acid* begins at once; several are gelatinized in 10 seconds, nearly all in 25 seconds, and all in 35 seconds except rare, large, triangular grains, in which the reaction may take 9 minutes. The reaction is qualitatively the same as in *M. arundinacea* with the following exceptions: First, in the small dome-shaped, round, etc., grains a bubble appears at the hilum, but it is quite small and does not enlarge so much. Second, in the few large grains under observation the fissures are much more clear-cut, the lamellæ more sharply defined and striated, and the refractive granules more brilliant, with more frequent linear arrangement during the progress of the reaction. The gelatinized grains are swollen but retain the general shape of untreated grain.

The reaction begins immediately with *ferric chloride*. A few grains are gelatinized in a minute, about two-fifths in 2 minutes, nearly all in 5 minutes, and all but rare resistant grains in 6 minutes, in which the reaction is usually complete in 10 minutes, rarely 17 minutes. The more resistant grains are the larger forms. The reaction is qualitatively the same as in *M. arundinacea,* and the method usually observed is the second type described for that species. The following exceptions are observed: First, the border formed around the grain is rather dull. Second, the starch of the larger grains is broken into rather large fragments, the lamellæ of which are very sharply defined and as they disorganize refractive granules appear in linear arrangement, which often do not completely gelatinize. The gelatinized grains are swollen but retain the general shape of the untreated grain.

Reaction begins immediately with *Purdy's solution*. Only a few scattered grains are gelatinized in 5 minutes, about one-twentieth in 15 minutes, about one-ninth in 30 minutes; no further progress in an hour. The reaction is qualitatively the same as in *M. arundinacea* with the following exceptions: First, since the majority of the grains are very different in form, the arrangement of the fissures is not the same; in the dome-shaped grains one coarse, clean-cut cleft passes from the hilum to the corners of the distal margin, and numerous delicate fissures radiate from all other points of the hilum. In round grains the fissures radiate like the rays of a star, often about five larger ones with delicate ones between; during gelatinization these fissures extend to the periphery of the grain, breaking the resistant starch into fairly large fragments. Second, in the large grains similar in shape to those of *M. arundinacea,* much more refractive lamellæ appear at varying points on the grain and (as they gelatinize) a larger mass of more brilliant, refractive granules develops, which more often have a linear arrangement. The gelatinized grains are swollen, but retain the general shape of the untreated grain. A few refractive granules and sometimes fairly large fragments of solid starch are found in the otherwise gelatinized grains.

STARCH OF MARANTA MUSAICA. (Plate 89, figs. 533 and 534. Chart 350.)

Histological Characteristics.—In *form* the grains are usually simple and are generally isolated, with a few aggregates and compound grains. Pressure facets are occasionally observed. Most grains are either slightly or quite irregular, much more so than in *M. arundinacea.* The irregularities appear as noted for *M. arundinacea,* but there is a greater variation in the contour of the different sides of a grain and the presence of a secondary set of lamellæ placed at varying angles to the primary set is very frequently observed. The conspicuous forms are irregular pyriform, sometimes with flattened sides, triangular, clam-shell-shaped, elongated ovoid, and ellipsoidal; also knob-shaped, club-shaped, oyster-shell-shaped, imperfect quadrangular with rounded angles, elongated cone-shaped, and grains of indefinite form. The broadened grains are elongated ovoid, having the distal end narrow and pointed, when viewed on edge. The other grains are not flattened.

The *hilum* is frequently not demonstrable, but it may be observed as a clear, round, non-refractive spot, usually eccentric about one-sixth to one-ninth, rarely one-twelfth, of the longitudinal axis. The hilum is rarely fissured, but sometimes a short, transverse cleft is found at this region. The hilum is much less distinct and the absence of clefts at this region is much more noticeable than in *M. arundinacea.*

The *lamellæ* are quite distinct and form circular rings near the hilum, but follow the outline of the grain quite closely at other points, especially in the triangular and shell-shaped grains. In some grains the lamellæ of one set vary in outline and direction, while very often a secondary set is placed at different angles to the primary set. The lamellæ are mostly fine, but often one to three rather coarse ones are interspersed among them between the hilum and the distal margin. A band of less distinct, very fine lamellæ is sometimes observed at the distal margin. On the larger grains often 28 to 32, occasionally 36 to 40, lamellæ are counted. The appearance of a large addition on the grain of a secondary set of lamellæ is much more clearly marked and more frequently observed, and there is greater variation as to direction of its axis, width, and number of lamellæ than in *M. arundinacea.*

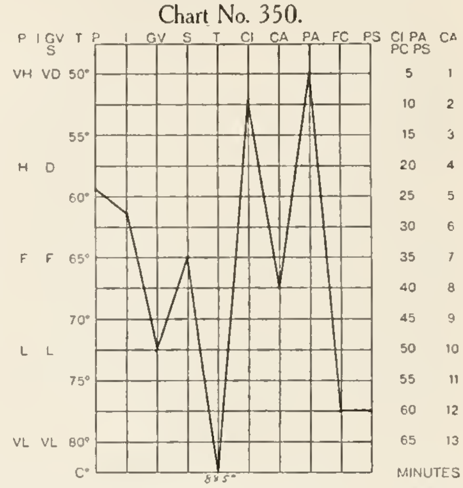
The grains vary in *size;* the smaller are 4 by 3μ, the larger are 36 by 20μ in length and breadth. The common size is about 26 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric and usually distinct. Its lines are rather fine and cross each other obliquely; they are frequently bent and sometimes bisected. The figure is more eccentric and irregular than in *M. arundinacea.*

The degree of *polarization* is high, but not so high as in *M. arundinacea.* There is a great variation in the different grains and often in the same aspect of a given grain. The variation in both cases is much greater than in *M. arundinacea.*

With *selenite* the quadrants are generally well defined, but not so clean-cut as in *M. arundinacea.* They are unequal in size and usually irregular in shape, and much more irregular than in *M. arundinacea.* The colors are more often pure, although there are more grains in which they are not quite so pure as in *M. arundinacea.*

Chart No. 350.



Curve of Reaction-Intensities of Starch of Maranta musaica.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep reddish to blue-violet, some rather rapidly and others gradually. The tint is a little lighter and redder and deepens a little quicker than in *M. arundinacea.* With 0.125 per cent solution the grains color a very light reddish to fair blue-violet, which deepens rather rapidly. There is greater variation in the different grains, and they deepen more quickly than in *M. arundinacea.* After heating in water until the grains are gelatinized and then adding iodine, the solution becomes a deep indigo-blue, and most of the gelatinized grains a deep blue, a few with reddish tint. The grains are colored a deeper and purer blue than in *M. arundinacea.* If the gelatinized grains are boiled for 2 minutes and then treated with iodine, most of the grain-residues become a fairly deep but rather bright blue, some having a reddish tint; the capsules are a reddish-violet, and the solution a very deep blue. The grain-residues color more deeply than in *M. arundinacea.* With an excess of iodine the grain-residues become very deep and the capsules a reddish-violet to heliotrope. The color is not quite so red as in *M. arundinacea.*

Staining Reactions.—With *gentian violet* the grains begin to color slightly at once and in 30 minutes are lightly colored, lighter than in *M. arundinacea.*

With *safranin* the grains begin to color slightly at once and in 30 minutes are fairly colored, lighter than in *M. arundinacea.*

Temperature Reaction.—The temperature of gelatinization is 88° to 89° C., mean 88.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in a minute, nearly all in 7 minutes, and all but a few resistant grains in 9 minutes, in which the reaction is usually complete in 12 minutes, rarely 20 minutes. The reaction is qualitatively the same as in *M. arundinacea,* but the old-rose color is purer in tint, the reaction is much slower, and many more grains become a deep wine-red previous to the bluish color that finally spreads over the gelatinized grain. Gelatinization with its accompanying bluish color starts in the way noted for *M. arundinacea,* but the hilum is much less prominent, appearing usually as a very small, dark dot, and this region is much less resistant since gelatinization from the proximal margin spreads over it and proceeds towards the gelatinized area at the distal end, which, in the meantime, has advanced more rapidly towards the center of the grain. The last portion of the grain to undergo the reaction is distal to the region of the hilum and much nearer the center of the grain than in *M. arundinacea.*

The reaction with *chromic acid* begins immediately. A few grains are dissolved in 2 minutes, nearly all in 7 minutes, all but parts of a few resistant grains in 8 minutes, and all in 11 minutes. The hilum becomes more distinct, but as a rule no bubbles appear there. The lamellæ are more sharply defined and striated. According to the shape of the grain the same types of fissures as those described for *M. arundinacea* are formed, but they are more sharply defined and are observed in many more grains. During the disorganization of the lamellæ near the central part of the grain, the refractive granules often appear in linear arrangement, which is not the case in *M. arundinacea*, as well as in those of very resistant lamellæ at the distal margin, which is observed but in a smaller number of lamellæ at this point in *M. arundinacea*. While the capsule of more grains is ruptured first at the distal end, it may break at the sides or even at the proximal end; in the latter method there may have been a protuberance or a secondary set of lamellæ at this end, since the lamellæ in such grains, when observed, are found to pass into solution first. The lamellæ of the triangular forms are more resistant than in those of *M. arundinacea*, gradually becoming either more and more homogeneous, slightly undulating, and the capsule finally breaking here, followed by solution of the entire grain; or the capsule first ruptures at both corners of the distal margin and the lamellæ at the proximal end; the sides nearby and three or four at the curved distal margins remain intact for some minutes later. Sometimes there is a lateral extension of one corner followed by the breaking of the capsule at this point. The reaction is qualitatively the same as in *M. arundinacea*, but the lamellæ are more resistant and during their disorganization more refractive granules first appear in linear arrangement, there is a greater variation in the points at which the capsule first ruptures, and the fissures extending distalwards from the hilum are always clearly defined.

Reaction begins immediately with *pyrogallic acid*. A few grains are gelatinized in 30 seconds, about half in 2 minutes, nearly all in 4 minutes, and all but rare grains in 5 minutes, these usually in 9, seldom in 11 minutes. The reaction is qualitatively the same as in *M. arundinacea*, but the hilum is not so distinct nor does a bubble usually form there; fissures extending distalwards from the hilum are always clearly observed and in the pyriform grains are often in the form of a single, root-like structure, while in the triangular and shell-shaped grains one coarse fissure radiates from each side of the hilum, with a cluster of smaller delicate ones (the central one of which is sometimes more prominent) between them; the lamellæ are more sharply defined and striated and during their disorganization refractive granules appear both irregularly embedded in the gelatinized starch and in linear arrangement, while in *M. arundinacea* only a trace of such granules may be observed in the more resistant grains. During gelatinization of the broadened grains with prominent corners at the distal margin, the lamellæ at these points are gelatinized before the curved central portion, with accompanying small swellings at these points; sometimes a similar small swelling in the center of the distal margin appears previous to the entire gelatinization of these very resistant lamellæ; this method of gelatinization has not been noted in *M. arundinacea*. The capsules are more irregular and distorted and bear less resemblance to the untreated grain than in *M. arundinacea*.

The reaction with *ferric chloride* begins in a few grains immediately. A very small number are gelatinized in a minute, only a few scattered grains in 5 minutes, about one-twelfth in 15 minutes, about one-fourth in 30 minutes, and about five-sixths in 60 minutes. The reaction is qualitatively the same as in *M. arundinacca*, with the exception of the following points: First, the hilum, while becoming more distinct than in the untreated grain, is neither so prominent nor does a large bubble appear there as in *M. arundinacea*. Second, the process of gelatinization is usually similar to that of the second type described for *M. arundinacea*, but the border which forms around the grain generally spreads over the hilum, a point slightly distal to this region being the last to be inclosed, instead of that directly around and including the hilum as noted for *M. arundinacea*. As the border advances over the hilum, its contour changes from a circle to a crescent-shaped figure with ends directed distalwards, from each end of which one fissure radiates. Fissures are now formed as noted in *M. arundinacea*, but during the disorganization of the lamellæ many more refractive granules appear in linear arrangement, and in the triangular forms there is a flaring at the corners of the distal margin, and very often a single row of refractive granules remains between these two points, even when the rest of the grain is gelatinized. Third, in grains with a secondary set of lamellæ, a separate border forms for the main body of the grain and for the addition; these finally include the entire grain, the last point to be affected in the secondary set being located at the border of the main body of the grain. Each set then has its separate center of gelatinization, that of the secondary lamellæ being more rapid; the different stages of the process are the same as those already noted. Fourth, the gelatinized grains are more distorted than in *M. arundinacea* and often retain refractive granules.

Reaction with *Purdy's solution* begins in a small number in a minute. Only rare scattered grains are gelatinized in 5 minutes. There is slight progress in 15 minutes, about one-thirtieth are gelatinized in 30 minutes, and about one-twentieth in 60 minutes. The reaction is qualitatively the same as in *M. arundinacea* with the exception of the following points: First, the hilum does not swell so much.

Second, when fissures of a similar character are present they are more sharply defined, but frequently very irregularly arranged clefts appear, which have no connection with the hilum. Third, the starch is often broken into many rather large, irregularly arranged, refractive fragments by means of the clefts above mentioned, and gelatinization in many grains does not advance beyond this stage. Fourth, the lamellæ throughout the grain are more resistant and, when disorganized, more brilliant, refractive granules appear, many having a linear arrangement. The gelatinized grains are much swollen and some retain the general shape of the untreated grain, while more of the ungelatinized starch is often present than in *M. arundinacea*, which appears to cause some distortion of the grain.

Differentiation of Certain Starches of the Genus Maranta.

Histological Characteristics.

Conspicuous Forms.

M. arundinacea: Usually simple, few aggregates and compounds, pressure facets rare, usually regular, irregularities due to depressions or to rounded, pointed, cone-shaped or nipple-like protuberances; ovoid, ellipsoidal, pyriform, triangular, nearly round, mussel-shell-shaped, ellipsoidal with central elevation at the side. Somewhat flattened.

M. arundinacea var. *No. 1:* Usually simple, rare compounds, no aggregates, pressure facets rare, generally irregular. Ovoid to oval and elliptical, clam-shell-shaped, mussel-shell-shaped, triangular with rounded angles, spherical.

M. arundinacea var. *No. 2:* Usually simple, few compounds, no aggregates, pressure facets rare, usually irregular. Ovoid to oval and elliptical; also clam-shell-shaped, mussel-shell-shaped, pyriform, triangular, spherical, dome-shaped.

M. massangeana: Simple, no compounds, many aggregates, pressure facets common, generally regular. Dome-shaped, round, polygonal.

M. leuconeura: Usually simple, rare compounds and aggregates, pressure facets common, usually regular. Dome-shaped, round, polygonal.

M. musaica: Usually simple, few aggregates and compounds, pressure facets occasional. Irregular pyriform, triangular, clam-shell-shaped, elongated ovoid, and ellipsoidal.

Hilum—Form, Number, and Position.

M. arundinacea: Form clear, round or lenticular spot; small round cavity or one or more fissures may be present. Position usually eccentric about 0.33 to 0.25 of longitudinal axis.

M. arundinacea var. *No. 1:* Form small, round, non-refractive; sometimes fissured. Position nearly eccentric about 0.16 to 0.25 of longitudinal axis.

M. arundinacea var. *No. 2:* Form distinct, relatively large, round, refractive; double hila common; often fissured. Position usually eccentric about 0.16 to 0.25 of longitudinal axis.

M. massangeana: Form round, clear, refractive spot; usually not fissured. Position usually eccentric about 0.40 to 0.42 of longitudinal axis.

M. leuconeura: Form round, clear spot; usually not fissured. Position usually eccentric from 0.46 to 0.16 of longitudinal axis.

M. musaica: Form frequently not demonstrable, clear, round, non-refractive spot; rarely fissured. Position usually eccentric about 0.16 to 0.11 of longitudinal axis.

Lamellæ—General Characteristics and Number.

M. arundinacea: Fine, less fine near the hilum than near the distal end; complete rings near hilum, but have shape of margin peripherally. 28 to 32 on larger grains.

M. arundinacea var. *No. 1:* Usually not very distinct, rather coarse, continuous circles or arcs of circles; vary in size and spacing in different grains. About 23 on larger grains.

Histological Characteristics.—Continued.

Lamellæ—General Characteristics and Number.—Cont'd.

M. arundinacea var. *No. 2:* Not very distinct circles or arcs of circles; these marginally follow outline of grain; two sets where double hila are present. About 38 on large grains.

M. massangeana: Fine, complete circular rings in round grains; have form of grains in dome-shaped grains. About 8 to 16.

M. leuconeura: Not demonstrable in small dome-shaped and round grains; distinct and delicate in large ovoid, triangular, and shell-shaped grains. About 32 on large ovoid and 20 to 26 on rounded triangular and shell-shaped.

M. musaica: Quite distinct, circular rings near hilum, but follow outline of grain when distal; secondary sets of lamellæ common; mostly fine. About 28 to 32 on the large grains.

Size.

M. arundinacea: From 3 to 36μ, commonly 24μ.

M. arundinacea var. *No. 1:* From 11 to 54μ, commonly 20μ.

M. arundinacea var. *No. 2:* From 7 to 54μ, commonly 28μ.

M. massangeana: From 4 to 26μ, commonly 16μ.

M. leuconeura: From 2 to 30μ, commonly 22μ.

M. musaica: From 4 to 36μ, commonly 26μ.

Polariscopic Properties.

Figure.

M. arundinacea: Quite eccentric to slightly eccentric and centric; lines distinct, fine, and intersect obliquely; generally straight; sometimes bent or bisected.

M. arundinacea var. *No. 1:* Usually eccentric, distinct, clear-cut; lines usually well defined and comparatively narrow; may be bent or otherwise distorted and placed at varying angles.

M. arundinacea var. *No. 2:* Usually eccentric, distinct; lines very clearly defined; lines at varying angles.

M. massangeana: Usually eccentric, distinct, lines rather fine, usually straight and usually intersect at right angles.

M. leuconeura: Usually eccentric, distinct, lines rather fine and usually straight, and usually intersect at right angles.

M. musaica: Eccentric, usually distinct, lines rather fine and intersect obliquely, frequently bent and sometimes bisected; more eccentric and more irregular than in *M. arundinacea*.

Degree of Polarization.

M. arundinacea: High, slightly variable in different grains and in same aspect of a given grain.

M. arundinacea var. *No. 1:* High, about the same as in *M. arundinacea*, but more variations.

M. arundinacea var. *No. 2:* High, about the same as in *M. arundinacea*, but more variations.

M. massangeana: High, about the same as in *M. arundinacea*, but more variations.

Differentiation of Certain Starches of the Genus Maranta.—Continued.

POLARISCOPIC PROPERTIES.—Continued.

Degree of Polarization.—Continued.

M. leuconeura: High, slightly lower than but of same variability as in *M. arundinacea.*
M. musaica: High, but not so high as in *M. arundinacea,* variation greater than in *M. arundinacea.*

Polarization with Selenite—Quadrants and Colors.

M. arundinacea: Quadrants clearly defined, clear-cut, sometimes irregular in shape, and usually unequal in size. Colors generally pure.
M. arundinacea var. *No. 1:* Quadrants well defined, irregular in shape, and unequal in size. Colors generally pure.
M. arundinacea var. *No. 2:* Quadrants very well defined, irregular in shape, and unequal in size. Colors generally pure.
M. massangeana: Quadrants clearly defined, clear-cut, commonly slightly irregular in shape and unequal in size. Colors generally pure, slightly less pure than in *M. arundinacea.*
M. leuconeura: Quadrants distinct, clear-cut, generally regular in shape and unequal in size. Colors generally pure.
M. musaica: Quadrants generally well defined, fairly clear-cut, usually irregular in shape and unequal in size. Colors generally pure, more often purer than in *M. arundinacea.*

IODINE REACTIONS.

Intensity and Colors.

M. arundinacea: Fairly deep; blue-violet.
M. arundinacea var. *No. 1:* Fairly deep, a little deeper than in *M. arundinacea;* blue-violet.
M. arundinacea var. *No. 2:* Fairly deep, the same as in *M. arundinacea;* blue-violet; more blue than in *M. arundinacea.*
M. massangeana: Fairly deep, deeper than in *M. arundinacea;* blue-violet to a reddish-violet.
M. leuconeura: Deep, deeper than in *M. arundinacea;* dull blue to a reddish-violet.
M. musaica: Fairly deep, less than in *M. arundinacea;* reddish to a blue-violet.

STAINING REACTIONS.

With Gentian Violet.

M. arundinacea: Fair.
M. arundinacea var. *No. 1:* Fair, little deeper than in *M. arundinacea.*
M. arundinacea var. *No. 2:* Fair, slightly deeper than in *M. arundinacea.*
M. massangeana: Light, lighter than in *M. arundinacea.*
M. leuconeura: Very light, distinctly lighter than in *M. arundinacea.*
M. musaica: Light, lighter than in *M. arundinacea.*

With Safranin.

M. arundinacea: Fairly deep.
M. arundinacea var. *No. 1:* Fairly deep, slightly deeper than in *M. arundinacea.*
M. arundinacea var. *No. 2:* Fairly deep, slightly deeper than in *M. arundinacea.*
M. massangeana: Fair, lighter than in *M. arundinacea.*
M. leuconeura: Light, distinctly lighter than in *M. arundinacea.*
M. musaica: Fair, lighter than in *M. arundinacea.*

TEMPERATURE OF GELATINIZATION.

M. arundinacea: 76 to 78° C., mean 77°.
M. arundinacea var. *No. 1:* 71 to 72° C., mean 71.5°.
M. arundinacea var. *No. 2:* 71 to 73° C., mean 72°.
M. massangeana: 68 to 70° C., mean 69°.
M. musaica: 88 to 89° C., mean 88.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

M. arundinacea: Begins immediately; complete in practically all in 3 minutes.
M. arundinacea var. *No. 1:* Begins immediately; complete in practically all in 3½ minutes.
M. arundinacea var. *No. 2:* Begins immediately; complete in practically all in 4½ minutes.
M. massangeana: Begins immediately; complete in practically all in 7 minutes.
M. leuconeura: Begins immediately; complete in practically all in 2 minutes.
M. musaica: Begins immediately; complete in practically all in 9 minutes.

Reaction with Chromic Acid.

M. arundinacea: Begins immediately; complete in practically all in 3½ minutes.
M. arundinacea var. *No. 1:* Begins immediately; complete in practically all in 2 minutes.
M. arundinacea var. *No. 2:* Begins immediately; complete in practically all in 1½ minutes.
M. massangeana: Begins immediately; complete in practically all in 3 minutes.
M. leuconeura: Begins immediately; complete in practically all in 2 minutes.
M. musaica: Begins immediately; complete in practically all in 8 minutes.

Reaction with Pyrogallic Acid.

M. arundinacea: Begins immediately; complete in 45 seconds.
M. arundinacea var. *No. 1:* Begins immediately; complete in all in 1 to 1¾ minutes.
M. arundinacea var. *No 2:* Begins immediately; complete in all in 2 minutes.
M. massangeana: Begins immediately; complete in all in a minute.
M. leuconeura: Begins immediately; complete in practically all in 35 seconds.
M. musaica: Begins immediately; complete in practically all in 11 minutes.

Reaction with Ferric Chloride.

M. arundinacea: Begins in a few immediately; complete in practically all in 5 minutes.
M. arundinacea var. *No. 1:* Begins in two-thirds in 2 minutes; complete in practically all in 10 minutes.
M. arundinacea var. *No. 2:* Begins in some at once; complete in practically all in 15 minutes.
M. massangeana: Begins immediately; complete in practically all in 15 minutes.
M. leuconeura: Begins immediately; complete in practically all in 6 minutes.
M. musaica: Begins immediately; complete in about five-sixths in 60 minutes.

Reaction with Purdy's Solution.

M. arundinacea: Begins in a few in 1½ minutes; complete in one-eighth in 60 minutes.
M. arundinacea var. *No. 1:* Begins immediately; complete in nearly all in 30 minutes; no further progress in an hour.
M. arundinacea var. *No. 2:* Begins in 30 seconds or less; complete in two-thirds in 30 minutes, and in four-fifths in 60 minutes.
M. massangeana: Begins in a few in a minute; complete in one-fiftieth in 30 minutes, and in one-tenth in 60 minutes.
M. leuconeura: Begins immediately; complete in one-ninth in 30 minutes with no further reaction in an hour.
M. musaica: Begins in a few in a minute; complete in one-thirtieth in 30 minutes, and one-twentieth in an hour.

NOTES ON THE STARCHES OF MARANTA.

Differences in the starches of the several species and varieties of this genus are very striking. Taking the starch of *M. arundinacea* as the type, it will be seen that the starches of the two varieties (see plates 88 and 89, figs. 523 to 534) and *M. musaica* belong to the same common type, the starches in each case being readily differentiated from each other, except probably as regards the two varieties. The starches of *M. massangeana* (stated by the grower to be the true species) and *M. leuconeura* have an entirely different type of grain. Notwithstanding this difference in the types of grains the reactions are in close correspondence. The starch of *M. musaica* differs quite as much from *M. arundinacea* and its varieties, although the grains belong to the same type, as do the starches of *M. massangeana* and *M. leuconeura* from the same group. The correspondence between the reactions of *M. arundinacea* and its varieties is very marked; and *M. massangeana* differs from the former chiefly in the aniline, temperature, and chloral hydrate-iodine reactions; *M. leuconeura* differs particularly in the aniline and temperature reactions; and *M. musaica* most noticeably in the aniline, temperature, chloral hydrate-iodine, chromic acid, pyrogallic acid, ferric chloride, and Purdy's solution reactions. The latter differs very markedly from the other Marantas and bears on the whole such close resemblances to *Calathea* that it seems that it should be classed with the latter.

GENUS CALATHEA.

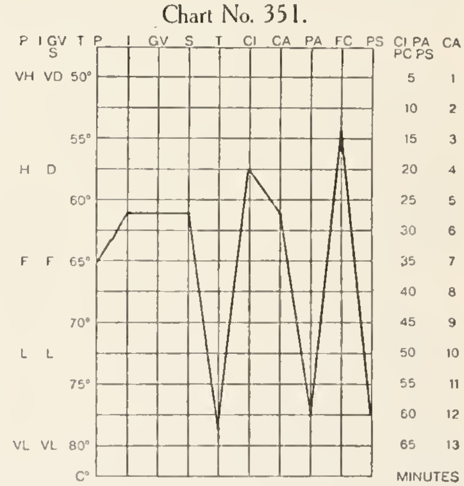
As stated under *Maranta*, most forms of the latter offered by the trade are Calatheas. These two genera and *Stromanthe, Phrynium*, and *Thalia* are closely related, all of which are in common cultivation mainly because of their fine foliage. The genus *Calathea* contains from 70 to 80 species, all natives of tropical America and Africa, chiefly the former. Starches were obtained from four species: *C. lietzei* Morr., *C. wiotiana* Makoy (*C. wioti* Hort.), *C. vandenheckei* Regel, and *C. vittata* Kœrn. The Calatheas studied in this section were received from horticulturists marked Marantas, and it was not until after the laboratory studies had been recorded, and comparisons made with *Maranta arundinacea* var. (Commercial No. 1), that it was found that they were Calatheas.

STARCH OF CALATHEA LIETZEI. (Plate 90, figs. 535 and 536. Chart 351.)

Histological Characteristics.—In *form* the grains are simple, with no compounds, aggregates, clumps, or pressure facets. The surface is usually irregular owing to the unequal development. The conspicuous form is the clam-shell type, the grains being usually somewhat longer than broad; also triangular with rounded corners, oval, elliptical, almost spherical, and elongated dome-shaped. The grains are flattened, and commonly about one-third to one-half as thick as wide. On edge they appear to be of a long, slender, ovoid form, the distal end being narrower than the proximal end. Frequently the proximal end is nodular, owing to lateral depressions, and the distal end is often notched.

The *hilum* is a rather small, fairly distinct, round spot, usually eccentric about one-fifth of the longitudinal axis of the grain and in or near the median line. There are no multiple hila. The hilum is sometimes marked by a round cavity or by a shallow and clean-cut fissure, which may be straight or curved, transverse or longitudinal. Rarely a number of thin fissures radiate from the hilum.

Chart No. 351.



Curve of Reaction-Intensities of Starch of Calathea lietzei.

The *lamellæ* are fairly distinct, rather fine circles or arcs of circles. They are quite regular, and a short distance from the hilum tend to follow the marginal outline. They vary somewhat in size in different grains and are usually larger and more distinct near the distal end. There are 16 to 20 on the larger grains.

The grains vary in *size* from 4 to 32μ. The common size is 22μ.

Polariscopic Properties.—The *figure* is eccentric, fairly distinct, but usually not clear-cut, as the lines are usually wide and not sharply defined, and broader and even less defined near the margin. They are sometimes somewhat bent or otherwise distorted or bisected.

The degree of *polarization* is fair, varying in different grains from high to low; it varies also in different aspects of the same grain, being highest when the grain is viewed on end or edge, and in different parts of the same aspect of a grain, being lower as a rule near the margin than near the hilum. It is not so high as that of the grains of *M. arundinacca* var. (Commercial No. 1).

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep blue-violet; with 0.125 per cent solution they color lightly but the color deepens rapidly. The color is not so deep as that of the grains of *M. arundinacea* var. (Commercial No. 1). After heating in water until the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues faintly or not at all. The capsules all color a red-violet with an excess of iodine and many retain blue-reacting starch at the proximal end.

Staining Reactions.—With *gentian violet* the grains begin to stain in 2 minutes, and in 30 minutes are fairly deeply stained, one as much as another. The color is not quite so deep as that of the grains of *M. arundinacea* var. (Commercial No. 1).

With *safranin* the grains begin to stain very lightly at once and in 30 minutes they are fairly deeply stained. The color is not quite so deep as that of the grains of *M. arundinacea* var. (Commercial No. 1).

Temperature Reaction.—The temperature of gelatinization is 78° to 79° C., mean 78.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 2 minutes, half are gelatinized in 9 minutes, and all in 20 minutes. The reaction is qualitatively the same as that of *M. arundinacea* var. (Commercial No. 1).

Reaction with *chromic acid* begins in 45 seconds and is over in 5½ minutes. It is the same qualitatively as that of *M. arundinacea* var. (Commercial No. 1).

The reaction with *pyrogallic acid* begins in some grains in 30 seconds and in most of the rest in 1¼ minutes. About four-fifths of the grains are completely gelatinized in 8 minutes. The reaction is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

The reaction with *ferric chloride* begins in a minute and is over in 13 minutes. It is qualitatively the same as that of *M. arundinacea* var. (Commercial No. 1).

Reaction with *Purdy's solution* begins in some grains in 2 minutes and a few are partially or completely gelatinized in 10 minutes. The reaction is qualitatively about the same as that of *M. arundinacea* var. (Commercial No. 1).

STARCH OF CALATHEA VITTATA. (Plate 90, figs. 537 and 538. Chart 352.)

Histological Characteristics.—In *form* the grains are simple, except a few compounds and aggregates, chiefly in the form of grains of two components. Pressure facets are rarely observed. There are a few clumps of grains and also of foreign matter. The surface of the grains is usually somewhat irregular, owing to slight depressions and nipple-like projections. The conspicuous forms are oval to ovoid and elliptical; some approach the clam-shell-shaped and mussel-shell-shaped. There are also spherical or nearly spherical, rounded triangular, pointed elliptical, and rod-like. Some of the rounded triangular forms are compound grains, usually doublets or triplets. When viewed from the edge the ovoid to oval and elliptical forms are usually broadly lenticular or spindle-shaped.

The *hilum* is a fairly distinct round spot, usually centric or nearly centric, or sometimes eccentric to about four-ninths to two-fifths, usually four-ninths. There may be 2 or more hila in the simple grains and at times as many as 4 to 6. The hilum may be fissured by a single fissure or the fissuration may be ragged and much branched.

The *lamellæ* are distinct, coarse, quite regular, complete rings around the hilum. In many angular and otherwise irregular forms they tend to assume the shape of the margin of the grain at about the third or fourth conspicuous lamella from the hilum; and in the case of grains with double or triple hila the first lamella around the hila may have the marginal shape. In the large grains there are 10 to 14 lamellæ.

The *size* of the smaller grains is 6 by 6μ, and of the larger 24 by 38μ in length and breadth. The common size is 20 by 28μ in length and breadth.

Polariscopic Properties.—The *figure* is usually centric or slightly eccentric and not very clear-cut, but regular. Its lines are rather thick and usually broaden as they proceed from center to margin. They are usually straight, but may be more or less bent, bisected, or otherwise distorted.

The degree of *polarization* is rather high. It varies in the different grains and in the same aspect of one grain. It is not so high as in *M. arundinacea* var. (Commercial No. 1).

With *selenite* the quadrants are as a rule not sharply defined, quite irregular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fair blue-violet; with 0.125 per cent solution they color very lightly and the color deepens somewhat. It is lighter than that of the grains of *M. arundinacea* var. (Commercial No. 1). After heating in water until the grains are completely gelatinized, the solution colors lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes both the solution and the grain-residues color fairly deeply. The capsules all color violet with an excess of iodine.

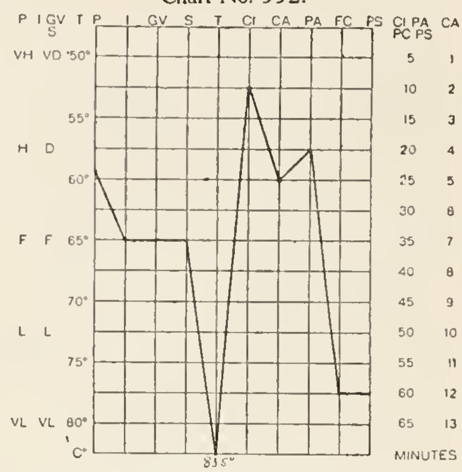
Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are fairly stained, some more than others. The color is not so deep as that of *M. arundinacea* var. (Commercial No. 1).

Temperature Reaction.—The temperature of gelatinization is 82.5° to 84° C., mean 83.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in many grains in 15 seconds, in all in 1½ minutes, and nearly all are gelatinized in 10 minutes. The reaction is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1), except that often the entire margin becomes gelatinous first, then the central portion of the grain.

With *chromic acid* the reaction begins in most grains in 15 seconds and in all in 30 seconds. It is complete in 5 minutes. It is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

Chart No. 352.



Curve of Reaction-Intensities of Starch of Calathea vittata.

Reaction with *pyrogallic acid* begins in most grains in 45 seconds. In 5 minutes one-half are partially and one-fifth of these completely gelatinized; in 10 minutes three-fourths are partially or completely gelatinized; and in 20 minutes three-fourths are completely and the remaining one-fourth partially gelatinized. The reaction is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

The reaction with *ferric chloride* begins in some grains in 45 seconds. In 30 minutes all are partially gelatinized and about one-fifth are completely gelatinized. About half are completely gelatinized in an hour, four-fifths in 2 hours, and all in 3½ hours. The reaction is the same qualitatively as in *M. arundinacea* var. (Commercial No. 1).

With *Purdy's solution* the reaction begins in some grains in 15 seconds and in a few more in 1½ minutes. In 8 minutes about one-half are reacting and one-fifth are completely gelatinized, and half are fully gelatinized in 30 minutes. The reaction is the same qualitatively as in *M. arundinacea* var. (Commercial No. 1).

STARCH OF CALATHEA WIOTIANA. (Plate 90, figs. 539 and 540. Chart 353.)

Histological Characteristics.—In *form* the grains are simple. There are a few small aggregates and a few clumps. Pressure facets are occasionally noted. The surface of the grains is sometimes slightly irregular, owing chiefly to nipple-like processes, slight depressions, and small, rounded protuberances. The conspicuous forms are oval, clam-shell-shaped, mussel-shell-shaped, triangular with rounded corners, elliptical, and flattened oblong; there are a few ovoid, spherical, elongated dome-shaped, pointed elliptical, rounded quadrangular, and various irregular forms. When viewed on edge many grains are rounded, wedge-shaped, or broadly lenticular. The proximal end of the grain is usually narrower than the distal end.

The *hilum* is a small round spot, usually eccentric about two-fifths to one-fifth, commonly about two-fifths, of the longitudinal axis. Two hila are occasionally found. No fissuration was observed except in a few grains which appeared to be undergoing disintegration.

The *lamellæ* are distinct, coarse, fairly regular, complete rings around the hilum; towards the distal end they tend to assume the shape of the grain and are probably incomplete. There is usually one, sometimes 2 or more, distinct, refractive lamellæ at about half the distance between the hilum and the distal margin of the grain. The number of lamellæ is about 12 to 16 on the larger grains.

The *size* of the smallest grains is 6 by 6μ; the large are 24 by 12μ to 18 by 12μ in length and breadth; the common size is about 18μ.

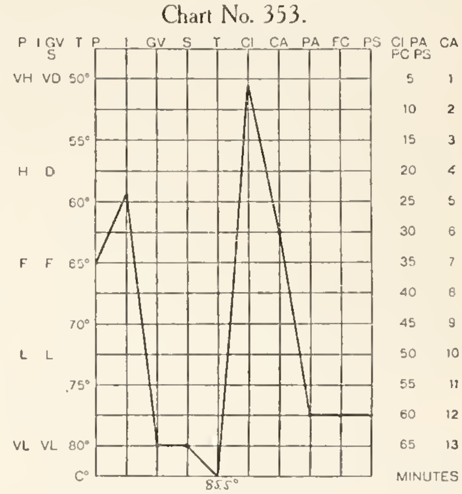
Polariscopic Properties.—The *figure* is eccentric and fairly clear-cut and generally regular. Its lines are usually straight and rather thin, but occasionally they are bent and they may be at various angles to one another.

The degree of *polarization* is fair. It varies in different grains and somewhat in the same aspect of a grain. It is not so high as *M. arundinacea* var. (Commercial No. 1).

With *selenite* the quadrants are fairly well defined, irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a deep violet tinged with blue; with 0.125 per cent solution they color lightly and the color deepens somewhat. The coloration is not quite so deep as that of the grains of *M. arundinacea* var. (Commercial No. 1). After heating in water until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors fairly deeply and the grain-residues fairly. The capsules become of a violet color when an excess of iodine is added.

Chart No. 353.



Curve of Reaction-Intensities of Starch of Calathea wiotiana.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are very lightly stained, one as much as another. The color is very much less than that of the grains of *M. arundinacea* (Commercial No. 1).

Temperature Reaction.—The temperature of gelatinization is 85 to 86° C., mean 85.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in all the grains in 30 seconds; nearly all are gelatinized in 5 minutes and all in 7 minutes. It is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1), but all the marginal starch usually becomes gelatinized before that of the interior of the grain.

Reaction with *chromic acid* begins in some grains in 15 seconds and in all in 30 seconds and is over in 6 minutes. It is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

The reaction with *pyrogallic acid* begins in some grains in 1½ minutes. All are partially gelatinized in 15 minutes and about half are completely gelatinized in 22 minutes. The reaction is qualitatively the same as that of the grains of *M. arundinacea* var. (Commercial No. 1).

Reaction with *ferric chloride* begins in some grains in a minute; almost all are partially gelatinized in 22 minutes; half are completely gelatinized in 1¾ hours, nearly all in 2 hours, and all in 2¾ hours. The reaction is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

The reaction with *Purdy's solution* begins in some grains in 45 seconds, and in 7 minutes one-third are partially gelatinized. The reaction is the same qualitatively as in *M. arundinacea* var. (Commercial No. 1).

STARCH OF CALATHEA VANDENHECKEI. (Plate 91, figs. 541 and 542. Chart 354.)

Histological Characteristics.—In *form* the grains are usually simple, with a few compounds and a few small aggregates usually in the form of one very large grain with one very minute grain. Pressure facets are occasionally found; clumps are rare. The surface of the grains is often somewhat irregular, owing chiefly to lateral protuberances, or nipple-like projections, or to indentations, usually of the distal end. The conspicuous forms are oval, ovoid, rounded triangular, and oyster-, mussel-, and clam-shell-shaped; also some elliptical, spherical, and nearly spherical forms. In a few grains the transverse diameter is larger than the longitudinal.

The *hilum* is a distinct round spot, eccentric about one-fourth to one-fifth, usually one-fourth, of the longitudinal axis. The hilum frequently is fissured. The fissuration may be in the form usually of a short, well-marked, transverse fissure, sometimes having a double curve. Fissures may be arranged in groups to form either irregular stellate figures or a cross.

The *lamellæ* are distinct, coarse, complete rings near the hilum. They are not so coarse but are more distinct near the margin and distal end. There are 2 or 3 or more highly refractive lamellæ in some forms at varying distances between the hilum and within one-half to about two-thirds of the length of the grain. The number may vary in the short broad to elongated from 8 to 23.

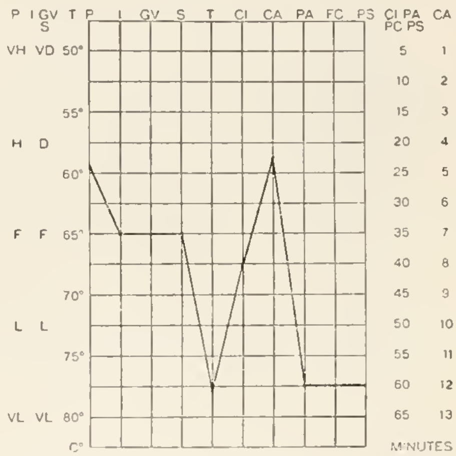
In *size* the smaller grains are about 8μ, and the larger oval and allied forms 46 by 28μ in length and breadth. The common size is 28 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, clear-cut, and regular. The lines are rather thin and usually straight, but occasionally they are bent or otherwise distorted or bisected.

The degree of *polarization* is rather high. It varies somewhat in different grains and in the same aspect of a grain. It is not so high as in *M. arundinacea* var. (Commercial No. 1).

With *selenite* the quadrants are usually well defined and irregular in shape and unequal in size. The colors are not pure.

Chart No. 354.



Curve of Reaction-Intensities of Starch of Calathea vandenheckei.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fair blue-violet; with 0.125 per cent solution they color lightly and the color deepens somewhat. It is not quite so deep as that of the grains of *M. arundinacea* var. (Commercial No. 1). After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly. The capsules are colored violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are fairly stained, some more than others. The color is less than that of the grains of *M. arundinacea* var. (Commercial No. 1).

Temperature Reaction.—The temperature of gelatinization is 77° to 78.5° C., mean 77.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in many grains in a minute. About two-thirds of the grains are completely gelatinized in 15 minutes and nearly all in 40 minutes. The reaction is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

The reaction with *chromic acid* begins in some grains in 15 seconds and in all in 30 seconds, and is over in 4½ minutes. It is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

The reaction with *pyrogallic acid* begins in most grains in 45 seconds, and four-fifths are completely gelatinized in 8 minutes. The reaction is qualitatively the same as that of the grains of *M. arundinacea* var. (Commercial No. 1).

Reaction with *ferric chloride* begins in a few grains in 1½ minutes. About two-fifths are completely gelatinized in 17 minutes; one-half are completely or nearly completely gelatinized in 23 minutes, two-thirds in an hour, and all are completely gelatinized in 4½ hours. The reaction is the same as that of the grains of *M. arundinacea* var. (Commercial No. 1).

The reaction with *Purdy's solution* begins in a few grains in 2 minutes, and a few are partially gelatinized at the end of 30 minutes. The reaction is the same qualitatively as in *M. arundinacea* var. (Commercial No. 1).

Differentiation of Certain Starches of the Genus Calathea.

Histological Characteristics.

Conspicuous Forms.

C. lietzei: Simple, surface somewhat irregular, rarely pressure facets. Clam-shell type triangular with rounded corners, oval, elliptical, almost spherical, elongated dome-shaped.
C. vittata: Usually simple, a few compounds and aggregates, rarely pressure facets, surface usually somewhat irregular. Oval to ovoid and spherical; some approach clam-shell and mussel-shell shapes.
C. wiotiana: Simple, surface sometimes slightly irregular. Oval, clam-shell-shaped, mussel-shell-shaped, triangular with rounded corners, elliptical, flattened oblong.
C. vandenheckei: Usually simple, few compounds and aggregates, surface often irregular. Oval, ovoid, rounded triangular, oyster-shell-shaped, mussel-shell-shaped, and clam-shell-shaped.

Hilum—Form, Number, and Position.

C. lietzei: Form rather small, fairly distinct, round, single; sometimes fissured; fissures usually small, single, shallow, straight or curved, transverse or longitudinal. Position usually eccentric about 0.2 of longitudinal axis.
C. vittata: Form fairly distinct, round, single or sometimes double; may be fissured, fissure single or ragged or much branched. Position usually eccentric about 0.44 to 0.40, commonly about 0.44, of longitudinal axis.
C. wiotiana: Form fairly distinct, small round, single or rarely double, no fissuration except probably in injured grains. Position usually eccentric about 0.40 to 0.20, commonly about 0.40, of longitudinal axis.
C. vandenheckei: Form distinct, round, single; frequently fissured; fissure usually short, well-marked and transverse. Position eccentric 0.25 to 0.20, commonly about 0.25, of longitudinal axis.

Lamellæ—General Characteristics and Number.

C. lietzei: Fairly distinct, rather fine, complete circles or arcs, quite regular. 16 to 20 on larger grains.
C. vittata: Distinct, coarse, quite regular complete rings around hilum; may be irregular and follow margin. 10 to 14 on larger grains.
C. wiotiana: Distinct, coarse, complete rings around hilum, probably incomplete near distal margin, fairly regular. 12 to 16 on larger grains.
C. vandenheckei: Distinct, coarse, complete rings near the hilum, and less coarse but more distinct near margin and distal end. 8 to 23 on larger grains.

Size.

C. lietzei: From 4 to 32μ, commonly 22μ.
C. vittata: From 6 to 24μ, commonly 20μ.
C. wiotiana: From 6 to 24μ, commonly 18μ.
C. vandenheckei: From 8 to 46μ, commonly 28μ.

Polariscopic Properties.

Figure.

C. lietzei: Usually eccentric, fairly distinct, usually not clear-cut.
C. vittata: Usually centric or slightly eccentric, usually not very clear-cut, but regular.
C. wiotiana: Usually eccentric, fairly clear-cut, usually regular.
C. vandenheckei: Usually eccentric, usually clear-cut and regular.

Degree of Polarization.

C. lietzei: Fair, lower than in *M. arundinacea* var. (Commercial No. 1).

Polariscopic Properties.—Continued.

Degree of Polarization.—Continued.

C. vittata: Rather high, but not so high as in *M. arundinacea* var. (Commercial No. 1).
C. wiotiana: Fair, lower than in *M. arundinacea* var. (Commercial No. 1).
C. vandenheckei: Rather high, but not so high as in *M. arundinacea* var. (Commercial No. 1).

Polarization with Selenite—Quadrants and Colors.

C. lietzei: Quadrants fairly well defined, irregular in shape and unequal in size. Colors not pure.
C. vittata: Quadrants usually not sharply defined, quite irregular, unequal in size. Colors not pure.
C. wiotiana: Quadrants fairly well defined, irregular in shape, unequal in size. Colors fairly pure.
C. vandenheckei: Quadrants fairly well defined, irregular. Colors not very bright.

Iodine Reactions.

Intensity and Color.

C. lietzei: Fairly deep, not so deep as in *M. arundinacea* var. (Commercial No. 1); blue-violet.
C. vittata: Fair, not so deep as in *M. arundinacea* var. (Commercial No. 1); blue-violet.
C. wiotiana: Deep, not quite so deep as in *M. arundinacea* var. (Commercial No. 1); violet tinged with blue.
C. vandenheckei: Fair, not so deep as *M. arundinacea* var. (Commercial No. 1); blue-violet.

Staining Reactions.

With Gentian Violet.

C. lietzei: Fairly deep, not quite so deep as in *M. arundinacea* var. (Commercial No. 1).
C. vittata: Fair, not so deep as in *M. arundinacea* var. (Commercial No. 1).
C. wiotiana: Very light, very much less than in *M. arundinacea* var. (Commercial No. 1).
C. vandenheckei: Fair, less than in *M. arundinacea* var. (Commercial No. 1).

With Safranin.

C. lietzei: Fairly deep, not quite so deep as in *M. arundinacea* var. (Commercial No. 1).
C. vittata: Fair, not so deep as in *M. arundinacea* var. (Commercial No. 1).
C. wiotiana: Very light, very much less than in *M. arundinacea* var. (Commercial No. 1).
C. vandenheckei: Fair, less than in *M. arundinacea* var. (Commercial No. 1).

Temperature of Gelatinization.

C. lietzei: 78 to 79° C., mean 75.5°.
C. vittata: 82.5 to 84° C., mean 83.25°.
C. wiotiana: 85 to 86° C., mean 85.5°.
C. vandenheckei: 77 to 78.5° C., mean 77.75°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

C. lietzei: Begins in most in 2 minutes; complete in half in 9 minutes and in all in 20 minutes.
C. vittata: Begins in many in 15 seconds, and in all in 1½ minutes; complete in nearly all in 10 minutes.
C. wiotiana: Begins in all in 1½ minutes; complete in all in 7 minutes.
C. vandenheckei: Begins in many in a minute; complete in two-thirds in 15 minutes and in nearly all in 40 minutes.

Reaction with Chromic Acid.

C. lietzei: Begins in all in 45 seconds; complete in all in 5½ minutes.

Differentiation of Certain Starches of the Genus Calathea.—Continued.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chromic Acid.—Continued.

C. vittata: Begins in all in 30 seconds; complete in all in 5 minutes.
C. wiotiana: Begins in all in 30 seconds; complete in all in 6 minutes.
C. vandenheckei: Begins in all in 30 seconds; complete in all in 4½ minutes.

Reaction with Pyrogallic Acid.

C. lietzei: Begins in most in 1¼ minutes; complete in four-fifths in 8 minutes.
C. vittata: Begins in most in 45 seconds; complete in three-fourths and partial in one-fourth in 20 minutes.
C. wiotiana: Begins in some in 1½ minutes; complete in about one-half in 22 minutes.
C. vandenheckei: Begins in most in 45 seconds; complete in four-fifths in 8 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Ferric Chloride.

C. lietzei: Begins in some in a minute; complete in 13 minutes.
C. vittata: Begins in some in 45 seconds; complete in half in an hour, and in all in 3½ hours.
C. wiotiana: Begins in some in a minute; complete in half in 1¾ hours, and in all in 2¾ hours.
C. vandenheckei: Begins in a few in 1½ minutes; complete in two-thirds in an hour and in all in 4½ hours.

Reaction with Purdy's Solution.

C. lietzei: Begins in some in 2 minutes; partially in a few in 10 minutes.
C. vittata: Begins in some in 15 seconds; complete in half in 30 minutes.
C. wiotiana: Begins in some in 45 seconds; partially in one-third in 7 minutes.
C. vandenheckei: Begins in some in 2 minutes; partially in a few in 30 minutes.

NOTES ON THE STARCHES OF CALATHEA.

The four *Calathea* starches differ sufficiently in their histological features to permit of their differentiation from one another. The variations in the conspicuous forms, hilum, lamellæ, and size taken collectively are quite characteristic. In their reactions they may also be distinguished. It will be seen that *C. lietzei* and *C. vandenheckei* are in close accord, and that *C. vittata* and *C. wiotiana* similarly agree, the chief differences between the couples being in the temperatures of gelatinization, and in the chloral hydrate-iodine, chromic acid, pyrogallic, and Purdy's solution reactions.

GENUS STROMANTHE.

This genus includes only five species of tropical foliage plants which, as before stated, are closely allied to *Maranta*, *Calathea*, *Phrynium*, and *Thalia*. Several of the species are commercially known as Marantas. Starch from *S. sanguinea* Sonder (*Maranta sanguinea* Hort.), probably of Brazilian nativity, was studied.

STARCH OF STROMANTHE SANGUINEA. (Plate 91, figs. 543 and 544. Chart 355.)

Histological Characteristics.—In *form* the grains are simple. There are a few small aggregates and a few small clumps. A few pressure facets are noted. The surface of the grains is generally quite smooth and regular. In a few grains irregularities are noted, due chiefly to single or double, nipple-like projections from the distal end and occasionally to lamellated masses of starch, probably added, usually to the distal end, after the rest of the grain was formed. The conspicuous forms are the elongated ovoid, with the distal end slightly narrower than the proximal, and often somewhat squared with a narrow depression in the center of this squared portion; and the narrow elliptical, which may be straight or bent, whose proximal and distal ends are of the same size; also a few obtuse-angled triangles, and among the small grains a few spherical or almost spherical forms. The grains are not flattened, and when seen on end appear spherical.

The *hilum* is not distinct and is often invisible. It is a small round spot, eccentric from about one-third to one-sixth of the longitudinal axis and in or near the median line. It is occasionally fissured, the fissure being either a small, single, curved, clean-cut, transverse line, or two small lines forming a cross. There is never more than one hilum.

The *lamellæ* are fairly distinct, rather coarse ellipses, or segments of ellipses, which are probably continuous. They usually follow the outline of the margin, but sometimes show waviness and other irregularities of outline. They vary in size in different grains, and are usually coarser and more distinct near the distal end than near the hilum, and in some grains one or more sets of lamellæ are added to or near the distal end, with their longitudinal axis forming an angle with the same axis of the primary part of the grain. There are about 12 to 15 lamellæ on the larger grains.

The grains vary in *size* from 4 to 46μ. The common size is 30μ.

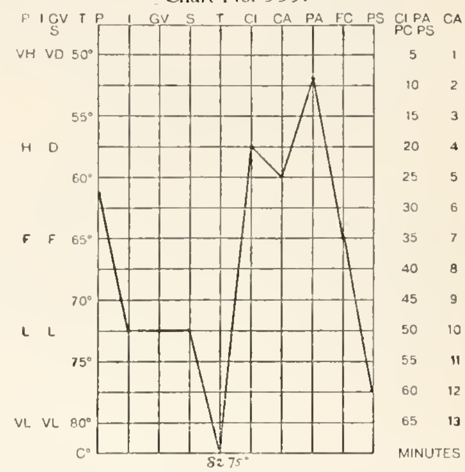
Polariscopic Properties.—The *figure* is eccentric, distinct, fairly clear-cut, and regular. Its lines are rather thin and sometimes broader and less clear-cut as they are nearer the margin, and sometimes bent, and bisected.

The degree of *polarization* is high. It does not vary greatly in different grains, but varies somewhat in different aspects of the same grain. It is highest when the grain is viewed on end. It is slightly higher than that of *M. arundinacea* var. (Commercial No. 1).

With *selenite* the quadrants are usually well defined, generally regular in shape, but unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a light blue-violet; with 0.125 per cent solution they color fairly, some slightly more than others, and the color deepens rapidly. It is much lighter than that of the grains of *M. arundinacea* var. (Commercial No. 1). After heating in water until the grains are completely gelatinized, the solution colors fairly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues lightly or not at all. The capsules are colored a red-violet with an excess of iodine, and many of them retain blue-reacting starch at their proximal end.

Chart No. 355.



Curve of Reaction-Intensities of Starch of Stromanthe sanguinea.

Staining Reactions.—With *gentian violet* the grains begin to stain at once very lightly, and in 30 minutes they are only fairly stained, one grain as much as another. The color is much lighter than that of the grains of *M. arundinacea* var. (Commercial No. 1).

With *safranin* the grains begin to stain at once lightly, and in 30 minutes they are fairly stained, one grain as much as another. The color is much lighter than that of the grains of *M. arundinacea* var. (Commercial No. 1).

Temperature Reaction.—The temperature of gelatinization is 82° to 83.5° C., mean 82. 75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in most grains in 1½ minutes. It is complete in half in 12 minutes, in practically all in 20 minutes. The reaction is qualitatively the same as that of the grains of *M. arundinacea* var. (Commercial No. 1), except that the reaction begins at the distal end.

The reaction with *chromic acid* begins in some grains in less than 30 seconds and in all in a minute, and is over in 7 minutes. It is the same qualitatively as that of the grains of *M. arundinacea* var. (Commercial No. 1).

With *pyrogallic acid* there is a very slight general reaction in 3 minutes and all the grains are partially or completely gelatinized in 15 to 25 minutes. The reaction is the same qualitatively as in *M. arundinacea* var. (Commercial No. 1).

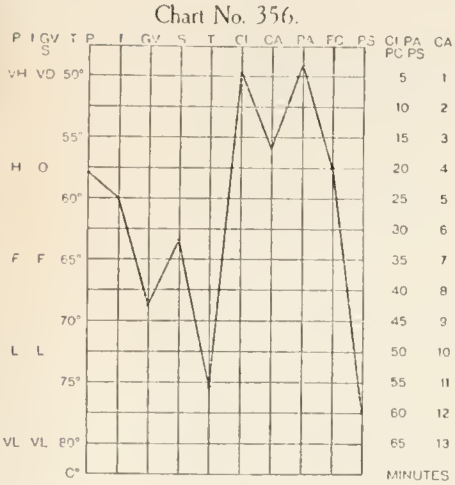
The reaction with *ferric chloride* begins in some grains in 2 minutes. Most grains are gelatinized in 15 minutes and all in 30 minutes. The reaction is the same qualitatively as that of the grains of *M. arundinacea* var (Commercial No. 1).

Reaction with *Purdy's solution* begins in many grains in 1½ minutes. A few are completely gelatinized and some others show a slight reaction, about two-fifths of the total number of grains being affected, in 15 minutes. The reaction is qualitatively the same as in *M. arundinacea* var. (Commercial No. 1).

NOTES ON THE STARCHES OF MARANTACEÆ. (Charts 356 to 358.)

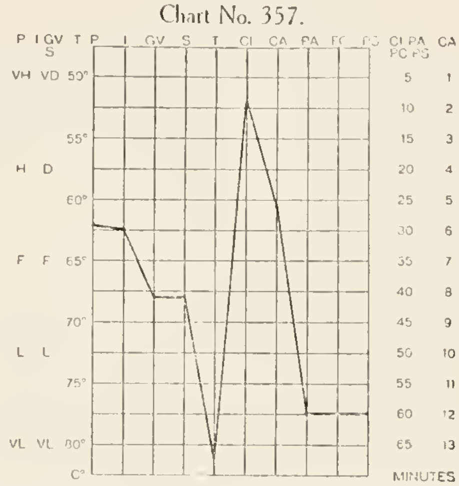
Among the starches of *Maranta* two types of grains will be observed, one represented in the starches of *M. arundinacea* and its varieties and *M. musaica;* and the other type by *M. massangeana* and *M. leuconeura*. Among the *Calathea* starches two types appear to be distinguished, primarily by the position of the hilum, in *C. lietzei*, *C. wiotiana*, and *C. vandenheckei* it being distinctly eccentric, and in *C. vittata* nearly or quite centric. There are also distinct differences in the forms and other characteristics of the grains. The starch of *Stromanthe* is histologically closer to *Calathea* than to *Maranta;* and that of *M. musaica* might upon histological grounds be taken for a *Maranta* or a *Calathea* starch. In their reactions these genera, while exhibiting the same type of reaction-curve, differ so that one is readily distinguishable from the other. Comparing *Maranta* with *Calathea*, it will be found that with the exception of the gentian violet reaction, the reaction-curve throughout is higher; and when compared with the curve of *Stromanthe* it is throughout distinctly higher. *Calathea* shows higher reactivity, except in the chromic acid, pyrogallic acid, ferric chloride, and Purdy solution. The differences brought out in the reactions are in accord with the generic classification of the botanist, except in the case of *M. musaica*, which, according to the peculiarities of the starch, is probably a *Calathea*.

Chart No. 356.



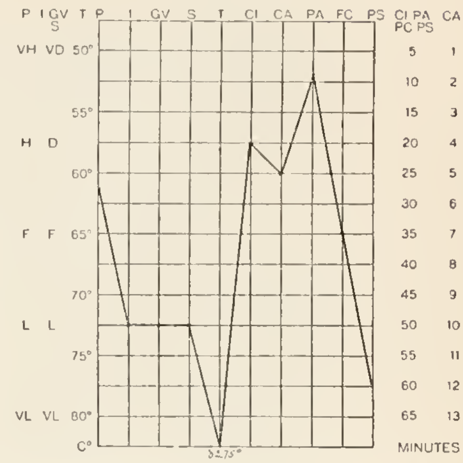
Composite Curve of Mean Reaction-Intensities of Starch of Maranta.

Chart No. 357.



Composite Curve of Mean Reaction-Intensities of Starch of Calathea.

Chart No. 358.



Curve of Reaction-Intensities of Starch of Stromanthe.

STARCHES OF NYMPHÆACEÆ.

Class, Dicotyledones. Order, Ranales. Family, Nymphæaceæ. Genera represented: Nymphæa and Nelumbo.

This family includes 8 genera and 53 species of water-lilies, widely distributed in temperate and tropical waters. It is typified by the genus *Nymphæa*.

GENUS NYMPHÆA.

This genus includes over 30 species and there is a large number of varieties and hybrids. Caspary divides the *Nymphæa* into two sections, which in turn are subdivided into 6 subgenera:

(1) *Lotos*, including two or three species native of Southern Europe, Asia and Africa.
(2) *Hydrocollis*, including about nine species native of tropical America.
(3) *Xanthantha*, including two American species.
(4) *Castalia*, including about six species native of Europe, Asia, and America.
(5) *Brachyceras*, including about twelve species distributed in the tropics of both worlds.
(6) *Anecphya*, including but a single Australian species.

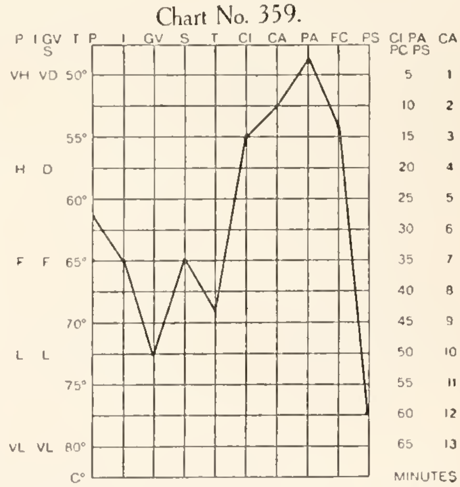
Hybridization has been carried on quite extensively, so that a large number of garden varieties have been obtained in this way. Starches from six sources were prepared, all of them being referable to *Castalia*. The specimens include the following: *N. alba* Linn.; *N. marliacea* var. *albida; N. marliacea* var. *carnea; N. gladstoniana; N. odorata* Ait., the sweet-scented water-lily; and *N. odorata* var. *rosea* Pursh., the Cape Cod water-lily or pond-lily. *N. alba* is a well-known species from Europe and Siberia, and the next three are recorded as garden varieties of *N. alba* and *N. alba* var. *rosea* and are very much alike. *N. odorata* is common in the eastern United States, and its variety is referred to Massachusetts.

STARCH OF NYMPHÆA ALBA. (Plate 91, fig. 545. Chart 359.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains and small aggregates, which commonly are in the form of doublets or triplets. Pressure facets are often found upon the isolated grains. There are some clumps. The surface of the grains is usually more or less irregular, owing chiefly to the deposition of secondary lamellæ placed at varying angles to the original set or to depressions of the margin. The conspicuous forms of the simple grains are ovoid, oval, and round; also dome-shaped to hemispherical, triangular with rounded angles, irregular ovoid or oval with squared end, elliptical, and various irregular forms. The grains are not flattened in any diameter.

The *hilum* is a distinct round, or occasionally lenticular, refractive spot. It is centric or nearly so in the round forms, and eccentric from very slightly to one-third, usually about two-fifths, of the longitudinal axis in other grains. Two hila are sometimes found in the simple grains. The hilum is often fissured; there may be either a single transverse fissure, two short fissures intersecting each other in the form of a cross or several arranged in a stellate figure, or two or three short radial fissures proceeding from the hilum. It is situated in the broader end of the ovoid type.

Chart No. 359.



Curve of Reaction-Intensities of Starch of Nymphæa alba.

The *lamellæ* are frequently not distinct directly around the hilum, but in some grains are coarse and plainly observed throughout the entire grain. They form complete rings around the hilum, tend to have the form of the grain not far from the hilum, and are sometimes undulating in outline as they approach the distal margin. One especially prominent lamella is frequently found at about half the distance between the hilum and the distal end. Secondary sets of lamellæ are not uncommon. The number of lamellæ varies from 8 to 15 in some of the larger grains.

The grains vary in *size;* the smaller are 3 by 3μ; the larger are 27 by 24μ in length and breadth. The common size is 19 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric except in the relatively few round grains, in which it may be centric. Its lines are distinct and broader, though less clear-cut at the margin; usually straight, but may be bent, of irregular thickness, or rarely bisected.

The degree of *polarization* is fair to high, varying somewhat in the same aspect of one grain, in different aspects of a given grain, and in different grains.

With *selenite* in most grains the quadrants are well defined, irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fair blue-violet; with 0.125 per cent solution they color very lightly and the color deepens slowly. After heating in water until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues fairly. The capsules are all colored a red-violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes are lightly stained.

With *safranin* the grains begin to stain lightly at once and in 30 minutes are fairly stained.

Temperature Reaction.—The temperature of gelatinization is 68° to 70° C., mean 69°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few grains, which are probably injured or in the process of digestion, in 30 seconds and in all the rest in 1½ minutes. About half of the total number are gelatinized in 6 minutes, nearly all in 10 minutes, and all in 15 minutes. The reaction begins at the distal end of the grains, the starch becoming dark and swelling. The whole margin then darkens and the process proceeds inwards, but more rapidly usually from the distal end and one side than from the rest of the margin. Just before the starch surrounding the hilum becomes much involved in the reaction, a bubble at the hilum begins to increase in size, and as the grain becomes more and more gelatinous the bubble increases to a great size. Finally, when the whole grain is darkened and presumably gelatinous, the bubble decreases in size and finally disappears. The gelatinized grains are fairly large and retain much of their original form; they show a central, round light portion surrounded by a dark band.

The reaction with *chromic acid* begins in some grains in 10 seconds, in the rest in 20 seconds, and is over in 2 minutes. The starch about the hilum becomes gelatinous and fine striæ appear radiating from the hilum throughout the grain. The grain swells rapidly and the less resistant starch passes into a semifluid mass in the center; the resistant starch forms a thick, coarsely striated band at the margin. This band is often divided into an inner and an outer portion, and the inner portion is divided by coarser striæ than the outer, and disappears as the grain continues to swell, while the outer portion forms a thin, homogeneous-looking capsule. Finally, this capsule dissolves at one point, usually the distal end. The semifluid starch within flows out and is dissolved, followed by solution of the rest of the capsule.

Reaction with *pyrogallic acid* begins in 20 seconds and is over in 2½ minutes. The starch about the hilum is transformed into a gelatinous mass and fine striæ appear radiating from the hilum throughout the grain. The less resistant starch is changed into a gelatinous mass which occupies the inner portion of the grain, and the more resistant starch forms a thick, striated band at the margin which becomes divided into an inner and an outer portion. The inner portion is not so dense and is more coarsely striated than the outer, and as the reaction progresses it is gelatinized. The outer portion remains, but as the grain swells it becomes thinner, less dense and homogeneous, until it has the form of a thin, transparent capsule which is much folded and crumpled. The gelatinized grains are very large and are distorted.

Reaction with *ferric chloride* begins in a few grains in 30 seconds, and is over in 13 minutes. A bubble appears at the hilum, and a very narrow marginal portion grows darker and somewhat clearer than the other part of the grain. The distal end shows slight fissures, and from these there is a protrusion of gelatinous material. The reaction progresses from these points to all parts of the distal end, until all the starch at this point is changed into a gelatinous mass inclosed in a thin, transparent, much folded, and wrinkled capsule. From the distal end the reaction progresses proximally until it nearly reaches the hilum, when the bubble, which is usually at the hilum, begins to increase in size, and then the whole proximal end of the grain swells. The more resistant starch is converted into a gelatinous marginal band, and while this is taking place the bubble at the hilum, having reached a large size, begins to shrink and finally disappears. Finally, when the grain is fully gelatinized it consists of a very thin, transparent capsule, much folded and crumpled, and inclosing a mass of semifluid starch.

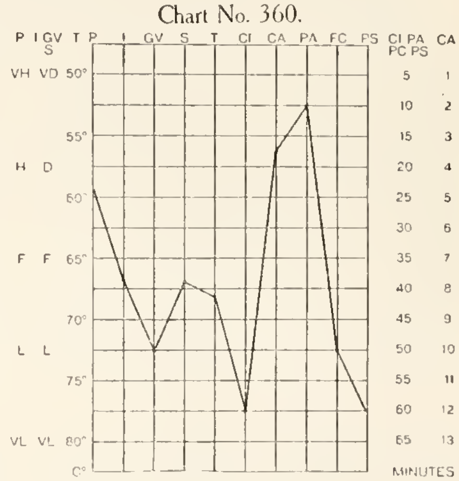
The reaction with *Purdy's solution* begins in a few grains in 45 seconds and in about one-third in 2 minutes. About two-fifths are nearly completely gelatinized in 15 minutes. The reaction, as far as it goes, is qualitatively the same as that with pyrogallic acid.

STARCH OF NYMPHÆA MARLIACEA VAR. ALBIDA. (Plate 92, figs. 547 and 548. Chart 360.)

Histological Characteristics.—In *form* the grains are simple. No compound grains were observed. There are some small aggregates, generally in the form of doublets and triplets, and also a few clumps. Pressure facets were noted on some grains. The surface of the grains is usually somewhat irregular, owing to the same causes as noted under *N. alba.* The conspicuous forms are round, ovoid, and oval; also elliptical, dome-shaped, hemispherical, angular with well-rounded angles, and various indefinite forms. The grains are not flattened. They are somewhat more irregular than *N. alba.*

The *hilum* is a fairly distinct, round, refractive spot, centric or nearly centric in the round forms, and eccentric from very slightly to one-third, usually about two-fifths, of the longitudinal axis. There are 2 hila in some grains. Fissures are fairly often found at the hilum; they may be transverse, diagonal, two short ones intersecting each other and forming a cross, three meeting at one point, or two slightly curved which proceed from a central point slightly nearer the proximal end.

Chart No. 360.



Curve of Reaction-Intensities of Starch of Nymphæa marliacea var. albida.

The *lamellæ* are indistinct in many grains, but if observed they are seen to form fairly coarse rings around the hilum; and when distinct throughout the grain they tend to follow the outline of the margin. Frequently one lamella, at from about one-fourth to one-half of the distance between the hilum and the distal margin, is more prominent than the others; secondary sets of lamellæ are not uncommon. The number was not determined.

The grains vary in *size;* the smaller are 6 by 6μ; the larger are 30 by 30μ or 28 by 24μ in length and breadth. The common size is 19μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric. Its lines are rather thick and become broader towards the margin. They are straight in many grains, while in others they are bent and occasionally bisected. The figure is essentially the same as in *N. alba.*

The degree of *polarization* is fair to high. There are variations in different grains, in different aspects of the same grain, and occasionally in the same aspect of a grain. It is higher than in *N. alba.*

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fair blue-violet; with 0.125 per cent solution they color lightly and the color does not deepen rapidly. It is slightly less than that of the grains of *N. alba.* After heating in water until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues fairly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes are rather lightly stained, the same as that of the grains of *N. alba.*

With *safranin* the grains begin to stain lightly at once and in 30 minutes are fairly stained. The stain is slightly less than that of the grains of *N. alba.*

Temperature Reaction.—The temperature of gelatinization is 67° to 69° C., mean 68°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute. It is over in half the grains in 15 minutes, in three-fourths in 50 minutes, and in all but a few in 1½ hours. It is the same qualitatively as that of the grains of *N. alba.*

The reaction with *chromic acid* begins in 45 seconds and is over in 3½ minutes. It is the same qualitatively as that of the grains of *N. alba.*

The reaction with *pyrogallic acid* begins in a minute. It is over in nearly all in 5 minutes and in all in 10 minutes. It is the same qualitatively as that of the grains of *N. alba.*

Reaction with *ferric chloride* begins in a few grains in 2 minutes. It is over in half the grains in 20 minutes, in nearly all in 40 minutes, and in all in 50 minutes. It is the same qualitatively as that of the grains of *N. alba.*

The reaction with *Purdy's solution* begins in some grains in 2½ minutes and about one-sixth are partially gelatinized in 20 minutes. The reaction is the same qualitatively as in *N. alba.*

STARCH OF NYMPHÆA MARLIACEA VAR. CARNEA. (Plate 92, figs. 549 and 550. Chart 361.)

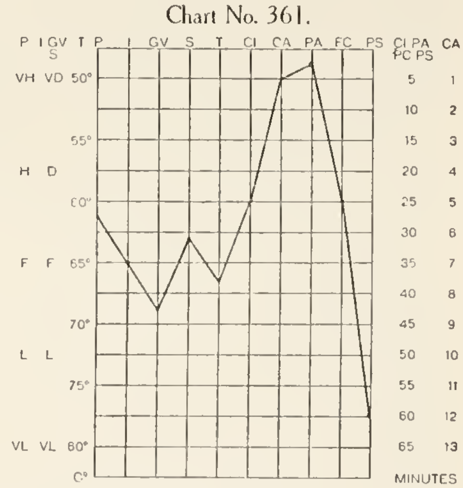
Histological Characteristics.—In *form* the grains are simple, no compound grains observed. There are a number of small aggregates, usually in the form of triplets or of doublets, the components frequently being very unequal in size. Pressure facets are noted on some grains. The surface is rather irregular, owing to the same causes as those noted for *N. alba.* The conspicuous forms are round, ovoid, and oval; also sugar-loaf, dome-shaped, and various irregular forms. The grains are not flattened in any diameter; they are quite similar in form to *N. alba,* but somewhat more irregular.

The *hilum* is a fairly distinct, round, refractive spot centric or nearly centric in the round forms, and commonly eccentric one-fifth to one-third, usually about two-fifths, of the longitudinal axis in most grains. There are sometimes 2 or 3 hila in one grain. The hilum is sometimes fissured, there being usually one short, diagonal, or transverse fissure, or several short fissures so arranged as to form a stellate figure, or three meeting at the hilum.

The *lamellæ* are rather coarse and form complete rings around the hilum. Frequently they are indistinct throughout or either near the hilum or near the margin. There is generally one coarse, very prominent lamella about half the distance between the hilum and the margin. The lamellæ are sometimes undulating and somewhat flattened towards the distal end, and those situated marginally tend to have the form of the outline of the grain. The number was not determined.

The grains vary in *size;* the smaller are 2 by 2μ; the larger are 36 by 32μ in length and breadth. The common size is 22μ.

Chart No. 361.



Curve of Reaction-Intensities of Starch of Nymphæa marliacea var. carnea.

Polariscopic Properties.—The *figure* is centric or generally more or less eccentric. Its lines are rather straight and thick and tend to be broader at the margin in many grains; they may be bent and occasionally are bisected.

The degree of *polarization* is fair to high. There is some variation in different grains, in different aspects of the same grain, and in the same aspect of a grain. The degree of polarization is the same as in the grains of *N. alba.*

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are generally pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a fair blue-violet; with 0.125 per cent solution they color very lightly and the color does not deepen rapidly. The color is the same as that of the grains of *N. alba.* After heating in water until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues fairly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes are lightly to fairly stained. The stain is more than that of the grains of *N. alba.*

With *safranin* the grains begin to stain very lightly at once and in 30 minutes are fairly stained. The stain is more than that of the grains of *N. alba.*

Temperature Reaction.—The temperature of gelatinization is 66° to 67° C., mean 66.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the grains begin to react in a minute. It is over in most grains in 13 minutes and in all in 25 minutes. It is the same qualitatively as that of the grains of *N. alba.*

The reaction with *chromic acid* begins in 10 seconds and is over in a minute. It is the same qualitatively as that of the grains of *N. alba.*

Reaction with *pyrogallic acid* begins in 15 seconds and is over in 2¼ minutes. It is the same qualitatively as that of the grains of *N. alba*, except that the bubbles formed at the hilum are larger and persist longer, and more starch is reduced to a semifluid condition, causing the capsule to be very thin.

The reaction with *ferric chloride* begins in a few grains in 30 seconds and is over in 25 minutes. It is the same qualitatively as that of the grains of *N. alba*.

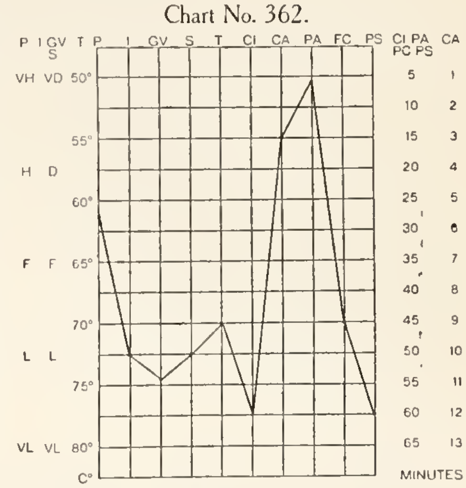
The reaction with *Purdy's solution* begins in 15 seconds. It is over in half the grains in 3 minutes and in three-fourths of the grains in 10 minutes. It is the same qualitatively as that of the grains of *N. alba*.

STARCH OF NYMPHÆA GLADSTONIANA. (Plate 92, figs. 551 and 552. Chart 362.)

Histological Characteristics.—In *form* the grains are simple; no compound forms were observed. There are several small aggregates, usually in the form of doublets consisting of grains of unequal size. There are a few clumps. Pressure facets are sometimes seen. The surface of the grains is usually irregular, owing chiefly to slight depressions and to secondary sets of lamellæ, which are placed at varying angles to the longitudinal axis of the primary set and are more commonly found than in *N. alba*. The conspicuous forms are irregular ovoid and oval and round; also dome-shaped to sugar-loaf and hemispherical, elliptical, and various indefinite forms. The grains are not flattened in any diameter. They are more irregular than in *N. alba* and have a stronger resemblance to *N. odorata*.

The *hilum* is a fairly distinct, round, refractive spot which is centric or nearly centric in the round forms, and eccentric about one-third to one-fifth, usually about one-fourth, of the longitudinal axis in other grains. It is located in the broader end of the ovoid forms, as is the case in all the species of *Nymphæa* studied. The hilum is frequently fissured. There may be 3 fissures in the form of Y; or two slightly diagonal fissures, which may meet at the hilum; or one fissure slightly above another at the hilum, from which they emerge at different planes; or a slightly curved transverse line.

Chart No. 362.



Curve of Reaction-Intensities of Starch of Nymphæa gladstoniana.

The *lamellæ* in many grains are indistinct, but if observed they appear rather coarse and may be visible throughout the entire grain. They form complete rings around the hilum, but towards the distal end and lateral margin tend to assume the shape of the margin. There is generally a shifting laterally of the axis of the lamellæ which lie near the distal margin, and sometimes a distinct second set appears at varying angles to the longitudinal axis of the first set. The number of lamellæ in some of the larger grains is 15.

The grains vary in *size;* the smaller are 2 by 2μ; the larger are 39 by 24μ in length and breadth. The common size is 26 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is centric in some round grains, but usually eccentric. Its lines are distinct and broaden towards the margin, but are usually bent and sometimes bisected. The figure is more irregular and less distinct than in *N. alba*.

The degree of *polarization* is fair to high, varying in different grains, in different aspects of the same grain, and in the same aspect of a given grain. It is the same as in the grains of *N. alba*.

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size, more irregular than in *N. alba*. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a light blue-violet; with 0.125 per cent solution they color very lightly and the color deepens slowly. The color is much less than that of the grains of *N. alba*. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the gelatinized grains fairly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes are lightly stained. The color is less than that of the grains of *N. alba*.

With *safranin* the grains begin to stain very lightly at once and in 30 minutes are rather lightly stained. The color is less than that of the grains of *N. alba*.

Temperature Reaction.—The temperature of gelatinization is 69° to 71° C., mean 70°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 2 minutes. About half the grains are gelatinized in 15 minutes, nearly all in 35 minutes, and all in an hour. It is the same qualitatively as that of the grains of *N. alba*.

Reaction with *chromic acid* begins in some grains in 15 seconds and in the rest in 30 to 60 seconds, and is over in 3 minutes. It is the same qualitatively as that of the grains of *N. alba*.

The reaction with *pyrogallic acid* begins in all the grains in 1½ minutes and is over in 6 minutes. It is the same qualitatively as that of the grains of *N. alba*.

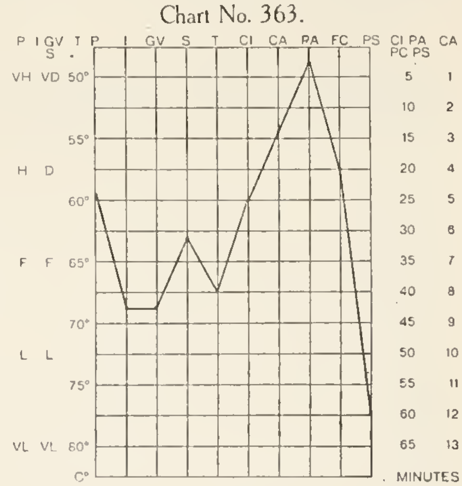
The reaction with *ferric chloride* begins in some grains in 1½ minutes. It is over in nearly all in 30 minutes and in all in 45 minutes. It is the same qualitatively as that of the grains of *N. alba*.

Reaction with *Purdy's solution* begins in some grains in a minute and in 15 minutes about two-thirds of the total number of grains are partially gelatinized. The reaction is qualitatively the same as in *N. alba*.

STARCH OF NYMPHÆA ODORATA. (Plate 93, figs. 553 and 554. Chart 363.)

Histological Characteristics.—In *form* the grains are simple. No compound grains were observed. There are a few small aggregates, mostly in the form of doublets and triplets, and a few clumps. Some grains have one or more pressure facets. The surface of the grains is rather irregular, owing to the causes noted under *N. alba*. The conspicuous forms are oval, ovoid, ovoid with pointed distal end, and round; also dome-shaped, rounded oval, either squared or cut off obliquely at the distal end, and various irregular forms. The grains are not flattened in any diameter. This starch resembles that of *N. gladstoniana* more closely than of *N. alba*, the irregularity of surface being more marked and there being a larger variety of forms.

Chart No. 363.



Curve of Reaction-Intensities of Starch of Nymphæa odorata.

The *hilum* is a fairly distinct, round, refractive spot, centric or nearly centric in the round forms and in the others eccentric one-fifth to one-third, usually one-third, of the longitudinal axis. There are sometimes more than one hilum in a single grain. A crescent-shaped cleft or irregular transverse cavity may be noted at the hilum, or fissures of various characters may be present. The most common fissuration is in the form of a short, curved fissure proceeding from each side of the hilum; or a slightly curved fissure just below the hilum; more rarely two fissures may intersect each other and form a cross, or three fissures may meet at the hilum, or several fissures may be arranged as a stellate figure.

The *lamellæ* form in some grains coarse, distinct rings or ellipses around the hilum, and are sometimes less prominent towards the distal end, while in other grains they are plainly observed throughout the entire grain. They tend to have the shape and irregularities of the outline of the grains when they are located near the distal margin, as in the case of *N. alba*. Secondary lamellæ are sometimes noted. The number of lamellæ in some of the large grains is 17.

The grains vary in *size;* the smaller are 4 by 4μ; the larger are 38 by 30μ in length and breadth. The common size is 24 by 20μ in length and breadth.

Polariscopic Properties.—The *figure* is centric in a few round grains, but more or less oblique in all other grains. Its lines are distinct and sometimes straight and generally broader and less clearly defined at the margin. They are frequently bent and occasionally bisected, and are more irregular than in *N. alba*.

The degree of *polarization* is fair to high, higher than in *N. alba*, with less variation among the grains.

With *selenite* the quadrants are usually well defined, irregular in shape, and unequal in size. The colors are usually pure. The quadrants are more irregular than in *N. alba*.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a light to fair blue-violet; with 0.125 per cent solution they color lightly and the color deepens slowly. The color is slightly less than that of the grains of *N. alba*. After heating in water until the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grain-residues fairly. The capsules all color a red-violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes some are lightly and others are fairly stained. The coloration is deeper than that of *N. alba*.

With *safranin* the grains begin to stain lightly at once and in 30 minutes are fairly stained. The reaction is deeper than that of *N. alba*.

Temperature Reaction.—The temperature of gelatinization is 67° to 68° C., mean 67.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 40 seconds. Most grains are gelatinized in 10 minutes and all in 25 minutes. The reaction is the same qualitatively as that of the grains of *N. alba*.

The reaction with *chromic acid* begins in 15 seconds and is over in 2¾ minutes. It is the same qualitatively as that of the grains of *N. alba*.

The reaction with *pyrogallic acid* begins in 15 seconds and is over in 2½ minutes. It is the same qualitatively as that of the grains of *N. alba*.

Reaction with *ferric chloride* begins in some grains in 45 seconds and is over in 20 minutes. It is the same qualitatively as that of the grains of *N. alba*.

Reaction with *Purdy's solution* begins in most grains in 15 seconds and is over in four-fifths of the grains in 30 minutes. It is the same qualitatively as that of the grains of *N. alba*.

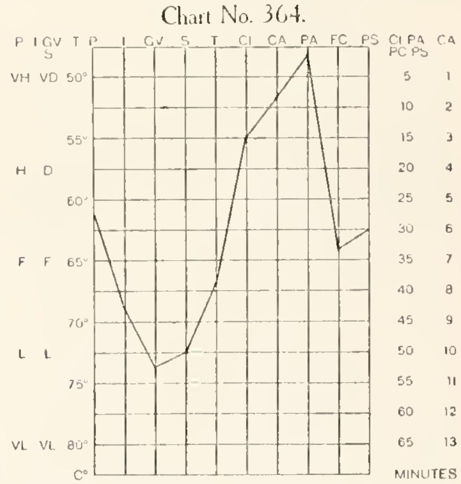
STARCH OF NYMPHÆA ODORATA VAR. ROSEA. (Plate 93, figs. 555 and 556. Chart 364.)

Histological Characteristics.—In *form* the grains are simple. No compound ones are observed. There are a number of small aggregates in the form of doublets, triplets, and quadruplets. There are some clumps, and a number of grains with pressure facets. The surface of the grains is generally somewhat irregular, owing to the same causes as noted under *N. alba*. The conspicuous forms are oval, ovoid, ovoid with pointed end, and round; also sugar-loaf-shaped, dome-shaped, elliptical, and various indefinite forms. There is a greater variation in form among the grains than in *N. alba*. Many elongated ovoid grains similar to those in *N. odorata* are observed. They are not flattened in any diameter.

The *hilum* is a fairly distinct, round, refractive spot, centric in a few of the round forms, eccentric in all other grains. The eccentricity is usually one-fifth to one-third, commonly about one-third, of the longitudinal axis. Fissures are sometimes observed at the hilum. The fissuration may be in the form of a short transverse line; or less commonly two short lines intersect to form a cross; or a diagonal line is transverse to the original or primary set of lamellæ.

The *lamellæ* are usually indistinct except one that is coarse and located at about one-fourth to one-half of the distance between the hilum and distal margin. In all respects they are essentially the same as in *N. alba*, but less distinct.

Chart No. 364.



Curve of Reaction-Intensities of Starch of Nymphæa odorata var. rosea.

The grains vary in *size;* the smaller are 6 by 6μ; the larger are 34 by 26μ in length and breadth, and 30 by 28μ in length and breadth. The common size is 20 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is usually more or less eccentric. Its lines are rather thick and broaden towards the margin; they are straight in some grains, but in others are bent and occasionally bisected. The lines are the same as in *N. alba*, except that they are less regular.

The degree of *polarization* is fair to high; it varies somewhat in different grains, in different aspects of the same grain, and in the same aspect of a given grain. It is the same as in the grains of *N. alba*, but less than in *N. odorata*.

With *selenite* the quadrants are fairly well defined and usually irregular in shape and unequal in size, more irregular than in *N. alba*. The colors are pure in many grains, while in others the blue is quite pure and the yellow fairly pure. The colors are the same as in the grains of *N. alba* except that in some the yellow is not so pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a light to fair blue-violet; with 0.125 per cent solution they color very lightly and the color deepens slowly. It is slightly less than that of the grains of *N. alba*. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the gelatinized grain-residues fairly. The capsules all color a red-violet on the addition of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain very lightly at once and in 30 minutes are lightly stained. The coloration is slightly less than that of the grains of *N. alba*.

With *safranin* the grains begin to stain very lightly at once and in 30 minutes are lightly stained. The coloration is less than that of the grains of *N. alba*.

Temperature Reaction.—The temperature of gelatinization is 66.5° to 67.5° C., mean 67°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 45 seconds and is over in 15 minutes. It is the same qualitatively as that of the grains of *N. alba*.

Reaction with *chromic acid* begins in 15 seconds and is over in 1¾ minutes. It is the same qualitatively as that of the grains of *N. alba*.

The reaction with *pyrogallic acid* begins in 15 seconds and is over in 1¼ minutes. It is the same qualitatively as that of the grains of *N. alba*, except that more of the starch is fully gelatinized.

With *ferric chloride* the reaction begins in a few grains in a minute and is over in 33 minutes. It is the same qualitatively as that of the grains of *N. alba*.

The reaction with *Purdy's solution* begins in 30 seconds. About two-thirds of the grains are partially gelatinized in 5 minutes, four-fifths are nearly completely gelatinized in 15 minutes, and nearly all are completely gelatinized in 30 minutes. The reaction is the same qualitatively as that of the grains of *N. alba*.

Differentiation of Certain Starches of the Genus Nymphæa.

Histological Characteristics.

Conspicuous Forms.

N. alba: Usually simple, few compound grains, few aggregates, some pressure facets, not flattened, surface usually more or less irregular, due chiefly to secondary lamellæ and depressions. Ovoid, oval, and round.

N. marliacea var. *albida:* Essentially the same as in *N. alba*, but greater abundance of round forms, and absence of compound grains, and somewhat greater irregularity of surface.

N. marliacea var. *carnea:* Essentially the same as in *N. alba*, but greater abundance of round forms, absence of compound grains, and more irregularity of surface.

N. gladstoniana: Essentially the same as in *N. alba*, but greater abundance of round forms and secondary lamellæ, absence of compound grains, and greater irregularity of surface.

N. odorata: Essentially the same as in *N. alba*, but greater irregularity of surface and larger variety of forms.

N. odorata var. *rosea:* Essentially the same as in *N. odorata*.

Hilum—Form, Number, and Position.

N. alba: Form distinct, round or occasionally lenticular, refractive spot; often fissured, occasionally 2 hila. Position usually eccentric from slightly to 0.33, commonly 0.40, of longitudinal axis.

N. marliacea var. *albida:* Form fairly distinct, round, refractive spot; fairly often fissured, occasionally 2 hila. Position usually eccentric from very slightly to 0.33, commonly 0.40, of longitudinal axis.

N. marliacea var. *carnea:* Form essentially the same as in *N. marliacea* var. *albida*. Position usually eccentric about 0.20 to 0.33, commonly 0.40, of longitudinal axis.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.—Continued.

N. gladstoniana: Form essentially the same as in *N. marliacea* var. *albida*. Position usually eccentric about 0.20 to 0.33, commonly 0.25, of longitudinal axis.

N. odorata: Form essentially the same as in *N. marliacea* var. *albida*. Position usually eccentric about 0.20 to 0.33, commonly about 0.33, of longitudinal axis.

N. odorata var. *rosea:* Form essentially the same as in *N. marliacea* var. *albida*. Position usually eccentric about 0.20 to 0.33, commonly about 0.33, of longitudinal axis.

Lamellæ—General Characteristics and Number.

N. alba: Frequently not distinct near hilum; complete rings around hilum tend to have the form of the outline of grain when not far from hilum, sometimes undulating, coarse. Secondary sets not uncommon. 8 to 15 on larger grains.

N. marliacea var. *albida:* Essentially the same as in *N. alba*, but less distinct. Number not determined.

N. marliacea var. *carnea:* Essentially the same as in *N. alba*, but less distinct. Number not determined.

N. gladstoniana: Essentially the same as in *N. alba*. 15 on the larger grains.

N. odorata: Essentially the same as in *N. alba*. 17 on the larger grains.

N. odorata var. *rosea:* Essentially the same as in *N. alba*, but less distinct. Number not determined.

Size.

N. alba: From 3 to 27μ, commonly 19μ.
N. marliacea var. *albida:* From 6 to 30μ, commonly 19μ.
N. marliacea var. *carnea:* From 2 to 36μ, commonly 22μ.
N. gladstoniana: From 2 to 39μ, commonly 26μ.
N. odorata: From 4 to 38μ, commonly 24μ.
N. odorata var. *rosea:* From 6 to 34μ, commonly 20μ.

Differentiation of Certain Starches of the Genus Nymphæa.—Continued.

POLARISCOPIC PROPERTIES.

Figure.

N. alba: Usually eccentric, lines distinct, broad and usually straight.
N. marliacea var. *albida:* Same as in *N. alba.*
N. marliacea var. *carnea:* Same as in *N. alba.*
N. gladstoniana: Same as in *N. alba*, but lines less regular.
N. odorata: Same as in *N. alba*, but lines are less regular.
N. odorata var. *rosea:* Same as in *N. alba*, but lines less regular.

Degree of Polarization.

N. alba: Fair to high.
N. marliacea var. *albida:* Fair to high, higher than in *N. alba.*
N. marliacea var. *carnea:* Fair to high, same as in *N. alba.*
N. gladstoniana: Fair to high, same as in *N. alba.*
N. odorata: Fair to high, higher than in *N. alba.*
N. odorata var. *rosea:* Fair to high, same as in *N. alba.*

Polarization with Selenite—Quadrants and Colors.

N. alba: Quadrants usually well defined, irregular in shape and unequal in size. Colors usually pure.
N. marliacea var. *albida:* Quadrants the same as in *N. alba.* Colors usually pure.
N. marliacea var. *carnea:* Quadrants the same as in *N. alba.* Colors usually pure.
N. gladstoniana: Quadrants the same as in *N. alba*, but more irregular. Color usually pure.
N. odorata: Quadrants the same as in *N. alba*, but more irregular. Colors usually pure.
N. odorata var. *rosea:* Quadrants the same as in *N. alba*, but more irregular. Colors usually pure.

IODINE REACTIONS.

Intensity and Color.

N. alba: Fair; blue-violet.
N. marliacea var. *albida:* Fair, slightly less than in *N. alba;* blue-violet.
N. marliacea var. *carnea:* Fair, the same as in *N. alba;* blue-violet.
N. gladstoniana: Light, much less than in *N. alba;* blue-violet.
N. odorata: Light to fair, slightly less than in *N. alba;* blue-violet.
N. odorata var. *rosea:* Light to fair, slightly less than in *N. alba;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

N. alba: Light.
N. marliacea var. *albida:* Light, same as in *N. alba.*
N. marliacea var. *carnea:* Light to fair, slightly more than in *N. alba.*
N. gladstoniana: Light, less than in *N. alba.*
N. odorata: Light to fair, more than in *N. alba.*
N. odorata var. *rosea:* Light, slightly less than in *N. alba.*

With Safranin.

N. alba: Fair.
N. marliacea var. *albida:* Fair, slightly less than in *N. alba.*
N. marliacea var. *carnea:* Fair, more than in *N. alba.*
N. gladstoniana: Light, less than in *N. alba.*
N. odorata: Fair, more than in *N. alba.*
N. odorata var. *rosea:* Light, less than in *N. alba.*

TEMPERATURE OF GELATINIZATION.

N. alba: 68 to 70° C., mean 69°.
N. marliacea var. *albida:* 67 to 69° C., mean 68°.
N. marliacea var. *carnea:* 66 to 67° C., mean 66.5°.
N. gladstoniana: 69 to 71° C., mean 70°.

TEMPERATURE OF GELATINIZATION.—Continued.

N. odorata: 67 to 68° C., mean 67.5°.
N. odorata var. *rosea:* 66.5 to 67.5° C., mean 67°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

N. alba: Begins in all in 1½ minutes; complete in nearly all in 10 minutes, in all in 15 minutes.
N. marliacea var. *albida:* Begins in a minute; complete in three-fourths in 50 minutes.
N. marliacea var. *carnea:* Begins in a minute; complete in most in 13 minutes, in all in 25 minutes.
N. gladstoniana: Begins in 2 minutes; complete in nearly all in 35 minutes, in all in an hour.
N. odorata: Begins in 40 seconds; complete in most in 10 minutes, in all in 25 minutes.
N. odorata var. *rosea:* Begins in 45 seconds; complete in 15 minutes.

Reaction with Chromic Acid.

N. alba: Begins in some in 10 seconds; complete in 2 minutes.
N. marliacea var. *albida:* Begins in 45 seconds; complete in 3½ minutes.
N. marliacea var. *carnea:* Begins in 10 seconds; complete in a minute.
N. gladstoniana: Begins in 15 seconds; complete in 3 minutes.
N. odorata: Begins in 15 seconds; complete in 2¾ minutes.
N. odorata var. *rosea:* Begins in 15 seconds; complete in 1¾ minutes.

Reaction with Pyrogallic Acid.

N. alba: Begins in 20 seconds; complete in 2½ minutes.
N. marliacea var. *albida:* Begins in a minute; complete in nearly all in 5 minutes, in all in 10 minutes.
N. marliacea var. *carnea:* Begins in 15 seconds; complete in 2¼ minutes.
N. gladstoniana: Begins in 1½ minutes; complete in 6 minutes.
N. odorata: Begins in 15 seconds; complete in 2½ minutes.
N. odorata var. *rosea:* Begins in 15 seconds; complete in 1¼ minutes.

Reaction with Ferric Chloride.

N. alba: Begins in 30 seconds; complete in 13 minutes.
N. marliacea var. *albida:* Begins in a few in 2 minutes; complete in nearly all in 40 minutes, and in all in 50 minutes.
N. marliacea var. *carnea:* Begins in a few in 30 seconds; complete in 25 minutes.
N. gladstoniana: Begins in some in 1½ minutes; complete in nearly all in 30 minutes, and in all in 45 minutes.
N. odorata: Begins in some in 45 seconds; complete in 20 minutes.
N. odorata var. *rosea:* Begins in a few in a minute; complete in 33 minutes.

Reaction with Purdy's Solution.

N. alba: Begins in a few in 45 seconds; complete in two-fifths in 15 minutes.
N. marliacea var. *albida:* Begins in some in 2½ minutes; complete in about one-sixth in 20 minutes.
N. marliacea var. *carnea:* Begins in 15 seconds; complete in three-fourths in 10 minutes.
N. gladstoniana: Begins in some in a minute; complete in about two-thirds in 15 minutes.
N. odorata: Begins in most in 15 seconds; complete in four-fifths in 30 minutes.
N. odorata var. *rosea:* Begins in 30 seconds; complete in nearly all in 30 minutes.

NOTES ON THE STARCHES OF NYMPHÆA.

The histological differences noted in these starches are almost wholly related to variations in the relative numbers of the different types of the conspicuous forms. In the reactions, the differences, as a rule, are within narrow limits, yet the sum of the variations in the case of each starch is distinctive.

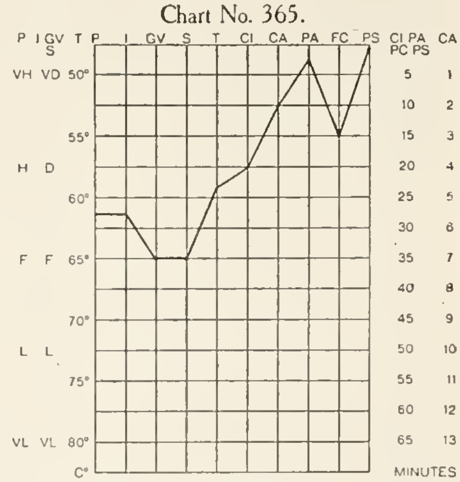
GENUS NELUMBO.

The genus *Nelumbo* or *Nelumbium* includes only two recognized species and a dozen or more cultivated varieties. One of the species is American and the other Oriental. *Nelumbo* is popularly known as the Egyptian lotus, but the lotus of the Ancient Egyptians that is figured in their statues, monuments, buildings, etc., is a *Nymphæa*, either *N. cærulea* Savigny (*N. stellata* Caspary, *N. scutifolia* Hort.), the blue lotus of Egypt, which is a native of Egypt and Africa; or *N. lotus* Linn. (*N. edulis, N. thermalis*), the white lotus, also a native of Egypt. Both of these species belong to the true water-lilies in contradistinction to *Nelumbo*, which does not. *Nelumbo nucifera* Gærtn. (*Nelumbium speciosum* Willd., *N. indica* Pers., *N. nelumbo* Karst.) is the Indian lotus, a native of tropical and semi-tropical Asia and of Australia, and now widely cultivated, especially in China and Japan, where the tuberous rhizomes are consumed as a food and used for the preparation of Chinese arrowroot (see *Marantaceæ*, page 811). The beans of *Nelumbo*, known as the Pythagorean bean or sacred bean of the ancients, are also used as a food. *N. lutea* Pers. is the American lotus or water chinkapin or wankapin, and is a native of the interior and eastern parts of the United States from the Great Lakes to Florida. Starches from both species were studied.

STARCH OF NELUMBO NUCIFERA. (Plate 93, figs. 557 and 558. Chart 365.)

Histological Characteristics.—In *form* the grains are simple. Aggregates consisting of two or rarely three components are occasionally observed. There are a few clumps and some grains have a single pressure facet. The grains are rounded and quite regular. The most conspicuous forms are the rounded ovoid, ovoid, and oval; also spherical, sugar-loaf, and hemispherical, the last two being comparatively uncommon. The ovoid grains have often a somewhat flattened end, suggesting the beginning of a pressure facet. There are modifications of these forms, such as ovoid forms with a broad and flaring end, elongated forms approaching the pyiform type, and somewhat triangular forms. Grains which are broader at the distal end show decided flattening at this part. Viewed from the end the grains appear spherical or ovoid.

Chart No. 365.



Curve of Reaction-Intensities of Starch of Nelumbo nucifera.

The *hilum* is a very distinct, very large, round refractive spot or cavity. It is eccentric usually about two-fifths to one-fourth of the longitudinal axis and is in most cases marked by several deep fissures, usually arranged in a stellate or 3-way fashion. There is occasionally a single transverse or diagonal fissure. The main fissures are usually ragged and subdivided at the ends. Occasionally there may be double hila, in which case there may be a fissure between the two, indicating probably the line of union of two component grains.

The *lamellæ* are fairly distinct, rather coarse, usually regular, concentric rings. Those about the hilum, and one or two centrally located, are apt to be coarser and more distinct than the others. They are generally very regular, but often show somewhat wavy outlines near the margin, and the distal lamellæ tend to follow the outlines of the margin of the grain. The number varies from 14 to 24 on the medium-sized grains.

The grains vary in *size* from about 10 to 40μ. The common size is 32μ.

Polariscopic Properties.—The *figure* is usually eccentric, distinct, quite clear-cut, and regular. All four lines are usually distinct and fairly broad, becoming broader and less clear-cut as they approach the margin. They may be bent. Occasionally double figures are seen.

The degree of *polarization* is high. It is higher when the grain is seen on end, and it varies somewhat in different grains, but not particularly in a given aspect of a grain.

With *selenite* the quadrants are well defined, irregular in shape, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color fairly deeply a blue to blue-violet; with 0.125 per cent solution they are only tinted. Some grains are colored more readily than others. After heating in water until all the grains are completely gelatinized, the grains are colored very deeply, but the solution not at all, with iodine. After boiling for 2 minutes, the grain-residues are much less deeply colored and some are reduced to granular masses which do not color at all; but the solution is colored deeply. With an excess of iodine the capsules become a blue-violet.

Staining Reactions.—With *gentian violet* the reaction begins in a minute and in 30 minutes all are deeply stained. Grains greatly fissured are at first stained more than the others.

With *safranin* the reaction begins at once and in 30 minutes the grains are well stained, but not deeply.

Temperature Reaction.—The temperature of gelatinization is 58° to 59.5° C., mean 58.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins slightly in 30 seconds. All are affected and about five-sixths are fully gelatinized in 20 minutes. The hilum often becomes very prominent as a dark spot or bubble. The margin grows clearer and darker and the inner portion light and opaque. The distal end grows dark and this coloration tends to spread all around the margin. Gelatinization with swelling and protrusion of the contents of the grain begins at the distal end and extends over the whole grain. In the aggregates, gelatinization begins with each component grain on one side at the line of fissuring. The proximal end may become dark, but there is very little gelatinization. The gelatinized grains are large, somewhat distorted, and somewhat lobulated. Commonly the distal end has alternate light and dark bands, above which is a round, clear space, representing the swollen hilum.

Reaction with *chromic acid* begins in 20 seconds and is over in 2 minutes. The hilum is prominent, but the lamellæ not especially so. The hilum swells, and if a bubble is present it is forced to one side and disappears. As the hilum swells, the whole grain is at first divided by fine radiating fissures, and then swells, a thin marginal ring being formed, which is striated and banded. The main mass of the substance of the grain is forced, in the form of a granular mass, to the distal end. This and the margin quickly clears. The grain is much swollen, one portion of the margin at the proximal end dissolves, and the granular contents are extruded and dissolved, followed by solution of the remaining parts.

The reaction with *pyrogallic acid* begins in 20 seconds and is over in 2½ minutes. The hilum, if fissured, becomes distinct as a dark bubble. It swells rapidly, especially in the direction of the proximal end. The bubble is forced to one side and disappears. There is an invagination of the margin from one side so that the grain has the appearance of a large central cavity surrounded by a double ring of banded, striated mass with a clear space between the two rows which represents the swollen hilum. The gelatinized grain finally becomes clear and may be either round, ovoid, or ring-shaped, and somewhat folded and seamed.

The reaction with *ferric chloride* begins in 30 to 60 seconds and is over in 15 minutes. The hilum appears as a dark bubble and the lamellæ disappear. The margin becomes clear and darker and the inner portion becomes light and opaque. Gelatinization begins with irregular protrusion at the distal end and may progress around the margin. Usually before gelatinization has progressed very far the hilum swells enormously. The thin, distinct marginal ring formed is finely striated. The ring soon becomes thinner and clearer. One side of the grains invaginates. The gelatinized grains are large, ovoid or round, lobulated at a distal end, and folded and seamed.

The reaction with *Purdy's solution* begins immediately and is over in 30 seconds. The reaction is so rapid that it is hardly possible to make out the steps. It appeared to resemble closely the reaction with pyrogallic acid.

STARCH OF NELUMBO LUTEA. (Plate 94, figs. 559 and 560. Chart 366.)

Histological Characteristics.—In *form* the grains are simple. No compounds were observed. There are a few aggregates which generally are in the form of doublets. A single pressure facet is noted on occasional grains. There are a few clumps. The surface is quite regular, but a few irregular forms are seen in which a set of lamellæ has its axis at an angle with that of the original set, rarely as much as at right angles. The conspicuous forms are ovoid, oval, and round, with modifications; also dome-shaped, hemispherical, and sugar-loaf-shaped, and some irregular forms.

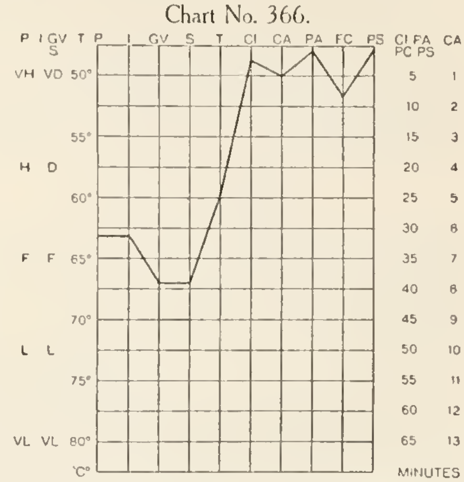
The *hilum* is a well-defined, fairly large, slightly round refractive spot, centric in a few round forms and eccentric in all other grains, usually from about two-fifths to one-third of the longitudinal axis. Two hila are occasionally found in one grain. A short transverse fissure is sometimes observed instead of the hilum. The fissuration is less than in *N. nucifera*.

The *lamellæ* are fairly distinct and usually rather coarse concentric rings. There is frequently a space around the hilum, in which the lamellæ are less plainly marked than the rest of the grain, and often one or two lamellæ are more prominent at about half the distance between the hilum and distal end. The lamellæ are sometimes slightly wavy towards the distal end; near this point they always tend to assume the shape of the grain and are probably incomplete. There are 13 to 24 on the medium- and large-sized grains.

The grains vary in *size* from 5 to 38μ. The common size is about 22μ.

Polariscopic Properties.—The *figure* is centric in a few round grains, but eccentric in all others. Its lines are rather thick and generally straight, but broader and less clear-cut at the margin; they are sometimes slightly bent and rarely bisected.

Chart No. 366.



Curve of Reaction-Intensities of Starch of Nelumbo lutea.

The degree of *polarization* is high to very high, varying somewhat in different grains, in different aspects of the same grain, and occasionally in the same aspect of a given grain. It is higher than that of *N. nucifera.*

With *selenite* the quadrants are well defined, irregular in form, and unequal in size. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are fairly deeply colored a blue-violet; with 0.125 per cent solution they color lightly at first, and the color deepens rapidly. The reaction is less than in *N. nucifera.* After heating in water until all the grains are completely gelatinized, the grains are colored very deeply, but the solution colors very slightly. After boiling for 2 minutes the solution colors very deeply and the grain-residues very lightly. The capsules all color a blue-violet with excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to color at once and in 30 minutes are fairly deeply stained, but not so much as *N. nucifera.*

With *safranin* the grains begin to color at once and in 30 minutes they color fairly, but not so much as *N. nucifera.*

Temperature Reaction.—The temperature of gelatinization is 59.5° to 60.5° C., mean 60°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 15 seconds and is over in 2½ minutes. It is the same qualitatively as that of the grains of *N. nucifera.*

The reaction with *chromic acid* begins at once and is over in 15 seconds. It is the same qualitatively as that of the grains of *N. nucifera.*

With *pyrogallic acid* the grains begin to react in a few seconds and is over in 45 seconds. The reaction is the same qualitatively as that of the grains of *N. nucifera.*

Reaction with *ferric chloride* begins in many grains in 30 seconds and is over in 8 minutes. It is the same qualitatively as that of the grains of *N. nucifera.*

The reaction with *Purdy's solution* begins at once and is over in 30 seconds. It is the same qualitatively as that of the grains of *N. nucifera.*

Differentiation of Certain Starches of the Genus Nelumbo.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

N. nucifera: Simple, few aggregates, few pressure facets, surface quite regular, rounded ovoid, ovoid, and oval.

N. lutea: The same as in *N. nucifera,* except less regular.

Hilum—Form, Number, and Position.

N. nucifera: Form very distinct, very large, round refractive spot or cavity; usually fissured, deep, stellate or 3-armed fissures, occasionally 2 hila. Position usually eccentric about 0.40 to 0.25.

N. lutea: Form the same as in *N. nucifera,* except the hilum is not so large, and the fissuration less. Position usually eccentric about 0.40 to 0.33.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Lamellæ—General Characteristics and Number.

N. nucifera: Fairly distinct, rather coarse, usually regular, concentric rings. 24 on the larger grains.

N. lutea: Essentially the same as in *N. nucifera.* 24 on the larger grains.

Size.

N. nucifera: From 10 to 40μ, commonly 32μ.

N. lutea: From 5 to 38μ, commonly 22μ.

POLARISCOPIC PROPERTIES.

Figure.

N. nucifera: Fairly distinct and fairly clear-cut, regular, usually eccentric.

N. lutea: Essentially the same as in *N. nucifera.*

Differentiation of Certain Starches of the Genus Nelumbo.—Continued.

POLARISCOPIC PROPERTIES—Continued.

Degree of Polarization.

N. nucifera: High.
N. lutea: High to very high, higher than in *N. nucifera.*

Polarization with Selenite—Quadrants and Colors.

N. nucifera: Quadrants well defined, irregular in shape, and unequal in size. Colors fairly pure.
N. lutea: Quadrants the same as in *N. nucifera.* Colors fairly pure.

IODINE REACTIONS.

Intensity and Color.

N. nucifera: Fairly deep; blue to blue-violet.
N. lutea: Fairly deep, less than in *N. nucifera;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

N. nucifera: Fairly deep.
N. lutea: Fairly deep, less than in *N. nucifera.*

With Safranin.

N. nucifera: Fair.
N. lutea: Fair, less than in *N. nucifera.*

TEMPERATURE OF GELATINIZATION.

N. nucifera: 58 to 59.5° C., mean 58.75°.
N. lutea: 59.5 to 60.5° C., mean 60°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

N. nucifera: Begins slightly in 30 seconds; all affected and about five-sixths gelatinized in 20 minutes.
N. lutea: Begins in 15 seconds; complete in 2½ minutes.

Reaction with Chromic Acid.

N. nucifera: Begins in 20 seconds; complete in 2 minutes.
N. lutea: Begins at once; complete in 30 seconds.

Reaction with Pyrogallic Acid.

N. nucifera: Begins in 20 seconds; complete in 2½ minutes.
N. lutea: Begins in a few seconds; complete in 45 seconds.

Reaction with Ferric Chloride.

N. nucifera: Begins in 30 to 60 seconds; complete in 15 minutes.
N. lutea: Begins in many in 30 seconds; complete in 8 minutes.

Reaction with Purdy's Solution.

N. nucifera: Begins at once; complete in 30 seconds.
N. lutea: Begins at once; complete in 30 seconds.

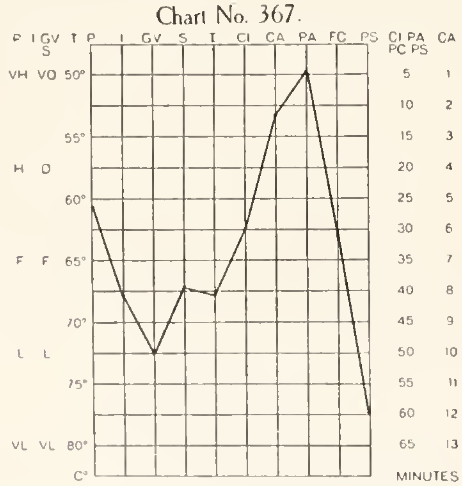
NOTES ON THE STARCHES OF NELUMBO.

The *Nelumbo* starches, in so far as their histological characters are concerned, differ noticeably only in the degree of regularity of the outlines of the grains, in the size and fissuration of the hilum, and in the size of the grains. In their reactions they are identical only in response to Purdy's solution. *N. nucifera* exhibits a higher degree of polarization, higher reactivity with iodine and the anilines, a lower temperature of gelatinization, and less sensitivity to chloral hydrate-iodine, chromic acid, pyrogallic acid, and ferric chloride.

NOTES ON THE STARCHES OF NYMPHÆACEÆ. (Charts 367 and 368.)

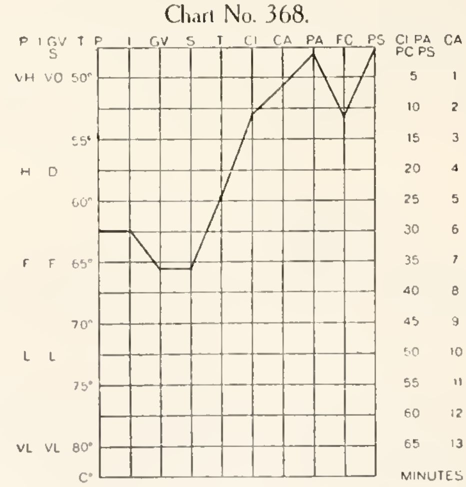
The starches of *Nymphæa* and *Nelumbo* exhibit similar histological characteristics, but the variations in form, hila, fissuration, lamellæ, and size are of value in distinguishing the members of the two genera. In the reactions, it will be noted that with the exception of the degree of polarization the *Nymphæa* starches are less sensitive than those of *Nelumbo.* The differences in the chloral hydrate-iodine, ferric chloride, and Purdy's solution reactions are very conspicuous.

Chart No. 367.



Composite Curve of Mean Reaction-Intensities of Starch of Nymphæa.

Chart No. 368.



Composite Curve of Mean Reaction-Intensities of Starch of Nelumbo.

STARCHES OF ANEMONACEÆ.

Class, Dicotyledones. Order, Ranales. Family, Anemonaceæ.
Genus represented, Anemone.

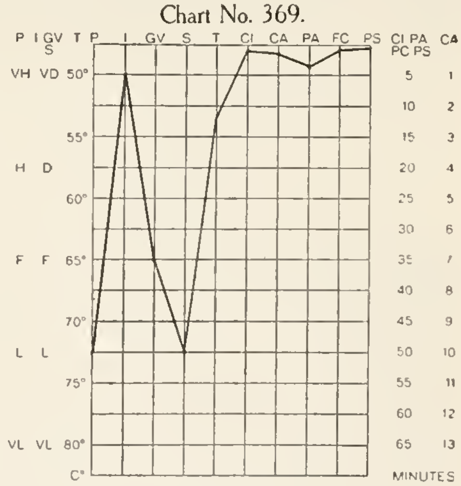
GENUS ANEMONE.

The family *Anemonaceæ* includes the genera *Anemone* and *Thalictrum* or meadow rue. *Anemone* includes about 85 species of bulbous-rooted hardy perennials, natives of the cool climates of the Northern Hemisphere, for the most part of the Old World, many of which are well-known garden plants. Starches from four species were examined: *A. apennina* Linn., a native of Italy; *A. fulgens* Gay (*A. pavonia* var. *fulgens* DeCand.), a native of France, and sometimes referred to as a variety of *A. hortensis* Linn.; *A. blanda* Schott and Kotschy, a native of the Taurus Mountains and Greece and closely related to *A. apennina;* and *A. japonica* Sieb. and Zucc., a native of China and Japan, and one of the finest members of the genus.

STARCH OF ANEMONE APENNINA. (Plate 94, figs. 561 and 562. Chart 369.)

Histological Characteristics.—In *form* the grains are simple and without pressure facets. There are no aggregates or compound grains, but the grains often occur in clumps which may easily be broken up. The surface of the grains is somewhat irregular, owing to few additions to the surface in the form of nipple-like processes. As a rule, the grains are rounded and quite regular in outline. They are usually elongated either in the longitudinal or transverse diameter. The most conspicuous forms are elongated ovoid, oval, elliptical, elliptical with one side flattened, and triangular with relatively very broad base; also broad ovoid, spindle-shaped, oval, round or nearly round, and various indefinite forms, due chiefly to nipple-like processes. The grains are sometimes slightly bent at the middle. They are not flattened, but may be narrower at the distal end than at the other, or thicker in the middle than at the ends.

Chart No. 369.



Curve of Reaction-Intensities of Starch of Anemone apennina.

The *hilum* is large and fairly distinct, and there is throughout its whole extent a depression on the surface of the grain. It may be a round spot, eccentric about one-third of the longitudinal axis, or it may have an elongated, lenticular form and run the length of either the longitudinal or transverse axis of the grain. The hilum is not always visible. It is at times distinctly fissured, but not often. From the reaction to chemical reagents the elongated hilum appears to consist in reality of double and triple hila.

The *lamellæ* are invisible.

The grains vary in *size* from 2 to 14μ. The dimensions of an average triangular grain is 9 by 5μ in length and width. The common size is 10μ.

Polariscopic Properties.—The *figure* is not always distinct, but if so it is clear-cut and usually irregular. It may be eccentric or centric and may be in the form of a cross or a long line with bisected ends as in the beans. It is usually quite regular in form, but the lines may be somewhat bent and otherwise distorted.

The degree of *polarization* is low in most grains, but is high in a few very large grains.

With *selenite* the quadrants are fairly well defined, irregular in shape, and usually unequal in size. The colors, except in the rare very large grains, are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored very deeply at once and the color quickly deepens until they are almost black; with 0.125 per cent solution the grains color at once and deepen rapidly. The color is bluish-violet. After heating in water until the grains are completely gelatinized, the solution is colored lightly and the grains very deeply upon the addition of iodine. After boiling for 2 minutes the solution is deeply stained, but the grain-residues very lightly. With a slight excess of iodine, the grains show a red-violet capsule. Some capsules still contain blue-reacting material.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After 30 minutes they are fairly stained, all very evenly, but the color is not much deeper that at first.

With *safranin* the grains stain at once, but lightly. After 30 minutes they are evenly stained, and but little more than at first.

Temperature Reaction.—The temperature of gelatinization is 53° to 54° C., mean 53.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins at once and all the grains are darkened in a minute; they darken at both ends, or less often at one end, and swell out evenly. This process extends around the margin on one side more rapidly than on the other, and then inward over the interior; when the latter part is darkened the whole mass swells somewhat. The gelatinized grains are fairly large, retain some of the original shape of the grain, and are uniformly dark. Later they show a light spot or spots that mark the swollen hilum or hila.

Reaction with *chromic* acid begins at once and is over in 20 seconds. The reaction appears to consist in the transformation of all the inner portion, attended by great general swelling, the grain becoming converted into a large, thin-walled mass. This capsule rapidly dissolves, but it was not possible to determine whether one part dissolved before the other.

The reaction with *pyrogallic acid* begins at once and is over in 3½ minutes. The hilum or hila swell. If there are hila, the starch between them is rapidly dissolved, the grain swells, and the more resistant outer part of the grains becomes a fairly thick, homogeneous band, which grows thinner and more transparent during the process of swelling. The gelatinized grains are large, somewhat folded and creased, but retain much of the original shape. They may show two or three lobulations corresponding to the number of hila in the original grain.

The reaction with *ferric chloride* begins at once and is over in 1½ minutes. The process begins usually at both ends of the grain, with great swelling. From these points it moves inward until it reaches the central part, which is now divided by a fissure corresponding to the fissure marking the hilum. These two parts of the grain separate and are then split up into a number of smaller pieces, which gelatinize independently. The gelatinized grain is large, lobulated, and irregular, but retains some of the original form.

With *Purdy's solution* the reaction begins at once and is over in most grains in a very few seconds and in all in a minute. The reaction is the same as that with pyrogallic acid.

STARCH OF ANEMONE FULGENS. (Plate 94, fig. 563. Chart 370.)

Histological Characteristics.—In *form* the grains are simple; very rarely they occur in small aggregates and they have well-defined pressure facets. They often occur in large clumps, which are very easily broken up. The surface is sometimes irregular, owing to the unequal development of different parts of the margin, especially to nipple-like protuberances. Some forms are bent near the middle or near the smaller end, and they are generally elongated in either the longitudinal or transverse diameter. The conspicuous forms are the elongated ovoid, oval, elliptical with one side flattened, and triangular with broad base. There are also some spindle-shaped, dome-shaped, round or nearly round, lenticular, and various indefinite forms. The grains are not flattened, but they are often narrower at the distal than at the proximal end. They are not always of the same shape in different aspects, owing to the nipple-like processes and other additions to the primary grain.

The *hilum* is large and distinct. There is usually a depression on the surface of the grain just above the hilum. If the hilum is round, as it is in the round and short broad forms, this depression is round. In the elongated forms it is usually elongated. In some elongated forms the hilum is a large, round spot eccentric about one-third of the longitudinal axis and in the larger end of the grain. It is usually fissured, and the fissure may be a simple transverse line or an irregularly stellate arrangement. There are grains with double or multiple hila.

The *lamellæ* are invisible.

The grains vary in *size* from 4 to 14μ. The dimensions of a large triangular grain are 12 by 8μ in breadth and length. The dimensions of the ovoid grain are 14 by 9μ in breadth and length. The common size is 10μ.

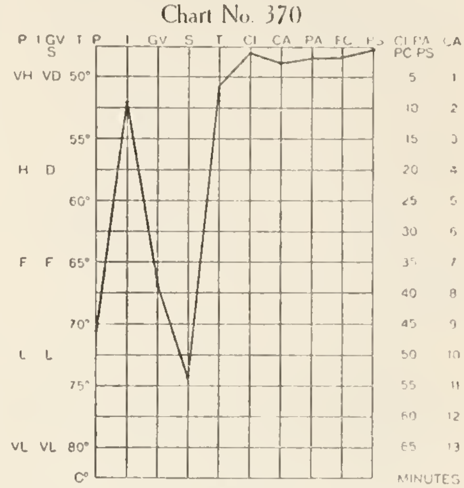
Polariscopic Properties.—The *figure* is not always distinct, but appears to be clear-cut and usually irregular. It may be in the form of a cross, or as a line which is bisected at each end, and centric or eccentric. The lines may be bent and otherwise distorted.

The degree of *polarization* is low in most grains, but is fairly high in some of the larger ones. It does not vary much in different aspects of the same grain. It is slightly higher than in the grains of *A. apennina.*

With *selenite* the quadrants are, as a rule, fairly well defined, irregular in shape, and unequal in size. In the smaller grains the colors are pure, not in the larger.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored at once deeply, and the color deepens very rapidly until the grains are almost black; the depth is the same as that of the grains of *A. apennina.* With 0.125 per cent solution the grains color at once and the color deepens rapidly, but the shade is not so deep as that of the grains of *A. apennina.* After heating in water until all of the grains are gelatinized, the solution is colored very lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors much more deeply, the grain-residues much less or not at all. On the addition of an excess of iodine the grains show a red-violet capsule. No grains are completely disintegrated.

Chart No. 370



Curve of Reaction-Intensities of Starch of Anemone fulgens.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes they are fairly stained. The color is lighter than that of the grains of *A. apennina.*

With *safranin* the grains begin to stain lightly at once, but after 30 minutes the color is light, slightly lighter than that of the grains of *A. apennina.*

Temperature Reaction.—The temperature of gelatinization is 50° to 51.5° C., mean 50.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in 1½ minutes. The reaction is identical qualitatively but not quantitatively with that of the grains of *A. apennina.* These grains do not react quite so rapidly, hence the process is more easily followed than in the grains of *A. apennina.*

The reaction with *chromic acid* begins at once and is over in 30 minutes. This reaction is qualitatively identical with that of *A. apennina.*

The reaction with *pyrogallic acid* begins at once and is over in 2 minutes. Qualitatively it is the same as that of the grains of *A. apennina.*

Reaction with *ferric chloride* begins in 20 seconds and is over in 3 minutes. Qualitatively it is the same as that of the grains of *A. apennina.*

Reaction with *Purdy's solution* begins at once and is over in a very few seconds. It is impossible to determine the steps of the reaction.

STARCH OF ANEMONE BLANDA. (Plate 94, fig. 564. Chart 371.)

Histological Characteristics.—In *form* the grains are simple. There are no aggregates, very rarely pressure facets, and there is some tendency to clumps which are easily broken apart. The surface of the grains shows some irregularities due to the irregular development of surface, chiefly in the form of nipple-like processes. The conspicuous forms are ovoid, elliptical, oval, lenticular, triangular. There are round or nearly round, spindle-shaped, and various indefinite forms. The grains are sometimes bent at or near the middle; they are not flattened in any diameter, but may vary in form according to the aspect viewed, owing to irregular development.

The *hilum* is not very distinct. A depression on the surface of the grain is always present at this point. In some forms it is centric. In some of the shorter forms the hilum is a round spot, eccentric about one-third of the longitudinal axis and usually in the median line. In the longer forms it is elongated or lenticular. When the grains are subjected to chemical reagents the elongated hilum is often seen to be a row of 2 or more hila. The hilum itself is not fissured.

The *lamellæ* are invisible.

The grains vary in *size* from 2 to 16μ. The dimensions of the lenticular or triangular grains are 10 by 6μ in breadth and length. The common size is 10μ.

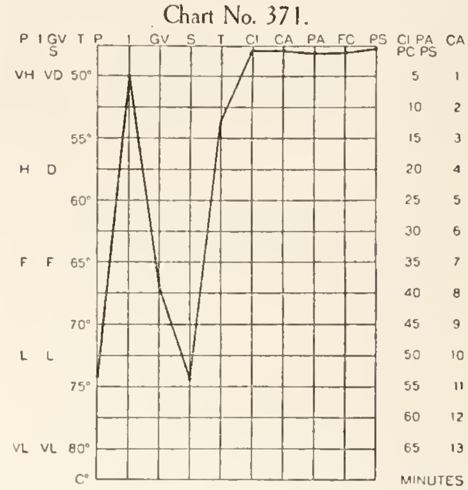
Polariscopic Properties.—The *figure* is not always distinct. It is either centric or eccentric, and usually irregular. The lines are clear-cut, well defined, and usually straight; they may be bent and otherwise distorted.

The degree of *polarization* is low in most grains, lower than in the grains of *A. apennina.*

With *selenite* the quadrants are clear-cut, usually irregular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution, the grains are colored at once very deeply; with 0.125 per cent solution they color well at once and the color quickly deepens. The color is the same as that of the grains of *A. apennina.* After heating in water until all of the grains are completely gelatinized, the solution is colored very lightly and the grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution is colored deeply and the grain-residues very lightly or not at all. When a slight excess of iodine is added all the grains show a red-violet capsule. The capsules which do not contain blue-reacting starch are very much distorted.

Chart No. 371.



Curve of Reaction-Intensities of Starch of Anemone blanda.

Staining Reactions.—With *gentian violet* the grains stain lightly at once and after 30 minutes are fairly stained. The color is lighter than that of the grains of *A. apennina.*

With *safranin* the grains stain at once very lightly and after 30 minutes are only lightly stained. The color is slightly lighter than that of the grains of *A. apennina.*

Temperature Reaction.—The temperature of gelatinization is 52.5° to 54° C., mean 53.25°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is complete in 45 seconds. Qualitatively it is the same as that of the grains of *A. apennina.*

The reaction with *chromic acid* begins immediately and is over in 10 seconds. It is qualitatively the same as that of the grains of *A. apennina.*

The reaction with *pyrogallic acid* and with *ferric chloride* begins at once and is over in 1 to 1½ minutes. It is qualitatively the same as that of the grains of *A. apennina.*

With *Purdy's solution* the reaction is very quick and is over in a very few seconds. Qualitatively it is, as far as could be determined, the same as that of the grains of *A. apennina.*

STARCH OF ANEMONE JAPONICA. (Plate 95, figs. 565 and 566. Chart 372.)

Histological Characteristics.—In *form* the grains are simple, with no aggregates. Many have one or two, rarely more, rather poorly defined pressure facets at the distal end. There are many easily separated clumps. The surface of the grains has some slight irregularities, due to unequal development, chiefly nipple-like processes. The conspicuous forms are dome-shaped to hemispherical, with one or usually two facets of unequal size at the distal end; also polygonal, quadrangular, and ovoid, regular or with a flat distal end, spherical, lenticular, and various indefinite forms. The grains when seen from the top commonly appear spherical.

The *hilum* is a distinct, single, large, round or triangular or elongated, non-refractive spot, usually eccentric about two-fifths of the longitudinal axis and to one side of the median line. It is rarely fissured, and the fissure is narrow, shallow, not distinct, and appears to be ragged. There are no multiple hila.

The *lamellæ* are invisible.

The grains vary in *size* from 1 to 12μ. The common size is 8μ.

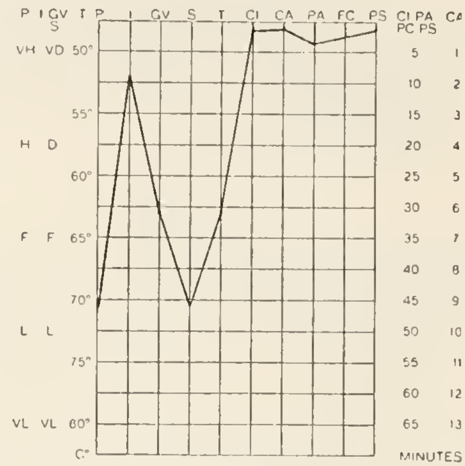
Polariscopic Properties.—The *figure* is usually eccentric, not always distinct, but clear-cut. Its lines are not thick and are of the same size throughout their length. The figure is regular and not distorted in any way.

The degree of *polarization* is low in most grains. It varies in different grains and in different aspects of the same grain, being highest when the grain is viewed from top. It is slightly higher than in the grains of *A. apennina.*

With *selenite* the quadrants are clear-cut, fairly regular in shape, and usually unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deeply a blue-violet, and with 0.125 per cent solution they color readily, and the color deepens rapidly. The reaction is slightly less than that of *A. apennina.* After heating in water until the grains are all completely gelatinized, the solution colors faintly and the grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors deeply and the grains fairly. The capsules color a red-violet with a very slight excess of iodine and all of them contain blue-reacting starch.

Chart No. 372.



Curve of Reaction-Intensities of Starch of Anemone japonica.

Staining Reactions.—With *gentian violet* the grains begin to stain at once and in 30 minutes are fairly stained, slightly deeper than those of *A. apennina.*

With *safranin* the grains begin to stain at once and in 30 minutes are lightly stained, more than those of *A. apennina.*

Temperature Reaction.—The temperature of gelatinization is 62° to 64° C., mean 63°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in 1½ minutes. It is the same qualitatively as that of the grains of *A. apennina.*

The reaction with *chromic acid* begins at once and is over in 15 seconds. It is the same qualitatively as that of the grains of *A. apennina.*

Reaction with *pyrogallic acid* begins at once and is over in nearly all the grains in 3 minutes, while the rest are almost completely gelatinized. It is the same qualitatively as that of the grains of *A. apennina.*

With *ferric chloride* reaction begins in most grains in 30 seconds and is over in 2½ minutes. It is the same qualitatively as that of the grains of *A. apennina.*

The reaction with *Purdy's solution* begins at once and is over in 1½ minutes. It is the same qualitatively as that of the grains of *A. apennina.*

Differentiation of Certain Starches of the Genus Anemone.

Histological Characteristics.

Conspicuous Forms.

A. apennina: Simple, no aggregates, no pressure facets, surface somewhat irregular owing to additions. Elongated ovoid, elliptical, elliptical with one side flattened, triangular with relatively very broad base.

A. fulgens: Essentially the same as in *A. apennina*, except few well-defined pressure facets, some dome-shaped.

A. blanda: Essentially the same as in *A. apennina*, except rare pressure facets.

A. japonica: Simple, no aggregates, many have 1 or 2 or more pressure facets, surface somewhat irregular. Conspicuous forms dome-shaped to hemispherical with 1 or usually 2 facets at the distal end.

Hilum—Form, Number, and Position.

A. apennina: Form fairly distinct, large, round, or lenticular; fissured, fissures small. Elongated hilum appears to be double or triple. Position eccentric 0.33 of the longitudinal axis, or centric.

A. fulgens: Form distinct, large, round or elongated, usually single, may be multiple; usually fissured, fissures simple or irregularly stellate. Position eccentric about 0.33 of the longitudinal axis or centric.

A. blanda: Form not very distinct, round or elongated, single or multiple, not fissured. Position eccentric about 0.33 of the longitudinal axis, or centric.

Histological Characteristics.—Continued.

Hilum—Form, Number, and Position.—Continued.

A. japonica: Form distinct, large round or triangular or elongated, single; rarely fissured, fissures narrow and shallow and not distinct. Position eccentric about 0.40 of the longitudinal axis, or centric.

Lamellæ—General Characteristics and Number.

A. apennina: Invisible.
A. fulgens: Invisible.
A. blanda: Invisible.
A. japonica: Invisible.

Size.

A. apennina: 2 to 14μ, commonly 10μ.
A. fulgens: 4 to 14μ, commonly 10μ.
A. blanda: 2 to 16μ, commonly 10μ.
A. japonica: 1 to 12μ, commonly 8μ.

Polariscopic Properties.

Figure.

A. apennina: Centric or eccentric, not always distinct, lines usually straight, clear-cut, usually irregular.
A. fulgens: The same as in *A. apennina.*
A. blanda: The same as in *A. apennina.*
A. japonica: The same as in *A. apennina.*

Degree of Polarization.

A. apennina: Low in most of the grains.
A. fulgens: Low in most of the grains, but higher than in *A. apennina.*

Differentiation of Certain Starches of the Genus Anemone.—Continued.

Polariscopic Properties.—Continued.

Degree of Polarization.—Continued.

A. blanda: Low in most of the grains, and lower than in *A. apennina.*
A. japonica: Low in most of the grains, but slightly higher than in *A. apennina.*

Polarization with Selenite—Quadrants and Colors.

A. apennina: Quadrants fairly well defined, usually irregular in shape, unequal in size. Colors not pure.
A. fulgens: Quadrants the same as in *A. apennina.* Colors not pure.
A. blanda: Quadrants the same as in *A. apennina.* Colors not pure.
A. japonica: Quadrants the same as in *A. apennina.* Colors not pure.

Iodine Reactions.

Intensity and Color.

A. apennina: Very deep; blue-violet.
A. fulgens: Very deep, but not so deep as in *A. apennina;* blue-violet.
A. blanda: Very deep, the same as in *A. apennina;* blue-violet.
A. japonica: Very deep, slightly less than in *A. apennina;* blue-violet.

Staining Reactions.

With Gentian Violet.

A. apennina: Fair.
A. fulgens: Fair, but less than in *A. apennina.*
A. blanda: Fair, but less than in *A. apennina.*
A. japonica: Fair, but slightly deeper than in *A. apennina.*

With Safranin.

A. apennina: Light.
A. fulgens: Light, slightly lighter than in *A. apennina.*
A. blanda: Light, slightly lighter than in *A. apennina.*
A. japonica: Light, slightly more than in *A. apennina.*

Temperature of Gelatinization.

A. apennina: 53 to 54° C., mean 53.5°.
A. fulgens: 50 to 51.5° C., mean 50.75°.
A. blanda: 52.5 to 54° C., mean 53.25°.
A. japonica: 62 to 64° C., mean 63°.

Effects of Various Reagents.

Reaction with Chloral Hydrate-Iodine.

A. apennina: Begins at once; complete in a minute.
A. fulgens: Begins at once; complete in 1½ minutes.
A. blanda: Begins at once; complete in 45 seconds.
A. japonica: Begins at once, complete in 1½ minutes.

Reaction with Chromic Acid.

A. apennina: Begins at once; complete in 20 seconds.
A. fulgens: Begins at once; complete in 30 seconds.
A. blanda: Begins at once; complete in 10 seconds.
A. japonica: Begins at once; complete in 15 seconds.

Reaction with Pyrogallic Acid.

A. apennina: Begins at once; complete in 3½ minutes.
A. fulgens: Begins at once; complete in 2 minutes.
A. blanda: Begins at once: complete in 1 to 1½ minutes.
A. japonica: Begins at once; complete in nearly all in 3 minutes, the rest are nearly gelatinized.

Reaction with Ferric Chloride.

A. apennina: Begins at once; complete in 1½ minutes.
A. fulgens: Begins in 20 seconds; complete in 2 minutes.
A. blanda: Begins at once; complete in 1 to 1½ minutes.
A. japonica: Begins in most in 30 seconds; complete in 2½ minutes.

Reaction with Purdy's Solution.

A. apennina: Begins at once; complete in a minute.
A. fulgens: Begins at once; complete in a very few seconds.
A. blanda: Begins at once; complete in a few seconds.
A. japonica: Begins at once; complete in 1½ minutes.

NOTES ON THE STARCHES OF ANEMONE.

These starches fall into two groups in accordance with their forms, those of *A. apennina*, *A. fulgens*, and *A. blanda* being of the same type, and that of *A. japonica* of an entirely different type; but there is not a corresponding division observed in relation to the reactions, excepting in the temperatures of gelatinization, the average of the first three is 52.3° and the temperature of the last 63°. Otherwise the reactions are very nearly alike.

STARCHES OF DELPHINACEÆ.

Class, Dicotyledones. Order, Ranales. Family, Delphinaceæ. Genus represented, Aconitum.

GENUS ACONITUM.

The genus *Aconitum* includes from 18 to 80 species, according to different authorities. Aconite is a native of temperate Europe, Asia, and North America, and is cultivated as an ornamental plant in both Europe and America, chiefly in the former. Starch was prepared from the tuberous roots of *A. napellus* Linn. (*A. tauricum* Jacq., *A. pyramidale* Mill.), the true monkshood or wolfbane, which yields a powerful poison, and is officinal.

STARCH OF ACONITUM NAPELLUS. (Plate 95, figs. 567 and 568. Chart 373.)

Histological Characteristics.—In *form* the grains are simple, no compounds being observed, but many aggregates and clumps. Many grains show one or more well-marked pressure facets; the surface of the grains is frequently irregular because of the pressure facets. The conspicuous forms are round and broadly ovoid, dome-shaped to hemispherical with one or two pressure facets; also pyriform, triangular with well-rounded angles, polygonal due to many pressure facets, and various indefinite forms. Many grains have the appearance of concave disks.

The *hilum* is not always visible, but when seen it is a round or oval spot, not very refractive. It may, even in the round forms, be eccentric from two-fifths to one-third of the longitudinal axis, but in most grains it is eccentric not more than two-fifths. A depression is sometimes found running through the grain just below the hilum. Fissures rarely occur, but occasionally 3 short ones are found at the hilum in the form of a Y.

The *lamellæ* are not demonstrable.

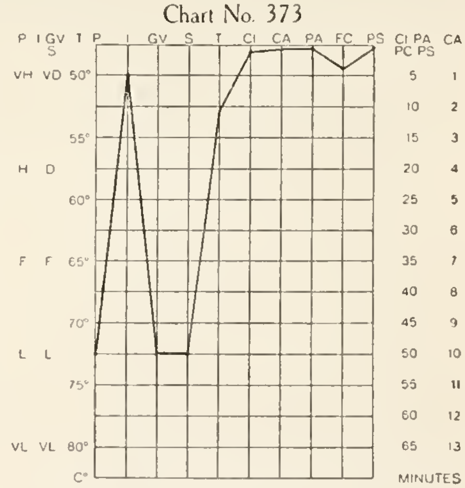
The grains vary in *size;* the larger are 12 by 12μ, or 12 by 14μ in length and breadth; the smaller 1 by 1μ. The common size is 7μ.

Polariscopic Properties.—The *figure* is usually more or less eccentric. Its lines are rather thick and straight in many forms, while in others they are bent or indistinct.

The degree of *polarization* is low. It varies somewhat in different grains and also sometimes in the same aspect of one grain.

With *selenite* the quadrants are usually fairly well defined, usually fairly regular in shape, but unequal in size. The colors are fairly pure.

Chart No. 373



Curve of Reaction-Intensities of Starch of Aconitum napellus.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a very deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. After heating in water until the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and some of the grain-residues lightly or not at all. The capsules all color a violet with an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly at once and in 30 minutes they are only lightly stained.

Temperature Reaction.—The temperature of gelatinization is 52° to 53.5° C., mean 52.75°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 10 seconds and is over in a minute. It begins at the distal end, which darkens first; then the starch at this point swells out and the process of darkening and swelling moves upward and inward over the rest of the grain. At times it affects all of the marginal region before that of the central portion. As the hilum is approached a bubble forms there which increases in size as the grain swells, more perpendicularly than transversely, and then decreases in size and finally disappears. The gelatinized grains are not very large and seem to consist of a light central portion surrounded by a dark, thick band.

The reaction with *chromic acid* begins at once and is over in 13 seconds. It is so quick that it is impossible to determine the different steps.

Reaction with *pyrogallic acid* begins at once and is over in 20 seconds; it is impossible to determine the separate steps. The gelatinized grains are large and distorted, but retain some of the original form. The capsules are folded, crumpled, and wrinkled.

The reaction with *ferric chloride* begins in a few seconds and is over in 3 minutes. It begins at the distal end and at the projections of the margin, which become gelatinous and swell to a great size. The process now moves inward and upward until all the starch is gelatinized, except a small portion at the proximal end. This end is often invaded by fissures which separate it into many small fragments which gelatinize independently of one another; but sometimes it is not so separated and becomes gelatinized gradually. The gelatinized grains are large, and often much distorted, but retain some of the original form. The capsule may be wrinkled and folded, but sometimes is smooth.

With *Purdy's solution* the reaction begins at once and is over in 6 seconds. It is impossible to determine the separate steps of the reaction. The gelatinized grains are large and often somewhat distorted, but many retain some of the original form. The capsules are often folded, creased, and wrinkled.

STARCHES OF HELLEBORACEÆ.

Class, Dicotyledones. Order, Ranales. Family, Helleboraceæ. Genera represented: Actæa, Cimicifuga, and Eranthis.

The *Helleboraceæ* comprise about 20 genera and 130 species of herbaceous perennials and annuals.

GENUS ACTÆA.

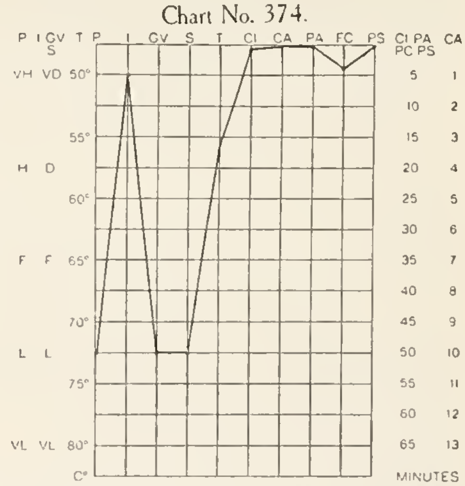
The genus *Actæa* includes a few both Old World and New World species which are popularly known as the black, white, or red baneberry, cohosh, or herb-christopher. Starches from two sources were studied: *A. alba* Mill. (*A. rubra* Bigel.), the white baneberry, a native North American plant; and *A. spicata* var. *rubra* Ait. (*A. rubra* Willd.), the red baneberry, also American.

STARCH OF ACTÆA ALBA. (Plate 95, fig. 569. Chart 374.)

Histological Characteristics.—In *form* the grains are simple. No compound grains are observed, but there are many aggregates and clumps. Many grains show one or more pressure facets, but without the sharpness of angle noted in faceted grains of other genera generally. The surface of many grains is irregular as the result of pressure. The conspicuous forms are round, ovoid, rounded with one part flattened or pointed, dome-shaped to hemispherical; also triangular with well-rounded angles, and ovoid with the distal end sharply pointed, sometimes polygonal with the angles rounded, and various indefinite forms. Many appear like disks, and some like concave disks.

The *hilum* is often invisible, but when observed is seen to be in the form of a round or lenticular, indistinct spot, sometimes centric but usually eccentric from slightly to one-third of the longitudinal axis. A depression, which scarcely amounts to a fissure, often crosses the hilum.

Chart No. 374.



Curve of Reaction-Intensities of Starch of Actæa alba.

No *lamellæ* are discernible.

The grains vary in *size;* the smaller are 1 by 1μ; the larger are 11 by 9μ in length and breadth, or 13 by 12μ in length and breadth; the common size is 8 by 7μ in length and breadth.

Polariscopic Properties.—The *figure* is usually more or less eccentric and generally indistinct. Its lines are rather thick but generally straight.

The degree of *polarization* is low. It varies in different grains and sometimes in the same aspect of a grain.

With *selenite* the quadrants are fairly well defined, slightly irregular in shape, and unequal in size. The colors appear to be pure but dull.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a very deep blue-violet; with 0.125 per cent solution they color fairly deeply, and the color deepens rapidly. After heating in water until the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues but little or not at all. The capsules all color a violet with an excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to stain lightly at once and in 30 minutes are rather lightly stained.

With *safranin* the grains begin to stain very lightly at once and in 30 minutes are lightly stained.

Temperature Reaction.—The temperature of gelatinization is 55° to 57° C., mean 56°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in 45 seconds. It appears in the form of a darkening and swelling of the distal end of the grain, followed by extension all about the margin; then the starch of the interior is affected and the whole grain becomes dark and swells. The gelatinized grains are not very large and usually have a light area in the interior surrounded by an ovoid dark mass. They retain some of their original form.

The reaction with *chromic acid* begins at once and is over in 6 seconds. It is so rapid that it is impossible to distinguish the separate steps.

Reaction with *pyrogallic acid* begins at once and is over in 10 seconds. It is so rapid that the separate steps can not be made out. The gelatinized grains are large and have a thin capsule that is much wrinkled and folded. They do not retain much of their original form.

The reaction with *ferric chloride* begins in many grains in 20 seconds and is over in all in 4 minutes. It begins at the distal end where the gelatinization occurs with great swelling. This process spreads upwards and inwards until only a small portion of the grain at the distal end is ungelatinized. This part now becomes partially divided into several pieces of unequal size which are rapidly fully separated, though still retained in the capsule, and gelatinized independently of one another. The gelatinized grains are large, much wrinkled, and distorted, and do not retain any of the original form.

Reaction with *Purdy's solution* begins at once and is over in 8 or 9 seconds. It is so rapid that it is impossible to distinguish the separate steps. The gelatinized grains are large and their capsules are much wrinkled and folded, but thicker than those formed during the reaction with pyrogallic acid.

STARCH OF ACTÆA SPICATA VAR. RUBRA. (Plate 95, fig. 570. Chart 375.)

Histological Characteristics.—In *form* the grains are simple. No compound grains are observed, but there are many aggregates and clumps. Facets are noted on many grains, but their angles and lines are not so sharp as in faceted grains of other genera generally. The surface is often irregular as a result of pressure. The conspicuous forms are round, ovoid, round with a depression or projection, to hemispherical, and various indefinite forms. Many grains appear like disks and some like concave disks.

The *hilum* is either a round or lenticular indistinct spot, sometimes centric, usually eccentric, from slightly to about one-third of the longitudinal axis. A depression which scarcely amounts to a fissure is sometimes found at the hilum, and occasionally it is fissured.

No *lamellæ* were discernible.

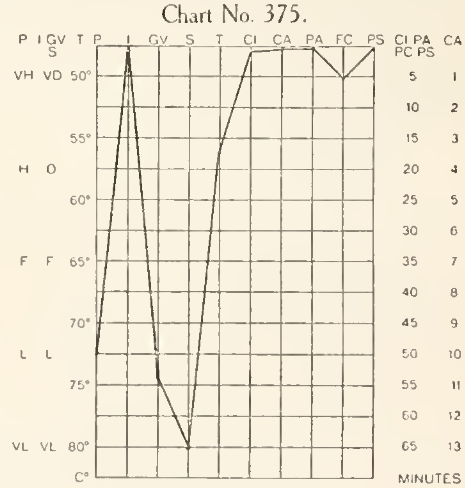
The grains vary in *size;* the smaller are 2 by 2μ; the larger are 6 by 6μ or 7 by 8μ in length and breadth. The common size is 5 by 5μ.

Polariscopic Properties.—The *figure* is usually eccentric, and generally it is indistinct, but when it is observed the lines are usually fairly thick and commonly straight.

The degree of *polarization* is low, varying in different grains and sometimes in the same aspect of a grain. It is the same as that of the grains of *A. alba.*

With *selenite* the quadrants are usually fairly well defined, slightly irregular in shape and unequal in size. The colors appear to be pure.

Chart No. 375.



Curve of Reaction-Intensities of Starch of Actæa spicata var. rubra.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a very deep blue-violet; with 0.125 per cent solution they color fairly deeply and the color deepens rapidly. It is deeper than that of the grains of *A. alba.* After heating in water until the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly or not at all. The capsules all color a violet when an excess of iodine is added.

Staining Reactions.—With *gentian violet* the grains begin to color lightly at once and in 30 minutes are rather lightly stained. The color is less than that of the grains of *A. alba.*

With *safranin* the grains begin to color very lightly at once and in 30 minutes are very lightly stained. The color is less than that of the grains of *A. alba.*

Temperature Reaction.—The temperature of gelatinization is 55.5° to 57.5° C., mean 56.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in a minute. It is the same qualitatively as that of the grains of *A. alba.*

Reaction with *chromic acid* begins at once and is over in 6 seconds. It is so rapid that the different steps can not be made out.

The reaction with *pyrogallic acid* begins at once and is over in 20 seconds. It is so rapid that the separate steps can not be made out. The gelatinized grains are not so wrinkled, folded, and distorted, but the capsules are thicker than those of *A. alba*.

The reaction with *ferric chloride* begins in many grains in a few seconds and is over in 5½ minutes. It is the same qualitatively as that of the grains of *A. alba*.

Reaction with *Purdy's solution* begins at once and is over in 15 seconds. It is so rapid that the details can not be made out. The gelatinized grains have the same appearance as those of *A. alba*.

Differentiation of Certain Starches of the Genus Actæa.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

A. alba: Simple, many aggregates, many pressure facets, surface often irregular because of facets. Round, ovoid, round with one part flattened or pointed, dome-shaped to hemispherical.
A. spicata var. *rubra:* Essentially the same as in *A. alba*.

Hilum—Form, Number, and Position.

A. alba: Form often invisible, indistinct, round or lenticular spot; a depression sometimes crosses the hilum. Position usually eccentric from slightly to 0.33 of the longitudinal axis.
A. spicata var. *rubra:* Form the same as in *A. alba*, except occasionally fissured. Position usually eccentric, as in *A. alba*.

Lamellæ—General Characteristics.

A. alba: Invisible.
A. spicata var. *rubra:* Invisible.

Size.

A. alba: From 1 to 13μ, commonly 8μ.
A. spicata var. *rubra:* From 2 to 7μ, commonly 5μ.

POLARISCOPIC PROPERTIES.

Figure.

A. alba: Usually more or less eccentric, generally indistinct; the lines are rather thick and generally straight.
A. spicata var. *rubra:* Essentially the same as in *A. alba*.

Degree of Polarization.

A. alba: Low.
A. spicata var. *rubra:* Low, the same as in *A. alba*.

Polarization with Selenite—Quadrants and Colors.

A. alba: Quadrants fairly well defined, slightly irregular in shape, and unequal in size. Colors appear to be pure but dull.
A. spicata var. *rubra:* Quadrants essentially the same as in *A. alba*. The colors appear to be pure but dull.

IODINE REACTIONS.

Intensity and Color.

A. alba: Very deep; blue-violet.
A. spicata var. *rubra:* Very deep, deeper than in *A. alba*; blue-violet.

STAINING REACTIONS.

With Gentian Violet.

A. alba: Rather light.
A. spicata var. *rubra:* Rather light, lighter than in *A. alba*.

With Safranin.

A. alba: Light.
A. spicata var. *rubra:* Very light, much lighter than in *A. alba*.

TEMPERATURE OF GELATINIZATION.

A. alba: 55 to 57° C., mean 56°.
A. spicata var. *rubra:* 55.5 to 57.5° C., mean 56.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

A. alba: Begins at once; complete in all in 45 seconds.
A. spicata var. *rubra:* Begins at once; complete in all in 1 minute.

Reaction with Chromic Acid.

A. alba: Begins at once; complete in all in 6 seconds.
A. spicata var. *rubra:* Begins at once; complete in all in 6 seconds.

Reaction with Pyrogallic Acid.

A. alba: Begins at once; complete in all in 10 seconds.
A. spicata var. *rubra:* Begins at once; complete in all in 20 seconds.

Reaction with Ferric Chloride.

A. alba: Begins in many in 20 seconds; complete in all in 4 minutes.
A. spicata var. *rubra:* Begins in many in a few seconds; complete in 5½ minutes.

Reaction with Purdy's Solution.

A. alba: Begins at once; complete in all in 8 to 9 seconds.
A. spicata var. *rubra:* Begins at once; complete in all in 15 seconds.

GENUS CIMICIFUGA.

This genus, which is allied to *Actæa*, includes about 10 species of perennial herbs, natives of temperate regions of Europe, Siberia, and North America. The best-known form of our American gardens is *C. racemosa* Nutt. (*C. serpentaria* Prusch.), the common black snakeroot or bugbane, a native of Eastern United States and Canada. The starch from this species was examined as a type of the genus.

STARCH OF CIMICIFUGA RACEMOSA. (Plate 96, figs. 571 and 572. Chart 376.)

Histological Characteristics.—In *form* the grains are simple. No compound grains were observed, but many aggregates and clumps. Many grains have one or more pressure facets. The surface of the grains is rather irregular owing to pressure. The conspicuous forms are round, oval and ovoid, and dome-shaped to hemispherical; also low triangular with rounded base, irregular lenticular, polygonal, and various indefinite forms.

The *hilum* is often not visible, and when seen it is round or oval, and not very refractive, and appears to be more or less eccentric. There is no fissuration at the hilum, but sometimes there is a depression passing through the center of the grain.

The *lamellæ* can not be distinguished.

The grains vary in *size;* the smaller are 1 by 1μ; the larger are 12 by 12μ or 8 by 10μ in length and breadth. The common size is 8 by 8μ.

Polariscopic Properties.—The *figure* is usually more or less eccentric. The lines are rather thick and usually straight and expanded towards the margin. In some grains they are bent.

The degree of *polarization* is low. It varies somewhat in different grains and sometimes in the same aspect of a grain.

With *selenite* the quadrants are generally fairly well defined, slightly irregular in shape, and unequal in size. The colors in a few are fairly bright and pure, while in others they are very dull.

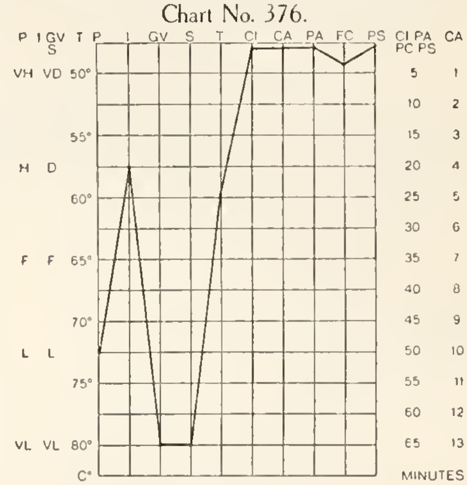
Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly, and the color deepens rapidly. After heating in water until the grains are completely gelatinized, the solution colors fairly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes the solution colors very deeply and the grain-residues lightly. The capsules all color a violet on the addition of an excess of iodine.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain very lightly in a minute and in 30 minutes they are very lightly stained.

Temperature Reaction.—The temperature of gelatinization is 59° to 60° C., mean 59.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in a few seconds and is over in a minute. The distal end darkens and the grain at this point becomes gelatinized and swells. The process then spreads upward and inward rapidly over the whole grain, and as it nears the hilum a bubble appears here which increases in size, then shrinks, and disappears as the rest of the starch at the proximal end darkens and swells. The gelatinized grains are not very large and retain much of their original form. They have a light, round space in the center surrounded by a thick, dark margin.

Chart No. 376.



Curve of Reaction-Intensities of Starch of Cimicifuga racemosa.

The reaction with *chromic acid* begins at once and is over in 10 seconds. It is so rapid that the separate steps can not be determined.

The reaction with *pyrogallic acid* begins in a few seconds and is over in a minute. The starch about the hilum begins to gelatinize, and this is followed by the gelatinization and swelling of all of the grain. Striæ do not appear, or if they do they are so fine that they can not be made out. The gelatinized grains are large and thin-walled and the walls are somewhat folded and wrinkled. The gelatinized grains retain some of the original form.

The reaction with *ferric chloride* begins in 15 seconds and is over in 3½ minutes. The reaction begins at the distal end, which becomes gelatinous and swells out irregularly. The process then spreads upward and inward over the rest of the grain until only the proximal end is ungelatinized. This part is fissured in several places and divided into two or three pieces of unequal size which gelatinize. The gelatinized grain is large and distorted, and the capsule is much wrinkled and folded.

Reaction with *Purdy's solution* begins at once and is over in 25 seconds. The several steps of the reaction can not be determined, but it appears to consist of the gelatinization of the starch surrounding the hilum and the general swelling of the grain. The more resistant starch forms a fairly thick homogeneous band at the margin, and this grows thinner and transparent. The gelatinized grains are large and somewhat distorted.

GENUS ERANTHIS.

Eranthis is a genus of hardy perennials which includes only 7 or 8 species, all natives of Southern Europe and Asia. The starch studied in this research was obtained from *E. hyemalis* Salisb. (*Helleborus hyemalis* Linn.), a well-known cultivated plant in this country, often referred to as the winter aconite.

STARCH OF ERANTHIS HYEMALIS. (Plate 96, figs. 573 and 574. Chart 377.)

Histological Characteristics.—In *form* the grains are simple. They do not occur in aggregates, but frequently in clumps which may readily be broken up. There are no pressure facets. The surface of the grains is rounded, but irregular owing to depressions and protuberances, some of the latter being nipple-like. The conspicuous forms are ovoid, round, or nearly round, oval, ellipsoidal, lenticular, pyriform, reniform, and various irregular forms. They are flattened, but one end may be thicker than the other.

The *hilum* is always fissured, but not always distinct. It is centric to varying degrees in the elongated forms, and centric to slightly eccentric in the round or nearly round grains. The fissures may be a single longitudinal line, somewhat ragged and irregular, or irregularly stellate, or less commonly an irregular cross. Very rarely 2 hila can be distinguished, and if present they are marked by fissures.

The *lamellæ* are invisible.

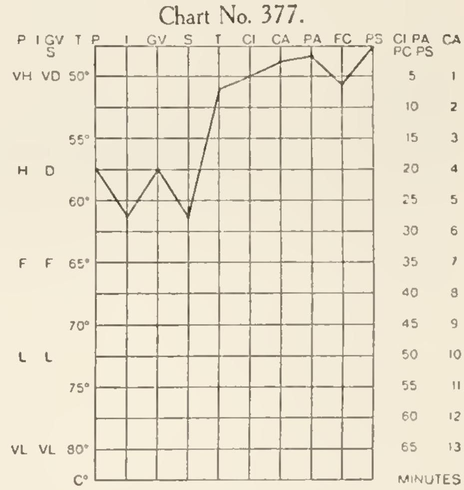
The grains vary in *size* from 2 to 20μ. The dimensions of the average grain are 14 by 10μ. The common size is 14μ.

Polariscopic Properties.—The *figure* is usually distinct, centric, or slightly eccentric, and clear-cut. It may be in the form of a cross or of a long line bisected at each end. The lines are rather broad and may be bent and otherwise distorted.

The degree of *polarization* is high. It varies somewhat in different grains, but not much in different aspects of the same grain.

With *selenite* the quadrants are fairly well defined and vary in shape and size. The colors are pure.

Chart No. 377.



Curve of Reaction-Intensities of Starch of Eranthis hyemalis.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored fairly deeply a blue-violet; with 0.125 per cent solution the grains color lightly at first, and then deeper. After heating in water until all the grains are completely gelatinized, the solution is colored very faintly and the gelatinized grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution is colored deeply and most of the grain-residues are colored lightly and some deeply. Almost all show a violet capsule upon the addition of a slight excess of iodine.

Staining Reactions.—With *gentian violet* the grains begin to color at once and after 30 minutes are deeply stained.

With *safranin* the grains begin to stain at once and after 30 minutes the color is fairly deep.

Temperature Reaction.—The temperature of gelatinization is 51° to 52° C., mean 51.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some grains in 15 seconds and is general in a minute. Most grains are darkened in 2½ minutes and all in 5 minutes. The process begins usually at the distal end, which becomes dark, followed by a darkening of the other end and then of the margin on one side. These portions now swell somewhat and the process moves inward over the whole grain. The line of demarcation between the swollen and the unswollen parts is fairly well marked. There is not much swelling of the whole grain until the hilum is reached, at which time there is sudden expansion in every direction. In some grains two ends are at first affected, and the process invades the inner parts from these two points. The gelatinized grains are fairly large and somewhat distorted, but retain some of the original form. They are uniformly dark.

Reaction with *chromic acid* begins at once and is over in 30 seconds. The process appears to consist in the widening of the fissures and the sudden dissolution of most of the starch, attended by great swelling. The grains at first are thin-walled, somewhat invaginated and wrinkled, but they rapidly disappear into solution.

With *pyrogallic acid* reaction begins at once in many grains, is general in 15 to 30 seconds, and is over in 2 minutes. It consists in the early swelling of the hilum, the melting down of the greater part of the grain into a gelatinous mass, and great general swelling. The gelatinized grains are large, thin-walled, somewhat wrinkled, and distorted, but retain much of the original form of the grain.

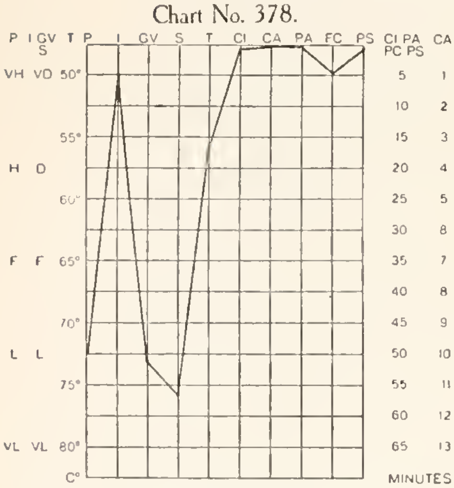
With *ferric chloride* in some grains reaction begins in 30 seconds and is general in 1½ minutes. The majority are gelatinized in 4 minutes and all in 7 minutes. The reaction begins at the ends of the grains with great swelling and irregular protrusions and spreads inward. The inner portion becomes split by fissures, usually in the position of the fissures originally dividing the hilum, and the pieces separate and gelatinize independently within the capsule. Large, irregular, gelatinized grains are formed, which are lobulated, folded, and creased, and retain but little of the original form.

The reaction with *Purdy's solution* appears to be practically instantaneous. In character it is like that of pyrogallic acid.

NOTES ON THE STARCHES OF HELLEBORACEÆ. (Charts 378 to 380.)

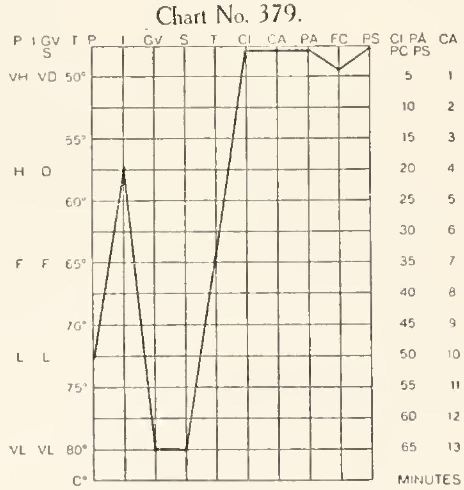
The starches of *Actæa* and *Cimicifuga* agree in histological peculiarities, but the starch of *Eranthis* is of a different type and accordingly readily differentiated. Corresponding relationships are seen in the reactions, the most marked differences being noted in *Eranthis*, as compared with *Actæa* and *Cimicifuga*, in the high degree of polarization; the low reactivity with iodine; the high reactivity with anilines; the low temperature of gelatinization; the greater resistance to chloral hydrate-iodine, chromic acid, pyrogallic acid, and ferric chloride; and the lower resistance to Purdy's solution. The chief differences between *Actæa* and *Cimicifuga* are recorded in the iodine, aniline, temperature, and Purdy solution reactions. The *Actæa* starches present no specially marked differences in either their histological features or reactions except in size and color reactions.

Chart No. 378.



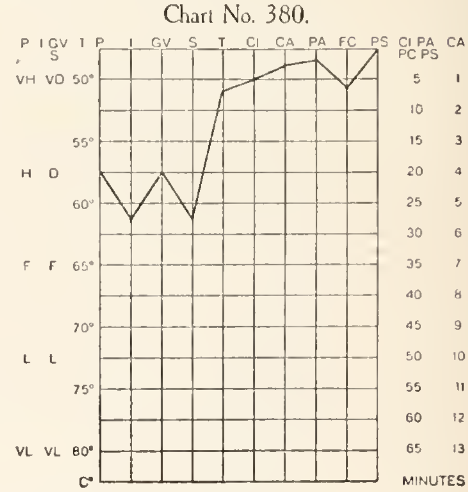
Composite Curve of Mean Reaction-Intensities of Starch of Actæa.

Chart No. 379.



Curve of Reaction-Intensities of Starch of Cimicifuga.

Chart No. 380.



Curve of Reaction-Intensities of Starch of Eranthis.

STARCHES OF RANUNCULACEÆ.

Class, Dicotyledones. Order, Ranales. Family, Ranunculaceæ. Genera represented: Ranunculus and Adonis.

The *Ranunculaceæ* include 4 genera and over 200 species which are widely distributed and abundant throughout the world in temperate and cold regions, and a few in mountainous parts of the tropics. The family is typified by *Ranunculus.*

GENUS RANUNCULUS.

Ranunculus includes at least 200 species, nearly half of which are found native or naturalized in North America, 15 species are found in Great Britain, and the others are widely distributed in Europe, Asia, and Africa. Starches from two species were studied: *R. bulbosus* Linn. (*R. speciosus* Hort.), a native of Eastern Europe and Africa, and naturalized in America and popularly known as the buttercup or crowfoot, and by other similar names; and *R. ficaria* Linn., known in England as the lesser celandine or pilewort or figwort, or Wordsworth flower, and which is native of Europe and Asia. Many species have when fresh a very acrid juice, but the acridity disappears upon drying or boiling, and after such preparation they are used as a food by man and cattle.

STARCH OF RANUNCULUS BULBOSUS. (Plate 97, figs. 577 and 578. Chart 381.)

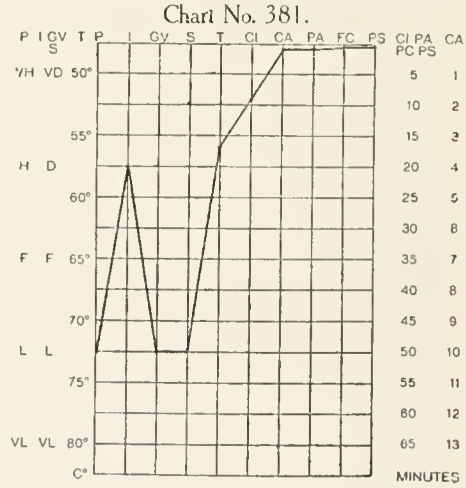
Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains, many aggregates, and some clumps. Some grains have pressure facets. The outlines of most grains are somewhat irregular, the conspicuous forms being the ovoid, oval, pyriform, elliptical, round, dome-shaped to hemispherical; also various indeterminate forms. The faceted grains do not show the sharpness of angle of the facets so commonly seen in the faceted grains of starches of other genera. Almost all show rounded irregularities, so that *en masse* they often resemble a cluster of pebbles. Most of them show a depression extending transversely across the grain, and some of the elliptical grains with a flattened base have a small hole or depression in the center of this part. Some grains appear to be disks and some concave disks.

The *hilum* is a comparatively large, quite distinct, round, non-refractive spot, situated eccentrically commonly about one-fifth of the longitudinal axis of the grain, even in the round grains. It is rarely fissured, and the fissure is narrow, short, and inconspicuous. The hilum is sometimes elliptical or lenticular. There were no double or multiple hila in the specimen examined.

No *lamellæ* are visible.

The grains vary in *size* from 2 to 15μ. The common size is 5μ.

Chart No. 381.



Curve of Reaction-Intensities of Starch of Ranunculus bulbosus.

Polariscopic Properties.—In *figure* the grains are so small and usually so slightly polariscopic that an interference figure can not always be made out; when seen it is clear-cut and distinct. It is slightly to markedly eccentric. The lines are of the same size and distinctness throughout their length, and are bent or otherwise distorted.

The degree of *polarization* is low.

With *selenite* the quadrants in most grains are not well defined, are usually quite regular in shape, but unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored a blue-violet immediately and deeply; with 0.125 per cent solution the grains color well and the color deepens quickly. The reaction is not quite so deep as that of *R. ficaria.* After heating in water until all the grains are completely gelatinized, the solution is colored fairly well and the grain-residues deeply to lightly with iodine. With an excess of iodine the capsules color a blue-violet.

Staining Reactions.—With *gentian violet* the reaction begins immediately, but after 30 minutes the color is not much deeper than at first. The grains are stained less than those of *R. ficaria.*

With *safranin* the reaction begins very lightly in 30 seconds, but after 30 minutes the grains are only slightly stained. They are not so deeply stained as those of *R. ficaria.*

Temperature Reaction.—The temperature of gelatinization is 55° to 57° C., mean 56°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds and is over in 9 minutes. Both hilum and lamellæ are obscured. Some grains darken all over and then swell; most of them show a beginning of reaction at the distal end, where a dark spot appears, followed by much swelling, with protrusion, which process spreads over the grain. Sometimes there is first bipolar swelling, or swelling from irregular points on the margin. The gelatinized grains so formed are fairly large and regular in outline. They show a dark marginal ring and often a dark mass at the distal end and a lighter inner area.

The reaction with *chromic acid* begins as soon as the reagent touches the grains, which vanish immediately.

Reaction with *pyrogallic acid* begins immediately and is over in a minute. The hilum swells and the rest of the grain becomes divided by five or six deep radial cracks. As the whole grain continues to swell these cracks open widely and the several parts of the grain become thinner and clearer until finally a large gelatinized grain is formed, which is rather smooth at the proximal end and folded and sacculated at the other.

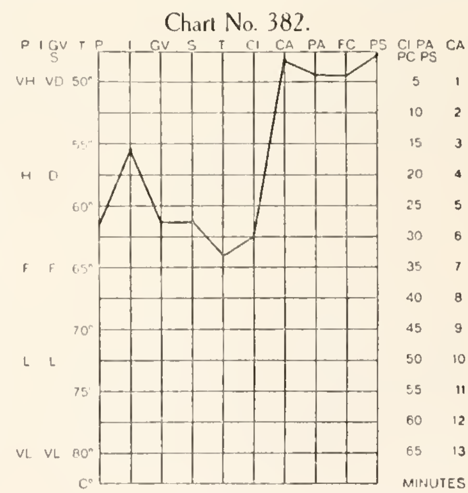
The reaction with *ferric chloride* begins immediately and is over in 30 seconds. The reaction begins by the gelatinization of the distal end, then of the proximal end, and finally of the inner central portion, which becomes divided by many fissures into small parts which fly apart and gelatinize independently. The gelatinized grains are large and very much crumpled and distorted.

The reaction with *Purdy's solution* begins immediately and is over in 30 seconds. The distal end swells, then the proximal end, and finally the central part. The gelatinized grains are large, much distorted and sacculated at the distal end, and round and fairly smooth at the proximal end.

STARCH OF RANUNCULUS FICARIA. (Plate 97, figs. 579 and 580. Chart 382.)

Histological Characteristics.—In *form* the grains are usually simple. There are some compound grains, no aggregates, a few clumps, and some grains with no pressure facets. The surface of the grains is quite smooth, but usually more or less irregular. The conspicuous forms are ovoid, round or nearly round, oval, elliptical, pyriform, and triangular grains with rounded angles. The grains are not flattened. In a few grains there is the appearance of a hole or depression in the distal end, such as is seen in *R. bulbosus.*

The *hilum* is fairly distinct. It is usually a small, round, non-refractive spot, very eccentrically placed, commonly about one-fifth of the longitudinal axis of the grain, but always in the median line, and often showing two radiating, non-refractive lines extending from it towards the distal end. The hilum is often marked by a slight fissure which extends transversely. It is frequently double, and the two hila may be very close or far apart, and may or may not be separated by a fissure. Usually each hilum is immediately surrounded by its own lamellæ, which later fuse with those of the other hilum.



Curve of Reaction-Intensities of Starch of Ranunculus ficaria.

The *lamellæ* are usually not very distinct, but when they can be made out they appear as comparatively coarse, regular rings or segments of rings, one or two of which are especially prominent. Those nearer the margin are more distinct than those near the hilum, but they were not sufficiently defined to be accurately counted.

The grains vary in *size* from 5 to 30μ; the common size is 18μ.

Polariscopic Properties.—The *figure* is eccentric and distinct. Its lines are sometimes clear-cut and at other times more or less greatly diffused. If there are two hila the figures are somewhat confused, but not bent or otherwise distorted.

The degree of *polarization* is fairly high. It varies in different grains, in different aspects of the same grain, and in different parts of the same aspect of a given grain.

With *selenite* the quadrants in most cases are not sharply defined, unequal in size, and irregular in shape. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color very deeply a blue-violet, especially about the edge; with 0.125 per cent solution they are fairly deeply colored and more deeply than the grains of *R. bulbosus.* After heating in water until all the grains are completely gelatinized, the solution is slightly colored and the grains very deeply on the addition of iodine. The grains are much swollen and distorted. After boiling for 2 minutes the solution is colored more deeply, but the grain-residues much less. With excess of iodine the capsules take on a violet coloration; all of them contain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the reaction begins immediately and after 30 minutes the grains are fairly deeply colored. The color is deeper than with *R. bulbosus.*

With *safranin* the reaction begins immediately and the grains color quite deeply. After 30 minutes the stain has deepened somewhat. The grains are evenly stained, and the color is deeper than in the grains of *R. bulbosus.*

Temperature Reaction.—The temperature of gelatinization is 63° to 65° C., mean 64°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in some grains in 30 seconds and the reaction is practically over in 30 minutes. Both hilum and lamellæ are obscured. A clear, dark area is formed about the margin which spreads inward. This area continues to darken, especially at the distal end of the grain, and sometimes at both ends. There is usually much swelling at two points at the distal end. Following this, the hilum and one or two nearby points swell in the form of little knob-like projections. This process extends around the margin and in the larger grains it is apt to proceed along one side more rapidly than the other. Thus, the unaffected central part of the grain becomes surrounded by an irregular, saccular gelatinous ring. The process finally extends all over the grain. The gelatinized grains are large and distorted. The margin is dark and very irregular, and within this is a lighter space somewhat irregularly crossed by dark lines and surrounding a dark mass at the center that is divided by light fissures.

The reaction with *chromic acid* begins immediately and is over in about 20 seconds. It is so rapid that it is difficult to distinguish the individual steps. The process seems to consist of rapid swelling, first of the hilum, which swells out at the end of the grain, and then of the whole grain, the inner part swiftly passing into a gelatinous mass. The distal end of the grain is dissolved at one point and the capsule opens, and the granular mass within flows out and dissolves, followed by solution of the capsule.

Reaction with *pyrogallic acid* begins in 20 seconds and is over in 3 minutes. The hilum swells greatly, expanding the proximal end of the grain. The other parts become divided by five or six deep radial fissures which extend almost to the margin. These open more and more widely, and more such fissures appear as the hilum, or rather the whole grain, swells, so that finally the swollen grain has the appearance of a number of small pyramids at the base and a large, clear space above bordered by a thick, homogeneous band. The pyramids soon become clear and finally gelatinize, followed by gelatinization of the marginal band, forming a large gelatinized grain which is smooth at the proximal end and folded and sacculated at the other.

With *ferric chloride* the reaction begins in 20 seconds and is over in 3 minutes. The hilum and lamellæ are not very distinct. The lower part of the margin first reacts with great swelling and irregular protrusion. Then the hilum swells out in the form of a small knob. These two parts become connected by the spreading reaction on both sides, so that there is formed an irregular, gelatinous ring which incloses the unaffected central part of the grain. This central portion becomes divided by fissures into small pieces which gelatinize separately. The process, however, does not take place so rapidly as in the grains of *R. bulbosus.* The gelatinized grains are very large, much crumpled, and distorted. The distal end has folds arranged according to lines of the lamellæ and the proximal end is swollen and wrinkled.

The reaction with *Purdy's solution* begins immediately and is over in about 25 seconds; the steps could not satisfactorily be distinguished. It appears that the hilum swells greatly and that the other parts of the grain are soon gelatinized, forming a large mass, which is smooth and saccular at the proximal end, but folded in lamellar form at the other.

Differentiation of Certain Starches of the Genus Ranunculus.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

R. bulbosus: Usually simple, a few compound grains and many aggregates, some pressure facets, surface somewhat irregular. Ovoid, oval, pyriform, elliptical, round, dome-shaped to hemispherical.
R. ficaria: Usually simple, some compound grains, no aggregates, no pressure facets, surface more or less irregular. Ovoid, round or nearly round, oval, elliptical, pyriform, triangular with rounded angles.

Hilum—Form, Number, and Position.

R. bulbosus: Form quite distinct, comparatively large, round or elliptical or lenticular, rarely fissured, fissures narrow and short. Position eccentric commonly about 0.2 of the longitudinal axis.
R. ficaria: Form fairly distinct, usually small, round, often double, often fissured, fissure slight and single. Position eccentric commonly about 0.2 of the longitudinal axis.

Lamellæ—General Characteristics and Number.

R. bulbosus: Not visible.
R. ficaria: Not very distinct, comparatively coarse, regular rings or segments of rings. Number not determined.

Size.

R. bulbosus: From 2 to 15μ, commonly 5μ.
R. ficaria: From 5 to 30μ, commonly 18μ.

POLARISCOPIC PROPERTIES.

Figure.

R. bulbosus: Eccentric, not always visible, but when seen the lines are usually clear-cut and of same size throughout and straight.
R. ficaria: Eccentric, distinct, lines clear-cut to diffused.

Degree of Polarization.

R. bulbosus: Low.
R. ficaria: Fairly high.

Polarization with Selenite—Quadrants and Colors.

R. bulbosus: Quadrants in most cases not well defined, usually quite regular, but unequal in size. Colors not pure.

POLARISCOPIC PROPERTIES.—Continued.

Polarization with Selenite—Quadrants and Colors.—Cont'd.

R. ficaria: Quadrants in most cases not well defined, irregular in shape, and unequal in size. Colors not pure.

IODINE REACTIONS.

Intensity and Color.

R. bulbosus: Deep; blue-violet.
R. ficaria: Deep, deeper than in *R. bulbosus;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

R. bulbosus: Light.
R. ficaria: Fairly deep, deeper than in *R. bulbosus.*

With Safranin.

R. bulbosus: Light.
R. ficaria: Fairly deep, deeper than in *R. bulbosus.*

TEMPERATURE OF GELATINIZATION.

R. bulbosus: 55 to 57° C., mean 56°.
R. ficaria: 63 to 65° C., mean 64°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

R. bulbosus: Begins in 30 seconds; complete in 9 minutes.
R. ficaria: Begins in 30 to 60 seconds; complete in 30 minutes.

Reaction with Chromic Acid.

R. bulbosus: Begins at once; complete in a very few seconds.
R. ficaria: Begins at once; complete in 20 seconds.

Reaction with Pyrogallic Acid.

R. bulbosus: Begins at once; complete in 1 minute.
R. ficaria: Begins at once; complete in 3 minutes.

Reaction with Ferric Chloride.

R. bulbosus: Begins at once; complete in 30 seconds.
R. ficaria: Begins in 20 seconds; complete in 3 minutes.

Reaction with Purdy's Solution.

R. bulbosus: Begins at once; complete in 30 seconds.
R. ficaria: Begins at once; complete in 25 seconds.

NOTES ON THE STARCHES OF RANUNCULUS.

These starches, while belonging to the same type, differ distinctly in the degree of regularity of outline, in the characters of the hilum and fissuration, in the lamellæ, and in the common size. The differences in the reactions are marked, except in the case of iodine, chromic acid, and Purdy's solution. *R. bulbosus* exhibits the lower degree of polarization and lower reactions with the anilines; a markedly lower temperature of gelatinization; and a higher sensitivity to chloral hydrate-iodine, chromic acid, pyrogallic acid, and ferric chloride.

GENUS ADONIS.

This genus contains only six species, all natives of temperate regions of Europe and Asia. The starch of *A. amurensis* Regel and Radde, a native of Japan, was studied as a type of the genus.

STARCH OF ADONIS AMURENSIS. (Plate 96, figs. 575 and 576. Chart 383.)

Histological Characteristics.—In *form* the grains are simple, no compounds observed; there are many aggregates, and very many grains have one or more pressure facets, which, however, do not show the sharpness of line and angle commonly found in faceted grains of other genera. The surface of the grains is usually irregular, owing chiefly to the pressure facets. The conspicuous forms are ovoid, round or nearly round, oval, dome-shaped to hemispherical, wedge-shaped, triangular with rounded corners, polygonal with rounded angles, and various indefinite forms.

The *hilum* is a non-refractive spot, eccentric in all the grains in which it could be distinguished. It may be round, lenticular, or triangular with rounded angles, with sometimes a depression passing diagonally from the hilum.

No *lamellæ* are visible.

The grains vary in *size* from 0.75 to 14μ. The common sizes are 9 by 7μ and 6 by 6μ in length and breadth.

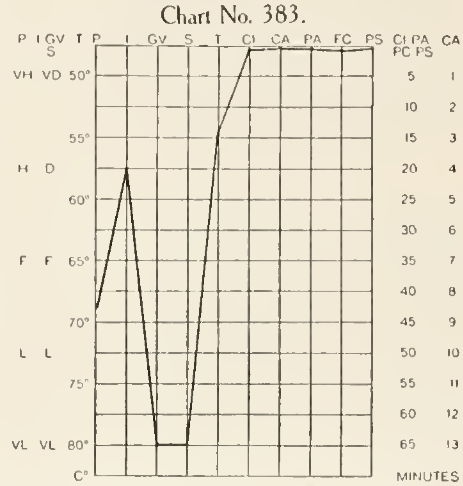
Polariscopic Properties.—The *figure* is eccentric. Its lines are thick and sometimes straight, but often bent. It is small and very difficult to determine in most grains.

The degree of *polarization* is low to fair, varying in different grains and often in the same aspect of a grain. In the majority of grains polarization is low.

With *selenite* the quadrants are well defined in some grains, usually irregular in shape, and unequal in size. The colors are pure and bright in a few grains, usually apparently pure but dull.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains all color a deep blue-violet; with 0.125 per cent solution they color fairly deeply, which color deepens rapidly. After heating in water until all of the grains are completely gelatinized the solution colors fairly and the gelatinized grains very deeply, on the addition of iodine. After boiling for 2 minutes, the solution colors very deeply and the grain-residues lightly or not at all. The capsules all color a violet on the addition of an excess of iodine.

Chart No. 383.



Curve of Reaction-Intensities of Starch of Adonis amurensis.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once very lightly and in 30 minutes they are very lightly stained.

Temperature Reaction.—The temperature of gelatinization is 54° to 55° C., mean 54.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in 45 seconds. It begins at the distal end, which becomes dark and then swells, and from here the process extends about the margin of the grain, and then inward, and the whole grain swells. The gelatinized grains consist of a large, light space in the interior surrounded by a comparatively thin, dark, marginal portion. They are fairly large and retain much of the original form.

The reaction with *chromic acid* begins at once and is over in 6 seconds. It is impossible to determine the separate steps of this reaction.

The reaction with *pyrogallic acid* begins at once and is over in 12 seconds. It is impossible to make out the separate steps of this reaction. The gelatinized grains are large, thin-walled, and retain some of their original form. The capsule is thin, and somewhat wrinkled and folded.

The reaction with *ferric chloride* begins in a few seconds and is over in a minute. It begins at the distal end and at the corners or more prominent parts of the margin. The starch at these points becomes gelatinous and the reaction spreads upward and inward over the rest of the grain, until only the proximal end is not gelatinized. This part is sometimes divided into several pieces, which gelatinize separately. The gelatinized grains are large and much distorted. The capsule is sacculated, folded, and wrinkled.

With *Purdy's solution* the reaction begins at once and is over in 10 seconds. It is impossible to determine the different steps of this reaction. The gelatinized grains are large and often much distorted. The capsule is folded, wrinkled, and sometimes sacculated.

NOTES ON THE STARCHES OF RANUNCULACEÆ.

The starch of *Adonis* bears a closer resemblance in its histological characters to *R. ficaria* than to *R. bulbosus;* but in comparison with the former the grains show a marked tendency to roundness and to a much smaller size. In the reactions, the most noticeable differences are noted in *Adonis* having a relatively low reactivity with the anilines, a lower temperature of gelatinization, and greater sensitivity to the chemical reagents.

STARCHES OF CRUCIFERACEÆ.

Class, Dicotyledones. Order, Papaverales. Family, Cruciferaceæ.
Genus represented, Cochlearia.

The *Cruciferaceæ* is a large family including about 175 genera and 1,500 species.

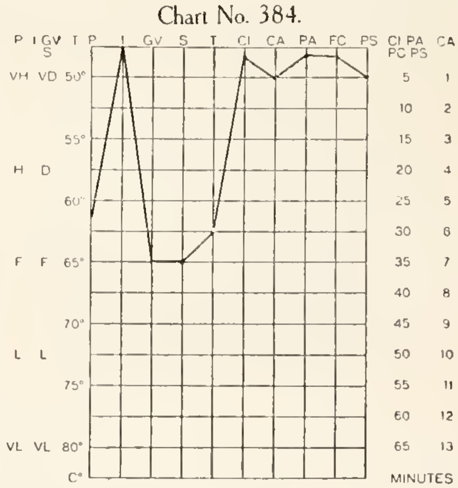
GENUS COCHLEARIA.

This genus is recognized by Warming, LeMaout and Decaisne, Joseph Hooker, and certain other botanists as *Cochlearia;* by Gray as *Radicula;* by Britton as *Roripa;* and by Robert Brown as *Nasturtium. Cochlearia* includes about 25 species, native of Central Europe, the mountainous parts of the Eastern Mediterranean region, and the Arctic region. The best-known species in the country is *C. armoracia* Linn. (*Nasturtium armoracia* Fries), the common horse-radish; its fleshy roots are used as a condiment and contain much starch. *C. officinalis* Linn. is the scurvy grass, a common perennial, chiefly European, that is eaten as a food and used as medicine.

STARCH OF COCHLEARIA ARMORACIA. (Plate 97, figs. 581 and 582. Chart 384.)

Histological Characteristics.—In *form* the grains usually are simple. There are many compound grains, some aggregates, and groups in which the dividing lines between the grains are so wide that they seem to be pseudo-aggregates rather than true aggregates. There are a few surface indentations and also a slight flattening of parts of some grains which might be regarded as pressure facets, but there are no well-defined facets. The conspicuous form is long, slender, regular elliptical or lenticular with blunt or pointed ends. Forms approaching the ovoid, a few round, and some irregularly polygonal and hemispherical are also to be seen. The two latter are formed from the others by the flattening of the surface described above.

Chart No. 384.



Curve of Reaction-Intensities of Starch of Cochlearia armoracia.

The *hilum* is large, but never very distinct. In the smaller rounded grains it appears as a round spot situated centrally or slightly eccentrically, and in or near the median line. It may be marked by a fissure or line beneath the surface of the grain, but which never communicates with the exterior, and there is sometimes a depression of the surface just above it. In the long forms the hilum takes the form of a long line extending almost from one end of the grain to the other and conforming more or less to the shape of the grain. It is even and clear-cut and has no subdivisions or ramifications; but sometimes in the long grains the hilum is situated at one end and an irregular fissure extends from it almost the length of the grain. There are no double or multiple hila.

The *lamellæ* are indistinct. When they could be distinguished, which was seldom, they appeared to be coarse and regular, and numbered about 4 to 5 on the larger grains.

The grains vary in *size* from 2 to 12μ; the common size is 18μ.

Polariscopic Properties.—The *figure* is usually centric, or slightly eccentric; it appears regular and distinct, and is often clear-cut. Its lines may occasionally be bent and otherwise distorted, and the bean type, consisting of one longitudinal line bisected at both ends, is not uncommon.

The degree of *polarization* is fair to high. It varies in different grains and somewhat according to the aspect of the grain.

With *selenite* the quadrants are usually well defined, fairly regular in shape, and unequal in size. The colors are not pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored an intense indigo; with 0.125 per cent solution they color deeply. After heating in water until all the grains are completely gelatinized, the solution is well colored and the grains very deeply and uniformly upon the addition of iodine. The grains are much swollen and distorted. After boiling for 2 minutes the solution is colored very deeply, but the grain-residues lightly. When a slight excess of iodine is added all of the capsules take a deep violet color and many of them contain blue-reacting starch.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and after 30 minutes are fairly but not deeply stained.

Temperature Reaction.—The temperature of gelatinization is 62° to 63° C., mean 62.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately and is over in 2 minutes. The hilum becomes distinct and the distal end darkens first, except in the elongated grains with the hilum extending almost the whole length; in these the two ends darken, without much swelling. This process spreads inward evenly over the whole grain. When the grain is fully swollen there is commonly some irregular lobulation along the margin. The gelatinized grains have a dark band around the margin and a lighter inner space. They retain much of the original shape of the grain.

Reaction with *chromic acid* begins immediately and is over in a minute. The hilum becomes very prominent and swells. The starch at the margin of the grain forms a thick homogeneous band which, as the grain continues to swell, becomes progressively thinner until one side or one end becomes invaginated. The margin at one end of the grain dissolves, followed by rapid solution of other parts of the capsule and of the entire contents.

Reaction with *pyrogallic acid* begins in 15 seconds and is over in 1½ minutes. The hilum is very prominent. The grain often begins to gelatinize at one end and, if the hilum is elongated, it swells near the point at which reaction has begun. This is followed by progressive swelling, apparently in segments, of the rest of the grain, with the formation of a clear inner space and a homogeneous marginal band. The direction of swelling is mainly longitudinal, very slightly transversely. The grains are very much elongated and thin-walled, with small dents on the margin to mark the different segments. In some grains the reaction may begin at both poles, and in such cases the central part often does not show much swelling. In the round or nearly round grains the process begins at the part most distant from the hilum, and from here it extends over the grain. When the reaction is completed the grains are much lobulated and distorted.

With *ferric chloride* the reaction begins in 15 seconds and is over in 2 minutes. The hilum is prominent. The long grains show gelatinization, sometimes at one end, but often at both. The starch at these points swells out to a marked degree. The middle portion of the hilum swells out rapidly and divides the remaining portion of the grain into two parts, which gelatinize separately. In the round and ovoid grains the process begins at the distal end, then at the other end, and finally at the portion around the hilum, which often seems to have been separated from the rest by a circular fissure and to have gelatinized separately. As the grains swell and become large, they usually invaginate at the distal end and sometimes have a segmented appearance. They are very large, lobulated, and crumpled.

The reaction with *Purdy's solution* begins in 10 seconds and is over in 5 minutes. The hilum becomes very prominent and then swells. The swelling of the grain takes place to a greater extent in the longitudinal than in the transverse axis. As the grain swells and the marginal band becomes thinner and clear, invagination takes place usually at one end. The swollen grains are large, much elongated, somewhat segmented, crumpled, and uneven.

STARCHES OF EUPHORBIACEÆ.

Class, Dicotyledones. Order, Geraniales. Family, Euphorbiaceæ. Genera represented: Jatropha and Manihot.

The *Euphorbiaceæ* include herbs, shrubs, and trees widely distributed in both temperate and tropical regions, especially in South America, comprising 200 genera and over 3,000 species. Some are poisonous, while others are edible; some are rich in starch; others yield castor oil, or croton oil, or caoutchouc, etc., and some are cultivated as foliage plants, etc.

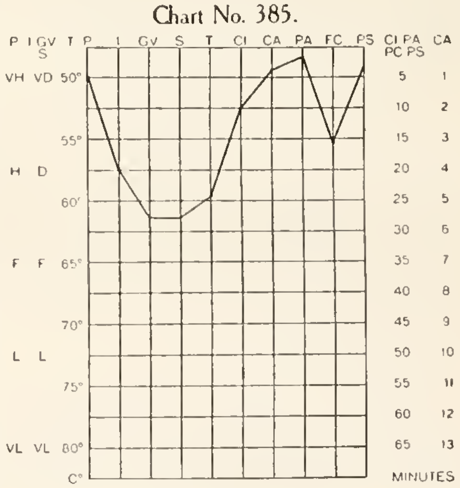
GENUS JATROPHA.

Jatropha is a genus of herbs and shrubs widely distributed in the warmer parts of both hemispheres, especially in South America. It embraces about 68 species, some of especial importance because of their richness in starch or oil. Starch was prepared from the roots of *J. curcas* Linn., the French physic or purging nut, which is grown for ornamental purposes, and also on a large scale in the Cape Verde Islands especially for the seeds or nuts, which yield a purgative oil. Other species of *Jatropha* bear seeds that have a similar oil.

STARCH OF JATROPHA CURCAS. (Plate 98, figs. 583 and 584. Chart 385.)

Histological Characteristics.—In *form* the grains are simple, isolated or in aggregates of two, three, and four components. Nearly all the isolated grains have pressure facets. The grains are rather irregular in outline, owing to the projections of the facets and to nipple-like or spicular processes. On account of the latter, the forms are not so regular as the faceted grains of other genera generally. The conspicuous forms are dome-shaped to hemispherical, round to nearly round, ovoid, and oval. Various polygonal and indefinite forms arise, chiefly through peculiarities of the pressure facets or nipple-like and spicular projections. In some aggregates the lines of demarcation between the component grains can not be made out. Seen from the side, they appear the same shape as from above, while from the end they are seen to be spherical, oval, or ovoid.

Chart No. 385.



Curve of Reaction-Intensities of Starch of Jatropha curcas.

The *hilum* is a comparatively large refractive spot. It may be round or elongated. If elongated, the form is probably due in some grains to a slight fissure; but in others it appears to be the actual shape of the hilum. It is fairly distinct and occasionally marked by a slight transverse or diagonal fissure, which may be divided. It is centric or eccentric from slightly to about two-fifths of the longitudinal axis and slightly to one side of the median line. There are rarely double hila.

The *lamellæ* are distinct, rather coarse, refractive and non-refractive rings. When an elongated hilum is present they are elliptical rather than circular; in other grains they are circular. Those nearest the hilum and in the central parts of the grain are coarser than those nearer the margin. They vary also in size and distinctness in different grains. In number they vary from 6 to 15. There are about 10 on a medium-sized grain.

The grains vary in *size* from 4 to 32μ, commonly 16μ.

Polariscopic Properties.—The *figure* is centric or eccentric and very distinct. The four lines of the cross are usually of about the same size and distinctness throughout their length, though some may be broader at the margin or elsewhere. If the hilum is elliptical in form, the figure is a single dark line divided at each end, instead of a well-marked cross.

The degree of *polarization* is very high. It is higher when the grain is seen on end and varies in the same aspect of a grain; it is low over some of the facets.

With *selenite* the quadrants are well defined, irregular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color deeply a blue-violet; with 0.125 per cent solution they tint readily. After heating in water until all the grains are completely gelatinized, the solution colors lightly and the grains deeply with iodine. The grains are folded, crumpled, and much distorted. After boiling for 2 minutes the solution is deeply colored, but the grain-residues much less. With excess of iodine the capsules become a dark violet.

Staining Reactions.—With *gentian violet* the grains tint slightly in 1½ minutes and after 15 minutes show a fairly deep color; all appear to stain with equal readiness.

With *safranin* the grains tint slightly in a minute and at the end of 15 minutes show a fairly deep color.

Temperature Reaction.—The temperature of gelatinization is 59° to 60° C., mean 59.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds. Almost all the grains are fully swollen in 10 minutes, but a few remain only partly swollen after an hour. The hilum and lamellæ are rendered distinct. The hilum appears as a dark spot or bubble. Gelatinization begins at the lines bordering the facets, with considerable protrusion, causing a fringe-like projection around each facet. Occasionally the proximal end also begins to gelatinize. If the grain has a long, transverse diameter, the ends corresponding to this diameter may darken and occasionally gelatinization will extend all around the margin; but usually the process extends from the distal end and finally includes the whole grain. The gelatinized grains are large, but not much distorted, and they show either an inner clear space surrounded by a dark marginal band or an inner dark mass surrounded by a lighter area, which latter is in turn surrounded by a dark marginal band.

Reaction with *chromic acid* begins in 20 seconds and is over in 45 seconds. The hilum swells very rapidly, forcing the substance of the grain out to the margin, which becomes more distinct. The margin is thick and shows finely striated, alternate refractive and non-refractive bands. The grain swells greatly and becomes lighter and more transparent, and finally one point in the marginal band or capsule is dissolved and the contents are extruded, the remainder of the marginal band finally disappearing in solution.

The reaction with *pyrogallic acid* begins in 30 seconds and is over in 2 minutes. The hilum becomes very distinct and is often marked by a dark bubble. It swells rapidly, as does the rest of the grain, especially the corners and lines of union of the facets, while the facet surfaces appear to become hollow. The substance of the grains is pushed out to form a wide, finely striated ring, which occasionally shows refractive and non-refractive bands. This ring becomes thinner and more transparent as the grain is gelatinized. The gelatinized grains are large, ovoid, or rounded, and somewhat distorted and folded at the faceted ends.

The reaction with *ferric chloride* begins in a minute. It is over in four-fifths in 5 minutes and in all in 16 minutes. The hilum is fairly distinct, but the lamellæ are indistinct. Gelatinization with some irregular protrusion first occurs at the edges of the facets. It occurs occasionally at both ends and may extend over the greater part of the grain before the hilum assumes a bubble-like appearance, and then suddenly swells to a great size, the bubble in the meantime disappearing. The portion of the grain still ungelatinized is pushed out to the margin, which appears as a wide, finely striated line partly surrounding a clear space. The gelatinized grains are large ovoid with a clear space representing the swollen hilum, which is elongated and narrow, and with a lobulated and crumpled appearance at the end where gelatinization began.

Reaction with *Purdy's solution* begins in 20 seconds and is practically over in 3 minutes, although a few grains are not completely swollen until 15 minutes have passed. The hilum swells enormously, pushing the substance of the grain out to form a narrow but very distinct marginal ring with clearly defined, striated, alternately refractive and non-refractive bands. There is a row of coarse granules just inside this ring. The grain continues to swell slightly and the band becomes clearer and thinner. There is formed a large, ovoid gelatinized mass, slightly folded and crumpled at the faceted end, at which there may be a granular mass which disappears in time. The gelatinized grains are fairly regular in outline and not much distorted.

GENUS MANIHOT.

This genus includes about 80 species of American perennial herbs and shrubs which are distributed chiefly in Brazil and Mexico—*Manihot, Manioc,* and *Manioca,* as the plants are variously called, and the cassava plant. *M. utilissima* Pohl, or the bitter cassava, is cultivated extensively, especially in Brazil, where starch is obtained from the tuberous roots, which sometimes weigh from 15 to 20 kilograms, and is prepared by drying on heated plates. This starch is sold as tapioca, also known as Brazilian arrowroot. (See *Marantaceæ,* page 813.) During this heating many grains are partially or completely gelatinized.

STARCH OF MANIHOT UTILISSIMA (COMMERCIAL TAPIOCA). (Plate 98, figs. 585 and 586. Chart 386.)

Owing to the injury to most of the grains by heating during the preparation of the starch, the grains are not normal in form or in their behavior with reagents.

Histological Characteristics.—In *form* the normal grains, which may be separated from the partially gelatinized masses, are simple and rarely found in aggregates of two or three components. They are fairly regular in outline and with no prominences or spicules. All of the isolated grains show pressure-facets, usually one or two or rarely three or four. The conspicuous forms are the dome-shaped to hemispherical; also spherical, ovoid forms with one or two facets, and polygonal forms with three or more facets. There are gelatinized and partly gelatinized grains, which may be readily distinguished from the non-gelatinized by their clearness, great size, and irregularity of shape, especially at the faceted ends, where there is especial prominence of the corners.

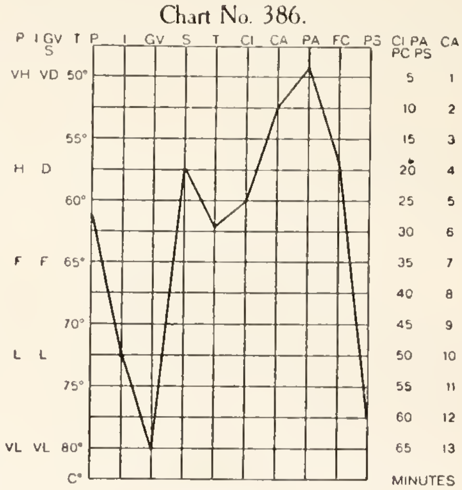
The *hilum* varies greatly in size. In the fully gelatinized grains it is not visible. In those partly gelatinized it varies in size according to the degree of gelatinization. In those apparently unaffected it is comparatively large and distinct, centrally placed, and slightly fissured, often in a stellate fashion. Often the ungelatinized grains show a concavity at the facets which appears to extend as far as the hilum.

The *lamellæ* are indistinct, round, rather coarse, regular, concentric rings, one or two of which may be larger than the others without much regard to position. There are about 8 to 10 lamellæ on a medium-sized grain.

The ungelatinized grains vary in *size* from 5 to 20μ. The common size is about 15μ.

Polariscopic Properties.—In the ungelatinized grains the *figure* appears centric or slightly eccentric and distinct. The lines are of very much the same size and distinctness throughout their length.

Chart No. 386.



Curve of Reaction-Intensities of Starch of Manihot utilissima.

The degree of *polarization* is fairly high, varying according to the aspect of the grain viewed. If the hilum is partially gelatinized the grain is not polariscopic in the center, and the completely gelatinized grains have entirely lost their polarization.

With *selenite* the unaffected grains vary in the definition of the quadrants, which sometimes are very well defined and at other times not well. They may or may not be regular in size or shape. In the unaffected grains the colors are fairly pure.

Iodine Reactions.—The gelatinized and partially gelatinized grains were colored an indigo in varying degrees. The apparently unaffected grains showed very little blue-violet coloration even with a 0.5 per cent solution. After heating in water until all the grains were completely gelatinized, the solution was colored deeply and the grains faintly with iodine; some of the grains were reduced to granular masses. After boiling for 2 minutes, the grain-residues do not color at all except on adding excess of iodine, when the capsules becomes a piukish-violet. Most are more or less reduced to granular masses.

Staining Reactions.—With *gentian violet* there is a slight reaction in 3 minutes, but after 25 minutes the normal grains are stained only faintly.

With *safranin* the grains begin to stain immediately and at the end of 25 minutes the normal grains are deeply stained. This reaction is much greater than with gentian violet.

Temperature Reaction.—The temperature of gelatinization is 61° to 63° C., mean 62°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 2 minutes in the ungelatinized grains and is over in 25 minutes. It is the same qualitatively as that of the grains of the nearly related genus *Jatropha curcas.*

The reaction with *chromic acid* begins in 15 seconds and is over in 2 minutes. It is qualitatively the same as that of the grains of *Jatropha curcas.*

Reaction with *pyrogallic acid* begins in 15 seconds and is over in 3 minutes. It is qualitatively the same as that of the grains of *J. curcas.*

Reaction with *ferric chloride* begins in some grains in 30 to 60 seconds and is over in 18 minutes. It is qualitatively the same as that of the grains of *J. curcas.*

With *Purdy's solution* reaction begins in 1½ minutes and consists in the rapid, complete gelatinization of those grains already partially gelatinous and in a slight enlargement of the hilum in the uninjured grains. After this initial reaction there is no further change.

NOTES ON THE STARCHES OF EUPHORBIACEÆ.

The starches of *Jatropha* and *Manihot* bear close histological resemblances, exhibiting only minor differences in the characters of the hilum and lamellæ. In their reactions they show marked differences in most instances. *Jatropha* has a lower degree of polarization, higher sensitivity to iodine and gentian violet, lower sensitivity to safranin, lower temperature of gelatinization, and greater sensitivity to all of the chemical reagents.

STARCHES OF PRIMULACEÆ.

Class, Dicotyledones. Order, Primules. Family, Primulaceæ. Genus represented, Cyclamen.

The *Primulaceæ* comprise about 25 genera and 315 species of herbaceous plants, for the most part natives of the Northern Hemisphere, chiefly of temperate and alpine regions, including many of the most highly prized species of garden plants.

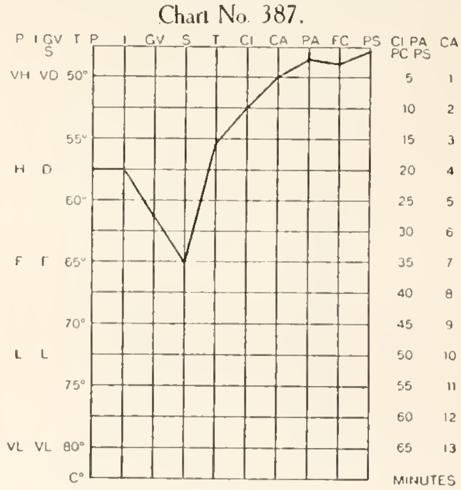
GENUS CYCLAMEN.

Cyclamen is a genus of about a dozen species of low, tuberous herbs, natives of the Mediterranean region and Western Asia. The fondness of swine for the tubers or corms led to the vulgar name sow-bread, that was formerly applied to the genus. Starches from two species were prepared, *C. repandum* Hort. and *C. coum* Mill., both from Southern Europe, the former probably a variety of the latter.

STARCH OF CYCLAMEN REPANDUM. (Plate 99, figs. 589 and 590. Chart 387.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains consisting of two components, with a few aggregates. Not infrequently several very small grains adhere to the distal end of one of the large grains. There is no tendency to form in clumps. There are pressure facets on some of the isolated grains. The surface of the grains is quite smooth, except when rendered irregular by nipple-like processes or pressure facets. The conspicuous forms are ovoid; oval, which usually have the distal end pointed and a small hole or depression at the end; and round or nearly round; also pyriform, dome-shaped to hemispherical, angular with rounded or sharp corners, elliptical, and some indefinite forms. The grains are not flattened.

Chart No. 387.



Curve of Reaction-Intensities of Starch of Cyclamen repandum.

The *hilum* is a comparatively small, round non-refractive spot, eccentric usually from one-fourth to one-sixth of the longitudinal axis of the grain, and on or to one side of the median line. Frequently there are 2, 3, or more hila in one grain, separated from one another by small fissures. They appear sometimes to be connected by a line and may not be of the same size. In one grain the hilum appeared to be an elliptical spot expanded at each end. Fissuration is rare.

The *lamellæ* are distinct, rather fine, and decidedly irregular. There appear to be two sets in many grains, one appears to partially or completely inclose the other; the internal system may be very large or very small, and it may lie transversely or diagonally to or in the same direction as the long axis of the inclosing system. If there are two hila, each has its set of lamellæ, at first separate and then fused. The lamellæ nearest the hilum are the larger and more distinct. There are usually about 20 on the larger grains.

The grains vary in *size* from 5 to 48μ. The common size is 28μ.

Polariscopic Properties.—The *figure* is eccentric and very distinct. Four lines are visible. These are frequently much bent and otherwise distorted because of irregularities of the surface of the grain and the presence of the two sets of lamellæ. If there are more than one hilum, each shows the beginning of a figure of which two lines unite with the lines of the figure from another hilum and do not extend farther, or they may fuse and be prolonged along the long axis of the grain. Double and curiously modified figures are occasionally noted.

The degree of *polarization* is high. At some points it is almost absent owing to thinness of the grain, at others very high, owing to thickness of the grain. It varies according to the aspect of the grain viewed, being higher when the grain is viewed from the end. In some grains it is absent, except from small areas of the marginal part.

With *selenite* the quadrants are well defined, unequal in size, and irregular in shape. The colors are very pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored immediately and deeply a blue-violet, but slightly less than the grains of *C. coum;* with 0.125 per cent solution the grains tint lightly and the colors deepen quickly. After heating the grains until all are completely gelatinized, the solution is very slightly and the grains deeply colored on the addition of iodine. The grains, while swollen, are not much distorted. After boiling for 2 minutes the solution is much more deeply colored, but the grain-residues very little. With a slight excess of iodine the capsules take on a violet color and but few of them retain some blue-reacting starch.

Staining Reactions.—With *gentian violet* the grains stain immediately, but rather lightly. After 30 minutes they are fairly deeply and evenly stained. The color is slightly less than in the grains of *C. coum.*

With *safranin* the reaction begins immediately, but the color is very light, and in 30 minutes the grains are fairly well and evenly stained. The reaction is the same as in *C. coum.*

Temperature Reaction.—The temperature of gelatinization is 55° to 56° C., mean 55.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a minute and in 10 minutes all the grains are gelatinized. The hilum becomes prominent as a dark spot; the lamellæ are obscured; the distal end darkens; and darkening gradually extends upward over the grain, especially around the margin, not, however, with much swelling or with much extension into the interior. The distal portion then swells and protrudes in the form of several saccular projections, and it becomes quite differentiated from the remainder of the grain before there is much change in the latter. The gelatinization which has somewhat extended proximally on both sides of the grain now advances over the grain as a whole, the hilum swells, and swelling occurs at the same time smoothly and evenly in other parts. In a few cases a thin-walled, blue-colored mass could be seen entirely surrounding the partially swollen inner part. The gelatinized grains are elongated and show a dark marginal ring surrounding a lighter inner space, which is cut up irregularly by dark projections from the marginal ring that extends entirely or only partially across this space.

Reaction with *chromic acid* begins immediately and is over in a minute. The hilum becomes prominent as a dark bubble, which later disappears. The lamellæ are not at this time altered. The hilum swells rapidly, and this process extends downward over the grain, which is broken into granules and then reduced to a finely granular, gelatinous aggregate as the grain continues swelling, until a large, gelatinized mass is formed which folds in at one side. The margin of the grain is now dissolved at the proximal end and opens out, allowing the gelatinized starch within to flow out and be dissolved, solution of the rest of the marginal part following.

With *pyrogallic acid* reaction begins at once and is over in 2 minutes. The hilum becomes very prominent as a dark bubble, and the lamellæ very distinct. The hilum begins to swell and the bubble quickly expands, then shrinks, and finally disappears. As the hilum continues to swell the margin at the proximal end invaginates, the invagination running along in a longitudinal line almost the whole length of the grain. The more resistant marginal parts of the grain form a thick, homogeneous-looking ring, which becomes thinner and clearer and finally remains only as a thin wall of the gelatinized grain. The gelatinized grains are large, somewhat irregular and sacculated at the distal end, and folded at the proximal end where the invagination took place.

With *ferric chloride* the reaction begins in 30 seconds and is over in 3 minutes. The hilum appears very prominent as a dark bubble. The lamellæ are obscured. The margin and the greater part of the central part of the grain become clearer and darker, leaving only a small, light, and opaque area about the hilum. The marginal starch at the distal end first swells out and becomes gelatinous and thin, and suddenly the process spreads over the entire grain until it reaches the light area about the hilum. This area becomes divided by several fissures into a number of small parts which rapidly separate and become gelatinized independently of one another. As the grains enlarge a line of invagination along the longitudinal axis occurs. The gelatinized grains are large, somewhat irregularly folded, and sacculated.

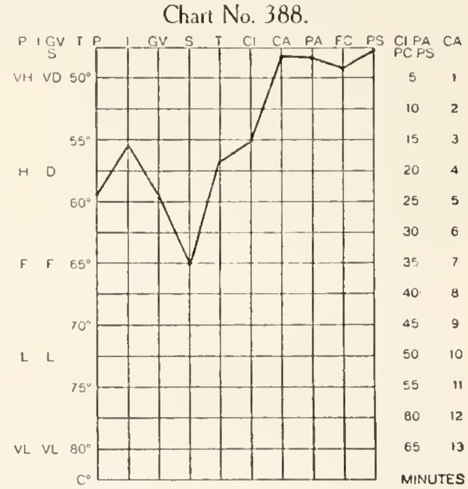
The reaction with *Purdy's solution* begins immediately and is over in a minute. The hilum and lamellæ become very distinct. The hilum swells and pushes out the end of the grain. The outer and more resistant parts of the grain are transformed into a thick, homogeneous ring which becomes gradually thinner and clearer as the grain continues to swell. Soon a line of invagination advances from the proximal end longitudinally along the whole length of the grain. The marginal ring finally disappears. The gelatinized grains are large and ovoid and usually deeply wrinkled in two or three places.

STARCH OF CYCLAMEN COUM. (Plate 99, figs. 591 and 592. Chart 388.)

Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains and occasional aggregates of small grains which consist of two, three, or four components. There are no clumps and but few grains with pressure facets. The surface of the grains is quite smooth, nipple-like processes being very uncommon, and the grains are markedly more regular than in *C. repandum.* The conspicuous forms are ovoid, oval frequently having the distal end pointed or flattened and a hole or depression, and round or nearly round. There are also pyriform, dome-shaped to hemispherical, angular with rounded corners, elliptical, and various indefinite forms. The grains are more regular in outline, there are fewer nipple-like processes, and a greater tendency to the ovoid and round types than in *C. repandum.* The grains are not flattened in any diameter.

The *hilum* is not very distinct, and is a small, round, non-refractive spot, eccentric about one-third to one-fourth of the longitudinal axis of the grain. There are rarely double hila, but never more than 2, and the hilum is never fissured. When there are 2 hila they are very close to one another, and never are separated by a fissure.

Chart No. 388.



Curve of Reaction-Intensities of Starch of Cyclamen coum.

The *lamellæ* are usually distinct. Many grains appear to be surrounded by secondary deposits which do not show a lamellar structure. The lamellæ are fine and generally regular and are more distinct near the hilum. There appears to be a certain waviness and irregularity in some of them which do not correspond with irregularities of the margin, but are less marked than in *C. repandum*, and there is no division of the lamellæ into two distinct sets or systems as in *C. repandum.* There were about 20 lamellæ on the larger grains.

The grains vary in *size* from 4 to 36μ. The common size is about 18μ.

Polariscopic Properties.—The *figure* is eccentric and very distinct. The four lines are more or less visible in whole or in part and are well defined and become broader at the margin of the grain. They are straight or slightly curved, as a rule, in marked contrast with the commonly markedly irregular lines of *C. repandum.*

The degree of *polarization* is high. It varies in different grains, in different aspects of the same grain, and sometimes in the same aspect of a given grain. It is not so high as in *C. repandum.*

With *selenite* the quadrants are well defined, irregular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains tint immediately and deeply blue-violet; with 0.125 per cent solution they tint lightly at once and the color deepens rapidly. The color is slightly deeper than that of the grains of *C. repandum.* After heating until all the grains are completely gelatinized, the solution is colored very slightly and the grains very deeply with iodine. The grains are swollen, but not much wrinkled or distorted. After boiling for 2 minutes, the solution is colored much more, but the grain-residues much less. All the grains have a violet capsule. The grains are not so much disintegrated as those of *C. repandum.*

Staining Reactions.—With *gentian violet* the reaction begins lightly at once and after 30 minutes the grains are fairly deeply and evenly stained, slightly deeper than the grains of *C. repandum.*

With *safranin* the reaction begins at once and after 30 minutes the grains are fairly and evenly stained. The coloration is the same as *C. repandum.*

Temperature Reaction.—The temperature of gelatinization is 56° to 57° C., mean 56.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 1½ minutes and is complete in 15 minutes. It is the same qualitatively as that of the grains of *C. repandum.*

Reaction with *chromic acid* begins immediately and is over in less than 30 seconds. It was so rapid that the details could not be made out, but appeared to be the same as in *C. repandum*.

The reaction with *pyrogallic acid* begins immediately and is over in 2 minutes. It is qualitatively the same as that of *C. repandum*.

The reaction with *ferric chloride* begins in 30 seconds and is over in 3 minutes. It is qualitatively the same as that of the grains of *C. repandum*.

Reaction with *Purdy's solution* begins immediately and is over in less than 30 seconds. It is so rapid that it is impossible to determine the exact changes, but apparently is the same as the reaction with pyrogallic acid.

Differentiation of Certain Starches of the Genus Cyclamen.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

C. repandum: Usually simple, few compound grains and aggregates, a few grains with pressure facets, not flattened, surface sometimes irregular on account of nipple-like processes and pressure facets. Ovoid, oval with usually a sharp pointed distal end in which there is a hole or depression, round or nearly round.

C. coum: Essentially the same as in *C. repandum*, but the grains are more regular in outline, fewer nipple-like processes, and greater tendency to ovoid and round types.

Hilum—Form, Number, and Position.

C. repandum: Form distinct, comparatively small, round, single, or multiple, may be elongated with enlargement on one or both sides; fissuration rare. Position eccentric usually from 0.25 to 0.16 of longitudinal axis.

C. coum: Form not very distinct, small, round, usually single and rarely double; fissuration rare. Position eccentric usually from 0.33 to 0.25 of longitudinal axis.

Lamellæ—General Characteristics and Number.

C. repandum: Distinct, rather fine, decidedly irregular; often two sets, inner set diagonal, transverse, or in the same axis as the outer. Usually about 20 on larger grains.

C. coum: Usually distinct, fine, little irregularity; only one well-defined set of lamellæ. Usually about 20 on larger grains.

Size.

C. repandum: From 5 to 48μ, commonly 28μ.

C. coum: From 4 to 36μ, commonly 18μ.

POLARISCOPIC PROPERTIES.

Figure.

C. repandum: Eccentric, very distinct, usually clear-cut, lines much bent.

C. coum: Same as in *C. repandum*, but the lines are straight or slightly curved.

Degree of Polarization.

C. repandum: High.

C. coum: High, not so high as in *C. repandum*.

POLARISCOPIC PROPERTIES.—Continued.

Polarization with Selenite—Quadrants and Colors.

C. repandum: Quadrants well defined, very irregular in shape and unequal in size. Colors very pure.

C. coum: Quadrants well defined, irregular in shape, and unequal in size, but much less irregular than in *C. repandum*. Colors pure.

IODINE REACTIONS.

Intensity and Color.

C. repandum: Deep; blue-violet.

C. coum: Deep, slightly deeper than in *C. repandum;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

C. repandum: Fairly deep.

C. coum: Fairly deep, slightly more than in *C. repandum*.

With Safranin.

C. repandum: Fair.

C. coum: Fair, the same as in *C. repandum*.

TEMPERATURE OF GELATINIZATION.

C. repandum: 55 to 56° C., mean 55.5°.

C. coum: 56 to 57° C., mean 56.5°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

C. repandum: Begins in a minute; complete in 10 minutes.

C. coum: Begins in 1½ minutes; complete in 15 minutes.

Reaction with Chromic Acid.

C. repandum: Begins at once; complete in a minute.

C. coum: Begins at once; complete in less than 30 seconds.

Reaction with Pyrogallic Acid.

C. repandum: Begins at once; complete in 2 minutes.

C. coum: Begins at once; complete in 2 minutes.

Reaction with Ferric Chloride.

C. repandum: Begins in 30 seconds; complete in 3 minutes.

C. coum: Begins in 30 seconds; complete in 3 minutes.

Reaction with Purdy's Solution.

C. repandum: Begins at once; complete in a minute.

C. coum: Begins at once; complete in less than 30 seconds.

NOTES ON THE STARCHES OF CYCLAMEN.

The very marked tendency of the starch of *C. repandum* to the oval and pointed oval form and to the prevalence of nipple-like processes is quite distinctive; and coupled with these features are differences in the hilum and size that are of importance. The starch of *C. cilicum* (plate 99, figs. 593 and 594) is distinctly different in gross histological characteristics from the other two, and can therefore be readily distinguished. The reactions of the starches of *C. repandum* and *C. coum* are very closely alike, yet sufficiently different to permit of the differentiation of the two starches.

STARCHES OF SOLANACEÆ.

Class, Dicotyledones. Order, Polemoniales. Family, Solanaceæ. Genus represented, Solanum.

The *Solanaceæ* include about 72 genera and 1,500 species, among which are a large number of well-known plants, of importance as sources of medicines, foods, condiments, etc. They are widely distributed in the warm climates of both hemispheres.

GENUS SOLANUM.

The enormous genus *Solanum* includes, according to published accounts, about 950 species, about three-fourths of which are distinct. About 15 species are natives of the United States. Starch was prepared from the tubers of *S. tuberosum* Linn., which were bought in the open market, and therefore of some horticultural form. This species, the common potato and so-called Irish potato, is a native of the Andes of Chili and Peru, from which regions it has been distributed over the civilized world. In the wild state the tubers are small, but by cultivation they have been increased to fifteen to thirty times the natural bulk. They are rich in starch, which is used in the manufacture of dextrin, sugar, and alcohol, and for laundering and other economic purposes, and it has at times been marketed as an arrowroot. (See *Marantaceæ*, page 813.) The consumption of the tubers as a food, as is well-known, is enormous.

STARCH OF SOLANUM TUBEROSUM. (Plate 100, figs. 595 and 596. Chart 389.)

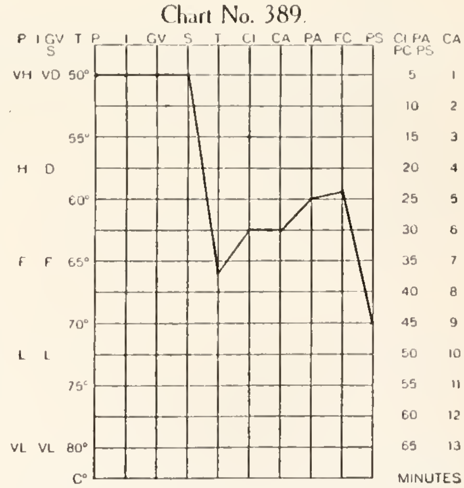
Histological Characteristics.—In *form* the grains are usually simple. There are a few compound grains which consist of two or three components; and there are aggregates, especially among the smaller grains, which consist of from two to four components. There are pressure facets on a few grains, sometimes one or two. There is no tendency to occur in clumps. The surface of the grains is rounded and quite smooth and irregularities of the margin are quite slight. The conspicuous forms are ovoid, flattened ovoid, oval, and round; also pyriform, rarely triangular with rounded angles, and dome-shaped to hemispherical. Some of the larger grains are slightly flattened.

The *hilum* is a distinct, small, usually round, nonrefractive spot. Rarely it is elliptical or lenticular. It is usually at the larger end of the grain, but often very much to one side of the longitudinal line. The hilum is sometimes marked by a small fissure which may be transverse, diagonal, longitudinal, and 3- or 4-armed. Double hila are not uncommon, and even 3 and 4 hila may be seen in a single grain. These may be grouped closely or be far apart, and they are usually separated by slight fissures.

The *lamellæ* are distinct, fine, and, as a rule, regular in outline and tend to follow the outline of the margin. The lamellæ average from 27 to 42 on medium-sized and large grains.

The grains vary in *size* from 15 to 70μ. The common size is 44μ.

Chart No. 389.



Curve of Reaction-Intensities of Starch of Solanum tuberosum.

Polariscopic Properties.—The *figure* is eccentric and distinct. All four of the lines are seen in part or in whole, one or two being much longer than the others. The lines are usually fairly clear-cut; they vary in width and are broader near the margin. Double figures are occasionally noted.

The degree of *polarization* is very high. Some of the larger grains show polarization colors. Polarization is as high in this starch as in any of the starches examined, with the possible exception of the cannas. It varies somewhat in different grains, in different positions of the same grain, and sometimes in different parts of the same aspect of a given grain.

With *selenite,* in most grains, the quadrants are very well defined, irregular in shape, and unequal in size. The colors are quite pure. In those grains which show polarization colors the quadrants are not well defined, the yellow quadrants are very light with greenish streaks, and the blue quadrants are almost yellow.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored at once very deeply a blue-violet; with 0.125 per cent solution they color lightly at once and the color deepens quickly. After heating in water until all the grains are completely gelatinized, the solution is colored fairly deeply, and most of the grains very deeply on the addition of iodine. After boiling for 2 minutes, the solution is colored very deeply and the grain-residues very lightly. With an excess of iodine the capsules take on a violet color. Many of the grains are more or less disintegrated.

Staining Reactions.—With *gentian violet* the staining begins immediately and in 30 minutes the color is very deep, in some grains much deeper than in others.

With *safranin* staining begins immediately and in 30 minutes the color is a very deep rose. The grains appear to be uniformly colored.

Temperature Reaction.—The temperature of gelatinization is 65° to 67° C., mean 66°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 5 minutes. Almost all the grains are gelatinized in 15 minutes and all in 30 minutes. The hilum becomes prominent as a dark spot or bubble, but the lamellæ are invisible. A light space may be seen extending from the hilum and opening out fan-wise at the margin. The margin becomes dark at the distal end at several points at which protrusion begins, the separate points soon becoming joined; or the reaction may begin at the proximal end, or at both ends, from which the reaction progresses over the grain and the grain swells until a large, gelatinized mass is formed which is composed of a dark, marginal ring surrounding a large, lighter, inner portion. (See plate 87, figs. 517 and 518.)

Reaction with *chromic acid* begins in 30 seconds and is over in 6 minutes. Both hilum and lamellæ are prominent. The hilum begins to swell and a number of irregular cracks or fissures appear in the central part of the grain, which run transversely or diagonally and widen out as the grain swells. The hilum continues to swell and the more resistant portions of the grain form a double ring whose inner portion is radially striated, while the outer shows very distinct alternate light and dark concentric rings. The inner substance of the grain collects at the distal end, where it forms a granular mass. The grain continues to swell, especially at the proximal end, until it is about five times the normal size. Invagination occurs, usually only at the proximal, sometimes also at the distal end. The marginal part which has been growing thinner and clearer dissolves at the proximal end, and also sometimes at the other end, and the inner, granular starch flows out and is dissolved. Solution of other parts of the margin follows slowly.

The reaction with *pyrogallic acid* begins in 3 minutes. Almost all the grains are affected and nearly all are completely gelatinized in 25 minutes. After this time there is no reaction. The hilum and lamellæ are more prominent than usual. The hilum swells slightly and a diagonal fissure extends down the grain on each side, outlining a very narrow inner portion. As the hilum continues to swell, this inner portion is split by a number of irregular fissures, the portions of grain-substance often adhering for some time. These parts are transformed into a granular mass at the base of the grain. The more resistant marginal portion of the grain forms a thick ring, which shows distinct, alternate refractive and non-refractive concentric bands, but is not distinctly striated. This ring becomes invaginated at the base as the grain continues to swell, and the marginal band clears very gradually until a large gelatinous mass is formed, which is rounded at the proximal end and folded and lobulated at the distal end.

The reaction with *ferric chloride* begins in 2½ minutes and is completed in 23 minutes. The hilum is prominent, but the lamellæ are obscured. The margin darkens and becomes clearer, and is fissured at the distal or proximal end, from which fissures a gelatinous substance protrudes. Suddenly the hilum swells and invagination occurs from the distal end of the grain almost up to the other end, causing the grain to show a double row of striated, banded material on either side of a clear space. This banded material gradually clears and becomes thinner, and there is left a very large, rather shapeless, gelatinous mass. Near the edge and outside of the cover-slip the grains do not react so quickly.

Reaction with *Purdy's solution* begins in 20 seconds and is over in 45 seconds. Both hilum and lamellæ become very prominent. The hilum swells slightly and a fine diagonal fissure extends down on each side from the hilum to the distal end, and outlines a very narrow, inner portion of the grain, which becomes broken by irregular transverse and diagonal fissures. As the grain continues to swell, the inner portion is converted into a homogeneous, granular mass that collects at the distal end. The more resistant parts of the grain are formed into a thick marginal ring which is finely striated and shows 2 or 3 very distinct, alternate light and dark, concentric rings. These rings become thinner and clearer, and the grain becomes invaginated at the base and a large and shapeless mass is thus formed.

STARCHES OF CONVOLVULACEÆ.

Class, Dicotyledones. Order, Polemoniales. Family, Convolvulaceæ. Genus represented, Batatas.

The *Convolvulaceæ* are closely allied to *Solanaceæ*, and include about 30 genera and 800 species of herbs and shrubs, chiefly of a twining or trailing character, which are natives of temperate and tropical regions of both the Old and New Worlds. Some are used as medicines, some as foods, some as garden plants, etc.

GENUS BATATAS.

The genus *Batatas* is by some authors included in the larger genus *Ipomœa*. It comprises about 20 species, mostly natives of tropical America. Starch was prepared from *B. edulis* Chois. (*Impomœa batatas* Poir.), which has been cultivated and naturalized in various countries and whose origin remains unknown. The tuberous roots, like those of *Solanum tuberosum*, are rich in starch, but contain much more sugar.

STARCH OF BATATAS EDULIS. (Plate 100, figs. 597 and 598. Chart 390.)

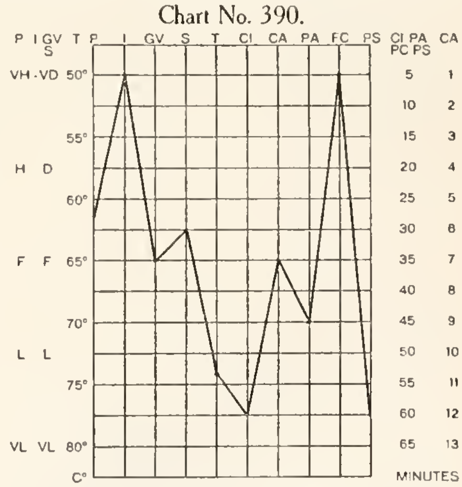
Histological Characteristics.—In *form* the grains are simple, and seldom occur in aggregates. Nearly all have pressure facets, and the facets are sharply defined and rarely number more than three on a single grain, generally only one or two. The conspicuous forms are the dome-shaped to hemispherical; quadrangular, spherical with or without one small facet, polygonal with three or more facets, very rarely ovoid, or oval, and various indefinite forms. From the top the grain appears to be spherical.

The *hilum* is a distinct, fairly large, round, nonrefractive spot, eccentrically placed, even in the spherical grains. It is in or slightly to one side of the median line and may be marked by a small transverse fissure, usually with small branches extending from it. The hilum is never double or multiple.

The *lamellæ* are quite distinct and follow the outline of the margin, even those near the hilum. They are comparatively fine, one or two being especially large and distinct. On the larger grains they vary in number from 14 to 28.

The grains vary in *size* from 3 to 26μ. The common size is about 16μ.

Chart No. 390.



Curve of Reaction-Intensities of Starch of Batatas edulis.

Polariscopic Properties.—The *figure* is eccentric and distinct. Four straight lines are seen, of much the same size, sometimes becoming broader at the margin of the grain; at the facets they may become very broad, or appear to widen and to merge into one another, which is probably due to the existence of a depression here.

The degree of *polarization* is fairly high. It varies with the position and size of the grain and in the same aspect of a given grain. It is apt to be absent at the facets.

With *selenite* the quadrants are well defined, usually irregular in shape, and unequal in size. The colors are fairly pure. The red dividing lines are broad.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored immediately and very deeply a blue-violet; with 0.125 per cent solution the grains immediately color lightly and the color deepens quickly. After heating in water until all the grains are completely gelatinized, the solution is colored lightly and the grains deeply on the addition of iodine. Some grains have the violet-colored capsule. After boiling for 2 minutes, the solution is colored much more deeply, the grain-residues but little or not at all. All of the capsules are colored violet by using very little iodine. A few grains are completely disintegrated.

Staining Reactions.—With *gentian violet* staining begins immediately and after 30 minutes the grains are colored fairly well.

With *safranin* the grains begin to stain immediately and after 30 minutes they are stained a yellowish-red, which is not very deep.

Temperature Reaction.—The temperature of gelatinization is 73° to 75° C., mean 74°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in 30 seconds. Almost all are blue in 7 minutes and after an hour all are completely gelatinized. The hilum becomes prominent, but the lamellæ are usually invisible. The margin becomes clearer and darker; and the edges and corners of the facets become darker and begin to swell quite uniformly. The process extends around the margin, without very much swelling, and then inward over the rest of the grain, which may be crossed by fissures and so divided into several pieces which gelatinize independently. The gelatinized grains are large and not much distorted except about the edges of the facets, and have a very thick marginal ring which shows in some cases concentric bands of varying degrees of darkness. Within the ring there is a lighter round or pyramidal area.

The reaction with *chromic acid* begins in 30 seconds and is over in 7 minutes. The lamellæ and hilum become very prominent. The hilum begins to swell regularly and uniformly. The more resistant outer part of the grain is formed into a thick marginal band, which is striated and very distinctly marked by two or three alternate light and dark refractive and non-refractive rings and bordered on the inside by a row of large granules or pyramids. The granules or pyramids occasionally break off and move inwardly, where they are broken down. One point in the margin protrudes, grows thin, and dissolves. The gelatinous granular material within the grain flows out and is dissolved, followed by solution of the remaining portion of the margin.

Reaction with *pyrogallic acid* begins in some grains in 30 seconds, and all are affected and nearly all completely gelatinized in 45 minutes. The hilum and lamellæ become very prominent. The grains are covered with fine striæ, and the hilum swells until all the resistant outer substance forms a striated, banded ring at the margin, which ring becomes thinner, clearer, and homogeneous as the grain swells, until a gelatinous mass is formed. The gelatinized grain is large and somewhat distorted and it may be much folded and sacculated, particularly at the distal end.

The reaction with *ferric chloride* begins in a minute and is over in 5 minutes. The lamellæ are not entirely obscured. The hilum swells, as a dark bubble, the bubble grows larger, then shrinks, and finally disappears. A marginal ring is formed, bordered by large granules on the inner side; it gradually grows thinner and clearer as the grain swells, and when the grain becomes very large the ring moves inward from the side and thus gives the appearance of a hole in the grain. The gelatinized grains are large and not much folded or crumpled, but somewhat distorted by the invagination from the side already referred to.

The reaction with *Purdy's solution* begins in some of the smaller and in the injured grains in a minute and in the normal grains in about 10 minutes. After 30 minutes there is not much change, and fully half are never affected. The hilum and lamellæ become very prominent. The reaction, as far as it goes, is qualitatively like that with pyrogallic acid.

STARCHES OF GESNERACEÆ.

Class, Dicotyledones. Order, Polemoniales. Family, Gesneraceæ. Genera represented: Gesneria and Gloxinia (Sinningia).

The *Gesneraceæ* include about 70 genera and 700 species of herbs and shrubs, natives of tropical and semitropical regions, chiefly of America. They are cultivated chiefly for their flowers. The fruits of some are used as a food.

GENUS GESNERIA.

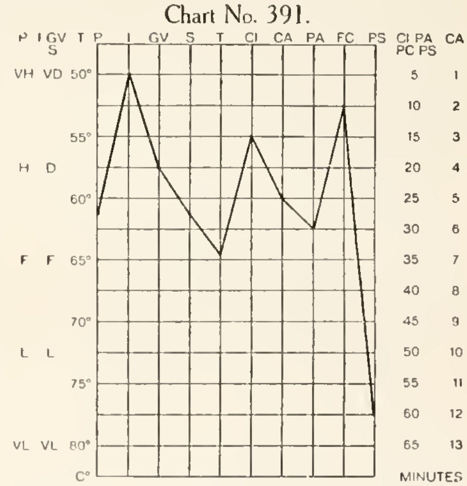
This genus comprises about 50 species of tuberous, bulbous, or rhizomatous herbs, natives of South America, chiefly of Brazil. Starch was prepared from *G. tubiflora* Hort.

STARCH OF GESNERIA TUBIFLORA. (Plate 100, figs. 599 and 600. Chart 391.)

Histological Characteristics.—In *form* the grains are simple; there are no aggregates or pressure facets, and only a few small clumps. The surface of the grain is generally irregular, owing in part to secondary deposits of starch, made after the original grain has been formed and other such irregularities of development, and in part to nipple-like processes. The additions are lamellated and usually at the sides or near the base of the grain. Often the lamellæ composing them may be seen to be continuous around the grain. A small hollow frequently extends into the substance of the grain from the distal end, which is usually squared. The conspicuous forms are the flattened ellipsoidal, which is usually straight but may be bent on the long or longitudinal axis. The proximal end is rounded and commonly larger than the distal end. There are also ovoid, pyriform, round and also triangular, club, gourd, and boot shapes, and various indefinite forms which arise from causes noted. The grains are not flattened, but owing to the secondary deposits they are sometimes broader than thick. They bear certain general and striking resemblances to the starches of *Dieffenbachia*.

The *hilum* is a not very distinct, small, non-refractive spot, situated usually very eccentrically at the larger or proximal end of the grain. It is commonly in or near the median line. There are neither double nor multiple hila. It is rarely fissured, and if so the fissure is a very small transverse line. In the grains with secondary additions, the hilum is always in the primary part of the grain, but it may be very much to one side of the longitudinal axis.

Chart No. 391.



Curve of Reaction-Intensities of Starch of Gesneria tubiflora.

The *lamellæ* are distinct and comparatively fine. Those near the distal end are the coarser, but not always the more distinct. In the grains with secondary lamellæ the lamellæ of the original grain are usually the more distinct. The lamellæ are regular, and excepting the circles around the hilum are in the form of arcs of circles having the form of the distal margin. They vary in distinctness in different grains. There are from 35 to 40 on the larger grains.

The grains vary in *size* from 6 to 46μ. The common dimensions of the largest ellipsoidal grains are 44 by 14μ in length and breadth. The common size is 22μ.

Polariscopic Properties.—The *figure* is very eccentric, distinct, and clear-cut. It exhibits many peculiarities, some being due to the secondary additions before noted, in which cases the lines, instead of ending at the margin of the primary part of the grain, may curve around the margin and are bent so as to extend down to the secondary additions, where they end. They are usually quite sharply defined and may be straight or curved, and a given line may be of equal or unequal width in its course.

The degree of *polarization* is fairly high. It varies in different grains, in different aspects of the same grain, and in parts of the same aspect of a grain.

With *selenite* the quadrants are well defined, very irregular in shape, and unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored immediately and very deeply a blue-violet; with 0.125 per cent solution they color deeply. After heating until all the grains are completely gelatinized, they color very deeply and the solution very lightly with iodine; some have a red-violet capsule. After boiling for 2 minutes the solution colors very deeply, but the grain-residues very lightly. With a slight excess of iodine all the grains exhibit a deeply colored red-violet capsule. Some of the capsules retain starch in the upper portion that colors a faint blue. The capsules are much lobulated, twisted, and distorted, especially at the base.

Staining Reactions.—With *gentian violet* the grains begin to stain at once. After 30 minutes they are deeply and evenly stained.

With *safranin* the grains begin to stain at once and after 30 minutes are fairly deeply and evenly stained.

Temperature Reaction.—The temperature of gelatinization is 64° to 65° C., mean 64.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in 30 to 60 seconds and most of the grains are darkened in 5 minutes. All are gelatinous and swollen and the reaction is complete in 15 minutes. The hilum usually becomes prominent, but not the lamellæ. The grain shows a dark spot at either the distal or the proximal end; this spot swells somewhat and the same process occurs at the opposite end and from these two points gelatinization spreads over the whole grain. There is usually a sharp line of demarcation between the swollen and unswollen portions. In the grains with secondary deposits which show a double base or distal end, the reaction begins in the part last formed. In a few cases the reaction begins at but one end and spreads over the grains. Usually the whole margin in such cases becomes darkened first, and then the inside of the grain. After the whole grain is completely darkened, swelling continues for a short time. During this reaction there is formed a comparatively large gelatinous mass, the enlargement occurring particularly in a longitudinal direction. There is formed a very irregular base or distal end that is lobulated and divided by light fissures; a round proximal end that has a round area surrounded by a dark ring; and a middle portion which may be homogeneously dark, but is usually crossed by one or two light fissures separating the dark mass into more or less irregular bands. The gelatinized grains retain some of the original shapes of the grains. There is often a wide, light space between the original grain and the added portion.

The reaction with *chromic acid* is general in 30 seconds and is over in 5 minutes. The hilum becomes prominent, but not the lamellæ. Two lines or fissures extend downward, one on each side of the hilum. The portion included by these fissures becomes lighter in color and is quickly broken up by other irregular fissures. The hilum swells, the swelling extending especially upward; the inner portion of the grain, which is irregularly granular, breaks down into a gelatinous mass. The more resistant starch at the margin appears as a rather thin ring, ragged on the inner edge and divided by fissures into a row of granules. This ring soon becomes a thin transparent coating which invaginates at one side. It dissolves either at the top or at the side, and the inner liquefied starch flows out and is dissolved, followed by a solution of the rest of the margin.

With *pyrogallic acid* there is a very slight general reaction in 1½ minutes. The majority of the grains are fully gelatinized in 15 minutes and all in 30 minutes. Both the hilum and lamellæ become very prominent. The hilum enlarges somewhat and two lines or fissures extend downward from the hilum, one on each side. The portion included between them becomes more transparent, the lamellæ fade away, and the grain presents a striated appearance, the striæ extending upward from the base. The proximal end enlarges rapidly as the hilum continues to swell. There is here a rather thin, homogeneous-looking band. The inner lower portion also finally passes into a gelatinous mass, leaving the margin very irregularly lobulated and folded. The margin becomes clearer and more transparent until finally a thin-walled mass is formed. This gelatinized grain is large and does not retain much if any of the original form. It is rounded and somewhat folded at the proximal end and is very irregular at the distal end.

There is a restricted reaction with *ferric chloride* in a few minutes, which becomes general in 3 minutes. Most grains are gelatinized in 6 minutes and all in 10 minutes. The hilum becomes prominent, but not the lamellæ. There are in general two methods by which the reaction may start and proceed: The hilum may swell somewhat and two fissures extend, one on each side, into the substance of the grain, the inclosed area becoming fissured from the base. The hilum continues to enlarge, the enlargement taking place particularly upward. The distal end in the meantime becomes gelatinous with much irregular swelling and lobulation, the central part finally reacting. The other type of process begins at the distal end, followed by reaction at the hilum, after which the changes are similar to that of the first type. The gelatinized grains so formed are very large, thin-walled, and transparent. They are very much distorted, lobulated, and infolded, and bear but little resemblance to the original grain.

With *Purdy's solution* there is a slight general reaction in a minute. A very few grains are completely gelatinized in 15 minutes, about half in an hour, and nearly all except the smaller grains are gelatinized in 2½ hours. The hilum and lamellæ are both very prominent. The reaction is similar to that with pyrogallic acid, but there seems to be a form of starch about the depression at the distal end of the grain which is especially resistant to this reagent.

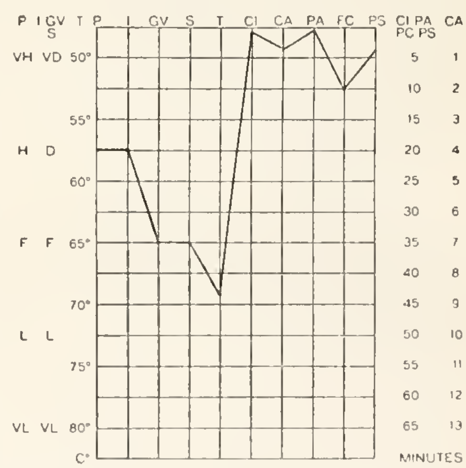
GENUS GLOXINIA (SINNINGIA).

The garden gloxinias belong to the genus *Sinningia* (which includes *Rosanowia*) and are forms of the *Sinningia speciosa* type. The genus comprises about 16 species, all of which are Brazilian. The starch studied in this investigation was obtained from an unnamed garden variety, and in accordance with usage is referred to as a *Gloxinia*. *Gesneria* and *Gloxinia* (*Sinningia*) have been hybridized.

STARCH OF GLOXINIA VAR. (Plate 101, figs. 601 and 602. Chart 392.)

Histological Characteristics.—In *form* the grains are almost wholly simple and isolated, except a small number which occur in small aggregates and occasional small clumps. There are a few compounds. Some of the isolated grains bear pressure facets. The grains are often irregular, which is chiefly due to the following causes: to the deposition of a secondary set of lamellæ placed at varying angles to the primary lamellæ; to the appearance of one or more indentations, probably pressure facets of small grains, at different points on the surface; and, rarely, to the presence of a finger-like or one or two small nipple-like protuberances at or near the proximal end. The conspicuous forms are club-shaped, elongated ovoid with a squared or sharply pointed end, ovoid, ellipsoidal, and triangular with rounded angles and either a curved or diagonal base. There are also nearly round, pyriform, somewhat mussel-shell-shaped, knob-shaped, and boot-shaped grains. The grains when seen on end are not flattened, except a few which are broader at the distal end.

Chart No. 392.



Curve of Reaction-Intensities of Starch of Gloxinia var.

The *hilum* is usually observed as a clear, round spot eccentric about one-sixth to one-fourth of the longitudinal axis. It is generally not fissured. A curved transverse cleft, or two clefts which intersect and form a cross, may be observed.

The *lamellæ* are arranged in groups of numerous fine lamellæ interspersed with from two to five which are coarser and more refractive. They are circular or elliptical complete rings near the hilum, but are probably incomplete and follow the outline of the grain when near the distal end. On the large grains 80 to 85 lamellæ have been counted and 46 to 50 on the medium-sized ones.

The grains vary in *size;* the smaller are 5 by 3μ; the larger are 76 by 28μ in length and breadth; the grains of common size are 30 by 18μ in length and breadth.

Polariscopic Properties.—The *figure* is eccentric and clean-cut. Its lines are rather narrow and intersect at an oblique angle. They are sometimes straight, but more often bent and occasionally bisected.

The degree of *polarization* is high to very high.

With *selenite* the quadrants are well defined, but unequal in size and irregular in shape. The colors are generally pure; there is a greenish tint in a few grains.

Iodine Reactions.—With 0.25 per cent Lugol's solution all the grains color a deep blue-violet, which deepens rapidly; with 0.125 per cent solution they soon color a light blue-violet, which deepens rapidly. After heating in water until all the grains are completely gelatinized and then adding iodine, the solution colors a bright indigo-blue and the gelatinized grains a deep blue. If the grains are boiled for 2 minutes and then treated with iodine, the solution colors a very deep indigo-blue, but most of the grain-residues remain colorless. With an excess of iodine the grain-residues color a deep blue, some with reddish tint, and the capsules color a wine-red.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to color immediately and in 30 minutes are lightly to fairly colored.

Temperature Reaction.—The temperature of gelatinization is 68.5° to 70° C., mean 69.25°. At this temperature there are several grains which show no apparent effect of the heat.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins immediately. A few grains are gelatinized in 30 seconds, and practically all in a minute. In the rare resistant grains the reaction is complete in 2 minutes. The grains color a deep old-rose immediately and a dark dot or line frequently appears at the hilum. Gelatinization begins either by the darkening of the distal end or in the secondary sets of lamellæ or protuberances on the grain, and gradually spreads all over the grain, accompanied by uniform swelling. The gelatinized grains are swollen, but retain the shape of the untreated grain.

The reaction with *chromic acid* begins immediately. A few grains are dissolved in 15 seconds, nearly all in 30 seconds, and all in 40 seconds. The hilum swells and a large bubble frequently appears at this point, which as it collapses is often accompanied by an invagination of the proximal end. Gelatinization quickly follows, and one or two large, internal, branched fissures pass from this gelatinized area towards the distal end. The outer lamellæ become sharply defined and striated, and when disorganized at the distal end a cluster of refractive granules may remain for a few seconds embedded in the more soluble starch. The grain continues to swell and the capsule is ruptured at the proximal end, followed quickly by a complete solution of the outpouring starch and later of the capsule.

The reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 15 seconds and all but rare resistant grains in 30 seconds. All are usually gelatinized in a minute, but rarely the reaction takes 3 minutes. A bubble appears at the hilum, which increases in size and then is expelled, frequently accompanied by an invagination of the proximal end. In the narrower grains from two to five internal longitudinal fissures, and in the broader grains a cluster of fissures, pass from around the hilum to the distal end and gelatinization of the entire grain with the occasional exception of a few refractive granules quickly follows. The gelatinized grains are much swollen and are more distorted at the distal end.

Reaction with *ferric chloride* begins in a few grains in 30 seconds. A small number are gelatinized in a minute, about two-thirds in 5 minutes, nearly all in 7 minutes, and all in 10 minutes. The hilum becomes distinct and sometimes a bubble appears which enlarges and collapses, the latter being accompanied by a breaking up of resistant starch into large refractive granules, which are finally dissolved. A lustrous border forms around the grain. Gelatinization accompanied by a rapid distension of the capsule usually begins at the distal end and advances towards the proximal end. In the less resistant grains the bubble at the hilum breaks, followed by similar gelatinization at the proximal end. In the most resistant grains the bubble continues to enlarge and persists until gelatinization has moved from the distal end and has about reached it, when it is expelled, the resistant starch breaking up into large granules which usually become completely gelatinized. Occasionally a few small, refractive granules remain. The gelatinized grain is much swollen and distorted and does not resemble the form of the untreated grain.

Reaction with *Purdy's solution* begins immediately. Many grains are gelatinized in 15 seconds, about three-fifths in 30 seconds, nearly all in 2 minutes, and all but very rare resistant grains and the distal parts of a few resistant grains in 4 minutes. The reaction is usually completed in the distal end in 6 minutes; but in the rare resistant grains (one in many hundred) the reaction may take an hour for completion. The hilum swells, a large bubble appears at this point, and the lamellæ become very distinct and striated. The bubble collapses, frequently accompanied by an invagination of the proximal end, and gelatinization of the starch in this region quickly follows. During this rapid gelatinization there is often a decided lateral expansion of the grain at this point. From the gelatinized area of the narrower grains two to five internal parallel longitudinal fissures, and from the broader grains a cluster of fissures, pass to the distal end, the starch of which latter is much more resistant than that of the proximal end. The lamellæ are finally gelatinized, except occasionally a few refractive granules at the distal end. The gelatinized grain is much swollen and is slightly distorted at the distal end, but the outline has a general resemblance to untreated grains.

NOTES ON THE STARCHES OF GESNERACEÆ.

The starches of *Gesneria* and *Gloxinia* exhibit histological peculiarities as regards form, hilum, lamellæ, and size that render them easily distinguishable. In their reactions they differ definitely in every one, excepting with ferric chloride. *Gesneria* is recorded as having a lower degree of polarization, a higher reactivity with the anilines, a lower temperature of gelatinization (4.75°), and less sensitivity to all of the chemical reagents except ferric chloride.

STARCHES OF CUCURBITACEÆ.

Class, Monocotyledones. Order, Campanulales. Family, Cucurbitaceæ. Genus represented, Trianosperma.

The *Cucurbitaceæ* include about 80 genera and 600 species. Most of them contain an acrid principle and in some this is present in sufficient quantity to render them acrid poisons. Some are used medicinally; others yield fruits, such as the cucumber, water-melon, pumpkin, etc., which are used as foods; and some are cultivated as garden plants.

GENUS TRIANOSPERMA.

This small genus is native chiefly of Brazil and the West Indies; one is from the Old World, from tropical Africa. The plants have thick, fleshy roots, which contain much starch. A preparation was obtained from *T. ficifolia* and studied as a type of the genus.

STARCH OF TRIANOSPERMA FICIFOLIA. (Plate 98, figs. 587 and 588. Chart 393.)

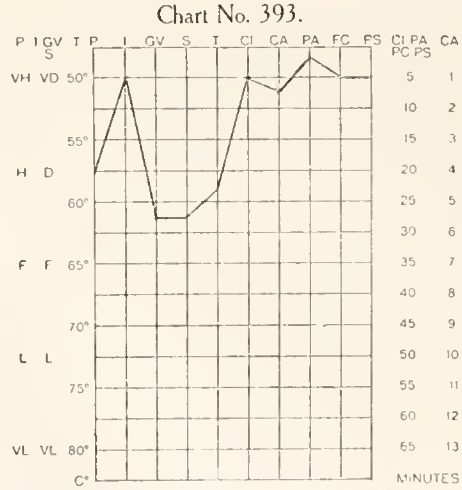
Histological Characteristics.—In *form* the grains are usually simple, with occasional compound grains and some small aggregates; nearly all have one or more large, clear-cut pressure facets. The surface is rounded and regular in outline, except when altered into irregular forms by pressure facets. The conspicuous forms are the dome-shaped to hemispherical, ovoid, round, pyriform, lenticular, quadrangular and polygonal, and indefinite forms.

The *hilum* is a very distinct, comparatively large, round spot, centrally or somewhat eccentrically placed and usually in the median line. At times it appears as a round cavity. It is sometimes fissured deeply, radially or irregularly. Rarely it is marked by a clear-cut cross or by a small transverse or diagonal fissure.

The *lamellæ* are very distinct, coarse, circular, and regular, and do not generally follow the outline of the margin, except when very near it. There is usually one very prominent lamella about halfway between the hilum and the margin. There are about 5 to 8 lamellæ on the larger grains.

The grains vary in *size* from 3.5 to 26μ; the common size is 14μ.

Chart No. 393.



Curve of Reaction-Intensities of Starch of Trianosperma ficifolia.

Polariscopic Properties.—The *figure* is centric or slightly eccentric, distinct, and usually clear-cut. One or two of the lines are usually broader and less clear-cut than the others and usually straight, but tend to vary in thickness along their course. The figure varies in distinctness in different grains.

The degree of *polarization* is high. It is highest in the ovoid and round grains, varying somewhat in different aspects of a grain and also in parts of the same aspect of some grains. At the facets it is low.

With *selenite* the quadrants are well defined, usually unequal in size, and irregular in shape. The colors are fairly pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored very deeply blue-violet; with 0.125 per cent solution they color deeply. After heating in water until all the grains are completely gelatinized, the solution and some of the grains are colored deeply on the addition of iodine. After boiling for 2 minutes, the solution is colored very deeply, but the grain-residues much less deeply or not at all. When an excess of iodine is added all the capsules are colored a dark violet.

Staining Reactions.—With *gentian violet* and with *safranin* the grains begin to stain at once and in 30 minutes they are fairly deeply stained, some more than others.

Temperature Reaction.—The temperature of gelatinization is 58° to 60° C., mean 59°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins at once and is over in 5 minutes. Both hilum and lamellæ become very prominent. A dark bubble appears at the hilum. The distal end of the grain begins to darken, especially about the edges of the facets, and there is often much swelling at these points. The whole margin darkens and the process spreads inward. Meanwhile the dark bubble at the hilum swells, the hilum swells, and the bubble first increases and then decreases in size. The hilum continues to swell with other parts of the grain until a gelatinous mass is formed. The gelatinized grains are large, but not very much distorted, and the edges of the facets are somewhat puffed out. In some cases there appeared to be two parts to the margin, a thick, dark inner ring, and a thin, light outer envelope.

The reaction with *chromic acid* begins immediately and is over in 1½ minutes. The hilum is frequently marked by a bubble. The lamellæ become distinct. The hilum swells somewhat and fine radial striæ appear running throughout the grain. The bubble begins to swell, accompanied by swelling of the hilum and other parts of the grain, and shrinks after reaching a certain size. The hilum and the grain, as a whole, swell with increasing rapidity as gelatinization proceeds. The more resistant part of the grain at the margin forms, at first, a thick, homogeneous band, which rapidly becomes thinner and transparent and finally invaginated at one side. One point dissolves, the contents are exuded and dissolved, followed by solution of other parts of the capsule.

Reaction with *pyrogallic acid* begins in 20 seconds and is over in 2 minutes. Both hilum and lamellæ become very prominent. The hilum swells slightly and the grain becomes divided by fine, radiating striæ. The starch at the margin forms a thick, radially striated band, which becomes thin and clearer. As the grain continues to swell invagination occurs, often very deeply in one side. The edges of the facets are swollen out, frill-like, about the facets. The gelatinized grains are large and occasionally somewhat distorted, especially when invaginated, but generally they are smooth and not wrinkled, except about the edges of the facets.

With *ferric chloride* the reaction begins in 30 seconds and is over in 5 minutes. The hilum becomes very prominent as a dark bubble, which frequently does not appear until other parts of the grain begin to react. As this bubble enlarges, the inner part of the grain is gelatinized and the grain swells. The bubble at the hilum, having reached its limit of expansion, begins to shrink and finally disappears. The grain continues to swell, but even more rapidly. The starch at the margin forms a thick, homogeneous ring, which becomes thinner, and finally in many grains invaginates, usually deeply, at some point. The gelatinized grains are very large, some are deeply invaginated, and the edges of the facets are filled.

The reaction with *Purdy's solution* begins in 30 seconds and is over in 3 to 5 minutes, but none of the grains is fully gelatinized. Both hilum and lamellæ become very prominent. The grain becomes divided by fine striæ, and the inner portion is transformed into a gelatinous mass, while the outer portion forms a striated, banded ring, which at first is very thick, but later somewhat thin, homogeneous, and transparent.

STARCHES OF CYCADACEÆ.

Class, Gymnospermæ. Order, Cycadales. Family, Cycadaceæ. Genera represented: Cycas, Dioon, and Zamia.

The *Gymnospermæ* are regarded by some authors as a subclass of *Dicotyledones*. Of the three orders of this class (*Gnetaceæ, Coniferaceæ,* and *Cycadaceæ*) the starches of representatives of only *Cycadaceæ* were examined. This peculiar order has affinities with the ferns, but resembles the palms, and its sexual characters are transitional between angiosperms and vascular cryptogams. There are recorded 9 genera and 75 species of *Cycadaceæ; Cycas* is the chief genus and includes about 20 species, several of which are quite widely cultivated.

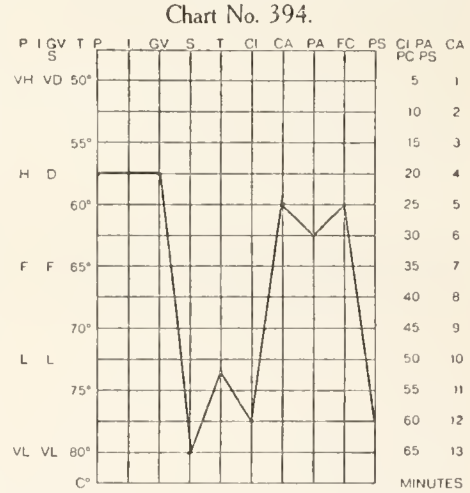
GENUS CYCAS.

The various species of *Cycas* are widely distributed throughout the tropical and subtropical parts of the Eastern hemisphere. Starches from the side-shoots of two species were studied: *C. revoluta* Thunb., the sago palm, a native of Japan and China, and the most common *Cycad* in cultivation; and *C. circinalis* Linn. (*C. thouarsii* T. Br.), a native of the East Indies to New Guinea.

STARCH OF CYCAS REVOLUTA. (Plate 101, figs. 603 and 604. Chart 394.)

Histological Characteristics.—In *form* the grains are simple. There are a few aggregates and clumps. Most grains have pressure facets, which rarely exceed three on a single grain, although four or five may occur. Occasionally three facets are grouped about a common center at the base of the grain and are usually sharply defined. The fundamental form of the grain is obviously spherical, and any modifications of this are due to the mutual pressure of grains. The small grains are generally spherical. The conspicuous forms are the hemispherical to dome-shaped with one to three facets at the base, round or nearly round, and ovoid. Various polygonal and indefinite forms owe their peculiarities chiefly to the presence of many facets.

Chart No. 394.



Curve of Reaction-Intensities of Starch of Cycas revoluta.

The *hilum* is a distinct, non-refractive, round spot of medium size, in most cases having the appearance of a round cavity communicating with the interior of the grain. It is placed centrally or very slightly eccentrically, and usually in the median line. Occasionally it is transversely fissured, but not extensively, and there may be a longitudinal or a 3-armed fissure. In one case a double, or possibly an elongated, hilum was noted.

The *lamellæ* are usually distinct, regular, concentric rings. Those near the margin tend to follow the marginal outline. In some of the larger and round types, one or two of the prominent, inner lamellæ show distorted areas which apparently are the remains of old pressure facets that have been covered by layers of starch. Some of the lamellæ are broader and more distinct than others, especially those midway between the hilum and the margin, and also those near the hilum. The lamellæ average about 10 to the larger grains.

The grains vary in *size* from 5 to 25μ. The common size is 14μ.

Polariscopic Properties.—The *figure* is centric, or slightly eccentric, and distinct, and is in the form of a very distinct cross. At the base another figure may be frequently seen which appears on the distal side of a depression of a facet. The lines of the cross are clear, straight, and of equal distinctness throughout, except towards the margin, where they are broader and less well defined.

The degree of *polarization* is high. It varies in different grains, but not very much in different aspects of the same grain, except at the base, where it is less marked.

With *selenite* the quadrants are sharply defined, regular in shape, but unequal in size. The colors are pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored immediately and deeply a bluish-violet; with 0.125 per cent solution the grains tint quickly and the color deepens rapidly. After heating the grains in water until all are completely gelatinized, the solution colors very slightly with iodine, but the grains color a dark blue. The grains are very much swollen and distorted. After boiling for 2 minutes the solution colors deeply, but the grain-residues less deeply to but slightly. The capsules are colored blue-violet and are much folded, crumpled, and otherwise distorted.

Staining Reactions.—With *gentian violet* the grains begin to stain in 3 to 4 minutes and in 30 minutes are deeply stained a dark, dull violet.

With *safranin* the grains begin to stain very slightly in 4 minutes and in 30 minutes the color is not much deeper.

Temperature Reaction.—The temperature of gelatinization is 73° to 74° C., mean 72.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in the smaller grains in a minute, in the larger grains in 3 or 4 minutes, and is complete in three-fourths of the grains in 45 minutes. The hilum becomes prominent. One of the central lamellæ stands out as a ridge. The grain begins to darken first at the angles of the facets and then all around the margin; or less commonly irregular points on the margin darken increasingly, the darkening spreading and later joining. This process usually extends inward evenly. The hilum swells last. The gelatinized grains so formed consist of a dark, very distinct marginal ring inclosing a lighter inner portion. They are not very large, and while somewhat distorted by protrusion of the parts first affected, much of the original shape of the grain is retained.

Reaction with *chromic acid* begins in 30 seconds and is completed in 5 minutes. The hilum becomes prominent as a dark spot or bubble, and the lamellæ are not increased in distinctness. Fine striæ radiating from the hilum appear throughout the grain; the hilum begins to swell and the striæ grow coarser and more distinct. The outer part of the grain is pushed outward to form a thick ring, which is radially striated and has alternate refractive and non-refractive bands. The band, as a whole, becomes much clearer and thinner, then dissolves at one place, and the inclosed liquefied starch flows out and then the rest of the ring dissolves rapidly. Often at one point this marginal band will be much thinner than at any other and dissolve more rapidly than the marginal parts generally of this and other grains.

The reaction with *pyrogallic acid* begins slightly in 1½ minutes and all but a few grains are completely gelatinized in 30 minutes. Both hilum and lamellæ are rendered more distinct than normal. The grains which react quickly show fine striæ radiating from the hilum. The hilum swells, while at the same time the base of the grain, especially at the angles of the facets, is invaded by large fissures, which portions of the grain swell out coincidently with the swelling of the hilum. In the proximal part of the grain the unaffected portion at the margin is formed into a striated band, which becomes thinner and more transparent, and finally forms a thin, homogeneous coating around the gelatinized inner part of the grain. In grains which react more slowly, the hilum swells and the rest of the grain is divided by fine radial striæ which extend from the hilum. A marginal ring is formed of the more resistant starch and this gelatinizes finally, the whole grain then becoming a gelatinous mass. At times there are two distinct parts of this marginal ring, both of which are finely striated and divided by a clear space or ridge which appears to occupy the same position as the prominent lamellæ noted in the normal grain. The gelatinized grains so produced are large and somewhat distorted, especially at the base, but retain much of the original form.

Reaction with *ferric chloride* begins in some grains in 3 minutes and is over in all in 25 minutes. The hilum is usually rendered very distinct as a dark spot or bubble. None of the lamellæ is visible except the one especially prominent about midway between the hilum and margin. The marginal starch becomes clear and darker; the inner portion of the grain, which is very much contracted, is opaque and light in color. In most grains practically all parts gelatinize at the same time, but in some grains the central part reacts first and the margin later. The gelatinized grains are large, but not greatly folded or otherwise distorted.

With *Purdy's solution* a very few grains show reaction in 7 minutes. Only a few grains are at all affected, but some are completely gelatinized in 3 hours. The hilum and lamellæ become very distinct in all the grains. In the very few grains which gelatinize completely, the process consists in the division of the grain by fine radial striæ, swelling of the hilum, and the gelatinization of the inner portion first, and the formation of a striated, ringed, marginal band with alternate refractive and non-refractive rings. This band is finally gelatinized and there is ultimately formed a large gelatinous mass. In most of the reacting grains the process stops at various stages.

STARCH OF CYCAS CIRCINALIS. (Plate 101, figs. 605 and 606. Chart 395.)

Histological Characteristics.—In *form* the grains are simple. There are a few small aggregates and many large clumps. Nearly all the grains show pressure facets which are very clearly defined. The number of facets to a single grain is commonly one or two or three, which facets are grouped at the base; but a larger number is not infrequent. The basic form of the grain is spherical, which form becomes modified in various ways by the position, size, and number of the facets. The conspicuous grains are hemispherical to dome-shaped, spherical, quadrangular and other polygonal forms. The grains are on the whole much more irregular in form than in *C. revoluta.* Looking down at the proximal end, the grains usually appear round.

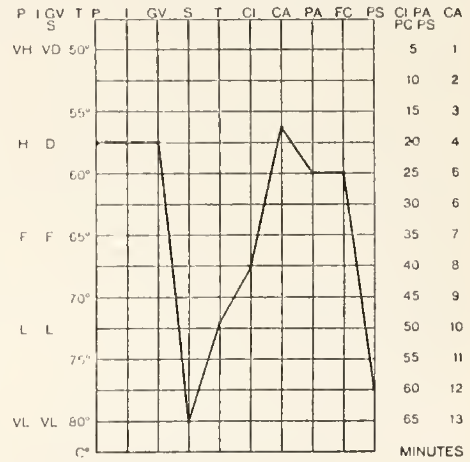
The *hilum* is a fairly distinct, medium-sized, round, non-refractive spot, usually not fissured; rarely a small transverse and longitudinal fissure may be seen. In some cases a distinct cavity at the hilum appears to communicate with the interior of the grain. The hilum is centrally or only slightly eccentrically placed. No double hila were present. One lenticular-shaped hilum was noted.

The *lamellæ* are in the form of distinct, regular, concentric rings. Those near the hilum are much more distinct than those near the margin, and one midway between the hilum and the margin and one quite near the margin are usually very distinct. Generally only those near the margin follow the marginal outline, the others being regular circular rings. They are comparatively fine and average about 8 in large grains.

The grains vary in *size* from 3 to 20μ. The common size is 12μ.

Polariscopic Properties.—The *figure* is centric or slightly eccentric and distinct. All the lines show equally well and are of equal distinctness throughout their length, except near the margin of the grain, where they usually become wider and less distinct; they tend to vary in width. At the facets there is often an appearance as of another figure, owing probably to the depression of the surface.

Chart No. 395.



Curve of Reaction-Intensities of Starch of Cycas circinalis.

The degree of *polarization* is high, about the same as in *C. revoluta.* It does not vary notably in the different aspects of the same grain, but there may be low degrees of polarization at the facets, probably due to a depression at this point. It varies in different grains.

With *selenite* the quadrants are sharply defined, of equal size, and regular in shape. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains are colored immediately and deeply a blue-violet; with 0.125 per cent solution the grains color at once lightly and the color deepens quickly. The depth of color is the same as that with *C. revoluta.* After heating in water until the grains are all completely gelatinized, the solution and the gelatinized grains color a fairly deep blue on the addition of iodine and many grains show a violet capsule on the addition of very little iodine. After boiling for 2 minutes, the solution colors more deeply, but the grain-residues color a very faint blue-violet. Some contain deep, blue-colored starch and all are much wrinkled, crumpled, and otherwise distorted.

Staining Reactions.—With *gentian violet* staining begins very lightly in 3 minutes and the grains are deeply and evenly stained a dull violet in 30 minutes. The depth of color is the same as with *C. revoluta.*

With *safranin* staining begins slightly in 4 minutes and in 30 minutes the grains are colored faintly and evenly, about the same as in *C. revoluta.*

Temperature Reaction.—The temperature of gelatinization is 71° to 73° C., mean 72°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins in some of the small grains in a minute and in the larger grains in 3 or 4 minutes. In 40 minutes almost all are completely swollen. The hilum is rendered prominent as a dark spot or bubble and the lamellæ become invisible. There occurs a darkening of irregular points on the margin, usually at the angles of the facets at the base, but sometimes on the rounded sides. These points protrude and from them the process extends all over the grain, causing a general swelling. The margin is usually affected before the central portion and in some grains it is the only part involved, in which case the grains have a blue, gelatinous ring in the form of many irregular, saccular projections surrounding a violet-colored, non-gelatinized, central mass. The gelatinized grains are not very large nor much distorted. The reaction affects a larger proportion of grains than in the starch of *C. revoluta*.

The reaction with *chromic acid* begins in 45 seconds and is over in 3½ minutes. The hilum becomes prominent, also the lamellæ. Fine striæ appear, which radiate from the hilum throughout the grain. The hilum swells and the marginal, ungelatinized portion of the grains forms a thick band, finely striated but not showing refractive and non-refractive rings. This band becomes dissolved at a given point, usually the angle of one of the facets, and the granular, gelatinous, semi-liquid starch inside flows out and is dissolved. The remainder of the band rapidly passes into solution.

Reaction with *pyrogallic acid* begins slightly in 1½ minutes and all the grains are completely gelatinized in 25 minutes. There appeared to be more reaction in grains outside the cover-slip than beneath it. The hilum and lamellæ are rendered more distinct. Some grains are invaded at the base by fissures, which extend from the margin and become gelatinized at these points, the rest of the grain meanwhile becoming covered by fine radial striæ. The hilum swells and a band of gelatinized starch forms at the margin, which band is finely striated, but not distinctly marked by alternate refractive and non-refractive rings. This part of the grain is transformed gradually to a thin, homogeneous, enveloping substance. The gelatinized grains thus formed are large and also somewhat distorted and folded if there has been any independent swelling at the base. As a rule, they retain much of the original shape of the grain.

With *ferric chloride* the reaction begins in some grains in a minute and is completed in 25 minutes. The hilum becomes prominent as a dark spot or bubble. The margin of the grains becomes clearer and darker, while the inner portion, which is very small, appears by contrast to be more opaque but lighter. A very rapid gelatinization of the more soluble portions of the grain occurs and then of the less soluble portions, the latter being located at the margin. Gelatinization is attended by great swelling; in some grains there is at first great swelling and protrusion from the angles of the facets, followed by gelatinization of the grain as a whole. The gelatinized grains are very large and ovoid in shape, and do not retain any of the original shape, but they are not much folded, invaginated, or crumpled.

With *Purdy's solution* the reaction begins in a few grains in 3 to 4 minutes and a very few are completely gelatinized in 1½ hours, although most are unaffected. The hilum and lamellæ become very prominent. The reaction consists, as in *C. revoluta*, in the appearance of fine striæ throughout the grain; the swelling of the hilum; the formation of a striated, peripheral band which shows more or less distinctly alternate refractive and non-refractive rings; the dissolution of this band; and the formation of a large, gelatinized grain which retains some of the original form, showing few wrinkles, lines, or distortions of any sort.

Differentiation of Certain Starches of the Genus Cycas.

HISTOLOGICAL CHARACTERISTICS.

Conspicuous Forms.

C. revoluta: Simple, few aggregates, pressure facets on most grains. Hemispherical to dome-shaped, round or nearly round and ovoid.
C. circinalis: The same as in *C. revoluta*, but with greater abundance of angular forms.

Hilum—Form, Number, and Position.

C. revoluta: Form distinct, medium-sized, round spot or cavity; sometimes fissured, fissures not extensive. Position centric or very slightly eccentric.
C. circinalis: Form and position the same as in *C. revoluta*.

Lamellæ—General Characteristics and Number.

C. revoluta: Distinct, regular, concentric, rather fine. About 10 on the larger grains.
C. circinalis: Same as in *C. revoluta*. About 8 on the large grains.

HISTOLOGICAL CHARACTERISTICS.—Continued.

Size.

C. revoluta: From 5 to 25μ, commonly 14μ.
C. circinalis: From 3 to 20μ, commonly 12μ.

POLARISCOPIC PROPERTIES.

Figure.

C. revoluta: Centric or very slightly eccentric, distinct cross; lines straight and vary in width.
C. circinalis: Same as in *C. revoluta*.

Degree of Polarization.

C. revoluta: High.
C. circinalis: High, the same as in *C. revoluta*.

Polarization with Selenite—Quadrants and Colors.

C. revoluta: Quadrants sharply defined, regular in shape, unequal in size. Colors pure.
C. circinalis: Quadrants the same as in *C. revoluta*. Colors usually pure.

Differentiation of Certain Starches of the Genus Cycas.—Continued.

IODINE REACTIONS.

Intensity and Color.

C. revoluta: Deep; blue-violet.
C. circinalis: Deep, the same as in *C. revoluta;* blue-violet.

STAINING REACTIONS.

With Gentian Violet.

C. revoluta: Deep.
C. circinalis: Deep, the same as in *C. revoluta.*

With Safranin.

C. revoluta: Very light.
C. circinalis: Very light, the same as in *C. revoluta.*

TEMPERATURE OF GELATINIZATION.

C. revoluta: 73 to 74° C., mean 73.5°.
C. circinalis: 71 to 73° C., mean 72°.

EFFECTS OF VARIOUS REAGENTS.

Reaction with Chloral Hydrate-Iodine.

C. revoluta: Begins in 1 to 3 or 4 minutes; complete in three-fourths in 45 minutes.
C. circinalis: Begins in from 1 to 3 or 4 minutes; complete in almost all in 40 minutes.

EFFECTS OF VARIOUS REAGENTS.—Continued.

Reaction with Chromic Acid.

C. revoluta: Begins in 30 seconds; complete in 5 minutes.
C. circinalis: Begins in 45 seconds; complete in 3½ minutes.

Reaction with Pyrogallic Acid.

C. revoluta: Slight reaction in 1½ minutes; complete in nearly all in 30 minutes.
C. circinalis: Slight reaction in 1½ minutes; complete in all in 25 minutes.

Reaction with Ferric Chloride.

C. revoluta: Begins in 3 minutes; complete in 25 minutes.
C. circinalis: Begins in 1 minute; complete in 25 minutes.

Reaction with Purdy's Solution.

C. revoluta: Begins in a few in 7 minutes; only a very few are completely gelatinized after 3 hours.
C. circinalis: Begins in a few in 3 to 4 minutes; only a very few are completely gelatinized in 1½ hours.

NOTES ON THE STARCHES OF CYCAS.

Histologically the two starches are practically identical and in the reactions they so closely correspond that such differences as have been recorded may fall within the limits of error of experiment.

GENUS DIOON.

The genus *Dioon* of Cycads includes two species, both natives of tropical Mexico. The best-known is *D. edule* Lindl.; *D. tomenosum* is a variable species. *Dioon* is stated to be the nearest of the *Cycadaceæ* to the fossil plants belonging to this family. A starch is prepared from the seeds and sold as a form of arrowroot. The starch used in this investigation was obtained from a specimen of *D. edule* obtained from the Botanical Garden of the University of Pennsylvania.

STARCH OF DIOON EDULE. (Plate 102, figs. 607 and 608. Chart 396.)

Histological Characteristics.—In *form* the grains are simple, with the exception of rare compound grains of few components. There are a few aggregates and small clumps. The majority have well-marked pressure facets. The grains are generally regular, but slight depressions and elevations of the surface are not infrequent, and occasionally a nipple-shaped process near the hilum or a pointed excrescence at either end of an ellipsoidal grain may be found. The most conspicuous forms are round, nearly round, dome-shaped, elongated ovoid, ovoid, pyriform, and ellipsoidal. There are also hemispherical, oyster-shell-shaped, polygonal and various irregular forms.

The *hilum* is observed as either a clear, round, or elliptical spot usually eccentric about one-third to one-sixth of the longitudinal axis, but centric in some of the round grains of fair size. The hilum is generally not fissured, but a delicate transverse or diagonal cleft may intersect it; or a small rounded cavity may be located at the hilum.

The *lamellæ* are often not demonstrable, but on some of the dome-shaped and ovoid grains it is possible to count 10 which are rather coarse, complete rings. The shell-shaped forms, which are few, have from 14 to 20 lamellæ appearing as indistinct, complete circles near the hilum, and which are probably incomplete and have the shape of the grain near the distal end.

The grains vary in *size;* the smaller are 3 by 2μ; the larger dome-shaped ones are 18 by 16μ; the large ovoid are usually 20 by 14μ, rarely 32 by 18μ, in length and breadth. The common size of the dome-shaped is 12 by 10μ and of the ovoid 12 by 8μ in length and breadth.

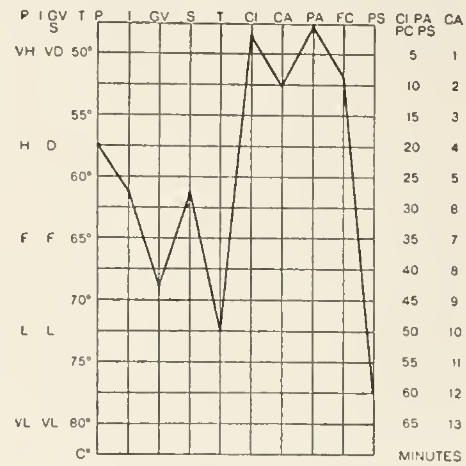
Polariscopic Properties.—The *figure* is usually eccentric. Its lines are rather broad, increasing in width as they near the margin of the grain, and they generally intersect obliquely. They may be straight, but often are bent and sometimes bisected.

The degree of *polarization* is high. There is a variation among the grains, some being much higher than others.

With *selenite* the quadrants are well defined, but generally unequal in size and irregular in shape. The colors are usually pure.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a fairly deep reddish-violet, which deepens rather slowly; with 0.125 per cent solution the grains color a light reddish-violet, which deepens rather slowly. After heating in water until all the grains are completely gelatinized and then adding iodine, the solution is colored a deep indigo-blue, the grains a deep blue with a reddish tint, and the capsules a reddish-violet to an old-rose. After boiling for 2 minutes the solution becomes more deeply colored, but the grain-residues of a much lighter color, on the addition of iodine. With an excess of iodine the grain-residues become a deeper blue and the capsules a deep old-rose to a wine-red.

Chart No. 396.



Curve of Reaction-Intensities of Starch of Dioon edule.

Staining Reactions.—With *gentian violet* the grains begin to color immediately. In 30 minutes the smaller grains, which are much more numerous, stain lightly, while the larger ones are fairly colored.

With *safranin* the grains begin to color immediately. In 30 minutes the smaller ones are fairly colored and the larger ones rather deeply.

Temperature Reaction.—The temperature of gelatinization is 72° to 73° C., mean 72.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* the reaction begins immediately. Some grains are gelatinized in a minute, nearly all in 1½ minutes, and all but rare resistant grains in 2 minutes. The reaction is complete in all in 4 minutes. The grains are colored a deep old-rose immediately and the hilum and fissures become very dark. Gelatinization begins at the distal end, accompanied by a deep bluish color which gradually spreads around the margin and then advances rapidly towards the hilum from the distal end until the entire grain is gelatinized and deeply colored. The gelatinized grains are swollen, but retain the shape of the untreated grain.

The reaction with *chromic acid* begins immediately. A few grains are dissolved in 30 seconds, nearly all in a minute, and all but parts of a few resistant grains in 2 minutes; the reaction is complete in these latter usually in 2½ minutes, rarely 3½ minutes. The hilum swells rapidly, and as the surrounding starch is gelatinized a mass of refractive granules appears and the outer lamellæ become very distinct and striated. The capsule ruptures at the distal end and solution of the exuding contents and capsule rapidly follows, a small area of outer lamellæ at the proximal end being the last to disappear.

Reaction with *pyrogallic acid* begins at once. A few grains are gelatinized in 15 seconds and all in 30 seconds. The hilum swells, and two longitudinal fissures, one on each side of the hilum, extend towards the distal margin. The part of the grain between these fissures is quickly gelatinized and the distal end swells and becomes distorted. The outer lamellæ at the sides and proximal end grow distinct and striated, and are more resistant, but soon gelatinize. The reaction is so rapid that the details can not be accurately determined. The gelatinized grains are much swollen and distorted.

The reaction with *ferric chloride* begins in a few grains in 30 seconds. A small number are gelatinized in 1½ minutes, more than half in 3 minutes, nearly all in 5 minutes, and all but rare resistant grains in 8 minutes. The reaction is usually complete in the latter in 10 minutes, rarely not until 20 minutes. The hilum and fissures become very distinct. A border which is lustrous and appears transparent forms marginally. Gelatinization usually begins at the distal end, accompanied by rapid distension of the capsule, and advances gradually towards the proximal end, at which point the resistant starch is broken into several large, refractive granules that are finally gelatinized. The gelatinized grains are much swollen and distorted.

The reaction with *Purdy's solution* begins in a few grains in 30 seconds. A small number are gelatinized in 5 minutes; about one-tenth are completely gelatinized and about half are partially gelatinized in 30 minutes. The hilum is swollen and the lamellæ become more distinct and striated, but in an hour there is no further progress. In the dome-shaped grains a longitudinal fissure passes from each side of the hilum to the corners of the distal margin and the grain is gelatinized between these fissures and at the distal end before the outer lamellæ at the sides and proximal end are affected. In ellipsoidal and ovoid grains the hilum swells and a single longitudinal fissure passes to the distal end. Gelatinization proceeds also more rapidly in these grains at the distal than at the proximal end.

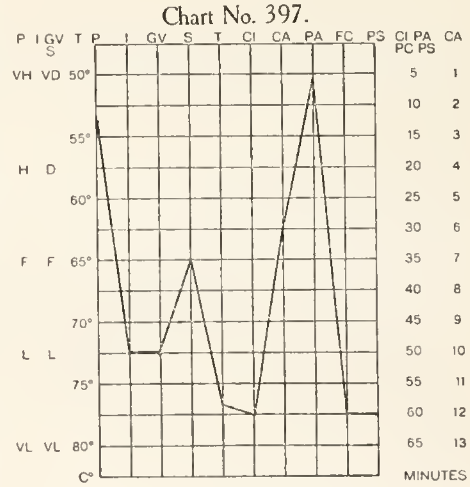
GENUS ZAMIA.

Zamia includes about 30 species, all natives of tropical and subtropical America. Florida species, *Z. floridana* DeCand. and *Z. pumila* Linn. (both frequently sold as *Z. integrifolia* Ait.), are important sources of a form of arrowroot known as comptie or Florida arrowroot (see *Marantaceæ*, p. 471). Starch was prepared from a specimen of *Z. integrifolia* obtained from the Botanical Garden of the University of Pennsylvania.

STARCH OF ZAMIA INTEGRIFOLIA. (Plate 102, figs. 609 and 610. Chart 397.)

Histological Characteristics.—In *form* the grains are simple with the exception of some compound grains of few components. There are a few aggregates and clumps. Well-marked pressure facets are found on some grains. The grains are often irregular as the result of depressions on the surface, of variations in the length of the sides, or of protuberances, chiefly in the form of a conical projection at the proximal end. The conspicuous forms are the almost round, ovoid, ovoid with distal end squared, dome-shaped, rounded triangular, and ellipsoidal. There are also hemispherical, lenticular, and various incidental forms.

Chart No. 397.



Curve of Reaction-Intensities of Starch of Zamia integrifolia.

The *hilum* may be observed as a clear, round, or elliptical spot, usually eccentric, even in some of the almost round grains. The eccentricity has a range of about one-sixth to two-fifths of the longitudinal axis. The hilum may be fissured by two diagonal clefts, which intersect and form a cross, or by an irregular group of ragged fissures. A small round or lenticular cavity may be observed at the hilum.

The *lamellæ* are not distinct, but in some grains from 8 to 14 may be counted. The lamellæ directly around the hilum, while usually not demonstrable, may be seen in the rounded grains to form complete circular rings throughout the grain. The outermost lamellæ in the rounded triangular and the dome-shaped grains have the shape of the outline of the grain.

The grains vary in *size;* the smaller are 6 by 5μ; the larger are 40 by 38μ in length and breadth. The common size of the nearly round forms is 16 by 15μ, of the ovoid 32 by 18μ, and of the dome-shaped 20 by 16μ in length and breadth.

Polariscopic Properties.—The *figure* is usually from slightly eccentric to quite eccentric, but it may be centric in some of the round grains of medium size. Its lines are rather broad and frequently intersect obliquely; they may be straight, but frequently are bent and otherwise distorted and sometimes bisected.

The degree of *polarization* is high to very high. The proportion of grains in which the polarization is very high is quite large. There may also be marked variations in the same aspect of a given grain.

With *selenite* the quadrants are well defined, but usually unequal in size and irregular in shape. The colors are generally pure, but there is a decided greenish tinge in many grains.

Iodine Reactions.—With 0.25 per cent Lugol's solution the grains color a light red-violet, which deepens somewhat slowly, some grains becoming much deeper than others; with 0.125 per cent solution they tend to color very lightly, the tint deepening very slowly. After heating in water until all the grains are gelatinized and then adding iodine, the solution colors a deep indigo-blue and the grains a fairly deep, brilliant indigo-blue, a few with a reddish tint. After boiling for 2 minutes and then treating with iodine, the solution becomes a very deep blue, while most of the grain-residues color very lightly, but a few fairly deep. The capsules become of a light reddish-violet color. With an excess of iodine the grain-residues color a deep reddish-purple and the capsules a deep heliotrope.

Staining Reactions.—With *gentian violet* the grains begin to color slightly immediately and in 30 minutes are lightly stained.

With *safranin* the grains begin to color slightly at once and in 30 minutes are fairly colored.

Temperature Reaction.—The temperature of gelatinization is 76° to 77° C., mean 76.5°.

Effects of Various Reagents.—With *chloral hydrate-iodine* reaction begins in a few grains immediately. A small number are gelatinized in 5 minutes, about one-tenth in 30 minutes, and about one-eighth in an hour. Only a few scattered grains color an old-rose at once, but gradually they take on this tint. The hilum becomes very distinct. As the clefts or the cavity sometimes found at the hilum swell, bubbles often are formed here which are expelled during the reaction. The deep blue color which accompanies gelatinization starts at the pressure facets of dome-shaped grains and gradually spreads. In grains in which a protuberance exists, the reaction starts at this point, while in round and nearly round grains a ring of dark blue color is formed marginally and gradually spreads over the entire grain. The gelatinized grains are uniformly swollen and retain the general shape of the untreated grain.

The reaction with *chromic acid* begins in a few grains in 30 seconds. A small number are dissolved in 3 minutes, nearly all in 6 minutes, and all in 10 minutes. The hilum swells and a branched longitudinal fissure proceeds from each side of the hilum towards the distal end. The lamellæ become sharply defined and striated, and are first gelatinized around the hilum and between the two longitudinal fissures. During gelatinization a great mass of refractive granules appears which gradually passes into solution. The grain continues to swell and finally the capsule is ruptured, usually at the distal end. The gelatinized starch gradually flows out and it and the capsule pass into solution.

Reaction with *pyrogallic acid* begins immediately. A few grains are gelatinized in 30 seconds, about three-fifths in a minute, about five-sixths in 5 minutes, and all but rare resistant grains in 6 minutes. The reaction is usually complete in these in 10 minutes, but rarely a grain may take 20 minutes for gelatinization. The hilum swells and a bubble appears, which enlarges and then gradually disappears as a succession of small bubbles is expelled. Usually either one or two large, branched, longitudinal canals pass from the hilum towards the distal end and the lamellæ become sharply defined and striated. As the starch is gelatinized a number of refractive granules appear, most of which are soon gelatinized. The reaction is more rapid at the distal than at the proximal end, where the lamellæ are comparatively resistant. In the round and nearly round grains, the starch is gelatinized without the formation of the large, branched fissures, but the reaction proceeds more rapidly from the distal to the proximal end than in the reverse direction. The gelatinized grains are much swollen and distorted.

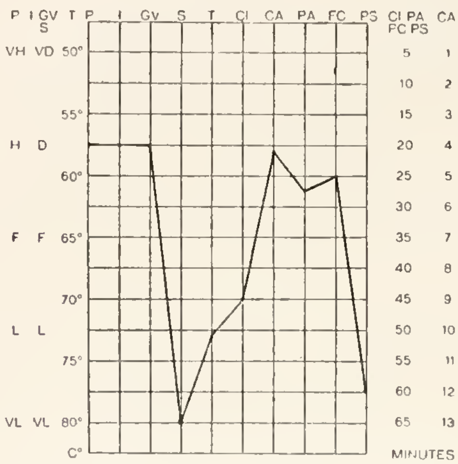
The reaction with *ferric chloride* begins in a few grains in 2 minutes. A small number are gelatinized in 5 minutes, very slight progress occurs in 30 minutes, and only a few grains are gelatinized even in an hour. The hilum swells and a large bubble usually appears, which is very persistent. A transparent, lustrous border forms marginally, which may increase in width until the entire grain is involved, followed by gelatinization. In other grains gelatinization begins at the distal end accompanied by rapid distension of the capsule at this point. When the reaction reaches the proximal end, the resistant starch here is broken into large granules, which are finally gelatinized. The gelatinized grains are swollen and distorted.

Reaction with *Purdy's solution* begins in a few grains in a minute and a very small number are gelatinized in 5 minutes. There is very little progress in 60 minutes, at the end of which time the reaction is complete in only a few grains. The hilum swells and the lamellæ become more sharply defined and striated. Usually one or two branched, longitudinal fissures pass from the hilum to the distal end. Gelatinization begins at the distal end, or in dome-shaped and hemispherical grains at the corners limiting the distal margin, and advances rather rapidly until near the proximal end, at which point the lamellæ are very resistant. Many refractive granules appear during gelatinization, which may persist for an hour, but in most of the very few grains that are affected they are finally gelatinized. The gelatinized grains are swollen and somewhat distorted, but many of them closely resemble the untreated grain in shape.

NOTES ON THE STARCHES OF CYCADACEÆ. (Charts 398 to 400.)

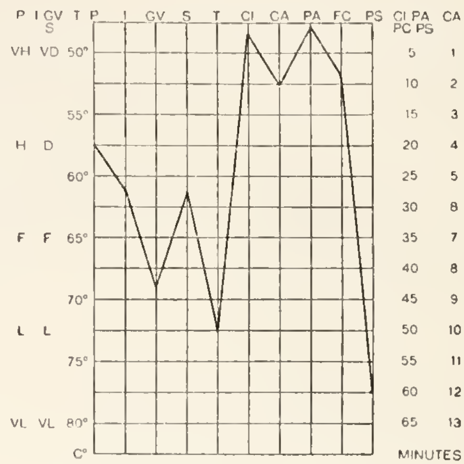
All the starches of *Cycadaceæ* belong to the same type. Those of *Cycas* and *Dioon* are so alike in all particulars that differentiation by gross histological characteristics seems impossible, but the starch of *Zamia* may readily be distinguished from those of *Cycas* and *Dioon* by the marked difference in size. By means of their reactions each genus can positively be differentiated one from the others, *Cycas* and *Dioon* being closer than either with *Zamia*.

Chart No. 398.



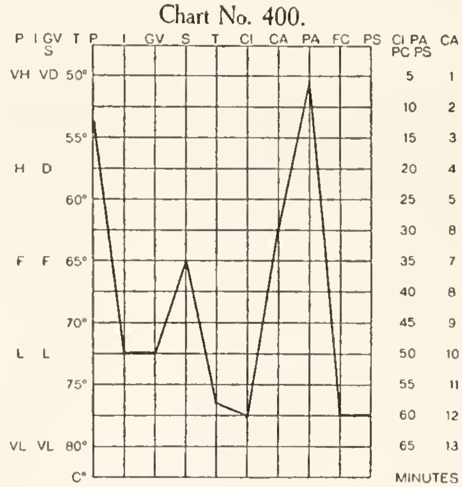
Curve of Reaction-Intensities of Starch of Cycas.

Chart No. 399.



Curve of Reaction-Intensities of Starch of Dioon.

Chart No. 400.



Curve of Reaction-Intensities of Starch of Zamia.

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