Anatomical Atlas of Vegetable Powders

Greenish and Collin

AN

Anatomical Atlas

OF

Vegetable Powders.

BY THE SAME AUTHORS.

THE

Microscopical Examination of Foods and Drugs.

A Practical Introduction to the Methods Adopted in the Microscopical Examination of Foods and Drugs in the entire, crushed, and powdered states.

BY

PROFESSOR HENRY GEORGE GREENISH.

LONDON: J. & A. CHURCHILL, 10s. 6d. net.

Précis de Matière Médicale.

Comprenant l'origine, les caractères extérieures, la structure anatomique, la composition chimique, les usages et les falsifications des drogues simples d'origine végétale ou animale.

BY

M. EUGÈNE COLLIN.

PARIS: OCTAVE DOIN, ÉDITEUR, 12 francs.

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OF

Vegetable Powders

Designed as an Aid to the Microscopic Analysis of Powdered Foods and Drugs.

By

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PREFACE.

DURING the past few years the anatomy of drug and the microscopical characters of powdered drugs and food-substances have attracted constantly increasing attention in this and other countries; and such studies now occupy an important place in the educational curriculum of pharmacists and analysts both in Europe and in America.

The works that deal with these subjects are few in number, and differ considerably in their treatment of the matter and in the character of the illustrations that form an indispensable accompaniment, but an atlas dealing with vegetable powders from an essentially practical point of view, provided with clear and accurate illustrations, and published at a price within the means of every student, was still a desideratum. We therefore willingly accepted the invitation of the Editor of the PHARMACEUTICAL JOURNAL to prepare a series of articles on the subject for insertion at intervals in the Journal. These articles have formed the basis of our "Anatomical Atlas of Vegetable Powders," which, however, has been rendered more complete by the addition of a number of drugs not treated of in the PHARMACEUTICAL JOURNAL.

Our thanks are due to the Council of the Pharmaceutical Society, and to the Editor of the PHARMACEUTICAL JOURNAL, not only for permission to reprint the articles published, but also for the unfailing courtesy which has been extended to us.

The subject matter has been divided into convenient sections, each of which is preceded by a brief discussion of the general structure of the drugs belonging to it. The anatomy of each individual drug is described, and the description followed by the enumeration in italics of the principal diagnostic characters. On the opposite page there will be found an illustration, in which the anatomical elements of the powder, especially those that serve to distinguish it from other powders, are reproduced with the greatest possible accuracy. The letters, etc., used in the illustration, together with their explanations, are arranged below it in alphabetical order.

We have endeavoured to figure only such tissues or elements, fragmentary or intact, as by their distinctive features or constant occurrence offer important and easily detected characters. We have avoided the reproduction of the various minute particles which, being found in many powders, do not assist in distinguishing one from the other. If the illustrations lack the artistic appearance of those in other similar works they are at least clear and accurate. Most of the drugs described are official in the British Pharmacopœia; those that are not, together with various starches, flours, etc., have been introduced to make the work more generally useful.

We trust that students of this fascinating subject will appreciate the object we have had in view, and welcome a work designed to guide them in one of the most intricate of their studies.

HENRY G. GREENISH.

EUGÈNE COLLIN.

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ANATOMICAL ATLAS

OF

VEGETABLE POWDERS.

INTRODUCTION.

The ever-increasing substitution of machinery for manual labour, and the facility with which water, gas, and steam power can be utilised in the preparation of pharmaceutical products, have considerably modified the conditions under which the profession of pharmacy is now exercised. The pharmacist living at a distance from great centres or not having such power at his command is often compelled to purchase various products from special laboratories working under favourable conditions. As a consequence, large manufacturing firms have come into existence, capable of supplying the pharmacist with many preparations equal to or even better than those that he could produce in his own laboratory.

But if the pharmacist is to entrust the manufacture of such preparations to industrial firms he must at least possess sufficient knowledge of them to enable him to identify them and detect sophistication. Among such products or preparations the vegetable powders occupy a prominent place.

Some of these powders, although used in pharmacy, are important chiefly as dietetic articles, such as the starches and flours; these may be called alimentary powders. Others, again, have a more decided medicinal value, and these may be called medicinal or officinal powders.

The starches, as their name indicates, consist almost entirely of starch grains, and seldom contain any of the *débris* of the cellular tissue in which they were contained. The flours and meals, on the other hand, especially those derived from cereals, have a more complex composition. Wheat flour, for instance, consists principally of starch, but it also contains the organic and inorganic constituents of the endosperm, as well as fragments of the seed-coats and pericarp of the grain. The identification of the flours depends, in great measure, upon the variations in the form and size of the starch grains they contain, but the tissues of the seed-coats and pericarps also exhibit notable features.

The officinal powders are much more numerous and more varied, as well as more complex in their composition. Their identification is attended with considerable difficulty, the more so as it requires a more or less complete knowledge of the structure of the drug that has been powdered. They may be divided into the following classes, according to the nature of the organ from which they have been prepared—viz., leaves, flowering tops, flowers, seeds, fruits, barks, rhizomes, roots and woods. Each of these classes possesses fairly well-marked distinctive characters.

The question may well be asked whether the vigorous grinding to which the drugs are subjected during the process of pulverisation does not crush and completely destroy the elements of which they consist, and thus render any morphological or anatomical study of them futile. It cannot be denied that the so-called impalpable powders are more difficult to identify than those prepared by the pharmacist in his own laboratory, but nevertheless each one of them contains certain elements that even the most prolonged trituration will fail to destroy and that serve to identify the powder.

During the pulverisation of a drug, the different layers of which it consists are usually separated as such from one another; thus parenchymatous, sclerenchymatous, and fibrous elements are separated from one another, but each of them retains its form and characteristics. But it often happens that even long-continued grinding fails to separate layers that abut upon one another. This may be frequently observed in the powders of fruits and seeds in which two, three, or even four layers may be found adhering together in the same relative position that they occupied in the original drug (linseed, pepper, wheat).

Thin-walled parenchymatous cells are frequently broken open by the trituration, and their contents are thus allowed to escape: this accounts for the presence in vegetable powders of isolated starch grains and calcium oxalate crystals, the various shapes of which often aid one in the identification of the powder. Elements of greater solidity, such as vessels, tracheids, and fibres are often not only separated from other elements, but broken into fragments; as, however, these elements are generally elongated and exhibit the same characters throughout the whole of their length, each fragment will usually preserve the distinctive features of the element of which it is a part.

Sifting does not appreciably complicate the identification of vegetable powders, as its action is usually confined to the separation of the larger particles of tissue from the smaller, and seldom results in the removal of isolated elements.

The microscope has long been used for the examination of the various starches and flours, but it is only within recent years that this method has been adopted for the identification of officinal powders. This advance had its origin in the recognition of the fact that external characters are not invariably reliable indications of identity, and that other more constant ones must be sought for in the anatomical structure; the change that has taken place in the conditions under which the profession of pharmacy is carried on has rendered such advance necessary.

The utilisation of the anatomical structure of a drug as a guide to its identification dates from 1847, when Schleiden, in his classical work on the sarsaparillas, showed that it was possible by this means to distinguish the commercial varieties from one another. Weddell in 1849, Howard in 1862, and others confined themselves to the examination of cinchona bark, but Oudemanns in 1854-56 published in his Commentary to the Dutch Pharmacopœia illustrations of the anatomy of official vegetable drugs.

In 1865 Berg's classical anatomical atlas appeared, and systematic work was more generally undertaken, as for instance in France by Planchon. These different authors, however, restricted themselves to describing the structure of the drugs and made no attempt to deal with their powders. The first to break ground in this direction was Vogl, and he was quickly followed by others. Tschirch contributed, in his 'Angewandte Pflanzenanatomie,' a number of valuable observations, which he has completed in his superb anatomical atlas. The latter work was the first to present a systematic account of the diverse appearance of the various anatomical elements in transverse, longitudinal, and surface section. The latter is especially valuable, as it is the aspect presented by the different elements in the powdered drug.

The first work that dealt specially with vegetable powders was Moeller's 'Pharmacognostischer Atlas,' in which, however, to a great extent large fragments or sections of the drug were represented rather than the elements as they occur in powders. At the same time Herlant produced in Brussels a work on officinal powders, in which he endeavoured to reproduce by photography the appearance of the principal powders used in pharmacy. It has, however, always appeared to us that a good drawing is to be preferred to a photograph. By the latter method starch, if present in quantity, may conceal important tissues, and at least two photographs would have to be made. Moreover, it must always be remembered that a drawing made to illustrate a vegetable powder consists of characteristic elements and tissues that have been selected from various parts of one slide, or even from several slides; they seldom or never occur in the field of the microscope at one and the same time, and therefore do not lend themselves to any mechanical method of reproduction.

Braemer and Suis have also published a work dealing with the leaves and illustrated in a similar way.

In 1893 one of us (E. Collin) published a little work entitled 'Guide Pratique pour la Détermination des Poudres Officinales,' in which an attempt was made to reproduce those elements of officinal powders that are characteristic and serve as means of identification. It was intended for the use of students of pharmacy, but the low scale upon which the drawings were made and the manner in which they were reproduced left much to be desired.

Finally, Koch is now publishing, under the title of 'Die Mikroskopische Analyse der Droguenpulver,' an atlas which will certainly be the most complete on the subject. Unfortunately, the high price at which it is issued places it beyond the reach of pharmaceutical students.

This was the principal reason that induced us to accept the invitation of the Editor of the *Pharmaceutical Journal* to publish a series of articles on the vegetable powders. We do not propose to write an elaborate treatise on the analysis of vegetable powders, but simply to describe and illustrate those elements that are characteristic of officinal powders, and thus to place within the reach of pharmaceutical students a series of studies and drawings that will enable them to identify the vegetable powders used in their profession.

The methods that are used for preparing these powders for microscopical examination are very simple. For starches it is sufficient to take a little from various parts of the specimen, so as to be sure of having an average sample, mix these in a watch glass and add a little dilute glycerin, stirring well with a glass rod. After the lapse of an hour the mixture may be again stirred, a drop transferred with the rod to a slide and covered with a coverslip. A simpler method still consists in transferring a little of the starch to a drop of water on a slide, well mixing and covering; in this case the preparation dries rather readily, but delicate markings are more clearly visible than they are in dilute glycerin. In either case great care must be taken that the quantity of starch is not too large in proportion to the quantity of medium in which it is mounted. If on examination the grains are seen to lie over one another, or even if they appear crowded, more of the mounting medium should be added or a fresh preparation made.

Many starch grains exhibit a delicate concentric striation, which, however, is often difficult to see; it may be made more visible by adding to the preparation one or two drops of a 2 per cent. aqueous solution of chromic acid.

In the case of flours it is often desirable to examine the structure of the particles of bran that it contains, as these frequently furnish valuable indications. This may be done by making a fresh preparation to which one or two drops of glacial acetic acid are added. The coverslip is dropped on and the slide warmed until the liquid begins to boil. By this means the starch is gelatinised and all the elements of the seed-coat and pericarp can be distinctly seen. The number of such particles present enables one to judge of the extent to which the sifting has been carried.

The procedure in the case of medicinal powders is practically the same, but it is advisable to allow the powder to soak in the dilute glycerin for twelve hours. Should starch be found, the shape and size of the grains must be observed, and at the same time the colour of the different elements in the powder should be noted. A little of the powder should then be boiled for a few moments in water to which a little caustic potash or soda has been added. After settling, the clear liquid should be poured off and the deposited powder examined, several slides of it being mounted. The treatment with alkali removes any starch that may be present, dissolves colouring matter, etc., and so clears the tissues, the latter effect being enhanced by the better expansion of the tissues under the influence of the alkali.

A strong solution of chloral hydrate (5 parts) in water (2 parts) often yields good service in clearing the tissues; a little of the powder should be mixed with two or three drops of the reagent and covered with a coverslip; it should then be raised to the boiling point for a few seconds and cooled. Or a little of the powder may be mixed with the reagent and allowed to stand for twenty-four hours before examination. It must, however, be always borne in mind that delicate markings are less easily seen in solution of chloral hydrate than either in dilute glycerin or water.

Measurements, when necessary, may be made with an ocular micrometer in the usual way.

SECTION I.

STARCHES.

(1) Wheat Starch.

Wheat starch (Fig. 1) is obtained from the fruits of several species of *Triticum*, as, for instance, *T. sativum*, Lam., etc. Like some other starches derived from cereal grasses it is distinguished by consisting principally of a mixture of a large number of very small grains with others of much larger size; intermediate grains are comparatively rare.

The small grains vary from 2μ to 8μ* in diameter, averaging about 6μ or 7μ; they are rounded or oval in outline, seldom polygonal or pointed.

The large grains in surface view appear sometimes rounded, sometimes slightly irregular or oval, but when, by touching the coverslip with the needle they are made to present their edges to the observer, they are seen to be flattened or lenticular in shape. They seldom exhibit any concentric striæ or evident hilum. They may attain as much as 45μ in diameter, but they average only 25μ to 35μ. In side view they are elliptical or sometimes spindle-shaped, and exhibit a longitudinal line that is always simple and usually straight or slightly wavy.

(2) Rye Starch.

Rye starch (Fig. 2) is contained in the fruits of the rye, *Secale cereale*, Linn. Like wheat starch it consists of a mixture of very small grains with large ones, together with a certain number of intermediate size. The large grains are discoid in shape, and often exhibit irregular protuberances, in consequence of which their side view is often less regularly fusiform or elliptical than it is in wheat starch. They average 40μ in diameter, but may attain 50μ and are therefore larger than the grains of wheat starch. Sometimes the concentric striæ are indistinct, sometimes they are easily visible. In the centre there is often a cavity with from three to five rays, and in such case the hilum is said to be stellate. Amongst the grains of medium and small size, hat-shaped and bell-shaped ones are to be found; these are very seldom seen in wheat starch. The small grains of rye starch are also rather larger than the corresponding grains of wheat starch; they vary from 3μ to 10μ in diameter.

* Measurements of microscopical objects are generally expressed in mikra a mikron, μ, is the one-thousandth part of a millimetre (0·001 Mm.).

PLATE I.

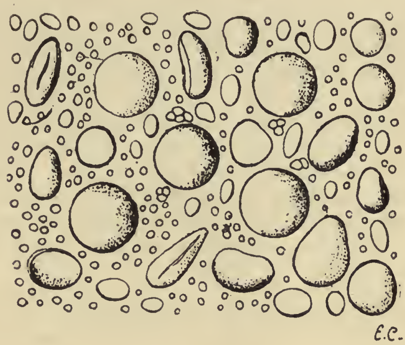

Fig. 1.—**Wheat Starch.**

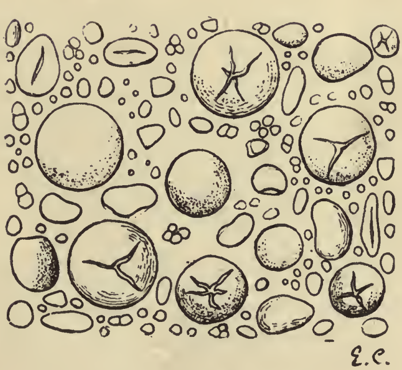

Fig. 2.—**Rye Starch.**

(3) Barley Starch.

Barley starch (Fig. 3) may be obtained from the fruits of *Hordeum distichon*, Linn., and other species of *Hordeum*.

Like both the preceding starches, barley starch also consists of a mixture of large and small grains, with few of intermediate size. They are rather smaller than the grains of wheat starch, and are also distinguished by their outline, which is less regular and often bears protuberances. In surface view the large grains are seldom round; they are more often slightly elongated or elliptical, sometimes reniform, bulb- or pear-shaped. In diameter they vary from 20μ to 35μ, many being between 20μ and 25μ. They have no apparent hilum, but some of them exhibit concentric striations. They are seldom fissured at the hilum, and when that is the case the fissure is much less conspicuous than it is in rye starch, and never stellate.

The grains of medium size vary from 10μ to 15μ in diameter, the small ones are about the same as those of wheat or rye-starch.

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(4) Maize Starch.

Maize starch (Fig. 4) is obtained from the fruits of the *Zea Mays*, Linn. The grains of maize starch exhibit a certain difference in shape according as they are derived from the mealy centre of the endosperm or from the translucent horny periphery.

Those from the centre of the grain, having been subjected in a less degree to mutual pressure, are irregularly rounded in shape, or at least not markedly angular; some are nearly round, others are elongated, oval or pear-shaped. The hilum is always rather large and conspicuous; the grains measure from 10μ to 25μ in diameter, the average being about 13μ to 15μ.

The grains from the horny part of the endosperm exhibit an angular contour due to the mutual pressure to which they have been subjected. Their appearance under the microscope varies considerably according to the position in which they lie. They are always easily recognised by their regular shape, angular outline, more or less uniform size, and, by the presence of a distinct hilum, which is sometimes rounded, but more often fissured, or stellate. The diameter of these grains averages from 14μ to 15μ but may sometimes reach 25μ or 26μ.

PLATE II.

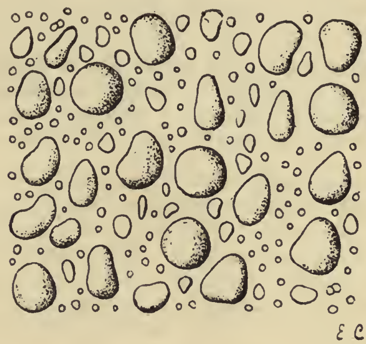

Fig. 3.—**Barley Starch.**

Fig 4.—**Maize Starch,**

(5) **Oat Starch.**

Oat starch (Fig. 5) is contained in the fruits of *Avena sativa*, Linn. It consists of two kinds of grains, viz., simple and compound.

The simple grains average about 10μ in diameter. They are mostly rounded in outline; very few are angular, but some are spindle-shaped or lemon-shaped. The latter should be specially noted as they form a distinctive feature of oat starch.

The compound grains are oval or rounded and more or less regular in shape, ranging usually from 35μ to 45μ in length, but attaining as much as 50μ. They consist of a varying number (5 to 200) of grains compacted together. The constituent grains vary in shape according to the position they have occupied in the compound grain. Those from the centre are angular, whilst those from the periphery are curved on one side and angular on the other; they are generally rather smaller than the simple grains.

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(6) **Rice Starch.**

Rice starch (Fig. 6) is obtained from the fruits of *Oryza sativa*. Linn. Like oat starch, it consists of both simple and compound grains.

The simple grains are tolerably uniform in size and shape; they range from 4μ to 6μ, sometimes reaching 8μ, and are generally angular.

The compound grains are ovoid or rounded in shape, but vary very much in size, according to the number of constituent grains that they contain.

Rice starch closely resembles oat starch; the grains are, however, uniformly rather smaller and never spindle- or lemon-shaped, When treated with water the compound grains are readily dissociated into their constituent grains, and so it happens that the former are seldom found in the rice starch of commerce.

PLATE III.

Fig. 5.—**Oat Starch.**

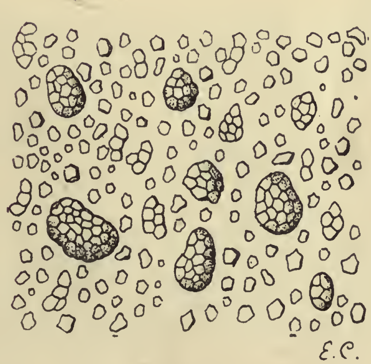

Fig. 6.—**Rice Starch.**

(7) **Potato Starch.**

Potato starch (Fig. 7) is obtained from the tubers of *Solanum tuberosum*, Linn. It is composed of grains of variable size, some being so large as to be visible to the naked eye. Typical grains of this starch are flattened, and have an oval, ovate, ellipsoidal or conchoidal outline. The hilum is punctiform, eccentric, and generally situated in the narrow end of the grain; it is surrounded by numerous distinct concentric striations, some few of which are much more conspicuous than the others. In addition to these typical grains there are a few others, smaller in size and rounded in outline, or rounded on one side and flattened on the other, these are sometimes attached by their flat sides in twos or threes.

The largest grains vary in length from 75μ to 110μ, those of medium size from 45μ to 65μ, and the smaller ones from 15μ to 25μ.

(8) **Maranta Starch.**

Maranta starch (Fig. 8) is obtained from the rhizomes of *Maranta arundinacea*, Linn., and other species of *Maranta.* It is commonly known in commerce as "arrowroot," a term, however, which is also applied to the starches of other and widely different plants.

The different varieties of arrowroot are distinguished by their geographical sources. Maranta starch is known as Bermuda, St. Vincent, West Indian or Natal arrowroot, according to the country in which it is prepared.

The grains of the Maranta starch are simple and rather large. They are irregular in shape, being rounded, ovoid, pear-shaped or sometimes almost triangular; the smallest ones are nearly spherical The largest bear numerous fine concentric striations, and a conspicuous rounded, linear or stellate, eccentric hilum. In some varieties of arrowroot (Natal) the rounded hilum predominates, in others (St. Vincent), the linear or stellate; it often resembles the wings of a poised bird. They average about 30μ to 40μ in length, but may attain to 45μ, 60μ, or even 75μ, as, for instance, in Bermuda arrowroot; the smaller grains vary from 7μ to 15μ.

PLATE IV.

Fig. 7.—**Potato Starch.**

Fig. 8.—**Maranta Starch.**

(9) Curcuma Starch.

Curcuma starch (Fig. 9) is obtained from the rhizomes of *Curcuma angustifolia*, Roxb., *C. leucorrhiza*, Roxb., and other species of *Curcuma*. It is more commonly known in commerce as East Indian arrowroot.

The grains of which this starch is composed are oval, elliptical, almost rectangular or rounded in outline. At one of their extremities they usually terminate in a short obtuse point in which the very eccentric punctiform hilum is situated, surrounded by concentric striæ. The grains are so thin that when viewed on their edges they appear extremely narrow; several may often be seen in this position adhering together by their flat sides. Mixed with these larger grains are smaller ones of similar shape.

Curcuma starch grains average from 30μ to 60μ in length, 25μ to 35μ in breadth, and 7μ to 8μ in thickness. The length of the smallest grains scarcely exceeds 15μ to 25μ, but the largest grains from *C. leucorrhiza* may attain as much as 140μ.

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(10) Tous les Mois Starch.

This starch (Fig. 10), which is also known as Queensland arrowroot, is obtained from the rhizomes of *Canna edulis*, Linn., and other species of *Canna*. The grains of which it consists are so large as to impart a satiny-white appearance to the starch. The majority are seldom less than 60μ or 70μ in length, whilst the largest occasionally reach 110μ to 130μ. They are usually simple and are elliptical, slightly oval, conchoidal, or sometimes reniform in outline; they are flattened and often prolonged at the narrower end to a short obtuse point in which the rounded hilum is situated, surrounded by concentric striæ.

PLATE V.

Fig. 9.—**Curcuma Starch.**

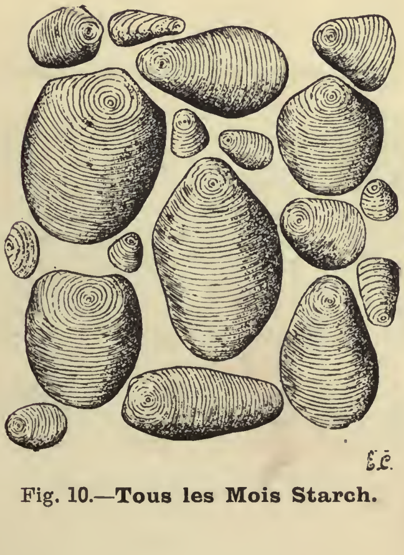

Fig. 10.—**Tous les Mois Starch.**

(11) **Dioscorea Starch.**

This variety of starch (Fig. 11) is obtained from *Dioscorea alata*, Linn., and other species of *Dioscorea*. It is often referred to as British Guiana arrowroot, but is better termed dioscorea starch. The largest of the grains of which it is composed measure 45μ to 90μ in length and 25μ to 60μ in breadth, while the smaller vary from 15μ to 30μ in length and about half that in breadth. In outline they are very variable, being often oval or elliptical, three-sided, with rounded angles, or sometimes curved. The larger extremity is often truncate and in the opposite narrower extremity the hilum is situated ; this is rounded, eccentric and surrounded by concentric striæ.

(12) **Banana (or Plantain) Starch.**

This is obtained from the unripe fruits of *Musa sapientum*, Linn., and has also been offered in commerce as Guiana arrowroot. The grains are simple and show a great variation in outline ; some are oval, ellipsoidal or elongated, whilst others are curved, bottle-shaped, bean-shaped, etc. They are always flattened, and therefore appear narrow and sausage-shaped when presenting their edges to the observer. The hilum is rounded, situated near one extremity and surrounded by concentric striæ. The largest grains measure 45 to 65μ, the smallest about 7μ, intermediate grains from 22 to 34μ.

The fruits from which the starch is prepared are often distinguished as plantains, and the plant yielding them is sometimes distinguished by the name *Musa paradisiaca*, Linn.

PLATE VI.

Fig. 11.—**Dioscorea Starch.**

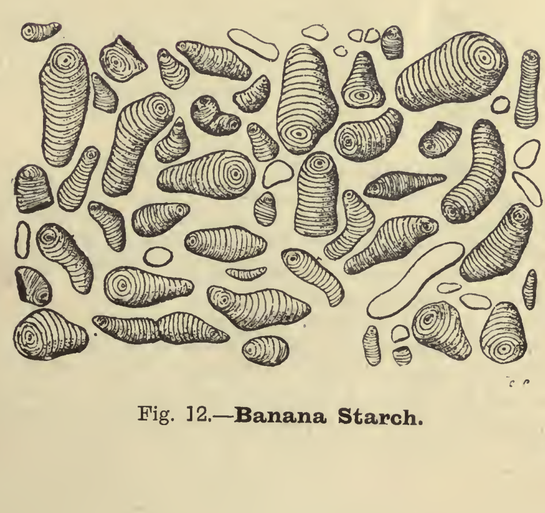

Fig. 12.—**Banana Starch.**

(13) Manihot Starch.

This variety of starch (Fig. 13) is obtained in large quantities from the tubers of *Manihot utilissima*, Pohl, and other species os *Manihot*. It is also known under the name of cassava starch, mandioc starch, Brazilian, Bahia, Rio or Para arrowroot, etc. The majority of it is converted into tapioca (see below) before exportation.

The grains are originally compound, consisting of two, three, or four component grains, and are occasionally found intact. Most of them, however, have been separated into their component grains. They are seldom quite round. Most of them exhibit one or two flat surfaces where other of the constituents of the compound grain have been attached, and are in consequence muller-shaped, cap-shaped, or shortly conical, curved on one side and irregular on the other, etc.; some are even polygonal. The majority possess a distinct rounded, linear or stellate hilum and delicate concentric striations. The largest measure 25 to 35μ in length, the smallest 5 to 15μ; many range from 15 to 25μ.

(14) Tapioca.

This substance is prepared from manihot starch, by heating and stirring the moist starch until it agglomerates into the little irregular, rugged masses that are known in commerce as tapioca; it is usually exported in this form, and constitutes an important article of food.

The granules of tapioca soften when soaked in water for a few hours, and a small portion, taken preferably from the whiter and more opaque part, can be broken up with the needles in a drop of water and covered with the coverslip, a little pressure being applied if necessary.

Many of the grains will be seen to have preserved their original shape, and exhibit a distinct hilum; in many the hilum is stellately fissured; in others the central part of the grain is a translucent mass, but the outline is still recognisable; whilst finally many have swollen into a shapeless, unrecognisable mass. These are the various stages in the gelatinisation of the starch by heat in the presence of moisture.

(15) Starch of Ipomœa Batatas.

Under the name of Brazilian arrowroot there is also found in commerce the starch of *Ipomœa Batatas*, Poir. (Fig. 15). The grains are for the most part isolated components of compound grains, but they sometimes occur in groups of two to four. They are very variable in size, the large grains measuring from 25 to 50μ, the small from 15 to 22μ. They also vary greatly in shape. A few are rounded, some are conical; others resemble a sugar-loaf cut obliquely, others again are cap or bell-shaped, or even polyhedral. They almost all exhibit a distinct hilum, which is sometimes stellate, sometimes fissured, usually eccentric, and surrounded by striæ.

PLATE VII.

Fig. 13.—**Manihot Starch.**

Fig. 14.—**Tapioca.**

Fig. 15.—**Starch of Ipomœa Batatas**

(16) **Arum Starch.**

This starch, formerly obtained at Portland from the rhizomes *Arum maculatum*, Linn., and known as Portland arrowroot, is no onger an article of commerce. It is, however, still prepared in Southern Europe and Northern Africa in small quantity from *A. maculatum* and other species of *Arum.*

The grain of arum starch are originally compound, but they generally occur isolated in the dry starch. Most of them, therefore, possess one or more flat surfaces. Some are hemispherical or conical, others curved on one side and provided with two flat surfaces on the other. The large grains seldom exceed 21μ in length; many grains measure from 7 to 15μ, and the smaller ones, 3 to 7μ.

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(17) **Tacca Starch**

Is obtained from the tubers of *Tacca pinnatifida*, Linn., and is also known as Tahiti arrowroot.

The grains vary both in size and shape. Typical ones are rounded, oval or even lenticular; some are elliptical, almost triangular, etc. The hilum is generally fissured, situated near the centre of the grain, and surrounded by concentric striæ. The larger grains measure 38 to 50μ, the smaller 15 to 25μ.

PLATE VIII.

Fig. 16.—**Arum Starch.**

Fig. 17.—**Tacca Starch.**

(18) **Sago Starch.**

Sago starch is obtained from the stem of the sago palm, *Metroxylon Sagu*, Rottb. and allied trees.

The form of the grains of sago starch varies according as they are simple or compound. Simple grains are oval, rounded, etc.; but the compound grains have a very remarkable shape. Each of these usually consists of a large grain to which 1, 2 or 3 small ones are attached. The large grain is conical or muller-shaped, and frequently bears one or two projections, to the flat ends of which the smaller grains have been attached; sometimes these two flat surfaces meet to form an angle.

The largest grains measure 50 to 65μ in length, the smallest 10 to 20μ. The hilum is very distinct, linear, transverse or oblique, sometimes stellate and usually surrounded by distinct striæ.

Commercial sago starch often contains débris of vegetable tissue, etc., left in it by the imperfect washing it has undergone. Sclerenchymatous cells, hairs and crystals may thus be found in it.

(19) **Pearl Sago.**

Genuine or East Indian sago (pearl sago) is largely prepared in Singapore from sago starch.

The starch is converted into sago by heating it whilst moist, as described under tapioca. Several varieties occur in commerce, differing in source and appearance.

Pearl sago, when examined under the microscope, exhibits starch grains in various stages of transformation, induced by the heat to which they have been subjected. Some of them have preserved their original shape and can be easily identified. Many are more or less altered; in some the central portion has been gelatinised and is transparent and homogeneous; others have swollen to an unrecognisable gelatinous mass.

PLATE IX.

Fig. 18.—**Sago.**

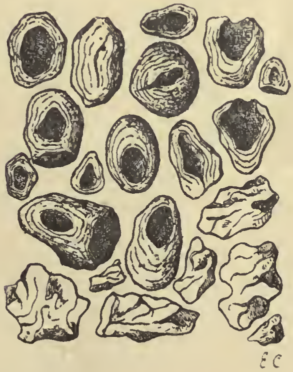

Fig. 19.—**Pearl Sago.**

SECTION II.

FLOURS.

Attention has already been directed to the difference in composition between starch and flour ; under the latter heading we propose dealing with the principal cereal flours that serve as food-stuffs for civilised peoples.

The determination of the quality and purity of the various flours is a matter of great importance and of some difficulty, often demanding considerable skill and experience. The microscopist may not be able to pronounce an opinion as to the nutritive value of a flour submitted to him, but he can obtain valuable information which should always supplement a chemical examination. In any case, microscopical examination can alone detect the admixture of one flour with another, and that is the form that adulteration usually takes. The most common of such admixtures is that of rye, maize, or rice flour with wheat flour.

The principal factor in the identification of a flour is the form and relative size of the grains of starch which it contains, but it is nevertheless absolutely necessary for the microscopist to be acquainted with the structure of the vegetable débris that are usually to be found in it, as these also furnish valuable indications of identity; moreover, he must avoid the error of attributing these to foreign substances, the presence of a limited proportion of the débris of the pericarp and seed coats being always tolerated in commercial flours.

(20) **Wheat Flour.**

A transverse section of a grain of wheat, examined under the microscope, exhibits the following layers :—

(1) *Outer epidermis* of the pericarp, composed of tabular cells which, in surface view, are polygonal, elongated, and have *thickened, pitted walls.* In the upper part of the grain it bears simple, unicellular, conical hairs, the lumen of which is somewhat abruptly enlarged at the base.

(2) *Hypoderma,* consisting of cells which, towards the exterior, closely resemble those of the outer epidermis, but in the inner part vary in form and often lignify.

(3) A layer of *transverse cells ;* these are tangentially elongated and have *thickened, pitted walls.*

(4) *Inner epidermis* of the pericarp, consisting of small cells with rounded section, but elongated in surface view; their tube-like appearance has gained for them the name of *tubular cells.* These four layers constitute the pericarp of the grain.

(5) Seed-coat or *brown layer* composed of two layers of cells closely applied to one another, and of a yellow or yellowish-brown colour.

(6) *Hyaline* layer; a layer of rectangular cells with small, narrow lumen.

(7) Proteid or *aleurone layer;* a single layer of cubical cells with very thick walls, and filled with a granular substance.

(8) *Endosperm,* consisting of polygonal cells filled with starch, the characters of which have already been described.

To whatever degree of fineness the flour may have been reduced it always contains portions of the pericarp and seed-coats in addition to the starch, although the latter, of course, constitutes by far the greater portion.

The diagnostic characters of wheat flour are :—

(a) *The shape and size of the large starch grains.*

(b) *The hairs, with lumen enlarged at the base, but in the upper part rather narrower than the wall.*

(c) *The thick-walled, pitted cells of the hypoderma.*

(d) *The thick walled, pitted transverse cells.*

PLATE X.

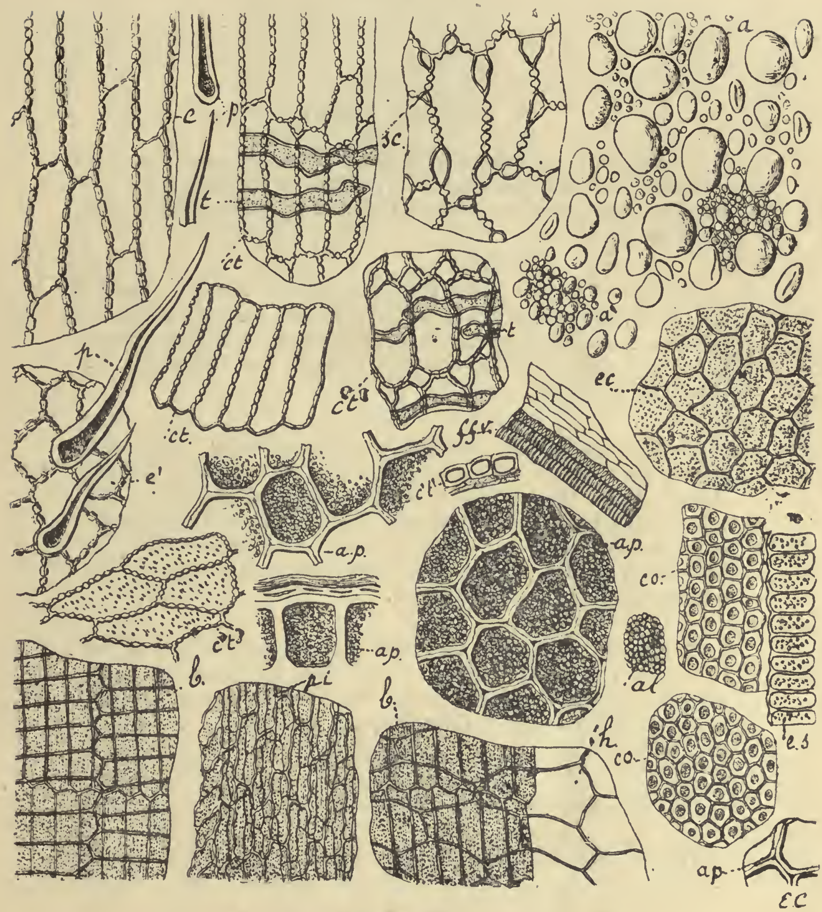

Fig. 20.—**Wheat Flour.** (× 240.

a, a′, Starch grains *without evident hilum, larger than barley starch, smaller than rye starch.*
al, Aleurone.
ap, Aleurone layer.
b, Brown layer.
co, Débris of cotyledon.
ct, *Transverse cells with pitted walls,* surface view.
c′ t′, *Transverse cells,* section.
e, e′, Outer epidermis of pericarp with *thickened and pitted cell walls*
ec, Scutellum.
es, Epidermis of scutellum.
ffv, Débris of the fibro-vascular bundle of the raphe.
h, Cells of the hyaline layer.
p, Hairs, entire or broken, *with lumen rather abruptly enlarged at the base.*
pi, Cells with brown pigment.
sc, Lignified cells of the hypoderma with *pitted walls.*
t, Tubular cells, surface view.

(21) **Rye Flour.**

The anatomical structure of the rye grain closely resembles that of wheat. The principal diagnostic features of the flour are to be found in the appearance of the hairs and in the size and characters of the starch grains.

The hairs of rye have about the same shape as those of wheat; they differ, however, in the lumen, for in the rye this gradually enlarges from apex to base, whereas in the wheat it is nearly linear in the upper part, and then suddenly enlarges and becomes bulb-shaped at the base.

Rye starch, as already observed, is generally larger than wheat starch, and there are always some grains that possess a distinct stellate hilum. It must not be imagined that all the grains will exhibit this feature, but it is safe to assert that in every sample of rye starch there will be found a notable proportion that show it. Rye starch is also characterised by the presence of a perceptible number of small bell-shaped grains.

There is also a difference in the shape of the lignified cells of the hypoderma; these are usually longer than the transverse cells, whereas in wheat they are shorter. The transverse cells are also more frequently rounded at the ends, and have thinner walls than they have in wheat.

The diagnostic characters of rye flour are :—

(a) *The hairs with less abruptly enlarged lumen and thinner walls than in wheat.*

(b) *The transverse cells which have thinner walls and fewer pits. they are mostly shorter than the hypoderma cells, and often rounded at the ends, where the walls are also rather thicker.*

(c) *The starch grains which are rather larger than those of wheat and often show a stellate hilum and concentric striæ.*

PLATE XI.

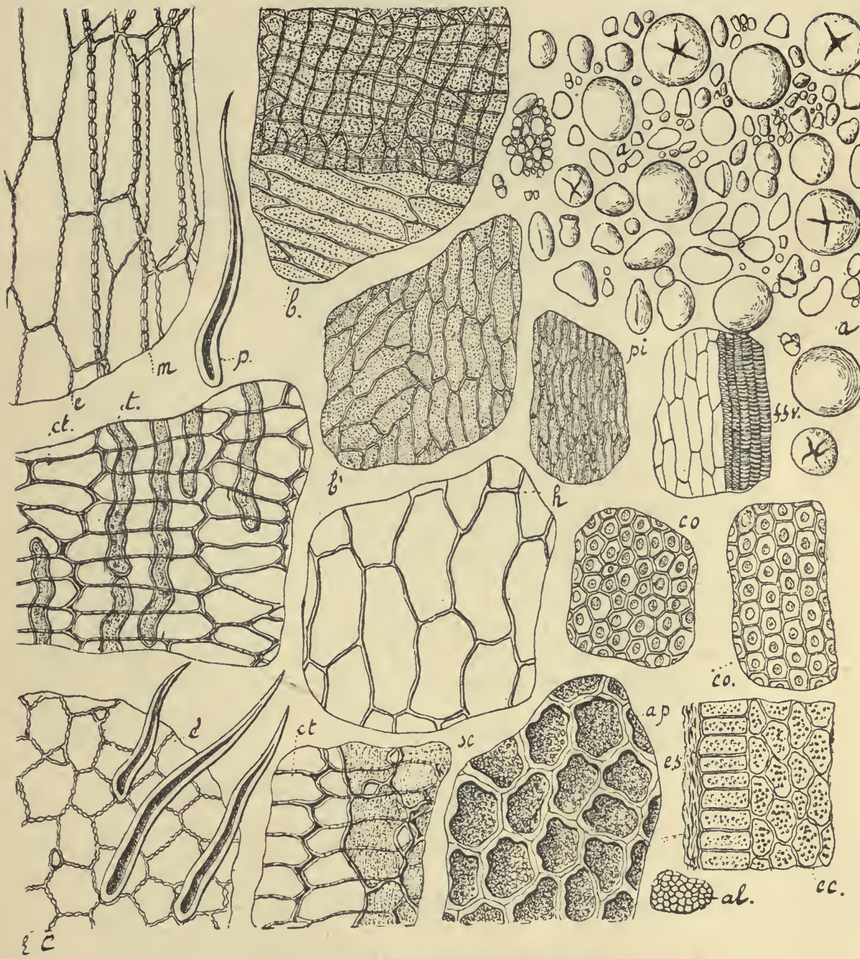

Fig. 21.—**Rye Flour.** (× 240.)

a, Starch the grains are *larger than those of wheat*, and often show a *stellate hilum.*
al, Aleurone.
ap, Aleurone layer.
b b′, Brown layer.
co, Cotyledon.
ct, Transverse cells; *the cell walls are thinner and less pitted than those o wheat.*
e, e′, Epidermis of the pericarp with *pitted cell walls.*
ec, Scutellum.
es, Epidermis of scutellum.
ffv, Fibrovascular bundle of the raphe.
h, Hyaline layer.
m, Hypoderma.
p, Protective hair.
pi, Pigment cells.
sc, Sclerenchymatous cells, *less abundant than in wheat.*
t, Tubular cells.

(22) **Barley Flour.**

In many respects barley resembles wheat and rye in its anatomical structure. One of the principal differences is to be found in the hairs which have a larger lumen than those of either wheat or rye. The walls of the epidermal cells of the pericarp are not pitted, nor are they so thick as those of the two latter grains. The aleurone layer invariably consists of two or three rows of cells, whereas in the wheat and rye there is only one row.

The grains of barley starch are smaller than those of wheat, and much smaller than those of rye. They are less regular in shape, and frequently *reniform*, but these characters are difficult even for an expert to determine, and the detection of barley flour when mixed with wheat or rye flour is very difficult. There is, however, one peculiarity that may facilitate the identification of barley flour. The barley grain is enclosed between two paleæ, and these adhere so firmly to the pericarp of the fruit that it becomes very difficult to effect their complete removal, especially from the groove on the ventral surface of the grain. The result is that barley flour often contains traces of the débris of the paleæ, and these are easily identified by the very remarkable sinuous walls of the outer epidermal cells, and by the little hairs on the inner epidermis. The double or triple layer of aleurone cells should also be searched for.

The diagnostic characters of barley flour are :—

(a) *The epidermal cells of the paleæ with thickened, sinuous walls.*

(b) *The hairs on the inner epidermis of paleæ.*

(c) *The thin-walled and not pitted epidermal cells of pericarp.*

(d) *The aleurone layer of two or three rows of cells.*

(e) *The starch grains, which are rather smaller than those of wheat, and often more irregular in shape.*

PLATE XII.

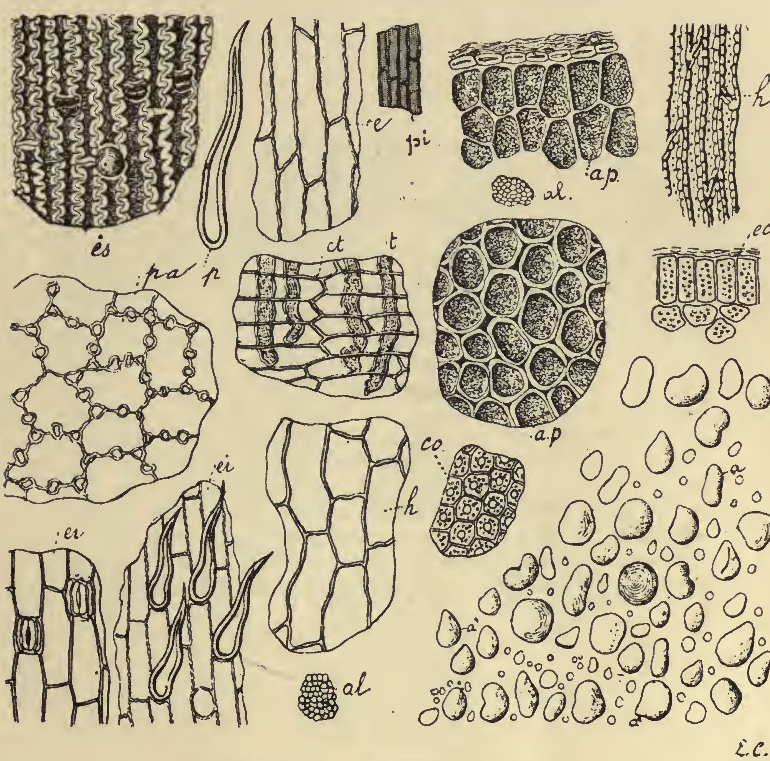

Fig. 22.—**Barley Flour.** (× 240.)

a, a', Starch grains, *smaller than those of wheat, and often reniform or exhibiting protuberances.*

al, Aleurone.

ap, Aleurone layer, *with two or three rows of cells.*

co, Cotyledon.

ct, Transverse cells.

e, Epidermis of pericarp.

ec, Scutellum.

ei, Inner epidermis of palea, *with little hairs.*

es, Outer epidermis of palea, *with sinuous cell walls.*

ffv, Fibro-vascular bundle of raphe.

h, Fibrous hypoderma of palea (in upper right corner of plate).

h, Hyaline layer.

p, Hairs on the epidermis of pericarp.

pa, Parenchyma of palea, *with intercellular spaces.*

pi, Pigment cells.

t, Tubular cells.

(23) **Oat Flour.**

The oat grain is also enclosed between two paleæ which may furnish valuable means of identifying the flour. The grain may also be distinguished from the three foregoing grains by the following characters :—(1) By the *elongated shape of the hairs which are also often geminate.* (2) By the *cells of the outer epidermis* of the pericarp, which have very thin walls and fairly numerous pits. (3) By the irregular polygonal shape of the *cells of the hypoderma*, of which, however, there is but little to be found. (4) By the *cells of the seed coat*, of which there is only a single row; they are polygonal or fusiform in shape, pale yellowish-brown in colour; their walls are smooth and seldom pitted, and the cells often exhibit an irregular arrangement. (5) By the *starch* which consists of small simple rounded grains associated with a number of large oval compound grains and the isolated angular constituent grains of the latter.

PLATE XIII.

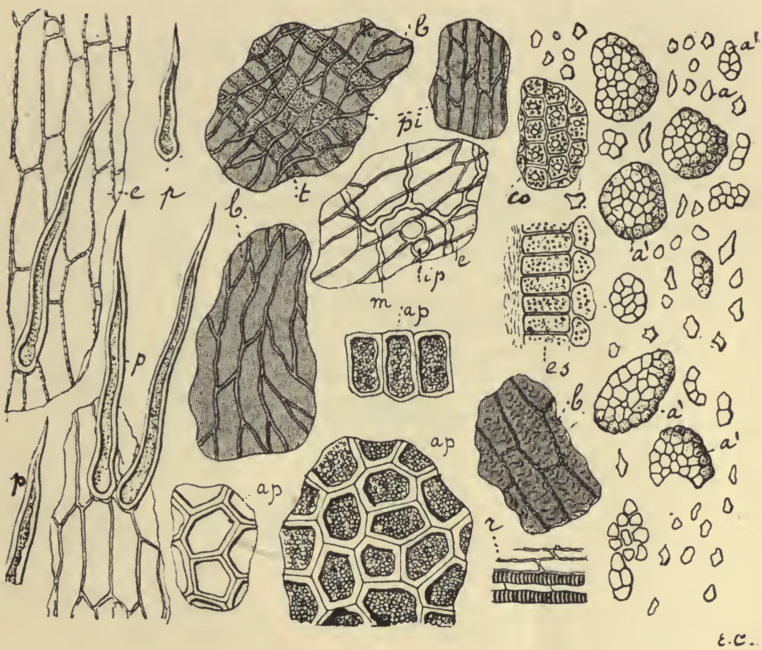

Fig. 23.—**Oat Flour.** (× 240.)

a, Starch grains, some of which are irregularly rounded, more often *angular fusiform*, or *with sharp edges.*

a′, Compound starch grains, *mostly entire, sometimes more or less broken up.*

ap, Aleurone layer.

b, Brown layer; the cells are fusiform, and *very irregular in direction.*

e, Epidermis of the pericarp *with thin cell walls, sometimes with, sometimes without pits.*

es, Epidermis of scutellum.

ip, Point of insertion of hairs.

m, Débris of the hypoderma.

p, Protective hairs, *often geminate,* and often much longer and narrower than those shown in the illustration.

pi, Pigment layer.

r, Fragments of raphe.

t, Tubular cells.

(24) **Rice Flour.**

In the rice flour of commerce there is only a very small proportion of the seed-coats of the grain, and the chief characters are therefore to be found in the size and shape of the grains of starch of which it almost entirely consists. These are as follows:—(1) *Small simple polyhedral grains.* (2) *Large or small compound grains*, oval or rounded in shape, and varying in size according to the number of constituent grains. (3) *Fragments of the above* of varying shape. (4) *Masses of starch* from the cells of the endosperm, or masses of several cells together.

The vegetable débris to be found in rice flour are only a few very narrow tubular cells closely attached to a layer of very small elongated cells. A knowledge of these characters is very desirable as the adulteration of wheat flour with rice flour is frequent at times.

PLATE XIV.

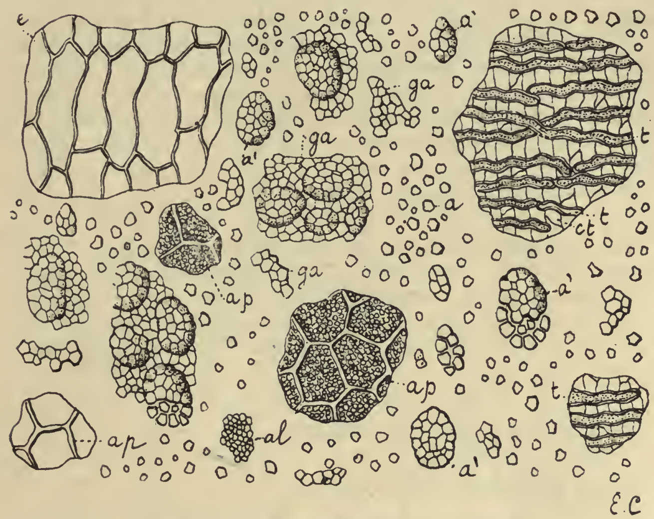

Fig. 24.—**Rice Flour.** (× 240.)

a, Starch, *very small simple grains.*
a', *Compound starch grains.*
al, Aleurone.
ap, Aleurone layer.
ct, Transverse cells.
e, Outer epidermis of pericarp.
ga, Masses of starch, composed sometimes of simple grains, sometimes of simple and compound grains.
t, Tubular cells, *very delicate and numerous and close together.*

(25) Maize Flour.

The anatomy of the grain of maize is analogous to that of the fruit of other cereal grasses; it is characterised by the following particulars:—Below the epidermis of the pericarp are two layers of cells that exhibit marked differences, those of the one having *pitted* and *relatively slightly thickened walls*, those of the other being smooth and relatively strongly thickened. Within these layers is one of *irregular cells with lacunæ* (transverse cells), and next to this the tubular cells that form the inner epidermis of the pericarp. The *tubular cells are smaller, more numerous, and closer together than they are in wheat.* During the ripening of the grain the seed-coats disappear almost entirely.

Maize starch is well characterised by the shape and size of the grains, those from the outer horny part of the endosperm being polyhedral and angular, whilst those from the inner mealy part are rounded. The details given under "Maize Starch" (see before) allow of this flour being easily distinguished from that of other cereals.

The diagnostic characters of maize flour are:—

(a) The *characteristic starch grains.*

(b) The *hypoderma.*

(c) The *numerous small tubular cells.*

PLATE XV.

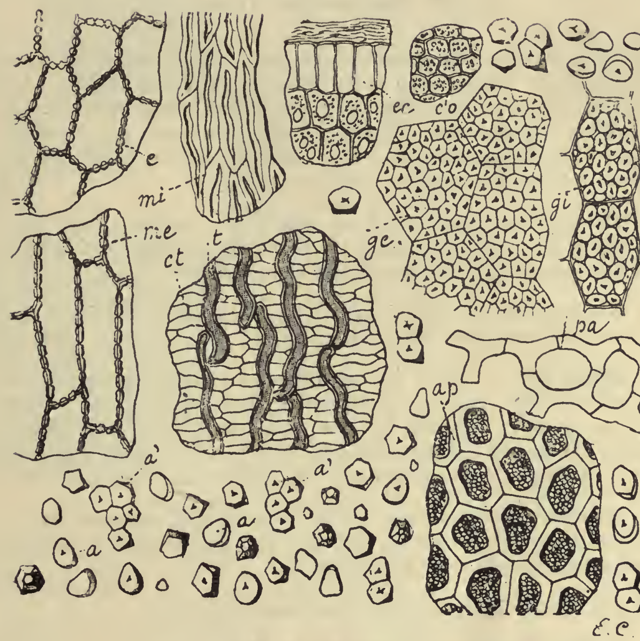

Fig. 25.—**Maize Flour.** (× 240.)

a, *Rounded grains of starch* from the mealy part.
a', *Angular starch* from the horny part.
ap, Aleurone layer; the cell walls readily swell in water, more readily still in caustic potash.
co, Cotyledon.
ct, Transverse cells, often irregular, separated from one another and resembling the tubular cells which they cross at right angles.
e, Outer epidermis of pericarp.
ec, Scutellum.
ge, Masses of starch from the horny part.
gi, Masses of starch from the mealy part.
me, mi, Layers next to the epidermis.
pa, *Branching cells with lacunæ.*
t, Tubular cells, *very numerous.*

(26) Buckwheat Flour.

The fruit of the buckwheat (*Fagopyrum esculentum*, Moench) is an achene. The pericarp is composed of (1) An epidermis consisting of a single layer of prismatic cells with thickened walls. (2) A fibrous hypoderma consisting of four or five layers of polygonal cells with thickened walls. (3) A layer of brown cells. (4) An inner epidermis of very long, flattened cells.

The seed is enveloped in three coats:—(1) An outer coat composed of cells with very sinuous walls. (2) A middle coat of cells with lacunæ. (3) An inner coat of elongated cells.

Within these coats is an aleurone layer consisting of a single row of cubical cells; then the endosperm filled with starch.

The grains of starch are simple, and either isolated or agglomerated into masses. The isolated grains are bluntly or sometimes sharply angular, or often rounded. They may attain 10 or 12μ in diameter, but average abcut 4 to 6μ. They possess a small distinct hilum, and exhibit a tendency to agglomerate.

Buckwheat starch always contains a number of abnormal grains larger than the others; they are irregularly enlarged, often bearing some resemblance to an hour-glass.

The diagnostic characters of buckwheat flour are:—

(*a*) The *characteristic starch grains.*

(*b*) The *epidermis of the seed-coat*, the cells of which have *very sinuous walls.*

(*c*) The *middle layer*, the cells of which exhibit *lacunæ.*

PLATE XVI.

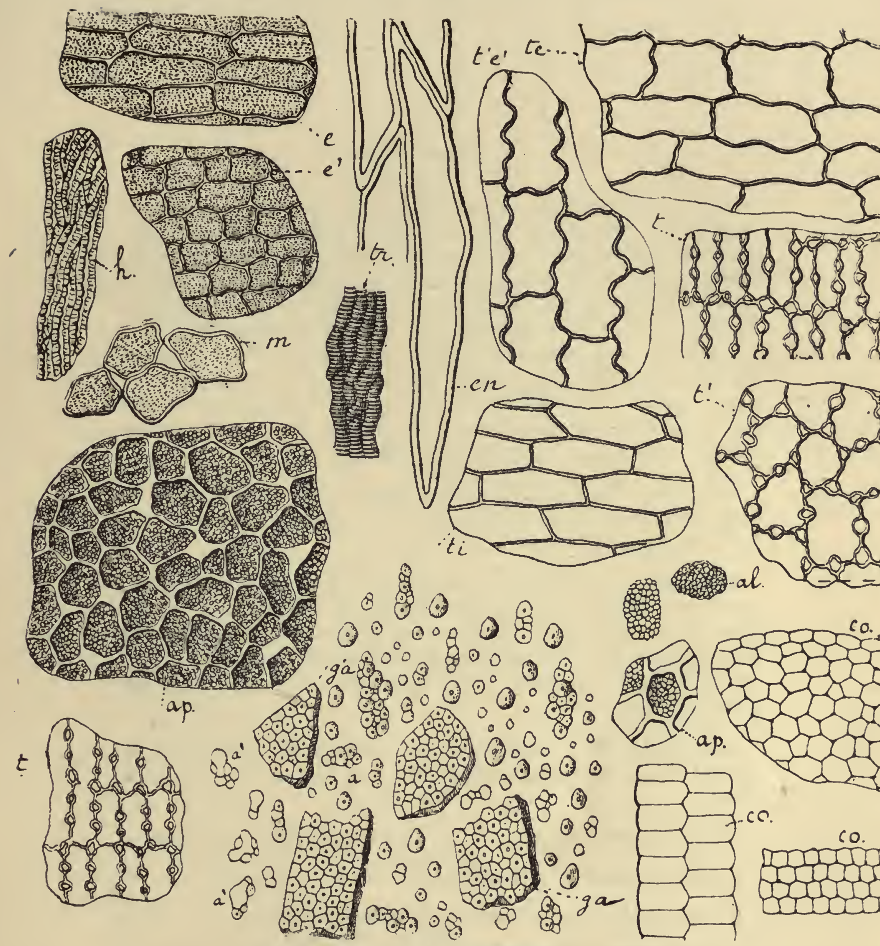

Fig. 26.—**Buckwheat Flour.** (× 240.)

a, Starch grains.
a′, Abnormal grains.
ap, Aleurone layer.
co, Cotyledon.
e, e′, Outer epidermis of pericarp.
en, Inner epidermis.
ga, Masses of starch.
h, Hypoderma.
m, Middle layers of pericarp.
t, t′, Middle seed-coat.
te, t′e′, Exterior seed-coat.
ti, Inner seed-coat.
tr, Vessels.

(27) **Bean Flour.**

The haricot bean, *Phaseolus vulgaris*, Linn., possesses an anatomical structure resembling that of other leguminous seeds. In the seed-coat the following layers can be distinguished:—(1) An epidermis consisting of prismatic cells, radially arranged, like palisade cells; the walls of these cells are much thickened and possess slit-like pits. (2) A layer of nearly square, or rectangular cells, each containing a *large prismatic crystal of calcium oxalate.* These cells are often called "bearer cells," and are found in all varieties of beans, but in many other leguminous seeds they are contracted in the middle (in transverse section), and free from calcium oxalate. (3) A layer of parenchymatous tissue.

The cells of the cotyledons are polygonal and exhibit at their angles either a collenchymatous thickening or more or less conspicuous intercellular spaces.

The starch of the haricot bean is in ovoid grains, seldom rounded, sometimes reniform, or exhibiting one or more protuberances. The hilum, which is usually very distinct, is elongated or fissured. In size the large grains vary from 30 to 75μ; many smaller ones are, however, to be found. The concentric striæ are usually distinct.

Bean flour is often made from the decorticated beans, but, in spite of that, a few fragments of the seed-coat can generally be found.

The diagnostic characters of the flour of the haricot bean are:—

(a) The remarkable *palisade cells.*

(b) The *bearer cells with crystals of calcium oxalate.*

(c) The *cells of the cotyledons.*

(d) The *characteristic starch.*

PLATE XVII.

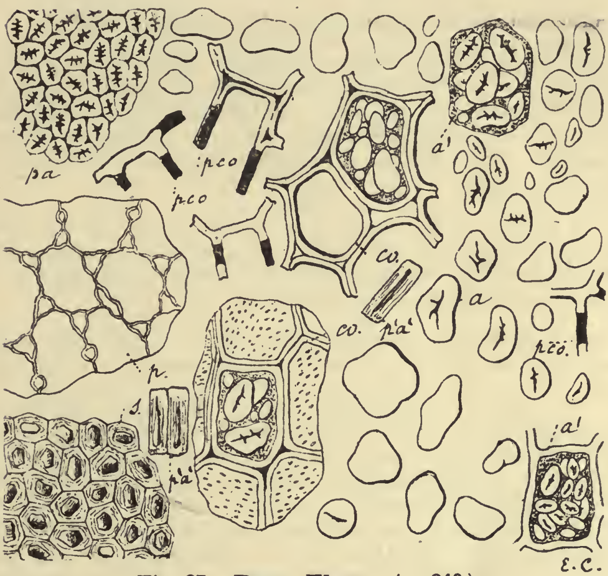

Fig. 27.—**Bean Flour.** (× 240.)

a, Starch grains with fissured hilum.
a′, Cell filled with starch and aleurone grains.
co, Cells of the cotyledons (*sometimes pitted*).
p, Spongy parenchyma.
pa, Surface view of palisade epidermis.
p′a′, Sectional view of palisade epidermis.
pco, Walls of the cells of the cotyledons (the black spaces are due to included air).
s, Bearer cells each enclosing *a large prismatic crystal of calcium oxalate.*

(28) **Lentil Flour.**

The lentil (*Lens esculenta*, Moench) resembles most leguminous seeds in structure.

The seed-coat is composed of the three following layers :—

(1) An epidermis consisting of a layer of palisade cells (about 40μ by 10μ) with a lumen that gradually tapers towards the cuticle; towards the upper part the wall is thickened by nearly vertical bars, the sections of which are distinctly seen in the surface view. The outer end of the cell is not flat but shortly and bluntly conical.

(2) A layer of parenchymatous cells (about 15μ by 15μ); these are contracted in the middle, and hence assume the shape of an hour-glass; they differ from the hypodermal layer of the bean in not containing calcium oxalate crystals.

(3) A layer of irregular parenchymatous cells with thin walls; this layer varies very much in the extent to which it is developed

The cotyledons are covered with an epidermis consisting of polygonal cells, all of which are elongated in the same direction. The cells of the cotyledons themselves are polygonal, their walls are thin and occasionally exhibit small pits. They are filled with starch and aleurone grains. The former occupy a position that is intermediate between bean and pea starch as regards their shape and appearance. Many are ovoid but less regularly so than bean starch; many exhibit a fissured hilum and distinct concentric striæ, but in others the hilum is not to be seen nor are the striæ distinct; size of the larger grains, 30μ to 40μ.

The diagnostic characteristics of lentil flour are :—

(a) The *palisade cells with conical ends.*

(b) The *hour-glass cells without calcium oxalate.*

(c) The *nearly parallel epidermal cells of the cotyledons.*

(d) The *thin-walled cells of the cotyledons.*

(e) The *starch intermediate in character between pea starch and bean starch.*

PLATE XVIII.

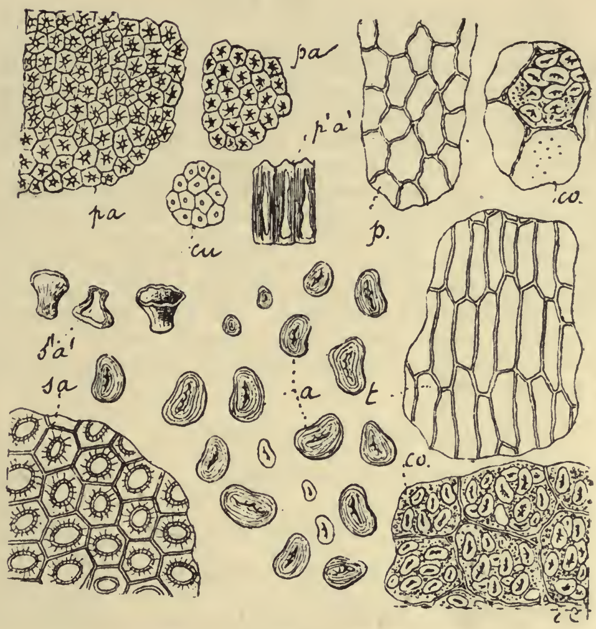

Fig. 28.—**Lentil Flour.** (× 240.)

a, Starch grains.
co, Cells of the cotyledon, some empty, others filled with starch and aleurone.
cu, Cuticle.
p, Parenchyma.
pa, Palisade cells, surface view.
p' a', Palisade cells, sectional view.
sa, Hour-glass cells.
s' a', Bearer cells (sectional view).
t, Epidermis of cotyledon.

(29) Pea Flour.

The pea (*Pisum sativum*, Linn.) much resembles the lentil in structure, but differs in the shape of the palisade cells, which are square at the apex instead of conical. These are thickened by similar bars visible in surface sections viewed from above, but not when viewed from below (size of the cells, 60μ or more in length, 12μ-15μ in width). The parenchyma of the seed-coat is composed of cells similar in shape to those of the lentil, but exhibiting conspicuous intercellular spaces. The cells of the epidermis of the cotyledons are elongated, but in varying directions instead of parallel to one another as in the lentil. The starch grains are rather larger than those of the lentil (30μ to 47μ), and many of them bear rounded protuberances. The hilum is comparatively seldom fissured, and even then the fissure is not branched as it is in bean starch; the concentric striæ are less regular, and often indistinguishable.

The diagnostic characters of pea flour are:—

(a) The *palisade cells with square ends.*

(b) The *characteristic hypodermal cells.*

(c) The *epidermal cells of the cotyledons not parallel.*

(d) The *starch grains with rounded swellings, less distinct unbranched hilum and less evident striæ.*

PLATE XIX.

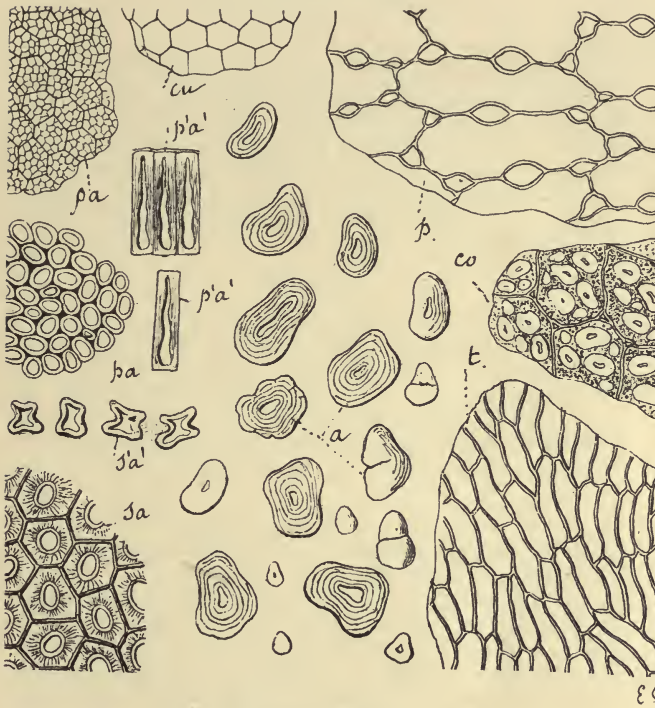

Fig. 29.—**Pea Flour.** (× 240.)

a, Starch grains.
co, Cells of cotyledon.
cu, Cuticle.
p, Parenchyma.
pa, Palisade cells, surface view.
p'a', Palisade cells, sectional view.
sa, Bearer cells.
s'a', Bearer cells, sectional view.
t, Epidermis of cotyledon.

SECTION III.

POWDERED LEAVES.

The chief diagnostic characters of powdered leaves are to be found in:—(*a*) The shape and appearance of the cells of the epidermis and mesophyll; (*b*) the stomata, their distribution and relation to the surrounding cells; (*c*) the presence or absence of secretory tissue; its nature if present; (*d*) the presence or absence of simple or glandular hairs and their nature, if present; (*e*) the presence or absence of crystals; (*f*) the presence or absence of pericyclic fibres; (*g*) the elements of the midrib.

Epidermis.

The epidermis presents certain anatomical features that are constant in all the leaves furnished by the same species growing under normal conditions. It is covered by a cuticle that is usually thin in the leaves of herbaceous plants (hemlock), but thicker in the leaves of shrubs (jaborandi). The cuticle is for the most part smooth, but it is sometimes furnished with more or less prominent ridges (belladonna), or even with protuberances (coca).

In transverse section the cells of the epidermis usually exhibit a rectangular outline, and this is especially the case with those from the interneural spaces, those that lie above or below the midrib being rounded at the angles and therefore more or less oval. The thickness of the outer wall and of the cuticle and cuticular layers should be observed, as well as the relative position of the stomata. In some leaves these are depressed below the surface of the epidermis, in others they are raised above it. In surface view the shape of the epidermal cells is extremely variable, but it is constant for the same species. Sometimes they are polygonal with straight walls (orange), but in very many leaves the walls are more or less undulating (tea), or even so sinuous as to present no regularity in shape or direction (foxglove). In thick, coriaceous leaves the epidermal cells exhibit the same shape over the entire lamina, except over the midrib, where they are commonly fairly regular and quadrilateral. In thin leaves, on the other hand, the epidermal cells over the midrib and lateral veins are almost always rectangular and elongated in the direction in which the veins run.

The presence of ridges on the surface of the cuticle imparts a very characteristic appearance to the epidermal cells in surface view; these then exhibit more or less distinct striations, and this becomes an important diagnostic character in the identification of the powder (hemlock, jaborandi, belladonna). If the cuticle bears protuberances these will appear in transverse section as projections from the epidermal cells (which may also themselves be papillose), but in surface view they are visible as not very sharply defined circles, often near the middle of the epidermal cell (coca). Occasionally a hypoderma consisting of one or more layers of cells may be found (boldo), and this may afford a useful indication of the identity of a leaf.

Stomata.

The arrangement of the stomata and the cells that surround them furnishes a very valuable indication of the identity of the powdered drug, especially as the character is a constant one. Vesque, in his studies of the comparative anatomy of plants, has shown to what extent this feature can be utilised. It exhibits a remarkable constancy in the leaves of certain natural orders, amongst which *Labiatæ*, *Caryophylleæ*, *Rubiaceæ*, *Apocyneæ*, *Malvaceæ*, and *Cruciferæ* may be mentioned. It should be added, however, that if the arrangement of the stomata is not found to be the same in the leaves of all plants belonging to large natural orders such as Leguminosæ, it is at least constant for all the leaves of one species. If, therefore, the arrangement of the stomata in any particular leaf is known, this character can easily be utilised to identify the leaf when powdered. The shape of the stomata should also be observed. Very often each stoma is surrounded by three, four, or five cells that exhibit little regularity in their shape or arrangement (*Scrophularineæ*); on the other hand in the leaves of many plants belonging to the sub-order *Papilioneæ* of *Leguminosæ* the stoma is flanked on either side by a crescent-shaped cell nearly parallel to the ostiole. This character occurs still more uniformly in the leaves of *Rubiaceæ*, *Apocynaceæ*, and *Asclepiadeæ*. In the natural order *Labiatæ*, the stoma is regularly placed perpendicularly to the wall separating two neighbouring cells (betony). This character can, therefore, be utilised in identifying the powders of leaves belonging to this natural order. In carophyllaceous leaves the stomata usually appear suspended from the wall dividing two neighbouring cells from one another.

Hairs.

Several of the officinal leaves are glabrous (orange, coca), but it is more common to find hairs either dispersed over the lamina or restricted to the veins. The shape of these hairs is constant for the same species, and often recurs in the majority of plants belonging to the same genus.

Hairs may be divided into two classes—viz., simple (or protective) and glandular, and these may be conveniently considered separately

(*a*) *Simple Hairs.*—These may be either unicellular or pluricellular, according as they consist of a single cell or of several cells. The former occur in senna leaves, the latter in belladonna and foxglove leaves. Their length, shape, thickness, and appearance may give useful indications in diagnosing a powdered leaf; thus in betony leaves they are pluricellular, thick-walled, and smooth, in foxglove leaves pluricellular and thin-walled, in senna leaves unicellular, thick-walled, and warty, and so on. They may, however, assume different forms in the leaves of different plants belonging to the same natural order.

(*b*) *Glandular Hairs.*—These are terminated by a cell or collection of cells that secrete volatile oil, oleoresin, etc., and thus often impart to leaves their characteristic odour. They are frequently so delicate that the touch of the finger or of the clothing is sufficient to rupture them, and liberate the secretion.

Glandular hairs may also be unicellular or pluricellular. The pedicel that supports the gland is usually very short and unicellular, but in some leaves the secretory cells are borne upon four or five superposed cells.

The gland itself may remain unicellular or it may divide by vertical or horizontal walls, or by both, and thus become pluricellular (*Solanaceæ, Compositæ*). In the latter case the mode of division does not appear to be very regular, but when effected by vertical walls it takes place in a definite manner, and the glands are called bicellular, quadricellular, or octocellular, according as they are divided by vertical walls into two, four, or eight cells.

Unicellular or bicellular glands are commonly rounded or oval; they are inserted on the epidermal cells and are irregularly distributed over the whole of the lamina of the leaf. They are rather caducous, and each, as it falls off, leaves a circular scar upon the epidermal cells, either near the centre or close to one of the lateral walls.

Quadricellular and octocellular glands are larger, and usually situated in depressions in the surface of the leaf. They are borne upon very short and rather broad pedicels, which are inserted between several epidermal cells, and, consequently when they fall off leave a scar that differs from that left by a unicellular or bicellular gland.

In examining powdered leaves it is only rarely that a portion can be found presenting a transverse section. Fragments of the epidermis almost always present their surface to the observer, and glands are, therefore, usually seen in surface view. In this case unicellular and bicellular glands appear ovoid or rounded, but quadricellular and octocellular glands exhibit a circular outline, the circle being divided into as many compartments as there are cells; in the centre the pedicel may be seen. In each cell of the gland droplets of volatile oil may often be observed.

The leaves of labiate plants bear both quadricellular and octocellular glands, in addition to which unicellular and bicellular ones can fairly often be found.

Crystals.

The presence or absence of crystals, and, in the former case, their shape and nature, afford valuable evidence in establishing the identity of a leaf. They generally consist of calcium oxalate and are usually rather small. Whenever they exist in a leaf they are always to be found in the powder, however fine it may be. Some leaves (foxglove) are entirely free from crystals, but most officinal leaves contain them distributed throughout the mesophyll, the cortex of the midrib, and the bast of the midrib and veins. Their shape generally remains constant in leaves of the same plant, but it may vary for different plants of the same natural order. Thus, in belladonna leaves the calcium oxalate usually assumes the form of sandy crystals, in henbane that of small prisms, in stramonium that of cluster crystals. In senna leaves both prisms and cluster crystals are found.

Secretory Tissue.

Perhaps no part of the anatomy of a plant is so constant in the form that it assumes and in its localisation as the secretory tissue. It may, therefore, afford the most valuable information, and should be carefully studied. The following forms of such tissue may be met with in leaves:—Oil cells (*Laurineæ*, *Piperaceæ*) internal oil glands (*Myrtaceæ*, *Rutaceæ*), secretory ducts (*Umbelliferæ*), lacticiferous cells (*Euphorbiaceæ*), and laticiferous vessels (*Campanulaceæ*).

Mesophyll.

The mesophyll is said to be *homogeneous* when all its cells assume the same form, but *heterogeneous* when they assume distinctly different forms; the latter is by far the more common, most leaves exhibiting a palisade tissue well differentiated from the spongy parenchyma. The palisade cells often adhere closely to the upper epidermis, and are not completely separated by powdering, hence in the powdered leaf they are generally seen in surface view, and appear then rounded and of uniform size. They may also be found isolated, or in groups, and presenting their rectangular longitudinal section to the observer. The regularity of their shape and the quantity of chlorophyll they contain allow of their being generally easily recognised.

Midrib.

The elements of which the midrib and lateral veins consist are always to be found in powdered leaves, and may sometimes be turned to account in identifying a leaf, although the structure of these tissues presents general features common to most leaves.

Next to the epidermis there is usually to be found a layer of collenchymatous cells of varying extent passing into the normal cortical parenchyma (or ground tissue) of the midrib. In the powdered leaves the collenchymatous cells usually exhibit their length, and are easily distinguished by their elongated shape and thickened walls.

The cells of the cortical parenchyma, on the other hand, in surface view have thin walls, and are rounded or polygonal in herbaceous plants, but usually rectangular or elongated in the leaves of shrubs ; they are usually to be detected in the powder.

The wood of the midrib and lateral veins may contain vessels tracheids, etc., the size of which is sometimes important ; the bast seldom offers valuable indications, but the presence or absence of well-developed pericyclic fibres may often be of use in identifying a powder.

The anatomical elements that may be found in leaf-powders have been shown to be very numerous, and most of them possess a certain diagnostic value, either high or low. They afford the pharmacist a ready means both of identifying the powders and of detecting sophistication.

(30) **Bearberry Leaves.**

The leaves of *Arctostaphylos Uva-ursi*, Sprengel (N.O. Ericaceæ).

The upper epidermis is composed of polygonal cells with slightly wavy walls, covered by a thick cuticle; they measure from 25 to 40μ either in length or width. The lower epidermis is furnished with very large stomata, surrounded by four, five, or six cells, which, however, are devoid of any regularity in their arrangement. Both short simple hairs and glandular hairs are occasionally to be found, but they are often rare. The former are one-celled and conical; the latter have a short two-celled pedicel upon which a large pluricellular oval gland is borne; the gland is divided by horizontal and vertical walls into several cells.

The mesophyll is heterogeneous, asymmetrical and destitute of internal glands. The midrib is plano-convex. The wood is fan-shaped, strongly curved below, but only slightly above; the bast passes gradually into a cortical tissue composed of more or less distinctly axially elongated collenchymatous cells. Both in this tissue and in the bast there are superposed rows of small cells, or axially elongated cells containing crystals of calcium oxalate; these may be prismatic or cluster crystals, both forms being frequently found in the same (elongated) cell.

The diagnostic characters of powdered bearberry leaves are:—

(a) The *lower epidermis with very large stomata.*

(b) The *crystal cells of the cortical tissue.*

PLATE XX.

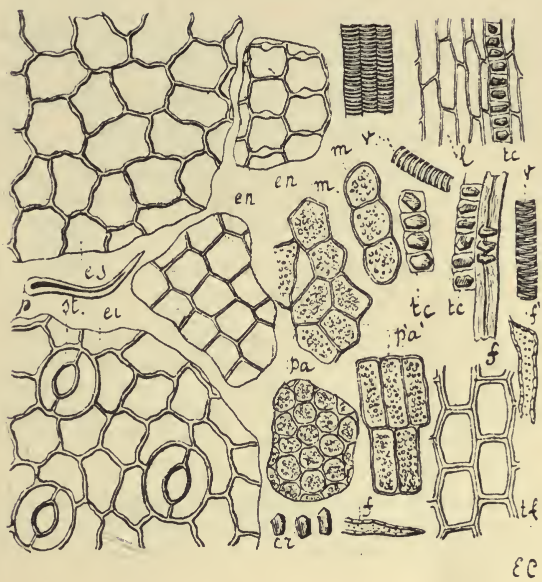

Fig. 30.—**Powdered Bearberry Leaves** (× 240).

cr, Prismatic crystals.
ei, Lower epidermis.
en, Neural epidermis.
es, Upper epidermis.
f, Fibrous cells, from midrib.
f′, Wood fibres, from small veins.
l, Bast.
m, Spongy parenchyma.
pa, p′a′, Palisade cells.
tc, Crystal cells in rows.
tf, Cortical tissue of midr
v, Vessels.

(31) **Belladonna Leaves.**

The leaves of *Atropa Belladonna*, Linn. (N.O. Solanaceæ).

The epidermis is composed of very large cells (up to 120μ long) with sinuous walls, and is covered with a *striated cuticle.*

Stomata occur on both sides, and so also do simple and glandular hairs, but many leaves are nearly glabrous.

The stomata are surrounded by three or four cells, one of which is smaller than the others; this peculiarity has been observed in most solanaceous leaves.

The simple hairs are *conical* and uniserial, consisting usually of three or four cells.

The glandular hairs vary considerably in appearance. Some are small, and consist of a unicellular or pluricellular gland supported upon a short pedicel; others are longer and composed of several superposed cells terminated by a rounded unicellular gland, or by a large pluricellular one with horizontal and vertical walls.

The mesophyll is heterogeneous and asymmetrical. Amongst the cells of the spongy parenchyma, which vary in shape, are some that are usually larger, and filled with sandy crystals of calcium oxalate.

The midrib is bi-convex; the wood is only slightly arched, and bounded by bast on both upper and under surfaces (bi-collateral bundles) as in all solanaceous leaves. Neither bast nor pericycle contains fibres. In the cortical tissue there are cells filled with sandy crystals of calcium oxalate.

The diagnostic characters of powdered belladonna leaves are:—

(a) The *large epidermal cells with wavy walls and striated cuticle.*

(b) The *stomata surrounded by three or four cells, one of which is smaller than the others.*

(c) The *cells filled with sandy crystals.*

(*d*) The *absence of pericyclic fibres.*

PLATE XXI.

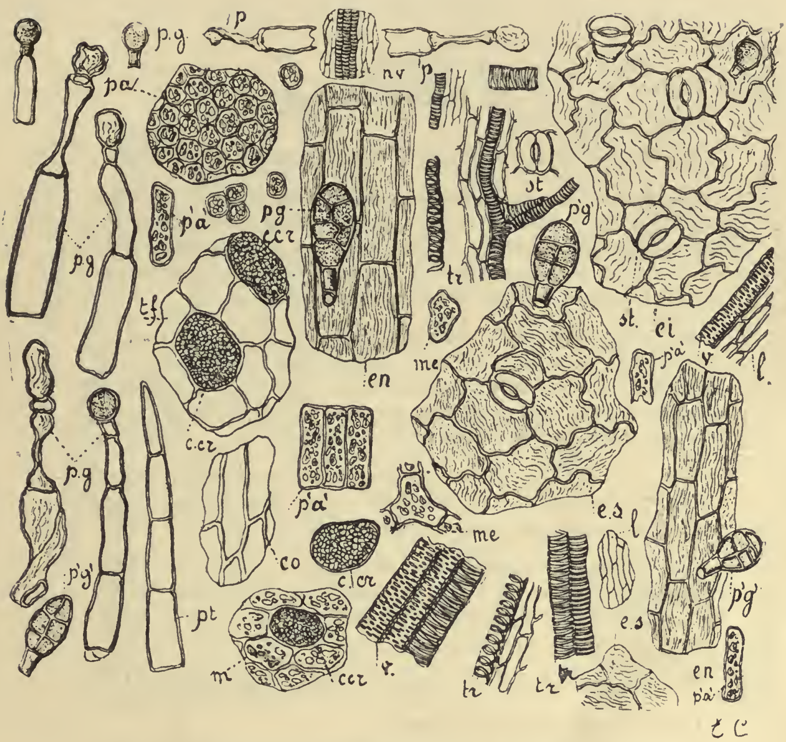

FIG. 31.—**Powdered Belladonna Leaves** (× 240).

c.cr, Cells with sandy crystals.
co, Collenchymatous cells from cortical tissue of midrib.
ei, Epidermis of under surface.
en, Epidermis over the veins, with striated cuticle.
es, Epidermis of the upper surface, with striated cuticle and occasional stomata.
l, Bast.
me, Branching cells of spongy parenchyma.
nv, Fragment of small vein.
pa, Palisade cells, surface view.
p'a', Palisade cells, in longitudinal section.
pg, Glandular hairs, long and short, with unicellular and pluricellular glands.
st, Stomata, surrounded by three or four cells, one of which is smaller than the others.
tf, Cortical tissue of the midrib.
tr, v, Tracheids and vessels.

(32) **Betony Leaves.**

The leaves of *Betonica officinalis*, Linn. (N.O. Labiatæ).

The cells of the interneural epidermis are *smooth*, and have *slightly wavy* walls; on both surfaces there are stomata and simple as well as glandular hairs. Each stoma is *enclosed between two cells, the long axes of which are at right angles to the ostiole*; this arrangement is common amongst labiate leaves.

The simple hairs are *long*, *pluricellular*, and *conical;* they are composed of from three to five cells arranged in a single series; these cells have strongly thickened walls. The hairs are enlarged at the base, and are deeply inserted between the epidermal cells, leaving a very conspicuous scar when they fall off.

The glandular hairs vary in shape and structure. Some are *very small* with *rounded* or *oval bicellular glands* borne upon a conical pedicel, others are *larger*, sessile, and *quadricellular*.

The mesophyll is heterogeneous and asymmetrical. The midrib is concave above, convex below, and covered by a *striated epidermis*. The wood is crescent-shaped; there are *no fibres* in either bast or pericycle. Betony leaf contains *no crystals*.

The diagnostic characters of powdered betony leaves are :—

(a) The *thick-walled conical hairs*.

(b) The *stomata enclosed between two cells at right angles to the ostiole*.

(c) The *glandular hairs*.

(d) The *absence of crystals*.

(e) The *absence of pericyclic fibres*.

PLATE XXII.

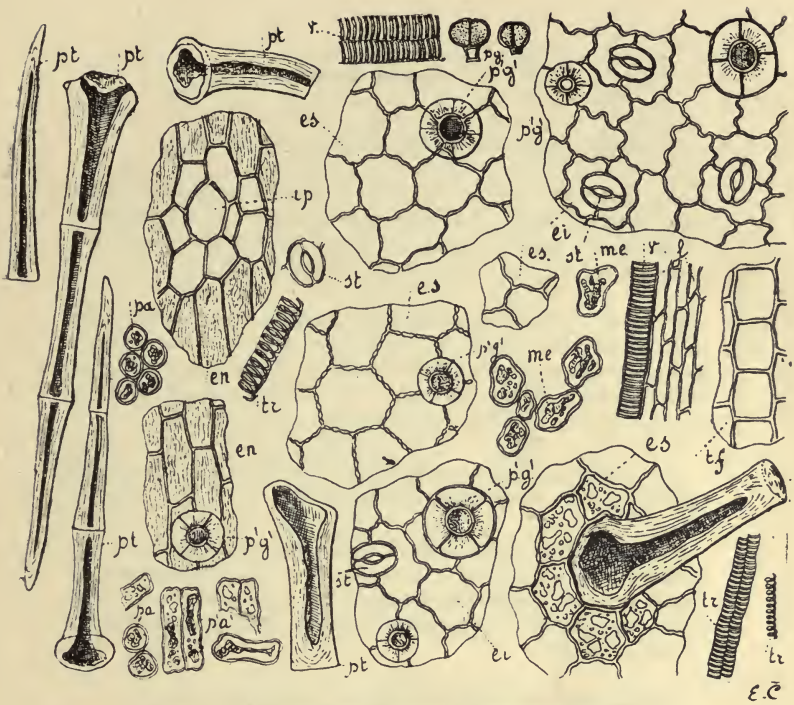

FIG. 32.—**Powdered Betony Leaves** (× 240).

ei, Epidermis of under surface, smooth.
en, Epidermis over the veins, striated.
es, Epidermis of upper surface, smooth.
ip, Scar of fallen hair.
l, Bast.
me, Mesophyll.
pa, Palisade cells, surface view.
p'a', Palisade cells, longitudinal section.
pg, Glandular hairs with bicellular glands.
p'g', Glandular hairs with quadricellular glands.
pt, Simple hairs with thick walls, some entire, some broken.
tf, Cortical tissue of midrib.
tr, v, Vessels, &c.

(33) Boldo Leaves.

The leaves of *Pneumus Boldo*, Mol. (N.O. Monimiaceæ).

The upper epidermis is composed of polygonal cells with rather thick and wavy walls. Below the epidermis there is a hypoderma consisting of a single or sometimes double layer of cells resembling those of the epidermis, but with rather thicker walls.

The lower epidermis alone is furnished with stomata; these are slightly raised and surrounded by four or five cells, of which one or sometimes two are smaller than the others. Both upper and lower epidermis bear simple hairs which are usually stellate, although here and there a very long unicellular hair can be found.

The mesophyll is heterogeneous and asymmetrical; it is well characterised by the presence of large oil-cells.

The midrib is concavo-convex. Below the wood there is a soft bast and a fibrous pericycle; above it there is a fibrous tissue in which two small inverted lateral bundles are sometimes to be found (near petiole). The cortical portion of the midrib contains numerous oil-cells.

The diagnostic characters of powdered boldo leaves are —

(a) The *epidermis and hypoderma.*

(b) The *very characteristic hairs.*

(c) The *presence of large oil-cell*

PLATE XXIII.

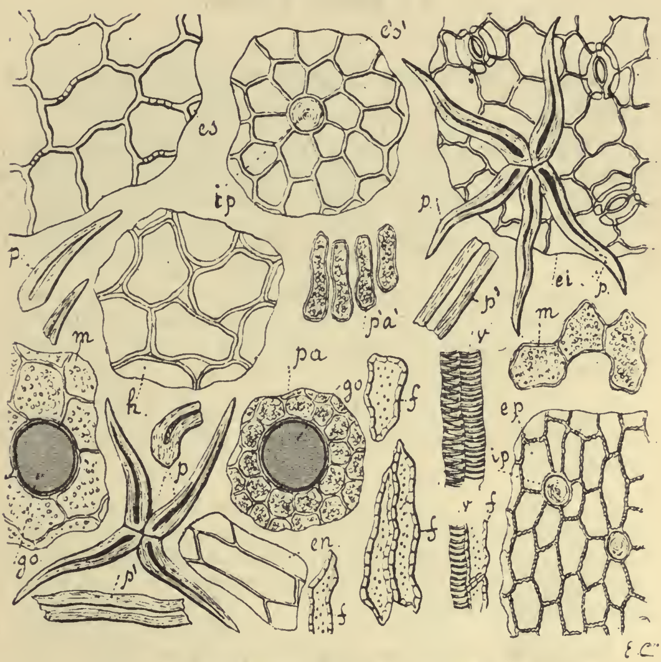

FIG. 33.—**Powdered Boldo Leaves** (× 240).

ei, Lower epidermis.
en, Neural epidermis.
ep, Epidermis of petiole.
es, Upper epidermis.
e's', Upper epidermis with scar of hair
f, Lignified cells.
go, Oil-cells.
h, Hypoderma.
m, Spongy parenchyma.
p, Stellate hairs, entire or broken.
p', Fragment of a one-celled hair.
pa, p'a', Palisade cells.
v, Vessels.

(34) **Buchu Leaves.**

The leaves of *Barosma betulina*, Bart. and Wendl. (N.O Rutaceæ).

The epidermis of the upper surface consists of polygonal cells, nearly every one of which contains sphærocrystalline masses or feathery tufts of hesperidin ; these dissolve in caustic potash with the production of a yellow colour. The cells also contain mucilage which is deposited on the inner side of the inner tangential wall.

The epidermis of the under surface is composed of similar cells, which also contain hesperidin, but less mucilage. Both surfaces are glabrous save for the occasional occurrence of a short, one-celled, thickwalled conical hair near the midrib.

The mesophyll is heterogeneous and asymmetrical; it contains rosette crystals of calcium oxalate and here and there a large oil-gland.

The midrib is concavo-convex in section. The wood is fan shaped ; below the bast there is a crescent of pericyclic fibres which vary in the extent of their thickening and lignification. In the cortical tissue, which contains but little collenchyma, there is often a large oil-gland.

The diagnostic characters of powdered buchu leaves are :—

(a) The *polygonal cells of the epidermis with crystalline masses of hesperidin.*

(b) The *abundance of mucilage.*

(c) The *presence of pericyclic fibres.*

(d) The *calcium oxalate in rosettes.*

PLATE XXIV.

FIG. 34.—**Powdered Buchu Leaves** (× 240).

cr, Calcium oxalate in rosettes.
ei, Lower epidermis with crystals of hesperidin.
en, Neural epidermis.
ep, Epidermis of petiole.
es, Upper epidermis.
f, Pericyclic fibres.
f′, Lignified cells from veinlets.
h, Hesperidin.
m, Mesophyll.
p, Protective hairs.
pa, p′a′, Palisade cells.
tf, Cortical tissue of midrib.
v, Vessel.

(35) Coca Leaves.

The leaves of *Erythroxylon Coca*, Lam. (N.O. Lineæ).

The epidermis of the upper surface is composed of polygonal cells covered with a rather thick, *smooth* cuticle; they measure from 30 to 45μ in length, and from 15 to 30μ in breadth.

The lower surface is well characterised by the papillose development of the epidermal cells. This peculiarity imparts a sinuous outline to the lower epidermis when seen in transverse section, but in surface view the papillæ appear as not very sharply defined circles. Each stoma is accompanied by two cells, with their long axes parallel to the ostiole; these cells are not papillose. The leaves are quite glabrous on both surfaces.

The mesophyll is heterogeneous and asymmetrical; the spongy parenchyma is composed of stellate cells, some of which contain prismatic crystals of calcium oxalate.

The midrib is bi-convex. Under the epidermis of both surfaces there is a rather thick layer of collenchymatous tissue. The wood of the meristele is curved, and below it is the bast beyond which again there is an arc of lignified pericyclic fibres; there are also two groups of similar fibres above the wood, one near each extremity.

The cells next to the pericyclic fibres contain prismatic crystals of calcium oxalate, as do also some of the cells of the cortical parenchyma.

The diagnostic characters of powdered coca leaves are:—

(a) The *polygonal papillose cells of the lower epidermis.*

(b) The *stomata accompanied by two cells with their long axes parallel to the ostiole.*

(c) The *presence of pericyclic fibres.*

(d) The *absence of hairs.*

(e) The *prismatic crystals of calcium oxalate.*

PLATE XXV.

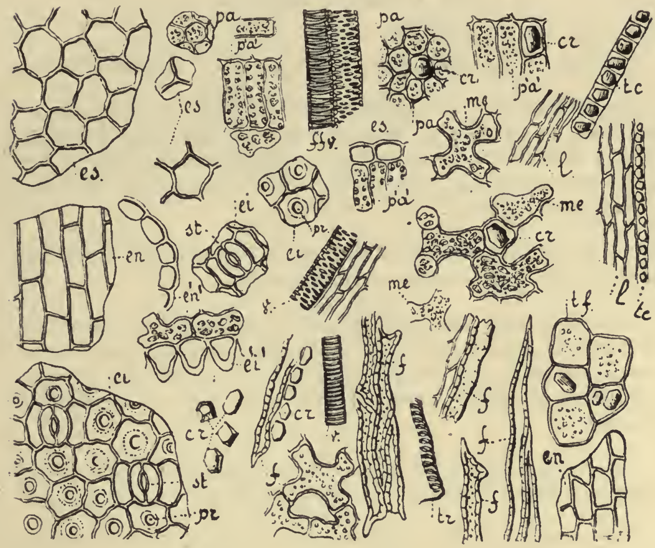

FIG. 35.—**Powdered Coca Leaves** (× 240).

cr, Prismatic crystals of calcium oxalate.

ei, Lower epidermis with surface view of papillose cells (*pr*).

e'i', Lower epidermis in section.

en, Epidermis over veins, surface view,

e'n', Epidermis over veins in section.

f, Pericyclic fibres,

ffv, Fragments of vessels from midrib.

l, Bast.

me, Spongy parenchyma.

pa, Palisade cells with crystals, surface view.

p'a', The same in section.

st, Stomata, with two cells parallel to the ostiole.

tc, Crystal cells.

tf, Cortical tissue of midrib.

tr, Small vessels. *No hairs either simple or glandular.*

(36) **Foxglove Leaves.**

The leaves of *Digitalis purpurea*, Linn. (N.O. Scrophularineæ).

The epidermis of the upper surface is composed of polygonal cells from 30 to 60μ long with slightly wavy walls and a *smooth cuticle*; that of the lower surface is similar, but the walls of the cells are more wavy. *Both surfaces bear stomata* and *simple as well as glandular hairs.*

The stomata are surrounded by three or four cells, which exhibit no regularity in either shape or arrangement.

The simple hairs are *pluricellular* and *conical*; they consist of from three to five cells with thin walls, the latter being *sometimes smooth, sometimes slightly warty.* These cells sometimes collapse and present alternately a narrow edge and a flattened surface to the observer.

The glandular hairs are shorter, and composed of from one to three cells with a *unicellular or bicellular gland.*

The mesophyll is heterogeneous, asymmetrical, and *destitute of crystals.*

The midrib, which is very strongly convex below, is also furnished with simple and glandular hairs. The wood is crescent-shaped, and neither bast nor pericycle contain any lignified elements.

The diagnostic characters of powdered foxglove leaves are :—

(a) The *characteristic hairs.*

(b) The *sinuous epidermal cells with small stomata.*

(c) The *absence of pericyclic fibres.*

(d) The *absence of calcium oxalate crystals.*

PLATE XXVI.

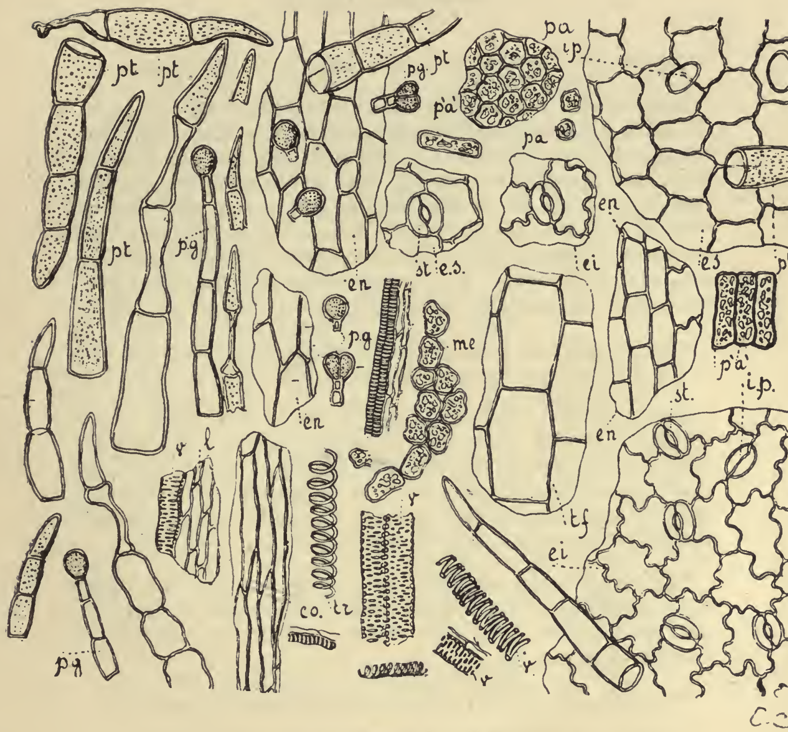

FIG. 36.—**Powdered Foxglove Leaves** (× 240)

co, Collenchymatous cells of the midrib.
ei, Lower epidermis, cells with sinuous walls.
en, Neural epidermis.
es, Upper epidermis.
ip, Scar of fallen hair.
l, Bast.
me, Spongy parenchyma.
pa, p'a', Palisade cells.
pg, Glandular hairs.
pt, Simple hairs.
st, Stomata.
tf, Cortical tissue of midrib.
tr, v, Vessels, &c.

(37) **Hemlock Leaves.**

The leaves of *Conium maculatum*, Linn. (N.O. Umbelliferæ).

The epidermis is glabrous and bears stomata on both its surfaces, but much more abundantly on the under than on the upper. The cells of the upper epidermis are from 60 to 90μ long, and 30 to 45μ wide; they have somewhat wavy walls, whilst those of the under epidermis, which are rather smaller, are sinuate and slightly striated. Towards the extremities of the ultimate divisions of the leaves the epidermal cells of the margin become papillose and bear well-marked striations. The stomata are surrounded by four cells which do not present any constancy in their arrangement.

The mesophyll is heterogeneous and asymmetrical; the cells of the spongy parenchyma are stellate.

The midrib is concave on the upper surface, and strongly convex on the lower; the epidermis of the latter is striated and covers a layer of collenchyma. The meristele contains but little wood, and there are no fibres in either the bast or pericycle. Immediately below the endodermis, and opposite the centre of the crescent-shaped bast, is a small secretory canal.

There are no crystals of calcium oxalate, but the cells of the upper epidermis contain sphæro-crystalline masses of unknown nature which are soluble in caustic potash, but insoluble in solution of chloral hydrate.

The diagnostic characters of powdered hemlock leaves are:–

(a) The *papillose epidermis of margin with striated cuticle.*

(b) *Absence of crystals of calcium oxalate.*

(c) *Presence of sphæro-crystals in epidermis.*

(d) *Absence of pericyclic fibres.*

PLATE XXVII.

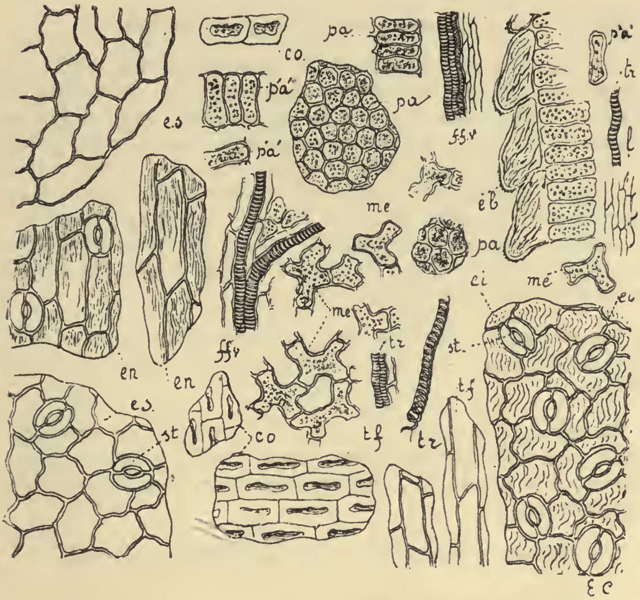

FIG. 37.—**Powdered Hemlock Leaves** (× 240).

co, Collenchymatous cells.

eb, Epidermis of margin, strongly striated.

ei, Lower epidermis, striated.

en, Neural epidermis, striated.

es, Upper epidermis, smooth.

ffv, Fragments of fibrovascular bundles.

l, Bast.

me, Spongy parenchyma.

pa, p'a', Palisade cells.

st, Stomata.

tf, Cortical tissue of midrib.

tr, Small vessels.

(38) Henbane Leaves.

The leaves of *Hyoscyamus niger*, Linn. (N.O. Solanaceæ).

The epidermis of both surfaces is composed of cells with very wavy walls and smooth cuticle; they vary from 40 to 100μ in length. Both surfaces bear simple and glandular hairs, as well as stomata. The latter are broadly oval, and surrounded by three or four cells, one of which is smaller than the others; this arrangement is commonly met with in solanaceous plants. The stomata average about 23-27μ in length. The simple hairs are *uniserial* and *conical*, and have thin walls. The glandular hairs are usually long, uniserial, and terminated by a *small bicellular gland*, or by a *large ovoid pluricellular* one.

The mesophyll is heterogeneous and asymmetrical; the cells of the spongy parenchyma often contain *prismatic crystals* of calcium oxalate.

The midrib is biconvex. The wood is curved, and has bast both above and below it, bicollateral bundles being constant in the natural order Solanaceæ. Neither bast nor pericycle contains any lignified elements.

The diagnostic characters of powdered henbane leaves are:—

(a) The *remarkable glandular hairs.*

(b) The *calcium oxalate, mostly in prisms.*

(c) The *epidermal cells with wavy walls.*

(d) The *stomata surrounded by three or four cells, one of which is larger than the others.*

(e) The *absence of pericyclic fibres.*

PLATE XXVIII.

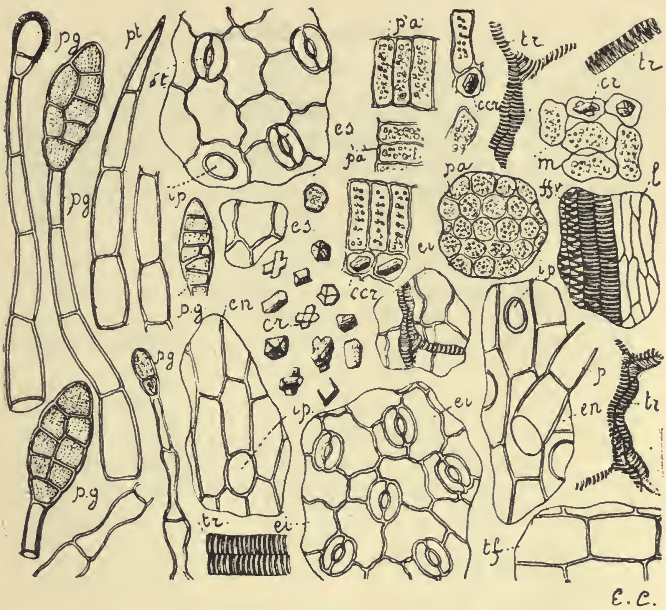

FIG. 38.—**Powdered Henbane Leaves** (× 240).

ccr, Crystal cells.

cr, Crystals of calcium oxalate.

ei, Lower epidermis.

es, Upper epidermis.

ffv, Portion of fibrovascular bundle of midrib.

ip, Scar of fallen hair.

m, Spongy parenchyma.

pa, p'a', Palisade cells.

pg, Glandular hairs.

pt, Simple hairs.

st, Stomata.

tf, Cortical parenchyma of midrib.

tr Tracheids and vessels.

(39) Henna Leaves.

The leaves of *Lawsonia alba, Lam.* (N.O. Lythrarieæ).

The epidermis of both surfaces is provided with stomata, which are surrounded by four or five cells; these cells, however, exhibit no regularity in their arrangement. The cuticle is thin on the under surface and, especially above the veins, striated.

The mesophyll is heterogeneous and symmetrical. There are two rows of palisade cells on either surface, and the lower part of the spongy parenchyma, which is composed of ellipsoidal, rounded or cylindrical cells, is very rich in large cluster-crystals of calcium oxalate.

The midrib is plano-convex. The wood is curved, and exhibits a layer of bast above as well as below. Between the bast and the lower epidermis there is a well developed arc of pericyclic fibres. The cortical tissue of the midrib is also rich in large cluster-crystals of calcium oxalate.

The powder often contains the débris of twigs, etc.

The diagnostic characters of powdered henna leaves are :—

(a) The *cuticle, striated over the veins.*

(b) The *numerous large cluster-crystals of calcium oxalate.*

(c) The *pericyclic fibres.*

PLATE XXIX.

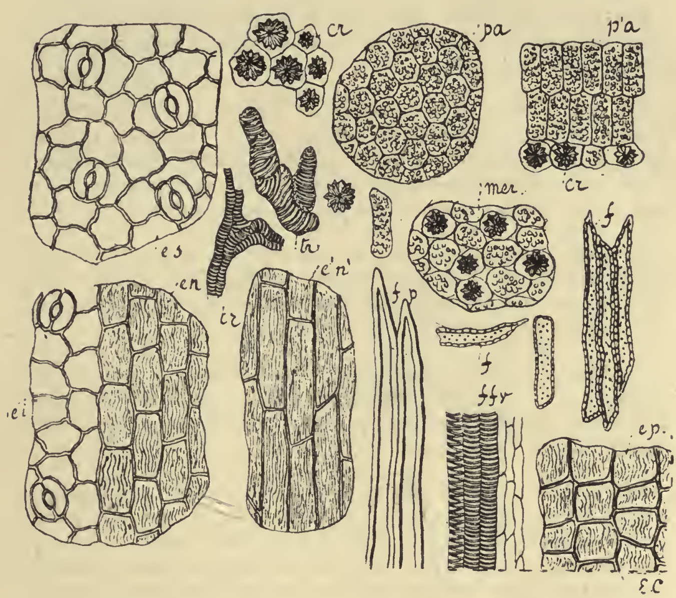

FIG. 39.—**Powdered Henna Leaves** (× 240).

cr, Crystals of calcium oxalate.
ei, Lower epidermis.
en, Neural epidermis.
e'n' Epidermis of midrib.
ep, Epidermis of petiole.
es, Upper epidermis.
f, Lignified cells of larger veins.
ffv, Débris of midrib.
fp, Fibres from petiole.
mer, Spongy parenchyma.
pa, p'a', Palisade cells.
tr, Tracheids.

(40) Jaborandi Leaves.

The leaves of *Pilocarpus Jaborandi*, Holmes (N.O. Rutaceæ).

The cells of the upper epidermis are polygonal with straight or slightly undulating walls and are covered with a very thick and strongly striated cuticle.

The cells of the lower epidermis are similar, but at most only slightly striated. The stomata, which occur on the under surface only, are surrounded by four or five tangentially arranged cells. Hairs are also occasionally to be found on the under surface; they are unicellular, conical, and have thick, smooth walls.

Here and there a group of epidermal cells may be found that are distinguished by their smaller size and thinner walls; these mark the insertion of external glands, the walls of which, however, are thin and not conspicuous.

The mesophyll is heterogeneous and asymmetrical; the spongy parenchyma is composed of irregular cells, many of which contain *cluster crystals* of calcium oxalate. In this tissue there are *numerous internal oil-glands.*

The midrib is nearly flat on the upper surface, but strongly arched below. There are two bundles of wood; the upper and smaller is nearly straight, whilst the lower and larger is nearly semicircular. Outside the wood is the bast, containing cluster crystals of calcium oxalate, and beyond the bast an interrupted circle of lignified pericyclic fibres.

The diagnostic characters of powdered jaborandi leaves are:—

(a) The *characteristic stomata*.

(b) The *upper epidermis strongly striated.*

(c) The *lignified pericylic fibres.*

(d) The *oil-glands, which, however, are seldom found intact in the powder.*

(e) The *length of the palisade cells* (30 *to* 45μ).

PLATE XXX.

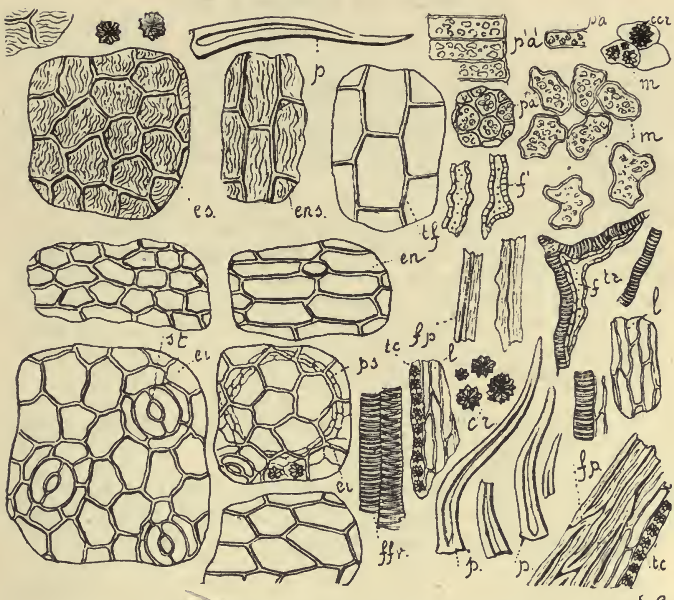

FIG. 40.—**Powdered Jaborandi Leaves** (× 240).

ccr, Crystal cells.

cr, Calcium oxalate crystals.

ei, Lower epidermis with stomata; an internal oil-gland can be seen below the epidermal cells.

ens, Epidermis of secondary veins.

es, Upper epidermis, strongly striated.

f, Pitted lignified cells from veinlets.

ffv, Portion of fibrovascular bundle of midrib.

fp, Lignified cells of pericycle.

l, Bast.

m, Spongy parenchyma.

p, hairs.

pa, p'a', Palisade cells.

ps, Internal oil-gland.

st, Stomata surrounded by four or five tangentially arranged cells.

tc, Crystal cells in rows.

tf, Cortical tissue of midrib.

tr, Tracheids.

(41) **Mate, or Paraguay Tea.**

The leaves of *Ilex paraguayensis* (N.O. Ilicineæ).

The upper epidermis is composed of small polygonal isodiametric cells (15 to 30μ), covered with a *very thick striated cuticle*; it is devoid of stomata and hairs.

The lower epidermis is composed of cells resembling those of the upper epidermis in shape, but of smaller size. It bears very numerous stomata, as well as a few water pores. The former are surrounded and partially overhung by a circle of four or five surrounding cells; the water pores are larger than the stomata. There are also a few unicellular, thick-walled hairs on the lower epidermis.

Above the veins the cells of the epidermis are nearly rectangular and very regularly arranged.

The mesophyll is heterogeneous and asymmetrical; some of the palisade cells contain crystals of varying form and size. The spongy parenchyma is composed of very irregular stellate cells.

The midrib is bi-convex. Next to the epidermis of both upper and lower surface is a layer of collenchymatous tissue. The cells of the cortical parenchyma contain numerous prismatic and cluster crystals of calcium oxalate. The wood is composed of a large, lower crescent-shaped portion, above which are two smaller slightly radiating upper portions; the whole is surrounded by bast and by lignified pericyclic fibres.

The diagnostic characters of powdered maté are :—

(a) The *small epidermal cells.*

(b) The *thick striated cuticle.*

(c) *Occasional unicellular conical hairs.*

(d) The *presence of pericyclic fibres.*

(e) The *numerous crystals of calcium oxalate.*

(f) The *stomata surrounded by a circle of cells.*

PLATE XXXI.

FIG. 41.—**Powdered Mate, or Paraguay Tea** (× 240).

ccr, Crystal cells containing both cluster crystals and prisms.
cr, Calcium oxalate crystals.
co, Collenchymatous cells.
ei, Lower epidermis.
en, Neural epidermis.
es, Upper epidermis.
ffv, Fragments of fibrovascular bundles.
fp, Pericyclic fibres, lignified.
l, Bast.
m, Stellate cells of mesophyll.
p, Unicellular conical hair.
pa, p'a', Palisade cells.
st, Stomata, surrounded by a circle of cells.
s't', Water pore.
tf, Cortical tissue of the midrib with numerous cells.
tr, Tracheids and vessels.

(42) **Orange Leaves.**

Orange leaves are obtained from the bitter orange tree, *Citrus vulgaris*, Risso (*Citrus aurantium*, var. *Bigaradia*, Hook. f.), belonging to the natural order Rutaceæ.

The epidermis is glabrous and covered with a rather thick cuticle; it is composed of polygonal cells, and is free from hairs of any kind, simple or glandular. Stomata occur on the under surface of the leaf only, and each one is surrounded by from four to six cells rather smaller than the other epidermal cells.

The mesophyll is heterogeneous and asymmetrical. The upper part is composed of two or three rows of palisade tissue, some of the cells of which are conspicuous by reason of their larger size; each of these cells contains a large octohedral crystal of calcium oxalate; this is a distinguishing feature of leaves belonging to the genus *Citrus*.

The spongy parenchyma of the leaf is composed of cells of varying shape, and contains large internal oil glands.

In transverse section the midrib appears nearly flat, or slightly convex towards the upper surface of the leaf, but strongly convex towards the lower surface. The wood, which has a similar shape, is covered with a layer of bast, and this again by a pericycle consisting of strongly lignified and thickened fibres. The cells next to the pericycle (endodermis) contain octohedral crystals of calcium oxalate, and similar crystals are also found in the cortical tissue of the midrib.

The diagnostic characters of powdered orange leaves are to be found in:—

(a) The *large crystals of calcium oxalate.*

(b) The *absence of hairs.*

(c) The *characters of the epidermis.*

PLATE XXXII.

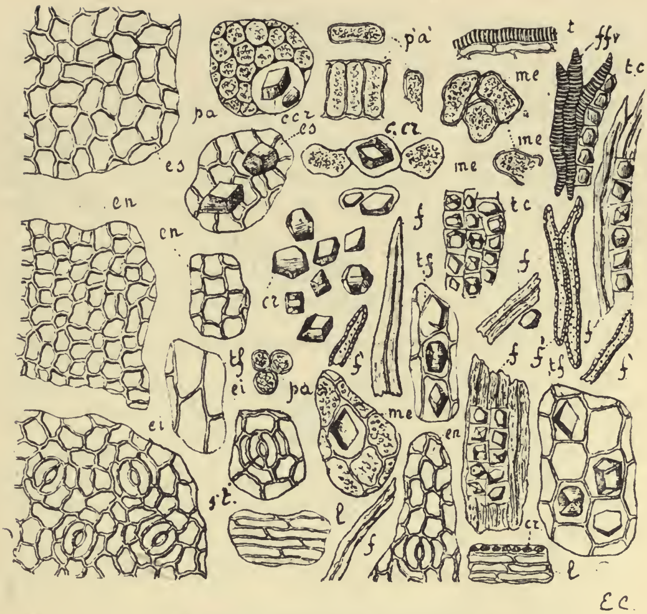

FIG. 42.—**Powdered Orange Leaves** (× 240).

c.cr, Cells with crystals (from the palisade tissue).
cr, Crystals of calcium oxalate.
ei, Epidermis of under surface.
en, Epidermis over the veins.
es, Epidermis of upper surface.
f, Lignified pericyclic fibres.
f′, Fibrous cells from small vein.
ffv, Fragments of fibrovascular bundles.
l, Bast.
me, Cells of spongy parenchyma.
p′a′, Palisade cells,
st, Stomata.
t, Tracheids.
tc, Cells with crystals (abutting on the lignified fibres of the pericycle).
tf, Cortical parenchyma of midrib.

(43) **Rue Leaves.**

The leaves of ***Ruta graveolens***, Linn. (N.O. Rutaceæ).

The epidermis of the upper surface is glabrous, and composed of large cells with *undulating delicately pitted walls*. The cells of the lower epidermis, which is also glabrous, have *sinuous* walls.

Stomata are to be found on the lower epidermis only; they are surrounded and partially overhung by four or five surrounding cells which exhibit no regularity in shape or arrangement.

The cells of the epidermis of the midrib also have pitted walls.

The mesophyll is heterogeneous and asymmetrical; the spongy parenchyma contains numerous cluster crystals of calcium oxalate, and in this tissue internal oil-glands are to be found.

The midrib is concave on the upper surface, convex on the lower; the wood is crescent shaped and there are no fibres in either bast or pericycle.

The diagnostic characters of powdered rue leaves are:—

(a) The *upper epidermis with pitted cell-walls.*

(b) The *stomata.*

(c) The *cluster crystals of calcium oxalate.*

(d) The *oil-glands.*

(e) The *absence of hairs and pericyclic fibres.*

PLATE XXXIII.

E. C.

FIG. 43.—**Powdered Rue Leaves** (× 240).

cr, Large cluster crystals.

ei, Lower epidermis.

en, Neural epidermis.

es, Upper epidermis with pitted cell-walls.

l, Bast.

m, Spongy parenchyma.

pa, p'a', Palisade cells.

st, Stomata surrounded and partially overhung by four or five cells.

tf, Cortical tissue of tne midrib.

tr, v, Tracheids and vessels.

No hairs, either simple or glandular.

(44) Sage Leaves.

The leaves of *Salvia officinalis*, Linne (N.O. Labiatæ).

The upper epidermis is composed of cells with slightly undulating walls; on the lower surface they are rather more sinuous. Both surfaces are provided with stomata as well as with simple and glandular hairs.

The stomata are enclosed between two crescent-shaped cells at right angles to the ostiole; this arrangement is common in labiate leaves.

The simple hairs are usually long and undulating; they are composed of two or three cells, the terminal one gradually tapering to a whip-like point.

The glandular hairs vary in structure. Some consist of a unicellular rounded gland, supported upon a unicellular or bicellular pedicel; in others the gland is large, octocellular and sessile. The mesophyll is heterogeneous and devoid of crystals; the midrib is concavo-convex, and there are no lignified element in either bast or pericycle.

The diagnostic characters of powdered sage leaves are:—

(a) The *position of the stomata.*

(b) The *characteristic hairs and glands.*

(c) The *absence of calcium oxalate crystals.*

(d) The *absence of pericyclic fibres.*

PLATE XXXIV.

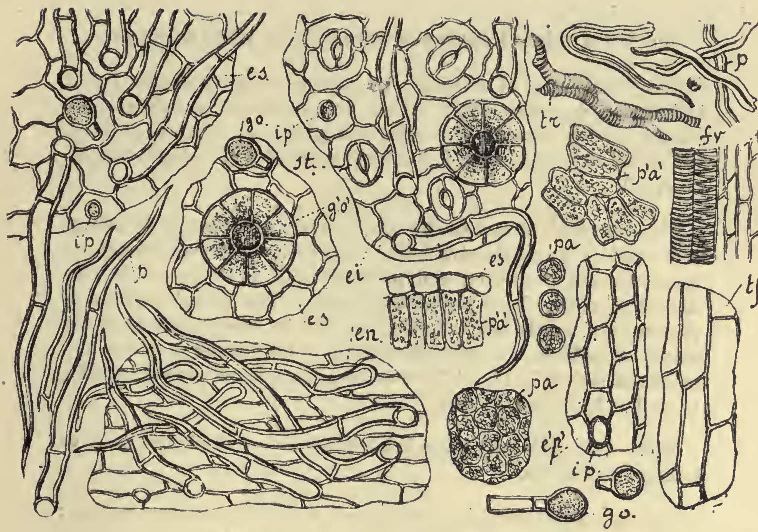

FIG. 44.—**Powdered Sage Leaves** (× 240).

ei, Lower epidermis.

en, Neural epidermis.

e'p', Epidermis of petiole.

es, Upper epidermis.

fv, Vessels from midrib.

go, Unicellular gland.

g'o', Octocellular gland.

ip, Scar of hair.

p, Simple hairs.

pa, p'a', Palisade cells.

st, Stomata with the ostiole at right angles to the walls separating two cells from one another.

tf, Cortical tissue of midrib.

tr, Tracheids.

(45) Savin.

The young twigs of *Juniperus Sabina*, Linn. (N.O. Coniferæ).

The young twigs of savin are densely covered with minute thick, imbricated, opposite leaves, which are appressed and frequently adnate to the stem for a considerable portion of their length—on the dorsal surface of each leaf a large depression (oil-gland) may be observed.

The transverse section of the leaf is nearly semicircular in outline and exhibits a centric structure. The cells of the epidermis are nearly square in section and provided with a thick cuticle. In surface view they have pitted walls, and in the lateral portions of the leaf are nearly isodiametric, whereas in the central they are axially elongated. Stomata occur only in the lateral portions, and are characterised by the little recurved projections at each extremity, as well as by being lignified.

Below the epidermis there is a hypoderma of thickened more or less lignified fibres.

The mesophyll consists of polygonal, rounded or elongated cells; near the dorsal surface there is a large oil-gland. The wood of the midrib is composed of tracheids, and below it is the bast, the cells of which are arranged in the regular rows characteristic of coniferous plants. On each side of the midrib there may be observed a group of lignified cells with areolated pits.

The diagnostic characters of powdered savin are:—

(a) The *characteristic stomata which even in young leaves are lignified.*

(b) The *epidermis with fibrous hypoderma, the latter not always easily seen.*

(c) The *lignified cells with areolated pits.*

Note.—The thickened lignified cells, *sc*, shown in the illustration, are characteristic of *J. phœnicea*, Linn., which is often sold in France in powder in the place of *J. Sabina.*

PLATE XXXV.

FIG. 45.—**Powdered Savin** (× 240)

ca, Cells with areolated pits.
cg, The same, viewed longitudinally.
ed, Lower epidermis surface view.
e'd', Lower epidermis in profile.
e"d", Lower epidermis with fibrous hypoderma.
ev, Upper epidermis.
fa, Reticulated fibrous cells.
fl, Bast fibres (of stem).
m, mesophyll.
pc, Cortical parenchyma.
sc, Sclerenchymatous cells of *J. phœnicea*.
st, Stomata.
tr, Tracheids.

(46) Alexandrian Senna.

The leaflets of *Cassia acutifolia*, Delile (N.O. Leguminosæ).

The epidermis of both surfaces is furnished with stomata and simple hairs. The cells of which it is composed are polygonal, averaging about 45μ in length, but attaining 70μ; they have straight walls, and are covered by a rather thick cuticle. The stomata are usually surrounded by two, three or four cells, of which *two are parallel to the ostiole.* The hairs are *one-celled and conical;* they may be straight or curved, and are sometimes enlarged towards the middle and slightly contracted at the base; their walls are moderately thick and warty.

The mesophyll is heterogeneous and *symmetrical,* there being palisade tissue on both surfaces; the spongy parenchyma is much reduced, and consists of oval or rounded cells. Both these cells and those of the palisade tissue contain cluster crystals of calcium oxalate.

The midrib is biconvex. There is a layer of collenchyma both above and below the meristele. There are no fibres in the bast, but there is a well-developed arc of lignified pericyclic fibres, both above and below the wood. The parenchymatous cells next to these contain prismatic crystals of calcium oxalate.

Indian senna closely resembles Alexandrian in its structure; it differs in having fewer hairs and larger epidermal cells.

The diagnostic characters of powdered senna are:

(a) The *characteristic hairs.*

(b) The *stomata accompanied usually by two cells parallel to the ostiole.*

(c) The *fibrous pericycle, accompanied by crystals.*

(d) The *isobilateral structure.*

PLATE XXXVI.

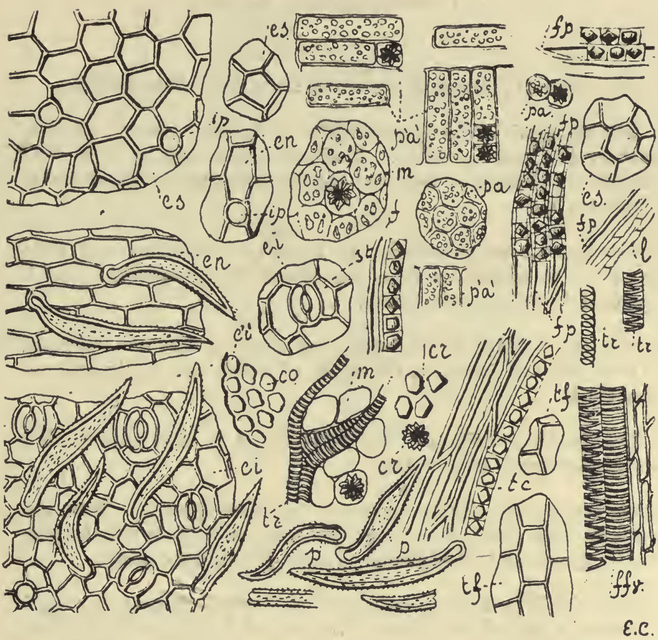

FIG. 46.—**Powdered Alexandrian Senna** (× 240).

co, Collenchymatous cells.
cr, Prismatic and cluster crystals.
ei, Lower epidermis.
e'i', Lower epidermis, sectional view.
en, Neural epidermis.
es, Upper epidermis.
f, fp, Lignified pericyclic fibres.
ffv, Débris of fibrovascular bundles.
ip, Scar of hair.
l, Bast.
p, Hair, one-celled, conical and warty.
pa, p'a', Palisade cells.
st, Stomata with two cells parallel to the ostiole.
tc, Rows of cells with prismatic crystals.
tf, Cortical tissue of midrib.

(47) **Stramonium Leaves.**

The leaves of *Datura Stramonium*, Linn. (N.O. Solanaceæ).

The epidermis of the upper surface of the leaf closely resembles that of the lower surface. Both are composed of cells with undulating or sinuous walls and bear stomata and simple as well as glandular hairs.

The stomata are surrounded by three (or sometimes four) cells, one of which is smaller than the others, an arrangement that is common in solanaceous leaves.

The simple hairs are *uniserial*, and *conical;* they are composed of from three to five cells, the walls of which are *warty* and not very thick.

The glandular hairs are short; the gland is oval, pluricellular, and borne upon a little pedicel.

The mesophyll is heterogeneous and asymmetrical. Both the palisade tissue and the spongy parenchyma contain simple prismatic crystals as well as cluster crystals of calcium oxalate.

The midrib is convex above and very convex below; the wood is strongly curved and there is a layer of bast above as well as below it. Neither bast nor pericycle contain any lignified elements. In addition to prismatic and cluster crystals of calcium oxalate the cortical tissue of the midrib contains cells filled with sandy crystals; these cells are large and often superposed.

The diagnostic characters of powdered stramonium leaves are:—

(a) The *characteristic hairs.*

(b) The *very numerous cluster crystals in the interneural mesophyll.*

(c) The *stomata of solanaceous type.*

(d) The *absence of pericyclic fibres.*

PLATE XXXVII.

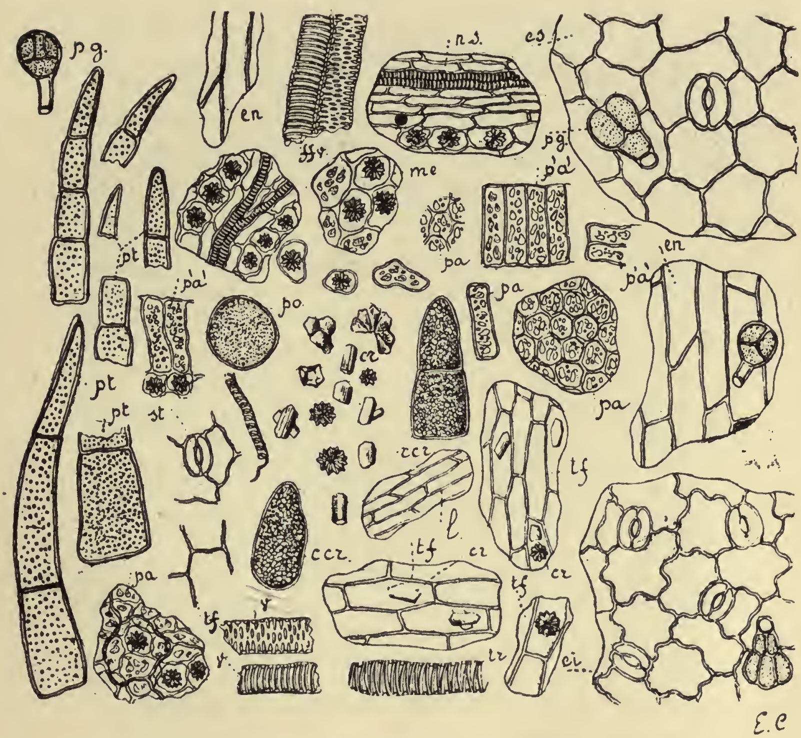

FIG. 47.—**Powdered Stramonium Leaves** (× 240).

cr, Crystals.
ccr, Crystal cells.
ei, Lower epidermis.
en, Neural epidermis.
es, Upper epidermis.
ffv, Débris of fibrovascular bundles.
l, Bast.
me, Spongy parenchyma.
pa, p'a', Palisade tissue.
pg, Glandular hairs.
po, Pollen grains.
pt, Simple hairs.
tf, Cortical tissue of midrib.
tr v, Tracheids and vessels.

(48) **Tea.**

The leaves of *Camellia Thea*, Link. (N.O. Ternstrœmiaceæ).

The upper epidermis is composed of cells with undulating walls and covered with a rather thick cuticle. The lower epidermis consists of smaller cells and is alone provided with stomata; the latter are surrounded by three or four tangentially elongated cells.

Simple hairs occur on both surfaces of the leaf, but they are more abundant on the lower; the number, however, varies with the variety of tea, and with the age of the leaf; they are unicellular, tapering and rather thick walled, varying very much in length, but often attaining 500-700μ.

The mesophyll is heterogeneous and asymmetrical. It is characterised by the presence of a large number of *sclerenchymatous idioblasts.* These are more or less branched and warty and often extend transversely from the upper to the lower epidermis. They vary very much in shape and in the thickness of the walls. The cells of the spongy parenchyma contain cluster crystals of calcium oxalate.

The midrib is biconvex. Under each epidermis there is a layer of collenchyma of varying thickness. The wood is arched and the *bast contains crystals of calcium oxalate.* The meristele is surrounded by a pericycle consisting of slightly lignified cells arranged in circle. The cortical tissue contains idioblasts which are usually rather larger and more branched than those of the mesophyll.

The little fragments of the stems, which are often to be found in ordinary tea, have a slightly different structure. The wood in them forms a circle within which there is a pith containing branched idioblasts; these have comparatively thin, pitted walls.

The diagnostic characters of powdered tea are:—

(a) The *characteristic hairs.*

(b) The *sclerenchymatous idioblasts, especially in petiole and midrib.*

(c) The *stomata surrounded by tangentially elongated cells.*

(d) The *calcium oxalate in cluster crystals.*

PLATE XXXVIII.

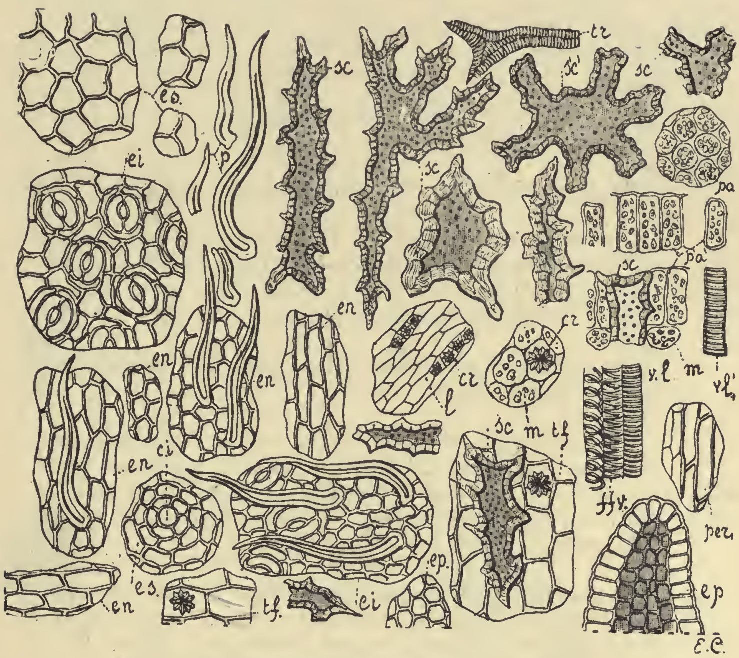

FIG. 48.—**Powdered Tea** (× 240).

cr, Crystals.
ei, Lower epidermis.
en, Neural epidermis.
ep, Apex of marginal tooth.
es, Upper epidermis.
ffv, Debris of fibrovascular bundles.
l, Bast with cluster crystals.
m, Spongy parenchyma.
p, Simple hairs.
pa, p'a', Palisade cells.
per, Pericycle, slightly lignified.
sc, Idioblasts from the mesophyll and cortical tissue.
s'c', Idioblasts from the pith of the stem.
tf, Cortical tissue.
tr, Tracheids.
vl, Vessel.

(49) **Tobacco Leaves.**

The leaves of *Nicotiana Tabacum*, Linn. (N.O. Solanaceæ).

The epidermis of both surfaces is furnished with simple and glandular hairs and also with stomata. The cells of the upper epidermis are polygonal and have slightly wavy walls, whilst those of the lower epidermis are sinu us.

The stomata are surrounded by three cells, one of which is smaller than the others.

The simple hairs are *uniserial* and conical. The glandular hairs vary in appearance. Some are long, uniserial and terminated by a *unicellular*, *bicellular*, or *pluricellular gland*; others are shorter and consist of a very large pluricellular gland borne upon a one-celled pedicel.

The mesophyll is heterogeneous and asymmetrical; the cells of the spongy parenchyma are oval or polygonal, and some of them are filled with sandy crystals of calcium oxalate. The wood of the midrib is arched and the bundles bicollateral.

The diagnostic characters of powdered tobacco leaves are:—

(*a*) *The characteristic hairs.*
(*b*) *The cells with crystal sand.*
(*c*) *The absence of pericyclic fibres.*

PLATE XXXIX.

FIG. 49.—**Powdered Tobacco Leaves** (× 240).

ccr, Cells with sandy crystals.

ei, Lower epidermis.

en, Neural epidermis.

es, Upper epidermis with stomata.

ffv, Fragments of fibrovascular bundle.

me, Cells of spongy parenchyma.

p, p², p³, Long pluricellular hairs with unicellular or pluricellular glands.

p⁴, p⁵, Short glandular hairs.

p⁶, Conical, pluricellular simple hair

pa, p'a', palisade cells.

st, Stomata surrounded by three cells, one of which is smaller than the others.

tr, Tracheids

v, Vessels.

SECTION IV.

FLOWERS AND FLOWERING TOPS.

The anatomical characters presented by powdered flowers and flowering tops will depend in the first place upon the number of different organs that are present in the drug. If the latter consists simply of petals the chief diagnostic characters will be found in the shape of the stomata, and in the papillæ which are generally met with on the surface of these delicate organs. Some petals are furnished with simple and glandular hairs in which case these, of course, may be utilised in establishing the identity of the powder. By such means as these the presence of calendula florets in powdered saffron may be detected; the former bear pluriserial hairs near the base of the corolla, and these are easily recognised in the powdered drug. The presence of secretory ducts may also sometimes be of service in determining adulteration, as for instance that of saffron with safflower, for the florets of the latter contain oleo-resin ducts that can be detected in the powdered drug.

Pollen grains are also often present on the corolla of the flower, and their presence, shape and size may afford information that should not be under-estimated. The pollen grains of the saffron-crocus are of considerable size and nearly smooth, whilst those of composite plants are usually furnished with numerous spiny projections. An abundance of pollen grains in powdered cousso indicates the presence of the staminate inflorescence which is inactive, and is excluded from official use.

If all the organs of which the flower is composed are present in the powder then the number of elements that may be made available for its determination is largely increased. In addition to the pollen grains the cellular tissue of the anthers will be present. The calyx almost always contains sclerenchymatous elements, and the receptacle often exhibits structural peculiarities that are of distinct value, as is the case with insect flowers. The powders of aromatic flowers and flowering tops are generally characterised by the presence of particular oil-glands which render them comparatively easy to recognise.

In addition to the flower itself flowering tops usually contain bracts, peduncles, and portions of the flowering stem. Such drugs exhibit when powdered a distinct increase in the débris of fibro-vascular bundles, whilst in some cases particular sclerenchymatous cells may be introduced, as such elements are frequently present in considerable number in the stem and its branches. The presence of palisade tissue generally indicates the presence of leaves or leafy organs.

(50) Chamomile Flowers.

The double or nearly double flower-heads of cultivated plants of *Anthemis nobilis*, Linn. (N.O. Compositæ).

The florets of the ray and the majority of those of the disc are white and furnished with ligulate corollas, which are lanceolate and terminate in a truncate three-toothed apex. In the centre there are usually a few inconspicuous, yellow, tubular florets to be found. The florets spring from the axils of lanceolate, obtuse paleæ inserted upon a conical receptacle. The paleæ are scarious at the margin, and often fringed near the apex.

The epidermal cells of the ligulate corollas vary in shape and appearance according to their position on the ligula. Those on the tubular part near the base are elongated and slightly striated; at this point the epidermis bears numerous pluricellular glands possessing the structure common to the oil glands of plants belonging to the order Compositæ (*go*, *g'o'*). Towards the apex the epidermis of the upper surface is destitute of glands, but is provided with a number of papillæ, and these produce considerable variation in its aspect in different positions; the lower epidermis is composed of sinuate, striated cells, amongst which numerous stomata, glands, and simple pluricellular hairs are to be found.

The epidermal cells of the involucral bracts vary according to their position on the bract. At the apex and on the margins they are long and fusiform with but slightly thickened walls; near the median line and over the fibro-vascular bundles they are elongated and provided with thickened pitted walls; near the base they are polygonal and isodiametric. Towards the base the epidermis also bears numerous stomata, hairs and glands. In the receptacle at the point where the bracts are inserted there are sclerenchymatous cells.

The style is composed of small cells rich in rosette-crystals of calcium oxalate; the stigmata are provided with characteristic papillæ.

The diagnostic characters of chamomile flowers are:—

(*a*) *The cells of the lower epidermis of the ligulate corolla; they have wavy walls and striated cuticle.*

(*b*) *The papillose upper epidermis of the same.*

(*c*) *The characteristic oil glands.*

d) *The elongated cells of the scarious margins of the tracts.*

PLATE XL.

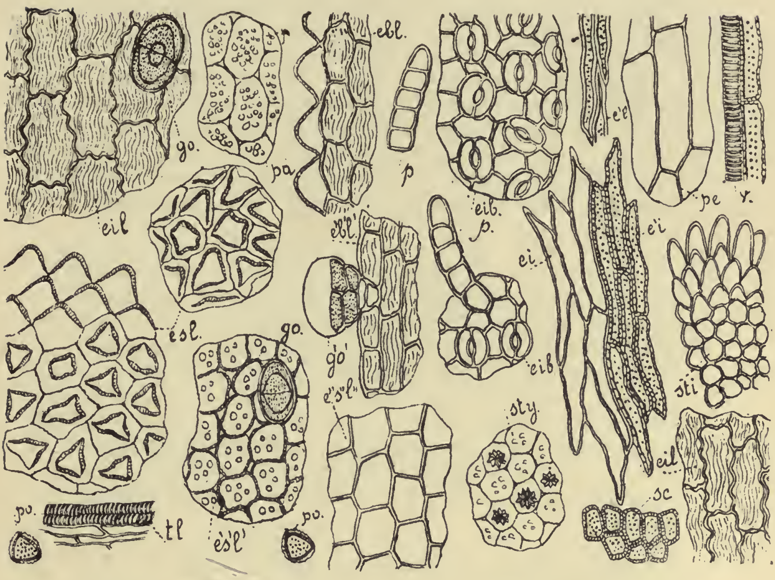

FIG. 50.—**Powdered Chamomile Flowers** (× 240).

ebl, Epidermis of tube of ligulate floret.
e'b'l, The same with gland in profile.
ei, Epidermis of involucral bract (margin).
e'i, The same (median portion).
eib, The same (near base).
eil, Lower epidermis of ligula.
esl, Upper epidermis of ligula (near the apex).
e's'l, The same (middle).
e''s''l, The a (near the base).
go, Oil gland (surface view).
g'o', Oil gland (in profile).
p, Pluricellular hair.
pa, Parenchyma from corolla.
pe, Epidermis of peduncle.
po, Pollen grains.
se, Sclerenchymatous cells from receptacle.
sti, Débris of stigma with papillæ.
sty, Débris of style.
v, Vessels, etc., from peduncle.

(51) Cloves.

The dried flower-buds of *Eugenia caryophyllata*, Thunb. (N.O. Myrtaceæ).

Each clove consists of a somewhat quadrangular stem-like portion slightly contracted at the base; this part is sometimes interpreted as a calyx-tube, sometimes as the solid lower part of the ovary. It is crowned by four thick, divergent, suboval calyx-teeth in the centre of which there is a small rounded body consisting of four imbricated petals enclosing the dried stamens and style.

The transverse section of the lower part of the stem-like portion exhibits the following characters:—The epidermis is composed of polygonal cells covered with a rather thick cuticle, and provided with stomata. Below the epidermis is parenchymatous tissue well differentiated into three layers, viz., an outer one with radially elongated cells, and numerous internal oil-glands, a middle, collenchymatous layer traversed by numerous fibro-vascular bundles in which thick sclerenchymatous fibres are conspicuous elements, and an inner, lacunous layer. In the centre there is a moderately large fibro-vascular bundle.

Both the teeth of the calyx and of the petals consist chiefly of parenchymatous tissue in which there are numerous oil-glands.

The anthers are composed of small cells with pitted walls, and larger cells with spiral thickenings.

The powder also contains numerous pollen grains as well as pericyclic fibres derived from the bundles in the lower part of the clove.

Powdered cloves possess no well-marked diagnostic characters; the following features may, however, be mentioned:—

(*a*) *Epidermis of lower part of ovary, with thick cuticle.*

(*b*) *Epidermis of calyx-teeth and corolla.*

(*c*) *Fragments of the oil-glands.*

(*d*) *Parenchyma of the corolla with numerous rosettes of calcium oxalate. Powdered cloves should not contain sclerenchymatous cells* (*clove stalks*) *or starch* (*mother-cloves*).

PLATE XLI.

Fig. 51.—**Powdered Cloves** (× 240).

an, a'n', Cells from the anthers, surface view and in profile.
col, Collenchymatous layer.
ccr, Crystal cells.
cr, Rosette crystals of calcium oxalate.
eca, Epidermis of calyx-teeth.
ef, Epidermis of filament.
eico, Lower epidermis of corolla.
esco, Upper epidermis of corolla.
etc, Epidermis of lower portion of clove.
fp, Fibres from the pericycle.
pco, Iarenchyma of the corolla with numerous calcium oxalate crystals.
pe, Cells of outer layers of parenchyma.
pf, Parenchymatous cells from filament.
pl, Cells of lacunous portion of parenchyma.
po, Pollen grains.
ps, Oil-glands.
tc, Crystal cells.
tr, Vessels, etc., from calyx-teeth and corolla.

(52) **Cusso Flowers.**

The pistillate inflorescence of *Brayera anthelmintica*, Kunth. N.O. Rosaceæ).

This inflorescence consists of a panicle of shortly stalked, purplish-red flowers. Each flower bears on its pedicel two rounded bracts. The calyx consists of two whorls of greenish sepals, a caducous, white corolla, abortive stamens, and two monocarpellary ovaries enclosed in the tube of the calyx. fter fertilisation the inner sepals bend over the young fruit and shrivel; the outer grow larger, and become deeply veined with purple, hence the pistillate inflorescence is characterised by its purplish-red colour. The branching floral axis is covered with shaggy brown hairs.

The staminate flowers are distinguished by their greenish colour; the outer sepals as well as the inner are small, and the calyx-tube encloses only a rudimentary ovary.

The organs of which the pistillate inflorescence consists are characterised by the presence of a great number of hairs, both simple and glandular. The former are always unicellular, long, and conical; their lumen is very narrow, or even linear, but is enlarged into a bulb-shaped cavity at the base. Three forms of glandular hairs are present. Some are small and unicellular others are larger, oval and pluricellular, others again are very large, unicellular, and rounded ; the latter are specially numerous on the sepals.

The diagnostic characters of powdered cusso are:—

(*a*) *The very abundant, long, unicellular hairs.*

(*b*) *The characteristic glands, of which three varieties are to be found.*

(*c*) *The parenchyma of the floral axis, rich in crystals.*

PLATE XLII.

FIG. 52.—**Powdered Cusso Flowers** (× 240).

ca, Epidermis of inner sepal.
c'a', Margin of inner sepal.
c''a'', Epidermis of inner sepal, with fragment of mesophyll.
cal, Epidermis of outer sepal.
cal', The same with three forms of glandular hairs.
cal'', Margin of outer sepal.
cr, Rosette crystal of calcium oxalate.
er, Inner epidermis of calyx tube.
f, Lignified fibre.
g, Small unicellular gland.
g', Pluricellular gland.
g'', Large unicellular gland from outer calyx.
l, Bast tissue.
p, Unicellular, simple, conical hairs, entire or broken very numerous in this powder.
pc, Cortical parenchyma from floral axis, with numerous crystal .
pe, Epidermis of a petal.
tr, Tracheids from the veins of flowers.
v, Vessels from floral axis,

(53) Indian Hemp.

The flowering tops of pistillate plants of *Cannabis sativa.* Linn. (N.O. Urticaceæ), cultivated in tropical districts of India.

In the flattened masses of which the drug consists, the following organs may be distinguished :—Stems, leafy bracts of a greyish-green colour, small bracteoles, filiform stigmata of a reddish-brown colour, and here and there fruits approaching maturity.

Stems.—The stems of the flowering tops are distinguished by long cystolithic hairs, and by the presence of numbers of rosette-crystals of calcium oxalate in the cortical parenchyma. The bast contains laticiferous vessels and tubular cells with calcium oxalate ; the wood-parenchyma consists of polygonal cells with slightly thickened, pitted walls.

Leafy Bracts.—The upper epidermis is striated and furnished with very short, conical hairs which are inserted between the epidermal cells ; the bases of these hairs are much enlarged, and contain cystoliths of considerable size. The lower epidermis is smooth, and provided with stomata and with simple as well as glandular hairs. The stomata are very numerous; they are surrounded by five or six cells which exhibit little regularity in their arrangement. The hairs are most abundant over the veins ; they are cystolithic, but are longer and much less enlarged at the base than those of the upper surface. The glands are large and sessile like those of labiate plants ; they are divided by vertical walls into several cells. The veins are characterised by the presence in the bast of laticiferous vessels containing a brown latex.

Bracteoles.—These bear numerous glands, some of which are sessile, but others of which are supported upon long pluricellular and pluriserial stalks. Below the lower epidermis of the bracteoles there is a layer of cells, each of which contains a rosette of calcium oxalate.

Stigmata.—These are covered with long papillæ.

Fruits.—The presence of these in the powder is indicated by the large sclerenchymatous cells derived from the hard layer of the pericarp.

The diagnostic characters of powdered Indian hemp are :—

(*a*) *The remarkable curved hairs with cystoliths at their base.*

(*b*) *The secreting glands and their pluricellular pedicels, often much broken.*

(*c*) *Fragments of parenchyma with numerous small rosettes of calcium oxalate.*

(*d*) *Laticiferous vessels of the bast with brownish, granular contents.*

PLATE XLIII.

FIG. 53.—**Powdered Indian Hemp** (× 240).

bef, Epidermis from margin of bract.
eb, Epidermis of bracteole.
eif, Lower epidermis of bract.
esf, Upper epidermis.
e's'f', Upper epidermis of bract, with palisade, **p'a',** in profile.
esfn, Neural epidermis of bract.
ffv, Portion of fibro-vascular bundle from bract.
go, Oil-gland.
l, Bast, rich in calcium oxalate.
mc, Mesophyll of bract, with crystals.
pa, p'a', Palisade.
pas, Papillæ of stigma.
pc, Cystolithic hairs.
pca, Cortical parenchyma of tem with crystals.
pgc, Stalked glands.
pgd, Stalk deprived of gland.
pgs, Sessile glands.
pta, Simple hair from stem.
pl, Lignified parenchyma of stem.
st, Stigma with papillæ,
tc, Crystal tubes,
tr, Vessels, etc.
vl, Laticiferous vessels.

(54) Dalmatian Insect Flowers.

The unexpanded flower-heads of *Chrysanthemum cinerariæfolium*, Vis. (N.O. Compositæ).

The following are the organs that should be present in Dalmatian insect powder; they are arranged in order of importance, and the particular distinguishing features are appended to each :—

Fragments of the Bracts.—The epidermis is striated and provided with numerous stomata, T-shaped hairs, and oil-glands; under the epidermis of the central part there is a very characteristic fibrous hypoderma; the margins are very thin and bear numerous T-shaped hairs.

Corolla of the Ligulate Florets.—This is characterised by the upper (inner) epidermis, which is papillose over the whole surface, and by the sinuous striated cells of the lower (outer epidermis.

Corolla of the Tubular Florets.—The epidermis is papillose near the apex, but smooth over the remainder of the corolla, the latter portion consisting of regular cells containing rosette crystals of calcium oxalate.

Calyx of the Tubular Florets.—The tissue of the calyx is strengthened by the presence of numerous elongated, lignified cells; at the junction of the calyx with the ovary there is a disc composed of large, very irregular cells, with thick lignified pitted walls. Very many of these cells contain a prismatic crystal of calcium oxalate, one in each.

Ovary.—The epidermis of the intercostal depressions is characterised by the presence of a multitude of oil-glands and clino-rhombic crystals. There is a lignified hypoderma similar to that of the lower part of the calyx. The walls of the ovary contain very large ducts filled with a brown, granular secretion.

Anthers.—The filaments consist of regularly arranged square cells; the pollen grains are tubercular and exhibit three pores.

Style.—The cells at the apex are papillose; those of the stigma present a scale-like arrangement.

Receptacle.—Characterised by large, rounded, pitted cells.

Peduncle.—Débris of this are furnished with T-shaped hairs and glands.

In addition to these, numerous fragments of fibro-vascular bundles may be found, large secretory ducts from the bracts, ovary, etc., as well as detached oil-glands and hairs.

The principal anatomical features that allow of the false insect flowers being distinguished from the genuine Dalmatian are *the size and sinuous shape of the epidermal cells of the ligulate corollas and the absence of oil-glands from the lower part; the paucity and smallness of the oil-glands at the base of the tubular corollas; the deep colour and characteristic appearance of the secretory ducts of the ovary; the characteristic cells of the walls of the ovary, and the shape of the hairs on the brac*

PLATE XLIV.

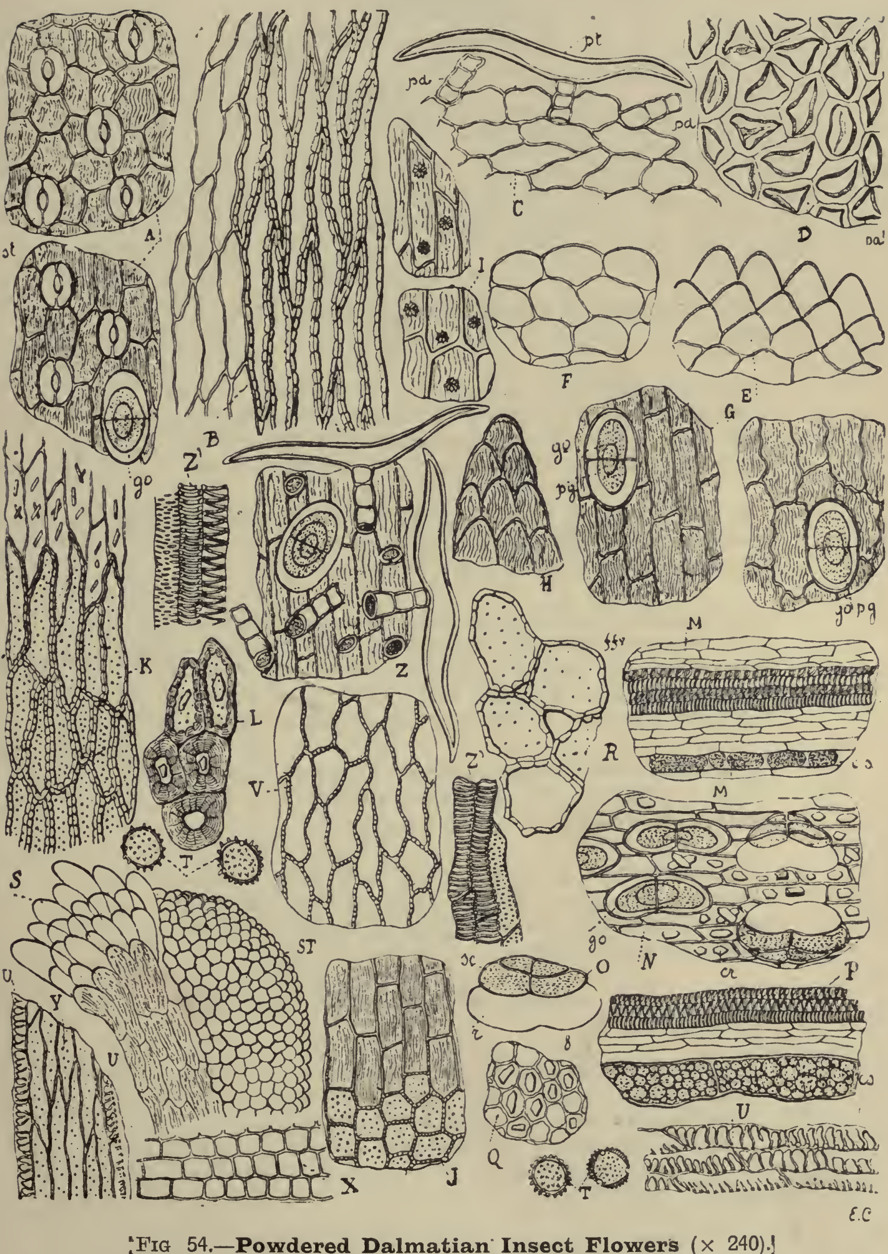

FIG 54.—**Powdered Dalmatian Insect Flowers** (× 240).

A, Outer epidermis of central portion of bract. **B**, Tissue of bract. **C**, Margin of bract. **D**, Upper epidermis of ligulate corolla. **E**, The same, in profile, near the apex. **F**, The same, surface view, near the base. **G**, Lower epidermis of ligulate corolla. **H**, The same, near the apex. **I**, The same, tubular portion. **J**, Epidermis of tubular corolla near the base. **K**, Similar part of calyx of tubular floret. **L**, Lignified celle at the junction of calyx and ovary. **M**, Parenchyma of tubular floret. **N**, Epidermis of ovary; intercostal portion. **O**, Oil-gland in profile. **P**, Parenchyma from wall of ovary. **Q**, The same, near the base. **R**, Tissue of the receptacle. **S**, Papillose apex of style. **ST**, Stigma. **T**, Pollen grains. **U**, Débris of thecæ of anthers. **V**, Upper portion of anther. **X**, Filament. **Y**, Connective. **Z**, Striated epidermis. **Z'**, Vessels from peduncle

(55) **Lily of the Valley.**

The inflorescence of *Convallaria majalis*, Linn. (N.O. Liliaceæ).

The lily of the valley produces a graceful unilateral raceme of fragrant flowers with white campanulate corollas, each of which bears on its inner surface six stamens with large anthers. The ovary is trilocular, and is crowned with a short, thick style.

The inner epidermis (*ei*) of the perianth is composed of polygonal cells with smooth cuticle, and is provided with stomata, each of which is surrounded by four or five cells.

The outer epidermis (*ee*) is striated, and consists of smaller cells. The parenchymatous tissue between these two layers is traversed by numerous fibro-vascular bundles, and contains aggregations of acicular crystals in some of the cells, which are distinguished from the neighbouring ones by their larger size.

The thecæ of the anthers are largely composed of spirally, thickened cells (*an*). The stigmata are covered with a striated cuticle, and provided with numerous papillæ.

The powder of this flower contains in addition numerous débris derived from the peduncles, pistils, ovaries, etc., as well as vessels derived from the veins, acicular crystals of calcium oxalate and pollen grains.

The diagnostic characters of powdered lily of the valley flowers are :—

(*a*) *Cells from the perianth with acicular crystals.*
(*b*) *Striated surfaces of the stigmata and papillæ.*
(*c*) *The epidermis of the peduncle with elongated cells.*
(*d*) *The cells of the perianth, with acicular crystals of calcium oxalate.*

PLATE XLV.

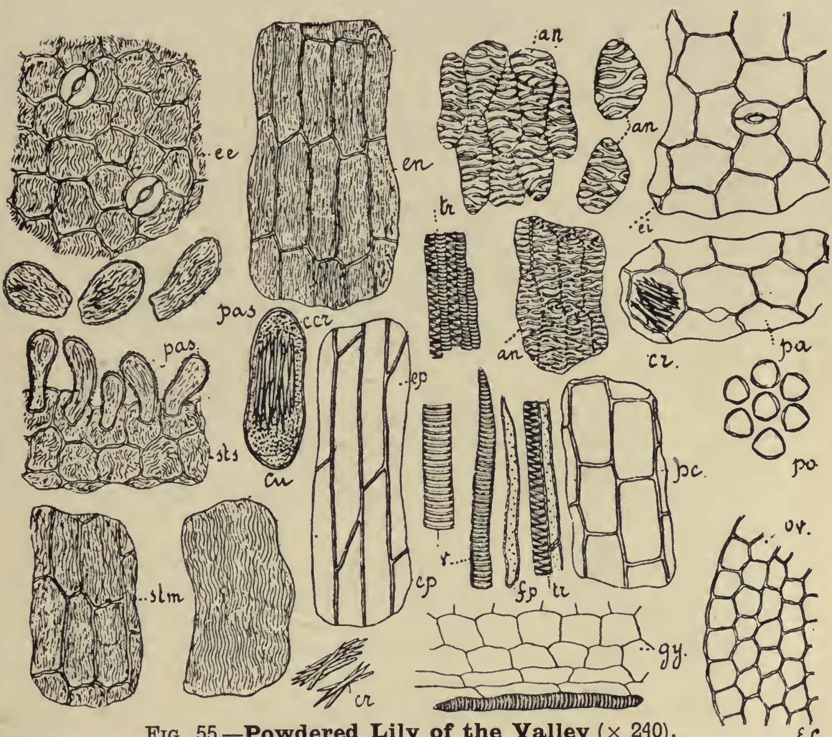

Fig. 55.—**Powdered Lily of the Valley** (× 240).

an, Cells from the thecæ of anthers.
ccr, Crystal cells from perianth.
cr, Acicular crystals.
cu, Débris of cuticle.
ee, Outer epidermis of perianth.
ei, Inner epidermis of perianth.
en, Neural epidermis of perianth.
ep, Epidermis of peduncle.
fp, Pericyclic fibres.
gy, Débris of pistil.
ov, Débris of ovule.
pas, Papillæ from stigmata.
pa, Parenchyma from perianth.
pc, Cortical parenchyma of peduncle.
po, Pollen grains.
stm, sts, Striated epidermis of stigmata.
tr, Vessels from perianth
v, Vessels from peduncle

(56) **Saffron.**

Saffron consists of the stigmata and upper parts of the styles o *Crocus sativus*, Linn. (N.O. Irideæ).

It forms a loosely matted mass of dark, reddish-brown flattened threads, amongst which a few narrower yellow ones can be distinguished. The upper, enlarged part of the flattened threads is the stigma of the flower, the lower narrower portion is the style.

The stigma is composed of polygonal or rounded, thin-walled, parenchymatous cells containing mucilage and an orange-red colouring matter, crocin (polychroite). This tissue is traversed by small fibro-vascular bundles, which appear rounded in transverse section. It is covered by a slightly thickened, easily detached cuticle, which on the upper surface of the stigma bears small protuberances (*pr.*). Near the apex the stigma is furnished with large papillæ. The yellowish lower part of the threads of saffron is provided with an epidermis consisting of slightly sinuous cells, and is traversed by a small fibro-vascular bundle.

The diagnostic characters of powdered saffron are:—

The orange-red colouring matter in the cells; it is soluble in water, but insoluble in fixed oil.

The upper epidermis of the stigmata with small papillose protuberances.

The large pollen grains.

PLATE XLVI.

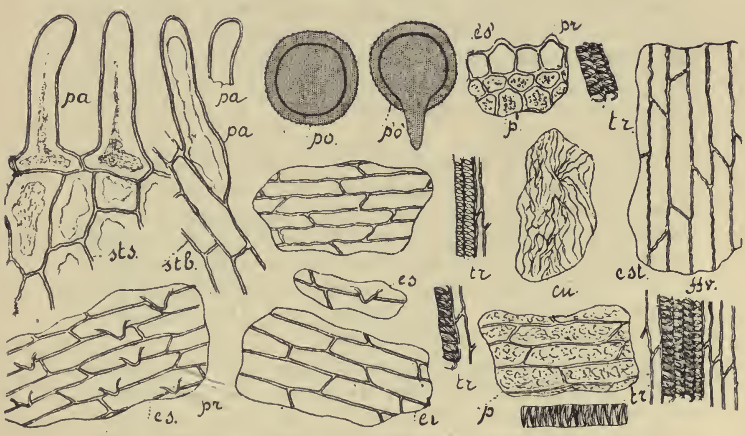

FIG. 56.—**Powdered Saffron** (× 240). E. C.

cu, Cuticle of stigma.
ei, Lower epidermis of stigma.
es, e's', Upper epidermis of stigma.
est, Epidermis of style.
ffv, Fibro-vascular bundle of style.
p, Parenchyma of stigma.
p', Transverse section of same.
pa, Papillæ at apex of stigma.
po, Pollen grains.
p'o', The same, with tube protruding.
pr, Warty projections on epidermis of stigma.
sts, Upper extremity of stigma, with papillæ.
stb, Upper margin of stigma.
tr, Vessels, etc.

(57) Santonica.

The unexpanded capitula of *Artemisia maritima*, var. α-*Stechmanniana*, Besser (N.O. Compositæ).

The capitula are very small, being only about 2 Mm. long, elongated and ovoid in shape; their surface is shining and glabrous.

The involucre consists of about ten to fifteen imbricated bracts. The lower of these are ovate in outline, and smaller and more distant than the upper ones, which are elongated. They are furnished with a conspicuous keel, on each side of which numerous oil-glands can be seen. The young bracts bear a few colourless woolly hairs over the midrib, but these fall off towards maturity. The upper bracts enclose from three to five florets inserted upon a naked receptacle. The corolla of each floret is contracted at the base, and divides at the apex into five short triangular teeth.

The involucral bracts are composed of a central opaque portion bordered on each side by membranous translucent wings, on which numerous oil-glands are borne. The epidermis of the translucent portion consists of elongated cells, but that of the central portion is composed of isodiametric cells with pitted walls. The latter portion bears numerous stomata, glands, and one-celled woolly hairs; the glands have the shape and structure characteristic of composite plants.

The transverse section varies a little according to the position of the bract on the axis, but there are certain general characters common to all of them. The midrib is flat on the inner surface of the bract, but angular on the outer. The substance of the bract is composed of rounded, polygonal or cylindrical parenchymatous cells containing chlorophyll, and is traversed by a fibro-vascular bundle. Below the outer epidermis of the peripheral bracts there is a curved hypoderma consisting of one or two rows of sclerenchymatous cells. A secretory duct may sometimes, but not always, be found within the endodermis, between the midrib and the epidermis of the upper (inner) surface of the bract.

The lower part of the corolla-tube bears a number of oil-glands; indeed this part of the plant appears to be richer in oil than any other.

The diagnostic characters of powdered santonica are:—

(*a*) *The epidermis of the central portion of the bracts with pitted walls, numerous stomata, and woolly hairs.*

(*b*) *The characteristic oil-glands.*

(*c*) *The elongated, thickened cells of the hypoderma of the bracts.*

PLATE XLVII.

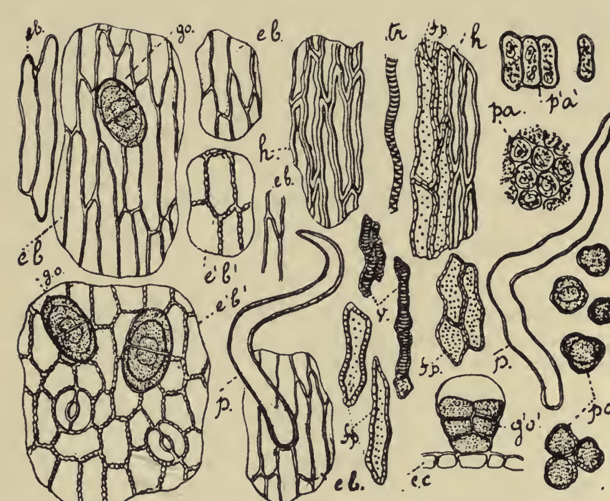

FIG. 57.—**Powdered Santonica** (× 240).

eb, Epidermis of the membranous wings of the bracts
e'b', Epidermis of the central portion.
ec, Epidermis of the corolla tubes.
fp, Fibrous cells from pericycle.
go, Oil-gland, surface view.
g'o', The same in profile.
h, Cells of the hypoderma.
p, Hairs from central portion of bract.
pa, p'a', Parenchyma of the bracts.
po, Pollen grains.
st, Stomata.
tr, v, Elements of fibro-vascular bundle.

SECTION V.

POWDERED SEEDS AND FRUITS.

The characteristic elements that are available for the identification of powdered seeds and fruits are undoubtedly more numerous than those at our disposal for powdered barks and roots.

Every seed is enveloped in seed-coats composed of several layers of cells exhibiting differences in structure. In some natural orders a most remarkable and constant analogy is to be found in the structure of the seeds, as for instance in Leguminosæ, but when the seeds of one natural order are compared with those of another, very striking and characteristic differences may be detected. These differences are to be found chiefly in the number of layers of which the seed-coats are composed, their arrangement and structure, which is often very complex, as well as their colour, the presence or absence of endosperm and the nature of the substances contained in both endosperm and embryo. It may, however, here be observed that the most exact and most constant, consequently, therefore, the most important of all the diagnostic characters, is usually to be found in the sclerenchymatous layer. Apart from their particular colour, which is the first thing that attracts the attention of the microscopist, the cells of which this layer is composed exhibit a remarkable constancy of shape in the same seed, and striking differences from the corresponding cells in the seeds of other species. To such an extent is this the case that these cells often furnish a means not only of identifying a single seed, but of distinguishing all the seeds belonging to a particular natural order or genus.

In order, however, to utilise these differences to the fullest possible extent, it is necessary to have an intimate acquaintance with the structure of each of the layers of the seed-coats, and to be familiar with their appearance when viewed in different positions. As we have already had occasion to observe, in vegetable powders it is usually the surface view of the various tissues that is presented to the observer, not transverse sections, and experience teaches us that to become thoroughly acquainted with the anatomy of a crude drug it is necessary to examine radial and tangential as well as transverse sections.

One of the best methods of studying the structure of a seed consists in separating the various layers as much as possible from one another and ascertaining the shape and arrangement of the cells of which they consist, not only on the convex surfaces of the seed but also in the grooves near the apex, the base and the raphé. Examined in this way a variety in form and in anatomical detail will be disclosed that a transverse section would have left quite unsuspected. The study of the illustrations that accompany our descriptions will amply justify our statements.

We have usually found one of the following processes very successful in disintegrating the coats of a seed. Rather thick transverse sections are made and boiled in water made alkaline with solution of potash. The sections are then mounted on a slide under a coverslip and examined; the finger is next firmly pressed on the coverslip, and at the same time sliding it a little along, so as to separate the various layers that have been loosened by the boiling in alkali.

Good results may also be obtained by simply separating the seed-coats from the kernel, soaking them for an hour or two in solution of potash, and then teasing them out with dissecting needles. In the case of very resistant layers that cannot be disintegrated by either of these methods, recourse may be had to maceration with nitric acid and potassium chlorate; after such treatment they will seldom fail to separate into their constituent cells.

Whichever method is adopted, it must be borne in mind that it is merely supplementary of sections in various directions. The latter are particularly necessary in order to avoid any error due to the action of the alkali on the cell-walls or to ensure that correct relative positions are assigned to the various ayers of cells observed.

In two of the seeds that we have studied (*Strychnos Nux vomica* and *Strychnos Ignatii*) belonging to the natural order Loganiaceæ, the structure is very similar, even to the long hairs that cover the surface of the former, but are found in patches on that of the latter ; a distinction, however, is to be found in the structure of the bases of the hairs, and this is sufficient to serve as a means of detecting the powder of either seed when mixed with that of the other.

These two seeds are also characterised by the horny nature of the endosperm. The walls of the cells are very thick, and consist of a modification of cellulose that swells even in cold water, more easily in hot water or alkaline solutions.

Areca nuts and nutmegs possess in addition a ruminate endosperm by which their identification is facilitated.

The nature of the substances contained in the cells of the endosperm may also be utilised in the identification of the powder. In many seeds, such, for instance, as those of cereal grasses, these cells are filled with starch. This reserve material is usually present in the form of distinct grains, but in some cases, as in guarana, the grains may have been gelatinised, and the starch is then in amorphous masses. Most of the officinal seeds contain aleurone grains, especially those in which oil is the principal reserve material. These are much more difficult to identify than starch grains, and are best examined in almond oil or glycerin, as water more or less rapidly disintegrates them. The aleurone grains of the more important seeds have been described and figured by Tschirch* and others.

In some seeds as, for instance, those of *Theobroma Cacao*, starch grains accompany the aleurone grains, and in such cases it is desirable to employ a solution of iodine in iodide of potassium which colours starch grains blue, but aleurone grains brownish-yellow. Aleurone grains are, however, more commonly accompanied by fixed oil, as in linseed, mustard seed, etc., than by starch. The shape, size, and composition of these grains may sometimes be utilised in the identification of a powder, especially the powders of decorticated seeds, which, of course, contain but very little débris of the seed-coats. Calcium oxalate crystals, for instance, are not very commonly found in the aleurone grains of officinal seeds, but are generally present in those of the endosperm of umbelliferous fruits.

* 'Angewandte Pflanzenanatomie,' p. 44.

The officinal seeds do not, as a rule, contain any secretory tissue, but instances to the contrary are by no means wanting. Thus, cocoa seeds contain large mucilage cells in the seed-coat; nutmegs, black pepper, and cubebs contain numerous oil cells and so on.

Sometimes organs that accompany the seed contain principles different from those present in the endosperm; thus, mace, which consists of the arillus of the nutmeg, contains amylodextrin, a substance that is distinct both from starch and aleurone grains; the thickening at the base of colchicum seeds contains starch, which cannot be detected in the endosperm.

As the fruit consists normally of the seed surrounded by the pericarp it is obvious that in addition to the characteristic elements furnished by the seed itself, those derived from the pericarp must also be taken into consideration. This part of the fruit is by no means lacking in cells or tissues that are of great value in the identification of the powder. It commonly contains sclerenchymatous cells of very varying shape and dimensions (cubebs), oil-cells (pepper), oil-glands (allspice), laticiferous vessels (poppy), etc. The powders obtained from umbelliferous fruits usually contain fragments of the vittæ which are easily recognised by their dark brown colour and by the tapetal layer of regular polygonal cells. Hemlock fruit contains no such vittæ, but in that case the powder is characterised by the shape of the cells in which the coniine is secreted, and by this means powdered hemlock fruit can be distinguished from other similar fruits. The pericarp may also be furnished with characteristic hairs or contain distinctive crystals that may be utilised for a similar purpose. Occasionally also the endocarp furnishes valuable diagnostic characters.

(58) **Areca Nuts.**

The seeds of *Areca Catechu*, Linn. (N.O. Palmee).

The seed consists of a copious, horny, ruminate endosperm covered by a thin brown seed-coat. The endosperm is white, but is traversed in various directions by narrow, dark brown lines which are infoldings of the inner layers of the seed-coat.

The cells of the endosperm are very characteristic in appearance. They are rather large, and are furnished with very thick and highly refractive walls pierced by large pits. They contain proteid matter which is coloured brown by iodine.

The brown folds of the seed-coat, which produce the ruminate appearance of the endosperm, consist of very dark brown, polygonal cells with pitted walls.

The cells of which the seed-coats are composed vary considerably in appearance. The outer ones are elongated, moderately thick-walled and more or less distinctly pitted and often exhibit intercellular spaces of varying size. The cells of the inner layers are more uniform in shape, being approximately isodiametric; their walls are more strongly lignified, and the pits more numerous.

The seed-coats are traversed by fibro-vascular bundles, the débris of which frequently occur in the powder.

At the base of the seed, where it is attached to the pericarp, there is a tuft of coarse fibres, traversing a thin pale buff-coloured coat that often covers the basal part of the seed. This coat is the inner portion of the pericarp. The fibres consist of very long, narrow, thick-walled, fibrous cells, the buff-coloured coat of elongated empty pitted cells with thinner walls than those of the outer cells of the seed-coat; they may be detected in the powdered seed.

The diagnostic characters of powdered areca nuts are:—

(*a*) *The characteristic cells of the endosperm with very thick walls and large pits.*

(*b*) *The remarkable sclerenchymatous cells of the seed-coats.*

(*c*) *Fragments of the ruminations, the cells of which have thin pitted walls and red-brown contents.*

PLATE XLVIII

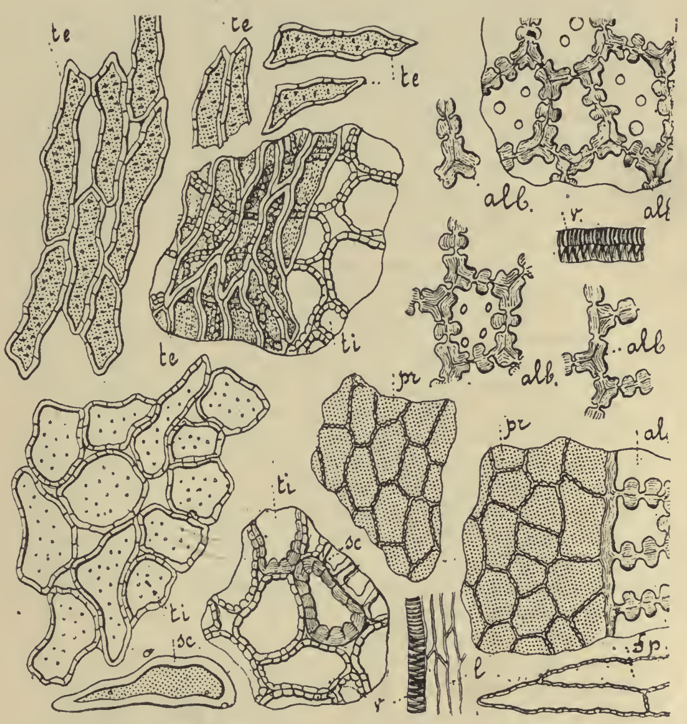

FIG. 58.—**Powdered Areca Nuts** (× 240)

alb, Cells of the endosperm with *very thick* walls and large pits.
fp, Cells from the part of the pericarp adhering to the seeds.
l, Bast tissue from the fibro-vascular bundles.
pr, *Dark brown pitted* cells from the ruminations.
sc, Sclerenchymatous cells of seed-coat, varying in size and shape.
te, Outer layer of seed-coat.
ti, Inner layer of same.
v, Fragments of vessels.

(59) **Cacao Seeds.**

The seeds of *Theobroma Cacao*, Linn. (N.O. Sterculiaceæ).

The seed-coats comprise four distinct layers :—(1) An outer layer (epidermis) composed of a single row of tabular cells which, in surface view (*te*), are seen to be elongated in the same direction; they are polygonal and have straight, smooth walls. To this layer there is almost always attached the inner epidermis of the pericarp (*end*), the cells of which are narrow and elongated; they cross those of the epidermis of the seed-coat at right angles or often obliquely.

Below the epidermis of the seed-coat is a layer consisting of several rows of parenchymatous cells, (*pa*, *pl*). In this tissue there is a row of large mucilage cells and numerous fibro-vascular bundles containing an abundance of small vessels.

The third layer is a single row of small sclerenchymatous cells (*sc*). In transverse section they resemble a horse-shoe, whilst in surface view they are polygonal.

Lastly there is a layer of varying thickness composed of collapsed cells with thin brown walls.

The endosperm, of which but little remains, consists of two distinct layers of cells. The outer (*ae*) is a single row of relatively large tabular cells, which, in surface view, are seen to be polygonal. They contain crystals of fatty matter, often grouped into little masses, and here and there crystals of calcium oxalate. The inner layer (*ai*) is made up of very irregular cells containing crystals of fat. It not only surrounds the kernel of the seed but lines the folds of the cotyledons.

The epidermis of the cotyledons is composed of polygonal cells containing granules of brown pigment. It bears the very remarkable hairs (*p*) shown in the illustration, but these often break off, and are then to be found on the membrane (endosperm) which surrounds the seeds.

The cells of the cotyledons (*co*) are polygonal and vary a little in their contents. Sometimes they are filled with starch and aleurone grains embedded in a fatty mass; sometimes acicular crystals or tufts of crystals are associated with fat and protoplasm, whilst some cells contain a brown amorphous pigment known as cocoa-red. The starch grains are very small some are simple, but many are compound, the aleurone grains are rather smaller than the simple starch grains.

The diagnostic characters of powdered cacao seeds are :—

(*a*) *The elongated polygonal cells of the epidermis of the seed-coat, crossed by the narrower cells of the inner epidermis of the pericarp.*

(*b*) *The sclerenchymatous layer of the seed-coat.*

(*c*) *The cells of the cotyledons, with small starch-grains fat crystals, etc., and the pigment-cells.*

(*d*) *The remarkable hairs.*

PLATE XLIX.

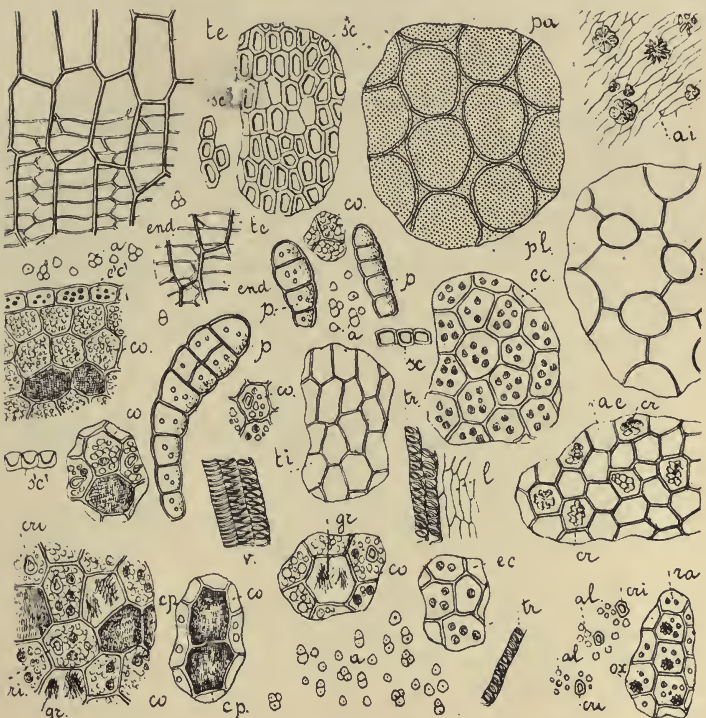

FIG. 59.—**Powdered Cacao Seeds** (×240).

a, Starch grains
ae, Outer layer of endosperm.
ai, Inner layer of endosperm.
al, Aleurone grains.
co, Cotyledon.
cp, Pigment cells containing cocoa-red.
cr, Crystals of fat.
ec, Epidermis of cotyledon, surface view.
e′c′, Epidermis of cotyledon, profile.
end, Inner epidermis of pericarp.
gr, Crystals of fat.
l, Bast from fibro-vascular bundles.
ox, Calcium oxalate crystals.
p, Pluricellular hairs.
pa, pl, Parenchyma of seed-coat.
ra, Cells of radicle.
sc, Sclerenchymatous layer of seed-coat, surface view.
s′c′, Sclerenchymatous layer of seed-coat, in profile.
te, Outer epidermis of seed-coat to which the inner epidermis of the pericarp (*end*) is adhering.
ti, Inner epidermis of seed-coat.
tr, v, Vessels, etc., from fibro-vascular bundle.

(60) Cevadilla Seeds.

The seeds of *Schœnocaulon officinale*, A. Gray (N.O. Liliaceæ).

The seed-coats comprise three distinct layers, all of which are brown in colour.

The outermost layer (*te*) is composed of a single row of radially elongated cells, the outer walls of which are considerably thickened. In surface view these cells are polygonal, and their walls are straight or slightly wavy, and deep brown in colour.

The middle layer (*tm*) is formed of several rows of rounded or polygonal cells with small intercellular spaces and inconspicuous pits; they are also coloured brown, but less deeply than the cells of the outermost layer.

The innermost layer (*ti*) consists of a single layer of elongated cells, with thin, pitted walls.

The cells of the endosperm (*alb*) are polygonal and isodiametric; the walls are colourless, very thick, and very conspicuously pitted. They contain a granular, nitrogenous substance and fixed oil.

In the powdered seeds, vessels (*tr*) and fibres (*f*) from the raphe are to be found.

The diagnostic characters of powdered cevadilla seeds are:—

(*a*) *The brown, elongated polygonal cells of the epidermis*

(*b*) *The cells of the endosperm with pitted or irregularly thickened walls.*

PLATE L.

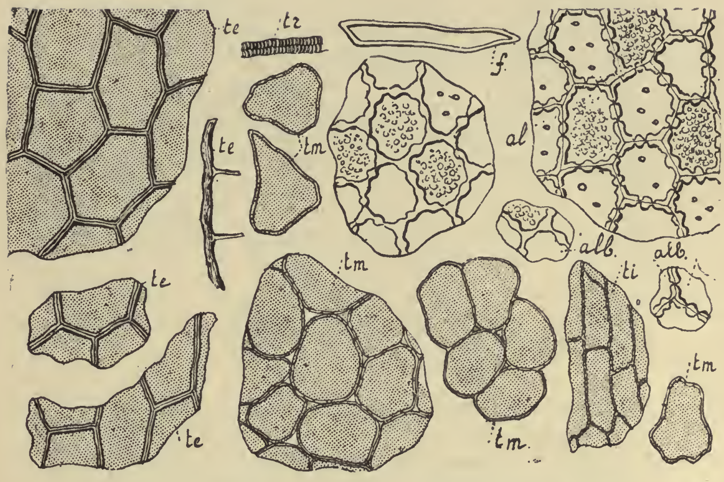

FIG. 60.—**Powdered Cevadilla Seeds** (×240).

alb, Endosperm.

f, Fibres from raphe.

te, Outermost layer of seed-coats

ti, Innermost layer of same.

tm, middle ditt

tr, Vessels.

(61) Colchicum Seeds.

The seeds of *Colchicum autumnale*, Linn. (N.O. Liliaceæ).

The seed-coat of colchicum seeds is composed of three layers all of which are brown in colour.

The outer layer (*te*) is the most deeply coloured, and consists of elongated cells which, in surface view, are seen to be rather large, and possess thick, brown, slightly wavy walls.

The middle layer (*tm*) is paler in colour, and consists of similar cells which, however, have thinner walls than those o the preceding layer.

The inner layer (*ti*) is made up of much smaller and more regular polygonal cells.

The thickening that is observable near the hilum of the seed is composed of thin-walled, polygonal, isodiametric cells (*ep*) characterised by the fact that they are filled with starch grains. The latter are convex on one side and concave or angular on the other; they often exhibit a small stellate hilum.

The horny endosperm consists of polygonal cells with very thick, pitted walls; they contain granular albuminoid substances and fixed oil.

The diagnostic characters of colchicum seeds are:

(*a*) *The large cells of the epidermis of the seed-coat with rather thick, brown walls.*

(*b*) *The cells of the endosperm with thick, pitted walls.*

(*c*) *The thin-walled cells of the thickening near the hilum filled with small starch grains.*

PLATE LI.

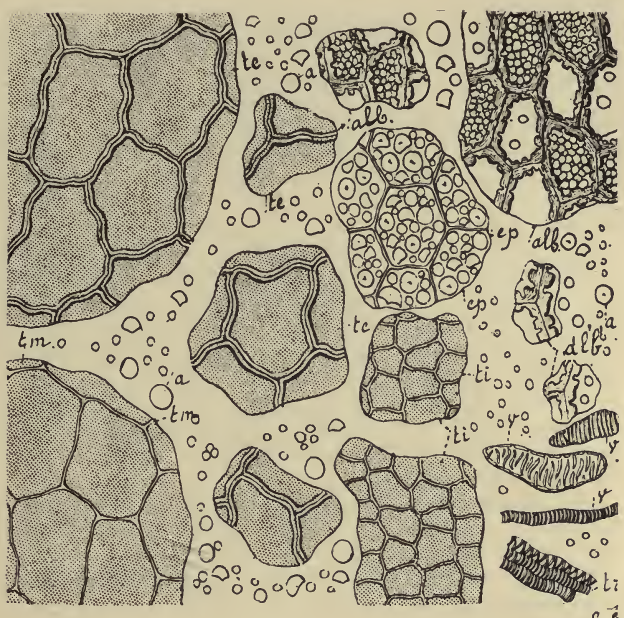

FIG. 61.—**Powdered Colchicum Seeds** (× 240).

a, Grains of starch from the thickened part of seed.

alb, Cells of endosperm.

a'l'b', Fragments of same.

ep, Cells from thickened part of seed.

te, Outer layer of seed-coat.

ti, Inner layer of same.

tm, Middle layer of same.

tr, v, Vessels, etc., from raphe.

(62) **Fœnugreek Seeds.**

The seeds of *Trigonella Fœnum-græcum*, Linn. (N.O. Leguminosæ).

The seed-coats resemble in structure those of most of the seeds belonging to the same natural order. They exhibit three distinct layers.

The *outer layer* (epidermis) consists of a single row of palisade cells. In section (*s'c'*) these cells appear about five or six times as long as they are wide; they are slightly conical at their upper extremity, but flat at the lower, and have strongly thickened and highly refractive walls. In surface view (*sc*) they have a polygonal outline, but vary in aspect according as the upper (*sce*) or lower (*sci*) extremity is under observation. (Compare the description of leguminous flours, pp. 41 to 45.)

The *middle layer* is constituted by a single row of cells of remarkable shape, known as "hour-glass" or "bearer" cells. The upper end of these cells is smaller than the lower, and in the middle they are usually somewhat contracted (*c's'*). The radial walls are provided at intervals with bar-like thickenings and the cells thus acquire somewhat the aspect of a shallow wicker basket. In surface view they exhibit the polygonal outline of the smaller (upper) end, and that of the larger (lower) end, the two being connected by the bar-like thickenings (*cs*).

The *inner* layer is rather thick and consists of flattened, tangentially elongated cells which, in surface view, show certain differences in structure. They may be polygonal and tolerably uniform (*p*) or they may be irregular, branching and separated by intercellular spaces (*p'*).

Next to the seed-coats is the endosperm, which consists of several rows of polygonal cells containing mucilage which, in contact with water, swells considerably. These mucilaginous cells have a very characteristic appearance (*cm*).

The cells of the cotyledons vary a little in appearance according as they are derived from the outer (*coe*) or the inne part (*coi*) of the cotyledons. They contain starch and aleurone, the former being sometimes in distinct grains, sometimes gelatinised.

Powdered fœnugreek is largely used as an ingredient in various cattle foods, and it is, therefore, useful to be acquainted with its anatomical characters.

The diagnostic characters of fœnugreek powder are :—

(*a*) *The palisade epidermis of the seed-coat.*
(*b*) *The basket-like hypodermal cells.*
(*c*) *The mucilaginous cells of the endosperm*

PLATE LII.

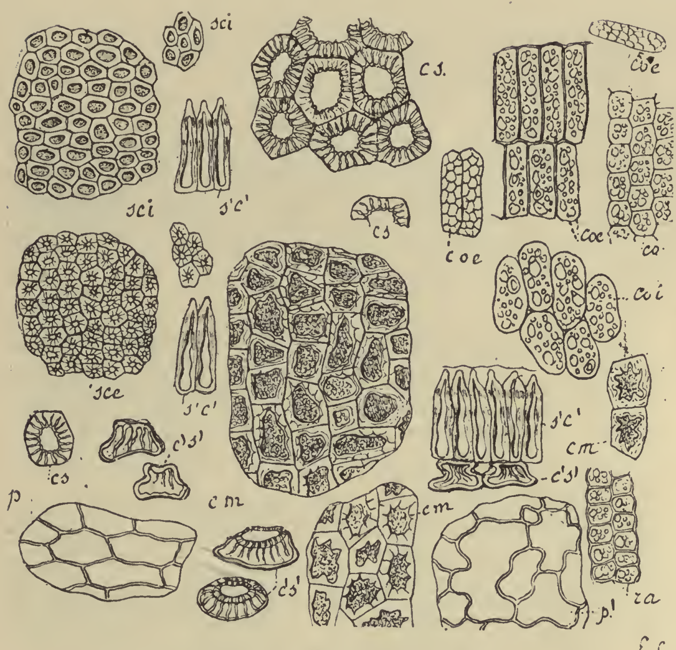

FIG. 62.—**Powdered Fœnugreek Seeds** (× 240).

cm, Mucilaginous endosperm; the *thick, striated walls swell considerably in contact with water.*

coe, Cells near the margin of cotyledon, containing aleurone grains and starch.

coi, Cells near the centre of cotyledons.

cs, Bearer-cells; surface view.

c's', The same in profile.

p,p', Parenchyma of seed-coats.

ra; Cells of radicle.

sce, Palisade cells (epidermis), surface view; upper surface.

sci, The same, lower surface.

s'c', The same, in profile.

(63) **Guarana.**

A paste prepared from the seeds of *Paullinia Cupana*, H. B. and K. (N.O. Sapindaceæ).

The seeds of this plant are covered with a dark brown seed-coat in which two distinct layers can be observed. The outer consists of a single row of cells which are much elongated radially and have thick brown walls; in surface view these cells are seen to have a very sinuous outline, and also to vary considerably in size.

The inner part of the seed-coat consists of parenchymatous tissue composed either of stellate cells with large intercellular spaces and slightly beaded walls or of polygonal cells without intercellular spaces and with markedly beaded walls. A few of the latter are thickened and lignified.

The large arillus at the base of the seed is composed of small polygonal isodiametric cells with pitted walls.

The endosperm is made up of large rounded or polygonal cells filled with gelatinised starch. Fragments of vessels and of fibres from the raphe may also be found in the powder.

The diagnostic characters of guarana are:--

(*a*) *The conspicuous cells of the epidermis.*

(*b*) *The beaded and pitted parenchymatous cells.*

(*c*) *The endosperm cells filled with gelatinised starch.*

PLATE LIII.

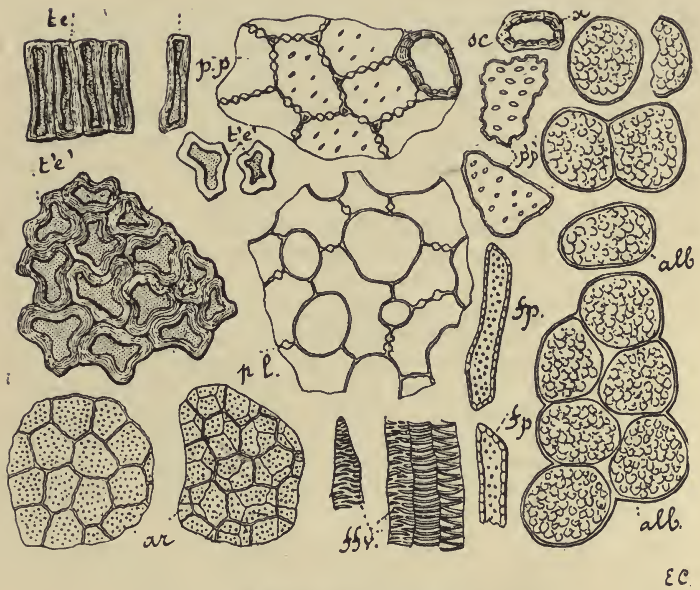

FIG. 63.—**Powdered Guarana** (× 240).

alb, Cells of endosperm.
ar, Cells of arillus.
ffv, Débris of vessels from raphe.
fp, Sclerenchymatous fibres from raphe.
pl, Stellate cells from seed-coat.
pp, Pitted and beaded cells from seed-coat.
p'p', The same cells, isolated
sc, Sclerenchymatous cells from same layer.
te, Epidermal cells, in profile.
t'e', Epidermal cells, surface view.

(64) Ignatius Beans.

The seeds of *Strychnos Ignatii*, Berg. (N.O. Loganiaceæ).

The Ignatius bean is covered, like nux vomica, with a n seed-coat, the epidermal cells of which have developed into hairs of extremely remarkable shape. These hairs are, however, easily detached, and in the commercial drug usually only isolated patches of them are to be found. They are distinguished from those of nux vomica by the base, which appears much ramified. During the process of pulverisation they become broken and separated to a great extent into detached strands.

The layer beneath the epidermis consists of rather small polygonal cells with thickened and pitted walls.

The endosperm is very hard and horny. The outer part is composed of rather small cells with moderately thickened walls and granular contents. Towards the centre of the seed the cells increase in diameter and their walls in thickness, the lumen at the same time assuming various, irregular shapes. Like the walls of the corresponding cells of nux vomica they swell when warmed with water, and still more so in hot dilute solution of potash; in the latter case the contents disappear almost entirely.

The diagnostic features of powdered Ignatius beans are :—

(*a*) *The characteristic hairs with remarkable bases.*

(*b*) *The polygonal cells of the subjacent layer.*

(*c*) *The cells of the inner part of the endosperm, with very thick walls which swell in hot dilute potash.*

PLATE LIV.

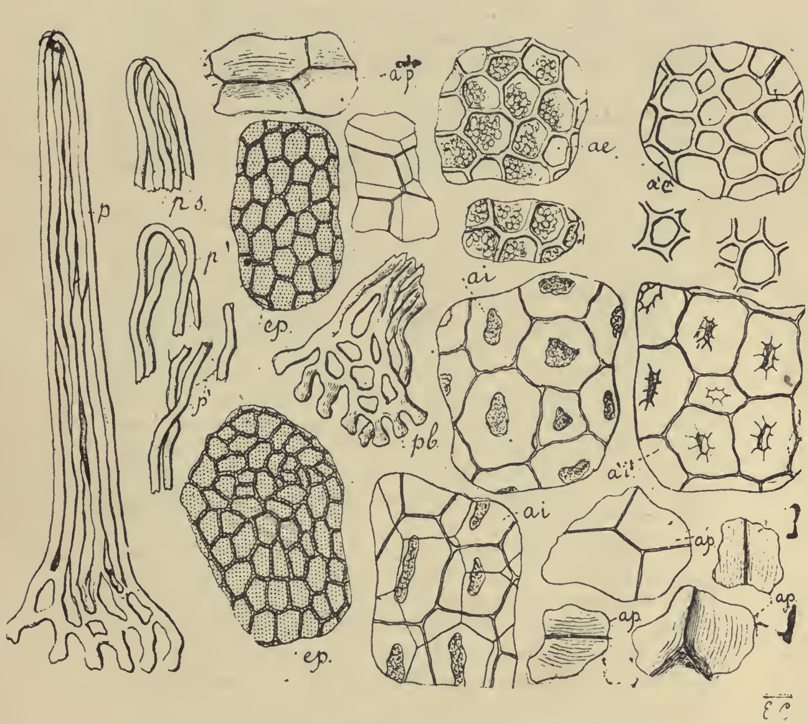

FIG. 64.—**Powdered Ignatius Beans** (× 240).

ae, Outer portion of endosperm.
a'e', The same, after boiling in dilute alkali.
ai, Inner portion of endosperm.
a'i', The same, after boiling in dilute potash.
ap, Portions of cell wall from endosperm.
ep, Polygonal cells of seed-coat.
p, Ha r.
p', Fragments of hairs.
pb, Base of hair.
ps, apex of hair.

(65) **Linseed.**

The seeds of *Linum usitatissimum*, Linn. (N.O. Lineæ).

The seeds are covered with a glossy brown, finely pitted coat in which the following layers can be distinguished:—

(1) *An outer layer* consisting of a single row of radially elongated cells. These cells contain mucilage which rapidly swells in contact with water. In surface view they appear polygonal, with thin, smooth and straight or only slightly wavy walls.

(2) *A parenchymatous layer* (*p*) composed of two rows of polygonal cells, which, in surface view, appear rounded and rather thick-walled, and often exhibit small intercellular spaces.

(3) *A sclerenchymatous layer* (*sc*) consisting of a single row of cells, which appear oblong or nearly square in section; in surface view they are long and narrow; these cells have thickened, pitted walls.

(4) *A hyaline layer* (*h*); the cells of which this layer is made up are very much flattened. The most easily visible of them form a single row of long, narrow cells, with very thin walls, crossing the sclerenchymatous cells at right angles. Here and there a second row of similar, but less easily visible, cells may be discerned crossing the previously mentioned layer at right angles. In the powdered drug layers (3) and (4) almost always remain united, and layer (2) is also generally attached to them (SP).

(5) *A pigment layer* (*tc*) consisting of a single row of flattened cells with pitted walls. These cells are filled with a dark brown homogeneous mass, which sometimes falls out intact; in surface view they are seen to be polygonal and isodiametric.

The cells of the endosperm (*alb*) are polygonal and contain aleurone grains and fixed oil; those of the embryo are similar, but are rather smaller and more regular.

The aleurone grains are characteristic; they are ovoid in shape, and contain a very distinct globoid and one or two large crystalloids.

The diagnostic characters of powdered linseed are:—

(*a*) *The pigment cells with pitted walls and amorphous dark reddish-brown contents.*

(*b*) *The sclerenchymatous cells, crossed at right angles by delicate, colourless, elongated parenchymatous cells.*

(*c*) *The thick-walled cells of the subepidermal layer.*

(*d*) *The characteristic aleurone grains.*

PLATE LV.

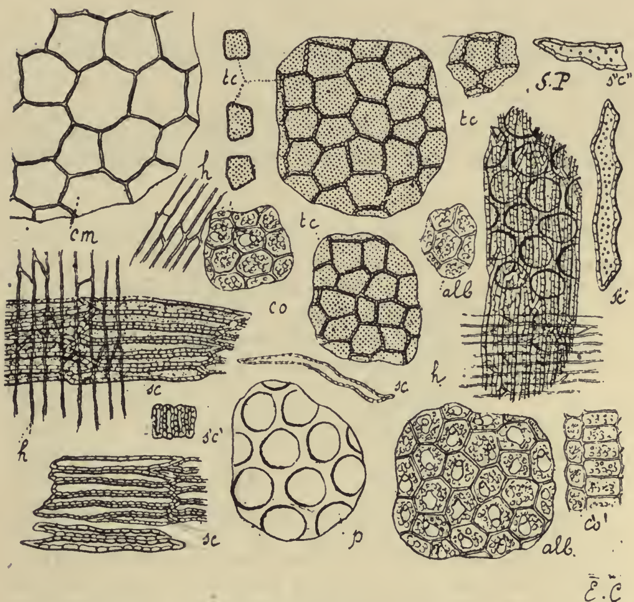

FIG. 65.– **Powdered Linseed** (× 240).

alb, Endosperm with aleurone grains and fixed oil.
cm, Mucilaginous epidermis.
co, Central portion of cotyledon.
c'o', Epidermis of same with subjacent layer of cells.
h, Hyaline layer.
p, Parenchymatous layer.
sc, Sclerenchymatous layer, surface view.
s'c', The same in section.
SP, The three foregoing layers united, as they usually occur in the powder.
tc, Pigment layer.

(66) **Mace.**

Mace is the fleshy arillus surrounding the seeds of *Myristica fragrans*, Houtt. (N.O. Myristicaceæ),

Mace consists principally of parenchymatous tissue containing numerous oil cells, and traversed by fibro-vascular bundles.

The cells of the parenchyma (*pa*) are pclygonal and isodiametric. They contain a remarkable substance, known as amylodextrin, embedded in a fatty mass. Amylo-dextrin occurs in grains of very irregular shape. Sometimes they are discoid or rounded but more often they are angular. Solution of iodo-potassium iodide colours them red.

The oil-cells contain either yellow volatile oil or reddish-brown oleo-resin.

The epidermis of both surfaces is covered with a thick cuticle. In surface view the epidermal cells (*eps*, *epi*) are strongly elongated axially; they are often fusiform, and have thick walls. Below the upper epidermis there is a collenchymatous hypoderma; this, however, is not continuous or uniform, but disappears in some places, whilst in others it is composed of two rows of cells.

The diagnostic characters of powdered mace are:—

(*a*) *The large, pointed, thick-walled cells of the epidermis.*

(*b*) *The oil-cells, many of which may be broken.*

(*c*) *The grains of amylo-dextrin in the parenchymatous cells.*

PLATE LVI.

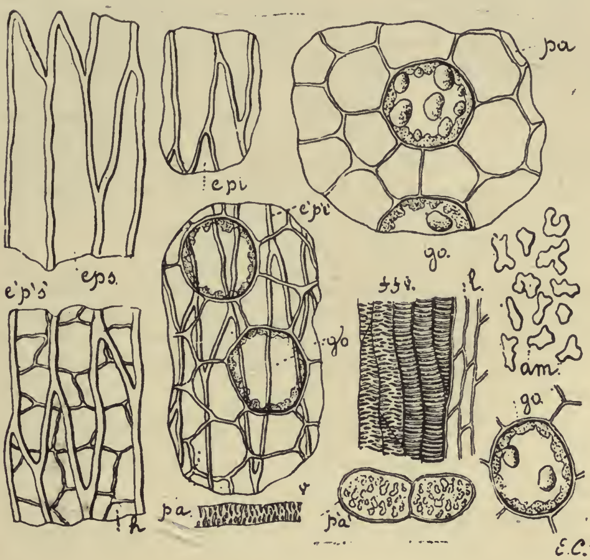

FIG. 66.—**Powdered Mace** (× 240).

am, Amylo-dextrin (very highly magnified).
epi, Lower epidermis, separated from subjacent parenchyma.
e'p'i', The same with parenchyma attached.
eps, Upper epidermis.
e'p's', The same with hypoderma attached.
ffv, Fibro-vascular bundle.
h, Hypoderma.
go, Oil-cells containing volatile oil.
l, Bast.
pa, parenchyma with oil-cells.
p'a', parenchymatous cells filled with amylo-dextrin.
v, Vessel.

(67) **Black Mustard Seeds.**

The seeds of *Brassica nigra*, Koch (N.O. Cruciferæ).

In the seed-coats the following layers can be distinguished:—

(1) *An epidermis* (*am*) composed of large thin-walled cells containing mucilage.

(2) A *single* layer of large *parenchymatous cells*, the walls of which are not collenchymatous, as those of white mustard seeds are. These cells are generally collapsed, and lie closely pressed on to the next layer of cells. In the powdered drug they are not easy to see.

(3) A *single* layer of dark brown *sclerenchymatous cells* (*sc*) which, in transverse section, exhibit the very characteristic thickening (*s′c′*) shown in the illustration. Some of these cells at regular intervals are longer than the others, and thus produce the pitted appearance of the seed as well as the peculiar, polygonal network seen in the surface view of the seed-coats.

(4) A thin *membranous layer* (*cm*) consisting of large, polygonal, flattened cells, containing a brownish amorphous substance. This layer is closely applied to the sclerenchymatous layer, and in the powder generally remains firmly adherent to it, producing, in part, the characteristic colour of the seed.

(5) Within the seed-coat is an *aleurone layer* (*ap*) consisting of rather thick-walled, polygonal cells, containing aleurone grains. Next to this row of cells is a layer composed of several rows of collapsed parenchymatous cells, the cavities of which are only indistinctly visible as faint lines.

The cotyledons (*co*) are covered by a transparent epidermis, consisting of polygonal cells. They contain small irregular aleurone grains, in each of which numerous minute globoids can be detected.

The powdered seeds contain very numerous fragments of the delicate tissue of the cotyledons and radicle ; in glycerin these exhibit the characteristic aleurone grains, which may also be found scattered over the preparation. Examined in chloral hydrate globules of fixed oil are very conspicuous Fragments of the seed-coat are easily recognised by their brown colour ; they usually present their surface view and exhibit the polygonal network above alluded to. Colourless, transparent fragments of the epidermis may also be found as well as portions of the aleurone layer.

The diagnostic characters of powdered mustard seeds are :—

(*a*) *The dark, yellowish-brown sclerenchymatous layer.*

(*b*) *The polygonal network exhibited by the upper surface of that layer.*

(*c*) *The small aleurone grains, each with numerous minute globoids.*

(*d*) *The mucilaginous cells of the epidermis.*

PLATE LVII.

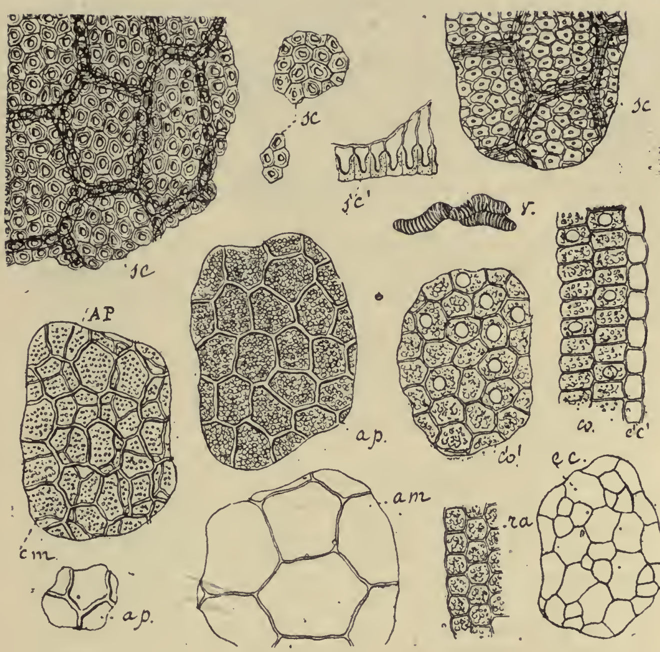

FIG. 67.—**Powdered Black Mustard Seeds** (× 240).

am, Mucilaginous epidermis without distinct concentric striations.

ap, Aleurone layer, isolated.

AP, The same together with the membranous layer, **cm.**

co, Margin of cotyledon in transverse section, with epidermis, **e'c'**.

ec, Epidermis of cotyledon, surface view.

ra, Radicle.

sc, Sclerenchymatous layer surface view; the cells are brown and exhibit the characteristic polygonal network.

s'c', The same in profile, showing the characteristic thickenings.

v, Débris of raphe.

(68) **White Mustard Seeds.**

The seeds of *Brassica alba*, Linn. (N.O. Cruciferæ).

The seeds are yellow in colour, and so minutely pitted that they appear smooth to the naked eye.

In the seed-coats the following layers can be distinguished :—

(1) An *epidermis* (*am*) made up of large cells containing mucilage which swells very rapidly and very considerably in contact with water.

(2) A *collenchymatous layer* (*col*) composed of two rows of polygonal cells, the walls of which are thickened, particularly in the angles

(3) A *sclerenchymatous layer* (*sc*) consisting of a single row of cells, the lateral and inner walls of which are thickened and pale yellow in colour. The cells are tolerably uniform in size and arrangement.

These three layers represent the outer seed-coat.

(4) A *membranous layer* (*cm*) composed of two or three rows of strongly flattened cells. These are free from the dark brown pigment which is contained in the corresponding cells of black mustard seed.

Within the seed-coats is the embryo surrounded by the aleurone layer (*ap*); the latter consists of a single row of isodiametric polygonal cells which have uniformly thickened walls and granular contents. The epidermis of the cotyledons (*ec*) is composed of irregular empty cells amongst which groups of two or three smaller ones may be observed; these are stomata in process of formation. The cells of the cotyledons themselves (*co*) are filled with aleurone grains and fixed oil. The aleurone grains are small and irregular in shape; they contain numerous minute globoids but no crystalloids.

The powder consists, like that of black mustard, largely of fragments of the cotyledons and radicle. The portions of the seed-coat are pale yellow in colour, and hence easily distinguished from the red-brown fragments of black mustard. The polygonal network that is so easily seen on the upper surface of the sclerenchymatous layer of black mustard is much less conspicuous.

The diagnostic characters of powdered white mustard are:—

(*a*) *The pale yellow sclerenchymatous layer.*

(*b*) *The epidermis cells with striated mucilage.*

(*c*) *The collenchymatous hypodermal layer.*

(*d*) *The small, irregular, aleurone grains containing numerous minute globoids.*

PLATE LVIII.

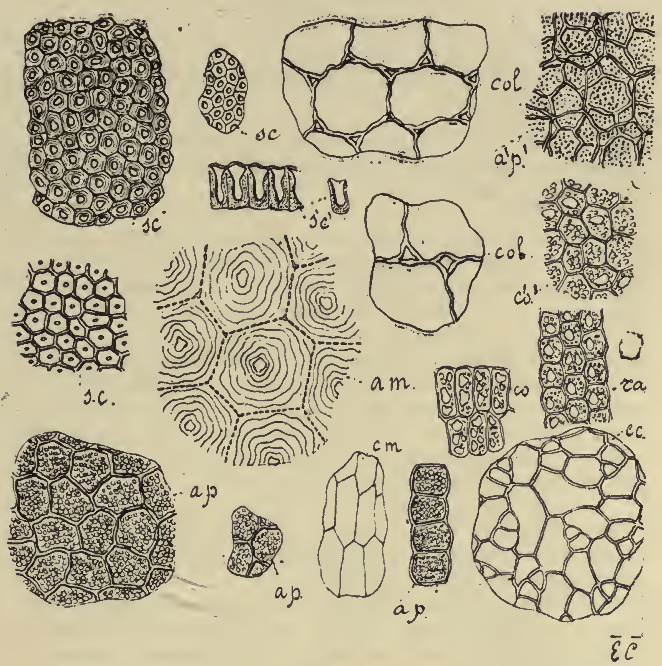

Fig. 68.—**Powdered White Mustard Seeds** (× 240).

am, Large mucilaginous cells of epidermis in surface view, showing concentric striation

ap, Isodiametric cells of proteid layer, containing aleurone grains.

a'p', The same, with membranous layer of seed-coat adhering.

cm, Membranous layer.

co, Cells from outer part of cotyledons.

c'o', Cells from inner part of cotyledons.

col, Collenchymatous cells.

ec, Epidermis of cotyledons.

ra, Tissue of radicle.

sc, Sclerenchymatous layer, surface view.

s'c', The same in profile.

(69) Nutmegs.

The kernel of the seed of *Myristica fragrans*, Houtt. (N.O. Myristicaceæ).

It consists of a ruminate endosperm covered by a thin brownish perisperm, which also penetrates the endosperm and produces the ruminations.

The outer layer of the perisperm (primary perisperm, *te*) is made up of a loose tissue consisting of irregular, colourless cells, often containing crystals of myristic acid. The tissue of the inner layer of the perisperm (secondary perisperm, *ti*) is denser, the cells are more regular and dark brown in colour. It is traversed by fibro-vascular bundles, and contains an occasional oil-cell. That part of the perisperm that penetrates into the endosperm retains its character at the margins of the ruminations, but the remainder consists of loose parenchymatous tissue, containing numerous oil-cells, which are sometimes isolated, but more often aggregated into groups.

The endosoperm consists of polygonal isodiametric cells containing starch embedded in a fatty mass. The starch grains are simple or compound; the former are rounded; the latter are composed of from five to eight component grains, which are more or less angular when isolated. Many of the cells of the endosperm contain in addition a large rhombohedral crystalloid (*cr*), acicular crystals of fatty matter and small aleurone grains. Here and there cells may be found in which the grains of starch are imbedded in dark brown oleo-resinous mass.

The diagnostic characters of powdered nutmeg are :—

(*a*) *The dark brown cells of the inner layers of the perisperm.*

(*b*) *The small starch grains.*

(*c*) *The presence of oil-cells.*

PLATE LIX.

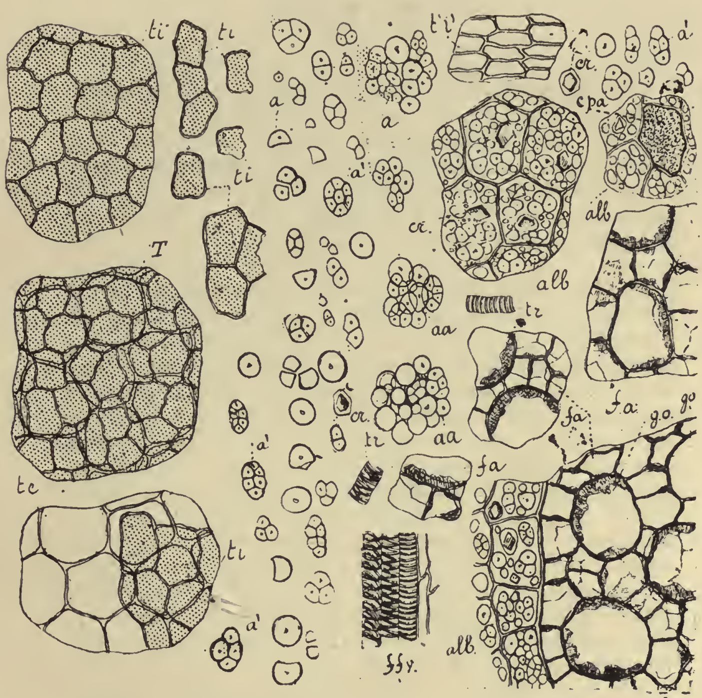

FIG. 69.—**Powdered Nutmeg** (× 240).

a, Starch grains; the *rounded ones are simple,* but the *angular are the isolated components of compound grains.*
a', Compound starch grains.
aa, Agglomerations of simple and compound grains.
alb, Cells of endosperm.
cpa, Brown cells in endosperm.
cr, Crystalloid.
fa, Brown ruminations in endosperm (infoldings of perisperm)
ffv, Fragments of fibro-vascular bundles.
go, Oil-cells, very abundant in brown ruminations.
te, Outer layer of perisperm.
ti, Inner layer of perisperm, surface view.
t'i', The same, in profile.
T, Outer and inner layers of perisperm adhering together.
tr, Vessels, etc.

(70) **Nux Vomica.**

The seeds of *Strychnos Nux-vomica*, Linn. (N.O. Loganiaceæ). The seed-coat is very thin, and consists simply of an epidermis, the cells of which have developed into hairs, below which there is a narrow layer of brown, collapsed parenchyma. The cells of the latter are thin walled; in surface view they appear polygonal (*ti*), but in profile they are so much collapsed as scarcely to allow the lumen to be detected.

The hairs which form the greater and more important part of the seed-coat are of very remarkable structure. The base of each is very thick walled, and often bears protuberances from the lower portion which fit into corresponding depressions in the neighbouring hair-base. It is marked with oblique pits, and passes above into a long tubular hair, which is bent nearly at right angles at a short distance from the base, so that the upper part of the hair lies nearly parallel to the surface of the seed. This upper part bears longitudinal rod-like thickenings, separated by narrow intervening thin-walled portions. These hairs are arranged in the same direction—viz., radiating from the centre of the seed, and impart to it its silky appearance. They are abundant in powdered nux vomica, but during the process of pulverisation the base becomes separated, and the upper portion is split into rod-like fragments by the fracture of the intervening thin portions of cell-wall.

The epidermis of the endosperm is composed of radially elongated cells with moderately thick walls. The cells immediately within are rather smaller, but they gradually increase, not only in size, but also in the thickness of the wall towards the interior of the seed.

The embryo is very small and forms but a very small proportion of the powder.

The diagnostic characters of powdered nux vomica are :—

(*a*) *The hairs; the bases are generally intact, but the prolongations are usually broken up into rod-like fragments of the thickened portions.*

(*b*) *The cells of the endosperm with very thick walls.*

PLATE LX.

FIG. 70.—**Powdered Nux Vomica** (× 240).

ae, Outer part of endosperm.
ai, Inner part of endosperm.
ap, Fragments of cell walls of endosperm.
bp, Bases of hairs, surface view.
b'p', Bases of hairs, in profile.
p, Rod-like thickened portions of hair, isolated.
ps, Apex of hair.
t, Inner portion of seed-coat, in profile.
t', Inner portion of seed-coat, surface view.

(71) **Stavesacre Seeds.**

The seeds of *Delphinium Staphisagria*, Linn. (N.O. Ranunculaceæ).

The seeds are provided with a dark brown coat, which is marked with reticulations and minute prominences.

In the seed-coat three very distinct layers can be distinguished.

The outer layer (*te*) is composed of a single row of brown cells, varying very much in dimensions as well as in shape. All the walls of these cells are strongly thickened, the outer more so than the radial or inner. The outer wall is also characterised by the ridges or tubercles that project from it. In surface view the cells are polygonal or irregular in shape, one side being sometimes rounded.

The middle layer (*tm*) is made up of several rows of polygonal, flattened cells with thin, smooth, straight or slightly wavy walls.

The inner layer (*ti*) consists of a single layer of cubical cells, with slightly thickened walls. In surface view these cells are very characteristic in appearance. They are polygonal, and all elongated in the same directions; their walls exhibit remarkable wrinkles, which take the form of very distinct linear projections.

The cells of the endosperm are polygonal and isodiametric; they contain granular proteid matter and fixed oil.

In the powdered seeds occasional fragments of vessels from the raphe may be found.

The diagnostic characters of powdered stavesacre seeds are :—

(*a*) *The characteristic cells of the epidermis.*
(*b*) *The elongated, wrinkled cells of the inner layer.*
(*c*) *The endosperm cells with oily contents.*

PLATE LXI.

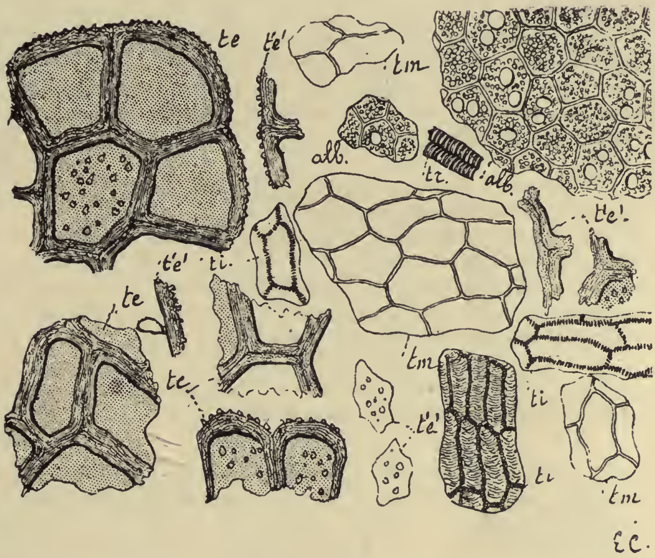

FIG. 71.—**Powdered Stavesacre Seeds** (× 240).

alb, Endosperm.
te, Tubercular cells of the outer layer.
t'e', Fragments of same.
tl, Elongated wrinkled cells of inner layer.
tm, Polygonal cells of middle layer.
tr, Vessels.

(72) **Anise Fruit.**

The fruit of *Pimpinella Anisum*, Linn. (N.O. Umbelliferæ).

The transverse section of the fruit exhibits the following structure:—

(1) An *outer epidermis* composed of flattened cells and provided with stomata as well as with numerous simple hairs In surface view the epidermal cells appear polygonal and strongly striated; the hairs are short, conical, thick-walled warty, and usually one-celled.

(2) The *parenchymatous tissue* next to the epidermis is made up of polygonal cells, and is traversed by secretory ducts. The number of the latter is variable, but always considerable, and they are placed close together. This tissue is also traversed by a number of fibro-vascular bundles surrounded by sclerenchymatous tissue of varying extent, the cells of which are polygonal and have thickened, pitted walls.

(3) An *inner epidermis*, consisting of a single row of cells, all of which are elongated in the same direction.

(4) A *seed-coat*, which is represented by a single row of brown flattened cells; in surface view these appear polygonal and isodiametric.

(5) An *endosperm*, composed of polygonal cells containing fixed oil and aleurone grains; in the latter a globoid or a rosette of calcium oxalate may be found.

The diagnostic characters of powdered anise fruit are:—

(*a*) *The short, stout, conical hairs.*

(*b*) *The numerous, narrow, brown oil-ducts.*

(*c*) *The sclerenchyma of the pericarp.*

(*d*) *The contents of the endosperm cells.*

PLATE LXII.

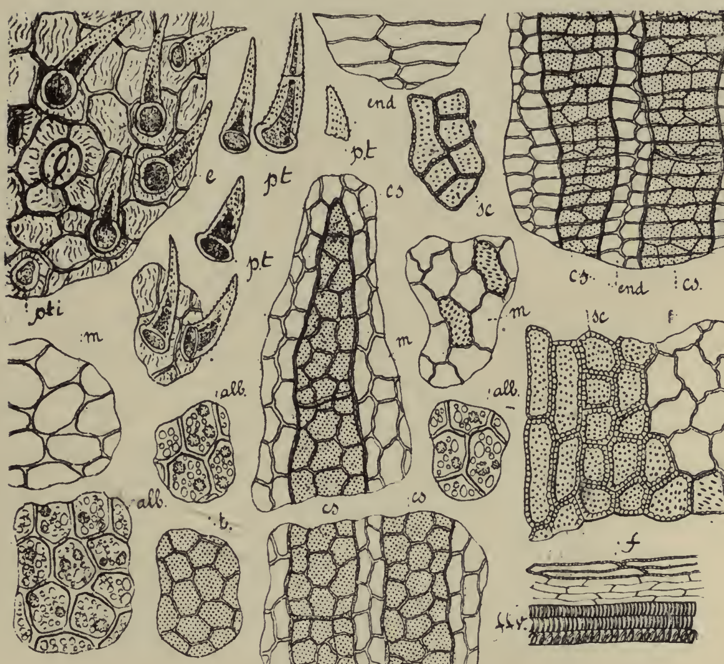

FIG. 72.—**Powdered Anise Fruit** (× 240).

alb, Fragments of the endosperm.
cs, Fragments of the narrow, brown, oil-ducts.
e, Outer epidermis of pericarp.
end, Inner epidermis of pericarp.
f, Sclerenchymatous fibres of fibro-vascular bundles.
ffv, Fragments of fibro-vascular bundles.
m, Parenchymatous tissue of pericarp.
pt, Hair.
ptl, Point of insertion of hair.
sc, Sclerenchymatous tissue of pericarp.
t, Seed-coat.

(73) Capsicum Fruit.

The fruit of *Capsicum annuum* L. (N.O. Solanaceæ).

The pericarp is composed of the following tissues:—

An epidermis of tabular cells, which are seen in surface view to be polygonal and to have thickened, pitted, yellow walls.

Next to the epidermis is a hypoderma consisting of four or five rows of tangentially elongated cells with collenchymatous and suberized walls; these cells contain red chromoplasts and droplets of oil. The hypoderma is followed by parenchymatous tissue made up of thin-walled, polygonal cells, and traversed by numerous bicollateral bundles.

Lastly, an inner epidermis composed of cells with thickened and pitted walls, which in surface view are seen to be irregularly sinuous. These thick-walled cells are interrupted at intervals by bands of polygonal thin-walled cells, the whole forming an extremely characteristic tissue.

The calyx possesses on its lower surface an epidermis bearing stomata, and composed of rectangular cells, which in surface view are polygonal and elongated. The epidermis of the upper surface is formed of irregular polygonal cells with pitted walls, and bears short uni cellular conical hairs as well as bi cellular and pluri cellular stalked gland of varying size.

The epidermis of the seed-coat is very characteristic. In surface view the cells of which it is composed are seen to be very large and provided with very thick sinuous walls, but in transverse section the outer wall is thin, whilst the radial and inner walls are thickened; immediately below the epidermis is a layer of parenchymatous tissue made up of polygonal cells with thin, pitted walls, next to which there is a thicker layer of polygonal, isodiametric cells. The cells of the endosperm are polygonal and contain small aleurone grains.

The placenta is covered with an epidermis of polygonal cells with pitted walls. Below the cuticle of these cells oily drops are secreted in which the active constituent, capsaicin, is contained; the latter may sometimes be observed in lamellar crystals. Next to the epidermis is a parenchymatous tissue composed of smaller irregular cells and traversed by fibro-vascular bundles.

The diagnostic characters of powdered capsicums are:—

(*a*) *The inner epidermis of the pericarp with thick-walled cells interrupted by bands of thin-walled;*

(*b*) *The epidermis of the seed-coat with large, thick-walled, sinuous pitted cells;*

(*c*) *The droplets of yellow or orange-coloured fixed oil;*

(*d*) *The thickened cells of outer epidermis of the pericarp.*

PLATE LXIII.

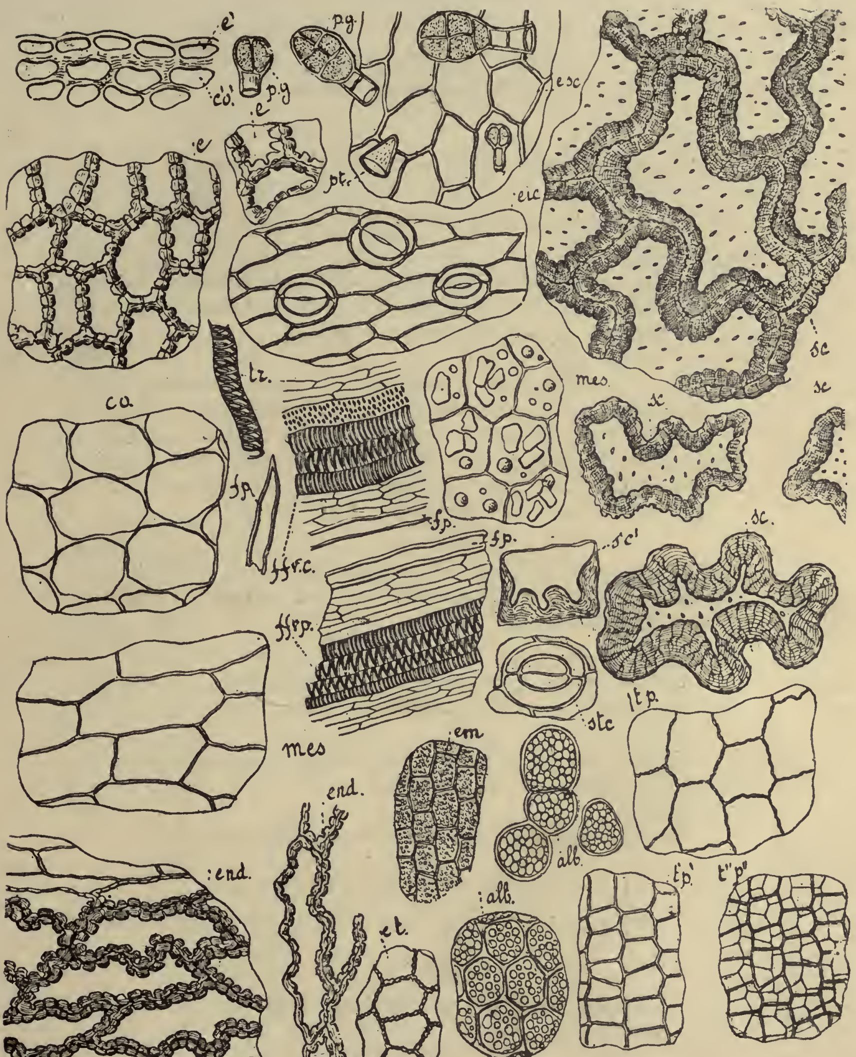

FIG. 73.—**Powdered Capsicum Fruits** (× 240.)

alb, Cells of endosperm of seed.
co, Collenchymatous hypoderma of pericarp, surface view.
c'o', The same, in profile.
e, Outer epidermis of pericarp, surface view.
e', The same, in profile.
elc, Lower epidermis of alyx.
esc, Upper epidermis of alyx.
em, Tissue of embryo.
end, Inner epidermis of pericarp.
et, Epidermis of placenta.
ffvc, Fibro-vascular bundle from calyx
ffvp, Fibro-vascular bundle from pericarp.
mes, Parenchymatous tissue of pericarp.
pg, Glandular hairs from calyx.
pt, Simple hairs from calyx.
sc, Sclerenchymatous epidermal cells of seed-coat, surface view
s'c' The same, in profile
stc, Stoma from calyx.
tp, t'p', t''p'', Parenchymatous tissue of seed-coat
tr, Vessel.

(74) Caraway Seeds.

The fruit of *Carum Carvi*, Linn. (N.O. Umbelliferæ).

The fruit exhibits the following structure:—

(1) An *outer epidermis*, composed of axially elongated cells with striated cuticle and pitted walls; here and there a stoma is visible, but it offers no remarkable features.

(2) A narrow layer of *parenchymatous tissue*, consisting of irregular polygonal cells; this tissue is traversed by fibro-vascular bundles, which are situated in the ridges of the fruit, and are supported by strands of sclerenchymatous cells; the latter possess pitted walls, but vary greatly in size and shape. Six large brown vittæ also occur in this tissue.

(3) An *inner epidermis*, composed of polygonal, thin-walled cells, which are all tangentially elongated and exhibit a v regular arrangement.

(4) The *seed-coat*, consisting of a single layer of small polygonal cells of a rather dark brown colour.

(5) The *endosperm*, made up of rather thick-walled cells containing aleurone grains and fixed oil.

The diagnostic characters of powdered caraways are:—

(*a*) *The abundant sclerenchymatous tissue.*

(*b*) *The absence of hairs and of spiral and reticulate cells*

(*c*) *The striated epidermis.*

(*d*) *The large cells of the inner epidermis and their regular arrangement.*

(*e*) *The small aleurone grains.*

PLATE LXIV.

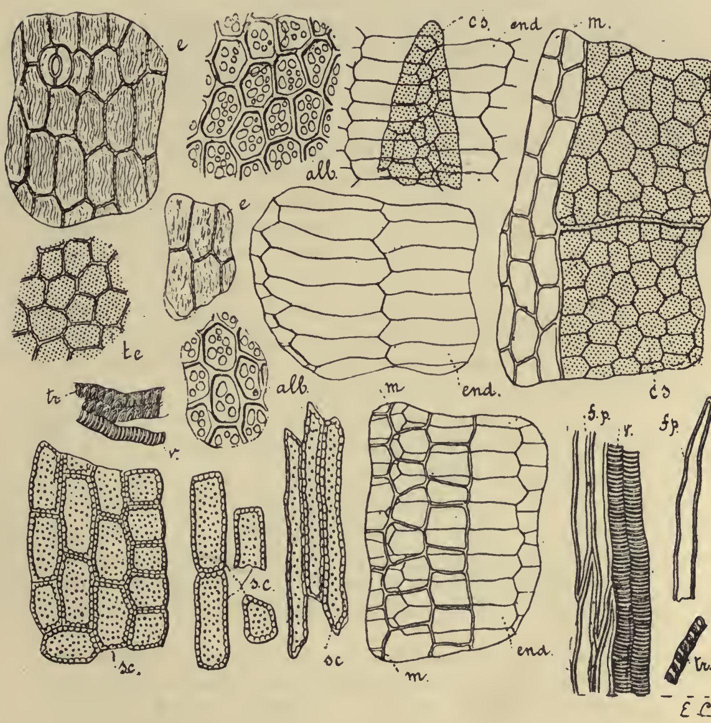

Fig. 74.—**Powdered Caraway Fruits** (× 240).

alb, Endosperm.
cs, Vitta.
e, Outer epidermis of pericarp.
end, Inner epidermis of pericarp.
fp, Sclerenchymatous fibre.
m, Parenchyma of pericarp.
sc, Sclerenchymatous cells.
te, Seed coat.
v, tr, Vessels, etc., from fibro-vascular bundles.

(75) Cardamon Fruits.

The fruits of *Elettaria Cardamomum*, Maton (N.O. Scitamineæ).

The pericarp of the fruit presents the following tissues :—

(1) An *outer epidermis* consisting of a single row of irregular polygonal cells with straight, smooth walls.

(2) A rather thick layer of *parenchyma* traversed by numerous fibro-vascular bundles, and containing scattered cells filled with brownish oleoresin. The fibro-vascular bundles are supported by a mass of fibres, most of which have thickened, pitted walls.

(3) An *inner epidermis*, resembling the outer in structrue but usually more or less collapsed.

The *arillus* is very thin and composed of several rows of elongated, yellowish, more or less collapsed, cells, containing small rounded or oval droplets of oil.

The seed is composed of the following tissues :—

(1) An *epidermis*, consisting of cells which appear rectangular in transverse section, but in surface view are seen to be much elongated and taper towards the ends; they are furnished with slightly thickened, undulating walls.

(2) A single row of *smaller cells*, also elongated in shape but crossing the cells of the epidermis at right angles.

(3) A single row of large rectangular *oil-cells*.

(4) A narrow layer composed of several rows of cells, the structure of which is not distinctly visible.

(5) An inner epidermis, consisting of a single row of brown or yellowish-brown, radially elongated cells with very thick walls, the cavity being shallow and almost entirely filled with a nodule of silica.

(6) A largely developed perisperm, the cells of which have thin walls, and are packed with minute starch grains; in the centre of each cell there is a prismatic crystal of calcium oxalate.

(7) An endosperm and embryo, the cells of which contain proteid matter.

The diagnostic characters of the powdered pericarps are :—

(*a*) *The parenchyma with empty cells and scattered resin cells.*

(*b*) *The fibres from the bundles.*

Powdered seeds are identified by

(*c*) *The characteristic epidermis.*

(*d*) *The sclerenchymatous layer.*

(*e*) *The fragments of perisperm with small starch grains and calcium oxalate crystals.*

PLATE LXV.

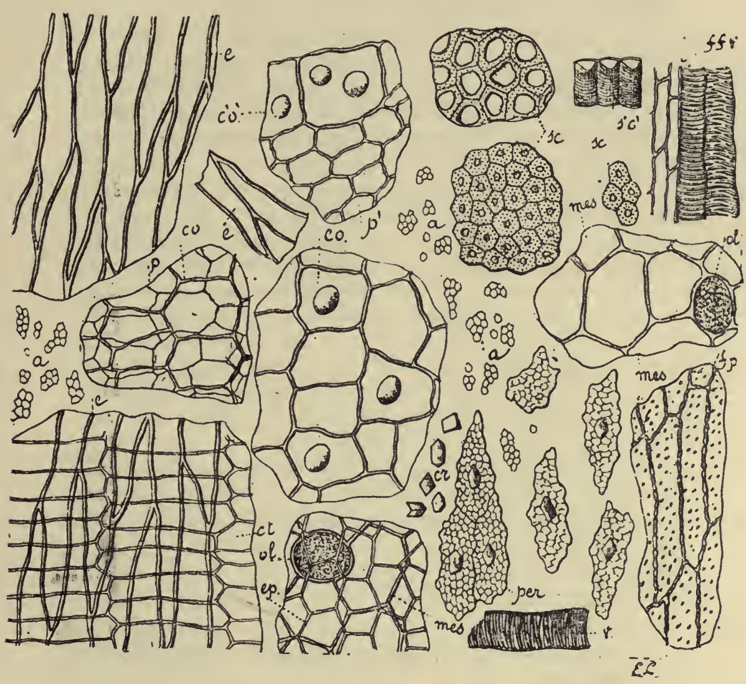

FIG. 75.—**Powdered Cardamom Fruits** (× 240).

a, Starch grains.
co, Oil-cells from seed-coat, surface view.
c'o', The same, in profile.
cr, Crystals of calcium oxalate from cells of perisperm.
ct, Transverse cells of seed-coat.
e, Epidermis of seed-coat.
ep, Outer epidermis of pericarp.
ffv, Fragment of fibro-vascular bundle of pericarp.
fp, Sclerenchymatous fibres from bundles.
mes, Parenchymatous tissue of pericarp.
ol, Oleo-resin cells in same.
p, Parenchymatous tissue of seed-coat, surface view.
p', The same in profile.
per, Cells of perisperm.
sc, Sclerenchymatous cells of seed-coat, surface view.
s'c', The same in profile, but without siliceous nodules.
v. Vessel from fibro-vascular bundle of pericarp.

(76) **Coriander Fruit.**

The fruit of *Coriandrum sativum*, Linn. (N.O. Umbelliferæ).

The dorsal portion exhibits in transverse section:—

(1) An *outer epidermis* composed of tabular cells which in surface view are seen to be polygonal, and have slightly thickened, pitted walls. It is often partially thrown off, especially from the intercostal regions; it is provided with stomata, and in some of the cells a prismatic crystal of calcium oxalate may be observed.

2) A tissue, corresponding to the *mesocarp*, which has undergone considerable differentiation, and in which the following layers can be distinguished:—(*a*) an outer layer of tangentially elongated parenchymatous cells; (*b*) a well-developed layer of sclerenchyma, traversed by fibro-vascular bundles, and forming a continuous and very thick protective tissue throughout the entire dorsal portion of the mericarp; the cells of which this layer is composed are elongated, have thick, pitted walls and cross in different directions; (*c*) one or two rows of flattened thin-walled cells; (*d*) two or three rows of large, irregular polygonal cells with very thick, pitted walls.

(3) An *inner epidermis* of flattened, tangentially elongated cells which in surface view are seen to be rectangular, four or five times as long as they are broad, and all elongated in the same direction.

(4) A *seed-coat* consisting of a single layer of pale yellow polygonal cells with slightly wavy walls.

(5) An *endosperm* made up of thick walled polygonal cells containing aleurone grains, fixed oil, and small rosette-crystals of calcium oxalate.

The structure of the commissural portion of the fruit is slightly different from that of the dorsal portion; the sclerenchymatous layer is absent, and the mesocarp is traversed by two large secretory ducts (vittæ).

The diagnostic characters of powdered coriander fruit are:—

(*a*) *The epidermal cells with prismatic crystals.*

(*b*) *The fibrous sclerenchymatous layer of the pericarp.*

(*c*) *The large sclerenchymatous cells in the inner part of the pericarp, to which*

(*d*) *The inner epidermis is often attached.*

(*e*) *The large secretory ducts.*

(*f*) *The minute rosettes of calcium oxalate in the endosperm.*

The last two characters are found in other umbelliferous fruits.

PLATE LXVI.

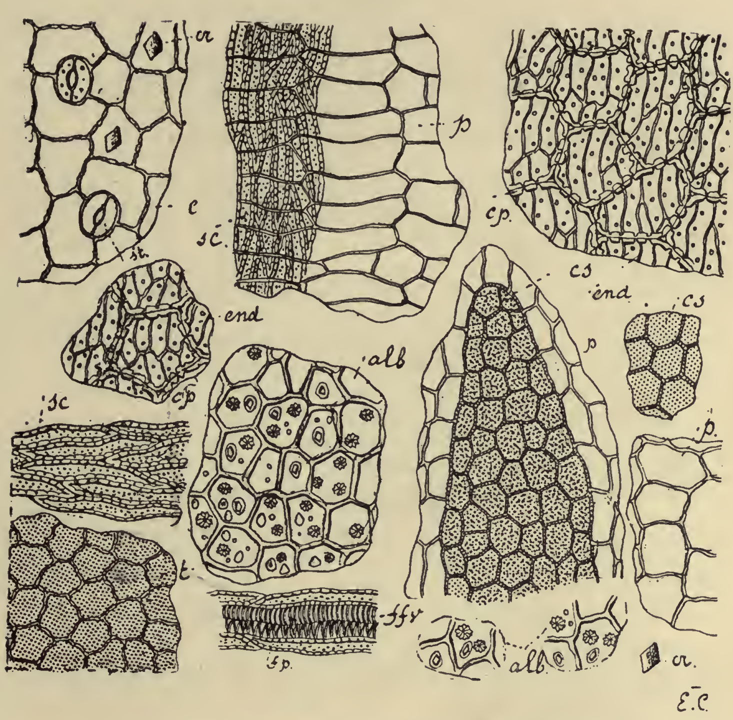

FIG. 76.—**Powdered Coriander Fruits** (× 240).

alb, Endosperm.
cp, Large sclerenchymatous cells of inner part of pericarp.
cr, Crystals of calcium oxalate from epidermal cells.
cs, Fragment of secretory duct.
e, Outer epidermis of pericarp.
end, Inner epidermis of pericarp.
ffv, Fragments of fibro-vascular bundle.
fp, Sclerenchymatous fibres.
p, Parenchymatous tissue from pericarp.
sc, Fibrous sclerenchymatous layer of pericarp.
st, Stomata.
t, Seed-coat.

(77) **Cummin Fruit.**

The fruit of *Cuminum Cyminum*, Linn. (N.O. Umbelliferæ).

The fruit exhibits the following structure :—

(1) An *outer epidermis* composed of polygonal cells and provided over the secondary ridges with conical, pluricellular, pluriserial hairs.

(2) A tissue, corresponding to the *mesocarp*, traversed by five fibro-vascular bundles situated below the primary ridges. This tissue also contains six vittæ, four of which are placed below the secondary ridges and the remaining two on the commissural surface. In this tissue and near the fibro-vascular bundles sclerenchymatous cells of varying shape are to be found; some are polygonal and elongated, others sinuous, etc., but all of them have thick, pitted walls. The bundles themselves are accompanied by sclerenchymatous fibres with lignified walls.

(3) An *inner epidermis* composed of tolerably regular polygonal cells all elongated in the same direction.

(4) A *seed-coat* consisting of brown polygonal cells.

(5) An *endosperm* with thick-walled cells in which aleurone grains, fixed oil and small rosette crystals of calcium oxalate are contained.

The diagnostic characters of powdered cummin fruit are :—

(*a*) *The pluricellular, pluriserial hairs.*

(*b*) *The sclerenchymatous cells from the mesocarp.*

(*c*) *The large oil-ducts.*

(*d*) *The contents of the cells of the endosperm.*

PLATE LXVII.

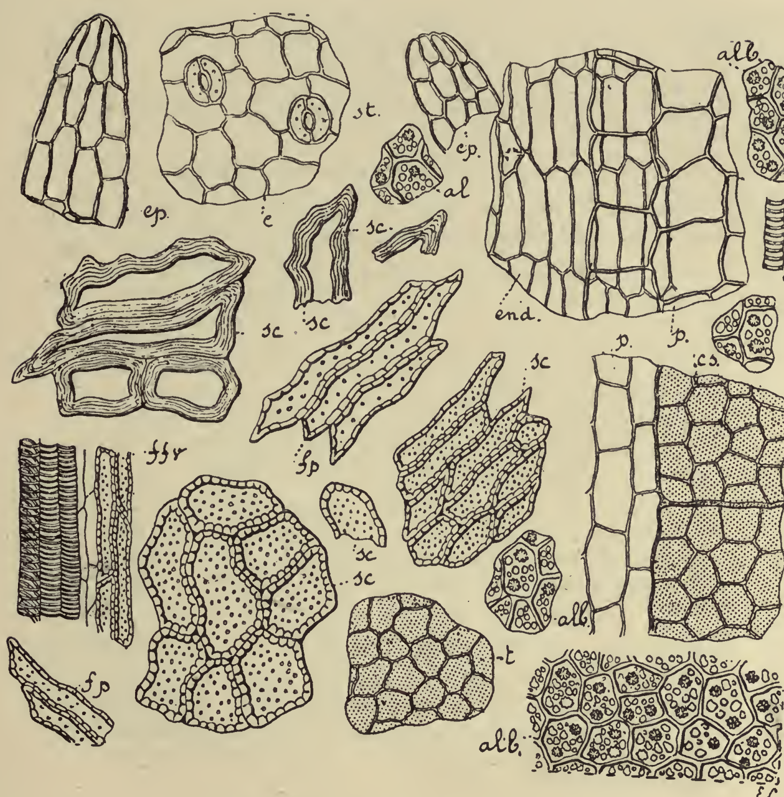

FIG. 77.—**Powdered Cummin Fruits** (× 240).

alb, Endosperm.
cs, Fragment of oil-duct.
e, Outer epidermis of pericarp.
end, Inner epidermis of pericarp.
ep, Pluricellular, pluriserial hairs.
ffv, Fragments of the fibro-vascular bundles.
fp, Sclerenchymatous fibres.
p, Large, polygonal, parenchymatous cells of mesocarp.
sc, Sclerenchymatous cells of mesocarp.
t, Brown seed-coat.
v, Vessels.

(78) **Fennel Fruit.**

The fruit of *Fœniculum capillaceum*, Gilib. (N.O. Umbelliferæ).

The transverse section exhibits the following characters :—

(1) An *outer epidermis*, composed of polygonal cells with straight walls and furnished with stomata.

(2) Parenchymatous tissue (*mesocarp*), composed of irregular polygonal cells; many of these are characterised by their reticulate or spiral thickening; they are either isolated or form groups in the ridges of the fruit, near the fibro-vascular bundles. There are six large vittæ, easily distinguished by the brown colour of their walls; four are situated on the dorsal surface of the fruit, and two on the commissural. The bundles are composed of tracheids with a few bast cells, supported by a mass of sclerenchymatous fibres with pitted walls.

(3) An *inner epidermis*, composed of a single layer of narrow, elongated cells; these cells are arranged in groups of some six or more, with their long axes parallel to one another, but at right angles or obliquely to the long axes of the cells of other groups.

(4) A *seed coat*; this consists of a single layer of brown polygonal cells.

(5) An *endosperm* made up of rather thick walled polygonal cells, containing aleurone grains, fixed oil, and protoplasm. Some of the aleurone grains contain a rounded globoid, others a small rosette of calcium oxalate.

The diagnostic characters of powdered fennel are:—

(*a*) *The spiral and reticulate cells of the mesocarp.*

(*b*) *The narrow cells of the inner epidermis and their characteristic arrangement.*

(*c*) *The absence of hairs.*

(*d*) *The thick-walled endosperm cells.*

PLATE LXVIII.

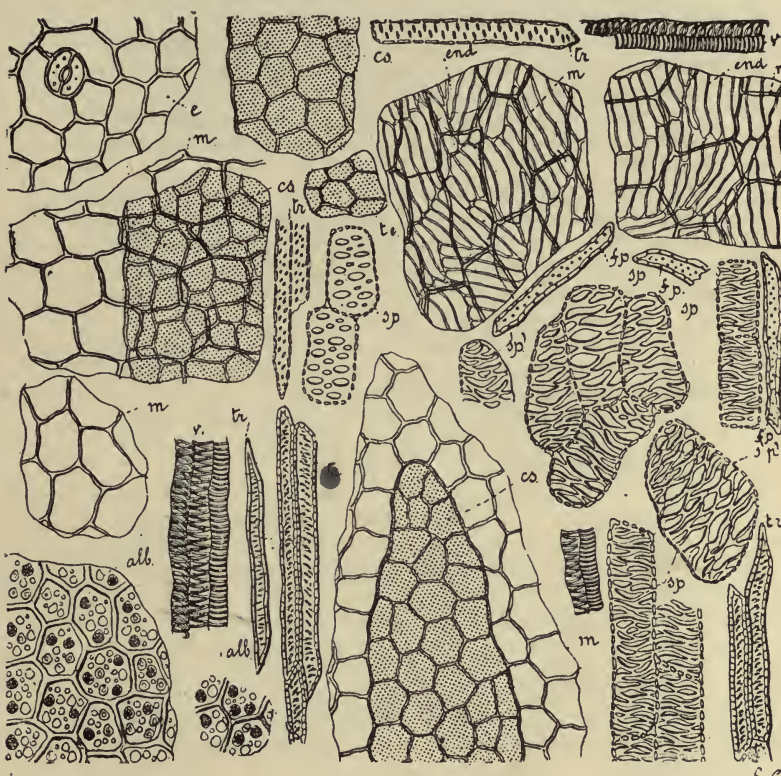

FIG. 78.—**Powdered Fennel Fruit** (× 240).

alb, Endosperm.
cs, Vitta.
end, Inner epidermis of pericarp.
fp, Fibres from the fibro-vascular bundles.
m, cells of mesocarp.
sp, Spiral and reticulate cells.
s'p', The same isolated, some intact, others broken.
te, Seed-coat.
tr, Tracheids from the bundles in the mesocarp.
v, Vessels, etc., from the carpophore and pedicel of the fruit.

(79) Colocynth Fruit.

The fruit of *Citrullus Colocynthis*, Schrader (N.O. Cucurbitaceæ).

The pericarp presents the following structure:—

(1) An *outer epidermis* composed of polygonal cells with strongly suberised outer walls.

(2) Several rows of *parenchymatous cells;* these are sometimes collapsed, sometimes tangentially elongated, and thickened at the angles to form a collenchymatous layer.

(3) A layer of several rows of *sclerenchymatous cells* with thickened pitted walls; the inner cells of this layer are radially elongated.

(4) A *parenchymatous tissue* composed of large polygonal, rounded, or oval cells, on some of which pitted areas are very distinct. This parenchymatous tissue, of which the pulp of the fruit is composed, is traversed by numerous bicollateral fibro-vascular bundles, some of which are accompanied by tubular idioblasts containing the active principle.

The seed exhibits the following layers:—

(1) An *outer hyaline layer* consisting of a single layer of flattened cells which swell in contact with water.

(2) A layer of *palisade cells*, the walls of which exhibit bar-like thickenings; these cells often contain a brown granular substance (in ripe seeds).

(3) A highly developed *sclerenchymatous layer*, the cells of which vary greatly in size and shape. Some have moderately thick pitted walls, but in most of them the walls are so thick as almost to obliterate the lumen, and are traversed by branching pits.

(4) A layer composed of a single row of coarsely pitted or *reticulate cells* which exhibit dome-like projections towards the interior of the seed; this layer is very characteristic.

(5) A layer of two or more rows of *parenchymatous cells* which in surface view are elongated; the cells of one of these rows are spirally thickened, giving the tissue a very characteristic appearance.

(6) The *cotyledons* are composed of thin-walled cells containing fixed oil and small aleurone grains in which a globoid is easily visible; the epidermal cells of the cotyledons have smooth, straight walls.

The diagnostic characters of the powdered pericarp are:—

(*a*) *The epidermal cells, especially in section.*

(*b*) *The sclerenchyma of the rind with mod rately thick walls.*

(*c*) *The large empty parenchymatous cells, often with distinct pitted areas.*

Of the powdered seed:—

(*d*) *The very characteristic palisade cells.*

(*e*) *The sclerenchymatous ring.*

(*f*) *The reticulate cells.*

(*g*) *The spirally striated cells.*

PLATE LXIX.

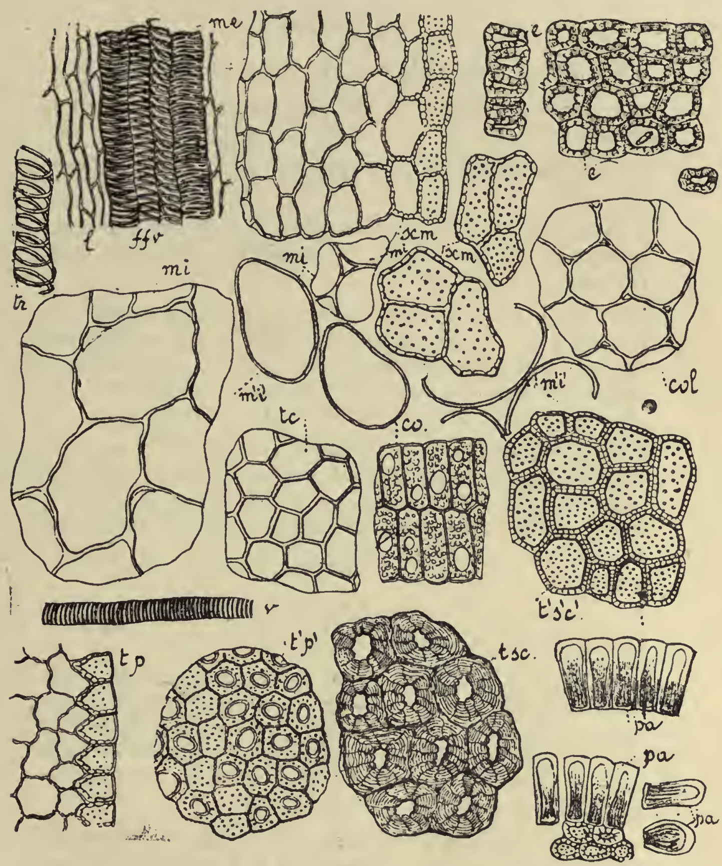

Fig. 79.—**Powdered Colocynth Fruit** (× 240.) *E. C*

co, Cotyledon.
col, Outer parenchyma of rind, often collenchymatous.
e, e', Outer sclerenchymatous layer of mesocarp of rind.
ffv, Fibro-vascular bundle from pericarp.
l, Bast tissue of bundle.
me, Outer portion of mesocarp.
mi, Inner layer.
m'i', Cells of the latter, isolated.
pa, Palisade cells of seed.
scm, Sclerenchymatous cells of mesocarp.
tc Epidermis of cotyledons.
tsc, Sclerenchyma of seed-coat.
t's'c', The same, outer rows.
tp, Reticulated and spiral cells of seed-coat, in seotion.
t'p', The same, surface view.
tr, v, Vessels, tracheids, etc.

(80) **Cubebs.**

The fruit of *Piper Cubeba*, Linn. (N.O. Piperaceæ).

A transverse section of the fruit exhibits the following structure :—

(1) An *outer epidermis*, consisting of a single row of brown cells.

(2) An interrupted *outer sclerenchymatous layer*, sometimes one sometimes two cells thick; these cells are irregular in shape and have thick, pitted walls.

(3) *Parenchymatous tissue*, composed of polygonal cells, containing a few starch grains; large oil-cells are scattered throughout this tissue, which often exhibits a differentiation into an inner and an outer layer (compare black pepper); near the middle it is traversed by fibro-vascular bundles.

(4) An *inner sclerenchymatous layer*, consisting of an uninterrupted single or sometimes double row of sclerenchymatous cells; these are radially elongated and have very thick, pitted walls; they are larger than the cells of the outer sclerenchymatous layer, and exhibit in surface view considerable regularity.

(5) An *inner epidermis*, composed of a single row of small cells, with thin, finely-pitted walls.

(6) The *seed-coats*, in which the following layers may be distinguished :—(*a*) An outer layer consisting of elongated cells with brown, thickened, wavy walls; near the hilum the walls of these cells are very sinuous; (*b*) a central layer, consisting of large, polygonal cells, with straight, colourless walls; (*c*) an inner layer of small, brown polygonal cells.

(7) A *perisperm*, of which nearly all the kernel consists; the cells are large, polygonal, thin-walled and packed with small starch grains. This tissue contains large rounded oil-cells.

The diagnostic characters of powdered cubebs are :—

(*a*) *The outer sclerenchymatous layer.*

(*b*) *The inner sclerenchymatous layer.*

(*c*) *The perisperm packed with small starch grains.*

(*d*) *The blood-red colour produced by concentrated sulphuric acid.*

(*e*) *The oil cells, many of which are broken.*

PLATE LXX.

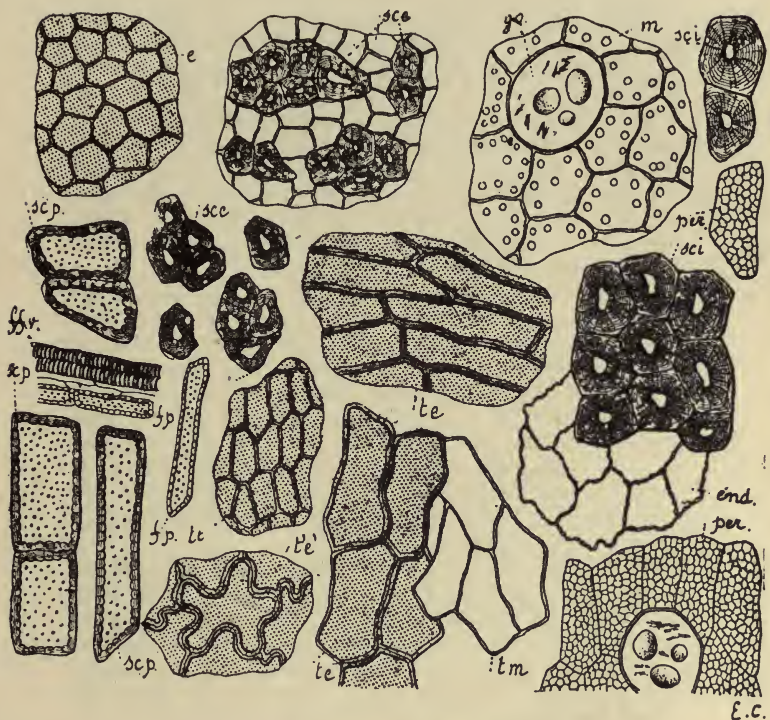

FIG. 80.—**Powdered Cubebs** (× 240).

e, Outer epidermis of pericarp.
end, Inner epidermis of pericarp.
ffv, Fibro-vascular bundle.
fp, Pitted fibres supporting the bundles.
go, Oil-cell.
m, Parenchyma of pericarp.
per, Fragments of perisperm.
sce, Cells of outer sclerenchymatous layer.
scl, Cells of inner sclerenchymatous layer.
scp, Sclerenchymatous cells of stalk.
te, Outer layer of seed-coat.
t'e', Outer layer of seed-coat near hilum.
ti, Inner layer of seed-coat.
tm, Middle layer of seed-coat.

(81) **Black Pepper.**

The fruit of *Piper nigrum*, Linn. (N.O. Piperaceæ).

A transverse section of black pepper exhibits the following structure :—

(1) An *outer epidermis* consisting of small cells with brown contents and a rather thick cuticle. In surface view these cells appear polygonal, and here and there a stoma may be seen; many of them contain small prismatic crystals of calcium oxalate.

(2) An *outer sclerenchymatous layer* abutting upon the epidermis or separated from it by a single row of parenchymatous cells. This layer is not continuous, but is interrupted at intervals by thin-walled parenchymatous cells. The sclerenchymatous cells vary somewhat in shape, but most of them are radially elongated, and contain a brown substance; their walls are thick and pitted.

(3) Parenchymatous tissue corresponding to the *mesocarp*, and constituting the bulk of the pericarp. The outer layers of this tissue consist of large polygonal cells, amongst which an occasional still larger oil-cell may be seen; the former contain a few small starch grains, the latter globules of volatile oil. The inner layers of parenchymatous cells have lignified walls and are more strongly tangentially elongated or even flattened so as to present a well marked line of demarcation, which is accentuated by the presence of fibro-vascular bundles. Oil-cells are more numerous in this inner part of the parenchymatous tissue than they are in the outer.

(4) An *inner sclerenchymatous layer* consisting of a single row of cells thickened on their radial and inner tangential walls; in surface view these cells are seen to be isodiametric, polygonal, and to have moderately thick, pitted walls; their cavities are colourless and larger than those of the outer layer of sclerenchymatous cells. This layer of cells is generally adherent to the brown seed-coat.

(5) A *brown and a yellow layer of collapsed cells* to which is firmly attached

(6) A *colourless layer of collapsed cells*; these last three layers constitute the seed-coat.

The kernel of the seed consists almost entirely of *perisperm*. The outer two or three rows of cells are polygonal and contain aleurone grains, but the others are elongated and are packed with minute grains of starch. Scattered throughout the perisperm are cells containing yellowish volatile oil.

The diagnostic characters of powdered black pepper are :—

(*a*) *The outer epidermis, together with the subjacent interrupted sclerenchymatous layer.*

(*b*) *The inner sclerenchymatous layer.*

(*c*) *The starch grains, often in compact masses.*

(*d*) *The oil-cells, the contents of which are coloured red by sulphuric acid.*

PLATE LXXI.

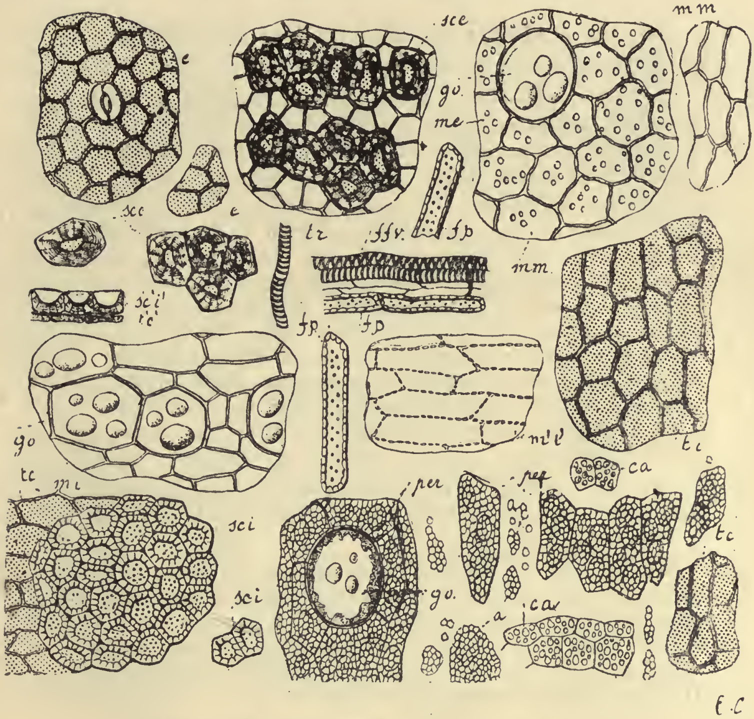

Fig. 81.—**Powdered Black Pepper** (× 240).

a, Starch grains.
ca, Outer layers of perisperm containing aleurone.
e, Outer epidermis of pericarp.
ffv, Débris of fibro-vascular bundle.
fp, Pitted fibrous cells from bundle.
go, Oil-cells.
me, Outer portion of mesocarp.
mi, Inner portion of mesocarp.
m'i', The same in longitudinal section.
mm, Cells from central part of mesocarp.
per, Cells of perisperm containing starch.
sce, Cells of the outer sclerenchymatous layer.
sci, Cells of the inner sclerenchymatous layer, in surface view.
s'c'i', The same in profile.
tc, The brown layer of seed-coat, in surface view.
t'c', The same in profile.

(82) **Pimento Fruit.**

The fruit of *Pimenta officinalis*, Lindley (N.O. Myrtaceæ).

The fruit possesses the following structure:—

The *outer epidermis* of the pericarp is composed of small polygonal cells covered with a rather thick cuticle; it is provided with stomata surrounded by several cells, and bears one-celled, conical, thick-walled hairs.

Below the epidermis is a mass of *parenchymatous tissue* differentiated into two layers, and traversed by fibro-vascular bundles. The outer of these two layers is characterised by the presence of a large number of oil-glands, which are often close together and so near to the epidermis as to raise it, thus imparting a roughness to the surface of the fruit. The inner part of the parenchymatous tissue contains numerous sclerenchymatous cells, either isolated or in groups. These cells vary very much in size, in outline, and in the thickness of their walls, which are traversed by branching pores; they contain a brown substance.

The *inner epidermis* of the pericarp (and of the dissepiment that divides the cavity into two cells) consists of delicate colourless elongated cells.

The *seed-coats* are thin and adherent to the seed. They comprise several layers. The outer of these is composed of polygonal colourless cells, all of which are elongated in the same direction; the middle layer is made up of rather large irregular or rounded brown cells exhibiting intercellular spaces. The inner layer resembles the outer one.

The *cotyledons* are composed of polygonal cells containing starch grains; the latter are mostly compound, the component grains being rounded on one side and flat or angular on the other according to their number (two, three, or four).

The *dissepiment* consists of a tissue of brown polygonal cells covered on either side with an epidermis similar to the inner epidermis of the pericarp; it contains numerous prismatic and cluster-crystals.

The diagnostic characters of powdered pimento are:—

(*a*) *The starch grains.*

(*b*) *The hairs.*

(*c*) *The sclerenchymatous cells.*

(*d*) *The small cells of the outer epidermis.*

(*e*) *The oil-glands.*

PLATE LXXII.

FIG. 82.—**Powdered Pimento Fruits** (× 240).

a, Starch grains from seed.
cl, Dissepiment.
cr, Crystals.
e, Epidermis of pericarp, surface view.
e', The same, in profile.
ffv, Fibro-vascular bundle.
fp, Fibrous cells from bundle.
go, Glands.
me, Outer layer of parenchyma of pericarp, surface view.
m'e', The same, in profile.
ml, Inner layer of parenchyma.
p, Hair from epidermis of pericarp.
sc, Sclerenchymatous cells of pericarp.
te, Outer layer of seed-coat.
tm, Middle layer of seed-coat.

(83) **Star Anise Fruit.**

The fruit of *Illicium verum*, Hooker f. (N.O. Magnoliaceæ).

The pericarp of the fruit exhibits the following structure :—

(1) An *outer epidermis* composed of a single row of tabular cells, which are covered with a thick cuticle bearing prominent ridges. In surface view these cells are polygonal, brown, and strongly striated.

(2) A tissue corresponding to the *mesocarp* and differentiated into an outer looser and inner denser portion. The outer portion is characterised by the presence of a large number of oil-cells, which are more numerous towards the outside than they are towards the interior; the latter region is traversed by fibro-vascular bundles.

The inner portion of the mesocarp is parenchymatous throughout nearly the whole of its extent, but at the margins, which form the ventral suture, it lignifies and forms a strongly developed mass of polygonal, thick-walled, pitted stone cells.

(3) An *inner epidermis*, which varies in structure according to the position it occupies; that part of it that lines the loculus of the carpel consists of elongated thin-walled cells, which, in surface view, appear hexagonal. As the sutures by which the carpel dehisces are approached the cells become shorter, the radial and inner tangential walls become thicker, but the outer tangential wall remains thin.

The seed is covered by several layers of cells :—

(1) An *epidermis* of radially elongated cells with pitted walls and small cavities ; in surface view they are seen to have sinuous walls.

(2) A *central tissue* differentiated into two layers, the outer of which is composed of very large parenchymatous cells with lignified, slightly thickened, pitted walls; the inner layer consists of smaller thin-walled cells.

(3) An *inner epidermis*, the cells of which are strongly axially elongated and contain crystals of calcium oxalate.

The *endosperm* is built up of polyhedral cells containing aleurone grains.

The stalks, which are often attached to the fruits, are characterised by the presence of a multitude of sclerenchymatous cells of varying shapes, many being provided with more or less prominent projections.

The diagnostic characters of powered star anise fruit are :—

(*a*) *The palisade epidermis of the seed.*
(*b*) *The inner epidermis with calcium oxalate crystals.*
(*c*) *The lignified parenchyma of the mesocarp.*
(*d*) *The inner epidermis of the pericarp.*
(*e*) *The outer epidermis of the pericarp, with striated cuticle.*

PLATE LXXIII.

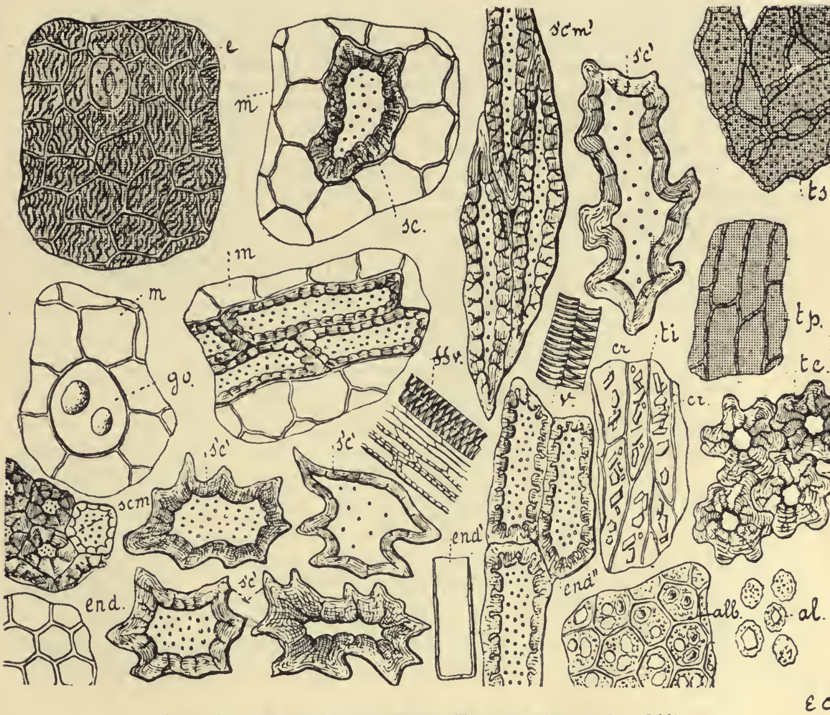

Fig. 83.—**Powdered Star Anise Fruit** (× 240).

al, Aleurone grains.
alb, Endosperm.
cr, Prismatic crystals of calcium oxalate.
end, Inner epidermis of pericarp, lining the cavity; surface view.
end′, The same in profile.
end″, Inner epidermis from sutural portion of pericarp.
ffv, Débris of fibro-vascular bundle.
go, Oil-cell.
m, Tissue of mesocarp.
sc, Sclerenchymatous cell from same.
s′c′, Sclerenchymatous cells from stalk.
scm, Sclerenchymatous cells near dorsal suture.
s′c′m′, The same, longitudinal aspect.
tc, Outer epidermis of seed-coat.
ti, Inner epidermis of same.
ts, Sclerenchymatous tissue of same.
tp, Parenchymatous tissue of sam
v, Vessels.

(84) Vanilla Fruit.

The fruit of *Vanilla planifolia*, Andrews (N.O. Orchideæ).

A transverse section of the pericarp exhibits the following structure:—

(1) An *epidermis* composed of a single row of flattened cells covered with a rather thick cuticle. In surface view, these cells are polygonal and either isodiametric or axially elongated; they have slightly thickened pitted walls, and contain octohedral and prismatic crystals of calcium oxalate, together with little rounded bodies also of calcareous nature. Here and there a small stoma may be observed.

(2) A *hypoderma* consisting of a single row of axially elongated cells with thickened, pitted walls; some of these cells also contain crystals of calcium oxalate.

(3) A *collenchymatous layer* made up of two or three rows of cells with smooth walls, which are thickened at the angles.

(4) A tissue corresponding to the *mesocarp*; this is composed of large polygonal cells, with smooth or pitted walls, containing traces of chlorophyll, sugar and oily protoplasm. In some vanillas (Mexican) a parenchymatous tissue of strongly reticulated cells is found in the outer part of the mesocarp, but in others this tissue is represented by a few reticulate cells near the bundles. In addition to octohedral crystals of calcium oxalate the mesocarp contains a considerable quantity of very large raphides either in isolated cells or in rows of cells placed end to end. The bundles that traverse the mesocarp are composed of spiral, annular or pitted vessels, together with bast tissue, and are surrounded by fibrous cells with strongly thickened, pitted walls. Towards the base of the fruit the parenchyma of the mesocarp exhibits lignification at various points.

(5) An inner epidermis, the cells of which near the median part of the carpellary leaf are prolonged into long, tubular papillæ containing protoplasm and globules of oil; the latter substance is also contained in the cavity of the fruit.

In the placentæ elongated, slightly lignified, pitted cells occur.

The seed exhibits the following layers:

(1) An outer layer of radially elongated cells, with very thick, brown walls; the cavity of these cells has the shape of an inverted T. In surface view the cavity appears linear, and the walls very thick.

(2) An inner layer composed of several rows of polygonal cells.

The embryo is made up of polygonal cells containing aleurone grains and fixed oil.

The diagnostic characters of powdered vanilla are:—

(*a*) *The outer epidermis of the pericarp, with calcium oxalate crystals and small stomata.*

(*b*) *The outer epidermis of the seed-coat.*

(*c*) *The parenchymatous mesocarp with large raphides.*

(*d*) *The reticulated cells.*

(*e*) *The oily contents of the papillæ and many of the cells of the mesocarp.*

PLATE LXXIV.

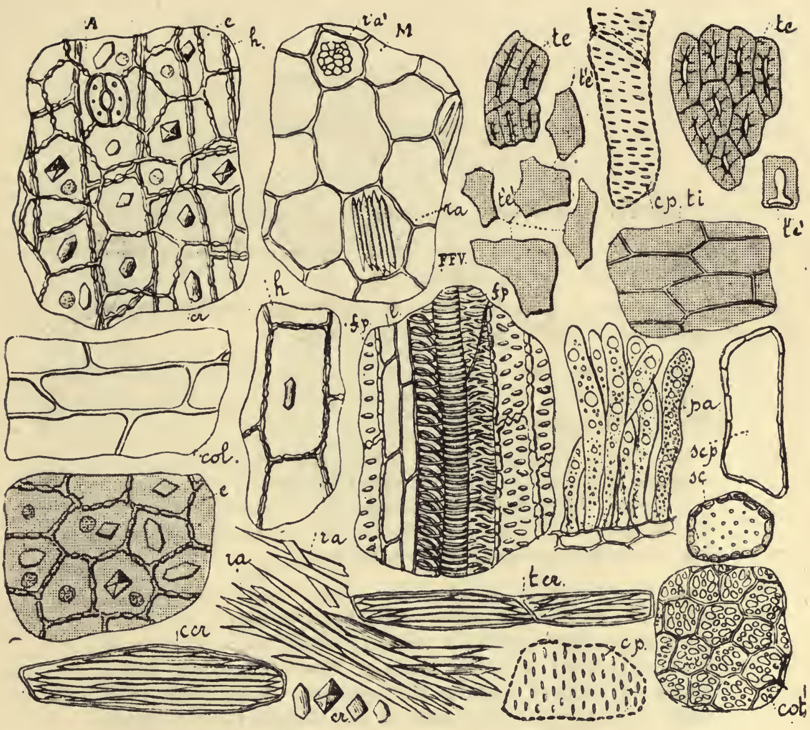

FIG. 84.—**Powdered Vanilla** (× 240).

A, Outer portion of the pericarp comprising the epidermis (**e**) with adherent hypoderma (**h**).
ccr, Cells containing raphides.
col, Collenchymatous cells.
cot, Cotyledon.
cp, Pitted cells distributed through the mesocarp.
cr, Prismatic crystals of calcium oxalate from the epidermis.
e, Cells of the epidermis with crystals and rounded calcareous bodies.
FFV, Fragments of bundle.
fp, Fibrous cells.
h, Hypoderma.
l, Bast.
M, Mesocarp with raphides entire (**ra**) and cut transversely (**r'a'**)
pa, Papillæ of inner epidermis.
ra, Raphides, intact; **r'a',** the same cut transversely.
sc, Sclerenchymatous cells from base of fruit.
scp, Sclerenchymatous cell from the placenta.
te, Brown, outer layer of seed-coat.
t'e', Cell of same, in profile.
ti, Brown, inner layer of seed-coat.
tcr, Rows of crystal-cells.

(85) Juniper Berries

The fruit of *Juniperus communis*, Linn. (N.O. Coniferæ).

Each of the three fleshy bracts which enclose the seeds exhibits the following structure :—

(1) An *outer epidermis*, consisting of a single row of brown polygonal cells with thickened pitted walls.

(2) A *hypoderma*, composed of two rows of brown collenchymatous cells, the radial walls of which are thickened, particularly in the angles.

(3) A tissue corresponding to a *mesocarp;* this is built up of irregular polygonal cells with intercellular spaces, and contains large ovoid oil-glands. It is traversed by fibro-vascular bundles, which, like those of most coniferous plants, exhibit tracheids, bast tissue, and areolated cells and fibres.

(4) A well-developed *sclerenchymatous ring*, composed of seven or eight rows of rather large cells, with very thick, pitted walls and narrow cavities, in many of which there is a single prismatic crystal of calcium oxalate. That part of this tissue which is directed towards the epidermis is bordered by a single row of oval or elliptical cells with slightly lignified pitted walls. Within the ring is a rather thick dense, brown layer of collapsed cells.

(5) An *inner epidermis* of elongated cells.

The seed-coat consists of polygonal cells; the endosperm contains aleurone grains; the cells of the embryo have very thin walls.

The diagnostic characters of powdered juniper berries are :—

(*a*) *The sclerenchymatous cells with crystals of calcium oxalate.*

(*b*) *The brown, pitted cells of the epidermis and the subjacent brown, collenchymatous layer.*

(*c*) *The large parenchymatous cells of the pulp.*

(*d*) *The areolated cells and fibres which, however, are not numerous.*

PLATE LXXV.

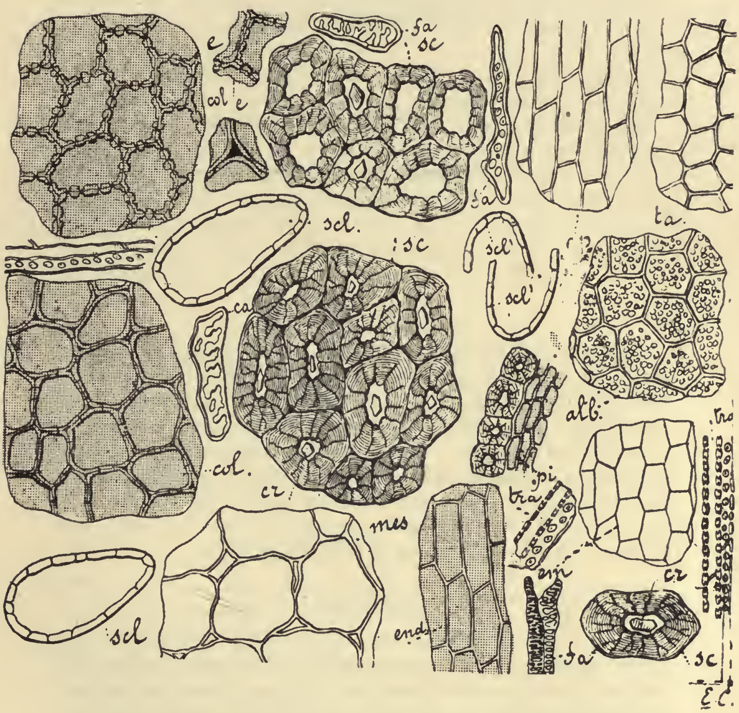

FIG. 85.—**Powdered Juniper Berries** (× 240).

alb, Endosperm of seed.
ca, Areolated cells.
col, Brown collenchymatous hypoderma.
cr, Prismatic crystals of calcium oxalate in cells of sclerenchymatous ring.
e, Outer epidermis of bract.
em, Embryo.
end, Brown inner epidermis of bract.
ep, Seed-coat.
fa, Areolated fibres and fibrous cells.
mes, Mesophyll of bract.
pi, Brown layer within the sclerenchymatous ring.
sc, Cells of latter.
scl, Large cells on outer margin of ring.
scl′, Fragments of same.
ta, Epidermis of endosperm.
tra, Tracheids.

SECTION VI.

POWDERED WOODS.

The structural elements of which the official woods are composed are limited in number, and also in the extent to which they vary in size, shape, etc.; in studying them, therefore, it is necessary to pay particular attention to the minute details of each of these elements. Diagnostic characters must be sought not only in the shape and size of the wood-fibres, vessels, wood parenchyma, and medullary rays, but also in the thickness of the walls of the various elements, in the nature and distribution of the pits, and in the nature of the cell contents.

Wood Fibres.

These, together with the vessels, make up the bulk of the official woods, and are therefore the most numerous elements met with in the powder; the chief differences they exhibit are in the thickness of the wall, the number and nature of the pits, and the nature of the contents. They exhibit their length to the observer far more often than their transverse section, and are usually more or less broken by the pulverisation to which they have been subjected, fragments from the central part of the fibre being from this cause not unfrequently lacerated or frayed at the broken ends. Sometimes they are isolated, but more frequently they are in groups associated with vessels, wood parenchyma, or portions of medullary rays. They may also differ in colour, those of guaiacum, for instance, are of a greenish-grey or brown colour, whilst those of red sanders wood are red, and those of quassia are colourless. The last-named contain only the remains of protoplasm, whilst the fibres of guaiacum contain resin, and those of yellow sandal wood contain oil.

Vessels.

All the official woods contain vessels, but as these elements are comparatively fragile, pieces of them only are to be found in the powder. Isolated fragments of vessels are always small, but larger portions are often to be found surrounded or supported by wood parenchyma or fibres.

Vessels may vary considerably in size in one and the same wood, but the structure generally remains constant for the same species. The thickness of the wall, and more particularly the nature of the pits are often characteristic features, thus the vessels of guaiacum wood are easily distinguished from those of red sanders wood, or yellow sandal wood by their very numerous small pits. If the vessels are large, small fragments showing the transverse section and the thickness of the wall are sometimes to be found.

Wood Parenchyma.

Wood parenchyma is found in all the official woods. In width the cells of this tissue closely approach the wood-fibres, but in longitudinal sections they are seen to be much shorter than the fibres. They also differ in having square ends and thinner walls with numerous, simple, circular pits, the pits of the wood-fibres being usually few in number, cleft, and arranged in a left spiral.

Medullary Rays.

These are also present in all official woods. In the powder they may present their transverse, tangential, or radial section. In the first of these which is comparatively rare the cells are rectangular, elongated, and arranged in one, two, or three rows. In radial section the appearance is somewhat similar, but the rows of cells are generally attached to wood-fibres, wood parenchyma, or vessels. In tangential section they form oval groups of cells inserted usually between the wood-fibres, the groups varying in size according to the number of cells in the height and width of the ray. In the powder fragments only of these groups are usually to be found. The contents of the cells and the pits on the walls may furnish useful information as to the identity of the powder.

Calcium Oxalate.

As in all drug powders the presence or absence of calcium oxalate crystals, their shape, size, and distribution must be taken into account. In some cases they are irregularly scattered through the cells of the medullary rays or wood parenchyma in others they occur in regularly superposed rows of cells.

(86) Guaiacum Wood.

The heartwood of *Guaiacum officinale*, Linn. (N.O. Zygophylleæ).

Microscopical examination shows that there is but little difference in structure between the sapwood and the heartwood; in the latter the fibres are more strongly thickened and lignified.

The wood exhibits the following structure:—

The medullary rays are closely approximated, one cell wide and contain a yellowish or brownish resin.

The vessels are numerous, large, mostly isolated, and often filled with resin. They are often wider than the distance between two medullary rays, and the latter therefore diverge to allow room for the vessels. In longitudinal section the walls are seen to bear numerous small pits.

The wood parenchyma forms narrow lines running transversely to the medullary rays; some of the cells contain prismatic crystals of calcium oxalate. Both the medullary ray cells and those of the wood parenchyma bear numerous simple rounded pits.

The wood-fibres are long, tapering, and often oblique in direction. They are very strongly thickened and lignified, and contain yellowish-brown or reddish resin; the pits are numerous and arranged in a left spiral.

The diagnostic characters of guaiacum wood are:—

(*a*) *The yellowish, brown, or red resin, with which most of the elements are filled.*

(*b*) *The one-celled medullary rays.*

(*c*) *The vessels with numerous small pits.*

(*d*) *The calcium oxalate crystals.*

PLATE LXXVI.

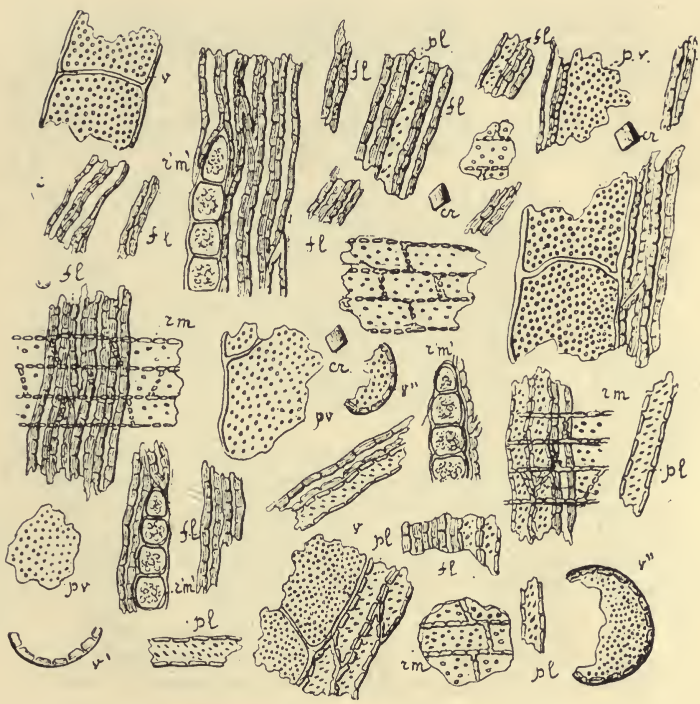

FIG. 86.—**Powdered Guaiacum Wood** (× 240).

cr, Prismatic crystals of calcium oxalate.
fl, Wood-fibres.
pl, Wood parenchyma.
pv, Walls of vessel.
rm, Medullary ray in radial section.
r'm', The same in tangential section.
v, Pitted vessels in radial section.
v', The same in transverse section.
v", The same in oblique section.

(87) **Jamaica Quassia Wood.**

The wood of *Picraena excelsa*, Lindl. (N.O. Simarubeæ).

The wood exhibits the following structure :—

It is traversed by medullary rays mostly two or three cells wide, the constituent cells being radially elongated, and having slightly thickened, pitted walls.

The tissue between the medullary rays is composed of wood-fibres, vessels, and wood parenchyma.

The wood-fibres have moderately thick walls and, when isolated, are seen to be very long, tapering gradually to a fine point, and bearing scattered, left-spiral, cleft pits.

The vessels are usually in groups of two or three, and frequently extend from one medullary ray to the next. Their walls are moderately thick, and bear numerous small pits which careful observation will show to be bordered. They often contain an amorphous yellow substance.

The cells of the wood parenchyma are usually axially elongated. In transverse section they appear square or polygonal with moderately thickened, pitted walls. They often contain large crystals of calcium oxalate usually in superposed cells, each containing a single crystal. This tissue is distributed in irregular concentric rings throughout the wood.

The wood of *Quassia amara*, Linn. (Surinam quassia) is similar in structure, but the medullary rays are usually one cell wide, and the calcium oxalate crystals are much less abundant.

The diagnostic characters of powdered Jamaica quassia wood are :—

(*a*) *The medullary rays, two or three cells wide.*

(*b*) *The presence of calcium oxalate.*

(*c*) *The long, moderately thickened fibres.*

(*d*) *The numerous small bordered pits of the vessels.*

PLATE LXXVII.

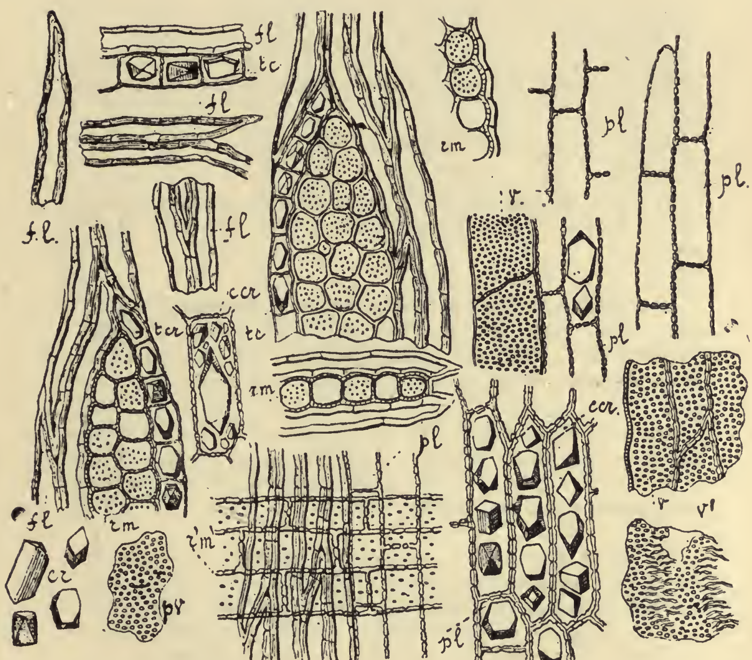

FIG. 87.—**Powdered Jamaica Quassia Wood** (× 240).

ccr, Crystal cells.
cr, Prismatic or rhombohedral crystals.
fl, Wood-fibres.
pl, Wood parenchyma, longitudinal aspect.
pv, Wall of vessel.
rm, Medullary rays in tangential section.
r'm', Medullary rays in radial section.
tcr, Superposed crystal-cells.
v, Portion of vessel.
v', The same with frayed wall.

(88) **Yellow Sandal Wood.**

The heartwood of *Santalum album*, Linn. (N.O. Santalaceæ).

The wood exhibits the following structure :—

The medullary rays are one or two cells wide, the cells having pitted walls and containing yellowish globules of volatile oil or oleoresin.

The vessels are rather large and usually isolated or forming at most small radial groups. Their walls bear numerous small bordered pits. They also contain yellowish oleoresin, which is most abundant in the vessels nearest the centre of the stem.

The wood-fibres, which with the vessels constitute the bulk of wood, have thick walls and obliquely pointed ends. They bear scattered cleft pits, and also contain a little oleoresin readily seen when the fibres are isolated.

The wood parenchyma is small in amount. The cells of which it is composed have moderately thick, pitted walls, and are distributed in tangential rows one or two cells wide, often forming irregular concentric rings. Some of them contain oleoresin, others well-formed crystals of calcium oxalate.

The diagnostic characters of powdered yellow sandal wood are :—

(*a*) *The volatile oil or oleoresin which is found in all the elements.*

(*b*) *The medullary rays one or two cells wide.*

(*c*) *The vessels which are mostly isolated.*

(*d*) *The wood-fibres with obliquely pointed ends.*

PLATE LXXVIII.

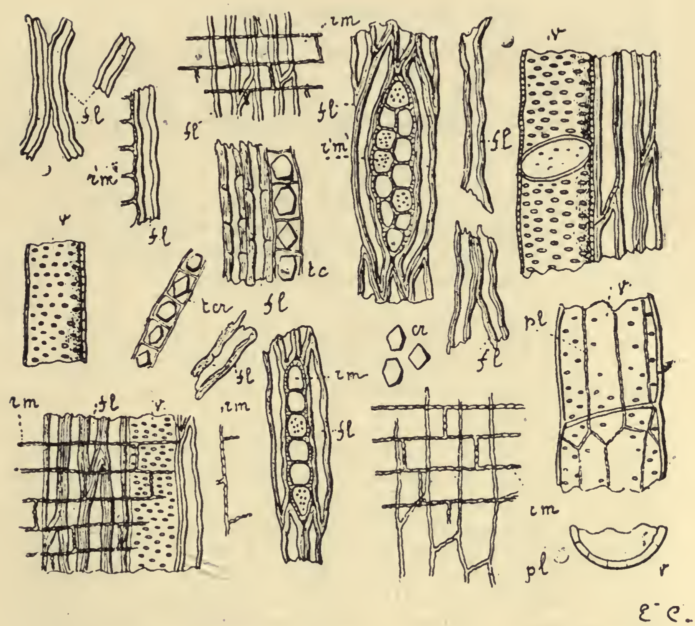

FIG. 88.—**Powdered Yellow Sandal Wood** (× 240).

cr, Prismatic crystals of calcium oxalate.
fl, Wood-fibres.
pl, Wood parenchyma.
rm, Medullary rays cut radially.
r'm', The same cut tangentially.
tcr, Superposed crystal cells.
v, Vessel, longitudinal aspect.
v', The same, cut transversely.

(89) Red Sanders Wood.

The wood of *Pterocarpus santalinus*, Linn.f. (N.O. Leguminosæ).

The wood exhibits the following structure:—The medullary rays are mostly one, sometimes two cells wide; the cells have moderately thick walls, and are strongly radially elongated; they often contain droplets of red resin.

The wood-fibres are polygonal in section, and have very thick reddish yellow walls, with few pits; they are more or less regularly distributed in tangential bands.

The wood parenchyma cells have thin pitted walls, and are filled with droplets of red resin; they are grouped in tangentially extended bands, about four or five cells wide. The vessels are very large, and have very thick walls; they are mostly isolated, or in small radial groups of two or three; like the wood parenchyma cells they contain red resin. In surface view the walls are seen to bear numerous, large, areolated pits. Prismatic crystals of calcium oxalate are found in superposed cells of the wood parenchyma, usually abutting on wood-fibres.

The diagnostic characters of powdered red sanders wood are:—

(*a*) *The red resin in the vessels and parenchymatous cells, and the reddish colour of the wood-fibres.*

(*b*) *The numerous, large, areolated pits on the walls of the vessels.*

(*c*) *The very thick walls of the wood-fibres which bear only scattered pits.*

PLATE LXXIX.

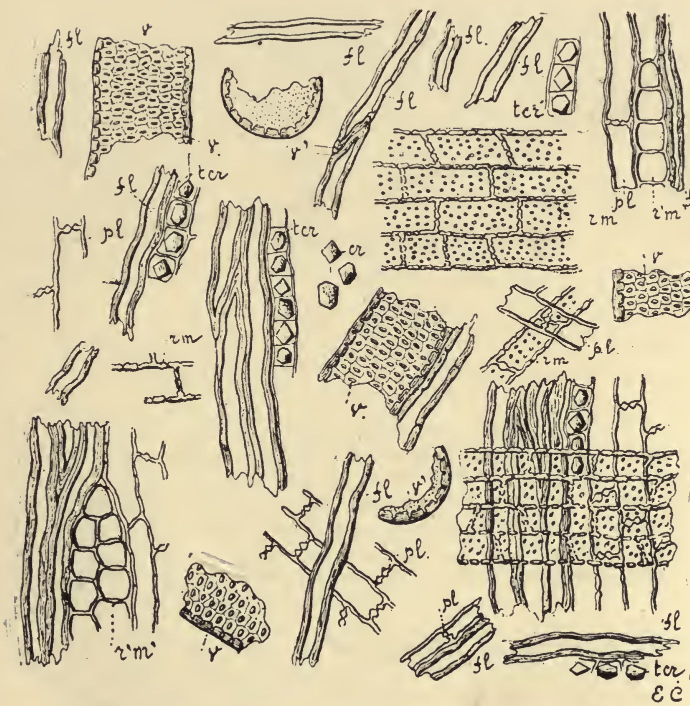

Fig. 89.—**Powdered Red Sanders Wood** (× 240)

cr, Prismatic crystals of calcium oxalate.
fl, Wood-fibres, longitudinal aspect.
pl, Wood parenchyma cells.
rm, Medullary rays in transverse section.
r'm , The same in tangential section.
tcr, Superposed crystal cells.
v, Vessel cut longitudinally.
v', Vessel cut transversely

SECTION VII.

POWDERED BARKS.

The cells and tissues contained in barks exhibit, as a rule, much less variety than those contained in leaves, flowers, seeds, or fruits, and, consequently, in powdered barks there are fewer diagnostic characters available for the purpose of distinguishing such powders from one another or from other powdered drugs. In studying this section, therefore, the student must pay particular attention to the details exhibited by the various elements present.

It is desirable, first of all, to point out the difference that exists in the definition of the term "bark." Modern botanists apply the term bark to those tissues of the stem that are cut off by successive phellogens, and consequently become dried up, forming a layer of varying thickness, composition, and character on the outside of many stems. Pharmacognosists, on the other hand, understand by bark all the tissues of the stem exterior to the cambium, and include in the term, therefore, bast, pericycle, endodermis, cortex and epidermis, together with any tissues that may be formed in these. Should secondary growth have taken place, then the tissues thus produced, in so far as they are exterior to the cambium, are included in the term bark. Older barks will therefore contain secondary bast in addition to primary, secondary cortex in addition to or in place of primary, cork in place of epidermis, and possibly also outer bark (the "bark" of botanists).

Neither vessels nor tracheids are to be found in barks except in those few instances in which the bark contains abnormally developed bundles. These elements therefore would, if found in a powdered bark, indicate adulteration, but care must be taken in drawing such a conclusion, as commercial barks sometimes retain small portions of the wood of the tree yielding them, from which they can with difficulty be separated. Amongst cell contents starch and calcium oxalate are perhaps the most important. Starch has already been alluded to, and the student will be well acquainted with the means by which starches may be distinguished from one another.

Calcium oxalate may be entirely absent (sassafras bark), or it may be present in one or more distinct crystalline forms (prismatic, rhombohedral, rosette, acicular, sandy, etc.). In some barks it assumes only one form, but in many there is more than one present ; the rosette and the prism are most commonly found in the same bark, but in cusparia the prism is associated with bundles of acicular crystals (raphides) ; the latter are generally agglomerated into bundles and enclosed in large oval cells. Usually the crystals are irregularly scattered throughout the parenchyma of the bark, but in some instances they are restricted in their distribution. Thus, in canella bark, each cell of the medullary rays contains a rosette crystal of calcium oxalate, while the bast parenchyma is free from it; in the pomegranate similar crystals are arranged in regular concentric lines in the bast, but are not found in the medullary rays.

When two forms of crystal, such as the rosette and the prism, occur in the same bark, the rosettes are generally scattered through the parenchyma, but the prisms are restricted to the cells abutting on the sclerenchymatous cells or bast fibres; these crystal-cells are often superposed so as to form long, axial rows.

Sclerenchymatous tissue is sometimes absent, sometimes present in considerable quantity ; in the latter case the size, shape and thickness of the wall may afford valuable indications of identity. Secretory tissue of any kind is characteristic ; sufficient reference to tissue of this kind has been made wher dealing with leaves.

The presence or absence of sclerenchymatous fibres (bast fibres) is important. They are more generally found in stem-barks than in root-barks. If present, the details of the elements, their thickness, the thickness of the wall, the number and shape of the pits should be observed.

The following are the chief tissues met with in barks :—

(1) *Cork.*—The cells of which this tissue is composed are usually rectangular in transverse section, tangentially elon-

gated, and arranged in radial rows. In surface view they are polygonal and isodiametric. Their walls are generally thin, but sometimes they exhibit a thickening on one or more sides; they are often brown, and sometimes contain a brown amorphous substance.

(2) *Cortex.*—The cortex consists of parenchymatous tissue in which groups of collenchyma are sometimes developed on the outer margin, that is abutting on the phellogen from which the cork has developed. The remainder of the cortical parenchyma is composed of rounded or tangentially elongated cells which are readily distinguished from the cork-cells by their larger size and more rounded shape, as well as by the absence of suberisation. This tissue often exhibits distinct intercellular spaces. It frequently contains groups of sclerenchymatous cells, usually in greater number and larger size than the bast ring. Secretory tissue of various kinds is also often found in this region.

(3) *Bast.*—The bast ring is composed of medullary rays alternating with bast rays; the latter consist of bast parenchyma and sieve tissue, with which there may be associated bast fibres, sclerenchymatous cells, and the varying forms of secretory tissue.

The cells of the bast parenchyma are usually smaller than those of the cortical parenchyma, and more regularly arranged. The bast fibres may be isolated or grouped. They vary in size, shape and thickness of wall, as well as in other details. The sieve-tubes, which are present in every bark, also exhibit differences in size as well as in the size, number, and position of the sieve-plates. They require special treatment to enable them to be well observed, but may, under certain circumstances, prove useful in the identification of a bark.

The tissue of the medullary rays is usually found in the powdered drug in the form of plates of parenchymatous cells, which are all elongated in the same direction, and transversely to the long axes of the bast fibres or bast parenchyma. They may contain starch, colouring matter, calcium oxalate, etc.

(90) **Alder Buckthorn Bark.**

The bark of *Rhamnus Frangula*, Linn. (N.O. Rhamneæ).

The bark presents the following structure :—

(1) *Cork*, varying in thickness according to the age of the bark. It is composed of a number of rows of flattened cells with thin walls and bright, purplish-red contents ; in surface view the cells are polygonal.

(2) *Phelloderm*, usually very narrow ; the cells resemble those of the cork in shape but they do not contain any red substance and the walls are not suberised.

(3) *Cortex*, the cells of which are mostly tangentially elongated, those abutting on the phelloderm being collenchymatously thickened. This tissue is characterised by the presence of numerous cavities containing mucilage, and by the absence of sclerenchymatous cells (compare cascara sagrada bark). Many of the cells contain rosette crystals of calcium oxalate.

(4) *Bast Ring*, containing numerous tangentially elongated groups of bast fibres, and traversed by medullary rays one or two cells wide. The bast fibres have very thick walls and are surrounded by cells containing calcium oxalate in very uniform prismatic crystals. The sieve-tubes are large, and have large sieve-plates on oblique walls.

The diagnostic characters of powdered alder buckthorn bark are :—

(*a*) *The cork cells with characteristic red contents.*

(*b*) *The bast fibres with crystal cells.*

(*c*) *The absence of sclerenchymatous cells.*

(*d*) *The presence of mucilage.*

(*e*) *The bright purplish colour yielded by the contents of the parenchymatous cells in contact with caustic alkali.*

PLATE LXXX.

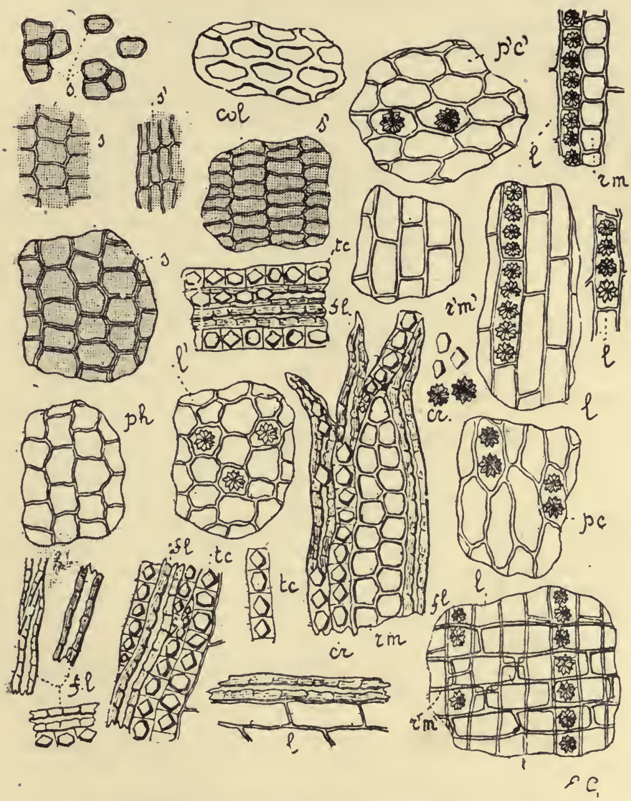

FIG. 90.—**Powdered Alder Buckthorn Bark** (× 240).

col, Collenchyma of the cortex.
cr, Prismatic and rosette crystals.
fl, Bast fibres with pitted walls.
l,l', Bast in longitudinal and transverse section.
pc, p'c', Cortical parenchyma, in longitudinal and transverse section.
ph, Phelloderm.
rm, r'm', Medullary ray in tangential and radial section.
s,s', Cork, in tangential and transverse section.
tc, Rows of crystal cells.

(91) **Cascara Sagrada.**

The bark of *Rhamnus purshiana*, D.C. (N.O. Rhamneæ).

The bark presents the following structure :—

(1) *Cork*, composed of several layers of small, flattened cells with brown contents ; in surface view these cells are polygonal.

(2) *Cortex*, the cells of which are tangentially elongated. Near the cork these cells are collenchymatous in character, forming a more or less continuous band of thickened cells. This tissue contains numerous large groups of sclerenchymatous cells, the individual cells of which are of irregular shape, and have very thick, striated, pitted walls. The parenchymatous cells abutting on these groups of sclerenchyma often contain prismatic crystals of calcium oxalate, whilst in the remainder of the cortical parenchyma numerous rosettes of calcium oxalate are to be found

(3) *Bast Ring*.—This tissue is traversed by medullary rays from one to four cells wide. It contains numerous, narrow, tangentially elongated groups of thick-walled bast fibres upon which parenchymatous cells containing prismatic crystals of calcium oxalate abut. These latter cells are arranged in long vertical rows, and their contents are very conspicuous in longitudinal sections. The sieve-tubes are mostly wide, and bear large sieve-plates on oblique walls ; they can by suitable treatment be detected in the powder. The bast ring contains in addition smaller groups of sclerenchymatous cells and numerous rosettes of calcium oxalate.

The diagnostic characters of powdered cascara sagrada are :—

(*a*) *The conspicuous bast fibres accompanied by calcium oxalate crystals.*

(*b*) *The groups of sclerenchymatous cells, or fragments of such groups.*

(*c*) *The small cork cells with reddish-brown contents.*

(*d*) *The large sieve-tubes with oblique plates.*

(*e*) *The purplish colour produced when the powder is treated with a caustic alkali.*

PLATE LXXXI.

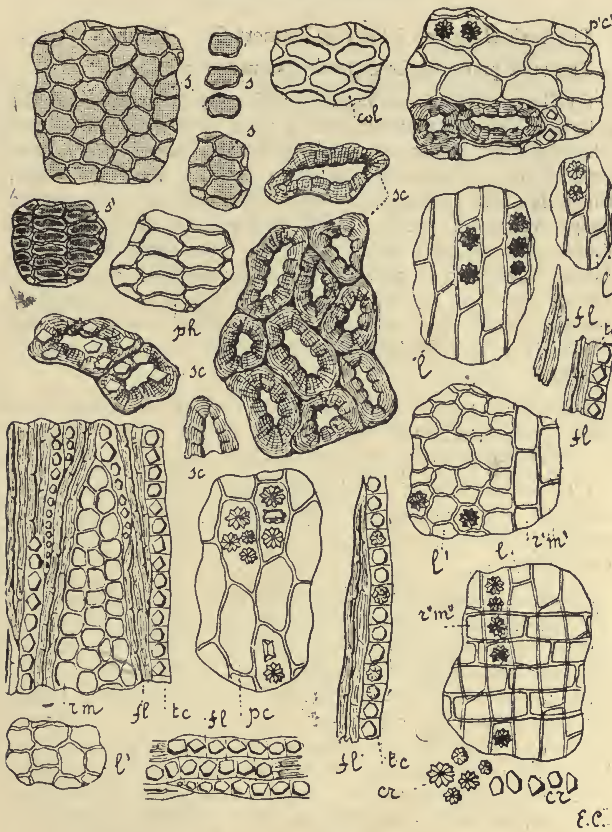

FIG. 91.—**Powdered Cascara Sagrada Bark** (× 240).

col, Collenchyma of the cortex.
cr, Prismatic and rosette crystals.
fl, Bast fibres.
l, **l'**, Bast in longitudinal and transverse section.
pc, **p'c'**, Cortical parenchyma in longitudinal and transverse section.
ph, Phelloderm.
rm, Medullary rays, tangential section.
r'm', The same, transverse section.
r"m", The same, radial section.
s, **s'**, Cork, in surface view and section.
sc, Sclerenchymatous cells.
tc, Rows of crystal cells.

(92) **Cascarilla Bark.**

The bark of *Croton Eluteria*, Bennett (N.O. Euphorbiaceæ).

The bark presents the following structure:—

(1) *Cork.*—This tissue varies considerably in extent, and the cells of which it consists exhibit a very remarkable structure. They are strongly thickened and lignified on the outer tangential walls, and the thickening extends over part of the radial walls, the cells thus assuming, in transverse section, a horse-shoe shape; the inner tangential walls and part of the radial walls contain innumerable minute crystals of calcium oxalate embedded in them, and present therefore a granular appearance. In surface view the cells appear polygonal, and uniformly thickened when the outer wall is focussed or thin walled, and filled with a granular substance when the inner wall is focussed.

(2) *Phelloderm*, consisting of several rows of radially arranged cells, containing prismatic crystals of calcium oxalate, colouring matter, or droplets of oleo-resin.

(3) *Cortex*, usually narrow, and composed of polygonal or rounded cells, containing prismatic or rosette crystals of calcium oxalate, sometimes of very large size, and droplets of oleo-resin.

(4) *Bast Ring*, generally of considerable extent, and traversed by numerous, narrow, medullary rays containing a brown substance or prismatic or rosette crystals of calcium oxalate. The bast rays contain numerous secretion cells and also bast fibres. The latter are either isolated or in small groups; they have very thick walls which, in surface view, often exhibit depressions. The secretion cells are rounded or polygonal; in longitudinal section they are rectangular, or bluntly conical, and are often superposed to form a transversely septate tube. They contain either a reddish-brown substance insoluble in alkali, or droplets of oleo-resin.

The cells of the bast parenchyma contain small grains of starch, or prismatic or rosette crystals of calcium oxalate. In radial sections the cells containing the latter are arranged in vertical rows.

The diagnostic characters of powdered cascarilla bark are:—

(*a*) *The characteristic secretion cells.*

(*b*) *The bast fibres.*

(*c*) *The cork cells with their remarkable thickening and calcium oxalate crystals.*

PLATE LXXXII.

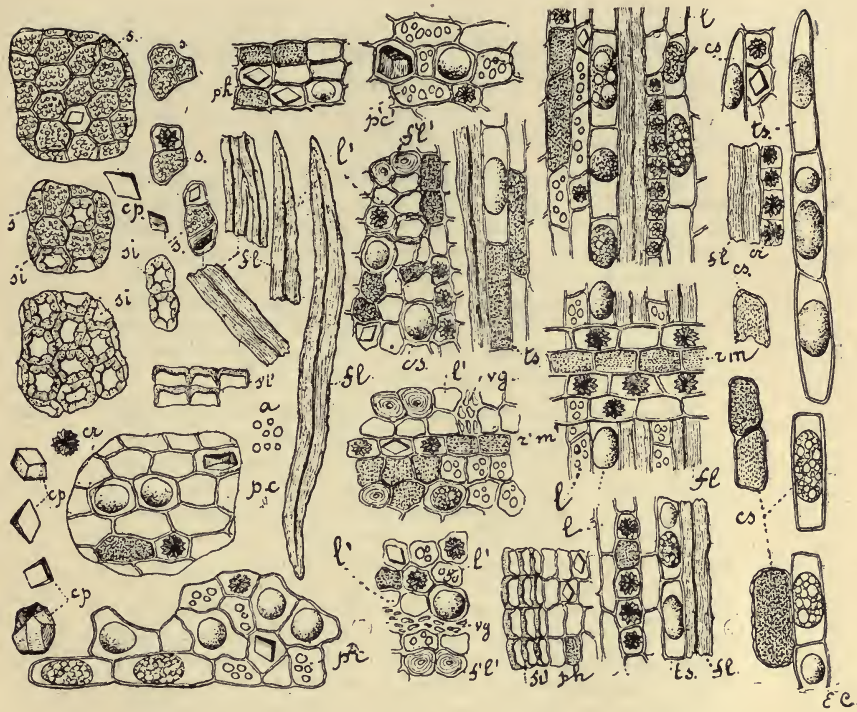

FIG. 92.—**Powdered Cascarilla Bark** (× 240).

a, starch grains.
cp, Prismatic or rhombohedral crystals.
cr, Rosette crystals.
cs, Secretion cells.
fl, Bast fibres.
f'l', The same, in transverse section.
l, l', Bast, radial and transverse section.
pc, cortical parenchyma, longitudinal section.
p'c', The same, transverse section.
ph, Phelloderm.
rm, r'm', Medullary ray, radial and transverse section.
s, Cork cells, showing surface view of the inner wall with granular calcareous deposit.
s', Phelloderm cells in transverse section.
si, Cork cells showing surface view of the outer thickened wall.
s'i', The same in section.
ts, Superposed secreting cells
vg, Sieve-tubes

(93) Cassia Bark.

The bark of *Cinnamomum Cassia*, Blume. (N.O. Laurineæ).

The bark presents the following structure:—

(1) *Cork*, in which layers of thin-walled, tabular cells alternate with layers of cells with thickened, brown walls.

(2) *Cortex*, which is moderately wide and characterised by the abundance of sclerenchymatous cells contained in it. Some of these cells have very thick walls with branching pits; others have comparatively large cavities and walls that exhibit a more or less conspicuous one-sided thickening. They occur either isolated or in small groups in the primary cortex, and also form a sclerenchymatous ring, which is interrupted at intervals by small groups of parenchymatous cells, and bears on the outer margin scattered bundles of pericyclic fibres.

(3) *Bast Ring*, constituting the greater part of the bark. It is traversed by medullary rays two cells wide, and contains numerous secretion cells as well as bast-fibres and sclerenchymatous cells. The secretion cells are mostly larger than the cells of the bast parenchyma, and are axially elongated; they may contain either mucilage or volatile oil, or a mixture of both. The bast fibres are either isolated, or occur in groups of two or three; they are larger but less numerous than those of cinnamon bark. The sclerenchymatous cells are also either isolated or in small groups. The cells of the bast parenchyma contain starch grains which are considerably larger than those of cinnamon bark. Many cells, especially those of the medullary rays, contain numerous minute prismatic crystals of calcium oxalate. The sieve-tubes are narrow, and have small, transverse sieve-plates.

The diagnostic characters of cassia bark are:—

(*a*) *The cork, some of the cells of which are thick walled.*
(*b*) *The isolated bast fibres.*
(*c*) *The sclerenchymatous cells, many of which are more strongly thickened on one side than on the other.*
(*d*) *The secretion cells, containing oil or mucilage*
(*e*) *The minute prismatic crystals of calcium oxalate.*

Typical specimens of cassia bark may be distinguished from typical specimens of cinnamon bark by the presence of cork, by the larger, thicker, bast fibres, and by the larger starch-grains, but the lower grades of cinnamon bark are often difficult to distinguish from cassia.

PLATE LXXXIII.

FIG. 93.—**Powdered Cassia Bark** (× 240). E.C.

a, Starch.
cr, Crystals of calcium oxalate.
fl, Bast fibres, entire or broken.
go, Secretion cells.
l,l', Bast, in longitudinal and transverse section.
pc, Cortical parenchyma.
ph, Phellogen.
rm, r'm', Medullary rays in longitudinal and transverse section.
s, s', Outer layers of cork, in surface view, and in profile.
sc, Sclerenchymatous cells.
se, s'e', Inner, thickened layers of cork, in surface view and in profile.

(94) **Cinchona Bark (Ledger).**

The cultivated bark of *Cinchona Ledgeriana*, Moens (N.O. Rubiaceæ).

The bark presents the following structure :—

(1) *Cork*, composed of several layers of thin-walled tabular cells filled with a dark-brown, amorphous substance ; in surface view the cells are polygonal.

(2) *Phelloderm*, consisting of several rows of cells with dark-brown walls.

(3) *Cortex*, composed of tangentially elongated polygonal cells, some of which are filled with sandy crystals of calcium oxalate, while others contain small, simple starch grains.

(4) *Bast Ring*, comprising the major part of the bark. The medullary rays traversing this tissue are usually two or three cells wide, and the cells have very thin walls. The bast-rays contain numerous scattered bast-fibres which vary somewhat in width (30 to 80 μ), but are usually rather large and fusiform in shape; their walls are very thick, conspicuously striated, and traversed by funnel-shaped pits. In the powdered drug the bast fibres are more or less broken, but the fragments are easily recognisable by their characteristic pits. The sieve-tubes are very narrow, and the sieve-plates are usually transversely situated.

The powder of cultivated cinchonas always contains fragments of very dark-brown cork and of foliaceous lichens ; they usually exhibit but few sclerenchymatous cells, but the botanical source cannot be accurately determined by means of the microscope.

The diagnostic characters of powdered cinchona bark are :—

(*a*) *The dark colour of the parenchymatous tissue.*

(*b*) *The very characteristic bast fibres.*

(*c*) *The small sieve-tubes.*

PLATE LXXXIV.

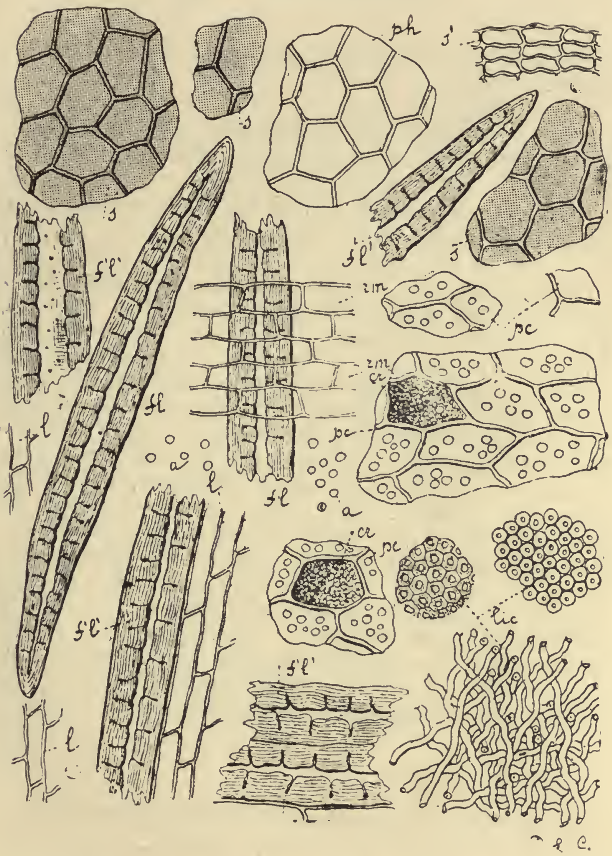

FIG. 94.—**Powdered Cinchona Bark (Ledger)** (× 240).

a, Starch grains.
cr, Cells with sandy crystals of calcium oxalate.
fl, f'l', Bast-fibres, entire and broken.
l, Bast.
lic, *Débris* of lichens.
pc, Cortical parenchyma.
rm, Medullary ray in long tudinal section.
s, s', Cork in surface view and profile.
ph, Phelloderm.

(95) Cinnamon Bark.

The bark of *Cinnamomum zeylanicum*, Breyne (N.O. Laurineæ).

The bark, which is deprived of the cork and of the majority of the cortex, presents the following structure:—

(1) *Cortex*, represented by two or three rows of tangentially elongated polygonal cells.

(2) *Bast Ring*, separated from the remains of the cortex by a continuous ring of sclerenchymatous cells, with thickened pitted walls, the thickening being often more strongly developed on one side than on the others. On the outer margin of this ring bundles of pericyclic fibres may be detected at ntervals, as in the case of cassia bark, but the sclerenchymatous ring of cinnamon differs from that of cassia in being continuous instead of interrupted. The bast ring is traversed by medullary rays, which are very narrow near the cambium, but enlarge towards the periphery. It contains secretion cells similar to those of cassia bark, and bast fibres that have very thick walls and are mostly isolated. The sieve-tubes are arranged in tangential groups, which in the outer portions of the bast ring are collapsed and exhibit traces only of cavities; they are narrow and have transverse sieve-plates. Many of the cells of the cortical parenchyma and medullary rays contain small starch grains or numerous minute crystals of calcium oxalate.

The diagnostic characters of cinnamon bark are:—

(*a*) *The absence of cork.*

(*b*) *The sclerenchymatous cells, sometimes thickened on one side more than on the others.*

(*c*) *The secretion cells containing oil or mucilage.*

(*d*) *The minute crystals of calcium oxalate.*

(*e*) *The small sieve-tubes with transverse plates.*

Typical cinnamon bark is distinguished from cassia bark by the absence of cork, by the bast-fibres, which are smaller and narrower, and by the starch grains, which are also smaller.

PLATE LXXXV.

FIG. 95.—**Powdered Cinnamon Bark** (× 240).

a, Starch grains.
cr, Minute crystals of calcium oxalate.
fl, Bast fibres with very thick walls, entire or broken.
go, Secretion cells.
l, l′, Bast in longitudinal and transverse section.
pc, Cortical parenchyma.
rm, r′m′, Medullary rays in radial and tangential section.
sc, Sclerenchymatous cells.
vg, Sieve-tubes, collapsed.

(96) **Condurango Bark.**

The bark of *Gonolobus Condurango*, Triana (N.O. Asclepiadeæ).

The bark presents the following structure :—

(1) *Cork*, of moderate thickness, composed of flattened, brown, tabular cells, which in tangential section are polygonal in outline.

(2) *Phelloderm*, also of moderate thickness, characterised by the presence of an abundance of prismatic or octohedral crystals of calcium oxalate.

(3) *Cortex*, the outer layers of which, abutting on the phelloderm, are collenchymatous. The cells of the cortical parenchyma are irregularly polygonal and contain small starch grains and rosettes of calcium oxalate measuring mostly from 8 to 20μ in diameter. The cortex also contains numerous laticiferous cells filled with a brown latex.

(4) *Bast Ring*, which, especially in young barks, is separated from the cortex by a ring of rounded bundles of thick-walled pericyclic fibres (primary bast fibres). The bast ring is traversed by narrow medullary rays, some of which are abruptly enlarged towards the cortex. The bast rays contain numerous laticiferous cells and sieve tubes, as well as large, irregular groups of sclerenchymatous cells, the walls of which are very thick, and have branching pits; these groups are bordered by cells with moderately thick pitted walls. The sieve tubes are rather large and have oblique sieve plates. The bast parenchyma is rich in starch grains and rosette crystals of calcium oxalate.

The diagnostic characters of condurango bark are :—

(*a*) *The laticiferous cells with brown latex.*

(*b*) *The sclerenchymatous cells.*

(*c*) *The pericyclic fibres.*

(*d*) *The abundant calcium oxalate in single crystals or rosettes.*

(*e*) *The large sieve tubes with oblique plates.*

(*f*) *The starch grains.*

PLATE LXXXVI.

FIG. 96.—**Powdered Condurango Bark** (× 240).

a, Small, simple starch grains.
col, Collenchyma.
cp, Prismatic and octohedral crystals from the phelloderm.
cr, Rosette crystals.
fl, Pericyclic fibres.
l, l′, Bast, in transverse and longitudinal section.
pc, Cortical parenchyma.
pd, p′d′, Phelloderm, in transverse and tangential section.
rm, r′m′, Medullary rays, in transverse and radial section.
s, s′, Cork, in tangential and transverse section.
vg, Sieve-tubes, in longitudinal section.
vl, v′l′, Laticiferous cells, in longitudinal and transverse section.

(97) **Cusparia Bark.**

The bark of *Galipea officinalis*, Hancock (N.O. Rutaceæ).

The bark exhibits the following structure :—

(1) *Cork.*—The characters of this tissue vary considerably in different specimens. Frequently there is on the outside a more or less extensive layer of thin-walled cells, and towards the interior a layer of thick-walled cells; or these conditions may be reversed, or the thin-walled cork may be almost entirely absent. In surface view the cork cells are polygonal in outline.

(2) A narrow layer of *phelloderm*, the cells of which, in surface view, also appear polygonal.

(3) *Cortex*, composed of tangentially elongated parenchymatous cells containing small, rounded starch grains. This tissue contains large oval cells, in each of which there is a bundle of acicular crystals of calcium oxalate; it also contains oil glands, and not unfrequently small groups of polygonal parenchymatous cells with moderately thick, pitted walls.

(4) *Bast Ring*, in which oil glands and small groups of bast fibres can be distinguished. In this tissue crystal cells are also present, but the cells themselves are not larger than the neighbouring parenchymatous cells, and the calcium oxalate takes the form of long, pointed, prismatic crystals. The bast fibres have very thick walls, and are grouped together in bundles of moderate size. The sieve-tubes are arranged in tangential bands, which alternate with similar bands of bast parenchyma; they may be distinguished by having rather thicker walls, and in the older parts of the bark are often collapsed.

The medullary rays are two cells wide, near the cambium, but enlarge towards the cortex.

When a section is moistened with dilute solution of ferric chloride a bright red colour is developed, especially near the oil cells.

The diagnostic characters of cusparia bark are :—

(*a*) *The presence of acicular and prismatic crystals of calcium oxalate.*

(*b*) *The oil glands.*

(*c*) *The bast fibres.*

(*d*) *The characteristic cork.*

(*e*) *The red coloration with ferric chloride (not always well defined in the powder).*

PLATE LXXXVII.

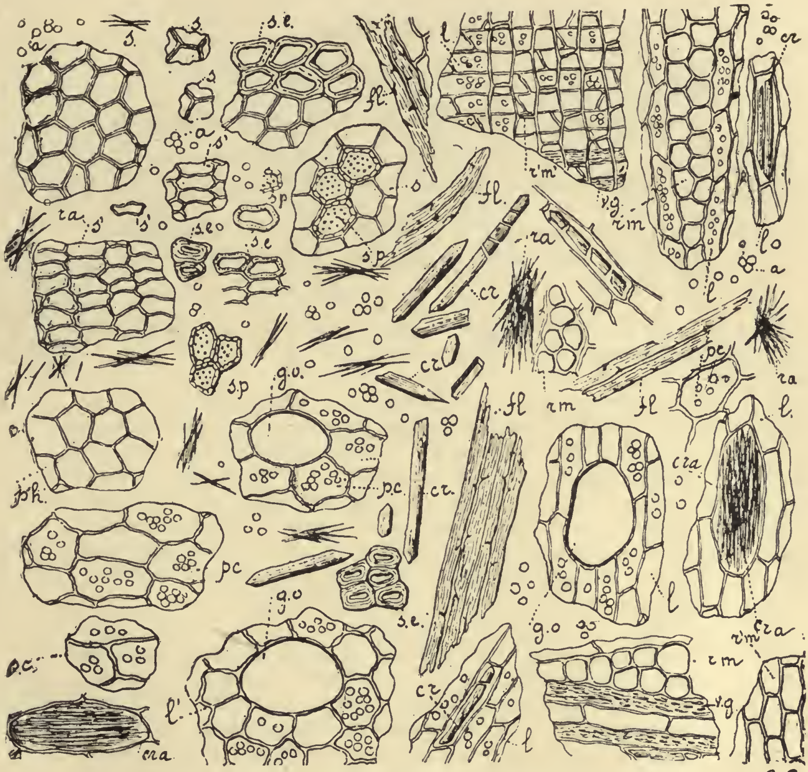

FIG. 97.—**Powdered Cusparia Bark** (× 240)

a, Starch grains.
cr, Prismatic crystals.
cra, Acicular crystals.
fl, Bast fibres.
go, Oil glands.
l, l′, Portions of the bast in longitudinal and transverse section.
pc, Cortical parenchyma.
ph, Phelloderm.
ra, Raphides.
rm, rm′, Medullary rays in tangential and radial section
s s′, Cork, in surface view and section.
sc, Sclerenchymatous cork cells.
sp, Sclerenchymatous cells from the cortical parenchyma
vg, Sieve-tubes.

(98) **Oak Bark.**

The young bark of *Quercus robur*, Linn. (N.O. Cupuliferæ).

The bark presents the following structure :—

(1) *Cork*, composed of a number of rows of moderately thickened, brown cells; in tangential section they are seen to be polygonal.

(2) *Phelloderm*, which is generally only slightly developed, and presents the usual characters.

(3) *Cortex*, the outer portion of which has developed into a collenchymatous tissue, containing brownish chloroplastids. The remainder of the cortex is composed of irregular polygonal cells amongst which there are scattered numerous isolated or grouped sclerenchymatous cells; these vary very much in size; some have very thick walls traversed by branching pits, but others have only moderately thick smooth walls. The parenchymatous cells of the cortex contain chloroplastids, tannin, and rosette crystals of calcium oxalate.

(4) *Bast Ring*, which in young bark is of moderate thickness, and traversed by narrow medullary rays. The bast rays contain numerous tangentially elongated groups of bast fibres with very thick walls upon which cells containing prismatic crystals of calcium oxalate abut. Many of the cells of the bast parenchyma are brown in colour, and nearly all of them as well as of the cells of the medullary rays contain tannin.

The diagnostic characters of the bark are :—

(*a*) *The presence of abundant tannin.*

(*b*) *The numerous sclerenchymatous cells of the cortex.*

(*c*) *The numerous thick-walled bast fibres.*

(*d*) *The characteristic cork.*

PLATE LXXXVIII.

FIG. 98.—**Powdered Oak Bark** (× 240).

ccr, Cells containing rosette crystals.
col, Collenchyma.
cp, Prismatic crystals, free or enclosed in cells, abutting on the bast fibres.
cr, Rosette crystals from the parenchyma of the cortex and bast.
fl, Fragments of bast fibres.
f′l′, The same, in transverse section.
l, l′, l″· Bast, in radial, transverse, and tangential section.
pc, Parenchyma of the cortex.
ph, Phelloderm.
rm, r′m′, Medullary rays in radial and tangential section.
sc, Sclerenchymatous cells.
tcr, Rows of crystal cells.

(99) **Pomegranate Root Bark.**

The root bark of *Punica Granatum*, Linn. (N.O. Lythrarieæ).

The bark exhibits the following structure :—

(1) *Cork.*—The outer layers of this tissue are often much flattened and in process of exfoliation ; the inner layers are composed of flattened, tangentially elongated cells, the inner tangential walls of which are thickened and pitted. In surface view these cells appear polygonal, isodiametric, and pitted.

(2) *Cortex.* — The cells of the cortical parenchyma are tangentially elongated, and contain a little chlorophyll, together with starch grains, and occasional prismatic crystals of calcium oxalate. Here and there, especially in old barks, large sclerenchymatous cells are to be found; they are usually isolated, seldom in couples, very irregular in shape, and have very thick, pitted walls.

(3) *Bast Ring.*—The bast ring is divided by one-celled medullary rays into very distinct bast rays, which are characterised by the great number of rosette crystals of calcium oxalate contained in them. These crystals are contained in the cells of the bast parenchyma, and, in transverse section are arranged in parallel tangential lines, sometimes single, sometimes double, alternating with rows of similar cells containing small starch grains. In longitudinal section the crystal cells are seen to be in vertical rows.

The root bark is distinguished from the stem bark more particularly by its greater disposition to form an outer bark by the production of secondary phellogens in the cortex. The stem bark also bears lenticels; these are filled with layers of thick-walled cork cells, between which there are numerous rounded cells with unequally thickened pitted walls (Tschirch's choriphelloid cells).

The diagnostic characters of powdered pomegranate root bark are :—

(*a*) *The large number and regular arrangement of the rosettes of calcium oxalate.*

(*b*) *The very large, thick-walled, pitted sclerenchymatous cells.*

(*c*) *The inner layers of cork cells, thickened and pitted on one side.*

(*d*) *The small isolated starch grains.*

PLATE LXXXIX.

FIG. 99.—**Powdered Pomegranate Root Bark** (× 240).

a, Starch grains.
cr, Crystals of calcium oxalate.
l, l', l", Bast ray, in radial, transverse and tangential section.
le, le', Choriphelloid cells of lenticels.
p, Prismatic crystals of calcium oxalate (from the cortex).
pc, Cortical parenchyma with prismatic crystals.
ph, Phelloderm cells.
sc, Sclerenchymatous cells.
se, Outer layers of cork, surface view.
s'e', The same in profile.
si, Inner layers of cork, surface view.
s'i', The same, in profile.

(100) **Quillaia Bark.**

The secondary bast of *Quillaja Saponaria*, Molina (N.O. Rosaceæ), to which portions of the dark-brown, outer bark are sometimes attached.

The bark presents the following structure:—

(1) *Outer Bark*, consisting of bands of cork cells alternating with bands of brown parenchymatous tissue containing numerous groups of bast fibres and large prismatic crystals of calcium oxalate.

(2) *Bast Ring*, completely traversed by medullary rays, usually three or four cells wide, in which prismatic crystals of calcium oxalate are occasionally to be seen. The bast rays contain numerous bast fibres, both isolated and grouped, together with prismatic crystals of calcium oxalate, many of which are of very large size (up to $1{,}000\mu$, or even more in length), and axially arranged. The groups of bast fibres are very irregular in shape, and only occasionally stretch from one medullary ray to the next. The individual fibres vary very much in appearance, being often cut obliquely. In transverse section they may be small ($10\text{-}12\mu$) or large (40μ) and rounded or angular, or they may be oval (60μ); the cavity may be a point or a slit. When isolated they have a very characteristic irregular outline, exhibiting remarkable enlargements; they taper to a fine point and near the apex are often forked; with dilute mineral acids they assume a reddish colour.

The sieve-tubes are comparatively wide, the sieve-plates large and oblique.

The diagnostic characters of powdered quillaia bark are:—

(*a*) *The very large prismatic crystals of calcium oxalate.*

(*b*) *The abundance of large bast-fibres of irregular shape.*

c) *The large sieve-tubes.*

PLATE XC.

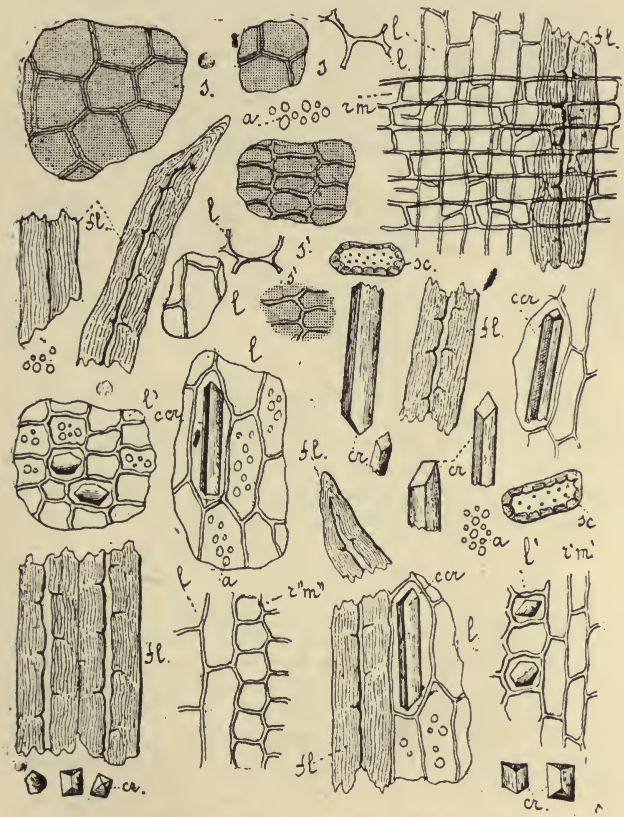

FIG. 100.—**Powdered Quillaia Bark** (×240).

a, Starch grains.
ccr, Crystal cells.
cr, Crystals of calcium oxalate.
fl, Bast fibres.
l, **l′**, Bast.
rm, **r′m′**, **r″m″**, Medullary rays in longitudinal, transverse, and tangential sections.
s, **s′**, Cork.
sc, Sclerenchymatous cells.

(101) **Sassafras Root Bark.**

The root bark of *Laurus Sassafras*, Linn. (N.O. Laurineæ).

The bark presents the following structure:—

(1) *Cork*, composed of large polygonal cells, with slightly thickened, yellowish brown walls.

(2) *Phelloderm*, the cells of which resemble those of the cork, but are colourless and not suberised.

(3) *Cortex*, consisting of polygonal cells with intercellular spaces. These cells contain starch grains, which are either simple or compound; the former are oval or rounded, and possess a very distinct stellate or fissured hilum, the latter are composed of two, three, or four grains which, when separated, exhibit one or more flattened surfaces. The cortex also contains large oil-cells filled with yellowish volatile oil.

4) *Bast Ring*, which comprises the majority of the bark, and is traversed by medullary rays one or two cells wide. Most of the cells of the bast parenchyma have smooth walls, but many are pitted. The bast rays contain numerous large oil-cells and large, isolated, fusiform bast fibres, the walls of which are so thick as to leave but very small cavities. The sieve tubes are arranged in tangential bands, and in the outer part of the bast ring are collapsed.

The diagnostic characters of sassafras root bark are:—

(*a*) *The oil-cells.*

(*b*) *The large, thick-walled, isolated bast fibres.*

(*c*) *The starch grains.*

(*d*) *The parenchymatous cells, with pitted walls.*

PLATE XCI.

FIG. 101.—**Powdered Sassafras Root Bark** (× 240).

a, Starch grains.

cp, Pitted cells from the bast ring

fl, Bast fibres.

go, Oil-cells.

l, l′, l″, Bast in radial, transverse, and tangential section.

pc, p′c′, Cortical parenchyma in transverse and longitudinal section.

ph, Phelloderm.

rm, r′m′, r″m″, Medullary rays in radial, transverse, and tangential section.

s,s′, Cork in surface view and profile.

vg, v′g′, Sieve tubes more or less collapsed, in longitudinal and transverse section.

(102) **Simarouba Bark.**

The root bark of *Simarouba officinalis*, D.C. (N.O. Rutaceæ).

The bark presents the following structure :—

(1) *Cork*, if present, consisting of brown, flattened, tabular cells.

(2) *Cortex*, composed of irregular, tangentially elongated, polygonal cells, and containing resin cells and rather large sclerenchymatous cells either isolated or in groups; these cells are very irregular in shape and have rather thick, lignified walls. The cortex also contains an abundance of prismatic or rhombohedral crystals of calcium oxalate.

(3) *Bast Ring*, comprising the major part of the bark and traversed by numerous medullary rays which are mostly two to four cells wide and widen somewhat abruptly towards the cortex. The bast rays contain numerous bast fibres arranged in tangential bands which alternate with thicker tangential bands of bast parenchyma and sieve tubes. The bast fibres are often accompanied by groups of sclerenchymatous cells. The individual fibres are rather large, irregularly flattened, and provided with moderately thick, lignified walls. The bast rays are also rich in prismatic crystals of calcium oxalate. The number of sclerenchymatous cells and of crystals varies, however, greatly in different samples of bark.

The diagnostic characters of simarouba bark are :—

(*a*) *The characteristic bast fibres.*

(*b*) *The sclerenchymatous cells.*

(*c*) *The crystals of calcium oxalate in the cortical parenchyma.*

PLATE XCII.

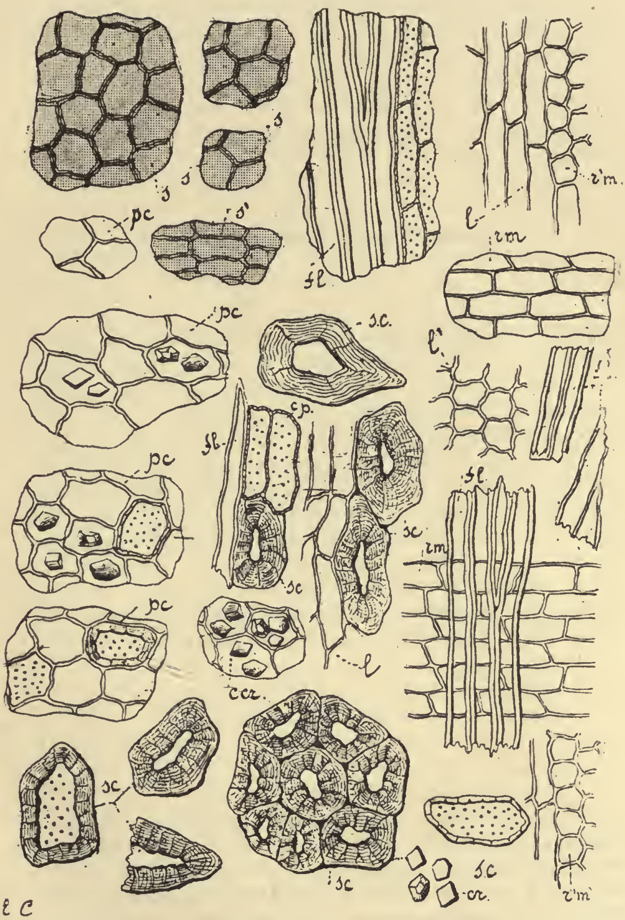

FIG. 102.—**Powdered Simarouba Bark** (×240).

ccr, Cells containing calcium oxalate.
cp, Pitted cells.
cr, Prismatic and rhombohedral crystals of calcium oxalate.
fl, Bast fibres.
l,l', Bast in longitudinal and transverse section.
pc, Cortical parenchyma.
rm, r'm', Medullary rays in radial and tangential section.
s,s', Cork in surface view and profile.
sc, Sclerenchymatous cells, isolated and in groups.

P

SECTION VIII.

POWDERED RHIZOMES AND ROOTS.

Rhizomes and roots often exhibit great similarity in appearance as well as in structure. Some drugs consist of rhizomes with roots attached to them (valerian), others of separate pieces of rhizome and root which, however, are often with difficulty to be distinguished (liquorice), whilst others, again, though generally styled roots, are really rhizomes (rhubarb). For these reasons it is desirable to deal with them together, although such a classification may not be altogether scientific. Most of such as are used in pharmacy are derived from monocotyledonous or dicotyledonous plants, only one—viz., male fern—being obtained from a fern. As the general structure varies according to the class to which the plant yielding the drug belongs, these classes may be considered separately.

1. Ferns.

The epidermis is succeeded by a tegumentary tissue consisting of the suberised and dark-coloured outer rows of the cells of the cortical parenchyma (metaderm). The steles are arranged in a diffuse ring and surrounded by a parenchymatous tissue that is continuous with, and may be considered part of the cortical parenchyma, the cells of which contain small starch grains, chlorophyll, etc. Each stele is surrounded by a distinct endodermis within which there is a single row of pericyclic cells containing starch grains. Within the pericycle is a ring of bast tissue, the centre of the stele being occupied by the wood. The bast tissue is composed of small parenchymatous cells and large sieve tubes, while the wood contains narrow spiral, together with larger scalariform and reticulate, vessels.

2. Monocotyledons.

From this class numerous official rhizomes are derived. The epidermis is usually succeeded by a rather thick layer of cork, within which there is a parenchymatous cortex traversed ongitudinally by fibrovascular bundles (leaf traces), and separated from the stele by the endodermis. The stele is composed of parenchymatous tissue, throughout which numerous fibrovascular bundles are distributed. These bundles are usually more closely approximated to one another near the endodermis forming a more or less dense ring, while towards the centre of he stele they are scattered. Although one bundle may fuse with another, they do not all unite to form a single ring of wood bundles surrounded by a ring of bast as they do in dicotyledonous rhizomes, nor is any merismatic layer (cambium) produced.

Monocotyledonous roots also have a distinctive structure. Within the outermost layer or epiblema there is a cortex composed of parenchymatous cells often filled with starch; the endodermis is usually distinct and often coloured; the stele contains a number of fibrovascular bundles so closely approximated to one another as to form within the pericycle a continuous ring which is not traversed by regular bands of parenchymatous cells analogous to medullary rays. Within the ring of fibrovascular bundles there is usually a more or less well developed pith.

Dicotyledons.

Dicotyledonous rhizomes commonly exhibit a tegumentary tissue composed of several layers of cork cells within which is a parenchymatous cortex traversed longitudinally by fibrovascular bundles (leaf traces). The endodermis is sometimes distinct, but sometimes it is difficult to identify. The stele differs from the stele of monocotyledonous rhizomes in the nature and distribution of the fibrovascular bundles it contains; in dicotyledonous rhizomes these are usually arranged in a single circle and often closely approximated, being separated by regular strands of parenchyma (medullary rays). Between each wood bundle and the pericycle there is a group of bast tissue, and between the bast and the wood a layer of merismatic tissue which ultimately forms a complete cambium ring.

During the earlier stages of their growth, dicotyledonous hizomes may easily be distinguished from roots, as the former possess the primary structure characteristic of stems and th latter that characteristic of roots. As the age of these organs increases, it becomes increasingly difficult to distinguish wi h certainty between them, for the primary structure becomes more and more obscure until it is finally undiscerni le. Th s is the case with most drugs, and it is often anything but an easy task to distinguish the one from the other. Rhizomes, however, generally possess a well-marked pith which is absent from roots, and they often exhibit also scars of leaves with buds in their axils from which roots are free; in transverse section it is usually easy to discover the leaf traces that proceed from the stele obliquely through the cortex to these leaves.

Principal Tissues of Roots and Rhizomes.

Before reviewing the principal tissues that are present in roots and rhizomes it may be observed that hairs, both simple and glandular, stomata and palisade tissue, all of which are commonly present in leaves, are almost wholly absent from roots and rhizomes and their powders. The sclerenchymatous and coloured layers that are characteristic of seeds are not found in roots, which may also be distinguished from seeds by the absence of aleurone grains. The presence of pitted and other vessels are sufficient to distinguish powdered roots from powdered barks, with the exception of those few of the former that contain abnormal vascular bundles. Monocotyledonous roots and rhizomes do not possess medullary rays, whilst in most dicotyledonous roots and rhizomes they are present and may be found in the powdered drugs in fragments, exhibiting typical appearances according as they present their transverse, tangential or radial section.

In some few cases it is possible to distinguish an admixture of powdered rhizome with powdered root, but generally speaking this is difficult, if not impossible. Gentian or liquorice rhizome, for instance, cannot be distinguished from the root when powdered, but an admixture of ipecacuanha or valerian rhizome with the root can easily be detected, as the rhizomes contain certain sclerenchymatous elements which are not found in the roots.

The following are the principal tissues that may be found in powdered roots or rhizomes: *epidermis* or *cork*, *phelloderm*, *collenhyma*, *cortical parenchyma*, *endodermis*, *bast*, *wood*, and *pith*. They are not, however, all of the same diagnostic importance; thus, for instance, the phelloderm and collenchyma are almost valueless from a diagnostic point of view, whereas sclerenchymatous cells, fibres, etc., are extremely important, as are also such cell contents as *starch*, *inulin*, *calcium oxalate*, etc.

Epidermis or Cork.

In some monocotyledonous rhizomes (sweet flag) the epidermis is persistent and no cork is formed, but in others (ginger) it may be thrown off comparatively early, and an abundant development of cork may take its place. In some drugs the cork cells of the root offer certain points of distinction from those of the rhizome (white hellebore). In dicotyledonous rhizomes the epidermis is usually replaced by a varying number of layers of cork cells. Occasionally the epidermis both of rhizomes and roots is found to be provided with hairs; these may be numerous and persistent (valerian root) or scattered and often broken off (zedoary rhizome).

Phelloderm.

The arrangement of the cells of this tissue is the same as that of the cells of the cork; they may be distinguished by their walls, which are not suberised.

Collenchyma.

Several rhizomes contain a layer of collenchyma abutting upon the epidermis (or cork); it presents the usual characters.

Cortical Parenchyma.

In most roots and rhizomes the cortical parenchyma consists of tangentially elongated cells; sometimes, however, these cells are axially elongated. The cortex of rhizomes is usually traversed by leaf traces, and may contain sclerenchymatous cells secretion cells, etc., of considerable diagnostic value.

Bast.

The arrangement of the bast in monocotyledonous rhizomes differs materially from that which obtains in dicotyledonous. In the former this tissue usually consists of a few small elongated cells, closely adherent to the vessels of the vascular bundle, which may be supported or surrounded by a crescent-shaped bundle of fibres. In dicotyledonous rhizomes the bast forms a much more considerable portion of the drug and of the powder. In many dicotyledonous roots the bast ring contains no sclenchymatous fibres, but in others such may be present, and they then constitute a valuable diagnostic feature.

Endodermis.

Most monocotyledonous rhizomes and roots contain a very obvious endodermis, the cells of which may furnish an important means of identifying the powder. In dicotyledonous rhizomes it is usually of little importance, and among the dicotyledonous roots those of aconite and valerian are the only drugs in which this tissue is to be detected.

Wood.

The stele of monocotyledonous rhizomes is usually composed of a parenchymatous tissue resembling that of the cortex, traversed by a number of collateral or concentric bundles; the latter are usually composed of a few vessels, together with a small column of bast, the whole being often supported by a sheath of sclerenchymatous fibres. The parenchymatous cells, the vessels, and the fibres may all afford valuable diagnostic evidence.

In monocotyledonous roots the vessels are generally very large and accompanied by numerous thick-walled, pitted fibres.

The wood of dicotyledonous rhizomes and roots is usually divided by medullary rays into wedge-shaped masses. These masses may consist of thin-walled parenchymatous tissue, in which vessels are scattered either singly or in small groups (gentian), or the parenchymatous tissue may lignify partially (liquorice), or completely (rhatany). In the centre the remains of the primary wood may often be found and recognised by its spiral vessels. Sometimes true vessels are entirely absent, as, for instance, they are from the wood of ipecacuanha root, which consists entirely of tracheids, wood fibres and wood parenchyma.

Medullary Rays.

These are found in dicotyledonous but not in monocotyledonous roots or rhizomes, and form, therefore, an important diagnostic feature. They are generally narrow in roots that have a completely lignified wood, but much wider in those that have a wood consisting largely of thin-walled parenchymatous tissue. They have been described, and their importance indicated, in the section dealing with woods.

Secretory Tissue.

Tissue of this kind is by no means of uncommon occurrence. As already pointed out, its presence or absence, and in the former case its nature, are of great importance. Sometimes two kinds of secretory tissue are present, as, for instance, in ginger and allied rhizomes. Here the cortex and stele contain oleo-resin cells, while the bundles contain narrow elongated cells, in which a dark brown substance is secreted. Bryony root contains elongated cells, analogous to laticiferous cells.

The remarkable glandular hairs that occur in the intercellular spaces of male fern rhizome and secrete a resinous substance may also be found whole or broken in the powdered drug.

Starch.

Some rhizomes and roots, as, for instance, gentian, senega and those derived from composite plants, are free, or practically free, from starch; others, such as golden seal, contain but little. It is, however, more usual to find considerable quantities of starch, to the characters of which particular attention must be directed. In the illustrations that accompany this section of the Atlas, we have endeavoured to retain as accurately as possible the relative size of the various starches, for this often constitutes the most conspicuous difference between them.

Inulin.

The rhizomes and roots of composite plants contain this substance as a reserve material in the place of starch. It is generally found in the parenchymatous cells of the bast ring and wood in the form of amorphous or indistinctly crystalline masses. Examined in a mixture of alcohol and glycerin these often exhibit a sphærocrystalline structure; they dissolve without swelling when heated in water.

Calcium Oxalate.

This substance may be entirely absent or it may be present, and then, as usual, in various distinctive forms. Thus belladonna root contains sandy crystals, gentian root minute needles, orris rhizome very large prisms, rhubarb enormous rosette crystals, ipecacuanha raphides, and so on. In some drugs (orris), these crystals occur in intercellular spaces and are enclosed in delicate suberised membranes; in others they are contained singly or several together in the interior of certain of the cells.

(103) **Aconite Root.**

The root of *Aconitum Napellus*, Linn. (N.O. Ranunculaceæ). The root presents the following structure :—

(1) *Tegumentary Tissue* (metaderm), composed of brown tabular cells which in surface view are polygonal and of variable size and shape.

(2) *Cortex*, consisting of polygonal parenchymatous cells filled with starch ; many of the cells also contain the brownish remains of protoplasm. Numerous sclerenchymatous cells, occasionally strongly elongated, with thickened, pitted walls, are scattered throughout this tissue.

(3) *Endodermis*, which is very conspicuous. It consists of a single row of rectangular, tangentially elongated cells with slightly thickened and often brownish walls.

(4) *Bast Ring*. This tissue is rather largely developed. Towards the exterior it is composed of irregular polygonal cells that do not exhibit any definite arrangement, but as the wood is approached they become more regular, isodiametric and assume a radial arrangement. It contains numerous groups of sieve tissue but no bast fibres.

(5) *Wood*, separated from the bast ring by a stellate cambium with about seven angles in which there are fibrovascular bundles of varying dimensions, those in the angles that project into the bast ring being larger than the others. The wood consists principally of parenchymatous tissue, the cells of which contain an abundance of starch in simple and compound grains ; the former are rounded ; the constituent grains of the latter vary in shape according to the number in the compound grain, and are usually rounded on one side and angular on the other. There is no calcium oxalate present.

The diagnostic characters of aconite root are :—

(*a*) *The starch grains.*

(*b*) *The presence of sclerenchymatous cells, but absence of bast fibres.*

(*c*) *The brownish contents of many parenchymatous cells.*

(*d*) *Absence of calcium oxalate*

PLATE XCIII.

FIG. 103.—**Powdered Aconite Root** (× 240).

a, Starch grains.
ca, c′a′, Cambium in longitudinal and transverse section.
e, Tegumentary tissue, surface view.
l, l′, Bast in longitudinal and transverse section.
m, *Débris* of parenchyma of the pith.
pc, Cortical parenchyma.
pce, Outer part of the same.
pl, Wood parenchyma.
sc, Sclerenchymatous cells.
tr, v, Pitted vessels, etc.

(104) **Belladonna Root.**

The root of *Atropa Belladonna*, Linn. (N.O. Solanaceæ).

The upper part of the root is an erect rhizome and differs somewhat from the root in its structure.

A root of moderate size presents the following structure :

(1) *Cork*, composed of tabular, tangentially elongated cells which in surface view are polygonal and isodiametric.

(2) *Cortex* (secondary), consisting of parenchymatous cells with rather thick walls and distinct pits ; near the cork these cells are tangentially elongated, but towards the cambium they become nearly isodiametric. In the cells of this tissue, as well as those of the parenchyma of the bast-ring and wood, starch grains and sandy crystals of calcium oxalate occur. The starch grains vary usually from 5 to 20μ in diameter, but may attain 30μ ; they are mostly compound and contain from two to four constituent grains ; the simple grains are rounded or oval.

(3) *Bast Ring*, which is not sharply delineated from the cortex and contains radially elongated groups of sieve-tissue, but no bast fibres.

(4) *Wood*, consisting largely of thin-walled parenchyma, throughout which radially elongated vascular groups are distributed, the centre of the root being occupied with the primary wood. The vascular groups contain a few pitted vessels, accompanied by tracheids and fibres.

The rhizome differs considerably from the root in structure. The wood is much more developed and usually forms one or more dense rings enclosing a distinct pith, and traversed by well marked medullary rays. Between the pith and the wood perimedullary bast bundles may be found.

The diagnostic characters of belladonna root are :

(*a*) *The starch.*

(*b*) *The sandy calcium oxalate.*

(*c*) *The characteristic tracheids and wood fibres.*

PLATE XCIV.

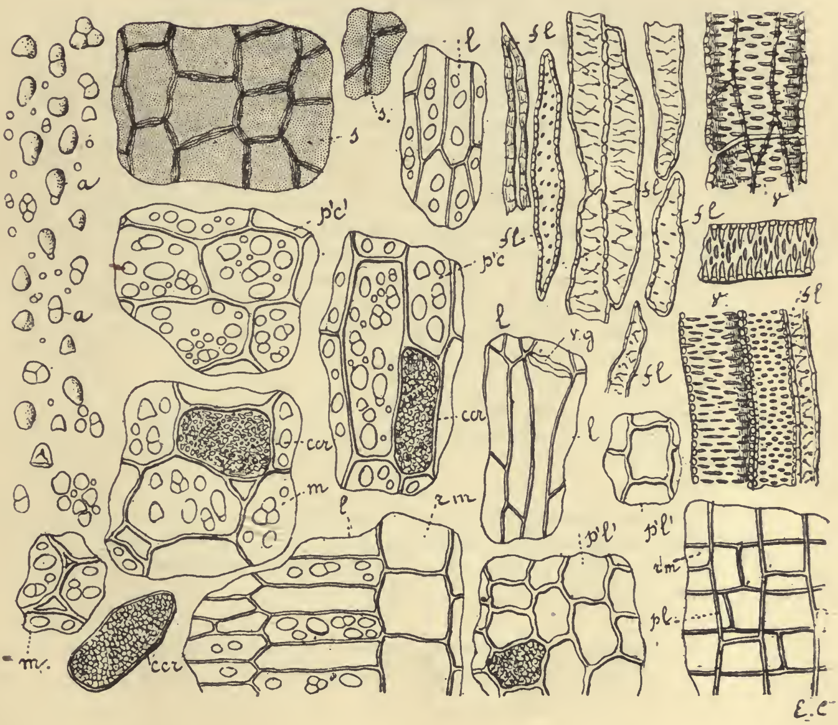

FIG. 104.—**Powdered Belladonna Root** (× 240).

a, Starch grains.
ccr, Cells with sandy crystals.
fl, Wood fibres.
l, Bast.
m, Cells of pith (of rhizome).
pc, p'c', Cortical parenchyma in longitudinal and transverse section.
pl, p'l', Wood parenchyma (from rhizome) after treatment with potash.
rm, Medullary ray.
v, Vessels.
vg, Sieve tube.

(105) **Bryony Root.**

The root of *Bryonia dioica*, Linn. (N.O. Cucurbitaceæ).

The root presents the following structure:

(1) *Cork*, composed of several layers of cells with yellow walls; in surface view these cells are either axially elongated or polygonal and isodiametric.

(2) *Cortex*, which is very narrow, consisting of parenchymatous cells containing starch and sclerenchymatous cells with slightly thickened walls. The starch is chiefly in simple oval or rounded grains with a very distinct hilum, but occasional compound grains, with two or three component granules, may be found. The cortex also contains small straight or branched laticiferous vessels.

(3) *Bast Ring*, in which laticiferous vessels are also found, together with sieve tubes, the latter being distinguished by their larger size.

(4) *Wood*, consisting principally of parenchyma, in which there are numerous radially arranged groups of vessels. These groups consist of large pitted and reticulated vessels surrounded by tracheids.

The diagnostic characters of powdered bryony root are

(*a*) *The starch grains.*

(*b*) *The large vessels.*

(*c*) *The large-celled cork.*

(*d*) *The absence of bast fibres and crystals.*

PLATE XCV.

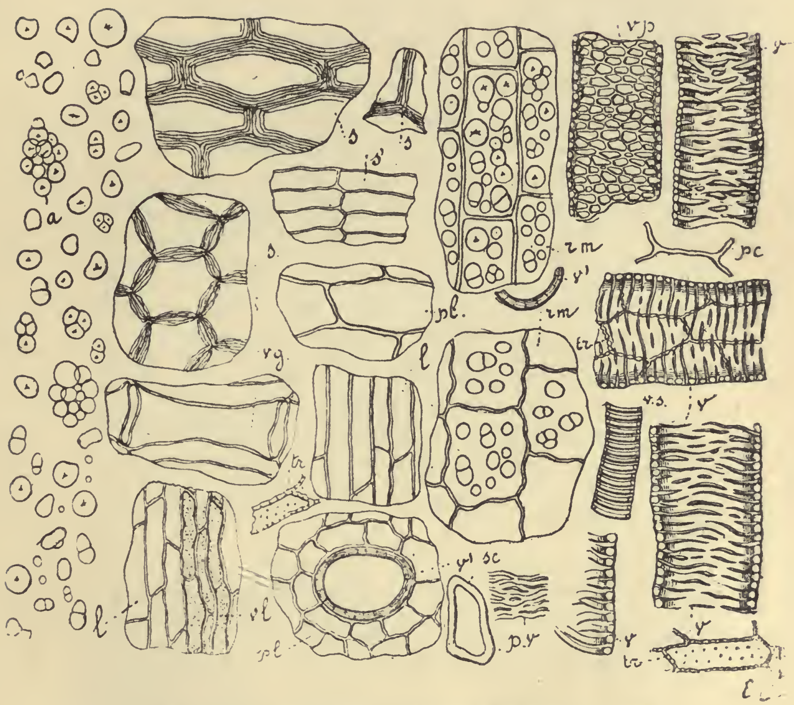

FIG. 105.—**Powdered Bryony Root** (× 240).

a, Starch.
l, Bast.
pc, Cortical parenchyma.
pl, Parenchyma of wood.
p.v., Walls of vessels.
rm, Medullary rays.
s,s′, Cork, surface view and in section.
sc, Sclerenchymatous cells.
tr, Tracheids.
v, vp, vs, Vessels.
vg, Sieve tubes.
vl, Laticiferous vessels.

(106) **Calumba Root.**

The root of *Jateorhiza Columba*, Miers (N.O. Menispermaceæ).

The root presents the following structure :—

(1) *Cork*, consisting of several rows of brown, tabular cells, which in surface view are polygonal and isodiametric.

(2) *Cortex* (secondary), the cells of which are polygonal and tangentially elongated; they contain large starch grains (20 to 70μ) which are mostly simple, irregularly ovoid, rounded or pearshaped and exhibit a very conspicuous cleft or stellate hilum. There are also compound grains with from two to six constituent grains, measuring about 8-20μ in diameter; these constituent grains are rounded on one side and angular on the others. Towards the periphery the cortex contains large, scattered, thicked-walled, sclerenchymatous cells either isolated or in groups; the cavities of these cells are large and contain one or more prismatic crystals of calcium oxalate; the walls are bright yellow in colour and often exhibit a one-sided thickening.

(3) *Bast Ring*, containing very long and narrow bast rays destitute of fibres.

(4) *Wood*, largely composed of parenchyma, traversed by scattered fibrovascular bundles. These bundles are narrow and radially elongated; they are composed of large pitted vessels surrounded by a layer of more or less thickened but only very slightly lignified fibrous cells.

The diagnostic characters of powdered calumba root are :—

(*a*) *The yellow colour of the sclerenchymatous cells and vessels.*

(*b*) *The sclerenchymatous cells with calcium oxalate crystals.*

(*c*) *The characteristic starch grains.*

PLATE XCVI.

FIG. 106.—**Powdered Calumba Root** (× 240).

a, Starch grains.
cr, Calcium oxalate crystals.
, l′, Bast in longitudinal and transverse section.
m, Parenchyma of wood.
pc, p′c′, Cortical parenchyma in transverse and longitudinal section.
rm, Medullary ray.
s, s′, Cork, in surface view and transverse section.
sc, Sclerenchymatous cells.
v, tr, Vessels, tracheids, etc.

(107) **Elecampane Root.**

The root of *Inula Helenium*, Linn. (N.O. Compositæ).

The root presents the following structure :—

(1) *Cork*, consisting of several rows of brown flattened cells, which in surface view are polygonal and axially elongated.

(2) *Cortex*, the cells of which are polygonal and tangentially elongated ; in this tissue oleoresin ducts occur.

(3) *Bast Ring*, traversed by wide medullary rays and containing large oleoresin ducts.

(4) *Wood*, divided by medullary rays of varying width into wedge-shaped bundles, each of which contains radially elongated groups of vessels, embedded in parenchymatous tissue, and numerous oleoresin ducts. Some of the bundles are supported by fibres with thickened lignified walls. The parenchymatous cells of cortex, bast ring, and wood, contain an abundance of inulin in colourless angular masses which dissolve without swelling when heated in water.

The diagnostic characters of powdered elecampane are :—

(*a*) *The abundance of inulin.*

(*b*) *The absence of starch and of calcium oxalate.*

(*c*) *The abundant parenchymatous tissue.*

PLATE XCVII.

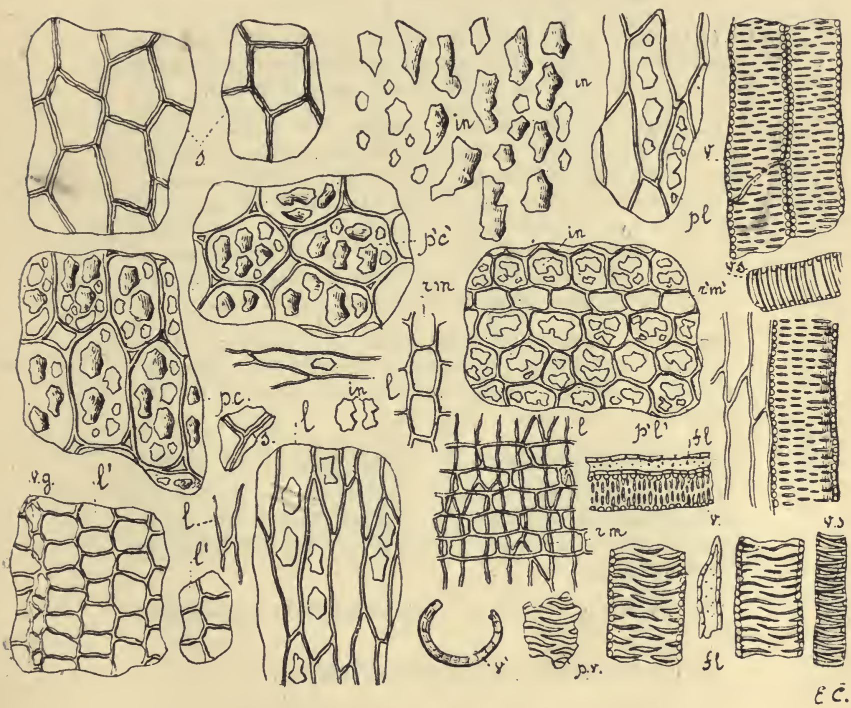

FIG. 107.—**Powdered Elecampane Root** (× 240).

fl, Wood fibres.
in, Inulin.
l, l', Bast in longitudinal and transverse section.
pc, p'c', Cortical parenchyma in longitudinal and transverse section
pl, Parenchyma of the wood.
rm, r'm', Medullary rays in longitudinal and transverse section.
s, s', Cork, in surface view and profile.
v, v', vs, Vessels.
vg, Sieve tubes.

(108) **Sweet Flag Rhizome.**

The rhizome of *Acorus Calamus*, Linn. (N.O. Aroideæ).

The rhizome presents the following structure:—

(1) *Epidermis*, consisting of a single row of cells covered by a rather thick cuticle. In transverse section these cells appear square, but in surface section they are axially elongated.

(2) *Cortex*, of which the layers abutting on the epidermis are collenchymatous and contain chlorophyll. The collenchymatous tissue passes into a dense parenchyma and this again into a spongy parenchyma, the air-spaces in which are large and separated from one another by a single layer of polygonal or rounded slightly pitted cells containing minute grains of starch. In this tissue there are numerous oil-cells commonly situated at the point of intersection of the rows of cells.

The cortex is traversed longitudinally by a number of fibrovascular bundles which are often accompanied by prismatic crystals of calcium oxalate in the cells abutting on the sclerenchymatous fibres.

(3) *Endodermis*, consisting of a single row of quadrilateral cells.

(4) *Stele*, similar in structure to the cortex. The wood of the fibrovascular bundles consists of spiral, reticulated and scalariform vessels; there is a distinct sheath of fibres with thickened pitted walls.

The diagnostic characters of powdered sweet flag rhizome are:—

(*a*) *The abundant thin-walled parenchyma.*

(*b*) *The very numerous minute starch grains.*

(*c*) *The numerous oil cells.*

(*d*) *The paucity of fibres.*

(*e*) *The numerous scalariform vessels.*

PLATE XCVIII

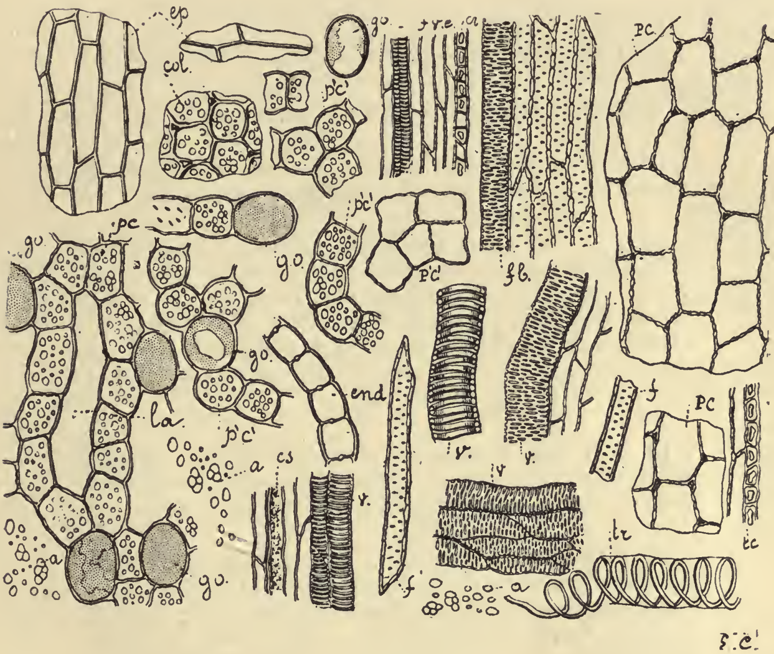

Fig. 108.—**Powdered Sweet Flag Rhizome** (× 240).

a, Starch grains.
col, Collenchymatous cells.
cr, Crystals of calcium oxalate.
end, Endodermis.
ep, Epidermis.
f, Fibres.
fb, Fibrovascular bundle from stele.
fvc, Fibrovascular bundle from cortex.
go, Oil cell.
la, Intercellular lacunæ.
pc, p′c′, Cortical parenchyma in longitudinal and transverse section.
PC, P′C′, The same after treatment with chloral hydrate or potash.
tc, Crystal cells.
tr, v, Vessels, etc.

(109) **Galangal Rhizome.**

The rhizome of *Alpinia officinarum*, Hance (N.O. Scitamineæ).

The rhizome presents the following structure :—

(1) *Epidermis*, the cells of which are tabular in transverse section, but polygonal and straight walled in surface view.

(2) *Cortex*, the cells of which have thickened, pitted, brown walls and are tangentially elongated in the outer part of the cortex but irregularly polygonal near the stele. It is traversed by scattered fibrovascular bundles containing spiral, annular and pitted vessels supported by a sheath of thickened pitted fibres. In each bundle a narrow tube filled with a brown secretion may be observed.

(3) *Stele*, which is separated from the cortex by a distinct endodermis. The stele is composed of rather thick-walled parenchymatous tissue traversed by fibrovascular bundles.

The parenchyma of both cortex and stele contains an abundance of starch grains and scattered rounded or polygonal cells containing brown oleoresin. The starch grains vary from 18 to 30μ in length and from 7 to 15μ in width; they are simple and elongated oval or flask-shaped; both hilum and striations are very distinct.

The diagnostic characters of powdered galangal rhizome are :—

(*a*) *The starch grains.*

(*b*) *The reddish brown oleoresin.*

(*c*) *The sclerenchymatous fibres.*

(*d*) *The absence of calcium oxalate.*

PLATE XCIX.

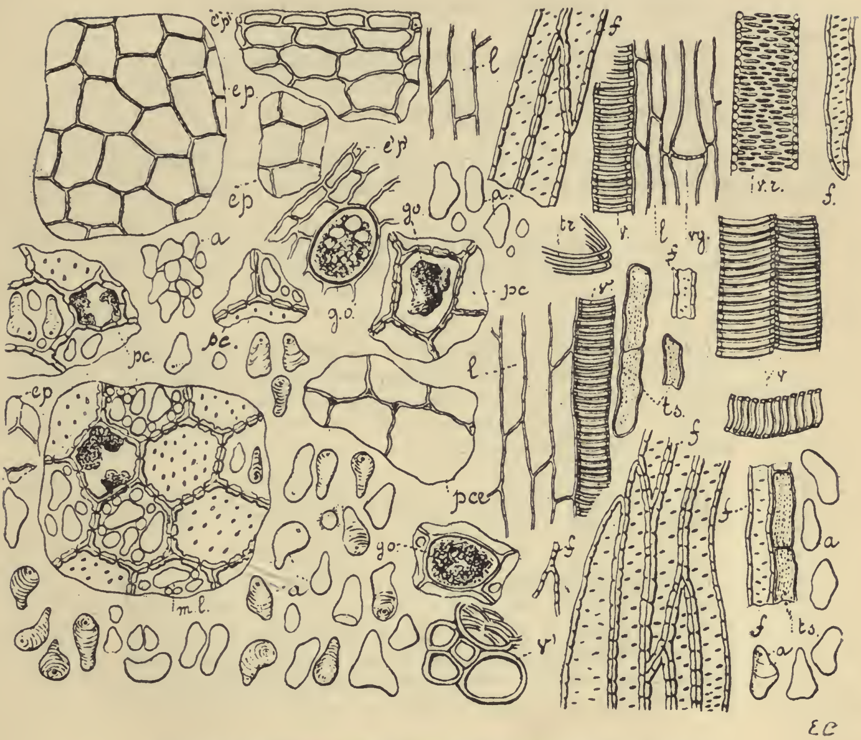

Fig. 109.—**Powdered Galangal Rhizome** (× 240).

a, Starch grains.
ep, e'p', Epidermis in surface view and section.
f, Sclerenchymatous fibres.
go, Oleoresin cells.
l, Bast.
ml, Parenchyma of stele.
pc, Parenchyma of cortex.
pcc, Outer layer of same, surface view
tr, v, v', vr, Vessels, etc.
vg, Sieve tubes.

(110) **Gentian Root.**

The root of *Gentiana lutea*, Linn. (N.O. Gentianaceæ).

The commercial drug consists of rhizome as well as root.

The root presents the following structure:—

(1) *Cork*, consisting of several rows of tabular cells which in surface view are polygonal and have slightly wavy walls.

(2) *Collenchyma*, the cells of which are rounded, have rather thick walls and contain an amorphous substance, very minute crystals, and small oily globules.

(3) *Cortical Parenchyma*, very narrow and composed of tangentially elongated polygonal cells, each of which contains a distinct nucleus and minute crystals, the latter being often collected in one of the angles of the cell. There is no sclerenchyma in the cortex.

(4) *Bast Ring*, the cells of which are small; it contains scattered groups of sieve tissue.

(5) *Wood*, consisting principally of parenchymatous tissue and traversed by medullary rays seven or eight cells wide. The vessels are scattered and isolated or in small groups; the wood parenchyma is not lignified, and closely resembles that of the bast ring, the cells containing minute crystals and oily globules. The root contains at most an occasional small starch grain.

The diagnostic characters of powdered gentian root are:—

(*a*) *The absence of starch.*

(*b*) *The presence of minute crystals and oily globules.*

(*c*) *The brownish colour.*

(*d*) *The large reticulated or scalariform vessels.*

(*e*) *Absence of sclerenchymatous cells or fibres.*

PLATE C.

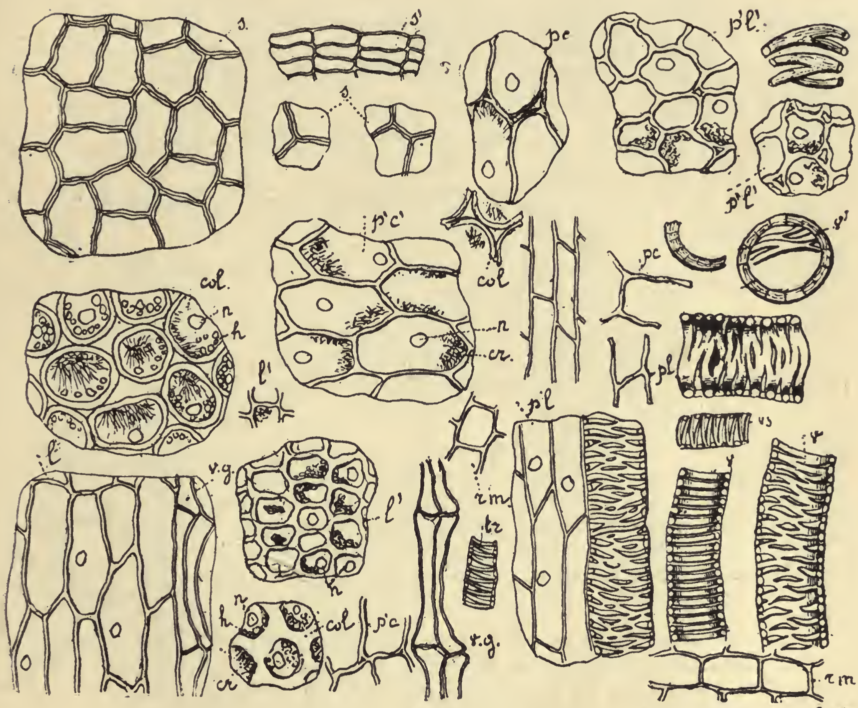

FIG. 110.—**Powdered Gentian Root** (× 240).

col, Rounded collenchymatous cells.
cr, Minute crystals.
h, Oily globules.
l, l′, Bast in longitudinal and transverse section.
n, Nucleus.
pc, p′c′, Cortical parenchyma in longitudinal and transverse section.
pl, p′l′, Parenchyma of wood.
rm, Medullary ray.
s, s′, Cork, in surface view and section.
tr, v, v′, Vessels, etc.
vg, Sieve tubes.

(111) **Ginger Rhizome.**

The rhizome of *Zingiber officinale*, Roscoe (N.O. Scitamineæ).

The rhizome presents the following structure, but the epidermis, hypoderma, cork and part of the cortex are often removed by peeling; this is particularly the case with Jamaica ginger.

(1) *Epidermis*, the cells of which are polygonal and thin-walled.

(2) *Hypoderma*, subjacent to the epidermis and consisting of a few rows of polygonal cells.

(3) *Cork*, of which there are usually several rows; the cells are rather large and thin-walled.

(4) *Cortex*, composed of polygonal, thin-walled, parenchymatous cells, most of which are filled with starch grains, but some contain yellowish-brown oleoresin, and these have suberised walls.

(5) *Stele*, resembling the cortex in structure. Both cortex and stele are traversed by numerous fibrovascular bundles which contain a few reticulated vessels, and are supported by a crescent-shaped mass of sclerenchymatous fibres, some of which are chambered. Narrow, axially elongated cells, containing a dark brown secretion, are occasionally to be seen abutting on the vessels.

The starch grains are very characteristic. They are simple and of considerable size, measuring 12 to 30μ in length; they are somewhat, but not strongly, flattened, and exhibit an ovoid, trapezoidal or sack-shaped outline; the striations are faint but frequently discernible.

Most of the oleoresin cells are broken during pulverisation and their contents escape; a few, however, remain intact.

The diagnostic characters of powdered ginger are:—

(*a*) *The starch grains; their number, size and shape.*

(*b*) *The oleoresin cells.*

(*c*) *The sclerenchymatous fibres.*

(*d*) *The thin-walled parenchymatous cells.*

PLATE CI.

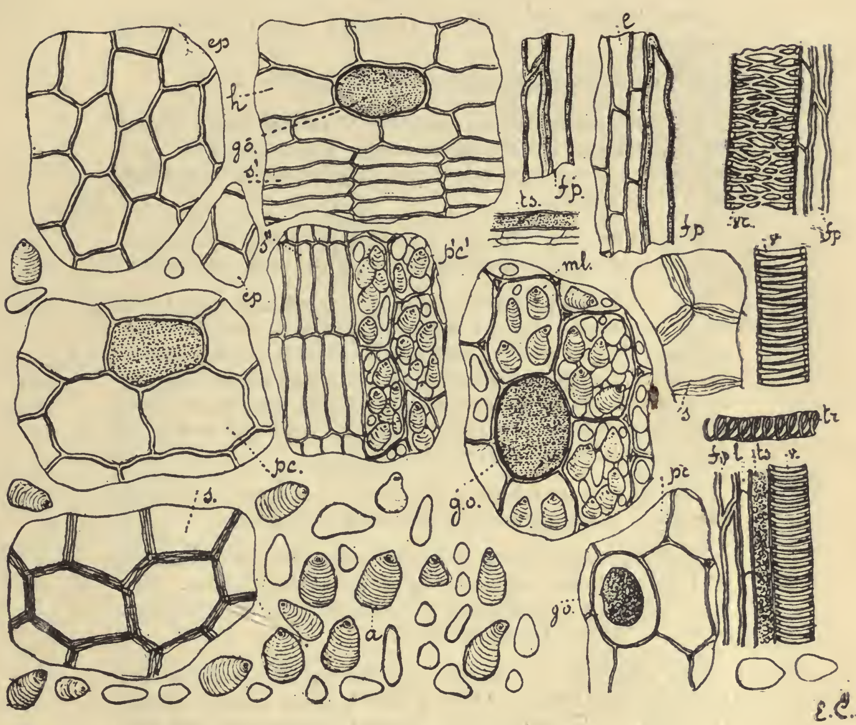

FIG. 111.—**Powdered Ginger Rhizome** (× 240).

a, Starch grains.
ep, Epidermis.
fp, Sclerenchymatous fibres.
go, Oleoresin cells.
h, Hypoderma.
l, Bast.
ml, Parenchyma of stele.
pc, Cortical parenchyma, the walls somewhat swollen by treatment with potash.
p'c', The same in longitudinal section.
s, s', s'', Cork, in surface view, transverse and longitudinal section respectively.
ts, Elongated secretion cells
v, vr, Vessels.

(112) White Hellebore.

The rhizome and roots of *Veratrum album*, Linn. (N.O. Liliaceæ).

The rhizome presents the following structure :—

(1) *Tegumentary Tissue*, consisting of several layers of dark brown, slightly thickened, suberised, parenchymatous cells which in surface view are irregular, polygonal and provided with wavy walls.

(2) *Collenchyma.* Subjacent to the tegumentary tissue is a layer of collenchymatous cells exhibiting the usual characters.

(3) *Cortical Parenchyma*, composed of rounded-polygonal cells with intercellular spaces. Most of these cells contain starch in small, simple and compound grains; the former are rounded, the latter consist of three or four angular component grains. Some of the cells are filled with a large bundle of acicular crystals of calcium oxalate. This tissue is also traversed by a number of fibrovascular bundles (leaf traces).

(4) *Endodermis*, the cells of which are yellowish brown in colour and thickened on their inner and lateral walls.

(5) *Stele*, consisting of parenchymatous tissue resembling that of the cortex and traversed by fibrovascular bundles. The latter contain principally pitted vessels and are supported by a sheath of lignified thickened fibres.

The structure of the root is different. The cells of the epidermis have thickened brown walls and are strongly axially elongated. The cells of the cortical parenchyma are also axially elongated; they contain starch grains and acicular calcium oxalate crystals. The cells of the endodermis are likewise strongly elongated; their walls are thickened, pitted, and of a brownish colour. The stele contains wood bundles alternating with bast bundles and supported by sclerenchymatous fibres which extend to the centre of the root.

The diagnostic characters of white hellebore are :—

(*a*) *The starch grains.*

(*b*) *The cells of the endodermis.*

(*c*) *The abundant raphides.*

(*d*) *The red colour gradually produced by the action of sulphuric acid.*

PLATE CII

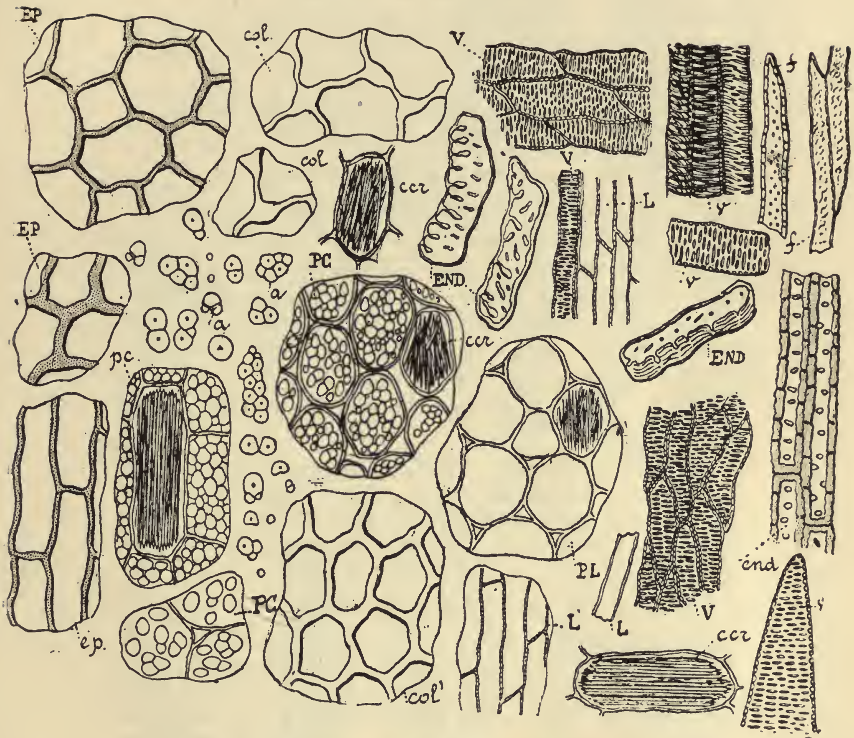

FIG. 112.—**Powdered White Hellebore** (× 240).

a, Starch grains.
ccr, Cells with acicular crystals.
col, Collenchyma of rhizome.
col', Collenchyma of root.
END, Endodermis of rhizome.
end, Endodermis of root.
EP, Tegumentary tissue of rhizome, surface view.
ep, Epidermis of root, surface view.
f, Sclerenchymatous fibres of root.
L, Bast of rhizome.
PC, Cortical parenchyma of rhizome.
pc, Cortical parenchyma of root.
PL, Parenchyma of stele of rhizome (after treatment with potash).
V, Vessels of rhizome.
v, Vessels of root.

(113) **Hydrastis Rhizome.**

The rhizome of *Hydrastis canadensis*, Linn. (N.O. Ranunculaceæ).

The commercial drug usually consists of the rhizome to which a number of wiry roots are attached.

The rhizome presents the following structure :—

(1) *Cork*, composed of several layers of brown, tabular cells which, in surface view, are polygonal and isodiametric.

(2) *Cortex*, the cells of which are rounded, thin-walled, and exhibit intercellular spaces. In longitudinal section these cells are axially elongated. They are filled with small starch grains, either simple or united three or four together into compound grains.

(3) *Bast Ring*, traversed by wide medullary rays and almost always destitute of fibres.

(4) *Wood*, consisting of radially elongated wood bundles separated by very wide medullary rays. Each bundle is composed of pitted vessels and tracheids, often filled with an amorphous substance, narrow wood fibres and non-lignified thin-walled parenchyma.

(5) *Pith*, the cells of which are rounded and full of starch.

The structure of the root is different. The epidermis is composed of axially elongated cells; the cortex is separated from the stele by a conspicuous endodermis, the cells of which have sinuous walls. The wood is represented by a ring of pitted vessels which encloses a pith and is surrounded by groups of bast tissue as well as by the pericycle.

Most of the elements of both rhizome and root are characterised by a more or less pronounced yellowish colour.

The diagnostic characters of powdered hydrastis rhizome are :—

(*a*) *The pervading yellowish colour.*

(*b*) *The minute starch grains.*

(*c*) *The absence of calcium oxalate crystals.*

(*d*) *The nature of the elements of the wood.*

(*e*) *The absence of sclerenchymatous cells.*

PLATE CIII.

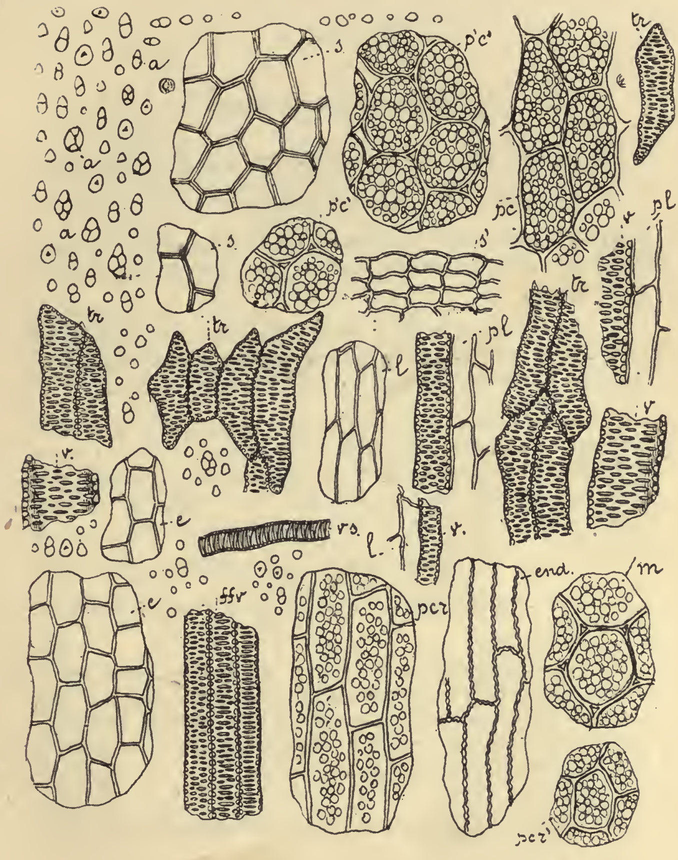

FIG. 113.—**Powdered Hydrastis Rhizome** (×240).

a, Starch grains.
e, Epidermis of the root, surface view.
end, Endodermis of the root.
ffv, Portion of fibrovascular bundle of root.
l, Bast.
pc, p'c', Cortical parenchyma of rhizome in longitudinal and transverse section.
pcr, pcr', The same of the root.
pl, Wood parenchyma of rhizome.
s', s', Cork in surface view and profile.
tr, Tracheids from rhizome.
v, vs, Vessels.

(114) **Ipecacuanha Root.**

The root of *Psychotria Ipecacuanha*, Stokes (N.O. Rubiaceæ).

The root presents the following structure :—

(1) *Cork*, composed of several rows of very narrow tangentially elongated cells which, in surface view are polygonal and isodiametric.

(2) *Cortex*, which is very largely developed and consists of tangentially elongated cells, most of which contain starch, but a few are filled with acicular crystals of calcium oxalate.

The starch grains are either simple or compound; the former are oval or rounded, the latter are composed of from two to five constituent grains, each of which usually exhibits one rounded surface and one or more flat ones. The single grains occasionally reach 12μ in length but never exceed 15μ.

The cells of the cortex diminish in size as they approach the

(3) *Bast Ring*, in which there are groups of sieve tissue but no bast fibres.

(4) *Wood*, composed of tracheids, wood fibres and wood parenchyma. It is remarkable for the absence of vessels. The tracheids have moderately thick walls, very distinct areolated pits, and often near the pointed extremities a large perforation, which is not always easy to see.

The diagnostic characters of powdered ipecacuanha are:—

(*a*) *The starch grains.*

(*b*) *The acicular crystals of calcium oxalate.*

(*c*) *The absence of vessels, presence of perforated tracheids.*

(*d*) *The absence of sclerenchymatous cells or bast fibres.*

PLATE CIV.

FIG. 114.—**Powdered Ipecacuanha Root** (× 240).

a, a′, a″, Starch grains, simple and compound.
ccr, Cells with calcium oxalate.
fl, Fibrous cells.
l, Bast.
pc, p′c′, Cortical parenchyma in longitudinal and transverse section.
ph, p′h′, Phelloderm in surface view and section.
ra, Raphides.
s, s′, Cork, in surface view and profile.
tra, Tracheids.

(115) **Undulated Ipecacuanha.**

The root of *Richardsonia* sp. (N.O. Rubiaceæ).

It is occasionally substituted for the root of *Psychotria Ipecacuanha*, but may be distinguished by the abundance of starch grains, most of which are larger than those of Brazilian Ipecacuanha and differ a little in shape. The wood is characterised by the presence of pitted vessels and wood fibres, both of which are absent from the genuine drug. By these means the presence of undulated ipecacuanha in the genuine drug may be detected without difficulty.

PLATE CV.

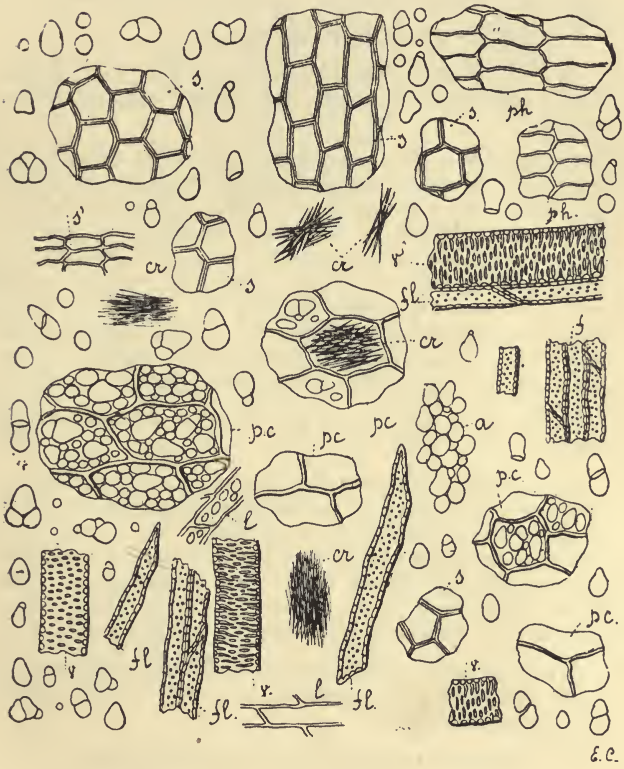

FIG. 115.—**Powdered Undulated Ipecacuanha** (×240)

a, Starch grains.
cr, Acicular crystals.
fl, Pitted wood fibres.
l, Bast.
pc, Cortical parenchyma.
ph, Phelloderm.
s, s′, Cork, in surface view and section.
v, Pitted vessels.

(116) **Jalap Root.**

The root of *Ipomœa Purga*, Hayne (N.O. Convolvulaceæ).

The root presents the following structure :—

(1) *Cork*, composed of a rather thick layer of flattened, brown, tabular cells which, in surface view, are polygonal and isodiametric.

(2) *Cortex*, of moderate extent, the cells of which are polygonal and contain starch and calcium oxalate. The starch occurs in both simple and compound grains ; the former are rounded and have a stellate hilum, the latter vary very much in size and shape, according to the number of the component grains. This tissue also contains numerous resin cells. These appear rounded or oval in transverse section ; in longitudinal section they are seen to be axially elongated and superposed in vertical rows ; they contain a brownish resin. The cortex also contains sclerenchymatous cells with thick, pitted walls.

(3) *Bast Ring*, narrow and rich in resin cells and stellate crystals.

(4) *Wood*, which is contained within the cambium, and is of very abnormal development. It contains a large number of bundles developed from abnormal merismatic tissue. The vascular portion consists of pitted vessels and tracheids. The parenchyma contains starch, resin cells and calcium oxalate crystals. The starch grains, both of this tissue and the cortex, are often gelatinised by the heat to which the drug has been subjected.

In the powdered drug there are but few intact resin cells, but numerous globules of secretion that have been liberated during the pulverisation.

The diagnostic characters of powdered jalap root are :—

(*a*) *The starch grains, many of which are gelatinised.*

(*b*) *The secretion cells and the droplets of resinous emulsion that have escaped from them.*

(*c*) *The sclerenchymatous cells.*

(*d*) *The rosette crystals of calcium oxalate.*

PLATE CVI.

FIG. 116.—**Powdered Jalap Root** (× 240).

a, a′, Starch in simple and compound grains.
ca, Cambium cells.
ccr, Crystal cells.
cr, Crystals of calcium oxalate.
f, Fibrous tracheids.
gr, Droplets of resinous emulsion.
l, Bast.
pc, Cortical parenchyma.
pl, Parenchyma of inner portion.
s, s′, Cork in surface view and profile.
sc, Sclerenchymatous cells.
v, vp, Vessels and *débris* of vessels.

(117) **Liquorice Root.**

The root and subterranean stem of *Glycyrrhiza glabra*, Linn. (N.O. Leguminosæ).

The root presents the following structure:—

(1) *Cork*, the cells of which are brown in colour and flattened; in surface view they are polygonal and isodiametric, their walls are slightly thickened and wavy in outline.

(2) *Cortex*, composed of tangentially elongated polygonal cells with intercellular spaces. The cells are filled with small simple starch grains. This tissue does not contain any sclerenchymatous cells, but near the periphery there are numerous cells containing prismatic or rhombohedral crystals of calcium oxalate.

(3) *Bast Ring*, characterised by the presence of numerous bundles of bast fibres arranged in concentric circles. Each bundle consists of a number of fibres with very strongly thickened walls, and is surrounded by small cells containing crystals of calcium oxalate. The bast consists of bast parenchyma traversed by numerous groups of sieve tissue, many of which are nearly obliterated.

(4) *Wood*, divided into wood bundles by medullary rays three or four cells wide. The wood bundles consist of vessels of varying size, but often wide (100μ), wood parenchyma and wood fibres, the latter closely resembling the bast fibres and like these accompanied by calcium oxalate crystals.

The diagnostic characters of powdered liquorice root are:—

(*a*) *The abundant, very thick-walled, grouped, yellowish bast fibres.*

(*b*) *The abundant calcium oxalate crystals.*

(*c*) *The small starch grains.*

(*d*) *The characteristic vessels, especially the larger.*

PLATE CVII.

FIG. 117.—**Powdered Liquorice Root** (× 240).

a, Starch grains.
ccr, Crystal cells, from cortex.
fl, Sclerenchymatous fibres, from wood and bast.
l, **l'**, Bast, in longitudinal and transverse section.
pc, Cortical parenchyma, in transverse section.
p'c', The same after treatment with potash.
p"c", The same in longitudinal section.
pd, Phelloderm.
pl, Pitted cells of wood parenchyma.
rm, **r'm'**, Medullary rays in longitudinal and transverse section.
s, **s'**, Cork in surface view and section.
tcr, Crystal cells in rows.
tg, **t'g'**, Sieve tissue in longitudinal and transverse section
v, **v'**, Vessels in longitudinal and transverse section.

(118) **Male Fern Rhizome.**

The rhizome of *Aspidium Filix-mas*, Swartz (N.O. Filicineæ together with the adherent bases of petioles.

Both rhizome and petiole-base present the following structure:—

(1) *Epidermis*, the cells of which are thin-walled and dar brown in colour; in surface view they are polygonal and elongated.

(2) *Hypoderma*, composed of five or six rows of cells, which are rounded in transverse section and very dark brown in colour. In surface view they are seen to be strongly axially elongated and provided with thick pitted walls.

(3) *Cortex* (ground tissue) consisting of large, polygonal, parenchymatous cells with distinct intercellular spaces. These cells contain a considerable quantity of starch in small simple grains, which are often compacted into little masses in the centre of the cell, or more commonly near one of its walls. Distributed throughout this tissue are large, axially elongated, intercellular spaces, in which one or more small oval or rounded oleoresinous secretion cells may be found, attached to cells of the parenchyma by a narrow neck.

(4) *Steles.*—The ground tissue is traversed by a number of steles of varying diameter. These contain a wood consisting of scalariform, pitted and spiral vessels, a bast in which there are numerous sieve tubes, a non-lignified pericycle, and an endodermis, the cells of which are also not lignified. The cells of the ground tissue bordering on the steles usually have pitted walls.

The brown scales attached to the rhizome consist of long fusiform cells with pale brown walls, which are free from pits and only slightly thickened.

The diagnostic characters of powdered male fern rhizome are:—

(*a*) *The large parenchymatous cells with small starch grains.*

(*b*) *The oleoresin cells.*

(*c*) *The fibrous hypoderma.*

(*d*) *The abundant scalariform vessels.*

(*e*) *The fragments of the scaly hairs.*

(*f*) *The absence of crystals.*

PLATE CVIII.

FIG. 118.—**Powdered Male Fern Rhizome** (× 240).

a, a′, Starch.
e, Epidermis.
ec, Fragments of scales.
end, Endodermis.
go, Oleoresin cells.
h, Hypoderma.
l, Bast.
la, Lacunæ in ground tissue.
pa, p′a′, Ground tissue in longitudinal and transverse section.
per, Pericycle,
tr, vs, Vessels, etc.

(119) **Marshmallow Root.**

The root of *Althæa officinalis* (N.O. Malvaceæ).

The root presents the following structure :—

(1) *Cork*, composed of several rows of flattened cells which, in surface view, are polygonal and isodiametric.

This part of the root is often removed by scraping; the finer qualities of powdered marshmallow root do not therefore contain any cork, but in the lower qualities, such as are used for veterinary medicines, it is almost always to be found.

(2) *Cortex*, the cells of which are polygonal and contain starch, together with an occasional rosette of calcium oxalate. The starch grains are mostly simple and oval or elongated in shape, measuring from 4 to 15μ in length; here and there compound grains with three or four component grains may be detected. Distributed throughout the cortex, and, indeed, through all the parenchymatous tissue of the root, are numerous cells filled with mucilage; these cells are rather larger than the surrounding parenchymatous cells, and the mucilaginous contents may be detected by examination in alcohol or by staining with solution of ruthenium red in lead acetate.

(3) *Bast Ring*, which is particularly characterised by the presence of numerous tangentially elongated groups of bast fibres. These fibres are very long, and their walls, which are not very thick, are only slightly lignified.

(4) *Wood*, in which the parenchymatous tissue is largely developed. The vessels are not numerous, they are either single or in small radially elongated groups, accompanied by a few thin-walled tracheids and surrounded by wood fibres. The parenchymatous cells contain either starch grains, or rosettes of calcium oxalate, and, as already observed, numerous mucilage cells are scattered throughout this tissue, as also throughout the cortex and bast-ring.

The diagnostic characters of powdered marshmallow root are :—

(*a*) *The numerous mucilage cells.*

(*b*) *The small starch grains.*

(*c*) *The long bast fibres with moderately thick walls.*

PLATE CIX.

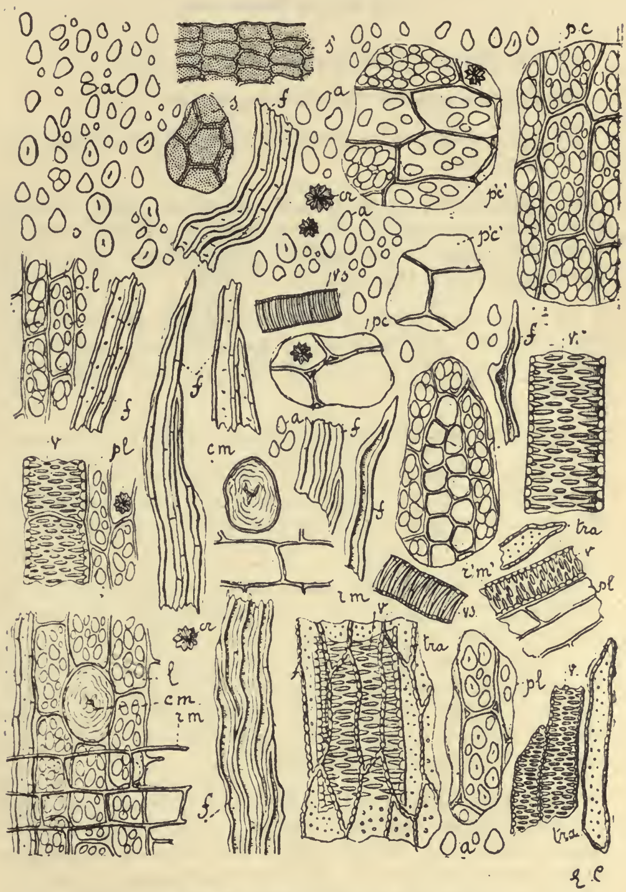

FIG. 119.—**Powdered Marshmallow Root** (× 240).

a, Starch grains.
cm, Mucilage cells.
cr, Crystals of calcium oxalate.
f, Sclerenchymatous fibres from bast ring and wood.
l, Bast.
pc, p'c', Cortical parenchyma in longitudinal and transverse section.
pl, Parenchyma of the wood in longitudinal section.
rm, r'm', Medullary rays in longitudinal and tangential section.
s, s', Cork in surface view and profile.
tra, Pitted tracheids.
v, vs, Vessels.

(120) **Orris Rhizome.**

The rhizome of *Iris florentina*, etc. (N.O. Irideæ).

The rhizome presents the following structure :—

(1) *Cork*, consisting of numerous layers of thin-walled cork cells, followed by

(2) *Collenchyma*, of which there are several rows. Both of these tissues are, however, removed from the rhizome by peeling before it is sent into commerce. The outermost layer of the commercial drug is therefore

(3) *Cortex*, part of which is also usually removed by the peeling; the cells are irregularly polygonal in shape and exhibit intercellular spaces; the walls are thickened and conspicuously pitted.

(4) *Endodermis*, the cells of which are tangentially elongated.

(5) *Stele*, composed largely of parenchymatous tissue, resembling that of the cortex, traversed by numerous concentric fibro-vascular bundles, which are closely approximated near the endodermis.

The parenchymatous cells, both of the cortex and the stele, are filled with starch grains of very characteristic appearance. They are mostly simple and vary from 25 to 50μ in length, and from 10 to 25μ in width. Many are elongated, oval or elliptical in outline, or rounded at one extremity and flat at the other; sometimes slightly curved or with irregular protuberances. The hilum is distinct, eccentric and stellate or branching. Here and there compound grains are met with.

Conspicuous also in both cortex and stele are very large prismatic crystals of calcium oxalate. These crystals attain a length of 250μ and a width of 30μ. They occur in intercellular spaces and are enclosed in suberised membranes. Sometimes more than one crystal may be found in the same intercellular space.

The diagnostic characters of orris rhizome are :—

(*a*) *The starch grains.*

(*b*) *The large prismatic crystals.*

(*c*) *The thick-walled parenchymatous cells.*

(*d*) *The absence of sclerenchymatous cells or fibres.*

PLATE CX.

FIG. 120.—**Powdered Orris Rhizome** (× 240).

a, Starch grains.
cr, c'r', Whole and broken crystals of calcium oxalate.
end, Endodermis.
ffv, *Débris* of fibrovascular bundle.
pc, Cortical parenchyma.
pl, Parenchyma of stele.
ppc, ppl, *Débris* of same.
tr, v, Vessels, etc.

(121) Pellitory Root

The root of *Anacyclus Pyrethrum*, D.C. (N.O. Compositæ).

The root presents the following structure :—

(1) *Cork*, composed of several rows of brown tabular cells, which, in surface view, are polygonal and do not exhibit any definite arrangement.

(2) *Cortex*, the cells of which are tangentially elongated near the periphery of the root, but become isodiametric towards the wood. In the outer portion of this tissue, which is often of small extent or even absent, there occur sclerenchymatous cells, the walls of which are thickened in varying degrees, and also small oleoresin ducts.

(3) *Bast Ring*, which is divided into bast rays by very wide medullary rays, in which there are distributed numerous large oleo-resin ducts; the bast rays are destitute of bast fibres.

(4) *Wood*, which is traversed by rather wide medullary rays in which there are numerous oleoresin ducts. The elongated wedge-shaped vascular bundles contain pitted and reticulate vessels, which are often grouped together. In the centre is the primary wood surrounded by thick-walled fibres. The root contains an abundance of inulin in the shape of irregularly angular transparent masses in the parenchymatous cells of cortex, bast ring, and wood. It does not contain any calcium oxalate.

The diagnostic characters of powdered pellitory root are :—

(*a*) *The abundance of inulin.*

(*b*) *The absence of fibres and of calcium oxalate.*

(*c*) *The presence of sclerenchymatous cells.*

PLATE CXI.

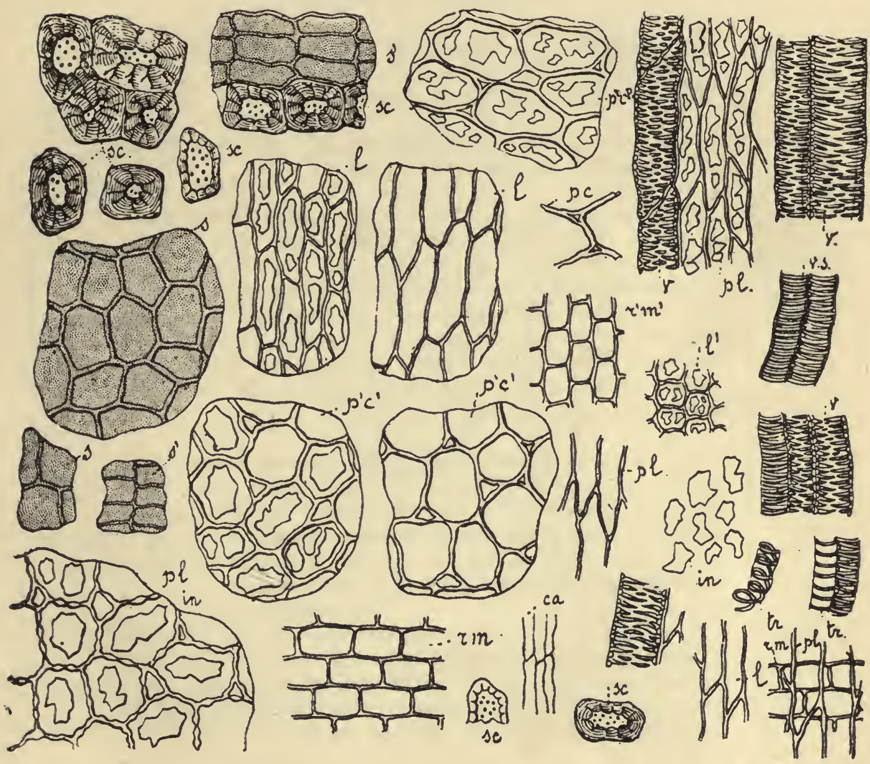

FIG. 121.—**Powdered Pellitory Root** (× 240).

ca, Cambium.
in, Inulin.
l, l', Bast n longitudinal and transverse section, with and without inulin.
pc, p'c Cells of outer and inner parts of the cortex, with and without inulin.
pl, p'l', Parenchyma of the wood in longitudinal and transverse section.
rm, r'm', Medullary rays in longitudinal and transverse section.
s, s', Cork in surface view and section.
sc, Sclerenchymatous cells.
tr, v, vs, Vessels, etc.

(122) **Rhatany Root.**

The root of *Krameria triandra*, R. et P. (N.O. Polygaleæ).

The root presents the following structure :—

(1) *Cork*, consisting of a number of cells with dark brown walls; in surface view they are polygonal.

(2) *Cortex*, the cells of which are polygonal and tangentially elongated; they have reddish-brown walls and contain colouring matter and starch. The starch grains are either simple or compound; the former are sometimes rounded, sometimes conical or pear-shaped; the compound grains contain from two to four constituents—the shape varying with the number and often stellate when there are three or four component grains. The cortex is narrow and free from sclerenchymatous elements.

(3) *Bast Ring*, characterised by the presence of numerous radially elongated bundles of sclerenchymatous fibres, with moderately thick walls; in transverse section these fibres appear flattened. Some of the cells of the bast parenchyma contain several small prismatic crystals of calcium oxalate; the others contain starch grains resembling those of the cortex.

(4) *Wood*, traversed by medullary rays one cell wide. The wood bundles consist chiefly of wood fibres with which are associated scattered pitted vessels and wood parenchyma. The cells of the latter, like those of the medullary rays, are distinguished by containing starch grains and colouring matter.

The diagnostic characters of powdered rhatany root are :—

(*a*) *The reddish-brown colour.*

(*b*) *The characteristic starch grains.*

(*c*) *The bast fibres.*

(*d*) *The crystals of calcium oxalate.*

PLATE CXII.

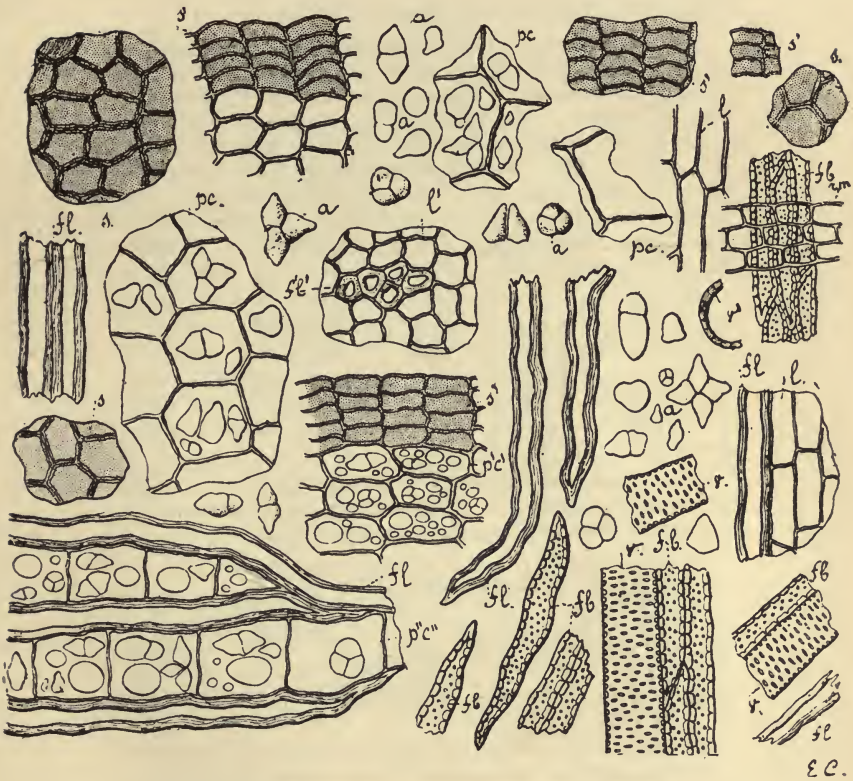

FIG. 122.—**Powdered Rhatany Root** × (240).

a, Starch.
fb, Wood fibres.
fl, **fl′**, Bast fibres in longitudinal and transverse section.
l, **l′**, Bast in longitudinal and transverse section.
pc, **p′c′**, Bast parenchyma.
p″c″, The same accompanied by bast fibres.
rm, Medullary ray in radial section.
s, **s′**, Cork in surface view and section.
v, **v′**, Vessels in longitudinal and transverse section.

(123) **Rhubarb Rhizome (Chinese).**

The rhizome of one or more species of *Rheum* (N.O. Polygoneæ) deprived of its cork and of the greater part of its cortex.

The rhizome presents the following structure:—

(1) *Cortex*, of which at most only a very narrow layer is left, the majority or sometimes the whole of it having been removed by peeling. It consists of polygonal cells containing starch and calcium oxalate. The starch is in simple and compound grains; the former are rounded, have a very distinct hilum and measure from 10 to 18μ in diameter; the compound grains contain from two to five component granules. The calcium oxalate usually assumes the form of large rosettes, sometimes attaining as much as 60μ in diameter. The cortex also contains large mucilage cells.

(2) *Bast Ring.*—Towards the cambium the cortex passes imperceptibly into the bast ring, which is traversed by medullary rays from three to five cells wide. These cells are filled with reddish-brown substances, and hence the rays are visible under the lens as reddish-brown lines. The bast parenchyma contains starch; the sieve tubes are mostly obliterated and there are no bast fibres.

(3) *Cambium*, which is visible to the naked eye as a dark line very near the periphery of the rhizome, is formed of five or six rows of cells which are free from starch and calcium oxalate.

(4) *Wood*, forming a very narrow ring within the cambium; it is traversed by dark yellow medullary rays, between which numerous vessels of varying size are scattered, either isolated or in groups. Abutting on the inner margin of the wood is a circle of abnormal bundles which constitute the remarkable stellate spots visible on a transverse section; these bundles have their bast in the centre and wood at the periphery.

(5) *Pith*, which is largely developed and is irregularly traversed by stellate bundles which pursue various courses; the medullary rays of these bundles are filled with reddish-brown colouring matter which gives rise to the characteristic marbled appearance of the rhizome; the white portions between these rays are parenchymatous tissue filled with starch and calcium oxalate.

The diagnostic characters of powdered rhubarb are:—

(*a*) *The very large rosettes of calcium oxalate.*

(*b*) *The starch grains.*

(*c*) *The vessels.*

(*d*) *The medullary ray cells with reddish-brown contents.*

PLATE CXIII.

FIG. 123.—**Powdered Rhubarb Rhizome** (× 240).

a, Starch grains.
ca, Cambium cells.
cr, Crystals of calcium oxalate.
l, Bast.
m, Pith.
pc, Cortical parenchyma.
pl, Parenchyma of wood.
rm, r'm', Medullary rays in transverse and tangential section.
v, Vessels.
vg, Obliterated sieve tubes.

124) **Salep.**

Salep consists of the enlarged roots of *Orchis mascula*, L.; *O. militaris*, L.; *O. morio*, L.; and other species (N.O. Orchideæ).

The root exhibits the following structure:—

(1) *Epiblema*, to which root-hairs are sometimes attached.

(2) *Cortex*, which is very narrow.

(3) *Endodermis*, of axially elongated cells with thin, wavy walls.

(4) *Stele*, traversed by a number of bundles. The parenchyma of the stele consists of polygonal cells, most of which contain starch that has been gelatinised by the boiling to which the root is subjected; some of the cells are much larger than the others, and contain mucilage in which acicular crystals of calcium oxalate are often embedded.

The diagnostic characters of powdered salep are:—

(*a*) *The abundance of mucilage.*

(*b*) *The gelatinised starch.*

(*c*) *The acicular crystals of calcium oxalate.*

PLATE CXIV.

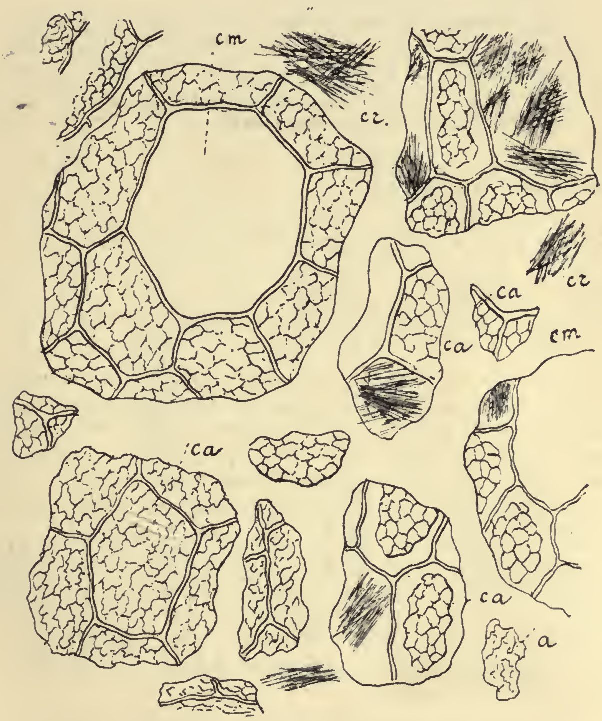

Fig. 124.—**Powdered Salep** (× 240).

a, Gelatinised starch.
ca, Cells filled with the same.
cm, Mucilage cells.
cr, Acicular crystals of calcium oxalate.

(125) Vera Cruz Sarsaparilla.

The root of *Smilax* sp. (N.O. Liliaceæ).

The root presents the following structure :—

(1) *Exodermis,* composed of several rows of cells, which exhibit in transverse section very strong thickening on the lateral and outer tangential wall, the cavity being small and situated near the inner tangential wall. In longitudinal sections these cells are strongly elongated axially and pitted.

Exterior to the exodermis the broken remains of root hairs may sometimes be found.

(2) *Cortex,* the cells of which are also axially elongated, and contain either starch or bundles of acicular crystals of calcium oxalate. The starch is in either simple or compound grains; the former are ovoid or rounded; the latter contain three, four, or five component grains which, when isolated, exhibit one rounded and one or more flat surfaces.

(3) *Endodermis,* which is rather conspicuous; the cells are radially elongated, and their lateral and inner tangential walls rather strongly thickened, so that they exhibit a horse-shoe thickening in transverse section. In longitudinal section they are seen to be strongly axially elongated, and one of the longitudinal walls is somewhat conspicuously thickened.

(4) *Stele,* composed of numerous, closely approximated fibro-vascular bundles, which are surrounded by a lignified pericycle; the pith in the centre is also lignified. The vessels are mostly pitted, and are surrounded by fibres with thickened walls. The pericyclic cells exhibit a similar structure. The cells of the pith are rounded in section, and their walls are slightly thickened; they contain starch.

Jamaica Sarsaparilla closely resembles Vera Cruz in structure, but may be distinguished by the cells of the exodermis and endodermis, which are nearly square in tranverse section and less strongly but almost uniformly thickened.

The diagnostic characters of powdered Vera Cruz Sarsaparilla are :—

(*a*) *The very remarkable cells of the exodermis and endodermis.*

(*b*) *The bundles of acicular crystals of calcium oxalate.*

(*c*) *The starch grains.*

PLATE CXV.

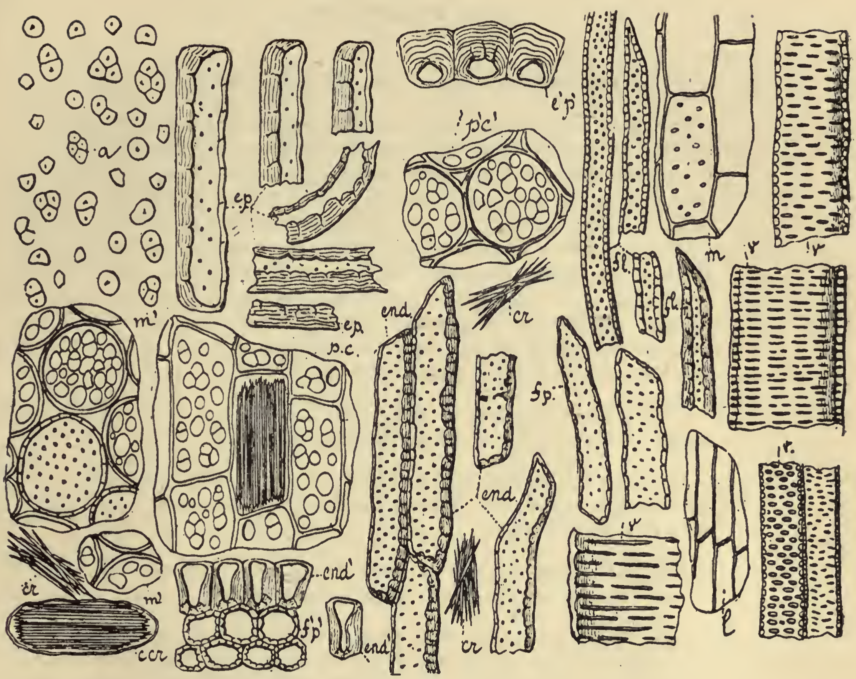

FIG. 125.—**Powdered Vera Cruz Sarsaparilla** (× 240).

a, Starch grains.
ccr, Crystal cells.
cr, Calcium oxalate crystals.
end, end', Endodermis in radial and transverse section.
ep, e'p', Exodermis in radial and transverse section.
fl, Sclerenchymatous fibres of stele.
fp, Pericyclic fibres.
l, Bast.
m, m', Cells of the pith in longitudinal and transverse section.
pc, p'c', Cortical parenchyma in longitudinal and transverse section.
v, Ve~~~ls.

(126) **Senega Root.**

The root of *Polygala Senega*, Linn. (N.O. Polygaleæ).

The root is sometimes normal in structure, but more frequently it exhibits abnormalities due partly to the irregular activity of the cambium and partly to the development of parenchymatous tissue in place of normal wood. The transverse section of a normally developed root exhibits a circular wood, composed of vessels and tracheids, surrounded by a rather thick ring of bast and cortex. In abnormally developed roots, semi-circular or wedge-shaped portions of the wood consist of parenchymatous tissue, and the bast ring and cortex are so strongly developed on one side, usually that opposite to the parenchymatous wood, as to form a projecting ridge.

The *cork* is composed of cells, which, in surface view are either elongated (root) or polygonal (crown of the root).

The *cortex* is narrow in the ridge, but a little wider on the opposite side of the root; it is composed of parenchymatous cells with rather thick walls.

The *bast ring* is wide and usually very strongly developed on he side opposite to the abnormal part of the wood.

The *wood* is composed normally of pitted vessels and tracheids, but does not exhibit medullary rays. The abnormal wood consists of parenchymatous cells. The parenchymatous tissue of both wood and bast contains minute droplets of oil, but neither starch nor calcium oxalate.

The diagnostic characters of powdered senega roo are :—

(*a*) *The absence of starch and calcium oxalate.*

(*b*) *The presence in the parenchymatous cells of minute droplets of oil.*

(*c*) *The abundant tracheids and parenchymatous*

(*d*) *The absence of sclerenchymatous cells and bast fibres.*

PLATE CXVI.

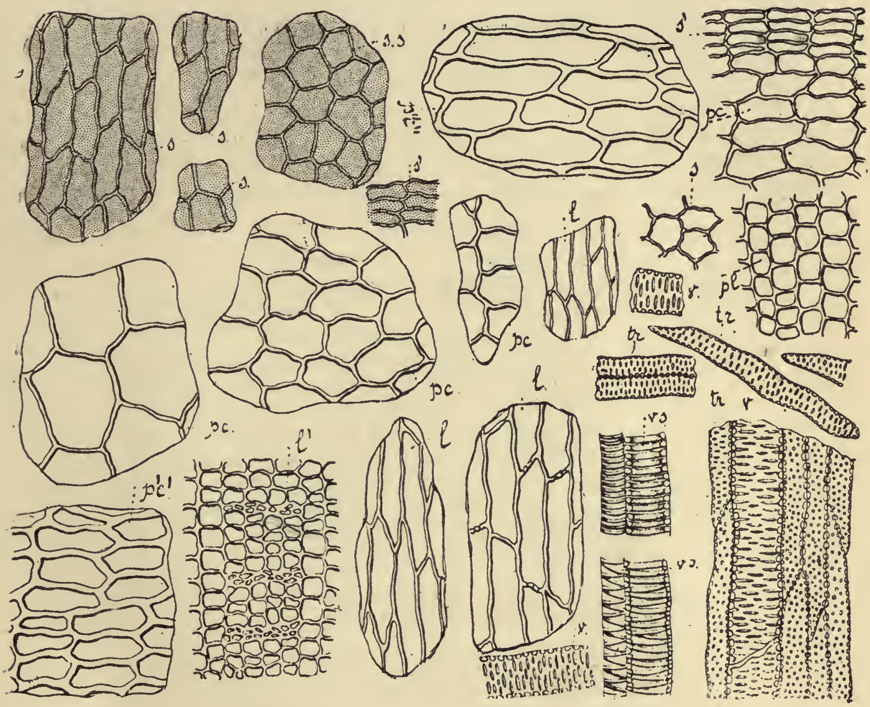

FIG. 126.—**Powdered Senega Root** (× 240).

l, l′, Bast tissue in longitudinal and transverse section.
pc, p′c′, Cortical parenchyma in transverse and longitudinal section.
pl, Parenchyma of wood.
s, s′, Cork of root, in surface view and section.
ss, Cork of crown of root.
tr, Pitted tracheids.
v, vs, Vessels.

(127) **Turmeric Rhizome.**

The rhizome of *Curcuma longa*, Linn. (N.O. Scitamineæ).

The rhizome presents the following structure:—

(1) *Epidermis*, of flattened cells, which are polygonal in surface view, and exhibit not very conspicuous pits on their side walls. It bears stomata and rounded scars of fallen hairs.

(2) *Hypoderma*, consisting of several layers of tangentially elongated polygonal cells, amongst which scattered oleoresin cells may be seen. Occasionally this tissue is absent.

(3) *Cork*, consisting of three or four rows of cork cells.

(4) *Phelloderm*, of the usual character.

(5) *Cortex*, of considerable extent, composed of polygonal parenchymatous cells, filled with starch and permeated with yellow colouring matter. The latter is changed to a deep crimson red with concentrated sulphuric acid; if alcohol is present the crimson substance dissolves in it. Much of the starch has been transformed by heat into gelatinised masses, but some intact grains may usually be found; they resemble ginger starch in outline, but are more strongly flattened (compare Fig. 9, p. 15) The cortex also contains numerous oleoresin cells, the secretion in which may be granular, or form droplets or irregular masses. It is traversed by vascular bundles (leaf traces), consisting of vessels and bast, but destitute of any sheath of fibres.

Starch grains that have escaped gelatinisation may also be found; they resemble those of Fig. 9 (p. 15).

(6) *Endodermis*, of rectangular suberised cells.

(7) *Stele*, composed of parenchymatous tissue, similar to that of the cortex and traversed by similar vascular bundles.

The diagnostic characters of powdered turmeric rhizome are:—

(*a*) *The yellow masses of gelatinised starch.*

(*b*) *The presence of an epidermis*

(*c*) *The characteristic vessels.*

(*d*) *The presence of oleoresin cells.*

(*e*) *The sulphuric acid reaction.*

PLATE CXVII.

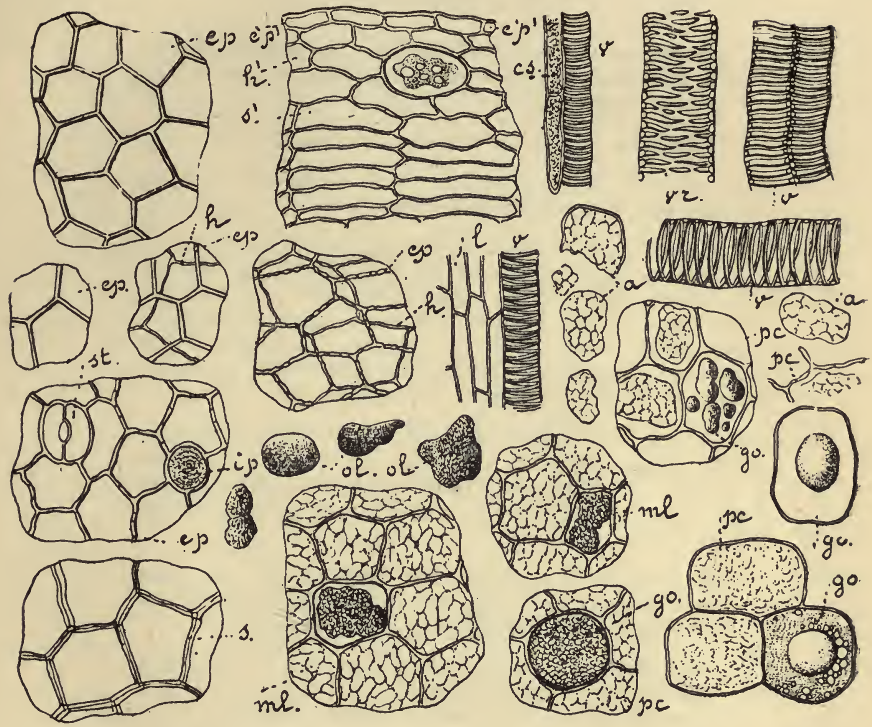

FIG. 127.—**Powdered Turmeric Rhizome** (× 240).

a, Gelatinised starch,
cs, Secretion cells accompanying the bundles.
ep, e'p', Epidermis in surface view and section
go, Oleoresin cells.
h, h', Hypoderma in surface view and section.
ip, Scar of hair.
l, Bast.
ml, Parenchyma of stele.
ol, Masses of oleoresin.
pc, Cortical parenchyma.
ph, Phelloderm.
s, Cork.
st, Stoma.
v, vr, Vessels.

(128) **Turpeth Root.**

The rhizome and root of *Convolvulus Turpethum*, R. Brown (N.O. Convolvulaceæ). The commercial drug consists of both rhizome and root.

The rhizome presents the following structure :—

(1) *Cork*, composed of several rows of tabular cells which, in surface view, are polygonal and isodiametric.

(2) *Cortex*, the cells of which are polygonal and contain starch and calcium oxalate. The starch grains are either simple or compound; the former are rounded; the latter often contain a considerable number of component grains, which vary in shape, according to the position they occupy in the grain. The calcium oxalate occurs in rosette crystals of variable size, sometimes singly, sometimes several together in a cell.

(3) *Bast Ring*, which is largely developed and contains numerous rounded resin cells, as well as an abundance of calcium oxalate. The outer part of this tissue is characterised by the presence of sclerenchymatous pericyclic cells with moderately thick walls.

(4) *Wood*, which is divided into two bundles by two wide medullary rays. It is composed of thick-walled pitted fibres pitted and reticulate vessels and wood parenchyma.

Old rhizomes are characterised by the presence of abnormal bundles in the cortex; in these the wood is surrounded by a wide bast ring in which there are numerous resin cells.

The root differs from the rhizome in the fact that the bast ring is free from sclerenchymatous cells, and that the wood is divided into five bundles by as many rather wide medullary rays.

The diagnostic characters of powdered turpeth root are :—

(*a*) *The resin cells.*

(*b*) *The starch.*

(*c*) *The rosette crystals of calcium oxalate and their distribution.*

(*d*) *The pitted wood fibres.*

PLATE CXVIII.

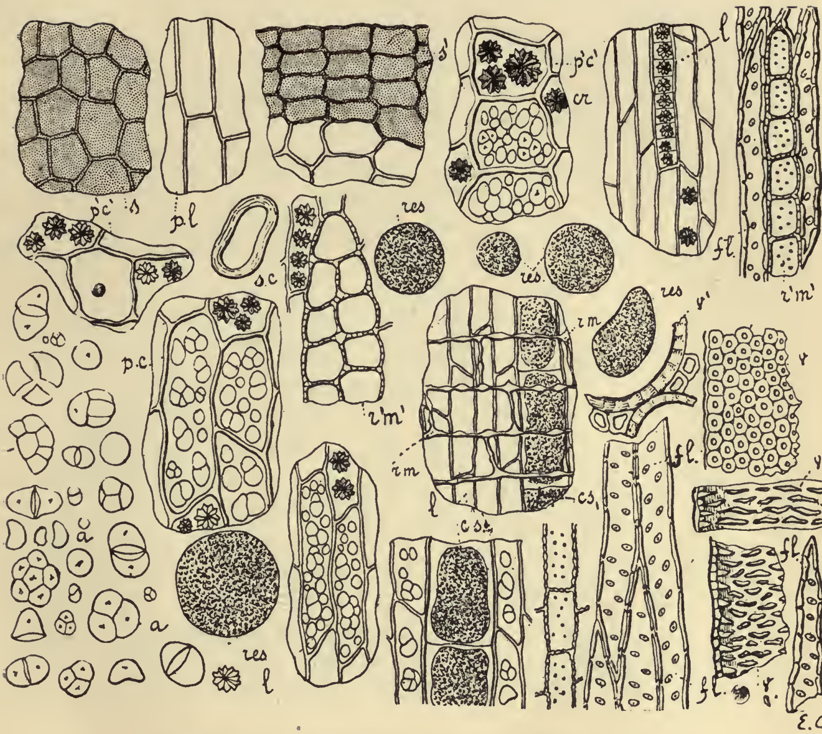

FIG. 128.—**Powdered Turpeth Root** (× 240).

a, Starch.
cr, Rosette crystals.
cs, Resin cells.
fl, Wood fibres.
pc, p′c′, Cortical parenchyma in longitudinal and transverse section.
pl, Parenchyma of wood.
res, Masses of resin.
rm, r′m′, r″m″, Medullary rays in longitudinal, tangential, and transverse section.
s, s′, Cork in surface view and section.
sc, Sclerenchymatous cells.
v, v′, Vessels in longitudinal and transverse section.

(129) **Valerian Rhizome.**

The rhizome and roots of *Valeriana officinalis*, Linn. (N.O. Valerianeæ).

The rhizome presents the following structure:—

(1) *Tegumentary tissue*, composed of large polygonal cells which are slightly suberised.

(2) *Cortex*, the cells of which are rounded or oval, exhibit intercellular spaces, and are filled with starch.

(3) *Endodermis*, consisting of a single layer of tangentially elongated cells containing volatile oil.

(4) *Stele*, in which a pericycle and a bast ring surround a circle of wood-bundles within which there is a very large pith. The pericycle is narrow, the bast parenchyma is collenchymatous and in the pith there are scattered groups of sclerenchymatous cells with thickened pitted walls.

The structure of the root is as follows:—

(1) *Epidermis*, the cells of which are rectangular in tangential section and axially elongated.

(2) *Hypoderma*, consisting of large cells containing volatile oil.

(3) *Cortex*, which is comparatively wide and contains in its cells an abundance of starch in simple or small compound grains; the innermost row of cells (endodermis) contains volatile oil.

(4) *Stele*, in which the wood bundles form an almost continuous ring enclosing a large pith, the cells of which also contain starch. The pith of the root does not contain sclerenchymatous cells as that of the rhizome does.

The diagnostic characters of powdered valerian rhizome and roots are:—

(*a*) *The cells containing volatile oil.*

(*b*) *The abundant starch.*

(*c*) *The epidermis of the root, with hairs.*

(*d*) *The sclerenchymatous cells.*

PLATE CXIX.

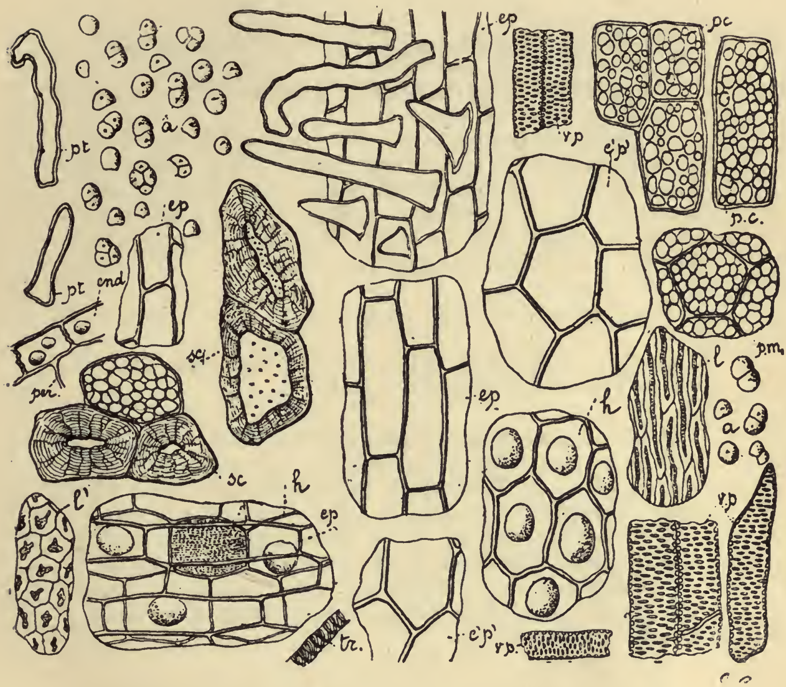

FIG. 129.—**Powdered Valerian Rhizome** (× 240).

a, Starch.
end, Endodermis.
ep, Epidermis of root.
e'p', Tegumentary tissue of rhizome.
h, Cells of the hypoderma of root.
l, l', Collenchymatous bast tissue, in longitudinal and transverse section.
pc, Cortical parenchyma.
per, Pericycle.
pm, Parenchyma of pith.
pt, Hairs on root.
sc, Sclerenchymatous cells of rhizome.
tr, vp, Vessels, etc.

130) Zedoary Rhizome.

The rhizome of *Curcuma Zedoaria*, Roscoe (N.O. Scitamineæ).

The rhizome presents the following structure:—

(1) *Epidermis*, the cells of which are flattened in transverse section, but in surface view are rather large; sometimes they are polygonal and isodiametric, sometimes axially elongated; the walls are thin. Here and there rounded cells with thickened pitted walls are to be found; these are the bases of large, unicellular, conical hairs, which have been broken off.

(2) *Hypoderma*, which is often absent.

(3) *Cork*, usually of considerable extent; the cells are large, and, in surface view, appear polygonal.

(4) *Cortex*, comparatively narrow and traversed by small fibrovascular bundles, some of which are accompanied by yellowish thin-walled fibres. The cells of the cortical parenchyma are mostly polygonal or rounded and contain starch, but a few contain yellowish oleoresin. The starch grains are large and simple, strongly flattened, and generally ovoid or sack-shaped; the hilum is close to the pointed end, and many grains exhibit distinct striations. They are considerably larger than either ginger or galangal starch.

(5) *Endodermis*, the cells of which are flattened and not lignified.

(6) *Stele*, of large dimensions; the parenchymatous tissue resembles that of the cortex.

The diagnostic characters are

(*a*) *The starch grains.*

(*b*) *The epidermis with scars of hairs.*

(*c*) *The oleoresin cells.*

(*d*) *The abundant, thin-walled parenchyma.*

PLATE CXX.

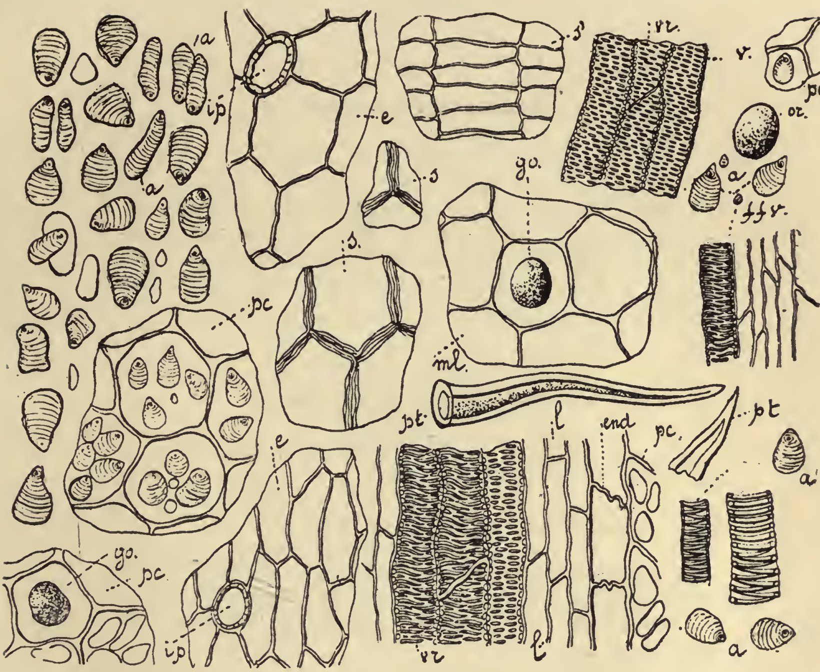

FIG. 130.—**Powdered Zedoary Rhizome** (× 240).

a, Starch grains.
e, Epidermis.
end, Endodermis.
ffv, Fragments of vascular bundles.
go, Oleoresin cells.
ip, Scar of hair.
l, Bast.
ml, Fragments of stelar parenchyma (after treatment with potash).
or, Masses of oleoresin.
pc, Cortical parenchyma.
pt, Hairs, entire or broken.
s, s', Cork, in surface view and section.
v, vr, Vessels.

SECTION IX.

CORMS AND BULBS.

This section forms a natural sequence to the previous one dealing with rhizomes and roots. It contains but two official representatives—viz., colchicum corm and squill bulb. The former is a contracted hypogæic stem, the latter is composed of a number of fleshy, modified leaves, enclosing a comparatively small axis.

131) Colchicum Corms.

Colchicum corms are obtained from *Colchicum autumnale*, L. (N.O. Liliaceæ).

The corm exhibits the following structure :—

(1) *Epidermis*, composed of a single layer of flattened cells which in surface view are seen to be very irregular in outline and arrangement ; they have brown, pitted, more or less wavy walls.

(2) *Ground tissue*, consisting of polygonal parenchymatous cells with distinct intercellular spaces and filled with starch. The latter occurs mostly in compound grains ; these usually have three—rarely four—components, which, when separated, are curved on one side and angular on the others ; they have a conspicuous stellate hilum ; the simple grains are rounded. This tissue is traversed by numerous bundles, each consisting of a group of vessels surrounded by a ring of soft bast.

The diagnostic characters of powdered colchicum corm are:—

(*a*) *The starch grains.*

(*b*) *The abundant parenchyma.*

(*c*) *The absence of sclerenchyma and of crystals.*

PLATE CXXI.

FIG. 131.—**Powdered Colchicum Corm** (× 240)

a,a', Starch in simple and compound grains.
e, Epidermis.
l, Bast.
pa, Parenchyma.
pc, Fragment of cell wall.
tr, Fragments of vessels.

(132) **Squill Bulb.**

The bulbs of *Scilla maritima*, L. (N.O. Liliaceæ).

The scales of which the bulb almost entirely consists exhibit the following structure :—

(1) *Epidermis*, composed of rectangular cells covered with a rather thick striated cuticle ; in surface view the epidermal cells are polygonal and axially elongated. The epidermis is furnished with rather large stomata.

2. *Parenchyma*, between the two epidermises. This tissue corresponds to the mesophyll of the leaf, and is composed of parenchymatous cells which are polygonal and irregular in the centre, but axially elongated in the layers near the epidermis. Most of the cells contain mucilage, and some of them calcium oxalate in addition ; the latter occurs sometimes in very large prismatic crystals of rectangular section, sometimes in delicate acicular crystals, which may be arranged in bundles or may be irregularly disposed. In the red variety of squill cells filled with red colouring matter are also present.

The parenchymatous tissue is traversed by numerous vascular bundles.

The diagnostic characters of powdered squill are :—

(*a*) *The abundant mucilage.*

(*b*) *The very characteristic calcium oxalate.*

(*c*) *The occasional stomata.*

(*d*) *The absence of starch.*

PLATE CXXII.

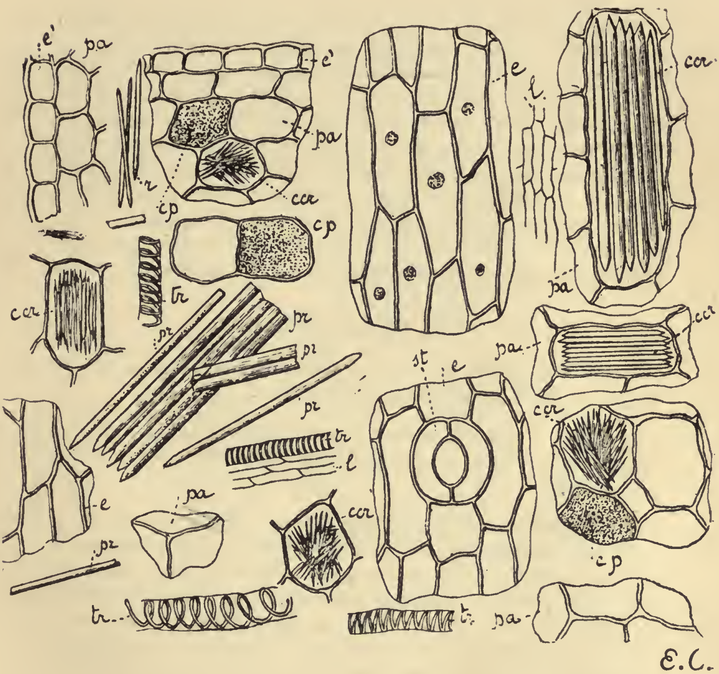

FIG. 132.—**Powdered Squill Bulb** (× 240).

ccr, Crystal cells.
cp, Cells filled with reddish pigment.
e, e′, Epidermis, in surface view and section.
l, Bast.
pa, Parenchyma.
pr, Long prismatic crystals of calcium oxalate.
r, Raphides
st, Stoma.
tr, Vessels, etc.

SECTION X.

FUNGI.

There are two officinal drugs derived from this class that are from time to time employed in pharmacy in the state of powder, viz., ergot of rye and white agaric. These drugs differ very markedly in structure from those that have been hitherto dealt with. They consist of long, narrow, tubular cells (hyphæ) which interlace with one another, exhibiting scarcely any definite arrangement, but becoming more or less compacted together so as to form a spongy (agaric) or even dense (ergot) mass. They are devoid of a true epidermis, of vascular bundles, of chlorophyll, and of starch. Marks of distinction are, however, not wanting, as will be seen from the followi ng descriptions :—

(133) **Ergot of Rye.**

Ergot of rye is the compact mycelium of the fungus *Claviceps purpurea*, Tulasne (sub-class Ascomycetes).

It occurs in slender, curved tapering masses about 1 inch in length, dark violet or almost black externally, nearly white internally.

The outer dark-coloured portion consists of flattened, elongated cells with very dark walls. The rest of the drug is composed of a dense mass of hyphæ which appear rounded in transverse but oval in longitudinal sections, thus exhibiting a slight tendency to an axial arrangement. These hyphæ contain an abundance of fixed oil intimately associated with protoplasm. Treatment with ether removes the oil and makes the cells more distinct; chloral hydrate dissolves the protoplasm, and the oil thus liberated rapidly forms globules. The cell walls are also readily seen after warming a section with acetic acid. There are no crystals of calcium oxalate present, nor any spores.

The diagnostic characters of powdered ergot are :

(*a*) *The characteristic structure.*

(*b*) *The abundance of oil.*

(*c*) *The dark outer layer.*

(*d*) *The absence of crystals and spores.*

PLATE CXXIII.

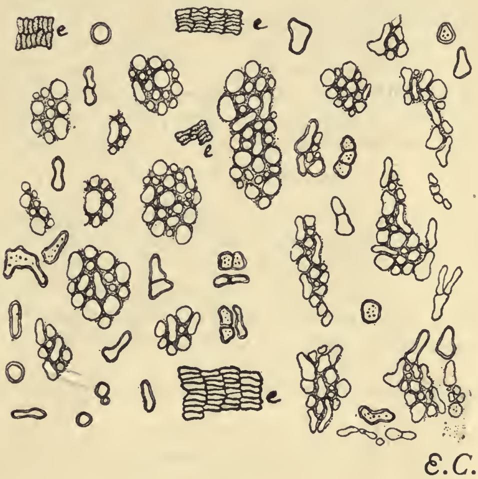

FIG. 133.—**Powdered Ergot of Rye** (× 240).

e, Portions of the dark brown outer layer.

(134) **White Agaric.**

White or larch agaric is the fungus, *Polyporus officinalis*, Fries (sub-class Basidiomycetes).

It is found in masses varying in size from that of the fist to that of a child's head. Externally it is reddish or yellowish; internally, white and spongy. The outer portion is often removed, and the remainder cut up into smaller, irregular pieces.

The tissue of which it is composed consists of a mass of loosely agglomerated, interlacing tubular hyphæ, which may often be rendered more easily visible by gently warming the preparation in acetic acid. Accompanying the hyphæ are crystals of calcium oxalate, small calcareous masses of varying size and irregular shape and numerous minute spores.

The diagnostic characters of powdered white agaric are:

(*a*) *The interlacing tubular hyphæ.*

(*b*) *The presence of calcium oxalate.*

(*c*) *The presence of spores.*

PLATE CXXIV.

FIG. 134.—**Powdered White Agaric** (× 240).

co, Calcareous concretions.

cr, Crystals of calcium oxalate.

h, h', Hyphæ.

sp, Spores.

SECTION XI.

SPORES AND GLANDS.

The pharmacist employs three drugs that come under this heading, viz., lycopodium, lupulin, and kamala. The structure of all of these is simple, and as the individual spores or glands are of very small size, they are usually entire. Adulteration, intentional or accidental, is very readily detected.

(135) **Lycopodium.**

Lycopodium consists of the spores of *Lycopodium clavatum*, L., N.O. Lycopodiaceæ, and probably other species.

Each spore has the shape of a low, broad, triangular pyramid resting upon a convex base, and is covered by a delicate network consisting of colourless, raised, transparent ridges. The walls are composed of an outer membrane bearing these projections and a thin uniform inner one. The spores contain fixed oil which can be made to exude by crushing them, and can be identified by appropriate reagents.

PLATE CXXV.

FIG. 135.—**Lycopodium** (× 240).

(136) **Lupulin.**

Lupulin consists of the glands obtained from the strobiles of the hop, *Humulus Lupulus*, L. (N.O. Urticaceæ).

Each gland consists of a hemispherical layer of cells, the common cuticle of which has been raised, dome-like, by the secretion of oil between it and the cell walls. When fresh, the gland is pale yellow or golden yellow in colour, and filled with a yellowish oily emulsion ; this, by keeping, gradually darkens in colour, and contracts to form a rounded, brownish mass. The glands measure from 140 to 200μ in diameter.

PLATE CXXVI.

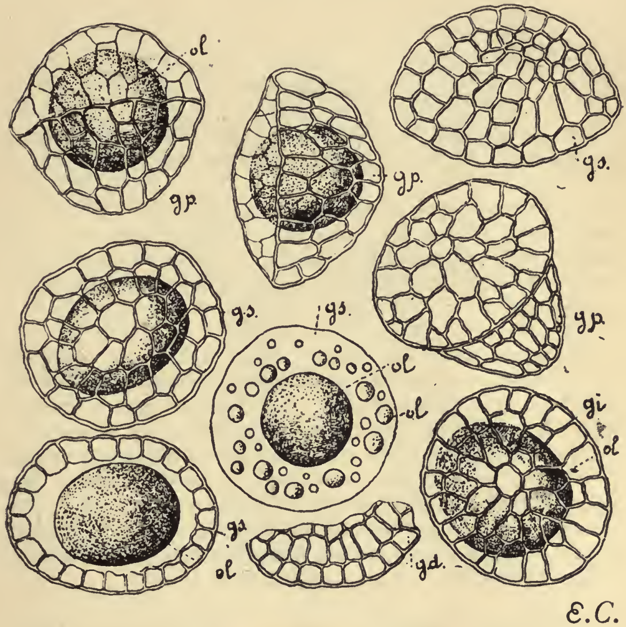

FIG. 136.—**Lupulin** (× 240).

gd, *Débris* of gland.
gi, Gland viewed from below.
gp, Gland viewed from side.
gs, Gland viewed from above.
ol, Oil.

(137) **Kamala.**

The glands and hairs that cover the fruit of *Mallotus philippinensis*, Müll. Arg. (N.O. Euphorbiaceæ).

The heterogeneous nature of kamala is visible even to the naked eye. Under the microscope it is seen to consist of minute, dark red, rounded glands, and groups of thick-walled hairs. Grains of sand and portions of vegetable *débris* are often also present.

The glands have the shape of flattened spheres. Each of them consists of a delicate membrane, enclosing a number of elongated cells that radiate from a common centre, and are enlarged at their free extremities. The red colour of the contents of the gland is often so deep as to obscure the structure, but it can be removed by solution of caustic potash. The appearance of the gland varies somewhat with the position in which it is viewed and with the plane that is focussed. Viewed from the side the cells assume a fan-like arrangement; from above or below they appear to radiate from a centre.

The hairs are usually grouped in tufts; they are thick-walled, bluntly-pointed, and divergent.

PLATE CXXVII.

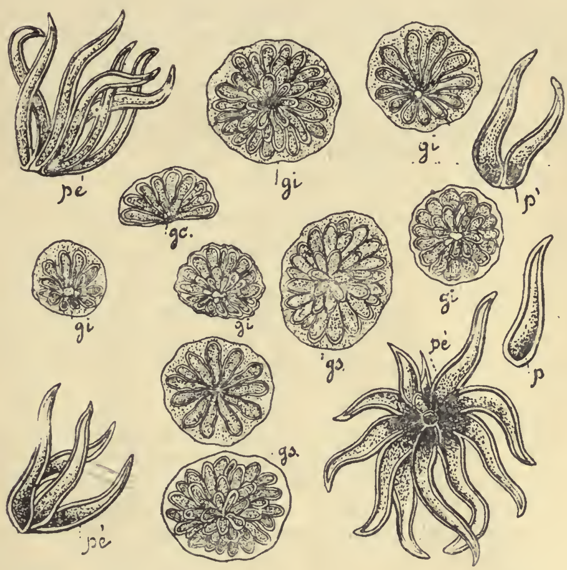

FIG. 137.—**Kamala** (× 240).

gc, Gland viewed from side.
gi, Gland viewed from below.
gs, Gland viewed from above.
p, p', pe', Hairs and portions of same.

SECTION XII.

(138) GALLS.

The official galls are abnormal developments on the twigs of *Quercus infectoria*, Olivier, resulting from the puncture and deposition of the eggs of *Cynips Gallæ tinctoriæ*, Olivier.

The drug exhibits the following structure :—

(1) *Epidermis*, consisting of one or two rows of tabular cells with brown, slightly thickened walls; in surface view these cells are polygonal and isodiametric.

(2) *Parenchyma*, which is differentiated into three distinct layers, viz., an outer, middle and inner layer.

The outer layer is somewhat hard and dense and made up of rounded or polygonal cells with rather thick walls and intercellular spaces; it is traversed by fibro-vascular bundles, and many of the cells contain chlorophyll, or thin, colourless, transparent, angular fragments of tannin.

The middle layer is less dense and more or less pulverulent. It is composed of large, rounded, polygonal cells with large intercellular spaces, the cells thus easily separating from one another ; they contain numerous fragments of tannin, which give them a characteristic appearance.

The inner layer consists of axially elongated, firmly adherent cells ; they also contain tannin, but many contain single crystals or rosettes of calcium oxalate. Towards the interior this tissue forms a sclerenchymatous ring of irregularly polygonal cells with thick pitted walls.

Within the sclerenchymatous ring is a parenchymatous tissue rich in starch, the grains of which are rounded and exhibit a stellate hilum.

The diagnostic characters of powdered galls are :—

(*a*) *The abundance of tannin.*

(*b*) *The sclerenchymatous tissue.*

(*c*) *The starch grains.*

PLATE CXXVIII.

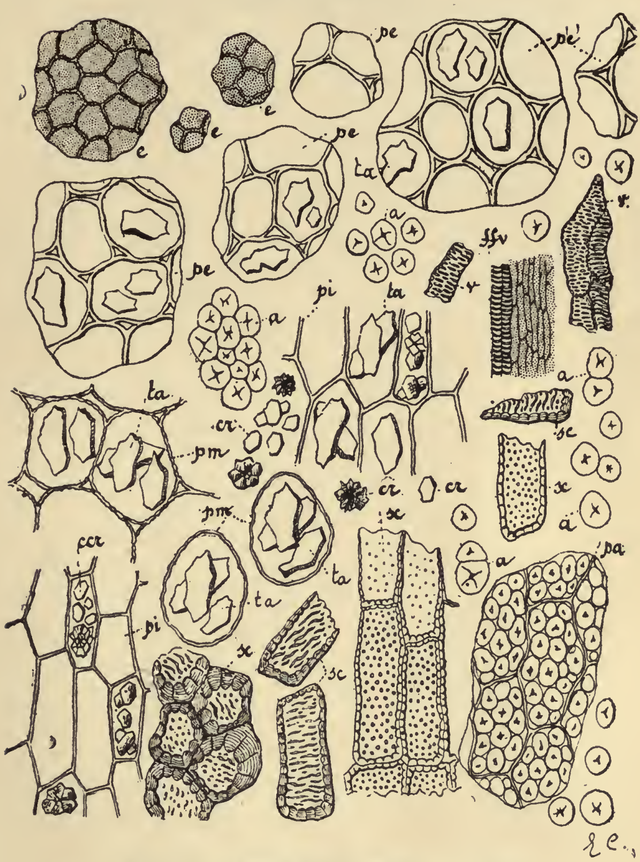

FIG. 138.—**Powdered Galls** × 240).

a, Starch.
ccr, Crystal cells.
cr, Prismatic and rosette crystals.
e, Epidermis, surface view.
ffv, Fibro-vascular bundles.
pa, Starchy parenchyma.
pe, p'e', Cells of the outer layer in surface view and transverse section.
pi, Cells of the inner layer.
pm, Cells of the middle layer, with fragment of tannin.
sc, Sclerenchymatous cells.
ta, Tannin.
v, Vessels.