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After School

DOMESTICATED ANIMALS AND PLANTS

97

A BRIEF TREATISE UPON THE ORIGIN AND DEVELOPMENT OF DOMESTICATED RACES WITH SPECIAL REFERENCE TO THE METHODS OF IMPROVEMENT

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PREFACE

Soon after the appearance of "Principles of Breeding" as a college textbook, numerous letters came to both the author and the publishers, suggesting a volume along similar lines, but less technical in treatment and better adapted to the needs of high and normal schools, and appealing more specifically to the general student.

These suggestions, together with the growing interest in agriculture both as an occupation and as a subject for instruction in schools of various grades, encouraged the production of the present volume, which runs along the same general lines as "Principles of Breeding," except that more information is afforded as to the origin of domesticated races and the source of the materials out of which they have been formed, and less space is devoted to function and to the more philosophic treatment of variation and heredity.

More attention is given also to the general subjects of natural selection and the survival of the fittest as shown in the way of the wild, — subjects of importance to the high-school student as affording the foundation principles for improvement, and also as contributing to a more rational understanding of the general principles of evolution than commonly exists in the popular mind.

An incidental purpose has been to insure the student of the secondary school an acquaintance with the essential facts of reproduction as illustrated in plant life, and with the foundation principles in heredity, especially in degeneracy and crime, as illustrated in regression tables and the law of ancestral heredity. If the author has been at all successful at this point, the student will derive indirectly and by inference, through this study of animals and plants, a certain knowledge of human relations which in all likelihood he would be unable to secure by the method of direct instruction, and yet which all thinking people need to possess, not only for their own protection, but for the intelligent interpretation of public affairs along sociological lines.

After all, the main purpose of the book and the main hope of the writer is to interest the student in affairs of the farm, and to enlist on the part of high schools the same interest in the teaching of agriculture and the preparation for the affairs of country life as is now exercised in the teaching of other subjects and the preparation for other phases of life. Wherever this new departure has been made it has been found that the educational value of subjects drawn from real life is surprisingly great, and the social and economic results are beyond computation. The hope to help this work forward has been, perhaps, the chief inspiration in the preparation of the following pages.

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TO THE TEACHER

This book is so arranged as to be adapted either to a brief or to a more extended course of study, a double purpose which is accomplished by dividing the subject matter into two parts.

Part I may be taken alone, constituting a brief course covering the essential principles that are fundamental to an understanding of hereditary transmission and of the business of plant and animal improvement.

Part II can be employed either as additional text or as reference matter, at the option of the teacher, and depending upon the time that is available.

In any case, whatever use is made of Part II, either as text or reference, it should be in connection with Part I, and not as succeeding it; that is to say, Part II should be taken in *connection* with or immediately following the first three chapters of Part I, and this use of Part II is highly recommended, because here is a collection of information, not commonly available, that throws light not only upon the sources of material out of which domesticated races have been made, but also upon many of the essential steps in improvement.

The author is especially anxious that the suggestions and exercises offered at the close of the chapters be accepted and followed. Each topic affords material full of interesting and profitable study, always from the standpoint of utility; and if the students will make some independent studies of this kind, they will be doubly repaid not only in the wealth of information accumulated, but in the experience gained in independent methods of study.

With the information afforded in the Appendix the teacher will be able to introduce the subject of stock judging. This introduction should be made early and continued throughout the study of the text. Almost any neighborhood will afford specimens entirely suitable for this purpose.

A glossary of terms will be found convenient in connection with both text and reference reading.

More explicitly, the purpose of the first three chapters is to bring out the way in which our domesticated races came among us, and our dependence upon their services. In this connection and at this point should come as much as possible of the detailed study of separate species as given in Part II.

The intent of the writer at this point is fourfold: first, to arouse interest in the field which affords the subject matter of the real discussion; second, to bring together a body of knowledge about domesticated animals and plants on which the student may rely, making it possible for other chapters to be less concrete and more abstract; third, to connect that body of knowledge with the zoölogy and the botany of the high school; fourth, to give the student some acquaintance with the behavior of animals and plants both in a state of nature and when undergoing domestication.

Chapters V and VI are designed not only to bring out the power of selection, but also to give the student some working knowledge of the complicated manner in which it operates in nature. Both error and bad science abound through the failure to distinguish between the facts of nature and the poetic license that is often employed by writers who choose nature subjects as means of teaching human truths. This kind of anthropomorphism we may wink at, if we understand what is meant when animals are made to talk and trees and flowers to think; but we cannot forgive that kind of pseudoscience wherein, though the purpose of the writer is plainly to teach the facts of nature, yet the facts are either badly distorted or incompletely conveyed.

In Chapter VII the distinct purpose is to draw the attention away from the animal or plant as an individual and direct it to the more or less independent units of which it is composed. A train of cars seen at a distance looks like a single unit, but when more closely examined it is found to consist not only of engine and of separate cars, but also of wheel and axle, brake and drawbar. The whole is actuated by the energy of the coal and controlled by intelligence, acting through steam and compressed air, by means of lever brake and bell cord.

Chapter VIII introduces a brief study of the variability of a single character, and it serves not only to fix conceptions as to type, but as an introduction to statistical methods of study now much employed in the problems of breeding. This chapter will afford material for an exceedingly valuable class of problems, and its mastery is especially urged.

In Chapter IX the attempt is made to convey the essential facts of reproduction and lay the foundation for the study of heredity through the medium of the plant. The hope is that here and in Chapters X and XI more is taught by inference than is taught directly. It has been a secondary aim of the author to convey knowledge and make impressions that are applicable to certain human relations as well as to the subject in hand, but which from the nature of the case cannot be conveyed by the direct method.

Chapters XI and XII are designed to teach rational notions of descent and to correct the prevalent notion that heredity in some way fails unless the offspring is a duplicate of the parent. The old dogma that like begets like, and that the offspring is like the parent, is modified to read, "The offspring is like the parentage," and the succeeding chapter deals with the distribution of hereditary family qualities through the various members of the back ancestry. It is hoped that the careful study of these chapters will prepare the student for the real behavior of characters in transmission, and will enable him to comprehend both regression and progression, as well as reversion and degeneracy. It will also serve to show that transmission and heredity are complicated, not simple, facts.

Chapter XIV discusses the relative influences of heredity and environment, a discussion that is useful from the standpoint of breeding, and even more so from the standpoint of human experience, particularly when we take into account the popular confusion of mind on these two points. The average student, noting the powerful influence of environment in the development of inherited tendencies, is likely not to fully realize that the environment is powerless except when the possibilities are presented by heredity. A study of this chapter should help to clear the mind of the student on this point.

Chapter XV is designed to acquaint the student with some of the practical facts and problems connected with the actual improvement of animals, and is frankly admitted as designed to stimulate interest in grading.

Chapter XVI, dealing with plants, is intended to make the methods of improvement still more familiar and to stimulate a desire to take a hand in its trial, which, if seriously undertaken, will be found not only interesting but highly educative.

Chapters XVII–XXI deal with the origin of domesticated races, and are designed as supplementary text or as reference matter, according to the needs of the school.

Any good high school may undertake something definite in the way of animal and plant studies with reference to practical improvement. The principles laid down in the text and the discussion are ample to enable it to do so, if teacher and pupil alike are so disposed, and the school may, if it will, become a force in the neighborhood.

First of all, it should have a little land on which at least a collection of common plants may be studied. A vacant lot in the city or a corner of a field in the country will answer, but a definite piece of land near the school, set aside for the purpose, is more desirable than either.

With the growing interest in agriculture, the best schools are being provided not with a farm which they do not need, but with a field of five to ten acres for experimental and demonstration purposes, which they do need. This work may well occupy a place in such a field.

At the least let the school study variability. This may be done advantageously with four classes of cultivated plants, namely, flowers, garden vegetables, small fruits, and farm crops.

Of the first, pansies, petunias, sweet peas, and hollyhocks are well adapted to the purposes; of vegetables, the best are potatoes and squashes; of small fruits, strawberries and raspberries; and of farm crops, none is better than corn, though wheat, oats, timothy, and clover all exhibit pronounced variations.

In some of these cases variability may be conveniently increased by crossing, as with the sweet pea, hollyhock, squash, and corn; and in the potato and strawberry an endless supply of new strains may be had by planting the seeds.

If at all possible, this study of variability should be accompanied by attempts at improvement, which is especially easy with flowers and not at all impossible with such crops as potatoes and corn.

Large animals are, for the most part, out of reach of the operations of the school, except as it can draw upon the farm animals of the neighborhood, which everywhere afford material practically unlimited, both in numbers and variety.

There is no more favorable material for study, however, than chickens, and a small poultry plant is entirely feasible and in every way desirable in connection with the school.

It is fundamental that some one be definitely charged with the responsibility and care of any and all plants and animals kept for school purposes. This responsibility and care may properly devolve upon the same party who cares for the building and the grounds.

It may seem to some that to do work of this sort, and to study matters of this kind, is not the proper function of the school, and that its advocacy is a passing fancy. To such, let the author say that a new era is upon us, — an era in which at least a portion of the time and energy of the schools must be devoted to useful things, and to none more properly than to the industry of agriculture, which directly engages the lives of one third of our population and provides food for all the people.

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PART I

THE MEANING OF DOMESTICATED RACES AND THE MANNER OF THEIR IMPROVEMENT

CHAPTER I

THE DEPENDENCE OF MAN UPON DOMESTICATED ANIMALS AND PLANTS

Animals and plants as sources of food · As sources of clothing · As sources of shelter · Vegetable products as sources of heat and light · Dependence of man upon animal labor · Animals a means of recreation · Animals and plants as sources of raw material for manufacturing purposes · Medicinal properties of animals and plants · The business of farming

Few realize the extent of our dependence upon the plant and animal life about us, and the variety of ways in which domesticated animals and cultivated plants have been made to serve the interests and forward the plans and purposes of man.

Animals and plants as sources of food. Aside from air and water there is no article of food, common or uncommon, that does not come directly from the animal or the plant.

Meat, milk, and eggs, the three standard animal foods, represent the body and its products. Bread, however made, represents the starchy seeds of certain plants, and edible oils are invariably of either plant or animal origin.

To these staples we add, for luxury and for health, a great variety of fruits and vegetables, not to mention sweets, but they all arise from plant life somewhere in the world.

Most of the food plants are cultivated, and most of the animals are domesticated. The savage may live by the hunt, but it is one of the first evidences of civilization that a race provides an ample and assured food supply in its domesticated animals and cultivated crops.

To be sure, a certain amount of meat still comes from game like the deer and the moose, but the proportion is small and is growing smaller every year. The pioneer, like the Indians, depended largely on the hunt, but the buffalo is extinct and the game animals generally are restricted to the protected preserves where they linger only by virtue of stringent laws.

Fish have been strictly undomesticated in the past, but now all the promising rivers and lakes are systematically "stocked," so that even these lowest of all food animals are almost half domesticated, in that they are systematically cared for. Any way we study the problem we always arrive at the same conclusion, namely, that we are absolutely dependent for food upon the products of plant and animal life.

Animals and plants as sources of clothing. Primitive man clothes himself in skins, like the Eskimo, if he needs their warmth, or in grasses, like the Fiji islander, if he does not. Civilized man, however, refining upon savage customs, weaves a cloth out of the fiber of the pelt or of the leaf, and cuts himself garments that fit the body and lend themselves to its movements. In this way the wool of the sheep and the fiber of the cotton and the flax furnish the material out of which the world clothes itself.

Aside from furs, and many of these come from lambs and from cats, we draw our clothing supply from animals and plants living under the direct management and control of man, that is, domesticated. The wool of the sheep, the fur of the vicuña, and the hair of the llama and the alpaca are all body coverings shorn for spinning. The fiber of cotton and of flax represent two of our principal crops the world over, and the silk that is spun by the insignificant worm represents an industry involving thousands of people, millions of worms, and acres of mulberry trees. In clothing, therefore, as in food, our supply is mainly drawn from domesticated races.

Animals and plants as sources of shelter. Such of our ancestors as were fortunate enough to inhabit mountain districts lived in caves, but as the more venturesome and ambitious sought their fortunes on the plains, where civilization develops, they made themselves tents or tabernacles of the skins of animals and afterward of woven cloth. Only later were shelters built of lumber, bricks, or stone. Our own race has developed its civilization in habitations made of wood, but with the passing of the years and the destruction of natural forests, we shall more and more build of indestructible materials not the product of either plant or animal life.

For our furniture and our furnishings, however, we shall always be dependent upon both, and we cannot say, even in this, that man is independent of the humbler life about him. Though in the past his draft for building materials has been upon natural supplies and not upon domesticated races, yet the attention that is now being given to forestry indicates the necessity of protecting and renewing the timber supplies in ways that amount almost to a domestication of our valuable woods.

Vegetable products as sources of heat and light. For ages wood has warmed the body of suffering man, cooked his food, and lifted the shadows from his soul. Not until after the opening of the twelfth century[1] did we begin to draw upon our coal deposits, and not until recent years have petroleum and natural gas ranked as heat- and light-producing materials.

But whether wood or coal, petroleum or gas, all reduce to the same ultimate basis, — vegetable growth and the carbon of the atmosphere harnessed by the green of the leaf operating under the energy of the sun.

None of these sources of heat is from cultivated plants, but the world supply of coal, and therefore of petroleum and gas, is limited, so that at no distant day we shall be obliged to secure our heat either from the sun direct, from wood growing in

[1] It is supposed that the first charter for mining coal was granted by Henry III to Newcastle-on-Tyne, 1239.

cultivated forests, or from alcohol produced by the starchy grains and vegetables.

In early days the fat of animals or of plants served for illumination, but with petroleum they passed, probably forever, out of use, and it is more than likely that in respect to illumination we shall be independent of both animals and plants.

Dependence of man upon animal labor. To harness the animals and put them to work is one of the primitive instincts of

FIG. 1. The famous Percheron stallion Brilliant

After a painting by the great animal artist Rosa Bonheur

man, and a book would be required even to outline the thousand ways in which man has been helped by his dumb companions, and in which his future happiness inevitably rests upon their labors.

It is the reindeer and the dog that make the polar regions habitable. It was the ox that traveled the plains and developed the Pacific coast in the days of '49. The last of the buffalo gave their flesh to feed the workmen that laid the Union Pacific — that first mechanical bond between the East and the West.

It is the horse that has fought the wars of the world and won out human liberty. Besides this, he has broken our prairies, sown and harvested our grain, and delivered it to the markets of the world. He has carried messages of victory and of sorrow, and down to the time of Washington he constituted the fastest mode of communication known, if we except only the carrier pigeon.

If all the animals of the world should die in a single day, the disaster in respect to labor would hardly be second to that in

FIG. 2. "I helped to build the Pikes Peak Railroad." The burro and the pack mule afford the best means of transportation over difficult mountain trails

respect to food. We might perhaps turn vegetarian, but if man should lose his animal servants, then he himself would at once be reduced to a beast of burden in a thousand ways not commonly appreciated or even understood.

The camel and the pack mule carry civilization into regions which would otherwise remain wilderness, and just as the burro may be said to have built the Pikes Peak Railroad, so the elephant and the water buffalo each has done and is doing its distinctive work, without which man would have failed to develop his civilization at certain significant points.

Animals a means of recreation. Wholly aside from the sport of hunting, our animal population contributes not a little to the diversion and the recreation of man. The old-time tournament[1] and the later fox chase ministered to the pleasure sense of man, as does the modern horse race. There is no enjoyment more exhilarating than driving behind a spirited horse, unless it be that primitive pleasure of riding; and the training of intelligent horses to the higher class of service is a business that rises to the rank of a fine art.

Thousands of ponies contribute not only to the health of children but also to their pleasure and development, both physical and mental, for no experience is better suited to stimulate resourcefulness in the child than is the everyday management of an animal of the horse kind.

The business of fancy breeding is a refining kind of enjoyment that for sheer fascination has no superior. As the clay in the hands of the potter, so is a flexible species in the hand of the breeder, as is evidenced by a glance at what has been done in the breeding of pigeons and of dogs (see pp. 93–95), and as will become evident as we proceed with the study now in hand.

Animals and plants as sources of raw material for manufacturing purposes. Animals may be thought to afford but little raw material for the manufacturer, but the wool and the skins, the bones and the slaughterhouse refuse, all work up into valuable material for factory consumption, providing endless necessities and even luxuries, from the covering of our hands and feet to brushes and combs, buttons and knife handles, gelatin and glue.

Plants and plant products are nearly all submitted to some process of manufacture before assuming forms suitable for the uses of man, and this affords opportunity for the exercise of

[1] See the story of "Ivanhoe."

unlimited employment and skill, not only in design but in execution as well.

When we regard facts such as these and consider the multitude of purposes to which wood is put, the use of pulp for paper, the flouring of grains, the carding and spinning of vegetable and animal fibers, then it is that we begin to realize how generally and how fully our domesticated animals and plants afford what might be called the raw materials of civilization.

Medicinal properties of animals and plants. It is not only in health but also in disease that animals and plants serve our needs. Nearly all medicinal preparations are from some species of plant, and each has its characteristic action on some portion or portions of the body or its functions.

Certain glands of animals, too, are coming to be much used in the preparation of medicines. If the thyroid gland of the child, for example, fails to develop, the mental faculties will be impaired; but the calamity can be averted by feeding the subject with the thyroid substance of the sheep.

And so in countless ways our lives have come to be bound up with those of the animals and plants that we cultivate, and our ability to maintain our civilization and insure our continued happiness will depend very largely upon the success with which we can maintain these animal and plant assistants and cause them to minister to our good.

The business of farming. The systematic and continued production of domesticated animals and plants, insuring a perpetual supply of their products, is the business of farming. Considered from the individual standpoint, we may like it or not according to our natural bent and our like or dislike of animals and the handling of crops, but looked at from the racial and economic standpoint, there is no more important work for the continued welfare of man than that of maintaining a continuous supply of plant and animal products.

Nor is this task a simple one. The supply must be ample for an increasing population with increasing needs, although plant production tends strongly to the deterioration of the soil. Besides this, both animals and plants must be brought and kept up to the highest standard of efficiency, and it is the purpose of this book to discuss some of the principles involved in securing and maintaining the highest attainable service on the part of both animals and plants; in other words, their systematic improvement from the standpoint of usefulness to man.

This being true, we cannot know too much about them, — their nature, their history, and the significant details of their reproduction and development. Accordingly, first of all, attention is invited to the source from which they have come down to us.

Summary. We are absolutely dependent upon plant and animal life for food, clothing, and heat, and very largely so for light, shelter, labor, recreation, medicinal compounds, and the raw material for manufacture. In a very large sense man has drafted into his service all other living things which seem capable of ministering to his prosperity; thus, if in no other way, proving his superiority over all other created beings.

Exercises. 1. Write essays showing what the horse has done and is doing for man.

2. Write essays showing how we would be affected, and how we would get on if we should suddenly be deprived of the cow.

3. What is the most useful domestic animal in your neighborhood, and why?

4. What is the most important crop of the locality, and why?

5. Calculate the value of all the animals of the United States and of your own state, and express it not only in totals but on the per capita basis.

6. In the same way estimate the annual output of crops, and compare with this the value of our exports.

7. Do the same for the animal products, meat, milk, and wool.

8. Calculate the amount and value of the grain and hay consumed annually by our domestic animals, and compare it to the cost of feeding our human population.

Reference. Year-Book, United States Department of Agriculture.

CHAPTER II

DOMESTICATED RACES ORIGINATED IN THE WILD

Domesticated races vary · Creation not yet finished · Most domesticated races have close relatives in the wild · Domesticated species existed first in the wild · Species change in domestication · Improvement sometimes slight · Domestication a gradual process · How the history of domestication is known · Not always able to identify the original · Distinction between feral and wild

Whence came our domesticated animals and our cultivated plants? Were our horses, our cattle, our sheep, and our swine created in the beginning as they are to-day, or have they descended from other, older, and somewhat different races? Were they made especially for our benefit, or have we drafted them into our service?

Were our wheat, our corn, our clover and alfalfa, our apples and vegetables, created for the particular delectation of man, or have they been discovered and appropriated by him to meet his special needs?

Were they always as they are now in form and color and quality, or have they been developed from preëxisting species and somewhat changed in the process?

Domesticated races vary. The last question is easiest answered. The domesticated races were not always what they are to-day, for many have arisen within recent times and some within the recollection of men yet living. For example, the Shorthorn cattle were developed in England within the last hundred and fifty years, and the trotting horse is an American product developed since the Civil War.

The most common pig of the Mississippi valley is the Poland China, which developed in the Miami valley as the Chester White developed in Chester County, Pennsylvania.

Wheat is very old, but corn is relatively new, and the variety known as Riley's Favorite was produced by James Riley, still living at Thornton, Indiana.

Grapes have been known since the earliest ages, but all the varieties growing east of the Rockies have been developed since the landing of the Pilgrim Fathers, and the most popular of all grapes — the Concord — originated within half a mile of the old homes of Emerson and of Hawthorne, and close by the little brown house where Miss Alcott lived and wrote "Little Women." Moreover, the writer has seen the original vine still growing by the old home of its originator, Ephraim Bull, as he has also seen the original stock from which all our navel oranges have sprung.[1]

Creation not yet finished. Just as every torrential storm brings down tons of rock and soil, changing permanently the face of nature; just as the rivers carry this "drift" from the uplands, extending the lowlands farther and farther into the sea; just as frost and flood combine to tear down the mountains and wear away the hills, so are influences at work everywhere to alter more or less permanently the character of the countless species of plants and animals that inhabit the earth.

So the Creator is still at work, and not only the forces of nature but man himself works with God in still further improving the earth and the living beings it everywhere supports. It is well, then, that man shall learn all he can as to how to operate to the best advantage in discharging his part of the labor of creation.

Most domesticated races have close relatives in the wild. The most casual observer recognizes the wolf as a kind of first cousin to the dog, and the jackal as a poor relation. Domestic cattle belong certainly to the same general class of animals as the bison and the water buffalo.

[1] It should be understood that the peculiar kind of orange called the navel has arisen at many different times and places in the world. Ours originated in southern California.

Any zoölogical garden or traveling menagerie will show a great variety of animals clearly catlike, and almost every mountainous country has its native sheep of some kind.

The zebra and the quagga of the circus suggest the horse, and the turkey of the New England forests not only resembles our great Thanksgiving bird, but is known to be its direct progenitor.[1]

FIG. 3. The timber wolf a wild relative of the domestic dog. Specimens at the National Park, Washington, D.C. Courtesy of the Superintendent

Among plants we have wild oats, timothy, and many kinds of clover; indeed, most of our pasture grasses are truly wild. We have also wild strawberries, blackberries, and raspberries, wild onions, parsnips, and carrots, and whichever way we turn the domesticated animal and plant is found to have a gypsy relative in the wild.

[1] For further data on the turkey, see Part II, Chapter XVII.

Domesticated species existed first in the wild. The plain inference from all this is that domesticated races originated in the wild. This conclusion is abundantly supported by a mass of incontrovertible evidence too voluminous for full presentation here, showing also that man has appropriated these wild species and put them to his service from time to time as he has felt the need. Some of this was done so long ago that the manner of the domestication is lost in the dim and ancient past, and the history of it must be read backwards if it is read at all; but some of it is so recent that the exact record exists both in printed literature and in the recollection of men that still walk and talk among us.

The more ancient races such as the dog and the horse, like wheat and barley, date from a period long before recorded history, and more than likely before the invention of the art of writing; but on the other hand, the American wild grape that clambers over the trees and shrubs of the eastern United States is known to be the parent of all the cultivated varieties grown east of the Rocky Mountains. In the same way most varieties of plums trace straight to the thickets of eastern American rivers. So again, the gooseberry and the currant, the blackberry and the raspberry, in all their varieties have been developed from wild races, and mostly within the last half century, just as all the varieties of the rose have arisen from the common wildling of the hedges and the hills. How this has been done and the story of it will develop in the student's mind as we come to inquire more specifically into the life history of the separate domesticated species.

Species change in domestication. It is not to be assumed that domesticated races are identical with their wild antecedents. On the contrary, in most cases, substantial improvement has taken place in domestication, as will be seen whenever a domesticated race is compared with its nearest wild relative.

There are many wild apples, but none so rich or so large as the best products of our orchards. Most wild oranges are insipid or bitter. One would have to look a long time to find wild grapes equal to the cultivated sorts. No wild potato has ever been found equal to the cultivated either in size or quality.

FIG. 4. American wild grape, parent of all cultivated varieties growing east of the Rocky mountains

No wild sheep equals the Merino in fineness of fleece or the Shropshire in quality of meat, and no wild animal of the cattle kind was ever known to give as much milk as the domesticated cow.

Improvement sometimes slight. In a few cases this improvement is far less pronounced than in others. For example, the best wild strawberries and blackberries are undoubtedly equal in flavor to the cultivated, though far inferior in productiveness and in size. The Catawba grape was found wild in North Carolina, practically identical with its present form, but it was the only vine of its kind.

The fur-bearing animals, like most kinds of fish, have never been domesticated; indeed, it is an open question if man could maintain artificial conditions that would preserve in captivity the same quality of fur attained in the wild state.

Domestication a gradual process. Civilization has developed not from one but from many centers, and many animals and plants have been domesticated, not once, but many times. Every "woods boy" has had his pet "coon" or crow, and every savage tribe its horde of dogs, each going to the wild for what it wanted.

Some parts of the world were ahead of others in the process of civilization and also in the business of domestication. While our own ancestors were chasing the Auroch[1] in the wilds of central Europe in Cæsar's time or hunting the wild boar[2] in the jungles of Germany, Asia had developed races and civilizations that had risen, run their courses, disappeared, and been forgotten, giving place to others. There, then, was probably the earliest domestication. Asia is our largest continental area, with the greatest diversity in soil, climate, and exposure. It is therefore richest in both animal and plant varieties, as it is oldest in civilization; and we are not surprised to learn that many of our most useful species were here domesticated so long ago that it is impossible to say when, how, or by whom it was accomplished.

Later than all this, however, and contemporaneous with the culture that belonged to Greece and the glory that was Rome's, the Indian of our own country was as wild as the buffalo and

[1] The probable progenitor of most European breeds of cattle.

[2] The wild parent of certain European breeds of pig.

he bear that he hunted or the turkey that our Puritan fore-ather tamed. When Demosthenes was developing his oratory, nd Alexander and Cæsar were extending their dominions, the Six Nations had probably not yet made the beginning of what n time would undoubtedly have developed into an Indian civ-lization, had it not been interrupted and finally destroyed by European discovery and invasion.

Within the recollection of men now living the Sandwich slanders were savages. Head-hunters and cannibals are not quite extinct in the Pacific Islands, while in Africa men are et hunted like wild animals by their savage neighbors. Thus avagery lingered even until our own time.

So it is that civilization is constantly springing up from new enters, giving us the opportunity of studying the methods of ts beginning; and so it is that the ways of primitive man are well known and are made a part, not of our imagination, but of uthentic history. So it is that we arrive at conclusions not only by inference and through relics of ancient peoples, but by actual observation of what men do in the primitive state, — of the real behavior of many and widely separated races that have for one reason or another been belated in their start towards civilization. In this way we are able to study the methods of domestication at first-hand.

How the history of domestication is known. In the case of all these peoples, however savage, some start has been made toward domesticating at least a few wild animals, and it is by putting together fragments such as these and adding the facts of recorded history that the story of domestication may be written almost if not quite from the beginning.

Even little matters throw great light upon such a history. For example, the bones of animals that were hunted for food during the stone age are left behind in great heaps, called "kitchen middens,"[1] while the bones of domesticated animals

[1] Especially numerous in western Europe. Most of these long bones have been split to get at the marrow.

are often found buried with human remains, as would be likely with special favorites. In those days, of course, animals were not yet domesticated for food, but only to assist in the hunt, an inference perfectly safe from the fact that most of the remains in the middens are of deer and reindeer, even yet not domesticated.[1] In all these various ways the history of domestication of many if not most of our animals is well known, if not in detail, at least in a general way.

Not always able to identify the original. However this may be, and however confident we may feel as to the processes of domestication, we often cannot speak with assurance of the exact wild species from which each particular domestic animal has been developed. We know that the ancestor was a wild animal, but which one or ones of the many similar races that must have existed in those remote times we have but scanty means of knowing.

This is partly because, through breeding and care, all domesticated races have been greatly changed from their appearance in the wild state, and partly because in very many cases the wild original may itself have changed, or even, perhaps, long ceased to exist anywhere on earth; indeed, it looks sometimes as if domestication had been the principal if not the only means of saving some of our most valuable species from utter extinction long ago.

Distinction between feral and wild. Until recent years immense numbers of so-called wild cattle, and of wild horses as well, roamed over our own western plains and over the pampas of South America. Such animals are not truly wild, because they do not represent an original stock, being merely the descendants of the cattle and horses brought over by the Spanish invaders, some of which escaped and "ran wild." Finding conditions favorable, such escaped specimens throve and freely multiplied, ultimately stocking the plains with roving bands of

[1] This statement may be questionable as to the reindeer, which is now semidomesticated.

both cattle and horses, as truly wild in temperament as any species that ever ranged the natural pastures.

Such descendants of escaped domesticated races, however, are called "feral," to distinguish them from a truly aboriginal stock, like the buffalo, that ranged our plains with our feral horses. Many cultivated plants also freely revert to the wild in unoccupied lands, but they are spoken of as having "escaped" from cultivation, so that the term "feral" is limited to animals.

Feral animals have most of the characters and appearance of the domestic forms from which they spring, except in respect to temperament, which is that of the truly wild, all of which constitutes an additional argument for their origin in the wild.[1]

The next step is to see how it was that animals and plants came to be domesticated and taken out of the wild for the benefit of man.

Summary. Domesticated animals and cultivated plants originated and existed for indefinite generations as wild, from which state they have been taken by man to meet his needs, and cultivated in order to insure a sufficient and unfailing supply. Some of these races were domesticated ages ago, some within the lifetime of men yet living, and all have been more or less modified from what they were in the wild state.

Exercises. 1. What wild animals or plants in your vicinity are, in your opinion, related to domesticated or cultivated forms?

2. What animals or plants that have never been domesticated would, in your opinion, prove valuable to man?

3. Make a list of the wild fruits and nuts native to your vicinity.

4. Make an exhaustive list of the cat tribe of wild animals, with notes on the character and habitat of each.

5. Make the same sort of study of the dog tribe, including wolves, foxes, and jackals.

References. 1. "Wild White Cattle of Great Britain." Storer.

2. The zoölogy and the botany in use in the local school.

3. Any good cyclopedia, or, better, a special treatise such as Lydekker's Library of Natural History (6 vols.)

[1] In this connection read Jack London's "Call of the Wild," one of the strongest pictures of this reversion that has ever been drawn, and an excellent dog story withal.

CHAPTER III

HOW ANIMALS AND PLANTS CAME TO BE DOMESTICATED

Domestication the result of necessity · Need for help in the hunt · Need for additional food · Need for clothing and shelter · Need for labor · Domestication the first step in civilization · The civilizing effect of slavery · What animals have done for us · Unused materials · Lost possibilities · Domestication a gradual process · Species that were domesticated

Domestication the result of necessity. Domestication both of animals and plants came naturally out of the needs of primitive man. If he could have maintained himself successfully on the spontaneous products of nature, he would never have undertaken the trouble of domesticating the wild animals and plants about him, and of assuming the labor and responsibility of their maintenance and care.

It early became, however, a matter of necessity. Primitive man, like the animals about him, lived under hard conditions. The "law of the wild"[1] was the law everywhere. Everything subsisted by virtue of its strength, its endurance, or its wits, and man, like his animal neighbors, spent most of his time in getting something to eat and in avoiding being eaten himself. As compared with the other animals, — for primitive man is little else than an animal, — our barbarian ancestors found themselves at no little disadvantage, purely on physical grounds. They were not as strong as many of the animals and were no match for them in fair battle. They were not as fleet of foot as most of the game they hunted. They could not trail by scent like the wolf, and if the hunter by sheer endurance stalked his game and walked it to death,[2] he was far from camp or cave where his

[1] See Chapter V.

[2] Man is probably the best walker among the animals and can easily outwalk even the horse in an endurance test.

little ones were, and most of the carcass was worthless when at last he had obtained it.

Primitive man was not long in discovering that his chief advantage lay in his wits. He was the only animal that knew enough to pick up a club and use it as a weapon, either of offense or defense. He was the only one that could manage fire.[1] He was the only one that could hurl a stone or make a machine to send a projectile of any sort.[2]

By aid of various devices, such as weapons and traps, the savage continued to subsist by his wits, and he was hard on the species he hunted. As a consequence game not only grew more scarce but it gradually learned the methods of this dangerous enemy, who struck where he was not, and became exceedingly wary, till scarcity and starvation were inevitable, calling for a fresh draft upon the wits.

Need for help in the hunt. The hunting habits of the wolf must have early attracted the attention of our barbarian ancestors. His ability to trail by the scent and his habit of hunting in packs, as well as his fleetness and his relentless endurance, could not have failed to impress themselves upon hungry hunters in very early times, and to possess a pack of such helpers must have been a primitive ambition.

Fortunately the nature of the wolf is such that he is easily tamed if taken young, and he succeeds well in captivity. His intelligence is of an order that responds to that of man in his hunting temper, and it is not strange that wherever primitive

[1] Monkeys and baboons will warm themselves by a fire, but do not know enough to replenish it. Fire was almost certainly at first obtained from volcanoes. Its production by friction and by flint and steel must have been much later achievements. Lightning is a common source of fire.

[2] The ingenuity of primitive man in making projectiles is truly remarkable. Bows and arrows, blowguns, and afterwards firearms, are progressive tributes to increasing intelligence; but of all projectiles, the boomerang is the most wonderful, considering the grade of savage that produced it. The writer has been told by travelers who have seen it done, that a skillful thrower could strike a mark with the boomerang, which would then return and fall near the thrower's foot.

man has been discovered he has had extensive packs of dogs; certainly if wolves of any kind were found in that part of the world.[1]

The dog was easily tamed, but he was fleeter of foot than man, his master, and both game and dogs were almost certain to be soon lost in the distance, leaving the master to come behind and take what was left after the death. Accordingly the horse must have early appealed to the primitive hunter on account of his fleetness.[2] With his horse and his dog and his

FIG. 5. Head of the collie and of the coyote. Note similarity in outline and general effect

weapons, however, the man was match for anything that roamed the forest or the plain, and with them he has established and made good his claim as lord of all creation.

Need for additional food. But all this was still harder upon the hunted, and game was rapidly killed off or driven away, till many a time the hunter returned empty-handed. Then it was that a few nuts or seeds gathered by the women brought grateful relief from what would otherwise have been distressing fast,

[1] Reference has already been made to the fact that our American Indians had made dogs out of the coyote or wild wolf of the prairie.

[2] As late as the times of the Old Testament, even the wild ass is frequently alluded to as a symbol of swiftness. This is especially true in Job and the prophets, having reference, probably, to the Syrian wild ass figured in the Ninevite sculptures.

and thus it was that agriculture had its beginnings in the frequent failure of the hunt.

As game grew more and more scarce the favorite fruits were held in higher esteem, the places where the large-seeded grasses grew were carefully protected, the other vegetation was cleared away, and the beginnings of cultivation were made. The next step was to gather stores of fruits, nuts, and seeds for the winter, and, last of all, to plant and care for the very best in some open space or bend of the river where fresh new soil awaited occupation. Thus did cultivation begin, and thus were women the first farmers.

Nothing was more natural than that the best should be gathered for eating, and the very choicest only reserved for planting. In this way the first steps in plant improvement were introduced at the very beginning of cultivation, and thus did our ancestors early learn the fundamental lesson of all breeding, namely, the better the parentage the better the offspring.

This utilization of plants as well as animals added vastly to the food supply and greatly insured its constancy and regularity. Savages who followed this course prospered and encroached upon their neighbors, while those who depended solely upon the hunt suffered periodic famine and faced, in the end, extinction,[1] for in a state of nature the "law of the wild" obtains among men as well as among the animals.

However, man was unwilling to give up his animal food with the growing scarcity of game. He had been in the habit of slaughtering the best,[2] without regard to the future,—an utterly wasteful proceeding, for in this way the hunt was not only fearfully destructive of numbers but of quality as well, and it is little

[1] Read the history of the Iroquois, or Six Nations, who raised crops, in contrast with that of the Canadian Indians who subsisted entirely by the hunt and were often forced in winter to eat the skins and even the bark of their wigwams.

[2] It is always the largest buck that is singled out for the chase. The best of everything is hunted, just as the woodsman, cutting a tree, even for exercise, chooses always the straightest and best, while the forester, who is the product of civilization, cuts always the worst, giving the best a still better chance.

wonder that hunting men starved periodically, when it took, as estimated, forty acres of good hunting ground to sustain one individual.

It was inevitable that the time should come when man must take better care of the wild animals or give up animal food.

The first step was to hunt and destroy the wild animals that preyed upon those that were of value to man,[1] and the next was to spare the finest males and all females with young.[2] Thus were the first steps in domestication and the beginning of improvement instituted at substantially the same time.

The next step was to provide food for this increasing stock of valuable semidomesticated animals. This was done in two ways. The easy way was to herd and drive the bunch to fresh pastures where there was good water. This required a considerable force of men and horses, not only to herd the animals but to protect them from robbers, because these herds were none too plenty and the feeding lands none too extensive.[3]

The other plan of providing food was to supply it directly from cultivated plants, confining the animals more and more as natural feeding grounds became exhausted. This is the more laborious of the two methods, but it is the one followed when natural feeding grounds (plains) are not extensive, and it is the one necessarily followed wherever lands become valuable. Thus did man save to his own use and preserve from extinction not only the dog and the horse, but all the animals good for food, and thus, in a measure, has he become their servant and caretaker in consideration of what they can do for him.

[1] To the knowledge of the writer a wolf hunt occurred in Illinois as late as the very close of the last century, — I am quite sure in 1898.

[2] At the discovery of South America the Peruvian Indians, orAztecs, were found to have already instituted an annual hunt by which all the animals of a great region were rounded up in some mountain valley, driven to close quarters, the worthless and dangerous beasts of prey systematically killed, and the supply of meat taken not from the best, but from the common animals, being careful to release the best for breeding purposes in order that the quality of the supply should not deteriorate.

[3] Read again the story of Abraham and Lot, Genesis xiii, 7–11.

Need for clothing and shelter. Food was not the only need of man supplied by the beast and bird of the forest. The skins were good for clothing and for tents, enabling the primitive hunter to leave his cave and other natural shelters, and erect his home wherever inclination or necessity dictated. The skins of those taken for food were, however, not enough to meet this need, and the world over animals with especially fine body covering have been hunted almost to the point of extermination for their fur, originally as a matter of necessity but in these latter days as a matter of luxury and profit.[1] So relentless has been that warfare, and so systematically has it been conducted, that our valuable fur-bearing animals are nearly exhausted and we ourselves will soon face the same issue with respect to these animals that our barbarian ancestors faced with respect to food animals, — domesticate or go without.

Even this has not fully met our need for the products of the animal body, and many species with a long coat have from time immemorial been shorn of their fleece, the "wool" to be woven into cloth and the animal saved to grow another crop. Thus did the scarcity of animals add one more step in our march of civilization, and add the loom to our industries.

Even this was not enough. The wool of sheep and the hair of goat and alpaca alone could not meet our new demands for fabric. Then came the resort to vegetable fiber, not only for clothing, but for cordage to take the place of the more expensive, and at last impossible, dried sinew and leather lariat.[2] Thus

[1] The Hudson Bay Company was founded in 1670, and chartered by the British government with special privileges to hunt fur-bearing animals in the Canadas, especially in the Hudson Bay territory. These hunters and trappers were really the first explorers, for they not only subsidized the Indians to hunt and trap, but themselves penetrated to the remotest depths of forest and mountain in search of the precious pelt. The quest for seal was no less ardent upon the water than was that for otter, mink, and beaver on the land.

[2] In certain portions of the tropics a tough and slender vine is used for binding together the timbers in fence and building construction. The cipo (pronounced *see-po*) is a vine of this kind, and is suggestively called the Brazilian nail.

a new list of plants came into cultivation, greatly extending our farming operations, — all in order to meet the needs of an advancing civilization. And the end is not yet, for the demand is still for more and better fabrics.

Need for labor. From the beginning man was a lazy animal. Like his associates, he bestirred himself only in the presence of extreme necessity. He acquired the horse to add to his fleetness of limb, and thereby learned the lesson that riding is not only faster but easier than walking.

Besides, when man undertook the somewhat wholesale domestication of animals and plants he assumed an immense burden not only of responsibility but of labor. If now he was to undertake to provide the horse's food, what more natural than that the horse should pull the plow[1] to raise his own provender? Then, too, with the accumulated property to be carried from place to place, not only for storage but for trading with people who desired exchange, still new uses for the horse were found.

In this and other ways not only the horse was put to work, but other animals like the ox, the camel, and the llama were domesticated chiefly for their labor. Thus with the passing of the hunt the old occupation of the horse is gone, but he has found other uses which are no less valuable in our eyes, and we cannot foresee the time when the so-called "horseless age" will be truly ushered in.[2]

Domestication the first step in civilization. Every hungry man is a savage, whatever his stage of development, and no race is ready to lay even the foundations of a civilization till it has provided itself with an ample and assured food supply. As long as primitive man depended solely upon the hunt, so long did he alternate between fast and famine, with the certainty that in the end the famine would get him.

[1] The original plow was not the traditional forked stick. It was without doubt simply a sharp stick drawn by a cord or vine, and held by the attendant in a slanting direction.

[2] In spite of all the talk about doing away with horses, their numbers and prices are steadily increasing.

But with animals to care for came property interests to de-end, and a feeling of responsibility developed which only can timulate that sober activity which marks civilization as distinct rom savagery.

With the primitive crops land came to have a value. This, oo, had to be defended, for savage enemies were not long in earning that cultivated fields on which were growing the next winter's food constituted the most vulnerable point in a neighbor.[1] Stores of grain also constituted peculiar temptations and necessitated walled or otherwise defendable cities.

The civilizing effect of slavery. There is a chapter of this ancient history most unpleasant to revive, but yet upon which we ought to be intelligent. It is difficult for us now to realize how slavery ever did any good in the world, or how it ever helped along towards civilization, yet a little reflection will serve to show how at one time it played an important part.

In the primitive division of labor it was natural that the men should be the hunters while the women stayed behind with the children. It was natural, too, that upon the return of the successful hunters, tired and hungry, their duty ended when the game was brought home and laid at the feet of the women, whose natural duty it was to skin the animals and prepare the meal.

Again, nothing was more natural than that the women should, during the absence of the hunters, scour the neighboring forests for such nuts and fruits and seeds as they could pick up; for experience taught that the hunt was not always successful, and that a dinner of herbs was better than none at all, besides contributing to the good humor of the men, who, in savagery, did not hesitate to abuse anybody who was unable to successfully resist.

Taken altogether, the lot of the women of primitive races is a hard and laborious one, with plenty of abuse thrown in. Now it is easy to see how scarcity of game, restricted hunting grounds, cultivated fields, and stores of food lead to warfare. But

[1] How this led to war has already been noted in connection with the Iroquois.

warfare means prisoners, and there is one thing more satisfying to a savage victor than to kill his prisoner and use his skull for a drinking bowl, and that is to take him home and turn him over as a slave to his savage wife, who is not slow to make him perform her labor and to vent upon him the abuse she has so often suffered herself, and which she and her children so well know how to bestow.

Imagine the satisfaction with which a victorious savage would regard the chief of a rival tribe whom he had brought as a present to his wife, as he saw him day after day doing the work of women! Imagine, too, the satisfaction of the woman in having the opportunity to belabor a man and perhaps encourage the children to practice cruelty upon him whom they had once learned to dread as a great warrior.

It is a hard picture, this primitive slavery, but it is only under conditions such as these that the savage man and the barbarian woman first came to stand on terms of equality; thus it is that slavery was the first emancipation of woman, and it is this institution, bad as it is, that first made leisure possible to womankind, and gave her honorable standing in the eyes of man. With the later chapters of slavery and its degradation to both races we are more familiar, but we cannot afford to forget, in our horror of this now extinct institution, the great service it once rendered to woman when the world was young.

What animals have done for us. The want of space does not permit the expansion of this thought, but it is one to which young people may well give some special study, for animals not only give their bodies and body products to be consumed, but they toil day after day for our advantage.

With the recent mechanical inventions, the business of carrying both freight and men has been largely removed from our animals, especially in our most highly civilized countries. And yet we do not forget the pony express of our western plains, nor fail to remember that it was within the memory of men yet living that the patient ox toiled day after day to drag endless emigrant trains across the boundless prairies, through the bottomless "sloughs" and over the Great Divide. "Westward the course of empire takes its way" would never have had its full meaning for us, except for the thousands of cattle that dropped by the wayside and left their bones bleaching on the prairies beside those of the buffalo relative, as tribute to the march of civilization westward.[1]

The development of South Africa is yet almost unwritten history.[2] Here no animal but the ox can endure the endless toil of the treeless plain, and he has been the constant attendant of the Boer from the Great Trek till the present, as he is likely to be for a considerable time to come.

Nothing is more common than for people that have become prosperous to forget, even perhaps to despise, the very means by which their prosperity came about, — to overlook the means in the enjoyment of results. These animals literally give their lives to our service, with no returns but feed and care, a fact which raises the question of our natural obligation in exacting this service. We are practicing upon them the "law of the wild" even yet. Doubtless the end justifies the means, and without a doubt it is right to use our animals to our own advantage, but every law, both human and divine, forbids that we abuse them.

In a large measure life in any form is a sacred thing. A man's horse or cow belongs to him only in the restricted sense that he is entitled to the service, and if necessary the life, only when he provides generously for the needs of the animal and surrounds it by as much comfort as possible. At best our animals are bits of God's creation which we are entitled to appropriate and use only under terms which we can justify before Him who is the judge of all.

[1] Even the first material for the Union Pacific was hauled by oxen, so that the ox gave his labor as the buffalo gave his flesh, and both gave their lives to this first connection between the East and the West.

[2] See James Bryce's "Impressions of South Africa," an excellent book dealing with primitive conditions.

Unused materials. It has been frequently mentioned that the world might have been much richer in domesticated races if it had seemed worth while, or if we had really set about it.

The bison, whether European or American, would have made a good domestic animal of the cattle kind. The quagga could be domesticated if we needed him. The bighorn of the Rockies would make a sheep, and the peccary or the wild boar would make a pig. The prairie hen would make a better fowl than the guinea hen, and any number of new dogs could be developed from the foxes and the wolves.

The wild rice of our northern lakes would make an excellent grain for lowlands. The milkweed may have possibilities as a fiber plant. Many of our native fruits and nuts have never been domesticated, and it is a startling fact that our original native grasses of the prairie, numbering many species, are being allowed to disappear without contributing a single new race to our cultivated grasses, — this, too, in face of the fact that we have yet no grass without a serious defect.

Except for the difficulty of restraint, the deer and the antelope would make valuable domesticated animals. The semidomestication of the skunk has already begun on the great skunk farms where they are raised in numbers for their skins. The frightful odor of this animal when on the defensive has given him an evil reputation, but in truth he is a most gentle animal, with much the disposition of the cat and without its savage ways. The flesh is exceedingly sweet and tender, and it is altogether likely that this little beast may yet become more nearly domesticated than will ever be possible with the ostrich, which seems incapable of affection.

Lost possibilities. Without a doubt many an animal or plant now extinct would have made a most valuable domesticated species, had it been taken in time. It is difficult to give examples because we know so little of extinct species, and because it is impossible to make direct comparisons between a domesticated and a wild race, either of the same or a different species.

FIG. 6. What a possibility for domestication! Not worth the trouble, however, in competition with domestic cattle. From specimen in the National Zoölogical Park, Washington, D.C. Courtesy of the superintendent

Many good and useful species, however, have been lost, and many far less valuable have lingered.

Just now we are beginning to realize the possible value of a species that has come upon the earth, made its way, and maintained its place among competitors, if perchance it possesses qualities that are now, or that by attention may be, developed into characters useful to man. The muskmelon is an example of a species most unpromising in nature, and therefore neglected almost until our own day, yet yielding readily to improvement and producing most delicious fruit. The tomato is another example, and asparagus another.

Recognizing these facts as never before, the Department of Agriculture at Washington is scouring the world in search of plants of possible economic value, or those that are likely to yield to the ameliorating influences of the breeder and the cultivator. Even if not now valuable, those that are likely to become so are well worth the most careful consideration. In this way domestication of plants is at last becoming a systematic, not to say a scientific, business.

This search for the possibly useful is coming to be nearly as systematic and far-reaching as the scouring of the earth, by such firms as Parke, Davis & Company, of Detroit, for plants with new and possibly valuable medicinal qualities.

Domestication a gradual process. Southeastern Asia was undoubtedly the first area of domestication, with Egypt a close second. Europe came later, and America last of all. Each made its contribution to the stock of domesticated animals and plants by adding what was lacking, by making use of some specially valuable native, or by utilizing the wild stock of the region when the cultivated races failed to acclimate, as was the case with European grapes in the eastern United States.

In a general way the history of these civilizations is the story of their domestications as well, and a critical reading of that history with this particular subject in mind affords many side lights on the people, as, for example, the terror of the Indians at the Spaniard on horseback, or the Israelites' fear of the mounted army of the Assyrians before the Hebrews obtained horses after the Exodus.

Species that were domesticated. The only consideration that seems to have guided man in his work of domestication is the possible usefulness of the species. No labor or pains seem to have been so great, and no timidity or ferocity so extreme, as to deter him from his purpose in the presence of a need unsatisfied that some natural species might gratify.

At this point, and before taking up questions of improvement, the student is strongly urged to turn to Part II and make a detailed study of the sources from which our domesticated animals and plants have been drawn. If it is impossible to do this for all species, let him at least do so for a selected number. The chapters in question are separated from the body of the work, so that they may be used either as text or reference, according to the circumstances and the need of the student or the school.

Summary. Domestication was, in the beginning, a matter of necessity in order to insure a constant and adequate food supply, and it has been continued as a means of contributing to the comfort and general prosperity of man. We have used what we needed and left the rest alone, leaving unutilized much valuable material. Without this domestication our present state of civilization could not have developed, and we could not spare any of the prominent races now, either plant or animal, without detriment to man.

The facts of this chapter will enable us to realize why the list of domesticated species is so extensive, and it will prepare us for a more particular and detailed study of special races both of animals and plants, as outlined in Part II, as it will also prepare us for a realization of the need of still further modifications and the means for effecting this improvement.

Exercises. 1. In what respects do pioneers experience the hardships and assume the habits of primitive man?

2. In what respects do camping parties revert to the primitive state?

3. Show under what disadvantages we would live without the horse, the cow, or any other common animal or crop.

4. Make a list of the domesticated animals and plants kept by the Egyptians during the sojourn of the Jews in bondage, in the delta of the Nile.

5. Make a list of the domestic animals kept by the Jews during the forty years' wandering in the wilderness.

6. What domesticated animals and plants did the Jews acquire after obtaining the Promised Land, and how did it affect their civilization? When did they acquire horses?

7. What animals and plants had been wholly or partially domesticated by the natives of North and South America before discovery by the white man?

References. 1. Any good book dealing with primitive or pioneer life, such as "The Oregon Trail" by Parkman, or the "Winning of the West" by Roosevelt.

2. The earlier chapters of the Old Testament.

3. "The Conquest of Peru." Prescott.

4. Any good book on the North American Indians, such as Parkman's "Jesuits in North America."

CHAPTER IV

NEED OF IMPROVEMENT IN DOMESTICATED ANIMALS AND PLANTS

Natural species not perfectly adjusted to our needs · Maintenance of animals costly · Further improvement needed · Need of more economic service · Some individuals better than others · Economic significance of differences in efficiency · The fact of variability established · Variability in a single character · Historical knowledge of original species needed

Natural species not perfectly adjusted to our needs. If our animal and plant allies had been especially created for our service, it is to be assumed that they would have been perfectly adapted to our needs; but as they were appropriated from the wild, they ofttimes but imperfectly meet our requirements.

For example, the horse is a little too timid, the bull too untrustworthy and ferocious, the wool of the sheep either too coarse or too short for many needs; and all animals make meat only at enormous expense of feed, requiring, roughly speaking, about ten pounds of grain or its equivalent for one pound of meat.

Corn has a little too much oil and not quite enough protein for the best feeding purposes, and the stalk is larger and heavier than we would like. Oats do not yield sufficiently in the warmer sections, and we still lack an ideal pasture grass for most regions of the earth.

And so we might go on indefinitely, enumerating particulars in which we could wish our domesticated races were better adapted to our requirements.

Maintenance of animals costly. Few realize the expense of maintaining our extensive animal population. One cow will eat thirty dollars' worth of feed in a year at ordinary prices, and more if she can get it. A horse will eat from fifty to seventy-five dollars' worth, according to the way in which he is kept.

Besides this, these animals require a large amount of labor in caring for their needs, and a still additional expense for the shelter of themselves and their feed.[1]

The animal population of the United States in millions as compared with the human is substantially as follows:

	Census of 1900	Estimated for 1910
Human population	75,000,000	90,000,000
Horses, mules, and asses	21,000,000	27,000,000
Cattle of all kinds	67,000,000	73,000,000
Sheep	61,000,000	67,000,000
Swine	62,000,000	68,000,000

With five people to the family, we can say that in general and on the average every family has one horse, four head of cattle, four sheep, and four swine, with several millions left over, — a total average of three animals for each human inhabitant, or fifteen to the family. The estimate for 1910 can be only approximate, for these proportions vary greatly.

It is little wonder that we raise immense acreages of hay, corn, and oats to maintain all these animals. It is only on careful thought that we realize how much of our lands and how much of our labor are devoted to the care and maintenance of the animals we have domesticated and brought to live among us, and whose support we have undertaken.

There is argument enough now for the highest attainable efficiency on the score of expense, but it must be evident to the most casual reader that with the increase of human population

[1] Read *Circular 118*, Experiment Station, University of Illinois, and see how extensive the barns must be to shelter the large number of inefficient cows necessary to return the same profit as would be returned by a few economical producers. In the case in hand, one class of cows return fourteen times the profit of the other. This would mean that in order to realize a certain net income, fourteen times as many cows of the one kind would have to be kept as of the other, which means fourteen times as much barn room, fourteen times as much capital tied up in feed, fourteen times as much milking, and more than fourteen times as much waste and risk.

and the enhanced value of lands, the time will come when it will be difficult, if not impossible, to support as large an animal population as we should like.[1] Surely it is high time even now to push forward this increase of efficiency to the end that values shall not be wasted, and to the further end that as population increases, our animal friends shall be less a burden upon us as we continue to enjoy their service.

Further improvement needed. With some of our older species the service is entirely satisfactory as to quality, but with most of the newer and many of the older there is yet much to be desired.

For example, wheat and oats are, so far as we know, ideal in their quality, except that we should like to see a larger proportion of strong plants with less shrunken grain. This, however, expresses itself in a matter of amount rather than in quality of food product. The cow gives us good milk, but not enough of it for the feed she consumes, and so others might be mentioned that are satisfactory except as to amount.

Coming to corn the case is different. This is preëminently a stock food, but it is deficient in both nitrogen and minerals, especially phosphorus. Can this deficiency be wholly or partly remedied by mixture with other crops, such as alfalfa, for example, or does something remain to be done in the way of altering the chemical composition of corn itself? If the latter, the indications are that we can accomplish it.

Horses are now certainly fast enough. A two-minute gait is at the rate of thirty miles an hour, which is neither safe nor desirable for ordinary use. However, in the opinion of city teamsters, the horse is not yet large enough. For their business

[1] Let the student exercise his imagination in picturing the condition as we approach the density of population of China, 400 to the square mile. How then shall animals be kept? Our population has doubled four times in the last hundred years. What will be the condition if this rate of increase should continue another hundred years? Let the student make some estimates covering this question. Let him also determine the effect of education upon coming problems of this kind.

it is desirable to haul as much freight as possible with one team, one wagon, and one driver.[1]

However fast the horse may go, he rarely pleases us in his gait or his endurance, nor are his intelligence and docility yet ideal. The horse is naturally a timid animal, and with his great power is dangerous and growing more so with his increasing spirit, unless his intelligence and tractableness are made to keep pace with his increasing energy and action. Our safety depends not upon our strength in his management, but upon the extent to which the horse will take training and our ability and skill in imparting that training.[2] Before a large proportion of our spirited horses are satisfactory at this point much is needed by way of further improvement.

In respect to fruits, vegetables, and ornamental plants much remains to be accomplished. Most of our fruits are relatively new and not completely acclimated or fully adapted to all our soils and conditions. Added to that is the fact that conditions in fruit raising have suddenly changed. The time was when every man picked from "his own vine and fig tree," but now we expect that most fruits will be transported long distances[3] and still reach the consumer not only sound but fresh. This is asking much, and the present call is for desirable "market varieties," meaning those which yield well, are of good quality, and will stand shipment, especially the latter.

[1] As a good example, Ginn and Company, the publishers of this book, had in their service a single team that could and did haul a load of over eight tons. It mattered but little that the wagon weighed three and three-fourths tons. One man drove the whole, and expensive labor and long delays were avoided.

[2] People who are not horsemen often think they are "able to hold any horse." Real horsemen know better, and fully realize that the bit and the line are at best only guides of a superior intelligence over one that is inferior but willing to yield itself to guidance. For driving purposes, therefore, a horse is valuable and safe in proportion as he has been trained and educated, and always under all circumstances amenable to direction and control.

[3] Consider the shipping of such delicate California fruits as peaches, pears, and grapes over the entire United States and the exportation of apples to Europe.

There is no especial difficulty in combining yield and quality, but the best varieties are in general too delicate to withstand shipment for long distances unless picked green, which is an injury to the flavor, except in such cases as the banana and the pear. That the ideal market apple has not yet been produced is a fact that shows what remains to be done. Many more new varieties of pears, grapes, strawberries, raspberries, and blackberries will continue to be produced before all sections will be supplied with the best varieties both for home use and market purposes.

Vegetables are in much the same condition as fruits. Vast improvement in most kinds has been effected within recent years, and it is still going on at a rapid rate. The tomato has been developed from the worthless "love apple" within the lifetime of men yet living, who remember when this now luscious fruit suffered an evil reputation as the supposed cause of cancer. Asparagus, lettuce, and radishes have been wonderfully improved within a generation, not to mention celery and sweet corn; and as matters are going now, onions will be made more delicate in their flavor, and many a vegetable will come into common use that is hardly yet introduced.

The development of new and beautiful varieties of flowers and other ornamental plants is only begun. Out of the materials at hand new and unheard-of effects will be produced now that plant breeding is coming to be studied and understood as a science.

Need of more economic service. The first great need for better plants and animals is in the interest of larger return for the expense involved. It costs no more to fit and cultivate the ground for a fifty-bushel crop of corn than for a thirty-bushel crop,[1] in which case the extra twenty bushels are clear gain. If ten or twenty ears of corn of the same variety, and as nearly alike as possible, be planted in separate rows side by side,

[1] The average corn crop is about thirty bushels, yet the most profitable crop at the University of Illinois has averaged ninety-six bushels for the last three years.

it will be found that some of the rows will yield two and often three times as much as others,[1] all of which proves that some varieties or strains will produce fifty bushels as easily as others will produce thirty, showing conclusively the need of better seed, or rather of the best that is obtainable.

Professor Fraser, head of the dairy department at the University of Illinois, has conducted many hundreds of actual tests, aiming to secure reliable data on the relative efficiency of cows. These tests are of two general kinds: one conducted away from the University on the commercial herds of the state, aiming to secure the yearly product with only approximate reference to the food consumption; the other conducted at the University under the most careful conditions, and aiming to secure records of the nutrients consumed, as well as of the milk and fat produced.

Of the commercial-herd tests something over twelve hundred individuals have been tested for periods running from one to three years. Their average animal production was 5521 pounds of milk and 219 pounds of fat distributed as follows:

Relative Milk-Producing Powers of 1200 Cows for One Year

Milk	Number below	Per cent below	Number above	Per cent above	Average
2,000 lb.	10	1 −	1190	99 +	5,554 lb.
3,000 lb.	69	6 −	1131	94 +	5,704 lb.
4,000 lb.	243	20 +	957	80 −	6,092 lb.
5,000 lb.	495	41 +	705	59 −	6,650 lb.
6,000 lb.	753	63 −	447	37 +	7,322 lb.
7,000 lb.	963	80 +	237	20 −	8,081 lb.
8,000 lb.	1096	91 +	104	9 −	8,943 lb.
9,000 lb.	1160	97 −	40	3 +	9,770 lb.
10,000 lb.	1186	99 −	14	1 +	10,734 lb.
11,000 lb.	1197		3		11,893 lb.
12,000 lb.	1199		1		12,117 lb.

[1] This is an experiment that every student can readily verify, and it is recommended that he do it.

RELATIVE FAT-PRODUCING POWERS OF 1200 COWS FOR ONE YEAR

Butter fat	Number below	Per cent below	Number above	Per cent above	Average
50 lb.	2	1 —	1198	99 +	219 lb.
100 lb.	24	2	1176	98	222 lb.
150 lb.	194	16 +	1006	84 —	238 lb.
200 lb.	490	31 —	710	59 +	263 lb.
250 lb.	837	70 —	363	30 +	302 lb.
300 lb.	1065	89 —	135	11 +	353 lb.
350 lb.	1140	95	60	5	394 lb.
400 lb.	1178	98 +	22	2 —	438 lb.
450 lb.	1194	99 +	6	1 —	477 lb.
500 lb.	1199		1		539 lb.

These tables should be read as follows: In the first table, 10 cows, or 1 per cent of the whole, gave less than 2000 pounds of milk; and 1190, or 99 per cent, gave more than 2000 pounds, the average of these being 5554 pounds, and so on for other values.

Some comments on these facts are significant. The average production of these 1200 cows was 5521 pounds of milk, and 219 pounds of butter fat. The best one fourth were able to produce an average of 7813 pounds of milk and 312 pounds of butter fat per year, while the poorest one fourth were able to produce on the average only 3435 pounds of milk and 137 pounds of fat; that is to say, waiving all questions of food consumption, the poorest one fourth produced but something over 43 per cent as much milk and fat as did the best one fourth.

A series of publications from the department shows exhaustively the meaning of these facts. Some of these were published before the entire number of records were in, but the relation between the good and the poor cow was substantially the same.

Some individuals better than others. One of the most striking facts in the above herd tests is the wonderful difference in efficiency of individual cows, even of the same age and breed. Thus they ranged all the way from less than 2000 pounds of milk per year up to over 12,000, and from less than 50 pounds of butter fat[1] to over 500 pounds. Manifestly a whole herd like the poorer cows would swamp their owner unless prices were enormous or unless their food consumption were correspondingly lower.

To test this point, the department conducted investigations into the relative efficiency of commercial cows on the basis of food consumed. Accordingly two or more cows were purchased from each of several of the largest commercial herds of the state, the aim being in every case to secure the very best and the very poorest individuals in the herd, according to the best basis of judgment at hand. The yearly record of these cows is shown in the following table:

VARIABILITY OF COWS ON THE BASIS OF FOOD CONSUMPTION

No. of cow[2]	Grade[3]	Total milk	Total fat	Digestible nutrient[4]	Ratio $n \div m$[5]	Ratio $n \div f$[6]
83	Good	11,794	382	7418	0.63	19.42
84	Poor	8,157	324	6737	0.82	20.79
85	Good	9,591	406	7532	0.78	18.55
86	Poor	3,097	119	4998	1.61	42.00
93	Good	9,473	358	7604	0.80	21.24
94	Poor	7,845	282	6706	0.85	23.80
95	Good	14,840	469	8379	0.56	17.08
96	Poor	7,685	324	6871	0.81	21.20
97	Good	8,562	291	6893	0.80	23.68
98	Poor	1,411	52	4062	2.88	78.00

[1] By butter fat is meant not butter, but the fat of butter. Commercial butter contains about 85 per cent fat, the rest being water, salt, curd, etc.

[2] Numbers by which the cows were designated in the records.

[3] Each group from the same herd.

[4] After multiplying number of pounds of fat by 2.4. This represents the amount of food digested by each cow.

[5] $n \div m =$ nutrients divided by milk produced.

[6] $n \div f =$ nutrients divided by fat produced.

A number of significant facts appear in this table. The herd which furnished Nos. 83 and 84 was evidently a good herd, for they were both good cows, though one was bought for a poor cow. While the two differ widely in total production, they differ almost correspondingly in food consumption, and the ratios for fat production were close together.

On the other hand, Nos. 85, 86, though coming from the same herd, betray wide differences. The good cow, No. 85, was more than twice as efficient as her mate, No. 86, whether we consider fat or milk.

Nos. 93 and 94, coming from the same herd, were both medium cows, which goes far to show that the herdsman's estimate of his cows is frequently far from correct.

The very low producing power of No. 98 is remarkable, requiring 2.88 pounds of nutrient for a pound of milk, and over 78 pounds of nutrient for a pound of fat,—not quite one quarter the efficiency of No. 83.

The very high efficiency of two of these cows is noticeable, being more than five times that of the poorest cow mentioned before, and more than twice the efficiency of the poorer cows in the permanent herd.

In addition to the above, some especially good individuals have been pitted for a long time against others of inferior ability. For example, Rose and Nora[1] consumed within a year almost exactly the same amount of the same kind of feed, the difference being less than 5 per cent. They were both relatively heavy feeders, each consuming something over 6000 pounds of digestible nutrients. Rose produced 564.82 pounds of fat, and Nora 298.64, a ratio of 1.9 to 1. When we remember that Nora, the poorer cow, was not a poor cow at all, but that she belongs with the best fourth of the 1200 tested in the

[1] The story of Rose and Queen, the latter another and a really poor cow, has been entertainingly told in *Circular 103* of the dairy department of the University of Illinois, which has issued also *Circular 118*, Cows *vs*. Cows, dealing with the difference in efficiency of cows, and its meaning to the profits of dairying and the cost of dairy products to the consumer.

commercial herds of the state, this difference is exceedingly significant. Rose was, of course, an exceptional cow, producing in another test over two and one-half times as much as her competitor, and making a twelve-year record of 7258 pounds of milk, and 360 pounds of butter fat on the average (384 pounds of fat for ten years), and never being beaten but once in all the dairy tests ever conducted at this station. Professor Mumford, also of the University of Illinois, has shown that substantially the same differences exist between beef animals in respect to the amount of gain for food consumed,[1] so that the principle involved seems general.

Economic significance of differences in efficiency. The meaning of all this is not at once clear, and some little effort is needed to fully appreciate the economic significance of differences such as are here brought out, and the consequent desirability of bringing our common animals to the highest possible degree of efficiency. When one cow can make two and one-half times as much as another on the same feed, the difference is not as two and one-half is to one, but many times greater. Under these conditions, when one cow makes 100 pounds of butter, the other will make 250 pounds on the same feed; but the question of relative profits depends also upon two other factors, — the cost of feed and the price of butter. For the sake of illustration let us suppose, first, that it costs the value of 50 pounds of butter to pay for the food consumed, which is the same in both cases. The profit would then be, in the one case, the value of 100 — 50 (or 50) pounds of butter; and in the other, 250 — 50 (or 200) pounds, which is *not two and one-half but four times as much.*

Suppose again that feed is higher or butter lower, so that it now costs the value not of 50 pounds but of 90 pounds to pay for the cost of feed. In this case the profit for the poorest cow is the value of 100 — 90 (or 10) pounds of butter, and for the other it is the value of 250 — 90 (or 160) pounds of butter,

[1] See "Principles of Breeding," p. 82.

which is *sixteen times as much*, not to mention the additional expense for shelter and labor, or the extra capital involved in the larger amount of feed consumed by the less economical cow. Surely we need no better argument to show the necessity for further improvement of cows.

We are in a transition stage, also, in the matter of meat production, and have need of the most economical consumers of our feed. If we neglect this point, our own meat will not only cost too much, but we shall be driven out of foreign markets by such competitors as Argentina. The first to suffer in such an event would be the farmers, and afterward all classes of people would suffer together.[1]

The fact of variability established. All this tends to establish the fact that all individuals of the same species are not equally valuable, and plenty of evidence of a similar character can be adduced to show that no two individuals, even of the same species or breed, are exactly alike.

Of the many hundreds of thousands of people personally seen by each of us, we find many similarities but no duplicates; moreover, the differences are many and extreme. Some individuals have dark hair, others light; with some it is thick, with others thin; now it is straight and again it is curly or wavy. Some eyes are blue; others are black or brown. One man is tall and slender, while even his brother is short and stout. Some are broad-shouldered; others are thin-chested, with narrow shoulders. Some have large hands and feet, others small, and a few have small hands with large feet. One has a mole on his cheek; another has one on his neck or his nose or perhaps none at all. One man has an extra thumb on one hand; another has six fingers on each hand. One is bow-legged; another is knock-kneed. Here is a hunchback, there a giant, and again we see a dwarf. One is crazy; another is a criminal. Some are handsome and others are ugly. Some are brilliant,

[1] The student may well study this question and show, by written argument, how it is that all classes will prosper or suffer together with the farmer.

others idiotic. Some are deaf, others lame or blind. Some are deficient by a hand; others lack a leg.

Some are musicians, others orators or actors. Some like mathematics; others love literature. Some are farmers, others lawyers or engineers. Many succeed; many fail. Between even the traditional twins that "look so nearly alike that their mother could not tell them apart," important differences will be found if a trained observer looks closely enough.[1]

All this is equally true of animals and plants. It is only to the untrained that all individuals of the same species look alike. Horses differ so much in size, color, conformation, gait, and disposition that it is difficult indeed to get together a "matched span."[2] Some are intelligent and proud of their work; others are foolish, sluggish, and unreliable. Sheep differ not only in the quantity of the fleece but in the fineness of the fiber as well as in the density and the evenness of covering.[3]

No two trees bear apples alike, and even different apples on the same tree differ not only in size but in quality. Some melons are fine in texture and flavor; others of equal size are "like pumpkins." One tree bears specially luscious peaches; another is next to worthless.

Among wildlings the same principle holds. Some horses are fleeter than others and some wolves more cunning.[4] Every woods boy knows the bushes that bear the most luscious berries and the tree that bears the largest and the best flavored nuts,

[1] Even opposite sides of the same individual are slightly different. One shoulder is higher than the other; one leg is longer or stronger than the other, meaning a longer step and causing lost people to travel in a circle. Everybody is either "right-" or "left-handed," meaning by this that the corresponding side is the better developed and capable of stronger or more accurate action.

[2] To the casual observer two horses colored alike are matched, but the horseman looks first to the gait, then to conformation and size, and last of all to the color.

[3] The wool is finest and longest on the sides and back, shortest underneath, and coarsest on the thighs.

[4] Read the story of Lobo in "Wild Animals I Have Known," by Thompson-Seton.

and every botanist will tell you that we may hunt forever without finding two plants exactly alike, so mightily are the materials mixed out of which races and individuals are made. This is *variation* or *variability*, and upon this fact are selection and improvement based.

Variability in a single character. Variability arises in two distinctly different ways: first, by different *associations* of characters, as when one individual is red and white and another is black and white; and, second, by different *degrees of development of the separate characters*, as when one individual is simply larger or fleeter or darker-colored than another. Either gives rise to what is known as variation, and either may afford the basis for natural selection.

FIG. 7. Jersey cow, Figgis 76106, property of C. I. Hood & Company, Lowell, Massachusetts. Champion and Grand Champion, World's Fair, St. Louis, 1904. 547 lbs. 6 oz. butter in 7½ months. Such a cow is worth perhaps a dozen of the ordinary kind that make 125 lbs. in a year

However the racial characters may be mixed in different individuals, it will be found on close inspection that the separate characters are themselves highly variable; that is to say, variability is not confined to individuals but is a property of each and every character that enters into the composition of individuals and of races.

Thus among sweet apples some are sweeter than others within the same variety, and this is true quite independent of color or size. Of all the trotting horses in the world some can go in 2:40, some in 2:30, a few in 2:20, and a very few in 2:05 or less.

Of a thousand ears of corn taken at random from the same field and of the same variety, some will be short and others long, while the rest will stand between. This is variability in a single character. It is, moreover, a kind of variability that can be exhaustively studied by exact statistical methods, — a study that is strongly recommended not only for its exactness but for its influence in fixing definite notions of type and that deviation from type which is called variability. These methods of study are given in a later chapter, a careful study of which is strongly recommended at this point.

Historical knowledge of original species needed. In order to devise practical methods of still further improving the domesticated races and more completely adapting them to the service of men, we need, first of all, to know everything possible of the character of the original species as they lived in a state of nature, — how they behaved toward one another and how they prospered before man interfered with their affairs. In other words, from the way of the wild we can learn substantial lessons as to methods of improvement, and this we propose to outline in the next chapter.

Summary. No plant or animal has yet been brought to its highest state of efficiency, though some individuals are vastly superior to others, and variability is universal. Besides this, our needs and our desires are constantly changing, mostly by way of advance. There is need, then, for still further improvement, and the best course to pursue in deciding upon methods is, first of all, to study species in a state of nature, where these species existed in the wild for many generations previous to domestication.

Exercises. 1. The student should calculate with as much accuracy as possible and report upon the cost of maintaining domestic animals in his own neighborhood, especially as influencing the cost of meat and milk production.

2. Let him compute the amount of land and the proportion of our crops devoted to the support of our animal population. Let him also estimate the relative cost of vegetable and animal food, remembering that a pound of meat contains no more nourishment than an equal weight of grain.

3. Take the domesticated animals and plants one by one and describe the changes we should like in each to still better adapt it to our needs, going well into the subject; as, for example, that blue grass would be a better pasture grass if it had, or could be given, a deeper rooting habit.

4. Plant ten ears of corn that look as much alike as possible, each in a separate row, and take the yield of each.

5. With the scales and the Babcock tester test at least ten cows for relative amount of fat in the milk.

6. Point out definite respects in which cows and corn, for example, need improvement, and do the same for other animals and plants.

CHAPTER V

THE WAY OF THE WILD

The astonishing abundance of life · The struggle for existence · Selective effect of the natural conditions · Competition for food · Competition for room · Competition most severe between individuals of the same species · Natural selection · Survival of the fittest · The individual and the race · Significance of numbers · Significance of vigor and length of life · Significance of offensive and defensive weapons · Significance of protective coloring and markings · Mimicry · Design in nature · Causes of color in animals and plants

Before we can discuss to best advantage the means of further improving our animals and plants it is necessary that we understand as well as possible the conditions and habits of life to which they were accustomed in the natural state before they came to us, because out of this we shall evolve a method of procedure for further improvement.

The astonishing abundance of life. The most conspicuous fact in nature is the astonishing abundance of life and the exceeding rapidity with which all living beings multiply. Whether animal or plant, large or small, powerful or puny, every species multiplies according to the laws of geometrical progression, each with a ratio of its own.

The effect of this fact upon mere numbers is a point not easily comprehended. The fastest-multiplying forms are the bacteria, some species of which are able, under good conditions, to double every twenty minutes. At this rate a single individual with its descendants would, if uninterrupted, fill all the oceans of the earth in an incredibly short space of time.

A single ear of corn of good size has one thousand kernels, and an average ear has, say, six hundred, each capable of reproducing a similar ear. How long would it take at this rate for the product of one ear to cover the cultivated earth?

Man is one of the slowest of animals to multiply, yet under good conditions his numbers may double in twenty-five years; indeed this rate has been maintained in this country because the population of the United States has doubled four times in the last century, with four wars to reduce numbers. If this ratio could continue for another hundred years, we should have by that time no less than fourteen hundred millions of people in this country, making a denser population than that of China to-day.[1]

Few wild animals are known but will breed faster than man, and it takes but slight exercise of the imagination to see how reproduction might go on, were there nothing to check it, until there would no longer be even standing room on earth for the animals alone, to say nothing of their food.

The possible rate of increase of plants is indeed enormous. It is said that the common pigweed ripens from three to four thousand seeds, and a large plant of purslane as many as a million, explaining one reason why they are such troublesome weeds. Plants that seed thus freely are exceedingly difficult of eradication, especially if the seeds are hardy.[2]

Plant lice are still more prolific than weeds. Dr. S. A. Forbes, state entomologist of Illinois, is authority for the statement that a single corn-root aphis is capable of producing ninety-eight young, and that sixteen generations are possible in a single season. At half this rate of increase he computes that if the successive offspring of a single female and her descendants for a single season could be put upon an acre of land at Cairo at the southern end of the state and placed as thick as they could stand, then on top of this set another acre, and so on without crushing till the end of the season, and if then the column could be tipped to

[1] Showing the extent to which social, economic, and political considerations will shortly turn upon our power to feed our people, and that in turn upon questions of land fertility.

[2] The cocklebur ripens two seeds in one bur. One of these is larger than the other and under equal conditions will germinate first. This weed, therefore, has two distinctly separate chances of propagation with respect to conditions of germination alone.

the north till it should lie upon the ground, it would reach to Chicago (360 miles) and twenty-three miles beyond into Lake Michigan; that is to say, that the descendants of a single corn-root louse at half the maximum rate could in a single season, if uninterrupted, reproduce enough to make a solid column 1 acre square and 383 miles long, — a perfectly inconceivable number. After this computation it is not difficult to believe the truth of the assertion that certain bacteria that can double in about twenty minutes would be able in a few days, if unrestricted, to fill all the oceans of the earth.

With this enormous birth rate it becomes important to study carefully the checks to increase, and the various means by which living things have been prevented long ago from absolutely overrunning the earth, where standing room, to say nothing of food, is limited. What, now, are the conditions and mutual relations between these immense numbers of diverse species as they live together in a state of nature?

The struggle for existence. In general, it may be said that species, are indifferent to each other except when interests clash, and then one or the other must go under, for the law of the wild is that everything lives not where it chooses to live but where it is able to live. When so many more individuals are produced than can possibly find food and room to survive, there ensues at once a battle for life, which has by common consent been called, as Darwin named it, the struggle for existence.[1]

This is a many-sided struggle, — a kind of three-cornered fight, — first against natural conditions in general, then against the competition of other species, and, last of all, against the competition of its own kind. This elemental warfare, for it is a warfare, though generally unknown to the participants and often not noticeable except to the trained observer, — this warfare is

[1] In this general connection read "Origin of Species by Means of Natural Selection," by Charles Darwin. It is an old and much misunderstood book, rather difficult, it is true, but well worth the careful reading of all students of life in the wild.

always on, and its complications are so many and so intricate and its consequences so profound that a little space is well devoted to its analysis.

Selective effect of natural conditions. There is a blind but wholesale struggle of living things against what may be called natural conditions, which assert their influence independent of struggle against competition with other living beings, and generally before it begins.

First of all are climatic and seasonal influences. Hosts of young things, both plant and animal, come into existence only to perish on the spot from adverse climatic influences. Many species exist, in northern latitudes for example, only by the narrowest margin, and one exceptionally hard winter will close them out by the millions. In this way whole fields of wheat and clover are "winter killed," as we say, and whole forests die after an exceptionally dry summer followed by an unusually severe winter.

A sudden freshet may wash away in immense numbers the season's crop of seeds of maple, elm, or oak, and send them downstream to rot in the lowlands. The same freshet may kill a valuable lot of mature timber downstream and change forever the flora of the locality.[1]

A wet summer may drown most of the bumblebees, and then the farmers need have small expectation as to the crop of clover seed, which is dependent upon bees for fertilization.

A late fall may so stimulate growth in peach trees and other tender plants as to prevent that "ripening" of the wood necessary to a successful endurance of extreme cold. On the other hand, a "warm spell" in winter may start the buds, after which a "cold snap" will kill outright in a day the prospective crop of the year. The apple crop is occasionally lost by late cold weather after "setting" of the young fruit. Of course this

[1] When the Chicago drainage canal was dug, many bodies of timber along the banks of the Illinois were killed by the new water level established, and many damage suits resulted.

particular instance has no direct effect upon vegetation, but it serves to illustrate the accident of season and its influence upon a new crop of seed.

Extreme and continued rains at pollination will reduce the yield of corn.[1] A hot wind may have the same effect by killing and drying up the tender young silk before the pollen has opportunity to fertilize.

Fire plays frightful havoc with vegetation, especially in the forest, and utterly prevents the appearance of certain species on fire-swept lands;[2] indeed, few can endure a periodic baptism of flame.

Again, every species has its northern and its southern limits, as well as its limits of higher and lower altitudes. As it nears these limits it not only exists with greater difficulty, but its existence is more precarious, and a little thing will turn the tide for thousands of individuals, perhaps temporarily, perhaps permanently.

The hard winter not only kills vegetation but freezes up the water supply and often shuts off the food till bird and beast in the melting snows next spring give mute testimony to the sufferings they have endured and the losing fight they have waged, just as a number of years ago the longspurs were caught in passage by a Dakota blizzard and were literally killed by the millions.

In this general way what may be called the blind forces of nature take their toll of life, and it is a heavy toll indeed, wholesale and sweeping, relentless as fate and tireless as time.

Competition for food. After all this, however, a heavy balance remains, — a balance always too heavy for the food supply.

[1] This is due to the fact that the pollen grains stick together and fall in little pellets rather than singly, as they should, in a fine yellow dust, reaching each of the thousand silks of a single ear, for every kernel has its independent silk.

[2] The jack pine has taken possession of certain old pine lands only because it has the habit of holding its cones and shedding its seeds gradually. If, therefore, the tree should be killed, there remains a stock of seed for renewal. All other species are exterminated by these fierce fires till the ground is again reseeded by the slow processes of nature.

Besides, these calamities of climate and season, of fire and flood, are occasional and local in their happening, not constant and general, so that in a large sense the free and unrestricted increase of earth's millions is thrown upon the world for maintenance, and there is not enough. The only alternative is a

FIG. 8. In a fight against snow and cold the bison can hold his own

wholesale destruction of individuals by starvation, in which the strongest alone survive.

The competition for food is, therefore, the chief element in the struggle for existence. There is no common food supply for all species, but everything, from the biggest to the littlest, from the strongest to the weakest, lives upon its neighbor, and it is literally true that the chief concern of each inhabitant of the wild, and the one upon which he bestows most of his time and his principal attention, is to secure something to eat and to avoid, in return, being eaten himself. With one eye on his prey and the other on his enemy he balances his chances and gambles with death every day of his life, — all without realizing either the magnitude or the intensity of the game he is playing.[1]

The big fish eat the little ones; the wolf and the jackal hunt beast and bird; the feathered tribe makes life intolerable for beetle, bug, and worm; and while beak and tooth and claw are busy with destruction, the parasite sucks the blood of the depredator or gnaws his vitals out as he hunts his defenseless prey. Nothing is exempt. It is a warfare not only of strength and cunning but of resistance and endurance as well.

This consumption of one species as food for another is immensely destructive of individuals. A single large animal in a day will consume seeds or small plants literally by the thousand; often, besides, it destroys as much as it eats. It is estimated that each cat on the average destroys fifty birds per year. One large fish will consume immense numbers of small fry. Most eggs of birds serve as food for snakes or other birds. Only a few are hatched, and most of these follow the fate of the egg in which life was destroyed before it appeared.[2]

Broadly speaking, and in general terms, animal life subsists upon plant life, and it in turn upon the mass of nonliving matter of which the world is made, so that the two together complete a kind of cycle, ending where they began, after the animal has finished its life and returned to dust. It will not do, however, to rest so important a matter on such generalized and imperfect statements. Briefly and substantially the facts are as follows:

All living structures[3] are characterized by more or less highly organized compounds, of which carbon, oxygen, and nitrogen are

[1] Man is undoubtedly the only animal that has any true knowledge of death, or appreciation of it when it has occurred. Wild animals attack moving things and are entirely satisfied with simulated death; that is, they fight whatever moves, but desist when motion ceases unless impelled by hunger, in which case they do not wait for cessation of motion, but eat the prey alive or as soon as its escape no longer seems likely.

[2] It is impossible to estimate the destruction wrought by such predatory animals as the blue jay, the kingbird, the hawk, and the cat.

[3] By this is meant the bodies of animals and the stems and leaves of trees and plants.

characteristic and essential elements. Now the world's supply of these important elements is in the form of exceedingly raw material floating in the air. Oxygen can be taken in by the leaves of plants and the lungs of animals and used at once and directly by the organism. Carbon and nitrogen, however, exist in the air in a condition useless for the direct needs of either plants or animals.

The great problem of subsistence is therefore, primarily, to get carbon and nitrogen, which all animals and plants alike, whether large or small, high or low, must secure in large and constant quantities in order to maintain life and its activities.

Now carbon exists in combination with oxygen as CO_2. This is a very simple but a very stable compound, and in this form no animal can use it. Only the green chlorophyll of leaves, and that in the presence of sunlight, can break this compact with oxygen, and thus the pioneer labor of securing carbon and bringing it into more complex compounds, especially those including hydrogen, is, and must be, performed by the higher plants; and on these and their remains must all animals depend for their carbon supply, as must also the nonchlorophyll plants like bacteria.

Of course many animals live on other animals and thus short-circuit the carbon problem, just as many bacteria are directly parasitic on living plants and even animals. In general, plants and animals both take their oxygen direct from the air, but a few bacteria and other low forms of plant life depend upon getting oxygen as they do carbon, — by taking it from its combinations, even in a living plant or animal. Such parasites are, of course, dangerous to life, and they lie at the base of some of our most troublesome plant and animal diseases.[1]

Nitrogen is still more difficult than carbon to bring into the combined state. It is a lazy element, and the immense stock in

[1] It would be a mistake to assume that all diseases, even those of a germ character, are due to vegetable parasites. It is now generally held that the germ of smallpox, for example, is a protozoön, that is, animal rather than vegetable, though at this level of life we are down where plants and animals shade into each other by almost imperceptible differences.

the atmosphere is useless alike to animals and plants except a very few species of bacteria which constitute, so far as we know, the only means for collecting available nitrogen except the slow and irregular action of electricity.[1] In this way all life, both plant and animal, depends almost absolutely for its nitrogen upon bacteria, the smallest of all organisms, invisible to the naked eye and so exceedingly minute that a hundred of them placed end to end would not reach through the thickness of this sheet of paper. On how slender a thread does the life of the world depend!

Every species, therefore, lives wherever it can find suitable food, and does not hesitate to attack another, living or dead, and consume its substance either by the rending of its flesh and the consequent quick destruction of life, by sucking its juices as an external parasite, or even by invading the very body of its prey and consuming its vitals with slow destruction. This is very common among insects, one species laying its egg in the body of another, where it hatches, producing a larva that lives at the expense of the host till death ensues, by which time he is ready to undergo one of his transformations and afterwards "go it alone."[2]

And so it is that food means indiscriminate slaughter by both sudden and lingering methods, so it is that the struggle for existence is chiefly fought out at this point, and so it is that the food supply is the chief consideration in fixing the prosperity and the life tenure not only of individuals but of species as a whole.

Competition for room. This is no less real than is competition for food, but it applies to plants rather than to animals, which seldom suffer for mere space. When, however, by chance plants come up too thick for standing room, they are bound to suffer

[1] The electric spark serves to combine nitrogen and hydrogen in small amounts, but the world's supply of nitrogen is supposed to be dependent upon bacterial action.

[2] It is common for wasps to sting a supply of insects, paralyze them, plant an egg in each, and pack them securely away to serve as food for the young larvæ as they hatch.

and the weakest are doomed. Under such conditions there is, of course, a competition for food from the limited amount of soil at hand, as there is also for moisture in time of drought; but the chief competition is for sunlight.

All growth in weight of plants is attended by the fixation of carbon from the carbon dioxide of the air, but the process is a chemical one that takes place only in the direct rays of the sun. The growth of plants is therefore absolutely dependent upon their leaves being constantly exposed to direct sunlight. When, consequently, individuals are closely crowded together, only the tallest can push their leaves up into the light, while the others are overshadowed and shut away from the only power that can put carbon into their structure. Accordingly they must die, not exactly from starvation but rather from inability to make use of the plant food of the air.

This is the principal way in which tall, quick-growing weeds injure crops by getting the start, and, being able to keep it, they kill the crop or greatly check it by shutting off completely or partially the direct sunlight. This is why sweet corn and Kafir corn are so much more difficult to raise than is Indian corn, especially in the moist climate of the so-called corn belt. The plants themselves are at first small and slow-growing, while the weeds of this region are quick-growing with rank stems and broad leaves, which quickly overtop and shut out the sunlight from the crop.

The same effects will follow the attempts to get a "stand" of alfalfa unless these weeds are kept cut off. The young alfalfa sends up at first but a slender stem with few leaves, and until the root is well established it is no match for rank weeds that reverse the process, namely, expend their first energies in producing stem and leaf. Indian corn, on the other hand, will, with a fair chance, grow almost as fast as any weed, and in any event always "keeps its head up."

We take advantage of this principle in killing especially troublesome weeds like Canada thistle and quack grass, which have the underground rootstock. Everybody knows that ordinary cutting or pulling avails nothing, for they merely send up new shoots from the buds already formed in the running rootstock under ground. If, however, this new shoot and leaf are killed by cutting off at once, and the next and the next treated in the same way as soon as they appear, the plant will die in time, for it has but a limited number of "buds" and a limited amount of food stored in the stem; and if it cannot soon get new leaves to the sun for more carbon, it must give up the fight and die. Plowing thoroughly once a week for a single season will kill any weed.

This struggle from overcrowding is best seen in the growth of young trees in the forest. Many more seedlings will start than can possibly live, for a fully matured tree needs and will take a space from ten to fifty and in some cases even one hundred feet across.

Accordingly when young trees stand thick a struggle at once ensues as to which shall overtop the others and get to the sunlight. The strongest will, of course, be the tallest and get the most light. This in turn gives it more carbon and greater growth, with still further advantage over its fellows, which manage to live as long as they can keep a few leaves in the sunlight, and then die when the failure, which is inevitable, really comes.

It is interesting and almost pathetic to see the extent to which this struggle for sunlight and life is sometimes carried. The writer once saw a specimen that had recently died out of a thicket of young maples. It was thirty-six feet high, yet was but one and three-fourths inches in diameter at the largest place, so completely had its little growth been converted into height at the expense of size in the vain effort to keep its few leaves bathed in the precious sunlight. This tree never stood quite alone, but leaned helplessly against its stronger neighbors after the fashion of a vine.

Among the trees that remain, the same principle applies as between the upper and the lower limbs. As new branches start out above in the struggle upward, the lower ones are shaded the same as those of the lower-growing trees, and ultimately for the same reason die and drop off. In this way trees growing in close proximity to each other develop tall bare trunks valuable for timber, while those growing in the open would not be forced upward by competition nor would the lower limbs be killed. Such trees develop beautiful tops, being lighted on all sides, but they never make timber trees, however old or mature.[1]

FIG. 9. The best possible condition for rapid growth, as it affords opportunity for maximum exposure of leaf surface. This grapevine consumed four years in covering the first ten feet of the derrick, but with this start it ascended the remaining forty feet in one year

Competition most severe between individuals of the same species. At first thought it would seem that members of the same race would live in peace and harmony together, and that the competition would be between different species only. But that is not so. In so far as competition exists at all between individuals of the same race it is the most severe of all.

In the competition for food, whether plant or animal, the needs of the same species are identical, the methods of growth in plants and the hunting habits among animals are the same, and the competition is much more direct than where needs are not quite the same and habits are somewhat different.

[1] It is suggested that the student verify the foregoing statements by visits to weedy fields and to young forests.

In respect to room the same principle holds. Plants of the same species have a nearly equal rate of growth, so it is a neck-and-neck race from start to finish, and often the struggle is so nearly equal that they all go down together. It is the case of Greek meeting Greek over again.

The best example of this is the familiar one of overseeding. Ofttimes the farmer in finishing his seeding of oats or wheat will drive across the end of the field to cover unseeded spots. In this way much of the strip thus covered gets a double seeding. The slender, "spindling" growth of leaf or stem and the greatly reduced yield of such places are familiar to all grain farmers, as is the general appearance of most fields of "sowed corn," where so much seed is put on that there is neither room, moisture, nor fertility to mature it all, so the total result is a weak, stunted growth of all the plants, engaged as they are in a mutually destructive competition.

The fact that a heavier yield of hay and pasture can be produced by ground sown to mixed grasses than when sown entirely to one variety depends partly upon the principle here under discussion, and partly, especially with pastures, upon the fact that different species take on their best growth at different seasons of the year, thus lessening by that much the direct competition.

The fiercest battles among animals are not those waged for food, which are for the most part exceedingly unequal conflicts. They are those waged between the males of the same species, which are in almost constant conflict, especially during the breeding season, those of different species rarely troubling each other except for food.

Among animals that herd in the wild, like horses, cattle, and bisons, one mature male in the prime of life assumes the leadership of the herd, and he will maintain it as long as he can master any younger aspirant that feels he has attained the strength and endurance to try conclusions. Some day the successful aspirant will arise and prevail over the favorite, who will then retire to the rear, and the herd will accept the new leadership. In this way only the very choicest and most vigorous survive to head the herd.

Natural selection. And so the competition goes on against fire and flood and drought and cold; against talon, tooth, and claw, till the weakling goes to the wall. When there is not enough for all, when the dinner of one means the death of another, when the problems of life become reduced to the elemental instincts of hunger and self-preservation, then slaughter begins and death and extermination are everyday employments. This is natural selection, or the weeding out of the weakest.

This reduction process of nature is not always attended with violence and bloodshed, but is often silent and inconspicuous though none the less relentless. The woodpecker digs his worm out of his burrow in the timber, and only the longest and hardest bill will provide enough when worms are scarce. This competition based on quality of bills is not conspicuous, but it is, after all, direct and effective.

A mass of vegetation of many species is growing on the same area.[1] As none can move they all must stay and fight it out together. Now is the struggle for room combined with that for food, and it is a battle royal with no noise but with plenty of fatalities.[2]

In this selective process the vigor of the conflict and the intensity of the selection are much dependent upon conditions, whether favorable or unfavorable to life in general. It might seem at first that where conditions of life are least favorable,

[1] Try the experiment of counting the number of different things that can be found growing together on a square yard of old turf.

[2] Read "The Battle in the Meadows," by Maxwell T. Masters. This fascinating little book describes the effect upon the mixed herbage of an old park at Rothamsted, England, when fertilizers of different kinds were applied. The effect of each upon the struggle between the different species growing together, some being favored by nitrogen, for example, and others by potassium or by phosphorus, constitutes one of the most fascinating nature stories ever written.

the reduction would proceed furthest, but, in general, such is not the case.

For example, many more species of plants will grow together on poor land than on rich, and if fertilizer be applied to such a spot supporting a feeble growth of many species, their number will be at once reduced.

The reason of it is that under generally hard conditions nothing succeeds well enough to institute a vigorous fight, but as soon as conditions are improved, as by the addition of fertilizer, then at once some species will succeed so well as to crowd others down and possibly out. This is one test of the natural fertility of lands, namely, the number of species found growing together upon it in a state of nature; and the same principle is employed by good farmers who make the land so rich that the crop will choke out the weeds.[1]

Survival of the fittest. The result of natural selection is the survival of the fittest. This does not mean the best from any standpoint of ours, but it does mean the ones that fit best into all the conditions that determine the issue of the struggle.[2] It would be the woodpecker with the longest and hardest bill, the wolf with the best scent and the highest speed, the bull with the sharpest horn and the strongest neck ; indeed, among savage animals it means the supremacy of the longest tooth and the sharpest claw.

Among the hunted it means the horse with the fleetest foot and the greatest endurance. It means the deer or moose with

[1] This principle also explains the relative inaction of the desperately poor and distressed portion of the degenerate class. If they were better fed, they would be more aggressive and consequently more dangerous. So does natural selection work among humans as elsewhere.

[2] For example, a savage and a sage may be so situated that skillful running alone will save life. Then for that purpose running becomes the test of survival, and the savage alone may be able to meet the test, in which case his is the best "fit" with the conditions. Under most conditions, however, the sage would have the advantage. All this means that the best trained man is the one that is able to meet and fit into the greatest variety of conditions that are likely to come his way.

the most inconspicuous color. For example, the white color of the albino deer, shown on page 102, would be against him, as it would be in favor of the polar bear with his different surroundings. It means the bird or beast most successful in hiding or in eluding its pursuers, and everything which helps in this will help to make the "fit" more perfect and thereby to more certainly insure survival.

With plants it means the fastest-growing stem which will most certainly reach the sun, or the deepest-running root which alone will secure moisture in time of drought; it means the most spiny covering which protects best against herbivorous animals, the most showy flowers or the most penetrating odors which best assure fertilization, or the most toothsome and conspicuous seeds which best attract bird or squirrel to carry off and bury, some portion of which is never recovered. These are the circumstances that determine the fitness to survive.

On careful study it will be seen that every species has some natural trait or character, which, in a state of nature, enabled it to survive, else it would not be here now; and of this species the individuals that possess this character in the greatest perfection are the ones that best withstand the rigors of natural selection. Species and individuals not possessing such natural advantages at once become extinct, as do those whose advantage is rendered worthless by some sudden change in the surroundings.

For example, the natural advantage of the birds generally is their aërial flight and their powers of rapid reproduction; with the yellow butterfly it is his offensive taste; with the caterpillar it is his hairy covering, which, like the spines of the porcupine, are unpleasant to the attacking party; with the cat tribe it is the prehensible claw and the silent tread; with the antelope it is his wonderful scent and his fleetness; with the pig it is his long snout with its remarkable rooter; with the elephant it is his trunk; with the beaver it is his tooth and his tail; with the snake it is his venom and his incurving teeth; with the sheep, bighorn, and chamois it is the ability to climb where only the eagles can follow, and to take flying leaps from crag to crag.

All species and individuals not possessed of some such natural advantage, or with whom the advantage has been rendered worthless, go down early in the struggle. Of course such great natural calamities as fire and flood, making wholesale destruction, take everything both good and bad, fit as well as unfit. Such events come so infrequently and so suddenly that nothing can meet their exactions.

The fate of species, however, is not settled by these sudden and calamitous events except in rare cases and for certain localities.[1] This fate is settled by the slow and relentless method we have described, in which literally thousands of every species undertake to supply the cravings of hunger and the needs of life to the best of their ability, but go down in the struggle to defeat and death, while others carry on the struggle with occasional success. These alone count in the line of descent.

The individual and the race. It is, indeed, a savage picture that we draw when we attempt to depict nature at work in her workshop with living beings for her tools and her materials. Everything is relentlessly pursuing its own advantage and spending its time in killing and eating or in being eaten in turn as it surrenders to the inevitable,—a savage tearing mass of animated matter spurred on by instincts not understood and by impulses incapable of comprehension, the end of which sooner or later, whether successful or unsuccessful in the struggle, is death.

Looked at in this large way, life at best is but a doleful picture, for, as some one has remarked, the life of every animal in the wild is a constant terror and its end a tragedy. The pathos of

[1] It is more than likely that such sweeping changes as the glacial epoch do operate to exterminate species at wholesale off the face of the earth. Instances are not wanting where species have been stranded by the retreating glacier, such as the wild primrose on Mount Washington and on the north side of a single ledge in southern Michigan. Many species, too, were swept off as the glacier advanced, and were unable to return with its retreat, as in England, which has a much simpler flora than has France, just across the Channel.

this fruitless struggle of millions as they stem the tide with difficulty for a moment, then join the inevitable stream of death, and the apparent heartlessness of it all, lead us sometimes to question the plan and to wonder if, after all, life is worth the living.

This is a gloomy view, however, to take of life, whether animal, plant, or human. There is another and a brighter picture, if only we will clear our vision to its perception.

Existence is a great mystery. The individual is but a unit in a gigantic plan — a never-ending, always-changing panorama of life. As Shakespeare says, "All the world 's a stage, and all the men and women merely players." Each acts his part and says his lines, then passes off, giving place to another, that the great drama may proceed and the whole picture be presented. The individual, therefore, is fleeting, but his race goes on forever, or as long as the balance of life is in its favor ; and one of the duties of the individual is to help preserve that balance, which he often does by surrendering his life.[1]

Among the lower species the grade of intelligence does not enable the individual to see the plan or even to know the issues, much less to anticipate its fate.[2] Accordingly it derives its enjoyment day by day in living its life, seeking its food, and rearing its young as if it were to live forever, and when the unconsciously approaching end comes — a brief struggle, lasting but a moment, and all is over. So nature is, after all, happy, for the tragedies of life are mostly unknown in advance, they pass quickly when they come, and are soon softened if not forgotten.

If only the fittest survive, then will the next generation be born of highly selected parents, and so will the race progress. This is evolution ; and whatever the place of the individual in the scheme, the race as a whole is bound to advance. Though

[1] In the time of war men do not count their lives in the struggle to preserve the nation or to repel invaders, any more than they have counted the cost of human liberty.

[2] As has been remarked already, the animal has no knowledge of death or of the meaning of life. Man is probably the only one that has the slightest intimation that life is limited.

the plan seems heartless, it is, after all, beneficent, when we regard the future and the coming generations as well as the present and the individuals.

So there is another and a brighter picture. We humans have been given a larger view of life than have the animals about us, and while we cannot comprehend all the plan, we cheerfully devote our lives not solely to our own enjoyment but also to that larger service to mankind in general, to the end that future generations may be the happier because of our having lived. Just as we are realizing the advantages of what our forefathers did for the world before us, so we make our contribution for the benefit of those that shall come after us.

It is for us, therefore, to recognize the fact of this great warfare in nature, and in man's affairs as well, without permitting it to embitter life; and to order our own lives and their activities to the advantage of the common good, getting our satisfaction day by day as we go along in the consciousness of faculties well employed, thankful after all for the opportunity to live, to enjoy the world, to contribute our share to the great upward struggle of the race, and to act our part and say our lines in the great drama of existence, all of which is a part of the divine plan, too large for our comprehension, just as the stars are too many and too far away, and the universe too vast and too complicated, for our understanding.[1]

In proportion as we see the distinction between the individual and the race, in that proportion will we understand the true meaning of the "great debt to nature," and we will come to appreciate that the principle, "to him that hath shall be given," is not so much for personal benefit as for the general good.

[1] This digression is made for the reason that many, especially young people, not knowing thoroughly the field of evolution but stumbling upon a portion of it by accident, are led to gloomy, short-sighted, and morbid views of life. It is hoped that as the subject is further pursued, the discussion may make clear many of the points which trouble the minds of many people often through life.

Significance of numbers. In so far as natural selection is a contest between different species the question of relative numbers is an important one, because the hazard of a good "fit" is greatly reduced with increasing numbers. Rare and slow-multiplying species not only run the chance of few good fits with the environment, but they recover slowly after disastrous experiences.

The stronghold of insect life is their rapid reproduction. A succession of adverse seasons may seem to have almost, if not quite, exterminated some troublesome species, but a few especially hardy and resistant individuals manage to live over, and, with their rapid breeding powers, soon produce a new stock even more vigorous than before. This is improvement by natural selection. In this way adversity is good for the species, — though fatal to most individuals, — and, providing only enough can live through to restock the region, the species will be rapidly modified by the selective process.

When it is a troublesome insect or weed that is involved, we are not interested in its prosperity, but the same principle applies to valuable species even in domestication. For example, it is the pigs that produce large litters whose descendants finally constitute the herd, while some favorite may, from sheer lack of breeding powers,[1] leave nothing behind.

The perfectly wholesale production of seed by plants in general is, to a considerable extent, an offset against their natural disadvantage in being fixed as to habitat and unable to move away from undesirable conditions to find better ones.

Significance of vigor and length of life. This is of even more importance to the race than is rapid reproduction. The experiences of life make the mature individual of higher usefulness than the younger, especially with races in which the young are cared for and to some extent trained by the parents.

[1] Farmers often fail to notice the operation of this principle, and keep many breeding animals because they are favorites in form or have fine pedigrees, when they are doing practically nothing as breeders. The herd will of course consist of the descendants of prolific breeders, which alone can produce numbers sufficient to afford material for good selection.

If the great problem in existence is the perpetuation of the species, then the individual helps the object forward in either one of two ways, — by reproduction to insure new numbers, or by improving conditions of life, thus reducing selection and lengthening existence.

The number of any race at any given time, therefore, is quite as much dependent upon the length of life as it is upon the rate of reproduction;[1] indeed, many disappearing races of men are slowly failing in the face of rapid reproduction because the individuals are not well enough conditioned to attain full and ripe maturity and establish and maintain good conditions of life.

This principle is of special application in the breeding yards. Suppose, for example, the farmer has three classes of cows of different degrees of fertility, — one that will raise but two calves, one that will raise four, and one that will raise six, before they die or stop breeding; and suppose, for sake of the illustration, that the descendants will do the same respectively. Remembering now that only half the descendants will be females, let us see how the account would stand with these three classes of cows and their descendants, say, at the end of the fifth generation.[2]

THE MEANING OF RELATIVE FERTILITY

Classes	Female offspring	Generations				
		First	Second	Third	Fourth	Fifth
First	1	1	1	1	1	1
Second . . .	2	2	4	8	16	32
Third	3	3	9	27	81	243

It is easy to see that cows of the third class and their descendants would not only soon constitute the herd but afford abundant material for selection in the meantime. It is so with

[1] Race suicide that is now so much talked about is not so much a matter of the size of families as is commonly supposed; it is quite as much involved in the matter of health and long life.

[2] See "Principles of Breeding," p. 199.

wild species; the new generations and, in the end, the stable stock is constantly arising, not from the general mass, but from a few exceptional family lines of great vigor, long life, and fair fecundity.[1]

Significance of offensive and defensive weapons. It has been remarked before that man is the only animal able to use weapons other than those with which nature endowed him. Some of these natural endowments are, however, remarkable both in their character and their usefulness.

It is natural for any intelligent being to make use of any part that will help either in defending himself from his enemies or in assisting him in taking his food. In this essential business some make use of one part, others of other parts.

In general, the extremities are likely to be covered with hard and often more or less sharp or cutting parts. If so, they are exceedingly useful to the possessor as means of inflicting injury by blows, puncture, or tearing. Horns, hoofs, teeth, and toenails are mighty weapons on the earth, and when the same species happens to have two or three of these natural weapons well developed at the same time, he is a formidable enemy. A notable instance is found in the tiger and the cat family generally. The grizzly bear has both tooth and claw terribly developed, but his claws are not retractable, and he is incapable of the stealth of the tiger.[2]

Not all species are armed with such terrible weapons, though every one has some advantage sufficient to enable it to secure

[1] It is so with people. Comparatively few individuals alive now will be in any way represented in the blood lines that people the world five hundred or even one hundred years from now. The people then living will trace their ancestry to a few of the most vigorous and virile, but not necessarily the most prolific, of existing families. The future of the human as well as other species depends quite as much upon quality and longevity as upon numbers.

[2] Enthusiastic amateur students of natural history often descant upon the beneficence of nature in thus providing her children with certain means of getting food, forgetting, it must be, the interests of the victim and assuming a partiality between the species that does not exist. Nothing was made especially to be eaten, nor are all the favors bestowed on a few species (see a later paragraph on Design in nature).

its food, else it would not have persisted; and species not so endowed, of which there have been many, have long since disappeared from the earth. It is only when the food is alive and able to fight or run that weapons of offense are useful except to rival males in battle. Herbivorous animals, like cattle, and vegetarians generally do not need weapons of offense and commonly do not possess them, though there are abundant exceptions.

The ostrich, for example, has no need of weapons of offense and its great speed constitutes sufficient defense; yet it can use its strong leg to advantage as a weapon in striking. The giraffe is without weapons, offensive or defensive, and cannot exist in the presence of enemies except those he can outrun. The elephant's trunk is primarily useful as a feeder, but he uses it upon occasion as a weapon of terrible execution.

For the most part the snake has no weapon but his teeth. Some paralyze by venom, but most of them are comparatively helpless, having no extremities but a harmless head and a useless tail. If, as in most cases, they are armed with incurving teeth, the victim once caught cannot well get away; but in general the snake must swallow the prey alive or kill it in the only way possible, namely, by crushing with its own body, — a most awkward but terribly effective way of getting on.

A few animals like the skunk are able to discharge an offensive secretion to a considerable distance and thus manage to secure a pretty wide berth. Others, like the hyena,[1] can discharge a liquid not particularly offensive but directed with considerable accuracy and disconcerting effect.

A few lucky fellows like the hedgehog, whose custom it is to let others alone, are so provided that they can roll themselves into a ball and defy the world. Others, like the squirrel, not so endowed must show a clean pair of heels.

[1] Said to be the only animal that hates everything and everybody, itself included. Practically incapable of taming, it never forms friends among either animals or attendants.

Some utterly useless species are well protected. The miserable little grass, *Danthonia spicata*, that grows freely over New England hills is thickly studded at the base of the stem with short but sharp hairy spines that cattle avoid. The nettle is covered with fine needlelike hairs which on contact discharge minute bits of acid capable of giving a burning sensation to people and thin-skinned offenders, but useless with most wild animals. The thistle, however, has a weapon worth while.

Speaking generally, weapons of offense or defense, especially the former, are good things to have, and when present are generally made the most of; but when absent another way is sought, and if one good enough is found, the species can be successfully preserved without weapons, as is the case with the antelope and deer, which are the gentlest of animals.

It is notable, however, that the character or part on which the species depends most for its existence is most highly developed, even though in other respects the animal or plant may be very defective. This, of course, is due to the fact that the effects of natural selection have been long felt in that particular part, while others have been neglected and left undeveloped. In this connection compare the remarkably efficient trunk of the elephant with his exceedingly awkward feet, which belong not to this but to prehistoric times, and have remained practically undeveloped and unchanged since the earliest ages.

Space could be filled indefinitely with this vast and most interesting phase of the subject. The important point is, however, to note the fact that while weapons are convenient they are not indispensable, and that some species that have the least use for them have some of the best ones, — bees, for example, — though whether in remote times they may have been more useful we can hardly say with confidence, because sometimes a sudden change in the surroundings renders useless a part that before was next to indispensable. Fig. 10 represents a tropical butterfly that spends much of its time on stakes and stubs where it is practically indistinguishable from the lichens, especially as it has the habit of resting with its wings spread flat and not folded back, as is characteristic of most species of the butterfly.

Significance of protective coloring and markings. Quite akin to the utility of weapons is the whole matter of protective coloring. By this is meant in general that color or an assemblage of colors which so blends with the surroundings as to make creatures inconspicuous on the one hand, or, on the other, to look like something which they are not, as, for example, when an insect or animal is colored similar to the ground or the foliage it inhabits, or when it looks like another species that is

FIG. 10. Lower and upper surface respectively of *Ageronia feronia* (author's specimen); general color, a greenish gray

commonly dreaded and avoided. Such utility is mainly defensive, though on occasion it might facilitate the approach of an animal upon its prey.

At close range the high colors — red, green, blue, etc. — stand out distinctly, but in the distance all colors tend to blend into a theoretical white, in fact, a dirty gray, as may be noted when viewing a distant scene where the earth and sky line meet almost imperceptibly.[1] Artists know this fact and use the grays for distant effects except when under strong sunlight.

This explains why so many animals that live more or less in the open are of a dirty brown or gray color. Of all shades it is

[1] On the principle that all colors taken together make white. In nature all colors do not exist in proper proportions and the general result is a gray.

most inconspicuous in the greatest variety of surroundings.[1] Thus deer and moose feed in safety both in winter and summer where they would be in far more danger if their coats were red or black; indeed, adaptation has gone so far in these animals that the coat is lighter in winter than in summer, and thus blends still better as the foliage gives place to snow.

The most highly colored birds are those that live among the foliage and flowers of the tropics. Snakes and lizards closely imitate the dull colors of the grounds they infest, and while the resemblance is not close, it is more effective than would at first seem possible. Many insects are as green as the leaves they sit upon, often for no other reason than that the green chlorophyll from the leaves they have eaten shows through the thin texture of their bodies. Others, like these shown in Fig. 10, are variously colored in close resemblance to their most frequent habitat.

Mimicry. Closely akin to protective coloring is mimicry; indeed, mimicry is the idea of protection carried a step further, in which the resemblance is not so much to the background as to some other specific object.

On the border line of the two is the peculiar marking of the zebra, the tiger, and the leopard, which at first thought would seem to make them conspicuous. However, the facts are that such a striped or spotted animal lies well hidden in the thicket or the jungle, for the peculiar markings and outlines of his body are not quickly distinguishable from the lights and shadows which the sunshine casts about him.

True mimicry, however, is more exact, and some cases are quite remarkable. Of all created things butterflies are able to show the best cases of mimicry from their remarkable coloration and from the general resemblance of the structure of their wings to that of leaves. For an example of color mimicry refer

[1] This is the reason why the United States has abandoned the blue uniform and the British the red for the dirty-looking but really serviceable and inconspicuous khaki.

again to Fig. 10. Like most colored insects this butterfly prefers localities colored like himself, and he often lights and sits for a considerable time on trees and poles more or less covered with lichens, from which he is indistinguishable except on the closest scrutiny.

This is true mimicry. The remarkable part of this particular case is the habit of lighting and the manner of sitting. The butterflies as a rule fold the wings together on the back immediately upon lighting, but this particular species, instead of folding the wings, spreads them flat and sits with them in that position. The resemblance to the lichen is not very exact, but

FIG. 11. Lower and upper surface respectively of *Anæa phidile* (author's specimen), a tropical butterfly of the color of a dead leaf

it is close in a general way, and the writer has often studied for some minutes to find the specimen and make out the outlines even when he had seen the creature in the very act of lighting.

Mimicry in structure is illustrated by another butterfly, which, with its wings folded together, exhibits a venation quite like that of a small leaf of the beech or similar tree. Being of a brown color, its resemblance to a dead leaf is close. It has two very different methods of lighting. Commonly it folds its wings not after lighting but before, in which case it flutters to the ground not unlike a dead leaf falling from the tree. In other cases it lights directly upon twigs or stems, in which instance it lights as would any other species, but stands with the hinder points of its wings close to the stem, the other portion standing out like a dead leaf not yet fallen. The peculiar long-drawn-out point at the rear of the wing, from its close resemblance to the stem of the leaf, heightens the deception (see Fig. 11).

Instances could be multiplied indefinitely showing how one form in nature imitates or more properly resembles another, generally to the advantage of one or the other, if not of both. For example, certain flies without stings closely resemble bumble-bees, not only in general appearance but also in manner of flight. The resemblance might be closer, but it no doubt is some advantage to the impostor and insures him a wider berth from boys, at least until they learn the imposition, after which its advantage is a matter of doubt, as any boy can testify who has had the satisfaction of tormenting "shade bumblebees."

Design in nature. The consistent student must not interpret these and similar facts too literally. The hasty observer and careless writer sees "design" in every detail. The fact is that in nature there are many resemblances of structure between widely separated species, and it is inevitable that similarities should occur. When once they happen to be of selective value, then natural selection rapidly shapes them up and makes the resemblance closer still.

For example, the flat, thin structure of the leaf requires some system of ribs and veins for its support. The wing of the butterfly has the same structural necessity and for the same mechanical reason. The two structures, therefore, the one plant and the other animal, are built and must be built upon a similar plan. It is inevitable, therefore, that there should be many close structural resemblances, and as the butterfly takes his initial color from the green of the leaf, these resemblances are often still further heightened by remarkable color effects. In many ways, therefore, butterflies resemble foliage.

Causes of color in animals and plants. The world owes no little of its beauty to the range and variety of color of its plants and animals, and it is worth the while to note briefly how nature produces such marvelous effects in such natural ways.[1]

Colors of animals and plants are due to the following distinctly different causes:

1. The manufacture of specific coloring materials or pigments either as a necessary part of the body activities or as a matter of accident. For example, the universal green color of plants is due to chlorophyll, the blue of which fades as the leaf ages or yields to the influence of cold, leaving the yellow behind to characterize the foliage of autumn.[2] The green of birds is due to a specific pigment with no physiological function like that of chlorophyll; it is a color never found in mammals.

Red, on the other hand, is widely diffused among both plants and animals. The red color of blood is due always to hæmoglobin, a substance also produced by a great variety of organisms. Red pigments, however, are produced by plants, especially in the flowering parts and in the leaves of certain species, rarely during the growing period, but more commonly late in the season.

Yellow, whether in plant or animal, is the result of an oily pigment, and the three pigments, yellow, blue, and red, in varying proportions and distribution are capable of producing about every color found in nature, though browns, blacks, and even occasionally whites are the result of specific pigment.[3]

[1] We have a habit of mind which leads us to feel that when an event or occurrence is known to be natural, then all mystery is cleared away. This attitude of mind is wrong, and it deprives us of some of our chief opportunities for higher meditation. We plant a seed and it grows into a tree. We say, "There is no mystery in that,—it was natural"; but the truth is that if we really consider all that has happened, we shall see that a greater miracle has been performed than the making of the dumb to speak, the blind to see, or even the raising of a man from the dead. With all of our philosophy and all of our science we know nothing about life, — whence it comes or how it works; we only know some of the things it does.

[2] The student is reminded that green is not a primary color, but a mixture of yellow and blue.

[3] The student will remember that the so-called three-color process of printing succeeds in reproducing practically all colors by the proper mingling of these three primaries — red, yellow, and blue. Nature does the same.

2. Closely akin to this is a second cause of color, namely, a body surface so delicate and transparent that the color of the creature is fixed by that of the internal parts, as in certain earthworms, in which the color is due to the blood showing through the transparent skin, while in related species a dark surface pigment obscures the blood and gives its own color to the worm. In other cases, as frequently in larvæ, which do not have red blood, the contents of the digestive tract show through the skin and give color to the insect. In this way all leaf-feeding larvæ that have transparent skins are green in color ; that is, they look green, though that which gives the color is only the chlorophyll of their food.

3. Very similar to the above is a class of cases in which the pigment, instead of being fixed at the surface, as in hair or skin, is contained in irregular-shaped cells extending from the surface to considerable depths beneath the skin. When the creature is at rest or in its normal conditions, the pigment lies near the surface and gives its color to the animal ; but if it be paralyzed with sudden fright, the surface layers of the skin contract and drive the coloring matter into the deeper layers and out of sight, so that the creature undergoes a blanching process quite akin to the sudden paling of the face when the blood is driven out of the surface veins by sudden fright.

4. A fourth cause of color, especially in animals, is the storing away in the cells of the body of certain waste materials taken in with the food and not digested or otherwise eliminated from the body. A common example of this is the color of many butterflies whose larvæ feed freely upon leaves. If the chlorophyll is not digested or otherwise changed, it is packed away, especially in the cells of the wings, either uniformly or in more or less regular patterns dependent on the structure. In such a case the butterfly would necessarily be green.

If, however, it should secrete some material that would dissolve out the blue part of the green, either wholly or in part, the butterfly would be yellow, either all over or in spots. If, however, the yellow should be dissolved away, then the creature would be blue, either wholly or partially, unless indeed it should also secrete red pigment, which would then discharge its own function in fixing tints which, with the blue, would extend to violet or even black.

Another very different case of the same order is the white or light color quite common to the under scales of snakes and lizards, an effect due principally to the storage there of lime, as we store the same substance in our bones, coming in both cases from the food. With them it is a thoroughly waste product, as it is with us late in life after the bones are finished, when it often makes trouble by collecting in the bladder or kidneys in the form of small stones.

5. The scintillating effect like the metallic luster of certain plumage is due not to pigment but to strictly mechanical causes. In the humming bird, for instance, the surface of the feathers is covered with minute striæ, which, by their unequal reflection and slight refraction of the light rays, give that beautiful play of colors with which we are all familiar, and which is not greatly different in its character from the play of colors in pearl, which is also due to the fact that the pearl consists of exceedingly thin laminæ laid one upon another.

6. There is still one more cause of coloration worth mentioning here. In a desert where everything is of a dull gray there is practically no white light, because certain rays are absorbed by the universal monotony of nature. If there is no white light, then nothing will appear in its natural colors, but everything will appear to be of a dull gray, because there are no other colors at hand to be reflected to the eye, just as in an artificial red light everything *appears red*, no matter what its color might be in perfect light, because there are no other rays to be reflected.

The student needs to be exceedingly careful, therefore, in generalizing about color markings and utility. The color, especially of animals, is often highly protective, and then natural selection tends to make it more so. On the other hand, the color may be unfortunate, in which case the species will go through the world with a perpetual handicap, except as selection is able to tone it down and relieve it of some of its hardship.

Color is not based upon utility, nor is it dependent for its function upon the presence of light. Some of the most brilliantly colored fishes reside in the depths of the sea, so remote that no ray of light ever reaches them. Everything must have some relation to light and therefore will have some color when brought into its rays. If it reflects them all, it will be white ; if it absorbs them all and reflects none, it will be black ; if it absorbs all but the red, it will reflect those rays and we will call it red ; if it absorbs the red and reflects only the yellow and the blue, we will call it green, and so on with the infinite changes and combinations that result through the relations of absorption and reflection.

So we might go on indefinitely, showing how fits and adaptations, with startling accuracy, arise after all in perfectly natural, not to say inevitable, ways. These details are not the result of design but of accident.[1] The design lies much farther back in the great scheme of life, infinitely more complex and wonderful than these details that strike our attention, and which exhibit rather the variety of nature's design than a deliberate intent at duplication or a determination to favor one species over another.

With this glimpse into the way of the wild we are prepared for a somewhat detailed discussion of the principal facts involved in the further adaptation of animals and plants to the needs and purposes of man.

[1] Those who might be inclined to object to the statement that every detail in nature is in a large sense accidental should consider such cases as the sloth, which is a grayish green in his natural haunts, but in captivity gradually loses the greenish tinge and fades out to a dull gray. The reason of this is that the greenish tinge was originally no part of the sloth, but was due to the green chlorophyll of the minute algæ that are enabled to live upon its hair, the moist climate and the sluggish habits of the creature being both favorable to the vegetable growth. Any number of equally striking instances could be given to show that color is in its origin largely accidental. Of course under natural selection only the more favorable cases could survive.

Summary. Infinitely more individuals are born into the world than can possibly find room and food. This sets up a struggle for food and room and the right to live, under which the fittest alone survive to reproduce their kind.

In this way the race is modified or improved, because each succeeding generation is born, not from average individuals, but from those that are best able to meet the demands. If conditions remain constant, in a few generations the "fit" becomes close; but if the conditions change, the standard of fitness and selection changes also, which necessarily results in a modification of the race in a new direction, *the principle being that whatever happens to individuals, the race as a whole will respond to selection from whatever standard administered. This is the principle on which the breeder operates, though his standards of selection are the ones that meet his needs, and may not be the same as those of nature.*

Exercises. 1. Estimate the number of seeds in a robust plant of purslane, pigweed, or plantain.

2. Ascertain the number of kernels on a single ear of corn, and calculate how long it would take one ear to produce seed enough to plant the entire state.

3. Outline the causes that prevent the unlimited increase of various species, especially man and the animals and plants most closely related to his affairs.

4. Make original studies into the different methods by which the most troublesome weeds persist in spite of our most persistent efforts to eradicate them; for example, Canada thistle, morning-glory, ragweed, purslane.

5. How is it that weeds "come up" in new lands never before cultivated, and what are the various ways by which birds and other animals carry weed seeds?

6. Go to the fields and observe the various ways by which seeds transport themselves, especially by wind and water. Make studies of definite species and describe carefully their habits of seed distribution; for example, wild cherry, thistle, cocklebur.

References. 1. "Origin of Species" (especially chaps. iii and iv). Darwin.

2. "Darwiniana." Asa Gray.

3. "Darwinism." Wallace.

4. "Color of Animals." Beddard.

CHAPTER VI

EFFECT OF NATURAL SELECTION

Natural selection means progressive development · Effect of selection upon the individual · Selection good for the species that can endure it · Selection fatal to a race that cannot endure its hardships · Interest of the individual and the race not identical · A close fit between a species and its environment is inevitable · Apparent exceptions due to absence of severe selection · Adaptation not necessarily perfect · Our standards of selection differ from those of nature · Not all the results of natural selection are useful to us · Our standards often require much readjustment of domesticated species · Natural selection always at work · Power of selection to modify type

Natural selection means progressive development. Natural selection and the survival of the fittest mean progressive development for the species, because each new generation is born, not from an average, but from a highly selected parentage, limited to the few that best fit the conditions of life as a whole. This means that each new generation is a little better born than the last, and that the "fit" becomes a little closer with each generation, till it becomes approximately perfect if conditions remain constant, all of which is to be counted an improvement of the species as measured by natural standards.

For example, the bills of woodpeckers are bound to become a little longer and a little better adapted to the needs so long as selection continues, because all below a certain standard are being constantly exterminated. Moreover, in many cases, the standard of selection is likely to rise as time goes on, working still further improvement. Thus deer and wolves frequently run wild in the same regions. The deer live upon vegetation, but the wolves live upon the deer. Both depend on their legs, the one for pursuit, the other for protection. Under conditions such as these, the slow and the crippled deer would be first killed off, and the fleetest would go scot free. On the other hand, the fleetest wolves would be best fed and the laggards would die of hunger. In this way both species would develop high speed and great wariness, and this development would progress further and further as the competition grew keener with each passing generation. The horse has almost certainly come up through a similar experience in ages past.

Effect of selection upon the individual. This effect is twofold. First of all, it sharpens the wits of the individual if he has any, and develops to the utmost whatever faculties he may possess. If by this he is able to withstand the competition, he is in every way the better for it.

If, however, as generally happens where the selective process is severe, it is only the few that are able to withstand, then the masses will go down in the struggle; so that the total effects of selection may be said to be hard upon all but the few individuals, and its chief advantage is to the race as a whole.

Selection good for the species that can endure it. By this we mean that if a number of individuals sufficient to keep up the population are able to meet the demands of selection, then the species will rapidly progress; and up to this point the more severe the selection the better for the race. This is an important distinction in all evolution that should never be forgotten, for it is only when undergoing severe selection that species change much in their characters from generation to generation.

Next to sudden calamity the greatest misfortune that can happen to a species or a race is a long succession of easy times, when the whole population settles down to a dead level of inactivity. Then are the days of extinction imminent, for matters will not always run in an accustomed rut, and when the days of sudden and unaccustomed changes come, they are likely to find things unprepared.

Selection fatal to a race that cannot endure its hardships. It matters little to the race what happens to individuals, so long as a sufficient number prosper. It is vital, however, that a sufficient number do prosper, for it is upon them that the succession depends.

If the conditions are so hard or the individuals so far below the standard that none, or at most but very few, can meet the demands of the struggle, then, of course, are the days of the species numbered, and thousands of races like millions of individuals have met these conditions and gone down under them since the world was young. We speak of these as extinct species, but who knows what buried possibilities were lost in the dim past when the elemental energies were at work laying the foundations of things?

Interest of the individual and the race not identical. In this way we fully realize that the interests of the race are not identical, indeed are often at variance, with those of the individual.

This is true, however, only for the existing generation, because the interests of future individuals are involved with those of the race, and whatever benefits the race as a whole is good for future individuals, just as we all, in these days, are happier for the bloodshed and self-sacrifice of the thousands of our forefathers who gave themselves up in labor and in war to make the world a better place in which to live.

In the struggles of a race with or against its environment one or the other must yield. With intelligent and powerful beings like men it is often possible to modify the conditions of life and not submit to the necessity of its hardships. When, however, this is impossible, either by reason of the rigidity of conditions or the helplessness of the race, then nothing remains but that the species as a whole should bow to the inevitable and bend its characters to conditions it cannot break. Here the sacrifice of individuals of one generation is fully compensated in the next, so that in the long run the interests of the race and the individuals that compose it are identical.

A close fit between a species and its environment is inevitable. This rapid shaping of a species in harmony with its surroundings is bound to bring about a close "fit" between a species and the peculiar circumstances by which it is surrounded.

It could not well be otherwise, certainly in so far as vital particulars are concerned. If the bill is a little too short or too soft to reach the worm as he burrows deeper, then it will be promptly lengthened, not in short-billed individuals but in the descendants of those with longer bills. If the marking of the butterfly is similar to a leaf or a lichen, then those individuals in which the resemblance is closest will profit most and the similarity will grow closer. If the relations between two species happen to be mutually beneficial, then those relations will be still better perfected in future generations by the selective process, till possibly they may become essential to the existence of one or the other, if not of both.

For example, certain moths have the habit of laying their eggs only upon particular plants, then of gathering a pellet of pollen off the flowers and storing it near the egg as food for the young larva, thereby pollinating the flower.[1] Some of these "fits" seem unaccountable except on the basis of intelligence or design, but when we remember not only the very low intelligence of the moth, but also the fact that she never sees the outcome of it all, since she will be dead before her own eggs hatch, the rôle of intelligence is eliminated. When also we remember that some of the best fits are peculiarly fatal to one of its members, we rule out design, for nature is not partial as between its creatures.[2]

Apparent exceptions due to absence of severe selection. The fit is often notably bad, as when the moth flies into the candle, impelled by an instinct it cannot control,[3] but to which it

[1] See the case of the yucca moth described in "Principles of Breeding," p. 105, which see also for a general discussion of Instinct, pp. 386–404.

[2] Ofttimes the insect's egg is laid inside the body of another creature, which is necessarily fatal, just as the fact that the best temperature and conditions for tuberculosis happen to fit alarmingly close with that of cattle (102°) and the extremely insanitary way in which many of them are kept in our hot and close basement barns. Surely this is not design, nor is it especially beneficent, for the tubercle bacillus certainly cannot have interests worth consideration, even if we disregard those of our cattle and our own as well. The fit is, nevertheless, close and complete.

[3] See "Principles of Breeding," pp. 394–397, for a discussion of the causes of instinctive acts.

responds at the cost of its life. Manifestly this is because of unusual conditions, for if there were very many naked lights in the world, relatively speaking, these moths would become extinct unless there were a sufficient number of individuals without this fatal instinct to keep the numbers good, in which case a new and real fit would be developed. The cause of the present misfit is of course due to the fact that the fatal selection is too rare to greatly affect the species; that is, the selection is not severe upon the species because, relatively speaking, it is not frequently exercised.

The foot of the elephant has been mentioned as a disadvantage. The immense branching horns of the stag are certainly far from being advantageous to him, or even a good fit with his brushy environment, with which they frequently become entangled. Many a stag has gone down to his death because his horns became entangled in the thicket or locked with those of an adversary, and many pairs of antlers are found lying between two skeletons, mute witnesses of the final death struggle in which the cause of the tragedy was the unfortunate horns that are commonly supposed to be protective.

The present point is, that while this is far from a good fit, yet the fatal consequences do not follow with sufficient frequency to affect the species. But few males are needed to perpetuate the species, and the small number that lose their lives by means of their unfortunate horns can well be spared, for they will not be needed in the propagation of the new generation. As will be readily seen, defects in females are much more dangerous to species than are defects in males.

Adaptation not necessarily perfect. The fit between various species and their environment, and the adaptation of their parts to the surrounding conditions, are not, therefore, necessarily perfect. It must be good enough to insure abundance of offspring for the next generation, and that is enough. Any race, therefore, can endure any handicap up to this point and prosper, and that is why natural selection carries improvement up to a certain point and stops. Nature does not aim at perfection, but every species is just as good as competition makes it, and no better.

Writers when discussing this topic often overstate the facts. They are impressed by the niceties of adjustment so frequently seen in nature, and rush to the assumption that everything is perfectly adjusted and perfectly adaptive. It is better to understand that upon the whole characters are and must be *highly but not perfectly adaptive; that such adaptations are achieved at great distress to individuals and temporary danger to the species, and that they will never be more numerous or closer than circumstances compel; so that each species generally survives with one or more handicaps, in which the fatalities are not sufficient to force a fit upon the one hand or bring about extinction upon the other.*

Looked at in this way, the animals and plants of the forest as we see them, even in a state of nature, represent a choice but not a perfect lot, born, upon the whole, as they are, from a highly selected though not perfect ancestry; that is, from the standpoint of nature these species were already highly bred when first domesticated by our forefathers.

Our standards of selection differ from those of nature. In nature selection is based only on the struggle for existence. Nothing avails that does not bear upon the supreme issue of mere ability to live and reproduce fast enough to keep ahead of the death rate and thus maintain the balance of life in favor of the species. Natural selection is thus based on anything and everything that affects the mere question of life, death, and reproduction, and nothing else. It secures, of course, great vigor, comparatively long life,[1] and at least a reasonable degree of fecundity together with the extreme development of whatever physical part or trait of character is directly concerned with the preservation and sustenance of life, and there it will stop.

[1] See Fig. 12. This is the same burro shown on page 7 in his working outfit, when engaged in building the Pikes Peak Railroad many years ago. His labors are done and he is now kept for photographic purposes. He illustrates the longevity of rare individuals.

Our selection begins, therefore, where natural selection leaves off, and it aims to secure also the development of some part or faculty that is of special value to us. For example, nature would develop a sharp horn in cattle and perfect the instinct to hide the young at birth,[1] but it would not develop the milking process to a very high degree for the reason that almost any cow in a state of nature could give enough milk to satisfy her calf.

FIG. 12. Old Dick, now fifty-six years old

Natural selection develops the speed and endurance of horses, as also, very likely, their vision and the quality of the hoof, but it does not develop the size we need for draft purposes, nor bring out the action nor the teachableness we desire for driving purposes.

The agility of sheep and goats is rather overdeveloped in nature for our purposes, but the fineness of the fleece and length

[1] Every farmer boy knows that the cow will hide her calf, and if conditions are at all favorable, it will take a good hunt to find it.

of staple needs further attention. It was good enough for them, but nothing attainable is too good for us, in our opinion at least.

In nature, if a plant seeds freely it will probably survive, and it makes little difference whether all or only a few individuals seed abundantly, but when we raise a crop we desire an abundant yield, and to secure this every individual plant should do its share. In domestication we want no laggards.

Fruits and flowers may easily be sufficiently sweet and juicy, or showy and fragrant to be attractive to animals and insects, and thus secure the essential points of fertilization and distribution; but with our refined sensibilities and educated tastes we require and exact the finest flowers, the most delicate colors, and the most delicious fragrance that can be produced by the most discriminating selection.

Not all the results of natural selection are useful to us. Some of the achievements of natural selection do not commend themselves to our favor, as, for example, when the seeds of the stipa grass, with their sharp and barbed points adapted to boring and their twisted, crooked tails adapted to pushing and twisting, get upon our animals and enter the flesh. Then our admiration for the fine adaptations of nature is turned to alarm, as it is when the botfly torments our horse to hatch her young in his stomach, or the yellow-fever germ enters our blood by way of the bite[1] of the mosquito.

Even some of our most useful species bring with them certain traits highly developed by natural selection, which are worse than useless for our purposes. For example, the extreme timidity of the horse, akin to that of the deer and the antelope, is useful to him in nature, no doubt, but for our purpose we should like to exchange it for the quiet confidence of the dog, which is born of boldness rather than of timidity and is toned down by association with his master. As it is, we must develop the confidence of the horse against his natural instincts.

[1] It is needless to remark that the mosquito does not truly bite.

We should be glad to be rid of the sharp horn, the surly disposition, and the fighting nature of bulls. We domesticated the race for its milk and its meat, not for its fighting qualities, but were forced to take these undesirable traits into the bargain, like a job lot at auction, and they have made us no little trouble ever since. We are beginning now to cut off these emblems of savagery, these weapons[1] of the woods, and still more sensibly to breed them off. The latter must, from the nature of the case, be a somewhat gradual process, particularly as our best breeds are so well fixed in other characteristics.

Our standards often require much readjustment of domesticated species. Having domesticated a species because of some valuable natural quality, we often institute conditions of life quite different from those under which the quality was developed and under which the species has lived, all of which make necessary the most radical readjustments on the part of the species in order to meet the new conditions and still maintain its natural faculties, not impaired, but improved if possible.

The pig affords the most conspicuous example of this change in conditions of life without change in our demands. We domesticated him solely for his flesh, which is exceedingly rich in fat.[2] In his wild state the pig lives an active woods life, subsisting on roots, nuts, and a little flesh when he can get it. He is, for example, an expert snake hunter, setting his feet on the

[1] The cruelty of cutting off horns has been greatly overrated. The horn is comparable not to the bone but to the finger nail, being an outgrowth of the skin merely. The practice of dehorning is mild as compared with the shocking and useless barbarity of docking horses. Every horn that is cut off prevents vastly more injury and misery than it causes.

[2] The ground hog or woodchuck during the summer lays on a great store of fat and during winter hibernates, that is, sleeps almost continuously, maintaining a low degree of vital activities at slight expense of food materials, which is met from the store of fat under his skin, just as the turnip or the beet sends up its seed stalk and ripens its crop from the food material stored in the root. The pig, like the bear, is a kind of half hibernator, that is, with a good store of fat he can endure long periods of scarcity and even go a considerable time without food, as has been learned when pigs have been accidentally confined under straw stacks for a number of weeks.

animal with great skill and at once ripping up the body with the teeth and tusks.

In domestication we change all this. We shut him up in a close little pen in the open sun, away from water, and feed him mostly on grain, or, in cases of extra care, on mush, perhaps cooked and steaming hot. Now the pig cannot sweat. He has no glands for the purpose. In nature he lives in the shade and runs to the river when oppressed by heat. He is not used to an exclusive diet of seeds, and has never accustomed himself to hot soup and steaming mush. He has not been selected on that basis, and what wonder that he makes the most of any water or even mud that he can reach, doing his best with snout and tusk to bury himself in the ground, and snapping greedily at alfalfa or clover hay pasture grass, or anything else that will help to restore the conditions to which he had been accustomed by long generations of selection! We must either change our habits of keeping the pig, as the best farmers are doing, or he will be obliged to radically change his nature, which will take much time and be exceedingly expensive to us, for it costs dearly to make over a species in respect to fundamental characters.

Again, we often add a requirement or two to the natural qualities which led to domestication, all of which will of course require no little readjustment of the nature of the species in order to meet new demands. For example, the chicken was doubtless domesticated for her eggs and the sheep for its wool, but we have made meat animals out of both. Beets were at first cultivated as a toothsome vegetable, but later developed for the sugar content, which vastly changed the nature of the plant, as it required substantial addition to the leaf surface.[1]

So examples might be multiplied indefinitely to show how we have added, and indeed are constantly adding, new requirements to our domesticated species, requiring additional selection,

[1] Sugar is practically carbon and water, and this new demand fell heaviest on the leaves, which, as has been explained, are the agents for fixing and bringing into the plant the carbon from the carbon dioxide of the air.

not only to develop still further their naturally valuable qualities, but to bring about more or less radical readjustments occasioned and made necessary by these new demands of ours.

Natural selection always at work. We must not for a moment suppose that our domestication and the new standards of breeding entirely do away with natural selection. In respect to tooth and claw, of course selection stops the moment we make warfare impossible, but in such fundamental matters as constitutional vigor, fecundity, and the vital and reproductive faculties natural selection never surrenders its hold upon a species.

FIG. 13. Rock or wild blue pigeon, *Columba livia*, and parent of all domesticated strains (see pp. 94 and 95). After Lydekker

Ofttimes we forget this and are brought up standing by the consequences. Sometimes our standards of selection are unwittingly at opposites with these fundamental matters, and then the shock and the lesson are severe. For instance, many an amateur breeder will select the fattest and smoothest pigs for breeding purposes, not knowing that these are neither the most prolific nor the hardiest. His herd soon runs out. Natural selection has been at work day and night to undermine his herd at the point of infertility.

Some very favorite strains of cattle or sheep are decidedly "shy breeders." If so, it may as well be understood that they will go down under the relentless work of natural selection, unless indeed the defect can be speedily remedied by finding prolific strains among the favorites.

Power of selection to modify type. Selection can do far more than develop a single type to conform to some single

FIG. 14. Types of pigeons developed from the rock or wild blue pigeon shown in Fig. 13

2, Barb; 3, Swallow; 4, Magpie; 5, Chinese owl; 6, English pouter; 7, Dragon; 8, Duchess; 9, Fantail; 10, Maltese hen; 11, Frillback; 12, English carrier; 13, Morehead

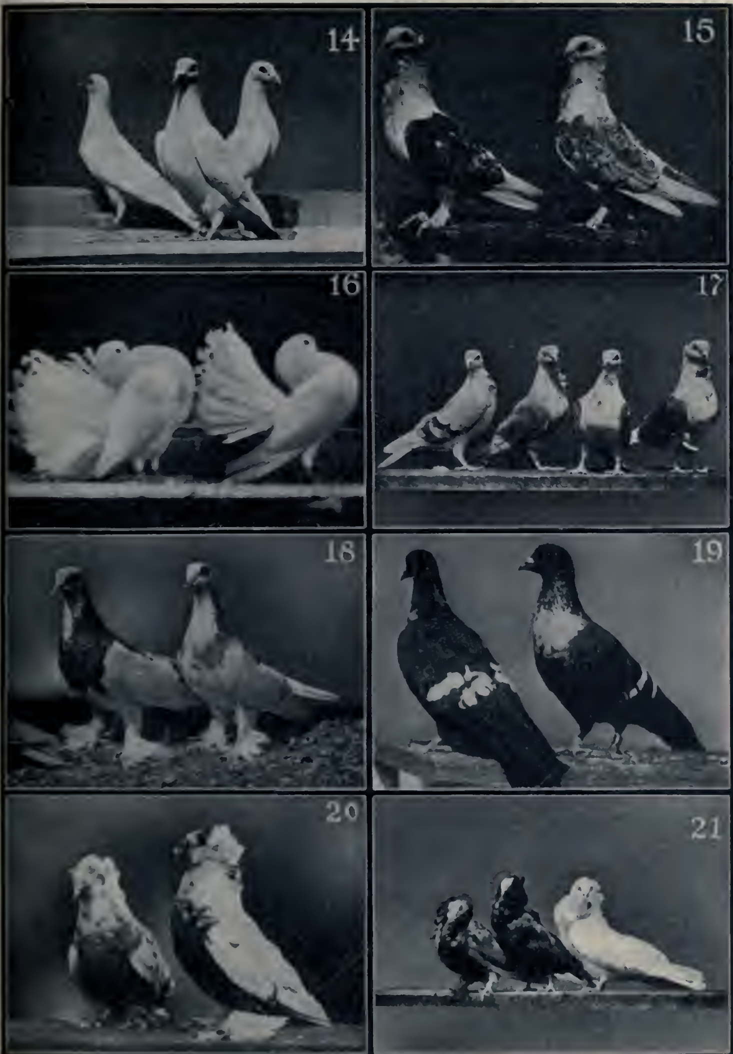

FIG. 15. Additional types developed from the wild blue pigeon, by selection and breeding

14, White homers; 15, Oriental frills; 16, Fantails; 17, Turbits; 18, Birmingham tumblers; 19, English sterlings; 20, Russian trumpeters; 21, Jacobins balance of natural condition of climate, room, and food supply. If these fundamentals are provided for, selection is able to modify type in many directions at the same time, so that from a single original stock a multitude of diverse forms may be built up.

There are no better instances of this than the pigeon, the many and diverse varieties of which have been bred within historic times from the single primitive form, the wild or blue rock pigeon (see Fig. 13). Hardly second to this is the wonderful variety in the different breeds of the dog, well known to all observers.

If this can be done with these species, what a future of possibilities is opened up for still further developing and improving our animals and plants of field, orchard, and garden!

Summary. The marvelous effects of natural selection and its power to modify type to fit the surroundings simply through the extermination of the inferior individuals, suggests to man a means of still further adapting these species to his own needs.

In nature the basis of selection is simply the power to live and reproduce fast enough to keep up with the death rate. Man, on the other hand, is interested in something besides mere life and reproduction.

For example, he keeps the cow for her milk, and he is interested in the amount she can give. In nature she needed only to give enough for the calf, and that only until he could wholly or partly shift for himself. In domestication, on the other hand, man considers the cow as a machine that should give all the milk possible and give it continuously. Manifestly, therefore, man must set up some additional standards of selection, and all the evidence is that he does this; the domestic cow reacts, and increases her output. This does not mean that a poor cow can be made into a good one by any process known to man, but does mean that if the dairyman breeds only from his best cows, the calves will develop into a better lot, on the average, than they would have been if he had bred from good, bad, and indifferent.

This is artificial selection, copied after nature's plan. It has been practiced from the earliest times, and is the process that has produced about all the improvement that has been made up to near the present day.

This plan of improvement by selection will be considered later in detail under the head of systematic improvement of animals and of plants.

Meanwhile we leave it here to develop another and a newer method of improvement, based on a more careful study and a more minute knowledge of the real constitution of living beings.

Exercise. Give the history of some breed of domestic animal, — cattle, horse, sheep, pig, dog, or chicken.

References. 1. "Types and Breeds of Farm Animals." Plumb.
2. "Dogcraft." Hachwalt.
3. "Survival of the Unlike." Bailey.

CHAPTER VII

UNIT CHARACTERS

Unit of study · Species composed of definite characters · Every individual possesses all the characters of the race · Characters developed and characters latent · Characters dominant and characters recessive · Correlation of characters · Lost characters · New characters · Characters and unit characters

Unit of study. In attempting to discover the ultimate principles involved in plant or animal improvement as we have learned to understand it, the special object of study is not the species as a whole nor even the individuals involved, but rather the particular characters that give the species value to man, and their relation to the general group of unit characters that compose the race. This study is undertaken with the purpose of developing a second method of improvement in addition to the one by simple selection already outlined.

Species composed of definite characters. It requires a little careful thought to fully realize that all species are composed of very definite characters,— some more prominent than others, some especially prominent in certain individuals and secondary in others, and still others that might be included, for all we know or can see, but that yet are never found.

For example, vertebræ and ribs are characters common to many species, a hairy covering to vastly fewer, horns to fewer yet, and smooth, sharp horns to very few. The short, smooth, sharp horn, characteristic of the bison, and the large, flat, corrugated one of the true buffalo are very different, the one from the other, but each is found in no other species. There is no evident reason why horses do not have horns like most cattle, but the fact is that this character is absent in the genus *Equus*.

The limitation of unit characters is well brought out in respect to color. Butterflies have black, white, red, green (with both its constituents, yellow and blue), and almost all conceivable shades and markings. Birds have the same, but with few cases of the green. Cattle have black, white, red, and a kind of yellow and blue, but no green. These colors combine, too, both in spots and roans. Pigs have black, white, and red, in which the combination is frequently spotted (piebald) but never roan. Horses have black, white, and a kind of red, mixed in both spots and roans, but no blue or green; that is to say, color characters are limited.

All this means that species are made up of certain definite characters, and these characters run through and among the individuals like colored threads in the warp and woof of cloth, throwing up here one pattern and there another, according to the relative intensity and frequency of the various units.

What is true of colors and color patterns is true of other characters of the race, and the term "unit character" is a good one to designate these half-independent and half-dependent assortments of physical features that go to make up the various species in nature. It is upon these unit characters separately, and not upon their composite effect, that the attention should now be fixed.

Every individual possesses all the characters of the race. After being convinced that no two individuals are alike, it is easy to assume that they differ in the particular unit characters they possess. This is a mistake. Every individual possesses all the characters of the race to which he belongs, whether they are evident or not, whether they are developed or undeveloped. Individual differences in most respects are quantitative rather than qualitative, that is, are due to relative development or non-development of characters that belong to the race rather than to actual difference in unit characters.

Some races are so rich in unit characters that not all can develop in any single individual, as, for example, color in cattle.

Some of the units are present in a high degree, and these are strongly developed, giving the visible appearance of the individual; others are present in low degree, remaining undeveloped, and out of evidence, leaving us to assume their absence.

The proof that every individual really possesses all the normal characters of the race is the fact that he will transmit them to his young, and that is why the offspring of two bay horses may be something else than bay. When such an offspring is, say, black, we assume that one and possibly both of the parents possessed unit characters of black as well as bay; that is to say, that some of the ancestors were black. Not only that, but if any of the ancestors were black, we assume that black unit characters are present, that they will be certainly transmitted, and will one day crop out.

The sire will transmit milking quality as well as the cow, though it is a character that develops only in the female. The truth is that he, as well as the female, possesses the character, but it is not functional in his case. It loses nothing by this fact, however, in transmission. People are often puzzled to account for traits of character that outcrop in children, but were noticeable in neither parent. The truth is that all ancestry is more or less mixed, and every parent can be counted upon to transmit many more unit characters than are present in his visible make-up. This is reversion, the so-called mystery of transmission or "failure of heredity," as it is often erroneously denominated. It is no failure at all, for real unit characters are all transmitted; whether they ever develop and become evident depends upon a variety of circumstances, chief of which are their relative intensity and the conditions of life to which the individual happens to be subjected during development.

Characters developed and characters latent. As has just been implied, the visible personality of the individual depends upon those particular characters that happen to have developed, and not at all upon that other and extensive possession of undeveloped or, as they are called, "latent" characters. The term is not a good one. They are latent only in the sense that they are not evident except as they outcrop in succeeding generations, when, with other blood lines, the new combinations become sufficiently strong or otherwise favorable to bring them out. They are not latent in the sense that their presence cannot be suspected. If we examine carefully all the unit characters in any race, we shall know positively what characters will be possessed by the descendants, but as to which will develop and give visible evidence of their presence in any particular individual we cannot predict. We shall see later, however, that if both sire and dam are black, knowing nothing about other ancestry, the offspring will stand even chances of being black also. If all the grandparents, however, were red, the offspring, even of black parents, would stand one chance in four of being red; or, what is the same thing, one fourth of all such offspring would be red and one half black, with the other one fourth unknown.

Characters dominant and characters recessive. Some characters are dominant, that is, strong and easily seen, while others are difficult of detection or easily covered up and obscured by stronger ones. Thus, in flowers, pink is easily lost in red; light blue, in purple; or yellow, in green. Small size is obscured by large size, and, in general, certain characters are much more readily seen than others. Those that are most evident are called the dominant, as distinct from the recessive, which are the less evident. Quite aside from mere visibility, too, certain characters seem more likely to appear in crossed forms than do their corresponding but equally noticeable characters (see the discussion under Mendel's law and the illustrations of guinea pigs in Chapter XI).

Correlation of characters.[1] The relations between the many unit characters that make up any race are in many respects striking. Certain characters move together in the relation of cause and effect. Such characters are said to be highly correlated. Certain others seem naturally opposed, and here the

[1] "Principles of Breeding," chap. xiii.

correlation is said to be negative. In general, while characters are more or less indifferent to each other, there is, for the most part, a low but real correlation. Methods of calculating this correlation are well known and are extensively used in statistical studies, but are rather too complicated for introduction here (see reference to "Principles of Breeding" just given).

FIG. 16. Albino deer. Specimen owned by State Museum, Augusta, Maine

Lost characters. In the vicissitudes of time and selection characters are sometimes lost. Thus the whale, which is a true mammal, like the cow, and which once lived upon the land, has lost its hind legs except for a few pelvic bones. Birds have lost one ovary. The whole snake family has lost one lung, and all but the python have lost all traces of their legs.

Some colors are the result of pigment formation. This quality is often lost, resulting sometimes in an albino individual, as in

Fig. 16,[1] or of an entire strain, as in cattle and pigs, and sometimes in a modified color, due to the absence of the definite pigment.

New characters. It is much easier to understand the extinction of characters and species than it is to account for the appearance of new ones; indeed, there is some reason to believe that both the fauna and the flora of the world are getting simpler, that is, so far as numbers of species are concerned, by which is meant that, in all likelihood, species are becoming extinct faster than new ones are appearing.

However, new characters are appearing and, as we shall see later, new strains and races, equivalent for present purposes to new species, are constantly developing. These arise sometimes through the loss of a character, but often by some new combinations of old characters, resulting essentially in new races. Good examples of this are found in the large number of new strains of garden flowers, fruits, and vegetables, each with some distinguishing trait that is especially valuable.

Characters and unit characters. A distinction must be here observed for the sake of accuracy. The term "character" is used in a very general sense to cover any quality or faculty of animal or plant to which we especially desire to allude.

For example, we speak of the quality of milk production, which, as a valuable commercial consideration in cattle, may be roughly spoken of as a *character*. Upon reflection, however, it will be seen that it is not a *unit* character, for the faculty arises not from a single physiological function but from several; that is to say, there are a variety of facts that would influence milk production, namely, the size of the udder, the glandular activity of the organ, the capacity to eat and digest large amounts of food, and perhaps a number of others unknown to us.

[1] Such a deer would of course have little chance of being spared either by the hunter or by natural enemies; hence no strain of albino deer can develop. The same is true as to albinism in bears, except in arctic regions where conditions are reversed.

Now it is evident that we might have cows with good udders and indifferent digestive powers. In other words, milk production is conditioned upon a number of minor factors, each able to behave somewhat independent of the others physiologically; that is, to behave as separate unit characters.

The term "unit character" is therefore used to indicate such fundamentally physiological elements as tend to behave somewhat independently of each other and to act as units in transmission from parent to offspring.

How these units are transmitted from parent to offspring, and how they behave in transmission, is the subject of succeeding chapters.

Summary. Each "character" has a real physiological basis, and such an ultimate unit of variability is called a "unit character." In common parlance we often use the term "character" for what must be the resultant of a large number of these units, as when we speak of milk production.

These unit characters are sometimes difficult to differentiate and identify, but often not; as, for example, a single color commonly behaves as a unit, while temperament and the more complex functions are evidently the resultants of many units.

Exercises. 1. Make a list of the color characters of horses, cattle, sheep, pigs, and other domestic animals.

2. Make a list of the characters common to the horse and the cow; the pig and the sheep; the hen and the goose; the hen and the pig.[1]

3. Make a list of characters possessed by the one but not by the other of the above couplets.[2]

[1] In this remember that character means any physical part like vertebra or rib, hoof or horn, color or odor, as well as any mental trait like timidity or fierceness, docility or nervousness.

[2] Thus while the hen and the pig both have round eyes, the hen has feathers instead of bristles. What is the seeming hair on the hen?

CHAPTER VIII

VARIABILITY OF A SINGLE CHARACTER[1]

Critical study of a single character · Types · Plotting the frequency curve · The mean · The typical individual · Variability or deviation from type · Average deviation · Standard deviation · Coefficient of variability · Suggestions as to taking measurements · Suggestions as to grouping · Suggestions as to numbers · Suggestions as to taking samples · Advantages of statistical studies

Critical study of a single character. We have seen that the individual and the race are made up of an intimate association of semi-independent units called characters. Now, owing to the differences in heredity and to the vicissitudes of development these characters are themselves, in many cases at least, highly inconstant, and it remains to study next the variability of a single unit character considered by itself alone.

Suppose we are to study corn characters one by one, as, for example, the length of ears. We find at once that different ears differ greatly in this respect. How, then, shall we describe this character so long as it is not uniform in different ears? We can do it only by first ascertaining the *type*, and next learning what is the *variability* or deviation from this type with respect to length, for, of course, variabilities differ in different characters even in the same species. It is the business of the present chapter to show how this may be done.

For this purpose take at random, that is, just as they come from the field, a lot of ears, say, 300 or thereabouts. Next decide upon a scale or "scheme" of measurements for grouping.[2]

[1] For a more extended study see "Principles of Breeding," chap. xii.

[2] It needs some practice in order to decide upon the most desirable scheme for any particular study. It is found that for length half-inch differences give as good results as do finer measurements, but that differences of one inch fail to give a smooth distribution. With half-inch differences the distribution is "smooth," that is, the numbers increase and decrease gradually.

Then measure each ear and record it opposite the figure in the scheme that comes *nearest* to the correct measure of the ear. When all the ears have been measured and the lengths recorded, you will have results similar to these of the following table, which is an actual case taken from a field of Reed's Yellow Dent, crop of 1906.

Distribution as to Length

V	*f*
4.0	
4.5	
5.0	1
5.5	4
6.0	6
6.5	7
7.0	19
7.5	31
8.0	37
8.5	59
9.0	46
9.5	39
10.0	23
10.5	11
11.0	2
11.5	1
12.0	
	286

By this we see that in all 286 ears were measured; that our scale was longer than it needed to be, for no ear was found as short as 4 inches or as long as 12 inches; that one ear was 5 inches long, four were $5\frac{1}{2}$ inches long, etc.; and that the number gradually rises to 59 and then as gradually declines, so that extremes of length are represented by relatively few ears.

Types. We are ready now to arrive at a rational conception of type. The most common length of ear is not 5 inches nor is it 10 inches, but it is $8\frac{1}{2}$ inches, because 59 out of 286 ears were nearer that length than any other. This is therefore the most usual, or, as we say, the typical length. This is not saying that it is the most desirable length, but that it is the length most commonly found.[1] Such a value is called the *mode*, and we say that 8.5 inches is the mode of this corn as to length.

Plotting the frequency curve. Such a lot of measurements is technically called a "frequency distribution" or, more briefly, a "distribution." It is always indicated by the letter *f*, as is the scheme of values by the letter *V*.

[1] That is, a blindfolded man drawing ears at random would draw this length oftener than any other; or if one's life depended upon a single draw, he would stand more chances by drawing this than any other length.

Frequency distributions are always characterized by a gradual rise to the mode and then by a corresponding fall. This "slope" of the frequency is best brought out to the eye by the system of plotting, in which the distribution is put into the form of a curve, called everywhere the frequency curve (see Fig. 17).

To plot this curve lay off the horizontal line $X'X$, and erect OY as a perpendicular. Next lay off distances on $X'X$ both ways from O, corresponding to the scheme of values, and erect perpendiculars from each. Then lay off on OY a distance corresponding to the modal value,—in this case 59,—and on each of the

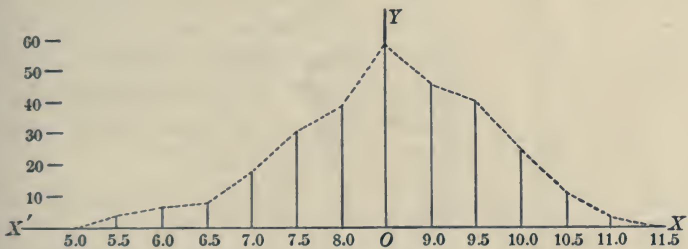

FIG. 17. The frequency curve

perpendiculars a distance corresponding to the number it represents. Last of all, connect these points with a curved line, and this line will be the so-called curve of frequency, which is a true picture of the variability of the character in question.

A glance at Fig. 17 will show that this distribution is not quite as smooth as would be desired,—a fault that would be corrected with a larger number of ears, in which case the slopes of the curve would be more regular and its character more uniform.

The mean. It is clear that two populations[1] might have the same mode but with very different distributions. There is therefore another conception of type quite aside from the highest

[1] "Population" is the technical term for the group of individuals studied, whether corn or cattle or people. In the present instance we are trying to study the variability as to length of ear in Reed's Yellow Dent, which is the population, by means of a supposedly random sample of 286 ears — rather too few for smooth results, but upon the whole fairly satisfactory.

frequency, and that is the average of all the measurements, technically called the mean.[1] The formula for the mean is $\Sigma fV \div n = M$.[2] In words, this means to multiply each group of the frequency distribution (f) by its corresponding value (V), add the results, and divide by the total number, all of which amounts to the adding together of all the lengths as originally taken and dividing by the total number. It is the usual operation of finding the average, known to every schoolboy, but it is best done methodically, and the method is well illustrated by the case in point, as shown in the accompanying table.

Distribution as to Length — finding the Mean[3]

V	f	fV
5.0	1	5.0
5.5	4	22.0
6.0	6	36.0
6.5	7	45.5
7.0	19	133.0
7.5	31	232.5
8.0	37	296.0
8.5	59	501.5
9.0	46	414.0
9.5	39	370.5
10.0	23	230.0
10.5	11	115.5
11.0	2	22.0
11.5	1	11.5
	Σ 286	Σ 2435.0

$2435.0 \div 286 = 8.514 = M$, the mean

By this we see that the average ear in this particular case was 8.514 inches long, differing somewhat from the mode or most frequent length. Either the mode or the mean can be taken as the type, according to the needs of the case, but the measure most commonly accepted as best representing the type is the mean or average of all.

The typical individual. Having determined the type as to a single character, it can be determined in the same way for any

[1] The mean is to be distinguished from the median, which is the middlemost; that is to say, if these 286 ears should be spread out in a row, beginning with the shortest, the median would be the ear at the middle point, with as many above it as below it in length. As our number is even, there would be no true median, for the 143d ear would have 142 below it and 143 above it. If there were one ear less, the median would be the 143d ear, and its length would be the median length.

[2] The Greek Σ (capital sigma) is the usual sign of addition or summation.

[3] Here V means value, as before, f means frequency, and fV means $f \times V$, or the values multiplied by their respective frequencies.

number of other characters that can be measured, weighed, counted, or in any other way accurately determined. Thus the following is an actual distribution as to weight of ears, in which the character is measured in terms of ounces instead of inches. Here the problem deals with a different unit of value, so that *V* now stands for ounces, while *f* stands for frequency, as before. The mode in this distribution is 9 ounces and the mean 8.807 ounces, the derivation of which is left for the student or reader by the methods already outlined.

DISTRIBUTION AS TO WEIGHT OF EARS IN OUNCES

V	*f*
2	3
3	8
4	11
5	16
6	24
7	28
8	32
9	39
10	36
11	35
12	22
13	14
14	7
15	4
16	1
	Σ 280

Mean = 8.807 ounces.

If now we should pick an ear that is 8.514 inches long and that weighs 8.807 ounces, it would be *typical both as to length and weight.* So in the same way other characters could be determined, such as circumference, number of rows, and in some cases even color, and any ear that was "on the type" as to *each* character could be fairly called a typical ear.

A typical individual is, therefore, one that is typical, or average, as to all the characters that are considered important. Practical experience will show that there are very few typical individuals in any species, provided very many characters are considered.

Variability or deviation from type. But the average gives us only partial information concerning the character we are studying. It gives us no indication of the spread or range of the distribution, as to how many of the population have deviated from the type, or how extensive was the deviation; that is, the *average* gives us no measure of variability, and it is such a measure that we now seek.

Average deviation. Referring to the original distribution of length of ears, let us consider how much each group of ears deviates from the mean or average length, which is 8.514—.

To avoid large decimals we discard the last figure and take the mean at 8.51. From this mean the shortest ear, which was 5 inches long, deviated 3.51 inches, the next group of four each deviated 3.01 inches, or a total deviation of 4 × 3.01 = 12.04. Each of the next group of six deviated 2.51, equaling 15.06 in all, and so on for all the groups. It is manifest that if we continue down the distribution in this way, calculating the deviation for each group, and then add all together, we shall have the total amount by which *all* the ears deviated from the length of their average, and it is equally evident that if this total be divided by the number of ears, we shall have the *average* deviation of these ears. Such an average is a fair measure of variability with respect to the character length in this particular variety. The formula would read as follows: $\frac{\Sigma f(V-M)}{n}$ = average deviation.[2] The process is carried out systematically[3] in the table above.

VARIABILITY AS TO LENGTH OF EAR — AVERAGE DEVIATION

V	f	$V-M$[1]	$f(V-M)$
5.0	1	− 3.51	3.51
5.5	4	− 3.01	12.04
6.0	6	− 2.51	15.06
6.5	7	− 2.01	14.07
7.0	19	− 1.51	28.69
7.5	31	− 1.01	31.31
8.0	37	− 0.51	18.87
8.5	59	− 0.01	00.59
9.0	46	0.49	22.54
9.5	39	0.99	38.61
10.0	23	1.49	34.27
10.5	11	1.99	21.89
11.0	2	2.49	4.98
11.5	1	2.99	2.99
	Σ 286		Σ 249.42

Mean = 8.514
249.42 ÷ 286 = 0.872 +, average deviation

[1] All deviations *below* the mean are denoted by the minus sign. In calculating deviation by this method these signs are disregarded. In the method to be next described these deviations are *squared* so that the minus signs disappear naturally.

[2] In words this formula means: subtract the mean from each of the values involved, multiply these differences by their respective frequencies (disregarding the minus signs), add these products, and divide by the total number in the frequency distribution.

[3] In all work of this kind systematic arrangement is desirable, not only on the score of neatness but of accuracy as well.

This gives 0.872 + as the average amount by which ears of this kind of corn deviate from their own average length. It is, therefore, a good measure of variability, and, taken together with the average, it gives us a good measure of this particular character, because it tells us not only what is the average length, but also what is the general or average tendency to *deviate* or depart from that length. In other words, we now have a good measure both of type and variability for this single character and for this particular population.

Standard deviation. The method of calculating variability just described has the merit of brevity and simplicity, but it so happens that mathematicians prefer a slightly different method. This difference consists only in squaring the several deviations before multiplying by their respective values, thus necessitating the extraction of the square root after division by the total number; thus $\sigma = \sqrt{\frac{\Sigma f(V-M)^2}{n}}$. This gives a slightly different value for variability, which, when derived by this method, is called "standard deviation" and is denoted by the small Greek letter σ (sigma). The method of systematically calculating standard deviation is shown in the table on page 112. The disadvantage of standard deviation as compared with average deviation is in the additional labor involved in its calculation, but it possesses many mathematical advantages in the solution of complicated problems. It is, therefore, the expression universally preferred by mathematicians. As the two results differ, the student must choose between them. The average deviation is so seldom used that it is given only as a means of explaining standard deviation on the common-sense [1] basis, and not because it will be used by the student. It is better in every way to follow custom in this matter and use the standard deviation.

[1] Mathematicians have a habit of appealing wherever possible to the instincts of "common sense" to evidence the reason for many things which, if absolutely demonstrated, would often require complicated formulæ and much abstract reasoning.

VARIABILITY AS TO LENGTH OF EAR — STANDARD DEVIATION

V	f	$V-M$	$(V-M)^2$	$f(V-M)^2$
5.0	1	− 3.51	12.31 +[1]	12.31
5.5	4	− 3.01	9.06 +	36.24
6.0	6	− 2.51	6.30 +	37.80
6.5	7	− 2.01	4.04 +	28.28
7.0	19	− 1.51	2.28 +	43.32
7.5	31	− 1.01	1.02 +	31.62
8.0	37	− 0.51	0.26 +	9.62
8.5	59	− 0.01	0.00	
9.0	46	0.49	0.24 +	11.04
9.5	39	0.99	0.98 +	38.22
10.0	23	1.49	2.22 +	51.06
10.5	11	1.99	3.96 +	43.56
11.0	2	2.49	6.20	12.40
11.5	1	2.99	8.94	8.94
	286			364.41

Mean = 8.514. $364.41 \div 286 = 1.2742.$

$\sqrt{1.2742} = 1.13 - =$ standard deviation (σ).

This standard deviation is considered, therefore, as the universal measure of variability, and the student will do well to work these values with original measurements until they come to have a real meaning. After this has been done for a time standard deviation will express as much about variability as does the radius about a circle.

Coefficient of variability. But one further step is necessary in the mathematical study of variability. The mean length of ear in this case was 8.514 inches, and its variability, that is, its standard deviation, was 1.13 inches; the mean weight of ear was 8.807 ounces, and the standard deviation was 2.854 ounces.

How now can we compare variability in inches with variability in ounces? In other words, how can we tell whether this corn is more variable with respect to length than it is with respect to weight, or vice versa? We cannot tell by direct

[1] The plus sign denotes that decimals are dropped.

comparison of the two standard deviations, because variability in one case is expressed in terms of inches and in the other in terms of ounces.

If, however, each of the standard deviations be divided by its mean as a base, then the quotients can be directly compared. Thus $1.13 \div 8.514 = 0.1327$, or, as it is more commonly written, 13.27, meaning thereby 13.27 per cent; and $2.854 \div 8.807 = 32.41$, showing that the corn is much more variable with respect to weight than it is with respect to length. Such a quotient — standard deviation divided by its mean — is known as the coefficient of variability, and, being entirely an abstract number, it serves as a basis on which the variabilities of any two distributions may be directly compared, whether dealing in terms of inches or ounces, feet or pounds or numbers, and whether the individuals involved are ears of corn, pounds of milk, bushels of grain, or any other races or characters where differences can be weighed, counted, or otherwise measured. The footnote[1] gives a few coefficients of variability for human measurements.

By the methods here outlined, any character or characters may be accurately studied as to both type and variability, provided the character can be accurately measured in some way, and provided also that sufficient numbers can be found to make the distribution fairly smooth.

It remains to offer suggestions as to certain details that are encountered in studies of this sort, and on which the student needs further information.

Suggestions as to taking measurements. In the scale just used, the measurements of corn were taken one half inch apart and the weights in ounces. Why? Why were not the lengths

[1]

Nose length	9.49	Head breadth	2.78
Nose breadth	7.57	Upper-arm length	6.50
Nose height	15.20	Forearm length	3.85
Forehead height	10.40	Upper-leg length	5.00
Under-jaw length	4.81	Lower-leg length	5.04
Mouth breadth	5.18	Foot length	5.92
Head length	2.44		

taken to, say, one quarter inch and the weights more accurately? The answer is that experience has shown that these are sufficiently accurate, and if the measurements had been taken finer, say to the quarter inch, the labor of calculating would have been doubled, and all without altering or improving results in any substantial way. What, now, is to decide the question as to accuracy of measurements?

Speaking generally, the object is not so much to get accurate measurements of all the individuals as such, as it is to make them comparable one with others; and it will be found by trial that measurements taken to the half inch in length of ears of corn, for example, will give practically the same results as those taken at a closer measure, as one fourth or one eighth of an inch. Not only is this true, but it is practically impossible to get the length of an ear of corn correctly within an eighth of an inch, as will be found by trial.

On the other hand, if we should take the measurements only to one inch, they would be too far apart for smooth distributions. The best easy test of the measurement to be chosen for "class" grouping, as it is called, is whether it gives a fairly "smooth" distribution. A glance at the distribution of length or of weight of ears will show that the figures slope off each way from the middle at a fairly uniform rate without any sudden break and without any number being greater than its neighbor nearer the middle. This is the best test of sufficient accuracy. In order to save labor the measurement will be taken as "coarse" as possible, but not so coarse as to break up the smoothness of the distribution or to make the groups too few. A little experience soon develops a judgment at this point which is better than anything that can be learned by instruction; but with all the experience of experts some trials have to be made whenever a new problem is taken, in order to determine the most desirable "scheme of measurements."

Suggestions as to grouping. After the scheme of measurement has been decided — as inches, half inches, ounces, pounds, feet, or what not — and the "class marks"[1] fixed, then the student is ready for measurements. The next question is where to record the various individuals measured. For example, suppose in measuring corn we have adopted the scheme, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, etc. We will rarely find an ear that measures exactly on the even inch or half inch. Most of them will fall somewhere between these various marks and will need to be assigned to one group or another somewhat arbitrarily. Now the rule is to assign to the nearest group. Thus suppose an ear measures $7\frac{1}{8}$ inches; it would be put into the 7.0-inch class because it is nearer 7 inches than it is to any other measurement of our scheme. Should it measure $6\frac{7}{8}$ inches, it would also go into the 7.0-inch class, and in doing so it would correct the slight error made in putting the other ear into a class too short for it. On the principle that as many will be too long as will be too short, we depend upon the law of chance[2] to keep our errors even.

On the same principle, if the ear should read $7\frac{3}{8}$, it would go into the 7.5-inch class; but if it should be $7\frac{1}{4}$, it would stand exactly halfway between the two classes, and here a careful decision must be made as to where it should be put. As it stands midway between 7 and 7.5 there are no more reasons for its going one way than the other, and in choosing a scheme of measurements it is well to avoid a scale that is likely to make too many fall upon this middle point.

There are but two things to be done with these midclass measures. They can all be put into the class above them, on the principle of the business man that calls half a cent a whole cent and then discards all smaller fractions; or, what is more accurate, every alternate measurement of this kind may be put once above and next below; that is, the first time a 7.25 measurement occurs it may be called 7.5, and then, to offset the

[1] The class marks are the various measurements, as 4 inches, 4.5 inches, 5 inches, etc., that make up the scheme of measurements.

[2] "Principles of Breeding," p. 365.

error, it may be called an even 7 the next time it occurs. The only trouble with this plan is the difficulty of keeping account of the many assignments. It is much easier to always put them in the class above (or below, if the worker prefers), but a slight error is introduced, affecting, of course, the mean, to raise or to lower it, though ever so slightly. In all but the best work it is better to admit this error than to keep an accurate account of the alternate assignment of the midclass measurements.

One more caution must be mentioned in connection with grouping measurements. Suppose we have a series running, we will say, as follows: 10, 11, 12, 13, etc., up to 50. If now we take them as they are, there will be some forty-one different groups, involving immense and unnecessary labor. The thing to do is to combine them into fewer groups, but in doing so it is important to observe great care in choosing the scheme for grouping.

For example, suppose we attempt to group them as follows: 10, 14, 18, 22, etc., reducing them to one fourth of the original number. What, now, will be the result? Consider the numbers, for instance, between 14 and 18. What is to be done with them? That is, how are the numbers represented by 15, 16, and 17 to be recognized in our new scheme? It will be noticed at once that we have chosen a scheme with *three* values between. Of these three values, 15 will of course go down with its new class mark, 14; and 17 will go up to 18. But what is to become of 16? Whichever way we put it the result will be to distort the distribution and prevent its being smooth; that is, it will put sudden humps and high spots into it, like saw teeth, that arise not from the variability in the true measurements but in the error introduced in the manner of grouping them.

The better way would be to choose a new scheme with an *even* number between the new values. For example, suppose we choose the following: 10, 15, 20, 25, 30, etc. Now there are four values between 20 and 25, namely, 21, 22, 23, 24, of which two can go up to 25 and two go down to 20, thus keeping true relative values and insuring a smooth distribution.

All this means that in choosing schemes of measurements and assigning values to class groups care must always be taken that the assignments are fair as between groups, in which case the distribution will be smooth and fairly representative of the population, all of which is far more important than is extreme accuracy in individual measurements.

Suggestions as to numbers. The number of cases needed is a rather difficult matter without getting involved in the question of probable error,[1] which is too complicated for consideration here. In general, large numbers are necessary. For work in corn 200 to 300 give good results, and in most ordinary problems this number answers very well. For extreme accuracy and for certain classes of problems much larger numbers are needed, but problems of that character involve considerations that are outside of our present purpose, which is to acquaint the student with the ordinary operations of statistical work.

Suggestions as to taking samples. When a comparatively small number of individuals (200 to 500) is to be taken as representative of the entire race to which they belong, it is necessary that the sample be carefully chosen. It should be what is called a "random sample." That does not mean a careless sample taken without regard to obvious differences, but it means a fair and representative sample. If the corn, for example, is husked and in a pile, there would be no better way than to shovel up the sample, taking whatever the scoop might deliver. But if the corn is in the stalk, the matter is different. If the ears are to be picked off, they must all be taken for a given area, for no man can be trusted to sort fairly, and areas enough must be taken to fairly represent the field.

Again, suppose one portion of the field is good, but that the corn in the low ground is partially drowned out, and the ears, of course, are small. In this case the proper proportion of the poor corn must be included or the result can be considered as representative only of the good portion of the field.

[1] "Principles of Breeding," pp. 437–440.

Advantages of statistical studies. From the standpoint of improvement, however, these methods give the breeder an opportunity to study characters carefully, to know their average value and the extent of their variability. Not only that, but records kept from year to year will show the breeder what progress, if any, he is making, and to what extent, if at all, the animal or plant is responding to his selection.[1]

Exercises. The student may well have much practice in solving distributions for mean, standard deviation, and coefficient of variability. Eight actual distributions are appended, five in length and three in ounces, but the student should have practice in taking his own measurements and in making his own scheme and grouping. These different distributions arise from different varieties or from different conditions of growth.

Length of ear			Length of ear				Weight of ear			
V	*f*	*f*	*V*	*f*	*f*	*f*	*V*	*f*	*f*	*f*
in.			in.				oz.			
2.5	1		3.0				1		1	
3.0	3	2	3.5				2	5	4	3
3.5	1	3	4.0	1		5	3	8	9	8
4.0	1	5	4.5	1	1	6	4	16	11	11
4.5	2	8	5.0	2	3	8	5	24	26	16
5.0	7	10	5.5	5	7	18	6	24	31	24
5.5	11	14	6.0	8	12	41	7	38	40	28
6.0	11	29	6.5	10	21	54	8	41	39	32
6.5	24	33	7.0	15	33	73	9	35	37	39
7.0	37	54	7.5	25	56	65	10	27	32	36
7.5	38	59	8.0	46	79	52	11	24	17	35
8.0	68	47	8.5	47	68	30	12	11	13	22
8.5	72	38	9.0	44	55	12	13	7	8	14
9.0	61	20	9.5	32	21	3	14	2	3	7
9.5	33	5	10.0	12	3	1	15	2		4
10.0	19		10.5	5	2		16			1
10.5	8		11.0	4						
			11.5	1						
			12.0							
	397	327		258	362	368		264	271	280

M = 8.015 M = 7.141 M = 8.322 M = 7.965 M = 7.063 M = 7.901 M = 7.860 M = 8.807

σ = 1.348 σ = 1.267 σ = 1.217 σ = 1.018 σ = 1.070 σ = 2.657 σ = 2.592 σ = 2.854

C = 16.82 C = 17.74 C = 14.62 C = 12.78 C = 15.15 C = 33.63 C = 32.98 C = 32.41

[1] "Principles of Breeding," pp. 434, 435.

Circumference of ear[2]				Number of rows on cob[2]			
V[1]	f	f	f	V	f	f	f
4.5	1	2		10			1
4.8	2	5	1	12	6	2	7
5.1	15	13	1	14	25	28	51
5.4	28	19	9	16	85	77	99
5.7	46	29	27	18	103	115	79
6.0	70	48	50	20	59	81	27
6.3	58	80	67	22	26	26	18
6.6	50	67	89	24	8	1	1
6.9	34	58	85	26	1	4	
7.2	5	18	23	28		1	
7.5	1	5	13				
7.8			1				
8.1			1				
	310	344	367		313	335	283

M = 6.121 M = 6.304 M = 6.505 M = 17.911 M = 18.107 M = 16.869
σ = 0.530 σ = 0.579 σ = 0.499 σ = 2.501 σ = 2.417 σ = 2.377
C = 8.66 C = 9.18 C = 6.90 C = 13.96 C = 13.35 C = 14.09

Original problems. Besides the solving of distributions given in the text, the student should have practice in devising and solving problems of his own. I know of no better method of teaching variability, and at the same time insuring rational conceptions of heredity, than by this methodical and accurate study of characters taken singly.

For this purpose the student may use not only dimensions like length and circumference, but he may use weights and numbers. He may take the heights of pupils in the school, the grades they make in classes, or he may take the yield of milk of many cows, or the weights of milk at the creamery. Anything

[1] Experience shows that it is better to take values by 0.25 instead of 0.30; thus, 4.50, 4.75, 5.00, 5.25, etc. These distributions were made smooth only by careful assignment of alternate measurements. This scheme of grouping has been discarded for this reason.

[2] Below each *f* column will be found the corresponding values. Thus of the first frequency, footing 310, the M = 6.121, the σ = 0.530, and the C = 8.66. In this way the answers can be identified for each problem contained in these tables.

that is variable, and where variability can be accurately measured, will afford a problem in statistical determination.

MILK AND FAT FROM 1200 COWS IN ILLINOIS DAIRIES[1]

Milk		Fat	
V	*f*	*V*	*f*
1,500	10	25	2
2,500	59	75	22
3,500	178	125	173
4,500	256	175	297
5,500	253	225	349
6,500	209	275	224
7,500	131	325	72
8,500	63	375	39
9,500	28	425	17
10,500	10	475	4
11,500	2	525	1
12,500	1		
	1200		1200

Milk	Fat
M = 5515	M = 218.25
σ = 1770.1	σ = 71.794
C = 32.11	C = 32.90

The solution of the problem on milk and fat tells us that cows vary among themselves 1770 pounds of milk and over 71 pounds of fat per year, but that the real variability of the two characters is practically identical — 32.11 and 32.90.

References. 1. " Principles of Breeding " (chap. xii). Davenport.
2. " Statistical Methods." C. B. Davenport.

[1] From the records of the dairy department of the University of Illinois; data collected by Professor Fraser.

CHAPTER IX

HOW CHARACTERS ARE TRANSMITTED

Every species of its own kind · The machinery of transmission · Fertilization · Fertilization in general · The material transmitted · Chromosomes · Development, or growth and differentiation · Termination to growth

The facts brought out in the last chapter show that many of the differences between individuals arise from variability in the degree of development of a single character, and that much opportunity for improvement lies in this field of selection.

There is, however, another and a greater cause of individual differences, and that is in the particular unit characters present. For example, everybody would recognize that there is more difference between a small draft horse and a racer than between the small drafter and a larger one of the same type.

This brings us to a study of the transmission of unit characters with a view to their control between parent and offspring for the purposes of improvement. The manner of this transmission, it will be seen, is the controlling factor in heredity and affords the principal basis for improvement.

Every species of its own kind. In a later chapter heredity and environment will be discussed, but here it is sufficient to call attention to the very large and obvious fact that whatever the influence of environment, the differences between individuals are not only great but inherent.

A kernel of corn and a kernel of wheat may be planted side by side in the same soil. If the soil be fertile and the season favorable, the crop will be good. If, on the other hand, the soil be poor or the season bad, then the crop will be small, but *the one will be corn and the other wheat in either case* ; all of which is but another way of saying that the real nature of the plant or the animal is not in the environment, but is inherent in the organism, the development being influenced but not determined by the conditions of life.

This particular nature which makes corn to be corn and not wheat, and wheat to be wheat and not barley, — this particular nature was implanted by the ancestry and will be transmitted to the descendants, in varying degrees perhaps, but yet true to nature if not absolutely true to type; that is to say, the descendants of corn will be corn and not wheat, for, as we have already noted, every individual will transmit all the characters of his race *and no others.*

The machinery of transmission. How, now, is this effected? How can the particular traits or unit characters that distinguish corn from wheat, or perhaps one kind of corn from another,—how can these specific differences, sometimes slight, be carried over and appear again with more or less exactness in the offspring?

To one accustomed to seeing everything producing after its kind, it all seems very natural, not to say inevitable, that this should be so; but the more the matter is studied the more difficult it becomes, and no subject in the realm of living matter is to-day giving scientists more trouble than this very one of transmission.

Whoever will take the trouble to visit a cornfield just after it is coming into tassel will have the opportunity of observing nature at work about some of its most important business.

First of all, he will see the embryo ear about halfway up the stalk, with a long fringe of tender "silk" pushing out from the end and after a time growing longer and dangling in the wind. If now the husks be carefully stripped down, the embryo cob will be discovered, and it will be found that each particular silk runs down and is attached separately and independently to a definite spot, which will one day, if all goes well, become a new kernel of corn.

Now, if all does go well, the silk will, after a few days, wither away, the spot on the cob at its base will begin to grow, and will in good time develop into a single kernel of corn; but if all does not go well, the silk will grow longer for a time, and finally wither away, but the kernel will not develop, and nothing but a bare cob will be found at husking time. What is it that decides whether there is to be or is not to be a kernel? The answer to that question involves the whole machinery of transmission.

Every farmer boy knows that at the top of the stalk is the tassel, and that this tassel has the habit at times of shedding large amounts of yellow powder, particularly after a rain or in the still hours of the early morning after a warm but quiet night. Most farmer boys know that in some way this golden-yellow dust, or "pollen," is connected with the crop, but few of them know in just what way.

FIG. 18. Ear covered for ten days with a paper sack preventing fertilization. The silk remained fresh and continued to grow. It has been known to reach a length of two feet while awaiting the pollen

If we use a microscope to magnify size, and see exactly what is involved and what is going on, it would be somewhat as follows:

First of all, the silk would be found to be soft and pulpy throughout its entire length, somewhat "sticky" and branched at the top or outer end, and connected at the base with a single cell, called an ovule.[1] Now this ovule is the important part, for it is what develops into the kernel of corn *if all goes well.*

[1] A "cell" is the structural unit of the plant or animal. As a building is made of bricks, so the plant or animal body is made up of cells or sacks filled with a semifluid matter known as protoplasm, which is a kind of general name for the material of different parts of the body; that is to say, the protoplasm of muscle, whose business it is to contract, is quite different from the protoplasm of liver, whose business it is to manufacture a definite secretion. The cells of different parts of the body structure contain, therefore, very different

It will be found that the characteristic thing which normally happens is this: one of the little particles of yellow dust drops upon the sticky tip of the silk, adheres, and begins at once to grow, not upward like a seed, but *down* the silk throughout its entire length to the ovule at its base.

Now the pollen grain is itself, like the ovule, a sex cell, though a very small one, with its nucleus and its surrounding protoplasm. The latter is consumed during the progress down the silk, but the nucleus descends until it reaches and unites with the nucleus of the ovule.

Fertilization. This is fertilization, after which the ovule, which would otherwise wither away, is capable of developing into a kernel of corn, which will be pure or mixed as to its unit characters according as the two nuclei that blended for its development were of the same or of different parentage.

The unit characters of the parents are undoubtedly contained in the two nuclei, and these are what decide the character of the offspring. It seems inconceivable that so small a bit of matter as a pollen grain or the nucleus of the ovule, each far smaller than the head of a pin, can carry so many and such profound potentialities; but the character of these two nuclei alone determine whether the kernel shall be white, yellow, or mixed, sweet, field, or pop corn. If both are from white parents, then the kernel will be white and will transmit white characters only; but if one be from a white parent and the other from a yellow, then the kernel will be mixed and will in its turn transmit both white and yellow characters. Corresponding results will follow if one should be field or pop corn and the other should be sweet corn.

Moreover, this kernel, whatever its parentage, may afterward "grow" and in its turn give rise to an entire new corn plant,

kinds of protoplasm, each with its own particular function to discharge. These cells lie closely packed together, like rubber bags filled with thickened water, and near the center of each is its "nucleus," which is its densest portion and the part which takes the initiative in cell division and growth. If it happens to be a sex cell, the nucleus is the repository of the hereditary matter and the seat of transmission.

bearing both silk and tassel and producing both ovules and pollen grains, each new kernel being independent of its neighbors.

Fertilization in general. This, roughly speaking, is characteristic of fertilization in general, whether plant or animal. A small male cell (the pollen grain in plants or the spermatozoön in animals) meets and fuses with the larger[1] female cell (ovule in plants or ovum in animals), which is thereafter capable of developing into a new individual possessed of all the characters of both parents.

FIG. 19. Kernels of corn growing on the tip of the tassel; occasional but not common

The method of effecting this union of the nuclei in fertilization and the time at which it takes place vary greatly in different species. In many plants both sex cells are borne by the same individual, either in one flower, as in the apple and the elm, or in separate flowers, as in corn.[2] In others, as the chestnut and the box elder, the male flowers are borne on one plant and the

[1] Though the female cell is always larger than the male, the nucleus, which seems to be the essential part, has the same number of chromosomes (see chromosomes), so that the male and the female parents have identical powers in transmission. The differences in size are apparently due to the amount of protoplasm surrounding the nucleus, probably as food material for the developing young and in no way connected with heredity. This difference is sometimes great, as in the egg of the hen, most of which is food material for the developing chick, while the male cell is microscopic.

[2] This bisexuality, or hermaphroditism, is also found in certain lower animals, as the earthworm.

female on another, following the plan of the higher animals, in which the two sexes are always identified with separate individuals. See also Fig. 19, which shows that the tassel is a modified ear with the female flowers normally undeveloped.

In the higher animals the ova are produced periodically and fertilization is variously effected. In fishes, for example, the eggs are fertilized by the male after having been deposited by the female. In frogs the eggs are fertilized during their deposition. In birds the eggs are "laid" as fast as they mature, but unless they have been fertilized by the spermatozoa of the male previous to being laid, they will not "hatch," just as the unfertilized ovules of the corn fail to develop, leaving the cob bare of kernels.

In mammals the ova ripen periodically like the eggs of the bird, with this difference, that if fertilized before escaping from the body, they are not discharged at all, but are retained in the uterus of the mother during embryonic development and are carried there until birth. The ova of mammals, unlike those of birds, are not supplied with sufficient nutriment to last through their comparatively long period of development, and this prenatal food is supplied directly through the blood of the mother.

The student hardly needs to be reminded that this blending of nuclei takes place and development follows only when the nuclei are not too dissimilar. For example, wheat would not be fertilized by pollen of corn, but it has been fertilized by that of rye. This mixing of very different races is known as hybridization. The most frequent case of hybrids among animals is the common mule, but a hybrid has been made between the lion and the tiger and very frequently among plants, as between the raspberry and the blackberry. We pass now to a more careful consideration of what is involved in transmission.

The material transmitted. All that is "handed down" from parent to offspring is, therefore, the minute bit of matter contained in the two nuclei and the small amount of surrounding protoplasm, — microscopic in almost all cases. Of course a single ovule with its pollen nucleus would develop but a single kernel, and the operation described must be repeated for every one of the thousand or more kernels of the ear, each of which for present purposes is a distinct individual.

The same is true for each grain of wheat, though in this case the ovule and the pollen are produced in the same flower and close together under the scale or chaff. So the process could be traced for every seed of all species, for each is a new individual. Among animals, also, but two nuclei are involved for each new individual whether as small as the cricket or as large as the elephant.

Little enough is known of the essential constitution of these remarkable bits of living matter called nuclei, but that little is too much to discuss exhaustively here.[1] It is enough for present purposes to call attention to the wonderful fact that these two bits of matter, too small to be seen and studied with the naked eye, carry with them all the characters of the race; moreover, as they constitute the only material transmitted from parent to offspring, they are the only vehicles of transmission. Other nuclei from other parts of the body can repeatedly divide, absorbing food as they do so, constituting growth, but these nuclei from the reproductive cells, excepting in certain lower species, do not grow till after union with others from the opposite sex.

Chromosomes. The nucleus of the animal or plant cell is something more than a formless bit of matter endowed with life. If the nuclei of several species be stained and examined under a high-power microscope, each will be found to contain a definite number of rods, rings, or other bodies, always the same in all the cells of all the individuals of the same species, but differing in different species. These are called chromosomes.

Another peculiarity about the chromosomes is that for all species that propagate bisexually the number is even; thus in mouse, trout, and lily it is 24; in ox, guinea pig, onion, and

[1] It may be conveniently pursued further in "Principles of Breeding," chaps. vii and viii.

probably man it is 16; in ascaris, 4 or possibly 2; while in artemia it is 168.

There is still another peculiarity about the chromosomes, namely, that the nuclei from the *sex cells have but half the usual number;* but after union of the two nuclei from the separate parents, the full number is restored, and from then on cell division and growth begin and proceed in the usual way, barring accident, till full maturity is attained.

These chromosomes, therefore, appear of importance, not only in growth (for the operation of cell division seems to be preceded if not characterized by the division of the chromosomes), but they appear to be *par excellence* the hereditary substance, that is, the bearers of heredity; all of which encourages the belief that most characters are in some way identified with definite portions of the hereditary matter of the nucleus, that is, with its chromosomes.

Development, or growth and differentiation. The process by which these two nuclei after fusion succeed in producing a new individual combines two phenomena, namely, growth and differentiation.

The process of growth means that this new cell, which is made up of two others, is able now to absorb food materials and to first increase in size, then to multiply in numbers by the process of repeated and indefinite division, until what was once a single cell comes to be a new individual with thousands of cells.

This is growth and it is astonishing enough, but the chief marvel is the differentiation that attends it. When these thousands of cells have developed from the one original, it will be found that they are *not all alike;* some are stem, others root, still others leaf, flower, or fruit. In the case of animals some are muscle cells, others constitute liver, brain and nerve, arm, leg, or eye.

In other words, growth has been attended by differentiation, so that the single minute mother cell has been able to give rise to many cells of many kinds, only a few of which are able to repeat the process of reproduction. Not only has differentiation taken place, producing different parts of many kinds, but they are of the same kind and in the same position as in the *parents*.

In a few cases accidents happen and development does not proceed in the orderly manner that commonly characterizes reproduction. These cases are extremely rare, but of sufficient interest to constitute the material of a separate chapter, dealing with what happens when development goes wrong.

Termination to growth. Still another marvel attends upon growth and differentiation, and that is, that it should all stop at the right point. It is difficult to comprehend that a man's arm should grow at all so as to be an arm and not a leg, but once started it is still more difficult to understand what should stop the growth at exactly or approximately the right time, and not allow it to proceed indefinitely, as it does in the nails, claws, and, to some extent, in the teeth of animals.

In general, plants have no "typical termination" to their growth, but increase in size as long as life lasts; that is, they seem unable to discharge their function except in connection with new growth and by means of recently formed tissues, while animals "get their growth," that is, function independently of new growth.

Summary. The only possibility of transmission of the unit characters of the parents to the offspring is by means of the minute bits of matter contained in the single sex cell from each parent, because it is the only material handed down to the new individual.

How this microscopic bit of matter can contain all the potentialities of the race and be able not only to grow and to differentiate with growth, but to stop at the right point, — how it can do all this is a mystery, but the fact is doubtless connected with the definite "architecture" or structure of the germ plasm which contains always a definite number of chromosomes.

Exercises. 1. Study the formation of pollen and the location of the pistil together with the method of getting the pollen upon the stigma in a variety of plants. Oats, wheat, beans, sweet peas, and hollyhocks are especially recommended.

2. Examine frog spawn, if any is available, and, if possible, obtain mounted slides showing the early stages of embryological development.

3. Set a nest of eggs under a hen and break one every other day after the first week.

CHAPTER X

WHEN DEVELOPMENT GOES WRONG

Differentiation with development · Underdevelopment, or dwarfing · Overdevelopment, or giants · Arrested development of a single character or part · Overdevelopment of a single part · Doubling of parts · Fusing of parts · When unit characters get misplaced · Abnormal growths

Differentiation with development. The greatest marvel of development is differentiation. That two nuclei not only from different cells but from different individuals should fuse, absorb food, and divide and subdivide into not hundreds but thousands of others, — all this is wonderful enough, particularly when we remember that without this union neither would be capable of dividing at all.[1]

After all, however, the marvel is that with development comes differentiation; that is, that the result of growth is not a lump of formless matter. On the contrary, here a leg, there an arm "buds" out; here an ear and there an eye or a tooth appears; here a lung forms to take in air and there a heart develops to pump over the body the stream of digested food that we call the blood, — and so on, bit by bit, the whole complicated structure of the body arises, each part in its proper place; and not only that, but in general an exceedingly striking resemblance to the particular parentage results, so that the being which develops from a fertilized ovum of the horse, for example, is not only another horse, instead of a cow or a pig, but it is a particular kind of horse, depending upon the special individuals from which he was born.

[1] There are a few exceptions to this statement, but they are concerned with parthenogenesis, which is not involved in the subject matter here under discussion.

It must not be assumed, however, that development always proceeds in this regular manner nor that the results are all perfect. A great variety of departures from the usual plan may occur, each with its attendant consequences, some of which are worth mentioning here, not so much for their own sake as to make the student intelligent upon the really complicated processes involved in development, and with which we must reckon in all attempts at improvement.

Underdevelopment, or dwarfing. In order to produce a perfect individual, differentiation must not only occur in proper form, but each of the various parts must grow to the normal size. If growth stops short of this point, it is a case of dwarfing. The dwarf is like the normal individual except as to size.[1] The separate cells of the body of the dwarf are of the usual magnitude, but the number is fewer; that is, cell division[2] has not continued the normal length of time.

Nearly all animals are subject to dwarfing, though it is approximately rare, if not unknown, in some. It is common with human beings as well as with horses, dogs, and chickens, in which dwarf species have developed.

The dwarf is very rare, if not unknown, among cattle and sheep, though, as in all species, a good many individuals are "undersized." The "titman," or "runt," in the litter of pigs is really a dwarf, the dwarfing process often being due to insufficient food at the start.

Dwarfing due to this cause will sometimes disappear with improvement in the conditions of life, though, in general, size and development lost in early life are seldom fully restored. Cell division and growth are more rapid at birth than ever afterwards, a steady decline setting in that does not permit full reparation for early checks to normal development, — a fact which

[1] So-called dwarfs are often misshapen things, but in these instances other accidents than dwarfing have occurred, as will be shown later.

[2] For a description of cell division in connection with growth, see "Principles of Breeding," pp. 145–152.

shows the importance of early food and care for the young of our domesticated species.

Plants are easily dwarfed, either by scarcity of food or by repeated planting of immature seed. Many species have their dwarf varieties, though others are artificially produced by grafting on other and smaller species, as, for example, the pear, which is dwarfed by grafting upon stock of the quince.

Overdevelopment, or giants. In normal development and differentiation, growth should not only proceed to the proper point, but it is fully as important that it *stop* at that point. If it does not, then overgrowth takes place and a giant is produced.

As the dwarf is the result of too little cell division and too few cells, so the giant is the product of too much cell division and too many cells; that is to say, of growth that did not stop at the right point.

Giants are common in man and frequent in cattle. So far as is known to the writer, they are unknown in horses, sheep, and pigs, though these species can all be increased in size somewhat above the normal by extreme feed and care in early life as well as by selection of parents above the normal.

Neither giants nor dwarfs possess special interest to the improver, because if we needed a smaller or a larger race than the normal, we should not depend upon these occasional individuals, which are abnormal, to produce it. Their mention here is for the purpose of making the student somewhat intelligent on the processes of life, to do which requires a number and variety of examples involving various phases of abnormal development.

Arrested development of a single character or part. Dwarfing may take place with respect to one or more parts or characters, while others proceed to normal development, giving a more or less distorted body.

This form of abnormality has many manifestations. In some cases, for example, a part is entirely missing, as if the unit character had been lost, as in a case, known to the writer, of a man whose feet were attached directly to the body, the legs having never developed.

A great variety of missing parts might be mentioned and specimens innumerable may be seen in almost any museum.[1] One or both horns may fail to develop or the two may fuse into one. A well-known calf in the Chicago stockyards never had but one front leg and was used for years as a "penholder."[2]

Men are frequently born minus one or both arms, or parts of the arm, and a student of the writer's, normal in every other way, had no forefinger on the right hand. Almost every neighborhood will afford similar examples.

Not infrequently the nondevelopment of a part becomes a regular and constitutional matter. The male narwhal, for example, develops the canine tooth as a long, twisted tusk, often attaining a length of seven or eight feet. The peculiarity is that normally only the *left* tusk develops, the right remaining rudimentary. In rare cases both are developed, *but never the right without the left.*

The snake has commonly but one lung, the other regularly failing of development along with his rudimentary legs, which are still represented by a few remains of bones in the pelvic region of such large specimens as the python.[3]

The whale is not a fish but a mammal, like a cow. It is developed from an old-time land animal, and its rudimentary legs are still to be found as parts of the skeleton. Both teeth and hair develop during the fetal life, but are absorbed and disappear before birth, never developing afterward.

[1] Abnormalities are sufficiently common and curious to give rise to their special study, which is known as teratology.

[2] A penholder is, in stockyard vernacular, an animal that is used to hold a yard or pen, which, so long as it is occupied, belongs to the owner of the occupant.

[3] Snakes, of course, are developed from prehistoric species with legs and probably at that time supplied with two lungs. The modern lethargic life renders such lung power unnecessary, and the restricted space in the elongated and constricted body makes it also impossible. So the modern snake gets along very well with one lung.

The ostrich is losing his useless wings, and those of the apteryx have gone, except that some of the bones can yet be found just under the skin of the breast. And so examples of missing or disappearing parts could be multiplied indefinitely, but enough have been given to show that development does not always proceed regularly, and that the arrest of one part does not necessarily prevent the development of others.

The most important phase of this subject to the general student is in the field of the mental and moral characters, especially with people. Idiocy is but the arrested development of one or all of the mental faculties, just as insanity is their breaking down from insufficient power originally or from overwork or abuse in life.

Just as we have idiotic people, so we have idiots among horses and dogs, a fact that destroys or greatly lessens their value in proportion to the kind of work we expect them to do. We have also insane individuals in both species, and some of the most dangerous runaways are due to sudden insanity of the horse, brought on by fright, old age, or disease.

Both horsemen and dog fanciers should understand that in these two species we are dealing with mental faculties of an order so high that any disturbance or shortage is a serious matter. Other animals are of a much lower order of mentality and we depend less upon their intelligence, so that relative idiocy is not so noticeable, nor is insanity so likely to appear, because they lead, upon the whole, a relatively tranquil life. Occasionally, however, a steer loses his head, as when being driven in a strange place, and when he does it is a good time to find cover.[1]

The most serious consequences follow the arrested development of the mental and moral faculties in man. We are only recently coming to recognize these unfortunate individuals as degenerates and to realize their wholly dangerous character. A

[1] This happens frequently about the stockyards in all markets, though commonly animals in large numbers are extremely quiet.

trip through any of our prisons by one who knows what to look for and is quick to recognize signs of arrested development will convince him that one of the problems of civilization is to deal with members of our own race who are not sufficiently developed to exist under civilized conditions except as a constant menace to society. When these facts are more generally realized we shall free ourselves of much maudlin sentiment and be on the road to solving this most perplexing and awful problem, — the problem of the human degenerate.[1]

Overdevelopment of a single part. Just as a part may fail to develop without destroying the individual,[2] so also can one or more parts attain extreme development, while most or all of the others may remain normal. A little of this commonly occurs among giants, which are, in man, generally disproportionally developed in the thighs; indeed, most extremely tall people get their height at this point.

Often the liver will begin growing and attain enormous size (hypertrophy); or if one kidney is removed, the other may become greatly enlarged through doing the work of both.

If the spleen is removed, the lymphatic glands of other parts of the body become greatly enlarged (compensating hypertrophy), a phenomenon akin to the sharpened hearing of blind people, but only partially comparable from the fact that practice and concentration of attention help to explain the skillful use of hearing by the blind.

[1] The extent to which the human animal may be destitute of one or more of our higher faculties can be illustrated only by appealing to the fact that as individuals are minus legs, arms, fingers, hands, ears, eyes, etc., so they can be and are destitute of many of the mental faculties necessary to an understanding and appreciation of the main facts and principles on which civilized society exists. Such individuals cannot live at large except as a constant menace. They should therefore, upon committing crime, be permanently withdrawn from society.

[2] Of course, if arrested development occurs in any vital part, death ensues. One of the most common cases of infant mortality is the failure of the heart to complete its development and therefore to properly circulate the blood, giving rise to the disease known as "blue baby," from the blue or nonaërated blood.

Doubling of parts. One of the most common of abnormalities is the increase of numbers of parts, especially by doubling. An extra finger or toe is by no means rare, and double thumbs or even double hands are not unknown (see Fig. 20).

The horse, having developed from a five-toed ancestor, has frequently an extra toe or two, as does the cow, though less commonly. Certain strains of sheep have four horns instead

FIG. 20. Symmetry within the variable part. Here it would seem that an attempt has been made to repeat the hand, or rather that an attempt at repetition of the thumb has resulted in a doubling of the hand. — After Bateson

of two, and occasionally the deer shows a cluster of horns instead of the normal growth.

Insects frequently double a leg or a wing, and turtles and snakes occasionally double the head;[1] indeed, there is almost no organ or part of the body that may not in rare instances be doubled[2] (see Fig. 21).

Doubling among plants is exceedingly common, being nothing more or less than branching. Double clover heads are found everywhere, double timothy heads rarely, and double wheat still more rarely. Double ears of corn, or, more properly, "fingered" ears, are frequently found, as are little ears on the end of the tassel (see Fig. 19).

[1] "Principles of Breeding," pp. 44, 64, 67.

[2] The so-called double-headed people of the shows have been in every case really twins united by fleshy growth, an abnormality that occasionally happens.

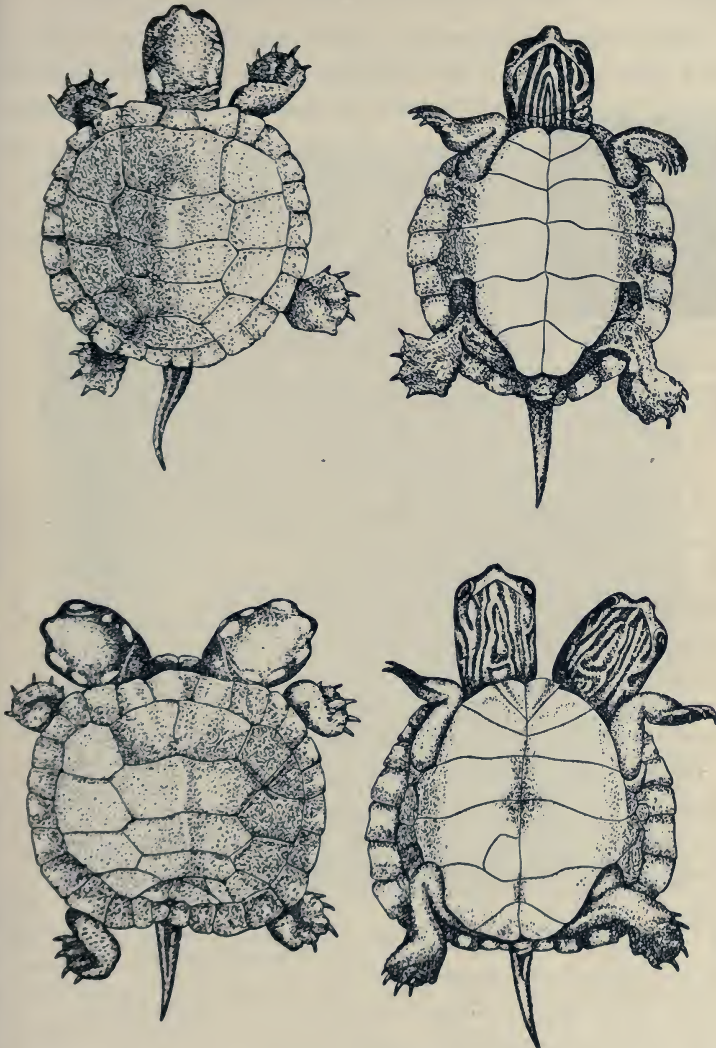

FIG. 21. Upper and lower surfaces of double-headed turtle compared with the usual specimens two to three days old. Note effect on shell plates both above and beneath. In this specimen the movements of the legs on opposite sides were not well coördinated. — After Bateson

The stooling of grain is a case of branching at the base and is a real doubling, as are the four-, five-, or six-leaved clovers.

FIG. 22. A hand-shaped corncob showing a tendency to branching of the ear, not at all uncommon

The whole matter of doubling is, of course, the result of an extra cell division at the proper point, — an abnormality that is sometimes hereditary but oftener not, though a strong tendency exists for any physiological habit proceeding from internal causes to become hereditary.

Fusing of parts. Quite the opposite of doubling is the fusing or joining of two parts into one. Thus the two kidneys may be joined at one end, making the horseshoe kidney. A pair of horns may be compounded into one. Two fingers of the human hand or the two toes of the pig[1] may be united into one.

FIG. 23. Compounding of paired organs: the two horns of this roebuck are united into a single beam for a considerable distance, but afterwards they separate. — After Bateson

When unit characters get misplaced. Perhaps the most remarkable fact of development and differentiation is seen when a normal structure develops in an abnormal place. Thus occasionally a tooth will develop in the roof of the mouth, as if the germ of it had in some way got misplaced but was able to grow in its new place, like a tree that is transplanted. Sometimes the eye of an insect will develop not as an eye but as an antenna.

[1] These are the so-called solid- or mule-hoofed hogs. This abnormality arises frequently and may be readily propagated, as it happens to be fairly hereditary. See "Principles of Breeding," pp. 55, 66.

Milk secretion is the function of glands that are normally confined to special parts of the body. It is not unknown, however, that the tissues of various parts of the body, especially in

FIG. 24. Abnormal horny growth on the head of a deer. Specimen in State Museum, Augusta, Maine. Courtesy of the superintendent

the region of the lymphatics, may alter their function and secrete real milk.

This development of a part out of place is not common, but it occurs frequently enough to show the fact that each part of the body is a kind of definite unit quite independent of other parts, all of which casts important light upon the semi-independent nature of unit characters.

Abnormal growths. Not only do unit characters occasionally get mixed up and jumbled together in quite remarkable fashion, but in rare cases growths occur which, if not formless, at least are in no sense of the term normal body growths. Often these are distorted imitations of the real part, as on the deer's head shown in Fig. 24; but often, if not commonly, they are overgrowths of some part of the body, induced possibly by irritation or perhaps by poisons, as in galls, in the characteristic tubercle of the disease known as tuberculosis, and in its namesake, the tubercle of the legumes.

Of this general character, too, is the tumor, that perverse overgrowth due to disorders not understood, but which, from the fact that they "have no typical termination," are not only extremely troublesome but often dangerous to life.

With this glimpse at the abnormal we are prepared to resume the normal and to discuss briefly how unit characters behave in transmission.

Summary. Development may go wrong in several ways. First, some part may not develop at all, or, on the other hand, it may far exceed its normal size or function. A part may even be doubled, two parts may fuse into one, or normal characters may get misplaced. The whole organism may exceed the normal size or it may stop short of the usual, and in rare cases abnormal growths may occur in almost any part of the body.

Exercise. Make collections of plants or parts of plants, including fruits and flowers, in which development has been in some way unusual. Such a collection is not representative of life processes, but it does show what may possibly happen when development goes wrong, and it fixes the conception of unit characters.

Learn by observation and inquiry all that you can about unusual animals in the neighborhood, either in regard to color markings or abnormal parts, getting photographs and accurate descriptions wherever possible. Let a collection of such specimens and photographs accumulate in the school for future studies in abnormal behavior during differentiation.

CHAPTER XI

HOW CHARACTERS BEHAVE IN TRANSMISSION

Characters tend to combine in definite mathematical proportions · Characters that do not blend · Mendel's law of hybrids · Dominant and recessive characters · Pure races may spring from crossing · Very few individuals pure · A second method of improvement · Improvement by hybridization complicated · Mutation and mutants · Origin of new and improved strains

The manner and machinery of transmission are exceedingly simple, but the mystery is, how so many and such different unit characters are contained in so small a bit of living matter, for that is all that passes over from parent to offspring. Many ingenious theories have been offered in explanation, but the mystery itself has never yet been solved. We do know much, however, of what in the end really happens, and in that, after all, the chief practical interest lies.

Characters tend to combine in definite mathematical proportions. In the case of the white and yellow corn, for example, if a yellow silk is fertilized by a white pollen grain, the resulting kernel will be a "half blood"; that is, one half its color tendencies will be yellow and one half white. If such a kernel now be planted where its progeny will again be fertilized by white pollen, the result will be a three-fourths white and one-fourth yellow generation. If the same be done again, the next generation will have seven eighths of the white "blood" with only one eighth remaining of the yellow, and so on indefinitely in regularly increasing and decreasing proportions. Of course the opposite result, but on the same plan, would have followed if the half blood had been bred successively with yellow rather than with white varieties.

Having found the principle, we can readily calculate the "blood" of the progeny of any known mixture. For example, the blood of a three-fourths white bred with a seven-eighths white would be $\frac{\frac{3}{4}+\frac{7}{8}}{2}$, or $\frac{13}{16}$ white with the remaining $\frac{3}{16}$ yellow, — this much for single kernels or for a whole generation of known mixed breeding.

Suppose now that white and yellow corn be planted together in the same field in equal proportions. What will be the nature of the crop? The answer to this question covers one of the most important points in plant or animal improvement, for there is no essential difference in principle between the two, and what applies to one applies equally to the other, so far as principles are concerned.

In such a field planted equally with white and yellow corn the first question is, Will all the kernels be mixed? Manifestly not. Under the law of chance [1] a yellow silk, for example, will have equal opportunities of being fertilized by a yellow or by a white pollen grain; that is to say, the ovule stands equal chances of developing as a pure or as a mixed kernel, and the same may be said of any kernel in the field, provided of course that the number of silks and of pollen grains are equal, as was specified in the problem.

When the season is over, the whole population of corn kernels of the field will then be as follows: on the stalks arising from yellow kernels $\frac{1}{2}$ will be pure yellow and $\frac{1}{2}$ will be mixed, yellow and white; on the stalks arising from white kernels $\frac{1}{2}$ will be pure white and $\frac{1}{2}$ will be mixed, yellow and white.

Now, as the corn was planted half and half, each kind of stalk represents half the crop. So we have for the field as a whole, $\frac{1}{4}$ pure yellow; $\frac{1}{4}$ mixed, white on yellow; $\frac{1}{4}$ pure white; $\frac{1}{4}$ mixed, yellow on white.

But as white pollen on yellow silk gives the same mixture as yellow pollen on white silk, we have our population reduced to the following: $\frac{1}{4}$ pure yellow, $\frac{1}{2}$ mixed, $\frac{1}{4}$ pure white, from which

[1] "Principles of Breeding," pp. 365, 504.

we deduce that with reference to a single character the total offspring resulting from mixed breeding between two races, in equal numbers where no selection is involved, will be in the proportion of $\frac{1}{4}$ pure of one variety, $\frac{1}{2}$ mixed, and $\frac{1}{4}$ pure of the other. This is in the proportion of 25 per cent, 50 per cent, and 25 per cent of the total population, or of 1, 2, 1. If the proportion between yellow and white had been as 2 to 1 instead of even, then the proportion of the pure and mixed kernels would have been different but still definite and easily computed.

Let us now see what would happen if this crop of pure white, pure yellow, and mixed should be planted together again, *each sort in its true proportion;* that is, just as would happen in nature, supposing all forms to be equally vigorous and equally able to withstand natural selection. We will tabulate this because it gets rapidly complicated. In the table let the different combinations planted be represented by the column headings across the top, and the different kinds of pollen produced be represented by the headings down the side.

Remembering that every kind of pollen will fall on every kind of silk, and in definite proportions, the results are as follows, the body of the table representing the various kinds of progeny and the footing at the bottom showing the final and total population.

	y^2	$2\,yw$	w^2
y^2 . .	y^4	$2\,y^3w$	y^2w^2
$2\,yw$.	$2\,y^3w$	$4\,y^2w^2$	$2\,yw^3$
w^2 . .	y^2w^2	$2\,yw^3$	w^4
Total, $y^4 + 4\,y^3w + 6\,y^2w^2 + 4\,yw^3 + w^4$			

In this table the exponents represent the number of infusions of pure blood; that is, y pollen on y silk gives y^2 kernels, or two infusions of y, as compared to the y of yw, which represents the first mixture of yellow and white, and so on for other combinations.

Now these facts are significant: first, we have all the combinations possible between y and w as the result of two admixtures; second, with all this admixture for two generations we still have some white (y^4) and some yellow (w^4) remaining as pure as if no mixture had taken place in the field; third, the coefficients expressing proportion as well as the exponents expressing infusions of blood stand in the exact form of the binomial theorem, that is, we have here reproduced the binomial $(y + w)^4$. Knowing this general theorem, the student can readily write the color or blood combination for any number of infusions with any degree of mixed breeding.

Another significant fact must be noted, namely, that although this formula becomes rapidly complicated with successive generations,[1] there are always a few individuals remaining just as pure as if no mixed breeding had been done, all of which means that in free and unrestricted breeding all possible combinations will take place. In systematic improvement it is the business of the breeder to allow only such blood combinations to be made as will result in desirable combinations and favorable results, preventing all others.

Characters that do not blend. When diverse characters are thus brought together, two very different results may follow. They may blend into a single new character, in which case our figures show the *proportions within the blood*, or they may remain distinct as two independent characters within the same individual. Stature and size as well as many colors blend freely, but not all characters behave in that simple way. For example, white and black blend freely in the human race, and the offspring of white and negro are mulattoes of various shades, according to the respective infusions; but colors do not blend in pigs, which are either black, white, or spotted, never roan or mulatto. Some colors blend in horses (roan), some do not. Some breeds of cattle have blended colors (Shorthorns); in others the colors remain distinct (Holstein-Friesian).

And so with characters generally. Many will blend and many others will not. When they will not blend, then the appearance is still less a guide to the real hereditary qualities, and under these circumstances it is little or no index to what will happen

[1] "Principles of Breeding," p. 506.

when the mixture is bred. This fact was long a great stumblingblock to breeders, involving the business of improvement in unfortunate and, as we now know, unnecessary mystery.

Mendel's law of hybrids.[1] This so-called Mendel's law, named for its first discoverer (I say first, for it was lost till rediscovered), attempts to predict what will be the real character of the offspring of mixed or hybrid parents when the characters of the mixture will not blend.

What really happens in such a case is this: The hybrid offspring, instead of possessing a new character which is a kind of mean or blend between the different characters of the two parents, will contain them *both;* and when these hybrids are bred together, their offspring will be not of one but of *three* distinct kinds, namely, a group that is like the one original and pure parent, another group that is like the other original and pure parent, and a larger group that is hybrid like its immediate parents.

For example, let x and y represent any two nonblending characters in separate individuals. What will happen when they are bred together, and when their hybrid offspring are afterwards bred among themselves?

The problem stands thus: One parent produces both x and y characters. The other parent also produces both x and y characters. What are the combinations that will take place? Manifestly these combinations will follow the law of chance. In one case out of four the two x's will unite, making pure x's (x^2); in one case out of four also the two y's will unite, making pure y's (y^2); and in the two other cases the x and the y will unite, making again xy offspring in numbers equal to both the others; that is, the total result of breeding together a lot of hybrid individuals with mixed characters x and y will be in the proportion

[1] Mendel, an Austrian monk, carried on experiments in his garden that brought out the principle here stated, but all of which was lost and lay unknown for many years. For a more extended account, see "Principles of Breeding," p. 513.

of $x^2 + 2xy + y^2$, in which x^2 and y^2 are pure as to this character, though descended from mixed parents on both sides.

Now the x^2 part of this offspring, having no y characters, will continue to breed pure x as well as if no y were involved in the make-up of its ancestry, and likewise for the y^2.

The $2xy$ part of this generation is hybrid like the parents, and, when bred together, will reproduce again the same general character of offspring as their hybrid parents of the last generation, namely, $x^2 + 2xy + y^2$; that is to say, when hybrids of nonblending characters are bred together they will produce three kinds of offspring. One will be like the one pure parent; another will be like the other pure parent, and the third group, constituting one half the total numbers, will remain hybrid. The two others will breed pure, but the hybrid will not.

Dominant and recessive characters. In truth, it is seldom in practice that all these three classes stand clearly out. Some characters are dominant over others; that is, more easily detected, such as strong colors over weak, huge size over small, etc.

Suppose now that we take such a case, representing the dominant or easily detected character by the letter D, and the recessive, as it is called, or the obscure character by the letter r. The result of breeding Dr hybrids with themselves will then be $D^2 + 2Dr + r^2$.

Now what will this kind of a population *look like?* The D^2, being pure, will of course be easily seen. The same is true of the r^2, though less distinct, because the recessive characters are less conspicuous; that is, 25 per cent of the population is clearly D^2 and another 25 per cent is as certainly r^2. But what about the remaining 50 per cent?

Clearly this 50 per cent (Dr) will *look* like pure D, because the r character, though actually present, will not be noticed, being recessive.

Accordingly the whole population, instead of looking like $25\,D^2 + 50\,Dr + 25\,r^2$, as it really is, will appear like $75\,D^2 + 25\,r^2$, the eye being unable to distinguish between the $25\,D$ and the $50 Dr$; that is to say, where one character is dominant and the other recessive, it is simply impossible to separate the pure dominant from the mixed dominant and recessive by appearances merely. It can only be done by a resort to the breeding test, when the really pure D^2's will produce only D's, while the real Dr's will produce back again the characteristic $D^2 + 2 Dr + r^2$ with its 25 per cent of pure r's. As has been already

FIG. 25. Showing albino sire and black dam with their offspring, all black. Below, a pair of the hybrid offspring and their litter (see text). From photographs furnished by W. E. Castle, Harvard University

explained, no such difficulty exists with regard to the pure recessive character, because from the first those that *look* like recessive *are* recessive. For this reason breeders are always glad when a desired character proves to be recessive, because it can be so much more easily separated from its associated character than can a dominant.

This behavior of unit characters in hybrids is beautifully illustrated by the work of Professor Castle with guinea pigs, as shown in Fig. 25. Here we have a hybrid offspring from an albino sire and a black dam. The offspring are all black, so black is dominant over white. Their offspring are, however, of two kinds, both black and white, but in the proportion of 3 to 1. Of this group of four, therefore, only one, the white, can with certainty be counted upon to breed true. Some of the blacks will also breed true, but only the breeding test will determine which they are.

This whole matter is up in full force in all attempts at improvement by crossing, whether among plants or animals, which is the reason why animal breeders especially avoid this form of breeding, though it is a favorite method in the improvement of plants, which can be produced in large numbers.[1]

When the parents differ in two unit characters, the case is more complicated, but the principle remains the same, namely, that all possible combinations will occur and a perfectly definite number of each may be expected. Again, Professor Castle's work with guinea pigs illustrates the point especially well.

In Fig. 26 are shown a dark-colored smooth-haired and an albino rough-haired parent. Their offspring were *all* dark and rough as shown in the middle figure, but some of their progeny were smooth and white as shown in the lower figure, while others were like each of the original parents, and still others like the first hybrid; that is, all possible combinations had been made. In this case the Mendelian expectation is 3 : 3 : 9 : 1.

Pure races may spring from crossing. The facts just presented show that *for characters that blend*, the hybrid will breed pure as a single new race, but that for characters that do not blend, the individuals may or may not be pure and may or may not breed true.

All the facts go to show that whether the offspring of hybrid parents consist of three groups as when only one character is involved, or whether they consist of many groups as when two or

[1] The student of breeding should understand, however, that crossing is equally effective with animals and plants, except that the very large numbers involved makes it too expensive for most individual animal breeders.

more characters are involved the groups may, by patience, be separated and new races established that will breed pure. The greatest difficulty arises in separating for the dominant characters, but the test is in the descendants.

It will be noted too, in this connection, that in these new races an absolutely new association of characters is often brought

Fig. 26. A dark smooth parent and an albino rough parent. Below is their dark rough offspring, and at the bottom one of the types that appeared in the grandchildren (see text), a new type associating the short coat and the white color. — After Castle, 1905, *Publication 23*, Carnegie Institution, Washington, D.C.

about as when the white color and the smooth coat have been brought together from two different sources. In this way new races that will breed true may be got out of a mixture whether the characters blend or not.

Very few individuals pure. What has just been said has reference to characters and not to individuals. As will be seen below, it is a difficult task to find an individual that is pure with reference to all his characters after they have once become entangled with others.

A second method of improvement. It is very clear that here we possess a means of improvement quite different from that of simple selection, and, moreover, it is one that will somewhat suddenly give rise to new races. The chief difficulty is to find and identify the comparatively few individuals that are pure with reference to all essential characters, and this is a reason for reducing the characters in breeding to the fewest possible.

As to nonessential characters the new race may remain hybrid for all the breeder cares. For example, if he is trying to combine amount and quality of milk, he will get along faster if he pays no attention to the color of the cows, and selects only the few that have the character he is after, leaving the color, for the present at least, to behave as a hybrid, to be managed later after the high milkers have been isolated.

Improvement by hybridization complicated. When but one nonblending character is involved, a full 50 per cent of the offspring of hybrid parents is pure as to that character, it being equally proportioned between the two parents.

If, however, another character be involved, then only a small proportion of the offspring that are pure as to the first character are pure also as to the second character, and so on for additional characters.

If all the desired characters are recessive, then all that is required is to wait until the rare individual appears that has these characters and no others; but if, as in most cases, some of the characters sought to be retained are dominant, the separation will be a tedious operation.

Mutation and mutants. Accidental crossing in nature is constantly producing new strains, most of which go down in the struggle for existence, but some of which are sufficiently vigorous and prolific to persist. They are seldom equally vigorous or equally prolific with the parent strains, else they would long ago have developed into good species. These strains can of course be seized upon when found, and it will be discovered, as we should expect, that a few of them will breed true, but that most of them will break up, like other hybrids, into a variety of forms.

Apparently quite independent of this, however, new forms occasionally arise by methods that do not seem to involve crossing. For example, polled or hornless cattle occasionally arise spontaneously, as we say; that is, without crossing or other known cause. Albino strains arise frequently in nearly all races. Thus we have white cattle, horses, sheep, dogs, cats, pigs; and, among wild animals, deer, bears, wolves, rabbits, mice, and rats, most of which are known to breed pure.

In a few cases, notably with sheep, the albino strain has been the favorite for obvious reasons, and the older stock, the brown or so-called black sheep, is well-nigh lost. With pigs the preference is about evenly divided between the black and the white.[1]

Among plants mutation is even more common or else more noticeable than among animals, and much of it arises from what is technically known as bud variation. Thus a peach tree may bear peaches in the usual way for a number of years, when suddenly one or two limbs or possibly the entire tree may bear a crop of nectarines for a year or so, and then resume the bearing of peaches.

The moss rose is a mutant of the common wild rose, which is the parent of all cultivated varieties. The strangest thing about bud variation is that the mutants thus arising often *breed true*, as do the moss rose and the nectarine.

The weeping habit among the willow, birch, beech, and other species of trees; the appearance of smooth among thorny or hairy strains, like the smooth gooseberry; and the reverse of this, namely, the sudden appearance of hairy or fuzzy strains among the smooth, — all these are now known as mutants.

[1] Certain red strains of swine have been built up mostly by selection, though possibly to some extent by mutation, the only red foundation being the reddish-tan tinge on the end of the hair of the wild boar.

Such radical departures from type were formerly recognized and popularly designated as "sports," as if nature in some sudden antic disposition, at play in her workshop, were disregarding all ordinary laws of procedure.

The modern name of mutants is better, and while these sudden departures are often independent of crossing, it is significant that they frequently breed true, showing that the changes involved are sufficiently profound to affect the germ plasm.

The selection and isolation of desirable mutants, therefore, constitutes a third method of improvement of animals and plants, the one most practiced by Luther Burbank.

Origin of new and improved strains. Three methods of improvement are therefore open to the breeder: (1) selection in imitation of nature; (2) crossing, with the understanding that new strains may also be shaped up by selection; (3) mutation, the fortunate mutants being seized upon and made the most of as a free gift of nature to the breeder's hand.

Doubtless all these means of changes in species are in operation everywhere in nature. Darwin expounded the first and De Vries the last, and a multitude of evolutionary literature exists. The student who is desirous of pursuing the general question of origin of species in nature will find the subject briefly sketched in Chapters XVII–XXI of Part II, with some standard references.

Summary. When distinct races are crossed hybrids are produced between all the characters involved. Some of these characters will blend. and the result will be a new combination which will thereafter *breed true as regards all such blended characters.*

But other characters will not blend, remaining distinct, in which case the gametes will continue to produce not one new and blended character, but both old characters in their original purity. Under the law of chance one fourth of the offspring would possess the character of the one parent in its purity, one fourth that of the other, and half would remain hybrid.

Inasmuch as some characters are naturally dominant and others recessive, the recessive individuals can be detected only where the recessive stands

alone, the 50 per cent hybrids containing both dominant and recessive being indistinguishable from the pure dominants.

This applies to single characters and not to entire individuals, which rarely are all dominant or all recessive.

Exercise. Make some crosses in corn and then plant the crossbred seed and cross again with a third different color of distinct variety, as white, yellow, and sweet, or white, yellow, and red.

References. 1. "Origin of Species by Means of Natural Selection." Darwin.

2. "Origin of Species by Mutation." De Vries.

3. "Mendel's Principles of Heredity." Bateson.

4. "Principles of Breeding" (chap. xiv, sec. xii). Davenport.

CHAPTER XII

HOW THE OFFSPRING COMPARES WITH THE PARENT, OR DESCENT WITH MODIFICATION

The complex nature of heredity · The offspring not like the parent · Mediocrity the common lot, whatever the parentage; regression · Some offspring better and some worse than their parents · The exceptional parent and his offspring · Progression · The exceptional offspring and his parent · Reversion · Degeneracy

Though the general process of improvement by selection is simple enough, certain additional facts and principles are involved with which the breeder needs to be acquainted in order to make the selection to the best advantage.

The complex nature of heredity. The most disconcerting principle in all improvement operations lies back of the obvious fact that the offspring is not like the parent. Having, as he nearly always does, two parents, he could not of course be like them both. The fact is, however, that for the most part he is not like either one of them, nor yet is he like the two combined. The most that can be said is that the offspring *resembles* his parents, and that all his characters are to be found somewhere in his parentage.

This all means that transmission is more a matter of family or general ancestral influence than it is of the two particular individuals that happen to be the immediate parents.

It has already been stated that every individual, whatever his personality, transmits all the characters of the race or family to which he belongs, and no others. Some of these characters may not be evident in his own make-up, but if they are in the blood of the family, they will be transmitted.

All this is not saying that all characters will be transmitted with the same intensity nor with the same probability of being evident in the offspring. Indeed, it is well known that all characters are not transmitted with equal intensity, but that rather, in general, the intensity of transmission is somewhere in proportion to the combined intensities of the two parents. This, of course, produces results quite different from either parent taken singly, and this, too, is true in general only, and not in every individual instance. The visible characters of one parent, therefore, or even of both, are not an absolute index of what will appear in the offspring any more than they are an absolute index of their real make-up. Indeed, there is no guide to what will happen in individual cases, though enough studies have been made to show about what does happen in the long run; that is, how offspring in general compare with the parentage.

The best studies that have ever been made in this field were those of Galton[1] upon the stature of English people. I reproduce his table here, for it shows, as nothing else can, the relation between offspring in general and their parentage, though it may be remarked that later and similar studies confirm the principle as to other characters and in other races, as with milk production in cattle (see "Principles of Breeding," p. 498A).

In this table the heights of 928 adult offspring are classified and compared with the stature of their parents. The heights of the offspring (adult children) are listed at the top in columns running from 62.2 inches and below to 73.2 inches and above, with intervals of one inch. The heights of the midparents are listed on the left in groups also an inch apart, running from 64.5 inches and below to 72.5 inches and above.

By midparental height is meant one half the combined height of father and mother *after increasing the mother's height by one eighth* (12.5 per cent), because Galton found that in general women are one eighth shorter than men, or rather that their height must be multiplied by 1.08 to convert them into "male equivalents." In this table all female statures have been so

[1] An English scientist, cousin of Darwin, and author of "Natural Inheritance," which see, together with "Principles of Breeding," pp. 479–482.

NUMBER OF CHILDREN OF VARIOUS STATURES BORN OF 205 MIDPARENTS OF VARIOUS STATURES[1]

HEIGHTS OF ADULT CHILDREN

	1 (Heights of Midparents)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16 Number adult children	17 Number mid-parents	18 Means of children	
a		Below	62.2	63.2	64.2	65.2	66.2	67.2	68.2	69.2	70.2	71.2	72.2	73.2	Above	. . .	. . .	. . .	*a*
b	Above	. . .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	1	3	. . .	4	5[2]	72.95	*b*
c	72.5	. . .	. .	. .	. .	. .	. .	. .	1	2	1	2	7	2	4	19	6	71.4	*c*
d	71.5	. . .	. .	. .	. .	1	3	4	3	5	10	4	9	2	2	43	11	69.9	*d*
e	70.5	1	. .	1	. .	1	1	3	12	18	14	7	4	3	3	68	22	69.5	*e*
f	69.5	. . .	. .	1	16	4	17	27	20	33	25	20	11	4	5	183	41	68.6	*f*
g	68.5	1	. .	7	11	16	25	31	34	48	21	18	4	3	. . .	219	49	68.0 +	*g*
h	67.5	. . .	3	5	14	15	36	38	28	38	19	11	4	. .	. . .	211	33	67.6	*h*
i	66.5	. . .	3	3	5	2	17	17	14	13	4	. .	. .	. .	. . .	78	20	67.1	*i*
k	65.5	1	. .	9	5	7	11	11	7	7	5	2	1	. .	. . .	66	12	66.8	*k*
l	64.5	1	1	4	4	1	5	5	. .	2	. .	. .	. .	. .	. . .	23	5	65.6	*l*
m	Below	1	. .	2	4	1	2	2	1	1	. .	. .	. .	. .	. . .	14	1	65.6	*m*
n	Totals	5	7	32	59	48	117	138	120	167	99	64	41	17	14	928	205	. . .	*n*
o	Means[3]	. . .	66.6	66.8	67.8	67.8	67.7	67.9	68.3	68.5	69.0	69.1	70.2	70.2	. . .	68.0[4]	68.6[4]	. . .	*o*

[1] Galton, "Natural Inheritance," p. 208.

[2] Error. Manifestly, four children could not have five midparents

[3] Row *o* shows the mean heights of the midparents producing the children of the corresponding column. For example, 67.8 (column 6) is the average height of parents producing 65.2-inch children.

[4] Excluding everything above 72.5 and below 64.5 in midparents, and everything above 73.2 and below 62.2 in offspring. If these values are included at the next measurement to the last given, the means become 68.1 and 68.7 respectively.

treated, thus eliminating the matter of sex, and all the "children,"[1] whether male or female, are thus considered as males. The rest of the table is self-explanatory. The heights of mid-parents are classified to half inches and recorded in the column at the left. The height of each adult "child" is recorded in its proper column and in a row opposite the height of his mid-parent, after which totals are added both ways.

Thus we see that of the whole 928 people whose stature was taken, 120 were 68.3 inches high (see column 9). Of these, 1 was born from 72.5-inch parents; 3 were born from 71.5-inch parents; 12 were born from 70.5-inch parents, and so on from the shorter parentage. In all there were 928 children and 205 pairs of parents, — of course duplicated in the case of brothers.

We are now ready to look a little further into the meaning of this table.

The offspring not like the parent. The very first fact that attracts our attention in this table is that the offspring are not much like their immediate parents, but that all sorts of parents (short, medium, or tall) produce all sorts of children (short, medium, or tall), and that the correspondence in height between specific parents and their particular offspring is not very close. In other words, like offspring may be produced by very dissimilar parents (see any column of the table); and, correspondingly, like parents, or even the same parents, in successive generations, may produce very dissimilar offspring (see any row in the table, as, for example, the very variable offspring of 68.5-inch midparents). This important fact lies at the basis of all breeding, as it does of most sociological questions, involving parentage.

Mediocrity the common lot, whatever the parentage; regression. Looked at closely, mediocrity seems to be the common lot. The average height of the people in this table is

[1] The student must remember that in this case the word "children" is used to mean simply offspring in general. These children were fully grown, and their heights are strictly comparable with those of their parents.

about 68.6 inches for parents and 68.0 inches for children (see columns 17 and 16). The most significant fact about this table is its tendency to cluster about these average values, which are nearest represented by column 9 and row *g*. Where these two lines cross is the densest part of the table, — around the number 34. Note, too, how the arrays (columns or rows of figures) resemble the frequency distribution with which we became familiar in the chapter on Type and Variability. Each of these arrays has the characteristic shape, — large in the middle, dwindling at both ends. Moreover, this large middle is in *all* cases, whatever the parentage, *not far from the middle point of this table*, though the table is somewhat *skewed* by the difference in the parental heights. To note more particularly, consider the offspring of about the average parent (68.5 inches, row *g*). Though these parents were all of an even height, their offspring were distributed from below 62.2 inches to 73.2, but the largest number (48) is very near to the average of the race.

Again, note the offspring of the 65.5-inch parents, which are below the average height of parents. Here the range in the offspring is from below 62.2 inches, as before, but stops at 72.2, with the highest numbers (11) at 66.2 and 67.2, *both taller than their parents*. Indeed, of this whole population of 66 children of the 65.5-inch parents, all but 22, or exactly two thirds, are *better than their parents*.

Still again, note the offspring of the 71.5-inch parents, which are extremely tall. Here the range is from 65.2 inches to above 73.2, or over an inch *shorter than their parents*. Again, of the 43 children of these extremely tall parents, 30, or nearly three fourths, are *shorter than their parents*. Again, of the 43 children of these extremely tall parents, 30, or nearly three fourths, are *shorter than their parents*.

The principle is, that whatever the parents, — short, medium, or tall, — the offspring tend strongly toward the mean of the race. This principle of tendency toward mediocrity is known as regression or the pull of the ancestry. The reason of it is that some of these short parents are children of tall people, and in these cases the height is helped out by the stature of the grandparent. Also, some of the extremely tall parents were themselves children of short grandparents, all of which lessens greatly their powers of transmitting as much stature as they themselves possess.

Some offspring better and some worse than their parents. A careful study of this table shows that whatever the parent, whether mediocre, inferior, or exceptional, the offspring will take the form of a distribution extending both ways from a mean or mode, said mean or mode being not far from that of the parent. If the parent is above the average of the race, the majority of the offspring will be below the parent; if, however, the parent is below the average, then the majority of the offspring will be better than their parents.

The exceptional parent and his offspring. There is a foolish notion that preachers' sons are especially likely to go wild. Let us analyze this problem in the light of this table. In the first place, admitting the parent to be exceptional, what are the chances of the offspring being also exceptional? This is an important question, — indeed, one of the most important in all studies in heredity.

Substituting general excellence in place of stature for the moment, let us refer to the table. We see at once that an exceptional parent, or even an exceptional midparent, which means two exceptional parents, is by no means certain of exceptional offspring, unless, indeed, the exceptional quality is of many generations standing. Take the case of the 70.5-inch parents, — two inches above the average. Of their entire offspring (68), 1 was almost a dwarf, 51 were shorter than their parents, and 7 were distinctly below the average of the race. This is one side of the question and accounts for the physiological fact that presidents, preachers, and other notable men are bound to produce some very ordinary people, all of which helps us to realize that mediocrity is the most common and the most likely lot of man, and that regression is always at work.

Progression. Now let us look at the other side of the question and see what is to be found after having disposed of this relatively large number of mediocre individuals, and let us see if, after all, the exceptional parent has not something to his advantage in the matter of offspring.

Note again that the other end of this array of the offspring of the 70.5-inch parents shows 17 individuals, or exactly one fourth, *better than their exceptionally good parents*. Not only is this true, but the higher we get among the exceptional parents, — 71.5, 72.5, etc., — the more is this true and the larger is the *proportion* of exceptional offspring. This is progression, and, as a principle, it is just as true and just as much to be counted on as are regression and mediocrity.

This principle of progression is the one that insures the results from natural selection and the survival of the fittest in nature, just as it is the one that insures that *selection anywhere will be followed by offspring, some portion of which, not all, will be a distinct improvement over even their exceptional parents.* It is on this principle that we rely for most of our improvement of domesticated animals and plants, and as it is the most important principle in evolution, the student is urged to remember it.

The promptness and rapidity with which improvement follows selection under this principle of progression is best shown by the opposite table exhibiting the results of Dr. Hopkins's experiments in altering the oil content of the grain of corn.

In this experiment ears of the highest and others of the lowest oil content obtainable were planted in successive years. The table shows the results in the crop both as to distribution and average for each of nine years, and is the best exhibition known to the author of the principle of progression and the results of selection.

In the study of this table it will be noticed that the oil content of the original seed was 4.70 per cent, but that the strain

PROGRESSION IN HIGH-OIL AND LOW-OIL CONTENT IN CORN[1]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1896	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25	4.5	4.75	5.0	5.25	5.5	5.75	6.0	6.25	6.5	6.75	7.0	7.25	7.5	7.75	8.0	8.25	8.5	Total	Aver.
Stock	. .	. .	. .	. .	. .	. .	1	15	20	41	36	25	15	5	4	1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	163	4.70
1897																												
H. 5.39	. .	. .	. .	. .	. .	1	. .	. .	10	15	19	24	3	7	1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	80	4.73
L. 4.03	. .	. .	. .	. .	. .	5	7	9	7	7	5	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	40	4.06
1898																												
H. 5.20	. .	. .	. .	. .	. .	. .	. .	1	7	29	37	50	35	24	22	6	2	2	1	. .	. .	. .	. .	. .	. .	. .	216	5.15
L. 3.65	. .	. .	. .	. .	8	9	31	31	19	9	1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	108	3.99
1899																												
H. 6.15	. .	. .	. .	. .	. .	. .	. .	. .	1	. .	2	10	16	22	24	18	12	3	. .	. .	. .	. .	. .	. .	. .	. .	108	5.64
L. 3.47	. .	. .	1	2	5	32	36	36	23	8	1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	144	3.82
1900																												
H. 6.30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	1	1	3	9	18	16	30	18	9	2	1	. .	. .	. .	. .	. .	108	6.12
L. 3.33	. .	1	3	8	32	39	32	20	6	3	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	144	3.57
1901																												
H. 6.77	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	2	3	10	13	26	21	28	15	7	1	. .	. .	. .	. .	. .	126	6.09
L. 2.93	. .	. .	2	12	34	43	29	5	1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	116	3.43
1902																												
H. 6.95	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	2	5	3	10	13	18	16	13	9	1	. .	. .	. .	. .	. .	90	6.41
L. 3.00	1[2]	6	34	19	16	9	5	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	90	3.02
1903																												
H. 6.73	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	1	10	10	19	18	21	13	5	2	1[3]	. .	. .	. .	100	6.50
L. 2.62	1	3	26	33	22	5	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	90	2.97
1904																												
H. 7.16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	1	. .	. .	. .	. .	3	9	8	12	15	18	18	8	6	2	1	101	6.97
L. 2.80	3	7	42	31	15	4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	102	2.89
1905																												
H. 7.89	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	4	9	19	15	21	17	19	7	5	4	120	7.29
L. 2.67	4[4]	21	42	31	19	1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	119	2.58

[1] Dr. Hopkins's experiments, *Bulletin 119*, Experiment Station, University of Illinois. See also "Principles of Breeding," p. 496.
[2] Accurately, 2.12. [3] Accurately, 7.71. [4] Also one ear at 1.75.

selected for high oil produced in the ninth year a crop as high as 7.29 per cent oil and one as low as 2.58 per cent. Note, also, the rapid rate at which the distributions separate from each other, — so rapid, indeed, that in the fourth crop (1900) they no longer overlap but entirely part company; that is, the lowest of the high oil is higher than the highest of the low oil.[1]

If the offspring of the exceptional parent is in many cases so decidedly exceptional, how did the tradition start about the mediocre sons of great men? Naturally enough. Some of these sons are truly mediocre, even inferior, as we have seen, and in this, as in other matters, a few cases make a great impression, provided they are sufficiently striking. Every preacher's son that goes wrong attracts special attention, — even more attention than does the long line of divines like the Edwardses or the Adamses, in which greatness almost invariably descended from father to son for many generations. This impression is akin to that other popular fallacy that people choose opposites in matrimony; that is, that tall people prefer short mates; dark-haired prefer light; phlegmatic prefer vivacious, etc. Now the facts are, so far as they have been studied, that people prefer and choose their like to a surprisingly large degree. For example, the correlation or ratio of correspondence between husbands and wives amounts to 0.28 in stature and about the same in eye and hair color, whereas if they tended to choose opposites, it would be negative, and if they were indifferent, it would be zero. The fact is, that if we see one tall woman with a little husband, or the reverse, the grotesqueness of it all strikes our attention and we remark about it, reminding ourselves again of the "law of dissimilars"; whereas we fail to notice the large number of properly assorted people that pass and repass, and thus overlook the real law that men and women in general mate by similarities and get along best when they do so. These few illustrations will show the need of accurate and somewhat extensive observation before hastening to generalization.

[1] For a fuller discussion, see "Principles of Breeding," pp. 492–499.

The exceptional offspring and his parent. A glance at the table on page 156 will show another great principle in transmission, namely, that a given class of offspring may be produced in various ways. For example, the heights of offspring as recorded in column 13 are clearly exceptional. These people are over six feet tall, but they were produced by all sorts of parents from 72.5 inches *down to 65.5*. While the parents were thus distributed, yet the greatest *number* of exceptional people (11) came from mediocre parentage, but the greatest *proportion* of tall people came from extremely tall parentage. Thus the 11 of this column were the product of 183 families (see column 16), while as many as 7 were produced by 19 midparents that were three inches taller, — another evidence of regression and of progression as well.

Reversion. When we see how many tall people beget short children and how many tall children come of short parents (see rows *h* and *k* in the table), we are not surprised that occasionally an unaccountable case will turn up, as when a red-headed boy is born of black-haired parents, and nobody can remember even a red-headed grandparent. Aye, remember; there 's the trouble. The total ancestry runs back for many generations and we remember but a few, — rarely back of the grandparent, — whereas each of us has over two thousand ancestors within ten generations. In the case of the red-headed boy some one of them was in all likelihood red-headed, and this that has turned up is a "reversion" to that ancestor; for *every individual transmits all the characters of his ancestry*, and anything that is transmitted may at any time become dominant and then visible. That is about all there is of the matter of reversion or throwing back, about which such a "to do" has been made. As a physiological fact it is interesting; as a matter in plant or animal improvement it hardly applies, for as soon as systematic selection is a little while practiced, the chance of reversion rapidly reduces to practically nothing.

Degeneracy. This is a matter of importance in human affairs rather than in those of the animal and plant, but facts such as this table shows, lead us to look with suspicion upon the individual that is "born short." He may be the offspring of excellent parentage, as in column 2, rows *e* and *g*, in which case the pull of regression will be greatly in his favor. But, on the other hand, he may be the product of bad parentage, as in column 2, rows *k*, *l*, and *m*, in which cases the matter is well-nigh hopeless, as many a poor girl has found, who has married a scamp to "reform him." He has broken her heart and wasted her life all because she did not know the simplest facts about transmission. If a man is well born, it is upon him to show his breeding, if he can, and if not, to prove that his ancestry was at least respectable and not much below mediocrity; and if he cannot do this, he is a great risk as a partner in any business. Disregard of these simple facts is responsible for the wholesale production of hereditary criminals, and until laws are framed and executed to prevent unbridled reproduction among degenerates, we shall continue to sow the wind and reap the whirlwind. Visit our prisons and poorhouses and be convinced that while some of the inmates are normal men with a bad history, most of them are there because of their unfortunate ancestry. The sooner we realize that, on the average, men are about what their ancestry as a whole is, the better it will be both for individuals and for the community. Study the left-hand side of the table in breeding corn for high and low oil (p. 161), and see how rapidly degeneration proceeds when parentage is restricted to inferior lines. Then also reflect on the danger of reversion if inferior blood is mixed with the good. The only safety in human affairs, as in those of animals and plants, lies in a long line of selected ancestry or, in other words, in good blood.

All characters that have ever been studied behave substantially the same as stature, and this table of Galton's, therefore, may be regarded as exhibiting the general law of heredity for all characters. By this we see that we are not to expect that the offspring will be like the parent except in a general way, and within more or less general limits; that we need not be surprised at almost anything that may happen in individual cases, from which we infer that we shall never be able to predict from the parents what a particular offspring will be, but that we can tell very close as to what they will be in the long run and on the average; and that the more uniform the ancestry, the more accurate will the prediction be, and the more uniformity will there be among individuals. We see, too, by the principle of progression, that under selection the correspondence between parent and offspring becomes rapidly closer.[1]

Summary. The individual offspring is seldom like the parent. It may be better (progression) or it may be worse (regression), but in general the offspring is like the parentage as a whole. More exceptional offspring arise from common parentage than from exceptional parentage because mediocrity is the common lot, yet the proportion of exceptional offspring is higher from the exceptional parent than from the mediocre.

Reversion shows that as long as even a trace of old-time characters exists, the gametes are not absolutely pure, and an occasional appearance of such ancient characters is inevitable. Being ancient, they are correlated with others, and are likely to creep upon the breeder unawares, like the high shoulders and thin flanks of cattle, or the inferior hams of pigs.

The offspring, therefore, is to be considered not so much the product of his personal parents as of his parentage as a whole.

[1] The reader should understand that this chapter is designed to treat of heredity as operative in a fairly homogeneous population, having no reference to its behavior in hybridization. Since the chapter was written, however, evidence is accumulating, tending to show that most species, and even varieties, are really made up of a number of similar but somewhat divergent strains, overlapping and more or less obscuring each other, and that the principal office of selection is to isolate the favored strain.

CHAPTER XIII

THE LAW OF ANCESTRAL HEREDITY[1]

The extent to which the offspring resembles the parent and the extent to which he resembles more remote ancestors · Chance of resembling a particular individual ancestor · The individual a composite · The number "two"

The extent to which the offspring resembles the parent and the extent to which he resembles more remote ancestors. We have seen already that all individuals transmit and all individuals possess more unit characters than can possibly be fully developed and represented in visible form in their own personality; that is, every race is rich in characters, — so rich that not all of them can be utilized in the make-up of any single individual.

We understand, then, that the offspring gets all his characters from and through his immediate parents; there is no other source. We understand, too, that he gets not only those that were specially developed in the personality of the parents, but all others of the race as well, and that out of these the personality of the offspring will be developed.

We understand, also, that the intensity of transmission is in proportion to intensity of possession, and this for the most part corresponds fairly well to the intensity of infusion of the racial characters among the back ancestors; that is to say, if a character is present in all the ancestors, it will almost certainly appear in the offspring, while if it is present in but half of the ancestry, the chances are even that it will be transmitted in the latent form.

All things considered, therefore, we should not expect the offspring to be *like* the parent, unless the ancestry were so pure

[1] For a fuller discussion of this subject, see "Principles of Breeding," pp. 525–534.

or the characters so few that all individuals are practically identical. This could not be in a race so rich in characters as man or even the common domesticated animals, which differ so decidedly in form, color, activity, and mental qualities, besides many internal activities that cannot be readily detected.

We should however expect that the offspring would resemble the immediate parents more closely than any other ancestors on the score of relative intensities and nearness of blood, and this expectation is fulfilled.

Galton and Pearson have given much study to this question, and, arriving at results from independent standpoints and by methods quite distinct, agree on the following formula as expressing what, *on the average*, is the degree of resemblance to be expected between the offspring and the several generations of ancestors backward: $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, etc., to infinity.

It will be noticed that each fraction of this series is exactly half of the preceding fraction; also that if the series be carried to infinity, the fractions would add up to 1, thus accounting for the total inheritance. This means, substantially, that in general and on the average the offspring will resemble, to the extent of half his personality, the two immediate parents, and of course will divide that resemblance between them equally.[1] To the extent of one fourth of his appearance he would resemble his grandparents, the resemblance being distributed between the four. One eighth of his visible characters may be credited to the next generation (great-grandparents), one sixteenth to the next, etc., indefinitely backward, thus accounting for all sorts of remote resemblances or atavisms.

All this is not saying that every individual will thus accurately divide his resemblances, but it is saying that for large numbers the resemblances will be found to follow this plan, and wherever

[1] This may seem wrong to the reader, because the offspring will resemble more closely the better bred parent. That, however, as we shall see, is due to the influence back of the parent. If the breeding were good enough, all the ancestors would be alike.

it has been tested on a large scale, as in the color of dogs, theory is found to be true to the facts.

This series of fractions, therefore, may be taken as a good statement of the law of ancestral heredity, or the probable resemblances between successive generations of the same family line, whether the line be of pure or of mixed breeding. Of course, as has been observed, if the line be extremely well selected and closely bred, then all resemblances will be close, and it may even look as if the resemblance to the immediate parents is absolute; but this is only because the near and the remote ancestors are alike, and a little study of species in general will convince the student that the natural proportions are as stated, which series also represents the relative degree of relationship and intensities as can be represented by no other series of fractions that could be arranged.

Chance of resembling a particular individual ancestor. This series of fractions refers to generations, not to individual ancestors. Each must be divided by the number of individuals of that generation in order to get the chance of the offspring resembling any particular ancestor, say, the paternal grandmother. The following table gives in condensed form this series of fractions, thus apportioned among the individual ancestors.

Effective Heritage contributed by Each Generation and by Each Separate Ancestor according to the Law of Ancestral Heredity

Generation backward	Contribution of each generation	Number of ancestors involved	Contribution of each ancestor
1	$\frac{1}{2}$	2	$\frac{1}{4}$
2	$\frac{1}{4}$	4	$\frac{1}{16}$
3	$\frac{1}{8}$	8	$\frac{1}{64}$
4	$\frac{1}{16}$	16	$\frac{1}{256}$
5	$\frac{1}{32}$	32	$\frac{1}{1024}$
6	$\frac{1}{64}$	64	$\frac{1}{4096}$

From this we see that an individual five generations back stands but one chance in over a thousand of impressing a character upon the offspring, and this chance grows rapidly less as we go backward, never, however, becoming zero; so that it is possible that resemblances to any ancestor, no matter how far removed, may crop out in individual cases from time to time, giving strange but not unaccountable cases of reversion. These are extremely noticeable, first, from their variety; and second, from the fact that complete ignorance generally surrounds all ancestry more than a generation or two back. What chance is there, for example, for knowing much about the separate characters of each of the thirty individuals involved in the first four generations only? The next generation backward would add thirty-two more, showing how rapidly the transmission becomes complicated, particularly when we remember that all the ancestry has contributed to the individual.

The individual a composite. This makes it look as if the individual were pretty well distributed among his ancestry from his parents backward, and that is exactly the condition of matters. The individual is a kind of mosaic, taking a portion (on the average one half) of his resemblances from his parents, others from his grandparents, and still others from earlier ancestors, even to the remote past.

At first thought this may seem impossible, but upon careful research we find that racial characters are but loosely held together,[1] and it is only upon reflection that we realize the extent to which combinations and recombinations take place and how resemblances come and go in a long line of ancestry.

In this way an individual may seem in some particular to resemble, we will say, the paternal grandsire, whereas the actual resemblance is not only to him but to perhaps a score or more of similar ancestors still further back and long forgotten, but whose blood lines combined with and intensifying those of

[1] Shown by the fact that the "correlation" or bond that compels characters to move together is very low, seldom as much as 50 per cent, so that almost literally it is a free-for-all contest when matters of hereditary resemblances are being determined. For a full discussion of Correlation, see "Principles of Breeding," chap. xiii.

the grandparent in this particular character bring it suddenly into prominence.

The number "two." The student cannot fail to be struck with the extent to which the number "two" figures in these affairs. The product of mixed breeding, if unrestricted, follows the binomial formula, giving definite mathematical proportions to the combinations of characters. The normal distribution when studying type follows the same formula, and the law of ancestral heredity is made up of fractions derived from the universal "two."

This is not accidental, but perfectly natural. Inheritance everywhere is the result of combinations of characters from two parents; not only that, but all growth is the result of cell division, which means parting into two, so that the number "two" lies at the very base of all affairs involving transmission. It is not strange, therefore, that the whole matter rests on a definite mathematical basis, that the chance combinations of characters can be predicted in the long run, or that the law of ancestral resemblances should be the very remarkable series $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, etc. It really could not be otherwise, with bisexual reproduction and with growth by cell division involving a splitting of the chromosomes as the two characteristic attendants upon heredity.

Summary. The offspring is a composite of all the blood of all his ancestors in proportions fairly definite. We cannot predict what the individual may be, but of large numbers we can predict that their resemblances to ancestral traits will follow the series $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, etc., in which the two immediate parents divide between them the chances of impressing the offspring; and the other fractions are each divisible by the number of ancestors of the corresponding generation, so that of large numbers of offspring a certain definite number (25 per cent of all) will resemble the one parent with respect to any given unit character, 25 per cent will resemble the other parent in respect to the same character, and the remaining resemblances will be distributed proportionately among the back ancestors. The number "two" characterizes all reproduction, which therefore tends to conform to the binomial theorem.

CHAPTER XIV

HEREDITY AND ENVIRONMENT

Mistaken estimate of environment · All the characters of the race, both good and bad, are transmitted to the individual by his parentage · The function of environment is to assist or to hinder in development · Environment does not add unit characters · Modifications due to environment

Mistaken estimate of environment. There has been handed down to us from our ancestors, by way of tradition, an altogether false estimate of the rôle of environment in matters of evolution and of life. This false estimate arose naturally as the result of the old-time assumption that all men were born alike, and whether they turned out to be good or bad depended entirely upon the influences by which they were surrounded.

Now no one can overestimate the power of good opportunities or the danger of bad influences, but it is highly desirable that we understand the facts as they actually are.

All the characters of the race, both good and bad, are transmitted to the individual by his parentage. We have seen already that every individual possesses all the characters of the race, because he can transmit them. Many of them may be undeveloped and invisible, and therefore we may not know that he possesses them till we see his progeny under favorable conditions for their development; but we may be assured that they are there in some degree of intensity, if they were known ever to have existed in the ancestry. Whether they develop or not will depend upon two factors: first, their inherent relative intensity; and second, the accident as to whether conditions of life are favorable or unfavorable.

I have been careful to say "transmitted by his parentage," not "his parents." They came through his parents, it is true, for there was no other way, and in that sense they came by them; but the responsibility may, as we now know, lie far back of the immediate parent. Of all this we have abundant illustrations in both the plant and animal world. In mixed breeding, under Mendel's law, we have seen already how long a character may linger and how easily it may outcrop even generations later. Reversions and the law of ancestral heredity teach us the same truth, namely, that all races have an exceedingly mixed ancestry, partly desirable and partly undesirable, and that all races have more characters than can be fully developed in any individual or under any single set of conditions.

The dog, our most faithful friend, is, after all, a descendant of the wild wolves of the forest, and he still possesses some of the ancient instinct to trail, to hunt, and to kill. In many cases, under unfavorable conditions, this wild instinct gets the better of him and he becomes a dangerous animal. The breeding of bull-dogs for ferocity is attended with great danger, because this particular trait is so closely in line with the old-time instincts of the savage ancestors. The only protection of the horse is flight, and we all know by experience that some individuals are by nature so timid that under unfavorable conditions they will run away and are ever after unreliable.

Many individuals of our own race are unfortunately "born short"; that is, with the better characters weak and those of savagery relatively strong. Such men are almost certain to be dangerous even under the best conditions. Unfortunately, too, many who are better born have yet enough of the barbarous to develop under unfavorable conditions and make them, too, dangerous, when under good conditions they would have been harmless. It is highly desirable that the best conditions possible be maintained, not only to prevent as many as may be from going wrong, but also to help us to know and to sort out the real degenerate, who is bound to go wrong anyhow. Again, and aside from all this, nobody knows exactly what his own ancestry is, — just what traits of character are waiting only for favorable conditions for development, nor just how much he can endure in the way of adverse circumstances without some of the more undesirable characters of his family line undergoing development and getting the upper hand.

By any and all counts, with our animals and plants and with ourselves we are bound to maintain the most favorable environment possible, but it should be on the score of its influence upon development, not under the mistaken idea that it can take the place of heredity or in any other way compensate for the failure of inheritance or mistakes of the ancestors.

The function of environment is to assist or to hinder in development. If environment is then so mighty a factor, is not the old tradition right after all? No. The characters of the family line are planted before birth by the particular ancestry, whatever that may be. In all cases they are both good and bad. In the best families and the purest blood, plant or animal, the bad have been reduced to a relatively low intensity and a corresponding low probability of development. In the worst families, unfortunately, the bad characters are the strongest ones, likely to develop even under the best conditions, because the better faculties are in low intensity — mathematically low in power.

Now the character of the individual in his own personality will depend not so much upon his total inheritance as upon the particular characters that develop, and these will depend very largely, though not entirely, upon the conditions with which he is surrounded, especially in early life.

To illustrate: Take ten ears of corn that look exactly alike. Plant them separately in rows, side by side, giving to each the same soil and the same cultivation; that is, surround them with the same conditions and opportunities. Will they yield alike? Most assuredly not. They may differ as much as 50 per cent, and possibly more. Why? They were bred differently; they inherited different powers of germination and of vigor in obtaining and assimilating the plant food of the soil.

Take a Jersey and a Shorthorn calf. Feed both all they will eat. Will the Jersey equal the Shorthorn in growth and in flesh? No; though he will be larger than another Jersey that has not been so well fed. Feed a race horse liberally, and will he make a draft horse? No. Starve a draft horse, and will he make a racer? No. Everything will make what it was born to make, or as near it as conditions permit. It is the function of the environment to provide the opportunity and the materials for development. If we desire the development of a particular character, it is wise, after having secured it in the transmission, to provide the means for its development. If, on the other hand, we are conscious of the presence of an undesirable character in the nature of the animal or the plant, it is wise to withhold and prevent as far as lies within our power all influences and conditions favorable to its development, and thereby make its appearance as difficult and as unlikely as possible, hoping that its ugly existence will remain forever dormant, understanding well that the longer it remains undeveloped and unencouraged the less likely is it to come to the surface.[1]

Environment does not add unit characters. Characters do not arise out of their environment. They were there before or they do not appear. Jersey cattle cannot be turned to red by keeping them in a red barn, nor does the color of the colt depend upon that of the working mate of the mother.

No man was ever made a thief by seeing others steal, unless he had a little of the thief in him before by inheritance. We ourselves are not yet so far removed from savagery but that these fundamental barbarisms still beset us to some extent. The savage steals and kills and tortures, and our race is not yet free from some slight taint of these elemental characters.

[1] That is why it is the highest duty of every person not only to keep *himself* safe, but also to keep his family line clean of undesirable blood lines which, if introduced, will crop out to plague generations yet unborn. We owe all this to the future. Unfortunately our own ancestors have not *all* lived up to their duty in this regard, as most of us can testify by our own evil if not dangerous impulses, mixed here and there with the best that is in us.

They do not belong with civilization, and civilization must eliminate them as fast as possible, first, by the control of degenerates; and second, by making conditions so good as to reduce the development of these uncivilized characters to a minimum.

This principle is well understood by farmers in dealing with animals and crops. They know that a well-bred animal needs good conditions, good feed, good shelter, and good advantages generally. They know that good varieties need good soil and favorable climate.

They know, too, that ill-bred animals will not respond to good feed and care, and that poor varieties will not become good by raising them on a good soil. The principle is universal, that the nature of the race is fixed by its breeding. Its personality may be helped or hindered, but cannot be created by its environment.

Modifications due to environment. If two individuals could be born alike, but grow to maturity in very different environments, the two would look very different. These differences are the modifications due to environment or the conditions and opportunities of life.

These modifications, we have seen, are due to the fact that any given environment is favorable to the development of certain characters and unfavorable to others. Thus a hot country is favorable to the development of spiny growth and harshness of leaf, but unfavorable to the growth of wool.

Two children are born with equal talent for painting. The one lives with artists all his life, the other with commercial people. Manifestly, the one will most likely be an artist and the other will most likely learn trade, unless, as in rare cases, the instinct is so strong as to be overpowering.

In one sense, therefore, all living matter is modified by and according to the conditions of life, but in another sense it is not, for no character can develop, however favorable the surroundings, unless the faculty was first inherited; that is to say, the environment cannot supply lacking unit characters.

Can modifications due to environment be transmitted? This is the old and much debated question of inheritance of acquired characters. It means in brief this: If a horse is spavined, will the spavin be transmitted to the offspring? If a man is a great musical performer, will his child be a better musician than if the parent never learned music? Also, would this musician's younger children inherit more of the musical faculty than would the older children, born before the highest development of the parent's powers?

Will the calf of a cow that has made a phenomenal record at the pail be itself a better cow than would the same calf from the same cow if she had only moderate feed and care? Will cutting off the horns of cattle tend to produce, by and by, a hornless race?

This is the class of questions involved at this point. The matter is too intricate for treatment here, except to say that, in the opinion of the author, the class of modifications here mentioned are not transmitted; for example, we have been cutting off the tails of lambs for many generations, but sheep are not yet born without tails. Heredity is not so easily influenced as all that, because the germ plasm (the sex cell) is not affected by an operation like dehorning or cutting off the tail.

There is doubtless a class of modifications that may affect the germ plasm and therefore be transmitted. I refer to all-pervading influences like temperature and alkalinity for lower organisms, and for the higher animals and plants, to nutrition and to definite chemical compounds, like poisons and toxins from contagious and infectious diseases.

The student who desires to pursue this subject at length is referred to "Principles of Breeding," pp. 221–345, and collateral literature.

Summary. What the offspring is at maturity depends, first of all, upon the possibilities born into him; and second, upon the opportunities for their development afforded by the environment. Every individual inherits all the faculties of the race, both good and bad, yet the fact remains that some of these faculties, both good and bad, are so exceedingly weak as to be practically wanting, and capable of development only in the most persistently favorable environment. However favorable the environment, faculties will not develop which were not inherited from the family line, any more than would living in a white house make a white man out of a negro child.

References. 1. " Principles of Breeding."

2. " Essays on Heredity and The Germ Plasm." Separate volumes by Weismann against the transmission of modification.

3. " An Examination of Weismannism and Post-Darwinian Questions." Separate volumes by Romanes, favoring transmission of modifications.

CHAPTER XV

SYSTEMATIC IMPROVEMENT OF ANIMALS

Origin of the "pure bred" · Pedigree registers · Advanced registry · Unregistered stock and scrubs · Systems of breeding · Source of sires · Herd improvement and breed improvement · Rational improvement · Choosing the breed · Breed differences slight · Market classes and grades · Knowledge of market requirements needful

Origin of the "pure bred." As the different species of animals were domesticated they were naturally kept by different races of men and under a great variety of conditions. These different people had different ideals and standards of selection, and these, together with the various natural conditions of food and climate, all helped to develop not one but many different varieties of the race; cattle, for example, and similarly for dogs, horses, sheep, and all other domesticated species.

Naturally some of these were better than others, and their special admirers would do what they could to prevent their mixing with other and inferior strains, that is, to keep them pure. In this way we have the so-called "pure" breeds, numbering in all more than a hundred more or less distinct strains, each with its own type and standard of selection.[1]

England, for instance, was from early times a great cattle country. In the central part, about Hertfordshire, there early developed a heavy strain known as Longhorns, since modified into the Herefords.

In the northeast another superior strain developed among the excellent stockmen along the river Tees and in the county of Durham, known first as Teeswater cattle, afterward as Durhams, and finally as Shorthorns, to distinguish them from the

[1] For a description of all the more common breeds of animals, see "Types and Breeds of Farm Animals," by Professor Plumb.

Longhorns of middle England, with which they came into competition in the show ring. All this was a hundred years ago, but the two strains or "breeds" are becoming more, rather than less, distinct because each is being selected to its own type, thus still further emphasizing its distinctive characters. No good stockman would now think of mixing them, so that everything keeps them apart, while nothing brings them together. Under conditions such as these the breeds become more distinct and their characters more fixed year by year.

In a similar way southwest England developed the Devons; southeast England the Norfolk and Suffolk, now known as the Red Polled; and Scotland developed the Ayrshire, Galloway, and Aberdeen Angus.

Horses, sheep, and swine, dogs, cats, and even pigeons, — indeed, all other domesticated animals, — have, in much the same way, developed a variety of favorite strains which in time come to be recognized as breeds, and the individuals of such distinct strains are spoken of as "pure breds."[1] Thus arose the so-called pure breeds, whose purity of blood is seen to be relative rather than absolute, for all of them when traced far enough back "run into the woods," that is, merge into the common stock of the region out of which they arose by methods here but briefly outlined.

Pedigree registers. It is manifest that the early breeders experienced much difficulty in determining purity of blood and in avoiding the use of individuals of mixed or impure blood lines, nor is it difficult to understand the necessity of some recognized record as the ultimate authority. The number of animals that any breeder might personally know to be pure would be exceedingly limited. Again, the purer the blood the more the animal is worth, other things equal; and the temptation for unprincipled stockmen to claim purity of blood for mixed animals is clearly extreme.

[1] The word "thoroughbred" is sometimes erroneously used to designate such animals. This term is the breed name of the English running horse and should never be used as synonymous with pure bred. Thus we can have a pure-bred cow, but a thoroughbred is a horse, and a running horse at that.

For all these reasons the establishment of a record in which should be recorded the pedigree of all animals claiming purity of blood became an early necessity. It was done first with the Thoroughbred at the time of the early English races,[1] and followed rapidly afterward with cattle, swine, and even dogs.

In the pedigree register the animal's name is recorded, but he is known and officially designated by his serial number, assigned by the secretary of the association. The pedigree records also the date of birth, the name and number of the sire and generally of the dam, together with the name of the owner and sometimes some distinguishing mark that may be used for identification. In general, the pedigree is a guarantee not only of purity of blood but also, in a general way, of the family lines to which the individual belongs. Identifying any particular individual with the pedigree is a matter that rests solely with the breeder, and for this reason the value of the pedigree of any animal is largely dependent upon the reliability of the owner, because he may falsify the report if he desires to do so.

[1] With the decline of chivalry after the crusades came the just, or tilt, in which first real and afterward nominal knights played at war. Later this developed into the fox or hare hunt, and later still into the horse race. From the first the horses figured largely, especially such as were taken from the Arabs at the time of the crusades. As the tournament descended to the hunt the relative importance of the horse increased, and as this in turn merged into the race, the horse was of far more consequence than the rider. So a boy was substituted for the owner, and thus the knight of the tournament became the jockey of the horse race. When the hunt first became the race, the fox or the hare was let loose in a circular course, well fenced, and then run down with riders and dogs; but later the fox and the fence were omitted on the assumption that the horse that could first get around the track would best be able to run down the fox, were the game a real hunt.

All this time the sport was confined to the gentry, whose horses were more or less directly descended from Arabian or other stock brought to England during or immediately after the crusades, which saw the practical end of the age of chivalry. As the sport grew, some way had to be devised to keep out the mob, and the rules early forbade the entry of any horse whose breeding could not be traced along certain approved lines. This led naturally to written and afterward to printed records of pedigrees, a custom that began naturally in horse racing and which has been extended to all breeding as being the most ready means of identifying blood lines and of establishing authentic records of breeding.

Manifestly, when a breeder files a pedigree with the request that it be published in the association record, the secretary is in a position to know whether the sire and dam mentioned are really owned by the breeder at the time mentioned, and to this extent the association can vouch for the accuracy of the pedigree; but nobody but the breeder can testify that a particular individual is the one covered by that pedigree. Here is where the honor of the breeder is involved, and it is a great tribute to modern business methods when we can truthfully say that it is rare indeed for a breeder to falsify a breeding record or to substitute an inferior animal for the one mentioned in the pedigree.[1] Some errors creep in through carelessness and inaccurate methods of record keeping, no doubt, but these are being reduced rapidly, and no class of men rank higher than breeders, whether judged by standards of accuracy or those of business honor.

The following specimens will illustrate about what is covered in the ordinary registered pedigree.

The first animal ever recorded was the running mare, À-la-Grecque, the first listed in the General Studbook, published 1808, the record running as follows:

Bred by Mr. Platt in 1763, got by Regulus — her dam by Allworthy — granddam by the Bolton Starling — great-granddam, Daisy Maid, by Bloody Buttocks — great-great-granddam, Bay Brocklesby by Old Pointer — great-great-great-granddam, Brocklesby, by Greyhound, out of Brocklesby Betty.

Year	Produce	
1772	ch. c. Pontac by Marske	
1773	f. by ditto (dam of Tencer)	
1774	ch. c. by Chatsworth	Sir L. Dundas
1775	f. by ditto	
1777	ch. c. Arske by ditto	
1780	b. c. Balloon by Telemachus	
1781	b. f. Emma by ditto (dam of Applegarth)	Sir T. Dundas
1783	b. f. Maria by ditto (dam of Marianne)	
1784	ch. c. Templar by Magnet	

[1] There are those who insist that no business men can be trusted, but the business of the breeder can be carried on in no other way than upon honor, and all associations exclude from their privileges any man who has defrauded in pedigrees.

By this we note that the pedigree runs entirely on the dam's side,— indeed, no sires were at first recorded; that her first offspring was a chestnut male[1] and dropped in 1772 when she was nine years of age, and that she raised a foal every year afterward except 1776, 1778, 1779, and 1782,—nine in all. Other pedigrees recorded in this volume trace freely to Arabian stock.

The next pedigree register was Coates's Herdbook, published in 1822 to record pedigrees of Shorthorn cattle or, as they were called, improved Shorthorns, as bred at that time largely by Mr. Thomas Bates and his associates in middle England, but tracing to the Teeswater cattle of the county of Durham.

This register recorded both bulls and cows, arranged alphabetically by name, but for the first time serial numbers were assigned, though only to the males. Thus the first one recorded (No. 1) is Abelard, calved in 1812; but further over in the volume we find Comet (155), calved in 1804, and the famous Hubback, calved in 1777. These early volumes are full of attempts to verify the breeding of early but famous animals then long dead, as were in many cases their owners as well.

So many Shorthorns have since been bred that the numbers have run very high. Sixty-nine large volumes are filled with the pedigrees of American Shorthorns only, the latest numbers running above 273000.

A typical Shorthorn pedigree would now be recorded as follows:

Palmer 270057.

Red, calved March 3, 1906. Bred by J. E. Gilbertson, Utica, Minn.; owned by Lars Somm, Rushford, Minn.; got by Old David 189406, out of Aurora (Vol. LIII, p. 711) by 5th Favorite of Springbrook 141617 — tracing to imp. Daisy by Wild 11134.

All this means that this record gives both the breeder and the owner, and affirms that the sire of the calf was Old David

[1] "c." stands for colt, which is male; "f." for filly, which is female; "ch." stands for chestnut, "b." for bay, "bl." for black, etc.

189406, and that the dam was Aurora, who is recorded in Vol. LIII on page 711;[1] that her sire was 5th Favorite of Springbrook, whose recorded number is 141617, and under which we would find his full pedigree; and further that this line of breeding traces to the imported cow Daisy, whose sire was Wild 11134.

Pedigrees for cows run the same, except that they have no numbers, but are arranged alphabetically by name under the breeders, also alphabetically arranged. This deplorable system makes it necessary to designate females by the number of the volume and the page on which their pedigrees appear. Manifestly, names are useless for purposes of designation because so many are duplicates.

The Hereford system is much better, as everything, male and female alike, is recorded by number in serial order, — a plan that is being more and more generally followed, whether the animals recorded are horses, cattle, sheep, or swine.

Advanced registry. It is readily noted that the ordinary pedigree is merely a guarantee against mixed blood lines; that is, that all the blood of the individual is of the specified breed and no other. It does not, however, pretend to say whether or not a particular individual is a good one. It may be the best of its kind or the poorest, and nothing in the pedigree would make the buyer the wiser. On this point he is dependent upon examination alone.

The advanced registry, however, is a kind of second registration, based upon performance, and is thus a guarantee of quality. Among horses it is based upon their track records,[2] and among dairy cows upon the amount of milk or butter fat made within a given length of time, according to an officially recognized test.

A specimen of advanced registry taken from the Holstein-Friesian books runs as follows:

[1] In the Shorthorn books the dams still have no numbers and must be designated in this awkward way.

[2] See the Year-Book.

No. 4044 Jolie Johanna Clothilde De Kol 72194

Jolie Johanna Clothilde De Kol 4044 A.R.O. In 3 yr. 7 mo. 23 da. 11,508 lb. fat	De Kol 2d's Mutual Paul 152 A.R.	Mutual Friend 3d's Paul 148 A.R.
		De Kol 2d 412 A.R.O. In 10 yr. 11 mo. 3 da. 21,261 lb. fat
	Jolie Johanna Clothilde 52356	Onyx Clothilde Pledge 23639
		Jolie Onyx 43770

Owned by W. C. Hunt, Liverpool, N.Y.; bred by George F. Carter, Syracuse, N.Y. Calved April 11, 1901. Official butter record: dropped calf December 4, 1904, at 3 yr. 7 mo. 23 da. of age; commenced record January 17, 1905; closed record January 23; 7 days' production, 11 lb. 5 oz. butter fat; milk, 345.5 lb. Attested by L. L. Devereaux, Cornell University, Agricultural Experiment Station.

The need of this kind of information is evident. The breeder, bent upon improvement, desires to buy and to keep the *best* of a breed, not the poorest or even the medium. A glance at the table on page 156 will show that the mass will always be mediocre, and that while much excellence springs from mediocrity, it is relatively infrequent, so that if a man desires to breed exceptional animals, he will get a larger proportion of such if he breeds from exceptional parents.

Here is where the problems of the breeder differ from those of political science. A glance at the table cited will show that a hereditary monarchy is certain to run, not occasionally but frequently, into mediocrity for its ruler. Let stature stand a moment for genius or statesmanship. Then a ruler represented by 70.5 inches in the table is certainly well above the medium, but his son may be anything from above 73.2 and better than the father down to below 62.2, the minimum of the race.

Republics, on the other hand, elect their rulers, that is, select them after birth and maturity, and have a chance to choose individuals above the mediocre, with no reference either to ancestry or descent, as the son is in nowise involved. This is why republics can have better average rulers. Though they are likely not to rise to the supreme height of some hereditary monarchs, they will never sink to the depths of others, and upon the whole they are safer.

The breeder, on the other hand, is concerned with the *offspring*, and he will stake his fortunes with the best bred ancestors, not because all their descendants will be equally good, but because the proportion will be higher.[1]

Unregistered stock and scrubs. Unregistered animals are of two kinds: first, those that cannot be recorded because their

FIG. 27. Inferior feeder, \$4.75 per hundredweight (1910); usual price, \$2.75 per hundredweight

From "Beef Production," by Mumford

ancestry is exceedingly mixed, — known as scrubs; and, second, those that are really pure in their blood lines but that cannot be recorded because the records are lost, or, for other reasons, their particular ancestry is not fully known. These are called simply unregistered.

[1] A glance at the table in question will show that while tall people spring both from tall and from mediocre parents, the greatest proportion is from the tall parents; thus $4 \div 19 > 5 \div 183$ (see rows *e* and *f* of the table).

The first class is, on the average, decidedly inferior because only partly improved, and though high-class individuals occasionally occur, even they are next to worthless for breeding purposes, because, under the law of ancestral heredity, the influences are so diverse that regressions and reversions will be common, even inevitable. The second class, on the other hand, may be virtually and even actually high-class, pure-bred animals, whose records may have been lost by fire or other accident, or are otherwise untraceable. Such animals may be every whit as useful for everyday purposes as are registered stock, but the impossibility of knowing or stating their blood lines of course destroys their sale value as breeders.

Now and always the great mass of our farm stock will be unrecorded animals. The business of the improver is to raise the quality of this stock to the nearest possible approach to the best recorded blood. This is the best we can hope to do, for there will always be a *few best animals*, and these are really the only ones worth recording. It adds nothing to the value of an inferior pure-blooded animal to record it, — indeed, it is better that such animals be not recorded, — and one of the first steps in practical improvement is to get rid of the pedigree scrub, meaning by that, those animals of good breeding which are themselves worthless.

We have, then, two great classes of animals: first, those whose ancestry is known and recorded; and second, those whose ancestry is not known. Manifestly, most of the best animals and all of those valuable for securing additional improvement are in the first class.

Systems of breeding. With these facts before us we are ready to discuss the relative merits of different systems of breeding, which may be briefly outlined as follows:

1. Mixed breeding, in which no attention whatever is paid to ancestry. It has the merit of cheapness and the disadvantage that no further improvement need be expected. If any systematic attempts should be made toward selecting to a constant

standard, then it would be at once necessary to keep records, and the animals so handled would be no longer mixed bred but would be on their way to becoming a new strain of pure breds.

2. Pure breeding, in which only registered animals are used. This system has the advantage of securing the best results, but

FIG. 28. Choice feeding steer, $6.25 per hundredweight (1910); usual price, $4.50 per hundredweight

From "Beef Production," by Mumford

it is relatively costly, especially with horses and cattle, but less so with the smaller and cheaper animals.

3. Grading, in which the sire is pure bred, but the dam is not. This system combines the advantages of both preceding methods. It is but little more costly than the first, and is, for practical purposes, almost as effective as the second.

4. Crossing, in which the sire is of one breed or set of blood lines, as Shorthorn, and the dam of another, as Jersey. This method combines the disadvantages of both the first and second methods in that it is as costly as pure breeding and in the end

not more effective than mixed breeding, which in truth it really is, unless the object be the formation of a new breed, which is a long and tedious task, but entirely feasible in theory, as we have seen.

Some additional points may well be noted upon these four systems of breeding. The first, or mixed breeding, has nothing to commend it to the progressive farmer. It is and always will be the method of the shortsighted stockman, who does not look ahead, and who sees nothing beyond immediate results, but who feels obliged and perhaps is obliged to be economical.

Pure breeding requires relatively large numbers, in order to afford material for selection. With the larger animals this means large capital, putting this method of breeding out of the reach of the average stockman. With the smaller animals, especially the prolific pigs and poultry, every man should breed only pure-bred animals. Whether he goes to the trouble of getting them recorded will depend upon whether he desires to sell to other breeders or only to raise for the open market.

With the larger and more expensive animals, grading is the form of improvement to be recommended for universal practice. Here the farmer uses the females already on hand and buys only the sire, which is the only recorded animal needed in this form of improvement.

This sire is half parent to every young thing born, so the first crop of young will be half bloods; that is, they will have half the advantage of pure breeding by the use of a single animal, while to give the offspring the other half would require the purchase not of a single animal but of as many as there are females in the herd, one dam for *each* offspring.

Suppose, for example, a farmer has thirty common cows. How will the expense run in the two methods of breeding? If he is to breed pure, he must sell these cows and with the proceeds buy pedigreed animals. It will take at least three common cows to buy one registered cow that is equally good as a performer, and if the pedigree "runs in the purple," it will take many more.

On this basis, however, the two plans would compare about as follows:

By grading, the farmer would have a crop of thirty half-blood calves. By pure breeding, his cows being reduced to one third, the number he could have would be but ten; that is to say, he has more "blood" and therefore more improvement in his thirty half bloods than in his ten full bloods, as well as more animals

FIG. 29. Choice (butcher) cow, $6.40 per hundredweight
Mumford, in *Bulletin 78*, Experiment Station, University of Illinois

to stock his farm and to afford material for selection. On the sire's side the expense has been the same.

As between grading and mixed or unimproved breeding, the advantage is clearly with the former. The females are the same in both cases. The cost of feed for the sire is the same, and the only difference is in his original cost. A sire suitable for grading purposes can be had for a hundred dollars, which would be but $3.33 extra for each calf, to *entirely pay for the bull with the first crop of calves*. But he will raise successive crops, and the scrub costs something, so that the increased cost of giving a calf half the advantage of pure breeding cannot be over a dollar apiece in a herd of this size. Moreover, this dollar is not on the calf but rather on the mature animal.[1]

Any way it is estimated, the great fact is, that by the system of grading, a single parent will give to *every one of the young of the herd half the advantage of pure breeding in the first generation.* When, however, these half bloods reach breeding age, their offspring from a pure-bred sire will be not half bloods but three-quarter bloods, and their offspring will be seven eighths, and so on indefinitely, according to the following table:

RATE OF IMPROVEMENT BY THE SYSTEM OF GRADING

Generation	Sire	Dam	Offspring	Per cent improvement
1	Pure	Scrub	½ blood	50.
2	Pure	½ blood	¾ blood	75.
3	Pure	¾ blood	⅞ blood	87.5
4	Pure	⅞ blood	15/16 blood	93.75
5	Pure	15/16 blood	31/32 blood	96.875

By this we see that after five generations of grading the offspring have attained thirty-one thirty-seconds, or nearly 97 per cent, of the improvement that is possible by the use of pure blood, and all by the use of a single animal only at any given time. By this we see, too, that the sire alone can in time accomplish practically as much improvement as sire and dam could both accomplish at once, and all at an expense vastly less.

Too much cannot be said in favor of improvement by grading. It is safe, cheap, and sure, and, moreover, it does not disturb the affairs of the farmer. It means only the initial cost of a well-bred sire, and after that the improvement of the herd will take care of itself; whereas, with scrub parents on both sides, no

[1] Of course, if the herd is being used for dairy purposes, only half the calves would be utilized, which would double the cost.

improvement is possible except by an outlay of labor and expense beyond that even of pure breeding, and at a cost of time far beyond that of grading.

It is difficult to realize why farmers do not more generally avail themselves of this perfectly rational and exceedingly economical means of improvement, and see in their yards at once crops of uniform young instead of the motley lot that disgrace

FIG. 30. Medium (butcher) cow, $4.75 per hundredweight

After Mumford

most of our barnyards. Their failure to do this is due to nothing but their failure to look ahead, to figure out the final outcome, and to look facts squarely in the face.

The young people who read these pages can do a lasting service by using their influence in every way possible to hasten the use of better sires. All old countries have learned the lesson long ago. We need to learn it at once. Let the young people start it and *begin now*.

Source of sires. Suitable sires can be had of any of the reputable breeders that advertise in our best journals, and at fair prices. They will cost more than they are worth for veal, of course, but it should be remembered that the buyer is paying not so much for the animal as for the long line of breeding that he represents. Consult again the law of ancestral heredity in Chapter XII and understand fully why it is that a well-bred

FIG. 31. Common rough (butcher) steer, $5.80 per hundredweight (1910); usual price, $4.25 per hundredweight

After Mumford

male, if only a few weeks old, is worth many times his ordinary market value and infinitely more than any scrub, no matter what his size, color, or other quality, which, like beauty, is in his case only "skin deep."

Herd improvement and breed improvement. Farmers are far more apt to practice crossing than grading, though it is vastly more expensive, and, as commonly practiced, leads to nothing, for reasons well understood by the student. I attribute this failure to our universal desire to experiment in something striking.

If crossing has any value, it is not to improve the herd of a farmer, but to afford material for improving the breed as a whole, and even this is a long, tedious, and expensive undertaking because of the operation of Mendel's law. Farmers who have tried it will say that crossing produces some good animals, but they are worthless as breeders. This is because of the principle just mentioned and the erratic behavior of characters dominant and recessive, as explained in Chapter XI.

The practical farmer should have clearly in mind what he desires to do. If he very much wants to improve the breed as a whole, then well and good. All breeds need it, but he may as well understand that he has undertaken a Herculean task that will take much time and no little money.

Most men are rightly after *herd improvement* merely; that is, to bring into their own herds the most they can afford of the best that has already been accomplished in improvement. Now the least that such a man can afford to do is to buy a sire of the desired breed and begin at once to improve his own herd. Then later he can improve the breed, if he is able.

Rational improvement. The rational procedure for the man who would improve his live stock is to secure a well-bred young male of the breed he prefers and "grade up," beginning with the females he has on hand, or such other common stock as can be bought on reasonable terms. Let him then raise several generations of grades, and later, if inclination offer and money permit, he can put in a few pure-bred females with his high grades and begin the production of a pure-bred herd; or he may go on with high grades indefinitely, well knowing that *for market purposes* the high grade is as good as the full blood.

Starting in this way he will have several substantial advantages, which may be enumerated as follows: (1) he will start cheaply; (2) he will produce relatively large numbers, making rigid selection possible; (3) he will discover the special breed characters quickly, as they will stand boldly out at once in the grade stuff; (4) he will gain much valuable experience with the breed in case he afterward desires to breed it pure.

Choosing the breed. No question is more common than this: What is the best breed? The only answer is that there is no best breed. Of course, one should not choose Percheron horses

FIG. 32. Prime steer, $8.70 per hundredweight (1910)
After Mumford

for carriage purposes nor Jersey cattle for beef. Thus, in a general way, the farmer should be informed about the breeds before he begins. This is not the time nor the place to discuss this question at length, but he can get this information from such books as Professor Plumb's,[1] and he cannot afford to decide so important a question as choosing a breed without giving some time to its study, because it is expensive both in time and money to make a change.

[1] "Types and Breeds of Farm Animals."

Above all, he should not choose it suddenly or impulsively, as do some, when overimpressed with a particularly striking display at the fair. The matter of the breed should be seriously studied, for once chosen it should not, under any ordinary circumstances, be changed for another. To do that is to so mix the breeds together as to make a jumble which is next to worthless for practical purposes, giving rise as it does to all sorts of troublesome and unexpected reversions, for Mendel's law is always operative in such cases.

Breed differences slight. As between the different breeds that are bred for the same purpose, the practical differences are slight and well within the personal factor of choice. For example, the four great beef breeds — Shorthorn, Hereford, Angus, and Galloway — were developed in as many different localities, and all in the hands of excellent stockmen. As with adherence to a political party or to a particular religious faith, an individual generally prefers the one with which he was brought up.

Many a man says, "I will not have horns." Then his choice is limited to Galloway and Angus. But he says, "I don't like black cattle." Very well; then he will have to get the Polled Durham. Then he may say, "I don't like roans." Then nothing is left for him but to make a breed of his own, with the probability that he will be dead and forgotten long before the feat is accomplished, for we cannot quickly build a breed to specification, as we can a house.

After the breed is chosen the breeder should become familiar with its "points" and also with the market requirements of the animals he proposes to produce.

To facilitate this study by the young I have added an Appendix, which gives sample scales of points both for pure-bred and for market animals. It is impossible to cover all breeds in a book of this size, but enough is given to afford exercise in stock judging, which is one of the most valuable accomplishments of the farmer.

It will be seen upon careful study that some of these points are based upon utility, while others aim at mere looks, often covering points that, from the standpoint of utility, are trifling. Now we keep cows, for example, for milk and butter, and those that can make the most for a given amount of feed are the best cows, quite independent of the length of the tail or the color of the tongue. Meat animals generally are valuable in

FIG. 33. Prime baby beef, $8.00 per hundredweight (1910)
After Mumford

proportion to the amount and quality of the meat they can make, and horses for their service at labor or upon the road. In pure breeding a great variety of minor matters are bound to enter in, and this fact constitutes one of its difficulties, but practical improvement of the mass of farm animals should proceed upon utility standards.

Market classes and grades. For animals that are shipped largely to the open market, like beef cattle, sheep, pigs, and even horses, definite classes and grades[1] have long since been established. There are now no less than seven classes and forty-eight grades of market cattle, eight classes and twenty-seven grades of swine, eleven classes and twenty-one subclasses of horses, and seven classes and forty grades of sheep, a few of which are shown in illustrations accompanying this chapter (Figs. 27–33). The value of these different grades varies of course at different times, but relatively the upper grades are out of all proportion with the lower. A careful study of these relative values will convince the student of what can be done by breeding.

Knowledge of market requirements needful. It is important that the stockman have pretty definite knowledge of market requirements, because they are the standard by which his animals must be sold and by which he will be paid. Want of this information is the cause of thousands of "unclassed"[2] animals upon the market. It is hardly necessary to remark that such animals make the owners little or no money. If, on the other hand, the owner knows in advance what the market will demand, he can shape his ideals and selections accordingly and thereby produce what the buyer really wants. Here is where accurate knowledge and intelligence are necessary to the best success in the live-stock business.

Exercise. Make a careful study of Chapter XVII, Part II, and get practice in stock judging, as outlined in the Appendix.

Reference. The *Breeders' Gazette*, which ought to be regularly taken by the school.

[1] For market classes and grades of cattle see *Bulletin 78*, Experiment Station, University of Illinois; for those of swine, see *Bulletin 97*; for horses, see *Bulletin 122*; and for sheep, *Bulletin 129*. Professor Mumford, head of the department of Animal Husbandry, began this important series of publications with the bulletin on cattle, which was followed by the others mentioned, prepared respectively by his associates, Professor Dietrich, Mr. Obrecht, and Mr. Coffey. In all cases the material was prepared in the stockyards, then submitted to the best experts, and may be considered as authentic.

[2] An unclassed animal is one that does not fall into any of the recognized desirable classes. Such animals make their way into the lower grades, and, as the supply always exceeds the demand, go for an extremely low price.

CHAPTER XVI

SYSTEMATIC IMPROVEMENT OF PLANTS

Improvement by selection · Crossing to produce new varieties · Application of Mendel's law in crossing · Separation of the desired character · Behavior of the recessive · Behavior of the dominant · When more than two characters are involved · Systems of planting · Records

The whole question of practical methods of plant improvement rests on an entirely different basis than that of animals. The evolutionary principles involved are identical, but the economic conditions are different, indeed almost opposite.

Animals are relatively few in number and costly both in breeding and in maintenance. Plants, on the other hand, are cheap, and the numbers may easily run into the thousands, all of which warrants methods in plant improvement that would be entirely impracticable with animals.

Improvement by selection. Plants, like animals, are subject to improvement by the ordinary methods of selection ; indeed, much improvement is effected in that way. Farmers keep up the quality of corn by selecting for seed the occasional superior ear. The best wheat is chosen for seed and carefully screened of inferior kernels. In this general way we are constantly practicing selection.

A new method of increasing yield of corn consists in planting selected ears, each in separate rows, carefully harvesting each row separately. Though the ears may have looked identical, the crop will vary greatly. That from some ears will be nearly uniform as to size and character of ear, while that from others will be exceedingly uneven, with many nubbins and inferior ears. The yield, too, will vary greatly, often running more than two to one in favor of certain ears, though they bore no visible indication of inherently superior powers. This experiment is so easily repeated that it is recommended for the student, and further data are hardly necessary in the text (see table, p. 204).

This method is akin to that employed for the increase of sugar in the sugar beet. When the Germans commenced the improvement of this crop, the sugar content was low, running from 4 to 6 per cent, while now whole fields run 15 per cent and occasional single beets are found as high as 25 per cent. This improvement has been effected in the following way.

Many promising beets are analyzed for sugar content and only the highest are selected for planting. The same process is repeated for two or three generations, the best individuals always being selected as "mother beets." The seed from the last selection is "multiplied" in the open field by planting without selection, simply to secure commercial quantities. Thus the commercial seed, while not *immediately* descended from selected beets, is but one or two generations removed from a highly selected parentage.

Crossing to produce new varieties. By the methods above mentioned any strain or variety may be greatly improved, but by the method of crossing we may bring together absolutely new combinations of characters and thereby produce new varieties, some of which are certain to be more useful than the old.

The reasons which practically rule out crossing as a means of improvement in animals, except in rarest cases, do not apply with much force to plants, because we can produce them in such enormous numbers and they are relatively so cheap that we can afford to throw away the most of them for the sake of getting the few or even the one that is useful.

Application of Mendel's law in crossing. The confusing element in crossing is the behavior of dominant and recessive characters when suddenly brought together in new combinations. Reference to the chapter on Mendel's law will refresh the point that characters combine in definite proportions, but that some are much more apparent than others which are easily obscured, and which therefore may go on hidden for a time, only to suddenly appear when the overshadowing dominant, for any reason, is absent.

Separation of the desired character. The separation of the desired character from its entanglements with others is sometimes easily effected, but more often with great difficulty, especially when dominant undesirable characters are involved. As an example of easy separation take the following theoretical case: Suppose we cross the colors black and white. Under Mendel's law we shall have offspring of the cross as follows: $b^2 + 2\,bw + w^2$, in which b^2 is pure black, w^2 pure white, and $2\,bw$ is mixed, black and white. In this particular case, therefore, we shall find the offspring of three distinct colors, all of which are easily separable, one from the other.

In the vast majority of cases, however, the characters do not blend in this way, so that the middle term does not stand out distinctly by itself. One of the characters generally overshadows, that is to say, is dominant over, the other, making it difficult, if not impossible, to separate by inspection the members of the middle term from the pure dominants; that is, to determine from a mixed population of offspring, arising from a crossed parentage, which ones are pure dominants and which are mixed, dominant, and recessive.

Behavior of the recessive. It will be remembered that recessive characters appear unassociated with the dominant in one fourth of all crossbred individuals, after the formula $D^2 + 2\,Dr + r^2$, in which D stands for dominant and r for recessive. For this reason it is comparatively easy to proceed when the character desired is recessive, because these individuals that seem to be recessive are really what they seem, pure recessive, and will breed pure.

Behavior of the dominant. It is not so easy, however, with the dominant, when that happens to be the character in whose improvement we are interested. Because it is dominant it will appear not in one fourth but in three fourths of the offspring;

that is, we are unable to discriminate between the pure D^2 and the $2\,Dr$ with its unnoticeable recessive, *r*. How, now, shall these be separated?

It is a long and difficult process. The only procedure is to plant the seeds, separately if possible. Those that are pure dominants will of course produce only dominants, while those that are mixed will produce both kinds; that is, among these no recessive will appear. In self-fertilizing species we can quickly separate the pure dominant strains, but when it is necessary to resort to cross fertilization, either natural or artificial, it is evident that the work is still more difficult. Under such circumstances the only way is to proceed at random until a strain appears that produces no recessives, when it may be confidently assumed that the parents were both pure dominants and that the separation has been effected.

When more than two characters are involved. It is sufficiently difficult to separate two characters, one of which is dominant. Manifestly, it is still more difficult to effect separations when three or more characters are involved, especially if we are concerned with all of them.

Of course, in practical improvement we neglect all characters that do not concern us, whether they are dominant or recessive; but, on the other hand, it is seldom that we are concerned with so simple a problem as the separation of a single character from its recessive or dominant associations. When our problem is to separate two or three such characters from their hereditary entanglements, the job becomes akin to hunting for the traditional "needle in a haystack," because the combinations are exceedingly complicated; for we remember that the individuals which are recessive as to one character may be dominant or mixed as to others.[1] The only way, however, is to run it down

[1] This is why, if Jerseys and Holstein-Friesians should be crossed, some of the offspring would be rich in certain Jersey characters and others in other characters, either Jersey or Holstein-Friesian; but under the law of chance not once in a million times, or more perhaps, would a single animal be pure Jersey with reference to *all* the Jersey characters. Besides this, it is more than likely

patiently by dealing with relatively large numbers, always remembering that recessives when evident are always pure, at least as far as their own dominants are concerned.

Systems of planting. In order to make safe and certain progress in improvement of plants, definite systems of planting must be observed. Two systems are in vogue, — the plot system and the row system. Each has its advocates, and each has its advantages for certain purposes.

The plot system is the older. In this system the seeds of a given selection are planted together in a small plot of ground, which is labeled and numbered. In the row system each selection is planted in a separate row, which is also labeled and numbered.

Whichever system is adopted, adequate methods of numbering and recording not only the ancestry of the planting but also the progeny or crop must be devised and rigidly adhered to; indeed, much of the success of improvement in plants, which necessarily run into large numbers, is dependent upon the skill and faithfulness of the record keeper.

Records. The exact form of the record will of course depend upon the particular plants and characters involved, and to some extent upon the system of planting adopted, whether in plots or in rows. For simple operations the student can devise his own system of records, and for more complicated cases he is referred to "Principles of Breeding," pp. 644–650, where complete illustrations are given of the method of record keeping in the wheat-breeding experiments at Minnesota, where the plot system is used, and in the corn-breeding work at Illinois, where the row system is in use.

The general principle is that every plot or row be designated by number, that every seed selection have also its serial number, and that full descriptions be recorded of all plantings. A little

that some of the Jersey and some of the Holstein-Friesian characters would blend, making anything like a pure Jersey or Holstein-Friesian forever afterward impossible.

study will enable us to put much meaning into these numbers. For example, suppose 20 ears of corn are to be planted. For the first year of an experiment, instead of numbering them from 1 to 20 it is better to number them from 101 to 120, next year from 201 to 220, and so on, so that the figure in the hundreds' place denotes the number of generations of improvement. Thus, if an ear should have the number 614, we know at once that it represents the sixth generation of improvement. In general, the following will be sufficient for the record of simple breeding operations: (1) number of seed; (2) description; (3) number of plot or row in which it is planted; (4) number of parent stock, — one number if fertilization is left open as in corn or closed as in wheat, but if crossed by hand, then two numbers will be needed, one for the male and one for the female parent.

With this information and these few general directions the student is amply able to begin experiments in plant improvement, and it is the earnest hope of the author that young people may quite generally appreciate the opportunity for improvement in seed and plant and flower, that still stands waiting the hand of the breeder. It is a fascinating field into which the student is advised, even urged, to enter, — cautiously at first, taking one or two simple things, remembering always that such work runs rapidly into numbers; then, as experience is gained, he may range farther afield.

It is no stretch of the imagination nor is it a chimerical dream to say that the students of our better schools, aided by their teachers, can, if they will, do more to further improve many of our cultivated plants than can the farmers themselves. It is well within their powers. They have the time and can acquire the skill, — things which are difficult to secure to the man that is busy in active commercial life.

As an example of what can be done in the improvement of a single character, I introduce the following table, which exhibits the results of ten years of selection for high and low oil of corn carried on by Dr. C. G. Hopkins of the University of Illinois.

In these experiments the planting was always made from the ears that contained the highest and lowest obtainable proportions of oil respectively. The selection may be roughly based on the size of the germ, the largest germs having the most oil.

TEN GENERATIONS OF BREEDING CORN FOR INCREASE AND DECREASE OF OIL

Year	High-oil plot, average per cent oil		Low-oil plot, average per cent oil		Difference between crops, per cent
	In seed planted	In crop harvested	In seed planted	In crop harvested	
1896	——	4.70	——	4.70	.00
1897	5.39	4.73	4.03	4.06	.67
1898	5.20	5.15	3.65	3.99	1.16
1899	6.15	5.64	3.47	3.82	1.82
1900	6.30	6.12	3.33	3.57	2.55
1901	6.77	6.09	2.93	3.43	2.66
1902	6.95	6.41	3.00	3.02	3.39
1903	6.73	6.50	2.62	2.97	3.53
1904	7.16	6.97	2.80	2.89	4.08
1905	7.88	7.29	2.67	2.58	4.71
1906	7.86	7.37	2.20	2.66	4.71

Exercises. Study and report upon any plant-breeding operations of the neighborhood, especially with reference to the following points: what improvements are sought; how seeds are selected, and on what points selection is based; how stored for the winter; how planted, and what records are kept.

Plant in separate rows ten of the best ears of corn obtainable, describe and number each ear, and give the same number to the row in which it is planted. Then make a careful study of the crop, both as to yield and uniformity, using the statistical methods for determining variability.

Plant separately from the tips, the middle, and the butts of the same ears of corn. Next year select a set in the same way from the respective crops, and continue the experiment for a series of years in order to get the cumulative effect of the late small kernels at the tip as compared with the early and large kernels of the base. Do not look for too much difference the first year.

Bring to the school garden any field crop or garden plant in which there is general interest, and begin work, looking to its improvement.

PART II

THE ORIGIN OF DOMESTICATED RACES

Part II deals with the material out of which domesticated species and varieties have been made. It aims to sketch briefly, as far as it is known, the history of domestication and to indicate as well as may be done at the present time the specific wild race to which each domesticated form is supposed to trace when run back to its wild progenitors. The limitations of space forbid anything more than the briefest outline, but to further assist the student the text is supplied with references to fuller sources of information.

The attempt to trace the history of domesticated animals and plants back to their primitive forms is beset with many difficulties. First of all, the domesticated races have been substantially altered during their long removal from the wild, subject primarily to man's selection ; and again, in the centuries that have elapsed since domestication, many a wild race has become extinct, and because of this we may often be deceived as to the exact parentage and be inclined to credit it to some near relative that has persisted ; still again, wild races themselves change without man's interference, and for all these reasons this attempt to assign definite sources of our domesticated races must be regarded as more or less approximate in its conclusions.

The student will be struck with the fact that most of our animals and plants trace to Old-World forms. This is not necessarily because the New World was less prolific in valuable material, but rather because civilization, as we know it at least, commenced in Asia and worked westward. In this way much valuable material indigenous to the American continent was neglected for no other reason than this, namely, that too good a start was already made with Old-World material; and only where something distinctly better was discovered here, as corn and the turkey, were American races utilized, excepting only when Old-World forms failed, as they did with the grape and the gooseberry.

The material of this part may be used in three ways: as text, to follow appropriate chapters in Part I as indicated; as reference matter, to be taken in connection with Part I; or as independent matter.

CHAPTER XVII

ORIGIN OF DOMESTICATED ANIMALS

Domesticated mammals · The dog · The horse · The ass · The ox · The sheep · The goat · The pig · The cat · Domesticated birds · The hen · The goose · The duck · The turkey · The peacock · The swan · The guinea fowl · Additional races and semidomestication · Unwelcome domestication

As the subject matter of Part II constitutes an application of the principles discussed in the early chapters, we are ready at once to proceed, without special introduction, to the detailed study of the origin of special races of domesticated animals.

Domesticated Mammals

The dog (***Canis familiaris***). Of all the wild animals that have been brought into the service of man, some form of dog was undoubtedly the first, for reasons brought out in the chapter, How Animals came to be Domesticated. His exact origin is of course unknown, but he has numerous wild relatives in all parts of the world, not only within historic times but even to the present day. The nearest of these are the wolf and the jackal in their various forms, both of which are said to breed freely with the domestic dog upon opportunity, and both of which, more especially the wolf, have been frequently domesticated. The Indian, for example, kept numerous "dogs," mostly developed from the

FIG. 34. The collie, one of the finest domesticated types

coyote of the prairie and often with a dash of blood of the timber wolf to give energy and ferocity (see Fig. 3).

A very doglike wild animal is the fox, which, however, is not commonly regarded as one of the immediate progenitors of the common dog on account of structural differences in the skull and the more significant fact that the pupil of

FIG. 35. The dingo, or wild dog of Australia; nearer the domestic dog than any other existing wild species

his eye is elliptical, whereas it is round in the wolf, the jackal, and the dog.

These slight structural differences, however, are counting for less than formerly in tracing relationships, and the fact that certain South American wolves are very foxlike, as are some of our dogs, leads us to be careful in denying the fox even remote connection with our domesticated races.

The wild animal nearest to the domestic dog seems to be the dingo of Australia. It might be called the wild dog of that island. Whether from life in a restricted area and with a simple fauna it has had less opportunity to exercise and develop its wolfish instincts than has its cousin of the continents, or whether the original stock was essentially more doglike, we do not know. We only know that the dingo is more like a dog than is any other wild animal of the present time, and that he is very like certain forms of the domestic species.

We know, too, that the line between the dog and the wolf is not distinctly drawn; that is to say, there is more difference between different breeds of the domestic dog than there is between certain breeds and the wolf of the wilds. On this point compare the common dogs as we know them with the Siberian wolfhound and with the timber wolf.

They all possess a common instinct to hunt and a common ability to trail by the scent.[1] True, a few breeds, like the poodle and the dachshund, have lost the hunting instinct, having been developed as pets, but in others it has been well preserved. The bulldog is more savage and more courageous than any wolf ever known. The mastiff does not hunt, but he watches, which is essentially the same thing. The St. Bernard, which is a gentle dog, displays his native instinct in hunting men for rescue.[2]

The bloodhound has a keener scent and greater ability to follow a trail than has any wolf, but he has lost the savage part of the hunting instinct; for, contrary to popular belief, he is quite satisfied to sniff his quarry at the end of the trail.[3]

The greyhound and the Russian wolfhound have lost their ability to trail, but preserve their old hunting instinct, so, while obliged to depend upon sight to discover the quarry, they are

[1] Curiously enough, the "bark" which is characteristic of the domestic dog and largely absent in the wild is readily acquired upon domestication, but abandoned by the same individuals upon assuming the feral state.

[2] Read the story of "Barry" of St. Bernard.

[3] The term "bloodhound" means *blooded* or *highly bred*. It has no reference to ferocity, for the bloodhound is the gentlest of all dogs, not excepting the poodle.

still most excellent hunters. The hunting hound still retains the original instinct to hunt in packs like the wolf, an instinct which, in the collie, has been developed into herding.[1]

These habits are not far from those of the wolf of the woods. This skillful hunter does not charge his prey, but he hunts systematically, singly, or in packs. A man being stalked by

FIG. 36. Prize-winning great Danes, the largest of all dogs. Winderbourne kennels, Washington, D.C.

wolves would be long unaware of his peril. He might see a single wolf running off to the side at a considerable distance, apparently disappearing in the bushes. Presently he might see another, perhaps following, perhaps in another quarter. If new to the woods, he might think that wolves were plenty but all great cowards, while if he knew their habits in hunting, he would

[1] Read "Bob, Son of Battle," in this connection.

know that the whole pack was upon his trail, not following straight but circling round him in a gradually narrowing and ultimately fatal spiral; for, gaining confidence with exertion and whetted hunger, the pack will ultimately make the charge at a favorable moment after the quarry is at bay and shows the first evidence of defenselessness. This is the natural method of the shrewdest and most cowardly hunter the forest of nature ever produced, and it is perfectly natural that such an animal should have been not once but many times domesticated. Thus came the dog to dwell among us.

The horse (***Equus caballus***). Unlike the dog, the horse has no near relative in the wild; that is to say, there is no existing wild species that, by any stretch of the imagination, could be regarded as the direct progenitor of the modern horse, or from which the horse could by any possibility be developed.[1] If all the dogs of the world should disappear, they could be reproduced from the wild; but if the domestic horse should disappear, he could not be restored from any other existing species.

While the immediate progenitor of the horse is, and likely has been for a long time, extinct, yet two significant facts remain. The first is, that he was almost certainly developed from some primitive stock in or near the semiarid plains of Central Asia, having wolves for his nearest neighbors and principal enemies. The other fact is equally significant; namely, that while the immediate progenitor is lost, we really know more of the ancestry and evolution of the horse than of any other animal domesticated or wild, living or extinct.[2]

[1] Objection might be made to this statement on account of the Tarpan, or so-called wild horse, which has been known on the steppes of Tartary and eastward to Central Asia certainly since the time of Pallas (1760), though it is now confined to the more remote regions of the interior. These animals are true horses; and if they are aboriginal stock, they are to be regarded as the real progenitor of our domesticated race. It is more than likely, however, that they are feral rather than truly wild.

[2] For a more extended account of the origin of the horse and his evolution upward, see "Principles of Breeding," pp. 298–305.

FIG. 37. Prehistoric five-toed horse restored, and compared in size with the head of the modern horse. — After Osborn

The best of evidence exists to show that the modern horse has developed from a diminutive five-toed ancestor not much larger than a jack rabbit. Fig. 37 shows this animal restored, and compared in size with the head of the common horse. The story is too long to be recited here, but should be read in collateral literature. Space permits us to note only the significant fact that actual relics have been found in western North America, and are still in existence, showing the entire evolution of the horse from the little five-toed animal just mentioned, up through the forms with three toes, to the present form with one, the so-called "splint bones" at the side being all that is left of the original digits II and IV, all traces of Nos. I and V having long since disappeared. Along with this reduction in the number of toes has gone a gradual increase in the size of the body and a hardening of the teeth till the readaptation was complete from a small and probably timid animal living on soft feed and low ground to the swiftest of all animals, of good size, subsisting on upland grasses and prairies and fitted for locomotion on hard land.

More than to any one else we are indebted for this history to Professor H. F. Osborn of the American Museum of Natural History, New York, who is now completing his material for an almost perfect history of the horse, from the diminutive ancestor down, or rather up, to the modern domesticated form, with many distinct types between, but merging into each other gradually and distinguished by differences almost imperceptible. Differing though they do from the modern horse, these many forms are clearly horselike, and, moreover, they are connected by unmistakable links that bind them all together as one of the greatest evolutionary achievements of the earth.

As has been intimated, this history has been largely traced through fossil remains found in western America, especially in Wyoming. Europe affords evidences of the same evolutionary processes, and without a doubt the same course of development could be traced in Asia, as will likely one day be done, if extensive explorations are made in that country.

We know that several horselike forms developed in South America, but that all perished for one cause or another, one at least from soft teeth. It is exceedingly remarkable that while the North American horse progressed almost up to the modern

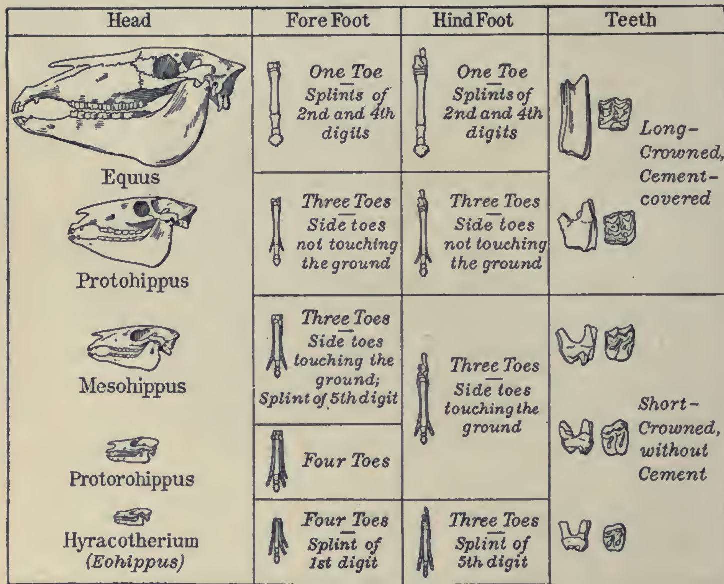

FIG. 38. Comparative drawings of skulls, feet, and teeth of prehistoric horses, showing evolutionary development. Reproduced, by permission, from "Origin and History of the Horse," by H. F. Osborn

type,[1] he became extinct for some reason, and, so far as we know, before he was ever domesticated.

What caused this extinction here and yet preserved the Asiatic form till man came upon the earth we cannot, with our present knowledge, even conjecture; though it is known that the

[1] He had reached the size of the Shetland pony with three toes, only one of which rested firmly on the ground, digits II and IV being much like the "dew claws" (digits II and V) of pigs; digits I and V being represented by "splints" (digits numbered I–V beginning on the inside).

horse, while able to maintain himself against wolves in Asia, is not able to withstand the puma, which has exterminated the feral horses in certain localities of South America.

All this, however, is but ancient history, and now we can only speculate upon what would have been our misfortune and our condition had the prehistoric horselike animal become extinct in Asia, as he did in the rest of the world, and we had been obliged to get on without the horse.[1]

Since his domestication the horse has doubtless changed but little. He is larger, stronger, and swifter, but structurally he seems to have been for a long time a finished animal. Under domestication he has developed the trot, until with some breeds it is an instinctive gait. This is a great tribute to breeding, for the trot is not a natural gait with animals of the horse kind, except for a few steps between the canter and the walk.

However early the domestication of the horse, — and it must have been very early, — its introduction into modern historic life is comparatively recent. For example, the Egyptian carvings and frescoes show nothing of the horse until after the close of the rule of the shepherd kings (1800 or 1900 B.C.), when that country first came into contact with Assyria. In Xerxes' army even the Arabs were mounted upon camels. The Hebrews had no horses until about the time of Solomon and after their acquaintance with the Syrians. The earliest human records of the horse are the Assyrian sculptures, where, curiously enough, the horseman is accompanied by an attendant who leads the horse, an attention which would be greatly scorned by his Cossack representative of to-day, as it would by any rider not the merest novice, showing that we have improved somewhat in horsemanship since the old Assyrian days.

The ass (***Equus hemionus*** **and** ***Equusasinus***). In eastern countries the ass has long been a favorite beast of burden, antedating the horse by many centuries. In our own country this animal has

[1] It will add to our appreciation of the horse if students will choose this topic for an occasional composition.

not been a favorite except in the form of the mule, which is half horse.[1]

Two distinct species of the truly wild ass are known, the Asiatic (*E. hemionus*) and the African (*E. asinus*). The former range over the more arid regions of Syria, Persia, Tibet, Mongolia, and western India, and the latter is indigenous to Abyssinia and the highlands of northeastern Africa generally.

It is from this latter stock that the common ass of Europe and America is descended, through the early Egyptian domestication. It is considered more than likely also, on account of their close resemblance, that the domesticated races of Asia trace to the same source rather than to the wild stock of their own country, at least so far as the historic regions of Palestine and the west are concerned, whose relations were from an early day much more intimate with the civilization of Egypt than with the wild and remote Asiatic regions inhabited by *E. hemionus*.

Upon the whole, it cannot be said that the ass has profited much by domestication. Fitted by nature to exist under hard conditions, man has made the most of his natural faculties in this direction, and he has generally suffered neglect and abuse above that of any animal that has ever been domesticated, unless it may be the Eskimo dog. Accordingly he is almost everywhere a dull, spiritless creature, poorly fed and ill conditioned generally, — a walking advertisement of a hard life.

All writers, however, both ancient and modern, agree as to the spirit, beauty, and fleetness of the wild ass, especially the African progenitor of the domesticated form. Bible history, too, teaches that the ass was not always regarded with the low esteem of the present day, but that in former times he was a general favorite in domestication as he was a common symbol among

[1] Strictly speaking, a "mule" is any hybrid or "cross" between distinct species. In common parlance, however, the term is limited to the offspring of the female horse and the male ass. The opposite or reciprocal cross between the female ass and the male horse is called the hinny. It does not differ materially from the mule, but is seldom seen because of the aversion to keeping the ass in numbers, as would be necessary to breed hinnies.

Hebrew writers for swiftness and spirit in the wild. It appears that he has suffered by comparison with the horse, of which he is instinctively regarded as a sort of poor relation. The Spanish people, however, have continued in their esteem of this useful animal, and it is to them that we owe the excellent quality of our modern stock, particularly as regards size, spirit, and finish.

It requires but the slightest contact with this peculiar relative of the horse to discover that anything like low spirits and inactivity are the result partly of poor feed and partly of an excessive suspicion of all new things and an exaggerated disposition not to run away like the horse, but to stop and investigate; indeed, curiosity is one of his principal faculties. As to intellect, he is easily underrated, for he is fully the equal of the horse, his stupidity being apparent and not real, like that of the ox.

The excessively long ears and large bone of the modern ass are the distinguishing features of the African stock, whereas the Asiatic has short ears, is lighter in limb, and so swift in action that it is said to be impossible for the hunter to run one of them down even with the best of mounts.

In connection with the domesticated horse and ass another group of closely related wild animals must be mentioned, the zebra (*Equus zebra*) and the quagga (*Equus quagga*). These strange horselike animals, in most respects nearer like the ass than the horse, exist in some three or four well-marked and more or less distinct races, all native to southern Africa.

The true zebra is smaller (twelve to thirteen hands)[1] than either the horse or the ass, lives in the highlands, and is covered on both body and legs with a beautifully complete system of black stripes on a background of dirty white.[2] The

[1] A "hand" is four inches, and is the universal unit for measuring the height of horses. This height is taken at the withers or shoulders, at what would be the highest point of the body when the animal is standing with his head down, as in grazing.

[2] Suggesting the reason for the ancient name "hippotigris,"—*hippo* (horse) and *tigris* (tiger),—a name similar in make-up to "camelopard" (camel leopard) for the giraffe.

quagga has shorter ears and wears more hair upon the tail than does the zebra. He is also somewhat heavier in the body and the stripes are less distinctly marked, fading out almost completely into a dirty white on the hinder and under parts of the body, except for a dark back stripe running from the withers to the setting on of the tail. The flesh of the quagga has

FIG. 39. The water buffalo of Asia and Africa. This is the only true buffalo, though the name is often applied to both the American and the European bison

long been esteemed by the Boers as food for servants, that is, natives.

In all of these types and races the zebra is timid in the wild and vicious in captivity. Accordingly he has never been domesticated or even fully tamed except to the extent seen in shows, and to the further extent that individuals are sometimes "in-spanned" with mules by the African farmers, thus making up a part of the team.

The ox. Our domesticated cattle are of two distinct species: *Bos taurus*, covering all European and American races and breeds; and *Bos indicus*, the smaller, lighter-limbed, and so-called sacred [1] or humped cattle of India, similar to the Galla cattle of Africa.

Both of these species have been so long domesticated and the countries they inhabit are so densely populated that it is impossible to identify the original wild stock of either. There is, however, no lack of material from which they might have sprung, for their wild relatives are numerous and our only difficulty is in assigning exact relationships.

These relationships, however, are more easily traced for the Indian cattle than for the European and American breeds, because the vast and largely inaccessible mountain wildernesses of the Himalayan foothills afford a secure retreat and harbor for a number of truly wild races of the cattle kind, almost any one of which might have been the true progenitor of *Bos indicus*.[2]

Perhaps the most notable of these, as it is the largest, is the gaur (*Bos gaurus*), a thoroughly wild and untamed animal inhabiting the hills and inaccessible highlands of India, extending as far eastward as Burma and the Malay Peninsula, where it is known as the sladong. This is a true wild ox of monstrous size, standing occasionally as high as eighteen hands, or six feet, in exceptional old males. His height is exaggerated by his exceedingly high withers, amounting to a hump, were it not that the elevation is prolonged into a ridge running well down the

[1] This is evidently another of the many erroneous but popular traditions. I am assured by the most reliable Hindus that these cattle are no more sacred than are any others; indeed, that they are not, all things considered, so highly esteemed as is the buffalo.

[2] These Hindu cattle are familiar to every boy that has attended the shows. They are smaller and more slender than our cattle, and their more suitable conformation and gentle disposition fit them so excellently for the road that they are freely used for purposes of travel in their own country. Ranging from a clear white to a dirty cream color, with their curious hump at the shoulders, they make a most striking appearance that would distinguish them from the common cattle of our own country, even to the most casual observer.

back. The color is brown, often tawny white. The horns are truly monstrous, being occasionally, according to good authority, as long as thirty-nine inches each, with a basal girth as high as nineteen inches. This animal is exceedingly wary, avoiding cultivated or open country of any kind, and, as has been said,

FIG. 40. The gaur, or great wild ox of the highlands of India

is never domesticated. He is a true wild ox in every particular, as large, undoubtedly, as the *Bos primigenus* of Europe ever was.

The gayal, sometimes called mithan, is a semidomesticated and near relative of the gaur, inhabiting the hilly lands of northeastern India. It is smaller than the gaur, and, being lower at the withers and higher at the hump, stands with his back nearly level. He runs wild in the more remote districts, and is to be regarded as an intermediate between the domesticated and the wild cattle of the Indian type.

The banteng, or native ox of Java, extending also well into the continent in the region of Burma, is a close relative of the gaur and the gayal, but nearer the common or domesticated form. It exists both domesticated and wild. All these species have a much better opportunity to linger indefinitely in their natural

FIG. 41. The yak, or wild ox of Tibet

state than had similar species in Europe, because of the immense stretches of hills and unbroken wilderness lying along the base and up the foothills of the Himalayan Mountains. Accordingly we are not surprised at being able to find here truly wild cattle.

Still higher up in the highlands of Tibet, fourteen to twenty thousand feet above the sea, is the yak (*Bos grunniens*), that hardiest of all the cattle kind, delighting in the wildest hardships of that most forbidding country. He is a true ox in all essential particulars, not very well endowed with vision but with the keenest scent. He can be domesticated and is employed as a beast of burden, but if unused for a little time, he becomes extremely wild and likely to escape on opportunity. In any event he steadily refuses to eat corn, confining himself to the hard and scanty grasses of his native plateaus.

Asia affords still one more relative of the cattle kind, though a little more distant than these just enumerated. This is the wild buffalo (*Bos bubulus*), the race to which the term "buffalo" properly belongs.[1] These curious animals are about the size of the largest of our common cattle, of a dun or mouse color, nearly destitute of hair, with long, flattened, and corrugated horns curving backward rather than forward, as in most of the cattle kind. The wild buffaloes are domesticated in both India and Burma, where they are highly esteemed for their milk, and where they are indispensable for labor in the rice fields and other lowlands[2] (see Fig. 39).

Their love for water is proverbial, and whether domesticated or wild the heat of the day will generally find them comfortably submerged in any accessible water, with only the nostrils sticking out. Nothing can restrain them from seeking this protection against heat and insects in the middle of the day, and if the farmer is slow in detaching the plow or wagon, it makes very little difference with the buffalo after he is fairly headed for the stream or the pool. The buffalo is wild on the plains of the Ganges, the Brahmaputra, and along the foot of the Himalayas, besides having become feral in the forests of Burma and other regions in southeastern Asia.

Besides these Asiatic species, closely related to our domestic cattle, we have the Galla ox, a humped race native to Africa and considered by Rütimeyer as closely related to the banteng of

[1] The term is popularly but erroneously applied to the American bison, which is structurally as far removed from the true buffalo as are our common cattle.

[2] These useful animals have also made their way as domesticated beasts of labor over considerable portions of Asia Minor, Egypt, and Italy, and may be seen in most of our shows and zoölogical gardens of this country and Europe.

Asia. Africa also possesses several distinct species of true buffalo, notably the cape buffalo of the south, — with horns much like those of the musk ox, — the Sierra Leone buffalo, and the small red or short-horned species of the western coast region.

In extinct forms of large size Africa is peculiarly rich. If accounts may be believed, the horn cores of one specimen from Algeria measured no less than eleven feet and another from the cape fourteen feet. As they would be considerably larger when covered with their horny sheath, the spread of the horns and the size of these animals must have been truly prodigious.

FIG. 42. Sir Donald, head of the largest herd of bisons in America
Canadian National Park, Banff, Alberta

It will be seen, therefore, that the domesticated cattle of both Asia and Africa have no lack of wild relatives both living and extinct, and the fact of their ultimate origin in the wild must be clear to the most casual student, — so clear that if the domesticated races should suddenly become extinct, they, or equally good successors, could be readily restored from the wild.

However this may be in the western continent, all closely related species were extinct in America, if, indeed, they ever existed, long before its discovery by the white man. The bison (*Bos americanus*), popularly but erroneously called the buffalo, a close relative of the European bison (*Bos bonassus*), was the only native wild animal of the cattle kind known to America. This noble animal literally abounded on the western plains and has practically become extinct within the memory of men still young; indeed the Union Pacific Railroad and its first contract with Buffalo Bill[1] practically sealed the death warrant of the finest wild animal on the western continent.

This animal would surely have been domesticated and made into a useful servant, had we not already possessed our common cattle, making it unnecessary to begin over again; just as we should have domesticated the prairie chicken except for the hen, and just as our forefathers did domesticate the wild turkey[2] of the New England woods.

The common cattle both of this country and Europe had an undoubted origin in one or more of the primitive races of the cattle kind that inhabited that country in the earliest times, descendants of which are now extinct, except as they have been preserved by accidental inclosure in the hunting parks of certain estates in England. In prehistoric ages the whole of Europe except Ireland was ranged over by an immense wild animal of the cattle kind, known to science as *B. primigenus*, or first ox.

Remains of this animal are found in brick clays and peat bogs in many places, from the skulls of which it is inferred that the spread of horns must have been at least four feet. Some of these skulls are pierced by flint arrowheads, showing that they were hunted probably for food as far back as the paleolithic or oldest stone age.

This animal or its immediate descendants persisted in the forests of Central Europe until comparatively recent times. It

[1] Colonel William F. Cody, a noted hunter and Indian scout, took the contract to supply the workmen with buffalo meat during the construction of this road. Thus the bison literally gave his life for the first transcontinental railroad. The great numbers killed under this contract (69 in one day and 4862 in one year) earned for Mr. Cody the name of Buffalo Bill, a name he will carry through life, and under which he organized and conducted his famous Wild West Show, exhibiting, as this is written, but a few miles away.

[2] See section on the turkey.

was hunted by Cæsar and his followers under the name of aurochs, or urus, as it was called by Charlemagne in the ninth century. (It was certainly encountered by the first crusaders and is known to have lingered in the neighborhood of Worms as late as the twelfth century.)

This was the great European wild ox, and it is from him that all our larger breeds of common cattle are universally supposed to have descended. Contemporaneous with him one or more smaller and more slender races[1] inhabited the same regions, especially toward the west. It is from these latter that the Jersey and its nearest relative, the Guernsey, are supposed to have descended, an assumption resting, of course, upon structural considerations rather than upon direct historic evidence.

A curious circumstance connects these ancient times with the living present. There are now in the hunting parks of several of the great estates of England herds of wild white cattle, notably those at Chillingham in southern Scotland and Chartley and Cadzow in northern England.

These herds are the direct descendants of the original wild cattle confined in these parks along with other game some eight or nine hundred years ago and perhaps longer; indeed, authentic mention is made of the Chillingham cattle in 1220, thus overlapping the known last days of the aurochs, with which they are supposed to be identical, though much reduced in size by reason of close confinement to the northern limits of their natural range.

All these so-called "park cattle" or "wild white cattle" are somewhat smaller than the larger breeds of domestic cattle of to-day. They are of a uniform dirty white color except the ears, muzzles, switch of the tail, and the lower portions of the legs, which range from brown to a brownish red. They are generally horned and in every way resemble common cattle except as to

[1] These are variously called *Bos longifrons*, *Bos frontosus*, etc., from the different specimens that have been found of these early "deerlike" forms of the cattle kind. It is significant that none of these cattle are found back of the later stone age.

size, color, and disposition, which is very wild. Their identity with the ancient aurochs is almost assured, leaving us to look with confidence upon these wild park cattle as the native stock out of which European and especially English breeds have been developed. As American breeds are almost exclusively derived

FIG. 43. Hood Farm Pogis 9 of 55552. A champion himself out of a champion sire and dam, and sire of a champion. Head of Hood Farm herd of Jerseys. Courtesy of C. I. Hood & Co.

from central and northern Europe, their lineage is fairly well established as running back to the aurochs, or *B. primigenus*, through the "park cattle"[1] of to-day.

An interesting confirmation of this assumption occurs frequently, especially among Devon cattle, which are known to have developed from the early native cattle of southern England.

[1] See "Wild White Cattle of Great Britain," by Storer, for a most fascinating account of these interesting remains of earlier days, that would have afforded richer relics had Europe possessed the inaccessible highlands of southern Asia as natural and safe retreats for these wild animals of the cattle kind.

These cattle are ordinarily solid red in color, but in rare instances a calf is dropped that is solid *white* except its ears and muzzle, which are invariably red or brown, closely resembling the modern wild white cattle of the parks.[1]

The sheep (***Ovis aries***). Here again domestication took place so long ago that its history is lost, and no man can say what were the precise species that furnished the foundation for our domesticated forms. Certain it is that wild animals of the sheep kind are and have been common on the earth in nearly all mountain regions of proper latitude.

FIG. 44. The Dorset, an English horned breed, nearer the bighorn than any other domesticated breed

There is no grander specimen of the wild sheep in all the earth than the bighorn of the Rocky Mountains, *Ovis canadensis*. Standing three and a half feet high at the withers (full-grown males), with strong, well-knit legs supporting a muscular body covered with a dense coat of light brown hair fading to a dirty white beneath, carrying throughout a dense coat of "shining white underwool," this animal as a whole is a striking specimen, even without reference to the head, which is, after all, the distinguishing feature of the bighorn.

This head is composed of a massive skull supporting a pair of truly immense horns, sweeping upward and backward, then

[1] This is "reversion," or resemblance to a remote ancestor rather than to the true parent, about which more was said in earlier chapters. The same thing happens in nearly all breeds, and it is so common that a visit to large stockyards like those of Chicago rarely fails to find at least one specimen of this kind. Riding past a freight train standing on a siding, not long since, I saw in bold relief among the cattle on one of the cars the characteristic dirty white face, upturned slanting horns, and red ears of the Chillingham cattle. It was an accidental product of an Illinois herd on his way to market, — mute witness of a history that is passing fast and must soon be read only in the books.

forward and outward in a graceful spiral curve not displayed by any other animal known to the wild. These horns have been known to measure thirty-three, and in rare cases forty, inches when measured along the curve, and with a girth at the skull of no less than fifteen or sixteen inches.

These magnificent animals choose their range far up the most inaccessible mountain ledges, and, when surprised, have the most marvelous ability both to clamber and to leap. They readily leap thirty or forty feet, striking safely on the feet,[1] and a drop down precipices of one hundred to one hundred and fifty feet is said to be well within their ability.

This true wild sheep ranges from the mountains of Mexico to those of Alaska. Its flesh is said to equal the best venison, and it would undoubtedly have yielded to domestication if we had not already been well supplied with sheep when the country was discovered.

On the Asiatic side the Kamchatkan wild sheep (*Ovis nivicola*) closely resembles the bighorn except that he is lighter in body and limb and finer in head and horn. As with him, both sexes are horned. Off to the southwest in northern Mongolia is the closely related argali (*Ovis ammon*), and further on in the highlands of Tibet is a slightly different species, *Ovis hodgsoni*. Still further to the southwest in eastern Turkestan, and at an elevation of ten to twelve thousand feet, is the wild Pamir sheep (*Ovis poli*), the only rival of the bighorn. This fellow can boast a horn measuring as much as sixty inches, but without the magnificent curve of the bighorn, as it stands out somewhat at the side, that is, has a greater spread. The mountain regions of southern Asia are well supplied with sheeplike animals, too numerous in their species even to be enumerated here.

Off to the west we have the Armenian sheep (*Ovis gmelini*), in the islands of the Mediterranean the Cyprian (*Ovis ophion*), and further west, in Corsica and Sardinia, the Mouflon (*Ovis

[1] It is asserted, but upon questionable authority, that a favorite habit of the bighorn when he doubts his legs is to light upon his head.

musimon). These are all horned sheep from which such a breed as the Merino might have descended with no more change than is often effected in domestication.

From these wild types the species shade off into the blue sheep of Tibet and the Barbary sheep, with its wealth of long hair on its throat and legs, and its horselike tail, but standing between the sheep and the goat, as the musk ox stands between

FIG. 45. Domestication complete. A wild mountain animal brought to the lowlands and ready to follow the call of man

the cattle and the sheep. From here on are a sheer multitude of more or less distantly related species, — goats, ibex, markhor, tahr, nilgiri, goral, serow, chamois, eland, kudu, antelope, nylghau, gemsbok, gazelle, springbok, puku, klipspringer, llama, alpaca, and scores of others down to the gnu, or wild beast with the horn of a musk ox, the head and mane of a bison, the tail of a horse, and body and legs midway between the horse and the cow.

It cannot fail to occur to the reader that the wild and inaccessible mountain regions and high plateaus of central and southern Asia have afforded a unique retreat for multitudes of the wild relatives of the larger of our domestic animals,[1] and that to a similar but less extent the mountain regions of Africa and of western America, both to the north and the south, have served the same significant purpose.

The domestic sheep are, roughly speaking, of four distinct classes: first, the horned varieties like the Merino and the Dorset, resembling most closely the nearest wild relatives; second, the common hornless and coarse-wooled breeds of England and America, such as the Shropshire, Lincoln, Cotswold, Leicester, and Southdown; third, the so-called fat-tailed sheep of southwestern Asia and northeastern Africa, in some strains of which the tail often reaches a weight of forty or fifty pounds and drags upon the ground, while in others, with shorter tails, the enormous amount of fat occurs in the rump;[2] fourth, a minor strain belonging to Iceland and remarkable for the fact that, like the Cyprian wild sheep, its horns are not limited to two, but, according to Youatt, may be three or any other number, odd or even, up to as many as eight.

It must be clear to the student that there is no dearth of evidence in nature for the domestication of sheep, and that, even yet, should all our common breeds be lost, they could be substantially restored from new material out of the truly wild. The greatest change made in domestication would seem to have

[1] It is difficult to realize that this "roof of the world" — this high and broken interior with its forbidding mountainous southern wall, in most places almost uninhabitable by man and hence practically given over to the wild — is not a small area, but rather a region of vast extent, not less than two thousand miles across. When this is fully realized it will not seem so strange that almost everything traces to a wild counterpart in "central Asia." It is the great leftover and uncivilized part of the world.

[2] This fat is exceedingly soft, more like marrow than tallow, and is often spread directly on bread and eaten as butter. It is the skins of the young lambs of these sheep that constitute the astrakhan of commerce, and it is their intestines from which the Germans make the so-called catgut for the violin and other small stringed instruments.

been in the length of staple and fineness in fiber of the wool, and probably in the accumulation of fat, for no wild sheep is known that has the fat-secreting habit of the fat-tailed breeds; indeed, most of the wild species are extremely short-tailed.

The goat. This near relative of the sheep has been domesticated from the earliest times, and his wild relatives are yet abundant in many parts of the world, particularly from the Pyrenees of Spain eastward to the great central plateau of Asia. The Angora, which is native to Asia Minor and is noted for its beautiful fleece; the Kashmir of Bokhara and Tibet, which is the source of the famous cashmere shawls; the Syrian goat of southwestern Asia; the Sudan goat of northern Africa; and the Egyptian goat of Egypt, from the lower Nile to its native hills in Nubia, — these are the principal races of interest from the standpoint of usefulness and domestication.

The pig. As with the sheep so with the pig; almost every region of the earth has its native species, no less than a score of which are well known and fully described by naturalists.

The peccary is the wild pig of Central and South America, though he is one of the farthest removed of the wild relatives in having not the simple stomach of the true pig but a complex digestive apparatus something like the ruminants. The common pig certainly does not trace directly to the peccary, which, however, would have afforded material suitable for domestication had it not been rendered unnecessary by the better forms already in our possession.

The great wild ancestor of our common pig exists in two well-marked species, the European wild boar (*Sus scrofa*) and the Indian wild boar (*Sus cristatus*).

The European species originally ranged over all Europe, northern Africa, and central and western Asia as far even as Mesopotamia and Beluchistan. It is now extinct in most of its former stamping grounds, but yet lingers in some of the forests of Germany where the boar hunt is a favorite form of amusement. The blood of this species has been freely employed in the development of the larger English breeds, such as the Yorkshire, the Tamworth, and the Berkshire, the latter so largely represented in that truly American breed, the Poland China.

The Indian wild boar is closely related and very similar to the European. He runs a little larger, standing often as high as forty inches at the shoulders. Like his European cousin he is a dangerous enemy and does not hesitate, when pursued, to attack whatever appears, — men, horses, elephants, or even tigers. Boar hunting, as it is called in Europe, and "pig sticking," as the term goes in India, are therefore counted specially fine sports for the hunter.

Both these species inhabit the forests of the lower lands and both cover extensive stretches of country. Their food is varied, ranging from grass roots and worms, which they dig from the ground with their serviceable rooters, to small animals, especially snakes, against which they seem to hold a special grudge, and which they are peculiarly skillful in killing by jumping and lighting with all four feet on the tail, ripping up the creature into "shoe strings" with their enormous tusks, which are the prolonged incisor teeth.

Besides the Indian wild boar southeastern Asia affords a large number of closely related but smaller races. There are no less than a half dozen of these well-marked species in the Malay Peninsula alone, besides the curious little pigmy hog (*Sus salvanius*) of the Himalayan foothills, standing only ten or eleven inches at the shoulders. Still again there is the masked pig of Japan, with its heavy folds of skin about the face and its immense drooping ears.

From some or several of these Asiatic species domesticated races were doubtless developed long ago. Certain it is that domesticated pigs were known in China before they were in Europe, and that much of the blood of modern domestic swine came originally from this stock, and would be traceable, if we knew the history, to some of these native races or their extinct relatives, of which there are many, ranging from a giant form about the size of a common mule down to one not much larger than the modern pigmy hog of India. Evidently the hog tribe has been a long time with us and has seen, as it is now seeing, exceedingly prosperous days.

Besides these already mentioned, Asia affords another notable species, the babiroussa, a little further removed from the true pig, as he has a pair of tusks rising from his nose and midway between his snout and his eyes. He is, however, essentially a wild pig, and in his natural habitat, the lowlands of Celebes, he is found both wild and domesticated.

Africa affords a goodly number of wild relatives, notably the gray bush pig (*Sus africanus*) of the south-central regions and the little red bush pig or river hog (*Sus porcus*) of the western lowlands. Aside from these true pigs there are several species of the so-called wart hogs, ugly specimens with immense heads and broad noses crowned with vicious tusks, deriving their name from three hornlike "warts" that develop on the side of the face just below the eyes.

Altogether the pig is not at all wanting in relatives of the woods, even without going to the more remote connections such as the rhinoceros, the hippopotamus, or the elephant. Of all our domesticated animals none are more readily traced to the wild and none more quickly or more thoroughly revert to the feral state. The pig in domestication is generally quiet and harmless, but he is capable of a good fight, and in the semiwild state a drove of hogs is an enemy more dangerous than most wild animals.

Quite contrary to popular opinion, the pig is among the cleanest of our domestic animals. Like the buffalo he seeks the water, or mud in absence of water, as a protection against the heat of the sun. Having no sweat glands, he gets no relief by evaporation from his own body, and his resort to the cooling effects of water is not only natural but necessary.

The cat (***Felis catus***). Here again domestication is lost in antiquity, but the origin is not difficult to trace. Wild catlike animals are common in the world, and nowhere more common than in North America, where the wild cat and lynx inhabited the primeval forests in more or less abundance. Indeed, the domestic cat possesses a wide range of wild congeners the world over, beginning with the tiger and the lion and shading off, through the jaguar, the leopard, and the puma, to its nearer relatives, the marbled cat (*Felis marmorata*) of the eastern Himalayas and Burma; the golden cat (*Felis temmineki*) of northern India, Tibet, and the Malay Peninsula; the fishing cat (*Felis viverrina*) of India; the spotted leopard cat (*Felis bengalensis*), and a great number and variety of similar species be-

FIG. 46. The European and the American wild cats respectively. Clearly our domesticated cat is more closely related to the former

longing to the same general region. Besides these there are the yellowish-gray Caffre or Egyptian cat (*Felis caffra*)[1], from which the European species, which he greatly resembles, has doubtless sprung; the common wild cat (*Felis catus*), which has inhabited England since the days of the mammoth, and at one time covered all Europe except the southern portion; the pampas cat of South America, the jungle cat of India, and so on into the lynxes, the hunting leopard, and other more distant relatives.

All wild animals of the cat kind are universally hated by hunters because of their stealth and innate savagery, for, whether tiger or leopard, panther, puma, jaguar, lynx, or wild cat, they

[1] Also called *Felis caligata* and *Felis maniculata*.

are the most terrible of all wild animals. It is also an open question if the domestic cat has not lost his usefulness long ago, if, indeed, he ever had any. He never was but half-domesticated at best, and while he is a universal favorite with children because of his furry coat and look of seeming intelligence, he is yet essentially a wild animal, almost incapable of true domestication. He has lost little of his innate savagery, and as a relentless foe of birds he has really become an enemy to our civilization. The sooner he could become extinct the better for our song birds on which we depend so much not only for our pleasure but for protection against the depredations of insects. The true nature of the cat should be more commonly understood in this respect, as well as its proclivity to throat diseases common to children. We can well afford to do without the cat.

Domesticated Birds

The domestication of birds[1] was a great achievement, whether viewed from the standpoint of its inherent difficulty, the quality and cheapness of their meat and eggs, or the utility of their feathers. All told, the domesticated birds cover many species, with scores of wild relatives in all parts of the world. Most of them being, in the wild state, good flyers, their distribution is much wider than is that of species more closely confined to locomotion on the ground.

Fig. 47. A trio of prize-winning barred Plymouth Rocks, property of Bradley Bros., Lee, Massachusetts

The hen. Of all the birds domesticated none is more valuable than the chicken (*Gallus domesticus*), whose undoubted progenitor, *Gallus bankivus*, can yet be heard cackling in the forests of Farther India; all of

[1] See Darwin's "Animals and Plants under Domestication," Vol. I, p. 236.

which suggests the fact that, as in many similar cases, we owe a lasting debt of gratitude to the ancient people of that far-off country for thus bringing into our service one of the most wary of all the wild birds, and making of it one of the most valuable of the domesticated races.

Its nearest relatives are the pheasants, and many exceedingly closely related species are found wild in widely scattered regions of the East, their favorite haunts being the forests of Farther India. The prairie chicken of the West, though a true grouse, is, to all intents and purposes, the American equivalent of this Asiatic product, and, had it been necessary, would have afforded material for a valuable domestic bird.

The goose. The wild goose yet lingers in many parts of the world, notably the gray lag goose (*Anser cinereus*), nesting in the northern British Islands, — the probable parent of the domesticated goose. Its American equivalent is represented by no less than three well-defined species, the snow goose of the far north (*Anser hyperboreus*), the smaller Ross's goose of the northwest and the blue-winged goose (*Anser cærulescens*), whose feeding and breeding places are along the great lakes of northern United States and Canada. Besides these there are many closely related species; indeed, they breed everywhere in the subarctic regions.

Here, again, it was a foreign strain that furnished the material for domestication, because the goose is an old-time favorite; indeed, it is probable that he has already passed his period of greatness among us. He has always been prized for his feathers, but cannot be regarded as the equal of either the chicken, the turkey, or even the duck as a table delicacy.

The duck. Here again the wild form is common, indeed so common as to be a favorite game bird. Of the numerous species the beautiful mallard (*Anas boscas*) is the typical game duck and is regarded as the parent and progenitor of the domesticated form. This species is said to inhabit the whole of the western hemisphere, wherever suitable feeding grounds can be found between the arctic circle and the tropics. He is a truly cosmopolitan bird, and it is not strange that many varieties and subspecies should have developed as the result of his widespread range and varied environment. Domestication of the duck is easy and has undoubtedly been accomplished many times. More than one hen has hatched a brood of wild duck's eggs, after which a timely clipping of the wings insured a flock of tame ducks.

The turkey. Here at last we come to a truly American bird, more fitting by far than the eagle to stand as the emblem of America.

When our Puritan ancestors landed on the forbidding shores of New England, they found the woods alive with a strange wild bird, wary and fleet both of foot and wing, but most excellent eating and easily tamed.

This native of the New World not only helped out in the "terrible winters," when food was scarce with the colonists, but he remained in domestication to grace the tables of comfort, and to-day the Thanksgiving turkey is everywhere the symbol of plenty.

Of the four contributions of the New World to domesticated species, namely corn, tobacco, the potato, and the turkey, the latter is the only animal, and he clearly outranks any other food bird that has ever been domesticated. Of this contribution to our civilization America may well be proud, especially as no similar species has ever been discovered elsewhere on earth, save only the related brush turkey of Australia and the outlying islands.

The American turkey exists wild in no less than three distinct species: *Meleagris americana*, the parent of the black turkey of the eastern United States; *Meleagris gallopavo*, of northern Mexico, parent of the bronze strains; and the beautiful *Meleagris ocellata* of Guatemala, Yucatan, and British Honduras, described as radiant, with its "greenish-blue eyespot shot with purple, while the metallic parts of the body feathers are golden or bronze green and the naked head and neck blue, covered with red warts."

The peacock. History shows this bird to have been an ancient table favorite in the Far East, but he has passed his period of favor and is now relegated to a back-yard ornament, if, indeed, he rises much above the level of a curiosity.

The peafowl, which is really one of the most gorgeous of pheasants, still dwells in the wild state in northern India and southeastern Asia, the most common species of India, *Pavo cristatus*, being closest to the domesticated race. Among his nearest relatives, structurally as well as geographically, are the peacock pheasants of the Malay Peninsula, extending even to the island of Borneo. The beautiful Argus pheasant has the eyespots in the wing rather than the tail, as in the true pheasant, and accordingly it is the wing that is displayed.

The swan. This bird, too, was anciently used for food, but is now seen only as an ornament in public and private lakes and ponds. The original abounds in nearly all the northern waters of the world, and ranges from pure white to solid black.

The guinea fowl. This noisy little hen is hardly worthy of being ranked as a domesticated fowl. The guinea is really an African pheasant, of which several distinct and widely different species are found wild along the western coast, from Liberia southward. It is rarely kept in numbers, but a few are often found with other poultry, "to scare off the hawks."

Additional Races and Semidomestication

Besides these animals with which we are best acquainted other species have been wholly or partially domesticated, either by ourselves or by other people, either in our own or other countries.

As the buffalo replaces our common cattle for labor in certain humid regions, so the elephant is extensively employed wherever he is found native, as in Asia and Africa. The camel is, and always will be, the ship of the desert.

The llama and the alpaca of the Andean plateau — the one to bear burdens, the other for its fleece — are both well known and only half-domesticated, as are the reindeer of the arctic regions and the ostrich of the desert.

A few strange cases of semidomestication can be mentioned, such as the cheetah, or hunting leopard, the falcon, or hunting hawk, and the quite general utilization of certain breeds of snakes in the tropics to rid the houses of vermin. To this can be added the fact that we occasionally employ the weasel to hunt out and destroy rats, as the Romans used the marten in place of the cat to hunt mice.

Besides these might be mentioned a small multitude of pets, representing nearly all species of wild animals, almost any of which may be tamed if taken when young, and most of which have been so treated not once but many times since their contact with the human race.

And so the list might be extended almost indefinitely, were the space available, to show fully how man has put to his own uses the wild animals of forest, lake, and plain during his long history on earth and his determined campaign to enslave them and bring them, so far as possible, into his service.

Unwelcome domestication. Certain species have volunteered to infest the habitations of man, attracted mostly by a liberal food supply. Among these would be mentioned the rat and the mouse, which are world-wide, both as house and as wild species. The house fly is another pest that, together with the rat and the mouse, is coming to be recognized not only as a common nuisance, but also as a fruitful carrier of infectious diseases.

Besides these, a great variety of insect pests especially haunt the habitations of man because there they find abundant food supply and favorable conditions of life generally.

Exercises. 1. Extend the study of particular species and follow out the wild connections, relatives, habitat, and habits further than in the text, employing for this purpose the facts of zoölogy and all the information available in histories, encyclopedias, and books of travel.

2. Secure information about the uses to which the less-known domesticated animals are put, using again all available sources of information.

3. Write compositions showing the extent to which any particular species, as the horse or the sheep, has been helpful in the advancement of our civilization, and how we should have been hampered had we been obliged to get on without him.

4. Write an account of your personal experience in taming some wild animal for a pet.

5. Write an account of your personal experience in training some young domestic animal as a pet or for work.

6. Point out in domestic animals some habit or trait that it has brought down from the wild, such as the pawing of snow by horses and sheep to get at the grass beneath.

References. 1. "Animals and Plants under Domestication" (Vol. I, chaps. i–viii, inclusive). Darwin.

2. "The Breeds of Domestic Animals." Plumb.

CHAPTER XVIII

ORIGIN OF CULTIVATED GRAINS AND GRASSES[1]

Cultivated plants, like domesticated animals, originated in the wild · The grasses · Wheat · Barley · Indian corn · Oats · Rye · Rice · Sorghum · Sugar cane · Millet · Buckwheat · Timothy · Blue grass · Redtop · Orchard grass · The Festucas · Miscellaneous grasses

Cultivated plants, like domesticated animals, originated in the wild. The succeeding chapter will show briefly how it was that the choicest plants, like the most useful animals, came to be appropriated by man, — taken out of their wild surroundings and more or less completely domesticated. The present chapter will deal with a few of the more important of the cultivated plants, some of which are not yet fully domesticated.

By far the most useful of all plants is the so-called grass family, used for grain, forage, and pasture. Botanically the grasses are distinguished by narrow, parallel-veined leaves on a jointed hollow stem bearing seeds on a more or less compact spike at the top, like timothy and wheat, or, occasionally, at one of the joints midway up the stem, as in Indian corn. These plants are valuable, first, for their seeds, which are numerous and large and distinguished for their starch content, and sometimes, as in corn, for their oil. They are also valuable for forage because the immature stem and leaf when cured are eaten greedily by nearly all domesticated animals.[2] Besides this, many of the smaller species, like blue grass and the so-called buffalo grasses

[1] See Darwin's "Animals and Plants under Domestication," Vol. I, chaps. ix, x, and "Origin of Cultivated Plants," by Alphonse de Candolle, for additional information about cultivated species. The latter volume has been freely drawn upon for material in the present chapter.

[2] Contrary to common belief, the pig likes hay, but he vastly prefers clover or alfalfa to timothy or any of the grasses. See under Leguminous Plants.

of the prairie, are excellent pasture; indeed, most pastures, cultivated or native, consist largely of true grasses with a more or less slight admixture of legumes.

Many of the true grasses are entirely unsuited to the uses of man. The seeds are too few or too small for grain, or the stems too coarse, too harsh, or too small for either hay or pasture. Of course such species have never been domesticated; indeed, but a small proportion are suited to our use, as we fully realize when we remember that the grass family numbers more species than any other known to botany.

Wheat. This widespread species is the greatest single food for man, and was, without doubt, one of the very first plants to be brought out of the wild and cultivated, as it certainly has been from the greatest antiquity. A small-grained variety has been discovered among the remains of the lake dwellers of Switzerland, dating from the early stone age of Europe — contemporaneous certainly with the Trojan War about 1200 B.C., and perhaps much earlier. The same kind of grain has been found in the pyramids of Egypt, dating back more than three thousand years before Christ, and the Chinese are known to have cultivated this "gift direct from Heaven" fully as early as 2700 B.C.

Names for wheat are various and widespread in many languages, showing again, and on philological grounds, that its cultivation dates from antiquity. The Egyptians called it *br;* the Hebrews, *chittah;* the Chinese, *mai;* in Sanskrit it was *sumana* and *godhuma;* and in Basque, *okhaya*.[1] All this was so long ago that it is now impossible to trace our wheat back to its original wild form. Though it covers nearly all the cultivated lands of the world and exists in many varieties both red and white, bearded and plain, there is growing nowhere on earth any known plant sufficiently near to wheat to be regarded with certainty as the original. Wheat exists now in four well-marked species:

[1] "Origin of Cultivated Plants," p. 356.

1. *Triticum vulgare*, the common wheat as we know it, both bearded and plain, red and white, winter and spring, a type that is very ancient.

2. *Triticum turgidum*, or *Triticum compositum* as it is sometimes called,—a branching-headed race passing by the common names of Egyptian wheat, wheat of miracle, or wheat of abundance; not of great antiquity, because old remains are not found and no name exists for it in either Sanskrit, Indian, or Persian.

3. *Triticum durum*, or hard wheat, growing plentifully in southern Europe under many names, none of which trace to ancient origin, nor are its remains discovered in antiquity, leaving the inference that it was derived from the common wheat, *T. vulgare*, and at a not distant date.

4. *Triticum polonicum*, or Polish wheat, cultivated in the east of Europe. Its original German name is *gümmer*, and its other names are individual or local, not connected with antiquity.

None of these races is known to grow wild anywhere on earth; indeed, they would not thrive as feral races, for wheat cannot long maintain itself against weeds and the more vigorous wild competitors.[1]

Besides the true wheats there are three closely related species that may well engage our attention in this connection. These are the common spelt (*Triticum spelta*), the one-grained wheat (*Triticum monococcum*), and the two-grained or starch wheat (*Triticum dicoccum*), the "emmer" of our own day.

The spelts stand to wheat much as the so-called husk corn does to common maize; that is, each kernel is enveloped in a tight-fitting husk or chaff of its own, like oats or rice. All these species were cultivated by the lake dwellers of Switzerland, and common names for these wheatlike grains abound, but they all trace to southern European or western Asiatic sources.

None of these species is positively known to be growing wild, although different observers have asserted the finding of each.

[1] This has been tried at Rothamsted, and a wheat field left to itself was soon entirely overrun by weeds.

The one most frequently claimed as a wildling is the monococcum, but this is best fitted of all the wheats to maintain itself in the wild state, as it thrives in the most forbidding land.

There is much reason also to consider this one-grained species as the most primitive of all the races, and the one that is probably nearest the original wild plants from which our wheats have been developed by countless generations of cultivation.

Some authorities are inclined to consider the spelts as having been derived from the true wheats by breeding, but that is hardly likely. The common facts of evolution, as we know them, now indicate that it is easier for a species to change by the loss of a character than by the acquisition of a new part.[1] This accords, too, with the well-known fact that the so-called husk corn, when planted, will give a considerable proportion of corn with naked kernels.[2]

While true wheat is nowhere growing wild, we may confidently regard the spelts, especially *T. monococcum*, as representing a primitive stock, lost so far as botanists go, or else unrecognizable because of great change in either the domesticated or the wild species or in both. Facts both botanical and philological, however, point to southeastern Europe and western Asia as the general region in which wheat was developed, some authorities confidently regarding Mesopotamia as the undoubted original home.

In the midst of all this doubt three facts are clear: first, wheat as we know it does not grow wild; second, it has been cultivated in substantially its present form for at least five or six thousand years, and probably in some form from the remotest antiquity; third, it does not readily maintain itself in the wild, so that it has either changed greatly or else its wild progenitor has been greatly altered or never did exist outside some remote and restricted area.

[1] See chapter on Mutation.

[2] Candolle mentions that one sowing gave 225 ears of husk corn and 105 of the common form ("Origin of Cultivated Plants," p. 394).

Totally aside from all this, however, the student should understand that there are still growing wild a number of closely allied species belonging to the same genus of heavy-grained, wheatlike plants. One of the most conspicuous of these is the common quack grass, *Triticum repens*, which maintains itself by its running rootstock, independent of its seeding, and is therefore a troublesome weed; another is the awned wheat grass, *Triticum caninum*, which is, along with several other species, indigenous to northern latitudes. It will be seen, therefore, that taking the world over there is no dearth of relatives of the wheat kind, not only in cultivation but also in the wild, nor should we expect at this date to find anywhere in nature species identical with strains that have been cultivated and selected for more than a hundred generations of man.

Barley. This, too, is one of the most ancient of cultivated plants, coming down to our own day in three distant races, recognized as species by the botanists: viz. the two-rowed, *Hordeum distichon;* the common or four-rowed, *Hordeum vulgare;* and the six-rowed, *Hordeum hexastichon*, the most commonly cultivated in antiquity.

The two-rowed barley has been found wild in western Asia "from the Red Sea to the Caucasus and the Caspian,"[1] though whether feral or truly aboriginal cannot of course be told. This barley has not been found in Egyptian monuments, but has been found among the remains of the lake dwellers of Switzerland before their use of metals, though the six-rowed variety seems to have been more commonly cultivated then.

The common four-rowed barley is said to have been seen growing wild in Mesopotamia, but it has been found neither in Egyptian monuments nor in the lake dwellings.

On the other hand, the six-rowed barley was well known among the ancients, being abundant in the lake dwellings of the early stone age and in the earliest Egyptian monuments, as well as in Italy during its bronze age. It is not known in the wild state.

[1] "Origin of Cultivated Plants," p. 368.

From all the facts Candolle draws this interesting inference:

"1. That the barleys with four and six rows were derived from *H. distichon*, — the two-rowed sort, in prehistoric agriculture anterior to that of the ancient Egyptians who built the monuments.

"2. That barleys with six and four ranks were species formerly wild, extinct since the historical epoch."[1]

Indian corn (*Zea mays*). This plant is often and most properly called maize in written descriptions, because the word "corn" is a general term for grain food. Thus "corn" in Bible times undoubtedly meant wheat, as it does in England to-day, or, at most, it might have included barley, which, as we now know, was a common grain among the Egyptians. With us, however, the term "corn" is unalterably associated with the maize plant, and we shall continue to follow the example of the New World and apply this term to our most important grain crop.

By any count, all things considered, Indian corn is the most important grain plant of the world, especially as food for domestic animals. It has never been a favorite for the white man, partly because it is inferior to wheat and partly because it is so much used for animals.[2]

This is the only one of our grain plants that did not come to us from the Old World. Like tobacco, potatoes, and the turkey, it is truly an American product. When the Spaniards discovered South America they found the Aztecs raising this crop freely, and when our forefathers landed in New England the Indians brought them corn to ward off starvation.

The mystery of it all is, where they got it, for nowhere on the continent or in the world is any wild plant found growing that might by any stretch of the imagination be called the

[1] "Origin of Cultivated Plants," p. 370.

[2] It seems to be a general principle that man will not freely eat the same food that he gives his animals. We look upon corn as cattle and pig food, and, while not unfit for human diet, yet it is not and will never become a favorite. We have imported the cowpea from Asia, where it is used for human food, but we feed it to cattle and do not think of eating it ourselves.

progenitor of Indian corn. All this strongly suggests that the Indians themselves procured it from some former race like the mound builders, which may not have been older than the races from which the Aztecs developed. In any event the origin of Indian corn is as much of a mystery as that of wheat, except that we know precisely when and where it came into the hands of the white man.[1]

This crop was the chief reliance of the Iroquois, or Six Nations, of western New York. The squaws raised large crops of it, which were stored in stockaded villages for protection against thieves,[2] and while the braves defended the stores and exterminated their enemies, the squaws cleared more land and raised more corn and apples.[3]

There are many evidences that corn is a comparatively new species on the earth. One is the large number of giant grasses found in the American tropics, many of which suggest a resemblance to maize, while others are clearly connected with broom corn, which is a close relative. The other evidence of its newness is its extreme variability not only in size but in the shape, location, and character of the grain.

[1] The Aztecs and Toltecs of Mexico and the Incas of Peru are not so very old as we measure antiquity. They were in the bronze age of their development at the time of the discovery of this continent by Europeans, as the North American Indians were in the stone age; but archeologists do not regard their remains as running much, if any, back of the time of Christ, though what civilization might have antedated them we have no means of knowing, except that they left nothing behind that will compare in age with the lake dwellers of Switzerland, the pyramid builders of Egypt, or the brickmakers of Babylon.

[2] To protect this store of food fierce wars were waged with their neighbors, and as offensive measures are always better than defensive, it became the custom to send out each summer one or more parties of young braves to wage wars of extermination on surrounding tribes. Nothing could stand against this alliance of the Six Nations and their methods, and they made themselves felt throughout all of eastern Canada, as far west as Illinois and as far south as the Carolinas. It was the beginning of what would undoubtedly in time have developed an Indian civilization if it had not been interrupted by the coming of the white man. In this way a cultivated crop is the beginning of civilization.

[3] The farming of the Iroquois was not limited to corn. Remains of the old Indian orchards may still be traced in the region of the lakes of western New York.

The kernel is generally borne upon an "ear" emerging from a joint about halfway up the stalk, and the pollen is ripened on a "tassel" at the top; that is to say, the female flowers are in one place and the male are in another.

In a few cases, however, stray kernels will be found on the tassel (see Fig. 19), showing the presence of female flowers at the top; and more rarely will a short tassel be found on the end of the ear, suggesting that the plant has but recently developed from a branching stem bearing, like timothy, both male and female flowers at the extremities. Of course pollen would fall most successfully on the lower flowers, and it is easy to see how, in time, a plant might develop like corn, with nearly all the lower flowers female and nearly all the upper ones male.

The grain is also exceedingly variable, ranging from the rough kernel of the "dent" to the smooth kernel of the "flint," and from the common starchy field corn to the shriveled sweet corn and the little pop corn of our gardens.

Another evidence of the newness of corn is its prompt and complete response to selection in almost any desired direction. In this way the color may be changed as well as the size of the plant, the number and height of the ears upon the stalk, or the width and shape of the leaves. Altogether it is an exceedingly valuable and unusually interesting plant, and we owe our Indian predecessors much gratitude for its preservation and transmission to us.

Corn is not a plant well calculated to maintain itself in difficult surroundings or under a very wide variety of hard conditions, so that, all things considered, it is not strange that this plant is not found widely disseminated in the wild.

First of all, it needs almost ideal conditions for its successful growth, and is easily killed out entirely. Again, the grain separates with difficulty from the cob. It has neither wings for flight nor means of burial in the ground, neither can it attach itself to the hair or fur of animals for distribution. Moreover, it easily rots in the same climatic conditions that are best adapted to its growth.

All things considered, it seems to be one of those plants that developed in a small area affording peculiarly favorable conditions, and, it is altogether probable, was never widely disseminated in the wild. It could not have been known at all in the ancient eastern world, or it would certainly have been cultivated, even though the people of those times depended far less upon grain and more upon pasture for maintaining their animals than we do, and though corn could never make its way for human food where wheat could be grown.

Oats. Two species of this grain are involved in the discussion, the common oat (*Avena sativa*) and the side oat (*Avena orientalis*), in which the grains are all upon one side of the head. This grain can by no means boast the antiquity of wheat and barley. It was grown by the ancient Greeks under the name of bromus, and by the Latins as avena. It has been found in the later lake dwellings of Switzerland (not very old), but it does not seem to have been grown by either the ancient Egyptians or the Hebrews.

No other cultivated grain can so well maintain itself in the uncultivated state, and for this reason oats have been found growing wild in many separated regions of the world, but there is little or no evidence that it is aboriginal in these places.

Besides these cultivated races, however, there are a number of closely related wild species which interest us, because it is possible that from such as these oats were originally had. In America we have both *Avena striata* and *Avena smithii*, both distinctly oatlike wild perennials. The Gartner brothers of England, who are among the greatest improvers of the oat, have imported a "wild oat" from eastern Asia, which is sufficiently close to the common oat to cross with it and to afford foundation for selection and ultimate improvement.

Rye (*Secale cereale*). Here at last we have a comparatively new grain among us. Candolle says that it is not found in Egyptian remains nor in those of the lake dwellers, that no name for it exists in either the Semitic, Sanskrit, or Chinese languages, and that the ancient Greeks did not know it.

As has been indicated, this is a plant that easily maintains itself in the wild condition. That wild rye has been many times discovered does not admit of a doubt, but, from the fact just stated, this would not be conclusive evidence of its aboriginal state.

However this may be, according to the best authorities there are no less than five or six closely related species growing wild in western Asia and southeastern Europe, particularly in the neighborhood of the Black and Caspian seas, leaving no doubt of the identity of its wild relatives and of the approximate region of its early cultivation.

Rice (***Oryza sativa***). At last we have a grain of ancient and honorable standing that still exists truly in the wild state, where it flourishes in the marshes of Cochin China. Being an aquatic plant, it more easily maintains itself outside of cultivation than can those species confined to the upland.[1]

Rice undoubtedly originated in China, where it has been cultivated at least since 2000 B.C., and whence it spread to India and gradually westward around the world. Candolle asserts, on what he considers good authority, that a thousand years elapsed between its cultivation in Babylon and its introduction into Syria, another two or three hundred before it made its way into Egypt, and it was not until 1468 that it was first cultivated in Italy. Its introduction into the United States is said to date from 1694, when a vessel from Madagascar put into a South Carolina port in distress. From a little sack of rice on board, given to a resident, it rapidly spread over the state and afterward to Louisiana, where its production has rapidly increased since the Civil War.

The history of this plant attracts attention to *Zizania aquatica*, the Indian rice or water oats of our own country. This curious

[1] The student must be impressed with the disadvantage under which wild plants, as compared with wild animals, labor in maintaining themselves in the original state. When the haunts of the wild are invaded by man, the animal retreats to other and more remote regions, possibly better than those he has been forced to abandon. The plant, on the other hand, being unable to move, must stay and take the consequences, and, being the prey of both animals and man, it is comparatively easily forced to extinction.

plant grows freely in the marshes and along the borders of our northern lakes, where it constitutes the feeding grounds of our wild geese in summer time. It is tall and vigorous, bearing a heavy crop of large starchy seeds. These seeds were much prized by the Indians, who gathered them in great quantities for food, which fact would undoubtedly have led in due time to its systematic cultivation.

Sorghum (***Andropogon sorghum***). This genus, Andropogon, with its many and diverse species, is a great puzzle to botanists, running as it does by almost imperceptible gradations into the genus Panicum, with its eight hundred and fifty or more species scattered well over the world.

The cultivated sorghums are of two widely different sorts, the commercial sugar-bearing sorghum, closely related to the sugar cane (*Saccharum officinarum*) and used mostly as a forage plant; and the nonsaccharine, to which belong broom corn[1] and the various grain crops cultivated under the names Kafir corn, durra (doura, dhourra, or dhoura), Milo maize, or Jerusalem corn. Botanists quite frequently designate the saccharine sorghums as *Sorghum saccharatum* and the nonsaccharine as *Sorghum vulgare*, all of which illustrates their difficulties in attempting to make a classification to fit the facts. The sorghums are of recent introduction as cultivated plants. They are not found among the remains of the lake dwellers or of the Egyptians. The name is absent from Chinese literature until recent times. The Greeks and Romans were unacquainted with the species, which are not mentioned in the Old Testament.

The origin of the sorghums is not clearly established. By many writers they have been credited to Asia, but the absence from Sanskrit of any word to designate sorghum is held by Candolle to argue against the assumption. When we add to this the fact that nonsaccharine sorghums abound in equatorial Africa

[1] It ought to be generally known that the great broom-corn districts of the world are in eastern Kansas and in the region about Arcola and Tuscola, Illinois.

in many species, we feel confident that we must refer the origin of our sorghums to the dark continent,[1] whence they spread first to Egypt and afterward east, north, and west.

Sugar cane (*Saccharum officinarum*). This remarkable sugar-bearing plant is only remotely related to the Sorghums. It is cultivated to-day in all the equatorial regions of the earth, for its sugar is a universal favorite, though it is of but comparatively recent introduction.

Its most ancient names are Sanskrit[2] (ikshu or ikshava). All of its nearest related species grow wild in southeastern India, the Malay Peninsula, and the outlying islands. Both these facts indicate the origin to have been in Cochin China or thereabouts, from which it spread first west with the India trade and afterwards to China, where it appeared not much, if any, before the time of Christ.[3] The Greeks and Romans had heard of it as *calamus*. The Hebrews were unacquainted with sugar, and to them honey and the honeycomb were symbols of sweetness. The Arabs introduced it into Spain, and from thence it made its way to the West India islands (St. Domingo, 1520, and Guadeloupe, 1644) and soon after became rapidly abundant.

Millet. This is a popular name for a great variety of useful plants. First of all, it is often erroneously applied to the Asiatic cultivations of the various nonsaccharine sorghums already mentioned.

Again it is applied to the pearl or cat-tail millet (*Pennisetum typhoideum*), to the foxtail millet (*Setaria italica*, the *Panicum*

[1] The writer saw growing freely in Brazil what would be taken anywhere to be a broom corn with an inferior brush. I had no means of tracing its habitat, but from the fact that broom corn was not only not cultivated in the neighborhood, but brooms themselves were unknown, it had every semblance of being indigenous. Granting even that to be true, we could not look upon South America as the original source of broom corn because it was known in Egypt before the discovery of this country.

[2] "Origin of Cultivated Plants," p. 157.

[3] The older Chinese writings are said to make no mention of it, which is significant, because the universal appetite for sweets made it a favorite at once upon acquaintance.

italicum of Linnæus, so commonly raised for hay), and to the true or broom-corn millet (*Panicum miliaceum*). These last two are the millets of literature, and it is somewhat difficult to keep them separated.

Millet has been cultivated as a food plant from great antiquity, at least two species being found common in the remains of the oldest lake dwellers, which, it will be remembered, were in the stone age. *S. italica* is probably one of the five seeds sown by the Chinese emperor at the annual public ceremony instituted some 2700 B.C., in which he plows a furrow before the people and scatters the five most important seeds therein, thus giving public testimony and the highest official endorsement to the importance of agriculture.

This Italian millet (*S. italica*) is the millet of ancient China, which is almost certainly native in southeastern Asia, where its related species abound, and whence it must have made its way to Switzerland by a northern rather than by a southern route, as it was unknown in Syria ; unless, indeed, it had a double origin, as is not at all improbable when we compare with it our common and abundant foxtail grass, the nearly related *Setaria viridis*, which could readily be made into a valuable grain-bearing grass.

The other true millet was also known to the lake dwellers, and from all accounts seems to have been native in southwestern Asia, possibly in the Egyptian side of Arabia.

Buckwheat (***Polygonum fagopyrum***). This useful grain is mentioned here quite out of its place, for it is in no way related to the grasses. It is a relative of the smartweeds, which, together with still closer relatives, grow freely over the northern United States.

The original of our common buckwheat grows wild in Manchuria, on the banks of the Amur River, and two or three related but inferior species, such as the Tartary buckwheat, are wild in Tartary and Siberia. From here it made its way into Europe, following the former species which had been introduced by way of Tartary and Russia during the Middle Ages (about 1400), under the name of Saracen wheat, a name that long confused authorities as to its nativity. The point was only recently cleared up and the true origin of this grain established in Manchuria, all of which tallies well with the fact that it was apparently unknown to the prehistoric people either of Europe or of Asia.

Timothy (***Phleum pratense***). This plant, so familiar to farmers as the great hay grass, is the same as the herd's grass of New England. It is native in Europe, as the small and related *Phleum alpinum*, or mountain timothy, is native to the higher latitudes and the upper levels of the northern Appalachian Mountains.

This great hay[1] grass is at best only semidomesticated, for it has never been systematically "improved," as have wheat, corn, and almost all the grain crops, so that only one variety exists.

Blue grass (***Poa pratensis***) (Kentucky blue grass, June grass, spear grass, etc.), like timothy, is raised in pretty much its original condition. It is native throughout the hilly lands of eastern United States from Pennsylvania westward, whence it has crept as far west as Iowa and Kansas and as far south as Tennessee, below which it does not seem to thrive. Like timothy it has never been improved and exists in but one variety, though it is very variable and there are more than eighty related species.

Redtop (***Agrostis vulgaris***), often called bent grass, is another wildling among the grasses, and some of the best redtop meadows are self-seeded. Most of the redtop seed of the world is produced in three or four counties of southern Illinois, showing that it is only fairly coming into domestication. It grows native in southern United States, over widely scattered regions both high and low, but only in the latter does it make growth enough to be of value.

[1] Timothy is unsuited for pasture because it grows a little bulb just under ground. If pastured when young, this little bulb will not form, in which case the sod will not endure; and if pastured after haying, the stock will soon learn to pull up and eat this bulb. This is what causes many farmers to wonder why their cattle thrived so well on stubble pasture in dry weather, when grass does not grow. It is also the reason why the meadow next year is a disappointment; the plants have been pulled up and killed. Timothy should not be pastured when it has been recently mowed, that is, stock should not be turned upon timothy meadows immediately after haying.

Orchard grass (***Dactylis glomerata***). This curious and very striking grass, grown but rarely, is a native of Europe, but is now found, according to Beal,[1] in North Africa, India, and North America. It is widely scattered but never popular, largely because of its bunchy habit of growth, its coarse stem and leaf, and its habit of crowding out other grasses but failing to completely occupy the ground itself. It ripens with clover, and because of its habit last mentioned it is better grown with that crop than grown alone.

The Festucas. This useful genus of grasses, too little known by American farmers, covers some eighty species growing wild in the cooler regions of the Old World. The most common and well-known species are the large *Festuca elatior*, or tall fescue (pronounced *fĕs'kū*), making excellent hay as well as pasture; *Festuca pratensis*, or meadow fescue, much like the above only slightly shorter; and the little bunchy *Festuca ovina*, or sheep's fescue, of slight value except that it will grow in shady places, making a better sod in groves than will any other known grass. These grasses are much esteemed in England, but not yet extensively cultivated in this country, where we have scarcely commenced to realize the variety and value of many native grasses, not to mention the less-known introduced sorts. Neither timothy, blue grass, redtop, orchard grass, nor festuca is mentioned by Candolle in his history of the origin of our cultivated plants. This must have been clearly an oversight, as they were all in common use long before the date of his writings (1882). The best book on our own grasses, native and cultivated, is "Grasses of North America," by Dr. W. J. Beal of Michigan Agricultural College.

Miscellaneous grasses. The list of grasses that have been of use to man, and that have more or less come under cultivation, is too long for even mention here. Some of them, like wheat, oats, and sugar cane, are as fully domesticated as corn, while others, like the bamboo, are equally useful but rarely cultivated.

[1] "Grasses of North America," p. 109.

In addition to all these should be mentioned that horde of wild things growing together and constituting such great natural pastures as the original prairie range of our own western states and their equivalent on the pampas of South America. Unfortunately none of these native prairie grasses has been domesticated, and most or all of them seem on the road to early extinction. This seems a pity, especially when we recall the fact that neither timothy, blue grass, nor redtop, nor yet any of the English grasses, seems fully adapted to the soil and climate of our prairie states.

England is the great home of grasses, native and introduced. Its moist, cool climate is especially favorable to the hay and pasture grasses. The tall oat, sweet vernal, and the more useful festucas are all well known and all have been long recovered from the wild. We should do as much for our native grasses, and fame if not fortune awaits the man who will develop from American native varieties even one really good hay or pasture grass suited to our conditions.

CHAPTER XIX

ORIGIN OF THE CULTIVATED LEGUMES

Clover · Alfalfa · The lentil · The bean · The pea · The vetch · The lupine · The soy bean · The cowpea

A certain class of valuable plants is known as legumes. The distinguishing botanical trait of legumes is that they bear their seeds in pods, like peas and beans. The pod may be large and straight as in these familiar species, small and inconspicuous as in clover, or spiral-shaped as in alfalfa. In all cases, however, the seeds, whether large or small, resemble beans in splitting readily into two equal parts, unlike corn or wheat or the seeds of the grasses generally.

The physiological distinction of leguminous plants is a very peculiar one, and one that is unknown in plants outside this particular family. It is this: there will nearly always be found growing on the roots of all legumes little nodules or warts called tubercles. These tubercles vary in size and shape from those of the red clover, which are not so large as the head of a pin, up to those of the soy bean, which are as large as a small pea.

These tubercles are really the home of millions of microscopic plants called bacteria, which are parasitic upon the legume; that is to say, they depend upon the host plant for food, and to that extent they are a disadvantage. This disadvantage is, however, more than offset by their exceeding usefulness in the matter of fertility.

The agricultural distinction of the legumes generally is that the bacteria within these tubercles have the power of taking the free nitrogen of the air and putting it into combinations that may be used as food for plants generally, a property that is not possessed, so far as we know, by *any other form of life*. When the student comes to realize, by the study of the fertility problem, the difficulty encountered by farmers in getting sufficient nitrogen into the soil for profitable growth of crops, then the real value of legumes as the only natural and cheap source of nitrogen will be fully appreciated.[1]

The nutritive significance of legumes lies in the high nitrogen and mineral content of both the grain and the stem. As the grasses are notable for their carbon content in the form of either starch or oil, so the legumes are remarkable for their nitrogen and mineral content, especially the former. The exceeding rarity of nitrogen gives it a high value for animal food as well as for fertility, all of which goes to make the legumes, agriculturally speaking, the most distinctive family of plants ever domesticated.[2] They make an ideal food for growing animals and a fair substitute for meat in the diet of man; indeed, wherever in the earth man has lived with little or no flesh food he has drawn the more heavily upon the seeds of legumes.

Clover. Under this general name are grouped a variety of species more or less closely related.

1. *Trifolium pratense*, the common red clover, sometimes called purple clover or meadow trefoil, the latter from its three-parted leaf.

[1] Nitrogen costs in the markets, in the form of commercial fertilizers, approximately fifteen cents a pound everywhere, but can be produced by legumes in the proper rotation for next to nothing.

[2] It is sometimes necessary to "inoculate" for the growth of legumes; that is, to apply the proper bacteria. The bacteria are not the same for different species of legumes. For example, the clover tubercle will not develop on the alfalfa nor that of the pea upon the bean. If the particular species, say alfalfa, has never before been grown in a locality, its specific bacteria will likely not be present, in which case the tubercles will not form and no nitrogen will be taken from the air, such a plant becoming a heavy nitrogen consumer instead of a nitrogen producer. Inoculation then becomes necessary, for if the tubercles do not form, the legume is very exhaustive to land instead of benefiting it, and ultimately itself dies of nitrogen starvation. Inoculation is generally effected by scattering over the surface a little soil taken from a field in which the same legume has grown with well-developed tubercles. One to one and a half bushels per acre is sufficient if evenly applied.

2. *Trifolium medium*, the mammoth, giant, or pea-vine clover, similar to the above, but with a growth so heavy that the stems no longer stand erect but lie creeping on the ground.

3. *Trifolium repens*, the common white or Dutch clover, growing wild in pastures everywhere in the northern United States and never cultivated.

4. *Trifolium hybridum*, the common alsike, similar to the above only larger, with a stronger stem and a touch of pink in the blossom, grown freely on moist ground for hay.

5. *Trifolium incarnatum*, the crimson or Italian clover; a short erect species with a long, beautiful scarlet "head," making a small quantity of good hay but rarely used by American farmers, as the yield is low.

These clovers are all leguminous plants and all serve the same purpose as soil restorers so far as nitrogen is concerned. The farmers' choice therefore turns on the question of yield and general usefulness.

This rules out white clover as a cultivated crop, but it has no difficulty in maintaining itself as a wild plant,[1] to the great advantage of our self-sown native pastures.

The scarlet clover is but recently introduced into cultivation. According to Candolle it exists wild in Gallicia, in Biscaya and Catalonia, as also in Sardinia, in Algiers, and in the valley of the Danube, in some of which places it may have been introduced since cultivation. It is surely indigenous in the neighborhood of the Pyrenees and also along the coast of Cornwall, where it is associated with a yellow variety which is truly wild also on the continent.[2]

This shows how the process of domestication is sometimes long deferred, and may even be abandoned if, after trial, the species is not found worthy, as will more than likely be the case with this particular clover.

[1] In this respect it rivals Kentucky blue grass, with which it is often associated, an association clearly advantageous to the blue grass, whose supply of nitrogen is thereby better assured.

[2] "Origin of Cultivated Plants," p. 106.

T. pratense and its nearly related form, *T. medium*, merge together in literature; indeed, the latter is to be regarded as little more than a variety of the other, to which botanists have given a specific name more for convenience than from necessity. Neither of these, however, has been long cultivated. *T. pratense* grows wild throughout Europe, in Algeria, in Asia Minor, and in southeastern Siberia. It must have been long known to the people of Europe, but its first known introduction into cultivation was in Flanders in the sixteenth century, from which it made its way into England in 1630, through the efforts of the Earl of Portland, then Lord Chancellor.[1] There is no Sanskrit or other Aryan name either for clover, sainfoin, or alfalfa, from which Candolle concludes that these people maintained no artificial meadows.

Clover is then a new thing just out of the wild, and ready, indeed waiting, for the hand of the improver. Its many related species and their wide natural range lend confidence to the hope that out of this new and fresh material may arise most valuable varieties for agricultural purposes.

Alfalfa (***Medicago sativa***), variously known also as lucern, French clover, purple medic, Chilean clover, Spanish trefoil, etc. has been long cultivated in western United States, where it was introduced by the Spanish in an early day. It was tried a few generations ago in New England and the eastern states along with other European "grasses," quite naturally bearing its French name, lucern. It did not, however, succeed. The general conclusion at that time was that this "child of the sun" required a deep, loose, sandy subsoil and was unable to thrive on the somewhat stiff clays of that region.

However, it gradually worked eastward from the Far West, jumping the Great American Desert with some difficulty and delay, and finally, after all these centuries, was a few years ago well introduced into Mississippi valley agriculture, where it easily outyields any forage crop known, commonly affording three

[1] "Origin of Cultivated Plants," p. 105.

cuttings whose total weight ranges from four to as high as five or six tons per acre.

We know now that the early failures of this plant were due not to clay subsoils but to the absence of its characteristic bacterium, without which it could not draw upon the free nitrogen of the air; thus it was thrown, like other crops, back upon the supply contained within the soil, which is insufficient, except in rare cases, to afford material for so heavy a feeder as this crop.[1]

This reason for its failure in the eastern states is supported by the fact that a few individual plants always succeeded. These were the ones that sprang from seeds which happened to have had a little of the inoculation from the soil in which the crop had been growing. Alfalfa, however, is a "clean-seeded crop." But little seed is sown, and it would take many years to establish so vigorous a feeder by the natural means of infection. The eastern farmers gave it up too soon. The Kansas people persisted till they succeeded, though it took a generation. Fortunately for Illinois and the upper Mississippi valley, when the attempt was made there Dr. Hopkins of the University of Illinois succeeded in showing that the question of success or failure turned upon the presence or absence of the characteristic bacteria. After having conclusively shown this, he secured a ton of soil from an old alfalfa field in Kansas. With this he thoroughly inoculated an acre of the university farm, and from this all Illinois and much neighboring territory have been inoculated and the culture of this wonderful plant successfully introduced for the first time in the Middle West without the usual and otherwise necessary delay of waiting for the slow inoculation from seed and the long-continued failures necessarily involved.[2]

[1] Alfalfa growing without inoculation is, of course, a nitrogen consumer, and as it lives for seven or eight years it will, long before that time, exhaust the nitrogen of most soils and die of starvation.

[2] Curiously enough it was learned that wherever the closely related plant, *Melilotus alba*, or sweet clover, grew wild no inoculation was necessary, and later it was discovered that soil taken from a sweet-clover spot would successfully inoculate for alfalfa, the first and only instance known in which the bacteria of one species will grow upon another. Whether the bacteria are identical

Though this newest of our crops did not come into our own agriculture until approximately the opening of the twentieth century, it is, after all, the oldest and most anciently known of all our leguminous forage plants, excepting only the cowpea and soy bean, which are used mainly for their seeds. Alfalfa was known to the Greeks and Persians, who called it medica because it had been brought from Media at the time of the Persian War (470 B.C.), though it apparently did not come into general cultivation until the first or second century after Christ.

Candolle[1] has no hesitation in affirming that alfalfa is wild in several provinces to the south of the Caucasus, in various parts of Persia, in Afghanistan, Beluchistan, and Kashmir. Its seeming nonintroduction into China and India is a mystery, explainable only on the theory that the people preferred the plants that bore heavy seeds, or that they neglected it for some unknown reason akin to that which evidently deterred the Aryans from developing cultivated meadows.

The student will not fail to be impressed with the remarkable significance of the fact that this oldest of all the cultivated forage plants should have been the last to be introduced into our own agriculture, nor will he fail to note the scientific basis for the failure of our first attempts, which, had they been successful, might have greatly influenced the development of the eastern and the middle states.

The lentil. This plant is evidently a puzzle to the botanists, by whom it is variously designated as *Ervum lens*, *Lens esculenta*, and sometimes it is put in the genus *Cicer*. This confusion is probably due in part to the fact that the plant has been long cultivated. It has already been remarked that man, when maintaining himself with a small amount of animal food, quickly turns to seeds of legumes as a source of nitrogen.

or only closely related is not yet known, but the student should understand that the sweet clover, though classified as a distinct species and in a different genus, is after all, in many respects, almost indistinguishable from alfalfa, especially in its earlier stages of growth.

[1] "Origin of Cultivated Plants," p. 103.

This probably accounts for the early cultivation of the lentil, which is one of the oldest of the legumes. It was cultivated by the later lake dwellers (bronze age) of Switzerland, was known by both the Greeks and Romans, and is mentioned freely in the Old Testament. Without a doubt Esau's famous mess of pottage was a dish of lentils.[1] This plant does not seem to have entered into Anglo-Saxon agriculture, and in many respects seems on the road to abandonment.

The bean (***Phaseolus vulgaris***), commonly called the haricot or kidney bean, was early credited to Asia. Candolle has shown, however, that it has not been found in the lake dwellings and that it was absent from the collection of leguminous seeds found by Virchow in the excavations at Troy, which included not only the common garden pea but the broad bean. He also calls attention to the absence of any name for the bean in either Hebrew, Sanskrit, or Chinese, and adds that there are no evidences of its use in ancient Egypt.[2]

It has never been found wild in any country, and its origin seemed a mystery until somewhat recently, when several varieties of the true haricot bean were found in some Peruvian tombs near Lima. These tombs may not antedate the Spanish invasion, but this find, together with the fact that some fifty related species are American[3] and not one European, leads Candolle to conclude

[1] See Genesis xxv. Also "Origin of Cultivated Plants," p. 322.

[2] This must not be confused with the broad bean belonging to another species, *Faba vulgaris* or *Vicia faba*, which in turn is not to be confused with the Lima bean (*Phaseolus lunatus*), also native to South America, where its wild congeners abound in the Amazon basin and central Brazil, whence it was probably introduced by the slave trade into Africa where it now abounds. The true broad bean exists alone in the genus *Faba*, and is not mentioned by Gray in his manual of American plants, wild or cultivated. It is the common bean of Europe, a small-seeded variety of which was grown by the lake dwellers in their bronze age and by the ancient Egyptians, though no specimens are found, a fact thought to be due to their being considered unclean by the priests. Candolle considers this plant to have had a double center of development, one about the Caspian Sea, the other in northern Africa, such double domestication being frequent. See "Origin of Cultivated Plants," pp. 316–321.

[3] Several of these near relatives grow wild in North America, a number of them being native to Illinois; for example, *Phaseolus perennis*, *Phaseolus*

that the bean is a South American contribution, a conclusion that is strengthened by the fact that shortly after the Spanish discovery the bean was mentioned almost simultaneously in several widely separated regions of the Old World.

Candolle sums up as follows:[1] "(1) *Phaseolus vulgaris* has not been long cultivated in India, the southwest of Asia, and Egypt; (2) it is not certain that it was known in Europe before the discovery of America; (3) at this epoch the number of varieties suddenly increased in European gardens and all authors commenced to mention them; (4) the majority of the species of the genus exist in South America; (5) seeds apparently belonging to the species have been discovered in Peruvian tombs of an uncertain date, intermixed with many species, all American."

The pea. This familiar plant exists in two species of interest to agriculture:

1. The field pea (*Pisum arvense*), grown both for its seed and its forage as stock food. This species undoubtedly grows wild in the Mediterranean countries, possibly also in the south of Russia, and has been only recently introduced into cultivation.

2. The garden pea (*Pisum sativum*), generally ranked as a separate species, but more than likely developed from the above by cultivation; at any rate it has been longer known to cultivation than has the less-improved field pea. It was cultivated by both the Greeks and the Romans, and a small-seeded variety has been found in the lake dwellings of Switzerland and Savoy (age of bronze). There seems to be no indication of its ancient cultivation in either Egypt or India.

The vetch (***Vicia sativa***), or tare, a leguminous plant closely related to the pea, is wild over nearly all of Europe, in Algeria, and in Asia Minor, as are several related species, especially *Vicia americana*, in this country.

diversifolius, *Phaseolus helvolus*, and *Phaseolus pauciflorus*. See Gray under Phaseolus.

[1] "Origin of Cultivated Plants," p. 343.

Vetches were sown by the Romans, as they are now by the English, as cattle food, but there is no evidence of ancient cultivation.

The lupine (***Lupinus albus***). This legume was cultivated by the ancient Greeks and Romans as cattle food, but, though it grows wild in many varieties in various parts of the world, including our own country, it has not been largely brought into use, and now it shows every sign of passing out of cultivation.[1]

The soy bean (***Dolichos soja***). This is a new crop to the western world; indeed, its introduction is but just being effected. It came to us from Japan, where, as in China, it has been cultivated from the remotest antiquity for human food. It is certainly wild in Japan and most likely also in the regions to the south, where related species flourish even in the island of Java. The crop is commonly called the soja, or soy bean, but it more closely resembles the pea, while the so-called cowpea is more like a bean. With us the crop is used exclusively for stock food, both grain and forage being useful.

The cowpea (***Dolichos chinensis***). This and the above species are giving the botanists much trouble. They are here put into the same genus, but they are being moved about so much, sometimes together and sometimes separated, that it is difficult to keep track of them. There perhaps is a growing disposition to separate them, but they are here put in the same genus awaiting the final decision of the botanists.

All this, however, does not concern us now further than to show that lines on which classification is based are often

[1] The student can hardly realize how rapidly species are recovered from the wild, cultivated for a time, and then abandoned for something better or at least for something else. Thus Darwin tells us, "Animals and Plants under Domestication," Vol. I, p. 336, quoting Heer, that the wheat of the lake dwellers in the early stone age was a small-headed variety with grains not half the size of modern wheat. This lasted down to the "Helvetico-Roman age and then became extinct," giving place to better races in turn, up to the latest improved and best yielding varieties. It appears, too, that in general these ancient grains were inferior to the modern, whether wheat, barley, oats, or what not, and that with cultivation has been associated a steadily progressive development.

indistinct and difficult to establish, and to prepare the student for seeing both of these species described under various names.

The cowpea has been recently introduced into our southern states from China, where it has been cultivated as human food from great antiquity. Like the soy bean this crop is fed freely to live stock in our country and consequently neither is used as human food.[1]

[1] Man has a strange aversion to consuming the same grain he feeds his stock, and he positively refuses to eat it if it be a recent importation. The first question asked of a new food plant is this: "Is it for man or animal?" without thinking it may be good for both; but the question once answered, the future of the thing is settled. This is why all efforts to introduce Indian corn into Europe to replace rye as human food have failed in the past and are likely to continue to fail in the future. Even the pauper resists what he considers to be putting him on a level with the animals.

CHAPTER XX

ORIGIN OF CULTIVATED FRUITS[1]

The apple · The pear · The plum · The sour cherry · The peach · The apricot · The orange and the lemon · The banana · The pineapple · The grape · The strawberry · The raspberry · The blackberry · The melon · Miscellaneous fruits

The list of fruits is an exceedingly long one. What we popularly call a fruit is, in general, not the seed, but rather the fleshy developed parts about the seed or seeds. For example, in the apple the whole pericarp or seed envelope takes on an extreme development, entirely and somewhat uniformly surrounding the seed capsules with a juicy fleshy growth. In the strawberry it is the receptacle on which the mass of seeds is attached that develops into the edible part. In the raspberry each individual seed is surrounded by a juicy growth similar to that of the peach, while the receptacle is left behind as the fruit leaves it, like a cap comes off the head. In the blackberry each seed develops its fleshy envelope, like the raspberry, but the receptacle comes off with the fruit, as in the strawberry.

The apple (***Malus malus***). This best of all the fruits has been long in cultivation, specimens of several varieties having been found in the remains of the lake dwellers, previous to the bronze age. These were small fruits, however, measuring only from an inch to an inch and a quarter in diameter and undoubtedly gathered from the wild. The fruit has therefore improved somewhat since these days, certainly in size and most likely in flavor as well.

The apple was cultivated by the Greeks under the name of *melon* and by the Latins as *malus*, clearly the same name ; but

[1] See "Principles of Breeding," chapter on Mutation ; also "Evolution of our Native Fruits," by Bailey.

the Basque *sagara* indicates a name independent of Aryan influence. Being an ancient Iberian people, the inference is warranted that the apple was cultivated there before the Aryan invasion.

Candolle makes the broad statement that the apple grows wild "throughout Europe, excepting in the extreme north," as well as to the south of the Caucasus and certain districts of Persia. At Trebizond, in Asiatic Turkey, the botanist Bourgeau is reported to have seen "quite a small forest" of apples, and there is good reason to believe that the tree grows wild in the mountainous parts of northwestern India.

The readiness with which the apple escapes from cultivation and "runs wild" makes it difficult to set original limits to its habitat, but botanists and fruit men are quite agreed, I think, that this great fruit is a native of southeastern Europe and the contiguous regions.

Besides the malus proper we have the wild crab apples, growing in various parts of the north-temperate regions. The Siberian crab (*Pyrus baccata*) has not only been semidomesticated, but has been hybridized with the common apple, giving *Pyrus prunifolia*, with a foliage, as the name indicates, resembling that of the plum. In this connection it ought to be remarked that the crab apples of all species and varieties are inferior to the common apple, fit only for cooking, or eating fresh when nothing better is available. The foliage and bloom, however, are so abundant and so beautiful that the crab has become a favorite tree for ornamental planting.

America has no less than five native apples, all crabs.[1] The largest of these is the Oregon crab, which ranges from northern California to Alaska, and is a real tree, often reaching a height

[1] "Evolution of our Native Fruits," pp. 249–273. This fascinating book is one of Bailey's best, and should find a place on the shelves of every school library. It gives a full account of the wild native fruits of North America, and is not only a mine of information but a source of inspiration as well. Its reading cannot fail to inspire the student through the wealth of natural resources in plant life, and it is fortunate that the study could be made in America before, as in the rest of the world, it should be too late.

of forty feet. The fruit is three fourths of an inch or less in diameter, is often gathered by the Indians, and was used by the early settlers in making jelly.

Two species of wild crab are found in the Mississippi valley and eastward, one in the north (*Pyrus coronaria*) and one in the south (*Pyrus augustifolia*), one in the prairie states westward (*Pyrus Ioensis*), and another known as the Soulard crab, named from the originator, J. G. Soulard of Galena, Illinois. The original was discovered in an apple thicket near St. Louis and sent to Mr. Soulard, who propagated it by grafting in a crab. Whether it is a mutant or chance seedling from real native stock, or whether it is a hybrid with the common apple, is not of course known, but is generally, I think, considered as the latter.

These apples are used only for cooking, especially jelly making, and occasionally for cider. They will not compare in quality with the *Pyrus malus*, although it should be understood that this species is propagated only by grafts, the seedlings being in most cases worthless.

The Indians made what use they could of the wild apple, and upon the advent of the white man adopted the common apple and made much of it, both in North and South America, where remains of old Indian orchards still exist, even in so old a region as western New York.

The pear (*Pyrus communis*). This fruit grows wild over the whole of temperate Europe and western Asia, and its closely related species, *Pyrus sinensis*, extends into Mongolia and Manchuria. In its native country it grows as a forest tree, particularly in France, where the greatest improvement has been effected, and from whence most of our best varieties have come. America has no native pear.

This fruit was cultivated by the Greeks and Romans and occasionally gathered with other wild fruits by the lake dwellers, but there is no evidence that it was cultivated by ancient peoples.

The plum. Of this favorite fruit we have two broadly different strains, the European (*Prunus domestica*), and the Americ-

(*Prunus americana*), with its variations, from which many of our best cultivated varieties are descended.

Plums were cultivated by the Romans, but were not known to the lake dwellers or other ancient people. They have been cultivated, too, in China from early times, but the original stock has not been certainly identified, though related species grew wild in the neighborhood of the Caucasus and in the western forests of the Chinese empire.

The plum was native in all the northern United States, and every pioneer has satisfied his "fruit tooth" and graced his table many times from the stock found growing along the river bottoms everywhere. Strangely enough, according to Bailey,[1] our best authority, no commercial variety has ever been developed from northern native stock east of Michigan, but the wild plums to the south and west have been prolific of good varieties. This was probably because the cultivated European sorts succeeded well in the north, making resort to the wild unnecessary, while from Virginia south they were not satisfactory. Here resort was naturally back to the wild. Thus necessity is the mother not only of invention but of domestication as well. The Miner was produced in Tennessee; the Robinson in North Carolina; the Wayland "came up" in a plum thicket in Kentucky; the Golden Beauty was "found wild" in Texas; the Pottawattamie in Tennessee; and the Newman in Kentucky. The Wolf originated from seed gathered from wild trees in Iowa, and the Rollingstone was "found" on the banks of Rollingstone Creek in Minnesota.[2]

Every boy knows that certain trees or bushes produce nuts or fruits much better than others of the same species. Every neighborhood that grows wild fruit of any kind has its trees or bushes which yield fruit of superior size or flavor, or both. It is from such as these that many new varieties have sprung, a fact to be borne in mind when we come to the discussion of mutation later on.

[1] "Evolution of our Cultivated Fruits," p. 170.

[2] "Principles of Breeding," p. 133.

The sour cherry (***Prunus cerasus***). The student will not fail to notice the close relationship granted the plums and the cherries in putting these seemingly very different fruits in the same genus. This illustrates one of the troubles of the botanists, for there also belong in the same goodly company the chokecherries and the wild, black, and red cherries, that grow upon branching stems like currants.

While America has some of these so-called wild cherries, they have never yielded to attempts at amelioration, and we are dependent upon foreign species for our fruits.

The species given above is undoubtedly a native of Asia Minor, in the neighborhood of the Caspian, and its allied species, the bird cherry (*Prunus avium*), from which our white and black varieties are developed, is wild in Persia and the hilly regions to the west as far even as Algeria. We will not enter into the dispute as to whether these two species are distinct, or whether the former has been developed from the latter, such discussions having lost much of their interest in recent days, since we have learned how quickly new forms may rise from others and present differences that any botanist, not knowing the history, would call specific.

Curiously enough, the cherry succeeds wonderfully as an ornamental plant in Japan, where it flowers profusely but rarely fruits.

The peach (***Amygdalus persica***). This delicious fruit is a strange customer in our orchards. A kind of mean between a bush and a tree, it yields one of the most toothsome fruits known to the palate. Its strangeness consists in its relation to another fruit, the nectarine, which closely resembles the peach, except that instead of the downy covering, it is smooth like the plum.

The strange part of it is that peaches and nectarines often grow upon the same tree; that is, a tree or a part of a tree that has always borne peaches may suddenly begin to bear nectarines, after which it may produce either peaches or nectarines.

If these nectarines be planted, the seed will produce not peaches, as a rule, but nectarines.[1]

This observation of Darwin's, early confirmed by later observations, came at a time when botanists, after much discussion, had about decided to put the nectarine in a separate species from the peach. The fact, however, that nectarines are often produced on the same tree with peaches, and often by a limb that in other years also grows peaches, — this fact, when clearly proved, put a stop to the discussion, and not only ended a puzzling debate, but showed also that specific lines cannot always be clearly drawn. The nectarine is therefore recognized as a sport, or, more properly, a mutant of the peach, because it arises not once but many times from that fruit. Incidentally we learn by this that new strains may arise from old stock repeatedly, and that certain combinations of plant and animal characters are constantly giving off new strains or species[2] represented by essentially new combinations.

As indicated by the name, the peach has been generally credited to Persia, from whence it was introduced into European cultivation shortly after the beginning of the Christian era.[3] This is not, however, proof of its Persian origin, neither is the fact of its being found wild in many districts of western Asia; for, like the orange, it easily escapes, and when it does so the seedlings are exceedingly inferior.

As no name for the peach is found either in Hebrew or Sanskrit, Candolle is inclined to give the peach a Chinese origin, consigning it to that limbo of all unknown and untraceable things, central Asia.

[1] "Animals and Plants under Domestication," Vol. I, p. 361.

[2] The term "species" is here used not in its narrow biological sense, but in the wider sense of strains that are sufficiently constant to breed among themselves.

[3] It is notable that the very ancient people seemed to have confined their agriculture to the production of necessary grains, and that the luxury of fruits and toothsome delicacies belonged to later times and more luxurious living generally.

Darwin, however, presents some excellent arguments for assuming that the peach is exceedingly new upon the earth, and possibly has never been truly wild, but developed from the almond (*Amygdalus communis*), which grows wild, or half wild, in the warmer regions of the Mediterranean and in western Asia. This argument is extremely fascinating, and even more convincing now than in the days when it was first presented. It is too long to be repeated here, and should be read in the original.[1] Briefly, he finds that the space between the almond and its near relative, the peach, is not wide, and is often, moreover, nearly bridged by inferior specimens of the seedling peach. Not only is this true but occasionally the almond will bear unusually fleshy fruit approaching a poor peach. Evidently the whole group — peaches, nectarines, and almonds — is an exceedingly miscellaneous lot, not yet having settled down into distinctive lines, if, indeed, they ever do become fixed and measurably inflexible. In any event, until then they will continue to bother the botanist.

The apricot (*Prunus armeniaca*). The apricot is related to the plum somewhat as the peach is to the nectarine, with two important differences. The apricot is essentially a plum with a downy covering, as the nectarine is a peach with the covering off; but the smooth form is the more common in the plum, as the downy peach is more common than the smooth nectarine. Again, the apricot is known in the wild state as a distinct self-perpetuating species. No man has detected a mutation either way between the apricot and the plum, and yet the consistent evolutionist must recognize the same fundamental relations between the two, except that in the case of the apricot and the plum the mutant is able to maintain itself indefinitely as a distinct species, which clearly the nectarine is unable to do, although nectarine seeds produce nectarines freely. The strain is evidently an erratic one, not easily maintained in nature for

[1] "Animals and Plants under Domestication," Vol. I, pp. 358–360.

any considerable length of time, and would soon become extinct were it not constantly renewed. Whether the apricot is a mutant from the plum, or the reverse, we could now only speculate, but from general reasoning we should regard the apricot as the original stock and the plum the mutant.[1]

The orange and the lemon. These two popular tropical fruits belong to a tangled group covered by the generic name *Citrus*, and including also the lime and the shaddock. While their original has not been identified in the wild, their origin is universally credited to eastern Asia, probably China. The principal strains of this genus are as follows:

The citron (*Citrus medica* proper), a large nonspherical fruit with an aromatic rind and a moderate amount of not very acid juice.

The shaddock, or grapefruit (*Citrus decumana*), large and round, juicy, slightly acid, extensively cultivated in southern Asia and in the tropics generally.

The lemon (*Citrus medica limonum*), juice decidedly acid.

The lime (*Citrus medica acida*), like the lemon, but much smaller; juice very acid.

The orange (*Citrus aurantium*), in two varieties, bitter and sweet, of which the latter is the cultivated, and of which the tangerine and the mandarin are minor strains distinguished by the easily separated rind, and for this reason often called "kid-glove oranges."

The citrous fruits have a pronounced acid quality and a lurking tendency to be bitter, a tendency that crops out strongest in the bitter orange, which is wild, and in the shaddock, which is cultivated.[2] These fruits have been long in cultivation, as fruits go,

[1] This is because the mutant is more commonly destitute of some character that is present in the original. Nearly every pubescent species, too, has its smooth variety, which in some cases succeeds better than the original. The fact that we do not see the mutation is no argument that it has not taken place. Plain wheat, for example, has certainly arisen from the bearded, which is to be regarded as the original stock. See further in the chapter on Mutation.

[2] It may be added that the common orange easily escapes from cultivation, in which case most of the trees bear insipid fruit, a few bitter, and occasionally

names for some of them being found in the Sanskrit. The mild acid varieties seem to have first attracted attention, the sweet orange seemingly being the most recent of all, though now the most popular in the West, where it has been greatly improved.

The banana (***Musa sapientum***), literally the food of the wise, from an old tradition that this was the special food of the Hindu philosophers. Its near relative, the plantain, sometimes reckoned as a separate species, *Musa paradisiaca*, is larger and coarser than the banana and generally requires cooking for the best results.

The banana is without doubt native to the lower regions of southeastern Asia and the outlying islands, where it has been cultivated from antiquity. It was early known to the Greeks, Latins, and Arabs as an Indian fruit, but the only ancient names are in Sanskrit. The ancient Egyptians and Hebrews did not know the plant, which Candolle considers to be a sign that its cultivation cannot be regarded as remote.

Whether the banana is also native to Africa and the New World is yet a matter of uncertainty. It was certainly known in both continents at a very early day, and Stanley, as well as earlier explorers, found the banana and the plantain both cultivated and wild in the depths of the Kongo. The plant almost never bears seeds.

The pineapple (***Ananassa sativa***). Without doubt this is truly an American plant, native in the regions of the Orinoco and northward. It was of course unknown till the discovery of the New World, but has since spread rapidly over all subtropical countries. It is clearly the finest tropical fruit when had at its best, which is rare.

The grape. The cultivated grape of to-day comes from two distinctly different sources, one the Old World, the other the New.

one bears fruit of a good quality. The writer speaks from experience in this, for it was his habit in riding over the mountains in eastern South America to depend upon the wild orange for refreshment. The trees bearing good fruit could readily be told at a distance.

The grape has been cultivated from ancient times and is believed by many to be our oldest fruit. Noah, good old man

FIG. 48. The wild persimmon of the South. With attention it might rival the grape in valuable varieties

as he was, lost his head over the fruit of the vine,[1] and he has been followed by many less worthy successors.

The Phœnicians are credited with the introduction of the grape into Europe, where more than fifteen hundred varieties

[1] Genesis ix.

are grown, all descended from a single species, *Vitis vinifera*, supposed to be indigenous to Asia.

Curiously enough, these European cultivated varieties failed utterly to grow in the eastern United States,[1] and our early forefathers suffered much extremity, or thought they did, by their inability to grow the European grape for wine, some good chroniclers going so far as to express a doubt if the Creator had ever intended such a country for human habitation.

Failing[2] in the attempts to grow the European grapes, the settlers naturally turned their attention to the native species that clambered everywhere and that early attracted attention. Thus Captain John Smith, for example, in the quaint language of the times (1607–1609) writes of the wild grapes of Virginia that they "climbe the toppes of the highest trees"; and speaking of the fruit, he says, "They bee fatte and the iuyce thicke: neither doth the tast so well please when they are made in wine."[3] From which we see that the attention of the time was mainly upon wine.

"America is the land of the grape," says Bailey,[4] who lists no less than twenty-two distinct species and thirteen varieties of grape native to the United States. The principal species are the following, which, directly or through their hybrids with the Old World wine grape, *V. vinifera*, have given rise to our common American cultivated varieties, distinguished by their round, juicy, many-seeded fruits as distinct from the fleshy European (now California) species:

1. *Vitis rotundifolia*, the muscadine or Southern fox grape.[5] Delaware to Florida and west to Kansas and Texas, and parent of the large musky Scuppernong.

[1] This was due, as we now know, to certain diseases that killed the leaves, probably the downy mildew and black rot. These grapes have been since grown out of doors in California for raisins, wine, and for shipping, and they appear on our markets now as the thick-meated "California grapes."

[2] The story of this failure is finely told by Bailey in his "The Evolution of our Native Fruits."

[3] "Evolution of our Native Fruits," p. 4.

[4] Ibid., pp. 98–117.

[5] Called by Gray, *Vitis vulpina*.

2. *Vitis labrusca*, the northern fox or skunk grape. New England and southward to Georgia along the Allegheny highlands. Parent of the Catawba, Concord, Isabella, Worden, and most of our commonly cultivated varieties.

3. *Vitis vulpina*, the river-bank or frost grape, commonly known as *Vitis riparia*. It is the common wild grape of the northern states east of the Mississippi, frequently hybridizes naturally with *V. labrusca* eastward, where they overlap, and is the parent of the Clinton, Elvira, Pearl, and others.[1]

The unrivaled Catawba was found wild in the woods of extreme western North Carolina in 1842. It is the great grape wherever it can be grown, and its seedling, the Diana, is an oldtime favorite.

A year later the Concord was discovered among some wild grapes that sprung up about the residence of Ephraim Bull at Concord, Massachusetts. The writer saw the original vine a few days ago (August, 1908) still growing by the little old homestead, just beyond the homes of Hawthorne and the Alcotts.

From the Concord have sprung the Worden, Moores Early, Pocklington, Eaton, and Rockland, of which the two first are famous. In the same way the Clinton and many other strains have come directly from the wild within the lifetime of men yet living, and many, by hybridizing, have given rise to yet other successful varieties. In this way have all the varieties of grapes grown in eastern or middle United States been produced directly from the wild and within the last generation.

The thick-meated European grapes were found to succeed in California, and they now reach our tables from the fruit stands. However high in quality and however valuable for raisins or for wine, I am sure that the average palate prefers the juicy varieties, developed though but recently from the native stock of the American forest.

[1] The student is urged to pursue further in the admirable work of Bailey, "Origin of our Native Fruits," pp. 1–126, the history, characteristics, and development of this greatest of American fruits.

The strawberry. The United States, like Europe from Lapland to the Mediterranean, was well stocked with wild strawberries. A good start had been made in an early day toward developing garden varieties from this source, and the writer has eaten freely in boyhood of such varieties.

Before final results were at hand, however, and before the best use had been made of this native stock,[1] a new species from Chile had been introduced into England, and from there to this country, where it has become the parent of all commercial varieties, wholly displacing the races developed from the native stock. The Chilean species extends into our own western mountains, but fails to succeed when brought directly from there to the East.

The strawberry is widely scattered over the earth, a fact due partly to its cosmopolitan character and partly to the facility with which birds scatter the seeds, in which respect this fruit is equaled by few and surpassed by none.

Notwithstanding all this, the strawberry is one of the newest of additions to cultivated plants, dating in all probability not back of the fifteenth century. It is difficult to realize how so luscious a fruit should be so long neglected, except upon the assumption that in its present form it has not long existed.

The raspberry. Europe supports many varieties of *Rubus idæus*, both red and white, but, like the grape, they all proved unsuited to American conditions, and, as before, recourse was had to the wild. Naturally the early efforts were directed to the red berries, following the European type, and later to the black caps, which upon acquaintance immediately took the lead.

The real cultivation of native American raspberries dates, according to Bailey,[2] not earlier than 1860, when L. F. Allen of New York sent out two red varieties, Allen's Red Prolific and Allen's Antwerp, which were "merely accidental varieties of

[1] It is an open question whether the wild red strawberry of the eastern United States is identical with the *Fragaria vesca* of Europe. The difference is evidently slight, but enough to lead some botanists to give it a separate name,—sometimes *Fragaria virginiana* and again *Fragaria americana*.

[2] "Evolution of our Native Fruits," p. 286.

the wild raspberry of his locality."[1] By 1867, however, the red varieties had increased to six, the black caps had been introduced under eleven varieties, one of which was an albino, and a series of purple varieties numbering five had come into favor.

The black cap has always been the American favorite among raspberries, and it is right that the name of the man to whom we owe its introduction should become a household word wherever the raspberry is eaten. It was Nicholas Longworth[2] of Cincinnati, who, as Professor Bailey puts it, was "the same prophetic spirit that put American grape growing on its feet." The first of these black-cap varieties was the Everbearing, which, by Mr. Longworth's account, he "found" in Ohio in full fruit and brought it into his garden, where it supplied his table "from the beginning of June until frost."

The story of the raspberry is a story for the poetic historian, as it is also for the student of natural history and the farmer; indeed, the story of the civilization of any great fruit or food crop is a chapter in the history of creation that any man may be proud to write and grateful to read. The temptation to dwell on fascinating details is almost overpowering, there is so much of human life and divine inspiration in it all; but it is quite aside from the present purpose, which is only to give a hasty outline sketch supplementary to the chief purpose in hand.

The blackberry. This close relative of the raspberry is not cultivated in the Old World, and nothing in the genus *Rubus* is mentioned by Candolle. The blackberry grows wild in Europe, but, like our huckleberry, has never been considered as a candidate for cultivation.

It gave much trouble in America before it would yield to the blandishments of the cultivator. Though flourishing remarkably in the wild over nearly all the eastern United States both north and south, it has been so shy of civilization that Professor Card has called it the "gypsy of the fruits," a name it undoubtedly

[1] "Evolution of our Native Fruits," pp. 287–289.

[2] The great-grandfather of the present Congressman Longworth.

deserves, for much labor and expense were bestowed on these shade-loving berries before varieties were developed that would thrive at all in the open.

But the troubles of the cultivators were fully equaled by those of the botanists, who have floundered in a sea of confusion in the endeavor to fix lines of classification that would separate and describe all the forms of these exceedingly variable races, which range all the way from the high-bush blackberry of the northern "clearings" to the creeping dewberries of the open, both of which have finally yielded to cultivation and given useful varieties, but only well within the recollection of men yet in middle age.

This confusion grew worse instead of better till Bailey (1898) untangled the matter and proposed names and descriptions, which, for the first time, fix the botanical character of our native and cultivated blackberries.[1]

The cultivated varieties trace to two strains of a single species, though many others are described and named, merging by almost imperceptible gradations into the dewberries. These two strains are the following:

1. *Rubus nigrobaccus*, the *Rubus villosus* of many. This is the common high-bush, long-clustered, rich-flavored blackberry of the northern woods and clearings, extending as far south as the mountains of North Carolina and as far west as Kansas. The fruit of this species is the best of all the blackberries, and is preferred by all lovers of fruit, from birds on the one hand to bears and boys upon the other. It was exceedingly shy of civilization, but has consented to produce a few varieties, of which the Taylor and Ancient Britain are considered by Bailey to be examples.

2. *Rubus nigrobaccus* var. *sativus*, the short-clustered, loose-seeded blackberry of the open fields. Strangely enough, however,

[1] This matter is discussed here at some little length, partly to fix names, but more especially to show the student the troubles of classification, troubles that arise by the overlapping of closely related strains. The full text of Bailey's excellent work will be found in "Evolution of our Native Fruits," pp. 366–385.

it is this wonderful "nondescript" berry, with its inferior fruit, that yielded best to cultivation and has given us the most of our cultivated varieties, of which the Snyder and Kittatinny are examples.[1]

Besides these there is the so-called "white blackberry" (*Rubus nigrobaccus* var. *albinus*), an albino variety midway between the main strain and the *sativus*, with the habits of growth and quality of fruit closely resembling the former, but of especially fine quality.[2]

The melon. Dear to the heart and palate of every boy is the melon. It exists in two well-marked and distinct species, belonging even to different genera:

1. The muskmelon, or cantaloupe (*Cucumis melo*), is certainly native both in Beluchistan and westward, on the coast of Guinea, and in central Africa and eastward. In the wild the fruit varies from the size of a plum to that of a lemon, and is commonly extremely insipid. This generally unpromising character is probably responsible for the fact that the melon was not cultivated in early times; indeed, it was not until our own day that really excellent varieties have been established, — all of which goes to show the power of cultivation and selection to work improvement, and that the wild plant often gives little indication of its hidden possibilities, which quickly appear when once they are unlocked and liberated by generous opportunity.

[1] A few cultivated varieties, like the Wilson and Rathbun, are considered to be hybrids between the blackberry and the dewberry (*Rubus villosus*).

[2] Burbank is erroneously credited with having "produced" the white blackberry in the sense of having created it. Now the white blackberry is a strain, probably a mutant, that frequently arises, as every woods boy knows, and Mr. Burbank's "production" consists in cultivating one or more of the many thousands of such "sports" produced by this great berry.

The student should understand that nearly everything has its albino (white) strain, which is altogether likely a mutant from the main stock. Thus we have the white blackberry, strawberry, raspberry, currant, apple, as well as the white rabbit, deer, horse, cow, pig, sheep, and so on, of practically all species. With the sheep, the white is the favorite stock, which was also true of the pig till the opening up of the corn belt and the origin of the Poland China breed, which happens to be black.

2. The watermelon (*Citrullus vulgaris*). For once there is no doubt of nativity. The watermelon is a characteristic contribution of the dark continent, and our colored brother evidently comes honestly by his natural appetite for this luscious fruit. It belongs to central Africa on both sides of the equator, where Livingstone "saw districts literally covered with it, and the savages and several kinds of wild animals eagerly devoured the wild fruit,"[1] which is sometimes, but not generally, bitter. This fruit was certainly cultivated by the ancient Egyptians, but there is no proof of antiquity, either botanical or philological, except in northern Africa.

FIG. 49. The huckleberry — good enough in the wild

It would be interesting, indeed, to follow the futures of other wildlings under civilization, such as the cucumber, the pumpkin, and the squash, but it is a long story and would lead us far afield. Inasmuch as our chief purpose here is to indicate rather than to exhaust a field, we must content ourselves with a hasty glance at what is really a fascinating prospect.

Miscellaneous fruits. There are, however, a number that merit further study. The gooseberry and the currant, both introduced from Europe, and both also wild over extensive areas of our own country,[2] and which have furnished cultivated varieties, are other examples of the fact that many species are

[1] "Origin of Cultivated Plants, p. 263.

[2] The writer as a boy knew two kinds of wild gooseberry, the "prickly" and the plain, both growing freely in the woods of Michigan. The latter was often brought into the gardens of the pioneers and successfully cultivated, furnishing, in some cases, the principal fruit of the pioneers.

wide-ranging races that may be, and likely are, subjected to cultivation at very many independent centers.

Added to these are many undeveloped possibilities in uncultivated fruits, like the huckleberry and the cranberry, which latter is coming into semidomestication in order to furnish the demand that goes with the Thanksgiving turkey.

The tropics afford an almost endless variety of fruits, some of them only just rescued from the wild. The forests and jungles of such formative regions as the Amazon valley abound in fruits as well as nuts in the greatest profusion and of the greatest variety. The world is being ransacked now for new and valuable varieties, either cultivated or wild, and very much of the work of domestication of plants is still going on even in our own day, though it is a question whether a new animal will ever be added by domestication. It looks rather as if in respect to animals we should be restricted in our possessions to what we can achieve out of the materials already in hand.

CHAPTER XXI

ORIGIN OF FARM AND GARDEN VEGETABLES AND MISCELLANEOUS PLANTS

The potato · The sweet potato · Miscellaneous tubers · Edible roots · The onion · The beet · Manioc, or mandioca · The turnip · Miscellaneous roots · Vegetables cultivated for their foliage · Cabbage · Celery · Lettuce · Asparagus · Plants cultivated for beverage · Coffee · Tea · Maté · Plants grown for sedative effect · The poppy · Coca · The betel · Tobacco · Fiber plants · Cotton · Flax · Hemp · Ornamental plants · Weeds

Many plants have a habit of sending out not only the upright stems that bear leaves, but also others that run along just above or just beneath the surface of the ground, and, by branching or sending out roots at the joints here and there, are able to propagate themselves without the help of seeds. Strawberries do this with "runners" above the ground. Quack grass and Canada thistle do the same, except that the stems run just below the surface, a habit which makes these two weeds peculiarly difficult to eradicate. Blue grass has the same habit, but, being valuable instead of worthless, we count the custom a virtue and not a vice.

In a few plants these underground stems greatly thicken, and these thickened stems, called tubers, are favorite foods, generally as a source of starch.

The potato (*Solanum tuberosum*). The most common and the most valuable of all plants of this order is the ordinary Irish potato. Its name "Irish" is a misnomer,[1] as it is truly an American product, its wild progenitor still being common along the coast of Chile and in the higher elevations to the northward. Several closely related species abound in the highlands of South and Central America as far north as Mexico, and a not distantly

[1] Bestowed from the fact that the cessation of the periodic famine in Ireland dates from the introduction of the potato.

related species is found as far north as Colorado, — the *Solanum rostratum*.[1]

At the discovery of America the potato was cultivated all along the Andean slopes and plateaus as far north as Granada. It was introduced into Europe by the Spaniards, and very likely from them it made its way to the United States, as it seems not to have been known to the Indians until after the discovery of this country by Europeans.[2]

This tuber is one of the cheapest and most important foods for man, and it has done more, perhaps, than any other plant to make famine in the western world practically impossible. It made little headway, however, until recent years, for as late as the time of the American Revolution but two varieties were known in England, a white and a red. Latterly, however, great improvements have been made, largely within the lifetime of men yet living. Varieties are now counted by the hundreds, and any number of new ones can be produced at will, so freely does the species vary.

The sweet potato (*Ipomoea batatas*). This is not a true potato at all, but belongs to the morning-glory family, whereas the potato belongs to the nightshades; moreover, the fleshy parts that are eaten are true roots, and not thickened underground stems or tubers like those of the true potato.

The origin of the sweet potato is mysterious. It was undoubtedly found in cultivation in the New World. Moreover, of the fifteen nearest related species, all are found wild in America, eleven of these are found only there, while four are found also in the Old World. It was certainly not known in Europe until after

[1] This native sand bur was the original food plant of the Colorado potato beetle, but when the potato reached that region the insect at once adopted it as a new host, and it spread rapidly eastward over all the United States, illustrating how quickly a wildling may change its habits and greatly profit by a new food plant.

[2] Sir Walter Raleigh is often credited with having introduced both tobacco and potatoes into England, having brought them from Virginia, but this does not mean that the potato was native there, nor that this was the first introduction into Europe.

the discovery of America. It was unknown to both the Romans and the Arabs, and was not introduced into Egypt until about a hundred years ago. On the other hand, Chinese literature mentions the cultivation of this plant as early as the second or third century, all of which is argument for an Asiatic origin.

In the opinion of the writer these are ample grounds for assuming a double origin of this most useful plant. The similarity between the flora of eastern Asia and certain portions of America is one of the best known facts in natural history. So valuable a plant as the sweet potato would attract attention anywhere, for all the preparation needed is roasting. Accordingly it would at once be brought into cultivation by any progressive race, and there is every reason why widely diffused species of this kind should be domesticated not once but many times, and their cultivation spread not from one but from many centers. I am of the opinion that it is both unnecessary and unscientific to assume a single origin for every cultivated plant. Species like the oaks, growing widely scattered over the earth without the aid of man, are proof of the wide diffusion of certain races by wholly natural causes. Given now this same wide diffusion with evident natural value to man, and we have all the conditions necessary for domestication and cultivation, not once merely, but wherever they and the needs of man come together. A good example of all this in modern days is ginseng, which is native in Arabia, China, and the United States. The Chinese prize this plant for its medicinal properties, and as their supply is short, we are not only hunting it out of the wild in the eastern hills of our own country, but are beginning to cultivate it for export.

Miscellaneous tubers. True tubers are not plentiful. The onion is not a tuber, being the thickened base of the upright stem. Beets and carrots are not tubers, being the true top or main root greatly enlarged. Peanuts are not tubers but true seeds, this plant having the curious habit of thrusting its blossoms, after fertilization, into the earth to mature and ripen the seed under ground.

Edible Roots

As has been indicated, certain roots have the habit of storing large quantities of starch, which greatly enlarges their size and acts as food material later on. Such plants commonly act as biennials in the temperate climate, growing and storing food one year, and sending up a stem and producing seed the next.[1]

The onion (***Allium cepa***). This savory root has been known from early times. The Greeks and Romans knew several varieties, as did the Egyptians. It has also long been cultivated in the various countries of southern and eastern Asia, under various names that have no similarity or other sign of philological connection.

The species has been found wild in western Asia in various localities, ranging from Palestine to Beluchistan, a fact which seems to satisfactorily settle its eastern origin.

On the other hand, both the onion and the leek were found common in America, all of which seems to be a puzzle to Candolle, who remarks that species of the genus *Allium* are exceedingly rare in America. On this point he could not have been well informed, for if the number of related species be few, they are certainly well and widely diffused. All pioneers will testify to the early abundance of the common wild leek (*Allium tricoccum*), to the great detriment of the butter of those days,[2] as we of our own time know the wild onion of various species to be

[1] In tropical countries this seed production need not wait till the second year, but may proceed directly upon the accumulation of sufficient store of food for the rapid maturing of seed. Here all distinctions as to annual, biennial, and perennial disappear. The century plant has the same habit, except that the food material is stored in the leaves rather than in the roots, and very much more than a single year is required. It does not require, however, as the name indicates, a full century before bloom. In most cases it is probably nearer a decade.

[2] The cows running in the woods and wild pastures ate freely of the wild leeks, which often were so abundant as to give a grassy-green appearance to the forests in the early spring. This so strongly affected the milk and butter with the disagreeable flavor of the leek as often to make the product unsalable, indeed uneatable.

widely scattered. Professor Asa Gray lists seven species of *Allium* as growing wild in northeastern North America, only one of which is naturalized from Europe. May not this also be a case of multiple domestication, if the writer may coin a term to indicate what he believes to have been a common thing in the early days of civilization?

The beet (*Beta vulgaris*). Whether as a garden delicacy or a food for stock, this plant is no mean addition to our gardens and fields, but as a sugar plant it ranks as of prime importance. It is the one plant that has made sugar production possible in the temperate zones. Beginning with but 3 or 4 per cent of sugar, by careful breeding it has been raised in sugar content till whole fields average 14, and single specimens have been found above 25 per cent. This achievement is mainly the result of German enterprise, and shows what science can do when applied to the ordinary affairs of life.[1]

The beet yet grows wild in the Canary Islands and all along the Mediterranean, and as far east as Persia and Babylon. It was cultivated by the Greeks and Romans, though its varieties have been greatly increased of late; indeed, it seems to be one of these fortunate species that is growing in favor, just as salsify is as certainly dying out.

Manioc, or mandioca (*Manihot utilissima*). This plant, of great significance in tropical agriculture, would not be mentioned here except for the fact that it is almost undoubtedly another of the American, and therefore comparatively late, contributions to the agriculture of the world, and except for the further fact that it is the source of our tapioca of commerce. The arguments for its western nativity lie in the fact of its comparatively ancient cultivation in tropical America, and the further fact that the

[1] This was not the result of accident, but of deliberate determination. The Germans felt the disadvantage of depending solely on the tropics for their sugar supply, and government chemists were set at work to discover, if possible, a sugar-bearing plant that could be raised in their latitude. The result is that beet sugar can compete in price with the cane, and the quality is not only equal but identical.

forty-two known species of *Euphorbiacea*, to which the manioc belongs, are all found wild in South America, and not one of them in the Old World,[1] than which no argument is better.

The turnip (***Brassica campestris***). This old favorite of the gardens, the white turnip, and the English field swede are but different varieties of the same species. When we attempt to study them from our present standpoint they introduce some interesting facts, not the least of which are the puzzles of the botanist.

The turnip is closely related to the cabbage and cauliflower (*Brassica oleracea*), the mustard, both black and white (*Brassica nigra* and *Brassica alba*), and the rape (*Brassica napus*), so valued for sheep pasturage as to constitute in many sections a staple farm crop.

All these plants grow wild in southern Europe and Siberia, and are especially abundant in England, Holland, Sweden, Denmark, and Finland. They have evidently but recently been introduced into cultivation, which tallies well with their half-wild behavior and their tendency to develop markedly distinct varieties, as do also cauliflower, Brussels sprouts, kale, and broccoli, — all from cabbage.

Miscellaneous roots. The list of roots is not long, but is hardly of sufficient importance for detailed treatment in our limited space. The carrot and the parsnip are both of consequence, and their wild congeners are common in Europe. The radish, though a garden vegetable, is better able to maintain itself in the wild than is almost any other of our cultivated plants, as any one can testify who has had occasion to deal with it as a weed. Like the horse-radish, it is a native of Europe, where it has long been cultivated. Salsify, which grows wild along the Mediterranean, is less cultivated than formerly, and seems to be one of those plants that is being abandoned and destined to extermination unless it can maintain itself in the wild, which it seems well able to do.

[1] "Origin of Cultivated Plants," p. 62.

VEGETABLES CULTIVATED FOR THEIR FOLIAGE

Cabbage (***Brassica oleracea***). Together with its mutants, cauliflower, kale, and Brussels sprouts, etc., this useful vegetable holds a prominent place in our garden agriculture. Cabbage grows wild in the south of England and Ireland, the Channel Islands,[1] and in Denmark. Its common name is Slavic (Kab), its botanical is Keltic (Bresic), and all facts go to show that its introduction, which is recent, proceeded from northwestern Europe as a center.

Celery (***Apium graveolens***). According to Candolle, this plant grows wild in damp places over a wide area, extending from Sweden to Algeria, Egypt, and Abyssinia, and in Asia from the Caucasus to Beluchistan and the mountains of British India. It has been known to cultivation since early times, being mentioned in the "Odyssey."

Lettuce (***Lactuca scariola***). This plant, like parsley, grows wild in southern Europe, though it has a wider range, extending from the Canary Islands to Mesopotamia. It was formerly, indeed until recently, raised in the gardens by thick seeding, each plant sending up a few broad and tender leaves. Latterly, however, this plant is being raised in a headed form like cabbage, with many close-clustered leaves that become well bleached and very tender.

Asparagus. This genus includes something like one hundred and fifty species, mostly native of southern Africa and southern Europe. When used at all, it is largely for ornamental planting, but the common garden species (*Asparagus officinalis*) has been cultivated for at least two thousand years for its young and succulent stems. These stems are small in the wild, seldom

[1] Darwin states that in the island of Jersey the cabbage sends up a stalk to the height of sixteen feet. He adds that the woody stems are not infrequently ten to twelve feet in height, and are used for rafters. This makes it easy to see how the Brussels sprouts have developed, and to understand that many of the *Cruciferæ* are developed into trees. The cabbage itself is indeed a heavy shelter of broad leaves growing on a greatly shortened stem.

equaling a half inch in diameter, but in cultivation they sometimes attain the size of the wrist, with high flavor.

To these might be added such garden crops as spinach, a native of Persia, and cultivated from ancient times; New Zealand spinach (*Tetragonia expansa*), which is our only contribution from that far-off country, brought to Europe by Captain Cook; chicory, which is wild over most of Europe and in western and northern Asia, and, in both the cultivated and wild state, used as a substitute for coffee; and many others, mere mention of which would too greatly extend our space.

Plants cultivated for Beverage

Coffee (***Coffea arabica***). This favorite of the Anglo-Saxon race, and of western races generally, grows wild in Abyssinia, where it has been used from time immemorial. This does not mean, however, that it has been long under cultivation, but rather that, like ginseng, it was hunted wild and reduced to cultivation only when the native supply failed. The name indicates Arabian origin, but while a fine quality is produced in that country,[1] it has never been found truly wild. A larger and stronger-growing coffee is the Liberian coffee (*Coffea liberica*), native in that country and subjected to the same uses.

Tea (***Thea sinensis***). Whether green or black, the species is the same. Its use is of very ancient date in China, being mentioned as early as 2700 B.C. It is used both wild and cultivated in Cochin China, and the best of authorities believe it to be a native of the "mountainous region which separates the plains of India from those of China."[2]

Maté (***Ilex paraguayensis***). This plant (pronounced *mä'tā*) is a native of southeastern South America, where it has long been

[1] This is the true Mocha, a small-grained, very fine-flavored variety. The common Mocha of commerce grows, however, on the same tree with other coffee. It is simply the small round bean growing alone at the end of the twig, whereas most of the berries grow as twins, with the flat surfaces together, forming a kind of bean. Even this Mocha is superior to other berries on the same tree.

[2] "Origin of Cultivated Plants," p. 119.

used, as has tea in China, where the wild product is yet more common than the cultivated, and where great quantities are consumed, as well as exported to Europe, under the name of Paraguay tea. It makes a pleasant drink as the writer remembers it in its own country, though, of course, to one not "to the manner born" it would be considered inferior to either tea or coffee.

Plants grown for Sedative Effect

In all countries and times the human animal seems not to have been quite happy till he could either find or produce something that would work directly upon his nerves. And he does not seem yet to have entirely freed himself from what must, when considered in the light either of philosophy or of evolution, be regarded as a confession of weakness.

This craving exhibits itself in two directions: first, as a stimulant, exciting the nerves to unusual activity, giving an artificial exhilaration, followed in extreme cases by a deep lethargy, largely destitute of consciousness; and second, something to act as a sedative, dulling the sensibilities and giving a kind of soothing freedom from care which is akin to sleep, yet without loss of consciousness.

Alcohol is the one great stimulating agent, and, as was once remarked by the late Professor Steel, who had traveled extensively among the primitive peoples of many lands, no tribe is too stupid or too lazy to make at least a dilute form of alcohol by the fermentation of some kind of vegetable juice.

For the sedative effects resort is had to a variety of vegetable substances, which are widely cultivated and will continue to be, at least until man pretty generally learns that it pays best in the long run to maintain a normal existence day by day, and not to tamper with the most delicate part of his anatomy, the nerves.[1]

[1] It may be remarked in passing that the basis of *all* patent medicines is either a stimulant by the use of alcohol, or a sedative through some of the well-known materials that have a more or less pronounced stupefying effect. If the nerves are stimulated, the patient seems to have a new lease of life; if

The poppy (***Papaver somniferum***). This is the plant cultivated for its opium, which is extracted from the milky juice, and from which morphine is made. Opium produces a deliciously dreamy, half-conscious state, out of which the subject wakens with reluctance, and into which he is most likely to again submerge himself. If he surrenders to this most dangerous drug for a little time, he is most likely to turn out an "opium fiend," with little prospect for the future, for experience shows that these unfortunate people will practice the cunning of the keenest lunatic to possess themselves of the drug, when once the habit is formed.

The opium poppy is native not to China but along both shores of the Mediterranean, where it has long been cultivated, even since the time of the lake dwellers. It spread into Arabia and India, where it is eaten, not smoked, and finally reached China in the neighborhood probably of 1500 A.D. These people, with malevolent instinct, learned to smoke the drug, in which way an exceptionally strong effect is produced. To the credit of modern China the cultivation of this poppy is being prohibited.

Coca (***Erythroxylon coca***). This is a narcotic plant growing wild in the Peruvian Andes, and is chewed by the natives with a little unslaked lime, producing an effect akin to that of opium. The alkaloid cocaine, which is extracted from the leaves, is, like opium and morphine, a dangerous drug, except in the hands of the physician, and is subject to the same abuse.[1] The leaves are exported in enormous amounts (over thirty million pounds a year), more than ten million people being addicted to the use of the drug. It is not yet cultivated, so far as is known to the writer, but a demand like this will bring cultivation when the

they are dulled by a sedative, he feels soothed: in either case he feels better and buys more medicine. Such medicines are known to the trade as "repeaters," because the more is used the more is needed, and the appetite once formed is insatiable.

[1] Some of the so-called "celery compounds," patent medicines of a few years ago, depended for their effect upon cocaine as does one of the popular and widely advertised drinks of to-day.

wild supply begins to fail,[1] unless in the meantime humanity learns wisdom.

The betel. Closely akin to the above in effect is the betel nut, almost universally chewed by the natives of the Malay Peninsula and the outlying islands, as is evidenced by their blackened teeth. The first effect is exhilarating, but later lethargy ensues. Habitual users become toothless, often as early as at twenty-five years of age.

Tobacco (***Nicotiana tabacum***). This plant serves exactly the same purposes to its users as does the opium poppy, the coca, or the betel nut to theirs, except that it is less powerful. It is chewed, smoked, and snuffed ; indeed, human ingenuity seems to be exhausted in devising ways of bringing these sedatives in contact with the nerves. As in the case of opium, smoking undoubtedly succeeds in producing more complete effects than does either chewing or snuffing.

The plant is undoubtedly of American origin, though this particular species is not known in the wild state. However, it was unknown to the Old World until after the discovery of America, Arabians and others having drafted into service other similar narcotic plants from their own country, all of which were abandoned upon the introduction of the new, stronger, and therefore favorite, American narcotic.

When this country was discovered the South American Indians both chewed and snuffed,[2] while from the Isthmus north they smoked, but neither chewed nor snuffed. The use of tobacco was therefore well-nigh universal in America before it was known in the Old World. Added to this is the fact that of the fifty species of *Nicotiana*, only two are found in the Old World, leaving to America the undoubted, if doubtful, honor of supplying to the world this new and now widespread narcotic favorite.

[1] The coca must not be confused with the useful cacao (*Theobroma cacao*), native of the Amazon, from the seeds of which chocolate and cocoa are made, nor must it be taken for the equally useful coconut, which is the product of a palm that is native to the tropical regions of both the Old and the New World, and that seems to have had a wider range formerly than now.

[2] Except those of the La Plata district, which had no narcotic.

Fiber Plants

The need for clothing, covering, and cordage, beyond the available supply of wool or other animal fiber, early led to the cultivation of plants that bore fiber, either about the seed or along the stem. Of these we have quite a variety.

Cotton (***Gossypium herbaceum***). This is the one great fiber plant of the world. The seed is surrounded by a fine, strong lint, from three fourths to two and one-half inches in length. It is not so fine as silk, nor so lustrous, and, not being a continuous thread, it is not so strong, but it is an excellent substitute; especially is this true of some of the new long-staple varieties.

Common cotton is native to southeastern Asia, whence its cultivation seems to have spread to China in the ninth or tenth century, to Greece and southern Europe in the time of Alexander, and thence to the United States, where it arrived something less than one hundred and fifty years ago.

Aside from all this, supported alike by botany, history, and philology, the remarkable fact remains, that when America was discovered cotton was found under cultivation in the West India Islands, from Mexico to Peru, and in Brazil. The species is considered to be different (*Gossypium barbadense*), though it has the same yellow flowers with red centers. The famous sea-island or long-staple cotton is considered as a strain of *G. barbadense*, rather than of *G. herbaceum*, which, however, covers the principal varieties of cotton raised in the states.

With us the cotton plant is a true annual, requiring reseeding every year, but in warmer countries it may live for a number of years, attaining of course considerable size.[1]

Flax (***Linum usitatissimum***). This is a most useful plant, now grown not only for its fiber, but for its seed, as a source of oil[2]

[1] At Para the writer "climbed into" a "cotton tree" about twelve feet high and several years old.

[2] This is the linseed of commerce, used in painting. Linseed meal is the ground seed before the oil is extracted, while linseed cake and oil cake are the residue after the oil is removed. Both are excellent feed.

and as stock food. Flax has been grown from the greatest antiquity. It was a great crop with the Hebrews and the ancient Hindus. The mummy wrappings of the Egyptian tombs were of linen. Flax has been found in a tomb of ancient Chaldea, older than the city of Babylon. The lake dwellers of Switzerland made use of it, and all evidence goes to show that it is one of the oldest of cultivated plants, hoary with age as it is heavy with honors.

The flax of the lake dwellers appears to have been the perennial species, *Linum augustifolium*, which is yet wild in the Mediterranean region, but was later displaced by the annual species, *Linum usitatissimum*, which has been cultivated for at least four or five thousand years, and is yet wild in the regions lying between the Persian Gulf and the Black Sea. Manifestly this is a species that has been so long cultivated, and one that so easily maintains itself in the wild, that its present range would be little guide to its original habitat, so that we cannot say with confidence to what country we owe the debt for flax.

Hemp (***Cannabis sativa***). This strongest of the fiber plants exists in two distinct forms, the male and the female, each a separate plant. This, too, is an old friend, dating as a cultivated plant from at least 1500 B.C., or before the Trojan War. Hemp is wild from southern Russia in the neighborhood of the Caspian, eastward to the desert of Kirghiz, beyond Lake Baikal.[1]

Besides the cotton, flax, and hemp we have jute, an old but not ancient fiber plant, widely scattered over the world; also manila, which is the trade name for the product of a fibrous banana of the Philippines, *Musa textilis*. Besides these, the coconut palm yields a fiber much used in the manufacture of matting, and that of another palm is used for the coarser qualities of brushes, and occasionally for brooms.

[1] The student is referred to "Origin of Cultivated Plants" and to contemporaneous literature for further information upon our fiber plants, whose history is one of the most interesting chapters in the development of the wild.

Ornamental Plants

Along with utility goes beauty, and the human animal has long surrounded his habitation with such flowering and other ornamental plants as happened to strike his fancy. The list is indefinitely long and the species are exceedingly varied. Whether for flower, fruit, or foliage, the number and variety of plants that minister to beauty are bewildering, and both are being rapidly increased by breeding.

Here is a world of beauty and of interest, not only to the artist but to the breeder, into which we can only glance and catch a glimpse in passing. We all admire the grace and fragrance of the rose, as well as its variety of form and color, ranging from the stately American Beauty of the hothouse to the delicate moss rose of the garden. This admiration is increased to wonder when we realize that they have all developed from the common wild rose that clambers over our fences and brightens our hedges in all the eastern United States, and that planted a multitude of bright eyes in the western prairies long before man was there to see.[1]

There is no more fascinating work than the bringing out of new forms of plant beauty, and young men and women who have the artistic sense developed, will find much in this realm of nature to stimulate to still further appreciation of the beautiful, and to show what may be done with the materials which the All-Father has placed in our hands, and the great principles with which he has taught us to work.

Weeds

Just as certain species of animals have attached themselves to us and our affairs without invitation, and continue without welcome, so have certain species of plants invaded our fields and gardens, quite against our desires and greatly to our

[1] Showing the mistake of the notion that all beauty was made expressly for man's enjoyment.

inconvenience and expense. We call them weeds.[1] Their domestication is not of our choosing but of their own making, and it has come about in any case because their individual requirements fitted almost perfectly with those of some other species which we were trying to domesticate and produce in quantity.

For example, chess (*Bromus secalinus*) is a plant having the same soil and seasonal requirements as wheat, though of a distinctly different genus. The seeds are near enough alike, however, to be separated with great difficulty ; hence some chess is nearly always sown with wheat. The chess plant is much hardier and much more prolific[2] than the wheat, so that if the two were thrown together, the chess would soon take the ground.

As it is, if anything happens to the tender wheat, as in winter killing, there is generally enough chess at hand to make a showing, even with less than two hundred spears to the stool, giving rise to the absurd belief that the wheat has "turned to chess."

Every weed has some natural advantage, generally arising in the crop conditions with which it most easily and naturally associates, and here is the vulnerable point of attack for its extenuation.

Weeds, of course, came out of the wild, and most of them still exist in the wild in the same regions which they infest as weeds. This is true of such as cocklebur, Canada thistle, quack grass,[3] etc., but others, like cockle and chess, are not found except in association with growing crops ; that is to say, they do not readily escape from cultivation.

The behavior of a weed upon first introduction is little indication of what its subsequent history will be. Wild lettuce, for example, spread over the western United States a few years

[1] The best definition for a weed is "a plant out of place."

[2] The writer once counted two hundred and four species of chess, each bearing a full "head" and all springing from a single root originating from a single seed.

[3] These weeds, however, are not, in most cases, truly wild, but have been "introduced" and afterwards have "run wild" like feral animals.

ago, to the great alarm of everybody, and nothing seemed able to stop it; but in a very few years it subsided, apparently of its own accord, and within a few more was practically extinct. Others "come and go" with the seasons, just as white clover is abundant in a wet season and then unnoticed perhaps for many years. It is still there, but is inconspicuous until conditions become peculiarly favorable. Still others are always with us, always a menace to the valuable cultivated crops, always ready to rob the land of its fertility and its moisture, and the farmer of his profits.

Exercises. 1. Make a list of wild plants in the neighborhood that are related to domesticated species.

2. Discuss the question whether any wild plants of the neighborhood could be made of economic use to man.

3. Make a herbarium of leguminous plants, taking care to preserve the flowers, the fruits, and the tubercles. These latter are difficult to secure. If the plant is pulled up, they will be stripped off. The plant should be carefully lifted out with a spade, and the earth should be removed by gentle shaking and then washing in a generous quantity of water.

4. Secure a small plat or field near the schoolhouse on which to raise different varieties for study and comparison.

5. Compare the pistils and the pollen-bearing parts of corn with those of Kafir corn, clover, beans, and alfalfa.

6. Raise some hemp, in order to note the difference between the "male" and the "female" plants. If hops are grown in the neighborhood, note same with them.

7. Write the story of the domestication of the American grape. For data see "Evolution of our Native Fruits," by Bailey.

8. What wild plants in your neighborhood might, in your judgment, make valuable plants in cultivation?

References. 1. "Origin of Cultivated Plants" (from which the data of this chapter are largely taken). De Candolle.

2. "Animals and Plants under Domestication" (Vol. I, chaps. ix and x). Darwin.

3. "Evolution of our Native Fruits." Bailey.

4. A good collection of seedsmen's catalogues, which is the best guide to new things.

APPENDIX

STOCK JUDGING

To be able to tell at sight a good animal from a poor one is a valuable qualification to the farmer and indispensable to the breeder. It is also good practice for the student to learn the art.

The best way to begin this study is by directing the attention definitely to different "points" of the animal and give them careful study, one at a time, guided in this study by some recognized standard.

Such a standard is known as a "scale of points," and to facilitate this work some standard scales are given for the students' use.

In practice these score cards should be copied on sheets and each animal "scaled" separately, after which the markings of different animals should be compared, as should also the work of different students upon the same animal.

It is for this work that the neighborhood supply of animals should be drawn upon, and perhaps nothing that can be done will tend so much to bring the school and the community together.

Besides all this there is no better way of teaching accuracy of observation than by the means of stock judging. The untrained observer sees the animal as a whole, but the student soon learns to separate the individual into separate characters or "points," and he learns thereby not only to recognize details, but also that animals, like people, may be partly good and partly bad. Altogether this line of work is commended to the schools and to the young.

STUDENT'S SCORE CARD

HEAVY HORSES

Scale of Points	Perfect Score	Student's Score	Corrected Score
Age, years			
Height, hands			
Weight, pounds			
Score according to breed	3		
Form, according to breed, broad, massive, — symmetrical	6		
Condition, carrying a good amount of firm flesh	2		
Quality: bone moderately heavy, clean, firm, and indicating sufficient substance, tendons well defined, hair and skin fine	5		
Color, according to breed	1		
Temperament, quiet, yet energetic	3		
Head, medium in size, not coarse, and showing character	2		
Muzzle, fine, nostrils large; lips thin, even; teeth sound	1		
Eyes, large, full, bright, clear	1		
Forehead, broad and full	1		
Ears, medium size, pointed; well carried and not far apart	1		
Neck, medium length and clean-cut, well muscled; crest well developed and nicely arched; throat latch fine; windpipe large; tapering from shoulder to head, and head attached at proper angle	2		
Shoulder, oblique, long, smooth, and covered with muscle extending into back; withers well finished at the top	3		
Arm, short, well muscled, elbow lying close to the body	2		
Fore legs, viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern, and foot. From the side a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joint and back of the hoof	3		
Forearm, heavily muscled, long, wide, and tapering from elbow to knee	2		
Knees, large, clean, wide, straight, and strongly supported	1		
Cannons, short, wide, clean; tendons large, set well back, not tied in below the knee	2		
Fetlocks, wide, straight, strong, free from puffiness	1		
Pasterns, strong, of medium length, angle with the ground 45°	2		
Feet, straight, medium size, even; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high; hoof head large	5		
Chest, deep, low, girth large, width of breast in proportion with other parts	5		
Ribs, long, well sprung	3		
Back, straight, short, broad, well muscled	3		
Loin, wide, short, thick, and neatly joined to hips	2		

STUDENT'S SCORE CARD (Continued)

HEAVY HORSES (Continued)

Scale of Points	Perfect Score	Student's Score	Corrected Score
Underline, long, flank low	1		
Hips, smooth, level, width in proportion with other parts, but not prominent	2		
Croup, long, wide, muscular	2		
Tail, attached high, well carried, well haired with straight and not too coarse hair	1		
Thighs, long, muscular, thick and wide, well muscled over stifle	3		
Quarters, heavily muscled, deep	2		
Hind legs, viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern, and foot. From the side a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	4		
Gaskins or lower thighs, wide, well muscled	1		
Hocks, large, strong, clean, and well defined, free from puffiness, coarseness, and curbiness	4		
Cannons, short, broad, flat, and clean, tendons large and set back, not too light below the hock	2		
Fetlocks, large, wide, straight, strong, free from puffiness	1		
Pasterns, strong and of medium length and obliquity, not so great as fore pasterns	1		
Hind feet, straight, medium size, even; smaller, and not so round as fore feet; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high	4		
Action, walk elastic, quick, balanced; step long	6		
Trot rapid, straight, regular, high; should not wing or roll in front, or go wide or too close behind . . .	4		
Total	100		

Animal . . . .

Student's Name . . . . Date . . . .

STUDENT'S SCORE CARD

LIGHT HORSES

Scale of Points	Perfect Score	Student's Score	Corrected Score
Age, years			
Height, hands			
Weight, pounds			
Score according to breed	1		
Form, according to breed, symmetrical, smooth, and stylish	5		
Condition, carrying a moderate amount of firm flesh	1		
Quality: bone clean, firm, and indicating sufficient substance; tendons well defined; hair and skin fine	3		
Color, according to breed	1		
Temperament, spirited, yet docile	2		
Head, not too large and showing character, features well defined and regular	2		
Muzzle, fine, nostrils large; lips thin, even; teeth sound	1		
Eyes, large, full, bright, clear	1		
Forehead, broad and full	1		
Ears, medium size, pointed, well carried and not far apart	1		
Neck, rather long, clean-cut, well muscled, tapering from shoulder to head and head attached at proper angle; crest well developed and nicely arched; throat latch fine; windpipe large	2		
Shoulder, oblique, long, smooth, and covered with muscle extending into back; withers well finished at the top	4		
Arm, short, well muscled, elbow lying close to the body	2		
Fore legs, viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern, and foot. From the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joint and back of the hoof	3		
Forearm, well muscled, medium length, wide and tapering from elbow to knee	2		
Knees, large, clean, wide, straight, and strongly supported	1		
Cannons, medium length, wide, clean; tendons large, set well back, not tied in below the knee	2		
Fetlocks, wide, straight, strong, free from puffiness	1		
Pasterns, strong, of medium length, angle with the ground 45°	2		
Feet, straight, medium size, even; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high; hoof head large	5		
Chest, deep, low, girth large, width of breast according to class	5		
Ribs, long, well sprung	4		
Back, straight, short, broad, well muscled	3		
Loin, wide, short, thick and neatly joined to hips	2		

STUDENT'S SCORE CARD (Continued)

LIGHT HORSES (Continued)

Scale of Points	Perfect Score	Student's Score	Corrected Score
Underline, long	1		
Hips, smooth, level, width in proportion with other parts, but not prominent	2		
Croup, long, wide, muscular, not drooping	2		
Tail, attached high, well carried, well haired with straight and not too coarse hair	1		
Thighs, long, muscular, thick, and wide, well muscled over stifle	3		
Quarters, heavily muscled	1		
Hind legs, viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern, and foot. From the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	4		
Gaskins or lower thighs, long, wide, well muscled	1		
Hocks, strong, clean, and well defined, free from puffiness, coarseness, and curbiness	4		
Cannons, medium length, broad, flat, and clean; tendons large and set back; not too light below the hock	2		
Fetlocks, large, wide, straight, strong, free from puffiness	1		
Pasterns, strong and of medium length, obliquity not so great as fore pasterns	1		
Hind feet, straight, medium size, even; smaller, and not so round as fore feet; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high	4		
Action, walk elastic, quick, balanced; step long	4		
Trot rapid, straight, regular, high; should not forge, wing, or roll in front, or go wide or too close behind	12		
Total	100		

Animal . . . .

Student's Name . . . . Date . . . .

STUDENT'S SCORE CARD

DAIRY CATTLE

Scale of Points	Perfect Score	Student's Score	Corrected Score
INDICATING MILKING QUALITIES, THIRTY POINTS			
Udder, capacious, full and attached high at the back, extending well forward; quarters evenly developed, preferably free from fleshiness (omit for male) . . .	14		
Teats, uniform, of convenient size and length, placed well apart, of nearly equal diameter from base to point, free from lumps, warts, extra orifices, or leakage throwing clean streams with reasonable pressure (rudimentary in male)	6		
Milk veins, large, tortuous, and much branched; milk wells large	4		
Rump, broad at both hip and pin bones, indicating pelvic capacity	3		
Temperament, inherited tendency of dairy function . .	3		
INDICATING FEEDING QUALITIES, THIRTY POINTS			
Barrel, long, deep, full at paunch, with plenty of space between last rib and point of hip	10		
Bone, medium, as indicated by clean face and legs with smooth joints, short cannons, and long, slim tail. Extreme fineness undesirable	3		
Withers, narrow, smooth over top, not higher than rump	3		
Muzzle, wide, full lips	2		
Face, broad between eyes, flat or dished, not bulging .	2		
Eye, full, clear, quiet, set well forward, not in side of head	2		
Neck, medium to thin on top, and fair length (thicker in males and crested with age)	1		
Throat, clean	1		
Dewlap, light	1		
Handling, skin medium thick, mellow, loose, not hard or papery; hair fine and soft, not wiry; inside of ears furry; switch long and silky	5		
INDICATING CONSTITUTION AND GENERAL HEALTH, TWENTY-FIVE POINTS			
Chest, deep and full, showing plenty of lung capacity, wide on the floor and full at the elbows	8		
Legs, straight, neither knock-kneed nor sickle-hocked .	2		
Back, straight, sometimes drooping with age	2		
Pasterns, short, strong, and upright	2		
General appearance, thrifty and vigorous	5		
Carriage, active but not nervous	6		
SYMMETRY, FIFTEEN POINTS			
The proper balance between the different parts of the animal's body, including general neatness and smoothness of form; in males greater relative development of shoulders, neck, and head	15		
Total	100		
Other particulars in which cows vary are not listed above because their connection with milk production is questionable, or at least not understood; for example, the escutcheon, rudimentaries, color, etc. **Weight**, estimated . . pounds; actual . . pounds.			

Animal . . . .

Student's Name . . . . Date . . . .

STUDENT'S SCORE CARD

BEEF CATTLE. BREEDING STOCK

Scale of Points	Perfect Score	Student's Score	Corrected Score
GENERAL APPEARANCE, FORTY POINTS			
Weight, estimated . . pounds; actual . . pounds. According to age	10		
Form, straight top line and underline, deep, broad, low-set, stylish	10		
Quality: firm handling; fine hair; pliable skin; dense, clean bone; evenly fleshed without ties or rolls	10		
Condition, deep even covering of firm flesh, especially in region of valuable cuts	10		
HEAD AND NECK, SEVEN POINTS			
Muzzle: mouth large; lips thin; nostrils large	1		
Eyes, large, clear, placid	1		
Face, short, quiet, expressive	1		
Forehead, broad, full	1		
Ears, medium size, fine texture	1		
Neck, thick, short; throat clean	2		
FORE QUARTERS, NINE POINTS			
Shoulder vein, full	2		
Shoulder, covered with flesh, compact on top, snug	3		
Brisket, advanced, breast wide	1		
Dewlap, skin not too loose and drooping	1		
Legs, straight, short, arm full; shank fine, smooth	2		
BODY, THIRTY POINTS			
Chest, full, deep, wide; girth large; crops full	4		
Ribs, long, arched, thickly fleshed	8		
Back, broad, straight	8		
Loin, thick, broad	8		
Flank, full, even with underline	2		
HIND QUARTERS, FOURTEEN POINTS			
Hip, smoothly covered; distance apart in proportion with other parts	2		
Rump, long, wide, even; tail head smooth, not patchy	2		
Pin bones, not prominent, far apart	1		
Thighs, full	3		
Twist, deep, plump, indicating fleshiness	4		
Legs, straight, short, shank fine, smooth	2		
Total	100		

Animal . . . .

Student's Name . . . . Date . . . .

STUDENT'S SCORE CARD

BEEF CATTLE. MARKET STOCK

Standard of Excellence	Perfect Score	Student's Score	Corrected Score
Weight, estimated . . pounds; actual . . pounds. According to age	10		
Form, straight top and underlines, deep, broad, low-set, compact, symmetrical	10		
Quality: hair fine; bone fine but strong; skin pliable; mellow, even covering of firm flesh, especially in region of valuable cuts; absence of ties and rolls	10		
Condition, prime; flesh deep; evidence of finish especially marked in cod, at tail head, flank, shoulder, and throat; absence of bunches, patches, or rolls of fat	10		
Head, clean, symmetrical; quiet expression; mouth and nostrils large; lips moderately thin; eyes large, clear, placid; face, short; forehead broad, full; ears medium size, fine texture	5		
Neck, thick, short, tapering neatly from shoulder to head; throat clean	2		
Shoulder vein, full	2		
Shoulder, well covered with flesh, compact	3		
Brisket, full, broad, but not too prominent; breast wide .	1		
Dewlap, skin not too loose and drooping	1		
Chest, deep, wide, full	1		
Crops, full, thick, broad	3		
Ribs, long, arched, thickly fleshed	8		
Back, broad, straight, thickly and evenly fleshed	8		
Loin, thick, broad, thickness extending well forward . .	8		
Flank, full, low, thick	2		
Hips, smoothly covered; width in proportion with other parts, but not prominent	2		
Rump, long, level, wide and even; tail head smooth, not patchy	2		
Pin bones, not prominent; width in proportion with other parts	1		
Thighs, full, fleshed well down to hock	3		
Twist, deep, full; purse in steers full	4		
Legs, straight, short; arm full; shank fine, smooth . . .	4		
Total	100		

Animal . . . .

Student's Name . . . . Date . . . .

STUDENT'S SCORE CARD

FAT HOGS. MARKET STOCK

Standard of Excellence	Perfect Score	Student's Score	Corrected Score
Weight, pounds			
Form, long, deep, broad, low-set, symmetrical, compact, standing squarely on legs	7		
Condition: thrifty, well fleshed, fat but firm	12		
Quality: hair fine; bone fine but strong; skin smooth; even covering of firm flesh, free from lumps and wrinkles	10		
Style, attractive	1		
Action, spirited, straightforward, regular, free and easy	2		
Constitution, chest capacious; brisket advanced and low; flanks full and well let down	5		
Coat, abundant, fine, straight, bright, smooth, evenly distributed, lying close to body	0.5		
Snout, medium length, not coarse	0.5		
Eyes, full, bright, not obscured by wrinkles	0.5		
Face, broad between eyes and ears, smooth	0.5		
Ears, fine texture, medium size, neatly attached	0.5		
Jowls, smooth, firm, medium size, not pendulous	1		
Neck, short, deep, thick, joining head to shoulders smoothly	2		
Shoulders, deep, full, compact, smooth, not too heavy	7		
Back and loin, long, broad, strong, even width, thickly and evenly fleshed	15		
Sides, long, deep, full, even width, free from wrinkles and flabbiness; ribs long, carrying fullness well down	12		
Belly, straight, even, not flabby, proportionate in width	2		
Rump, long, wide, even width, thickly and evenly fleshed, rounding from loin to root of tail, not too drooping	5		
Hams, broad, especially at upper end, deep, full, well fleshed and plump, not too fat	12		
Legs, straight, strong, tapering, medium length, set well apart; bones smooth; joints clean; pasterns upright; feet medium size, not sprawling, squarely placed	4		
Tail, medium in size and length, smooth, tapering, not set too low	0.5		
Total	100		

Animal . . . .

Student's Name . . . . Date . . . .

The preceding score cards are made from the standpoint of utility and without reference to breed characters. They are in actual use for class work. In addition to this some breeders' associations have adopted a special scale of points designed to bring out the distinctive characters or points in the breed. Two of the many are here given as samples. It will be noticed that in these latter much attention is given to matters of appearance as distinct from utility.

SCALE OF POINTS FOR JERSEY COWS

	Counts
HEAD, SEVEN POINTS	
A. Medium size, lean; face dished, broad between eyes and narrow between horns	4
B. Eyes full and placid; horns small to medium, incurving; muzzle broad, with muscular lips; strong under jaw	3
NECK, FIVE POINTS	
Thin, rather long, with clean throat; thin at withers	5
BODY, THIRTY-THREE POINTS	
A. Lung capacity, as indicated by depth and breadth through body, just back of fore legs	5
B. Wedge-shaped, with deep, large paunch; legs proportionate to size and of fine quality	10
C. Back straight to hip bones	2
D. Rump long to tail setting and level from hip bones to rump bones	8
E. Hip bones high and wide apart; loins broad, strong	5
F. Thighs flat and well cut out	3
TAIL, TWO POINTS	
Thin, long, with good switch, not coarse at setting-on	2
UDDER, TWENTY-EIGHT POINTS	
A. Large size and not fleshy	6
B. Broad, level, or spherical, not deeply cut between teats	4
C. Fore udder full and well rounded, running well forward of front teats	10
D. Rear udder well rounded, and well out and up behind	8
TEATS, EIGHT POINTS	
Of good and uniform length and size, regularly and squarely placed	8
MILK VEINS, FOUR POINTS	
Large, tortuous, and elastic	4
SIZE, THREE POINTS	
Mature cows, 800 to 1000 pounds	3
GENERAL APPEARANCE, TEN POINTS	
A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail	10
Total	100

SCALE OF POINTS FOR HOLSTEIN-FRIESIAN COWS

	Points
Head, decidedly feminine in appearance; fine in contour	2
Forehead, broad between the eyes, dishing	2
Face, of medium length; clean and trim, especially under the eyes, showing facial veins; the bridge of the nose straight; the muzzle broad	2
Muzzle, broad with strong lips	1
Ears, of medium size, and fine texture; the hair plentiful and soft; the secretions oily and abundant	1
Eyes, large, full, mild, bright	2
Horns, small, tapering finely towards the tips, set moderately narrow at base, oval, inclining forward, well bent inward, of fine texture, in appearance waxy	1
Neck, long, fine and clean at juncture with the head, free from dewlap, evenly and smoothly joined to shoulders	4
Shoulders, slightly lower than hips, fine and even over tops, moderately broad and full at sides	3
Chest, of moderate depth and lowness, smooth and moderately full in the brisket, full in the fore flanks (or through the heart)	6
Crops, moderately full	2
Chine, straight, broadly developed, open	6
Barrel, wedge-shaped, well rounded, with a large abdomen, trimly held up (in judging the last item age must be considered)	7
Loin and hops, broad, level or nearly level between the hook bones, level and strong laterally, spreading from chine broadly and nearly level, with hook bones fairly prominent	6
Rump, long and high, broad with roomy pelvis, nearly level laterally, comparatively full above the thurl	6
Thurl, high, broad	3
Quarters, deep, straight behind, roomy in the twist, wide and moderately full at the sides	4
Flanks, deep, comparatively full	2
Legs, comparatively short, clean and nearly straight, wide apart and firmly and squarely set under the body; feet of medium size, round, solid, and deep	4
Tail, large at base, the setting well back, tapering finely to switch, the end of the bone reaching to hocks or below; the switch full	2
Hair and handling, hair healthful in appearance, fine, soft, and furry; the skin of medium thickness and loose, mellow under the hand; the secretions oily, abundant, and of a rich brown or yellow color	8
Mammary veins, very large, very crooked (age must be taken into consideration in judging of size and crookedness), entering very large or numerous orifices, double extension, with special developments such as branches, connections, etc.	10
Udder, very capacious, very flexible; quarters even; nearly filling the space in the rear below the twist, extending well forward in front, broad and well held up; teats well formed, wide apart, plumb, and of convenient size	12
Teats	2
Escutcheon, largest, finest	2
Perfection	100

GLOSSARY

In the following glossary of terms used in the text and the references no attempt is made to furnish exact definitions. The purpose has been rather to supply the secondary-school student with an adequate working idea of the meaning of the terms as commonly employed, maintaining at the same time scientific accuracy, without aiming to attain that exhaustive discrimination which might be demanded by the highly specialized student.

Accessory chromosome. That particular chromosome which, at least in certain species, has its mate in the female but not in the male, and which is therefore supposed to be associated with the determination of sex.

Acquired character. Modification of hereditary characters due to environment or habits of life.

Adaptation. The "fit" which is brought about between the environment and the species. See Natural selection and Survival of the fittest.

Advanced registry. A registry based on performance and not simply upon pedigree.

Ancestry. Those members of past generations that are related to any given individual by descent.

Average deviation. A mathematical expression measuring variability obtained by averaging the deviation of all individuals from the mean of the race or population.

Breed. A definite variety or strain of animal bred to a special type.

Breeding. The intelligent combining of known blood lines in either animal or plant production. Specifically, also, the mating of animals.

Biophore. A term used by Weismann (pronounced *Viseman*) to denote the smallest conceivable unit of living matter.

Castration. The removal, by the knife, of the testicles of the male, thus preventing reproduction.

Character. Any trait, faculty, or physical feature of the individual or species that can be identified and more or less accurately described.

Characters, dominant. The more prominent of two mutually exclusive characters, and which therefore characterize three fourths of the offspring of hybrid parents.

Characters, latent. Those racial characters that remain undeveloped and therefore unnoticed in a given individual, but which may appear in his descendants because belonging to the ancestry.

Characters, recessive. The less conspicuous of two characters which are mutually exclusive, and which therefore characterize but one fourth of the offspring of hybrid parents.

Chromomeres. See Chromatin granules.

Chromosomes. The dots, rods, rings, or other bodies that exist in definite numbers in the nucleus and that derive their name from the readiness with which they assume color under the various staining reagents employed by biologists to bring out structural differences under the microscope.

Chromatin granules. The minute granular masses of which the chromosomes appear to be composed; synonymous with chromomeres.

Cross breeding. Synonymous with crossing.

Crossing. The fertilizing of one species by the male of another species, race, or variety. Synonymous with cross breeding.

Cytoplasm. The cell contents that surround the nucleus.

Degenerate. The individual which has inherited in strong degree the worst characters of his race with few or none of the best, though he may have one or more exceptional faculties.

Determinant. Such an association of ids (Weismann) as may be able to fix the character of a part in its development.

Development. Progressive change; specifically the appearance of racial characters in the individual as growth proceeds.

Differentiation. The appearance of distinctly differing organs and parts during and after embryonic development.

Dominant characters. See Characters, dominant.

Dwarf. The individual in which the process of growth has been arrested abnormally early. See Giant.

Embryo. The fertilized ovum after growth and differentiation begin.

Embryonic development. Growth and differentiation of the embryo.

Environment. The conditions of life as a whole, both good and bad, that surround the individual or the species, by which it may be either benefited or oppressed, but with which it must live and compete.

Eugenics. The doctrine that human beings should be well born by attention in marriage to the well-known facts of heredity.

Evolution. The theory that species originate by development from other and preëxisting species by means of more or less gradual modifications either through crossing or the influence of the environment, or both; over against the older theory that each species was specially and separately created, and that it remains unchanged and unchangeable.

Fetus. The more or less perfectly developed embryo before birth.

Gamete. A reproductive cell either male or female.

Genetics. The science of breeding from the standpoint of the transmission of hereditary characters without regard to the influence of environment.

Germ plasm. Reproductive or sex cells in general, without reference to sex.

Germinal matter. Synonymous with germ plasm.

Giant. The individual in which cell division and growth have proceeded beyond the normal. See Dwarf.

Grading. Breeding scrub or unpedigreed stock to registered males.

Heredity. The transmission of racial characters from ancestry to offspring.

Hybrid. The offspring of hybridization, carrying the blood of two or more species or races.

Hybridizing. That kind of crossing in which the male and female are of different species or of distinctly different races.

Id. A term used by Weismann to denote an orderly and definite association of biophores operating together towards the determination of a definite character.

Latent characters. See Characters, latent.

Mammals. Certain species of higher animals in which the fertilized ovum is retained and embryonic development takes place inside the body of the mother until birth; specifically, those species which suckle the young.

Maturation. The final stages of division in sex cells just before attaining the conditions suitable for fertilization.

Mean. The average.

Mendel's law. The law which states the way in which racial characters will be distributed among the offspring of hybrid parents.

Methodical selection. The imitation by man of the operation of natural selection as he attempts to secure the favorable development of especially desirable characters in domesticated animals and plants.

Mimicry. The resemblance of one species to another or to some natural object in such a way as to be protective against possible enemies.

Mitosis. The process of cell division in ordinary growth. See also Maturation.

Mode. The most common or typical value of a racial character.

Mutant. An individual or strain essentially new and produced spontaneously by nature through crossing, bud variation, or otherwise; synonymous with the older term "sport."

Mutation. The production of mutants or sports, which see.

Natural selection. The oppressive effect of the environment by which many individuals are unable to endure, and which therefore operates to destroy a large proportion of the race. Those which are able to endure the hard features of the environment not only survive, but, prospering by other conditions, are said to be *selected* in this natural way.

Nucleus. That part of the cell which contains the chromosomes, which takes the lead in cell division, and which seems normally to be equally divided between the daughter cells, whether in ordinary growth or in maturation.

Ovary. The organ in which the ova or female reproductive cells develop.

Oviporous. Said of species which lay eggs in which, like birds, the embryonic development takes place outside the body of the mother by the process of hatching.

Ovule. The female sex cell of the higher plants, which, upon fertilization by the pollen cell, is capable of developing into a new plant.

Ovum. The animal female sex cell, which, when fertilized by the male sex cell, is capable of developing into a new individual. Plural, *ova*.

Pedigree. The ancestry of an animal or plant; especially the list of the names and registry numbers.

Pedigree register. The official publication in which pedigrees are printed, each breed having its own.

Physiological unit. A term used by Galton and others to denote those ultimate particles of living matter that determine characters, covering the same general conception that later was covered by Weismann with his more minute distinctions of biopheres, ids, and determinants.

Pollen. The male sex cells of higher plants.

Pollen grain. A single cell of pollen.

Progression. Advance as measured by the ancestry.

Protective coloring. Any color effects which, by mimicry or otherwise, make the animal less conspicuous.

Protoplasm. Living matter in general.

Pure breeding. Mating only registered animals together. Coming to be used also in plant breeding.

Pure bred. An animal or plant whose ancestry is registered on both sides.

Recessive characters. See Characters, recessive.

Reduction. The halving of the characteristic number of chromosomes during the process of maturation.

Registration. The filing for print with the officers of a breeding association of the pedigree of a pure-bred animal.

Regression. The tendency of individuals toward the mean of the race, whether the immediate parentage be better or inferior to the average.

Reversion. An instance in which the offspring resembles a remote ancestor more closely than it does the immediate parent.

Score card. A scale of points upon which breeds or individuals may be assessed and judged, character by character and point by point.

Scrub. An animal that has little or no pure blood in its ancestry.

Selection. In general, the limiting of reproduction to certain favored individuals, either by nature or by man.

Selection, methodical. The selective process as carried on by man in order to accomplish changes especially desired by him. See Methodical selection.

Selection, natural. The selective process as determined by the environment. See Natural selection.

Spaying. The removal of the ovaries of the female, thus preventing reproduction.

Spermatozoön. The male sex cell among higher animals. Plural, *spermatozoa*.

Sport. See Mutant.

Standard deviation. A mathematical measure of variability the same as average deviation, except that the several deviations are squared in determining its value. See Average deviation.

Survival of the fittest. The triumph of those individuals which are able to compete successfully with the environment.

Testis. The organ in which the spermatozoa or male reproductive cells develop. Synonymous with testicle. Plural, testes.

Thoroughbred. The name of the English running horse, often improperly used for pure bred.

Thremmatology. The science and practice of improving domesticated animals and plants.

Throwing back. Synonymous with reversion.

Type. The most usual form of a character or of an individual; also used for the form that is desired in attempted improvement.

Unit character. The smallest element that physiologically tends to behave more or less independently in the formation of plant or animal characters.

Unregistered stock. Animals that are undoubtedly of pure breeding but whose pedigrees have been neglected or lost.

Use and disuse. The effect of use or disuse upon the development of an hereditary character and its consequent retention or loss by the individual or race.

Uterus. The female part in which the embryo develops and from which it separates at birth. Synonymous with womb.

Variation. The fact that individuals of the same race and breeding are not alike, but differ more or less among themselves.

Zygote. A united pair of reproductive cells.

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[1] References to figures are indicated by an asterisk, as 189*.

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