THE CORNELL READING COURSE
FOR THE FARM

PUBLISHED BY THE NEW YORK STATE COLLEGE OF AGRICULTURE
AT CORNELL UNIVERSITY, ITHACA, NEW YORK
A. R. MANN, DIRECTOR OF EXTENSION SERVICE

LESSON 144 THE PLANT SERIES APRIL, 1919

HOW THE PLANT PRODUCES SEED

L. W. SHARP

Published and distributed in furtherance of the purposes provided for in the
Act of Congress of May 8, 1914

THE CORNELL READING COURSE FOR THE FARM

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"No other human occupation opens so wide a field for the profitable and agreeable combination of labor with cultivated thought as agriculture."—ABRAHAM LINCOLN.

The increased area for world food production in 1919 indicates that New York farmers should return to sound permanent systems of farming. The combination of cultivated thought with labor not only is agreeable but results in efficiency in farming, which makes profits possible when price levels are becoming lower. The State College of Agriculture offers lessons for home study free to residents of New York State. The reader may obtain consecutive instruction on the subjects in which he is interested, and also the new lessons as issued. The attached discussion paper gives further information.

The reading-course lessons for the farm are elementary and brief, and are intended to arouse a desire for additional knowledge. Advanced reading courses in farm crops, fruit growing, and vegetable gardening, provide more complete instruction in accordance with modern correspondence methods. Reports on the reading and practical exercises are corrected, graded, and returned to the reader with suggestions from specialists. The only expense in each advanced reading course is the cost of a textbook and practice material.

The reading-course lessons make useful material for educational programs in granges and other local organizations. In a number of communities groups have organized for the discussion and study of common problems and have adopted the name *Cornell Study Club*. This may be done in connection with an existing organization or independently. Assistance is given in organizing and conducting Cornell study clubs.

Correspondence is a medium for the exchange of helpful information. Letters will receive careful attention.

HOW THE PLANT PRODUCES SEED

L. W. Sharp

Every one is familiar with the fact that the production by the plant of seed and fruit follows the appearance of the flower. This publication discusses the connection between these two phenomena and shows how flowering leads to the production of seed and fruit. Before taking up such a discussion, however, attention must be given to two other matters of general biological importance. The first of these pertains to the cell; the second is the fact of sexuality in plants.

THE CELL

When a person looks at a brick building a half mile or more away, he can make out its general shape, its windows and other conspicuous features, but any smaller details of structure are wholly invisible. If he moves up close to the building and so gets a much enlarged view of it, he sees a large number of small units, the bricks, which are arranged in definite ways and, together with other materials, make up the building.

A similar comparison may be made in the case of the plant. If a portion of a plant, a leaf for example, is examined, its general form and certain gross features of its structure, such as stalk, blade, and veins, can be seen. Further than this nothing definite can be made out with the naked eye; the leaf, like the building viewed from a distance, appears to be "all of one piece." If, however, the leaf is examined with a microscope of sufficient power, it will be found to be composed of an immense number of little units, called *cells* (fig. 96, B, page 260).

A closer view of one of these cells (fig. 96, C) reveals the all-important fact that it is primarily an organized mass of colorless, slimy, living substance, called *protoplasm*. This protoplasm is what Huxley fittingly called "the physical basis of life," for, so far as is known, the phenomena of life are always associated with this substance. The cell always has at least two parts; first, a mass of more or less watery protoplasm, called *cytoplasm*, which may make up the greater part of the bulk of the cell; and second, a distinct rounded mass of somewhat firmer special protoplasm, called the *nucleus* (plural, *nuclei*). The nucleus floats in the cytoplasm, and altho both are composed of protoplasm they do not mix, for they are separated by a delicate membrance. In many cells there are also other bodies, for example the *chloroplasts*, which contain the green coloring matter. In the plant cell the cytoplasm commonly contains one or more large droplets of watery cell sap, and the whole cell is usually bounded by a rather firm cell wall. For the present discussion, however, the plant cell may be thought of as a little, walled mass of protoplasm with at least two main parts: cytoplasm and nucleus.

The whole body of the plant — leaf, stem, root, flower parts, seed, and all — is made up of millions of these cells. The same is true of the animal body; it is composed entirely of cells and their products. Many plants and animals have bodies microscopic in size and consisting of a single cell, but the ones most commonly met are composed of a vast number of cells. Furthermore, every many-celled individual, plant or animal, begins its life as a single cell. This cell divides to form two cells, which hang together; these two divide to form four, and so on until all the cells of the body are produced. These cells, while multiplying in this way, become differentiated into many kinds and together build up the various tissues and organs of the body. The cell may therefore be called the *unit of structure*, and studies of its physiological activities show it to be *the unit of function*. All this is known as the *cell theory*; it was stated about eighty years ago and has since become firmly established as one of the fundamental propositions in biological science.

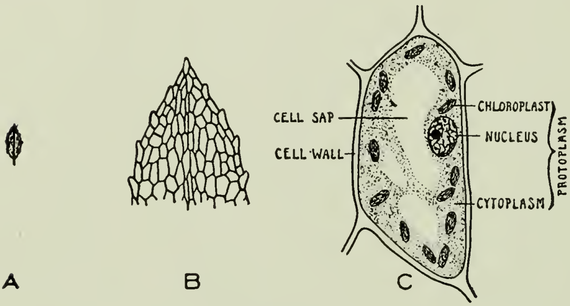

FIG. 96. CELLULAR STRUCTURE OF A MOSS LEAF

A, Leaf of moss, natural size; B, a portion of the moss leaf enlarged, showing the outlines of the cells; C, a single cell greatly magnified, showing the principal parts

SEX IN PLANTS

A second fundamental feature of plant life is that of sexuality. It is commonly known that in animals offspring are produced as the result of a sexual process. This is also true of plants; the embryo contained in the seed is the result of a sexual process. Altho many plants have in addition other modes of reproduction, sexual reproduction has been found in all but a few obscure lowly forms, and is just as fundamental a feature in plants as in animals. In both cases the central fact of the process is the union of the nuclei of two sexually differentiated cells. The cell that results from the union gives rise, by a series of divisions, to all the cells of the body of the new individual.

THE FLOWER

Upon the basis of these two important biological conceptions — the cellular structure and the sexual origin of the organism — flowering and seed production can be better understood. The nature of these processes can be made clear by describing what happens in a particular case. The cherry is chosen as an example, not only because its flower and fruit are familiar to all, but also because its development is typical of a large class of fruits, including the peach and the plum. The flower will first be examined, after which the steps leading to the formation of the seed and the fruit will be described.

A longitudinal section of the cherry flower, showing its various parts, is given in figure 97, A. At the base is the *receptacle*, from which the other flower parts appear to arise. Beginning with the outermost parts is a ring of *sepals*, together constituting the *calyx*. The sepals are usually rather firm in texture and afford protection to the other young parts before the flower opens. Next is a set of *petals*, together constituting the *corolla*. The petals are commonly more or less showy, and thru their showiness play a very important secondary part in the reproduction of the plant. This is discussed in greater detail under methods of pollination.

Next to the petals is a set of *stamens*; in the little sacs, *anthers*, at their tips are produced the *pollen* grains. The stamens are often referred to as the male parts of the flower, since they contribute the male element in the process of sexual reproduction. In the center of the flower is the *pistil*. The pistil shows three general regions: the *ovary*, or swollen portion at the base; the elongated *style*; and the *stigma*, or expanded tip. The pistil is often called the female part of the flower, because the female element is borne within it.

Within the ovary is a small, rounded body, the *ovule*. In the young cherry flower there are two ovules, but usually only one comes to maturity. The ovule is the part that is to become the seed; therefore its structure (fig. 97, B) should be studied carefully. It consists primarily of a central portion surrounded by an envelope, or *integument*. In the central portion is a cavity, the *embryo sac*, partly filled with cytoplasm. In this sac can be seen several cells with their nuclei; one of these cells is the *egg*. An egg is not ordinarily considered so small and simple a thing, for the hen's egg, with its comparatively large size and elaborate structure, is perhaps the most familiar type of egg. These features of the hen's egg are due, however, to the presence of a large amount of storage material and a hard shell, and in the case of a fertile egg to the fact that at the time it is laid it has already undergone the first stages of develop-

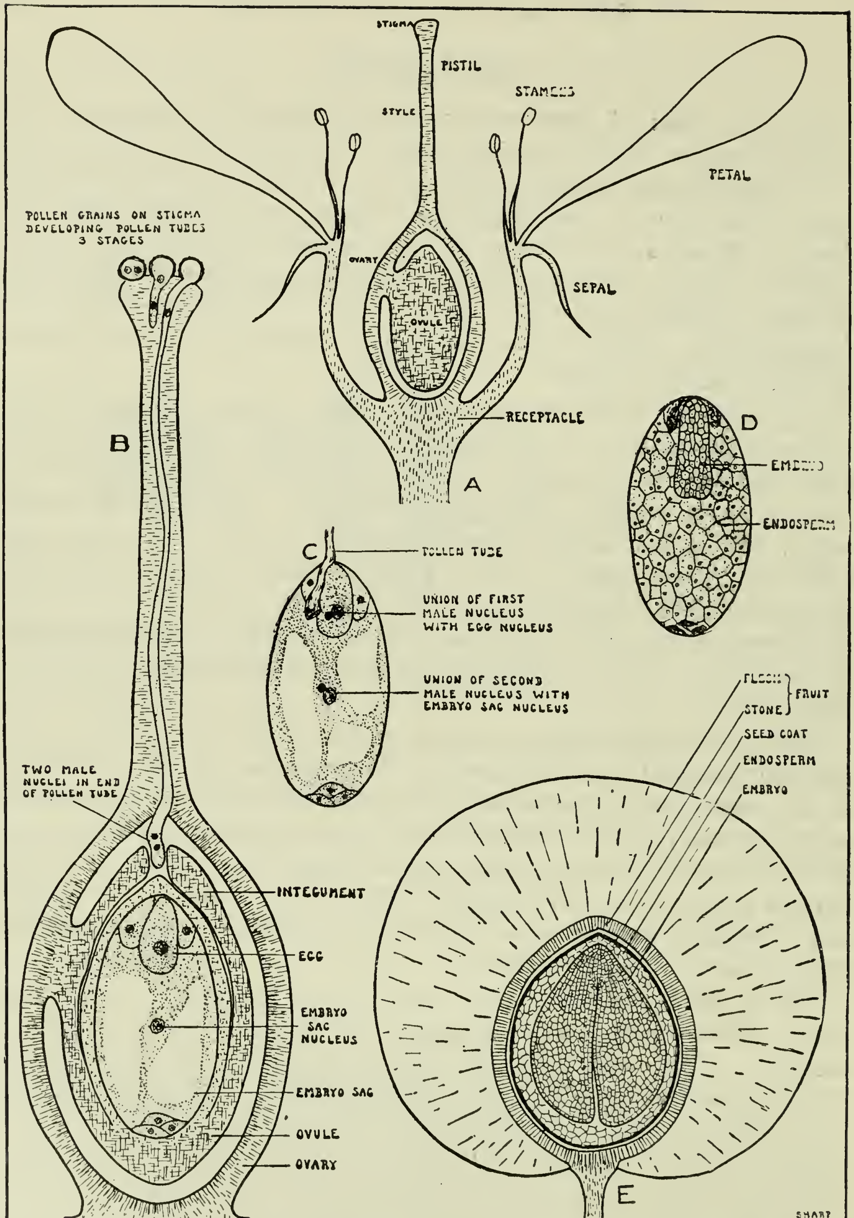

FIG. 97. MAIN STEPS IN THE DEVELOPMENT OF THE SEED AND THE FRUIT FROM THE FLOWER

These diagrams are based in general on the cherry, but, for the sake of clearness, proportions have been somewhat altered and many unimportant details have been omitted

A, Longitudinal section of cherry flower, enlarged 8 diameters. B, Pistil, showing structure of ovule and development of pollen tubes, enlarged 20 diameters. C, Embryo sac with double fertilization in process. D, Development of the embryo from the fertilized egg; the endosperm has developed and filled the sac. E, Longitudinal section of a nearly ripe cherry, enlarged 8 diameters. When fully mature the endosperm will have been entirely digested by the embryo, which will fill the seed completely. The seed coat in the cherry is only a brown papery lining of the pit ment into a chick. The real nature of an egg is consequently obscured in such an example. An egg before fertilization is fundamentally a single cell, altho various modifications may be present in its structure. Floating freely in the cytoplasm of the embryo sac is the embryo sac nucleus. There are also other cells in the base of the sac, but they play no important part in seed production.

In brief, the pistil at the time the flower opens contains an ovule, and within the ovule is an egg. All is now ready for pollination.

POLLINATION AND FERTILIZATION

The pollen grains are shed from the anthers, and thru various agencies are brought to the stigma, where they are held by a sticky secretion. This is *pollination*. The pollen grain (fig. 97, B) at this time is a heavily walled cell with two nuclei. Very soon the thin inner portion of the wall pushes out thru an opening in the hard outer portion and forms a pollen tube, which begins to grow downward thru the tissues of the style. As this tube grows longer, the nuclei wander into it and one of them divides to form two male nuclei. The tube continues to grow, pushing down into the cavity of the ovary and finally, thru an opening in the integument, directly into the embryo sac. There it bursts and discharges the two male nuclei into the cytoplasm of the sac (fig. 97, C). A curious and very significant thing now occurs. One of the male nuclei penetrates into the egg cell and there unites with the nucleus of the egg; the two nuclei flow together completely. This is *fertilization*, and it should not be confused with pollination, which is merely a preliminary step. The other male nucleus advances to the embryo sac nucleus and unites with it. These two unions of nuclei are together called double fertilization, but the union of the first male nucleus with the egg nucleus is the more important of the two.

After pollination and fertilization have occurred, the petals, the stamens, and the cup-shaped part of the receptacle (the "shuck"), wither and drop off.

DEVELOPMENT OF THE SEED AND THE FRUIT

What results from the two nuclear unions described?

The fertilized egg is the cell that is to give rise thru a long series of divisions to the many cells of the new individual, as pointed out in the brief discussion of the cell theory. An early stage in the development of the new individual is shown in figure 97, D. The fertilized egg cell has divided into a number of cells, forming a growing mass in which the parts of the new plant have not yet been formed. This is the *embryo*.

Meanwhile the nucleus formed by the union of the second male nucleus with the embryo sac nucleus has divided repeatedly and produced a mass of tissue filling the embryo sac. This is the *endosperm*, a nourishing tissue that is gradually digested by the growing embryo, which lies embedded in it.

While the embryo and the endosperm are developing within the embryo sac, the integument of the ovule becomes modified and forms the *seed coat*. The wall of the ovary also undergoes great modification and becomes the tissue of the *fruit*. All these processes — the development of the embryo, the formation of the endosperm, the transformation of the integument of the ovule into the seed coat, and the transformation of the ovary wall into fruit tissue surrounding the seed — are going on at the same time, and the result is shown in figure 97, E, which represents a longitudinal section of a nearly ripe cherry. Beginning at the outside is the flesh, which represents the outer part of the ovary wall. Within this is the hard wall of the cherry stone, which corresponds to the inner portion of the ovary wall. The wall of the ovary thus differentiates into two layers of fruit tissue: the flesh, and the stony wall of the pit. Inside the cherry stone, or pit, is the seed, which may be lifted out when the stone is cracked open. The seed coat, as already stated, represents the integument of the ovule. In many plants this seed coat becomes very thick and hard, but in the cherry it is thin and papery. In this case the stony layer of the fruit, rather than the seed coat, affords protection to the embryo.

Within the seed are the endosperm and the embryo. The greater part of the endosperm has now been digested by the growing embryo, and by the time the cherry is fully mature the remainder will have been used. The embryo further shows a certain degree of differentiation. The point at its upper end is to be the root, which emerges first from the seed at the time of germination, and below are the two seed leaves, or *cotyledons*, which are most conspicuous soon after the embryo has freed itself from the seed coat. The stem will develop from a point between the cotyledons.

During the resting period of the seed, in case it has such a period, the embryo remains in a dormant, tho living, condition; and when brought under conditions suitable for germination, it merely resumes its growth. The statement is often made that when sown the seed dies and the new plant comes to life in some mysterious way. This is contrary to fact, for altho the seed coat, which forms no part of the new plant, usually decays, the embryo has been living from the first and simply continues its development when germination occurs. The chain of life is not broken.

The fruit therefore represents a ripened ovary, and the seed a ripened ovule. The most important fact concerning the seed is that it contains a new individual in a partly developed, or embryonic, state — a new individual that is the result of sexual reproduction.

In the preceding paragraphs have been pointed out the parts of the flower that are essential to reproduction, and how in the case of the cherry the ovule and the ovary become converted into the seed and the fruit. Other examples will show how these same principles apply to seeds and fruits of other types.

If a bean flower is dissected, the elongated ovary will be found to contain a row of ovules. After pollination and fertilization have occurred, the ovary enlarges, thickens, and becomes the bean pod, while the ovules are converted into a row of bean seeds within it.

In the apple, the pear, or the quince, is a somewhat different condition. The ovary is not simple like that of the cherry, but is divided by partitions into five compartments, each containing several ovules. Furthermore, the receptacle grows up around the ovary, so that the ovary appears to be below the flower rather than within it. It is very much as if the part of the receptacle that projects upward around the ovary in the diagram of the cherry flower, were brought close to the ovary and joined with it. The ovary of the apple is, in effect, embedded in the receptacle. This whole structure ripens into the apple fruit. If an apple is cut in two transversely, in the center can be seen five compartments of the ovary with ripened ovules, or seeds. The core therefore represents the modified tissue of the ovary, while the flesh around the core is receptacle tissue. So altho both the cherry and the apple have abundant flesh, it is not of the same origin in the two cases. In the cherry it is the ripened outer portion of the ovary, while in the apple it is mostly ripened receptacle and the ovary is only the central portion, or core. The flesh of the strawberry is also receptacle tissue.

Indian corn illustrates still another type of seed production. In this case stamens and pistils are not borne together in the same flower. There are flowers with stamens only, *staminate* flowers, in the tassel, and flowers with pistils only, *pistillate* flowers, on the cob. Each young corn grain on the young ear is an ovary containing a single ovule. The silks, which later project beyond the husks, are the greatly elongated styles. The stigma in this case is not a conspicuous part at the end of the style, but is an elongated area lying along the side of the silk. The pollen tube must grow a long distance thru the silk to the ovule within the ovary, or young grain. After fertilization the styles wither and the grains ripen, and consideration of what flower parts are concerned shows at once that the corn grain is really a fruit, not merely a seed. Its external coat represents the ripened ovary wall, not the ripened integument as in the case of a seed. Within this outer coat is the seed proper. The bulk of the grain is occupied by the endosperm, or starchy portion, and the embryo, or so-called germ.

The cherry, the bean, the apple, and the corn grain, altho they differ greatly in appearance, have many fundamental features in common. In every case the embryo within the seed is formed by the development of a fertilized egg cell. In all, the endosperm results from a second nuclear union; in the corn this endosperm is abundant, but in the bean, the apple, and the cherry it has been digested by the developing embryo. The coat of the seed in all four examples is formed by the transformation of the ovule tissues, or integument. In the ovary wall are the greatest differences. In the corn the ovary wall simply hardens closely around the ovule tissues and forms the resistant covering of the grain. In the bean it hardens but remains separate from the ovules, or seeds, and forms the dry pod. In the cherry it develops into two layers: an inner stony portion, which forms the wall of the pit; and an outer fleshy portion, which is edible. In the apple the ovary is embedded in the receptacle, which grows up around it and later develops into edible flesh.

As a rule, therefore, the pistil and the structures it contains become the fruit and the seed. Since the pistil is the most sensitive to injury of all the flower parts, the reason is apparent why late spring frosts affect certain fruit crops disastrously.

METHODS OF POLLINATION

The reason why flowering precedes the development of seed and fruit is now apparent, for the seed and the fruit are transformed flower parts. If there were no flowers, neither seeds nor fruit would be produced, as in the familiar case of young fruit trees that do not bear. Since this intimate connection of flowers on the one hand and seed and fruit on the other is established, it is further manifest from the description of the processes involved that pollination is of the greatest importance, for if pollination fails to occur no seed and fruit are produced even tho flowers are present. The next question is, then, How is pollination brought about?

In many flowers both stamens and pistils are present and ready to function at the same time. Many other species, however, have the stamens and pistils located in different flowers, as in the case of corn, or even on different plants, as in the case of the willows and some varieties of the strawberry. This explains why in cultivating such varieties of strawberries both staminate and pistillate plants must be set together in order to get a crop. Also, even tho both stamens and pistils are present in the same flower, in many cases they are not ripened at the same time, so that as far as pollination is concerned the situation is much the same as if a single flower had only one kind of organ. In the flowers of the first kind, in which stamens and pistils are present together, the transfer of pollen from stamen to stigma would not appear to be a difficult matter, but in the case of stamens and pistils borne in different flowers, or even on different plants, pollination becomes a serious problem. Solution of this problem is of course of vital importance to the plants, because of the part played by pollination in the process of reproduction. The following examples show how the problem has been solved in a few cases.

Fig. 98. DIAGRAMS SHOWING THE STRUCTURE OF FLOWERS THAT ARE CHIEFLY WIND-POLLINATED

A, Flowering portion of grass with three inflorescences, each containing several flowers. B, Single grass flower, showing the three dangling stamens, from which the pollen is carried by the wind, and the pistil with two feathery stigmas upon which pollen blown from other flowers may be caught

In many land plants the pollen is carried from the stamens to the stigmas of other flowers by air currents. The pollen grains are so small that they form a fine, dust-like powder, and may be carried many miles by the wind. This wind pollination occurs in many common plants, such as grasses (fig. 98), oaks, and pines. But any one who has walked thru a cornfield at the time the pollen is being shed from the flowers in the tassels of the corn, or who has had his boots well dusted by the pollen from the ragweed along the roadside, or who has seen the clouds of yellow pollen ("showers of sulfur") being carried away from a pine tree on a breezy day, can scarcely fail to see that this method of pollination is extremely wasteful. Out of the myriads of pollen grains formed in the corn tassels only a few are brought to the proper place on the silks; the majority are lost. In other plants the staminate flowers are in many cases a long distance, even many miles, from the pistillate flowers; in these instances an even greater portion of the pollen must be wasted. But nature has developed more efficient and precise methods of pollination than that by air currents.

Such a method is pollination by insects, which carry pollen from the stamens of one flower to the stigma of another. The hum of bees over clover fields and around blossoming fruit trees is one of the commonest sounds of the open country in summer, and is indicative of one of the most remarkable adjustments in nature. The bee is concerned only with the getting of nectar and pollen for food, but as it flies from flower to flower it unconsciously brings about a very effective pollination for the plant. As the bee reaches into the flower for nectar, its body becomes more or less covered with the dusty or sticky pollen, and when it alights upon the next flower of the same kind some of this pollen is almost certain to be rubbed off on the stigma. This cross-pollination is thought for certain reasons to be more advantageous than close pollination (pollination within the same flower), and the insects thru their visits bring it about even in flowers that have both stamens and pistils. The

A B

FIG. 99. TWO TYPES OF FLOWERS IN WHICH POLLINATION AND CROSS-POLLINATION ARE EFFECTED BY INSECT VISITORS

A, Longitudinal section of violet flower, showing nectar (n) in the spur formed by the lower petal. In reaching for the nectar the insect brushes against the stamens and the stigma, bringing about pollination. B, Longitudinal section of lady's-slipper showing stigma (a) and stamen (b), which are rubbed against by the bee as it attempts to escape from the pouch by the route indicated by the arrow

flower from which the pollen comes must, as a general rule, be one of the same species as the flower pollinated, tho not necessarily of the same variety of that species.

If the characters of the flowers that are pollinated thru the agency of insects are compared with those of the flowers that are wind-pollinated, notable differences are seen at once. The wind-pollinated flowers are relatively inconspicuous; they have small petals or even none, and no decided odor, and produce little or no nectar. The insect-pollinated flowers, on the other hand, usually have very showy corollas and decided odors, and in addition produce a much greater amount of nectar than do the wind-pollinated flowers. Evidently there is a definite connection between these characters and insect pollination. The insect has an amazingly keen sense of smell, and as it flies about searching for food it catches the odor of flowers on the breeze and is at once attracted to the flower, which contains food in the form of nectar and pollen. As the insect draws near the flower, the showy corolla attracts it to the proper place. The insect is thus aided in its work of food gathering, and, since the arrangement of the flower parts is commonly such that the insect cannot get at the nectar without rubbing against stamens and stigma (fig. 99, A), the insect in turn unconsciously renders the plant an important service, that of pollination.

Beginning with the work of the great naturalist Darwin, many volumes have been written about the marvelous structures that various flowering plants have developed in this connection. In many cases the structure of the flower has become profoundly modified, and all sorts of arrangements are present whereby pollination by insects is rendered more precise and effective. This is notably true of the orchids and members of the mint family. For example, in the lady's-slipper, a common orchid (fig. 99, B), the bee, which has crowded into the pouch in search of food, must rub against the stigma when it attempts to escape by the only easy route (indicated in the figure by the arrow). Having previously received pollen from other flowers, the bee thus brings about pollination. After rubbing against the stigma it also brushes against the stamens, and so receives a supply of pollen, which will be deposited on the stigma of the next lady's-slipper visited. In this way precise cross-pollination results.

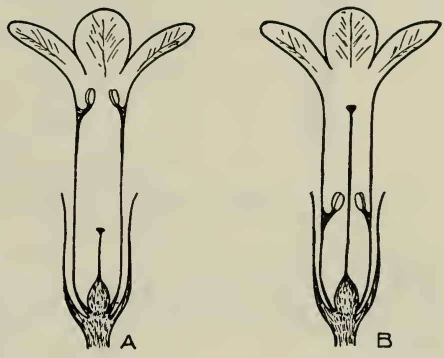

Fig. 100. TWO TYPES OF PRIMROSE FLOWERS WITH PARTS SO ARRANGED AS TO INSURE CROSS-POLLINATION

A, Short-styled flower; B, long-styled flower. This arrangement of floral parts is known as heterostyly, and is explained in the text

Another arrangement insuring cross-pollination is known as *heterostyly*, and is illustrated by the diagrams of the primrose in figure 100. The primrose flowers are of two types: in one the style is short and the stamens are inserted high up on the corolla tube; in the other the style is long and the stamens are inserted much lower. An insect that is too large to enter the corolla tube to get the nectar secreted at the bottom must reach for it with his long sucking apparatus, or proboscis. In thus reaching for the nectar in the short-styled flower, the insect receives on its head a mass of pollen from the stamens near the top of the tube. When it visits a long-styled flower, this pollen is rubbed on the stigma, and at the same time a new mass from the stamens below is received near the end of the proboscis. The short-styled flower next visited will receive this pollen upon its stigma. The long-styled flower is usually pollinated with pollen from the high stamens in the short-styled flower, while the short-styled flower receives pollen from the low stamens of the long-styled flower. Cross-pollination thus occurs in the majority of cases.

Many flowers have odors that are exceedingly pleasing to the human sense of smell, but many others have an odor like that of carrion, offensive to man but very attractive to insects that lay their eggs in such material. Such odors are very effective in bringing about pollination, and the effect on human feelings is a minor matter.

FIG. 101. PETUNIA FLOWER

This flower has a long corolla tube in the bottom of which nectar is secreted; therefore it is visited by insects with long mouth parts, such as the moth shown in figure 102

Some flowers, because of their peculiar structure (fig. 101), are regularly visited only by insects with long mouth parts, such as those possessed by moths and butterflies (fig. 102). Clover is regularly visited by the bumblebee, which, by means of its long proboscis, can get the nectar that many other insects are unable to reach. Furthermore, in some flowers only one kind of insect can perform the service of pollination, and if that particular kind is kept away from the plant no seeds can be produced. In time this would result in the extinction of that species of plant, and there is reason to believe that this has occurred in certain cases. Therefore specialization of this kind, if carried too far, may endanger the very existence of the plant.

From the foregoing discussion the true meaning of flowers should be clear. They are often thought of only as objects of beauty, and certainly the beneficial aesthetic effect they have should never be wholly disregarded. But the flower is of benefit primarily to the plant itself, and its chief value lies in the way in which it brings about pollination and therefore a more effective reproduction. The great variety of adaptations developed in this connection and the surprising degree of refinement to which many of them have been carried, testify to the extreme importance of effective pollination to the plant in its struggle for existence. In the paramount need of more certain reproduction is found the key to the evolution of the flower and its many modifications.

FIG. 102. MOTH WITH LONG PROBOSCIS

Such long mouth parts enable moths to reach the nectar in flowers with long corolla tubes, such as the petunia shown in figure 101

(Drawing adapted from a photograph by M. V. Slingerland)

THE CORNELL READING COURSE FOR THE FARM

The Cornell Reading Course for the Farm provides consecutive instruction on subjects selected by the reader, furnishes lessons on subjects of general interest as they are issued, and encourages correspondence by means of the discussion paper. Residents of New York State may register without charge for one or more of the following series in the reading course. If particular lessons are desired instead of a course of reading they may be obtained on request.

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PUBLISHED BY THE NEW YORK STATE COLLEGE OF AGRICULTURE
AT CORNELL UNIVERSITY, ITHACA, NEW YORK
A. R. MANN, DIRECTOR OF EXTENSION SERVICE

LESSON 144 THE PLANT SERIES APRIL, 1919

HOW THE PLANT PRODUCES SEED

DISCUSSION PAPER

The discussion paper takes the place of the teacher in encouraging thought and self-expression on important points in the lesson, and aims to assist the reader in reviewing and applying them. Each discussion paper filled out and returned is read carefully, and a personal reply is made to questions on any agricultural subject. In order to continue a course, the reader should sign and return the discussion paper so that another lesson may be sent. Questions are included on the discussion paper for the purpose of assisting those readers who desire to give the lesson special study. The preparation of answers is optional.

The available reading-course lessons for the farm are arranged in series on the following subjects: THE PLANT, THE SOIL, FARM CROPS, LIVESTOCK, DAIRYING, FRUIT GROWING, THE HORSE, POULTRY, VEGETABLE GARDENING, FLOWER GROWING, BEEKEEPING, FARM FORESTRY, COUNTRY LIFE. New readers may enroll in one or more of these subjects. The first lesson in the series is sent on enrollment, and subsequent lessons are sent, one at a time, on the return of discussion papers. The reader may register for The Plant Series by signing and returning this discussion paper. The space below on this page is reserved for registration in other series, and also for names and addresses of residents of New York State likely to become interested in the reading course.

(Detach, sign, and return for the next lesson in this series.)

(In answering questions, attach additional paper if needed and number the answers.)

1. What are the units of which all plant and animal bodies are built up? Of what are these units composed? How do they multiply?

2. What are the most essential parts of the flower? Why?

3. What is the difference between pollination and fertilization? Which is really the sexual process?

4. What is the origin of the embryo in the seed?

5. What occurs when the seed germinates?

6. Can you think of any value to the plant of an elaborate fruit around the seeds?

7. How is pollination brought about? How does a conspicuous flower aid in pollination?

8. How do you account for the fact that when there are rains or high winds during the flowering period an orchard produces a poor crop of fruit?

9. How is one kind of crop contaminated by a closely related kind grown in the same vicinity? Why is it not contaminated by plants of other widely different kinds?

Name..

Address...

Date..

(*Address all correspondence to the Reading Course for the Farm, College of Agriculture, Ithaca, New York.*)