CHAPTER V

PHYLUM — SPERMATOPHYTA. PART I

FLOWER, FRUIT AND SEEDS

A Seed Plant. The Spermatophyta are *Seed Plants*. Sometimes they are called the Flowering Plants. But the word *flower* has a variety of meanings. For example, according to one idea, the strobilus of Equisetum (Fig. 52 *B*) might be considered a flower, but it is not a seed plant. According to another definition, pine trees would be excluded from flowering plants although they have seeds. It is altogether more satisfactory to define this group as those plants which have seeds.

Seed plants constitute the most conspicuous vegetation of the present stage in the evolution of the earth. They furnish man with the larger part of his food supply and other products essential to the existence of civilized people. The formation of the *seed* is of the greatest importance in the evolution of the dominant position occupied by the Spermatophyta.

They are often called *Phanerogams*, plants whose organs and methods of reproduction are *very evident*. The Thallophyta, Bryophyta and Pteridophyta were called *Cryptogams* because it was thought their organs of reproduction were *obscure*. The facts are quite the opposite of this, *i.e.*, the organs and methods of reproduction are more easily studied in the so-called Cryptogams.

There are two groups of Spermatophyta: (*a*) Gymnosperms and (*b*) Angiosperms. The plants of the first-named group have naked or exposed seeds and those of the second group, hidden seeds.

CLASS I. GYMNOSPERMAE

The Gymnosperms are survivors of more ancient forms than the comparatively modern and specialized Angiosperms. Fossil Gymnosperms have been found in the coal beds of the Carboniferous Age.

Two prominent groups of the Gymnosperms are (1) the Cycads and (2) the Conifers. Cycads grow in or near the tropics; Conifers, as a rule, grow in the temperate zone.

Fig. 55. — Cycas celebica. N. Y. Botanical Gardens. (Photo. by Fread.)

Order 1. Cycadales — Cycads

Morphology. A Cycad (Fig. 55) resembles a tree fern in appearance. There is an upright trunk with a crown of large, tough, pinnately-divided leaves at the top of the plant. The leaf may survive more than one year. The stem has a large pith, cylindrical zones of vascular tissue, and a conspicuous cortex containing a great amount of stored starch. New stem tissue develops from special formative tissue called the cambium.

Reproduction. The plant is dioecious, *i.e.*, some individuals are male and others are female. In both cases, spores are produced in a strobilus or cone at the apex of the stem. Each strobilus (Fig. 56) has a central axis surrounded by scale-like sporophylls, *microsporophylls* (Fig. 57) in male or *staminate* cones and *megasporophylls* in female or *carpellate* cones, and each type of sporophyll develops sporangia; *microsporangia* and *megasporangia*, respectively. Microspores are produced in *microsporangia* and megaspores in *megasporangia*.

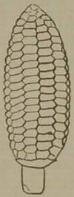

Fig. 56. — Male strobilus or cone of Zamia.

While still within the microsporangium, the microspore develops into a three-celled male gametophyte. From its similarity to homologous bodies in Conifers and Angiosperms, *these* microspores (or three-celled gametophytes) are known as *pollen grains*. Many thousands of these are produced by a single male cone. When freed from the cone, they are carried away by air currents. Some, by chance, may fall on the strobilus of a female tree. Each megasporophyll develops on its upper surface two megasporangia, consisting of tissue called the *nucellus*, around which develops tissue called the *integument*. Within each nucellus is a *spore mother cell* which develops into *four megaspores*, three of which abort; the remaining one develops a *megagametophyte* (Fig. 58), at one end of which are two or more archegonia. So that around the mature megagametophyte is a thin layer of tissue, the *nucellus*. Outside of this is a thicker tissue, the integument, consisting of an inner hard *sclerotesta* and an outer fleshy *sarcotesta*, almost entirely covering the nucellus except for a tubular hole called the *micropyle*. The canal leads to the outer end of the nucellus. At this inner end of the canal, just outside the nucellus, is a little space called the pollen chamber. Between the nucellus and the necks of the archegonia is a small space also, called the archegonial chamber.

FIG. 57. — Microsporophyll of Zamia with sporangia.

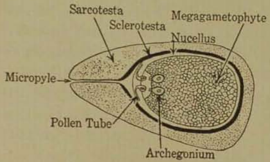

FIG. 58. — Megasporangium (♀) of Zamia. From Smith and Others, *General Botany*, Revised Edition, copyright 1928, by The Macmillan Company, reprinted by permission.

When the pollen grains are shed, a few may land on a carpellate cone whose sporophylls have opened out to catch them. The pollen grain sifts down to the opening of the micropyle, into which it is drawn, and so down to the pollen chamber just outside the nucellus. The whole process of transportation of the pollen is called *Pollination*, a *distinguishing seed-plant feature*. Each pollen grain (now a three-cell male gametophyte) develops a thread-like pollen tube which grows into the nucellus, absorbing food from it, and so into the archegonial chamber. From the pollen tube two sperm cells which have later developed in this microgametophyte are discharged into the chamber. Each sperm cell (Fig. 59) is cone-shaped with a spiral band of cilia about it. They swim, spinning about, in the archegonial chamber. One works its way

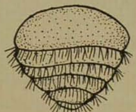

FIG. 59. — Sperm cell of a Cycad. From Smith and Others, *General Botany*, Revised Edition, copyright 1928, by The Macmillan Company, reprinted by permission.

down the neck of an archegonium and fertilizes the egg there. A zygote is the result, and from this, an embryo plant develops (Fig. 60). The remaining part of the megagametophyte, the endosperm,[1] stores up a reserve supply of food for the young embryo. The *hard* inner and the outer *fleshy* integuments form two seed coats. They are part of the old sporophyte; the endosperm is part of the megagametophyte and the embryo is a new young sporophyte, so that three generations are represented here. All these parts constitute the *seed.*

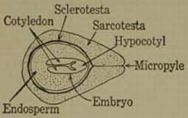

FIG. 60.—Seed of Cycad with embryo. From Smith and Others, *General Botany*, Revised Edition, copyright 1928, by The Macmillan Company, reprinted by permission.

After the seeds fall out of the carpellate cone, they usually remain *dormant* for a time, but *later germinate* under proper conditions. Life activities speed up; the endosperm is used as food in the development of the embryo to a stage when it can maintain itself independently.

Comparison with Selaginella. At this point let us compare Cycads with Selaginella, a Pteridophyte.

1. In Selaginella microsporophylls and megasporophylls occur on the same strobilus. In Cycads there are two kinds of strobili, male and female. Microspores are developed in microsporangia on microsporophylls and megaspores in megasporangia, etc.

2. The microspore develops into a miniature male gametophyte, for the most part within the microsporangium, and the megaspore develops into a female gametophyte, still within the megasporangium. Both gametophytes are homologous[2] with the prothallus of the fern and with the green sex-organ-bearing Marchantia plant.

3. Motile sperm are produced, but in the Cycad their *free swimming range is very much restricted.* A new method is introduced to effect this.

4. In the Cycad, a new structure appears, the Seed, formed within the female gametophyte and its megasporangium while the latter is still connected with the old sporophyte.

5. It is evident therefore, that a *Seed* involves first, the embryo sporophyte; second, its parent gametophyte and third, the parent sporophyte from which the latter developed.

[1] The so-called endosperm of Cycads has the same general appearance and function as that of Angiosperms, but the two are not strictly homologous.

[2] See page 194.

Order 2. Coniferales — Conifers

The second group of Gymnosperms are the Conifers, such as pine trees, hemlocks, spruces (Fig. 61), cedars and firs. They usually possess a tall, straight trunk with radiating branches: longer ones below and shorter ones toward the top, giving a cone-shaped effect to the whole tree — a form which resists very well the destructive effect of heavy weights of snow, so prevalent in the habitat occupied by many Conifers. The leaves are green scales or needles, a form admirably adapted to resisting cold.

Fig. 61. — Blue Colorado Spruce. N. Y. Botanical Gardens. (Photo. by Fread.)

Reproduction. Reproduction is similar in many respects to that of Cycads. In the Pine, reproductive organs are produced in two kinds of cones: male and female, *i.e.*, *staminate* and *carpellate*. The staminate cones (Fig. 62 *A*) are small and do not persist very long. Each is composed of lateral scales (Fig. 62 *B*) (microsporophylls), which possess microsporangia in which microspores or pollen grains (Fig. 62 *C*) are produced. Pollen is transferred to the carpellate cones by the wind, and for this purpose an immense amount of pollen is produced by a conifer forest in the spring. The carpellate or female cones (Fig. 62 *E*) in some species grow to a very large size. The cone scales, or megasporophylls (Fig. 62 *F*), become hard and woody. Each cone scale produces two megasporangia, consisting of a megaspore mother cell surrounded by tissue called the nucellus, which in turn is surrounded by the integument. The megaspore mother cell gives rise to four megaspores, three of which abort. After a series of divisions a female gametophyte (Fig. 62 *G*) is organized from the remaining megaspore with two or more archegonia in each of which is an egg. The pollen grains, carried by the wind, fall on the upper surface of the edge of the megasporophylls and fall down to the micropyle in the integument, where they germinate and form *pollen tubes* (Fig. 62 *D*). Each pollen tube (Fig. 62 *H*) penetrates the nucellus and sends a *male nucleus* down to the egg cell in each archegonium. *There are no free-swimming sperm present.* An embryo is formed in each archegonium, but only one usually matures. The mature *embryo* (Fig. 62 *I*) is inside the megagametophyte, with the *endosperm.* Around them is the *thin* paper-like nucellus and around this the integument which becomes the hard seed coat. Attached to it

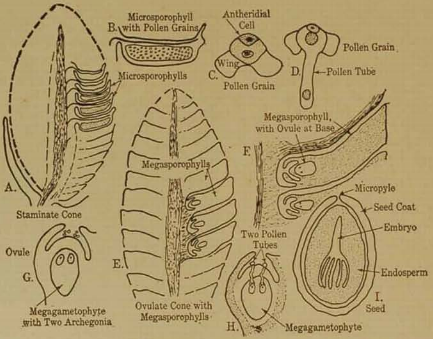

FIG. 62. — Reproduction in the pine. From Sinnott's *Botany*, McGraw-Hill Book Co., reprinted by permission.

is a scale thus adapting the seed for wind dispersal. The seed is detached from the cone scale, when the tree is shaken by the wind, and being light in weight, is carried some distance by air currents. Or it may be distributed by seed-eating mammals, such as squirrels. Conifers are ancient plants and there are not many species of them. Nevertheless they flourish vigorously in the cooler regions of the earth, both in the northern and southern belts of the temperate zones.

Summary. In review, the life history of the Conifers is similar to that of the Cycads and to a certain extent to that of Pteridophyta and Bryophyta.

1. In the Gymnosperms (Cycads and Conifers) there are stami-

nate or male cones (strobili) and carpellate or female cones. The staminate cones possess microsporophylls and the female cones, megasporophylls.

2. Microspores are produced in microsporangia on the microsporophylls, and megaspores are produced in megasporangia on the megasporophylls.

3. The microspore develops into a diminutive male or microgametophyte, while the megaspore develops into a simple female or megagametophyte, with two or three archegonia, each with one egg.

4. Pollen grains are shed from the male cones and dispersed by air currents. If the pollen grain of a Conifer reaches a female gametophyte, it develops a pollen tube. But in the case of the Cycad, the pollen produces free-swimming sperm. In the Conifer, there are *non-motile sperm cells,* which are produced in and carried to the egg cell by growth of the pollen tube.

5. While the method differs in the two cases, the end result is the same, namely, the fusion of a male sex cell with a female sex cell, resulting in the formation of a fertilized egg or zygote, the first stage in the life of a new individual (sporophyte).

6. With the appearance of spore dimorphism, earlier seen in Selaginella, there develop two kinds of very diminutive gametophytes, one of which has the job of producing sperm cells and the other, egg cells.

7. Motile sperm, noted first in Oedogonium, are present in all groups of green plants up to and including Cycads, although absent in the next higher group, the Conifers.

8. The retention of free-swimming sperm is not essential, provided some mechanism is present to insure the union of male and female sex cells. The substitution of the pollen-tube method of fertilization is a specialization which is peculiarly adapted to the Conifers and higher Seed Plants. It makes more certain a tremendous production of embryo plants (seeds) and has played no small part in bringing about the world-wide dominance of the Angiosperms.

CLASS II. ANGIOSPERMAE

Definition. The Angiosperms form seeds inclosed in special parts of the megasporophyll, *i.e.*, they have hidden seeds, hence the name. They are divided into two great groups: A. *Dicotyledons*

(Fig. 63) and B, *Monocotyledons* (Fig. 64). As examples of the first, we have such plants as beans and peas, and apple, oak and maple trees. Examples of the Monocotyledons are rice, corn, wheat and palm and bamboo trees. The word *cotyledon* refers to a seed leaf formed in the seed and related to the nourishment of the embryo plant at time of germination. Dicotyledons possess two of these seed leaves and monocotyledons have one.

FIG. 63. — Elm Tree. (Photo. by Fread.)

Morphology of the Flower. Angiosperms possess a root, stem and leaf system, which will be discussed in detail presently. Since we have just been studying reproduction in the Gymnosperms, it seems best to introduce at this point a study of the organ of reproduction in Angiosperms, *i.e.*, the flower. This at first appears to be a new structure, unrepresented in the lower phyla and in the Gymnosperms. A study of the flower, however, reveals the fact that its essential parts are microsporophylls and megasporophylls, each sometimes in separate flowers, both very often in the same flower. In addition to the above, there are frequently present special leaf-like parts called *petals* and *sepals*, the first-named being usually colored white, pink, etc., and the latter, green. Petals and sepals, if present, constitute a *perianth*, although some flowers have no perianth.

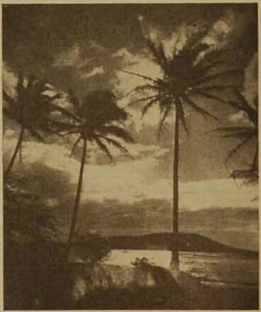

FIG. 64. — Coco Palms — Hawaii. (Photo. by Baker, Honolulu.)

A typical flower possesses four whorls of parts (Fig. 65). These usually occur in groups of three or multiples of three in the monocotyledons and in five (sometimes in four) or multiples of five in the dicotyledons. The *calyx*, composed of green *sepals*, is the outermost series. Inside the calyx is the *corolla* composed of *petals*, which may be red or blue, etc. Inside the petals are the *stamens* or *microsporophylls*. Each *stamen* has a long stalk or *filament* at the end of which is a microsporangium, the *anther*, in which *microspores* or *pollen grains* are produced. Inside the whorl of stamens is the last set of parts, the *carpels* or *megasporophylls*. These possess *megasporangia* in which *megaspores* are developed.

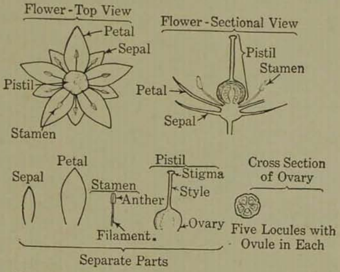

FIG. 65. — Parts of typical dicotyledon flower. From Sinnott's *Botany*, McGraw-Hill Book Co., reprinted by permission.

In the willows the flowers have no perianth. These trees are dioecious, *i.e.*, one type of tree produces only staminate flowers or, as they are commonly called, catkins. The other type of tree produces only carpellate catkins. The catkins also appear before the leaves or simultaneously with the leaves. In the sycamore there is neither calyx nor corolla and on the same tree are both staminate and carpellate catkins, but they are different flowers. Separate staminate and carpellate catkins occur in the birch and walnut, *i.e.*, both types of flowers (Fig. 65 *A*) on the same tree. In the apple, cherry and pear, the flowers possess all four series of parts.

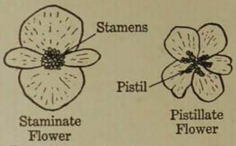

FIG. 65 *A*. — Staminate and pistillate flowers of Begonia. Both found on same plant. Such flowers are *imperfect* since neither possesses *all* the *essential* organs for seed formation. Stamens *and* pistil are *essential* organs. Sepals and petals are *not essential*, although a flower without them is *incomplete*.

A strobilus of lower plants, such as Equisetum, has a central axis around which sporophylls are arranged spirally. Some angiosperm flowers retain something like such an axis with sporophylls similarly arranged. If the axis were shortened to a mere knob, a great reduction of sporophylls would necessarily follow and these would tend to be arranged in circles instead of spirals. Flowers are borne at the end of branches. The floral parts are borne on an expanded end branch known as the *receptacle*, which is thought to be a much-shortened axis of a strobilus and the whole flower and its receptacle homologous with a strobilus. Sometimes the sepals are united, as may be the petals, the stamens and the carpels.

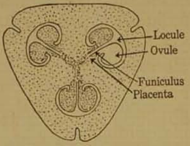

FIG. 66. — Cross-section of ovary of young Lily flower.

The flower of the primrose has a united calyx and corolla. The most common type of fusion is that of the carpels, forming what is known as a *pistil* although some pistils consist of only one carpel. The pistil (or carpel) has a knob on the top called the *stigma*. It is sticky and sugary. Below the stigma is a connecting neck or *style* and below at the base is an enlarged part called the *ovary*. A cross-section of the ovary (Fig. 66) reveals one or more chambers within. These chambers or *locules* contain *ovules*. Often but one ovule occurs in a locule. Each ovule (Fig. 67) usually consists of two integuments, outer and inner, inside of which is the nucellus containing the megaspore mother cell. The ovule is connected to the wall of the ovary by a tiny stalk called the *funiculus*. At one end of the ovule a passageway occurs in the coats and extends to the nucellus. This passageway is the *micropyle*.

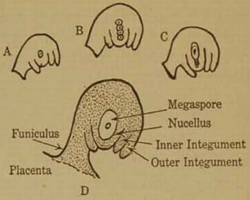

FIG. 67. — Development of megaspore. *A* — Shows megaspore mother cell within nucellus of young ovule; *B* — It has divided twice, forming four megaspores; *C* — Three of these degenerate; *D* — The remaining megaspore grows larger and will become the female gametophyte as shown in Figs. 69 and 70. From Smith and Others, *General Botany*, Revised edition, copyright, 1928, by The Macmillan Company, reprinted by permission.

Flowers are necessary for the production of seeds which contain embryo plants. These are the result of fertilization or the union of male and female sex cells. In the lower plants we found that water is necessary for fertilization, and enables the sperm to swim to the egg cells. In the flowering plants it is necessary for pollen to be deposited on the stigma of the flower by other agents. The transfer of pollen from stamens to pistil is called *pollination*.

Pollination. Some flowers are so constituted that the stigmas are pollinated from the stamens of the same flower. This is *self* or *close*-pollination. The legume plants, peas, beans, peanuts (Fig. 68), are examples. Self-pollination tends to maintain continuance of plant traits, and this is very desirable at times. *Cross-pollination* tends to introduce variation. In many trees there are two kinds of flowers — (*a*) staminate and (*b*) pistillate. Pollen is produced in great quantities and is carried about by air currents, so that the pistillate flowers are for the most part pollinated by pollen from other trees. In other flowers, insects effect cross-pollination. It has been thought that they are attracted by the gayly colored petals although recent experiments throw doubt on this supposition. At any rate, bees do collect pollen and nectar from flowers; and on such expeditions they visit flower after flower and do transfer pollen from the stamens of one flower to the pistil of another. They also probably transfer pollen from one to a different species. If this happens, it is usually ineffective. In some flowers, self-pollination is prevented, for the stamens and pistil do not mature at the same time. There are many devices to prevent self-pollination. The Date Palm has been cultivated for over fifty centuries. It is dioecious, so that to produce fruit, pollen from the flowers of the *male* tree must be transferred to the pistils of the *female* tree. This has been known ever since date culture has been practiced. Theophrastus, an early Greek botanist living in the time of Aristotle, described how the date grower shook the "dust" of the male flower over the "fruit" of the female flower.

Fig. 68. — Peanut plant. The flowers are self-pollinated. They are covered with earth, and seeds form in earth.

In 1876 Charles Darwin published a book on "The Effects of Cross and Self Fertilization in the Vegetable Kingdom." He concluded that cross-pollination produced better results. Darwin used the word *fertilization* for what is better termed *pollination*.

Fertilization (Fig. 69). We have learned to define fertilization as the union of a male and female gamete, resulting in a zygote. When a pollen grain (microspore) falls on the stigma of a flower of the same species, it develops a *pollen tube*. This is a long, slender filament which grows down the style to the ovary, into a locule and through a micropyle of an ovule into and through the nucellus around a female gametophyte and so into the latter. The pollen tube has only three nuclei and no cell walls. This three-nucleated microscopic thread-like filament is the male gametophyte of the flowering plants. It is homologous[1] with the male Marchantia plant and the prothallus of the fern. One of its nuclei is vegetative, and the other two nuclei are sex nuclei, *i.e.*, may be considered sperm nuclei. They are not motile. This arrangement is an advantage because fertilization may be effected in flowers at the ends of branches *away from* the ground. The seed plant has been freed from restrictions which keep the plant at the earth's surface. While the pollen tube has been developing, the single-celled megaspore mother cell (Fig. 67), within the nucellus of the ovule has divided twice, forming four megaspores, three of which degenerate. The fourth megaspore divides three times (Fig. 70), forming an eight-nucleated female gametophyte or embryo sac. This is homologous with the female Marchantia plant, with the female prothallus of the fern, the female gametophyte of Selaginella, of the Cycad and of the Pine.

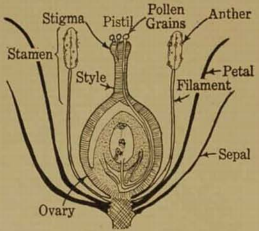

FIG. 69. — Parts of a flower. Pollen grains (microspores) are shown on stigma. The right one has formed a pollen tube which has penetrated the ovule and discharged two male nuclei into the female gametophyte. From Sinnott's *Botany*, Revised edition. McGraw-Hill Book Co., reprinted by permission.

Three nuclei of this embryo sac move to the end opposite the micropyle and soon degenerate. Two others, called *endosperm nuclei*, take up a position near the center and the other three arrange

[1] See page 194.

themselves near the micropyle. *One* of *these three* is the egg nucleus. Its neighbors soon degenerate. The pollen tube, as stated, penetrates the nucellus around the embryo sac, its vegetative nucleus disintegrates and the two sperm nuclei are delivered to the embryo sac. The first sperm nucleus moves up to the two endosperm nuclei and all three unite. The other sperm nucleus unites with the egg nucleus and fertilization is complete. Both fused nuclei now initiate a series of cell divisions.

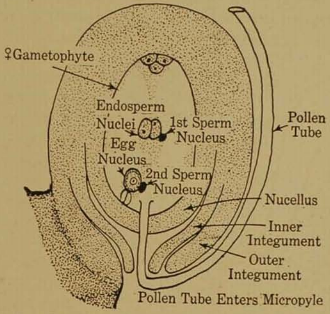

FIG. 70. — Enlarged diagram of the ovule shown in Fig. 69. From Sinnott's *Botany*, Revised edition. McGraw-Hill Book Co., reprinted by permission.

Formation of Seeds. The cells formed from the egg-sperm nucleus form the small *embryo plant.* The other nucleus formed by the union of the endosperm nuclei and the first sperm nucleus form what is known as the *endosperm.* This usually attains considerable size in monocotyledon seeds (Fig. 71), being many times larger than the embryo and consisting of food for the use of the embryo at the time of germination. In dicotyledon seeds the endosperm is usually soon absorbed and in its place, two *seed leaves* (Fig. 72) are developed from the embryo stem. These increase to a relatively great size (as in beans), being filled with food to be used by the embryo at germination. In either case the material for endosperm or cotyledons is delivered to the ovule through its funiculus and thence to the embryonic structures within. Immediately around the embryonic structures is the

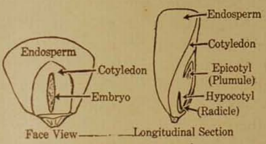

FIG. 71. — Corn grain.

nucellus and outside this are the integuments. In a short time, the floral parts wither away, the nucellus and integuments become hard, dry and impervious to water, and the seed with its complement of food is prepared to pass long weeks during the fall and winter in a dormant condition. It will " awaken " into active life, at germination.

Seeds. (*a*) *Monocotyledon* (Fig. 71). On one face of the corn seed near the pointed end is an oval-shaped area along the mid-line of which is the embryo. The greater part of the volume of the seed is endosperm. This seed is covered with a seed coat, which consists of the dried old *wall of the ovary* and the integuments. So that although a grain of corn is mostly seed it is also a fruit. Between the embryo and the endosperm is the single cotyledon which partially surrounds the embryo below in addition to being connected with it posteriorly. The greater part of the embryo is called the hypocotyl. This is the portion below the cotyledon. The portion of the embryo above the cotyledon is called the epicotyl. The portion of the plant above ground develops chiefly from epicotyl. The lower tip of the hypocotyl is the radicle or primary root. The food stored in the endosperm is transferred to the embryo during its early development.

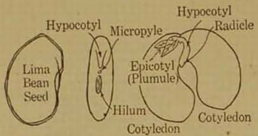

Fig. 72. — Lima bean seed.

(*b*) *Dicotyledon* (Fig. 72). The lima bean seed is large enough to enable us to understand the structure of a dicotyledon seed. The seed was taken from a pod (fruit) which is the dried wall of the ovary. The tough coats about the seed itself are the remains of the old integuments of the ovule. One edge of the seed shows a depression and on the face of this, a scar or hilum where the ovule was attached to the funiculus; at one end of this is a little pit, the micropyle, through which the pollen tube entered. After soaking in water the seed coats are easily removed. We find *two* large, thick cotyledons or seed leaves. These are connected with and are part of the embryo.

Sugar and proteins and fats derived from the bean plant were transferred to these seed leaves during seed formation and stored there for the future use of the embryo. At one end between the cotyledons is the embryo proper. The greater part of it below the cotyledons is the hypocotyl. The portion of the embryo above the cotyledons is the epicotyl. We see the embryonic leaves at this point. The endosperm in dicotyledon plants is not usually prominent. Its function as a storehouse of reserve food for the growing embryo is taken over by the cotyledons. Seeds contain food in concentrated form and there is very little water in them. Because of the concentrated food, man uses seeds as his staple food supply. First in importance is wheat, then corn, rice, oats, rye, beans, peas, etc. Seeds contain proteins, starches, mineral salts, and some contain valuable oils and some contain vitamins.

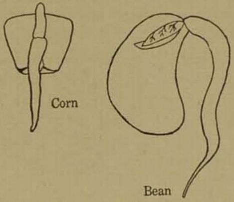

FIG. 73. — Germinating seeds.

Germination (Fig. 73). When seeds are surrounded by the proper temperature, moisture and air, they will germinate. This means that the little embryo will sprout or start growing. Peas may be planted in cold soil while warm soils are necessary for corn. Most seeds have to undergo a period of rest and dryness before sprouting. Well-dried corn gives better crops than undried seed. Germination takes from a few days to two weeks. The cotyledons of the pea remain in the earth, but those of the bean are raised above the earth. The cotyledon of the corn serves as an organ to transfer digested food, *i.e.*, sugar, fat and proteins, from the endosperm to the growing embryo. The food stored in the cotyledons of the bean is also digested and transferred to the growing embryo bean plant. After the food of the cotyledons has been used up, they wither and fall off. The digestion of stored food material is accomplished by means of ferments or enzymes which are present in the seed. Conditions favorable to germination activate these enzymes. Man propagates many of his useful trees by vegetative reproduc-

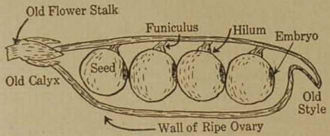

FIG. 74. — Pea pod, a simple fruit.

tion with *slips* and *grafts*. However, the world's supply of seed food is raised from seed.

Fruit. A simple fruit is a ripened ovary with its seeds. The mature wall of the ovary is called the *pericarp*. This may become dry at maturity and split, as in the *pod* of the pea (Fig. 74). The mature fruit of the *lily* is also dry at maturity and is called a *capsule*. Nuts, as the English walnut, are fruits in which the pericarp becomes very hard. A *grain* of corn or wheat (or of any grass) is a fruit in which the seed coats are united with the thin, dry pericarp. In the peach, the outer part of the pericarp is *fleshy* but the inner part forms the *hard pit* inclosing the seed. In the apple (Fig. 75) part of the pericarp forms the *core* while the rest of the pericarp and the receptacle form the fleshy part of the fruit. In the orange (Fig. 76) the ovary is expanded, the *chambers* being filled with juicy *pulp*. Most of the fruits with which we are familiar have had wild ancestors which have been domesticated and greatly improved by plant breeders.

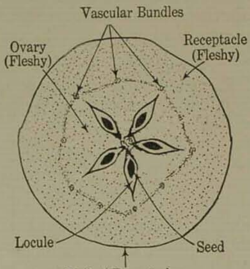

FIG. 75. — Section of apple.

Distribution of Seeds. After the production of seeds, their distribution takes place. Any agency which will scatter seeds and keep them from crowding favors the possibility of developing mature plants. Animals feed on fruits, for example. In the digestive tract of the animal, the fleshy part of the fruit is digested, but many of the seeds are unharmed and pass out with the feces and probably, at places distant from the place where the fruit was obtained. Some seeds have no fleshy coverings. Dry seeds, such as those of *Bidens*, have two prongs with sharp barbs which stick for a time to the hairy coats of animals and so are distributed.

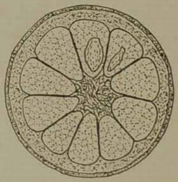
FIG. 76. — Section of orange.

The seed of the dandelion or of the prickly lettuce (Fig. 77) is a veritable parachute. Released from the plant the wind blows these little parachutes hither and thither and the seed is planted far from its place of origin. The seed of the milkweed is somewhat similar in structure. The seed of the maple tree has wings. Nuts contain plant embryos. Certain animals feed on nuts, the embryos of which are destroyed. But the animals using this kind of food gather in supplies of nuts, and in the process of gathering and transportation many drop on the way and thus are distributed. There are also many interesting mechanical devices by which seeds are thrown from the pod.

At this point, it is well to take stock of the principal points of resemblance between the flower and organs of reproduction in lower forms.

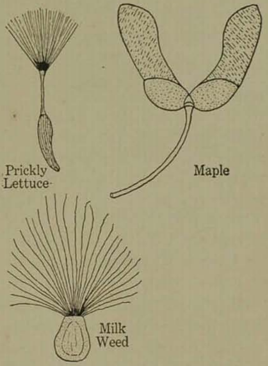

Fig. 77. — Seeds distributed by wind.

Comparison of Reproduction in Angiosperms with that of Lower Forms. 1. The flower of Angiosperms is to be regarded as a specialized strobilus in which the receptacle is homologous with the axis of the strobilus of lower forms and stamens and carpels are sporophylls. Petals and sepals are specialized floral parts.

2. Stamens produce pollen grains or microspores and carpels (pistil) produce megaspores.

3. The pollen tube apparatus is a male gametophyte and the embryo sac is a female gametophyte — and both homologous with gametophytes found in lower forms.

4. The seed contains the embryo which is a new immature sporophyte, while the seed coats are persistent remains of the old sporophyte.

5. Alternation of generations, which occurs for the first time in the Algae, is continued throughout all the remaining plant

groups. The gametophyte becomes reduced to microscopic proportions, while the sporophyte is greatly elaborated.

6. Sexual reproduction insures diversification of zygotes, resulting from the chance union of sex nuclei with different hereditary qualities. Spore production insures distribution through space, since plants cannot move about like animals.

7. The seed with its embryo, food for the embryo and protecting seed coats, is a device to carry the new individual over potentially destructive periods, to reduce infant mortality during the most hazardous period in the life of the new individual and also to transport it to a new environment before it begins its career.

Further consideration is of interest. Spores are very small in order to be wind transported. Many are destroyed, and in order to obviate this, great numbers of spores are produced by plants which still retain the independent gametophyte. In seed plants, spore destruction is greatly reduced, as megaspores, for example, are protected within tissues of the megasporophyll. Phyla which possess independent gametophytes expose the delicate organs of reproduction to destructive forces. In the seed plants, the gametophytes are reduced in size and complexity, so that it is possible for them to be inclosed within the tissues of the sporophyte. The embryo develops for a time within the parent plant until it has established young root, stem and leaf organs. It absorbs food material from the mother plant and stores this in endosperm or cotyledons, available for use at germination. It is protected by tough and waterproof seed coats. Then physiological activities slow down. It is discharged from the mother plant. It still lives, with fires of metabolism dampered. In this dormant state it may survive several unfavorable seasons. When proper conditions arrive, life activities within speed up; growth starts; the embryo bursts its bonds; vigorous roots, leaves, stem and branches rapidly develop.

(Selected References at end of Chapter VII)