/or

TALKS AFIELD

ABOUT PLANTS AND THE SCIENCE OF PLANTS

BY

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The author has written this little volume for those who desire a concise and popular account of some of the leading external features of common plants.

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TALKS AFIELD.

As the casual observer considers the plants about him he is impressed by the great differences between the common species, and he is perplexed in an attempt to find any attributes or characters which will serve to associate naturally one plant with another. He may have a remote knowledge that botanists have arranged plants into certain great natural orders or families, but he is at a loss to discover upon what characters these families rest. The sizes and shapes of plants, the forms of their leaves, the shapes and colors of their flowers, are so extremely variable that they appear to differ much more than they agree. What similarity, other than that which one shrub bears to another, has the willow, laden with its "pussies" of silver and of gold, to the alders and the poplars and the birches which grow in the same tangle? Or wherein lies the kinship between the buttercup of the meadow and the clematis that clambers over our doorway?

Notwithstanding the great external dissimilarities of plants, the botanist is able to trace relationships which are decisive. The characters which determine these relationships are not confined to any organ or to any part of the plant: they may exist in the roots, in the stems, in the leaves, in the general habits of the plants, but especially in the flowers and the fruits.

This leads us to a definition of the term fruit. The botanist uses this word in a very general way. It is applied to the seed-case and its contents. The fruit may be a poppy-pod with its innumerable seeds, a pea-pod, a rosy berry like the currant, an orange, a pumpkin, a beech-nut, an acorn, a walnut, a spore-case of a fern or a moss, or a grain of wheat. The contents of the seed-case are not always true seeds, and we must now demand a definition of a seed. If we remove the thin outer covering of a bean and pry apart the halves of which it is composed, an object like Fig. 1 will be presented. Between the large separated portions is a little object not unlike a bud, and

Fig. 1.

below it is a minute projection. If the bean were placed in moist sand and allowed to germinate this bud would be seen to develop into two green leaves and the little projection to push downward into a root. The little leaves continue to grow and the old halves of the bean are pushed up into the air as shown in Fig. 2. These dry halves soon fall away; but they have performed an important function in furnishing food to the young plant while it was germinating and establishing itself in the soil. They are therefore like leaves in some respects, and they are called the seed-leaves or cotyledons.

Fig. 2.

These thick cotyledons with the little bud and the initial stemlet constitute the embryo. Sometimes this embryo does not occupy the whole of the seed, but is imbedded in a mass of starch, which contributes to its support when it germinates. This is illustrated in the seed of the pine, Fig. 3. The seed, then, consists essentially of an em-

Fig. 3.

bryo or initial plantlet inclosed in an integument. There are other bodies in the lower plants which possess the functions of seeds in reproducing the plant, but which are entirely different in their structure. These bodies are the spores of ferns, of mosses, of moulds, and other low plants. They are commonly simple and very minute cells, and they contain no embryo. The dust that flies from a common puff-ball is made up of

Fig. 4.

spores, as represented at Fig. 4. Some spores are made up of two or more cells, as shown in Fig. 5. Spores are usually borne in some kind of a spore-case.

Fig. 5.

With an idea of what constitutes a spore, a seed, a fruit, and with a common knowledge of flowers, we are prepared to understand in a general way

The Leading Subdivisions of the Vegetable Kingdom.

Botanists commonly recognize two great sub-kingdoms of plants, known as the flowerless and flowering plants, or the cryptogams and phenogams. The flowerless plants are spore-bearing, while the flowering are seed-bearing. The flowerless plants are far the more numerous, and the greater part of them are as yet very imperfectly understood. On account of our imperfect knowledge of them, together with numerous difficulties in the way of studying the lower species, there is no generally accepted method of classifying them. For our purpose it is sufficient to say that flowerless plants are divided into Fungi, Algæ, Lichens, Mosses, and Ferns. There are two important facts, which we may profitably consider, relating to the methods by which these plants gain sustenance. There are two classes of plant foods: one is composed of substances which are found in the earth and the air, such as water, carbonic acid gas, lime, potash, and ammonia, commonly designated inorganic substances; the other is composed of materials which are made out of these inorganic substances by the plant itself, such as woody fibre, starch, and other vegetable or organic products. Most of the plants which we observe possess the power of making over inorganic or earthy materials into organized or vegetable materials; or, in technical language, they assimilate. All such plants contain green or red coloring matters. Some plants, however, of which mushrooms are examples, live entirely upon organic matter in something the same manner as animals do; they must therefore live upon decaying substances, when they are known as saprophytic plants, or upon live plants or animals, when they are known as parasitic.

In a general way we may say that the lowest class of plants are the FUNGI. The plants which are commonly included under this term are exceedingly numerous, and their individual characters are extremely variable. Some of them are so small as to be seen with difficulty through the best microscopes, while the largest are giant puff-balls which weigh many pounds. The fungi all live upon organic matter, — they are either saprophytic or parasitic. Most of them are grayish or neutral-tinted.


Fig. 6.

The lowest and the most minute of all known organized structures are the *Bacteria*. Under this denomination are included great numbers of microscopic plants, which are very imperfectly understood. They are simple in structure, each individual consisting of a single cell. (Fig. 6.) They are often united into chains or masses. A bacterium multiplies by dividing into two individuals, these two individuals again dividing, and so on in a geometrical progression. A simple calculation will demonstrate how enormous must in a few days be the increase if this progressive breaking in two continues unmolested at intervals of an hour or two. Professor Cohn calculates that from one of these minute organisms sufficient numbers will have been reproduced in five days to fill full the oceans of the world! Ordinarily these plants are not more than $\frac{1}{2500}$ of an inch in thickness, while many are much smaller. Indeed, it is highly probable that there are many species so minute that our best microscopes have not yet revealed them. Of the ordinary kinds an aggregation of from one hundred to three hundred placed side by side would not exceed in length the thickness of this paper. Most bacteria, and perhaps all, have the power of moving spontaneously. They whirl, quiver, move slowly and steadily, or perhaps dart rapidly across the field of the microscope. In color they are usually white, although some species possess beautiful tints of red, of blue, of yellow, or even green. Occasionally the housewife is arrested in her work by the appearance of blood-colored spots on cold potatoes or other articles of food, and as likely as not she half accepts the old superstition which supposed them to indicate the anger of God; she does not suspect that the spots are aggregations of many minute living plants which have come from the air. Bacteria are nearly everywhere present, in the air, in all stagnant or impure water, in all fermenting and decaying substances, and often in the human body. When moist substances in which they grow become dried up, they wither and escape as dust into the atmosphere to be revivified when again they fall under favorable conditions. In the air near the suburbs of Paris M. Miguel finds an average of about eighty bacteria to every square yard of air. Some of these, magnified a thousand times, are shown in Fig. 7. The floating dust in the sunbeam is composed of larger bodies than these bacteria. It is made up largely of fragments of lint, of spores of moulds, and of pollen of flowers. It is clearly demonstrated

Fig. 7.

that to the bacteria are due many diseases of man and the lower animals, and perhaps of common plants as well. Among such diseases are anthrax and splenic fever in cattle, and small-pox, scarlet fever, and probably consumption, cholera, and other scourges of the human race. Pure water contains no life, but the water of ditches, of stagnant pools, of impure cisterns, contains myriads of these minute plants. The souring of milk and many changes of fermentation are due to them. They are also the cause of decay. While they themselves depend for life upon the organic products of other plants and of animals, they are the direct means of reducing all organic life to decay and disintegration. They hold the keys of life; they complete the grand cycle of nature by which all living things return to the earth from whence they came.

A little higher in the scale of existence are the *Yeast Plants*. These minute bodies are propagated rapidly in yeast and other ferments, and by their physiological action produce important chemical changes. The invisible plants which spring up in bread yeast give

Fig. 8.

off carbonic acid gas and alcohol, which, in their escape, puff up the dough, causing it to "rise." A yeast plant magnified nearly eight hundred times is shown in its different stages at Fig. 8.

The *Moulds* which grow on nearly all decaying substances have a greater external semblance to the common idea of a plant than have the yeast plants and bacteria. Fig. 9 represents the bread mould magnified, the spores escaping from the apex. Fig. 10 shows the cheese mould with the fruit borne in a different manner.

Fig. 9.

Fig. 10.

Fig. 11.

Under the common denominations of *Rust*, *Mildew*, and *Blight* are included many very dissimilar kinds of fungi. They are parasites, which commonly attack the leaves and young shoots of flowering plants, often causing great annoyance to the farmer. The grape mildew is a familiar example. When the leaves are attacked they show the disorder in yellowish-brown patches on the upper side, and soon after they become sere and dead. The under surface of the leaf will reveal to the searching eye the cause of the trouble. There will be seen thin, frost-like patches, as represented in Fig. 11. Under the microscope, each of these patches is seen to be made up of a forest of such objects as appear in Fig. 12. This picture represents a grape leaf cut across, the line *n m* showing the upper surface, and *o p* the lower surface of the leaf. Among the cells of the leaf the root-like threads of the fungus, *c c*, are searching for food. The tree-like object above bears numerous globular buds, which drop off and act as spores in reproducing the plant. These buds are killed by the action of frost; they are therefore often called "summer spores." The

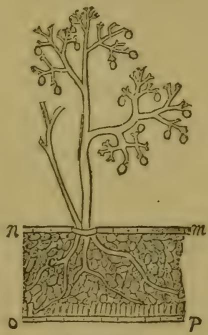

Fig. 12.

genuine spores, or "resting spores," are in the substance of the leaf itself. The rust of wheat, the scab on apples, and many other forms of plant diseases are similar in nature to the grape mildew. The manner in which the spores of some fungi are borne is shown in Fig. 13, which represents a magnified cross-section of the plum-knot, so much dreaded by horticulturists. In the peculiar club-shaped receptacles or asci are seen the spores.

Fig. 13.

The *Polypores* include those peculiar shelf-like fungi which grow on logs and decaying trees. They may be recognized by a reference to Fig. 14. These fungi are peculiar in having a hard and durable substance, although a few of them are soft in texture. The genus Polyporus comprises

Fig. 14.

the greater part of our common shelf-fungi. The polypores are so named from the numerous pores which sharp eyes may often discover on their under surface. In these little holes the spores are borne. Some of the soft polypores are edible, while some of the corky ones are tough enough to be cut into excellent razor-strops. Some of the larger species attain a horizontal diameter of three or four feet. A beautiful species in Guinea is worshiped by the natives.

The *Puff-balls*, *Mushrooms*, and *Toadstools* are remarkable for their rapid growth, and often for their great size, peculiar colors, and curious shapes. They are widely distributed over the earth, but are most abundant in moist and warm climates. They grow upon nearly all kinds of decaying matter. Occasionally they prove the presence of decaying substances where one would least expect it; they spring up in a night, from dry pastures and lawns. The genus Agaricus includes the mushrooms, of which there are no less than a thousand species. The Agaricus campestris, "field agaric," is now extensively grown in vegetable gardens. If we were to examine critically this mushroom in its early stages of growth, we would find a mesh of underground root-like fibres, with little mushrooms springing from them, as in Fig. 15. This mesh is known to gardeners as the "spawn," and it is what they plant; to the botanist it is the mycelium. A full-grown mushroom is shown in Fig. 16. Underneath the conical top are shown the "gills" upon which is borne the fruit.

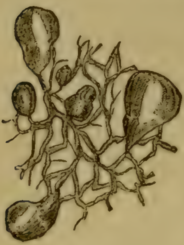

Fig. 15.

Many of our common mushrooms and similar fungi are highly esteemed as articles of food. There is no criterion, however, by which the non-botanist can distinguish the good species from the noxious ones. It is probable that the poisonous character of many of them has been much exaggerated, although there is no doubt that some of them are dangerously noxious. M. A. Curtis, a well-known Southern botanist, subsisted largely upon fungi during the straitened periods of

Fig. 16.

our civil war, and he urged the soldiers to resort to mushrooms instead of poor beef. In North Carolina he found seventy-eight edible species.

The ALGÆ include the sea-weeds and many minute or inconspicuous green plants which inhabit pools and lakes. Here are included plants which, in varieties of size, of shape, and of structure, exceed the wildest pictures of the imagination. Microscopic diamond-shaped or globular or irregular and curiously marked objects which swim in ponds and deep seas, more like animals than plants; delicate threads of green, more slender than a spider's web, which form the scum on ponds and the green tints on old boards and roofs; fairy-like feathers and tresses of beautiful red, which make up the "flowers of the ocean;" broad, leathery, and sombre "devil's aprons," large enough to load down a man; curiously punctured "sea-cullenders;" great tree-like plants which make forests under the seas; — these are some of the forms of algæ. The ocean has a wonderful flora, and scarcely less wonderful is the varied plant-life of every pond and pool. The ocean and fresh waters support their peculiar kinds of these flowerless plants.

They all agree, however, in possessing the one important power of assimilating, of obtaining their living from the inorganic matters which are contained in water, and they therefore necessarily contain leaf-green or other equivalent coloring matters. In the power of assimilating they differ essentially from all fungi.

Peculiar to fresh water are the *Desmids*, a few species of which are highly magnified in Fig. 17. These microscopic plants are composed of one cell, and are bright green in color. On account of their spontaneous movements they were long regarded as animals, but their methods of reproduction class them with plants.

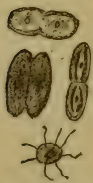

Fig. 17.

The power of moving from one place to another is not now regarded as at all incompatible with the idea of a plant. The desmids, as well as many other of the lower plants, have two kinds of reproduction: one is a dividing of the plant into two, and the other is a reproduction by means of spores.

The *Diatoms* are much like the desmids, and for a long time they also were supposed to be animals. From the desmids they differ in their yellowish-brown color and their very peculiar siliceous shells. When the plant dies the shell remains and settles to the bottom of the ocean or the lake. Aggregations of these shells harden into rock. Many durable flint rocks of dry lands are found to be made up entirely of them, the same as chalk is known to be composed of the shells of minute animals. In some places the floor of the ocean is now being slowly covered with these remains, which will gradually harden into impervious rock. Of all plants, the diatoms are the most widely distributed. They abound amid the ice in the polar seas, in hot springs, at a depth of two thousand feet in the ocean, sometimes on mosses and other plants which grow in moist places, and everywhere on submerged sticks and stones, upon which they often make a slimy covering. In the ocean the diatoms are eaten by mollusks, which in turn are eaten by fish, and the fish are eaten by birds. The little shells are often found intact in beds of guano. Many interesting species have been discovered in the stomachs of fish.

Fig. 18.

One of the most marvelous of all plants is the so-called *Red Snow* of the arctic regions and high mountains. (Fig. 19.) This "snow," which has been so long regarded with wonder, is an aggregation of immense quantities of a minute red alga, known to botanists as Protococcus nivalis. It is almost incredible that at such low temperatures any plant can grow so rapidly. The red snow was known to Aristotle, and was probably observed by him on the mountains of Macedonia.

Fig. 19.

Among the *visible algæ* are numbers of species which form the slime on stagnant pools and the green films on flower-pots and boards. A thread of the common zygnema, which makes much of the scum on frog-ponds, is magnified in Fig. 20, and the spiral band of leaf-green which imparts the characteristic color is plainly shown. Every one who has wandered on the beach of the ocean is familiar with numerous forms of the higher and larger algæ. These curious and often beautiful plants lend a peculiar charm to the sea; they force upon one the thought that many wonderful pro-

Fig. 20.

ductions are entirely hidden from human sight, and they afford a proof that organic life is universally distributed. Our common sea-weeds do not grow at great depths; they abound along the coast, where they cling to rocks, to shells, and to each other. In warm temperate and tropical countries the red species are numerous and very beautiful. The waters of the Great Lakes are remarkable for their entire lack of visible algæ. Many sea-weeds are edible, the most widely known being the Irish moss.

The LICHENS include a great variety of peculiar plants which are in many respects like fungi. They differ from the fungi in not being saprophytic or parasitic, and in growing much slower and enduring longer.

Fig. 21.

Every one knows the dry, gray "moss" on stones, logs, and the trunks of trees. (Fig. 21.) Nearly all lichens draw their nourishment from the air and rain, although a few live in water. In the interior of the gray mass of the lichen are green or yellowish granules, which possess the power of assimilating. These granules, or gonidia, are represented by the black dots in Fig. 22. A

Fig. 22.

peculiar discussion has arisen in late years, in regard to the true nature of these gonidia, and some botanists contend that they are not a part of the lichen at all, but are algæ, and that the surrounding gray portion is a fungus which draws its nourishment, in a parasitical way, from these algæ. This view does away with the great group of lichens, and resolves these plants into fungi which are parasitic on or about algæ. We will follow the old and common method, however, of calling these plants, with their gonidia, lichens. Lichens are reproduced by means of spores in very much the same manner as many fungi. Of all visible plants, lichens possess the power of adapting themselves to the widest differences of climate and surroundings. They are at home under the snows of the polar regions, and equally so in the burning sun of warmer climates, where they wither in drouth and revivify in rain. They increase as we travel northward or southward from the equator.

Some of the lichens are edible and others are medicinal, while a number are important sources of dyes.

Under the general term Mosses or Musci are included two very dissimilar orders of plants. One order, known as *Liverworts* or *Hepaticæ*, includes plants which have little or no distinction of root, stem, and leaf. The frond or main portion of the plant spreads out over the ground much after the manner of a green lichen, and from this

Fig. 23.

shapeless form the fruit stalks arise. One of the commonest species is figured, about natural size, in Fig. 23. On account of the many different forms which this plant assumes, it is known as the "many-formed Marchantia," Marchantia polymorpha. The fertile or spore-bearing plant is shown at the right in the figure, and the sterile at the left.

The true *Mosses* are familiar to all. They are widely distributed over the earth, abounding most in cool and moist woods. Their graceful forms and crisp appearance have always won for them a place in popular favor. We can all recall scenes of cool and quiet woods where

> Cleanly moss in patches lay
> In darksome nooks unseen;
> And murmuring rills with laughter play
> 'Mid mounds of freshest green; —
> Where Nature clothed her scars and dross
> With bright and seemly mats of moss.

About nine hundred different species of mosses occur in North America north of Mexico. The structure of a moss may be readily learned by a reference to Fig. 24, which represents the common pigeon-wheat moss that grows on dry knolls. At the top of the thread-like stem is seen the fruit. The stem at the left shows the immature fruit, which is covered by a hairy cap or calyptra. As the fruit matures this calyptra falls off and discloses the capsule or pod as represented at the right. An enlarged capsule is shown in Fig. 25. On its top is a lid or cover which falls off when the fruit is fully mature, and lets the many minute spores escape.

Fig. 24.

The highest of the large divisions of flowerless plants are the FERNS. Of all plants, these are probably the most generally admired. Among them are to be found the greatest variety of forms, of size, and of texture. The little Trichomanes Petersii of Alabama is scarcely an inch high, while some of the species of the tropics are in size and appearance like trees. Some creep along on the ground and over rocks, while others climb high on bushes. They inhabit every cool retreat in wood and glade, and offset, by their delicate texture, the aspects of coarser plants. The species

Fig. 25.

which occur in the United States east of the Mississippi are over one hundred and twenty-five in number. Of these probably the greater part are not recognized by the casual observer. A few of them grow in dry and open places and in sunny swales where they are popularly known as brakes. Three or four of them are troublesome weeds to the farmer. Some of them are evergreen and may be seen in winter protruding from the snow on hillsides. When transplanted to the garden many of the species grow well and are highly ornamental. It is imperative, however, that they be planted in a shady place which is protected from strong winds. In former years the propagation of ferns was regarded as a great mystery. No flowers or seeds could be detected by the curious. In Shakespeare's time the mystic "fern seed" was supposed to be a potent agent in the incantations of witches. The whole process of the reproduction of ferns is now understood, and nearly every one is familiar with the peculiar dots of fruit on the backs of the fronds or leaves. Fig. 26 illustrates the fruit-dots on the common rock polypody. If we magnify one of these fruit-dots we find it to be composed of many


Fig. 26.

globular bodies as in Fig. 27. By taking a side view we discover that each of these bodies is raised on a stalk. (Fig. 28.) Inside each of these bodies are born numerous spores. It frequently occurs that the fertile leaf, that which bears the spore-cases on its back, is oddly contracted and rolled up, so that it loses nearly all resemblance to a leaf. Ferns with the fertile frond transformed in this manner are often called "flowering ferns." One is represented in Fig. 29. One of the most peculiar of all ferns is that known

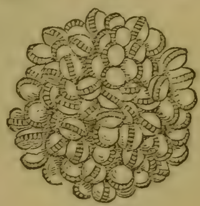
Fig. 27.


Fig. 28.

as the walking-leaf fern. (Fig. 30.) The tips of the slender fronds bend to the ground and take root. This interesting species is common in many parts of the Central States.

Fig. 29.

Another fern of our cool woods bears little bulblets on the frond, and these bulblets fall off and reproduce the parent. The odd little schizæa, perhaps the rarest of ferns, a plant for which the collector searches industriously in the low pine barrens of New Jersey, is pictured life-size in Fig. 31.

There are a few remaining small orders of flowerless plants, but with two exceptions their members are not sufficiently known to warrant a description here. These two exceptions are the CLUB MOSSES and the EQUISETUMS or HORSE TAILS. Club mosses are largely used for decorative purposes at Christmas time; indeed, they furnish almost the entire supply of winter "evergreen" in the East. There are less than a dozen species in the

Fig. 30.

Fig. 31.

eastern United States. A reference to Fig. 32 will show how they differ from true mosses: the fruit is borne in a peculiar spike, which is made up of many spore cases. The Horse Tails are often known as scouring rushes, from the use to which they are put on account of the great quantity of silex contained in their stalks. They are odd-looking plants, readily recognized by a reference to Fig. 33. In former ages plants similar to these attained to the size of trees.

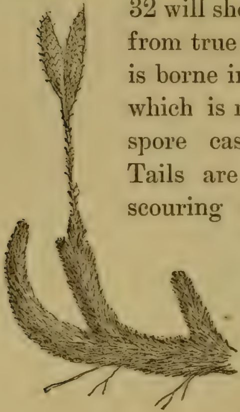

Fig. 32.

Fig. 33.

Having taken a cursory glance at the flowerless plants, we will now turn our attention to

SOME OF THE MOST INTERESTING FEATURES OF FLOWERING PLANTS.

Our first duty will be to find out what a flower is, and to do this we must pull one to pieces and see of what it is composed.

Fig. 34.

Let us pick a cluster of flowers from an apple-tree. The first thing that attracts our attention in this cluster is the beautiful color, the delicate blush or pure white of the flowers. The first glance may discover no other parts in the flowers than these showy "leaves." A closer look will reveal five green "leaves" beneath the colored ones, as shown in the half-opened flowers in the cluster. To distinguish these two distinct sets of floral leaves, botanists designate the showy ones petals and the green ones sepals. Both together they constitute the floral envelope. The petals and sepals appear distinct enough from each other in the apple flower, but we shall find flowers in which they are very much alike. In the centre of each blossom are delicate threads. A flower cut in two lengthwise (as in Fig. 46, page 56) will disclose these inner organs. Of these organs there are plainly two kinds. Those on the outside bear yellow boxes on their ends. These threads, with their boxes, are the stamens; the boxes are the anthers.

Fig. 35.

If the anther is enlarged, as in Fig. 35, it is seen to be composed of two boxes lying parallel to each other, each one opening by a slit on its outer side. From this slit the pollen, a fine yellow dust, is escaping. The inner organs in Fig. 46 are totally unlike the stamens. Of these organs there are apparently three, all united below into one and to the little apple which we have cut through at the base. It is evident, then, that this miniature apple with its three-parted projection is one compound organ. This organ is the pistil. The apple part is the ovary, the parted projection is the style, and the five little flattened tips are the stigmas. We have now discovered all the leading parts of the apple flower, — the sepals, the petals, the stamens with their anthers, and the pistil with its ovary, three-parted style, and three stigmas. We will now apply our knowledge to the common marsh-marigold or "cowslip," which gladdens every meadow swale in early spring. (Fig. 36.) In this flower the sepals, apparently, are not present. Here we must remember arbitrarily that when either row of the floral envelope is wanting, the botanist supposes that the petals are the missing organs. It is therefore necessary to call the showy petal-like leaves of the marsh-marigold the sepals. Such showy sepals are petaloid or "petal-like." The short stamens and pistils in the centre of the flower are clearly recognized, but instead of one

Fig. 36.

pistil there are many closely packed together and bearing no styles; all there is to these pistils is a little ovary and a minute sessile stigma. These ovaries ripen into pods or fruit, like Fig. 37. The flowers of the buttercup, of the wind flowers or anemones, of the clematis, of the pretty hepatica or liver-leaf, and other plants, are made up in essentially the same manner as those of the marsh-marigold, and they are therefore all united into one family, the Crowfoots. If we examine the morning-glory flower in Fig. 38 we notice at once that the petals are all united into one bell. Since we cannot speak of the petals individually, we must now speak of them collectively; we therefore call the bell the corolla. But even if the petals were not united we could properly speak of them collectively as the corolla. The sepals, taken together in like manner, may be styled the

Fig. 37.

Fig. 38.

calyx. In the mint flower, Fig. 39, the petals are united in a peculiarly irregular manner.

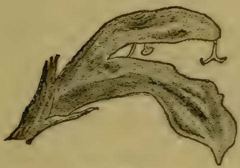

Fig. 39.

Fig. 40.

ner. If we were to pick one of the dark purple clusters which are seen on the bare twigs of the ash in early spring, we should discover that it is made up of many flowers. One of these flowers is shown in Fig. 40. It has no calyx, no corolla, simply two stamens and a styleless pistil. We pick a gold-dusted "pussy" from a willow, examine it closely, and find it to be made up of many little flowers like *a* in Fig. 41. Each of these little flowers is composed solely of two anthers which are subtended by a minute scale! Let us find another willow bush which bears greener and less conspicuous

a Fig. 41.

"pussies." These "pussies" are made up entirely of flowers which are composed of one pistil! (Fig. 42.) Finally, we inquire into the ways of the snow-ball or hydrangea in the garden. Each of the flowers which go to make up the snowy balls is found to consist of nothing but a calyx and corolla!

Fig. 42.

How shall we define a flower? It is not essential that any flower have showy colors, or sepals, or petals, or stamens, or pistils. And we might even take exception to Webster's careful definition that the flower is "that part of a plant which is destined to produce seed," for the flowers of the cultivated snow-ball and the outer ones on the heads of all sunflowers and the stamen-flower of the willow cannot produce seeds. This definition may be regarded as in the main correct, however, and the so-called neutral flowers are to be looked upon as anomalies. Outside the sunflower family these flowers are of rare occurrence, unless they are produced by cultivation, as in the case of the snow-ball. If our definition includes the stamen-bearing flower of the willow we must modify it after this manner: The flower is that part of the plant which is destined to produce or to aid directly in producing the seed. The office which the stamen-flower exerts in aiding to produce the seed will be discussed at another time. (Page 77 *et seq.*)

It now remains to find names for some of the different kinds of flowers. A flower which has calyx, corolla, and one or more stamens and pistils is said to be *complete;* if any of these organs are missing it is *incomplete.* One which has only floral envelopes, as the snow-ball, is *neutral.* One which contains both stamens and pistils is *perfect;* when either stamens or pistils are wanting it is *imperfect.* One bearing only stamens is *staminate;* only pistils, *pistillate.* When a flower has both calyx and corolla and the petals are not united, it is *polypetalous;* when the petals are united, as in the morning-glory and mint, it is *gamopetalous* or *monopetalous;* when either calyx or corolla, or both, is absent, it is *apet-*

alous. When all the sepals, all the petals, all the stamens, and all the pistils are alike, the flower is *regular;* when any or all of them are unlike, as in the pea and bean, or when a gamopetalous corolla is not equally lobed, as in the mint, it is *irregular.*

In this connection it remains but to be said that flowers vary as widely in size and in appearance as they do in essential structure. The smallest of flowers is that of the little Wolffia which floats on ponds throughout most of the Northern States, the entire plant being smaller than an ordinary pinhead. The largest flower is that of the Rafflesia, a parasitic plant of the Javan forests. They are sometimes over a yard across. Many flowers possess no colors other than green. The flowers of our grasses and cereal grains are green and usually inconspicuous, and the same may be said of the flowers of most forest trees.

The manner in which the stems of flowering plants increase in diameter must next demand our attention. There are two general methods by which this increase takes place. If we cut off a corn-stalk (Fig. 43) we observe that there are many threads running through it lengthwise. A cross-section of the trunk of a palm would reveal a similar structure. Contrast with these stems a cross-section of an oak, as shown in Fig. 44. In this section there are conspicuous layers or rings of wood; the internal threads are not to be seen. The corn-stalk and the trunk of the palm increase in diameter by the addition in the interior of new threads which stretch out the surface of the stalk. These plants are inside growers or endogens.

Fig. 43.

Fig. 44.

The trunk of the oak increases in diameter by the addition of new wood in layers near its surface. It is, therefore, an outside grower, or an exogen. In the Northern United States the endogens are all herbs, with the single exception of the straggling green-brier or smilax. In warmer climates the endogens are represented largely by palms and similar plants. It is evident from the manner in which these inside growers increase in diameter that there must soon be a limit to this increase. In tree-like plants the outside or bark portion soon becomes so indurated as to resist further stretching, and even if this were not the case it is scarcely conceivable that new fibres could long be added in the interior. Endogenous plants seldom become large in diameter. Most palms are as thick when they begin to ascend from the ground as they ever will be. As a rule palms do not branch; they grow entirely from the terminal bud, and if this bud be destroyed the plant perishes. Endogens have no true bark, none that can be readily stripped off, and they have no pith. The grasses, sedges, the lily tribe, the orchids, and the rushes are endogenous plants. Exogens include our woody plants and our trees, and also many of our herbs. If we strip the bark from any of our trees in spring we shall find a mucilaginous covering remaining on the wood. This covering is being made for the formation of new wood. It is cellular in character; the walls of its minute cells are thin, and the cells themselves contain building materials in the liquid state. This new layer is the cambium; upon one side it forms bark and upon the other side wood. When this cambium becomes hard the wood portion is called the sap-wood. This sap-wood differs from the heart-wood in being composed of thinner-walled cells and in containing more soluble or organic matters, but it is chiefly distinguished by its lighter color. In some trees it does not appear distinct from the heart-wood. On account of the climate of temperate regions the making of cambium is arrested every autumn, and when a new layer is formed the next spring a mark is left which defines the annual increase of the trunk. In cold and unpropitious seasons the growth is light and the layer is thin, while in moist and warm years the layer is much thicker. These layers are therefore meteorological records of the years. It sometimes happens that a pinching drouth or other cause will entirely arrest the formation of cambium in early summer and subsequent rains will cause the growth to be resumed, but between these two layers a mark will be left and two rings will be formed in one season. The number of rings, therefore, are not always a true index to the age of the tree. The growth of the trunk causes the dead outside bark to stretch and split, and to form ragged ridges running lengthwise the trunk. The interior of exogenous stems is occupied by a pith (Fig. 44), and from this pith lines radiate in all directions. These lines are the medullary rays. The interior dark portion is the heart-wood, and the outer light portion the sap-wood. The stems of our exogenous herbs increase in essentially the same manner as the trunks of trees.

It is a singular fact that there are peculiarities of the seeds and of the flowers of endogenous and of exogenous plants which distinguish the two groups as readily as does the manner of growth. It will be remembered that in our study of the bean on page 2 we discovered two seed-leaves or cotyledons. It is found that the seeds of all endogens contain but one cotyledon, while those of exogens contain two or more. The endogens are therefore often styled Monocotyledons and the exogens Dicotyledons. The parts of the flower in the endogens are usually in threes or in multiples of three: that is, there are three, or six, or nine sepals and petals and stamens and pistils, or some higher number which is a multiple of three. It is not necessary that these organs be all present in any one flower, but such as are present fall under this rule. Thus a lily has six sepals, six stamens, and a three-lobed pistil. Exogens, on the contrary, never have the parts of their flowers in threes but usually in fives or multiples of five. Aside from these differences between endogens and exogens, there is a nearly constant distinction in the leaves. In the endogens the veins in the leaf are not usually distinct, but when conspicuous they are seen to run parallel to the midrib, — they are parallel-veined. The leaves are usually long and narrow like those of rushes, lilies, and grasses, and their margins are not notched. There are some exceptions, the most prominent being the leaves of smilax, and of the trilliums or wake-robins. Most of the leaves of exogens have netted veins, although the pinks and some others have not.

The Classification of Flowering Plants.

There is no science in which the arrangement of objects into a series of subordinated groups is so thoroughly and minutely worked out as in botany. A knowledge of the methods by which botanists classify plants is of vital importance to one who under-takes to know much of botany; and the classification itself is of interest to the logician, as affording the best illustration of inductive and dichotomous arrangement. The system of botanical classification is founded upon the inductive principle of first learning the characters of individual plants, and then seizing upon the most salient and permanent features by which many plants may be associated together. Among the apparent confusion of forms and of structures in plants, it is not strange that the ordinary observer fails to recognize any general points of agreement. There evidently must be more points of agreement than of difference between two or more plants before we can group them together. They must agree with one another, but must differ from other groups. The two great sub-kingdoms or series of plants illustrate this proposition: the flowerless plants possess a common character of reproducing themselves by spores, while the flowering plants agree in reproducing themselves by means of seeds; between these two sub-kingdoms there is a great external dissimilarity in this respect. These characters of spore-bearing and of seed-bearing are not readily recognized by those unfamiliar with the study of plants, and they were not hit upon by the early botanists. The characters employed by the early herbalists and botanists in making their classifications illustrate the extent of the knowledge of plants at the time, and a comparison of successive methods of classification indicates the advancement in such knowledge. For instance, upon being told that Dioscorides in the first century divided plants into aromatic, alimentary, medicinal, and vinous, one is at once impressed with the thought that Dioscorides studied plants from a medicinal point of view, and that he understood their medicinal characters better than any other features. A very early classification, and one which denotes a superficial knowledge of plants, was that which recognized the three divisions of trees, shrubs, and herbs, and this classification was not entirely dispelled until Linnæus rejected it in the middle of last century. It is strange that the forms of flowers did not earlier attract attention. Fuchs, a studious German whose botanical labors are appropriately commemorated in the name Fuchsia, was perhaps the first to define any of the parts of the flower. He called the anthers the apices, and the floral envelope, at least in some cases, the gluma. Fuchs published a botanical work in 1542. Hieronymus Tragus, another German, published an herbal in 1551, in which he associates some of the mints, the mustards, and the sunflowers. The first indication of a general scientific arrangement of plants occurs in the "De Plantis Libri" of Andreas Cæsalpinus, published in Florence in 1583. In a vague manner Cæsalpinus pointed out ten classes: the first included plants which bear but one seed, as the peach, almond, and cherry; the second, such as had but one seed receptacle or case, as the rose; the third, those which had two seeds; the fourth, those with two seed receptacles, and so on through those with four seed receptacles; then followed a class having more than four seeds and one having more than four receptacles. These classes were largely artificial and arbitrary, but they brought together plants which have natural affinities. The plants included by Cæsalpinus under Legumina are essentially those at present included in the order Leguminosæ, or the Pea family, and his Bulbaceæ correspond pretty closely to our Liliaceæ, or lily-like plants. John Ray, of England, made important improvements in classification in works which he published in 1682 and 1686. Ray classified on characters of the flowers and fruits. In 1690 Rivinius made a disposition of plants founded upon the character of the corolla alone. It remained for Joseph Pitton de Tournefort, of Paris, to enlarge this system of classification. In 1700 Tournefort published eleven classes founded upon the shape of the corolla, and for more than fifty years these classes were recognized. This man was an acute observer and an accomplished botanist. He is commonly regarded as the greatest botanist prior to Linnæus. The names of some of his classes still remain, as the Labiatæ, Umbelliferæ, Liliaceæ, Rosaceæ.

Linnæus is by common consent regarded as the greatest of botanists. He was a Swede, and lived from 1707 till 1778. Linnæus entered upon his scientific labors at a time when the knowledge of plants and animals was vague and superficial, and when there were no acceptable methods of classifying and arranging either natural objects or the knowledge of them. He entered the field as a reformer. In this capacity he was admirable for his skill, and still more so for the success he won. He brought order out of confusion. His work extended to all kinds of animals and to minerals. Through his exertions a new life was imparted to the pursuit of scientific learning. In this connection we can consider but two of the important reforms instituted by Linnæus, but these two are among his most conspicuous labors. He made a radical change in the nomenclature of natural objects, and he propounded a new and important system of classification. We will first speak of the reform in nomenclature. Before Linnæus plants were named in scientific works by a Latin phrase, which was commonly used in the ablative. Thus "Acer foliis palmato-angulatis, floribus subapetalis, sessilibus, fructu pedunculato corymboso" was the name of the red maple. Rendered into English the name reads: "Acer with palmate, angular leaves, sessile and nearly apetalous flowers, and stalked fruit in corymbs." Acer is the generic or general name of all the maples, the same as the word maple is the generic name. The different kinds or species of maples were distinguished from each other by the descriptive phrases. These phrases were unwieldy and inconvenient, and Linnæus saw what confusion and unpleasantness must come from a multiplication of such names. A very small part of the plants of the world, or even of Europe, were then described. Linnæus adopted the method of making the name of each plant consist of two words, one a substantive and a generic name, the other an adjective and a specific name. Thus the red maple became in botanical language Acer rubrum. The adoption of this binomial nomenclature, as it is called, meant more than simple convenience to the botanist: it gave a fixedness to genera and to species. The genera of plants were but vaguely defined before this time. We might illustrate a vaguely defined genus by supposing that the term maple might include ashes or other trees beside the true maples, or that one person might apply the name to one set of plants, and another person to a different set. The idea of genus is an important one. This idea is supposed to have originated with Conrad Gessner, an obscure German, who died in 1565; at least most of the merit of the invention is to be ascribed to him. The strictly scientific definition and use of the genus began with Tournefort, however. A more particular mention of the binomial nomenclature will be found on page 159.

The Linnæan System of Classification, although now wholly superseded by the Natural System, was an exceedingly important one, because it first brought strict order into the arrangement of plants and because it recognized the presence and importance of the stamens and pistils. Under the discussion on the *Sexes of Plants*, this classification will be mentioned again. The Linnæan system is strictly artificial, a fact which its author fully understood, but with the imperfect knowledge of the science at that time he could not aim at a natural classification. Under his system the knowledge of botany increased rapidly, and before he died the beginnings of a natural classification were made. The Linnæan or artificial system divided the whole vegetable kingdom into twenty-four classes, founded entirely upon the number, situation, and connection of the stamens. Using the Greek word *andria*, man, for stamen, the names of the first thirteen classes are made up as follows: Monandria, flowers with one stamen; Diandria, flowers with two stamens, and so on to flowers with twelve stamens. Then follow others founded upon the position and other characters of the stamens. These classes are divided into orders founded upon the number of styles or stigmas. Using the Greek *gynia*, woman, the ordinal names are made after the same manner: Monogynia, Digynia, etc. Linnæus observed the distinction between flowering and flowerless plants, and originated the names Phenogamia (or Phenerogamia) and Cryptogamia. His beautiful scheme of classification was used until within the last half century.

The Natural System attempts to bring together those plants which most nearly resemble each other in all essential particulars. It does not attempt to make a system; it accepts the system wrought out by the Creator, and endeavors to follow it closely; the more closely it follows nature the more nearly it approaches perfection. Although we cannot hope to have attained perfection in this system, it is a beautiful and scientific structure, and so far as it rests upon natural resemblances and differences must remain essentially undisturbed. If the order of relationship between plants lay in a line, one plant giving rise to another of higher order, and that one to but one other of still higher order, and so on to the most highly developed of plants, a natural system of classification would present no difficulties. Such is not the case, however. Taking almost any plant as a starting point, we find not only a line ascending and another descending from it, but we find several lines developing in different directions; and some of these lines may be suddenly suppressed, or they may become so modified as to present an equal number of resemblances to each of several starting points. To properly associate plants in a lineal classification, as we necessarily must attempt to do in our books, as if we were enumerating a straightforward genealogy, is therefore an impossibility. Bèrnard and Antoine Jussieu, uncle and nephew, residents of Paris, were the immediate founders of the natural system in outline, although Linnæus and others had indicated such a system. It has been much improved by subsequent botanists. A. P. De Candolle early in this century rearranged the natural families, or orders, into what is known as the Candollean sequence. This sequence supposes that the highest plants are those in which all the parts of the flower are present, and in which they all stand by themselves, the sepals not being joined to each other or to the petals, the petals not being joined to each other or to the stamens or pistils, and so on. De Candolle assigned the highest place to the Crowfoot or Buttercup family and the lowest to the Grass family. This sequence is essentially maintained at present. Of course the genera and the species of plants are the same in any system of classification. Classification is simply a method of arranging them.

The most general division of the vegetable kingdom is into flowerless and flowering plants, — Cryptogams and Phenogams. We will exclude the cryptogams from our consideration, as we have already discussed their provisional arrangement. Phenogams may be divided into inside-growers or one-seed-leaved plants, — Endogens or Monocotyledons, — and outside-growers or two-seed-leaved plants, — Exogens or Dicotyledons. Excluding the endogens, we find that the exogens are most readily subdivided upon characters of the floral envelopes: the individuals fall under three divisions, — Apetalæ, Gamopetalæ, and Polypetalæ. These terms find an explanation on page 35. Each of these divisions contains its natural orders or families, as does also the class of Endogens. The natural orders or families are large groups of plants which have a general similarity in flowers, fruit, leaves, and general habit. Being entirely natural they are not readily defined, and their limits are not commonly clearly cut. For instance, the Pea or Pulse family includes some six thousand five hundred plants, which agree tolerably well in producing a certain kind of fruit or pod, and most of them bear the peculiar pea-like flowers, although the Acacias do not. We may present a general view of the larger divisions of flowering plants, mentioning only the most important natural families, as follows: —

Class I. ENDOGENS. Including
- *Gramineæ*, or Grass family.
- *Cyperaceæ*, or Sedge family.
- *Liliaceæ*, or Lily family.
- *Iridaceæ*, or Blue Flag family.
- *Orchidaceæ*, or Orchid family.
- *Palmaceæ*, or Palm family.

Class II. EXOGENS.

Division I. APETALÆ, Including
- *Cupuliferæ*, or Oak and Beech family.
- *Urticaceæ*, or Nettle and Mulberry family.

Division II. Gamopetalæ, Including

Solanaceæ, or Nightshade and Potato family.

Labiatæ, or Mint family.

Scrophulariaceæ, or Figwort and Snapdragon family.

Ericaceæ, or Heath and Whortleberry family.

Compositæ, the great composite-flowered family, including sunflowers, daisies, etc. (See p. 60.)

Rubiaceæ, or Madder family.

Caprifoliaceæ, or Honeysuckle family.

Division III. Polypetalæ, Including

Umbelliferæ, or Parsnip and Carrot family.

Cucurbitaceæ, or Pumpkin and Melon family.

Saxifragaceæ, or Saxifrage and Currant family.

Rosaceæ, or Rose family. (See p. 54.)

Leguminosæ, or Pea family.

Caryophyllaceæ, or Pink family.

Cruciferæ, or Mustard and Cabbage family.

Ranunculaceæ, or Buttercup family.

The *Coniferæ*, or Pine and Spruce family, belongs to the Exogens, but on account of certain peculiarities it is not included in either of the three divisions. Under each family are arranged the genera, and under each genus the species. To illustrate more particularly the methods of classification within the order, synopses of the Rose and Composite families are given farther on. The number of orders or families of flowering plants admitted by latest authorities is 200, including 7,585 genera, and nearly 100,000 species!

The Rose Family.

The limits of the natural orders of plants were made by the Creator; they are natural boundaries. The botanist associates those plants which resemble each other in the essential structure of flower and fruit, and names the group thus formed after some one of its prominent members, or after some striking peculiarity of the group. Thus botanists find about a thousand species of plants which resemble the rose, and they are collectively designated the Rosaceæ or Rose family. When these thousand plants are studied and compared a family definition is made. It is often a difficult task to make a definition which will include so many plants and exclude those of other families.

It is especially difficult in the Rose family, which includes plants of very variable structures. Some orders or families are more natural than others; they include plants which agree in possessing some one or more peculiar distinguishing characters. Examples of such families are the Cruciferæ or Mustard family, Umbelliferæ or Parsnip family, and Compositæ or Sunflower family.

The Rose family is not so well defined as many other families. As now understood it includes two or three families recognized by the older botanists. We shall find it profitable to examine a few rosaceous flowers before considering the general definition of the order. Fig. 45 represents a cherry flower cut in two lengthwise. At *p* is seen the pistil, the lower part of which (the ovary) ripens into the cherry. At *c c* is shown the calyx, upon the top of which are borne the stamens and the petals. The end of the flower-stalk where it joins the flower, *r*, is called the receptacle. Fig. 46 represents

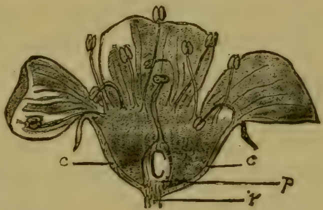

Fig. 45.

an apple-flower. Here the stamens and petals are borne on the calyx as before, but the ovary or young apple does not appear to be distinct from the calyx. The dotted lines at c c show the position of the calyx, however, and that it is united with

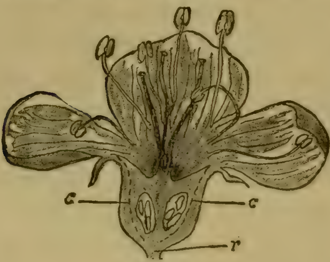

Fig. 46.

the ovary. As the fruit ripens this adnate calyx thickens and becomes fleshy, and forms the edible portion of the apple. The core of the apple is the fruit, while the surrounding portion is thickened calyx! The upper extremities of this calyx are seen in the five appendages in the

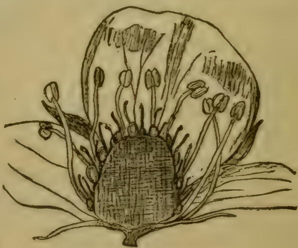
Fig. 47.

"blossom end" of an apple. Fruits made up in this peculiar manner, as apples, pears, quinces, and medlars, are designated pomes. We also notice that in this flower there are three styles represented, while in the cherry flower there is only one. The receptacle at *r* is like that in Fig. 45. In Fig. 47 is shown a section of the strawberry flower. Here again the stamens and petals are attached to the short calyx, but the centre of the flower presents a peculiar appearance. The central body is the receptacle much enlarged, and over its surface are scattered numerous little pistils, which ripen into the fruits or "seeds" of the strawberry. The elongated receptacle becomes red and fleshy, and is called a strawberry, while in fact it is not a berry, not even a fruit, but the fleshy end of a flower stalk! If we were to examine a blackberry we should find its centre to be filled with the white and elongated receptacle, over the surface of which are packed the little fruits. These little fruits are like those on the strawberry, only that they are fleshy. The blackberry is therefore a collection of many little fruits. The raspberry resembles the blackberry, but the receptacle does not separate from the bush with the fruits. We will next examine the rose itself, a halved specimen of which, with the petals removed, is shown in Fig. 48. The stamens and petals are borne on the calyx as before, but the fruiting portion presents a new anomaly. Several little pistils or fruits are borne inside a cavity. The walls of this cavity are made up of the adnate calyx on the outer side and of the concave receptacle on the inside. When the fruits are ripe this fleshy urn closes up more or less completely, and forms altogether the "rose hip" or, as it is often erroneously called, the "berry."


Fig. 48.

Among all these complexities of structure in the rosaceous flowers are there any constant characters? We have noticed one decisive peculiarity: the petals and stamens are borne on the calyx. We may have noticed other peculiarities. For instance, the flowers are regular, all the stamens, all the petals, and all the pistils being alike; the stamens are not united with each other; the petals are not united with each other; the sepals are united below into a tube; the pistils are borne inside the calyx, not below it as in some plants, *i. e.*, the pistils are superior. Now, all these plants are Exogens, and they belong to the division Polypetalæ;

and we may further define them by saying that they have regular flowers, with the distinct stamens and petals borne on the calyx tube and the pistil or pistils superior. The greatest differences in the structure of the flowers we have seen to lie in the adhesion of calyx tube and pistils, or calyx tube and receptacle, and in the odd forms of the receptacle rather than in the pistils or fruits themselves.

We may divide the Rose family into three sub-orders or sub-families: —

Almond Sub-Family. — Comprising plants whose flowers bear mostly one pistil, to which the calyx tube is not united, a normal receptacle, and which produce stone-fruits or drupes. Here are included almonds, peaches, apricots, nectarines, cherries, and plums.

Rose Sub-Family. — Pistils usually many, distinct, not becoming large in fruit, and not united with the calyx tube, the receptacle often peculiarly developed. In this sub-family may be included the roses, strawberries, blackberries, raspberries, and spiræas.

Pear Sub-Family. — Pistils united with each other and with the calyx tube, which becomes thick and fleshy at maturity. Here are included the pomaceous (pome-bearing) plants, apples, pears, quinces, medlars, service-berries, mountain-ash, and hawthorns.

Under each of these sub-families are included the genera, of which the whole Rose family contains about seventy. The representative genus of the Pear sub-family is Pyrus. Pyrus malus is the common apple, Pyrus prunifolia the crab-apple, Pyrus communis the pear, and Pyrus Cydonia the quince. There are five native species of Pyrus in the northeastern United States. One of the most familiar is Pyrus Americana, the mountain-ash. The wild crab-apple, common in glades from western New York to Wisconsin and southward, is P. coronaria, and the dog-berry or choke-berry of swamps, a bush and fruit resembling the whortleberry, is P. arbutifolia, "arbutus-leaved Pyrus."

The Composite Family.

The largest and the most readily recognized of all orders is the Compositæ. This great family includes about 10,000 species, fully one ninth of all flowering plants. These species belong to nearly 800 genera. One thousand six hundred and ten species occur in North America north of Mexico, but 59 of these have been introduced from other countries; 237 genera are represented. The largest genus of this family is Senecio, which contains nearly 900 species, only 57 of which occur in this country. The largest genus in America is Aster, which comprises 124 species, and the next is Solidago, golden-rods, comprising 78 species.

The members of the Compositæ have three easily recognizable peculiarities: the individual flowers or florets are small and they are compacted into a conspicuous head, which is commonly mistaken for one flower; the calyx is represented by soft hairs or little teeth borne at the apex of the little fruit; the anthers are united in a ring about the style. The outer flowers in the head are often furnished with a long ray or notched petal on one side, and these rays appear like the petals of one simple flower. Fig. 49 represents the blue flower of an aster with the conspicuous rays

Fig. 49.

of the outer flowers and the less showy interior or disk flowers. If we were to cut in two a garden coreopsis, as in Fig. 50, we could readily discern that the yellow rays

Fig. 50.

are not a part of the disk flowers. If from this coreopsis we were to remove all the flowers but two, as in Fig. 51, we should see that the ray flowers bear little resemblance to the disk flowers. The erect disk flower in the centre has minute teeth near its base in the place of a calyx, and the petals are united into a five-parted tube. The flower is therefore one of the Gamopetalæ. The ray flowers have the minute calyx teeth, scarcely

Fig. 51.

shown in the figure, but there is apparently only one petal, which is rolled into a tube below. The end of this petal is furnished with five notches; why do they not represent the five united petals? We notice these notches in the chicory and in most other ray flowers of this family. The ray flowers in the coreopsis have no stamens or pistils: they are neutral flowers. The disk flower has two deflexed stigmas, below which is the ring of five united anthers. The anthers and stigmas are enlarged in Fig. 52.

Fig. 52.

Each of the disk flowers is subtended by a bract or bristle, one of which is shown in Fig. 51. In all the composite flowers the receptacle is greatly developed, usually presenting a nearly flat, expanded surface. In the cultivated sunflowers this receptacle, with its covering of florets, is often over a foot across. Fig. 53 represents a floret of the pestiferous Canada thistle. At its lower extremity is the ovary, which ripens into the one-seeded fruit. On its apex is borne the downy pappus, which answers to the calyx, and the five-parted corolla is seen above. Here, then, the ovary is inferior; in the rosaceous flowers we found it to be superior to the calyx. The pappus may con-

Fig. 53.

sist of many soft hairs, as in the thistle, or of barbed teeth, as in the beggar's ticks (Fig. 54), or of minute teeth, as in the coreopsis. In most cases it is a means of distributing the seed, either by floating it in the air or by attaching it to clothing or the coats of animals. In the dandelion it is raised on a slender stalk. (Fig. 55.) The whole head in the composite flowers is more or less surrounded by little green leaves, like a calyx. These leaves constitute the involucre. The involucre is shown at *i* in Fig. 56, and again in Fig. 57, where it is compact and tube-like and covered with hooked bristles, making the well-known bur of the burdock.

Fig. 54.

Fig. 55.

Fig. 56.

We are now familiar with the essential structure of the flowers of the Composite family, — the aggregation into heads, the pappus, the united anthers, the gamopetalous corolla, the enlarged receptacle, the involucre,

Fig. 57.

the rays, and the chaff or bristles on the receptacle. The rays are often entirely absent, as in the boneset and thistles, and sometimes all the flowers have rays, as in the chicory and dandelion. Sometimes there is no indication of pappus, and the chaff is often wanting also. The beauty of the heads of composite flowers is due almost entirely to the conspicuous rays. These rays sometimes contain both stamens and pistils, sometimes only pistils, and sometimes neither.

Although the Compositæ includes such a vast array of plants, inhabiting every climate, there are very few of them which furnish edible or useful products. The important edible species are lettuce, endive, chicory, and salsify or vegetable oyster, and its ally, scorzonera. Most of the species are herbs, a very few attaining the character of low shrubs. If the order lacks in edible or other useful species, it superabounds in ornamental ones. The daisies are all members of the Composite family. Botanically, the daisy is a little European perennial, less than six inches high, which, in its double form, is cultivated in our gardens. Popularly, the name is applied to all the white or azure-rayed Compositæ which so profusely decorate our glades and meadows. The wild asters, plants peculiarly American, are the popular daisies west of New England, where the intruding white-weed or ox-eye daisy has not yet overrun the meadows. The American autumn blossoms with asters and golden-rods, the twin emblems of the season's maturity and harvest. Poets have always loved the daisies: —

> "The daisy scattered on each mead and downe,
> A golden tuft within a silver crown;
> Faire fell that dainty flower! and may there be
> No shepherd graced that doth not honor thee!"

Shakespeare wrote of "daisies pied and violets blue." The etymology of the word suggests a poem: it is derived from the old Saxon *day's eye.* The sunflowers are the most conspicuous members of the family. Nearly all the species are North American. Forty species are described from this continent, north of Mexico, and of these twenty occur in the Northern States east of the Mississippi. They are miniatures in size of heads as compared with the great sunflowers of the garden. All the species are yellow-rayed, with the exception of one or two which are entirely rayless. The common garden sunflower was introduced long ago into Europe, and its nativity has been until lately a matter of doubt. It is now found that a wild species of the plains west of the Mississippi, a plant which bears heads but an inch or two in diameter, exclusive of the rays, is the parent of our cultivated plant. The Indians of the East early obtained it from beyond the Mississippi, and they were cultivating it about the eastern shores of Lake Huron when Champlain and Segard visited them nearly three centuries ago. The Indians used the seeds for making hair-oil and for eating. Under their cultivation the flower-heads began to assume their abnormal size. One of the sunflowers is the artichoke of our gardens, which yields edible subterranean tubers. This plant is also a native of our Western plains, and it has a history not unlike that of the sunflower. It was introduced into Europe as early as 1617, and the Italians began its cultivation under the name of *Girasole Articocco*, Sunflower artichoke. The name *Girasole* became corrupted into Jerusalem, and the plant is now commonly known in England as Jerusalem artichoke. It has commonly been supposed that the plant is a native of Brazil, but late evidence affords proof that our Indians cultivated it, and that from them it was obtained by early adventurers. In 1629 the tubers had become very abundant and cheap in London, according to Parkinson, a botanist of that time. As the culture of the potato spread, that of the artichoke decreased. The true artichoke is a very different plant from this tuber-bearing sunflower, although it is a composite. It is a native of Southern Europe and Barbary. To botanists it is known as Cynara Scolymus. The part eaten is the large unopened flower head. The Cardoon, which is occasionally grown in this country for the bleached inner leaf-stalks, is also a Cynara.

Having now obtained an idea of some of the principles of classification, we are prepared to consider a few of the striking peculiarities of common plants. With very few exceptions the essays which follow can be verified by the unprofessional observer. They relate mostly to the visible parts and operations of plants. The essays are selected at random from the book of Nature, from which every one is invited to read. They may aid as interpreters to some of the perplexing passages to be found there. With the exception of the first essay, they do not deal with nutrition or microscopic structure, and in lieu of a better opportunity we may now say a word in regard to this microscopic feature of botany. In the hands of the botanist the compound microscope reveals a wonderland in the interior of every plant. It uncovers the framework of every organ, and reveals a complicated structure of cells, vessels, and fibres. It opens the tiny cells themselves and discloses in each a chemical laboratory, replete with implements and materials for the manfacture of starch, sugars, acids, and leaf-green, and numerous other needs of the growing plant for the making of cells and the ripening of fruits. It exhibits beautiful forms of various substances, sharply angled crystals, and materials in motion. It explains many of the mysteries of the multiform protoplasm which is necessary to the life of each individual cell. The microscope gives us a clew to the relations of plants to their surroundings and to the animal world. All this minute study, though laden with deepest interest and full of meaning, is recondite and entirely foreign to the purpose of this little volume.

A Peep at the Inside.

The ordinary visible plants are made up of great numbers of microscopic cells of an infinite variety of size and shape. When these cells begin to grow they are usually spherical, but they soon become curiously compressed or contorted by the pressure of one upon another. In portions of the plant where the pressure is the same upon all sides, the cells become symmetrically twelve-sided, as in the magnified portion of pith in Fig. 58.

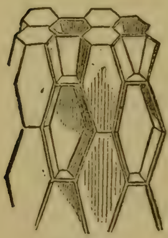

Fig. 58.

It is not often, however, that such cells occur. Some cells become much elongated; and when they have woody walls, they are known as the wood cells. (Fig. 59.)

Fig 59.

Other elongated cells are those which are commonly known as vessels. They are tubes which run through the stems of plants, often having upon their walls peculiar markings, as dots, disks, spirals, and rings. Portions of vessels with these annular and spiral markings are shown in Fig. 60. Odd forms of cells are shown in the hairs upon the leaves and stems of

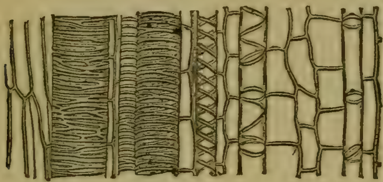

Fig. 60.

plants. Hairs of the pumpkin vine, each hair composed of several cells, are shown in Fig. 61, and one-celled hairs of another plant are shown in Fig. 62. The external cells of plants are usually flattened and often bordered by irregular margins. These flat-

Fig. 61.

Fig 62.

tened or tabular cells make the epidermis. The outlines of the thin epidermal cells of the leaf of the snap-dragon are figured in

Fig. 63. If we were to make a cross-section of a leaf, cutting across the leaf from the

Fig. 63.

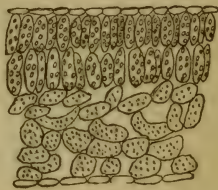

Fig. 64.

upper surface to the lower, and were to examine the section with a microscope, an arrangement something like that in Fig. 64 would be presented. On the upper surface are to be seen the flattened epidermal cells, while immediately beneath them are two rows of long palisade cells. The under surface is also faced with the flattened cells.

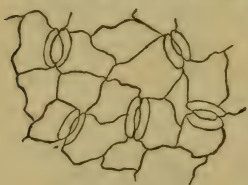

Fig. 65.

The lower half of the interior of the leaf is made up of a loose aggregation of irregular cells, between which are air spaces. If, now, we magnify a portion of the under surface of the leaf we discover many crescent-shaped cells lying face to face, with an opening between them.

(Fig. 65.) These openings are the breathing pores or stomata, and they are situated directly over air spaces. The crescent-shaped cells are called the guard cells of the stomata, and they have the power of regulating the size of the opening into the leaf, often completely closing it. The grains in the cells of Fig. 64 represent the pigment which gives the green color to the leaf; these are the chlorophyll grains, "leaf-green" grains. Although they usually occupy but a portion of the cell, they are still so close together as not to be recognized by the eye, and they therefore present a continuous appearance of green. The epidermis, both above and below, is mostly destitute of chlorophyll, and transparent. The cell contents are as variable as the cells themselves. All growing parts contain a whitish granular liquid known as protoplasm. This protoplasm is the life-giving element of plants, from which are formed new cells, and starch and other products which the plant stores up for future use. All seeds and tubers and bulbs store away starch to feed the plantlet while it is germinating and establishing itself in the soil.

We have before remarked that all plants

which possess leaf-green also possess the power of assimilating; that is, they can make starch and similar compounds out of inorganic matters, such as water and carbon dioxide. Animals cannot assimilate; they eat organic products which have been prepared by plants and digest them into other organic products. Neither can all plants assimilate, as we have seen in the case of fungi. Plants also have a power akin to digestion, for they make over the starch-like materials, which are formed by assimilation, into other organic compounds. This change is called metastasis. The plant through its roots takes in various compounds which are dissolved in water. These compounds contain carbon, hydrogen, oxygen, nitrogen, sulphur, iron, potassium, and other materials. The plant takes these solutions in through its roots by a modification of the phenomenon known to physicists as osmose, a sort of soaking-in process. The pressure exerted by the liquid as it comes into the root through this osmotic action forces the "sap" upwards, but the chief cause of its rise is to be found in another fact: the stomata on the under surface of the leaves are open if the weather is clear and moist, and water is constantly evaporating from them. As fast as this evaporation takes place more water is needed. A demand is made upon the cells in the interior of the leaf which contain more water than those near the stomata, and as these interior cells lose some of their water they in turn call upon cells still more distant, and so on until the call is made all through the stem and to the minute root hairs which derive their water from the earth. This water does not flow upwards in tubes or cells, but it is soaked up through the thick walls of the wood cells, and it keeps soaking upwards as fast as evaporation pumps it out through the leaves. In this manner the water from the earth, laden with its food materials, finally reaches the leaves; and there, in conjunction with carbonic acid gas from the air, in the chlorophyll grains in the minute cell laboratories, and with the aid of sunlight, occurs the wonderful transformation into organic materials. These materials afterwards pass into the protoplasm and are used in building new cells. During the process of assimilation oxygen gas is set free and given off through the stomata. This oxygen is necessary to the life of animals, while the carbonic acid gas which is exhaled by animals is necessary to the life of plants. Assimilation can take place only in the sunlight, but growth — the formation of new cells — takes place more rapidly at night. During this growth and the metastasis which is necessary to it, — the changing of one organic compound into another, — the plant is breathing; air is taken in through the stomata, or the air of the air-spaces is used if the stomata are closed. This breathing is strictly comparable to that of animals, as the oxygen is used and carbonic acid gas is given off. The stomata act as valves; they regulate largely the amount of water given off and the amount of air taken in. They are open in sunlight, but are nearly closed in darkness. During a severe drouth, when the roots cannot find sufficient water, they close and allow no evaporation to take place. When the atmosphere is moist they are wide open. If the leaves are the lungs of the plant because they breathe, they are more emphatically the stomachs of the plant because they assimilate and digest.

The Sexes of Plants.

The stamens, as we have seen, bear powdery grains of pollen in their anthers. This pollen is the male element of the plant, and it must be carried to the pistil before that organ can produce seeds. The stamens are, therefore, the male or sterile organs of the plant, and the pistils are the female or fertile organs. The universal doctrine of the sexes of plants was first clearly enunciated by Linnæus in 1735, and his elegant system of classification was built upon the numbers and characters of the essential or reproductive organs. While this system was so expedient in the arranging and studying of plants, it was also important because it recognized the functions of the stamens and pistils and brought them prominently into the consideration of botanists. The idea of sex in plants did not originate with Linnæus, however. As early as the days of Herodotus, two sorts of date-palms were distinguished, one sterile and the other fertile, and it was known that the fruitfulness of the fertile plant was increased by shaking trusses of the sterile plant over it. Cæsalpinus observed that some hemp plants were sterile and others fertile. Sex was probably first clearly perceived by Zaluzianski, a native of Poland, who wrote early in 1600. Nehemiah Grew, of England, in 1682, was more precise in his definitions and remarks concerning the stamens and pistils. In 1694, Jacques Camerarius, a German, gave the first decisive proof that sexes occur in plants just as truly as in animals, and his letter upon the subject, "De Sexu Plantarum," has become celebrated. The statements made by Camerarius obtained currency among naturalists, and they were generally accepted. Tournefort, however, was incredulous, but one of his pupils, Sebastian Vaillant, publicly professed his belief in the sexes of plants. It is said that Linnæus first obtained his idea of sex from reading Vaillant's dissertation, which he had found by accident. Linnæus' own observations soon confirmed the imperfect statements of his instructor, and it was not long before he startled the world with the doctrine of universal sexuality in flowering plants, and built thereon his system of classification.

For nearly a hundred years it was supposed that the pollen grains, after they had fallen upon the stigma, burst open and discharged their contents, which in some manner fertilized the ovules or young seeds. In 1823 an Italian, Amici, perceived that the grains of pollen upon the stigma of an African plant changed into tubes, which he designated the pollen tubes. Four years later, the celebrated Brongniart confirmed the ob-

Fig. 66.

servation of Amici, and found that the tubes were produced in many plants, and furthermore that they penetrated the soft tissue of the stigma. It is now known that the pollen grain germinates after it falls upon the stigma, and sends a minute tube down through the stigma and style, finally penetrating the ovule or seed-forming body. One of these tubes must reach each ovule before the ovule can develop into a seed. In just what manner the pollen tube acts upon the embryo-sac of the ovule is not known. We can make an ideal picture of these pollen tubes as represented in Fig. 66, the figure at the right representing a longitudinal section of a portion of the stigma. M. Brongniart compared the appearance of a stigma penetrated by pollen tubes to "a pin-cushion entirely filled with pins stuck into it up to the head."

If we refer to our talk about the flower on page 29 *et seq.*, we can readily understand how a flower which contains both stamens and pistils, as the apple, is *perfect*, and all which do not contain both organs are *imperfect*. The greater part of our common plants have perfect flowers. In many of our trees, as the walnut, butternut, hickories, oaks, chestnut, beech, and birches, the stamens and pistils are borne in different flowers on the same tree. Such plants are said to be *monœcious*, — the flowers are borne in "one house." In the willow and some other plants the staminate and pistillate flowers are borne on entirely distinct plants, — in "two houses," and such plants are termed *diœcious.* In some of the maples there are staminate and pistillate and perfect flowers on the same plant; they are *polygamous.*

The pollen grains vary widely in size and form. Some of the forms are shown in Fig. 67, which represents respectively the pollen

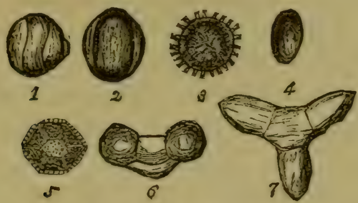

Fig. 67. (After Gray.)

of the musk-plant, wild cucumber (Echinocystis), mallow, lily, chicory, pine, and evening primrose.

Cross-Fertilization.

How is the pollen transferred from the anther to the stigma? In the perfect flowers, where the stamens and pistils are placed almost in contact, we can readily imagine how such transfer could take place, but how is it performed in the monœcious and diœcious plants? And if we were to examine critically the perfect flowers, we should find that even there this transfer is not a simple one, for in most cases the anthers and stigmas do not ripen simultaneously, or there is some impediment in the way of the simple falling of the pollen upon a contiguous stigma. Linnæus, and his successors for over half a century, taught that the pollen fertilized the stigmas in the same flower. Koelreuter, about 1761, appears to have been the first to recognize the aid of insects or other external agencies in the transfer of the pollen; but the first observer who made definite investigations and who caught any glimpse of the plan of nature in fertilization was Conrad Sprengel, a German. In 1787 he studied the flowers of the wild geranium, and, attracted by the delicate hairs borne on the interior of the corolla, and impressed with the idea that "the wise Author of Nature would not have created even a hair in vain," and becoming convinced that these hairs protect the honey from rain, he came to the conclusion that all minor organs and appendages of the flower subserve some important end. He continued his studies, and six years later published a small treatise upon the subject, wherein was laid the first stone in the magnificent science which has since been erected upon the mutual relations of plants to active external agencies. The science slept, however, until that critical student of nature, Darwin, made investigations and published his celebrated work upon the "Fertilization of Orchids," in 1862. Since that event a rich special literature has sprung up, an important part of which has been contributed by Darwin himself.

Two terms which have now come into general use are *close-fertilization*, or *self-fertilization*, and *cross-fertilization*. Close-fertilization refers to the impregnation of a stigma by pollen from its own flower, while cross-fertilization denotes the impregnation of a stigma by pollen from a different flower. It is now known that close-fertilization is not the common occurrence in the vegetable kingdom, and that in nearly all species cross-fertilization takes place to a greater or less extent. "Nature seems to have wished that no flower should be fertilized by its own pollen," said Sprengel, a statement not strictly true, for there are some flowers in which cross-fertilization cannot take place. Darwin's statement is better: "Nature abhors perpetual self-fertilization."

It is evident that cross-fertilization must take place in diœcious and monœcious plants.

Here the pollen is commonly carried by the wind, occasionally by insects. Delpino has called the wind-fertilized plants *anemophilous*, "wind lovers." Most grasses and sedges, although they may have perfect flowers, are wind-fertilized. The flowers of anemophilous plants are usually small and inconspicuous. They have no need of showy colors. It is only necessary that they produce an abundance of pollen, much of which must be wasted by careless winds, and possess a large and rough stigma to catch the floating grains. The grasses afford instructive examples of wind-fertilized flowers. Pines produce pollen in wonderful abundance, and the air of pine forests is often yellow with it in spring. The "sulphur showers" which occur in some localities are due to the bringing down of this pollen by the rain. Many farmers find that the pollen from corn in full tassel is irritating to the eyes. Every one has noticed how suddenly the bright anthers are thrust out on their slender stalks from the long heads of timothy and other grasses; were the flat and feathered stigmas so conspicuously colored, instead of being greenish-white, they would attract our attention as well. In Fig. 68 a grass flower enlarged and in full bloom is shown in side view at *a*, the three anthers and two stigmas protruding. At *b* is a back view of a flower; *c* represents a spikelet of flowers. Acquainted with these facts, we can see something of life and utility in the breeze that sways the sedge or listlessly fans the meadow.

Some diœcious plants are not fertilized by wind or insects. Along the borders of slow streams, growing two or three feet under the water, the eel-grass or tape-grass is common. The long and narrow soft green leaves do not arrest

Fig. 68.

the attention of the casual passer-by, neither, perhaps, do the peculiar clove-shaped flowers, an inch long and greenish-white, which float at the ends of long and slender threads. When I have repeated the story of its behavior this plant may be deemed more worthy of attention. The staminate or male plant bears many very small and inconspicuous flowers, which are collected in a tightly covered ball and borne on short stalks far under water, as seen in *A* in Fig. 69. When the little flowers are about full-grown the covering of the ball breaks open, splits into three parts, and each flower, securely wrapped up in its sepals, separates itself from its stemlets and rises to the surface of the water. When upon the surface its three sepals open and the anthers mature. The pollen is discharged upon the water and is carried by the currents to the clove-like female flowers which have raised themselves on long stalks to reach the surface (*B*). The three broad stigmas receive the pollen, the ovules are impregnated, and then the long stalk coils up and draws the fruit under water to ripen. This curious plant bears a name which does honor to A. Vallisneri, an early Italian botanist, and which records the phenomenon of the spiral contraction of the flower-stalk: it is known as Vallisneria spiralis.

The most peculiar adaptations for cross-fertilization are those which attract insects and other animals, and which make the insect to be an unconscious but an indispensable aid to the plant. Delpino calls these "insect loving" plants *entomophilous*. There

Fig. 69.

are nowhere in nature such examples of reciprocal benefits as in the relations of flowers to insects and insects to flowers. The flower attracts the insect by showy colors or by perfume, and gives it nectar or pollen for the aid it renders in cross-fertilization. Attractive petals and perfumes are the flower's advertisements to insects. If they are removed the insect visits are suspended, and the plant suffers in the production of seeds. If this strict utilitarian view strips some of the poetry from flowers, it nevertheless adds a sublimer sentiment which overlooks a simple adaptation to please the senses of man, and places the beauty of flowers upon the plane of definite plan and purpose which have been slowly evolved through the ages. It represents a beautiful natural adaptation and a sublime creation.

Scarcely two species of entomophilous flowers have the same contrivances to insure cross-fertilization. One of the commonest modifications of the flower towards this end is *dichogamy*, or the maturing of the anthers and stigmas at different times. Flowers whose anthers develop first are said to be *proterandrous*, and those whose stigmas develop first are *proterogynous*. An examination of almost any showy flower will reveal either proterandry or proterogyny. When the anthers are mature they discharge their pollen, either by slits or various kinds of pores; when the stigmas are fully matured they usually present a peculiar viscid or roughened appearance under a lens. As a well-known example of a proterogynous flower we may take the common figwort or scrophularia, a tall plant, with inconspicuous small flowers, common along banks and in fence-rows. The flowers bear a copious supply of honey; in fact, the plant is often grown for bees, being sometimes known as Simpson's bee-plant. In Fig. 70 is shown a flower as it appears soon after opening, showing the ripe pistil and the anthers curled up and immature. A flower a day or two older would show an over-mature and wilted style but fully developed anthers. If a bee visits Fig. 70 in search of honey it lights upon the deflexed lip of the corolla, and as its body is thrown forwards the stigma rubs off any pollen which may adhere to the insect's body; and when it visits an older flower the pregnant anthers give it

Fig. 70.

a new pollen supply. The hairs of bees and other insects hold the pollen. It will be seen that this fertilization by the bee in the figwort is a hit-and-miss operation, and much pollen must necessarily be wasted. Still the stigma cannot well be fertilized by the pollen of its own flower, for it is not receptive when the anthers mature. If, however, the stigma receives no pollen it will probably remain receptive until its own anthers mature, for it prefers close-fertilization to none at all. It is an interesting study to observe the relative times of maturing of anthers and stamens in common flowers. In none of the showy flowers do they mature simultaneously unless there is some special impediment in the structure of the parts which forbids close-fertilization.

Many plants are found to have *dimorphous* flowers; that is, perfect flowers of two kinds borne on different plants. One plant bears flowers which have long and protruding styles and short, hidden stamens, as in *A*, Fig. 71; another plant of this same species bears flowers entirely opposite in character, the stamens being long and the styles short, as in *B*. The short stamens in *A* and the short style in *B* always remain as short as they are figured. These flowers are fertilized in much the same manner as those of the figwort. The stamens and pistils ma-

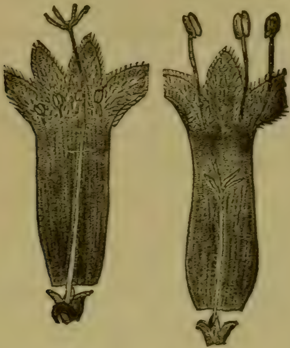

Fig. 71.

ture simultaneously. An insect in visiting *A* would brush off pollen on the long style, and as it reached into the flower would have pollen dusted upon its head from the short stamens. The insect visits *B*, and, by reaching into the flower, brushes some of the pollen from its head on to the short style, while the long stamens unload some of their pollen on the insect's body, to be applied to the next long style which it visits. In this manner the pollen from short stamens usually fertilizes short pistils, and the pollen from long stamens fertilizes long pistils. Now, it may happen that pollen may be rubbed off on to the stigma of its own flower. What then? Simply this: the pollen is usually powerless upon the stigma of its own flower. Darwin found that the pollen either will not act upon its contiguous stigma, or it acts slowly and waits for the more potent foreign pollen. Some plants have *trimorphous* flowers, which bear stamens and petals of different lengths, borne upon distinct plants.

Fig. 72.

A flower of the kalmia, or common wide-leaved mountain laurel, is shown in Fig. 72. The ten anthers are held in little pockets in the corolla, and they are not released until some insect touches them, when they fly inward and throw their pollen upon it. Fig. 73 represents a pea-flower. The ten stamens and the pistil are hidden in the small lower projec-

Fig. 73.

tion of the flower. The bee lights upon this lower portion, and its weight forces the petals down, while the stigma, carrying pollen from the surrounding anthers on its hairy style, protrudes and strikes the bee and dusts it with pollen.

Many flowers are especially fitted for fertilization by moths. Such are most of the long-tubed flowers. As most of the long-tongued insects are nocturnal, so many of the long-tubed flowers open only at night, and they are furnished with light colors that they may be seen in darkness. Many of them exhale strong perfumes at nightfall, as the petunia. As the moths whir about the petunias, and the evening primroses, and other flowers at nightfall, think what attractions the plants offer the insects, and what advantages they expect to derive from their visits. Some long-tubed flowers are fertilized by humming-birds. This is at least sometimes the case with the flowers of the trumpet creeper. Some flowers possess putrid odors to attract flies, as the common herbaceous smilax or carrion-flower. A few are fertilized by snails.

There is no doubt that in most cases close-fertilization is a direct disadvantage to the plant; it is akin to the in-breeding of farm animals. The uniformity with which all flowers favor cross-fertilization is proof that a foreign pollen is needful to insure the best results in the production of seeds. Darwin experimented with plants grown from seeds produced by cross-fertilization and those produced by close-fertilization, and the former were the most vigorous. When there is cross-fertilization between different species of plants, as between apples and pears, or wheat and rye, the offspring of the seeds produced are called *hybrids*. In common parlance this term is incorrectly used to denote the offspring of two plants of the same species.

Hidden Flowers.

The blue "hooded violet," Viola cucullata, so named from its peculiar habit of folding the lower portion of its leaves upwards and inwards, is common in shady glades all over the North. Its large flowers are bright and attractive. In a certain shady nook there is a patch of these "Johnny-jump-ups" which appears to be continually renewed by new plants, and yet, as I have visited the patch every June after the flowers were gone, I could find few seed-pods and no runners, by means of which the plants could renew themselves. One sultry August day I wandered to this shady nook, half forgetful of the violets that bloomed there in the springtime. I could scarcely recognize the numerous great leaves raised on their foot-long petioles as the full-grown individuals of which I had seen the earlier stages, overtopped by the flowers, in May. A careless scuff among the leaves disclosed a number of peculiar whitish buds on curved peduncles an inch long and half buried in the dead leaves and the grass. (Fig. 74.) A dissection of one of the buds revealed a miniature flower, bearing no petals, to be sure, but furnished with a good stigma and well-developed anthers. I had abundant proof that these flowers produced seeds, for there were many fully developed pods lying under and upon the mould. Here, indeed, was a mystery. How was it possible for cross-fertilization to be effected between these hidden, inconspicuous, unopened flowers? There was but one conclusion: these

Fig. 74.

flowers must fertilize themselves. Here was no expensive glitter of petals, no unnecessary pollen to be wasted by improvident insects. Dame Nature had evidently constructed these flowers after the strictest economy, but the patch of violets still prospered and increased more abundantly than did the yellow violets in the neighboring wood-lot, which produced quantities of hairy pods every spring. It was a matter of no little wonder why the expensive blue flowers should be produced at all, when they apparently accomplished so little, and the insignificant hidden flowers accomplished so much; still, I was glad that Nature had not adopted such a penurious economy with all her flowers.

I soon learned that these hidden flowers of the violet were no new thing. Darwin, of course, had seen and studied them. Subsequently I found them on many different plants, as the little dalibarda, the wood sorrel, and others. Darwin gives a list of fifty-five genera which have one or more species upon which the hidden or cleistogamous flowers are found. The Leguminosæ or Pea family contains more than any other. Some of the species produce these flowers entirely under ground, as the Amphicarpæa of our woods, while in the grasses they are often concealed in the sheaths of the leaves. In one country a species may produce only cleistogamous flowers, while in another country it may produce none. In some parts of Russia the little toad-rush, or Juncus bufonius, produces no flowers but these hidden ones, but I do not know that such flowers have been observed on the plant in this country. The common wild touch-me-not, Impatiens fulva, has become naturalized in England, but it seldom produces any other than cleistogamous flowers there. The proportion of the hidden to the ordinary showy flowers is about 20 to 1. Cleistogamous flowers were somewhat known before the time of Linnæus, and they occasioned warm discussion upon the doctrine of sexes.

Cleistogamous flowers are of benefit to the plant in producing seeds economically. Besides the saving in petals, stamens, peduncles, and in the diminution of parts, there is a very great saving of pollen. It is calculated that the average cleistogamous flower of wood sorrel produces 400 pollen grains, of touch-me-not, 250, and of the grass Leersia, 210. Compare these numbers with 243,600 grains in a flower of fall dandelion and the 3,654,000 in the peony! The showy flowers occasionally produce seeds through the aid of cross-fertilization, and such seeds no doubt tend to correct the evil tendencies of continual in-breeding.

The Arrangement of Leaves.

It is usually a matter of great surprise to the uninitiated in botany to learn that the leaves of plants are arranged in a definite order. Can it be possible that each of the ten thousand leaves upon the great elm in front of my window is placed upon the twig in such an exact manner as to form a part of any system of arrangement? A little twig from this tree presents an appearance nearly like Fig. 75. Beginning with the lowest leaf, we find that the third one above is directly over the first. The fourth is over the second, the fifth over the third, and so on. If we draw a line from the left to the right around the stem, beginning with the first leaf, it will complete the circumference

Fig. 75.

of the stem when it reaches the third leaf. The angular distance between the first leaf and the second is just one half the circumference of the stem, and it is the same between the second and the third. We will

Fig. 76.

therefore express this distance by the fraction $\frac{1}{2}$. We can use this fraction to represent more than the angular divergence: the denominator 2 represents the number of leaves above the first touched by one revolution of the line about the stem, and the numerator records the fact that the line passed but once about the stem in finding a leaf situated directly over the first.

Fig. 76 represents an alder twig. Here the fourth leaf is over the first. Now passing our line around the stem we find that it encounters three leaves, beyond the first, in making one turn. The angular divergence between the leaves is $\frac{1}{3}$, and the denominator records the number of leaves and the numerator the one revolution.

Fig. 77.

An apple twig, Fig. 77, represents a more complicated arrangement. In this case the sixth leaf is over the first. Our line now encounters five leaves, but it passes twice around the stem before it reaches a leaf situated directly over the first. We must now express our angular divergence by $\frac{2}{5}$, the 5 again representing the number of leaves and the 2 the number of turns about the stem.

If we were to examine the osage orange of our hedges, the flax, or the holly, we should find the ninth leaf over the first, and our line would make three turns about the stem. This arrangement we must represent by the fraction $\frac{3}{8}$. Let us make a comparison of these fractions, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$. If we add together the first and second, just as they stand, we secure the third, and if we add the second and third we get the fourth. If we add the third and fourth in like manner we get $\frac{5}{13}$, and the next successive addition would give us $\frac{8}{21}$. These latter fractions are verified by observation in the cones of pines and in the rosettes of house-leeks, the "hen-and-chickens" of the gardens. The scales on pine cones are simply reduced leaves, beneath which are borne the peculiar flowers. In the cones of some pines the arrangement is expressed by $\frac{13}{34}$ and $\frac{21}{55}$, and the florets in the heads of large sunflowers are often arranged after the complicated plan of $\frac{55}{144}$. When the leaves are closely packed together, as in the pine cones and the rosettes of the house-leeks, we can readily trace the spirals with the eye. It is interesting to secure a large ripe head of a garden sunflower, brush off the remains of the florets, and then study

Fig. 78.

the various circles as represented by the black fruits.

The arrangements above mentioned refer to plants with alternate leaves. Upon many plants the leaves are opposite, as in Fig. 78, and the third pair of leaves is usually placed over the first. Frequently the leaves are whorled, as shown in the galium or bed-straw in Fig. 79. In some whorls or circles there are ten or more leaves. Fascicled or clustered leaves are shown in the larch or tamarck, Fig. 80, and in the pitch pine in Fig. 81. In the pines the number of leaves in a cluster is a reliable aid in determining the species. In the white pine the leaves are always five in each fascicle, in the scrub or Jersey pine two, and in the pitch pine three. The study of the arrangement of leaves is known as phyllotaxy, "leaf arrangement." It has proved the existence of definite order where order is least to be expected. It has discovered this order in the disposition of leaves, and in the arrangement of the parts of the flower, and in many cases even in the arrangement of the seeds in the pod.

Fig. 79.

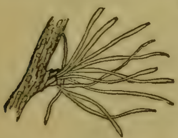

Fig. 80.

Fig. 81.

The Compass-Plant.

Adventurers upon the prairies of Illinois and upon the plains west of the Mississippi early recognized a leaf compass in the great lower leaves of the rosin-weed. These leaves stand nearly vertical, with their faces presented to the east and the west, and their edges to the north and the south. So marked is this polarity that travelers can often direct their journeyings by the positions of the leaves. The first record which was ever made of the polarity of the compass-plant was that given by Major Benjamin Alvord of the United States Army to a scientific journal in 1842. A second communication appeared from him the next year. So incredulous were scientists in regard to the polarity of the plant, however, that Major Alvord in 1849 again made record concerning it, this time before a body of scientists in Cambridge, and with the support of statements by other army officers.

There have been many conjectures as to the cause of the peculiar attitude of the leaves of the rosin-weed. Major Alvord at first supposed that the leaves contained sufficient iron to render them magnetic, but a chemical analysis disproved this proposition. It was next supposed that the resinous character of the leaves render them susceptible to electrical currents, but rosin being a non-conductor of electricity, this hypothesis also fell. Dr. Asa Gray suggested the true explanation of the phenomenon: both surfaces of the leaf have essentially the same structure, there being nearly as many stomata on the upper as on the under surface, — about 52,700 to the square inch above, and 57,300 below; this renders both surfaces equally sensitive to light, and the leaf twists upon its petiole until both sides share equally in the sunlight.

The compass-plant occurs in open glades and on prairies from Michigan to some three hundred miles west of the Mississippi. It is a large and coarse herb, attaining the height of six or seven feet. It is one of the Compositæ. This is the plant of which Longfellow speaks in Evangeline, mistaking it for a delicate species: —

> "Look at this delicate plant that lifts its head from the meadow;
> See how its leaves all point to the North as true as the magnet:
> It is the compass-plant that the finger of God has suspended
> Here on its fragile stalk to direct the traveler's journey
> Over the sea-like, pathless, limitless waste of the desert."

Other plants beside the rosin-weed show polarity in their leaves. It is conspicuous in the stem leaves of the lettuce-weed, Lactuca Scariola, a tall plant which occurs along streets in northern cities, a waif from Europe. Closely allied to this plant is the garden lettuce, but not until last year, when Professor J. C. Arthur observed the circumstance, were its leaves known to exhibit polarity. If the plant be allowed to go to seed the leaves along the stem usually show the phenomenon. Some leaves of the common horse-weed, or mare's tail, Erigeron Canadense, are found by Dr. W. J. Beal to exhibit polarity.

How Some Plants get up in the World.

It is a significant fact that Nature does nothing solely for display; all her beauty subserves some definite economy. She makes the useful the beautiful; utility comes before beauty. This fact should make her attractions more attractive, for while it does not lessen the beauty, it increases the conviction that definite plan and purpose, that perfect adaptability, are everywhere present. We love the flower the more when we know that the beautiful colors and perfume are the means of perpetuating the species. So we have more regard for climbing plants when we learn that their graceful climbing raises them into the sunlight which is necessary for their growth. Many more plants can grow upon any piece of ground if a part of

Fig. 82.

them are climbers, than if all are stiff-stemmed plants which crowd each other.

We may make five tolerably definite divisions of climbing plants, based upon the manner in which they climb: scramblers, root-climbers, leaf-climbers, twiners, and tendril-climbers. The scramblers are not true climbing plants. They include such plants as the briers and brambles, which scramble over bushes by means of hooks or bracing leaves. The root-climbers send out roots, which adhere to trees and walls. These roots shun the light and dive into crevices, where they attach themselves. The poison ivy is a familiar example. The leaf-climbers are not numerous in the Northern States. The most familiar example is the common clematis or virgin's bower, which coils its leaf-stalk about a support, as in Fig. 82. The most interesting of the climbers, however, are the twiners and tendril-bearers, and to them we will turn our attention in a more particular manner.

Twiners. — We will commence with a young plant of the hop. The first two or three "joints," or, more properly, the internodes, as the plant rises from the ground, are upright and stationary. The space between one joint or node of the stem and another is termed an internode, a term which it will be convenient to use. If we watch the young internodes as they grow, above the second and third, we shall notice that they do not stand upright, neither do they remain long in one position. At different times we shall find them pointing towards the east, the south, or the north; in short, they are revolving in search of something to twine upon. When the young internode is very short, say two or three inches long, its motion is so slow as scarcely to be observed. If we mark the position of its tip, however, at different times of the day, we find that it makes a complete revolution in about twenty-four hours. As the shoot increases in length the motion becomes more rapid, a complete revolution being made in two or three hours. If the shoot strikes no support, it will make thirty or more revolutions and then become rigid. Before this number of revolutions has been made, other and younger internodes will have been formed, and they revolve in the same manner as the first and lower one. All the younger internodes will be carried around by the lowest one which is revolving, and each one will be making its own separate revolution, so that the whole stem presents a peculiarly crooked appearance. About three internodes will be in motion at one time. The circle which the tip of the stem describes may be four or five feet in diameter, and it will move at times over thirty inches an hour. There is another peculiarity about this movement: it is always in one direction, from the right to the left of the observer, or in a course coinciding with that of the sun. If the revolving shoot were to strike a thin stick, it would coil about the stick in the same direction in which it was revolving, the same as a rope swung around the head would coil about a stick which should come in its way.

We can extend our observations to other twiners with equal interest. Most of them revolve in an opposite direction from the hop, or in a course opposed to the apparent motion of the sun or the direction of the movement of the hands of a watch. Beans, morning-glories, wistarias, and others twine in this direction. With very few exceptions the plants of one species always twine in one direction. In some cases the tip of the shoot is abruptly bent or hooked, and it is thus enabled to grasp a support more readily. Vines seldom twine about a large support, as the tip of the shoot has nothing to support it while making the first long coil. This inability to grasp a support four or five inches in diameter is a direct advantage to the plant, as it prevents the wasting of growth: the same length of stem will raise a plant much higher when coiled about a thin support than about a thick one. The upward movement of any part of the plant does not cease when it has coiled itself about a support, especially if the support is smooth. The coil of a twiner may be aptly compared to a compressed spiral spring; the coil becomes looser and slides up the support. If the support is not a high one the coil will sometimes bound off its top, and often the shoot begins again to revolve.

The immediate cause of the revolving of the shoots of twiners is the lengthening of the cells on one side of the shoot more than on the other. When the cells elongate on one side the shoot is bent over, pushed over, and it becomes convex on that side. If now the cells elongate still more a little to one side of the first elongation, the greater convexity will occur at that point, and the tip of the shoot will be moved from its original position. If this elongation were to travel gradually all around the stem from the point of starting, all the sides would in turn assume the greatest convexity, and the tip would have made a complete revolution. The convexity of the shoots of twiners is readily verified by observation. Each internode may be likened to a bow which has its convex and its concave sides directed successively to every point of the compass. It is not to be understood that this elongation or growth is uniform on all sides of the stem; in fact, it is commonly not so, and the shoots oftener revolve in ellipses or irregular paths than in true circles. One ordinarily associates the revolving with a twisting of the stem, but no such twisting takes place to any extent. There are three reasons why twisting of the stem does not cause the motion: the young shoot begins its revolution before any twisting is to be observed; few stems twist more than three times around while they make thirty or more revolutions; many plants revolve which never twist.

Tendril-Climbers. — The tendril-climbers exhibit more remarkable peculiarities than the twiners. Before us is a picture (Fig. 83) of the "wild cucumber" or Echinocystis of our glades, and which is now generally grown over windows and bushes. Opposite the three-lobed leaf is a three-parted tendril. A critical observation of the growing plant would discover a revolution of the two upper internodes the same as in twiners, only of less extent. The tendrils also revolve, sweeping

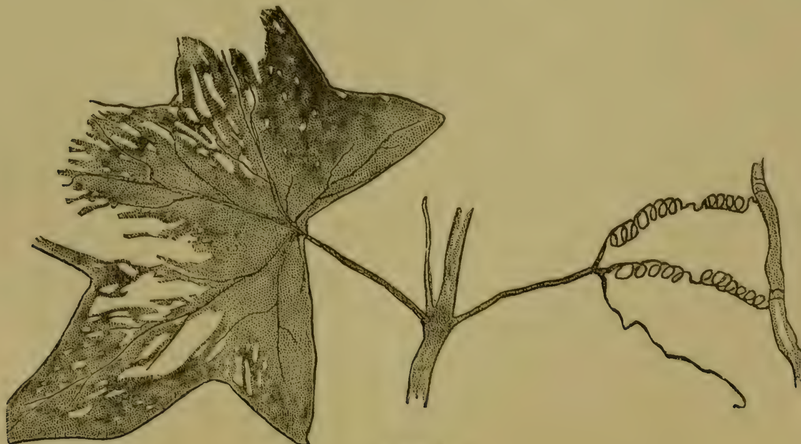

Fig. 83.

through ellipses or circles several inches in diameter. The parts of the tendril revolve in such a manner as to strike the stem of the plant if there were not some counteracting motion. They avoid striking the stem by bending abruptly upwards just before they reach it, and after they have passed it they again fall into their inclined position. In most tendril-climbers the young shoot is bent to one side in such a manner as to avoid the revolving tendril. The concave side of the tip of the tendril is highly sensitive to a touch, and when it strikes a stick it coils about it in one or two minutes. If the tendril is rubbed it will begin to coil and cease its motion, but after a time it will resume its former shape and begin again to revolve. Almost any touch, ever so slight, will induce the coiling, although raindrops, coming with much force, have no effect upon it. Although the sensitive tendril coils so readily about any support which it touches, still if two tendrils should strike together they do not coil, but shake hands and pass by. If a vine be thrown from its support to the ground so that the tendrils hang downwards, these organs cease for the time to revolve, but soon raise themselves to a horizontal position, when they begin again to move.

About a day after a tendril of the wild cucumber has found a support and has attached itself, it begins to coil up, drawing the plant closer to the support. Now simple coiling must always be accompanied by the revolving of the end of the tendril as many times as there are turns in the coil, or if the end is fastened the tendril must twist that many times. Both these things are impossible in this tendril, for the end is secured, and the continued twisting would soon rend it. A glance at the figure will solve the difficulty. There is a blank place in the centre of the tendril, and there is an equal number of coils on each side of this space. In other words, the lower part of the tendril has coiled in one direction, and the upper part has coiled just as many times in an opposite direction. This simple arrangement occurs in all revolving tendrils. The spiral coiling of the tendrils means more than simply drawing the plant closer to the support. The coils are highly elastic, and during wind storms they stretch and throw the strain nearly equally upon all contiguous tendrils. If the tendrils were straight they would be almost immediately snapped during a gale. Darwin used to go during gales to a hedge where the bryony, a nearly related plant, grew in abundance to watch the behavior of the tendrils. He says that the plant always "safely rode out the gale like a ship with two anchors down, and with a long range of cable ahead to serve as a spring as she surges to the storm."

If a tendril which has come in contact with a support and has wound half way around it be examined again in a day or two, it will be found to have coiled two or three times around the support, although it may not have increased in length. From a number of experiments Darwin concluded that the tendril actually crawls around the stick by an undulatory, worm-like motion. If a tendril is not fortunate enough to find a support it remains straight for several days, as if in wait; but finally it drops down and coils up in one continuous direction, and is thereafter useless. The coil of tendrils about a support, unlike that of the stems of twiners, is not necessarily in the direction of the free revolution.

The tendril of the pea is the transformed extremity of a compound leaf, each branch of the tendril representing a leaflet. All tendrils are understood to be transformed leaves, flower-stalks, or other organs. That of the woodbine, Fig. 84, is a transformed flower branch. The tendrils of the pea revolve in ellipses, making a revolution in about an hour and a half. In this case only

Fig. 84.

side tendrils coil when a support is reached, the terminal one remaining straight.

There are many curious modifications of tendrils. In the Virginia creeper or wild woodbine they end in disks, which hold to trees with great tenacity. These disks are not shown in the figure. In the bignonia of our Southern States they shun the light, after the manner of roots, and find their way into deep crevices for attachment.

Carnivorous Plants.

It is an interesting discovery of modern science that many plants catch small animals and eat them. It is a discovery which taxes our credulity if we accept it, and still one which is easy of verification by every one. Few discoveries relating to animals and plants have excited more wonder or called forth more comment than this. This comment has not been confined to scientific journals; nearly every periodical has had something to say about it.

> "What 's this I hear
> About the new carnivora?
> Can little plants
> Eat bugs and ants
> And gnats and flies? —
> A sort of retrograding:
> Surely the fare
> Of flowers is air,
> Or sunshine sweet;
> They should n't eat,
> Or do aught so degrading."

Although the statement that many plants are truly carnivorous is startling, it is nevertheless verified by abundant investigations, and it has taken its place among the undisputed facts of botanical science. We can best understand the nature of carnivorous plants by studying two or three common species.

Fig. 85.

The curious side-saddle flower or pitcher plant, Sarracenia purpurea (Fig. 85), occurs in mossy swamps all through the Northeastern States, while southward there are other and more peculiar species. The leaves of these odd plants are transformed into long tight trumpets or pitchers, which always contain water. Berry-pickers who frequent swamps for whortleberries and cranberries often know them as "Indian dippers," and they use them as cups to dip water from the creek. A single large and very curious purple flower nods from a long stem in spring and from its fancied resemblance to a side-saddle has originated one of the popular names of the plant. If the contents of a pitcher be examined the fluid will be found to contain quantities of dead and decaying insects which have fallen into it. A study of the pitchers will soon convince us that the presence of the insects is not purely accidental. They are attracted to the open pitcher, light upon its rim, and venturing too far they fall into or slide down the cavity, and they are prevented from making an escape by the stiff and sharp hairs which point downwards like so many bayonets. When they have fallen into the liquid, which is not entirely water, they are soon drowned, and the plant feeds, in a saprophytic manner, upon their remains.

Our Northern pitcher plant is less actively insectivorous than some of the Southern species, and especially less than the Sarracenia variolaris, which has been minutely studied. In this species a hood or cover projects over the mouth of the pitcher, excluding all rain. The pitcher secretes a viscid liquid, which speedily dispatches all unfortunate insects which fall into it. About the mouth of the pitcher is a secretion of a sugar-like substance, which attracts numerous flies and smaller insects. This secretion extends even down the outside of the pitcher to the ground, presenting a honey-baited pathway, which arrests all wandering insects, especially ants, and allures them upward to the fatal opening. Once upon the rim of the pitcher they gorge themselves with the delectable honey, unwarily getting a little farther down on the inside, until finally they slip on the glossy surface and soon find themselves inextricably entangled among the bristling deflexed hairs. All attempts to escape are futile, and they soon come in contact with the viscid liquid, from which they are never rescued. So perfect is this fly trap that a fly or other insect never escapes from it. It is said that the plants are sometimes grown about the house as fly-traps, but although they catch flies in abundance the odor from the decaying insects is not pleasant. The plant absorbs food from the mingled contents of its pitchers. So persistently do some of the Sarracenias catch flies that they cannot be cultivated on account of the bursting of the pitchers from overloading unless the mouths are closed with cotton. Some animals have learned of the peculiar habit of the Sarracenias and have taken to stealing the food which the plant has caught. Two species of insects, a fly and a moth, are habitually associated with some of the Southern pitcher-plants. They have learned apparently to evade the seductive honey and the fatal trap, and in some manner drop their eggs into the mingled contents of the pitcher, where the larvæ thrive. Birds are said to slit the pitchers to secure the insects.

A very singular plant, closely allied to the Sarracenias, is the Darlingtonia of California, represented in miniature in Fig. 86. This plant grows in the vicinity of Mt. Shasta at an altitude of 1,000 to 6,000 feet. The pitchers are eighteen to twenty-four inches high and an inch or less in diame-

Fig. 86.

ter, except at the inflated top. They are spirally twisted about half a revolution, the twist being usually to the left. Running lengthwise the pitcher is a narrow wing, extending from the ground to the orifice. This wing is best seen in the pitcher to the right in Fig. 86. The top of the pitcher is an inflated sac two to four inches across, with translucent dots or windows in its roof, and having an opening underneath an inch or less in diameter. At the upper extremity of this opening hangs a two-lobed blade, resembling a fish's tail, which is attractively colored and peculiarly twisted, and furnished on its inside with stiff hairs pointing upwards. Like the Sarracenias this plant has the honey-bait about the mouth of the pitcher and the secreted fluid in the tube. A crawling insect finds the base of the pitcher, and wishing to explore follows the fence-like wing upwards until he comes to the sweet-lipped brim. Other insects are at once attracted by the gaudy fish-tail blade, and they light upon its outer surface. This blade is twisted in such a manner that an insect lights upon the outside, follows the enticing folds, and presently finds himself upon the inside of it. He walks upwards easily, but the instant he turns back the menacing bayonet hairs prevent his progress. He keeps on and now he begins to scent the feast of honey which is spread for him. He enters the opening, eats, becomes satiated, and decides to leave. He looks for a place of egress, and is attracted by the pretty windows in the roof. He becomes bewildered in this dim Castle of the Doges, and every step over the deceptive hairs brings him nearer his doom.

The family Sarraceniacæ, to which these plants belong, is restricted to the New World. It is represented by three genera: Sarracenia, with six species, inhabiting the Eastern United States; Darlingtonia, with its one species, D. Californica; and Heliamphora, with its one species, H. nutans, in Venezuela. All the species bear pitchers, and they are all insectivorous.

The sundew is an unattractive plant, which grows in swamps and wet places. It is represented nearly natural size in Fig. 87. The peculiar ladle-like leaves are trimmed with bristling hairs, which bear on their ends little drops of glistening "dew" which give the plant its name. These hairs are known as tentacles. If any object falls upon the

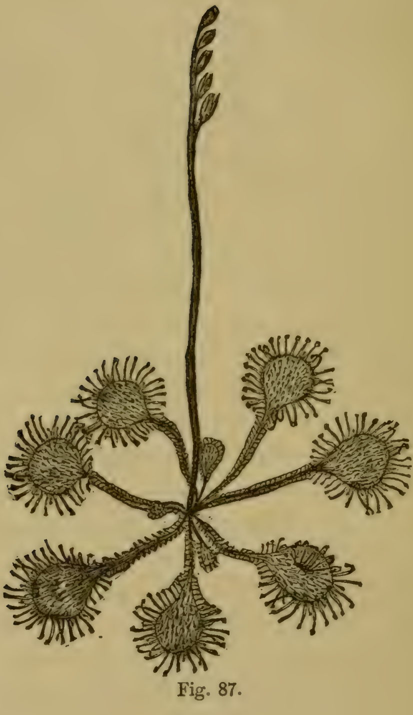

Fig. 87.

leaf the tentacles begin slowly to move inwards, until they finally shut down tightly over the object, as we can imagine the fingers to shut down over an object in the palm of the hand. We will suppose this object to be an insect. As soon as it alights upon the leaf the tentacles throw out more of the viscid "dew," which holds him securely, and the more he struggles the more the substance is poured out and the faster the surrounding tentacles come to the aid of the weak ones near the centre of the leaf. Once upon the leaf the insect is doomed. The leaves of the drosera or sundew lie upon the ground, and they are therefore more apt to be visited by ants and other crawling insects. If an unfortunate ant comes in contact with one of the extended tentacles he is caught by the attractive glue, and the tentacle at once begins to move inwards just as a finger is bent over to the palm. The tentacle does not go alone, but its neighbors come to the feast as well. When the insect is thoroughly entrapped under a number of deflexed tentacles, an acid secretion is thrown out which digests it. After the feast is over the tentacles return to their former position and lie in wait for another victim. If a little stone should drop on the leaf the tentacles are summoned in more slowly than before, and finding out their mistake they return to their normal position much more rapidly. A tentacle will often begin to move in ten seconds after it is touched, and in from one hour to four hours it will be completely deflexed. Mr. Darwin fed beef to plants of sundew and they accepted it as readily as an insect. Although the pressure of a gnat's foot will cause a tentacle to move, a drop of rain will not affect it!

The Venus' fly-trap, or dionœa, of North Carolina, is a botanical ally of the interesting sundew, but its contrivance for capturing insects is very different. The leaves are borne at the base of the flower-stalk, as in the sundew. Fig. 88 represents three of the leaves. The trap portion has two valves or jaws, about the edge of which are stiff and insensitive hairs or bristles. The trap secretes no viscid material to hold the insect. Two or three hairs on the inner faces of these jaws are highly sensitive, and the slightest touch will cause the trap to fly together, the bristles interlocking like the teeth of a bear-trap. The unwary insect is caught before he thinks of danger. The jaws do not at once close completely, however. The teeth interlock and the jaws remain a little ajar, and this allows any very small insect, which is not worth the plant's consideration, to es-

Fig. 88.

cape. A larger insect, upon finding escape impossible, would again touch the sensitive hairs in his struggles, and the jaws would close tightly and crush him. As soon as the jaws come together a digestive secretion is poured out from the leaf, and the jaws remain in contact until the insect is digested, — eaten up! They then open to allure another insect. The little hairs, although sensitive to the slightest touch, are not influenced by wind or rain.

The Smallest of Flowering Plants.

"The green mantle of the standing pool" is usually caused by one of three sorts of

Fig. 89.

Fig. 90.

plants, either long and slimy threads of zygnema and allied algæ, or flattened disks of green a quarter of an inch or less across, or minute green grains. The algæ we have referred to in our earlier pages, but the disks and the grains are still new to us.

The little leaf-like disks are complete plants, floating free, and hanging their roots into the water. They are known as the duck-meats, or to botanists as lemnas. In the Northern States there are about six species, of which the commonest, Lemna minor, is represented in Fig. 89. The flowers — for these little plants produce true flowers — are produced from the margin of the frond or leaf-portion, as in Fig. 90. In the Northern States some of the species have never been seen to flower, although L. minor blossoms abundantly in sheltered ponds. They propagate largely by a sort of budding. A new individual grows out from a cleft in the

Fig. 91.

old frond, and after a time detaches itself and becomes free. In the fall little buds or frondlets are formed, which sink to the bottom of the pond, and rise and vegetate in the spring.

It is to the floating grains, however, that I wish to call attention at present. They are represented at about natural size in Fig. 91, at *A*. These little bodies are the smallest flowering plants known. They consist simply of a minute frond, entirely destitute of roots. There are two species in the Northern States, one distinguished by its globular form and its habit of floating a little beneath the surface, and the other (enlarged at *B*) flattened above and floating on the surface. Although these plants are so very small, they often occur in immense quantities. I have seen them piled up five inches deep on the borders of a wind-swept pond. At *C* in Fig. 91 is shown a plant in flower, the front half of the plant being cut away. The little plant is monœcious; the stamen, *s*, comprises one flower and the globular pistil, *p*, the other. They are both sunk nearly to their tops in the frond. These plants probably do not blossom in this northern climate. They propagate after the manner of the lemnas by means of offshoots. In *C* is shown a young frond, *b*, springing from the parent.

Some forty years ago a Frenchman, Mons. H. Weddell, was traveling on the Paraguay River, in South America, and having shot a rare water-bird, he observed that its feathers were covered with peculiar green grains. Upon turning to the pond where the bird had been wading he observed that it also was covered with the little grains. Mons. Weddell was a botanist, and he soon found that the little plant was in full bloom. He recognized it as a new species of the genus Wolffia, and named it from the country in which he found it, Wolffia Brasiliensis. The plant has since been found on our own ponds. It is the flat-topped species pictured in Fig. 91. The genus Wolffia does honor to John F. Wolff, a German, who wrote in 1801 upon the lemnas.

If we were to attempt to find the average in size of flowering plants between the two extremes, — the pigmy Wolffia and the giant eucalyptus of Australia or the redwood of California, — we should be obliged to select a plant about twenty inches high, — say a geranium of the window-garden.

Witch-Hazel.

The common witch-hazel, the tenacious bush which so often brings trouble into newly-cleared pastures, is one of the most unique and interesting of all the shrubs of the American forest. It possesses the strange habit of counterfeiting spring by putting forth its flowers with the falling of the leaves. The narrow band-like petals imitate the prevailing yellow colors of the autumn. The flowers are conspicuous and pretty, still they are commonly overlooked. One does

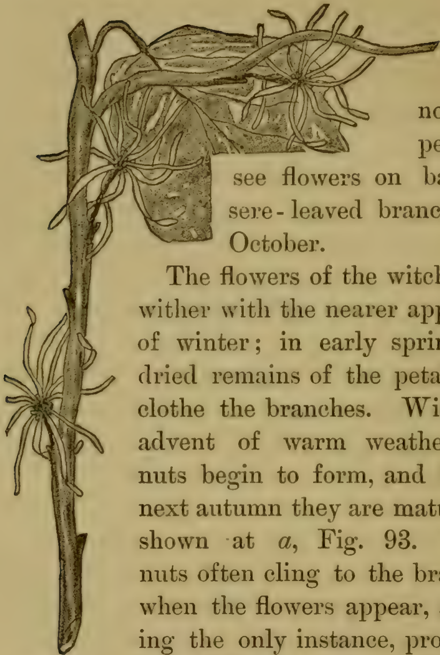

Fig. 92.

not expect to see flowers on bare or sere-leaved branches in October.

The flowers of the witch-hazel wither with the nearer approach of winter; in early spring the dried remains of the petals still clothe the branches. With the advent of warm weather the nuts begin to form, and by the next autumn they are mature, as shown at *a*, Fig. 93. These nuts often cling to the branches when the flowers appear, affording the only instance, probably, in the North, of a shrub which bears conspicuous fruit and flowers at the same time. The nuts possess a peculiar interest. Through the action probably of

Fig. 93.

alternate dryness and moisture they split open forcibly and throw the four black and shining seeds to a distance of fifteen or twenty feet. In this manner does the plant sow its seeds. The ruptured pod is shown at *b*, in Fig. 93.

Superstitious notions were long associated with the witch-hazel. Its common name is a record of the foremost of these notions combined with the resemblance of the plant to the true hazel. The branches were once used as "divining rods," by means of which deep springs of pure water and veins of precious metals were supposed to be revealed. Even in recent years I have seen forked branches of the peach and linden dexterously balanced in the hand and their occult vibrations taken as infallible indications of streams of pure water beneath the surface. Fortunately for the magicians who perform with these mysterious branches, there are few places where any intelligent person would look for water that springs may not be found at a reasonable depth. Astrology was also debtor to the witch-hazel branches, if Token has written aright: —

> "Mysterious plant! whose golden tresses wave
> With a sad beauty in the dying year,
> Blooming amid November's frost severe,
> Like a pale corpse-light o'er the recent grave.

> If shepherds tell us true, thy wand hath power,
> With gracious influence, to avert the harm
> Of ominous planets."

The witch-hazel has been held long in repute on account of its medical virtues, and it is the source of a popular remedy of the present day. The Indians are said to have made preparations of its bark for the treatment of tumors and inflammations.

The wych-hazel of England is an elm, whose wood was used in olden times in the construction of wyches or chests. This antique spelling is often erroneously applied to our American shrub.

A Thistle Head.

The studious observer of nature is constantly impressed with the unlimited numbers of curious little contrivances and peculiar habits by means of which the commonest plants and animals are prepared to overcome the obstacles which surround them, for be it known that even plants have obstacles to surmount, if they perpetuate their species. A plant must hold its own against its stronger and more aggressive neighbors or suffer the fate of many of our native plants, which have been driven out by Old World weeds;

it must possess some means of scattering its seeds beyond the limits of severe competition; it must struggle against uncongenial climate and the ruinous changes wrought by man; and it must elude or repel the attacks of herbage-loving and seed-loving animals. One who is interested in the fascinating peculiarities of common objects is often pained at the sneering estimate put upon them by less observant people. No one is prepared to study nature so long as he regards any phenomenon, however slight in itself, as trivial and unworthy his regard. He must not attempt to play the critic with nature. He must assume the attitude of a patient learner, who accepts all things as worthy his study and consideration.

These thoughts were forced upon me by the curious behavior of a ripe thistle head which I carelessly picked in a morning ramble. The involucre, or "leaves," of this thistle head was snugly closed about the closely packed pappus-bearing seeds. So tightly were the seeds packed inside the involucre that the long white plumes of pappus stood rigidly erect. When a seed was removed from the head the tension was released, and the pappus began to spread out, as in Fig. 94, *a*. So different in appearance were these thistle seeds, with their pappus all standing erect, from those which were floating in the centre of round balloons all over the fields that I could scarcely believe them the same. How could they get out of the tight thistle head? I carelessly laid my thistle head in a sunny window, and soon forgot it. An hour later I was surprised to find that a complete metamorphosis had taken place. The head had spread open in every direction, and the seeds were actually crawling out of it. A closer observation at once revealed the nature of the movement. Under the influence of the heat the head had spread open; then the pappus on every seed began to spread, more rapidly in the centre of the head where the heat was more directly concentrated. The spreading of the pappus plumes loosened the seeds and forced them apart until some of them were quite out of the head. But the most striking part of the performance occurred after the outer pappus plumes on each seed had reached a horizontal position.

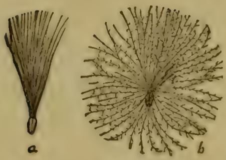

Fig. 94.

When they began to bend downwards from the horizontal the seed was lifted rapidly out of its place. The movement of the pappus was plainly visible, and in a few minutes after I had noticed the opening of the head the round balloons, with a seed, or fruit, in the centre of each (Fig. 94, *b*), were piled in a fairy little mountain, ready to be carried away on the first zephyr.

Willow Twigs.

By the side of a brook and in sight from my window is a clump of white willows. This sunny April morning, as I strolled toward the brook to note any signs of returning life along its banks, I noticed that underneath the willows were lying numerous small branches which had been broken off squarely near their bases. They were lying in the water, or very near it, and knowing that these trees have a wonderful propensity to grow from cuttings, I thought that unless the branches were removed we should soon have a tangle of young willows. I have been surprised many times at the sudden snapping off of the branches of certain wild willows when I jostled them in impetuous botanical rambles. It is even more surprising that these same branches are sometimes tough enough for withes above the one brittle spot near the base. There must be some significance to this peculiar disposition, and I know of none so probable as that suggested by Dr. W. J. Beal, who thinks that in this manner do willows undertake to propagate themselves. This is certainly a beautiful provision: the very enemies which browse or break the plant become active agents in its dissemination!

A Talk About Roots.

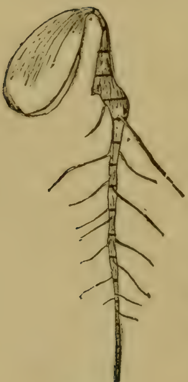
Fig. 95.

Figure 95 represents a young squash plant which has been removed carefully from the earth and marked at regular intervals throughout its whole length with cross lines of waterproof ink. This plant is again set in loose, clean sand, and in a few days it presents the appearance of Fig. 96. It will be seen that a peculiar change has taken place besides the increase in size of the plant; the lines upon the root portion

Fig. 96.

of the plant are the same distance apart as before, but those upon the stem portion have separated to three times their former distance. In other words, the root has grown from its extremity alone, while the stem has elongated between its extremities and has lifted the seed-leaves into the air. We have discovered a fundamental difference between the root and the stem. The root is ever increasing by additions to its young extremity, crawling by this means around stones and whatever obstacles lie in its way, or taking the direction of attractive food supplies. The stem, on the other hand, meets few obstacles to its continuous growth, and each internode, or the space from joint to joint, increases more or less throughout its whole length. It must not be understood, however, that there is no limit to this stretching of the internode, for it very soon ceases, and the upper node or joint becomes stationary. Then the younger and succeeding internodes stretch until they in turn become stationary; so it happens that there may be several internodes, one above the other, elongating at the same time, the lower and older ones perhaps slowly, the upper ones rapidly. The length to which each internode grows will depend upon the habit of the plant and upon incidental circumstances. Some plants habitually produce longer internodes than others. Incidental circumstances appear to be more closely associated with the length of the internode, however. An apple-tree which is neglected may produce internodes one or two inches long, while another tree which receives good culture may grow them two feet long. The leaf-bud which is formed in the fall contains the rudiments of a complete branch which is to grow the next summer; there are just as many nodes or joints in that minute bud-branch as there will be in the future twig, but the length to which the twig will grow between these joints will be determined by the character of the season and the thrift of the plant. The root has no nodes or joints; it goes on in its peculiar searching manner, branching and rebranching with little or no regularity.

There is another still more apparent difference between the root and the stem: the root descends into earth and darkness, but the stem rises into air and sunlight. But why should there be this opposite habit in parts so closely associated? There is nothing in the structure of stem or root, so far as we know, which would cause either of them to take a special direction. To be sure, the roots seek the earth to secure food for the plant, but that fact does not explain how they are enabled to practice such discrimination. It may be that gravitation has something to do with this downward tendency of the root, as many botanists have supposed, although it is difficult to see why the stem should not be similarly influenced; and, moreover, it sometimes happens that roots grow upwards in search of food. After all that has been said and done about the reasons for the downward direction of roots, we are forced to say that we do not know what makes them enter the earth, any more than we know what makes some seeds germinate slowly and others rapidly; we can do no more than to adopt a name which has been given to the phenomenon by botanists. This name is *Geotropism*, from the Greek for *earth* and *to turn*.

Another distinction between stem and root is the absence from roots of all forms of leaves and buds. This distinction will enable us to distinguish between true roots and certain underground stems which are root-like in character. The buds, or "eyes," upon the potato, as well as its mode of growth, prove it to be a subterranean stem. So also are the underground runners of quack or quitch grass, Canada thistles, and other pests. If we look into the more minute life histories of these underground stems, we find additional and even more decisive proofs that they are in no sense roots; we find that they do not imbibe nourishment for the support of the plant, but are simply means for propagating it. It is at once apparent that the underground stems of the quack grass and the thistle naturally serve as very active agents in plant propagation, and a moment's reflection will reveal the same fact in regard to the potato, which is native to countries where frost does not destroy the tubers. Plants which possess underground runners, and which also bear seeds, are doubly prepared, other things being equal, to overcome obstacles of environment. Another class of underground stems are those which become thick and more or less woody, and which are best illustrated in strong perennial herbs. The heavy rhizomes — for so are subterranean stems called — of rhubarb, May-apple, and blue-flag are familiar. These stout rhizomes do not often serve as extensive natural propagators, although most of them die away at one end and grow at a corresponding rate at the other end. At the newly formed extremity they send up a new stalk, an operation which is repeated every year, while the older stalks die, thus forcing the whole plant slowly along. Any of these underground stems are capable of emitting roots. There are many roots which are very similar to these rhizomes and to subterranean stem-tubers. The sweet potato is a true root, and while it does not possess buds, it has the power of forming them when necessary. It is worth remembering that in eating Irish potatoes we eat a thickened stem, but in eating sweet potatoes we eat a thickened root; and that when we plant pieces of the tubers of Irish potatoes we are planting buds, but when we plant similar pieces of sweet potatoes we are planting smooth sections of a root which will soon give rise to buds. The tubers of dahlias are true roots; so also are beets, carrots, parsnips, radishes, and turnips, but in these cases a portion of the stem is also thickened, so that the top of the beet or the turnip is true stem. All thickened roots and thickened rhizomes are reservoirs of food supplies for the plant, and these reservoirs are drawn upon when the plant has need. Compare the thick, plump tubers or roots of dahlias, potatoes, and turnips as they appear in the fall, with the shriveled remains of these tubers after they have been planted and pumped dry by the growing young plants; then imagine these plants in a warmer climate where long, dry seasons must be endured, and you can appreciate the importance to the plant of such infallible storehouses.

The primary office of roots is to supply nourishment to the plant. They always demand that this nourishment be dissolved in water. The liquid food is taken into the thin-walled outer cells of the young rootlets by a sort of imbibition process, and it is passed by a similar process from cell to cell. If we were to remove very carefully from the soil a young plant of Indian corn, or indeed any young plant, and wash it, we should observe a delicate covering like mould upon the young roots. This covering is made up of many minute white hair-like bodies,

Fig. 97.

called root-hairs. (*a*, Fig. 97.) These root-hairs are prolongations of the root cells, as shown, much enlarged, at *b*, Fig. 97. They are the most active agents in the absorption of food, and upon thrifty plants they are always very numerous. The tearing off of these root-hairs is one reason why plants suffer so much from careless removing and transplanting.

As fast as the roots become stiff and hard the root-hairs die, and those portions of the roots no longer gather food for the plant; they become constantly more rigid, and after a time partake more or less of the nature of the stem from which they grow. They now perform the second office of roots, that of hold-fasts or anchors to keep the growing plant in position against wind and frost. As roots have fewer offices to perform than stems, and as their environments are less diverse, they do not generally vary widely one from another in different species of plants. They are much simpler in structure than stems, and it is only when they are old that they begin to take on many of the features of the stem to which they belong. Young roots, whether of endogens or exogens, agree in possessing an endogenous structure;

that is, they are inside growers, the same as palms and corn.

The first root of any plant is developed from the lower extremity of the minute stemlet which lies between or below the seed-leaves in the seed. It was once supposed that this stemlet is a true root in miniature, and it has consequently been called the radicle (Latin, radix, *root*). It is now known, however, that this little organ is true stem, and of late it has been called the caulicle (Latin, caulis, *stem*). This caulicle is shown in Fig. 1. From the caulicle the root arises when the seed germinates. Other roots soon arise from this first root, and these branches again branch and rebranch indefinitely. But roots may arise from stems or even from leaves as well as from other roots. Wherever a runner or decumbent branch comes in constant contact with the ground roots are apt to form. Upon this fact depends the practice of layering adopted by nurserymen. Roots are also produced from the nodes in cuttings of various plants; and the florist knows how to make a score of fan-shaped pieces of a begonia leaf strike roots from their lower ends. It is a significant illustration of the adaptability of any part of a plant to circumstances, and as well also of the individuality of these parts, that rootless stem-cuttings at once emit roots and stemless root-cuttings often emit stems. The "suckers" that arise from the severed roots of apple and pear-trees and the successful propagation of blackberries and other plants from pieces of roots are familiar examples of entirely stemless and budless roots that give rise to stems. Occasionally roots arise from the exposed surfaces of stems, as in the climbing poison ivy; and here we find a third office of roots, for they are essential aids to the climbing. Indian corn emits peculiar aerial roots from its lower nodes, and in a similar manner do many palms and other tropical plants. These roots enter the ground and serve both as feeders and hold-fasts. In warm countries many plants subsist entirely upon food which is gathered from the air by aerial roots. These are the air-plants, great numbers of which are members of the peculiar orchid family. One of these is the vanilla plant, which clambers over trees and drops its long, cord-like roots into the humid air. The familiar long-moss which decorates the forests of our Southern States has the most northern range of any of our air-plants. Another interesting and still more peculiar class of roots are those of parasites, plants which steal their food directly from other plants. Many of our common flowering plants are either wholly or in part parasitic. The wild gerardias and some related plants attach some of their roots to the roots of other plants and thus obtain a part of their nutriment, but otherwise these plants are not peculiar and their fair exteriors give no hint of the robbery that is hidden beneath the surface. Other kinds of plants, however, make an open profession of their guilt, for their white and blanched colors testify that all their food is stolen ready made,

Fig. 98.

and they need no leaf-green with which to elaborate crude materials. Such plants are the Indian-pipes and beech-drops. The roots of parasites are usually broadened and sucker-like where they attack some other root, as is shown in Fig. 98.

The Importance of Seeing Correctly.

Three professional fruit-growers expressed an opinion concerning the manner in which sweet cherries are borne on the tree. The first contended that the fruit grows from side spurs on twigs which grew last fall. The second was equally positive that it is borne on short spurs which grow from the point of junction between last year's wood and the wood of the year previous. The third supposed that cherries grow in pairs from most of the buds on both last year's and two years old wood. Each of these men had grown cherries for at least a dozen years, and yet neither of them knew this one of the simplest facts connected with their daily labor, and which might be made apparent by a few minutes' close observation. It is surprising that many of the commonest and most interesting of every-day phenomena, though they lie right before the eyes of every man, are never seen by the great majority of people. Most persons are walking through a wonderland with their eyes shut. The interesting things detailed in these pages are but a very few random leaves rudely torn from the book of nature. The leaves that remain are fully as inviting, and they are doubly profitable when Nature herself tells the story.

One needs practice, along with scientific training, to interpret aright all the things that he may see. A farmer of my acquaintance noticed that grasshoppers appear shortly after the stems of golden-rods become affected with peculiar frothy swellings, and he at once asserted that the grasshoppers bred in the golden-rods! If he had carefully cut open these swellings he could have found proof enough against his assertion. Another friend noticed that the long-stalked and therefore conspicuous flowers of his pumpkins had all died: he immediately proclaimed to his neighbors that his pumpkins were blasted, and that the entire crop in that vicinity would be small! Had he known that these flowers were staminate, and that when they had shed their pollen their mission was ended, he should have had greater wonder if they had not died. Still another friend discovered a minute insect boring into a pear-tree, and as that tree happened to be blighted he announced that a certain insect was the cause of pear blight; nevertheless, a score of other trees which had the blight would probably show no sign of the ominous insect. It is never safe to draw conclusions hastily, and especially not from one or two detached observations. I will relate a very sober incident, of which an account was published a short time since in an agricultural paper, and I request that my readers bear it in mind as an antidote against hasty conclusions. An observing fruit-grower possessed a plat of smooth-fruited gooseberries. A favorite family cat, having unceremoniously died, was buried underneath one of the gooseberry bushes, and behold! the next year that bush bore hairy berries, and has so continued to do unto the present day!

But beside a remedy for indifferent habits and these aids to mental perception and logical reasoning, one needs some purely physical apparatus to enlarge his eyesight. This apparatus is the microscope. I do not speak of the compound microscope, which is much too complex an instrument to place in the hands of a novice, but rather of the simple lens or hand-glass. A handy pocket

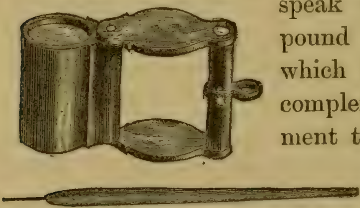

Fig. 99.

lens is one that shuts up in a tortoise-shell or german-silver case, like Fig. 99, and which may be purchased for two or three dollars. Such a little lens will magnify enough for purposes of common out-door observation. A stand may be made for it by fastening a wire two inches long vertically into a block, and then sliding the lens down

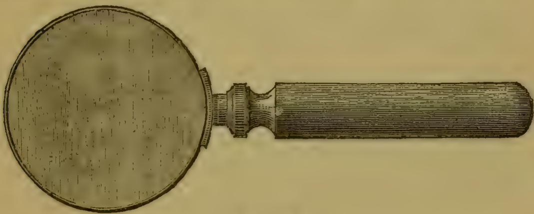

Fig. 100.

upon the wire by means of the hole in the handle. Then if a couple of needles be stuck in sticks, as represented in the lower portion of Fig. 99, and used as priers and forceps, both hands may be employed in picking a flower or bud to pieces, while the eye watches the whole operation through the microscope. An excellent lens for examining rather large objects and for studying plants without dissecting them is a reading-glass two or three inches in diameter, as shown in Fig. 100.

How Plants are Named.

It is a popular notion that when a botanist finds a new plant he at once recognizes it as new and immediately gives it any name which may please his fancy. To the non-botanist it appears one of the easiest of matters to define and name a new plant, while in fact it requires a broad knowledge, an extreme accuracy of expression, and an uncommon acumen. What is a new plant? The botanist, with a manual in hand of all the plants known to occur in his region, finds a plant which does not agree with any of the descriptions in the book. He at once recognizes the plant as a violet, for instance, but he finds no name for it. The first thought comes, May this not be an abnormal form or a peculiar variety of some old species? May there not be intermediate forms all the way between this plant and the bird's-foot violet, which it much resembles? And who is to decide the limits of the species? Who is able to pronounce whether the new plant is entitled to a full specific rank, or whether it is a mere variety, a form? "Species are judgments," says our great botanist, and necessarily he who has the best judgment, who has had the best training and the longest experience, is the best fitted to make such judgments. He knows that violets which are widely different in general appearance may be only extreme forms of one species. If the difference lies in the color, he gives it little attention, for he knows that color varies in all plants. If the difference lies in the shapes of the leaves, he gives it more attention, still does not rely upon it, unless the leaves are wholly and essentially unlike between the one and the other. Here again it is a matter of judgment as to what constitutes this essential difference. The common hooded violet ordinarily has large heart-shaped leaves, still they occasionally vary so as to resemble the much-cut leaves of the bird's-foot violet. A difference in the shapes of the parts of the flower is of more consequence. The general habit and appearance of the plant are important. If, after considerable thought and study, the botanist satisfies himself that the violet is a new species to his region, that it is not a form of any of the species described in his botany, then his trouble has just begun. It is not enough that the plant be new to his region: it is not new if there is another violet like it in the world! He must now cultivate a critical acquaintance with the violets of all countries, and with them he must compare his plant. He will look especially towards the violets of certain countries, knowing that the flora of his region resembles some foreign floras more than others. If he lives in the Northern United States, he will look especially at Arctic American or Northern European or Eastern Asian species. Having satisfied himself that the violet has never been named in any country, he must next describe it. This is a difficult task. He must be able to seize upon the permanent features of the plant and to describe them in a concise and accurate manner: he must describe the plant so accurately as to distinguish it unmistakably from all other violets. Next comes the naming of the plant, which is a comparatively easy matter. The first name will be Viola, the generic name of the violets. The second or specific name must be one which is not applied to any other violet. It could not be called Viola blanda, "sweet violet," because Willdenow long ago used that name; neither could it be called Viola rotundifolia, "round-leaved violet," as Michaux has used the name. The specific name must agree with the generic name, Viola, in gender, and it must be Latin or Latinized. A proper name decided upon, as perhaps Viola verna, "spring violet," the botanist publishes it with the scientific description of the plant, and thereafter the name is written with the author's name attached, to show who published the species. Thus we write, Viola blanda, Willd., and V. rotundifolia, Michx., the names of the authors being abbreviated.

This binomial, "two-name" system of naming natural objects is an exceedingly beautiful and convenient one. The names of the nearly 8,000 genera of flowering plants must all be different from each other, but the same specific name may be used over and over again, only changing it in each case to suit the gender of the generic name. Thus we might use the word verna, meaning spring, for a plant in each of the 8,000 genera. There could be a spring violet, a spring rose, a spring chrysanthemum, or a spring bramble, — Viola verna, Rosa verna, Chrysanthemum vernum, Rubus vernus. One hundred thousand species of flowering plants are easily and readily named by this method, and their names can be borne in the memory. The names of varieties are made after the same pattern as the names of species: Viola cucullata var. palmata represents a palmate-leaved variety of our common hooded violet.

A Chapter on Plant Names.

There are other associations than those of verdant fields and woods and fragrant flowers connected with the names of plants: there are attractive bits of history, interesting reminiscences, or curious tangles of etymology. Many of the scientific names of plants can be traced back to the earliest periods of history, from whence they have descended through the centuries by irregular paths, now applied to one object, now to another, now receiving some impression of popular notions or superstitions, at times lost sight of altogether, and as often resurrected in a new guise, perhaps, until finally they have been rescued by the modern scientist and stereotyped in ponderous Latin. The common names of plants have for the most part even more intricate histories, for they have been indelibly associated with the every-day speech of the common people. Their origin is often lost in the mists of antiquity. The common names of many cultivated plants are very similar in widely different languages, and these similarities are proofs that the plants have migrated from one people to another, carrying with them the old names, which have become modified to suit the genius of the foster tongue. We can sometimes trace these common names, as spoken by different peoples, back to one common origin, which must be coincident with the origin of the plant itself. In this manner we can trace the word *apple*, and its equivalents in modern languages, to an Asiatic origin, and we are justified in saying that the apple was native to that Asiatic region, and that it was carried to the westward by the early migrations of men.

An apt illustration of this growth of names is found in the specific name of the common garden carnation, Dianthus Caryophyllus, and in the name of the Pink family, Caryophyllaceæ, to which it belongs. Among the Greeks the clove was known as caryophyllum or caryophyllus, literally "nut-leaf," probably in allusion to the bud-like or nut-like form of the spice. When the carnation began to be cultivated it was found to possess so strongly the odor of cloves that it was used as a substitute for them in the seasoning of wines, and it soon came to be called caryophyllus. The name was not lost to the clove, however, for the clove-tree is now known to botanists as the aromatic caryophyllus (Caryophyllus aromatica). Other plants closely related to the carnation began, in time, to be associated with the name caryophyllus, and when the pink-like plants were arranged into one group, that group was designated the Caryophyllaceæ. The true pinks themselves were dedicated to Jupiter, hence the genus was called Dianthus, "Jupiter's flowers." Linnæus indicated the history of the carnation by naming it Dianthus Caryophyllus. But the name caryophyllus has not stopped here. In common writing it became corrupted, and in mediæval Latin it was called *garoffolum* or *gariofilum*. The French changed it into *giroflée*, from which were made the Old English words *gyllofer* and *gilofre*, each with a long o. The word subsequently developed into *gilliflower*. Thus far these names appear to have been applied to our carnation pink, but after a time a new difficulty arose. Certain members of the mustard family, in the double forms of their flowers, bear a close resemblance to some of the carnations, and the name gilliflower was often transferred to them. To distinguish the one from the other the term clove-gilliflower was often applied to the carnation, and stock-gilliflower, "woody-stemmed gilliflower," was applied to the mustard-like plant. The name carnation or coronation, derived from the old custom of making chaplets or *coronæ* from these and similar flowers, came into use for the clove-pink and it ceased to be called gilliflower. Finally, the name has been dropped from the mustard-like plant also, leaving us but a remnant, *stocks*, for these well-known plants of the flower garden, the ten-weeks' stocks and similar varieties.

An equally interesting history is connected with the common purslane or "pusley," a weed so unattractive and so pernicious in its character as to be commonly deemed entirely unworthy a history. In this case, according to Dr. Prior in his invaluable "Popular Names of British Plants," the proper Latin name of the plant early became confounded with a very different name which was popular in the Middle Ages. A beautiful translucent sea-shell was known as *porcellana.* When Marco Polo returned from his wonderful travels to the far East near the close of the thirteenth century, he could find no name so appropriate for the beautiful pottery which he had found in China as *porcellana*, the sea-shell. The word became familiar as Marco Polo's adventures became widely known, and we still know this fine pottery as porcelain. It is probable that the plant portulaca, or purslane, was then cultivated as a salad plant, as it is to-day by the French. The plant was surely familiar, while its Latin name was probably less so, for this name became confounded with the like-sounding *porcellana* which finally descended to the plant: the insignificant waif of the gardens became indelibly associated with the sea-shell and the beautiful dishes!

The name huckleberry, which is applied indiscriminately at the West to several species of Vaccinium and Gaylussacia, is evidently a corruption of whortleberry. Whortleberry is in turn a corruption of myrtleberry. In the Middle Ages the true myrtleberry was largely used in cookery and medicine, but the European bilberry or vaccinium so closely resembled it that the name was transferred to the latter plant, a circumstance commemorated by Linnæus in the giving of the name Vaccinium Myrtillus to the bilberry. From the European whortleberry the name was transferred to the similar American plants.

The showy corn-cockle, which has to be pulled from nearly every wheat-field in the country, and which most farmer boys associate with back-aches, is connected with quite as complex a history as is the carnation or purslane. Botanists are now agreed in calling this plant Lychnis Githago, but it was formerly known as Agrostemma Githago. An outline of the history of its botanical and popular names may be given as follows: The pungent seeds of the nutmeg-flower or fennel-flower (Nigella sativa) of old gardens are employed by the Egyptians and other Oriental peoples as condiments and as medicines. These seeds were at one time considered acceptable substitutes for pepper, and they have always been associated with such aromatic-pungent seeds as caraway and dill. This plant is probably the fitches of which Isaiah gave the manner of sowing and reaping: "When he hath made plain the face thereof [the ground], doth he not cast abroad the fitches and scatter the cummin, and cast in the principal wheat, and the appointed barley, and the rye in their place? . . . The fitches are not threshed with a threshing instrument, neither is a cart-wheel turned about upon the cummin, but the fitches are beaten out with a staff and the cummin with a rod." The cummin here mentioned is another of the aromatic, caraway-like products of the parsley family. The nutmeg-flower, now rarely seen in gardens, is akin to the common Damascus nigella or mist-flower, a plant known to romantic minds as love-in-the-mist. To the Latins the nigella or nutmeg-flower was known as *gith* or *git*. There appears to have been a time some three hundred and more years since when the curious in history and science were uncertain to what plant the name gith was applied. Its seeds were no doubt brought into Western Europe at that time, and so closely do they resemble those of the cockle that this latter plant assumed the name of the gith. The black seeds of the true gith gave it in Greek the more classic names *melanospermon* and *melanthion*. When the cockle was found to be a much different plant from the gith, it received two new names, each meant to record the gith-like character of its seeds, — one *gith-ago*, the other *pseudo-melanthion*. When Linnæus, in the middle of the last century, brought order out of the confusion of the names of animals and plants, he found no less a name for the brilliant cockle than the poetic Agrostemma, "crown of the fields!" To complete the name he added the popular though historic githago, making the Agrostemma Githago of botanies. The genus Agrostemma is now included in the genus Lychnis, — Lychnis is a Greek word for a light or lamp, — and our plant now carries the less pretentious name, Lychnis Githago. Perhaps the common name, cockle, also records an allusion to the aromatic seeds of the gith. It is pretty clearly derived, though indirectly, perhaps, from the Latin *caucalis*, a name which was early applied to some caraway-like plant with which the gith was probably associated. The name cockle may have been applied first to the gith and afterwards to the plant we now know as cockle. Old English writers, however, used the word for weeds in general, but no doubt always with a special reference to the wheat-field pest. It is supposed that the word was used to designate this plant when Shakespeare made Biron exclaim, in "Love's Labor 's Lost,"—

"Allons! allons! sow'd cockle reap'd no corn."

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