A YEAR'S BOTANY

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A YEAR'S BOTANY

ADAPTED TO HOME AND SCHOOL USE

BY

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ILLUSTRATED BY THE AUTHOR

RIVINGTONS
London, Oxford, and Cambridge
MDCCCLXXIV

PREFACE.

THE greater part of the following pages has already appeared in twelve papers in the *Monthly Packet* of 1872 and 1873.

These papers were originally written with a view of bringing some of the most attractive parts of Botany before the notice of the readers of the *Monthly Packet*, and by this means inducing them to continue its study in the flowers around them, with the help of other books. When the request was made that I would add to these papers, and reprint them as a whole, I complied with it because it came from experienced botanical teachers, who assured me that such a book would be useful; and from school-mistresses, who, having tried the experiment of using the original papers for class-teaching, were anxious to have a more complete set of the same kind to put in the hands of pupils preparing for the University Local Examinations.

I have therefore added three more papers to the original twelve, and have carefully revised and re-written much of the original text. I have also tried to illustrate it intelligibly. In almost all cases the illustrations are drawn from nature, and I have never made them diagrammatic, except when I was absolutely obliged, because I think the tendency of diagrammatic drawings is to make the reader satisfied with them, without verifying each point in the flowers themselves.

In the Appendix I have kept in view the wants of students preparing for the University Local Examinations. This Appendix is not intended for the general reader; only for students preparing for an examination in which technical terms will be used, or for those who are intending to read other books on Botany, which would not be intelligible without a knowledge of the terms. In all cases the book should be read *first*, and the parts of the flowers known and understood in ordinary language; afterwards technical terms will have lost their power to confuse.

The books to which I owe most are *Leçons Élémentaires de Botanique*, by Le Mâout; Gray's *Structural and Systematic Botany; Die Befruchtung der Blumen durch Insekten*, by Hermann Müller; *Die Geschlechter-Vertheilung bei den Pflanzen*, by Friedrich Hildebrand; all Mr. Darwin's writings on botanical subjects; and various papers which have appeared on cross-fertilization in *Nature* and the *Science Review*.

Also my husband has helped me so much (1) by a set of lectures of his which I attended, (2) by suggestions, and (3) by entirely writing three of the original papers for the *Monthly Packet* when I was ill, that, though my name is given to the book, it is really almost as much his as mine.

RUGBY, *September* 8, 1874.

CONTENTS.

LIST OF WOODCUTS.

A YEAR'S BOTANY.

CHAPTER I.

GENERAL DESCRIPTION OF FLOWERS.

THERE are two ways of studying Botany.

One is to begin the subject by examining the internal structure of the plant, to learn about cellular and vascular tissues, chemically to test their components, and then gradually to trace their development and integration into roots and stems, and finally into leaves, flowers, and fruit, marking each stage of the inquiry with a fresh mass of long and incomprehensible terms.

This method may be called that of proceeding from the "unknown to the known;" and almost all the English Botany-books that have ever been written are an exemplification of it, and therefore, and I believe therefore *only*, is Botany so often stigmatised as a dry uninteresting study.

Who can be expected to begin a new subject by feeling interested in whether the cellular tissue of a certain stem is composed of *Prosenchyma* or of *dodecahedral Parenchyma*, especially if, as is almost sure to be the case, he is not a sufficiently good microscopist to be able to distinguish the one from the other when he sees them?

But if the other method be followed, that of proceeding from the "known to the unknown:" if a familiar flower be taken, and the wonderful contrivances shown by which its various coverings, its shape and stalk, are all made subservient to the protection of its most precious part, the seed—nay, how even its beauty and scent are used as flags to attract, and bribes to induce the insect world to wait upon it and do its messages; then by the time the student comes to the examination of this seed, it will have ceased to be merely a bead-like grain, and will have become to him the token of success of all the manifold cares he has seen expended on it; and *then* to study its minutest structure, and learn how from a little shapeless lump it has become the germ of a new plant, with leaves and stem wrapped round in its tiny self, will have become to him a labour of love, which no long words can render unattractive.

This plan is followed by many French botanists, by J. J. Rousseau in his "Lettres Elémentaires sur la Botanique à Madame de L.," by Vaucher in his "Histoire Physiologique des Plantes d'Europe," and even more fully and successfully by Le Mâout in his "Leçons Elémentaires de Botanique," the "Prèmiere Etude" in which seems to me an ideally good way of opening the subject. I have endeavoured to follow his method, at any rate in this introductory chapter, and to adapt it to the flowers more easily found by my readers; and I hope by this means to be able to prove the truth of my statement that Botany is *not* dry and uninteresting, but full of fascination from the very beginning—a fascination which lies not only in what is known, but in the number of beautiful problems yet unsolved, and open to the patient work and examination of every intelligent observer.

But first I must beg that my readers will give me a fair trial; that they will pick the flowers described, and examine them, *while* they read the description; and that they will trace every law, arrangement, and peculiarity, in their living illustrations. Sometimes these may not be seen at the first glance, or even in the first specimen, but they must pick fresh flowers, look and look again, and take *nothing upon trust*, remembering that one of the chief lessons Botany has to teach is how to use both eye and hand.

We will now begin the examination of our flowers. All that will be needed will be a couple of needles (these are more convenient for use if fitted to the end of a short bit of stick or pencil, which is easily done with the help of a little sealing-wax), a sharp penknife, and a pair of scissors; some sort of magnifying-glass will be wanted soon, but nothing will be described in this first chapter that really needs it.

The flowers you should provide yourselves with, are—*Buttercup, Wall-flower, Cucumber* or *Vegetable-marrow, Gorse* and *Garden Pea,* and *Primrose.*

The Buttercup.—Let us begin with a buttercup, and see what we can make out about it. Take one of the round green buds; in a small one there is not a sign of yellow to be seen, but if you look at an older one, two or three narrow streaks will be apparent, proving that there is something not green inside; press your finger against the top of this bud, and the green covering will open out into leaves, separate one from the other, and showing a ball of yellow. Pull these leaves gently, they will come off without tearing the rest of the flower, and you will see that there are five of them, all exactly alike, and that they are covered outside with soft white hairs, while inside they are smooth and shiny.

After these are removed, we come to the glossy golden leaves, with which in their full-blown shape we are all familiar; they are so closely folded one over the other, that we cannot tell whether they will finish our flower or not. Pull them off, one by one, and see how pretty they are when held up against the light, with all their veins showing, and making them look like yellow foliage leaves in miniature. There are five of them, and they, like the outer leaves, have two different sides, the inner one being bright and glistening, while the outer is of a paler, duller yellow; and there is another difference which has probably already caught your eye; the whole surface of the outer side is smooth, but at the base of the glossy side there is a small protuberance, like the swelling of the bottom of the leaf (fig. 1, *n*); if you push this about with a needle, it will prove to be a minute scale, placed *vis-à-vis* to the yellow leaf, and covering a little sticky lump. There are five yellow leaves, the same number that we counted of outer green ones, and it is curious to notice the relative positions of the two. Take a fresh, well-opened flower, and hold it upside down, you will see that each space left between two green leaves is occupied by a yellow one, *i.e.* if we call the outer leaves 1, 3, 5, 7, 9, the inner ones would be 2, 4, 6, 8, 10; and would be arranged thus:

Fig. 1.
Petal of buttercup.

1 . 3 . 5 . 7 . 9
2 . 4 . 6 . 8 . 10

Having laid these aside, we find there is still left an indefinite number of thin yellow spikes, with thickened widened tops, ranged round a green raised centre, which is a good deal like an unripe strawberry. This centre, as well as the spikes round it, are placed upon the swollen top of the flower-stalk, which is large enough to support not only them, but also the two sets of leaves which you have pulled off.

If you now take one of the yellow spikes (fig. 2), and look at it closely, you will see that what we called its thickened widened top is in fact a small pouch, which has two hardly perceptible slits. These, when the flower is fully blown, open of their own accord, and let out a quantity of minute yellow dust. As the flower which we are now examining is only in bud, it will be necessary, in looking at its dust-spikes, carefully to insert a needle into their slits, and hasten the process of opening, in order to see the contents of the pouches; but one glance at a flower that is beginning to wither will leave no doubt that they would, later on, have opened of themselves,

Fig. 2.
Dust-spike of buttercup (*magnified*).

for the yellow dust will be seen scattered all about the flower leaves.

When these are all removed, the raised centre of the flower only is left (fig. 3). It will be more convenient to look at this in a withered flower, in which, if you poke it about a little with your needle, you will find that it easily separates into a number of small green things, looking like unripe seeds. Cut one of these open with your penknife. It will prove to be a pod, containing one very small grain, which is fastened at the bottom by a scarcely visible thread (fig. 4).

Fig. 3. Seed-organ of buttercup.

We have now examined all the parts of our flower, and the question naturally arises, "Of what use are they?" The use of the little grain is evident. It is to be perfected into a ripe seed, fall to the earth, and there become another plant like that from which it itself sprung; and the thread fastening it to the pod is the medium through which the food necessary for its well-being reaches it.

Fig. 4. Split seed-pod of buttercup (*magnified*).

The use of the outer covering is also clear. It wraps round the young bud, keeping off all rough winds and rain, and protecting the flower in its tender infancy.

The glossy inner covering serves as an additional protection, for, as you remember, it grew in such a way as to fill up every interstice left by the green leaves; but it has besides other wonderful and beautifully contrived uses, of which we will only say for the present that the little lumps at the base of each leaf are most important for due success.

The dust-spikes also, with their slender thread-like stalks, and curious double pouches, have their work in the world to do; but we must leave the consideration of what that is, till we have looked at a few more flowers, and for the present I can only say their business is curious enough to be well worth our waiting to understand.

THE WALL-FLOWER.—Let us now turn to the wall-flower (fig. 5), and see how it will help us on our way. It is very unlike the buttercup in its appearance and manner of growth, and it will therefore be interesting to notice what are the points of resemblance between the two flowers, as they will be *likely* to be the rule in the flower world, though of course we must examine many more flowers before we can so far generalise as to feel *sure* of rules. (Should you have no wall-flowers at hand, the meadow cuckoo flower, the garden stock, or any sort of cress, will answer the purpose equally well.)

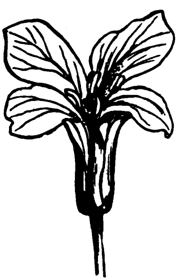


Fig. 5.
Wall-flower blossom.

Take a good-sized bud: you will see that the outer covering is composed of four brownish-green leaves, fitting exactly at the edges. These four leaves are not quite like each other; two of them are opposite and equal, and of a smaller size, while the other two, also opposite and equal, are larger, especially near the base, where they have a swollen appearance.

Pull these off, and you come to four coloured sweet-smelling leaves, most delicately and beautifully veined (see fig. 5). These wrap round each other in the bud, but in a full-blown flower are spread out in the shape of an equal-armed cross; to this arrangement they owe the botanical epithet of *Cruciform*, which is given to all flowers of this appearance. Their shape is rather curious, being thin and stalk-like at the base, and opening into a round out-spread leaf towards the upper part. They grow alternately with the outer leaves—that is, the space between each two of these is occupied by one of the coloured leaves, as in the buttercup.

In the buttercup, you remember, after we had disposed of the two coverings, we came to the dust-spikes; and here again we find them, not as there, indefinite, but six in number (fig. 6 represents four of them), and not all alike, two being shorter than the other four, and having their pouches farther from the centre.

Just a hundred years ago, Madame de L——, J. J. Rousseau's clever cousin, was puzzling herself about this very difference and the reason of it. Rousseau was teaching her botany by correspondence, and had set her as a problem "to discover the reason why these two dust-spikes are shorter than the rest, and why two leaflets of the outer covering are more protuberant than the other two." Her answer was right as far as it went, and pleased Rousseau, for he writes, June 19th, 1772:—"Your solution of my question is perfectly right. You have accounted very well for the swelling of the outer leaves, and the shortness of the two dust-spikes, by pointing out the *bending* of these two (see fig. 6). One step more would have led you to the primary cause of this structure: for if you ask once more *why* these dust-spikes are thus bent and consequently shortened, I answer that you will find a little gland on the enlarged top of the stalk, between the central organ and the dust-spike (see fig. 6); and it is this gland, which, by throwing it to a distance, and forcing it to take a round, necessarily shortens it. There are two other glands, one at the foot of each pair of longer dust-spikes; but being on the outside of them, between them and the outer covering, they do not oblige them to bend, and therefore do not shorten them," and as there is no bend in them, there is nothing to cause the leaves outside them to bulge. "These four glands," Rousseau goes on to say, "or at least vestiges of them, are more or less visible in almost all cruciform flowers, and are much more distinct in some than in the stock." You have probably already guessed that these little "glands" have the same purpose as the sticky lumps we noticed in the buttercup, though what this purpose is remains yet a mystery; as Rousseau says, "We anticipate a little too much in the inquiry into the use of these glands, let us therefore return for the present to our flowers."

Fig. 6.
Dust-spikes of wall-flower.

In the wall-flower, as in the buttercup, the whole flower is placed upon the swollen top of the stalk; the swelling is here very plainly to be seen, as are also the little marks left, where each leaf has been removed.

We now come to the seed-organ, which, instead of being formed of a number of little seed-pods, each containing one grain, is here seen as one column, thick, rather shorter than the four dust-spikes immediately surrounding it, and having a slightly forked top. The pouches of the dust-spikes are shaped somewhat like an arrow-head, and their slits, turning towards the centre of the flower (see fig. 6), are visible, even in the bud. Look at a fully-blown flower. The slits in the dust-spikes are open; the forked top of the central column is damp and sticky, and has several grains of minute yellow dust adhering to it. Turn again to our bud. The slits in the dust-spikes are quite closed; the forked top of the central-column is *not* sticky, and has no dust upon it at all! Do you see how the wall-flower is helping us towards the solution of our enigma, viz. the use of the dust-spikes?

Fig. 7.
Split seed-pod of wall-flower.

The seed-column is but small in the bud, so it will be more convenient to look at it in a full-blown or faded flower. Such you will find lower down on the branch from which you picked the bud. If you cut one of them across, you will see that it is a pod containing seeds, and that it is divided into two, by a thin partition running down the middle. Now split it from top to bottom; the seeds are fastened to the middle partition by short cords (fig. 7); on carefully removing this partition you will see that seeds grow on the other side of it also, in exactly the same manner.

Now what has our wall-flower taught us? We have seen that it, as well as the buttercup, is placed on the swollen top of the stalk; that it also consists of an outer covering and an inner covering, so arranged that every space left in the outer covering should be occupied by a leaf of the inner; of a set of dust-spikes, and a seed-organ, not, as in the buttercup, split up into a number of tiny pods, but forming one large one: in both cases these seed-organs contain grains, and nourish them by means of cords.

The use of the dust-spikes still remains a mystery, but the presumption that they *have* some important function is much strengthened by finding that a flower in many respects so different to the one before examined does not dispense with them. Also you have probably begun to suspect that there is some connection between the top of the seed-organ becoming sticky and the pouches letting out their dust.

THE CUCUMBER.—There are some plants which bear two different sorts of flowers, one containing no dust-spikes, the other no seed-organ; that is, no organ with grains. The melon, cucumber, vegetable-marrow, oak, and hazel, are all examples. We will take the cucumber flower, as you are almost sure to have access to vegetable-marrow or cucumber plants. The flowers of these plants differ in small particulars, but as the structure of both is rather complicated, we will not attempt a minute examination of them, but only dwell on one very important point common to both.

Look at any flowering branch. There are several bright yellow flowers on it, very unlike any we have hitherto examined, but still evidently flowers; look again, they are not all alike, some of them have long, thin swellings just beneath the flower (fig. 8), which look like miniature cucumbers or vegetable-marrows, while others have no appearance of the kind, and are besides a good deal smaller (fig. 9). Open one of the first

Fig. 8.
Fruit-bearing cucumber flower.

named of these, cutting through the flower into the swelling below it; you will find the outer covering and the inner covering all joined together, in a way that makes them difficult to recognise, and a multitude of grains in the swelling below the flower, which show that in spite of its position, it fulfils the same office as other seed-organs, and is the receptacle for the seeds; but you will find not only no *dust-spikes*, but no organ of any shape or kind containing dust. Now cut open one of the other smaller flowers (fig. 9); there are the two coverings as before, and besides them, curious-shaped pouches, each twisted into the form of an *s* lying sideways, which, though they grow on nothing that can be called a *spike*, are evidently full of dust; but, however far you cut, you find no seeds—the flower is without a seed-organ.

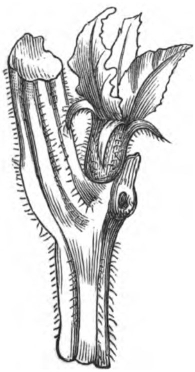


Fig. 9.
Dust-bearing cucumber flower.

If you consult any gardener on the subject, he will tell you that he expects the flowers with swollen stems (*i.e.* those containing seed-organs) to come to fruit, and the others to wither and die unproductively. Apparently then these unproductive flowers are useless, merely a freak of nature! So suppose we go to a cucumber frame, whose plants are not yet in blossom, and cut off every bud whose stem is not swollen before it opens. The consequence will be that the buds with swollen stems will flower as usual, but after they have withered, no growth of the miniature fruit at their base will take place; and if one of these is cut open, it will be seen that the little grains in it, instead of growing and ripening, are drying up and withering away. Thus our improvement upon Nature's plans has prevented a whole cucumber bed from bearing fruit!

But yet the use of these unproductive flowers is not decided; we have only proved that they *have* a use, and it evidently lies in the dust-spikes, for they are the only organs possessed by them, and not by the productive flowers.

Let us go to a cucumber frame at a distance, where the flowers are in full bloom, and take a little dust from one whose dust-pouches are already open; then let us drop this dust into one of the flowers with swollen stems on the bed upon which we have been experimenting. It will readily be received, and retained by the sticky top of the seed-organ; and the result will be, that *this* flower, unlike its neighbours, will be productive.

This is an easy experiment, and it is so difficult for any one unacquainted with the manifold mysteries of Botany, to believe that the presence or absence of a little yellow dust should make all the difference between an eatable cucumber, with seeds enough for indefinite multiplication, and a dry withered lump of no use to any one, that it is worth the destruction of a few cucumbers to have ocular demonstration of the fact.

Now, having determined that the use of the dust-spikes is to change the little round grains in the seed-organs into fruitful seeds, and that they are indispensable for this purpose, a new question arises: How is the dust borne from the pouches to the sticky top of the seed-organ needing it? In some flowers, as the wall-flower, the matter is simple enough, for the slits in the pouches turn towards the seed-organ, and surround it in such a way, that when they open, some of their dust must of necessity come in contact with, and adhere to, its sticky top. In other flowers, as the fuchsia, the seed-column is much longer than the dust-spikes; but here the flowers hang down their heads, as if on purpose to enable it to catch the dust as it falls; nevertheless, many flowers remain, as the evening primrose, having long columns, and short dust-spikes, which carry their heads erect, and in the formation of which no counterbalancing alterations have been discovered. There are others, as the cucumber has just taught us, which have two sorts of flowers, one containing the seed-organ, the other the dust-spikes; and there are yet others, as willows, poplars, red and white campion, etc., which not only have two sorts of flowers, but bear them on different plants.

In cases like the cucumber, it is possible (supposing very favourable circumstances) to believe the wind blows the dust from one flower to another. But what happens when the flowers grow on different plants? The wind cannot carry it, for even supposing it to blow in the right direction at precisely the right time, it would scatter the minute particles far and wide in the first few yards.

We must turn to the animal kingdom for the solution of this puzzle.

When you have seen bees and other insects buzzing from flower to flower, you have probably thought them busy about their own work alone; but in fact the honey they collect is the wages they receive for doing the flowers' messages. These messages are always the same, the diffusion of dust from the pouches to the seed-organs of flowers; and no one noticing the quantity they sometimes have upon their hairy bodies, and the number of flowers into which they fly, can doubt that they do their work thoroughly. By the time that the pouches have opened to let out their dust, or the tops of the seed-organs have become sticky, the nectar-cells are already filled with honey. Of these last we have not spoken by name, but I think if you put your tongue to the little "glands" in the wall-flower spoken of by Rousseau, or to the lumps observed at the base of the yellow leaves in the buttercups, their sweet taste will determine you that they deserve the name of nectar-cells. Look at them again, you will see that in both flowers they are so situated that the insects visiting them must rub against the dust-spikes and the seed-organ before reaching them, and that there is therefore no fear of their getting honey before they have earned it. In all flowers, whatever their shape or size, the situation of the nectar-cells is similar with regard to the other organs of the flower.

There is yet one difficulty to be disposed of. How can the insects know where their work is needed?

Here comes in the use of the varied bright colours and sweet scents of the inner covering of flowers! The red campion flower has different flowers on different plants. Imagine a bee having just done sucking the nectar from a plant bearing dust-spikes, and highly satisfied with the supply it had gained from it! Fancy it hovering about in doubt as to which flower next to enter! Would it not instantly be attracted by the *appearance* and *scent* of one like that which had lately pleased it so well, and eagerly try its fortune there? It is very likely that this second plant would be one with seed-organs, just needing the dust with which it was covered.

Hence the necessity that plants should, for their own sakes, have different sweet scents and bright colours, and not solely, as is often supposed, for man's pleasure and enjoyment.

After this long digression, let us return to our practical examination of flowers, with, I hope, a new interest in all the arrangements of their structure, which seem to mean so little to us, but which may mean so much to them.

GORSE AND PEA.—We will now turn to a flower, very unlike those we have hitherto examined—viz. the wild gorse. Its structure is rather complicated, but as you are sure to be able to find the flower itself to examine, I hope to be able to make it clear. We will look at it and the garden pea together; they both belong to the same tribe, and the slight differences between them help to make the structure of both plainer, and are besides very wonderful to see, because we can understand the—or, at any rate, one—reason for nearly all of them.

Pick then a white pea-flower from your vegetable garden, and a sprig of prickly gorse from any common near, and let us begin by examining the latter. Hitherto we have been careful in observing how all the parts of our different flowers grew from the swollen top of the stalk. Now we shall have to notice a digression (not very easy to trace), in so far as part of the flower is concerned.

Take a bud ready to open. There are no green leaves to be first pulled off, for the whole flower is tinged with yellow. The *outer covering* (fig. 10, *o, c*) seems to be made up of two large brownish-yellow leaves, entirely covered with a thick down, meeting at the edges, and enfolding the rest of the flower. I say, this covering "seems to be made" of two leaves, because a closer inspection will show that if you press the upper of these leaves against your thumb-nail, it will be clearly divided into two at the top; while the lower of them will in like manner divide into three. This may seem but a faint indication of the compound nature of the leaves; but a glance at the garden pea (see fig. 14, p. 17) will settle the question, for in it, the outer covering is evidently composed of five leaves, joined to each other about half-way up. Try to rob the gorse of its protecting leaves; you will find that quite at the bottom they are fastened to the yellow inner leaves, and that therefore you will leave a little of them behind. The fact is, that though *they* do grow on the stalk, the yellow leaves and dust-spikes do not, but on a little ledge composed of their point of junction with the stalk. This, as I said before, is not easy to trace, and I do not think it can be done till the same mode of growth has been seen more plainly marked in other flowers.

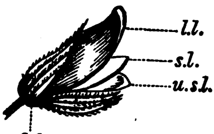


Fig. 10.
Flower of gorse.

Now we come to the *inner covering*, very irregular in shape, and somewhat so in colour. It is composed of five leaves, three of which are of a darker, brighter yellow than the other two. The top leaf (fig. 10, *l, l*) (*i.e.* the one growing just within the division of the outer covering that splits into *two*) is here much the largest. "But," you will say, "surely this leaf is really *two*, for it is far more plainly divided at the top than the leaves of the outer covering." This is quite true, but nevertheless the reasons for considering it as one only, are conclusive; in the first place, it is clearly *veined* as one; there is a large mid-vein in the centre, from which all the lesser veins spring; in the second place, we have seen in our other flowers that when the two coverings were composed of an equal number of leaves, these were arranged alternately. This rule is adhered to if the large leaf be considered as one, but transgressed if we call it two; and last, but not least, the pea has foreign relations in which this large divided leaf has shrunk into one of ordinary size and shape.

Pull off this leaf, remarking how firmly it is fastened by its narrowed thickened base (fig. 11, *ll*). Next, there are two narrower side leaves (fig. 10, *s*, *l*, and *u*, *s*, *l*), also of a very bright colour, growing between the two parts of the outer covering, and in such a way as to be just overlapped by the broad top one. Each of these has near the base a curiously-shaped little cavity (fig. 11, *sl*), into which a corresponding protuberance in the two lowest, lighter leaves, closely fits, and keeps the whole flower compact. These last leaves are quite hidden by the side leaves in a young flower (fig. 10), but when you have pulled it to pieces you find them slightly joined into the shape of a little boat (fig. 11), of which the pointed hairy base may be considered as the keel (*k*), and all four of the lower leaves are fastened to the rim formed by the outer covering and stalk, in such curious and various ways that they may rather be said to *hook* on to it than to grow upon it.

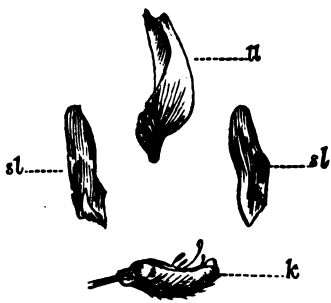


Fig. 11.
Detached inner-covering leaves of gorse.

When these are removed, we come to the *dust-spikes*, ten altogether, in sets of five long, five rather shorter. The pouches of all of them open by two slits turned towards the centre of the flower. Their stalks have expanded and joined together, so as to form a thin sheath round the central column (fig. 12). The dust-spikes are so variable in length in this flower, that it may not be possible to see that one short one comes between two long ones, though this ought to be the case.

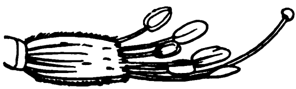


Fig. 12.
Dust-spikes of gorse (*enlarged*).

The *seed-organ* is in the form of a longish rounded pod, with a curved neck, stretching out beyond the dust-spikes. The top of it is sticky, and if you look at a bush of gorse, you will see it projecting beyond the keel in most of the fully-blown flowers, because the neck has become more curved than in fig. 12. Cut open the pod; it contains only one cavity (not, as that of the wall-flower, two separated by a thin partition), and the grains are suspended by short cords from the top (fig. 13). These grains may be plainly seen in the seed-organ of even a young flower. It is evident that they are the most important part of the plant, as upon them depends its diffusion and multiplication. We have already seen how carefully their well-being is considered in the matter of their perfection, how even insects are pressed into their service for this purpose! Now let us glance again at our flower, and see how wonderfully contrivance is heaped upon contrivance for their protection!

Fig. 13.
Split seed-pod of gorse.

First (see fig. 10, p. 14), we have the outer covering, so covered with hairs, that it is as good for keeping out rain as a waterproof cloak; in the buttercup, when you pressed the bud, it separated into five leaves; here there are five leaves, just the same, but they are so tightly joined that you may press till the whole bud is bent without making them separate at all, and when the bud is older, they only separate into two, and continue to enfold the flower to a certain extent till it fades. When the flower pushes back its waterproof cloak, it has the additional shelter of the big yellow leaf at the top, which, though really but one leaf, is bent like the roof of a house, in order that the rain may run off it (*ll*); then the two lowest leaves (see fig. 11), which we should naturally expect to find separate, are slightly joined, their line of junction being covered outside with silky hairs, and form a little boat for the seed-organ to rest in; and because all this is not enough, the seed-organ itself is covered with the softest down (see fig. 13), and the stalks of the dust-spikes, usually so thread-like, have expanded into an additional tight-fitting covering for it (see fig. 12).

Now turn to the garden pea (fig. 14). The pod of this flower will eventually become much larger in proportion to its size than that of the gorse, so that it cannot be protected by a joined outer covering, as that would cramp it; also it needs much *more* protection, as instead of having a short stalk, and being closely hedged in with thorns, it grows on a long thin stalk, and is blown about by every wind. You will see how wonderfully the old contrivances are altered to meet the new circumstances. The danger of the thin stalk would evidently be lest the flower, being caught by the wind, should be blown wide open, and thus the rain and cold should penetrate to the centre of the flower. Compare a gorse with a pea-flower, and see how this danger is averted. There are lumps in the two lower leaves (those forming the boat), and hollows in the side leaves into which they fit, in both flowers; but, besides these, there are lumps in the *side* leaves, and curiously winding hollows in the *bottom* leaves in the pea, and the four leaves fit so tightly, that if pulled they will often tear before separating. Then look at the large leaf (fig. 15); in the gorse its edges come beyond the side leaves, and slightly fold over them, to keep them in place; but in the pea there are four plainly-marked lumps, two on each side, which

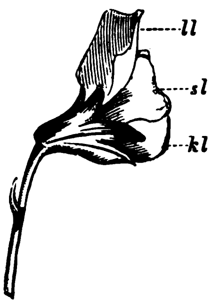


Fig. 14.
Flower of garden pea.

fit into corresponding hollows in the side leaves; and for fear this should not make all tight enough, the end of the large leaf is prolonged into two thin tongues, which cling round the rim, to which the inner part of the covering is attached.

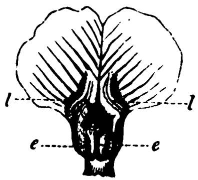


Fig 15.
Large petal of garden pea.

Again, notice how much wider open the large leaf is in the pea than in the gorse; this may be partly to give more room for the expansion of the pod, but it is also because it has a different office to fulfil: in the gorse, the flower was stationary, and the big leaf was the *roof*, keeping the rain from soaking in; in the pea, the stalk being long and slender, the big leaf is wanted to perform the office of a *sail*. Watch a pea-flower in a high wind, or hold one in your hand by the end of its stalk, and blow it strongly; whichever way you blow, the sail is instantly caught, and twisting round on the flexible stalk to which it is so firmly fastened, it presents itself between its tender freight and any breath of cold or damp that could harm it.

There is still one more point to notice. In the gorse, the dust-spikes form a tight covering round the seed-organ; they apparently do the same in the pea, but if you look more closely you will see that one of them (the one exactly *under* the sail) is loose (see fig. 16, in which the loose dust-spike happens, contrary to the usual custom, to be much shorter than its brethren), so that the seed-organ can come out from its swaddling-clothes directly they become too tight for it.

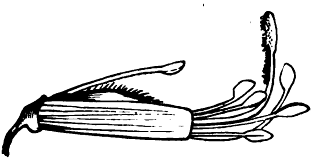


Fig. 16.
Dust-spikes of garden pea.

Now we must leave this wonderful flower, the history of which seems more like a fairy tale than a series of scientific facts; and I hope my readers agree with me in thinking that after one has put aside the stories of one's childhood, with a sorrowful feeling that the delight and the marvel of the Fairy Princess and Aladdin's Wonderful Lamp are gone from us for ever, it is a real addition to one's pleasures in life to wake up, as it were, and find that there are fairy tales only waiting to be read, scattered all about GOD's beautiful world; to find in them the same marvellous contrivances, the same unexpected results, that charmed us in our old tales, the only difference being that now the living verifications of the stories are around us; and the results tell of a purpose, and a wisdom, and a love that fills us with something more than wonder.

THE PRIMROSE.—We have now come to the last of our flowers for examination; it differs in many respects from those we have hitherto seen, and is important, as affording a good exemplification of how some of the botanical terms in use first came to be given to the different parts of the flower.

Hitherto the *outer coverings* of our flowers have generally been composed of separate leaves; in the primrose, on the contrary, the outer covering seems to be in one piece, curled into the form of a *cup*, and prolonged at regular intervals into five thin spikes. Split it with your penknife, just between two of these; and then carefully cut it round the bottom; take it from the stalk, and laying it out flat, hold it between your eyes and the light. Does it still look like one piece, or is it not far more like five tiny leaves, veined just like any ordinary primrose leaf, and joined to each other by the edges rather more than half-way up? The seams are easily distinguishable from the rest of the leaves, from their white filmy appearance, and transparency when held against the light.

We now turn to the *inner covering*. It too is all in one piece, and is so slightly attached to the top of the stalk, that you are almost sure to have loosened it, however carefully you took off the outer covering. Take another primrose, and look at it before it is loosened; there is then no doubt that it is formed of five leaves, yellow, notched at the edges, most delicately and beautifully veined outside, and ornamented inside with deep yellow spots, which combine to form a golden crown at the centre of the flower. Look at its under surface; here you see the pale yellow tube formed of the united leaves, running down into the green *cup* below them, and you should notice that the five spikes, or as we found them to be, tops of five leaves, come exactly between the five yellow leaves forming the inner covering; give these a gentle pull, and they will instantly separate from the stalk, showing that they are joined into a tube rather more than half-way, and that if they were separate, their shape would be a good deal like that of the wall-flower's coloured leaves, viz. thin and stalk-like for some distance, and afterwards opening into a round outspread leaf.

It has probably struck you that *inner covering* is a somewhat poor and inadequate name for that which forms the whole beauty of one of our most beautiful flowers, especially as, though the *tube* does evidently perform a most useful protective office, it is difficult to see how the outspread leaves do anything but smell sweet, and gladden the eyes of man, bird, and insect; and you will probably prefer their other, more botanical name of *crown*, a name which they deserve either because they are the chief glory of the flower, or from their shape, or from the shape formed by the golden spots in the centre.

We now turn again to the remains of our flower, expecting to find dust-spikes; but there is nothing left except the green cup with a seed column, having a swollen base, a very long neck, and a small round head resting in it. As we are examining this flower with a view to its fanciful similitudes, snip off the points of the cup, and see how comically it and the seed column represent a tiny pestle and mortar. But we have not found our *dust-spikes*. Has the primrose, then, like the cucumber, two different sorts of flowers, with central organs in one sort, and dust-spikes in the other? Before deciding that this is the case, let us make sure they are nowhere concealed in our flower. Split open the tube of the crown; you will see at once that it is stopped up by five little yellow bags (fig. 17, *ds*). They are very unlike any dust-spikes we have seen, for they have no stalks at all and are closely fastened to the yellow tube, instead of growing from the top of the stalk, as does the rest of the flower; but there is no difficulty in recognising them, for the tube is quite dusty with their contents. Also if you hold your yellow tube to the light you will see their stalks welded with it, and running quite to its base, thus proving that they really start from the top of the stalk as in other flowers. There is, however, a difficulty about their position; try to separate the crown into its five leaves. This you can do by tracing the mid-vein of the expanded leaves down to the base of the tube; you will find that a dust-spike is attached to each of the separate pieces, *i.e.* that though there are five outer-covering leaves, five inner-covering leaves, and five dust-spikes, and the two outer sets grow alternately with each other, the dust-spikes break through this rule, and grow *opposite* to the leaves of the inner covering (see Fig. 17, *ds*). We must go for the solution of this puzzle to a near relation of the primrose, which has, besides the five dust-spikes seen in the primrose, little scaly appendages, which are evidently vestiges of dust-spikes, just at the top of the tube, and *between* the leaves of the crown. We see from this that the ideal number of dust-spikes for the primrose is ten, in two sets of five each, and that it is the outer set which is wanting. This near relation of the primrose is called the *Samolus Valerandi*, and is very unlike it in appearance, though belonging to the same botanical family. I have only seen it growing once, and that was in a valley in Cornwall, where a trickling stream had broken its way through the hard rock, and was springing

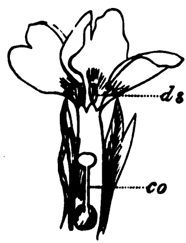


Fig. 17.
Primrose with short seed-organ.

over the *débris* left in its course, just about to join the sea; and there, nestling under a ledge of rock, which alone separated it from foxgloves and ferns, and luxuriant boughs of honeysuckle and wild roses; washed by spray of the sea on one side, and the stream on the other, the *Samolus Valerandi* reared its delicate stalk, bearing numbers of tiny white flowers, from among its deep glossy green leaves, and looked so beautiful, that it seemed almost a pity to have to pull its flowers to pieces to search for the vestiges of the missing stamens.

There is not much to be said about the *seed-organ* at present, except that the three parts which we have noticed in most of our other flowers are here very plainly to be seen, viz. the rounded base, the long neck, and the sticky head; and the base is full of little seeds, apparently stuck on to something hard in its centre.

There is one curious fact about primroses. If you pick a handful of them and look into the flowers closely, you will see they are not all alike, for some have long seed-organs, standing out beyond the end of the tube, and dust-spikes fastened so low down in it that you cannot find them at all without cutting it open (fig. 18); while others have their dust-spikes inserted almost at the top of the tube, and filling up its orifice, while their seed-organ is so short that it only reaches to about the middle of the tube (see fig. 17). This may seem to be only chance, but if you look at the plants from which the flowers came, you will find that all the flowers on the same plant are exactly alike, and that the plants are pretty evenly divided into those that have flowers with long seed-organs, and those that have them with short. Later on we will discuss the theories to which this peculiarity in primroses has given rise, but at present it is enough to remark that it considerably adds to the difficulty of describing them, as one does not know which sort of primrose is being examined, and is therefore obliged to describe in a way that will suit either.

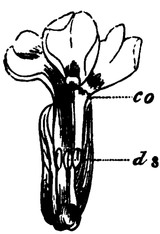


Fig. 18.
Primrose with long seed-organ.

We have now come to the end of our flowers for this chapter. If the examination of flowers is entirely new to any of my readers, I would suggest to them that there is no quicker or pleasanter way of learning to know flowers than by picking and examining a good many, and making tabular notes of their main characteristics. To show you what I mean, I will end this chapter by the notes* of the flowers we have examined together.

BUTTERCUP.

Parts of Flower.	No.	Separate or United together.	Where coming off.	Remarks.
Outer leaves.	5	Separate.	The top of stalk.	
Inner leaves.	5	Separate.	The top of stalk.	These have a curious little scale, covering a small green lump, at the base.
Dust-spikes.	Indefinite.	Separate.	The top of stalk.	
Seed-organ.			The top of stalk.	Divided into a number of tiny pods, each holding one seed.

You must leave the second and third columns blank in describing the seed-organs, till we have examined them more minutely.

WALL-FLOWER.

Parts of Flower.	No.	Separate or United together.	Where coming off.	Remarks.
Outer leaves.	4	Separate.	The top of stalk.	Two of these are larger than the others, and bulge at the base.
Inner leaves.	4	Separate.	The top of stalk.	White and thin half-way up, then opening into a bright coloured leaf.
Dust-spikes.	6	Separate.	The top of stalk.	Two shorter than the rest, and pushed out by small green lumps, the effect of which is to cause the bulging of the two outer leaves.
Seed-Organ.			The top of stalk.	In one pod divided into two chambers by a thin partition.

* The idea of making tables or schedules is due to the late Professor Henslow.

GORSE.

Parts of Flower.	No.	Separate or United together.	Where coming off.	Remarks.
Outer leaves.	5	United.	The top of stalk.	These are united, two into one at the top, and three into one at the bottom of the flower, and only separate by small teeth.
Inner leaves.	5	Separate; the two bottom ones joined slightly.	The rim made by the outer-covering leaves.	The top of these is the largest, and protects the rest. The two side ones are like each other, and so are the two bottom ones.
Dust-spikes.	10	United by their stalks.	The rim made by the outer-covering leaves.	These form a thin tight covering round the seed-organ, their pouches being quite separate.
Seed-organ.			The top of stalk.	This has a long curling neck, and a sticky crest, which is difficult to distinguish.

PRIMROSE.

Parts of Flower.	No.	Separate or United together.	Where coming off.	Remarks.
Outer leaves.	5	United more than half-way.	The top of stalk.	These form a *cup*.
Inner leaves.	5	United into a tube more than half-way.	The top of stalk.	These have deep yellow spots in the centre, and are arranged in the shape of a *crown*. They very easily come off.
Dust-spikes.	5	Separate.	The tube of the crown.	These have no stalks at all, and are *opposite* to the divisions of the yellow leaves.
Seed-organ.			The top of stalk.	The neck is long and upright, and the top round; and its whole appearance is like that of a *pestle*, as it stands in its mortar or *cup* formed by the outer leaves.

CHAPTER II.

ON FLOWERS WITH SIMPLE PISTILS.

SPECIMENS wanted for this chapter are—some leaves and stem of the *ivy*, of the *fuchsia*, and of the *lily of the valley*; the *marsh-marigold* (Caltha palustris) in seed, a *buttercup*, a *laurel leaf*, *buttercup* in seed, *garden-pea* in seed.

We have already examined the buttercup, wall-flower, pea, gorse, and primrose.

In all of these we have found four parts, viz. an outer covering, an inner covering, dust-spikes, and a seed-organ.

This leads us to think—and those among my readers who have followed my suggestion of examining a good many flowers, will feel convinced—that this division into four parts is the *rule* in flowers, and that, though it is impossible, before examining a flower, to prophesy anything about the shape, size, or number of the parts, it may be pretty confidently predicted that these four will in some form or other be found. Therefore, it is time to settle what name we will call them by.

Another thing must also have been learnt from a general examination of flowers, and that is, that many flowers have their outer covering leaves joined into a cup, and their inner leaves into what may not inaptly be called a crown, as you saw in the primrose.

Let us now suppose ourselves in the position of the botanists who first named these parts, remembering that whatever name is chosen, must for convenience' sake be applied to the same parts in *all* flowers. We can, if we like, keep to our old terms of "outer-covering leaves," and "inner-covering leaves;" these have the advantage of being *always* true, whatever flower is being described; whereas if we talk of "cups," and "crowns," the analogy entirely breaks down in half the flowers that grow. But the first expressions are so long and awkward, and besides, convey so little idea of the appearance of the thing described; whereas the latter are so short, and when true, so apt and picturesque, that I think we should feel much tempted to adopt them after once pointing out why it was done. This, at any rate, is what the early botanists did; and the outer coverings of flowers have gone by the name of *cups*, and the inner of *crowns*, ever since. Unfortunately, the significance of these terms is somewhat hidden by their being clothed in foreign garb, and called *calyx*, from a Greek word, κάλυξ, meaning cup, and *corolla*, which is the Latin for crown. As science belongs to no nation, but is common to the whole human race, it is reasonable that its special terms should come from a language that is studied by educated men of all countries; and we should therefore have no right to grumble if they came either all from Latin or all from Greek, instead of, as is the case, being derived sometimes from one, sometimes from the other, sometimes from a mixture of both, and sometimes, as you will presently see, having no derivation at all.

Also we must remember that the use of a foreign terminology, however good in kind, however beneficial as making it easier to read the works of foreign writers on the subject, has its dangers; there is always a chance of losing the idea of the thing meant, from not understanding the word expressing it; and how much is this danger increased when the word is so badly chosen that it really does not express the thing at all! It is the fear of this confusion which makes it worth while to go on for some time with roundabout modes of expression, at the risk of their becoming tiresome, because this plan *does* ensure the nature and purpose of the commonest parts of the flower being really known. English people must be specially on their guard against this danger, because while many German botanists retain the words in their homely form all through their books, and call the cup *kelch*, and the crown *krone*, merely stating by the side the scientific terms for them, and better still, keep to the same terms for their separate parts, and speak of *kelch-blätter* (cup-leaves) and *krone-blätter* (crown-leaves); English botanists always leave the analogy of the cup and crown altogether when they speak of their separate parts; cup-leaves they call *sepals*, and crown-leaves *petals*. This last is from a Greek word, πέταλον, meaning spread out, and was appropriate enough, as it was originally used, when it was applied * only to coloured leaves that were separate as in the wall-flower, and *corolla* was kept for coloured leaves that were united. Now-a-days both terms are applied to all flowers, which leads to an awkward mixing of metaphors, for who ever heard of *outspread* as applied to a crown?

For the use of *sepal*, no one has ever been able to give a reason; no probable derivation has been found for it; and it remains doubtful whether it was formed from the union of different words, or whether it was adopted simply because sepal and petal make a sort of jingle together.

Each dust-spike is called a *stamen*, which is derived from the Greek στήμων, coming through the Latin *stamen*, and meaning a thread; and we have no word for all the dust-spikes collectively. When this word was adopted, nothing seems to have been noticed about the dust-spikes except their long thin stalks; after a time some means of distinguishing these from the pouches was wanted, so they were called *filaments*, also meaning threads, but derived from another Latin word (*filum*,) and the pouches were called *anthers*, from ἀνθηρὸς, *flowering*. The reason for this name is not clear; but it may have something to do with the fact that the pouches burst at the time of the *flowering*. Nothing was known about the wonderful life-giving power of the dust, or *pollen* (Latin, meaning fine dust), till long

* "Geschichte der Botanik," by Sprengel.

after the giving of the names; so it is natural that the appearance only of the dust-spikes should be described.

The seed-organ is called the *pistil*, from the Latin *pistillum*, signifying pestle. It doubtless owes its name to the resemblance which we noticed in the primrose, and which is apparent in a good many other flowers. The swollen base of the pistil, in which the seeds are, is called the *ovary* (from Latin *ovum*, an egg), and means a store-house of eggs, just as *apiary* means a store-house of bees. In some flowers the little white grains are so like the eggs of an ant, that this seems a very appropriate name. The sticky top is the *stigma*, from *στίγμα*, which means a *brand*; "in many plants this organ resembles the sort of brand with which the ancients used to *stigmatise* or mark the condemned."* The neck joining these two parts is called the style *στῦλος*, or *column*, evidently from those flowers in which it is long and thin, and bears a large stigma at the top. The pistil is the name for the seed-organ collectively; you will see presently that it, like the other organs, is composed of parts.

We now have plenty of short terms to help us in describing our flowers; but before beginning to make use of them, we ought to spend a few minutes in looking at leaves. In our first chapter we used the word *leaf* for a good many different parts of the plant; we spoke of *foliage-leaves*, of *outer-covering leaves*, and of *inner-covering leaves*, and all this without any very clear understanding of what a leaf really is. We are now going to examine our flowers rather more critically, especially with a view to understanding the structure of the seed-organ; and for this purpose it will be well to compare the foliage-leaves of a few different plants, in order to find out the different parts that a leaf must have, and be able to recognise it under all its wonderful disguises.

Pick a leaf of ivy, a branch of fuchsia, and a lily of the valley stem, with its two leaves, one of which seems to grow

* Le Mâout. Sixième Etude.

from the middle of the stem. Hold one of each of these leaves up to the light, with their backs towards you, and notice the difference in their veining.

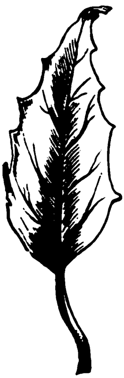


Fig. 19.
Fuchsia leaf.

The *fuchsia* (fig. 19) has one very large mid-vein, which looks like the continuation of the leaf-stalk, about ten veins of a secondary size branching out from it, and an infinite number of tiny veins running out into every part, and making the whole leaf a wonder of delicate network.

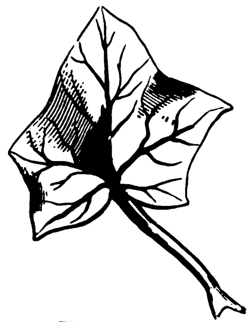


Fig. 20. Ivy leaf.

The ivy (fig. 20) has no one vein much larger than its fellows; as soon as the leaf begins to expand, the stalk seems to separate into five, and branch out into five different directions; from these all the lesser veins spring, which here also make their network spread to every part of the leaf, though it is less easy to distinguish than in the fuchsia, because the texture of the skin is thicker.

Fig. 21.
Lily of the valley leaves.

The *lily of the valley* leaf is very different (fig. 21). In it there are no principal veins, no criss-crossing of numberless small ones; all the veins are about the same size, all spring from the base of the leaf, independently of each other, and all run their solitary course to the top, as nearly parallel to each other as the shape of the leaf permits.

Here, then, we see an important difference; the ivy and fuchsia leaves are *net-veined*, while the lily of the valley is *parallel-veined.* You should notice this distinction carefully, as it is one of the primary differences between plants; the first question to ask in determining their names is whether their leaves are net-veined or parallel-veined; and all leaves can be classed under one or the other of these two heads. You will also probably have noticed that the leaf-stalk does not cease when the leaf expands; in the fuchsia it ran up to the top of the leaf, getting smaller and smaller as it went, and constantly throwing off lesser veins, *feather-wise*, on either side of it; in the geranium it separated into five, *finger-wise*, which five fingers also constantly threw off lesser veins, and so decreased in size. The truth is that the leaf-stalk is part of the leaf, just as much as the back-bone is part of an animal. It contains all the bundles of fibre which are necessary for giving strength and consistency to the rest of the leaf; and whether these happen to continue wrapped together for some time—in which case there is a long leaf-stalk—or to begin to separate directly they come out from the main stem—in which case there is no leaf-stalk at all—is a matter of very little importance; this you can see in the lily of the valley, where the longer leaf seems to have a stalk, while in the shorter the expansion of the leaf begins quite at the base, and wraps round the other stalk in a narrow form before opening out into an ordinary leaf.

Look again at your fuchsia branch, and notice how the leaves grow in pairs, and how, between every leaf and the main stem is a tiny bud, growing as it were in the lap of the leaf-stalk, and protected by it. To every pair of leaves there is a pair of buds, which will eventually become either branches or flowers. Here is a new protection for our already tenderly-guarded flowers; every one of them had a nursing-leaf to take care of it in its infancy!

Tear your lily leaf, in order to see of what it is composed. If you tear it cross-ways, you will be able to make out that it has three parts, viz. an upper skin, an under skin, and some pulpy substance between. You will be surprised to see that the skins are perfectly white, and only seem to be coloured, because, being transparent, we see through them the colour of the pulpy substance.

Now we may return to our more interesting description of flowers, feeling pretty sure of being able to recognise a leaf, in whatever shape it may be, and also to settle whether our plants have their foliage-leaves net-veined or parallel-veined, and if the former, whether they are veined *feather-wise* or *finger-wise*. We must not stop to discuss the wonderful functions of foliage leaves. I will only say that they are the plant's digestive organs, by which the raw food taken in by it is assimilated, and becomes the nutriment necessary for carrying on its life and growth. Speaking roughly, they are to plants what stomachs are to animals.

MARSH-MARIGOLD.—Pull up a whole marsh-marigold plant; or if this is too large, cut off a branch near the root. You will recognise it by its great cool-looking yellow flowers growing in damp shady places, or along the bank of a stream, and surrounded with large glossy leaves.

The leaves are of two sorts, some growing on the stem, wrapping round the flower-stalk, and having either no stalks at all, or very short ones; while the others do not grow from the stem, but from the *stock*, or thickened part, just above where it joins the root; these have enormously long thick leaf-stalks, and are called *radical* leaves, from *radix*, a root; the others are called *cauline* leaves, from *caulis*, a stem. Sometimes the radical and cauline leaves, growing on the same plant, are so unlike as to require two quite different descriptions; but in our marsh-marigold they are much alike, being of nearly the same shape, having the same curiously dented margin and the same sort of veining, arranged as in the geranium, *finger-wise*.

Flower.—Now we come to the yellow flower (fig. 22), which is very like a large buttercup.

"But," you will say, "here we break our rule about the four parts of flowers at once. This flower has no calyx."

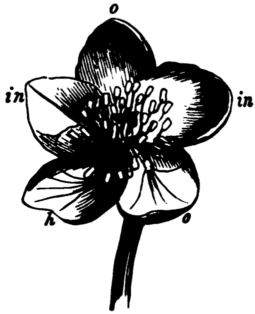


Fig. 22.
Marsh-marigold.

I can only reply that there is no rule without an exception, and that this flower undoubtedly *is* an exception, in so far as it has only three parts. But you must remember, we found the use of the calyx was to *protect* the plant; while that of the corolla was partly for protection partly to attract the insects. If, then, the five great yellow leaves are sufficient for both purposes, there is no reason why this particular flower should not dispense with one of its coverings. As these leaves have to fulfil the offices of both calyx and corolla, we had better not call them either *sepals* or *petals*, but simply *covering-leaves.* Take a bud, and pull it to pieces, noticing carefully whether the yellow leaves are so arranged as to be capable of their double duty.

Their arrangement is best seen in the sepals and petals of the wild rose, in which you had better look at it, if you do not see it clearly in your marsh-marigold.

There are two outer leaves, entirely covering the rest of the bud; and one of these keeps all tight by wrapping over the top of the other. Pull these off; there is still nothing of the stamens or pistil to be seen, but a compact mass of yellow leaves, one of which is still outermost, wraps over the tip of another; pull it off, and we find the other, in its turn, wrapping over and holding tight the last leaf of all. Now turn to a full-blown flower, and see how its leaves are arranged on the stem. At first it seems as if we saw the alternate arrangement which we admired in the buttercup and geranium, and others of our flowers in the last chapter.

But this is evidently impossible, as there cannot be two sets of alternate rows out of an uneven number; and a curious modification of the arrangement is therefore necessary. There are two leaves with both their edges outside (*oo*, in fig. 22); these are like the outer row of an alternate arrangement. There are two more with their edges entirely inside (*in, in*), growing within and alternating with these other two; and the fifth leaf fills up the space by having one edge in and the other out (*h*). You may try for a long time, but you will never find a more ingenious way of placing *five* leaves so that they shall have all the advantages, both for protection and compactness, which the ordinary alternate arrangement affords. Compare these leaves with the petals of your old friend the buttercup. You will find one difference: the little honey-bag at the base is wanting.

Stamens.—These are just like those of the buttercup, having large *anthers* and long thin *filaments.* The anthers are in the shape of arrow-heads; and you will have no difficulty in tracing the two slits through which they shed their *pollen.* But there is a curious thing about these slits: we found that the pollen was useless, unless it attained to the sticky crest of the flower; now there are several sticky crests in our marsh-marigold, all apparently waiting for the fructifying dust; and yet, the slits are turned *away* from them, and towards the yellow leaves, which are sometimes quite dusty from the contents of the pouches. This arrangement is common to the whole of the buttercup family (of which the marsh-marigold is a member), but very rare indeed in any other family. It is thought by many botanists* that just at the time when the slits open, and the stigmas become sticky, a movement takes place in the slender filaments of the stamens, which, though slight, is sufficient to twist the anthers round, and turn their slits towards the centre of the flower, and that by this means the pollen is shed upon the stigmas. I must confess that I have watched a good many

* Vaucher's "Histoire Physiologique des Plantes," vol. i. p. 4.

flowers of the buttercup family, and failed to convince myself of the truth of this theory, and am rather inclined to think that the wind and insects carry the pollen from one flower to the other; but it is one of the problems that cannot be solved without the testimony of many observers, and one also that every one of my readers can help to solve, as nothing is needed but good eyes and patient watching.

Fig. 23.
Pistil of marsh-marigold.

Now we come to our *pistil* (fig. 23). It is composed of several pods, growing like the rest of the flower, on the swollen top of the stalk, and quite separate from each other, as you can prove by pulling one off, and seeing that the rest are left uninjured; and its name, as applied to it, seems somewhat absurd, as it certainly bears no resemblance to a *pestle*. Split one of these pods open, on the side turned towards the centre of the flower (fig. 24); you can easily do this with the help of your needle, which ought to go between two rows of seeds, growing one on each side of the pod. These are so arranged as to fit in between each other when the pod is closed; and thus the chance of pressure to the delicate little things is avoided. We said the seeds *grew* on each side of the pod; but if you look closely, you will see they are attached, by means of very short and slender threads, and that the edge is thicker than the rest of the pod. Now pull off all the seeds, open the pod as flat as you can, and hold it up to the light. What does it resemble? I am sure you will see at once that it is just like a tiny leaf, having no stalk, and a somewhat thickened tip and sides; and if you examine it more carefully, you will find its mid-vein, its lesser veins branching out *feather-wise*, its two skins, and the pulpy substance between them; it must therefore be a veritable leaf.

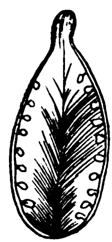


Fig. 24.
Split pod of marsh-marigold (*enlarged*).

Now let us imagine that a foliage leaf has to become a marsh-marigold pod, and trace the changes it would go through. First, it would begin to fold up; but before its edges met, they would double in upon themselves like a hem (this is a convenient metaphor, but not quite correct, as a hem is generally doubled twice, and the leaf only once), and the hems on the two sides of the leaf would be tightly joined together, so as to form the seam which we opened, and which would later on have split of its own accord. Thus a pod would be formed; and inside, on the two hems, just where we should put stitches, the little seeds would come. But how is the sticky crest made? The sides of the leaf are neither hemmed nor fastened together quite to the top; they therefore come open, and try to turn back into their original position; and it is this part that becomes sticky. The botanical term for a leaf folded in to contain seeds is *carpel*, from καρπός, (Greek for fruit).

You must not understand from this explanation that every pod has really been an open leaf in its infancy, and gone through this metamorphosis. I only want you to see clearly that in the marsh-marigold the pistil, no less than the yellow covering, is made up of veritable leaves, differing in size and formation from the foliage leaves, just as the petals differ in colour.

But granted that this is true of the marsh-marigold, is it also true of other flowers? How can we believe, for instance, that the pistil of the *primrose* is formed of leaves? We must suspend our judgment on this point for the present; though, judging from analogy, it seems probable that the formation of the same organ in different flowers must have the same origin.

You should notice the top of the stalk, on which all the parts of the marsh-marigold grow, and which is very perceptibly swollen. Its botanical name is the *receptacle*, because it *receives* the calyx, corolla, etc.

We can now make a complete table of our flower.

MARSH-MARIGOLD.

ORGAN.	NO.	SEPARATE OR UNITED.	WHERE COMING OFF.	REMARKS.
Yellow covering leaves.	5	Separate.	The receptacle.	Only one set of covering leaves, very like the petals of the buttercup, but having no nectar-cell at the base.
Stamens.	Indefinite.	Separate.	The receptacle.	Having two slits in their anthers, turned away from the centre of the flower.
Carpels.	Indefinite.	Separate.	The receptacle.	The style is hardly perceptible in these carpels. They split by their *suture* (Lat. *sutura*, a seam), and each carpel contains several grains. This plant has both radical and cauline leaves, which are veined *finger-wise*.

We will now turn to the buttercup again, taking one *in seed*, and try to fill up the blanks that we were obliged to leave in our tabular notes of that flower. We decided that the pistil was made up of a number of little pods, each of which, when cut open, contained a single seed. Take one of these little pods again, and look at it carefully, through a magnifying-glass if you have one (fig. 25). Does it not instantly remind you of a marsh-marigold carpel, in spite of the difference in its shape? There is a scar where it was detached from the stalk; slit it open from this scar to the slightly bent top, and you will see one seed attached to the corner at the base by a short nourishing cord; and if you have slit the pod in *exactly* the right place, you will also be able to distinguish the *thickened edge* on either side of your slit, running up to where the pod becomes narrow. This leads us to think that it must be formed in the same way as the marsh-marigold pod, of one carpellary leaf, with folded-in edges, and that our slit goes through their line of junction, although we are not able, owing to the thicker coarser texture of

Fig. 25. Split carpel of buttercup (*magnified*).

the leaf, to see the mid-rib, which there should be at the opposite side of the pod. But how can there be only *one* seed? The office of the thickened edges is to bear *seeds;* and here there is not even one seed to each thickened edge! The answer to this is that in the very young pod there are probably two seeds, each fastened to the base of its own thickened edge; but as time goes on, the pod is not large enough for them both, and the stronger gradually squeezes its weaker brother to death, and continues to grow, till it completely fills up the pod, which does not split, as in the marsh-marigold, but falls to the earth with the seed. The two young seeds have never been really *seen* in the buttercup; but as they have been frequently seen in the carpels of other flowers which only bear one perfect seed, we have a right to suppose them to be present in the buttercup also.

You can now complete your table of the buttercup, and compare it with that of the marsh-marigold.

You will see that the only difference is that the buttercup has two, the marsh-marigold one, covering; and this, as we have seen, is not a matter of very great importance. Evidently, then, though the marsh-marigold is *not* a buttercup, it is more like one than most other flowers—more like, for instance, than a wall-flower. It is therefore not surprising that it should belong to a large group of flowers, of which the buttercup is the type. This group is called *Ranunculaceæ*, or "The Ranunculaceous Family," *i.e.* the family which resembles the ranunculus or butter-cup; and its members are not difficult to recognise. Every British flower, whether with one or two coverings, that has its pistil and stamens growing in the same flower, all its parts separate from each other, and all coming off from the top of the stalk freely, belongs to this family, provided it also has its foliage leaves net-veined. (This last distinction is only important for the sake of excluding the very small family to which the flowering rush belongs.)

You are now able to begin collecting; and I should strongly advise those of my readers who wish to become practical botanists to lose no time in setting to work. Make a portfolio of a large thick sheet of paper; write upon it—"Ranunculaceæ;" then carefully dry and mount all flowers whose table agrees with the rules given above, and place them in it. By this means you will not only have the beginning of a good collection, but you will also become acquainted with the various branches of the family in a way that is impossible from the mere reading of books, and will, I am sure, be astonished to find what different and apparently unlikely flowers it numbers among its relations, *e.g.* the garden larkspur and wild clematis.

We can now fill up one more of our tables, thanks to our examination of the marsh-marigold pistil, viz. that of the gorse. Take a garden pea-pod, which is like the gorse, and rather better for examining; it still has its calyx round it, though it has grown very large, and has but little left of the pretty curling style which we admired when the pods were wrapped in their filament robe, and resting in their petal boat; but this makes it none the worse for our purpose. Split your pod, taking care that it opens on the side on which the peas are growing, and you will see a seed chamber just like that of the marsh-marigold (fig. 26). If, however your pod is older and you split it carelessly, as if you were shelling peas, the seeds will be left in a double row *opposite* to where the pod has split, growing on strong nourishing cords, which are fastened to the thickened edges; thus the pea naturally splits, *not* by its seam, as in the marsh-marigold, but by the mid-rib. Later on, when the seeds are ripe, the pod would split of itself, both by the mid-rib and the seam. The pistil of the pea therefore is easily comprehended, as formed of *one* carpellary leaf, with the seeds growing

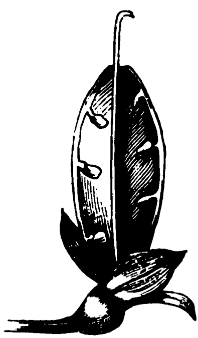


Fig. 26
Young pea-pod.

on the *suture* or seam. When this is the case, whether the pistil is formed of a single carpel as in the pea, or of several separate carpels as in the marsh-marigold, it is convenient to describe the seeds as having the *sutural* mode of attachment.

In the next chapter I hope to complete the examination of different sorts of pistils. Meanwhile you will find it a most interesting problem to pick different flowers, and try to make out the structure of their pistils, seen by the light of what you already know of the formation of that of the marsh-marigold.

CHAPTER III.

ON FLOWERS WITH COMPOUND PISTILS.

SPECIMENS wanted for examination, *common stonecrop* (Sedum acre); plant of *foxglove* (Digitalis purpurea); branch of *white campion* (Lychnis vespertina); *heartsease* (Viola tricolor); *shepherd's purse* (Capsella bursa-pastoris); and *dead nettle.*

We have now examined carefully the pistil of the marsh-marigold, and if you have followed my advice, and begun a collection of flowers belonging to the ranunculaceous family (*Ranunculaceæ*), you are by this time pretty well acquainted with its form of pistil. However much this differs in minor points in the various flowers you may have met with, whether smooth like the columbine, or covered with prickles like the corn buttercup, whether styleless like the marsh-marigold, or furnished with a long feathery appendage like the clematis, it is always alike in the one essential point of having pods separate from one another, and each pod formed of a single leaf curiously folded in, and modified in size and shape.

We saw too in our last chapter that the pea and the gorse resemble the marsh-marigold in having pods formed of a single leaf; the main difference between them being that whereas the marsh-marigold has a little group of these pods all growing together at the top of the stalk, the pea and gorse have but one, into which they pack all their seeds. We will now leave the *apocarpous* pistils (from ἀπό, from, *i.e.* separate from), *i.e.* pistils whose seed-chambers are formed of a single leaf, and try to make out how other pistils, many of which look as if no modification of leaves could make them, are formed; and for the solution of this problem we must examine a good many flowers.

THE STONECROP.—The yellow stonecrop (*Sedum acre*) is a very good plant to help us on our way towards understanding more complicated pistils. It grows on rocks and old walls, and has masses of dazzling yellow flowers, which make it well deserve its common name of "gold dust." There is another sedum very like this, except that its flowers are white, slightly tinged with pink (*Sedum anglicum*), which is generally to be found on garden rockeries, though its proper habitat is barren commons, and places near the sea; and this will do as well as the yellow kind for following the description.

Pick a good-sized piece of the creeping straggling plant. We have spoken of the striking differences between the foliage leaves of different plants, and here is a good example. Can you imagine two things more unlike than the graceful deeply-cut leaves of the wild geranium, and these fat stumpy excrescences, in which the veining has so entirely disappeared that it is difficult to settle to which of our three sorts of leaves they belong? if, however, you look at a leaf that has grown brown and thin from old age, you will be able to distinguish one mid-rib and no other large vein at all, and this will make you pretty sure that it belongs to the section of feather—or as they are botanically called, *pinnately*-veined leaves; this word is derived from the Latin *pinna*, a feather. The leaves are *entire* at the edge, *i.e.* neither cut nor notched, and they have no leaf-stalks; this makes their arrangement on the large stem, which is very curious, more easily traced.

Leaf-arrangement of Stonecrop.—In the fuchsia two leaves always grew from the same spot, or *node* (Latin, *nodus*, a knot) as it is called, from the little knot generally perceptible where a leaf separates from the stem: these leaves in the fuchsia were exactly *opposite* to each other, *i.e.* one grew on one side of the stem, the other on the other; if one pointed east, the other pointed west. There is another arrangement very common to plants, in which only *one* leaf grows at a node, and the one next above it is exactly opposite to it; *i.e.* supposing we call the nodes 1, 2, 3, 4, 5, 6, and imagine that the leaves growing at 1, 3, 5, point east, then those growing at 2, 4, 6, would point west. This may be seen very plainly in wheat, barley, or any grass. It is the proper *alternate* arrangement; but botanically this term is applied to all the various and complicated arrangements in which only one leaf grows at a node.

We must only glance cursorily at the arrangement before us (fig. 27); one leaf grows at a node (1), but the next above it by no means points in the opposite direction; and though the third is veering round towards the direction of number one, it is not till we come to the *sixth* leaf (6) that we find one really pointing in the same direction as the first. You will find this true wherever you look; in whatever direction the leaf that you select for number one points, the sixth, and none till the sixth, will point in the same. I cannot attempt to explain the rationale of this leaf-arrangement of five, at present. I only draw your attention to the fact because it is one that ought to be noticed, and also because it is such a wonderful exemplification of the truth that nothing comes by chance. What can seem more hap-hazard than the way leaves stick on to the stem! and yet here we find them growing by regular arithmetical rule!

Fig. 27.
Leaf-arrangement of stonecrop.

Now we come to the easy pretty part of our work, viz. the flowers; their golden stars are to be seen all up the stalk, but the eldest, which have mostly gone to seed now, are to be found between the branches, and low down on the plant.

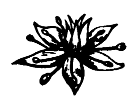


Fig. 28.
Flower of stonecrop.

Calyx.—This is composed of five fleshy leaves, which can only be distinguished from the foliage leaves of the plant by their position. Some botanists consider that these are joined at the base, and that the small rim round the pistil on which the petals and stamens grow is formed *by them*, at the point where they open out into leaves; but the later and probably more correct view which is held by French and some English writers is that this rim is due to a curious dilation of the *receptacle*, which is welded together with the bases of the three outer whorls of the flower, so that while the pistil grows on the top of the stalk in the ordinary way, the sepals, petals, and stamens all come off this *flower-rim* (as we will call it) so close to each other as to become somewhat attached. When we study the rose family, you will see this sort of growth more plainly.

Corolla.—This has five yellow pointed petals. In all but colour they are more like ordinary leaves than anything else upon the plant; their mid-rib is plainly marked by an indentation on the upper, and by a thick green line on the under, surface; and by holding a petal up to the light, you may also see a few lesser veins branching out from these. The petals grow on the *flower-rim*, just within, and alternately with the sepals. They are really separate from each other, though the filament growing between each two petals sometimes makes them seem to be slightly united.

Stamens.—These also come off with the petals, and apparently grow on them; I say "apparently," because as a matter of fact they also spring from the flower-rim, though they are for a short distance joined to the petals. You will have no difficulty in believing this if you look carefully at the flower before you, for you can almost *see* that the five stamens which grow between the petals are really coming from the flower-rim, they are so slightly attached to the petals on either side of them, while the other stamens, though they only come off from the petals about a quarter of the way up the mid-rib, can yet be clearly traced to the bottom of the petals; also there is the analogy of the primrose to help us, where the stamens were welded with the petals for the whole length of their filaments, and yet we settled that they really sprang from the receptacle. The anthers so soon tumble off, that you must look for them in a bud; they are like those we saw in the wall-flower, though much smaller, and have the same mode of opening by two slits near the edge of the side that is turned towards the centre of the flower.

So far the arrangement of the different parts of our flower has been just what we should expect; the petals alternated with the sepals, and the stamens were evidently in two sets, the five growing *between* the petals being older than the other five; but now we come to a difficulty, the pistil is composed of five carpels, and these do not grow *between* the five young stamens, but exactly opposite to them. I am unable to tell you the reason of this; as far as I know, no satisfactory one has ever been suggested, and there is no friendly relation like the *Samolus Valerandi* to step in and tell us whether anything is missing, and if so what; nor do the plainly marked nectar-cells (see fig. 30, *n*) help us, for they also grow opposite to the carpels. I may therefore submit the matter to my readers as a riddle with an unknown answer, for that there is an answer somewhere for every difficulty, whether great or small, that comes in our way, we may feel perfectly sure, and I cannot too often repeat that hunting for these answers is one of the main fascinations of Botany. One does not need to have much knowledge, nor any special ability, to watch and think about flowers; and every one who does this is almost sure to discover some beautiful little nicety, some fresh adaptation which throws a new light on everything he has before heard or read on the subject. Of course it may, and in ninety-nine cases out of a hundred will, be true that the discovery has been discovered by some one else before; but that does not take away from the delight of making it, nor does it prevent it from being a possession, and having a life of its own which no second-hand knowledge can possibly have—and besides, there is always the chance of the hundredth case!

Pistil.—To return to our flower. The pistil, which grows on the receptacle, is a good deal like that of the marsh-marigold, though the carpels instead of being numerous are always five. In many of the faded flowers you will see these have done for themselves exactly what we did for the marsh-mallow pods with our needle, *i.e.* they have split, and show on each thickened edge, or *placenta*, as it is called, a row of seeds (fig. 29). These seeds are of a longer narrower shape than any we have hitherto seen, and are fastened to the edge by thicker cords. You see the pods have not split to the top, and if you look closely you will see that the edges are not folded in, or turned down for the hem as far up as in our other pod, and that above this turning down, and below the beginning of the sticky surface, the pod is much narrower. It is as if instead of being formed of a broad equal-shaped leaf like the laurel, it was made of one broad at the base, and tapering towards the top, as the lilac, and thus we get some idea of the formation of the *style*, which was entirely wanting in our former pod, and which is here only present in a very modified form.

Fig. 29.
Split carpel of stonecrop (*enlarged*).

Cut through the middle of the whole pistil, *i.e.* through all five carpels (fig. 30). There are the pods almost touching each other, and in each of them two seeds may be seen attached by their nourishing cords to the *corner* of the pod that is near the centre of the pistil; this is exactly where you would expect to find them, if you remember that you are seeing the inside of the pod, with one seed growing from each folded-in edge.

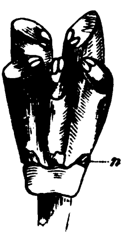


Fig. 30.
Section of stonecrop pistil (*enlarged*).

Now cut through this same pistil as close to the bottom as you can. Instead of seeing five distinct carpels with the seeds in each, we now have *one organ only*, divided into five chambers, and two seeds growing from the central corner of each chamber. Do you see what has happened? Figure 30, showing a section of the upper part of the pistil, will help you, because in it you see how nearly the carpels meet in the centre—in the section made lower down, they have not only met but grown together. The five seams meeting in the centre form the *axis* of the pistil, from which all the seeds grow, though in a section only two of them are to be seen in each chamber; the partition walls, which separate these chambers, are formed of the sides of the carpel, each wall being made of the sides of *two* adjacent carpels. Do you now begin to see the way in which a pistil, not partially united, like the one before us, but apparently single, may in reality be formed of several carpels?

We will finish this flower with its table.

STONECROP.

PARTS OF FLOWER.	No.	SEPARATE OR UNITED.	WHERE COMING OFF.	REMARKS.
Sepals.	5	United at the bottom.	The flower-rim.	Very thick and fleshy.
Petals.	5	Separate.	The flower-rim.	
Stamens.	10	Separate.	The corolla.	Five of these barely joined to the corolla, while the other five are welded with it some way up.
Carpels.	5	United at the lower part.	The receptacle.	Quite separate from each other in their upper half. Several seeds in every carpel.

THE FOXGLOVE.—The foxglove (*Digitalis purpurea*) is a very good flower in which to see this perfect union of the carpels. It is unnecessary to describe the plant, for every one knows its long stems, bearing at the same time beautiful full-blown flowers low down, large pink buds supposed to resemble one finger of a *glove* higher up, and small buds still covered by their green cups at the top.

Pull up a whole plant; you will find one principal stem, and other shorter ones branching out from it. Near the root are quantities of great green leaves growing on long stalks; they are coarsely notched, veined *feather-wise*, with the veins standing out quite plainly even in their intricate network, the effect of which is to give the upper surface of the leaf a wrinkled appearance. As we get higher up the stem, the leaves gradually become smaller, and have their blades prolonged into narrow wings on either side of the leaf-stalk (as we saw in the larger leaf of the lily of the valley), till by the time we reach the place where the flowers begin they have become quite small, and stalkless or *sessile; i.e. sitting* on the stem—from the Latin *sessilis*, sitting. In the angles or *axils* between these upper leaves and the stem the flowers grow, and each little leaf before us has in its time protected a tiny flower-bud from wind and rain, though now it has long done its work, and been outgrown by its nursling: these reduced leaves, with flowers growing in their axils, are called *bracts*, from Latin *bractea*, a thin plate; not a very good simile.

Owing to the twisting of the stem, the arrangement of the leaves upon it is somewhat difficult to trace; but by looking at the *bracts*, you will, I think, be able to see that it is the same which we noticed in the stonecrop, *i.e.* with whatever leaf you start, the sixth, and none till the sixth, will point in the same direction.

Now we come to the *calyx*, which is *persistent*, *i.e.* has not fallen off with the petals. There are five sepals, joined at the base, but otherwise separate. The top one of these is very small, the two on either side of it larger, and the bottom pair largest of all.

Corolla.—Look at the petals and try to count them. Probably you will decide that there are *four* joined almost to the top. This is the natural idea, as in most foxgloves there seem to be only four *lobes* (as the divisions of a united calyx or corolla are called), the top one opposite to the small sepal, the two side ones smaller, and coming between the side and bottom sepals, and a very large bottom one, coming between the two large sepals.

The law of alternance, however, makes us guess that the top lobe is really formed of two, and though these are in our flower perfectly united, there is a plainly marked line of junction exactly opposite the small sepal, while in a good many foxgloves the two leaves separate a little below the top, and then of course the flower is five-lobed, and there is no difficulty about it.

Stamens.—There are four stamens (fig. 31), which come off with the corolla, and are joined to it for about half their length. Two of these are long, two shorter, and where they separate from the corolla they bend, the short ones slightly, the long ones very much, in such a way that the anthers of each pair meet and form two arches, one above the other. You should notice, too, that the short stamens shed their dust before the long ones (see fig. 31). The position of these anthers seems as if only the short pair of stamens could possibly be alternate with the petals, but if they are looked at near the base before they have bent (see fig. 31), it will be seen that the part of the filament which is joined to the corolla exactly covers the *seam* formed by the junction of the adjacent petals; *i.e.* is exactly in its proper alternate position. Four seams are thus covered, but the one formed by the junction of the two top petals has no corresponding stamen. We must go to a near relation of the foxglove, viz. the snapdragon (Antirrhinum), to see what has become of it: in it we shall always find a *vestige* of a stamen in precisely the right place, which not unfrequently prolongs itself into a perfect one with anthers and all complete. We may therefore consider that as the ideal number of stamens for the primrose is ten, so for the foxglove it is *five*, though for some reason it does not produce more than four. The anthers are curiously fastened to the filaments; but this we will not stop to explain at present.

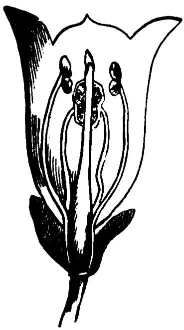


Fig. 31.
Section of foxglove.

Pistil.—Now take one of the pistils from your long stem (fig. 32), and look at it carefully. Is it formed of one, two, or

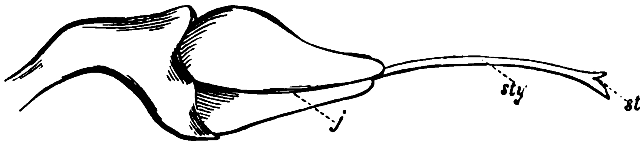


Fig. 32.
Pistil of foxglove, with the calyx cut off.

more carpels? Cut it open (fig. 33), the seeds grow, a great many together, on a large thick *axis* (fig. 33, *a*) in the centre. It cannot therefore be an *apocarpous* pistil, *i.e.* one formed of a single leaf, or the seeds would grow on the side-seam, as we have seen in the marsh-marigold. Empty your cut pistil of some of its seeds, you will see that it is divided into two chambers, the place where the two join being very visible outside (fig. 32, *j*); this, and the two stigmas (*st*) into which it separates at the top, leads us to think that it is formed of *two* leaves.

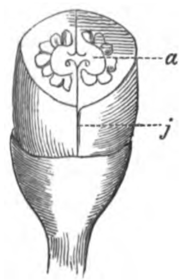


Fig. 33.
Section of foxglove pistil.

Look again at the stonecrop pistil (fig. 30), and see how the seams of the five carpels would form an axis with seeds growing round it, if they were more closely joined. Now can you understand what has happened in the foxglove? Its two carpels are *entirely* united, so that the two seams, each seam formed of two placentas, meet in the middle and form an enlarged axis, and their sides, now *double* by being formed of two joined carpels, divide the pistil into two chambers. The long style, or rather styles (fig. 32, *sty*), are united the whole way, and the two leaves are only separate in their stigmas. "But," you will say, "each placenta bears one row of seeds; there are four placentas, there ought therefore to be only four rows of seeds, two in each chamber, whereas the whole widened axis is covered with them." The answer to this is, that while the placenta is the part adapted by nature to bear seed, it is only a convenient arrangement for the sake of avoiding undue pressure that these should grow one at a time; if therefore this danger is otherwise removed, as by increased room, there is no reason why the number of seeds should not be increased. When a pistil, as in our foxglove, is formed of carpels whose seams meet in the middle and form an axis on which the seeds grow, and whose sides divide the pistil into partitions, it is said to have *axile placentation.*

The foxglove belongs to a very large group of flowers, called the "Scrophularia Family" (*Scrophularineæ*). Its members may always be distinguished by having united irregular corollas, two pairs of stamens, one longer and one shorter (or sometimes one pair only), joined to the corolla, and a pistil composed of two united carpels, having axile placentation. It is one of the most interesting groups to study and to collect, and a good many flowers belonging to it are to be found nearly all the year round. The following table (in almost all particulars) applies to the whole family. The *remarks* of course apply specially to the foxglove.

FOXGLOVE.

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	5	United just at the bottom.	The receptacle.	Unequal in size, one being very small.
Petals.	5	United almost to the top.	The receptacle.	These are unequal, and look like four, the two on either side of the small sepal being often *completely* joined.
Stamens.	4	Separate.	The corolla.	In two pairs—filaments curiously arched.
Carpels.	2	United; stigmas only separate.	The receptacle.	Placentation axile. Very long style.

LYCHNIS.—There are two sorts of Lychnis, or as they are often called *Campion*, one white and the other red. There is very little difference except that of colour between them, so either will serve for examination. Pick a long stem. The leaves are deep green on their upper surface, paler green underneath, and like the stem very hairy (fig. 34). They are *sessile* (*i.e.* have no stalk) grow in pairs some distance apart, and are *pinnately veined*, though few of the lesser veins are visible. A great many flowers are to be seen branching out from the stem, but their manner of growth is very different from that of the foxglove. *There* the bottom flower expands first, and the stem goes on bearing flower after flower *indefinitely*. *Here* you see the main stem is stopped by a single flower, and obliged to subdivide in order to continue its growth; the two subdivisions are in their turn stopped in a similar way; and so the plant goes on, constantly arrested by flowers, and constantly subdividing. This is called the *definite* mode of flowering, because each flower *definitely* stops the prolongation of the special stem on which it grows.

Fig. 34. Campion.

The Campion is one of the plants that has its flowers with stamens on one plant, its flowers with pistils on another. We will first examine a *staminate* flower. It can easily be distinguished from the pistillate by its smaller straighter calyx. Fig. 34 is taken from a pistillate plant.

Calyx.—The sepals are five in number, very pale coloured, and are joined into a cup almost to the top. The veins are darker, and plainly seen, the mid-vein being distinguishable to the top of the leaves. The other lines, which might be mistaken for mid-veins, are formed by the junction of the different leaves.

Corolla.—The petals are also five, quite separate, and fastened to the receptacle, just within the calyx, and alternating with its lobes. They are very curiously shaped, having a long thin claw, in which you may see one prominent mid-vein, and two smaller side-veins running all the way up, and finally opening into a white deeply-cleft leaf. On the inside of the petals, just where the claw opens out into a leaf, there are four small white fingers (fig. 35), which combine to form a perfect circle round the interior of the flowers.

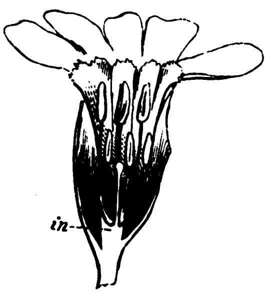


Fig. 35.
Section of a staminate campion flower.

Stamens. — There are ten stamens; five are longer and older than the other five (see fig. 35), and alternate with the petals—the five shorter stamens are opposite the petals, and often slightly attached to them. Having pulled off these stamens, we find left upon our stalk a small white lump in the middle, with a short thread-like green thing coming out from the middle of it (see fig. 35), and this is all there is to answer for a pistil!

We will now turn to a pistillate flower. You will probably find a plant not far from where you picked your last specimen, with ripe pistils at the top of the short thick stem, and higher up on the plant, between stems which have bifurcated many times, flowers fit for examination. Look again at fig. 34, which represents an old swollen pistil, and flowers and buds growing higher up.

The sepals and petals are just like those of the staminate flower, except that they are somewhat larger, and the sepals are made to bulge by the ovary inside. We need not therefore describe them again, but may pull them off, and go straight to the interior of the flower. There we find a large ovary with five white curling styles at the top (fig. 36) but no stamens. If, however, you look closely, you will see ten green points round the top of the concave receptacle, as shown in fig. 36. These seem to indicate the vestiges of stamens, and make one wonder whether the campion at some distant period of its history used to have both stamens and pistil in the same flower.

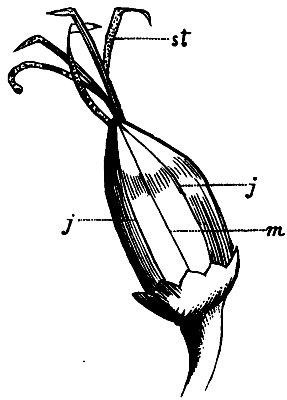


Fig. 36.
Pistil of campion.

Pistil.—Look carefully at what we have called the five curling *styles :* you will see that the side of them which turns to the centre of the flower is rather hairy and moist. It is the stigma, or more correctly the *stigmatic surface*, running the whole way down the style (fig. 36, *st*), instead of being confined to a small space at the top, as in our other flowers, *i.e.* the carpellary leaf has begun to unfold sooner than it generally does. If we remember that the use of the stigmatic surface is to catch and retain the pollen, and that in this flower all pollen must be brought by insects from another plant, it seems a natural provision that the sticky surface should be unusually large.

The foxglove has taught us that the five styles and stigmas are a pretty sure indication of the number of the carpellary leaves forming the pistil, and the *ten* lines which may be seen running up a very young pistil will not disturb us, if we remember the calyx of the campion, which showed us that ten lines may mean five mid-ribs (Fig. 36, *m*) and five lines of junction, (*j*). Cut your pistil across the middle (fig. 37). You see as in the foxglove a mass of seeds, with no perceptible stalks, growing on a thickened axis (*a*); but there are no partition walls joining the edge of the pistil to the axis; nothing to indicate the number of carpels of which it is formed. To explain this difficulty, we must imagine a pistil with five carpels formed like the foxglove: and we must further suppose that as it ripens the partition walls break away. What would be the effect of this? Evidently a pistil exactly like the one before us. You can prove that something like this is the true explanation, by looking at the pistil in a bud, where the partition walls project some distance towards the middle; and even in the specimen before us there is a sign of where they were, in the angles of the pod, which are marked *j* in the illustration. This sort of placentation, like the axile, only without the partition walls, is called *free-central*, because its central axis is *free* from the walls of the pistil.

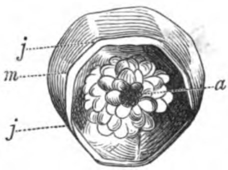


Fig. 37.
Section of campion pistil.

We shall want two tables of the campion, one for the pistillate, one for the staminate flower.

STAMINATE FLOWER OF CAMPION.

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	5	United.	The receptacle.	The tips are separate.
Petals.	5	Separate.	The receptacle.	These have a long thin claw, and a delicate fringe where they open out into blades.
Stamens.	10	Separate.	The receptacle.	Five long, five short, the five long alternate with the petals.
Carpels.	0			There is a thread in the middle of the flower, which seems like the vestige of a seed-organ.

PISTILLATE FLOWER OF CAMPION.

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	Same as in Staminate flower.			
Petals.	Same as in Staminate flower.			
Stamens.	0			There are ten points round the base of the pistil, which may indicate vestiges of stamens.
Carpels.	5	United.	The receptacle.	Five long styles, with stigmatic surface. Placentation free central.

You probably think that the distinguishing mark of the family to which the campion belongs is having the stamens and pistils in separate flowers; but this is not the case, as most of the members of the family have no such peculiarity; its members may, however, be easily recognised, as though it is large, and comprises apparently very different individuals, they all have pistils with free-central placentation, and all their parts grow on the receptacle. The typical flower of this group is the pink, and it is therefore generally called "The Pink Family" (*Caryophyllaceæ*); this name does not mean that all the flowers belonging to it are *pinks*, only that they all have certain characteristics which are most plainly seen in the pinks.

Fig. 38. Split primrose pistil.

Now turn to a primrose or cowslip plant: plenty of ripe pistils are to be found on them all the summer, and you will see that they are formed just like that of the campion, except that they are even more perfectly united, not even the styles and stigmas being separate; still they have free-central placentation; and if you look at one of the pods which is split (fig. 38), and compare it with a split campion pod, you will find them exactly alike, each of them having *ten* points, in which you will easily recognise the termination of the ten lines which we noticed in the campion. I hope you will now agree with me, that through the gradations of the *sutural*, *axile*, and *free-central* placentations, we have satisfactorily proved that the primrose, as well as the marsh-marigold pistil, is really formed of leaves.

There is only one other sort of pistil, but that is quite different from any we have hitherto been considering. We shall find a good example of it in our heartsease.

THE HEARTSEASE.—The easiest variety of this flower to examime is the small bright-coloured one (*Viola tricolor*) which is so common in gardens.

The stem is weak and straggling, so that it is not easy to settle how the flowers are arranged, but a young plant in which the stem is still upright will show that it belongs to the set of *indefinitely* flowering plants, for the flowers grow at uncertain intervals up each flowering stalk, and the lowest will have come to seed while the highest are still in bud.

Calyx.—This is formed of five delicate thin green sepals, which do not seem to spring from the receptacle, but to be fastened to it so as to leave both ends free (fig. 39); you must snip them off with your scissors, noticing that even in them the irregularity of our flower is visible, for the lowest pair is the largest and straightest, the side pair is shorter and a good deal bent, while the top odd one is most comically curled round upon itself in a flower, which, unlike our figure, still possesses its petals.

Fig. 39.
Calyx and pistil of heartsease.

Corolla.—In this the irregularity is far more plainly seen, being apparent in colour and shape as well as size. The colour especially varies so much in different flowers that no one description is certain to be correct even for the flowers of the same plant.

In the specimen which I am looking at, the two top petals are of a beautiful velvety purple, and of a rounded shape, but narrower where they join the stem. The two next are much paler, are delicately veined with deep blue, and have a pretty little yellow brush at the centre of the flower, where their blade ceases, and a thin transparent *claw* begins. The lowest odd one is much larger, of a still paler lilac, with more yellow, and stronger marked veining. It too has a double brush of hairs arranged in two lines, but they are low down on the claw, and entirely concealed while the petal is in its natural position. Careful handling is required to see that the petals really are fastened to the receptacle just within and alternately to the sepals, the lowest one being afterwards prolonged into a cornet-shaped tube, containing a drop of honey at the bottom, and forcing the two lowest sepals some way apart.

Stamens.—These are not easy to recognise in the five little yellow leaves with their orange tips, which are now exposed (fig. 40). They look as if they were slightly joined to each other, and have very short filaments and flattened anthers, which come just below the orange tips, and have their slits turned towards, and indeed almost touching, the seed-organ. We have seen nothing like these orange tips before, nor are they of any importance here, being of a dry scaly substance, very apt to drop off. The upper three of the stamens are just alike, the lower two are, at the spot where they join the receptacle, prolonged into spurs, which you may find fitting into the hollow tube of the bottom petal, and helping to keep the flower in its right place. Fig. 41 represents the *inner* surface of one of these spurred stamens. They all five grow alternately with the petals, and are really separate.

Fig. 40.
Stamens and pistil of heartsease (*enlarged*).

Pistil.—Now we come to the pistil, which, with its round ovary, thin bent style, and very oddly shaped top, is something like a tiny unfledged bird. The stigmatic surface is contained in the hollow which forms the bird's eye (see fig. 40). We take it for granted that this pistil is composed of carpellary leaves, but how, and of how many? Take a withered flower, with a large pistil, and cut it across the middle. You will see no axis, nothing whatever in the centre of the pistil, but three rows of seeds on the sides (fig. 42). Evidently the formation of this is quite different from what we have hitherto seen; nevertheless, it is very simple. We must put out of our heads altogether the idea of a pistil as formed of a number of little pods, each made by the curling up of a single leaf, and think of three *open* leaves, with their *edges* joining each other. Three seams would thus be formed, each of which would be made half of the edge of one leaf, half of the edge of another (*j*). Imagine these edges turned in to form a hem, and seeds growing on the hem, and we have our pistil before our eyes (*m* indicates the mid-rib of one of the three leaves). The great difference between this and the other sorts of pistils is that in them each placenta was formed by the union of the two edges of the *same* leaf, while here it is formed by the union of two *different* leaves; the result of this is that, while in other compound pistils the seeds are fastened to the centre and face the outside, here they are fastened to the side and face the centre. They are therefore said to have *parietal* (*paries*, side-wall) placentation.

Fig. 41.
Spurred stamen of heartsease (*enlarged*).

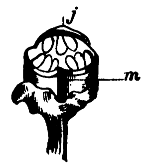


Fig. 42.
Section of heartsease pistil (*enlarged*).

We have now come to the end of our pistils. They may be divided into two groups—viz. those that are formed of *separate* carpels, which are called *apocarpous* pistils, as the marsh-marigold, pea, etc.; and those which are formed by the uniting of more than one carpel, which are called *syncarpous* pistils (from σύν, *with*, *i.e.* united with). This last group must again be divided into (1) those which have *axile placentation*, as the foxglove; (2) those which have *free central placentation* as the campion, and (3) those which have *parietal placentation*, as the heartsease. I advise you to examine these different forms in a great many flowers for yourselves before you feel sure that you thoroughly understand their structure; for there is no point on which young botanists more often make mistakes.

We will now make a table of the heartsease. You will find on examination that it answers equally well for the violet.

HEARTSEASE.

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	5	Separate.	The receptacle.	They are joined to the stalk at about one-third of their lengths, and are unequal in size.
Petals.	5	Separate.	The receptacle.	Very unequal in size and colour. The three lowest having claws and little brushes—the lowest prolonged into a tube.
Stamens.	5	Separate.	The receptacle.	Very short filament. Scaly orange tips. The two lowest prolonged into spurs which fit into the tube of the bottom petal.
Carpels.	3	United.	The receptacle.	Stigmatic surface in a hollow at the end of the style. Placentation parietal.

Before entirely leaving this subject of pistils I must mention two puzzling modifications of the regular forms, which you are sure to meet with in your examination of flowers, and which you will not be able to understand without a few words of explanation.

The first of these is found in the *Cruciferæ*, or Crucifer family, and may be seen in the wall-flower (fig. 43), stock, or cress; but perhaps the best flower for us to look at it in is the shepherd's-purse (*Capsella bursa-pastoris*), which is to be found growing along most road-sides, and in every kitchen-garden not utterly devoid of weeds. Look at one of its purse-shaped pods, and try to discover to which of our four sorts of pistil it belongs. If you hold it up to the light, you will see at once that the seeds are not all attached to one side, as in the pea or buttercup pod; it cannot therefore be an apocarpous pistil, and must have axile, free-central, or parietal placentation, although at first sight it looks equally different from all these sorts of pistils. Take hold of the two ears of the purse with your two hands, and pull them gently (fig. 44). They will separate from the bottom, leaving seeds with their tiny stalks on each side of the two thickened edges which are now left exposed, and which are really the torn-off edges of the leaves. These edges meet at the top, and are prolonged into a short point, and the space between them is filled up with a thin membranous substance. Now suppose for an instant that we have got rid of this membrane altogether; there is then no difficulty in recognising in our shepherd's-purse a pistil of two leaves, having parietal placentation. The mid-ribs of the two leaves run up the back of the curious ears we have noticed; the leaves meet, form their placentas (the thickened edges we have spoken of), bear their seeds, and unite in one point or *style*, exactly as we saw in the heartsease. This is a perfectly true description of our pod, for the membrane is only a curious prolongation of the placentas. There are two placentas to each margin on which the seeds grow, one belonging to one leaf, the other to the other; after these have borne their

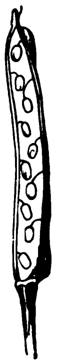


Fig. 43. Wall-flower pistil.

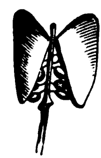


Fig. 44. Shepherd's-purse pistil (*enlarged*).

seeds they are prolonged between them, till they meet in the middle and form the curious double membrane which we see. This *false partition*, as it is called, is characteristic of the crucifer family, and makes it very easy to distinguish. Its other, still plainer characteristic, of having cruciform flowers, is not a safe guide, as there are cruciform flowers which do not belong to the crucifer family. If your eyes are strong enough to enable you to dissect one of the flowers of the shepherd's purse, you will find its table exactly like that of the wall-flower, or stock.

THE DEAD-NETTLE.—The second anomalous sort of pistil is to be found in the *Borage* and the *Labiate* (or *lipped-flower*) families. Pick a dead-nettle in blossom, which belongs to the latter of these two families. It is unimportant whether you choose the red flowered one (from which figs. 45 and 46 are drawn), or the white one, whose handsome clusters stand forth very conspicuously among the early spring, and late autumn flowers. You should notice that these clusters flower *indefinitely—i.e.* the lower ones blossom first, and grow on a curious square-shaped stem. The leaves are opposite, and each pair points at right angles to the one below it—*i.e.* if the two leaves of the first pair point east and west, the leaves of the next pair will point north and south. The flower (fig. 45) has five sepals, joined about half-way, then separating into long thin points. The corolla is tubular, and clearly divided into two; it is the upper of these divisions which is supposed in its shape and position to resemble an upper lip, as opposed to the three lower ones, which are more or less united to each other, and form the lower lip; and it is to this fancied resemblance that the family owes its name of *Labiate*. If you remember the foxglove, you will not be surprised to find that the top lobe is really formed of two leaves, which, though completely united in this flower,

Fig. 45.
Dead-nettle flower.

are divided in some members of the family, as the ground-ivy. As in the foxglove, there are four stamens growing in pairs, two long, two shorter; but in this flower it is impossible to tell where they start from, as they are fastened to the back of the corolla all the way up the tube, and only separate where it opens out into lips. So far our flower has been extremely like those of the Scrophularineæ; and indeed the only striking distinction between the flowers of the two families is to be found in what we are now coming to—the pistil. Pull off the white corolla. It will come off bodily, stamens and all, and probably will bring with it the long style, whose two-forked stigma is apt to get entangled among the stamens. Now tear open the calyx, and you will find what look like four little green nuts (fig. 46) resting on a somewhat enlarged receptacle. You will at first sight be inclined to say, "This is simple enough—here is an apocarpous pistil, composed of four separate carpels;" but if you consider a moment, you will find it difficult to account for the one long style with its forked stigma. The formation of this pistil is so different from any we have hitherto seen, that it is too much to expect you to discover how it is made for yourselves, and I will therefore describe it shortly. The two-forked stigma may be trusted; there are two carpels, each folded in on itself, which meet (*j*) and bear their seeds in the middle: the pistil therefore has axile placentation. Each carpel bears two large seeds only, one on each placenta, but the axis formed by the meeting of these four placentas is very short, and for some inexplicable reason the mid-ribs (*m*) of the two carpels enlarge and get fastened to it, thus making two extra partitions, and forming a tiny chamber for each seed. This sort of pistil is peculiar to the Borage and Labiate families. If you find it in a flower with an open regular corolla and five stamens, you may know that you have a member of the Borage family; if in a

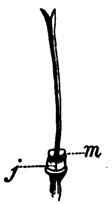


Fig. 46. Pistil of dead-nettle.

flower with an irregular corolla, and only four stamens, you may be sure that it belongs to the Labiate family, of which also the curious square-shaped stem which we noticed is very characteristic.

In order to be quite sure of the characteristics of the Labiate family, we had better finish this long chapter with its table :—

DEAD-NETTLE.

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	5	United half-way.	The receptacle.	
Petals.	5	United.	The receptacle.	Divided into two *lips*. The upper formed of two, the lower of three petals.
Stamens.	4	Separate.	The corolla.	In two pairs, one pair shorter than the other.
Carpels.	2	United; stigmas only separate.	The receptacle.	Placentation axile. The four seeds plainly visible, and looking like little nuts.

It will be found a good plan to get some flower of the Borage family, as the common borage, the comfrey, or the forget-me-not, and make a table of it, in order to compare it with our table of the Labiatæ.

CHAPTER IV.

ON FLOWERS WITH APOCARPOUS FRUITS.

SPECIMENS wanted are—A plant of *Herb Bennett* (Geum urbanum); a branch of *brier rose* with hips on it; a *plum* or *apricot*, a *blackberry;* and an *apple.*

In our last chapter we studied the various ways in which leaves are modified and united for the formation of pistils. We have now to trace the changes which these pistils undergo in ripening. Hitherto we have only seen how the seed-houses are built, how their inmates are nourished, and how the growth of the dwelling keeps pace with that of the indwellers, so that the doors may be safely shut and fastened without risk of either crushing or stifling them. But plants do not remain infants to be taken care of, any more than people. When they are old enough, and strong enough, they must leave their home and go out into the world, and in due time form other plants, which shall again bring forth seeds in their turn. It is with this entrance into the world that we now have to do: we have to see how in one plant where each seed dwells solitary, house and seed fall to the earth together, and together await the rain and warmth, which decays the one, and awakens the other into active life; we have to notice the various ways which other seed-houses, where many inmates dwell together, have of opening, and letting them go their several ways; and how other plants again have most wonderful and ingenious methods of either themselves scattering their seeds, or of inducing the animal world to come to their aid and carry them. Sometimes we can understand how the arrangement we see is for the good of the plant; but whether we can do this or not, we may always feel perfectly sure that it does in some way or other help it, in its main purpose of multiplying.

When a plant has its pistils ripe, and its seeds ready to fall, or fly, or be carried, as the case may be, it is said to be in *fruit*. This word "fruit" is a very confusing one. In ordinary language it means almost any part of a plant that is edible (a "potato" was the instance of fruit given me by one of a Botany Class). In Botany we should expect it to mean the ripened pistil only; but as in ripening the pistil often becomes attached to and incorporated with some other part of the flower which becomes fleshy, botanists have taken an intermediate course, and defined fruit as the pistil and any other organ attached to it. This definition is of course independent of whether the pistil is dry or fleshy. Botanically, a poppy-head is as much a fruit as an apple. This same intermediate sort of method runs through the nomenclature of the different *kinds* of fruit also. Botanists found many words vaguely used in common parlance; they had to choose between altogether making new ones, or adhering to and defining the old ones. They chose the latter plan; and the result is that while many fruits have the same common and botanical names, others are called quite differently, *e.g.* the strawberry is as far from being a botanical "berry" as anything well can be.

Another difficulty about fruits is that different authors have different ways of classifying them, and are not entirely agreed even as to the meaning of all the terms. For the sake of simplicity, I shall give the clearest and most general classification, and ignore the small modifications of it, which you will have no difficulty in understanding when you come across them.

We cannot quite follow the divisions of the unripe pistils, because these sometimes change so much in the process of ripening, but the best plan is to do so as much as possible.

Fruits are first divided into those with *apocarpous* pistils, as those of the buttercup, pea, etc.; and fruits with *syncarpous* pistils, as those of the foxglove, lychnis, or heartsease. We shall only have space for the first division in this chapter.

You have seen that all apocarpous pistils are similarly formed of one carpellary leaf folded in on itself, the only difference between one and another of this sort of pistil being the number of these separate carpels that there are on the stem, their length of style and stigma, etc.; but all apocarpous *fruits* are by no means thus simply and similarly formed, as you will presently see.

There are only three of the families with apocarpous pistils that it is necessary for our present purpose to study; and with two of these, viz. those of the ranunculus and pea families, you are already acquainted. When you have examined some members of the third, which is the *Rosaceæ* or rose family, you will be able to understand all the ways in which the seeds of apocarpous pistils are let out into the world.

HERB BENNETT.—Pull up a plant of the common avens, or Herb Bennett (*Geum urbanum*). Its botanical name of Geum is probably derived from γεύω, "I give to taste," as the roots of it were formerly much used for soaking in wine to give it an aromatic flavour, and for the sake of some medicinal properties which the plant was supposed to possess. Its leaves are somewhat different from any you have hitherto seen, and are besides so variable that at least four descriptions would be necessary to give an adequate idea of them. The top ones are almost entire, but they become more deeply cut as they grow lower on the stem (fig. 47), until at last they are cleft quite to the mid-rib, and divided into three (or sometimes five) *leaflets*. If you imagine these three or five as forming one large leaf, you will see that its principal veins would have left the mid-rib at different places, and it would therefore have been said to be feather-veined; as, however, it is cut up into leaflets, the whole is a compound feather-veined leaf, or, as it is called, a *pinnate* leaf: each leaflet is itself feather-veined. There is another thing to be noticed about these leaves. Do you see the curious sort of wings growing on the main stem, one on either side of the leaf-stalk (fig. 47, *sti*), just where it

Fig. 47. Stem of Herb Bennett.

parts from the stem? These little supernumerary leaves are common to a good many plants, and are called *stipules* (from *stipula*, little stalk); they are to be found varying in size and shape at the base of the lower stem leaves of our plant. The radical leaves differ considerably; they have long stalks, are coarser in texture, and generally have several small leaflets, with one very large one at the top.

Now we come to the flower; possibly its little yellow petals may have dropped off, but even if they have, it will answer our purpose. There are five ordinary sepals, united at the base, with five very tiny ones alternating with them. Hold the pistil of the flower with one hand—its long styles will furnish a capital handle—and pull these sepals carefully down with the other, you will then see plainly the *flower-rim* (called by some authors calyx-tube) to which we referred in our last chapter (p. 43), with the sepals, petals, and stamens all coming off from as nearly as possible the edge of the same circle. Fig. 48 represents a Herb Bennett flower, from which the petals have fallen, cut in half, and much magnified. You see there the dilated receptacle (*r*); and the flower-rim (*rr*) at some little distance from it, from which the sepals, petals, and stamens seem to grow. I say *seem* to grow, because we know that they really spring from the main stalk, and that what we have called the flower-rim is formed of all of them welded together. The petals alternate with the larger sepals, and the stamens are numerous. The pistil grows, not on the flower-rim, but on the part of the receptacle which is a direct prolongation of the stalk, and which is here considerably enlarged and lengthened (*r*). There are a great many carpels (*a*) separate from each other; these are formed of one leaf, folded in exactly as we saw in the buttercup, though their long dry styles (*sty*) and curiously twisted stigmas give them such a different appearance. In them, as in the buttercup, only one seed comes to perfection, and the pod does not split, but falls to the ground with its contents. This sort of fruit is defined as apocarpous, dry, and *indehiscent* (*i.e.* not splitting), and its botanical name is *achene.* Fig. 49 is a Herb Bennett *achene* cut open to show the thickened skin of the seed (*s*), and the kernel or seed itself entirely filling up the cavity.

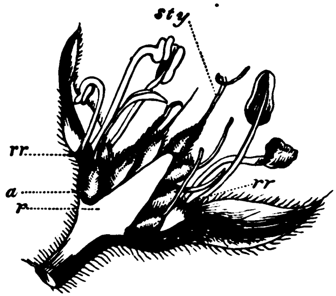


Fig. 48.
Section of a Herb Bennett flower (*magnified*).

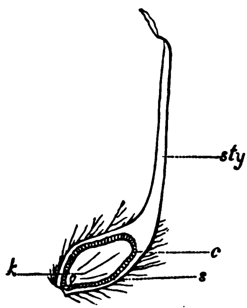


Fig. 49.
Herb Bennett achene (*magnified*).

THE STRAWBERRY.—The flower of the strawberry is almost exactly like that of the Herb Bennett; and, strange though it may seem, its fruit also is similar. The part we eat is the lengthened receptacle (fig. 50, *r*), become so soft and large as to loosen and entirely envelope the real fruits (*a*), of which we only become aware by feeling them crunching between our teeth. Therefore, though it is true that we eat the fruit of the strawberry, no one can say that it is for the sake of the fruit that we eat strawberries. Fig. 51 is a magnified strawberry achene, showing its stigmatic surface (*st*), which withers up as it ripens, and the scar (*sc*) where it was attached to the receptacle.

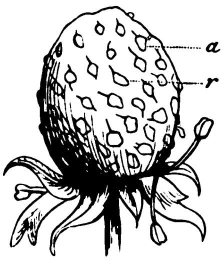


Fig. 50. Strawberry.

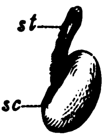


Fig. 51. Strawberry achene (*magnified*).

Do you now begin to see how it may be for the good of the strawberry plant to develop this luscious substance, of which birds and human beings are so fond? The strawberry has a long straggling stem, requiring a rich soil and much moisture to bring its seed to perfection. If all its seeds fell near together, the young plants would choke each other and perish; but as it is, birds are obliged to take the seeds for the sake of the fruity receptacle, at which one may constantly see them pecking, and they drop one here, one there, where there is plenty of room for them to flourish; and all this is done without risk of hurting the seed, protected as it is by the hardened walls of its little home.

THE BRIER-ROSE.—There is one other sort of achene which we must examine, partly because the way in which the fruit is protected is so curiously like and yet unlike those we have seen, but also because the plant on which it grows is peculiarly interesting. Pick a good branch of the brier-rose. Its beautiful sweet-scented flowers should be over, and the rich red hips have taken their place. The leaves are like those we saw on the Herb Bennett, compound and pinnate, but instead of being divided into three leaflets, there are sometimes five, sometimes seven. The leaflets also are pinnately-veined and regularly notched at the edges like the teeth of a saw. The leaves are stalked, and have stipules at the base, which run up their stalks instead of opening out at once as they did in the Herb Bennett. At the top of each little branch come generally one, but sometimes two or three hips, swollen and red, with their five sepals at the top, a quantity of withered stamens growing just inside them, and besides these a bunch of some stiffer brown hairs coming up in the middle. Before examining this fruit, I wish to call your attention to a most beautiful similarity which we can trace between the arrangement of the foliage leaves and sepals of this plant. Look at these latter carefully. Do you see how different they are from each other? Two have curious leafy appendages on both sides; two are quite smooth at the edges; and one is leafy on one side and smooth on the other. If you think of our observations on the marsh-marigold covering-leaves (p. 33), how two of these were entirely outside, two entirely inside, and one half and half, you will be able to understand the signification of these different edges. Now look at the arrangement of the foliage leaves of the rose. They are evidently in sets of five—*i.e.* choose any leaf you please, and observe which way it points, the fifth above it, and none till the fifth, will point in exactly the same direction. We have seen this arrangement so often that it is time to try and discover the meaning of it. Tie a bit of string to the leaf *below* the one (fig. 52, *o*) you mean to begin counting, and pass it over five in succession, till you come to the fifth above where you tied it. Your string will have gone exactly twice

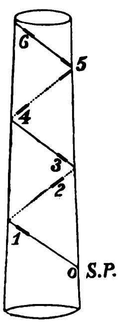


Fig. 52.
$\frac{2}{5}$ arrangement of foliage leaves.

round the stem. If it had gone only *once* round, over five leaves arranged at equal distances from each other, each leaf would have been $\frac{1}{5}$ of the whole distance round, from the last; but as it goes *twice* round, each leaf must be $\frac{2}{5}$ of the distance round, from the last. Look at fig. 52. The dotted line represents an imaginary line on the side of the stem where one could not really see it: *1* (which means the first leaf) is $\frac{2}{5}$ of a revolution from the starting-point (*S.P.*); *2* is $\frac{2}{5}$ from the first leaf, and therefore $\frac{4}{5}$ from the starting point; *3* is $\frac{6}{5}$; *4* is $\frac{8}{5}$; *5* is $\frac{10}{5}$, *i.e.* has exactly completed two revolutions round the stem. Now let us see how these leaves would be arranged if, instead of growing up the stem, they had no spaces between them, but simply grew round it. Imagine that you put your hand at the top of *5* in fig. 52, and push it down till all the numbers are level with each other. Fig. 53 will be the result, as you will see by carefully examining the two figures. But fig. 53 is exactly the arrangement of the sepals in our rose, as you will easily see by the help of fig. 54, which is the *lines* of fig. 53 turned into leaves. *1* and *2* are entirely outside, and have leafy appendages on both sides; *4* and *5* are entirely inside, and are smooth at the edges; *3* is half in and half out, it therefore has one smooth and one leafy side. You therefore see that in the case of the rose exactly the same

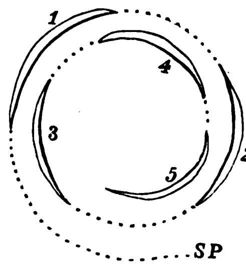


Fig. 53.
$\frac{2}{5}$ arrangement depressed.

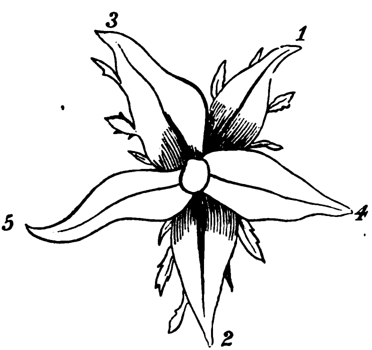


Fig. 54.
$\frac{2}{5}$ arrangement in rose sepals.

arrangement is followed in the foliage leaves and sepals of the same plant—the only difference being that between the first there are, and between the second there are not, internodes. The same arrangement can be traced in the *petals* also of the rose, and would be a convincing proof, if any were needed, of the fact that sepals and petals are veritable leaves. But it is not for the sake of any proof that I have pointed it out to you, but because it is such a beautiful example of the way in which one great plan runs through the making of a whole plant; and of how this plan, without being broken through, is modified in the most delicate way for the better perfection of every part, even to the extent of making a single sepal smooth on one side and leafy on the other. It always seems to me as if this one example were answer enough to the people who talk as if Botany were a string of dry names, leading to nothing.

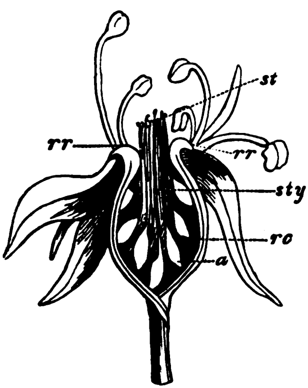


Fig. 55.
Section of rose.

To return to our fruits. How is the hip formed? Pick a rose from your garden, or better still a brier-rose from the hedges, and with the help of fig. 55, which represents a rose cut through the middle, you will soon solve the question. In Herb Bennett (fig. 48) we saw part of the receptacle having the carpels at the top of the stalk in the ordinary way, while the other part was dilated and concave, and welded with the rest of the flower which came off from its rim. Here we see this same rim (*rr*), but appearing much higher, at the top of what well deserves the name of a *flower-tube* (*rc*); and the carpels, instead of growing on an ordinary receptacle, also spring from this same flower-tube, not on the rim, but all up its sides (*a*). The styles are long and stiff, ending in little round knobs; and it was these which we noticed (*sty*) pushing through the narrow opening at the top of the receptacle-tube. The carpels are quite separate from each other, and become hard and horny when ripe. Each is formed of a single leaf, which encloses one seed (fig. 56), and does not split when ripe; they are therefore called *achenes*. What part then becomes soft and pulpy, and gives the birds their favourite autumn food? Evidently the dilated flower-tube, formed of the receptacle and the bases of the other parts of the flower, just as we have seen the receptacle alone doing in a very different shape in the strawberry; and probably in both flowers the good to the plant is the same—viz., the inducing birds to carry and scatter the seeds.

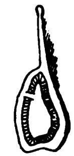


Fig. 56. Rose achene.

You are now well acquainted with the sort of fruit called *achene*. There are only two other sorts of dry apocarpous fruits, and both of these contain several seeds.

Follicles.—These split by their seams, or *sutures*, as the carpels of the marsh-marigold and sedum, and are called *follicles* (fig. 57).

Legumes.—These split both by their sutures (*s*) and by their mid-ribs (*m*), as gorse, pea, and bean pods, and are called *legumes* (fig. 58); from this term the proper name of the pea family is derived, which is *Leguminosæ* (or family of legumes). These fruits are so simple as to require no further explanation, especially as you have examined them both before.

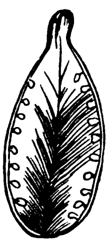


Fig. 57. *Follicle* of marsh-marigold.

Now we may leave the *dry* apocarpous fruits, and turn to those in which either all or part of the carpels becomes fleshy; and these are by no means so simple.

You remember how every leaf is composed of three parts—the outer skin, the inner skin, and the pulpy substance between. Names have been given to those parts when they occur in ripe carpels for the greater convenience of speaking of them separately: we shall come to these presently.

Look at any sort of stone-fruit, as a plum, cherry, or apricot. If flowers are to be had, all the better, but it is not a matter of

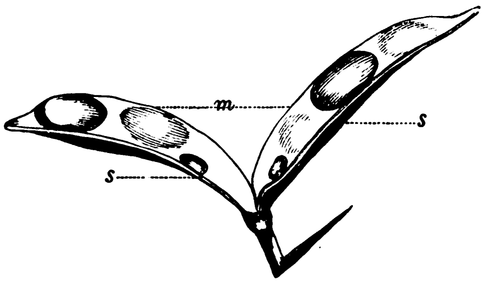


Fig. 58. Split *legume* of scarlet runner.

much importance, since they are very like others we have examined, as you can see from fig. 59, which represents the section of a cherry flower. The five sepals, five petals, and numerous stamens, all grow on the rim (*rr*) of the flower-tube; and at the very bottom, though not quite in the middle of it, on the veritable end of the stalk, rises one solitary carpel (*c*), with a long style. Now and then, two carpels may be seen in a young flower growing side by side; but there is not room for more than one to come to perfection, and the second perishing one only suffices to explain the apparent one-sidedness of his more successful brother. After a while calyx, corolla, and stamens drop off, the flower-tube withers, and the carpel only is left; this too soon loses its long style, and begins to grow larger and rounder. Take any one of the stone-fruits, and try to see what part in it has become fleshy. Evidently the carpel only is before you (fig. 60), for, as we have seen, all the rest of the flower has dropped off. The skin of your fruit, therefore, must be the outer skin of the carpel, or the *exocarp*—

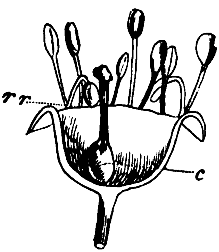


Fig. 59.
Section of cherry flower.

from ἐξώ, outside (*e*); the succulent part which we eat, the pulpy substance between the two skins, or *mesocarp*—from μέσος, middle (*m*). But what has become of the inner skin or *endocarp* (from ἐνδόν, inside)? It has grown so hard and stone-like (*en*) that you will have some difficulty in cracking it, to find inside the one seed (*s*) filling up the whole space, and attached to the thickened edge of the endocarp by a short cord. When, as sometimes happens, there are two seeds—or kernels, as they are commonly called—in the same peach, or apricot, it means that neither seed has been sufficiently stronger than the other to kill it, but that both have made a hard fight for life. The botanical name for all stone-fruits, *i.e.* for all apocarpous fruits with fleshy mesocarp and stony endocarp—as the cherry, plum, apricot, etc.—is *drupe*, from *drupa*, an over-ripe olive.

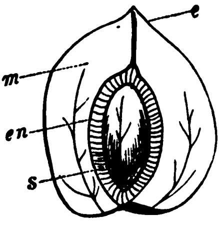


Fig. 60.
Section of an apricot.

The blackberry and raspberry have fruits very like the plum and cherry, though their appearance is so dissimilar. The only real difference is, that as their flower-tube is lower, and their ordinary receptacle, which bears the carpels, longer and more enlarged —more like what we saw in Herb Bennett (fig. 48)—there is room for many carpels, instead of only one, to come to perfection. Each one of these is a miniature stone-fruit (fig. 61), with black shiny exocarp (*e*), fleshy mesocarp (*m*), and hard endocarp (*en*), enclosing one seed (*s*), which is fastened to it by a plainly-marked nourishing cord (*nc*). When a number of *drupes* come to perfection in the same flower, as in the blackberry, they are called *drupels*, *i.e.* little drupes.

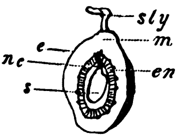


Fig. 61.
Section of a blackberry drupel (*enlarged*).

THE APPLE.—We have now only one more sort of apocarpous fruit to examine, viz. that of which the apple is the type. You would have thought it hopelessly confusing had we taken it at first; but I hope that now, seen by the side of the rose, you will have no great difficulty in understanding it.

The section of a young flower is much like that of the rose, except that the carpels (fig. 62, *c*), instead of growing all up the sides of the flower-tube, and being indefinite in number, are always five, and grow at the bottom of the tube, or top of the stalk, whichever you like to call it. When the rose fruit ripens, the flower-tube only becomes fleshy; in the apple, both it and the outer parts of the carpels all get fleshy together, and are so intermingled, that it is difficult to tell where one ends and the other begins; though a certain difference often found in the texture of the apple, not far from the centre, and marked by a dotted line in fig. 63 (*e*), is supposed to indicate the outer skin of the carpels. The endocarp becomes horny, and forms the core (*en*) which we all know, in the middle of the apple; but so entirely is every nook and corner filled up with the fleshiness of the mesocarp (*m*), that it seems as if the pistil were a compound one, with axile placentation. Nevertheless, you can see that the five endocarps are really separate, and that each of them contains one or two seeds (*s*)—pips, as they are commonly called—or very often one perfect seed, and one poor little shrivelled one. You can also see the five styles running up to the top (*sty*); and

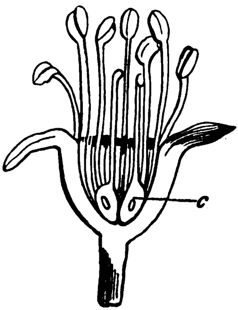


Fig. 62.
Section of an apple flower.

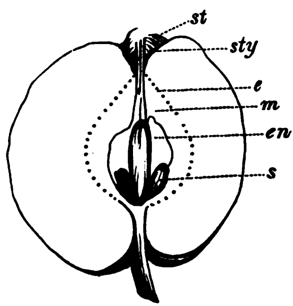


Fig. 63.
Section of an apple.

there are often dots in the outer fleshy part of the apple, which, as you remember, is formed of the flower-tube, indicating the fibrous bundles which at the top opened into sepals and petals. This sort of fruit, formed by the conglomeration of the flower-tube with the exocarp and mesocarp, while the endocarp becomes horny, is called *pome.*

We have now come to the end of our apocarpous fruits, and our examination of the rose family; and will finish this chapter with tabular notes of the first member of it which we examined —viz. the

HERB BENNETT.

Organ.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	10	United at the base.	The flower-rim.	Five of these are very small. Authors who consider that what we call the flower-tube is formed of the calyx only, of course call the sepals united half-way.
Petals.	5	Separate.	The flower-rim.	
Stamens.	Indefinite.	Separate.	The flower-rim.	These come off at almost exactly the same point as the sepals, and often get joined to them.
Carpels.	Indefinite.	Separate.	The receptacle.	These grow from the direct prolongation of the stalk.

You have probably noticed that the curious flower-rim of the Herb Bennett, or flower-tube of the rose, bearing the outer parts of the flower, is the only difference between this family and that of the buttercups. The description of the buttercup family is "Having calyx and corolla (though sometimes one of these is wanting), all the parts separate, and all growing on the receptacle." The description of the rose family, "Having calyx and corolla (though both are not always found), calyx united, all the other parts separate, but most of them growing on the dilated flower-rim."

CHAPTER V.

ON FLOWERS WITH SYNCARPOUS FRUITS.

SPECIMENS wanted for this chapter are—the *hazel-nut*, *acorn*, and *head* of *dandelion* in seed; *Herb Robert* (Geranium robertianum) and *willow herb* (Epilobium montanum) both in flower and seed, a *fuchsia*, *walnut*, and *fig*.

We found in our last chapter that apocarpous fruits had three principal divisions: (1) those that are dry and do not split, as *achenes;* (2) those that are dry and do split, as *follicles* and *legumes;* (3) those that are fleshy, as *drupes*, *pomes*, etc.; we also examined several flowers producing such fruits, and considered the special characteristics of the families to which they belonged.

We shall now see that the same three divisions may be adopted in studying *syncarpous* fruits, *i.e.* fruits resulting from pistils composed of more than one carpel. The examination of their flowers will introduce us to new families, and we should try to begin to separate off the families into their different types, as a help towards their ultimate classification.

Dry and Indehiscent Syncarpous Fruits.—This sort of fruit is less largely represented than among apocarpous plants, and remembering that the primary object of all fruits is to start their seeds in the world under the most advantageous circumstances, it seems rather surprising that it should be represented at all. In the case of the rose and buttercup, where the pistils are composed of a great many separate carpels, we do not expect each carpel to contain many seeds, and can understand that the protection of the *one* seed in each carpel may be the thing most necessary for the welfare of the plant; but how can it be for the advantage of any syncarpous pistil that all its seeds should be shut up together, and fall to the ground in exactly the same spot? You will see what really happens, as you examine the examples.

THE HAZEL-NUT.—It is of little consequence whether you take hazels from the woods or filberts from the dessert-dish, provided that your specimens are not prepared for eating, but have all their pretty leafy husk round them. In the latter case you must call to mind how they look on the trees, growing sometimes in bunches of twos and threes, sometimes solitary, and always with several large bracts wrapping round the nut, and acting as a protection against wind and weather. There are no remains of flowers either within or without these bracts, no withered petals, or dried-up stamens, such as we saw hanging to so many of the fruits in our last chapter: and even if you had looked months ago, when the nuts now so hard and brown were tiny soft green balls, quite concealed by their leafy covering, the case would have been the same. We must go back to the very early spring to learn the origin of these nuts, and even then, the hazel flowers are so unlike anything we generally call by that name, that it is no easy matter to recognise them. Do you remember the long graceful catkins (fig. 64) (called by children "lambs-tails," as the softer ones of the willow are called "pussy-cats"), which one sees waving on the hazel trees in March, while their boughs are still brown and bare? These are really masses of staminate flowers. Each flower (fig. 65) is composed of eight stamens only, covered first by two small scale-like bracts (*sca*), and outside by one large overhanging bract (*b*), which is very hairy, and acts exactly the part of a thatched roof. The stamens are beautifully packed:


Fig. 64.
Sprig of hazel.

the two lowest are very short-stalked, the next three longer, and the top ones which fit in under the roof, the longest of all. You can see from fig. 65 the way in which they split, and let out their pollen.

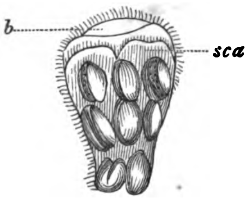


Fig. 65.
Staminate flower of hazel (*magnified*).

Looking at the picture of *one* flower, it seems as if the stamens do not meet with their fair share of protection, and rather need a calyx or corolla; but if you turn to the whole catkin (fig. 64), and see how the flowers are arranged, hanging down their heads, with their little thatched roofs coming over them, and each flower sheltering the one underneath it, you will see there is not much fear of any harm happening to them.

But we have mentioned no pistillate flowers, nothing but masses of staminate ones, and from these we know it is quite impossible that nuts should be produced. Have you never seen, generally near the top of the branches, little pink twigs sticking out from what look like ordinary leaf-buds? (see fig. 64). These are really collections of pistillate flowers, and the pink twigs are the long styles, two of which belong to each flower. You may often count ten or twelve of these, indicating that five or six flowers are enclosed within the tight-fitting bracts; but later in the year, when this covering loosens, you look in vain for your five or six nuts, and see instead a number of withered styles, and sometimes two or three, but often only one nut (fig. 66) swelling and thriving at the expense of its starved brethren. You then see what the pistillate flower is

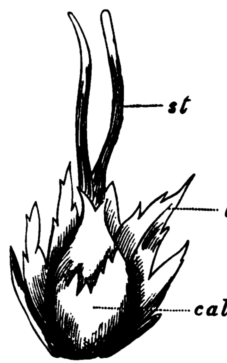


Fig. 66.
Young hazel-nut (*magnified*).

like; it, like the staminate, is incomplete, having a united calyx (*cal*) fitting so tight round the pistil that it is difficult to see what good it does, but neither corolla nor stamens. The carpellary leaves are completely united in their ovaries, but higher up separate into two very long pink styles (*st*), showing that the pistil is composed of two; and the whole flower rests in a leafy bract. If you cut a pistil open while young (fig. 67), you would find two seeds (*s*) growing from the centre, and surrounded by a green, somewhat pulpy substance, and it would be evident to you that the placentation was axile, though only one seed in each chamber was growing.

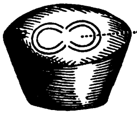


Fig. 67.
Section of young hazel-nut (*magnified*).

Now turn to your full-grown nut. The leafy bract has become the "husk," and has so enlarged and split, that it looks as if it were composed of several leaves. The calyx has grown to the top of the ovary, where it is just visible as a ridge, with a little scar in the middle which shows where the styles broke off. The carpels have become so hard, that you must crack them before you can see their contents; and when you have done this, you will find, not, as you have a right to expect, *two seeds*, but one very large one, filling them completely up. Yet your nut, when it was young, had two seeds, as represented in fig. 67, one of which has now been starved and crushed. You see therefore that though the fruit of the hazel begins so differently from apocarpous fruits, it ends by being in very much the same situation as the rose or buttercup, and has only *one* seed on which to expend its care; it is therefore natural enough that the carpels should become hard, and continue to protect it till they rot and it is ready to sprout. The whole of this story seems to show that for the hazel the important thing is, not that it should have a great many seeds, but that those which come to perfection should be as good and strong as possible. Almost every nut that you eat has been the winner in three competitive struggles: (1) he and his brethren in the same pistil have beaten the other flowers in the pink-twigged bud; (2) he has beaten the twin brother that should have shared his carpel; (3) he has fought with the successful seed in the other carpel, and as this last is the hardest fight of all, so it not unfrequently is drawn, and then we find two kernels in the same nut. In speaking of the fruit of the hazel, Botany and common conversation are for once agreed, as the term for a syncarpous, dry, indehiscent fruit is *nut*.

Fig. 68.
Staminate catkin of oak.

ACORN.—The fruit of the oak is also properly speaking a nut, though here Botany has adopted its common name of acorn and Latinised it, so that it is oftener called a *gland*. Its flowers are something like those of the hazel; the staminate ones grow in loose catkins (fig. 68), not closely packed as in the hazel, but with a space between each flower, which flower consists of six to ten stamens with a calyx of six or eight sepals growing round them (fig. 69). The pistillate flowers grow one or two on a short stalk which is placed in the axil of a leaf (fig. 70): they are separate from each other, and each of them has a whole collection of tightly-fitting *cup-like* bracts; it also has a calyx growing round and joined to the ovary, as you saw in the nut, and at the top, coming through this, are three stigmas, showing that the pistil is composed of three carpels. If you pull off the cup from a young acorn, and cut it across (fig. 71), you will see plainly its axile

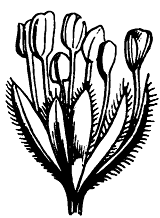


Fig. 69.
Single staminate flower of oak (*magnified*).

placentation, and the two young seeds in each chamber. Later on five of these have perished, and one is occupying the whole cavity; thus, though the successful seed in the oak has only one struggle for life, it cannot be an easy one, as he has five competitors. The little spike that one finds at the top of the acorn is the remains of the stigmas with the top of the calyx surrounding them. Both the hazel and oak belong to the family of the *Amentaceæ*, or, as it is sometimes called, the "Catkin Family."

Fig. 70.
Fruit of oak.

The winged fruits of the ash, sycamore (fig. 72), etc., which are commonly called "keys," though they are really nuts, go by the name of *Samara*, and in them two or even more seeds come to perfection. If you pick any of these you will easily understand that their curious shape is caused by a thin expansion of their carpels, which enables them to be carried and scattered by the wind. They are found in very different families.

Fig. 71.
Section of young acorn.

Fig. 72.
Sycamore samara.

Dandelion.—There are other fruits, which though they are syncarpous, become so like achenes when ripe that they often go by this name. If they are called "syncarpous achenes" or "pseudo-achenes" there is no harm in this; but unless they have some prefix, the plan is apt to be confusing. The dandelion is a good example of a *pseudo-achene*. Pick one covered with its fluffy fruit. It would occupy a whole paper to discuss fully all the wonderful contrivances of this flower, and we must put off a thorough examination of it till later on; so I will only say that the dandelion, instead of being a single flower, is a whole mass of tiny ones, all growing on a *common receptacle*, and every little bundle of hairs which you blow away from your dandelion carries with it the fruit of a perfect flower (fig. 73). The good of these hairs to the flower is evident. Each dandelion plant has a great many flower *heads* (as these collections of little flowers are called), and as each head has some hundreds of separate flowers, it is clear that these would choke each other, and no ground could support them if their seeds all fell close together; accordingly each fruit is provided with its own balloon of fluffy hairs, called a *pappus* (*pap*), and upborne by these it rides upon the wind, over hedge and field, and forms new dandelion colonies far from the parent plant.

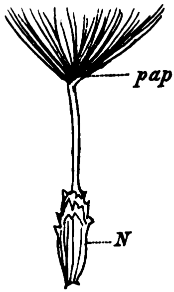


Fig. 73.
Dandelion fruit
(*magnified*).

If you cut open one of these fruits near the base, you will find one seed only, occupying the whole of the pistil, and making it seem exactly like an achene. Nevertheless, when this pistil was young it was composed of two carpels, and divided at the top into two distinct stigmas (fig. 74, *st*). We know therefore that the same thing has happened which we saw in the hazel, and that one seed has flourished at the expense of three others. This somewhat incomplete explanation will, I hope, prevent your being puzzled if you see the fruits of dandelions, daisies, and thistles, called *achenes* instead of by their more correct name of *nuts*. These flowers all belong to the *Compositæ*, or family of Composites.

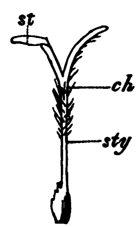


Fig. 74.
Dandelion pistil without the pappus
(*magnified*).

To the fruits of Borages and Labiates (see p. 62), on the other hand, the term *nut* is always, and rather incorrectly applied; for though it is true, in so far as each quarter of the fruit is covered by its own peculiar bit of carpel, it is not true, according to the general interpretation of "indehiscent," by which it is meant that the whole fruit continues covered by its carpels, and falls to the ground at once.

Dry and Dehiscent Syncarpous Fruits.—We have now come to the second division of our fruits. In apocarpous pistils you will remember there were only two modes of dehiscence; either by the seam, as in the *follicle;* or by the mid-rib and seam, as in the *legume.* As there are many more families with syncarpous than with apocarpous pistils, and as each of these pistils is composed of more carpels, and as a rule, contains more seeds, you would expect to find their ways of letting out these seeds more numerous. As a fact, their modes of dehiscence are *so* numerous, that I shall not attempt to give any of the long names that have been devised, but shall call them all by their common name of *capsule.* This is applied to all fruits with syncarpous and dehiscent pistils, no matter how they are formed, or how they split. Very many of these follow the apocarpous plan, and split either by the original carpels coming apart from each other and opening, as the St. John's Wort, or the carpels both open by their seams and split down their mid-ribs, but only part way, as you saw in the Lychnis and Primrose (fig. 75), or sometimes the mid-ribs only split, the carpels continuing united, as in the violet and heartsease. But besides these simple and comprehensible ways, there are many others: sometimes the fruit opens by pretty little round windows, as the poppy (fig. 76); or it has two queer holes looking like eyes, as the snapdragon (fig. 77); or the carpels come off, splitting from the bottom upwards, and never separating quite at the top, as

Fig. 75.
Split primrose pistil.

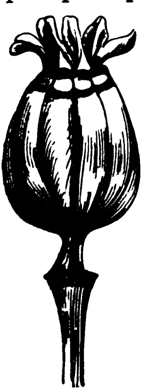


Fig. 76.
Ripe capsule of poppy.

Fig. 77.
Ripe capsule of snapdragon.

the crucifers (fig. 78); but as it is quite impossible to tell you all the ways in which syncarpous pistils split, and still more impossible to trace their curious devices for scattering their seeds, I will confine myself to two or three examples.

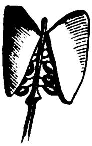


Fig. 78.
Shepherd's-purse pistil (*enlarged*).

Herb Robert.—This plant has deeply-cut leaves, which become of a brilliant red in the autumn, and form its chief beauty. The flowers are at the top of the branches, while lower down are masses of fruit with their round ovaries enclosed in hairy persistent calices, bearing the long pointed styles, which have given the plant its common name of "cranesbill."

In the flower (fig. 79) you should notice the five hairy sepals, with their prominent veining; the five pink petals growing alternately, their thin claws exactly fitting into the spaces between the sepals; then the ten stamens with their widened filaments, five shorter, and outside the other five; but here we come to a difficulty, for the shorter stamens, which are evidently older as well as outer, grow opposite to the petals, and appear to upset the law of alternance, till on careful examination you find, growing between the petals, five very plainly-marked nectar-cells, which seem to have taken the place of a third row of oldest stamens. Granting this explanation to be correct, the geranium is a perfectly regular flower, for the carpels are also five, separating into five beautiful little pink stigmas at the top, each of which, as well as of the seed-chambers at the base, comes exactly between two of the long stamens. The whole flower grows on the receptacle, *i.e.* on the direct top of the stalk.

Fig. 79.
Herb Robert flower.

If you now cut across the pistil near the base, you will find that the placentation is axile, and that each chamber is entirely filled with one large seed, while the other lies brown and shrivelled at its base. The calyx remains after the petals and stamens have dropped, and fits tightly round the fruit: but if you watch a perfectly ripe pistil, you will see a curious change take place; the sepals will gradually open for the second time, and the carpels will split, not exactly by their seams, but in such a way as to leave these seams still on the axis (fig. 80, *sc*); the styles (*sty*) then separate from the base, and spring away from it, each style carrying its split carpel (*car*) containing the one large seed in it. These do not split quite to the top, but the jerk of their spring often causes the ovary, *i.e.* the part of the carpel which contains the seed, to separate from the style: this breakage would spoil the whole contrivance, were it not provided against by each ovary having two tiny silky threads (*th*) which are fastened to the base of the stigmas, and which hold them in their right position, till a breath of wind comes to carry them to a distance.

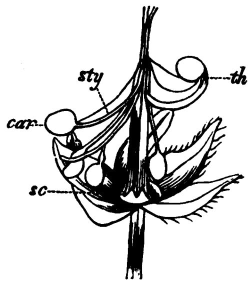


Fig. 80.
Ripe capsule of Herb Robert.

The same sort of mechanism is carried even further in a family nearly related to the geranium (fig. 81), in which the carpels split at the base, and roll themselves up (*spl cap*) with such a violent jerk that the seeds are sometimes thrown five or six yards. This plant belongs to the balsam family, and has the appro-

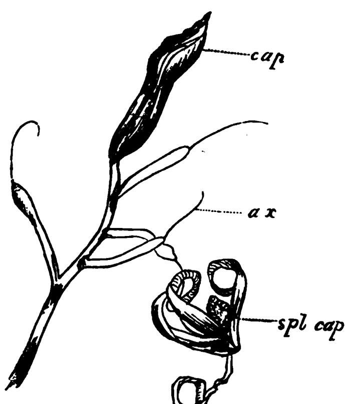


Fig. 81.
Ripe capsule of wild balsam.

priate name of "noli me tangere" (do not touch me). I am afraid you will not be able to find a specimen, for gardeners generally cultivate the far less graceful double sorts, and I have never seen it growing wild except in Cumberland, where it is most luxuriant and beautiful. Fig. 81 represents a little sprig of it, with a seed-vessel not split (*cap*); one that has split, and scattered all its seeds except one, which is still clinging to it (*spl cap*); and three flower-stalks, from which seeds, capsule and all, have burst away, leaving only the thread-like axis (*ax*). I had some difficulty in picking this specimen for drawing, for as I touched the plant, the ripe capsules split, and jerked away, and this was almost the only one which did not entirely leave the plant, and as you can see, *it* is quite free, and only caught by the axis.

Fig. 82 represents a flower and bud of this wild balsam; and you may be surprised that it, with its long spurred sepal and curiously modified flower, should be spoken of as any kin to our perfectly regular wild geranium. The steps by which this relationship are proved are very curious. Look at any common garden geranium; you will find one of its sepals larger than the others, and within this large sepal is a hole about a quarter of an inch long, and large enough for a pin to be inserted without injury to the stalk. This is a transformed nectar-cell (you remember how plainly we saw these in the wild geranium), and is the beginning of the irregularity which may be seen exaggerated in the large garden geranium, the nasturtium, and the canary-creeper, till it culminates in the wonderfully queer-shaped balsam.

Fig. 82.
Flower of wild balsam.

This is a very good example of how the same *type* of flower may exist through many different shapes and appearances; and this fact is quite as important in the classifying of families themselves, as in the assigning of plants to their proper families. You have now seen a good many families which have for their main characteristics *their petals separate, and all their parts growing from the receptacle*, or top of the stalk; viz. those of the buttercup, crucifer, violet (our example was a heartsease), pink, and geranium.

GERANIUM.

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	5	Separate.	The receptacle.	Very hairy.
Petals.	5	Separate.	The receptacle.	Having a thin white claw and pink blade.
Stamens.	10	Separate.	The receptacle.	Five of these are shorter and outer, and older than the other five. These grow *opposite* to the petals. The filaments of all ten are widened.
Carpels.	5	United.	The receptacle.	The pink stigmas only are separate. Placentation axile. The carpels spring up when ripe, leaving their sutures on the axis.

Evidently these families have something in common with each other, which they have not with peas, labiates, or plants which flower in catkins, and it is therefore natural that they should all belong to the same botanical *Division of Thalamiflorals, i.e.* plants flowering on the *thalamus* or receptacle. By degrees you will find that other families also have common characteristics which separate them off into groups.—But we must now return to our *capsules*.

Willow Herb.—There is one more kind of capsule to which I wish to call your attention. It is common to all willow herbs, and may be seen equally well in the small pink-flowered one (fig. 83), so abundant in the hedges, and in the great handsome one which grows by the river-side, and makes it gay all through the summer time. The pistil is very long and thin, and, unlike any we have examined, grows entirely below the rest of the flower. It is enclosed by the dilated flower-tube, in somewhat the same manner as the rose, except that this tube is united to the ovary all the way up. What this flower-tube is, is disputed. French and some English botanists consider it a hollow receptacle joined to the ovary; the older theory is that it is the lower part of the calyx, united up to the top of the pistil, soon after leaving which it opens out into its four sepals; and that the rest of the flower grows on this calyx. The former is, I think, the more correct theory; but one thing is certain, and that is, that however the different parts may be welded together, they must in reality spring from the top of the stalk. The petals grow on the flower-rim at the top of the ovary, just within and between the sepals; they are four in number, but so deeply cleft that you might easily mistake them for eight; they are very prettily rolled in the bud, like the tiles of a house, one over the other. Next to these, and growing from the same rim, are eight stamens, four long and four short. Pull these off; and the pistil only is left, which, with its long ovary, distinct style, and four broad sticky stigmas, is a perfect example of the division of this organ into three parts.

Fig. 83.
Flower of willow herb.

Fig. 84.
Ripe capsule of willow herb.

If you cut a young ovary through the middle, you will find that it is composed of four carpels, has axile placentation, and very numerous seeds. Now look at an older seed-vessel: you will see the carpels splitting by their mid-ribs, and showing numberless seeds, one under the other, and each provided with its own floating apparatus, and ready for voyaging about the world (fig. 84). There are thus two different sorts of plant-balloons; one, as the dandelion showed us, for carrying the house as well as the single inmate; the other, when the inmates are many, to help each individual on its independent way.

WILLOW HERB (EPILOBIUM).

Parts of Flower.	No.	Separated or United.	Where coming off.	Remarks.
Sepals.	4	United a short way after they leave the ovary.	The rim at the top of the ovary.	In this flower the *flower-tube* is joined to the ovary all the way, and the rim is at its top.
Petals.	4	Separate.	The rim at the top of the ovary.	Rolled in the bud like the tiles of a house.
Stamens.	8	Separate.	The rim at the top of the ovary.	Four long and four short.
Carpels.	4	United.	The receptacle.	Clearly marked style, separating into four large stigmas. Placentation axile.

(A flower with a *rim* at the top of the ovary, from which the sepals, petals, and stamens all seem to grow, is often said to have an *inferior* ovary, because the ovary is *below* the rest of the flower, and a *superior* calyx, because this is *above* the ovary.)

Now we will leave the capsules, which, as you see, are to be found in all sorts of families; and I hope the few examples I have given may be enough to show they are well worth studying carefully, as every apparently purposeless difference between their manners of dehiscence is sure to have its own reason—and plants are not like people, they *cannot* have mistaken reasons.

Fleshy Syncarpous Fruits.—The botanical name for a fleshy syncarpous fruit is *berry*, and it is applied to all fruits answering to this description, whatever their placentation or size may be ; thus the fruit of the fuchsia, which has axile placentation, and even of the large melon and cucumber, are all as true berries as the gooseberry, which, as you see in fig. 85, has parietal placentation. We will glance at the fuchsia for the formation of this fruit, since it is a near relation of the willow herb (being in fact of the same family, *Onagraceæ*), and in spite of its hanging head and bright-coloured sepals, resembles it in all important respects. But its pistil, instead of being dry, and splitting, has become fleshy, and is a good example of our third division of syncarpous fruits. It is composed, as we saw in the willow-herb, of four carpels, with axile placentation, and several seeds growing in each cell. As the fruit ripens, the carpels become swollen and sticky, the axis in the middle particularly enlarging in size ; the fruit comes below the flower, it is therefore not composed of carpels only, but of them and their agglomerated covering, which partake in the general swelling, and is called the flower-tube, according to our view of the structure of the flower.

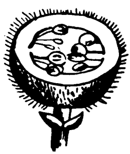


Fig. 85.
Section of gooseberry.

The walnut does not exactly correspond with any of our descriptions. It is composed of two carpels, and when growing on the tree is encased in a quantity of green pulpy substance which is their swollen exocarp (fig. 86, *ex*), and mesocarp (*m*), the shell of the walnut being the hardened endocarp (*en*), and the funny crinkled kernel which we eat is the one successful

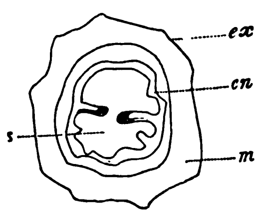


Fig. 86.
Section of young walnut.

seed (*s*). Thus you see it resembles a stone fruit or drupe (p. 75) in every respect, except that two carpels instead of only one go to its composition, and accordingly it is generally called a *syncarpous drupe.*

Collective Fruits.—Now we have come to the end of our apocarpous and syncarpous fruits; but before quitting the subject, I must say a few words about the small group of *Collective Fruits,* which differ from those we have described in being the result not of one, but of several pistils. The mulberry (fig. 87) is an example of this. It looks so like a very large blackberry, that you would probably imagine it to be the fruit of one apocarpous pistil; but instead of this, each little black thing is the product of a whole flower (fig. 88), and is composed of its two carpels, and four covering-leaves, which have all become juicy together; the two withered stigmas may generally be seen in the middle of each ripened pistil. The stamens grow in a separate flower. A more curious example of a collective fruit is that of the fig. We said at the beginning of this chapter that it was difficult to distinguish the pistillate flowers of the hazel; still it was at any rate possible—but has any one of my readers, at any time of the year, seen a fig-tree in blossom? You may watch the tree from the depth of winter when its every branch is brown and bare, till the summer sun is glistening on its luxuriant green leaves, but you will never find a

Fig. 87. Mulberry.

Fig. 88.
Mulberry flower
(*enlarged*).

single flower. Nevertheless, there are few trees which bear so many flowers, or are in blossom for so long a time, but they have found a safe hiding-place, viz. the middle of the fruit. You remember the *common receptacle* of the dandelion, on

Fig. 89.
Staminate flower of fig.
(*magnified*).

which all the little flowers grew. The fig has also a common receptacle, which becomes sweet and succulent, and is the part we eat; but it has undergone a curious metamorphosis. I can best describe it by comparing it to an umbrella. Imagine this to be open, with masses of little flowers growing all over it: these flowers are some of them *staminate* (fig. 89), (*i.e.* having stamens and no pistil), and the rest *pistillate* (fig. 90), (*i.e.* having pistil and no stamens); the former grow at the edge of the umbrella, the latter all over it, up to its apex. Now imagine that a violent gust of wind comes, and turns your umbrella completely inside out in such a way that it is almost closed, and in all respects perfect, except that what was the wrong side is now the right, and the flowers are all inside. "But," you will say, "if the stamens and pistils are on different flowers, how is it possible that the pollen of the one should reach the stigmas of the other? Wind cannot blow inside a fig." This is quite true, but no umbrella quite closes, neither does our fig; there is a hole left at the top, and through this hole multitudes of tiny flies and insects creep, probably attracted by the sweet smell of the ripening fig, which promises them a rich reward inside. You remember the

Fig. 90.
Pistillate flower of fig.
(*magnified*).

staminate flowers grew on the *edge* of the umbrella—this is now the *top*, and therefore as the insects go in, they get covered with pollen, which they rub against the stigmas of the pistillate flowers in their search for honey. Both the mulberry and fig belong to the same family as our stinging nettle (*Urticaceæ*).

The pine and fir cones are also collective fruits, but we are not ready to examine their structure at present, so I will bring our long dissertation on fruits to a close with a table, which will make it easy to remember them.

NATURE OF FRUIT.	IF APOCARPOUS, TO BE CALLED	IF SYNCARPOUS, TO BE CALLED
Dry and indehiscent.	Achene.	Nut.
Dry and dehiscent.	Follicle, Legume.	Capsule.
Fleshy.	Drupe, Drupel, Pome.	Berry.

Collective fruits are those formed of several pistils.

CHAPTER VI.

ON STAMENS AND MORPHOLOGY OF BRANCHES.

SPECIMENS—*rose; camellia;* stamens of *stock, ivy, snapdragon,* and *heath; fuchsia leaf; pollen* from various plants.

We have now spent some time in examining flowers and fruits carefully; and we have found that, in spite of the different appearances of sepals, petals, and carpels, they, as well as the foliage leaves, are all the same organ, variously and wonderfully modified to enable them better to fulfil their special functions. We have also seen that all these modifications seem to have the same object, *viz.* the protection and perfection of the young seeds, the future plants. It is for their sake that the sepals are small enough to cover them closely, and curiously arranged that no drop of rain may find its way in; that the petals have colours as manifold as the rainbow; and that the carpels are so transformed as hardly to be recognisable as leaves at all. The foliage-leaves also, as we shall see by-and-by, have their broad flat surface in order to prepare a plentiful supply of nourishment for the plant, on the healthiness of which the well-being of the seed depends.

Flowers, however, do not generally consist of sepals, petals, and carpels only; they have also stamens, and about these stamens we know absolutely nothing, except that they too are somehow essential to the seed; for the experiment on the cucumber-frame (p. 10) proved that without them the cucumber seeds never became young plants at all, but withered and died in their infancy; and this same experiment taught us also that the useful part is the fine powder or *pollen*, contained in their anthers, which is caught by the sticky stigmas of the pistil, and which then gives to the tiny green balls inside, their power of independent life and growth. We now want to make out whether these stamens are an entirely new organ, or only another modification of an old one, and also how they manage to send their pollen to the only place where it can be of use. You doubtless remember how insects are bribed into their service to act as carriers, and can guess that this part of the subject will be as curious and interesting as the devices of the fruit for helping the ripe seeds to reach their destination.

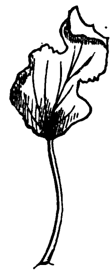


Fig. 91.
Petal from a rose.

First, as to what organ a stamen really is. Stamens look even more unlike leaves than the carpels, yet one has a suspicion that in the end they will turn out to be another modification of this most changeable organ. Pick a double rose from your garden and compare this with its sister the wild brier-rose. You remember that that had five petals and an indefinite number of stamens (p. 72); but your garden rose has more petals than you can count, and if it is what gardeners call a "perfect" one, no stamens at all. What then has become of all the stamens, and whence have the numberless petals appeared? A common garden rose (as the old china) will answer this question; for there you will see in the centre of the flower some stamens, though not nearly so many as in a wild rose, and the outermost of these are almost sure to be in the stage of turning into petals. Figs. 91 and 92 are both taken from a half-double rose, in which were ten or twelve stamens in the transition stage, still retaining their filaments, but with the anthers turned into more or less perfect leaves. Fig. 91 grew near the centre of the flower,

Fig. 92.
Another petal
from a rose.

and is therefore entirely crinkly and misshapen, and has a long filament; while fig. 92, which was farther from the centre, is almost a perfect petal on the right side, and its filament is much reduced in length. Very often it is the filament which has become petal-like, while the anther retains its former shape, as in fig. 93.

Fig. 93.
Another petal from a rose.

This same sort of change may be seen going on in many flowers besides roses. Camellias generally look most absolutely regular, but if you can find one of these, which gardeners despise because it is imperfectly doubled, and pull it to pieces, you will probably meet with filaments which have become petal-like, and have shrivelled anthers at the top or sides; and other ordinary filaments bearing little leaves instead of anthers, all in the same flower; and you may also notice that the smallest petals do not look like one perfect leaf, but are divided as if they were made up of both filament and anther become leafy (fig. 94).

Fig. 94.
Petal from the centre of a camellia.

The azalea is another flower which is very apt to produce anthers on its petals, and blades on its filaments.

One sort of columbine has a very odd way of doubling. Two kinds are cultivated in gardens. One in its natural state has five sepals and five petals—both pink, and hardly differing from each other except in position; there are numerous stamens, growing round a pistil composed of several separate carpels. When this flower is planted in rich soil, its filaments begin to turn into petals in the ordinary way, sometimes with, sometimes without, shrivelled anthers attached to them; in the course of many generations the flower becomes more and more double, until the anthers gradually cease to occur on the petals, and nearly all the stamens, and often the carpels too, disappear.

But it is the other commoner sort which I want you to notice.

It has five sepals, the same colour as the corolla, though easily distinguishable from them by the difference of shape; five petals, which have turned into pretty little hoods with long curled nectaries at the base (fig. 95); an indefinite number of stamens, and five separate carpels. The columbine belongs to the same family as the buttercup; its long nectary is therefore very interesting as being an exaggerated form of the little fold, which we noticed at the base of our buttercup petals (fig. 96).

Fig. 95.
Petal of columbine.

Fig. 96.
Petal of buttercup.

To return to its method of doubling. Fig. 97 is a fancy picture; its left side represents a single flower, the sepals of which have been pulled off, but which is otherwise perfect. The right side shows what happens when it is planted in rich soil and begins to double — the anthers turn into hoods, the top ones only retaining their filaments; and the lower petals, which are smaller than in a single flower, get pushed off the receptacle, and are only kept in position by fitting closely to the petal above it. You will notice that the double side of the flower has six petals and one stamen, while the single side has only one petal and four stamens: this fact of there being more petals than can be accounted for by the usual number of stamens, is very common in double flowers, and results from the fact that the whole plant is in a state of unusual strength. The water-lily, even in its natural state, is another example. It always has petals changing

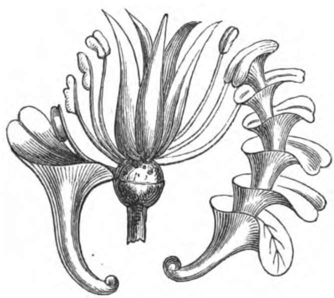


Fig. 97.
Columbine double on one side, single the other.

into stamens (fig. 98); but after developing one (1) or two (2) or even more rows of these transition leaves, it produces perfect

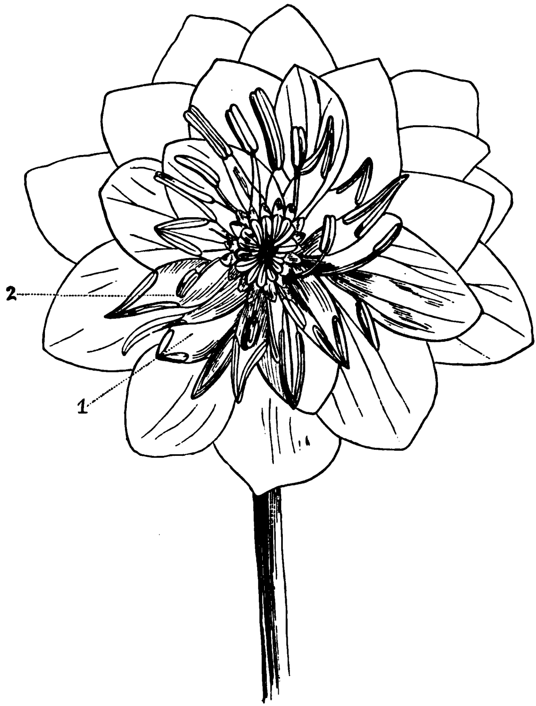


Fig. 98. Dried flower of water-lily.

stamens, with pollen in their anthers, and the seed-organ in the middle of the flower is strong and healthy.

I might go on multiplying instances of this sort *ad infinitum*; and the ease with which our flowers double is a fact known and constantly used by gardeners, by whom a great bunch of leaves with no power of producing seed is thought more beautiful than a natural flower with all its wonderful machinery in perfect order.

This same power of change is well illustrated by looking at the animal world. Thus our hands and feet certainly look as little alike as stamens and petals; but under peculiar circumstances they become much less different, though they cannot be said absolutely to turn into each other as these do. For instance, if a man is unable to use his feet in walking for a long time, his heel becomes more like the under part of his wrist, and loses a great deal of the soft padding given him for the purpose of standing on, so that walking is for a time most painful. Again, if a man loses or is unable to use his hands, his toes become by practice so finger-like that he is able to do many things with them, which to us would seem quite impossible. The best known instance of this is the man at Antwerp, who may constantly be seen in the picture-gallery there, industriously painting with his feet. I had never heard of him, and the first time I saw him I was for a moment unable to believe my eyes. He had no hands, but there he sat painting away as busily as any one. He held his palette on the great toe of his left foot, and with the toes of the other foot, he rubbed his colours, held his brush, and painted. After a time he wanted to go into the luncheon-room, so he stretched out his feet for his shoes (he was painting in foot-mittens), pulled each on with the toes of the other foot, and walked away. I have heard that he sometimes puts on his hat with his feet, but when I have seen him he has kept it on while painting.

This is an argument for the similarity of hands and feet very like the one of stamens turning into leaves. But we are not satisfied with this in the study of animals, so we turn to anatomy, and find from it that the similarity is not a matter for speculation, but is a certain fact, for the bones which form the hands and arms are the same in number and nature of fastening as those that form the feet and legs. Anatomy teaches us besides more wonderful things than these; it shows how things so dissimilar as the wing of a bird or a bat are also modifications of the same organ as our hands and feet. Fig. 99 shows a bat's wing—let us compare it with a man's arm; *el* corresponds to the elbow-joint, *fa* to the long forearm, that is, the part between the elbow and wrist; *a, b, c, d,* to the four fingers, in which the joints have disappeared, as the stiffer they are, the better for the purposes of the bat; but where is the thumb? You see it at *e*, very short, and with a little hook at the end, by which the bat hangs when it sleeps. Over all these bones a thin membrane is tightly stretched, very light, and admirably adapted for flight.

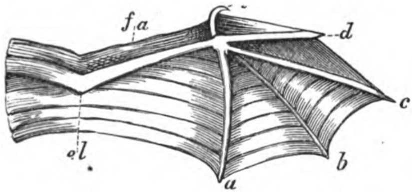


Fig. 99. Bat's wing.

We will now return to our stamens, and see whether we can find in their structure proofs, similar to those furnished by anatomy, of their similarity to leaves. Pick the stamens of a buttercup (fig. 100), a heartsease (fig. 101), and a snapdragon (fig. 102).

Fig. 100. Dust-spike of buttercup (*magnified*).

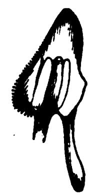


Fig. 101. Spurred stamen of heartsease (*enlarged*).

There are considerable small differences between these, but some characteristics are common to them all. They all have a long stalk, and a wider thicker part at the top. Now pick a fuchsia leaf (fig. 103), and compare it with your stamens. The stalk is there, though shorter, and so is the wider part at the top, though in the leaf it is not thicker. Can you now trace the modification? In the stamens the leaf-stalk (or filament) is longer; this is, as we know, a matter of very small importance, for it merely means that the fibres which

Fig. 102. Snapdragon stamen.

Fig. 103. Fuchsia leaf.

are necessary to form the framework of the leaf-*blade* (as the flat open part is called) have remained in bundles a little longer; and besides, fig. 101, which represents a very leaf-like stamen from the heartsease, shows that a stamen *may* have a short stalk, for in it, what looks like a filament is only a curious spur-like appendage (see p. 57). The anther is far more altered from the ordinary type of leaf-blade. You remember we found these to be constructed on a framework of fibre, and to consist of an upper skin, an under skin, and some pulpy subtance between; now cut your anther, it has a prominent mid-rib (called the *connective*), and is covered by an upper and under skin; but here the resemblance ceases, for the pulpy substance is of an entirely different nature, being made up of a quantity of fine dust, or *pollen*. Fig. 104 represents a leaf at the top, which at the bottom has turned into an anther. It is an entirely fancy sketch, for no leaf has ever been obliging enough to perform this metamorphosis before our eyes.

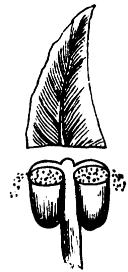


Fig. 104. Half stamen, half foliage leaf.

Now that we have reduced our flowers to leaves, all growing on a stem, let us see whether we can go a step farther, and trace any resemblance between the growth of a flower and that of an ordinary leaf-bearing stem, which we call a branch. If you look at a good long branch of any plant in the spring-time, you will see buds growing in the axils of many of the leaves, and unless you happen to be acquainted with the manner of inflorescence of the particular plant you are looking at, you will be unable to tell whether these buds will ultimately become secondary branches or flowers, because *both* of these equally grow in the axils of leaves. If one of these buds turns out to be a branch, it will have first a bit of stem, then either one, two, or more leaves growing at a *node* or knot; then there will be another bit of stem, or *internode;* then another node, with its one or more leaves; and so on. If, on the other hand, it turns out to be a flower, it will begin in just the same way with its bit of stem, then will come the *receptacle*, which we may fairly compare with the first node on the branch, and round this will grow two or more leaves, as the case may be; but here the analogy ceases; for instead of another internode, we find another set of leaves, and others again after these, all growing as closely together as possible. Do you remember the sepals of the rose, and the

Fig. 105. Monstrous growth of tulip flower.

wonderful way in which their growth round the stem corresponded with the growth of the foliage leaves up the stem? (p. 71). The only difference was, that the foliage leaves had, and the sepals had not, internodes; and seeing how unequal the internodes often are in length when they are present, this did not seem a very important difference. We now have to see whether there is any evidence that in the flower this suppression of internodes is carried still farther, and that it is only another form of the same type as the branch.

Fig. 105 represents a flower which seems to have existed on purpose to answer this question. It is a tulip, which grew in a friend's garden some years ago, was dried, and has been waiting to be drawn ever since. It ought to have six covering-leaves, three growing just within and alternately with the other three, six stamens, and three carpels. Our flower has, as you see, seven covering-leaves, three stamens, and three carpels; but it has ceased to be a proper flower at all, and has turned into a regular flowering branch, with internodes of different lengths between nearly all its leaves up to the carpels.

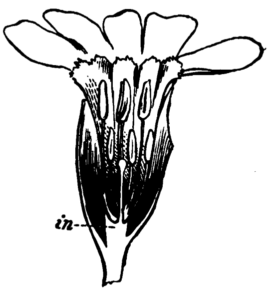


Fig. 106.
Section of a staminate campion flower.

Fig. 106 is a section of a staminate campion, in which there is always a slight internode (*in*) between the calyx and corolla leaves.

Plants sometimes show another sort of proof; for instance, I have before me a rose-branch (fig. 107) that seems trying to turn into a flower, for the internodes have disappeared between four leaves, and they are growing all close together like a set of sepals. Some bits too of the leaves have turned red (*r r*), and the green sepals (*g*) are growing within a large red petal (*p*), so that altogether a most curious confusion between foliage leaves, petals, and sepals, is apparent.

But granting, as I think you will now be ready to do, that the absence of internodes in a flower is no insuperable objection to considering it as a modified branch, there are still other difficulties to be disposed of. When we examined the arrangement

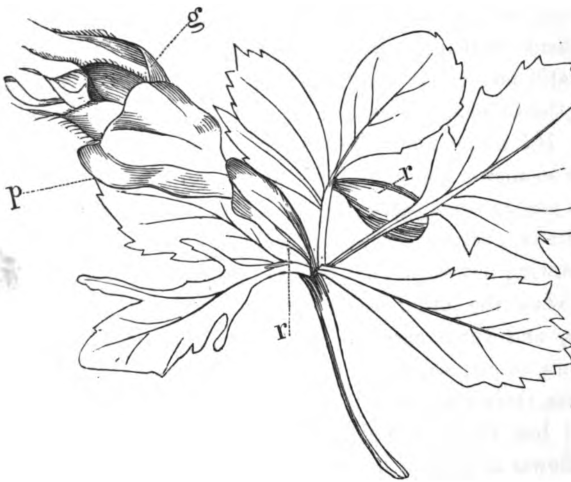


Fig. 107. Monstrous growth of rose-branch.

of the leaves on the rose-branch, we found that they grew in sets of five, and that the sixth leaf, *i.e.* the first of the new set, grew exactly above the first of the former series (p. 70); but in the flower of the rose we do not find that the petals (which correspond to the second series of leaves) grow *above* the sepals, but alternate with them. Various theories have been started to account for this, but the true explanation seems to be the superiority of the alternate arrangement for the well-being of the flower. The only way to explain any modification is that it enables the organ in question to do its work better; if, then, close packing is, as we have many times seen to be the case, one of the elements of the usefulness of the different parts of the flower, and if the alternate arrangement is better for this close packing, which, as you must remember, is not wanted in the foliage leaves, then the alteration in position is accounted for.

We have now traced a resemblance between a flower and the simplest sort of branch, viz. one that bears only leaves and is therefore called a *terminal* branch, because it terminates the plant in its own particular direction. But most branches are not terminal, as they have growing at some of their nodes, buds of either flowers or twigs; and to these more complicated branches, flowers as a rule bear less resemblance, though every now and then a flower gives additional proof of being a veritable branch by indulging in some strange freak, and either throwing out side-branches, or going on producing a stem and leaves through the flower.

Fig. 108 represents a strawberry, in which the stem has been continued through the fruit so as to end in a branch of leaves. This strawberry was originally figured in an American magazine, and is described by Dr. Maxwell Masters in his "Teratology," which is a wonderful collection of vegetable monsters.

Fig. 108.
Monstrous growth of strawberry.

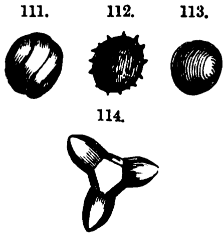
Our whole flower, then, turns out to be only a branch under another form, and every organ on it a modified leaf. It is just a hundred years since a few great botanists dimly grasped this idea. It was hinted at by Linnæus, and more plainly seen by Caspar Wolff, but it was first clearly expounded by Goethe some years afterwards; and one hardly realises what a discovery it was, and how it changes Botany from a mass of curious facts into a great science with the same eternal law running through all, till one sees it from the point of view of the philosopher-poet. I do not mean that Goethe was right in all his conclusions and deductions. Many of these are fanciful—others, as we now know, utterly mistaken; but he thoroughly grasped the central idea of botanical morphology, *i.e.* he understood how the same thing performs different functions under changed forms; and he saw the wonder of this, and the beauty of it, in a way that other people who are not poets, but only botanists, cannot do.

Now we will return to our stamens, and examine some of the differences between them and ordinary leaves. The business of foliage leaves is to present as large a surface as possible to the sun and rain; and for this purpose, their length and thickness of stalk, the way in which they are fastened to it, and even their shape, are all adapted. But the business of stamens is very different: they have to keep their pollen dry till it is ripe, and then to get it to the sticky top of the pistil that is in need of it; and for this, their shape, position in the flower, and whole structure, is adapted. Evidently the first thing necessary is some mode of egress for the pollen, which can be of no use while it remains shut up in the stamen. Accordingly all anthers have their own way of splitting. The commonest way is to burst by two long slits running the whole way down the anther—either exactly at the edge, or near it, but slightly turned towards the centre of the flower, as you have seen in the wall-flower, rose, sedum, hazel, etc. Sometimes, again, these slits are turned not towards, but away from, the centre of the flower, as the buttercup has taught us. Besides these obvious modes of dehiscence, there are others much more curious; some anthers open by valves, as the common barberry (fig. 109), or by two funny little holes at the top, as most heaths (fig. 110). In all cases the same thing is let out, a curious yellow dust, which is too small to be seen clearly with the naked eye, but which makes a very pretty object when put under the microscope. You will then see that it consists of a number of very minute grains of different size and shape, according to the sort of

Fig. 109.
Stamen of barberry
(*magnified*).

Fig. 110.
Stamen of heath
(*magnified*).

plant it is taken from, but all plants of the same sort have exactly similar pollen. Fig. 111 is a highly magnified pollen-grain from the musk plant; 112 is taken from a melon stamen; 113 from a cherry, and 114 from an evening-primrose stamen. But these grains do not continue all their lives in their rounded shape. Some time ago I wanted to look at some campion pollen in the microscope; accordingly I shook some out of a ripe stamen, and to keep it in place on the mounting-glass I fastened it with a drop of weak gum. On taking it out a few days afterwards, I found that it had sucked in the gum, and with a rapid sort of growth peculiar to itself, had sent out long shoots all over the glass, so that the original grains were all much reduced in size, and some had almost disappeared. This is a good exemplification of the growth of pollen-grains when they reach a stigma. They suck in the curious glutinous matter with which it is bedewed (and which we have hitherto supposed to be useful only for catching the pollen), grow with wonderful rapidity, and send their shoots right down the style to the tiny seeds in the ovary—sometimes, as in the crocus, a distance of several inches. These little grains, in their turn, suck in the contents of the pollen shoots, and thence gain their power of ripening, and eventually becoming young plants. *What* this power is that is thus given is a mystery about which we know even less than we know *why* these very seeds, when they have ripened, lie dormant all the winter, and wake with the bird's songs in the spring time; or *how* they drink in the dew of heaven as it trickles through the soil, and turn it into stem and leaves and flowers; or *why* the chemical contents of a certain soil should be life and health to the seeds of one plant, and should shrivel the tissues, and kill by slow poison the seeds of another.



Different sorts of pollen (*magnified*).

There is another thing you should notice in stamens, viz. the way in which the anther is attached to the filament.

The commonest mode of attachment is the one we have seen in the wall-flower (fig. 6, p. 7), where the connective runs the whole way to the top of the stamen, and there is a clearly defined back and front.

Sometimes, again, the anther is joined to the connective through its whole length, but there is no distinction between back and front. This is an uncommon mode of growth in English flowers.

The third, and perhaps the prettiest of the ordinary sorts of attachment, is when the anther is attached to the filament by the middle of its back, and so slightly that it seems rather to be balanced than to grow there. This is to be seen in all grasses (see fig. 194), in the evening primrose, and in many other flowers.

All these modes of growth are doubtless important in helping the pollen to reach its right destination. We shall consider some of the wonderful devices which have this object, in our next chapter.

CHAPTER VII.

ON FERTILIZATION.

IN our last chapter we found that both ordinary branches and flowers spring from the same type, of which they are only different modifications. We saw that, as all borne by the one are foliage-leaves, so all borne by the other are also leaves, however much they may differ in appearance, not only from foliage-leaves, but even from each other.

We further found the reason of all these differences to lie in the various purposes they are meant to fulfil. The offices of all flower-leaves are different from those of all foliage leaves; but the offices of all flower-leaves are not similar; they are therefore divided into sets; to each set a special duty is given to perform, and the leaves are modified in size, and shape, and manner of growth, according to what that duty is.

None of the flower-leaves, not even the carpels, have undergone such curious modifications as the stamens, or *staub-blätter* (dust-leaves) as the Germans happily call them. We may suppose therefore that their uses must be proportionably curious.

These uses are twofold; they have first to produce pollen, and afterwards they have, with the help of the other parts of the plant, to help this pollen to reach its proper destination. If we considered their first vocation alone, which is all that botanists ever did till recently, we should wonder why dust-leaves should have strayed so very far from the normal type of leaf; for would not any ordinary leaf, with an ordinary short stalk, answer all the necessary purposes, provided its blade was very thick, had a power of splitting when ripe, and contained pollen instead of the usual pulpy substance? And we should wonder yet more why stamens are not all formed on the same pattern, instead of having such divers shapes, and sizes, and ways of splitting.

But if we remember their second vocation, and consider them with a view to the ultimate destination of the pollen, we see at once that any amount of variety, and any number of curious devices, may be expected.

Pick any flower you like; if you examine it carefully, you will see how its shape, the way each flower is fastened to the stem, the part of the pistil which becomes sticky, and many other details, all affect the ease or difficulty with which pollen can reach the stigma.

Sometimes it is not the flower only, but the whole plant, which has to be modified in order that the pollen may reach its destination; as is shown by the following instance.

The *Vallisneria spiralis* is a water-weed, a native of quiet pools and ponds in South Europe, which may sometimes be seen in England, growing in fresh-water aquariums. It has long thin leaves, many of which reach from the root to the top of the water. Its flowers are *diœcious* (in two houses), *i.e.* the stamens and pistils not only grow on different flowers, as in the hazel, vegetable marrow, etc., but on different plants, as in the willows, etc. The pistillate flowers are purple; they are provided with long thin stalks which spring from the root-stock, and are curiously curled like a corkscrew. The staminate flowers grow in bunches, something like catkins, on short straight stalks, also springing from the root-stock, and each bunch is enveloped by a large white bract, which prevents it from being hurt by the water.

Now comes the difficulty. We have two flowers, both at the bottom of a pond—the one contains pollen, the other the pistil needing the pollen. How is one to get to the other? We saw in the case of the cucumber, where the pistils and stamens were only on different *flowers*, that no seeds were set unless winds or insects did the business of pollen-carriers. But winds cannot blow, nor honey-eating insects live, under the water. Perhaps you will think that fishes are pressed into the service, and in some way persuaded to carry the pollen on their noses. This would however be useless, as the pollen would instantly be washed off any stigmatic surface, and besides, it is spoilt by being wetted. I must tell you the solution of the puzzle, for I am sure you will never guess it. As soon as the pistillate flower is ready to blossom, its curious corkscrew stem suddenly elongates, uncurling just enough to take it to the top of the water, where it opens, and lies, lazily floating about. When the stamens on the other plant are ripe for bursting, the short stalk on which they grow snaps off, and they, still wrapped round by their bract, being lighter than water, slowly rise, till they too have come to the top, when they emerge from their covering. When once there, all difficulty is over; they either themselves come in contact with the pistillate flowers in the course of their floatings, or their pollen is carried by the insects which are now able to visit them. When the seed is set, and the flower begins to wither, its stalk screws itself up again, and carries the seed down to the place where it is eventually to be sown. This story would be difficult to believe, were not every seedling Vallisneria spiralis that ever grew a proof of it.

"But," it may be objected, "by far the majority of plants have their stamens and pistil in the same flower. Of course there must be curious devices in a few diœcious plants; but generally speaking the matter is simple enough, and the pollen is sure to reach the stigma without any special modification of either the stamen itself, or the rest of the flower."

This was the opinion held by most botanists twenty or thirty years ago; but recent discoveries seem to show that the number of flowers in which the pollen simply falls upon its own stigma is very much smaller than was formerly supposed. The chain of reasoning which leads to this opinion is rather complicated, but well worth studying carefully, as it is entirely based on careful and intelligent examination of various flowers.

In the first place, there are many flowers, as almost the whole family of orchids, which, though they are *perfect* (*i.e.* have both pistil and stamens in the same flower), are nevertheless so constructed that it is impossible for the pollen of the one to reach the stigma of the other without the intervention of insects. This fact is so well known, that I have heard of orchid fanciers, who, when they receive a rare foreign orchid from abroad, know that it is vain to expect any seed from it, unless they have some of the special sort or sorts of insects which visit it in its own country sent with it. They have found by experience that not only are insects requisite, but a special *kind* of insect; for however many English bees and moths they turn into their orchid-houses, the flowers wither and fall, and no seed is set; whereas if they shut up only one or two of the proper insects with the flowers, they have plenty of good seed. When you examine orchises carefully,* you will see the extreme complexity of their structure makes this necessity for a special shaped insect to act as pollen-carrier, quite comprehensible.

This then—that in some flowers the intervention of insects for the perfection of pollen seed is necessary—has been known for some time, but a new and far more important fact in the history of these wonderful flowers has of late years been brought to light. Mr. Darwin—who, however much many people may dissent from his theories, is acknowledged by every one to be one of the most accurate observers that ever lived—has made a whole series of experiments upon orchids,† by which he shows that the pollen of one flower must in almost every case be carried by the insect, and deposited on the stigma of a *different* flower. I have not space to describe his experiments here, but it will give some idea of their thoroughness to mention, that he examined and wrote down the details of 207 flowers of one single sort, and that no less than twenty-four sorts are included in his investigations.

* See Chapter XV. † Darwin on "Fertilization of Orchids."

Thus, though these flowers seem to be complete in themselves, they are, in almost all cases, in precisely the same case as the cucumber or the willow. Which of these plants they most resemble depends upon whether the insect bearing the pollen happens to visit flowers upon the same, or a different plant. We may sum this up shortly by saying, some perfect flowers are in the same condition as if their stamens and pistils grew in different flowers.

Now we come to another case, for the discovery of which we are also indebted to Mr. Darwin's indefatigable researches. Do you remember, in the first chapter (page 22), noticing the curious fact that some plants of primroses had flowers with long styles and short stamens, while the flowers of other plants had long

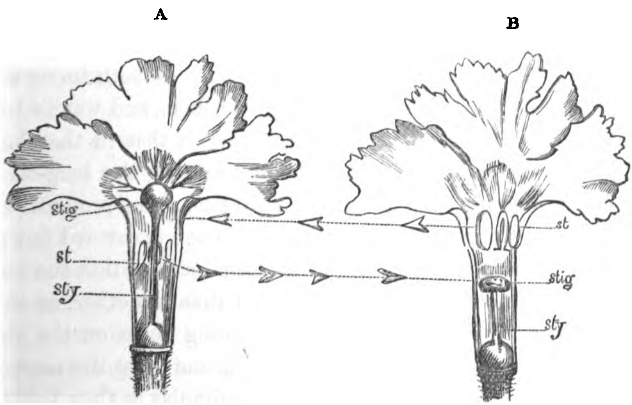


Fig. 115. Sections of pistillate (A) and staminate (B) primulas.

stamens and short styles? This is true not only of primroses, but also of all cowslips, polyanthuses, auriculas, etc., and of the Chinese primulas (Primula sinensis), from which fig. 115 is drawn.

Pick a good many of these flowers, and look at them carefully. In this particular sort of primula the long-styled form is so much the more common, that you may have some difficulty in finding any examples of its short-styled brethren; but this is only because gardeners generally gather seed from long-styled primulas, and there is no reason to suppose that either form preponderates when the flower grows wild in its native China. Now comes the question, How does the pollen reach the stigma in the two forms? In the long-styled form the help of insects seems necessary, for as all primulas hold their heads remarkably erect, it is difficult to see how the pollen from the stamens (A, *st*) should get up to the stigma (*stig*). In the short-styled form (B), the stamens being above the stigma, it seems at first sight as if the pollen would naturally fall on it; but if you examine a real primula, you will see that the throat is so narrow just below the insertion of the stamens, and so completely blocked up by the five anthers, that it is almost impossible for any pollen to drop through unless either the anthers are touched, or the whole flower is roughly shaken. Mr. Darwin put these conjectures to the proof.* He covered a number of plants of both forms with fine gauze, so that no insects could get to them, and watched the result. He found in the Chinese primrose that in the short-styled form *very* few flowers had any seed; in the long-styled form considerably more; but in both forms the proportion of seed was very small compared with that of the uncovered flowers, to which insects had free access. It seems curious that the long-styled form should have had more seed than the other, as there seems more possibility of the pollen falling down on the short style, than of its reaching up to the long one; but the reason is that the corollas always fall off these primulas as they begin to fade; in the long-styled form the anthers are dragged over the stigma, which thus becomes bedaubed with pollen (A), while in the short-styled form this falling of the corolla has no effect (B). This is a good illustration of the remark at the beginning of the paper, that the setting of the seeds is affected by the whole *habit* of the flower. Who would have thought that the pollen reaching its stigma could depend on the time and manner of the

* "Darwin on the Dimorphic Condition of the Species of Primula," read before the Linnæan Society, November 21, 1861.

withering of the corolla? But Mr. Darwin's discoveries did not end here. He took upon himself the office of the insects, and became pollen-bearer to his gauze-covered primulas; and the result of his experiments surprised him considerably. He found that when he took pollen from a long-stamened flower (B), and put it upon the stigma of a long-styled flower (A), he got a great deal more seed than when he took pollen either from the same flower, or from another flower of the same form. In the same way, a short-styled flower produced more seed when pollen from a short-stamened flower was put on it, than when it was given either its own pollen or that of another short-styled and long-stamened one. He therefore clearly proved that it is best for primulas, whether they have long or short styles, to have their pollen brought from flowers growing on different plants; and the quantity of seeds produced by many sorts of primulas leads one to think that the pollen is, generally speaking, so brought. The fact of the long stamens in the one form, and the stigmas in the other form, coming to so nearly the same height in their respective flowers, is favourable to this result. Look at figure 115: if a bee has visited B, he must, while sucking the honey at the bottom of the tube, have got his head and the top of his proboscis covered with pollen; now suppose him to fly to A, he will naturally place himself in the same position with regard to the second as to the first flower, and the same part of him which before touched the anthers will therefore now touch the stigma. The use of the similarity of position of the short styles and stamens is not so evident.

This case is, as you see, very different from that of the orchids. It is not impossible, nor even very difficult, with the help of insects, that the pollen of one flower should reach its own stigma, but it is *better for the flower* that pollen from another plant should be brought to it. We may sum this up by saying, it is beneficial to some perfect flowers that they should be diœcious, and their structure *tends* to make them so.

This idea of benefit to the plant in diœciousness introduces a totally new element into the discussion, and makes it both more interesting and more complicated, as you will presently see.

The vast majority of plants are neither actually diœcious like the Vallisneria, nor necessarily so, like the orchids, nor with two forms, pointing to a sort of semi-diœciousness, like the Primulas. They have their stamens and pistil in the same flower, and the obvious supposition is that the pollen of the one either falls, or is brushed by insects, on to the stigmatic surface of the other. "But," it was urged by botanists, "primroses are not different in their whole nature from the rest of the vegetable world; if it be for their benefit that the pollen of *one* flower should set the seeds of *another* flower, the same fact must hold good of other plants." This led to the careful examination of many perfect flowers, which were formerly supposed to have no element of diœciousness in them, and to the discovery of various wonderful devices; for the new theory gives a harder task to the perfect flowers, than even to those which like the Vallisneria have their stamens on one plant and the pistils on the other; in the latter case, they have to provide for the pollen reaching its proper destination; in the former, they have also to *prevent* its reaching its own stigma, which may be called its *im*proper destination.

I will begin by telling you of a simple observation made by Mr. Kitchener and myself. I choose this, instead of the very many more intricate ones which have of late been made known to the world, partly because of its simplicity, but more to show you what easy and interesting work hunting for the devices of flowers is. We were staying among the English Lakes, and spent three weeks in a cottage on Rydal, which was perfectly surrounded with the common yellow musk. Bees and moths were constantly buzzing about among the sweet-scented flowers, which made us think they were probably doing some good to the plants as well as to themselves, for it proved that they found plenty of honey, and the inhabitants of the vegetable world are not more unselfish than those of the animal; they do not provide a plentiful supply of honey unless they are pretty sure to get their *quid pro quo.* Accordingly we picked a good many flowers in all stages of their development, from quite young buds to old and withered specimens, and spent a whole morning in examining them. The musk is a member of the Scrophularia family (see p. 50). It has a united five-lobed calyx, a united five-lobed corolla (fig. 116), with a number of hairs where the tube opens out, four stamens, two longer than the other two, and a two-carpelled pistil, united in the ovary and style, but separating into two stigmas. The first thing that strikes one is the size of these two stigmas (*stig*). Each of them is larger than a stamen, and they are like regular white leaf-blades. Sometimes they are closed one against the other, as in fig. 117; sometimes they are completely open, and the lower one flattened back upon the style, as in fig. 118. Now comes the question, Can the pollen from the stamens fall upon these large, widely-opened stigmas? Fig. 116 shows the relative positions of the stigma and stamens, from which you see that it certainly cannot; for not only is the stigma well above the stamens, but as it is tightly pressed against the back of the tube of the corolla, it is also behind them. We may therefore conclude that we were right in conjecturing that the insects were earning their honey by doing good service to the providers of it; but whether this service is to rub the pollen on to its own stigma, or on to the stigma of another flower, still remains undecided. Let us follow the course of a bee. Fig. 118 is taken from a lately opened flower, in which the stigma is wide open, and the older shorter set of stamens are just beginning to split, while the longer younger pair show no signs

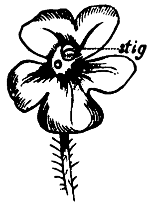


Fig. 116.
Musk flower.

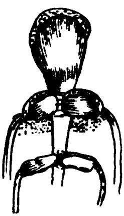


Fig. 117.
Closed stigmas of musk.

of doing so. Fig. 117 is taken from a flower that is beginning to fade: the stigma is almost closed; both sets of stamens have burst some time ago, and the older pair are quite shrivelled up. I cannot vouch for the accuracy of the details of these drawings, such as the exact relative length of the stamens, the manner of insertion of the anthers on the filaments, etc., as they are taken from rough sketches made while we were examining the flowers; but in all matters concerning our present subject, they are certainly correct. Now suppose the bee goes into the withering flower first (fig. 117), he will get in without touching the stigma, for that is closed; but he will rub a good deal of the pollen from the long stamens on his head, or trunk, while he is sucking the honey; and with this he will fly away. If he now goes to a younger flower, as fig. 118, he cannot help, on entering, depositing some of the pollen on its wide flat stigma, which must touch the top of his head as he bends down to suck the honey, or the upper part of his trunk as he unfurls it; and thus his work will have been done, and he will have *cross-fertilized* the flower—*i.e.* he will have brought to its stigma, pollen from another flower. But suppose, on the contrary, the bee had visited fig. 118 first, would he not then equally have put the pollen from its *own* stamens on the open stigma in going out? This question puzzled us for some time, and its solution is very curious. Suppose our bee has no pollen about him at all; there is only one way in which he can conveniently enter the flower, viz. on the wide lower lip (see figure 116), which seems provided purposely as a landing-place for him; in the act of unfurling his proboscis, he must touch the open stigma with his head or trunk; no sooner has he done so, than it shows a curious sort of sensitiveness, like the far-famed sensitive plant, and begins to shut up. Meanwhile, the bee pushes his trunk down the tube; if the flower is only just open, the

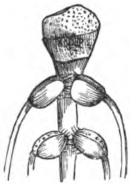


Fig. 118.
Open stigmas of musk.

stamens may not have burst, and in the musk the stigma becomes sticky rather before the stamens send out their pollen; but if, as is more likely, one pair are bursting, as in fig. 118, he is sure to get very thoroughly dusted in his descent, especially as each pair of anthers is slightly held together by the interlacing of little hairs, which serve to hold them exactly in his path. While he has been sucking his honey, the stigmas have been gradually closing, or rather the lower one has, for as far as we could make out, the upper one continues almost stationary. If he has spent from thirty to forty seconds in his feast, it will be quite closed by the time he emerges, and no amount of pollen rubbed on its outer surface will have any effect, as that is not sticky: even if he has finished his meal quickly, the lower stigma will have gone some way towards closing, and will be in such a position, that in his passage out he cannot help pushing against it, and by so doing hastening its closing; therefore from this flower also he will fly away with plenty of pollen to deposit on another stigma, and without having placed one single grain on its own stigmatic surface. I think we may therefore conclude that in the musk the relative position of the pistil and stamens, their slightly different time of becoming mature, the extraordinary size of the stigmas, and their sensitiveness, are all quite as much in order to prevent pollen from reaching the stigma of its own flower, as they are to enable it to get to the stigmas of other flowers; and their combined effect is to render self-fertilization very nearly, if not quite, impossible.

The pea-flower family is a wonderfully rich one in devices for obtaining cross-fertilization. Much has been done in it in the way of observation and experiment by both English and foreign botanists, but a rich field of inquiry is still left unexplored.

If you forget the construction of the flower, you had better turn back to page 13 and read the description of the gorse and pea. We said there that all the wonderful contrivances of these two flowers had "for one end" the preservation of the seed.

We are now ready to understand how many of them serve another purpose at the same time, thus proving that when we have found out a clear use for any special modification in a flower, we must not let our delight at our discovery make us certain that we have reached the bottom of its history.

Pick a bit of the little yellow birds'-foot trefoil (*Lotus corniculatus*) that grows by the road-side in the summer; or if you cannot find this, a sprig of the greenhouse coronilla, from which drawings 120 and 121 are taken, will answer the purpose. Both these flowers have the same contrivances, though it is on the former that Dr. H. Müller's observations are made.*

There are ten stamens, nine with filaments united to form a tube, and one loose like the pea-flower (fig. 119). These stamens are all enclosed within the curiously-shaped keel formed by the two lowest petals, which, in our flower, are slightly united at the top as well as the base.

Fig. 119.
Stamens of garden pea.

The stamens burst, and shed their pollen while the flower is still in bud; after the bursting, the five outermost grow both longer and thicker at the tops, and by so doing push the pollen, which in this flower is slightly moist, into a tight mass at the top of the keel. Fig. 120 shows the compressed pollen through its petal-covering (p). While this has been going on, the flower too has been enlarging and blowing, and by the time the pollen is well pressed up, it stands open and erect, with its bright yellow standard (or topmost petal) expanded, to catch the eyes of any hungry bee,

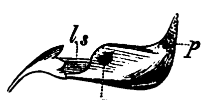


Fig. 120.
Keel of coronilla
(*enlarged*).

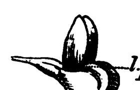


Fig. 121.
Flower of coronilla.

* Die Befruchtung der Blumen durch Insekten, p. 127.

and its two side petals outspread, as if on purpose to afford an inviting landing-place for it (fig. 121, *lp*).

Some members of the pea family do not seem to produce any honey at all, but all those that do store it in the same place, viz. in a narrow rim round the receptacle.*

No sooner does a bee (for these are the insects which most frequent our flowers) enter a birds-foot trefoil, and bend down his head to the little hollow under the big standard, than the platform on which he stands is depressed by his weight, and with it the keel also is drawn down, since the petals forming this are joined to the side petals by curious swellings and hollows, as we saw at page 15. The result of this depression is that the slightly closed keel opens at the top, and the pollen shoots out, not in powder, but in small moist masses, which adhere to the hairy under surface of the bee. As he goes on with his work he pushes his head more forcibly into the narrow space between the standard and the keel, and probably also struggles somewhat in his efforts, thereby depressing still more the platform on which he stands. This further depression not only brings out more pollen, but also causes the long stigma and some of the stamens to protrude, and the stigma is thus pressed against the bee, and rubbed by its every movement. Now if the bee is only just beginning his round of visits to the birds'-eye trefoil, the only effect of this will be that the stigma will be thoroughly covered with its own pollen; but if, as is more likely, he has already been to other trefoil flowers, pollen from them will be rubbed upon the stigma, and the flower will be cross-fertilized.

Supposing that a flower never gets visited by an insect at all, a chance which must happen now and then, the stigma without ever emerging from the keel would still be covered with its own pollen. Whether in this case it would bear less

* This was written before Mr. T. H. Farrer's paper on coronillas appeared in the July 2, 1874, number of *Nature*. He thinks that some species have their nectar in glands *outside* the calyx.

seed (as we saw in the primroses), or what the result would be, is not known, and Dr. H. Müller remarks that good experiments on this point are much to be desired. These should be made by covering several plants with fine gauze while still in bud, and so preventing the access of bees to them.

There are two points in this story to which I wish to call your attention.

(1.) The time of the bursting of the stamens, which is in this flower probably, in many others certainly, before the stigma becomes sticky. It is one of the commonest expedients which flowers have for preventing self-fertilization.

(2.) Many members of the pea family do not produce honey, yet as *most* of them are found to contain honey round the rim of their receptacle, the honeyless flowers are visited by bees who are unaware of their deficiency, and who in their unsuccessful search, do all for the flower that it needs.* It seems likely that this fact may account for the absence of honey in some other flowers, for if a flower gains all the advantage of having honey without the loss of expenditure of producing it, clearly that flower is better without it. On the other hand, it would never do for too many flowers of one sort to cease to produce honey; lest the insects should learn to disbelieve in its existence, and cease coming to hunt for it.

The details of this one pea-flower will help you to examine for yourselves other members of the same family, and you will find it a most interesting work to try to make out the reasons of their various modifications. Sometimes, when there is a loose stamen, there are little holes on each side of it by which, and by which alone, the bee can gain his nectar feast; and in some flowers you will be able to trace how the

Fig. 122.
Dust-spikes of gorse (*enlarged*).

* Entomologists will be reminded here of the deception which the edible Leptalis plays upon the birds by resembling the uneatable Heliconia. See Wallace's Essays on Natural Selection, p. 80; or the Rugby School Natural History Report for 1867, p. 26.

insect is thus induced to place his weight on the exact spot at which it will be most useful for the fertilization of the flower. Again, when there is no loose stamen as in the gorse (fig. 122), the whole structure of the flower is often so arranged that if there were one it would be evidently useless. Sometimes the pollen shoots out in tight moist masses, as we have seen; sometimes it puffs out in clouds, as in the gorse, and the suitableness of both these methods for the special flowers in which they are found is not hard to make out. Generally it is the hairy under surface of the bee which carries the pollen; sometimes (*e.g.* in the scarlet runner) the keel with its precious freight is twisted spirally, so that the sticky stigma rubs the back of his head and clears him of foreign pollen; and *after* this some collecting hairs lower down on the style give him a fresh load to carry to another flower. All this and very much more you can see for yourselves in the flowers.

I will finish this chapter with telling you as shortly as possible some of the contrivances of a very different family from the pea. These have been discovered separately by Hildebrand* in Germany, and by Dr. Ogle in England,† in several species of Salvia.

Salvia splendens; a beautiful flower of a delicate shape, and with sepals of almost as brilliant a scarlet as the corolla, is the one from which the illustrations are taken. It is not mentioned by Dr. Ogle, but very slight modifications make his observations suit it. Any sort of Salvia will do for my readers to follow the description with. They all belong to the Labiatæ, *i.e.* they are of the same family as the

Fig. 123.
Flower of Salvia splendens.

* "Die Geschlechter—Vertheilung bei den Pflanzen."

† "The Fertilization of Salvia, and of some other Flowers," by William Ogle, M.D., published in the July number of the *Popular Science Journal* for 1869.

white nettle, and have like it the curious four-seeded ovary, which we noticed in a former chapter (p. 62), and a long thin style divided into two curling stigmas. In fig. 123 you see the five-lobed corolla with its lowest petal rounded and outspread to afford an inviting landing-place (LP) for bees and other insects. The stamens are quite different from any we have examined. Instead of the normal number of four, there are only two which bear any pollen, the other two having in our flower quite disappeared; even when they are visible they have diminished into little threads, with nothing like an anther between them. The two pollen-bearing ones are also so strangely modified as to be hardly recognisable; each of them is fastened to one of the side lobes of the lower lip of the corolla (fig. 124); they have short strong filaments (*fil*), and then, instead of an ordinary two-lobed anther, they have an enormously long connective (*con*) with one anther-lobe at the top, and in the flower before us nothing but a slight swelling (*l.an.l.*) at the lower end of the connective, where the other anther-lobe should

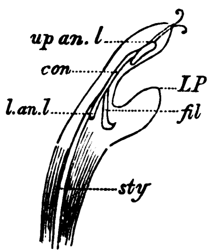


Fig. 124.
Section of Salvia splendens.

be. Thus, instead of four stamens, each bearing its double-lobed anther, we find only two lobes altogether. These two, however, as if to make up for the deficiency of their brethren, are most profusely supplied with pollen. Fig. 125 is a front view of the two stamens, and shows how the lower useless ends of the connectives are joined together. Now let us consider all this curious mechanism with regard to its position and use in the flower. Suppose a bee to light on the lower lip of fig. 123, LP. The honey is secreted at the base of the tube, which in this flower is so long that he cannot stand still,

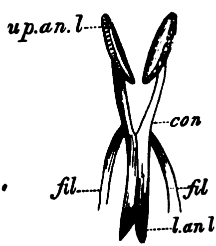


Fig. 125.
Front view of Salvia stamens.

as on the musk, and extend his proboscis to the glands, so he is obliged to force his way down the tube. He does not touch the forked stigma in doing so; that is stretched out far above him, and the upper anther-lobes are also snugly tucked into the overhanging upper lip, and apparently quite out of his way; but the lower end of the connective (fig. 124, *l.an.l.*) is directly in his way, and he cannot fail to hit it with his head. Figs. 126 and 127 will show you what the effect of this will be; the upper anther-cells will come round with a swing and hit the bee full on the back, just as the bag of flour or sand used to do in the old game of quintain, which our forefathers played at in the reigns of the Plantagenets; and in the case of the bee the result will be the same—he will come away with a very dusty back. You can easily see the effect of trying to push a pencil down the tube of the corolla; it will touch the lower end of the connectives, and the result will be the same as in fig. 127. The bee having done his feast, will back out of the flower in the queer way common to bees, and will no more touch the stigma than he did in going in. However many flowers he visits of the same age as the one we have been describing, the effect will be the same—he will get more pollen and part with none; but at last he is sure to enter an older flower, and when he does so the case will be quite different; for the style grows on, increasing in length after the flower has blossomed, and as it is from its position obliged to grow in a curve, its stigmas soon hang down in front of the entrance of the flower, as shown

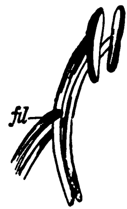


Fig. 126.
Side view of Salvia stamens.

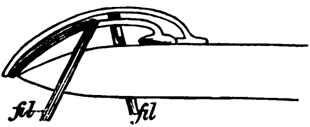


Fig. 127.
Action of Salvia stamens.

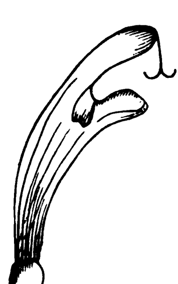


Fig. 128.
Older Salvia flower.

in fig. 128. When a bee tries to enter a flower in this stage the result is obvious, his be-pollened back must touch the bending stigmas, and leave on them some of the trophies of his game of quintain, and so he will have done his work, and cross-fertilized the flower.

I might multiply indefinitely wonderful stories of this kind, both from the papers of Dr. Ogle and of many other writers both foreign and English; but I think I have said enough to show that there is reasonable ground for supposing that cross-fertilization by means of insects is the rule rather than the exception among flowers.

You may be inclined to ask, "Why, if the advantage of a flower being diœcious is so great as to be worth all these wonderful contrivances, is not the matter made a certainty by the stamens always growing in one flower and the pistil in the other, as in the Vallisneria?" There are several objections to this.

(1) According to the present plan the number of stamens and pistils being double of what it would then be, the chance of cross-fertilization is much greater; (2) In case bad weather should keep the insects away at the proper time, it is better that there should be a chance of the flower having a little seed set by its own pollen, as in the case of the long-styled primrose; and (3) There is reason to think that there are some flowers, as the white nettle, which blossom all the year round, and which, while in the summer they are fertilized by insects, in the winter never thoroughly open, and by their bud-like shape force the stigmas down to the bursting anthers, and so get their own pollen and set some seed.

The next chapter will be on the first growth of seeds, and I should advise my readers to prepare their specimens beforehand. Broad beans and some Indian corn should be put in water to soak, and some mustard-seed sown on wet flannel. Some of the beans should be soaked only for a day or two; others should be put in water about a week before they will be wanted.

CHAPTER VIII.

ON SEEDS.

SPECIMENS wanted—*Soaked broad beans; nuts; almonds in the shell; hemp-seed; mustard-seed sown on wet flannel; soaked Indian corn.*

We have now become acquainted with the most important parts of the grown-up life of a plant. We have seen it in bud, in flower, and at seed-time, and in all these stages of its career we have remarked how the well-being of its descendants rules its growth and habits. We have now to study these descendants in their infancy.

Those of my readers who have followed the advice given them at the end of the last chapter, will have broad beans and Indian corn soft and swollen from soaking. Some of the beans will be only slightly enlarged, while others will have burst their brown covering, and sent out white sickly-looking leaves and roots. Let us take one of the first-mentioned of these, and see what we can make out about it. (Should you have omitted to put any seeds to soak, you can make them fairly fit for examination in a short time, by pouring boiling water upon them; and I strongly advise you to do this, as this chapter is quite useless unless the descriptions are followed in the living seeds. The illustrations are only meant to indicate what you are to look for in these.)

You have before you (fig. 129) a large brown seed, much thinner at one end than the other, with a long black mark at the thick end (*scar*), which is considerably depressed, and has the effect of dividing the bean into two ears. The scar is left by the separation of the bean from the little stalk which originally acted as nourishing cord, as you see from fig. 130, which shows a bean still attached to the seam of the pod. Now press the bean between your finger and thumb; at one end of the scar you will see a small drop of water ooze out. You should hold your bean with the scar pointing to your right, and with the water oozing from the *lower* part of it, *i.e.* in the same position as is represented in fig. 129. If you now dry it, and look carefully at the spot from which the water came, you will be able to find the tiny hole, like the prick of a pin (fig. 129, *lg*) through which it emerged. Just below this, and pointing exactly towards it, you may also notice what seems to be a triangular swelling below the skin (*rad*). Turn to the other end of the scar, and you will see there too a slight protuberance of a cord-like shape (fig. 130, *ft*). running along the edge of the bean for about an inch, and ending in a round discoloured mark (*fh*). You may also see (though this is not shown in fig. 130) that this cord-like swelling is continuous with one of the same size and shape, which starts from the seam of the pod (*pl*) and runs down one side of the short stalk into the bean.

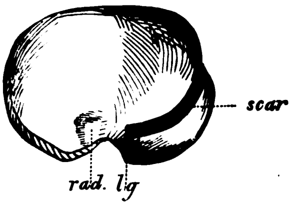


Fig. 129.
Soaked broad bean.

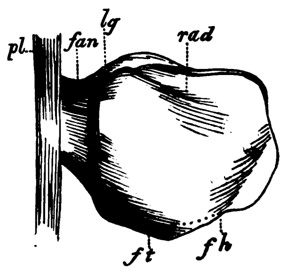


Fig. 130.
Broad bean attached to the pod.

Now remove the covering from your bean, being careful not to injure its contents. The skin is thick, and, as you will find by scraping it with your knife, really double, the outer skin being brown and leathery, the inner white, and as fine as gold-beaters' skin. It is important to be quite clear about the relative positions of the skin and its contents. If you find yourself confused about this, when you have laid down the skin of your first bean, you must start afresh with another. The black scar which we noticed is in the outer skin alone. The reason of the triangular swelling is evident enough, as a strong white shoot is now apparent, fitting into a neat little pocket in the skin; but on turning to the other side of the bean, we see nothing in its smooth white surface to account for the cord-like protuberance which we noticed there. Evidently then, this must be, like the scar, only skin-deep. Look carefully at the covering which you have taken off, and you will find between the two skins, or rather, in the outer of them, a tiny tube running from the scar to the discoloured mark (fig. 130, *fh*). This is in fact a feeding-tube (*ft*) starting from the pod, going down the seed-stalk, and then along the edge of the bean; and through it enough nourishment passed, while the bean was still on the parent plant, to change it from a small shapeless lump into the large healthy seed before you. The discoloured spot, or *feeding-hole* (*fh*) is the place where the tube ended, and the nourishment passed through the inner skin into the white substance of the bean itself. The hole at the other end of the scar (fig. 129, *lg*), which also does not go beyond the skin, is necessary for the welfare of the bean in another way, as through it the fructifying pollen-tube passed, which we have found to be essential to the existence of every sort of seed.

Now we will return to our bean: the brown skin is gone, and we have before us the young plant pure and simple. Its separation into two is plainly marked, and two short hinges on either side of the shoot are visible, joining this to the main seed. Try to divide the bean by putting your knife into the line apparent between the two ears; it will separate easily, and you will see that it is made up of two lobes flattened on the inside, and nowhere united, except by the two short hinges. Pull open these lobes (as is done to a growing pea represented in fig. 131) being careful not to burst their hinges, and you will see inside, lying in a hollow formed by an indentation of each lobe, another white shoot, much smaller than the triangular one outside, but evidently continuous with it. Fig. 132 represents one lobe of a bean with the shoot lying in its cradle. Cut both thick lobes off by their hinges, and examine the shoots carefully; the upper one, though so small, is clearly composed of leaves curled one round the other, while the lower one (*rad*) is solid and made of stem alone. Now try to find a bean which has begun to grow, and see what changes it has undergone (fig. 133). The brown skin has burst, the two lobes have come slightly apart, the shoot has pulled itself out from between them, grown longer, its miniature leaves have become more defined, and probably are beginning to unfold. The other shoot too has lost its triangular shape, has greatly lengthened, and is beginning to throw out a few white fibres, which prove it to be, as you have doubtless already guessed, the root-bearing part of the plant. Here then is a perfect plant—leaves, stem, and root, complete. But what are the two flat lobes which formed more than three-quarters of the seed? They are our old friends—leaves, turning up in a new capacity, as storehouses of nourishment for the infant plant. Look at them in the different beans before you, and you

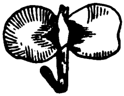


Fig. 131.
Split pea seed.

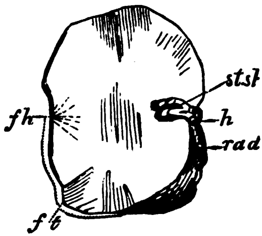


Fig. 132.
Half a broad bean.


Fig. 133.
A growing broad bean.

will see them thinner in proportion as the shoots are longer; the reason of this is that these shoots have fed upon them, and imbibed their substance through the hinges (fig. 132, *h*) or stalks which we have noticed.

It seems curious that the leaves, which are themselves part of the plant, should serve it for food, but the fact is not without analogies in the animal world. If any of my readers have kept dormice, they must have noticed how large and fat they are in the autumn, and how thin and starved-looking when they wake in the spring time from their long sleep. This is because, being unable to use their mouths when sleeping, they have fed upon themselves during the winter. They do not need much nourishment while they are asleep, but what they do need, they get from their fat little selves.

Our bean when it begins its life is in somewhat the same position as a dormouse in the winter—it needs food, and has no mouth to eat with. Accordingly, it lives upon the food stored up in its thick seed-leaves, till it is provided with the fibrous roots which may fairly be called its *mouths*, and the green leaves which serve it for digestive organs.

We have now, I hope, gained some idea of the formation of the bean, and the uses of the different parts of its seed; but as the modes of packing the young plant into the seed are almost as diverse as the ways in which seeds are arranged in their pods, we must examine a good many before we can form an adequate general idea of the infant life of plants.

First of all, seeds are divided into those which have two lobes or *seed-leaves*, as the bean, and those which have only one. For the present we will confine our attention to the former of these classes.

The essential points to be noticed in seeds are two: (1) their manner of growth in the ovary; (2) their manner of packing into their skins. With regard to the second of these points, viz. the packing of the plant, there is an important general rule, which is that the *radicle* (*i.e.* the triangular shoot which eventually bears the roots, fig. 129, *rad*) always points to the little hole through which the pollen-tube passes (*lg*), while the upper shoot points to the *end* of the feeding tube (fig. 132, *fh*), *i.e.* to the spot at which the nourishment leaves the tube and becomes dispersed in the lobes. The position of this hole for pollen, or *micropyle* (little gate), as it is called by botanists, differs greatly in different seeds, and of course influences the whole packing of the plant in the seed-skin.

Nettle Seed.—The common stinging nettle is one of the few plants which has the simplest possible arrangement, both as to arrangement of the seed in the ovary, and also in the interior packing of this seed. I am afraid you will have difficulty in finding and examining nettle seeds, and must therefore trust to fig. 134 for helping you to understand their structure. It represents a vertical section of the fruit of the nettle. The ovary is one-seeded, and the point of attachment of the seed, *i.e.* the point where we should find the *scar* if the seed were taken out, is exactly at its base. The "little gate" (*lg*) points in the opposite direction, *i.e.* towards the stigma at the top of the ovary. When the scar and little gate are thus arranged, the seed is said to be *erect in the ovary.* The best definition of an erect seed is, that "a straight line can be drawn through its scar and *micropyle* (little gate), which shall pass through the stigma."

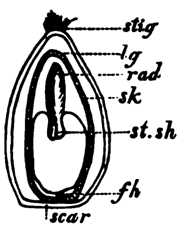


Fig. 134.
Section of nettle fruit
(*magnified*).

We can now put the ovary out of our heads, and consider the way in which the future plant is packed into its coats, which in fig. 134 are represented by two lines with little bars between them (*sk*). This also is very simple in our nettle. The outer shoot or *radicle* (*rad*) must, as you remember, point towards the little gate; this is here exactly at the top of the seed (*lg*); it therefore does so without being obliged to curve as in the bean. The stem-shoot must also point to the feeding-hole, *i.e.* to the spot at which the nourishment from the parent plant enters and becomes dispersed in the seed-leaves. In the bean, the stem-shoot pointed to a spot some distance from the scar; (see fig. 132, (*fh*), where imaginary nourishment is shown entering the seed-leaf); it was therefore necessary to have a feeding-tube to convey the nourishment from the end of the scar to this spot. In the nettle, on the contrary, the stem-shoot (*st sh*) points exactly to the scar, there is therefore no need of a feeding-tube, and accordingly we find none. Evidently, then, the packing of the nettle plantlet in its seed is very different from that of the bean. We can draw a straight line from the scar, which shall pass through the feeding-hole, the stem-shoot, and the radicle; whenever this is the case, the plantlet is said to be *upright*. Therefore in the nettle not only is the seed *erect in the ovary*, but the plantlet also is *upright* in the seed. You must be very careful not to confuse these two things, which are perfectly distinct, though in the present instance they happen both to be met with in the same seed. You should notice that in the nettle the stem-shoot will not pull itself out from between the seed-leaves, as we saw it do in the bean, but the two seed-leaves will part to allow it to grow up between them, and it will feed upon the thickness of these leaves in precisely the same way as we have before noticed.

Hazel Nut.—Now we will leave the nettle, and return to our old friend, the hazel nut. You will have no difficulty in getting plenty of these for examination. Hitherto we have only studied the fruit (page 81), now we will see what we can make out about the contents of that fruit. The hard shell is, as you know, composed of the calyx and two carpels, which have become entirely joined together. The black mark at the bottom shows where this fruit was joined to the stalk. Crack its shell, and you will find inside one seed or kernel, the only survivor of the four which were originally present. It is attached almost at the top to a long fibrous cord (fig. 135, *ax*), which you will probably mistake for the seed-stalk. It is really the axis of the pistil, which used to be in the middle of the ovary with four seeds joined to it, but which is now, by the undue size of the one seed, broken off from the ovary, and pushed out of place. What is the position of our seed in the ovary? It is not fastened at the base, it cannot therefore be *erect*. Its place of attachment is almost at the top; it is therefore said to be *pendent in the ovary*. And the little gate (*lg*) is at the top of the scar which marks this place of attachment.

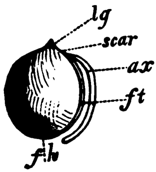


Fig. 135.
Seed of hazel.

Now pour boiling water on your nut, and let it soak for a few minutes; at the end of that time you will be able to scrape off the curiously veined outer skin, and will find still left the thin inner coat, which in the bean we compared to gold-beaters' skin. Take this off also; you will find a minute shoot at the top of your nut, evidently the *radicle* (fig. 136, *rad*), and running from it on either side is a faint line, which shows where the two lobes may be separated. They are not really joined, but their having spent a long time in a hard inelastic shell has pressed them very close together, and made them much harder to get apart than in the bean. When they are separated, you will find lying between them, and pointing exactly downwards, a tiny stem-shoot (*st sh*) proportionately much smaller than in the nettle, but nevertheless unmistakable. Remembering our old rule about the stem-shoot pointing to the feeding-hole (*fh*), we know that this must be at the bottom of the seed. We also know that the nourishment entered the skin-coats by the stalk which united it to the pod (fig. 135, *scar*). There must therefore in this seed be a feeding-tube to convey it from the scar to the spot at the bottom. In fig. 136 the course of this feeding-tube

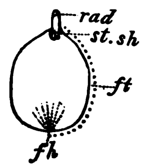


Fig. 136.
Half of hazel seed.

is marked by a dotted line outside the seed-leaf (*ft*); it is of course impossible to see it really, as we know it to be imbedded between the two skins, which are removed. Now compare the packing of this plantlet with that of the nettle. There we could draw a straight line from the scar through the end of the feeding-tube, which should also pass through the whole plantlet, and end at the tip of the radicle. Here we can do nothing of the kind, so it cannot be *upright*. In the nettle the stem-shoot pointed exactly to the scar, and was opposite to the radicle and little gate; there was therefore no need of a feeding-tube. Here we find just the contrary. The little gate adjoins the scar, the stem-shoot points in the opposite direction, and a feeding-tube has to run the whole length of the seed. This sort of plantlet is called *inverted*, because it is just contrary to the arrangement of the *upright* plantlet. The inverted is the commonest of all ways of packing the infant plant, and is not always easy to recognise, as there are various modifications of it. You should, however, notice that in the plantlet itself there is no curve; the stem-shoot being the direct continuation of the radicle. Perhaps its simplest definition is, "having a feeding-tube, and the two shoots being uncurved."

Almond.—The almond is a very pretty example of this same sort of seed, and by reason of its larger size is much easier to examine than the nut. It belongs to the rosaceous family, and the fibrous husk which you must take off is the same part of the fruit as the stone in the apricot, cherry, etc. (p. 75). This, the fibrous endocarp, being removed, you find a large oblong seed (fig. 137) with a long scar near the top, showing where it was attached to the husk. Its position in the ovary is then, like that of the nut, *pendent*. It clearly has a feeding-tube also, for you can see its cord-like swelling running from the base of the scar to

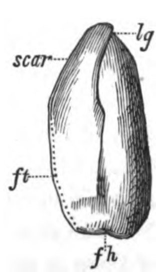


Fig. 137.
Seed of almond.

nearly the bottom of the seed (*ft*), where the end is made visible by a curious sort of darkening and contraction of the skin. Now blanch your almond, and divide its two seed-leaves, one of which is considerably larger than the other. You will find the stem-shoot (fig. 138, *st sh*) cradled most cosily between the two leaves, but as the radicle points not exactly to the top of the seed, but rather to one side of it, the whole plantlet lies somewhat diagonally. The reason of this is that though the little gate was *near* the scar it did not join it (fig. 137, *lg*), and the effect of this is to shorten the feeding-tube by the same distance as the little gate is from the scar. Nevertheless, as there is a feeding-tube, and the plantlet is not curved, it comes under our definition of *inverted.*

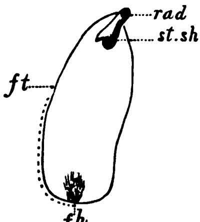


Fig. 138.
Half of almond-seed.

The Hemp.—In the third type of seed, both holes, viz. the feeding-hole and the little gate, are close together. When this is the case, the plantlet is bent round upon itself, as both its shoots have to point to the same place. The bean was an example of this; but not a perfect one, as in it there was a feeding-tube, and the stem-shoot pointed to a spot at some distance from the scar. In a perfectly *curved* plantlet, as this arrangement is called, there is no feeding-tube.

The hemp-seed is a very good one for us to look at, and if any of my readers keep canary-birds, they will be sure to have some at hand. What we call the hemp-*seed* is in fact the whole fruit, and you had better pour some boiling water on this to enable you to get the husk off without injuring its contents. You will find one seed, wrapped as usual in two coats; the outer of these is green, the inner white and transparent. You will not be able to see any signs of the seed-stalk, which was exactly at the top of the seed, and attached it to the top of the ovary. The seed is then, as in our two preceding examples, *pendent in* *the ovary.* The two coats will easily come off, and you will then have a plantlet with two seed-leaves folded rather differently from those we have hitherto seen. Fig. 139 shows it, somewhat magnified, lying in its coats, which have been carefully cut, their contents being left whole. The scar is at the top, the little gate (*lg*) and the feeding-hole (*fh*) are close together, both of them adjoining the scar. We know that the radicle must point to the first of these, the stem-shoot to the second; it therefore follows that both shoots must point to nearly the same spot, *i.e.* be *curved* in upon each other. Pull off the outer of the two seed-leaves by breaking its hinge, and see whether the direction of the stem-shoot answers our expectation. You see it plainly, though it is so small, lying in the cradle of the remaining seed-leaf, growing from the unusually long radicle (fig. 140), and curled round so as to point at the end of the radicle. If you put it under a microscope, you will be able to see two beautifully perfect leaves of the future plant cut into teeth at the edges, and covering the bud, which will hereafter develop into other leaves and stem and flowers.

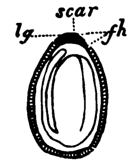


Fig. 139.
Seed of hemp with the skin cut (*magnified*).

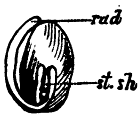


Fig. 140.
Half of hemp-seed (*magnified*).

Of course there is no feeding-tube to the hemp; the feeding-hole is close to the scar, so there is no occasion for it.

You have now examined the three types of plantlet, viz.—

The Upright.—When a straight line can be drawn from the scar to the little gate, which shall go through the whole length of the future plant (see fig. 134).

The Inverted.—When a feeding-tube is necessary to convey the nourishment from the parent plant to the feeding-hole, *i.e.* to the spot opposite the stem-shoot. In this type the plantlet itself is straight (see figs. 135 and 137).

The Curved.—When the plantlet is bent round upon itself, so that both shoots point towards the same spot. The hemp (fig. 140) is a perfect example of this; the bean (fig. 132) an imperfect example.

To one or other of these types you ought to be able to refer the seeds of all *dicotyledons;* this word is constantly used by botanists, and comes from *di-*, two, *cotyledon*, a seed-leaf.

There are, however, two more things to be noticed before leaving this large *class* and considering the other, and in England much smaller, class of *monocotyledons*, or plants with *mono-*, one, *cotyledon*, seed-leaf.

First. We have spoken as if the thick seed-leaves had only one office, viz. that of storing up ready prepared food for the young plant, till it had root enough to suck in, and leaves enough to digest, other food for itself. In most of the seeds which we have examined this has been their only office, and, it being done, they decay—never having come above the soil at all. Sometimes, however, these very seed-leaves, after they have been thinned by feeding the plantlet, themselves come above the ground, turn green, and begin their work of digestion. They do this when they are either not fat enough originally to last the plant for any length of time, or when the plant is a slow grower and thus takes a long time before its stem-leaves have expanded. Whether the seed-leaves come above the ground or not, depends upon whether the plantlet lengthens *below* as well as above its two hinges. In the bean (fig. 133) it lengthens above only, and therefore, as we have seen, the seed-leaves are never moved from their original position But look at the mustard-seed, which I advised you to sow on wet flannel; you will find each plantlet with the seed-leaves entirely out of the seed-coats, unfolded, just below the stem-shoot, and, in fact, forming the first leaves of the future plant (fig. 141). If you examine a just expanding mustard-seed, you will be puzzled to see

Fig. 141.
Seedling of mustard.

a *curved* plantlet with apparently *four* thin seed-leaves; but watch the plant a little longer, and you will see the four unfold into two, and turn into the round leaves which we eat in "mustard and cress." You will instantly recognise those plants whose seed-leaves come above ground, for they are always round, smooth-edged, and unlike the ordinary leaves of the plant. A young sycamore, laburnum, or maple tree, is a good example of this.

Secondly. All the seeds which we have examined have been composed wholly of two shoots, the one ascending (stem-shoot), the other descending (root-bearing), and of two seed-leaves, which last form the principal part of the seed. But this is not always the case. Sometimes the seed-leaves are quite small in proportion to the rest of the seed, and then some other food besides that contained in them must be provided for the young plant. The violet is a good example of this (fig. 142). The seeds grow in an ovary formed of three carpels, having parietal placentation (see page 58). Their position in the ovary is neither *erect* as in the nettle, nor *pendent* as in our other examples. They are fastened to the sides of the ovary, and point straight in to the middle; they therefore deserve their name of *horizontal in the ovary.* If one of these is cut through the middle, it will be found to have a straight plantlet, its radicle pointing to the scar, and a long feeding-tube (*ft*) conveying the food from the parent plant to the spot towards which the stem-shoot points. You cannot see this stem-shoot, but its direction is indicated by the two little cotyledons (*cots*); and it clearly belongs to the type of *inverted* plantlets. But the whole thing, seed-leaves, stem-shoot, and radicle, does not half fill the seed-coats. The rest of the space is occupied by a white starchy substance, which becomes soft as soon as the plant begins to grow,

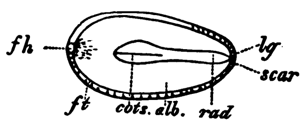


Fig. 142.
Section of violet seed (*enlarged*).

and is sucked in, not through any special place, but through the whole surface of its tender young skin. This starchy substance not only performs the same office as the white in a bird's egg, which nourishes the chick while in the egg, but is formed of as nearly as possible the same constituents. It is therefore known by the name of *albumen*, or white of egg (*alb.*)

Now we may leave the seeds of dicotyledons, and spend a few minutes in looking at those of monocotyledons.

Take your soaked Indian corn, or if you have not provided any, have some boiled for about half-an-hour. The seed is chiefly made of what looks outside like yellow horn, but on one side of it you will see an oblong white marking, showing the presence of some different substance under the skin. This is the young plant, which resembles the violet in having all the rest of the seed made of the albumen on which it is to feed. Try to get this little plant out by cutting the skin round it with a sharp knife, and then pressing the seed with some force. You ought to get a thick triangular body (fig. 143); and if you poke it about with your knife, you will find on its flat side (*i.e.* the side which was visible through the skin) a small shoot. The main part of this triangular body is composed of the one thick cotyledon (*cot.*) The little shoot is the future stem (*st sh*), which is continued very faintly in the other direction into what, for the sake of convenience, we may call the radicle (*rad*). Now take another grain of Indian corn, and cut through the middle of its white mark. You should get a section like that represented in fig. 144, showing the white floury albumen, which lies beneath a layer of horny substance, the one seed-leaf, which is different in colour as well as consistency, and the little shoot lying along the skin in one corner

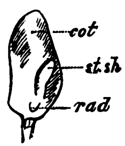


Fig. 143.
Plantlet of Indian corn (*enlarged*).

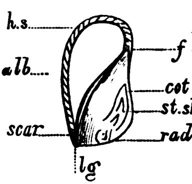


Fig. 144.
Section of Indian corn (*enlarged*).

of this seed-leaf. The black scar is very apparent, near the base of the seed, but rather to one side of it. The little gate (*lg*) is at the lower end of this, towards which the radicle points. The stem-shoot is composed of several leaves, fitting one inside the other, and points in the opposite direction to the radicle. The feeding-hole (*fh*) must therefore be at some distance from the scar, which proves the necessity of a feeding-tube, and our plantlet must belong to the common type of *inverted*. Look at wheat which has been sown some time. You will find the stem-shoot lengthened and sending out leaf after leaf, each one curiously sheathing around those younger than itself; but the radicle will not have lengthened at all. It will have remained in its former place, and several roots incased in soft covering will be found growing from it.

We have now found three differences between dicotyledons and monocotyledons: (1) the former have two, the second one seed-leaf; (2) monocotyledons have no proper radicle; (3) the leaves of dicotyledons are net-veined, of monocotyledons parallel-veined (page 30).

In our next chapter you will see the differences between the radicles of dicotyledons and monocotyledons more plainly.

CHAPTER IX.

ON EARLY GROWTH AND FOOD OF PLANTS.

SPECIMENS wanted—A plant of *groundsel;* a young plant of *goose-grass;* a young plant of *wheat.* Freshly picked *laurel* leaves. Pulp of a ripe *orange.*

In our last chapter we looked at plants in their infancy. We pulled off their winter wraps, and saw them cradled in their hollowed-out seed-leaves.

Now we will examine some older plants, and see what changes they have undergone while growing up.

Pull up the largest groundsel plant you can find. In the mass of branches, leaves, flowers, and roots before you, it is not easy to see what has become of the simple plantlet, encircled in its nursing leaves, and consisting of its one ascending and one descending shoot. The first resemblance to strike one is, that here too we have the ascending and descending mode of growth, even more plainly marked, for all the branches point upwards, while all the roots pierce their way down into the earth. Let us look at another plant, not so far removed from its infantine stage. A bit of young goose-grass (fig. 145) is very good for examination, and you will be sure to find plenty in any hedge or garden, or coming up in the pots of any green-house. Here there will be no difficulty in recognising the different parts of our plantlet. The two large leaves (*cot*) hanging down their heads, and beginning to fade, are the seed-leaves, like those which we last month saw in the bean, nut, hemp, etc. In the goose-grass they have come above ground, and done their duty as the first leaves of the plant. All that you see above these belongs to the stem-shoot, which in the seed was curled up between them. As to the long straight stalk below these seed-leaves, different botanists give it different names; some call the whole of it *radicle,* without making any distinction between the part that does, and the part that does not, bear roots; others keep the name of radicle exclusively for the root-bearing part at the end. I think the simpler plan is that of the older botanists, viz. to include all growth below the seed-leaves under the general name of radicle (as we have done in the last chapter), and to consider that this radicle consists of two parts, viz. of the stalk, bearing neither roots nor leaves, which we will call *stemlet* (*st let*), and of its continuation into the *main root,* which will branch out and bear many lesser roots (*mr*). Between these two parts of the radicle you may often see a twist or slight swelling in the stalk, which betokens a change in its structure. This is called the *collum* or neck of the plant (*col*).

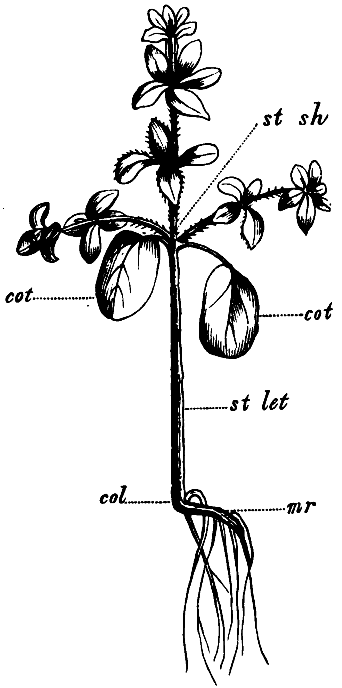


Fig. 145.
Young plant of goose-grass.

Now return to your groundsel. All the branches, stems, and flowers, evidently spring from one main stem. This in its infancy was a stem-shoot lying between two seed-leaves. In some groundsels you will find the radicle consisting of a short *stemlet*, and an exceedingly branched *root;* in others the stemlet will be entirely wanting, and you will have the *col.* immediately between the leaves and roots. If you put one of the smallest of these roots under a microscope, you will see that the greater portion of it is bare and stringy-looking, but that nearly at the tip it is furnished with most delicate white fibres.

Now pull up a young plant of wheat, about the size of the one represented in fig. 146. One glance at the straight parallel-veined leaves will assure you that it belongs to the class of *Monocotyledons*—*i.e.* it had but one seed-leaf to take care of it during its infancy. Compare your wheat with the section of Indian corn we made in our last chapter (p. 142, fig. 144). You there saw a stem-shoot composed of several leaves folded one within the other, and a much larger fatter seed-leaf or *cotyledon* wrapping round the whole. The cotyledon is not to be seen in the plant before you, as it remained in the seed-coats and there decayed; but the leaves which are now so long and green, are the very same which might have been seen a few weeks ago wrapped

Fig. 146.
Young plant of wheat.

round in the seeds, and as you may notice, they have not, even now, completely unfolded. The seed-skins of the wheat-seed are still attached to the bottom of its stalk, but they are quite emptied, not only of the young plant, but of the albumen which served to fill the greater part of them. It has all become soft, and helped to feed the plant before you.

Now compare the wheat plant with that of the goose-grass which you have just examined, and which you know to be a *dicotyledon*. There are a good many differences. That had a regular branching main-stem, with leaves growing two or more at a node. The stem of the wheat seems to be principally formed of enfolding leaves even to its base, and it shows no signs of branching. Below the seed the differences are still more striking, for the radicle is wholly wanting, there is neither stemlet nor main root. The stalk ends abruptly at the bottom of the stem-shoot (*st sh*), and through its tip (*col*) a number of roots push their way, all equal in size and length. If you put one of these under a microscope, you will find it softer and more fibrous than those of the goose-grass, and you will also see that it is provided with a sort of sheath at the top, where it protruded from the stem.

We have now examined plants as well as seeds belonging to the two great classes of dicotyledons and monocotyledons, and have seen that the same peculiarities which we noticed in the one, are also apparent in the other; *i.e.* we have found that the chief change which a plant undergoes in growing up, is the self-evident one of becoming greener and larger.

This brings us to another and very important question, though it is one which I have only space to touch upon slightly. What makes a plant get larger? We are so accustomed to see the growth of plants daily and hourly going on around us, that it requires some little thought to realise what a wonderful thing it is. We put a seed into a pot, we water it, and expect that in due time it will send up its leaves and stem, and eventually flowers; but what should we say, how should we express our wonder, if the greatest chemist in the world were, out of a handful of earth and a little water to make—I will not say a perfect plant—but anything like a single leaf? Just at first, as we have seen, the seed was nourished by food stored up either in its cotyledons, or outside them within the seed-coats, in the form of albumen; but this was soon disposed of, and afterwards, what was there for the plant to live on, what *could* it get at but earth and water and air? Even here the wonder is not ended, for supposing the plant can do with no other food but these, *how* does it live on them? We can account for the growth of animals, because we see them eat, and know that their food is chemically acted on and turned into blood, flesh, etc.—but who ever saw a plant eat? What has it that can serve it for a mouth?

First—as to what the plant lives on. We have seen that earth, air, and water, are the only things a plant can get at, from which it follows that it must live on them, *i.e.* it must have the wonderful power of taking in some part of its surroundings, and turning this into stem, leaves, etc. The only other way in which its growth would be possible, would be to suppose it endowed with the power of creating itself out of nothing, which is manifestly absurd.

We will, for the moment, put the earth out of the question, and consider the water and air, what they are made of, and how they can possibly nourish the plant. This phrase, "what the air is made of," requires a little explanation. Every animal, vegetable, or indeed almost everything we see around us, is a compound organism, *i.e.* it is so made as to be capable of being separated by chemistry into various component parts. When anything is no longer capable of being separated, it is said to be an *element.* In the present state of science only sixty-four elements have been discovered. Everything therefore in the world, whether animal, vegetable, or mineral, is compounded of these, or is itself one of them. It is a wonderful thought, that all the innumerable forms we see around us are reducible into so small a number of materials; but it is still more wonderful that the main part of every living organism, whether animal or vegetable, is made of only four elements, and that no animal or vegetable exists in which these same four cannot be found. That is to say, that in the main the same materials are used in the formation of a jelly-fish as of a fir-tree, of a sea-weed as of a horse, the *proportions* in which they are found, and the ways in which they are combined, constituting the enormous differences between them. These are called the *organic elements;* and if we can find them existing in the air and water, we shall be somewhat nearer to understanding how it is possible for plants to be nourished without having access to any other food: we shall see, too, how it is that animals (though having the same constituents) are unable to live in the same way as plants.

Air, when perfectly pure, consists of two elements, viz. oxygen gas and nitrogen gas: these are nearly in the proportion of one part by bulk of oxygen, to four parts of nitrogen gas. They are in no way combined, but are both said to *pervade* the atmosphere. Oxygen is a colourless, tasteless gas, without which no animal life is possible even for a few minutes. The presence of oxygen may be ascertained by seeing whether a candle will burn, the flame being really a sign that oxygen is combining with something else. Thus when a taper is put down into a mine or pit, it is seen by the way in which it burns whether there is a sufficient quantity of oxygen in the air for a man to be able to live in it. Nitrogen is also a gas, a small quantity of which is soluble in water.

Water is also made of two gases, *oxygen* and *hydrogen*, in the proportion of eight parts by weight of oxygen, to one part of hydrogen. These two gases, unlike those which *pervade* the atmosphere, are regularly *combined*, as is seen by their forming a matter so different from both of them as water.

Hydrogen gas is hardly ever found in a free state; when wanted for chemical experiments, it is obtained by abstracting it from water.

We have now mentioned the only three elements to be found in perfectly pure air and water, viz. oxygen (which is found in both), nitrogen, and hydrogen. Let us therefore turn to plants, and see whether the same constituents may be traced in them also. Take any plant you like, and burn it—presently you will find nothing left but a small quantity of ash; all the rest will have passed away in combustion or steam, and mixed with the air. The quantity of ash varies in different plants, but speaking roughly we may call it four-hundredths of the whole plant. In it, extremely minute portions of various elements may be found. If a chemist had analysed the other ninety-six hundredths as they passed away, he would have found them to consist of *the* four elements, which are oxygen, hydrogen, carbon, and nitrogen. This last exists but in small quantity, and only in certain parts of the plant; we will therefore put it out of the question for the present.

The main bulk of every plant consists of a substance called *cellulose;* this is found in the roots, stem, leaves, and flowers, and, speaking roughly, the whole plant may be said to be formed of it. When it is chemically tested and weighed, it is found that in 162 grains of cellulose are 72 grains of carbon, 80 of oxygen, and 10 of hydrogen. The oxygen and hydrogen we have no difficulty in accounting for; we have seen that they both exist in water, and in the very same proportions in which they are afterwards found in the cellulose, viz. in the proportion of one of hydrogen to eight of oxygen. Every part of a plant has access to water, either as rain soaking down to the roots, or as vapour surrounding the stem and leaves. If in the spring time, after the fall of heavy rain, you make a slit in any young growing wood, the quantity of water which will ooze out will make you quite sure that the power of drinking in water is one possessed by plants. But in our cellulose 72 parts out of

162, *i.e.* nearly half its whole weight, consist of *carbon*. Where can this come from? We found none in the air or water. Carbon is very different from the other elements which we have been considering. They were gases which combined to form other matters; carbon, on the contrary, is a *solid* which combines with oxygen to form a gas. Pure charcoal is the form in which we are all familiar with carbon; this when combined with a certain quantity of oxygen forms carbonic-acid gas; the proportion in which they combine is three parts in weight of carbon to eight of oxygen, *i.e.* in eleven grains of carbonic-acid gas there will be three grains of carbon and eight of oxygen. Hitherto we have spoken of perfectly pure air as composed of oxygen and nitrogen, but no air which an animal has once breathed in and out is perfectly pure; there is always a certain admixture of carbonic-acid gas.

You may prove this by a very simple experiment. Lime-water is what is called a *test* of carbonic-acid gas, *i.e.* its presence may be discovered by a certain change which it causes in the lime-water. Put some of this into a tumbler (you can easily procure it from any chemist), then blow into it with a pair of bellows. The water will bubble, but provided the air taken in by the bellows be tolerably pure, no further change will take place. Now get any sort of tube, and yourself blow down it into the lime-water. It will speedily become thick and milky looking, and after standing for a few minutes, a white sediment, consisting of fine grains of marble, will settle at the bottom of the glass. This change in the lime-water is caused by the carbonic-acid gas, which you, in common with all other animals, have in your breath.

You see, therefore, that in all ordinary air there is sure to be a certain quantity of carbonic-acid gas, and this is further increased by the fact that all decaying matter, whether animal or vegetable, gives off this same product. The way in which the carbonic-acid gas is taken in is twofold. It is soluble in water, therefore a certain portion of it is taken down to the roots in every drop of water which passes through the impure air; but a greater quantity is taken in directly by the leaves in its gaseous state.

We see, therefore, where all the principal ingredients of plants come from; the oxygen and hydrogen from the water, the carbon from the air in the form of carbonic-acid gas. But there is still a difficulty which I hope has struck you. The plant has got its full quantum of oxygen in the water; it is taking in eight ounces more for every three of carbon in the carbonic-acid gas. What then does it do with this extra supply? If you put some laurel leaves in a glass of water, and then set it in a sunny window, you will soon have some help in answering this question; for after a few minutes the edges of the leaf, and then the sides of the glass, will be bedewed with a multitude of tiny bubbles. These bubbles are pure oxygen gas escaping from the leaf. The green parts of a plant have the wonderful power of separating carbonic-acid gas into its two elements, of keeping the carbon and of sending out the oxygen through the leaves and stem. The leaf goes on doing this again and again as long as the sun-light lasts, till it has got the proper amount of carbon to mix with the hydrogen and oxygen and make into cellulose.

It is this power of separating and *assimilating* (as it is called) the carbon from carbonic-acid gas which gives to plants their enormous importance in the world. Try to imagine what the consequences would be if all vegetation were to vanish from off the face of the earth. Probably the ordinary idea of these consequences would be that "a great deal of the prettiness that makes life pleasant would fly away with the flowers, and a good deal of the comfort of the dinner-table depart with the vegetables;" but few people realise that we too, and every animal living, should speedily disappear with the plants; for we should die of starvation. Carbon is quite as necessary to the existence of animals as it is to that of plants; but they, not being endowed with the power of either digesting charcoal or separating it from the carbonic-acid gas of the air, are absolutely dependent on plants for the preparation of their daily food.

As to the nitrogen, which, though less in quantity, is no less important for the life of the plant, it is chiefly taken in with the rain, since every drop in falling through the air dissolves, and brings down with it an almost inappreciable quantity of the free nitrogen pervading the atmosphere. Various combinations of nitrogen are found in the earth, which enter the plant, dissolved in water, through the roots.

The other parts of the plant, which eventually form the ash, are taken from the soil by the water in its passage through it to the roots ; but here we come to a certain individuality in plants.

We have all heard that such and such a plant requires a chalk soil, or that another will not live except in gravel. The reason of this is that some plants require the elements dissolved by water in passing through chalk, while others require those obtained from gravel. Here, too, we see the rationale of manuring, and of the rotation of crops ; the former being to give to the soil certain constituents of which the plants growing in it stand in need ; the latter, to avoid going on sowing crops in need of the *same* constituents, of which the soil has just been exhausted. Boussingault says in his *Economie Rurale*,* "A medium crop of wheat takes from one acre of ground about twelve pounds, a crop of beans about twenty pounds, and a crop of beets about eleven pounds, of phosphoric acid, besides a very large quantity of potash and soda. It is obvious that such a process tends continually to exhaust arable land of the mineral substances useful to vegetation which it contains, and that a time must come when, without supplies of such mineral matters, the land would become unproductive from their abstraction."

Now, having gained some idea of the food of plants, we come to the second question, of how they take it in. Before answer-

* English Translation, page 493, quoted in Gray's "Structural and Systematic Botany," p. 188.

ing this, we must look for a moment at their internal structure. Take a bit of the pulp of a ripe orange, and pull it about with your dissecting needles. You will easily separate it into a number of spindle-shaped bodies (fig. 147). These may be compared to thin india-rubber balls, filled with liquid, and capable of being made of almost any shape by compression. They are called *cells*, their walls are formed of *cellulose*, and similar ones, but incredibly smaller in size, in some shape or other, form the entire substance of all young plants. The youngest stage in which you have seen plants is as perfect plantlets rolled up in their seed-coats, but the very first sign of them is a single cell fastened to the seed-coat close to the *micropyle*. This cell grows larger and longer, and very soon divides into two; the second cell again subdivides, and so the growth continues, till a perfect plantlet, with its radicle, seed-leaves, and stem-shoot, is formed. As the plant grows older, and having more weight to support, requires greater consistency, it has *vessels* as well as cells. These differ from cells in being larger and in having thicker walls, with often a coating of a harder substance inside the cellulose. Vessels may be considered as formed of several cells with their partition walls broken away; they form a considerable part of trees and plants with woody stems (fig. 148), but all the parts of every plant in which growth is taking place consist of cells. The size of these varies not only in different plants, but in different parts of the same plant; in choosing the cells of orange or lemon I have taken the largest, because you can understand their structure best; in general, cells are almost too small to be seen, or separated; but you may gain some idea of their minuteness,

Fig. 147.
Cells of orange.

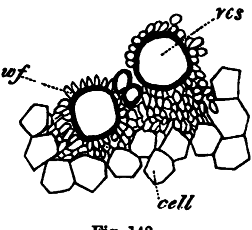


Fig. 148.
Vessels, cells, and woody fibre from a monocotyledon (*highly magnified*).

from hearing that a hundred thousand of them, or sometimes even a million, are contained in a square inch.

"But," it my be said, "since all these cells have walls, we are getting no nearer the solution of the difficulty of the plant's power of taking in food." Nevertheless it is quite certain that young roots, which are formed entirely of cells, do in some way or other take in water, and pass it on from cell to cell. This you will be able to see, if you put a growing hyacinth in a white bottle and colour the water, for the coloured fluid will be perfectly apparent entering the long white roots, and gradually *ascending* them. Thus not only must the cell-walls be permeable by water, but the plant must have some power of pumping the water *up*. This power depends on a well-known physical property, called the law of *osmose*, which is that "all liquids of unequal density separated by a porous partition have a tendency to mix." You can prove this for yourself by a simple experiment (fig. 149). Take a decanter, and fill it with water; then take a glass funnel with a long narrow neck, tie a bit of bladder over the broad end, and put some treacle and water into the ball of the funnel, but not enough to come into the neck; now put the funnel into the decanter, fitting the neck into a cork to keep it in place. After a few hours you will see the water round the funnel becoming slightly discoloured, and you may be sure that the water is running in, as the treacle and water are beginning to rise out of the ball into the neck: when once the mixture has begun, it continues with great rapidity, and soon the contents of the funnel will get far above

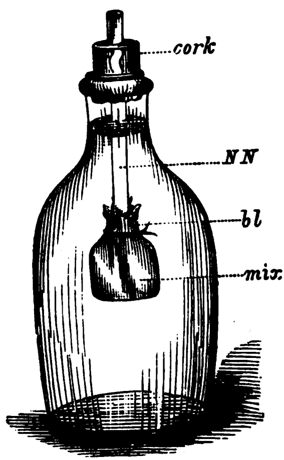


Fig. 149.
Experiment to show endosmose.

the level of the water outside, and eventually flow out of the neck at the top.

To return to our plant. You remember the thin fibrils of the roots which you looked at under the microscope. Quite at the end, these are furnished with a hard sort of sheath to enable them to pierce the soil without injury; but the rest of their length (and especially the part near the tip) is formed of young elastic cells, with very thin walls. Every cell is filled with a liquid considerably thicker than water; this corresponds to the treacle and water in the funnel. Outside the roots in a rainy season is abundance of water, which first by falling through the air, and then by trickling through the soil, has obtained everything necessary for the plant's food; this corresponds to the water in the decanter. Do you see how this will, by our law of *osmose*, be forced up the plant? Fig. 150 represents a perfectly simple string of five cells, each of which is filled by its own thickish liquid. Cell 1 is supposed to be resting in a drop of water: very soon, as our experiment has taught us, a little of its contents will ooze out through its porous walls, which will be immediately replaced by a greater quantity of the outside water. The contents of Cell 1 will then consist of a mixture of its original contents and water; this is thinner than the liquid of Cell 2, therefore the same thing will take place again, and some of the mixture will mount into Cell 2; this process will be repeated again and again, till some portion of the water from the soil has passed into the larger roots, and through them up into the stem. It may seem as if even then these wonderfully minute cells could have little power for taking in food to form the trunk of a mighty tree; but when you remember (1) that every cell in contact with water is *constantly* taking a little of it in, and sending it up the plant; (2) the great number of these cells in the smallest rootlet; (3) the enormous quantity of these rootlets

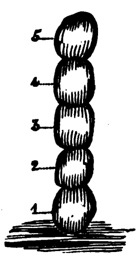


Fig. 150.
String of cells.

in even a small plant—you will be able to believe that a sunflower has been known to take in the extraordinary quantity of thirty-four cubic inches of water in twelve hours. Of course this was only under specially favourable circumstances; for all plants do not "drink" equally, nor the same plants equally at all times.

It may have struck you that as the mixture gets thicker and thicker with every cell it passes through, by the time it has gone through a few millions there will be no perceptible difference between the density of its contents and of the cell above it. This is true, but when the mixture has got into the branches that are swayed by the wind, this very swaying forces it up, through what is called centrifugal force. You may prove this by taking a glass of water and waving it backwards and forwards. When the mixture gets higher still, the difficulty is removed by the fact that the cells of every part of the plant which are exposed to the heat of the sun are being partially emptied by evaporation, and the space thus made is speedily filled up by the contents of the cells in their neighbourhood. It is thus that the water from the earth is enticed into the leaves, as they, having the greatest surface exposed to the air, are the most exposed to evaporation.

The elements which enter the leaf are oxygen and hydrogen in the form of water, with some nitrogen and earthy matters from the soil dissolved in it. These are said to constitute *crude sap*. Then the wonderful process of vegetable digestion, or *assimilation*, begins. The agents in this are the green colouring matter of the leaf and the sun's rays. The crude sap is mixed with the carbonic-acid gas of the atmosphere, and the superfluity of oxygen is separated, and sent back again into the air, and thus a mixture is formed called *elaborated sap*. This is all ready to be made into cellulose, and it passes down the plant again, being gradually used up in the formation of new cells.

We have now traced how the water becomes impregnated with all the constituents necessary for the food of the plant; we have seen how it enters the plant at the roots, and is gradually forced up it into the leaves, where it is *digested*, and sent down again ready for use. I have spoken as if the roots were the only "mouths" of the plants, the leaves the only digestive organs; but as a matter of fact, though they do by far the most of the work, the rest of the plant is helping: wherever there are cells in contact with moist air, a little water is taken in; wherever there is green colouring matter and sunlight, a little assimilation is going on.

Before leaving this part of the subject, I must say a few words about a wonderful self-regulating apparatus possessed by the leaves. You know how rapidly evaporation takes place when any liquid is exposed to air and heat—how soon, if you put a saucer with a little water in it in the sunshine, the saucer will be left dry. Unless some special provision were made, every leaf of a tree would be like a saucer with a bit of bladder tied over the top, and you can fancy the enormous amount of evaporation that would then take place. It is of extreme importance that the water should be speedily passed off, because, say a certain quantity of nitrogen is needed, very likely gallons of water must be taken in, sent up, and drained off through the leaves and stem, before enough has been obtained. But it is also important that this evaporation should not always go on at the same rate. When the air is damp and the earth saturated with water, it cannot go on too fast; but when the earth is dry, at which time it is likely that the sun will have special power, there is great danger of the precious leaves being withered up and dying. To prevent this, their upper surface is provided with very compactly-packed cells to keep in the moisture (fig. 151), and the under surface with what I have called the "self-regulating apparatus." This consists of a number of crescent-shaped holes in the skin (fig. 152). These are open to the air, and as they are situated close to the spaces between the cells, it is by them that

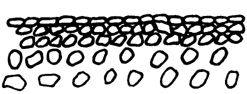


Fig. 151.
Upper cells of leaf (*magnified*).

the air and the carbonic acid enter the leaf. When the air is moist, and therefore the plant can afford to part with some portion of its water, these little holes—or *stomata*, as they are called—are open (*os*), and evaporation takes place rapidly through them. When the air is dry, the stomata are the first parts of the plant which become slightly shrivelled, and thereby tightly closed (*cs*). The number of stomata varies in different plants from hundreds, to hundreds of thousands on the square inch of the under surface of the leaf. As a rule, this is the only part of the plant where they occur; but water-lilies, and all plants with floating leaves, have them on their upper surface—cactuses have them in their fat succulent stems.

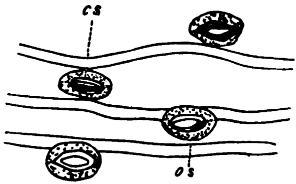


Fig. 152.
Stomata of leaf (*magnified*).

In the next chapter I shall hope to say a little about the different ways in which the elaborated sap comes down in the two great classes of plants, and how, in some plants, it is stored up for future use, and then we will leave the internal structure altogether, and examine more flowers to see how we can make practical use of the knowledge of their structure which we have obtained, for the purpose of recognising and classifying them. The structural work we have lately been doing has, I fear, been rather dull; but I shall be quite content if it has helped you to realise even faintly the wonderful order established in the world—how the mineral kingdom *furnishes* the elements for animal life; how the vegetables *prepare* these, and then how the animals use them, and give back as refuse fresh food for the vegetables, to be separated, purified, partly returned to the mineral kingdom, partly worked up into fresh food.

CHAPTER X.

ON WOOD, STEMS, AND ROOTS.

SPECIMENS wanted—Piece of *lilac* or *elder* stem of one year's growth; ditto of two years' growth; piece of spurge stem; thin sections from various sorts of wood; a bit of *cane; honeysuckle* or *hop-stem; crocus* plant; any *bulb;* various sorts of roots.

We have seen how the food of plants is principally taken in, either in a liquid or gaseous state; how the crude sap mounts up the stem till it reaches the leaves, and how when there it is combined with the carbon from the carbonic-acid gas in the impure air, and thus becomes *elaborated* sap, *i.e.* a material fit for being used by the plant for the formation of new cells, etc.

So far we could speak generally, for all plants have much the same way of feeding. Dicotyledon and monocotyledon and even the higher *acotyledons* (*i.e.* plants without proper flowers or seeds, as mosses and ferns), all imbibe by their leaves and roots, and their crude sap mounts up the stem into the leaves, taking advantage of every soft-walled cell or bit of young wood that it can find. But the route of the descending and elaborated sap, and the whole internal growth of the stem, differs in the three great classes of plants. This is seen by examining sections of woody stems.

We are all familiar with the look of an oak or fir trunk, with its age marked by rings, and its pretty shining sort of cross-grain. These, as well as all other English *trees*, belong to the Dicotyledon class; and if you are able to get a slice of wood from a monocotyledon, as a bamboo cane, sugar cane, or butcher's broom, you will be instantly struck with the difference: for you will see no rings, no cross-grain, nothing but a mass of cells, with bundles of vessels and woody fibre dotted about apparently at hap-hazard. The whole look of monocotyledonous trees too is very different from those to which we are accustomed. They have generally long, straight trunks, with a mass of leaves quite at the top. Englishmen complain greatly of the monotony of the forests in the tropical climates, where the trees are nearly all monocotyledons, and every one exactly like its neighbour, and long for the rest to the eye of our many-branched oaks and elms, where every tree seems to throw out its boughs with an individuality of its own, subject of course to the general rules of branch-arrangement of its species.

Dicotyledons.—Now take a bit of any common tree of *one year's* growth, as a new shoot of an elder or lilac tree, and see what you can make out about it. You will find (fig. 153) that it is divided into three parts, viz. the pith in the centre, *p*, then a harder white part which we call the *wood*, *w*, and then the covering. This consists of the inner or fibrous bark, *in.b*, and the outer bark, *ont.b*, which is made up of a sheath of green cells, and an outer layer which gives the wood its peculiar tint. The whole is covered with a thin skin like a leaf.

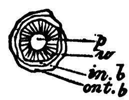


Fig. 153.
Section of lilac-stem, one year old (*enlarged*).

We will now examine a piece of wood of *two* years' growth. You will get this from the same tree from which you cut your one year's wood by making a section of the branch below the node from which your twig grew.

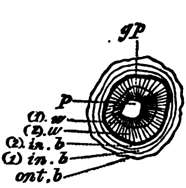


Fig. 154.
Section of lilac-stem, two years' growth (*enlarged*).

Fig. 154 shows what you must try to see. First, there is the pith in the centre, *p*, then the ring of wood immediately surrounding it, *w* (1), which, however, will be whiter and harder-looking than in the younger stem; outside this there will be another ring of wood, *w* (2), and then a thicker rim of bark than in your one year's stem. The rings of this are not easy to distinguish, but if a thin slice of wood is cut and held up to the light, it is sometimes possible to see the difference between the *in.b.* (2) and *in.b.* (1) of our figure.

Thus you see two new rings have been formed in the course of the year, an outermost ring of wood and an innermost ring of bark. This proves that the *growing* place of the wood is between the woody and the bark rings. This growing place is called the *cambium layer* (*gp*). It is hardly distinguishable even with a strong microscope, and then only as a number of young, often half-formed cells. The strong line therefore with which it is marked in our figure is quite imaginary. This cambium layer continues quiescent during great part of the year, but in the spring and summer the enlargement and separation of cells, which we call *growth*, takes place. The innermost of the cells separate into new cells towards the centre of the stem; these eventually become woody fibre, and form the new ring of *wood;* the outermost cells grow towards the circumference, become long and stringy, and form the new ring of *inner bark.*

"But," you will say, "how do the cambium cells get the elaborated sap necessary for this enlargement and subdivision?"

Let us suppose we have a stem one year old: the roots have sucked in the water and its contents; the stem has used its thousand pumping-machines for sending it up to the leaves; and the leaves have set their wonderful little stomata to work, and with the help of the sun have turned it into building-material ready for use. This cannot remain in the leaves crowding up the cells which are wanted for fresh work, and it naturally goes down the stem by those cells which, being youngest, are the easiest to pass through. These are the cambium cells, and thus they are provided with what they want—material for forming into new cells. So it is that the elaborated sap is used up in its way down. Every leaf and every bit of green stalk sends its contribution to the grand supply.

We have hitherto spoken as if the stem were made up of a series of continuous rings, but this is not quite true, for if you examine a thin slice of the stem of almost any dicotyledon through a microscope, you will see a number of rays coming out from the pith and pointing to the circumference. Fig. 155 represents a section of an apple-tree of one year old, considerably magnified. You see in it a large quantity of pith formed of loose cells, which entirely break away and leave a hollow space in the centre; from a rim round this pith (*ms*) rays branch out looking somewhat like the spokes of a wheel. These rays point towards the circumference, and divide the woody fibre into a number of thin wedges with their points turned inwards. They are made of pith, *i.e.* there are only cells in their formation, so that they are easily compressible. Possibly you already guess their use, at any rate you will see what it is presently. These rays are much more clearly seen in some sorts of wood than in others. In the stem of the clematis, for instance, or of the spurge (fig. 156), they are plainly visible with the naked eye. The shiny sort of cross-grain, of which we spoke just now, and which is more or less to be seen in all dicotyledonous wood, is due to them.

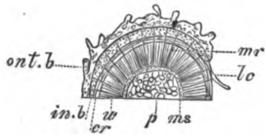


Fig. 155.
Section of apple-tree stem (*magnified*).

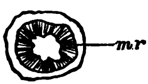


Fig. 156.
Section of spurge.

Now let us take our dicotyledonous tree on to its third year. A fresh ring of woody fibre is formed *inside* the cambium layer, a fresh ring of inner fibrous bark *outside*. Of course, as the stem gets larger every year, the woody fibre of the earlier years cannot help being squeezed a little inwards, and so the pith gradually disappears. In an old stem you will find no pith: and now you see one use of the pith rays; if these woody rings were *complete*, they could not be squeezed in, but the space between the wedges being cellular, and therefore able to be compressed, the wood of earlier years allows itself to be driven inwards. Still the space is not unlimited, and as year by year the new rings of wood are added, the older rings get harder and more tightly packed, and are called *heart*-wood; they are no longer porous, and the sap ceases to pass up through them; on the other hand, the new rings are called *sap*-wood, and they form the channel of communication for the watery sap to mount from the roots to the leaves. With the growth of the wood, a corresponding but thinner growth is formed of inner bark, which is very tough, as you may prove for yourselves by peeling any young branch. This toughness is much greater in some plants than in others; thus it is from the inner bark of flax that we get our *linen*, from the inner bark of hemp that we get our *ropes*. Of course the bark must be very much stretched, as year by year the wood inside grows in diameter, and this fibrous inner bark will stand a considerable amount of stretching, but the outer bark is of very different consistency, and after a few years its thin lining disappears, the branch ceases to be green, and has a tight appearance, like a person whose clothes are too small for him. After a while the outer bark cracks all over, and although the skin heals outside (just as when you cut your finger the outer skin heals, but the scar is left), yet if you look at the many rifts and cracks in the bark of an old tree, you will see traces of the constant splitting caused by the enlargement inside.

The outer bark of some trees is of much larger growth than in others; for instance, the cork-tree, a kind of oak, has such a thick layer of cork in its outer bark that we are able to get our corks from it.

You see from this ringed manner of growth that if a mark be made in any dicotyledonous tree *deeper* than the cambium layer, as new rings of wood are formed the mark will gradually be buried in the tree; and thus it is that arrow-heads broken off in the stem of a tree, or the names of lovers carved when it was in its growth, have come to light when the tree was cut down and sawn up hundreds of years afterwards, and all that we can guess of the story of the lovers is the time when they lived, which is told us by the numbers of rings of wood which the tree has made.

Most wonderful things some trees thus tell us of their age; the Wellingtonia, for instance—that noble tree, which we know only in its youth as lately imported into our parks and gardens—is proved by its rings in its native haunts on the shores or in the mountains of California to be the oldest living thing upon the earth. Ages and ages have passed away—Britons, Romans, Saxons, Normans, English, have ruled in this island—and yet these self-same trees are growing in the self-same spot where they were growing when our Lord was living on the earth, and where they were fifteen centuries before Columbus found out the continent on which they grow.

It is gloomy to think that these mighty things are fast dying out; few young ones appear to flourish in the old forest, and the greed of man is fast cutting down the noblest of the old race for the money which their wood will produce. Had not the hand of man transported some young plants to Europe, the whole race might have soon become extinct, like the mammoth or the Irish elk.

We said in our last chapter (p. 154) that vessels as well as cells were to be found in the stems of plants. Now is the time to examine into this, and I think you will be surprised to see the wonderful lace-work that the various sorts of cells and vessels combine to form. You should put thin slices of first one plant, then another, under your magnifying glass. A strong power is not needed, and the only difficulty is to cut the slices thin enough; this, however, is not really hard to manage if you take a very sharp knife, and only try young stems of about a year old. It is very pretty to see the individuality of the special sort of plant appearing in minute differences in its internal structure. Of course in slices across the stem, you only get the *ends* of the cells, vessels, etc., and for examining them carefully, you must make longitudinal sections.

We will now go through, in a general sort of way, what you may expect to find in the different parts of your stem.

Pith.—This is found in the centre of young stems, and is made up of large, loosely-packed cells (see fig. 155). Sometimes small lumps are visible in them; these are the cell-contents, deposited by the ascending fluid, which in the spring-time makes the pith of a growing plant all bright and glistening like silver lace.

The cells of the *Medullary* (*medulla*, pith) *rays* are much more tightly packed than those of the centre pith. Nevertheless in some young plant, as the clematis, you can see that they are really similar. While the plant is young, these thin-walled cells are the highways of communication between the pith and the outer parts of the stem. Afterwards, as you have seen, the wood becomes more tightly packed, and they are pressed out of existence, leaving only a slender silver line to show where they have been.

Medullary Sheath.—This name is given to a slender ring of *spiral vessels*, generally found immediately outside the pith. You will remember (p. 154) that vessels may be considered as formed of several cells, whose partition-walls have broken away. The vessels of which we are speaking gain the greater consistency needed from their larger size by a *spirally* arranged deposit of *lignine* on their inner surface. Fig. 157 is drawn from the seed of a small annual (*Collomia grandiflora*). It has been prepared and set up in a peculiar way, and is highly magnified. You will notice that in one spiral vessel only (*a*) the vessel walls remain; in the others, the spiral markings alone are left, and even these, in the case of *b*, are much pulled out of shape. This *lignine*, which forms the bulk of all wood, is made of the same constituent as ordinary cellulose, but differs from it in having a rather larger proportion of carbon and hydrogen, and is therefore harder; also, "according to some authors, it is impregnated by foreign substances, gradually infused from the fluid contents." * You will be able to find these spiral vessels with the help of a microscope; and Professor Gray says,

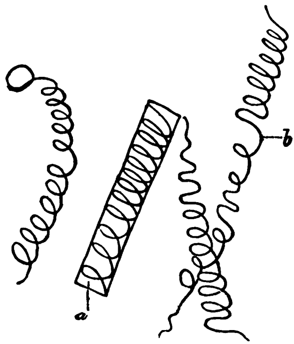


Fig. 157.
Spiral vessels (*highly magnified*).

"They may be detected by breaking a woody twig in two, after dividing the bark and most of the wood by a circular incision, and then pulling the ends gently asunder, when their spirally coiled fibres are readily drawn out as gossamer threads." †

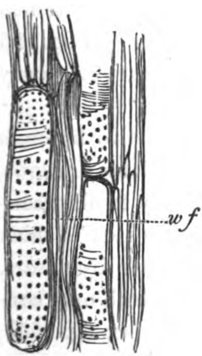


Fig. 158.
Longitudinal section of elm (*highly magnified*).

Wood.—This is made up of long, thin cells or *fibre*, pointed at the ends, and so arranged as to offer the greatest possible resistance to pressure (fig. 158, *wf*). Their walls are formed of lignine, and gradually become so thick that in old wood hardly any remains of the hollow cell is to be found. There are vessels scattered about among the woody fibre. The commonest kind in dicotyledons are the *dotted* vessels (fig. 158), as they are called from the manner in which their lignine deposit is arranged. Vessels are easily recognised by their large size, and you will find

* Henfrey's Elementary Course of Botany, p. 486.

† Gray's Structural and Systematic Botany, p. 119.

it very interesting to discover for yourselves the different sorts, and to trace the different ways in which they are arranged in the woody fibre. At first they seem to come anywhere by chance, but after looking at and comparing many stems, a sort of order grows out of the confusion, which you find to be characteristic of some special sort of plant.

Cambium region.—We have spoken of this before. It is made up of young, half-formed cells, and can only be seen, even with the microscope, at certain times of the year. Its place in the stem, however, is clearly indicated by the ease with which you can peel any twig, since the division between the wood and the barks is due to these cambium cells.

Inner Bark.—This, like the wood, continues to increase through the whole life of the tree. Sometimes each year's growth can be traced in it as plainly as in the wood, but oftener one can only make out a gradual thickening of the layer. The tissue peculiar to this part of the stem is made up of *liber* or *bast* cells. These somewhat resemble the wood cells mentioned above, but they are much longer and more flexible. In fig. 155 (*lc*) you may see one that has got loose and is straggling away from its brethren.

Outer Bark.—We said this was made up of two layers, a green and a corky one. The green layer cannot long continue, for, as you doubtless remember, light is necessary to all greenness in plants. As soon, therefore, as the corky part is thick enough effectually to exclude light, the green layer disappears. The cork-bark is composed of thin-walled cells, which only contain air. Their surface is very rough and uneven (see fig. 155); and just as the arrangement of the inner bark is fitted for toughness and elasticity, so this seems formed on purpose to break away easily as soon as the stem is able to get on without its covering.

This short explanation of dicotyledon stems, though rather useless if simply *read*, will, I hope, be enough to enable you to understand and enjoy the examination of them with which it is meant to be accompanied. We will now leave them, and turn to their less regularly arranged relations.

Monocotyledons.—You may have some difficulty in picking for yourselves a stem of this growth, but if you invest in a halfpenny cane from any toy shop you will find that a section of it will answer our purpose admirably. You will look in vain for pith, or rings of wood, or even proper bark; and if you put your section under a magnifying-glass you will find that the whole stem is composed of a mass of cellular tissue, with vessels scattered here and there about it without any apparent order in their arrangement. Round each of these sets of vessels woody and liber cells are arranged. Fig. 148, p. 154, shows one bundle taken from a magnified section of sugar-cane. In every *bundle*, as it is called, are all the constituents which we found in the interior of our dicotyledonous stem. There are the *vessels*, often *reticulated* (*i.e.* with the lignine deposit arranged so as to form a criss-cross on the sides), the closely-packed *wood* and *liber* cells, and the cellular tissue immediately surrounding these, takes the place of the cambium region, and has the same power of increasing and dividing whenever the cells are provided with sufficient material. But the *bark* which we have been examining in our lilac and apple is here entirely wanting. The tree is covered with a *rind*, which is inseparable from the rest of the stem, and differs from it mainly by reason of its greater hardness.

You may notice in your cane that the cells are rather loosely packed in the centre, but that towards the circumference they are more compressed, and there are more bundles of vascular and woody tissue. If you are able to get a young growing monocotyledon this difference will be still more plainly marked, and you will also observe how large a one or two years' stem is in proportion to a dicotyledon of the same age.

The manner of growth of the two sorts of trees will account for this. Dicotyledons are often called *Exogens*, or outside growers, because they begin by being small, and gradually enlarge outside, having therefore their oldest, hardest wood inside; and we have seen the special provisions for their growth in their elastic inner and brittle outer bark. Monocotyledons, on the contrary, are called *Endogens*, or inside growers. In them the rind gets hard after a few years, and incapable of further distention. The growth of this wood is therefore limited; it is like a growing person who cannot hope to get a new suit of clothes, and so has the foresight to get one made which will allow for many years' growth. At first there are only a few bundles of woody fibre in a large mass of cells; year by year every new leaf that is formed sends down some elaborated sap, and a fresh bundle is formed, at first in the heart of the stem, and then, as it finds the middle places already engaged, bending outwards till it reaches the rind, which it adheres to and tends to make harder and stronger.

If we compare a lofty palm-tree crowned at the top with a simple cluster of foliage, and a spreading oak with its branches stretching down on this side and on that, we see how well adapted the mode of growth of each is to its wood. The palm-stem bears comparatively little weight; what weight there is acts straight down the stem, and as there are no branches the strain on the stem is the same at bottom as at top; hence there is no necessity for it to be thicker at the base than at the top.

But the oak has its weight diversely distributed with its side branches, and the strain of wind or of weight acts more on the lower part of the stem, which carries *all* the branches, than on the higher, which supports only a few; hence the lower stem is required to be stronger than the higher; and that it must be so is clear from its mode of growth, unless the old wood has begun to get rotten, and then indeed the time for the noble fabric's fall is near at hand; the wind comes, and as the lower part of the tree can no longer do its duty, the crash follows.

The roots, too, it may be noticed, not only act as mouths, as we have seen (p. 156), but afterwards as holdfasts; and there is a remarkable adaptation to the needs of the tree in the main root and widely-spreading root-branches of a dicotyledon, and in the almost parallel comparatively unbranched roots of a monocotyledon.

Acotyledons.—We must say a few words about the growth of these plants before leaving this part of the subject, though, as acotyledons are plants without proper flowers or seeds, the study of them is hardly comprised in that of ordinary botany. The highest sort of acotyledon must be looked for in the magnificent tree-ferns of tropical regions; the lower we have constantly around us in the troublesome forms of *mould* (as bread mould, cheese mould, etc.) and *mildew.* The very lowest sorts of acotyledons are plants formed of a single cell, and are only visible with the microscope; the various sorts of mould are formed of a string of cells, and all mosses, sea-weeds, etc., are simply cellular structure wonderfully arranged to look like perfect trees or herbs in miniature. In some club-mosses (which are not really mosses at all), ferns, and some other plants of this class, we find vascular and woody tissue, in which, however, no special arrangement can be traced. As dicotyledons are called *outside* and monocotyledons *inside* growers, so acotyledons have received the name of *acrogens* or *point growers,* because, instead of constantly increasing in length and thickness all along the stem as their brethren do, they increase from the point *only, i.e.* they grow from node to node, and then, as it were, begin again. This may be well seen in the mare's tails (Equisetaceæ), where each plant looks like a number of small plants somewhat insecurely fastened together at the nodes.

Stems.—We now know something of the internal growth of stems, and will consider their external growth, and the reasons of some of the extraordinary modifications which they undergo.

Hitherto we have thought of them only as highroads of communication between the roots and the leaves. This is their most constant and obvious use, but there is another, on which this is to a certain extent dependent, for it would be of no use for the stems to pump up the crude sap to the leaves, if, when it got there, the leaves were unable to perform the necessary assimilating process for want of light. As you will see, this fact is never lost sight of in the formation and habit of the stem. Consider that leaves require the greatest possible amount of light and air, and then look round any thickly growing wood, and you cannot fail to be struck with the beautiful adaptations of the different plants for gaining the desired end.

Erect Stems.—The fir trees with their strong *erect* trunks carry their boughs far away from all intruders, and hold their leaves free to the sun and winds of heaven.

Spines.—The hawthorn generally grows in a thick hedge, so it throws out a leafy twig here and there as opportunity serves, and when there is no chance of light coming to the leaves does not waste its strength in producing them, but turns its branches

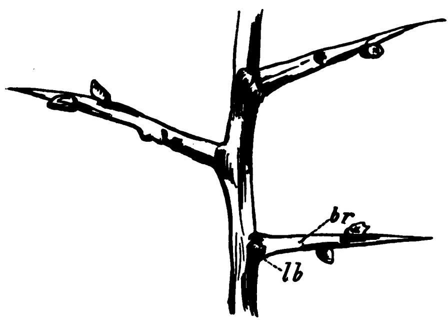


Fig. 159. Branch spines of hawthorn.

into thorns (or *spines* as they are botanically called), which serve as a protection against browsing animals (see fig. 159).

Climbing Stems.—The honeysuckle and hop, and other thin-stemmed plants, are in danger of being choked in the struggle for existence, so they give up their independence, and use their neighbour's strength for their help instead of letting it prove their destruction, and accordingly we see them twining here and there, wherever they see a stem that will serve their purpose, and so they too get *up*, and gain the needful sun and air for their precious leaves.

Mr. Darwin has given a most interesting account of how this climbing process is performed. He got a young hop plant, put it in a pot, and watched it carefully for a long time. He says its proceedings can best be described as a constant bowing round in a circle, feeling for something round which to twine: thus, whenever we find a stem twisted like a corkscrew, we may know that the plant has "felt" in vain for a support round which to revolve.

Branch Climbers.—Other plants again do not climb by their main-stems, but turn some of their side branches into flexible *tendrils*, and climb by them. The vine (fig. 160) is a good ex-

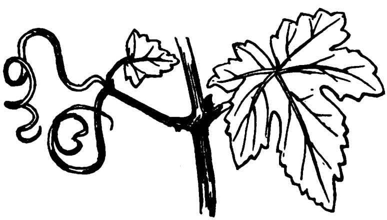


Fig. 160. Branch tendril of vine.

ample of this sort of climber. Evidently all these plants have an advantage over their more stalwart brethren, as they expend very little material on stem-building, and so have the more for the produce of their leaves, flowers, etc. Thus most climbers, as the white convolvulus and hop, are remarkable for their luxuriant foliage; but they, in common with all other dependent natures, have the counterbalancing disadvantage of being able to get on very badly without their helpers. Take away the support from a climber, and though it struggles on, on the ground, soon its leaves become dull-looking, and the whole plant has an unhealthy appearance.

Runners.—Some plants with long thin stems do, however, manage to lead an independent life. The strawberry is a good example of this. The first year it is simply a tuft of radicle leaves, with short flower-stalks; then it sends out a long tough-looking shoot, which runs upon the ground till it is clear of the large overshadowing leaves of the parent plant, when it sends out roots, forms a new plant, and has the same chance of air and sun that its parent had a year ago.

Underground Stems.—Now we will leave our ordinary stems, and turn to those which relinquish all air and light for themselves, and burrow underground for the good of the plant to which they belong. We all know the troublesome suckers which come up at short distances from the root of standard rose trees. They evidently are branches of the old brier stock on which the standard is grafted, and branches cannot grow from roots. They must therefore be attached to the old plant by an underground stem, and if you have the patience to dig deep enough you will find that this is the case. Many plants, as grasses, English ferns, irises, etc., have no above-ground stem at all; others again, as the rose, have both upper and underground stems. The botanical name for ordinary underground stems is root-stock or *rhizome.*

Tubers.—Some stems have a third extraordinary use, besides the two ordinary ones of serving as highroads of communication, and frameworks of leaves, and turn into storehouses of spare building-materials. Starch and sugar are made up of the very same elements as the cell-walls of plants; it is quite true that some chemical action will be necessary before the starch or sugar can become proper building material for cells; but such a change is no more than happened in the young bean, when its seed-leaves were gradually deprived of their starch, and the starch itself built up into roots and leaves. Many plants in the grown-up state have similar reserves of food: thus the potato has a stem growing underground, which swells out into knobs at intervals; these knobs or *tubers* are the part of the plant which we eat. That they belong to the stem, and not to the root, is proved by the eyes, which, as we know, will send out shoots and leaves; a true root would not do this. The whole of the potato-tuber is made up of cells, each cell containing several little grains of starch; here then is a mass of material ready for the plant when it wants it. If you have never tried it, it will be worth while to put a potato away in a dark cupboard, and look at it after a few weeks. The eyes will be seen to have grown enormously; the leaves will be white, for the *green* colour only comes to leaves in sunlight; and where has the material for the new growth come from? clearly not from the earth, for the potato is not planted; nor from the air, for without greenness nothing but air, or possibly watery vapour could enter through the atmosphere; evidently, then, it must have been manufactured out of the original potato, which accordingly you will see shrunken and dried up.

Corm.—The crocus shows us another stem used as a storehouse. Dig one up from any garden (fig. 161), and you will see that the base of the stem forms a hard mass, called by botanists a *corm*, from *cormus* a solid bulb. Look at it carefully, for it tells a curious story of its manner of life; the corm planted, let us suppose, in October, will be seen to have given rise to a young shoot immediately above it; this shoot has sent up leaves, and possibly flowers. The young shoot is already showing a shape like its father's, by thickening at its base. But while the son-corm (fig.

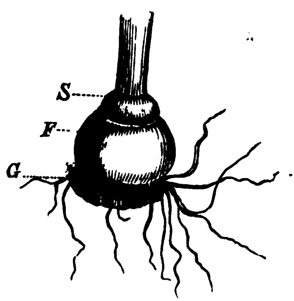


Fig. 161. Corm of crocus.

161, *S*) is sending up leaves, and storing up material, what is happening to the father (*F*)? he is gradually being eaten up by his family; not only is the eldest son immediately above him sucking food out of him, but several younger ones may often be seen growing at the side, which at the season's end will break off into independent corms ready for a future year's flowering period; and does not the father bulb deserve to be eaten up? for has he not last year devoured *his* own father? in fact, very possibly you may see the scaly remains of the grandfather (*G*) still adherent to the base of the father. Of course, as there are leaves and fibrous roots, much of the nutriment of the flowering plant comes from outside; but the use of the corm is to hurry on the growth of the young shoot by supplying it with building-material ready assimilated.

Bulb.—Now look at a hyacinth, or onion, the last of the vegetable storehouses which we will examine. Here the leaves as well as the stem are to be seen, as a bulb differs from an ordinary stem, chiefly in having neither branches nor internodes, and in the swelling of the stem and leaves, both of which are fattened by the ready prepared nourishment contained in them.

Succulent Stem.—Another use of the stem is as a cistern for water; some plants are obliged, by the climate in which they live, to get on, with only supplies of water at long intervals; hence, like camels, they must take in water while they can. Cactuses are examples of such plants; in them there is a large stem capable of holding a great deal of moisture, and offering little surface to the drying rays of the sun—a surface very small compared with the surfaces which the leaves of a plant usually expose to them; in some species the surface is the smallest mathematically possible in proportion to the cubic contents of the plant; and what are the cactus leaves doing meanwhile? they are not leaves at all, but are merely prickly mid-ribs; weapons of defence to prevent the plants from being browsed upon.

"But," you will say, "how can the assimilation processes be managed in these leafless plants?" The reply to this is that the whole habit of the plant is sluggish; it grows slowly (*how* slowly, no one will realise unless he has kept cactuses), and therefore needs but little food, and that little is digested by the green stem in which stomata may be found, and which therefore both assimilate and transpire.

Roots.—Now we will leave our stems, and pass on to roots. You will perhaps be surprised to hear that it is in some cases very hard to distinguish between these two parts of a plant. The ordinary unbotanical distinction is that a stem grows above ground, while a root burrows in the earth. But the potato, bulb, etc., have taught us that this is not always true. The most obvious distinction is that while stems bear buds and leaves, roots bear nothing but smaller roots; and this is true as far as it goes, but it is not enough to enable one always to know the two apart, since stems, when laid upon the ground, often produce roots, as we have seen in the strawberry plant. An examination of the internal structure will not help us, for if we cut through the main root of a dicotyledon (monocotyledons, you may remember, have no main root, p. 147), we find that it is merely a continuation of the stem, having the same rings of wood, etc.

A moment's thought shows us this is quite natural,—that, in fact, stems and roots *ought* to be alike; for their purposes are very similar; they both are highroads of communication, and they both are frameworks—the former of branches and leaves, the latter of roots and rootlets. But their business as frameworks leads us to a real distinction: we saw that the stems not only had to bear their branches and leaves, they also had to carry them to places suitable for performing their special functions. Now the rootlets, which alone have the power of absorption, need very different places from the branches: air and light are of no use to them; all they want is to burrow in search of moisture, and of ammonia formed by decaying matter;

and the larger roots, which answer to the branches above ground, have to grow so as to enable them to do this. Therefore, as it is the nature of moisture to sink, so roots grow *down*, while stems as a rule grow *up*.

Also stems (except among the acrogens) grow along their whole length, gradually thickening as time goes on. Roots grow only at one point, a short distance from their tip. The very tip is formed of older harder cells, which act like a thimble, and protect the tender young ones immediately behind them. These young cells are furnished with elaborated sap, which is probably passed down from the low leaves on the plant; and, like the cambium cells of the stem, they increase by division.

The reason of this different manner of growth in stems and roots is obvious. Strength is a necessity to the stem, and bulk no disadvantage; to the roots, on the contrary, slenderness is the main thing to be desired, for how otherwise could they twist their way between stones into moist corners, always protected in their pushing life by the thimble at their tip?

The fourth difference which we will notice is that stems send out their branches, and branches their leaves, according to a fixed arrangement. This plan would not do at all for the roots. They send out their roots and rootlets wherever there is room for them to grow, and moisture for them to absorb. If you look at any growing root through a glass, you will see that its absorbing surface is much increased by the delicate root-hairs or *fibrils*. These are the outer tender cells of the root prolonged into hairs, and they, as well as all the cells round them, are busily employed in sucking in sustenance for the plant.

The plant needs most food at its growing time, that is, in early summer when the leaves are exhaling quickly, and the descending sap is being used up to form new branches. At this time the roots are obliged to work hard, or the plant would starve; accordingly they spread and increase, and constantly renew their delicate absorbing parts. This is the time at which it is most dangerous to move plants, for not only are the roots in their tenderest state, but their due working is also of the greatest importance to the plant. If you move a plant at this time, you must try by copious watering to induce the leaves to do double work and drink in enough to keep the plant alive, but you will probably fail, and your plant will die of starvation before the roots have found their way about the new soil. In the autumn, on the contrary, the plant has ceased to grow, and the roots are resting after their hard spring work, and at this time they may generally be transplanted with safety.

Taproot.—We will now examine the different *kinds* of roots, keeping in mind their purpose. *Taproot* is the botanical name for what we have hitherto called the main root; it is the direct downward prolongation of the radicle (see fig. 145, *mr*, p. 145).

Fibrous Roots.—*Fibrous* or *thread-like* roots are common to all monocotyledons, which of course cannot have a taproot (see fig. 146, p. 146). All annual or one-year dicotyledons have these roots also, branching out in a mass from the main root. Can you guess the reason of this? The plant has but one year to live, it must therefore send out its leaves and flowers with all haste, or there will not be time for its precious seeds to ripen before the frosts come and end all its chances. Naturally, then, its roots are thin and scattered, and have the greatest amount of absorbing surface possible, for *immediate* food is their one desideratum.

Tuberous Roots.—For some roots, however, more than this is necessary. If you look at a dahlia or beetroot, you will find that it completely dies down in the winter, but sends up a mass of new leaves early in the spring. How does it live, and where does the food for the new leaves come from? Ordinary roots might suck it in in its crude state, but how could they get it elaborated without the help of leaves or green stem? and without elaborated sap, as you know, no growth is possible. Dig up your beetroot: you will find that its taproot has swollen enormously, and turned into a storehouse, where ready elaborated sap has been kept all the winter. You can tell that it is the root and not any underground stem that has thus swollen, because it is evidently *below* the collum (see fig. 145, p. 145). In the dahlia the case is much the same, except that here several roots have swollen. Both these plants are said to have *tuberous roots*.

Aerial Roots.—Some roots do not grow under ground, but, as their name betokens, in the air. Look at a plant of ivy. It has a proper underground root, performing its ordinary duties; but, besides this, all along the stem are numerous short rootlets which are used for nothing but climbing. Several tropical trees, as the mangrove and banyan trees, have these aerial roots growing from their branches, whence they wave about and lengthen, till at last they reach the ground, when they send out ordinary roots and give rise to new trees, thus forming a miniature forest, independent as to their roots, but all joined at the top.

Epiphytes.—These properly deserve the name of *air* plants, for, unlike the ivy, they have no underground growth at all. Their roots are useful for a foothold only, and the whole business of absorption, as well as assimilation, is performed by the leaves and stem. Many of the gorgeous orchids of tropical climes grow in this way. Doubtless you have seen them in hothouses, clinging by their roots to blocks of dry wood, and sending out enormous leaves and flowers. They are not easy to cultivate, as they will only live in a constant vapour-bath; for the plant must get its whole supply of water from the air.

Parasites.—At first sight parasites—*i.e.* plants which live on other plants, as the mistleto, dodder, etc.—seem very like the epiphytes; but this is not the case, as the orchids of which we have spoken, even when growing on the trees of their native forest, do not drink in nourishment from these trees by their roots, but get an honest livelihood from the air. Parasites, on the contrary, send their roots into the tree or shrub on which they grow, and suck up and live upon its sap. Sometimes these plants grow on the branches, which they gradually kill, as the mistleto; sometimes on the roots of trees, as all the orobanches; sometimes, again, they twine all about the plant, as the dodders. Some of these plants have green leaves, as the mistleto, which strikes its roots into the new wood of the tree on which it grows, and sucks the ascending or crude sap. When it has done this it is no better off than if it had absorbed it from the earth in an honest manner; it is obliged to pass it up to its leaves, and assimilate it like other plants. Others again, as the

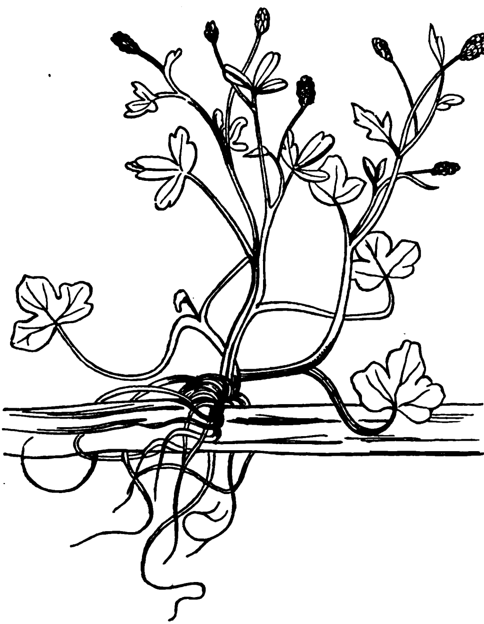


Fig. 162. Ranunculus sceleratus, parasitic on Œnanthe fistulosa.

orobanches and dodders, have no leaves, nothing green about them, only a brown or pink coloured stem, and sometimes pretty flowers. The reason of this is obvious: they rob the plant on which they grow of its ready elaborated sap, and therefore need no assimilative organs of their own. The orobanches send their roots down into the roots of the plant, suck their juices, and come up fat, brown, and unhealthy-looking by its side. The dodders twine all over the plant, and are provided with little suckers which pierce the skin of the bark, and so take from it the sap which is passing down from its leaves.

Every now and then one finds a plant belonging to a family of independent habits, itself become lazy and leading a parasitic life. Fig. 162 is an example of a buttercup which had fastened itself on to the succulent stem of a water dropwort, and was drinking in its life-juices.

CHAPTER XI.

ON LEAVES.

SPECIMENS wanted—All sorts of leaves; branches of *barberry*, *gorse*, *acacia*, and *rose;* a plant of *sundew;* pieces of *clematis*, *sweet-pea*, *vetch*, and *Virginian creeper*.

Having examined stems and roots, we now come to the expanded bits of stems which are called *leaves*.

We have seen that these have three ordinary uses :—

(1.) They regulate the amount of transpiration, acting thus like the skin of an animal.

(2.) They take in gases through their stomates into the spaces between the cells, and there choose by a chemical action which elements they shall pass into the plant, and which they shall set free. In this they act somewhat like an animal's mouth and stomach in one.

(3.) They absorb moisture, though not so much as the roots.

For these uses certain requisites are indispensable, viz. largeness of surface, thinness of skin, greenness, sufficient length either of leaf-stalk or blade to reach up to the sunlight: largeness of surface, because the required actions of transpiration or absorption will go on the more rapidly the larger the surface exposed; thinness of skin, because thickness of skin would retard these two actions; greenness of skin, because the chemical action by which the elaborated sap is formed will not take place except in the parts where the green oily colouring matter is present; and lastly, exposure to sunlight, because without sunlight the green colouring matter is not formed, and therefore the formation of the proper sap is prevented.

You must try and bear these requisites in mind, in order that you may be able, as you often will be, to see how wonderfully the peculiarities of a leaf of a particular plant are made to suit its special needs, which of course vary with the climate and locality in which it lives.

One curious adaptation we may notice at once: in general the stomates of a leaf, by which the gases enter, are on the under and unexposed sides of the leaf, and not on the upper side, and for this reason, that the gas will enter as easily below as above, and were the stomates above it would be difficult to prevent too great evaporation. From this rule we have the beautiful exception of plants with floating leaves. These have no chance of being too much dried up by the sun, seeing that their under skins are perpetually exposed to the surface of the water, and accordingly we find their stomates on the upper side, which alone is exposed to the air; while leaves growing entirely below the water have no stomates at all. So again we have leaves which, instead of growing in the ordinary way horizontally (*i.e.* with an upper and under side), grow vertically, as a lily of the valley leaf (see fig. 21, p. 29). These have both sides equally exposed, and the stomates are therefore equally distributed on its two surfaces.

In our botanical researches hitherto we have been able to get on with few terms and not very many troublesome details. Our work has all been of a sort to lead up to and go hand-in-hand with the practical business of collecting, and yet none of it has been done for the express purpose of learning how to make a good collection. Now that we have come to leaves, however, we must to a certain extent consider the needs of a collector, for in naming plants great attention must be paid to the details of the leaf, because the differences which separate one species or variety of plant from another, sometimes depend on the leaves alone.

There is no part of Botany so overladen with cumbrous terminology as that which relates to leaves. In almost every text-book, strings of epithets are given, by which the manner of growth, shape, edge, etc., of leaves can be most accurately described; and in learning these terms in order to be able to use the Floras, which tell you the different plants to be found in our fields, you will soon be inclined to grumble at the many hard names you will meet. It will keep you in good humour with these details if you try to think for yourself what is the good to the plant of this kind of leaf, of that kind of leaf-stalk, or of this complicated leaf-arrangement; and in this no less than in the more attractive parts of Botany, which have told us of the suitability of shape of the irregular crowns, and the many adaptations for fertilizing and shedding the seeds, will you begin to wonder at the lavish variety of contrivance, and the marvellous adaptability of structure, which meet you at every turn.

The chief points to be considered in a leaf are eleven in number. If you make yourself thoroughly acquainted with these, you will have no difficulty in picking up the minuter details from any *Flòra* (or collector's book) which you may happen to use.

1. *Where placed?* that is, from what part of the plant is the leaf taken, from the branches or from immediately above the root? This statement is absolutely necessary, because many plants have leaves growing just above their roots so different from the other leaves that you would hardly recognise them as coming off the same plant—as, for instance, in the herb Bennett (p. 67); or again, other plants, like the ivy, have quite different leaves on their *blossoming* branches from those which they have on their *foliage* branches.

2. *How arranged?* Leaves may either grow several at a node, forming a *whorl* round the stem, as in the goose-grass and woodruff; or two at a node, *opposite*, as in the white lamium or dead-nettle; or one at a node, *alternate*, as in the sedum and dog-rose. We noticed some of the more remarkable alternate

arrangements in an early chapter (p. 70), when we found the leaves to be arranged in a spiral, as may be clearly seen in the sedum and dog-rose; in monocotyledons we commonly find the fourth leaf above the first, the fifth above the second, and so on; this is the arrangement of one-third, and by it three rows of leaves are formed; in dicotyledons, the commoner arrangements are our old friend two-fifths, and a more complicated one of three-eighths. Now what is the use to the plant of this regular arrangement? Why should not all the three, five, or eight leaves of the whorl grow together at the same node, or one above the other? Clearly to prevent one leaf from hiding up the other, and thus to allow each to get exposure to the air and sunlight.

3. *How stalked?* Here again we have arrangements for bringing the leaves out to the light; see how long the stalks are of some of the ivy leaves on a wall; were it not for their long stalks, they would never reach out from under their neighbours, and would be deprived of air and light. Very often on the same plant the lower leaves will be *stalked*, while the upper leaves near the flowers and nearer the light will be *sessile* (see p. 67), or clasping the stem, *amplexicaul*, as the groundsel, or meeting on the other side, so that the stem seems to grow through them, when they are called *perfoliate;* or sometimes, as in the upper leaves of the French honeysuckle, a pair runs into one, when they are said to be *connate.* In other plants the leaves run along the stem, not leaving it till they get higher up than their proper place, so reaching the light they want, as in the *thistles*, whose leaves are said to be *decurrent*, or running down the stem.

If the leaf has a stalk, we have to settle at what point this is joined to the leaf, whether at the base of the blade, as in the laurel, the ivy, and most leaves, or whether it joins the blade in the middle, and spreads out its fibres like the whalebone rays of an umbrella. Now what sort of plants can hold up their leaves in this way, without one leaf shutting out the light from another? Surely only such plants as have stems creeping along the ground, so that each leaf can rise up in its place, making a series of little one-legged tables all along. You have only to look at the garden Indian cress (fig. 163), the plant which is wrongly called the nasturtium, to see how suitable this mode of leaf-attachment is to a creeping plant; or at the wood-sorrel with its three leaflets, or at other plants which will suggest themselves to your mind. Simple leaves like the Indian cress are said to be *peltate*—*i.e.* made like a shield, from the idea that each of these leaves is held up just as a shield was held over his head by the Grecian soldier, who crouched down beneath it.

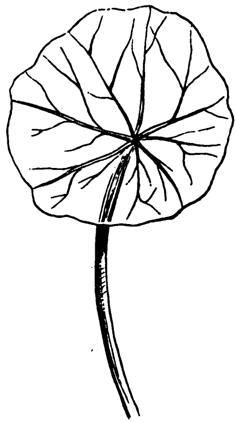


Fig. 163.
Leaf of Indian cress.

4. *With what stipulation?* You have already seen, in the case of the herb Bennett (p. 67), what *stipules* are. These little leaflets are too characteristic of different families to be neglected; their presence or their absence must be stated; and, when present, they must be described in the same way as an ordinary leaf would be. In some plants, where the leaf has been adapted to some extraordinary use, the stipules play the part of real leaf; as in some species of pea, where the leaf is used as a climbing instrument, and the stipules become the feeding apparatus.

5. *How veined?* Whether feather-wise (*pinnately*), as the fuchsia (see fig. 19, p. 29); finger-wise (*palmately*), as the geranium, and Indian cress (fig. 163); or with parallel veins, as the lily of the valley (see fig. 21, p. 29), and all monocotyledons.

6. *How far cut?* Whether forming a compound leaf, like the rose (fig. 164), which, as its cuts go feather-wise, is called a

pinnate leaf; or, like the horse-chestnut (fig. 165), which is called a *palmate* leaf, because the cuts go finger-wise, though

Fig. 164. Pinnate leaf of rose.

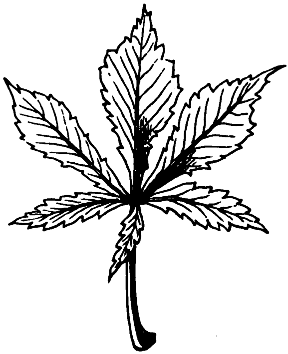


Fig. 165. Palmate leaf of horse-chestnut.

each separate leaflet is pinnately veined. You can always distinguish a compound leaf by seeing whether the leaflets are quite separate, so that they can be detached without tearing their neighbours. Leaves are sometimes doubly or trebly compound, as many ferns, herb Robert leaves, *i.e.* each of their leaflets is cut up again into leaflets. If the leaf is *simple*, *i.e.* not cut to the mid-rib, it is often cut for some distance; as the dandelion (fig. 166), the cutting of which gives the name to the whole plant, from its teeth bearing a fancied resemblance to those of a lion (*dens leonis*). When this is the case, it is necessary to express how far the cutting extends, and it would need a small glossary to explain all the terms which have been invented for this one purpose.

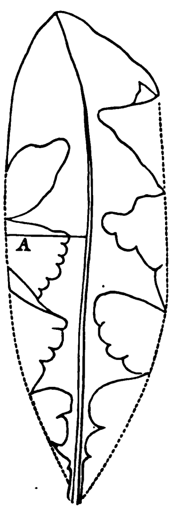


Fig. 166. Outline of pinnately-veined leaf.

The simplest plan is to state what fraction of the leaf, as one-third, one-fourth, etc., is cut. Thus, in the case of the dandelion and all feather-veined leaves, you suppose an imaginary line drawn round the leaf, which is indicated by the dotted line in fig. 166; then you draw a line (A) from the mid-rib to the dotted line through one of the deepest cuttings, and see what fraction of this line goes through the leaf, and what fraction through the cutting. In the figure before us the cutting is rather more than three-fourths of the whole line. If you want to settle the cutting of a finger-veined leaf, as the fig or ivy (fig. 167), you take the outline in the same way, but you draw the measuring line (A), *not* from the mid-rib, but from the base of the leaf, *i.e.* from the point whence the five principal veins start. Thus we find that our ivy-leaf is cut rather more than one-fifth.

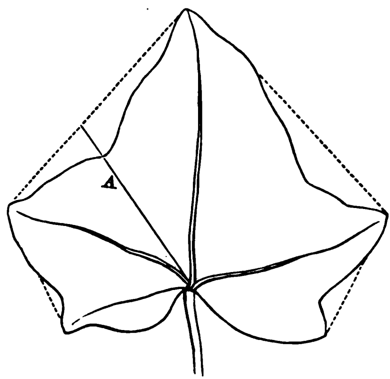


Fig. 167. Outline of palmately-veined leaf.

7. *Shape?* The shape of the leaf must be given, which is judged from the general outline, viz. the dotted lines mentioned above. If the leaf is compound, the shape of the leaflets must be also given. The different kinds of shape are best learnt by practical examination of leaves; and if you wish to understand the various terms used in collecting, I must refer you to the Appendix at the end of this book, or to "Bentham's Handbook of the British Flora," which is by far the best Flora for your purpose, and in the introduction to which you will be able to learn the precise sense in which he uses each term.

8. *Edge?* Whether the margin of the leaf is *entire*, like the ivy, or marked with teeth; if the latter, with what sort of teeth? whether, like those of a saw, like the rose-leaf (see fig. 164), when they are called *serrate;* or rounded, like those of

many geraniums, when they are called *crenate* (from *crena*, a mediæval Latin word used in architecture to denote the intervals between battlements); or with sharp teeth, pointed straight on, and having curves between them, as some fuchsias (see fig. 19, p. 29), when they are simply called *dentate*, or toothed.

9. *Point?* Whether the leaf ends bluntly like the Indian cress, or has a point like the fuchsia.

10. *Colour?* You must be careful here to notice the colour of both the upper and under side, as they are often different.

11. *Hair?* Whether the leaf is smooth, when botanists call it *glabrous* (*glaber*, smooth), or hairy. Here again both sides must be looked at, as the upper surface is often smooth, and the under covered with a soft down, as many willows.

Fig. 168. Pinnate leaf of rose.

These are the eleven points to be considered. We will now describe our rose-leaf (fig. 168) as an illustration of how the descriptions should run.

Rose-leaf; growing on the stem, arranged in two-fifths, with a short stalk, stipules shaped like an arrow-head, feather-veined, compounded of five leaflets, each leaflet oval in shape, with an edge toothed like a saw, and pointed; a bright green colour above, and beneath a lighter green, bearing a few hairs, each with a minute cell at the tip containing a sweet-smelling liquid.

In this short paragraph every one of the eleven questions is answered, as you will see by comparing it with them, therefore the description of leaves is not such a very lengthy matter after all.

Now we come to the extraordinary uses to which some leaves are applied. We have seen in Chapter VI. how the floral organs—cup-leaves, crown-leaves, dust-leaves, and pod-leaves—are all really leaves adapted to new uses; now we have to see the unexpected functions often performed by foliage leaves.

Leaves as Weapons.—Many a plant turns its usually harmless leaves into weapons of defence, as the nettle, which lengthens the superficial cells of its leaves, stiffens their tips to make them prick, and deposits in each a tiny drop of poison, of the efficacy of which all my readers have probably been made painfully aware.

Other plants have the veins of their leaves hard and pointed, as the holly, and it is very curious to notice how, when the tree has reached a certain height, and so is safe from its enemies, it only produces smooth unprickly leaves. In the barberry some of the leaves, instead of having these leaflets, are turned into three sharp thorns or *spines*. In the gorse there are no leaves at all, only a mass of soft green points, and in the case of the cactus, something of the same sort has happened, as we have seen before.

Other plants, as the acacia trees of our gardens (*Robinia pseudacacia*), turn not their leaves but their *stipules* into thorns. Thus it is not enough to say that a plant has spines. We must settle whether they are transformed *branches* (see fig. 159, p. 172), or *leaves*, or *stipules*. This can generally be done without difficulty by looking at their position. If, however, we find a prickly plant with thorns scattered all about the stem, as many roses (see fig. 164), we may know they are simply enlarged cells, and are correctly called *thorns*.

You will be surprised to hear of a plant which uses its leaves as *offensive* weapons, but I do not know what else one can call the fly-traps of the common sundew (*Drosera rotundiflora*). This plant belongs to the saxifrage family, and grows in marshy places. Its leaves have a number of sticky hairs, especially round the edge, which are so irritable that they close on the slightest touch, thus acting exactly like mouse-traps, except that flies instead of mice are their victims. No sooner does an unfortunate insect settle on one of them, than the hairs close upon it, and the harder the prisoner struggles the more irritability is excited, and the tighter is it pressed. A foreign member of this same family (*Dionæa muscipula*), called Venus' fly-trap, is even more successful in its murderous business than our sundew. Of course there must be some good to the plant in this curious arrangement; but whether this is to provide itself with fly-soup, or whether it has some quite different purpose to which the fly-catching is an accidental adjunct, is not certain. Various experiments have been made on the *Dionæa muscipula*,* which seem to show that in this plant there is a fluid at the tops of the sticky hairs, which really has the power of digesting animal substances, and it is therefore supposed that the juices of the fly are sucked into the plant, and serve as nutriment to it; but very decisive proof will be needed before one can thoroughly believe in a carnivorous plant.

Climbers.—Another use to which plants turn their leaves is by making of them a succession of hands with which to climb. They twist them slowly round and round in the sunlight, in the same way as the hop does its stem, (see p. 173), till they come in contact with some obstacle to which they can cling. Different plants twist different parts of their leaves; thus the clematis and canary creepers climb by the revolving power of their *leaf-stalks;* the sweet pea has large stipules, and only two out of five or seven leaflets are leafy, while the rest are reduced to thread-like and twisting tendrils (fig. 169); in the wild yellow vetchling (*Lathyrus alphaca*) this transformation is carried further still, for there all the leaflets become tendrils, while the great wing-like stipules perform the duties of the leaves. In the real vetches there are often sixteen to twenty leaflets to each compound leaf, and

Fig. 169. Leaf of sweet pea.

* "How Plants behave," by Asa Gray, p. 45. (New York.)

the last three of these are generally enough to perform the climbing part of the leaf's business; accordingly we find only these reduced to threads.

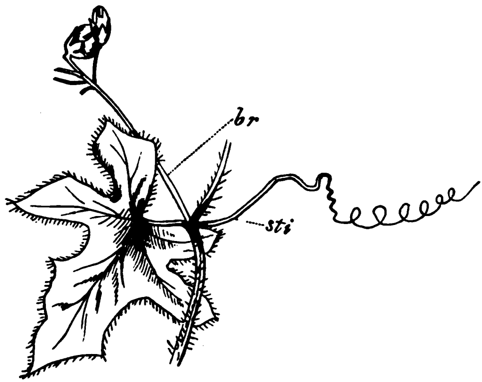


Fig. 170. Stipule tendril of common bryony.

The common bryony (*Bryonia dioica*) is a plant with beautiful tendrils (fig. 170). I have called them modified stipules in the illustration, but botanists disagree as to their origin, some considering them to be stipules, others leaves, and others again branches.

Of all creepers commonly grown in England the Virginian creeper (*Ampelopsis hederacea*) is the most ingenious. It belongs to the same family as the vine, and like it (fig. 160, p. 173) climbs by its modified flower-branches; but, instead of merely producing tendrils with a revolving power, it forms little sticky pads at the end of each of them. These cling so tightly to the rough brick walls on which Virginian creepers generally grow, that in the winter, when all the little branches have died off, these may still be seen adhering to the wall.

A year or two ago, I tried to make a Virginian creeper climb up the pole that supports a verandah. It grew very well for the first foot or so, for the stem could support it thus far; then it sent out its little pads and tried to cling to the pole, but that was too slippery for them, and the wind blew them off again and again before they had had time to take firm hold, and it was not till I steadied the plant by many tyings that it really got on, and was able to make use of its hundreds of hands.

There is another curious sort of foreign plant called *Nepenthes* or pitcher-plant, which is sometimes to be found in English green-houses. This not only turns part of its leaves into bare mid-ribs, which we have compared to hands, but in these hands it holds cups for the rain to fall into, provided with closely-fitting little lids which open and shut apparently at will. You may say this is too strange to be true, but look at fig. 171, which is a picture of a sort of pitcher-plant which grows in a friend's green-house, and you will see the facts are not exaggerated. Botanists used to consider that the little lid was only the leaf, and all the rest leaf-stalk; but recent observations and comparisons with kindred plants have proved that the proper leaf begins with the blade, though it is afterwards reduced to the mid-rib only. Whether these pitchers are meant for catching rain, or only for holding self-distilled moisture, or whether they have some other quite different use, is among the, as yet, unsolved problems of botany.

Fig. 171. Pitcher-plant.

With this last description, which is like a fairy tale from leaf-land, we must say good-bye to this part of our subject, and turn our attention to the comparatively dry details of classification.

CHAPTER XII.

ON CLASSIFICATION.

WE have now looked at the different parts of plants in detail, and in the course of doing so have become acquainted with a great many of one sort and another. By this time, therefore, you must be feeling the need of grouping your new acquaintances in some sort of order, lest you should forget all about their peculiarities; for instance, supposing half-a-dozen plants to have some particular mode of growth in common, it will evidently be a saving of trouble to remember this half-dozen under one head instead of each individually.

Also, you need some help to enable you to find out the names, and to group for yourselves all the new acquaintances, which I hope you will make for yourselves in the flower world. It would take more than one lifetime to make and name even a poor collection, unless some sort of a classification had been devised to guide us through the labyrinth of plants; but the process of collection will be a barren one, unless we use such a classification as will not only teach us the names of the plants we find, but will also guide us as to their various properties, the laws of their arrangement, and the laws of their growth.

Up to this time my readers have been, as it were, introduced to their plants as to strangers: when a person is introduced to us of whom we previously know nothing at all, we start with the name only, and learn facts about him gradually; at first we only remark the peculiarities of his personal appearance, then we begin to talk together, and we perhaps gather that he is agreeable and intelligent; but as yet, all we can learn of him does not aid us, except to help us towards making an accurate description of his person and character. But suppose further that we learn accidentally that he is an American, at once we are provided with new subjects for conversation; we feel as if we knew a great deal about him already; we have a clue to explain many of his personal peculiarities, his manners, his accent, and so on: if we go on to find from which State he comes, whether a Southern or a Northern State, we seem in one word to have learnt a hundred fresh things about him; and supposing that our own acquaintance with American life is sufficient, we learn more of him if we know to what town he belongs, and still more if he happens to belong to a family in that town, some of whose members are already within our circle of acquaintance. It is this sort of intimate acquaintance that the knowledge of a plant's position among other plants ought to give us; at present, with regard to our plants, we are only in the stage of having learnt somewhat of their individual appearance, structure, and nature; we have not learnt as yet to sort them into their great classes, their divisions, or their families. It is true that here and there several plants have appeared having such a family likeness that we have quite naturally grouped them together, as the Buttercup and Rose families; or we have come across some widely spreading difference, separating two great classes, as, for instance, the number of seed-leaves, or the growth of wood. But we have got no system which will supply us with the information in each case, to what class, to what family, any given plant must belong.

Every one has probably felt the difficulty, when introduced to an entire stranger and forced to make conversation, of not being able to make happy guesses, such as I supposed in my above illustration, of the country, town, and family, to which the stranger belongs. If we did but know these things, there seem such hundreds of things we could say; but what topics of conversation can we devise interesting to a person of whom we know nothing except what we can see with our eyes?

This kind of difficulty ought never to occur to a botanist in making acquaintance with his plants; he ought not to have to trust to happy guesses, the inspiration of the moment; he will have certain fixed rules, by which, at the cost of a little perseverance, he can make out for certain the class of his new plant, to what family it belongs, and what sort of relatives it has; of course he will soon learn to discard this process, and to recognise many plants by their family likeness; few, for instance, who have examined a crucifer, as the wall-flower or stock, will have any difficulty in recognising many others by their remarkable family likeness; but even in this he may either be deceived or puzzled, and he will then always have his fixed rules of classification to fall back upon.

Classification of plants has then two objects to fulfil: it not only enables us to know one plant from another by its name, as we distinguish William from John, or Ramsgate from Margate, by their names; it not only enables a learner to refer any strange plant to its proper place, and so learn its name, just as a person admitted to the House of Commons might learn the name of an orator by turning over a photographic album which contained named portraits of all the members. It has another object, viz. that in so far as it is a good classification it should do more than this; it should tell us at once much that we want to know about the plant—for instance, what internal structure its stem must have, what sort of a seed it will have, even supposing the bud yet unfolded, what medicinal properties its relatives have, and which it may therefore be suspected of having; and besides this, it should suggest a great many fresh points for examination.

The classification which is now adopted in Floras is called the "natural" classification; and it is so called because it does, as far as botanical knowledge has been able to enable it, fulfil the above test of a good classification. It does, in the logician's language, provide that "plants shall be thought of in such groups, and the groups in such order, as will best conduce to the remembrance and the ascertainment of their laws."

This will be best seen by comparing the natural with some of the earlier principles of classification.

Plants might be classified with more or less advantage by any rule, however arbitrary; thus in a botanical dictionary plants are classified by the first letter of their names; of course the plants which begin with A are not likely to have anything else in common with one another, but yet the arrangement is distinctly of use in enabling us to find out what is said in the dictionary about any plant whose name we already know.

Scarcely less arbitrary is the common division of plants into trees, shrubs, and herbs; a useful arrangement for the practical purpose of the gardener, but not one which either groups like things together, or enables us to learn anything of the laws of plants. How unsatisfactory such a classification is, is shown by the fact that families which in England are represented by herbs only, in the tropics are represented by trees; and, indeed, the very same plants which are shrubs or even herbs in one climate may attain to the dignity of trees in another.

Let us go back to the earliest writers we can find. The first botanists of any note came from the school of Aristotle, the tutor of Alexander the Great; of these the greatest was Theophrastus, the successor of Aristotle. This philosopher, however, had no idea of any classification as a means of teaching the nature of plants; he simply regarded them as they required to be classified for their uses to man, to the farmer and the gardener. Thus we find him separating garland-plants * from pot-herbs, corn-plants from pulse-plants, such as peas and beans; and again he divides plants into (1) annuals, (2) those that die down every

* His term of *garland-plants* very probably suggested to later botanists the use of the word corolla or crown for that part of the plant most useful for ornament.

winter, but come up again in spring, botanically called *herbaceous* plants, (3) shrubs, and (4) trees. None of these distinctions form a true basis of classification : in the first place, they do not include all plants; there are many plants which come under neither of the first four heads ; and again, there are others, like the scarlet-runner, which might come under the three heads of a garland-plant, a pot-herb, and a pulse plant; and thirdly, the plants collected under each head have little or nothing else in common. So again, the division of plants by a later Greek into plants good for food, good for smell, good for making wine, and good for medicine. Of course no one now cares to learn these odd classifications, but they are very instructive, as showing us the poor ideas which even the cleverest men produced on this subject.

A lapse of time without result to Botany ends with the revival of learning in the fifteenth and sixteenth centuries. The diffusion of the habit of exact drawing, "especially among the countrymen of Albert Durer and Lucas Cranach, and the invention of woodcuts and copperplate," * had not been without its effect in producing a more accurate habit of observation, and in calling attention to smaller organs, such as stamens and pistils, which had hitherto almost escaped notice.

Attempts began to be made to arrange plants not according to their uses, but according to what they really were. At first superficial characters were chosen, and thus artificial systems were formed ; no character could really be the basis of a natural classification, unless the members of each group into which it separated plants resembled one another not in one character only but in many.

Suppose, for instance, we had an artificial classification for animals, and grouped them according to their colour, we should

* Whewell's Inductive Sciences, vol. iii. page 234 ; to which work, as also to Sprengel's Geschichte der Botanik, I am much indebted in this chapter.

have green frogs, green parrots, and green butterflies, all in the same group, with scarcely another character in common; or again, if we grouped them by the length of their tails, we should have the tiger, the mouse, and the crocodile. Our botanists did not choose quite so absurd characters as these, but yet the result in many cases was to group together plants certainly as different as a tiger from a mouse.

Thus one man* chose the shape of the corolla, another † the fruit alone, another ‡ the fruit and corolla combined, another § the pistil and stamens alone, and another ‖ by a happy inspiration hit on the cotyledons.

The fault of all these classifications was, that although they succeeded in bringing together many plants which ought to be grouped together, yet they formed many of their groups of very miscellaneous plants.

Of the early groupings the most natural was that by Tournefort, the French professor of Botany at the Jardin des Plantes, towards the end of the seventeenth century; this was based on the form of the corolla. Now it happens that several groups of plants, which have the same shaped corolla, have many other points in common—in fact, so many points of agreement that the more we study them the more the agreement comes out; these groups of plants are therefore natural groups, they make together a *kind* of plant different from all other plants, and they bear in the shape of their corolla a sort of notice of the other points of agreement which a more minute investigation would disclose.

It was for this reason that several natural groups, or, as we should call them, natural families, occur in this arrangement. Thus we recognise there the pea-flowers—plants with a blossom with its standard, wings, and keel, like the pea or the gorse; it is true that, as Tournefort judged by the corolla alone, other families, as the milkwort, got mixed up with them. It is odd how a superficial resemblance will deceive even a practised eye. I sent

* Tournefort. † Cæsalpinus. ‡ Ray. § Linnæus. ‖ Lobel.

lately to a gardener for fifty specimens of "any pea-flower," to illustrate a lecture I was going to give. I had not time to examine the tin containing the specimens till the moment arrived; my specimens were just being handed round to the audience, when, to my horror, I found they were of the milkwort family, and no use for my purpose whatever. My friend, the gardener, had, like Tournefort, selected his plant by one character alone; had he looked inside one of the corollas he would have seen at a glance that, whatever else the flower was, it was not a pea-flower.

But for all this, Tournefort managed to group together the crucifers, *i.e.* those plants which have the wall-flower for a type; the labiates, which have the salvia or the white lamium; and other natural groups.

Linnæus, the great Swedish botanist of the middle of the last century, chose the number of stamens and carpels for his critical characters. By so doing he succeeded in choosing a system which was above all others easy of application; there is no difficulty whatever in counting the number of stamens, and hence the long favour which his system enjoyed, and indeed still enjoys. But while we find it very easy to assign any plant to its proper class, according to his plan, yet these classes often contain plants with very little in common, and some very clearly marked natural groups are separated—thus some of the grasses are in the class with two stamens (Diandria) and some in that with three (Triandria.) Hence in the Linnæan system we fail to group together such plants as by being so grouped can be most easily remembered and most clearly understood.

It is true that Linnæus deviated from his own system in order to form special classes for such natural groups as had, as one of their distinguishing characters, a very peculiar and special dust-organ—as the Tetradynamia, which are our Crucifers; the Syngenesia, which are our Composites, a well-marked family, which I hope to discuss in detail in my next chapter; and Gynandria, which are our Orchids.

In these cases his groups are good, because they make us think at the same time of those kinds of plants which possess this peculiarity of their dust-organ; but in general we are not certain to have anything in common between plants which have a given number of stamens and carpels.

And the great botanist felt this, for before his death he indicated that he was aware that his system only answered a temporary purpose, till a truer and more natural one could be worked out; and he went so far as to sketch out the characters of some thirty natural groups, which have now been adopted as families in the natural system.

We have yet to consider the natural system, as it is called, which has now superseded the Linnæan system: not that it is in all respects a *natural* system, for in some points it is as artificial as its predecessors, but *natural* in as much as it professedly aims at natural, and therefore really distinct grouping, and to a great extent has succeeded in its aim.

The chief originators of a natural system were the French botanists Jussieu and De Candolle. It is the system of Jussieu as modified by De Candolle and successive botanists that forms the basis of the classification now in use; and according to it our English Floras, and Mr. Bentham's among the number, are arranged. A more complete system has been made by the great English writer, who died a few years ago, Dr. Lindley; but his improvements have hardly yet found their way into our text-books.

Two main features run through the natural system—(1) the division of all plants whatsoever into three great classes; (2) the arranging of plants into smaller groups, called families. Both these points have been naturally and not artificially carried out.

The three great classes have been already pointed out—viz. Dicotyledons, Monocotyledons, and Acotyledons. The character upon which these classes are based—viz. the number of the cotyledons—might at first seem arbitrary and artificial, but when it is seen that with this difference many others are connected, the naturalness appears; thus we have the following distinctions :—

DICOTYLEDONS.	MONOCOTYLEDONS.	ACOTYLEDONS.
Flowering plants (*Phanerogams*).	Flowering plants (*Phanerogams*).	No true flowers (*Cryptogams*).
Two or more cotyledons.	One cotyledon.	No cotyledons.
Wood in rings.	Wood in isolated bundles.	Wood in patterns, not rings.
Net-veined leaves.	Parallel-veined leaves.	
Ruling number 4 or 5.	Ruling number 3.	

Besides these differences, there are others which hold *generally* true, but not always; and indeed a botanist soon learns to distinguish the class to which a plant belongs by its general habit.

It is an error to suppose that there are no plants which seem to lie on the border land, and while agreeing in most respects with one class, yet in one or more, and perhaps those important respects, seem related to another class. Thus the embryo of the parasitic dodder, which may be seen climbing over our furze and heath, seems to be acotyledonous, yet as it in other respects agrees with dicotyledons, and is akin to the convolvulus, it is grouped in the convolvulus family.

Of the smaller groups or families some have already been introduced into these chapters by the long description of typical specimens; thus we have had of dicotyledons the Buttercup Family, known by having all its floral parts separate and free; then the Crucifer Family, a well-marked group, easily recognised by its six stamens, four long and two short, coupled with a peculiar ovary; the Pea-flower Family, known by its curious-shaped corolla and its distinctive stamens; and several others.

The long table which accompanies this chapter is intended to give practice in determining the family to which any plant found in the field belongs. There is extreme difficulty in making such a table accurate and yet complete; but the experience of some years has shown that the table here given can be used with great practical utility.

You will find marked in it almost all the families represented by native plants in England; it would be impossible to include in such a table all the families there are in the world; for according to the system of Adrien de Jussieu there are 216 families, 12 belonging to acotyledons, 30 to monocotyledons, and 174 to dicotyledons.

The number of families being so large, attempts have been made, more or less successfully, to combine the *families* into groups less large than *classes*, which have been called *Sub-classes* or *Divisions;* at present these divisions are somewhat artificial, for they separate many families, which from a general point of view seem closely allied, and the series in which the families so divided present themselves, fails to fulfil the logician's definition of a good classification mentioned above (p. 198), because it does not really conduce to the remembrance and the ascertainment of their laws of growth. De Candolle himself spoke of this series as "a mere scaffolding, better or worse suited to accomplish its end."

You will see by the table that the Dicotyledons are divided into three divisions—Polypetals, Gamopetals, and Incomplete.

(1.) *Polypetals* have both calyx and corolla (with a few exceptions), petals not united; and are divided into two subdivisions:—

Thalamiflorals; stamens free, *i.e.* coming off the receptacle.

Calyciflorals; stamens not free, *i.e.* not coming off the receptacle.

(2.) *Gamopetals* have both calyx and and corolla, petals united.

(3.) *Incomplete* have not both calyx and corolla.

The divisions of Monocotyledons and Acotyledons may be seen at a glance from the table.

We have thus the whole vegetable kingdom divided into classes, classes into divisions, divisions into families. Farther than this, families are divided into genera, genera into species, and species sometimes into sub-species or varieties.

In the case of the plants described, it will have been noticed that each plant has *two* Latin names; thus *Sedum acre* (p. 41) meant that the plant described belonged to the genus *Sedum*, and was distinguished from the other kinds of Sedum by the epithet *acre*, or biting. The name does not tell us the family, which we are supposed to guess from our knowledge that all Sedums belong to the family Crassulaceæ, and to the division Polypetals.

All plants of the same species resemble one another in almost all points, or at least only differ in minor points, according to the individual peculiarity of the plant, just as one animal may differ from another of the same species—one horse from another, for instance. If any set of individual plants are markedly and constantly different from all the rest of their species, and resemble one another in that difference, they are called a variety—thus there are varieties of rabbits, pigeons, dogs, and of most domestic animals.

A few words as to how to use the long table. In the first place, it does not profess to enable you to determine the *genus* and *species* of the plant, it only enables you to determine its *family;* and, as was said before, it is only intended to apply to native British plants: it is no use therefore attempting to run down garden or green-house plants, unless they are also found wild in England.

If it is desired to determine the genus and species, recourse must be had to a Flora, such as the one by Mr. Bentham, which was recommended to you before. You should then turn to the family in which you know from the long table that the plant is included, and endeavour, from directions given you there, to find out its name. An example will be the best way of making this clear.

Let us suppose a flower has been found in the fields. I will take an easy one, and my readers will probably guess which it is as we run it down. I look at it, and see that its oblong wrinkled leaves are net-veined. I therefore know I shall find it in the class dicotyledons, which occupy the first ten columns of the table; I see that it has both calyx and corolla; hence it is not in the ninth and tenth columns (which contain the families of the Incomplete division). I next notice that the yellow corolla, although its limb is divided, yet has its petals united below into a tube; hence it is not to be found in the first five columns (which contain the Polypetalous families), and we infer that it is somewhere to be found in the Gamopetalous division, which occupies the sixth, seventh, and eighth columns.

Proceeding down what may fancifully be called the genealogical tree of the Gamopetals, we find that the division separates into two branches—those with ovary not free, *i.e.* joined to some other organ (as in willow herb), and those with ovary free. The ovary of our plant is free, and the corolla is regular: these two facts will take us safely to the seventh column: but how are we to tell to which of the twelve families in that column it belongs?

It is not of the Heath family (Ericaceæ), because its stamens grow on the corolla. It *may be* of the Primrose family (Primulaceæ), (as possibly you have guessed before now), for the stamens *do* grow opposite to the divisions of the corolla, the placenta is free-central, and the seeds many. Still we must not conclude that *it is* of the Primrose family till we have found a separate reason why it cannot belong to either of the other families in the column. If my readers will provide themselves with either a primrose or a cowslip, they will be able to find out the reasons: thus, for instance, its free-central placenta will prove that it is not a gentianaceous plant, its one-celled ovary will show it is not of the Boragineæ—and so on. We therefore conclude that it is some plant of the family Primulaceæ, of which the primrose itself is the best type. To what genus or species it belongs we could not ascertain for certain (always supposing that we did not know it beforehand), without turning to the family in the Flora. I will assume that the plant is really the primrose itself, although we are supposed not to know it. We turn to the page in the Flora where the Primulaceæ are treated: in Bentham it is at p. 300: we there learn that there are nine genera of British Primulaceous plants, and a table somewhat similar to the long table is given to enable us to determine which is the right genus.

Of these nine, the Hottonia is out of the question, as being an aquatic plant; four others are discarded, because their leaves are all opposite or whorled, whereas our plant's leaves are radical; among these are the pimpernel and the moneywort; the four remaining are the primrose, the cyclamen, the trientale, and the samole, of which we read in the first chapter. The two latter are rejected, because their stems are leafy, whereas the stems of our plant are *not.*

The shape of the corolla will be sufficient to determine between the primrose and cyclamen genera. It seems very odd that the last genus to be rejected is the cyclamen, a plant at first sight so utterly unlike the primrose: yet if the cyclamen be examined, it will be soon seen to have all the characteristics of a true Primulaceous plant.

We have then established that our plant is a Primula; but then which is its species? *Primula* what? Turn to the Primula genus; Bentham gives us only two species to choose from—*veris,* whose corolla is yellow, and *farinosa,* whose corolla is pale lilac. It is then *Primula veris,* Linn. The abbreviation succeeding the name is short for Linnæus, and always indicates the name of the botanist who first gave the name of *Primula veris* to this particular plant.

But it happens that our journey is not yet done: of *Primula veris* there are three well-marked varieties; indeed, so well marked, that most botanists rank them as three separate species; viz. var. Primrose, var. Cowslip, and var. Oxlip. Referring once more to our specimen, we see that it has its flower-stalks radical and one-flowered, and that therefore it is *not* the cowslip or the oxlip, which have an umbel of several flowers, but is the true primrose variety of the *Primula veris*, the Primula being a genus of the family Primulaceæ, of the division Gamopetals and the class Dicotyledons.

It will be thus seen that plants, as it were, grow with their names and the names of their families written inside. No pictures, only practice, is wanting. The more plants a young botanist runs down, as it is called, the better: at first he should choose those plants which are not only easy of dissection, but of which he is able to tell at the end whether the family he arrives at is the right one, by knowing beforehand the common name of the plant. Let him try a crocus, a violet, a buttercup, and so on. After a little practice he will begin to trust himself to go right, even if he is attempting to name a plant with regard to which he has not the faintest conception what it is. This will be found very interesting, and if hard work with a Bentham be added to a study of the long table, there is no doubt considerable progress will soon be made towards becoming a real botanist. At first I should say to beginners—by all means *avoid* illustrated books; learn to trust to your dissecting needles, and to the description you make of your specimen: let the final test be, not whether your plant looks like a more or less accurately painted picture, but whether your notes of it tally with the description in the Flora of the species to which you wish to refer it. Another caution should be—Do not attempt the more difficult plants at first; such families as the *Umbellates*, of which the chervil and the hemlock are types, the *Composites*, of which the daisy, the thistle, and the dandelion are types, the *Sedges*, and the *Grasses*, are great stumbling-blocks to beginners; therefore avoid them at first: if a plant has been run down to one of these families, do not attempt as yet to go on to its genus and species. Perhaps in the next chapter help may be given you with regard to some of these families; an unknown Umbellate cannot possibly be named, unless a specimen with leaves and *ripe* fruit be procured.

Again, some genera are hard, because botanists differ as to the number of distinct species, and the distinctions between the different species and the different varieties are too subtle or too superficial to be recognised till after special practice; against the following genera I would specially caution my readers: Rosa and Bramble (*Rubus*), in the Rosaceæ; Hawkweed (*Hieracium*), among the Composites; Willow (*Salix*), among the Catkin family. To these should be added the *water* buttercups, all of which Mr. Bentham, who takes the extreme view of reducing the number of species, classes under the species *Ranunculus aquatilis;* whereas other botanists, who take the other extreme view of promoting almost all the recognisable varieties into species, count up as many as twenty species. It is because Mr. Bentham takes this simpler view, that his Flora is the best to place in the hands of beginners. There is quite enough work for many a month in learning the well-marked species, about which there is no doubt, before we begin to study the disputed genera, which are sometimes called *polymorphous*, that is, assuming many forms.

With these many cautions, and somewhat tedious directions, the reader is commended to the interesting work of collecting, classifying, and naming plants.

NOTE.—In the Table of Families, only the characters are given which are necessary for distinction from some other family in the same column. The rest of the characters of the family must be learnt from the Flora itself. Where a family occurs in more than one column, it is because some genera would come in one column and some in another.

Several families, only represented by one British species, and that species local and rare, have been omitted for the sake of simplicity; these are the Frankenia, Tamarisc, Elatine, Polemonium, Elæagnus, Sandalwood, Aristolochia, and Restio Families.

The English name of the family is in most cases taken, after Bentham, from the typical English genus.

The numbers refer to Bentham's Flora, to which, as far as possible, the table has here been adapted throughout.

The sign ∞ means numerous or indefinite.

The term *separate*, as applied to sepals, petals, etc., means that each member of the set of leaves or *whorl* is not united at all to the other members of the *same* whorl.

The term *free* means that the whorl comes off the top of the stalk without being joined at all to any other whorl.

Under the head "coming off the flower-tube or flower-rim," are included all flowers which in Botany are generally called "*perigynous.*"

The black lines in columns 5 and 8 indicate that the families below them belong to the preceding columns.

CHAPTER XIII.

ON UMBELLATES, COMPOSITES, SPURGES, AND PINES.

SPECIMENS wanted—*Sprigs of shepherd's-purse, chervil, chickweed; heads of groundsel, dandelion, and daisy; plant of spurge*, and *catkins of Scotch fir.*

We have spoken of the ways in which flowers have, by different men and at different times, been arranged in groups, and have traced the growth of the system which we now use. We have seen how the main thing to be desired in a system of classification is that each group should have *several* and *important* likenesses; and we have found how system after system has been superseded as imperfect, because, either for the sake of ease in naming flowers, or for want of scientific ideas, their framers have neglected these fundamental points. We will now take two or three families, which may be called ideal ones, so striking are the points of resemblance between the members of them, in spite of very great apparent differences.

The first of these families is that of the *Umbelliferæ*, or "umbrella-bearing plants." Pick a bit of chervil, or wild carrot, or hemlock, or even of parsley from your vegetable-garden, and you will see at once the justice of the name; for all these plants, like most others of the family, give out a number of flower-stalks from the same spot, just like the wires of an umbrella, and then, from the top of each of these, lesser umbrellas with masses of little flowers.

It will be interesting to notice how such an odd structure as these complicated umbrellas can arise. To see this we must go back to our old friend the foxglove. When this magnificent flower is out we have a long stem of blossoms, each blossom being on its own flower-stalk and nursed in the axil of its own *bract*. First the lowest blossom comes out, as we saw (pp. 46 and 51), and then one after another younger blossoms come out at each successive node up the stem, as the plant strains upwards to the air and sunlight. You will remember we described this mode of flower-arrangement as *indefinite*. Such a stem, bearing a flower at each node, each on its own flower-stalk, is called a *raceme*, from the Latin *racemus*, a bunch of grapes. Another kind of indefinite arrangement is found in plantain and wheat; these plants have a similar flower-arrangement, only they have no little flower-stalks: the arrangement is in this case called a *spike*. But our plant grows differently from either of these; it has no intervals between its blossoms; they all start from the same place, and grow, each on its own little flower-stalk, like a bunch of cherries. It would appear then that, just as in an ordinary flower the internodes between sepals, petals, and so on, are never developed—although in certain curious states they may prove their existence, as in the case of the tulip (fig. 105, p. 104)—so here the internodes between blossom and blossom are suppressed, and the umbrella-like growth is the result. The best way to imagine this is to suppose you have a foxglove, with flowers and buds growing all the way up the stalk, and that you are able to press the top and all the intervening flowers down to the same level as the lowest; you will then have a bunch with the oldest flowers, which were the lowest, outermost, and these will be the first to flower. Test this in each of your specimens, and you will find it the invariable rule for the centre of the bunch to be in bud, while the outermost circles of flowers are fully blown. "But," you may object, "what has become of the *bracts*?" The need for them being gone, as there are no longer single flowers to nurse, they are in many cases crowded out of existence; but you may often see them in a rather decrepit state, as round the large bunches of the parsley, and round the large and small bunches of the wild carrot. Such a bunch is called an *umbel*, from the Latin *umbella*, meaning *parasol;* so you see, that in this case the botanists use the same name as was naturally suggested by the flower-arrangement itself. But in our family we generally find not a simple umbel, but a whole umbel of umbels, so to speak, growing at the top of the flower-stalk : this is a *compound umbel.*

We have thus seen three of the chief forms of *flower-arrangement*—the *raceme*, the *spike*, and the *umbel*—all having this in common, that the lowest flowers, or in the case of the umbel the outermost flowers, come earliest into blossom. They are therefore called *indefinite.* We shall speak of a fourth kind called a *head* when we come to our next typical family.

As blossoms are really branches with hardly any internodes—generally none besides the flower-stalk, and in some flowers not even that—you will be at a loss to think of any kind of flower-arrangement in which the lowest blossoms, being in reality the lowest branches, and therefore the eldest branches, will not come out first. How otherwise, you will say, can each blossom in its turn be at the top and nearest to the light? Is it not delicious to see how, in the shepherd's-purse, for instance, the early blossoms enjoy the air, then the heart of the raceme prolongs itself, and other blossoms have their chance—the length of the flower-stalk enabling each blossom in its turn to have the best place; and can any other arrangement effect this as well?

Yes, there is another arrangement which equally well provides for this. Do you remember our old friend the campion (p. 51)? In it and in the chickweed the leaf-arrangement is *decussate*, *i.e.*, as in the dead-nettle, the successive pairs of opposite leaves alternate one with the other. Thus, supposing one pair to point north and south, the next pair point east and west, the next north and south, and so on. In the axils of these leaves come the branches; hence there are two branches at each node.

But what becomes of the main stem? It ends in a single blossom, and you will observe that that blossom is always more advanced than any of the blossoms on the branches that grow out right and left from beside it.

It seems then that in this flower-arrangement the eldest blossom is the one which grows at the end of the stem. Let us call this flower the eldest son: on each side of its stalk come two leaves, and in the axil of each of these comes a branch ending in a blossom, the *second* blossom in point of age; I would call it a second son but that it has its twin, so that there are in fact two second sons, and you will see that to pursue the metaphor will become rather confusing; for each second blossom gives rise, as the eldest blossom did, to two leaves, and to two third blossoms growing in their axils. Now as there were two second blossoms there will be two pairs of third blossoms; and, twice two making four, we have four blossoms of the third order. Following out the pattern, we shall have twice four, or eight, blossoms of the fourth order, and so on as long as the plant has strength to go on blossoming. You will often notice that of the two branches of the second order one is more vigorous than the other, and hence it may go on to the eighth or ninth order, while its twin has had only strength as yet to reach the fourth or fifth.

You will easily be able to trace out this plan in the chickweed, which is in flower almost all the year round. A flower-arrangement in which the end-flower blossoms first is said to be *definite*.

Now, having seen that these two plants have a rather unusual flower-arrangement in common, suppose we run them down to their respective families with the long table, and see whether this is only a superficial resemblance, or whether it is the sign of many other more important ones. We will take the lychnis first. You have already examined it once (p. 51), and will therefore be on familiar ground.

(I am supposing that you have a lychnis, either white or red, in your hand, and the long table spread out before you.)

Its leaves are net-veined, therefore it belongs to the class *dicotyledon;* its petals are separate, and its stamens are *free, i.e.* come off the receptacle, therefore it belongs to the subdivision Thalamifloral, and you may fold up all but the first three columns of your long table. The carpels are united, therefore it cannot be one of the families in the first column. Cut the pistil open, and look at the placentation; there is a central axis, with masses of seeds growing on it, and no partition-walls connecting it with the circumference (see fig. 37, p. 54). Therefore its placentation must be free-central, and it must be a member of one of the third column families. It cannot be the first (Polygalaceæ) because it is regular. The description of the second family (Caryophyllaceæ) exactly agrees with it, for it is regular, has a definite number of stamens, free-central placentation, and five sepals. You may therefore be almost certain that you have a member of the Caryophyllaceæ or Pink family, and a glance through the remaining five families on your column will make you quite sure, as each of them has some peculiarity evidently not belonging to your flower.

Now take your chickweed, and run that down in the same way. You will soon establish that it, too, is one of the Caryophyllaceæ, and therefore a near relation of the lychnis; and when you become better acquainted with this family, you will find that all plants belonging to it have this same flower-arrangement (or *inflorescence,* as botanists call it), in which the central blossom is the eldest. This is a significant fact, for plants are not put in the pink family by reason of their flower-arrangement; you will find no allusion to it in the long table, and yet in this point all our plants grouped for other reasons in this family are found unsuspectedly to agree; this coincidence proves to you how *natural* the grouping has been.

It will be a mistake to suppose either that all plants which grow in this flower-arrangement (a *cyme* * of two branches, as it

* From the Greek κῦμα (1), a wave; (2) a sprout.

is called) belong to the Pink family, or that a plant would be turned out of the Pink family if it failed to exhibit this arrangement as a sort of ticket of admission. In the same way there are plants of the Umbellate family which do not flower in *umbels*, but which, from their many other points of family likeness, cannot be excluded from it; and again, many plants which flower in umbels do not belong to the family.

Another form of the flower-arrangement in *cymes* is when the plant never produces both the branches of the cyme; thus, for instance, there is, let us suppose, one blossom of the first order, and there ought to be two of the second order, and four of the third; but at each node where there ought to be *two*, one only is developed, so that there is only one of the second order, one of the third, and so on. You will see a good type of this in the forget-me-not: from the nature of the growth, which is never straight on, but branching off at each node to one side, we should naturally expect to find the young branch, spiral in the bud, rolled up like the frond of a male fern before it comes up and uncurls; and such is really the case; cymes of one branch are curled in their early stages; as the short internode uncurls, each blossom in its turn becomes erect and faces the light; after a little while another internode uncurls, and another blossom is brought above the former one, to occupy the advantageous position it previously held, and which it requires no longer, now that it is withering and running to seed. By this very remarkable arrangement the same results are produced by the cyme of one as by the raceme; just as at a review each soldier in turn passes before the commanding officer at the saluting point, so each blossom salutes the sun and passes on, giving place to the others.

Run down any forget-me-not (*Myosotis*) to its family, and you will find that it belongs to the Boragineæ; and here again you will see that a growth in cymes, especially cymes of one branch, is characteristic of the whole family.

But we are all this while keeping the Umbellates waiting.

Umbellate Family.—The description which follows will almost equally apply to chervil, parsley, cow-parsley or hemlock.

Take off one of the umbels of the second order, and from it take one single blossom. Fig. 172 is drawn from the wild chervil, because, though its flowers are rather small for examination, it is to be found more nearly all the year round than any other member of the Umbellate family. At first sight you will despair of finding any calyx: no sepals are to be seen: five petals fall off easily and separately, and, as far as can be seen, come off from the top of the seed-vessel, not as in the willow herb (p. 90), from the flower-rim rising from the seed-vessel. The five separate stamens which alternate with them come off in the same way; but cannot we find some trace of the calyx? Let us look at the fruit a little closer (fig. 173); it is surmounted by two stigmas (*stig*), and consists of two carpels, each carpel containing one seed suspended from the top of its cell.

Fig. 172. Flower of wild chervil (*enlarged*).

Fig. 173. Fruit of chervil (*enlarged*).

If some ripe fruits are at hand, it will be seen that the two cells come off one on each side, with their single seed in each, leaving a partition behind (fig. 174). This partition somewhat resembles the axis left behind in a geranium, when all the five carpels have jumped away; and is to be regarded as a prolongation of the flower-stalk up the middle of the flower. The details thus far are common to almost all the family; but the shape, size, roughness, etc., of the fruit vary much in different kinds of Umbellates.

Fig. 174. Split fruit of chervil.

Still we have seen no trace of calyx. Turn to the parsley (fig. 175), which has a ribbed pistil, and count the ribs round the fruit; can any clue be obtained from that? if the fruit is made up of two carpels only, we shall

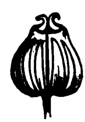


Fig. 175. Fruit of parsley.

expect two or four ribs, whereas in most Umbellates you will count ten prominent ribs. Does not this remind us of the ten prominent ribs of the calyx of many flowers whose petals run in fives—in the primrose, lychnis, and others? Is it impossible for the calyx to have become united to the other whorls all shut up together inside—carpels, stamens, petals, and sepals, all bound together at their base, so as to allow the free ends of all except the sepals to come out and show themselves? Not only possible, but indeed almost certain; for there is a sort of ridge, and some signs of five little teeth, which in some flowers clearly betrays where the tube ends. But here, again, as in our sixth chapter, we may get help from the extraordinary forms which some specimens of plants of this family exhibit: in carrot, parsley, cow-parsley, and other genera of this family, blossoms have been seen, though, of course, very rarely, in which the five sepals are distinct from the rest of the flower, and separate from one another. These monstrosities confirm the theory that in all Umbellates a calyx of five sepals is present, although joined to the ovary, and therefore concealed.

It may be well here to give a table of an Umbellate plant.

PARTS OF FLOWER.	No.	SEPARATE OR JOINED.	WHERE COMING OFF.	REMARKS.
Sepals.	5	United entirely.	The ovary.	Five small teeth.
Petals.	5	Separate.	The ovary.	Size variable, according as petals point outwards or inwards.
Stamens.	5	Separate.	The ovary.	
Carpels.	2	United.	The receptacle, but joined to calyx-tube.	Two cells; one suspended seed in each cell: axis forms a partition between the cells.

The leaves of plants of this family are very beautiful; some are simply compound, but with the leaflets deeply divided (as in the cow-parsley); others again, as the chervil, are trebly compound, and even the leaflets of the the third order are divided. As the tables of these plants are all the same, and as we have thirty-eight genera of British Umbellates, some help towards recognising different plants must be sought from the leaves; but the real distinctions are based on the ripe fruit; hence, as was stated in the last chapter, it is impossible to refer an unknown Umbellate to its proper genus and species, unless ripe fruits are at hand. In the fruits of many species there are long channels running down them, a little below the surface, which contain oils; these channels are called *vittæ*, and some of the distinctions of genera are founded upon them. The presence of these vegetable oils gives a pungent taste to some of the fruits; the caraway (*Carum carui*), for instance, which we use for seed-cake, and which is not really the *seed*, but the half-fruits of an Umbelliferous plant.

For the sake of those of my readers who have been practising how to name plants with Mr. Bentham's Flora, we will just see what questions would arise in the naming of an Umbellate. Our plant is really the wild chervil, common everywhere; but this must at present be a profound secret; the name of the plant is to be discovered inside the flower. Let us turn to the long table; net-veined leaves, and ruling number 5, shows that the plant is a dicotyledon; the separate petals take us to Division Polypetals; and the stamens not free, but coming off the ovary, take us to the second column of the subdivision Calycifloræ, and we have our choice of the five families in it: our plant is neither a tree, a climber, a parasite, nor are its styles united, hence we arrive at 35 Umbelliferæ.

On turning to the place (p. 184) in Mr. Bentham's book, we are asked a series of questions—(1), Are the leaves undivided, or the contrary? Answer, The contrary. We are then directed by the figure at the end of the line, to turn to question 3. Are the leaves prickly, fleshy, or neither? Answer, Neither. The figure at the end of the line directs us to question 4. Is the fruit smooth, or the contrary? Here comes in the unavoidable necessity of having ripe fruit, for it is hardly possible from a young ovary to tell whether the ripe fruit will be smooth, hairy, or prickly. Our fruit is smooth, and we are thus guided to question 12. Here the answer depends on the shape of the fruit. Our fruit is "long and narrow," and we are directed to question 46. Question 46 asks whether the fruit is less or more than half an inch long? we answer, "Less," and are sent to 48. Here we are asked if the fruit has any stalk or not, and finding that our fruits are stalked, we conclude that we have a plant of the chervil genus in our hands.

We then turn to the Chervil genus, the 32d genus in the Umbelliferæ. We have yet to determine its species. It is not the burr-chervil, which has a markedly *hispid* or rough fruit; and the perfectly smooth, unribbed fruit of our specimen proves it to be the wild chervil (*Chærophyllum sylvestre*, Linn.) There are many members of the Umbellate family to be found in every hedge in England, and it is most interesting work to examine them, and find out their small individualities, which are hidden at first by their great superficial resemblances. So my readers may practise plenty of this "running down" for themselves.

Compositæ.—We will now turn to our second typical family, which shall be that of the Composites. The groundsel is a member of it, and we will take that for examination, because it grows everywhere, and is always in flower, even when the snow is on the ground.

Pull up a whole plant of it, and notice the strong tap-root, with the number of fibrous roots coming out from it; also the deeply-cut leaves, so shining, and yet so hairy; the manner in which these leaves grow on the stem, too, is interesting; they have no stalks, and their side tips project about half-way round the stem, so that they may be called *amplexicaul.*

Take one of the fully-blown flowers (fig. 176), and try to make a table of it, similar to the one we have made of the chervil. First, low down on the blossom, we come to several scaly-looking minute leaves with their black tips; these surround a cup of green leaves, united almost to the top, where they, too, are surmounted by black points. There are more of these leaves, as indicated by their tips, than we can easily count, and besides, their number does not seem to be the same on different blossoms. Shall we then call them an indefinite number of sepals? We had better examine further before deciding about this.

Fig. 176. Head of groundsel.

Try to pull off this green covering. You will find that it sticks to something inside, and you will be obliged to tear the whole blossom. You then find that each of the double hooks which protrude above the green case (fig. 176) is the centre of what looks like a miniature flower. Take one of these out, and put it under your magnifying glass. If you choose one from the middle, it will be still in bud, if one from the outside, it will be open, as represented in fig. 177.

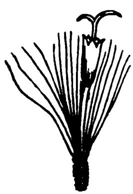


Fig. 177. Floret of groundsel (*magnified*).

We now know that the green covering was no true calyx, for that protects one flower, whereas inside our case are more flowers than we can count. If you think of the *parsley* with its several *bracts* all growing at the same level, you will be able to solve the problem.

In the parsley each blossom grew at the end of a separate stalk, and at the point where these stalks came off were several bracts; theoretically there ought to have been a bract to each flower-stalk, so that each flower might be considered as growing in the axil of a bract, but there were more flowers than bracts.

Now the flower-arrangement of the groundsel only differs from that of the umbel, in its flowers having no separate stalks; and consequently the stalk has to swell out and form a sort of platform so as to receive the crowd of little flowers (*florets* we will call them). As in the umbel the outer flowers were the first to blossom, so here the outermost rings of florets are the first to open, and then those next to them, and so on, till last of all the central florets open. We see why this should be so; the flower-arrangement is in both cases in reality the same as that of a hyacinth, or mignonette, or foxglove: the stem keeps sending out blossoms in the axils of bracts, the lowest or outermost coming naturally first to maturity; but in the dandelion even the flower-stalks are gone, and the branch is reduced to the flattened *disc* laden with florets.

This flower-arrangement is called a *head*, and all Composites will be found to flower in heads; but it is remarkable that when there are several heads on the same branch, the heads themselves will be found to be arranged definitely, *i.e.* the central head will always flower before the others.

Let us now take a single floret.

Choose one which is open: you will have to make a special table of it. You will perhaps begin with the mistake of saying there is no calyx; but I think you will find evidence to show that one exists.

Look first at the corolla; try and pull it out from amid the fluffy stuff (see fig. 177) which surrounds it; you will see that the corolla comes off in one piece from the top of the ovary. Now when the corolla breaks off in this way from the top of the ovary, what is generally the case with the calyx? Just as the lower part of the corolla must be in reality so tightly fastened to the ovary that it never comes off, but is left attached to the ovary when the rest breaks off at the top; so that of the calyx may be fastened on outside, in such a way that calyx, corolla, and ovary, and even the fibres which lead up to the dust-spikes as well, are all welded together. What then is the fluffy stuff? It is the only trace of a free part of the calyx, coming away at the top, and enveloping the corolla.

Now as to the shape of the crown; it is united into a thin tube (like the primrose) for about two-thirds of its length, and then opens into a tiny erect bell, the five teeth of which (see fig. 177) show clearly that it is composed of five leaves.

But where are the stamens? These form the most peculiar part of the floret, and you will probably hunt for them in vain, unless you remember how in the primrose we found them hidden in the tube of the corolla, after we had been unable to find any external trace of them.

In the groundsel, however, I doubt whether you will recognise them when you do see them, for they are united by their *anthers*, and form a ring round the style (fig. 178). This mode of union is unlike anything we have seen before, and taken together with the flowering in a head, is characteristic of the Composite family. You must be careful to look out for it before settling that your head is a Composite, or you will include the scabious, and other members of the Teasel family. Our groundsel stamens have very short filaments by which they are joined to the petals. It is not easy to cut and lay open the petals and anthers without tearing the latter; but if you can manage to do so, you will see that each is joined in a line between two tips of the corolla, *i.e.* that the stamens are alternate with the petals. The pollen is let out by two long slits looking towards the centre.

Fig. 178. Stamens of groundsel (*magnified*).

The pistil consists of two carpels, as is shown by the double crest at the top. The description of the fruit of a Composite, with its *one* seed suspended from the top of the ovary, is given at p. 84, under the head of the dandelion. We there spoke of its floating apparatus under the name of balloon, but as it differs from that of our flower in having a long neck, we can more correctly call our fruit a shuttlecock, with the ovary itself for cork, the calyx for its velvet covering, and the fluffy part or *pappus* for feathers.

But our pistil is not yet in fruit; its style and stigmas have still to be considered, and very important they are to the well-being of the flower. In fig. 177 a fully-blown floret is drawn, and you there see the style standing out from the corolla, and having its two stigmas well open. Fig. 178 was taken from a younger floret, and accordingly the stigmas are only partly open, and have not completely emerged from the anther-tube. If you examine one of the still younger florets, which you can find in the middle of your groundsel head, and which are still in bud, you will be able to see no trace whatever of the stigmas. The truth is, that the stamens ripen first; till they are ready to shed their dust, the style is quite short; at about this time it lengthens rapidly, and pushes its way through the splitting anthers. You will naturally conclude that the pollen then adheres to its sticky stigmas, and that thus the flower is fertilised. But there is a difficulty in the way of this; the stigmas are *closed*, and necessarily so, for if they were open, they could not possibly get through the narrow passage in the middle of the anthers, and the surfaces, which will hereafter become sticky, are closely pushed against each other, so that their outer unsticky sides are all that can come in contact with the pollen.

Therefore, even here, though the pistil and stamens both grow in the same flower, and are particularly large in proportion to the covering leaves, you see we are met by the question, How can it be fertilized?

We will leave the solution of this difficulty for a near relation of the groundsel to solve, and proceed to make a table of our flower.

GROUNDSEL.

PARTS OF FLOWER.	No.	SEPARATE OR UNITED.	WHERE COMING OFF.	REMARKS.
Sepals.	Supposed to be 5	United.	The ovary.	Crowned with a pappus of hairs.
Petals.	5	United.	The ovary.	Regular: in a tube $\frac{2}{3}$ of their length, then opening into a bell-shaped flower.
Stamens.	5	United by anthers.	The corolla.	
Carpels.	2	United.	The receptacle, but joined to calyx-tube.	One cell only, and one seed suspended.

Almost every statement in this table is true of all Composites, as the structure of the stamens and carpels never varies, though some florets do not contain both stamens and pistil; the shape of the petals does vary, being regular and bell-shaped in some plants, as in our groundsel, and irregular and *strap-shaped* in others—as, for instance, in the dandelion, which we will now examine.

Dandelion.—Notice first the leaves surrounding the florets—*involucral bracts*, as they are called: they are turned back, separate from each other, and more numerous than those on a groundsel head. Also the disc is larger, and the florets consequently more loosely packed than those we have been examining. Take one of these, and look at it carefully: at first you can hardly fancy that it is a flower at all, it looks so like a bright yellow strap; presently, however, you find the double crested style coming out from its tube of anthers (fig. 179); and seeing that the yellow strap is united into a tube at the base, and has five very

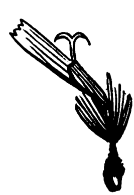


Fig. 179.
Floret of dandelion (*magnified*).

minute teeth at the top, you guess that it is really five petals made into one of the curious-shaped corollas in which nature seems to delight. Below the corolla tube is the hairy pappus, not this time growing immediately above the ovary, but separated from it by a short neck, the use of which you will see presently. In the dandelion as well as the groundsel the style pushes its way through the ripe anthers, and in it there is a special contrivance in the shape of hairs for brushing the pollen out. But (see fig. 180) the hairs are *below* the crests, and when the floret is fully blown, you may often see many grains hanging on to them, which, however, it is quite impossible that their own sticky stigmas should ever reach, as you may assure yourselves by looking at their relative positions in the figure. But do you remember how the outermost floret blossoms first? The result of this is that when row three (counting from the outside) has just pushed up its styles and loaded its little pollen-collecting brushes, but has not yet had time to open its crests, its elder brethren in row two have already expanded their crests, and are ready enough for the pollen which may be brought them by insects, or blown them by any breath of wind. In the groundsel, the florets are so tightly packed that they probably get the pollen from their neighbours by contact; and it may be for this reason that no brushes are needed, as when the nearest stigmas themselves touch the styles as they ascend from the midst of their anthers, they are certain to get any grains of pollen which may be adhering to them.

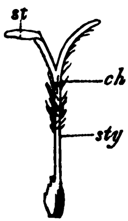


Fig. 180.
Dandelion pistil without the pappus (*magnified*).

It is a significant fact that the *outside* row of many Composites has florets which contain a pistil, but no stamens. I will leave it to my readers to decide the reason of this.

The family of the Compositæ is very large, and the variation in the shapes of the florets of the different members has caused it to be divided into three tribes.

(1.) The *Thistle-heads*, whose florets are all regular and tubular, like the one we examined in the groundsel. All thistles belong to this tribe.

(2.) The *Strap-shaped*, which, like the dandelion, have all their florets irregular and strap-shaped, and are called *ligulates*.

(3.) The *Ray-bearers*, which combine both sorts of florets, having an outside row or *ray* of irregular strap-shaped ones, and the rest of the florets made up of regular tubular ones. These are called *corymbifers*. In most of them the ray-florets have no stamens, and in all, they blossom before their more central brethren. The daisy, great yellow corn chrysanthemum, Michaelmas daisy, etc., are all examples of this tribe.

One naturally wonders why this family should have flowers so very different in appearance among its members. Is there any advantage to the plant in the various-coloured conspicuous rays to be seen in this last tribe? If there is an advantage, why should it be confined to this tribe alone?

I think if you remember the pollen-laden brushes, and the older brethren waiting for and wanting their burden, you will be able to solve the first question; and the brilliant-coloured thistles with their tightly-packed florets will help you to answer the second.

With this hint I will leave to your consideration the following problems:—(1.) What is the use of the brilliant-coloured ray? (2.) Why does such a flower as the thistle require none? (3.) How do you account for the insignificant appearance of the groundsel?

But all this time we are leaving our dandelion only half examined. Turn to a head whose fruits have ripened, and see how a breath of wind sets them all floating. A change, you will notice, has taken place during the process of ripening, which further facilitates this (fig. 181).

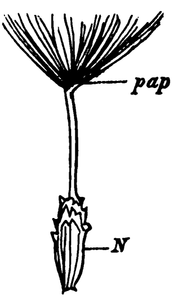


Fig. 181.
Dandelion fruit
(*magnified*).

The necks of the ovaries have grown till they are about an inch long, and the pappus stands out nearly at right angles to the style, so as to balance the fruit like a parachute in the air. Thus, when once a breath of wind has set a flight of these flying machines in motion, they are driven along steadily with the wind, perhaps for miles. I have heard of a pappus-chase after a composite seed-vessel for more than a mile in a high wind over some downs. This contrivance shows what terrible enemies such weeds as dandelions, thistles, sow-thistles, and other Composites will be; for even suppose a gardener has once cleared his ground of them, if the garden lies to leeward of a neighbour even a mile off who has neglected to keep down his weeds, the seeds of his idleness will be sown in the industrious man's garden, despite all his care.

To help my readers in learning to run down Composites, I will give the successive answers and numbers arrived at in determining the name of the common groundsel (Bentham, p. 234). We shall get it to the tribe of *Corymbifers*, instead of to the *Thistle-heads*, as you would expect, because some groundsels have a row of small ray florets, though our species has not. (1) Florets all tubular, (2) involucre of bracts and leaves not prickly, (3) Florets yellow, (5) leaves alternate, (7) outer ray-florets not larger than the central ones, (8) having pappus of hairs, (12) bracts in one principal row, (13) leaves pinnate and toothed; this brings us to Genus XVII., *Senecio*. Turning to Genus XVII. the answers, "Leaves cut and divided," and "Ray none," determine the plant to be *Senecio vulgaris*, Linn.

Before bidding good-bye to the Dicotyledons, I must say a few words about two families which are likely to puzzle you. These are the Euphorbiaceæ and Coniferæ.

Euphorbiaceæ or *Spurge* Family. This, as you will see by turning to your long table, comes under the division Incomplete, and I think you will presently say that it well deserves its name. The dog mercury (*Mercurialis perennis*) is a member of this family. The pistillate and staminate flowers are separate, growing sometimes on the same, sometimes on different plants. The pistillate flower consists simply of three bracts, two filaments which never bear any anthers, and a pistil of two carpels with branching crests. The staminate flower has three bracts, and from nine to twelve stamens. Thus far, the family is easy enough to understand; but turn to one of the spurges, the large genus which gives its name to the family, and I think you will be puzzled. There is only one sort of blossom (fig. 182) growing in the middle of two leaves, which in some species are *connate*. You will probably conclude that this is one flower, that the four bract-like *glands* (*g*), as they are called, are the sepals, that the petals are wanting, and that the curious trilobed thing which you see hanging out is a pistil of three carpels, surrounded by its six or seven stamens in the usual way. This is simple enough, but how then do you account for the long internode between the ovary and the receptacle? The truth is, that you have before you an *inflorescence;* the half-moon glands (*g*) take the place of ordinary involucral bracts, and each stamen is a whole flower, in which calyx, corolla, and pistil are all wanting. The trilobed thing is also a whole flower, growing on a long stalk, and consisting of its three carpels only. The inflorescence therefore consists of a number (generally from eight to fifteen) of staminate flowers, and one pistillate. This view, which seems at first sight rather startling, is confirmed by a little joint (*j*), which may be seen some way below each of the anthers. The stem below this joint is considered as flower-stalk, above it, as filament.

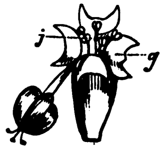


Fig. 182.
Spurge inflorescence
(*enlarged*).

Coniferæ or *Pine Family.*—The Scotch fir will do to illustrate the strange habit of this family. As we saw two sorts of catkins in the willow, so we find them here: one made up of staminate flowers, the other of pistillate. In the Scotch fir the staminate catkins are small and wonderfully full of dusty pollen, as you will see if you shake a tree in blossom. Each flower is made up of a little scale bearing two stamens on its inner surface. When they have shed their dust, they shrivel up, and the catkins gradually disappear. The pistillate catkins are in the shape of a *cone*, and their flowers are very curious, as each is composed of a bract bearing two *naked seeds*, *i.e.* ovules without any carpels whatever. Some botanists try to dispose of this anomaly by arguing that the bract on which they grow is really an open carpel. Another still stranger thing about these seeds is, that instead of containing one, or two cotyledons, there are several, varying in number from three to eighteen. Nevertheless the whole habit of the tree makes it necessary that it should be put into the Dicotyledon class, and considered as an anomalous member of it. As the fruit of the pine ripens, the seeds are provided with wings, the bracts harden and become woody, and a *fir-cone* is formed.

These few words will, I hope, give you the clue to these two puzzling families; and I think you may now hunt for members of every English Dicotyledon family, without fear of meeting with any insuperable difficulties in understanding them.

CHAPTER XIV.

ON SOME MONOCOTYLEDONOUS FAMILIES.

SPECIMENS wanted—A wild *arum plant; yellow flag* or *garden-iris; common wood-rush* (*Luzula campestris*); *cotton-sedge* (*Eriophorum polystachyum*); and *common quake-grass* (*Briza media*).

We must now turn our attention to the Monocotyledons. If you look at your long table you will see only four short columns, containing fourteen families in all belonging to this class, and making it look very small compared with the many long columns of Dicotyledonous families.

We will only speak of a few of the most widely spread Monocotyledonous families, and leave you to make acquaintance with the others alone.

Aroideæ.—This is the second family mentioned in the long table. The first, *Typhaceæ*, or the family of bulrushes, is one of those I will leave you to study for yourselves. The stately white arums of our greenhouses, and the "lords-and-ladies" which make our hedgerows gay with their brilliant scarlet berries, are both members of the Aroideæ or Arum family.

If possible, dig up a whole root of the "lords-and-ladies" while it is in blossom—that is, before any sign of the red berries has appeared, and while the pale lilac (or sometimes yellow) spike peeps out from its enfolding leaf-sheath. The real leaves, you will notice, are very unlike this one. They have long stalks growing from the root-stock, which is swollen and hard, and is therefore called tuberous. They are shaped like the top of a barbed spear, and are curiously spotted, thus giving the plant its name of *Arum maculatum*, or spotted arum. Also you will be surprised to see that, unlike the sheathing leaf, and in spite of their class, they are somewhat net-veined, thereby illustrating the old adage that no rule is without its exception. In the greenhouse species you will see that the big glossy foliage leaves follow the proper parallel-veined rule.

But we have spoken of our plant as being "in blossom," and yet have seen nothing like ordinary flowers on it. Look closely at the curious spike, with its yellow or lilac top. It is enclosed by an enormous flowering bract, which is called a *spathe* (see fig. 183), as it protects not one flower only, but a whole inflorescence. In the greenhouse arum it is the great white *spathe* which gives the plant its beauty, and which is commonly called its flower. Inside this is the spike or *spadix* (see fig. 183), with numerous flowers growing round it. First, close to the stalk, is a cluster of pistillate flowers (*p*). These are completely hidden by the spathe in a real flower, though they can be seen in fig. 183, because a part of it has been cut away. Each pistillate flower consists of a pistil only, composed of a single carpel. At the top of the cluster formed by these is a ring of little lumps, with ends which at first sight look like stigmas. These never come to anything, and go by the name of *rudimentary pistils* (*r.p*). Above these there is a short space, and then comes a cluster of pale lilac (or yellow) staminate flowers (*st*). These again are as simple as they can possibly be, for each consists of one stamen which has a very short filament, and opens to let out its pollen by four little holes. Above these is a cluster of rudimentary stamens (*r.st*), and then comes the long club-shaped top of the

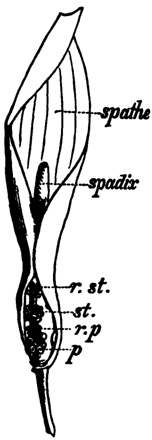


Fig. 183.
Inflorescence of common arum.

spadix, which in our greenhouse arum is of such a beautiful orange colour.

What the use of this brilliant orange club is to the flower I do not know; whether it attracts insects to carry the pollen from spike to spike, or whether the pistillate flowers are fertilized by the pollen falling from the staminate ones growing immediately above them in the same spike. It is certain that they are in some way reached by pollen, as is proved by the beautiful red berries into which the insignificant-looking pistillate flowers turn, and which rear themselves on a long stalk long after leaves, and spathe, and the rest of the spadix, have withered away.

It possibly strikes you that *berry* cannot be a correct term for an apocarpous fruit. This is true, but appearance here has triumphed over correctness, and they are always called by that name. If you cut one of them open, you will find from two to six ovules imbedded in a quantity of red jelly.

Alismaceæ.—This is a particularly pretty family to examine, if you have the opportunity of getting water-plants, and do not mind hunting for them in the marshes. The beautiful flowering rush (*Butomus umbellatus*) belongs to it, and the common arrow-head (*Sagittaria sagittifolia*), the name of which is so descriptive of its leaves that it alone is enough to guide you to the plant. In the flowering rush you should notice the curious way in which the seeds grow not only on the placentas of the single-leaved carpels, but all over their inner surface. Besides these two there are several other water-plants, all easy to run down to their names with the help of your long table and Bentham, and almost all having pretty flowers.

Iridaceæ.—This is the next family which we will look at, leaving the Rush family to succeed it, though it comes before it on the long table; and missing the Orchidaceæ, because that must have a chapter to itself. To it belongs the crocus, with its wonderful long style and its habit of maturing its ovules underground and sending them up into the sun to ripen. The iris, too, which gives the name to the family, is well worth careful examination.

I have not made a drawing of it, for no woodcut can adequately represent its beautiful contrivances, which are shown by one glance at the flower itself. I suppose, therefore, that you have an iris in your hand, either the wild yellow flag from the marshes (*Iris pseudacorus*), or a purple one from a garden. You see six covering leaves, three much larger than the other three, and growing outside and alternately with them. The outer ones bend back, and have a beautiful bed of yellow or white down coming up to the place where the leaf begins to bend. The inner three are either upright or bending slightly forwards so as to touch at the tips and form an arch over the centre of the flower. There are three stamens with very long anthers, which are alternate with the petals, and therefore opposite to the large outer leaves. These anthers split *outwards*. Inside them are three curious stiff leaves which will probably puzzle you. These may be considered as leaf-like styles, and their business seems to be to push the stamens outwards and forwards, so that the pollen from their anthers falls exactly on to the soft bed prepared for it on the outer covering leaves. As to the pistil, its ovary is long and three-carpelled, has parietal placentation, and grows below the rest of the flower. In the centre of the flower it opens out into the curious flat styles which we have noticed, and the stigmatic surfaces are to be found on the outer surface of their two appendages, quite at the top and well *above* the stamens. Thus it is impossible for the flower to be self-fertilized. There are three roads by which bees and other insects can enter it in search for honey—viz. the three spaces between the stamens and the outer leaves; and in each of them there is a double arrangement for dusting an insect with pollen, for not only does he get it on his back from the anther immediately above him, but his hairy legs are also covered with it from the downy bed on which they rest, and which, as we have noticed, has been plentifully sprinkled with it. If the next flower which he visits is bending down its leafy stigmas, it is sure to receive some of this, and so be cross-fertilized.

Juncaceæ or *Rush Family.*—You will have no difficulty in finding an example of this family in the common field wood-rush (*Luzula campestris*). Look out for low tufts of a *rush-like* plant sending up flowering stems of about four or five inches high. Fig. 184 will help you to know it, and if you have once seen the grass-like leaves fringed with long whitish hairs, you can hardly fail to recognise the plant.

Fig. 184.
Common field wood-rush.

The blossoms are irregularly crowded together in clusters; there are at least three such clusters, the oldest and most advanced being terminal and sessile (*t.c*), and the others mounted on two flower-stalks on each side of the central cluster; the arrangement of the clusters is therefore a cyme of two or more, while the arrangement of each cluster is a short irregular spike, almost compressed into a head.

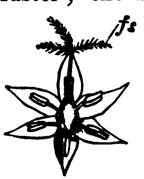


Fig. 185.
Single flower of common field wood-rush (*enlarged*).

Each flower has six separate covering-leaves (fig. 185), all alike, the outer three of which may be regarded as sepals, and the inner three as petals.

A considerable difference will be noticed between the blossoms which are just out and those which have been out some time. Before the covering-leaves open the pistil is seen protruding, and three large stigmas, furnished with little feathery hairs (*fs*), are seen hanging down. At this time no trace of any stamens can be seen, but if the covering-leaves be opened with a knife, six little stamens, with unburst anthers, will be found nestling beneath them (see fig. 185). A little later, the stigmas will have shrivelled, the covering-leaves will have opened of themselves, and the six anthers will have begun to protrude in their turn, and shed showers of dust. If a flowering stem be shaken on a windy day, a cloud of dust will be seen drifting to leeward.

It will readily be seen that in this plant self-fertilization is thus rendered impossible by the fact that the pistil comes to maturity before the stamens. How then are these plants fertilized? By insects? Hardly; for they have no attractive corolla like their first-cousins the lilies, nor any sweet nectaries like their second-cousins the orchids. Probably then by the wind; for we have seen above, that the pollen is set free in clouds from the later flowers, while the neighbouring flowers in an earlier state have specially long and large stigmas hanging out to catch the pollen-grains.

The seed-vessel consists of one cell and three seeds, but it betrays its origin from three carpels, not only by its three stigmas, but by its triangular shape.

It will be well for my readers to make a table of this flower, which by its leaves and ruling numbers is clearly a monocotyledon. Cross-fertilization by means of the wind occurs in other plants, in the case of the stinging nettle for instance, and of the pines; and the recent observations of foreign botanists have shown that it is at least possible in our cereals; in wheat, for instance, oats, and rye.

We will now turn to the two last families of the monocotyledons, which, as the long table will show you, belong to the division *Glumaceæ*, have a column to themselves, and are distinguished as having "chaffy bracts instead of covering-leaves."

Cyperaceæ or *Sedge Family.*—Some sedges and some woodrushes have a superficial resemblance which might puzzle you, though their structure is really quite different. If you once compare a wood-rush and a lily, you will see that the wood-rush flower is really a dry lily, while the sedge flower is utterly unlike anything we have examined.

Try to find a bit of common cotton-sedge (*Eriophorum polystachyum*). You should, if possible, have two specimens, one in flower, the other in seed, *i.e.* after it has become cottony. The root is short and fibrous, the leaves long, sheathing, and grass-like. The flowering stems are long and stiff, and end in a cluster of from two to eight bunches. This cluster has a long thin bract protecting it, and you should notice that while the inner bunches are almost sessile, the outer ones have thin drooping stalks. Take one of these bunches, or as they are called *spikelets*, and examine it carefully. It is made up of a number of little flowers, one of which, magnified, is represented in fig. 186. You see it has no calyx or corolla, no sort of covering except the one dry leaf (*g*) in the axil of which it grows. This leaf is called a *glume*, and it, or something resembling it, is common to the sedge and grass families. The flower itself consists of three stamens with long anthers growing at the top of their filaments, and a pistil with round ovary, clearly-marked style, and three plumy stigmas (*stig*). At the bottom of the ovary are a number of hairs (*h*), which may remind you of the pappus of the Composites, except that there the hairs come off at the top of the ovary. As there we said they might be considered as representing the free part of the calyx, so here we may perhaps think of them as morphologous to the whole of the corolla and calyx. The sedge family is most largely represented in England by the Carex genus, which has no less than forty-six English species belonging to it.

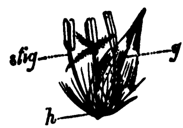


Fig. 186.
Flower of common cotton-sedge (*magnified*).

These Carices differ in many respects from the flower which we have been examining. Their stamens and pistil are always in different flowers, sometimes growing on the same, sometimes on different plants, and in the pistillate flower there is a green sort of loose covering round the ovary through which the style protrudes, sometimes bearing two, sometimes three stigmas. The spikelets are arranged sometimes in *spikes*, sometimes in loose clusters, as our cotton-grass.

I think you will now have no difficulty in recognising members of the Cyperaceæ. Their *glumes* and *spikelets* distinguish them from all except the grass family, and that, as you will presently see, has well-marked distinctions of its own. I cannot promise you that you will find running them down to their proper species so easy a task. Many of their little brown flowers look much alike, and careful examination is required to find out the minute differences between them.

Gramineæ or Grass Family.—There are a few terms peculiar to this family, and always used by botanists in describing it, with which I fear it will be necessary for you to burden your memories. The flowers of grasses are, like those of the Cyperaceæ, arranged in *spikelets*, which spikelets are again arranged either in *spikes*, as the wheat, or in a loose irregularly spreading inflorescence called a *panicle*, like the common quake-grass (fig. 187). This will be a very good grass for examination, as every one knows it, and its different parts can be made out even when dry. Take one of the spikelets off its delicate stalk, and pull it to pieces. Outside are two empty glumes, *imbricated*, *i.e.* the outer one overlaps the base of the other like the tiles of a house. Inside,

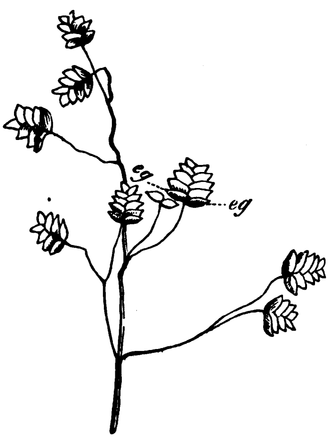


Fig. 187.
Panicle of common quake-grass.

and between these two, are six or eight little flowers packed closely together, and also imbricated. Take one of these florets, and examine it carefully. Fig. 188 represents one considerably magnified. It is enclosed within two more chaffy bracts; the larger of these is called the *flowering glume* (*fg*); the smaller, which may be known by having a little nick at its tip, and two main ribs running down the back, is called the *pale* (*p*). Take these off, and inside you will come to the flower proper, as at present we have only removed bracts, which have no place in the floral table. Of flower itself we find very little. There are three stamens, with the finest, most delicate filaments imaginable, and *versatile* anthers (*vs*), *i.e.* anthers fastened by the middle of their backs to the filaments (see p. 110). These mature before the two-carpelled pistil, one of whose plumy stigmas you can see peeping out from between the flowering glumes (*stig*).

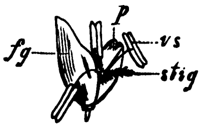


Fig. 188.
Flower of quake-grass (*magnified*).

Now fancy a plant in full blossom; it flowers *indefinitely*. Therefore, if the top flowers have blown, the stamens on the lower branches will have withered, and the long feathery stigmas will be protruding. Higher up the stamens will have split, and their versatile anthers, just balanced on their thread-like filaments, will wave to and fro in every breath of wind, and shed showers of pollen on the plumes held out to catch them. Thus you see cross-fertilization is a most natural and easy matter in the grass family. We have spoken of our flower as if it consisted of stamens and pistil only, but there are really two little covering leaves or scales, as may be seen in fig. 189 (*l*), which was drawn from the fruit after the stamens had fallen, and the two styles had grown up at the top of the pistil, which are not to be found in a young flower. These two little scales are

Fig. 189.
Fruit of quake-grass (*magnified*).

called *lodicules*, and are supposed to represent the *perianth* or covering-leaves. In many grasses you will be unable to see them at all, but in others, as the wheat, they are clearly visible.

The dissection and naming of grasses is troublesome at first, but the differences are not really difficult to detect, and there are few large families in which plants can be more certainly named by a patient observer than the grass family.

We will run down our quaking grass as an example. But first I must mention that many grasses have the veins of some or all of their glumes prolonged into sharp points called *awns*. The barley is a good example of this.

Another characteristic of grasses is, that at the top of the leaf-sheath is a little scaly appendage, *ligule* as it is called, from *ligula*, a little tongue.

Turn to Bentham, page 520. Our spikelet contains more than one flower, which takes us to 24; they grow in a panicle, 25; there are no awns, so we go to 40; the spikelets grow in a *loose* panicle, which takes us to 43; the outer glumes are shorter than the flowers, 45; we have three or more flowers, 46. Our spikelets are not oblong, and our glumes are closely packed and very spreading, therefore our genus is No. 34 Quake-grass. Turn to page 553. We have only to settle between two species. Ours is perennial, as you may see from the creeping root-stock; also the *ligule* of the leaves is short; it is therefore *Briza media*, or the common quake-grass.

CHAPTER XV.

ON ORCHIDS.

SPECIMENS wanted—The *Helmet-Orchis* (*Orchis morio*); and all other orchids that can be found.

We have now come to our last chapter, which we will devote to a slight sketch of the orchids. If any of my readers wish to study their wonderful history in detail, I recommend them to read "Fertilization of Orchids," by Mr. Charles Darwin. It is more interesting than any novel that ever was written; and the account of how Mr. Darwin reached his conclusions about the orchids is a splendid lesson in the right way to observe.

First of all pick your flower. The helmet-orchis (*Orchis morio*) is the one I am going to describe, because it is one of the first to flower, as it comes out early in May, and also one of the easiest to understand; but even it has a sufficiently complicated structure, and I fear you will find it impossible to understand it thoroughly unless you are able to obtain a specimen to pull to pieces as you read.

The plant has a tuberous root, and its leaves are parallel-veined and sheathing. At the top of the stalk come the flowers, growing —is it in a raceme or a spike? Look carefully, and settle this question. Each flower (fig. 190) grows in the axil of its own bract (*b*). Does it also grow on its own little leaf-stalk? This is the question which you have to settle.

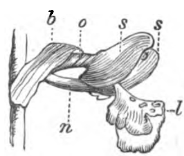


Fig. 190.
Flower of helmet-orchis.

Now let us pull our flower to pieces: first, and evidently growing outside, is a purple leaf, veined with deeper purple, and slightly covering two other leaves (fig. 190, *ss*) with its edges. These three leaves make up the outer whorl of covering leaves, and are the sepals of the flower. The top outside sepal is hidden in a side view of the flower, and therefore cannot be seen in fig. 190.

Snip off the sepals, hold the flower by its long tube, and look straight into it. At the top are two narrow veined leaves (fig. 191, *pp*) growing alternately with the remains of the sepals; and at the bottom, growing almost at right angles with these, is one very large leaf, which is curiously spotted in the centre, slightly slit at the sides, and prolonged into the long tube which you are holding (fig. 190, *n*). These are the three petals, growing alternately with the sepals. Snip off the two top ones, noticing how they, with the three sepals, form the curious sort of *helmet* which gives the flower its name.

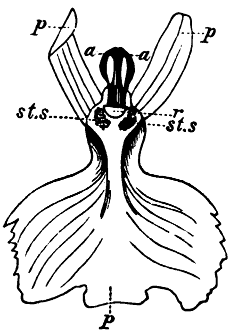


Fig. 191.
Front view of helmet-orchis, the sepals being removed (*enlarged*).

We now expect to find stamens and pistil, but all that we see to account for these organs is a queer little appendage (fig. 191, *r*), something like a watch-pocket, perched upright at the back of the tube, just between the two top petals, and protected by the helmet from wind or damp. Touch the little box (*r*) with a sharp pencil, it will break along the front line, and you will see that it is full of sticky matter. The appendage above it will open at the sides (*aa*), and two thin yellow stalks, with green club-shaped tops, will spring out and fasten tightly to the point of your pencil. They are unlike anything you have seen before, and require very careful examination. Put one of them under a magnifying-glass, you will see that the top is made up of a number of wedge-shaped lumps (fig. 192, *pp*). Push the top about with one needle, holding the stalk firmly with the other, and still looking through your magnifying-glass. The result will be that the lumps will separate, and if you pull carefully, you will be able to make the club stretch out to two or three times its ordinary length; but directly you remove your needle, the lumps will spring together again, and the whole club will retake its former shape. Possibly you already guess that what you have been looking at is the contents, an extraordinarily modified anther, made up of a number of little packets of pollen (fig. 192, *pp*), tied together by elastic threads. It is so unlike the same part in any other sort of flower that it has been necessary to invent new names for it and all its parts. Thus the whole of the organ represented in fig. 192 is called a *pollen-mass*. The yellow stalk (which is formed of the ends of all the elastic threads joined together) is called the *caudicle* (*c*), and the membrane on which it stands, and by the under surface of which it stuck to your pencil, is called the *viscid disc* (*d*). Each of these pollen-masses is the pollen of one anther (fig. 191, *aa*), and the two together are therefore the contents of one ordinary stamen. This is all that our flower can boast of in the place of the three stamens which the sepals and petals had led us to expect; but I think you will presently allow that it well knows how to perform all the duties generally adjudged to several stamens.

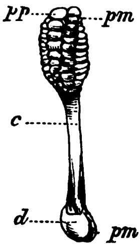


Fig. 192.
Pollen-mass of helmet-orchis (*magnified*).

We have hitherto seen nothing at all like a pistil, and you may be inclined to decide that our flower is diœcious; but if you cut through the curious curved support on which it stands, you will find it is an ovary full of seeds growing on the side walls in three sets; it must therefore have parietal placentation, and be formed of three carpels. Our question as to the inflorescence of the plant is also settled, for the ovary is sessile, and the flowers therefore grow in a *spike*. You have seen some other flowers, as the evening primrose (p. 90), in which the ovary was quite below the rest of the flower, but there we found a long style and clearly-marked stigmas. Here there is no style whatever, and no ordinary stigmas. The top of the ovary is *confluent* with the tube of the large petal, and inside this, just below the one stamen, are two shiny, sticky spots, which are two stigmatic surfaces (fig. 191, *st.s st.s*). But we found that the ovary was formed of *three* carpels. Where is the third stigmatic surface? It is transformed into a little round box, full of sticky matter, called the *rostellum* (fig. 191, *r*), and the ends of the caudicles of the pollen-masses are so firmly fixed to it that when removed they bring away with them part of its outer membrane, which we have called their *viscid discs* (fig. 192, *d*).

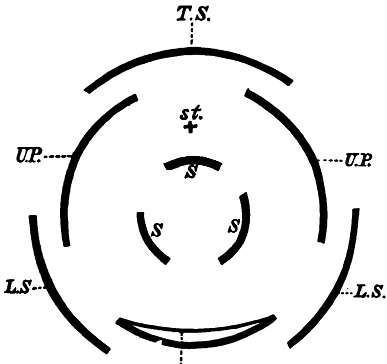


Fig. 193. Plan of helmet-orchis.

TS represents the top sepal; *LS LS* the two lower ones; *UP UP* are the two thin petals; *Lip* the large lower one; *SSS* are the three stigmatic surfaces, the top one of which is, as you know, transformed into a little box; *st* is the one odd stamen, modified into two pollen-masses lying in their pockets.

Fig. 193 is a plan of the flower, from which you see that, except for the one odd stamen, the law of alternance is observed in this apparently lawless flower. Some botanists account for this deviation by supposing that the normal number of stamens is *six*, though five of them are generally wanting.

Now we will leave the structure of the flower, and try to make out the reason of some of its modifications. Look at the two pollen-masses shut up in their little pockets, and the three stigmatic surfaces, one enclosed in the rostellum, the other two quite below and out of the way of the pollen-masses. It seems impossible that any of the pollen-grains which we have seen so securely tied up in their little pockets should reach these sticky surfaces; and you may remember that we stated before (p. 114) that without the aid of the insect world it is impossible. Mr. Darwin and other botanists have many times covered orchis plants with gauze or glass, so that no insects should have access to them, and the result has invariably been that not a seed has been set. Yet any faded orchis picked in a wood or field has numbers of its ovaries swelling, and with their seeds evidently set. Let us see how the insect does his business. Perhaps the easiest way to explain this will be to tell you of a bee which I have just been watching at work. Dr. Müller gives an interesting account of his observations on bees, in a field of orchises in Germany; and as I was anxious to see whether English bees would behave in the same way, I picked a number of helmet-orchises, put them in water, and placed a large bell glass over them. Then I caught a common bee, and put him too under the glass. For the first few minutes he buzzed about and seemed uncomfortable, but soon he settled on a flower, thrust his head into the opening, and remained for some seconds busily sucking the honey. When he drew out his head I saw to my delight that he had both pollen-masses sticking to his face close to the spot where his feelers are attached. Fig. 194 is a rough front view of his head when he first came out. You must notice that the pollen-masses are standing *out* from his face in exactly the position they would naturally be, since they are fastened by the lower surface of their viscid discs. Now, supposing he visits another flower

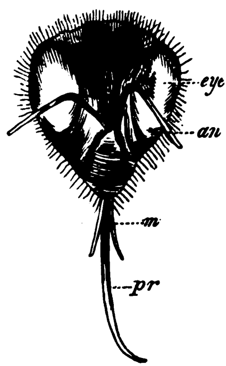


Fig. 194.
Head of bee as he emerged from helmet-orchis.
(*magnified*).

while they are in this position, they will be no more likely to touch the stigmatic surfaces than if they had stayed in their pockets. My bee did not go to another flower directly; he buzzed about against the glass for a little while, and as he did so I saw the pollen-masses gradually droop until they were in the position drawn in fig. 195. If the bee had now gone to another flower and sucked its nectar he could not have helped pushing either one or the other of these pollen-masses against one of the stigmatic surfaces (see fig. 191); and while he was extracting the honey the pollen-grains would have been caught by its stickiness, so that when he came away some of the thin elastic threads binding the packets of pollen together would have snapped, leaving the grains to fertilize the flower. As a matter of fact, my bee was not thus useful, for I was so pleased with what he had already done, and so much afraid that he would pull off the pollen-masses in the angry efforts which he made with his fore-legs, that I put a bit of sponge saturated with chloroform under the bell glass, and as soon as he was quite insensible, cut off his head, in order to be able to draw the position of the pollen-masses accurately. Mr. Darwin, in his "Notes on the Fertilization of Orchids," published since his large work on the subject, says he has seen a "bee (*Apis mellifica*) with from ten to sixteen pollen masses attached to it." The depression of the pollen-masses which we have noticed may easily be seen if you put a sharp-pointed pencil down the nectary, for it will push down the front of the little pocket (fig. 191, *r*), the sticky bases of the discs will adhere to it, and after about forty seconds of exposure to the air it will gradually begin to droop, not exactly downwards

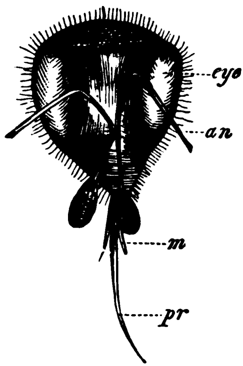


Fig. 195.
Head of bee a minute afterwards (*magnified*)

but in a slightly outward direction. If you watch it under a microscope while this is taking place, you will see that it is due to a curious contraction in the little bits of membrane at the base of the pollen-masses which we have called the viscid discs (see fig. 192, *d*). These do not alter their position on the pencil, but seem to shrivel up, and by so doing alter the angle at which the stalks of the pollen-masses are attached to them, and bring them into exactly the place in which they are wanted. You will easily understand this action if you think of the way in which a strip of sticking-plaster curls up if it is exposed to the air after it has been moistened. The way in which the moist viscid disc curls up is similar to this.

But we have not yet come to an end of the curious contrivances of our flower. It is evidently necessary that the little discs should be *firmly* attached to the insect, as, if they moved while he was flying, they might get out of the position in which they are wanted. Accordingly the gummy stuff contained in the rostellum has the chemical property of setting hard like cement after a few seconds' exposure to the air; and when once it is thus set hard, no wind, nor even efforts of the insect, are able to move the discs. But it takes a few seconds to set. How is the insect to be persuaded to hold his head still while it is setting?

The answer to this question was found out while quite another problem was occupying botanists. We have spoken several times of the *nectary*, *i.e.* the long tube at the base of the front petal (see fig. 190, *n*). It was formerly doubted whether this had any right to its name, as botanists hunted in vain for the smallest drop of honey in any part of the tube, and long ago Sprengel made up his mind that it was one of the "sham honey-producers," a sort of deception not unknown in the flower world (see p. 124). Mr. Darwin, however, was not satisfied with this conclusion; he got a number of flowers, and examined them for twenty-three days consecutively, looking at them "after hot sunshine, after rain, and at all hours,"* without, however, finding the least trace of honey: still he hunted on, and at last was rewarded by finding that as in some old houses secret chambers are found in the thickness of the walls, so the helmet-orchis has its secret chamber at the base of the tube between the two membranes, and here it hides its honey. The insect, therefore, is obliged to *spend some seconds* in boring through the inner membrane for the honey with the tip of its proboscis, and meanwhile the gum at the base of the discs is setting hard on his head. Could any more ingenious plot be devised for bribing it to hold its head still? But this is not all. Sometimes an insect visits a flower, pushes against the rostellum, ruptures it along the delicate line in front, depresses its lip so as to expose the viscid discs, and, after all, either fails altogether to remove the pollen-masses, or much oftener removes only one of them. If, when the insect flew away, the front part of the rostellum remained depressed, the contents of the little box would soon lose its stickiness, the bases of the discs would become hard, and either one or both of the pollen-masses, as the case might be, would be wasted. This, however, is provided against, for no sooner is the pressure of the insect removed than the lip of the rostellum springs up with an elastic movement, covers up the gum, and keeps all damp and sticky for the next comer.

There are some members of the orchid family whose gum does not become hard by exposure to the air, and which therefor have no apparatus for keeping it damp. In them of course it is unnecessary that time should be given for the discs of the pollen-masses to become cemented to the insect, and accordingly their nectar is found in the ordinary place, free at the base of the tube.

There is just one other point to be noticed. We have seen in the case of the primrose (p. 118), that when a plant is cross-fertilized, it is for its advantage that the pollen should come

* Darwin on The Fertilization of Orchids, p. 48.

from another plant. In the case of our flower, the depression of the pollen-masses took about forty seconds, if therefore the insect flew straight into another flower on the same spike, the pollen-mass would be still in its useless position, and it would not be till it had visited several flowers, and probably *left* the first plant that they would have reached the proper position for performing their office of cross-fertilization.

In all this we have been considering only one species of an enormous family, for the orchid family comprises no less than fifteen English genera, and the genus *orchis*, to which our flower belongs, contains nine other species. When I tell you that there are very few of these species in which self-fertilization is not made impossible by the structure, and very few again whose method of cross-fertilization is exactly alike, you will agree that the subject is too large a one to be treated of thoroughly in a short introduction to botany. I think, however, that any one who thoroughly understands the fertilization of *Orchis morio* will be able to make out the manner in which the same end is attained by slightly different means in many of the other orchids.

I must, however, warn you that different species are fertilized by different insects. For instance the spotted orchis (*Orchis maculata*) so much resembles *Orchis morio* that one would naturally expect to find that it too was visited by bees, whereas the main agent in its fertilization has been found by Mr. George Darwin to be a certain fly (*Empis livida*).* Speaking roughly, you may expect to find orchids with very long nectaries visited by insects which have a very long proboscis, as moths, butterflies, etc., while those whose nectaries are not too long to be reached by bumble bees, hive bees, and flies, are generally fertilized by them.

Now we must bring our "Year's Botany" to an end; and I can only say that if my readers have found it only half as

* Notes on the Fertilization of Orchids, by Charles Darwin; published in the *Annals and Magazine of Natural History*, Sept. 1869.

pleasant to read the stories which the flowers are continually telling us, as I have found it to try and act as their interpreter, they will agree with me that, whatever else Botany may be, it is not *dry*.

Some of my readers may wish to study other books on Botany, or to pass an examination in the subject, and may therefore find it necessary to become acquainted with botanical terms, which have been omitted from this little book, because I believe them to be a hindrance to a beginner, and unnecessary for the general reader.

I have endeavoured to put all the principal terms into the Appendix, under the heading of the special part of the plant to which they belong, and with such explanations as shall make their signification clear; therefore, any one wishing to master them can do so quickly and easily.

If the meaning of any particular word is wanted, it should be looked out in the *Index*, where the reader will be referred to the section in the Appendix in which he will find it explained.

APPENDIX.

IN describing flowers you should, if possible, have the whole plant before you.

(I.) PLANT.—If you can, you should state whether this is an *annual*, *i.e.* a plant only living for one year (p. 179); a *biennial*, a plant flowering the second year, and then dying; or a *perennial*, a plant flowering year after year (p. 240).

(II.) ROOT.—This may be *fibrous*, as the roots of all grasses (p. 179); a *taproot* (p. 179); or *tuberous*, as the beetroot (p. 179). Also a plant may have *aerial* or air-roots, as the ivy (p. 180); or the roots may only be useful as footholds, as in the case of many orchids, when they are called *epiphytes* (p. 180); or they may be *parasites* (p. 180).

(III.) STEM.—This may be either above or below ground.

(*a*) *If above*, it may be *woody*, as the stem of all trees; or *herbaceous*, *i.e.* dying down every winter, but coming up again in the spring (p. 199). Also it may be *erect* (p. 172); *climbing*, either by the main stem or by some of the branches (p. 172); *prostrate*, *i.e.* lying along the ground; or having *runners*, as the strawberry (p. 174).

(*b*) *If below*, it may be a *rhizome*, as the iris, in which case it may have *suckers* or *offsets*, as the rose; have *tubers*, as the potato (p. 174); or a *bulb*, as the hyacinth (p. 176); or a *corm*, as the crocus (p. 175).

(*c*) If there is a stem above ground, its *shape* should be mentioned, whether it is round or square; whether any branches are turned into *spines* (p. 172); whether any cells have grown large and turned into *thorns* (p. 191); whether the stem is *hairy;* or *glabrous*, *i.e.* without hairs (p. 190).

(*d*) Also you should mention the growth of the wood, whether it be *in rings*, as all *dicotyledons* (p. 161); or in *bundles*, as all *monocotyledons* (p. 169).

(IV.) BRANCHES.—When you can, you should state how these are arranged, whether *whorled* = *verticillate*, *i.e.* several starting from the same node (p. 185); *opposite*, two growing at the same node on different sides of the main stem (p. 41); *decussate*, *i.e.* opposite, and each pair at right angles to the pair below it (p. 213); *alternate*, only one branch growing at a node (p. 185).

(V.) FOLIAGE LEAVES.—(*a*) **How placed?** Whether *radical* leaves, *i.e.* leaves growing from the root-stock (p. 31); or *cauline*, *i.e.* stem leaves (p. 31). (When there are both radical and cauline leaves, both must be described, if they differ.)

(*b*) **How arranged?** Whether *whorled* = *verticillate* (p. 185); *fasciculate* = *clustered*, like a Scotch fir; *opposite* (p. 185); *decussate* (p. 213); or *alternate* (pp. 42, 185); if alternate, whether arranged $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, etc. (p. 70).

(*c*) **How inserted?** Whether *petiolate*, *i.e.* having a leaf-stalk or *petiole*, and, if so, whether the petiole joins the leaf at its base, as the laurel, or at the middle of the blade, as the Indian cress, when it is called *peltate* (p. 187); or *sessile*, without a leaf-stalk (pp. 47, 186); or *amplexicaul*, clasping the stem (p. 186); or *perfoliate*, meeting on the other side, so that the stem seems to go through them (p. 186); or *connate*, when a pair of leaves runs into one (p. 186); or *decurrent*, when the leaf runs along the stem, as in the thistles, etc. (p. 186); or *sheathing*, as in the grass family. (See fig. 146, p. 146.)

(*d*) **What stipulation?** Whether *stipulate*, having stipules (p. 67), or *exstipulate*, without stipules. (If stipulate, the stipules should be described as if they were ordinary leaves.)

(*e*) **How veined?** Whether *pinnately* (feather-wise) veined (pp. 41, 187); *palmately* (finger-wise) veined (pp. 30, 187); or *parallel-veined* (pp. 30, 187).

(*f*) **How far cut?** Whether *simple*, *i.e.* consisting of one leaf only (p. 188); or *compound*, cut into leaflets (p. 188). If simple, whether not cut at all, or $\frac{1}{4}$ cut, $\frac{1}{2}$ cut, $\frac{3}{4}$ cut, etc. (p. 188). If compound, whether *pinnate*, having the cutting to the mid-rib, as in the rose (p. 188); or *palmate*, having the cutting to the base of the leaf (p. 188). Compound leaves are sometimes described according to the number of their leaflets as *binate*, having two leaflets; *ternate*, three leaflets, etc.; so doubly compound and trebly compound leaves are *bipinnate; tripinnate;* or they may be *biternate; triternate.* (The cuttings of the leaflets as well as of the leaves should be described.)

(*g*) **Shape?** There are three main kinds of shape.

(1.) Those in which the leaf is equally broad at equal distances from the middle of the blade (the breadth being taken as at right angles to the mid-rib); such shapes are *round; rotund, i.e.* almost round; *elliptic*, less round than rotund; *oval*, still less round; and *linear*, very narrow, like crocus leaves.

(2.) Those in which the breadth of the leaf at any distance from the middle of the blade is *less* than at the same distance towards the place where the blade joins the stem or leaf-stalk. The terms describing this sort of shape commonly end in *ate*, as *ovate*, when the blade is about half as broad as long; *lanceolate*, when it is narrower, and ends in a point; *cordate*, is heart-shaped; *cuneate*, is wedge-shaped. Sometimes the base of the blade is produced into two little *auricles* or ears, as in the leaves of arums. When these auricles are pointed downwards the leaf is called *sagittate*, or arrow-shaped; when they point straight out it is called *hastate* or halbert-shaped.

(3.) Those in which the breadth of the leaf at any distance from the middle of the blade is *greater* than it is at the same distance towards the place where the blade joins the stem or leaf-stalk. For this sort of shape the same terms are generally used as in (2), only with the prefix *ob*, as *obovate, oblanceolate*, etc.

In terms applied to leaves, when the leaves vary between two terms, both should be used, as *lanceolate-ovate, sessile-amplexicaul.* (In compound leaves the general shape of the whole leaf as well as that of the leaflets should be given.)

(*h*) **Edge?** Whether *entire*, as the ivy (p. 189); or *serrate*, cut like a saw (p. 189); *crenate*, with rounded teeth and sharp intervals (p. 190); *dentate*, having sharp teeth with curves between them (p. 190); *sinuate*, with rounded teeth and rounded intervals, like the oak (fig. 68, p. 82); *wavy*, not flat, like the holly.

(*i*) **Point?** Whether *acute, i.e.* pointed (p. 190); *obtuse, i.e.* blunt; *cuspidate*, or *acuminate*, when tapering into a point; *aristate*, when ending in a hair-like point.

(*k*) **Colour?** This may generally be described in ordinary words, but *glaucous,* which means that the leaf is of a pale bluish tint, covered with a sort of bloom, is a useful word. Both sides of the leaf should be described.

(*l*) **Hair?** Whether *glabrous,* without hairs (p. 190); or, if hairy, whether *setose, i.e.* having stiff erect hairs; or *hirsute,* covered with hairs not so stiff; or *tomentose, i.e.* cottony; or *canescent,* when the hairs are so small as to be hardly visible, but their effect is to give the surface a whitish appearance.

(VI.) INFLORESCENCE.—Whether *definite = centrifugal,* having the terminal flower flowering first (p. 214); *indefinite = centripetal,* having the bottom or outside flower blossoming first (p. 212); or *irregular.*

(*a*) If definite, whether flowering in a *cyme* of 1, 2, or 3 (pp. 214, 215).

(*b*) If indefinite, whether a *raceme,* having flowers on short *peduncles* or stalks flowering all up the stem, as the foxglove (p. 212); a *spike,* like a raceme, only without stalks to the flowers (pp. 212, 244); a *catkin,* like a spike, only having *imperfect* flowers, *i.e.* flowers which have not both stamen and pistil, as willows, etc. (p. 79); a *corymb,* like a raceme, only the lower flowers have longer stalks than the upper ones, so as to bring them all to the same level; an *umbel,* all the flower-stalks starting from the same point (p. 213); a *compound umbel,* when each peduncle of the umbel subdivides into smaller flower-stalks or *pedicels,* each bearing a flower (p. 213); or a *head,* when all the flowers are sessile, start from the same point, and have an enlarged common receptacle or *disc* to receive them (pp. 84, 213, 222).

(*c*) If irregular, whether a *panicle,* as many grasses (p. 238); or, if your inflorescence seems to belong to none of the kinds described, state which it most resembles, and add the termination *ose,* as *racemose.*

(VII.) BLOSSOM.—Whether *perfect,* having stamens and pistil in the same flower (p. 114); *monœcious,* having pistil and stamens in different flowers, but on the same plant, as the cucumber (p. 9); or *diœcious,* having stamens and pistil growing on different plants, as the willows (p. 112). (If the flower is imperfect, both *staminate* and *pistillate* blossoms should be described.)

(*a*) **As to Covering.** If the covering is single, it is generally called a *perianth;* if double, it is divided into *calyx* or cup leaves, each of which is called a *sepal* (p. 27); and *corolla*, or crown leaves, each of which is called a *petal* (p. 27.)

(*b*) Terms used for scheduling **Flowers with double Perianth.**

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.		Separate (*polysepalous*). United (*gamosepalous*).	The receptacle (*free*) (*inferior*). The ovary (*superior*).	See (*c*) below.
Petals.		Separate (*polypetalous*). United (*gamopetalous*).	The receptacle (*free*) (*hypogynous*). Flower-rim or flower-tube (*perigynous*). Ovary (*epigynous*).	See (*d*) below.
Stamens.		Separate (according to number: if 1, *monandrous;* if 2, *diandrous;* if 3, *triandrous;* if 4, *tetrandrous;* if 5, *pentandrous;* if 6, *hexandrous;* if 7, *heptandrous;* if 8, *octandrous;* if 9, *enneandrous;* if 10, *decandrous;* if more than 10, *polyandrous*). United (if in bundles by filaments, according to number of bundles: if in one bundle, *monadelphous;* if in two, *diadelphous*, and so on); (if united by anthers, *syngenesious*). If two stamens are long and two short, they are called *didynamous*. If four are long and two short, *tetradynamous*.	Receptacle (*free*) (*hypogynous*). Flower-rim or flower-tube (*perigynous*). Corolla (*epipetalous*). Ovary (*epigynous*). If forming a column with the stigmas, as in the Orchids, *gynandrous*.	See (*e*) below.
Carpels.		Separate (*apocarpous*). United (*syncarpous*).	Receptacle, and not attached to any other whorl (*free*) (*superior*). Attached to calyx (*inferior*).	See (*f*) below.

It should be noticed that *free* is often used in the third column. It means coming off the receptacle, and being detached from any other whorl.

EXAMPLE OF FLOWER WITH DOUBLE PERIANTH, SCHEDULED WITH AND WITHOUT TERMS.

(*THE WALL-FLOWER.*)

Parts of Flower.	No.	Separate or United.	Where coming off.	Remarks.
Sepals.	4	Separate = Polypetalous.	Receptacle. Free = inferior.	
Petals.	4	Separate = Polypetalous.	Receptacle. Free = hypogynous.	
Stamens.	6	Separate and tetradynamous.	Receptacle. Free = hypogynous.	
Carpels.	2	United = Syncarpous.	Receptacle. Free = superior.	

If the flower has a single perianth, as the marsh-marigold (p. 32), it is scheduled in the same way, except that *phyllous* is used instead of *sepalous* or *petalous;* thus a marsh-marigold's separate *perianth* leaves would be described as *polyphyllous.*

(*c*) **Remarks on Calyx.**—The calyx may be *caducous, i.e.* falling off as soon as the flower opens, as the poppy ; *deciduous,* falling off when the ovules are fertilized ; or *persistent,* remaining after the rest of the flower has withered (p. 47).

The *æstivation* or arrangement of the sepals may be *valvate,* when all the leaves come off at the same level, so that no one is completely exterior. Valvate æstivation is sometimes *twisted.* The æstivation is *imbricate* when the leaves come off at slightly different levels, *i.e.* whenever one leaf is completely exterior, and one completely interior. The $\frac{2}{5}$ arrangement described at p. 71 is called the *quincuncial* form of *imbrication.*

The calyx may be *regular, i.e.* when all the sepals are alike, or *irregular,* in which case the irregularities should be described. The general shape may be *erect* or upright ; *divergent* or spreading ; *reflexed,* with the tips of the sepals turning back.

In a gamosepalous calyx the united part is called the *tube;* the part where the sepals spread out, the *throat;* and the spreading part the *limb,* which is generally composed of several *lobes* (p. 47). Sometimes the separate part of the sepals turns into hairs, as in the composites, when it is called the *pappus* (pp. 84, 224).

(*d*) **Remarks on Corolla.**—For æstivation the same terms are used as about the calyx. (Special forms are found in the Pea-flower and Scrophularia families.)

The corolla may be *regular* or *irregular.*

The general shape, and shape of irregularities, should be described. The thin part of the petal is called the *claw* (p. 57). In the pea-flower family the large petal is called the *standard*, the two side petals are called *alæ*, or wings, and the two bottom ones form the *carina* or *keel* (fig. 11, p. 15). In other families one petal is produced into a lip or *labellum* (fig. 190, *l*, p. 241), or into a spur for honey, which is called a *nectary* (fig. 190, p. 241).

(*e*) **Remarks on Andrœcium.**—*Andrœcium* is the name given to all the *stamens* or dust-spikes (p. 27) taken together. Each stamen is composed of *filament*, or stalk (p. 27), and *anthers*, which are the pouches to contain the *pollen* (p. 27).

The anther is divided into two *lobes*, which are joined by a *connective* (p. 103), and it *dehisces* or splits to let out the pollen. The anthers may be *introrse*, *i.e.* their slits turned towards the centre of the flower ; or *extrorse*, *i.e.* their slits turned outwards. The anthers may be *innate*, fastened to the filament like an ordinary leaf, without marked distinction between back and front ; *adnate*, fastened by the back, so as to make a distinction between back and front ; or *versatile*, balanced on the filament (fig. 188, p. 239).

(*f*) **Remarks on Pistil.**—This is the name given to the whole of the seed-bearing organ (p. 28). It consists of one or more *carpels* (p. 35). Each carpel is divided into the *ovary*, where the *ovules* or little grains are ; the *style* or neck ; and the *stigma* or sticky top (p. 28). The seam of the carpel is called the *ventral suture* (p. 36) ; the midrib the *dorsal suture.* The *placentation*, or arrangement of the seeds in the ovary, is *sutural* if the pistil is apocarpous (p. 39). If the pistil is syncarpous, it may be *axile*, when the seeds are joined to an axis in the middle, and the pistil is divided into chambers (p. 50) ; *free-central* like axile, only having no chambers in the pistil (p. 54), or *parietal*, when the seeds grow not in the centre, but on the side-walls of the pistil (p. 58).

(VIII.) FRUIT.—When the pistil and any part of the blossom adhering to it is ripe, it is said to be in *fruit* (p. 65). The outer skin of a ripe carpel is called the *exocarp* (p. 74) ; the inner skin the *endocarp* (p. 75); and the part between, the *mesocarp* (p. 75).

(*a*) A fruit which results from apocarpous pistils may be an *achene*, which is dry, and *indehiscent, i.e.* not splitting (p. 68); a *follicle*, which is dry, and splits by the *suture* or seam only (fig. 57, p. 73); a *legume*, which is dry, and splits by both sutures (fig. 58, p. 74). If the fruit is fleshy, it may be a *drupe, i.e.* having a fleshy mesocarp and stony endocarp (p. 75); a *drupel*, if it is one of several drupes growing on the same fruit (p. 75); or a *pome*, if the fleshy part is formed by the united flower-tube, exocarp, and mesocarp, while the endocarp becomes horny (p. 77).

(*b*) A fruit which results from a syncarpous pistil may be a *nut*, which is dry and indehiscent (p. 82); if it has wings, like a sycamore fruit, it goes by the name of *samara* (p. 83). Dry and dehiscent fruits are called by the common name of *capsule* (p. 85). Fleshy and indehiscent fruits are called *berries* (p. 92).

(*c*) *Collective fruits* are those resulting from several pistils, as the fig (p. 93).

(IX.) OVULE.—This is the grain before it becomes a *seed*. It consists of *nucleus* or kernel, and of two skins, the *primine* or outer coat, and *secundine* or inner coat. The hole in the skins through which the fertilizing tubes enter is sometimes called the *foramen*, sometimes the *micropyle*, or little gate (p. 134). The little stalk, by which it is joined to the placenta of the ovary is called the *funicle*, and its point of attachment to the ovules is called the *hilum*. There is in some ovules a *raphe* or feeding-tube (fig. 132, *ft*, p. 132), carrying nourishment from the parent plant, and ending in a *chalaza* or feeding-hole (fig. 132, *f h*, p. 132).

(*a*) Ovules may be *erect in the ovary* (fig. 134, p. 134); *pendent in the ovary* (fig. 135, p. 136); and *horizontal in the ovary* (fig. 142, p. 141).

(*b*) They may also be *orthotropous* or upright in the seed (p. 135); *campylotropous*, or curved (p. 139); and *anatropous*, or inverted (p. 137).

(X.) SEED.—Most of the same terms are used in decribing the ovule after it has grown into a seed, except that it then consists of an *embryo* or plantlet (p. 137), and the two skins are called, the outer the *testa*, the inner the *tegmen*. Sometimes the embryo is surrounded by a white substance called *albumen* (p. 142), in which case the seed is said to be *albuminous;* sometimes the embryo entirely fills the coats, in which case it is said to be *exalbuminous*.

The embryo consists of one or two *cotyledons* or seed-leaves (p. 140); a *plumule* or stem-shoot (fig. 132 *st.sh*, p. 132); and a *radicle* or descending shoot (p. 134).

INDEX.

The Arabic numbers refer to the body of the work, the Roman numbers to the Appendix.

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CATENA CLASSICORUM—continued.

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master the territorial element, receiving, however, in the course of the struggle some moderating and tempering influences from the opponent principle.

CHAPTER II.

THE PEOPLE.

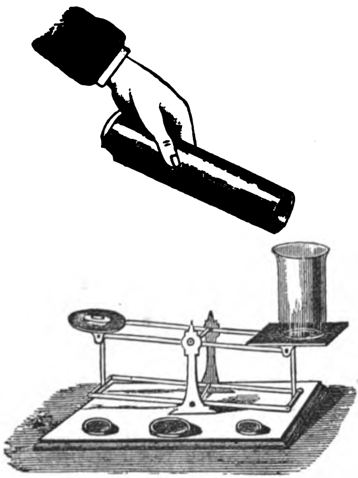
1.[1] **Classes of the People.**—The English settlers in Britain were from the first divided into the two great hereditary classes of Eorls (the *principes* of Tacitus) and Ceorls,[2] both free, but the former of noble, the latter of ignoble birth. The oath of an eorl availed against that of six ceorls, and there was a corresponding difference in the amount of the weregild or compensation-money to be paid for the murder of a member of the two classes; which in the case of a ceorl was only 200 shillings (whence he was called a *twyhyndman*), but in that of an eorl 1200 shillings. Besides these distinctions between the two classes, another was introduced, which had not existed when the people dwelt in the forests of Germany. Their private wealth had then consisted of household furniture, armour, and cattle, while their land was regarded as the common property of the tribe. But after settling upon the conquered soil of Britain, they made continually increasing encroachments on the folc-land, or land common to the whole people, by converting portion after portion of it into boc-land—land held by private individuals, by book or charter. Landed wealth was at first the accompaniment of noble birth or personal merit, and when it became dissociated from these, it was gradually looked

[1] For the periods of our history to which the sections marked 1–6 in the different chapters correspond, see the Preface.

[2] The words have now under the modernised forms of *earl* and *churl*. acquired totally different meanings.

In Fig. 16 is represented a very pretty experiment, showing that this gas is heavier than air. First, balance a jar with a weight. I say *balance* a jar. Is that exactly correct? Is there not something in the jar? "No," you will perhaps say, "it is empty." But think a moment. That jar is full of something, and that something has weight. It is full of air. We have balanced, then, a jar full of air. Now if, as represented, carbonic acid gas be poured into the jar on the scales, the jar will descend and the weight will rise. Why? Because there is now a gas in the jar that is heavier than air.

Fig. 16.

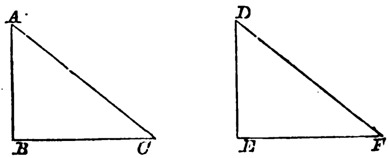


If you have a jar filled with this gas, you can take it out with a little bucket, as seen in Fig. 17. As you take one bucketful after another out, it can be poured away as water; and air will take the place of the gas as fast as it is removed.

If a soap-bubble fall into a jar of carbonic acid gas, it will not go to the bottom as it would if the jar were full of air. It will descend a little into the jar, and then ascend and remain in its open mouth. Why is this? The air that is blown into the bubble is lighter than the gas in the jar,

PROPOSITION B. THEOREM.

If two triangles have two angles of the one equal to two angles of the other, each to each, and the sides adjacent to the equal angles in each also equal; then must the triangles be equal in all respects.



In △s *ABC, DEF,*

let ∠ *ABC* = ∠ *DEF*, and ∠ *ACB* = ∠ *DFE*, and *BC* = *EF*.

Then must AB = DE, and AC = DF, and ∠ *BAC* = ∠ *EDF.*

For if △ *DEF* be applied to △ *ABC*, so that *E* coincides with *B*, and *EF* falls on *BC*;

then ∵ *EF* = *BC*, ∴ *F* will coincide with *C*;

and ∵ ∠ *DEF* = ∠ *ABC*, ∴ *ED* will fall on *BA*;

∴ *D* will fall on *BA* or *BA* produced.

Again, ∵ ∠ *DFE* = ∠ *ACB*, ∴ *FD* will fall on *CA*;

∴ *D* will fall on *CA* or *CA* produced.

∴ *D* must coincide with *A*, the only pt. common to *BA* and *CA*.

∴ *DE* will coincide with and ∴ is equal to *AB*,

and *DF* .... *AC*,

and ∠ *EDF* .... ∠ *BAC*;

and ∴ the triangles are equal in all respects. Q. E. D.

COR. Hence, by a process like that in Prop. A, we can prove the following theorem:

If two angles of a triangle be equal, the sides which subtend them are also equal. (Eucl. I. 6.)

thus: if the articles had cost £1 each, the total cost would have been £2478;

∴ as they cost $\frac{1}{6}$ of £1 each, the cost will be £$\frac{2478}{6}$, or £413.

The process may be written thus:

3*s*. 4*d*. is $\frac{1}{6}$ of £1 | £2478 = cost of the articles at £1 each.

£413 = cost .... at 3*s*. 4*d*. ...

Ex. (2). Find the cost of 2897 articles at £2. 12*s*. 9*d*. each.

£2 is 2 × £1	2897 . 0 . 0	= cost at £1 each.
10*s*. is $\frac{1}{2}$ of £1	5794 . 0 . 0	= ...... £2 ....
2*s*. is $\frac{1}{5}$ of 10*s*.	1448 . 10 . 0	= ...... 10*s*.....
8*d*. is $\frac{1}{3}$ of 2*s*.	289 . 14 . 0	= ...... 2*s*. ....
1*d*. is $\frac{1}{8}$ of 8*d*.	96 . 11 . 4	= ...... 8*d*. ....
	12 . 1 . 5	= ...... 1*d*. ....
	£7640 . 16 . 9	= ...... £2. 12*s*. 9*d*. each.

NOTE.—A shorter method would be to take the parts thus:

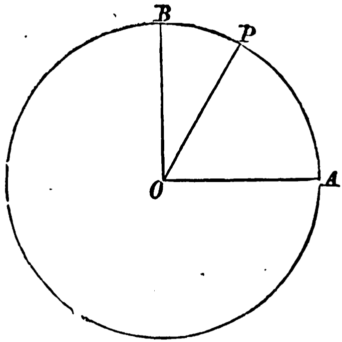
10*s*. = $\frac{1}{2}$ of £1; 2*s*. 6*d*. = $\frac{1}{4}$ of 10*s*.; 3*d*. = $\frac{1}{10}$ of 2*s*. 6*d*.

Ex. (3). Find the cost of 425 articles at £2. 18*s*. 4*d*. each.

Since £2. 18*s*. 4*d*. is the difference between £3 and 1*s*. 8*d*. (which is $\frac{1}{12}$ of £1), the shortest course is to find the cost at £3 each, and to *subtract from it* the cost at 1*s*. 8*d*. each, thus:

	£ s. d.	
£3 is 3 × £1	425 . 0 . 0	= cost at £1 each.
1*s*. 8*d*. is $\frac{1}{12}$ of £1	1275 . 0 . 0	= ...... £3 ....
	35 . 8 . 4	= ...... 1*s*. 8*d*. each.
	£1239 . 11 . 8	= ...... £2. 18*s*. 4*d*. each.

28. ***To shew that the angle subtended at the centre of a circle by an arc equal to the radius of the circle is the same for all circles.***



Let O be the centre of a circle, whose radius is r;

AB the arc of a quadrant, and therefore AOB a right angle;

AP an arc equal to the radius AO.

Then, $AP=r$ and $AB=\frac{\pi r}{2}$. (Art. 14.)

Now, by Euc. VI. 33,

$$\frac{\text{angle } AOP}{\text{angle } AOB}=\frac{\text{arc } AP}{\text{arc } AB},$$

or,
$$\frac{\text{angle } AOP}{\text{a right angle}}=\frac{r}{\frac{\pi r}{2}}$$

$$=\frac{2r}{\pi r}$$

$$=\frac{2}{\pi}.$$

Hence
$$\text{angle } AOP=\frac{2 \text{ right angles}}{\pi}.$$

Thus the magnitude of the angle AOP is independent of r and is therefore the same for all circles.

89. Case II. The next case in point of simplicity is that in which four terms can be so arranged, that the first two have a common factor and the last two have a common factor.

Thus

$$x^2+ax+bx+ab=(x^2+ax)+(bx+ab)$$
$$=x(x+a)+b(x+a)$$
$$=(x+b)(x+a).$$

Again

$$ac-ad-bc+bd=(ac-ad)-(bc-bd)$$
$$=a(c-d)-b(c-d)$$
$$=(a-b)(c-d).$$

Examples.—XVIII.

Resolve into factors:

1. $x^2-ax-bx+ab.$
2. $ab+ax-bx-x^2.$
3. $bc+by-cy-y^2.$
4. $bm+mn+ab+an.$
5. $abx^2-axy+bxy-y^2.$
6. $abx-aby+cdx-cdy.$
7. $cdx^2+dmxy-cnxy-mny^2.$
8. $abcx-b^2dx-acdy+bd^2y.$

90. Before reading the Articles that follow the student is advised to turn back to Art. 56, and to observe the manner in which the operation of multiplying a binomial by a binomial produces a *trinomial* in the Examples there given. He will then be prepared to expect that in certain cases a *trinomial can be resolved into two binomial factors,* examples of which we shall now give.

91. Case III. To find the factors of

$$x^2+7x+12.$$

Our object is to find two numbers whose product is 12,
and whose sum is 7.

These will evidently be 4 and 3,

$$\therefore x^2+7x+12=(x+4)(x+3).$$

Again, to find the factors of

$$x^2+5bx+6b^2.$$

Our object is to find two numbers whose product is $6b^2$,
and whose sum is $5b$.

These will clearly be $3b$ and $2b$,

$$\therefore x^2+5bx+6b^2=(x+3b)(x+2b).$$

πρὸς ἑωυτοῦ τὸν χρησμὸν εἶναι, ἐστρατεύετο ἐς τὴν Περσέων μοῖραν. Ὡς δὲ ἀπίκετο ἐπὶ τὸν Ἅλυν ποταμὸν ὁ Κροῖσος, 3
τὸ ἐνθεῦτεν, ὡς μὲν ἐγὼ λέγω, κατὰ τὰς ἐούσας γεφύρας διεβίβασε τὸν στρατόν· ὡς δὲ ὁ πολλὸς λόγος Ἑλλήνων, Θαλῆς οἱ ὁ Μιλήσιος διεβίβασε. ἀπορέοντος γὰρ Κροίσου ὅκως οἱ 4
διαβήσεται τὸν ποταμὸν ὁ στρατὸς (οὐ γὰρ δὴ εἶναί κω τοῦτον τὸν χρόνον τὰς γεφύρας ταύτας), λέγεται παρεόντα τὸν Θαλῆν ἐν τῷ στρατοπέδῳ ποιῆσαι αὐτῷ τὸν ποταμόν, ἐξ ἀριστερῆς χειρὸς ῥέοντα τοῦ στρατοῦ, καὶ ἐκ δεξιῆς ῥέειν· ποιῆσαι δὲ ὧδε. ἄνωθεν τοῦ στρατοπέδου ἀρξάμενον, διώ- 5
ρυχα βαθέην ὀρύσσειν, ἄγοντα μηνοειδέα, ὅκως ἂν τὸ στρατόπεδον ἱδρυμένον κατὰ νώτου λάβοι, ταύτῃ κατὰ τὴν διώρυχα ἐκτραπόμενος ἐκ τῶν ἀρχαίων ῥεέθρων, καὶ αὖτις παραμειβόμενος τὸ στρατόπεδον, ἐς τὰ ἀρχαῖα ἐσβάλλοι· ὥστε, ἐπεί τε καὶ ἐσχίσθη τάχιστα ὁ ποταμός, ἀμφοτέρῃ 6
διαβατὸς ἐγένετο. οἱ δὲ καὶ τὸ παράπαν λέγουσι καὶ τὸ ἀρχαῖον ῥέεθρον ἀποξηρανθῆναι. ἀλλὰ τοῦτο μὲν οὐ προσ-

§ 2. **πρὸς ἑωυτοῦ**] *E sua parte.* *πρός* = from the direction of (110. 2, n.), from the point of view of, and so favourable towards. Cf. *πρὸς τῶν ἐχόντων, Φοῖβε, τὸν νόμον τίθης*, Eur. *Alc.* 57.

§ 3. **τὰς ἐούσας γ.**] The plural of a single bridge (205. 3, n.).

§ 4. **ταύτας** = *τὰς ἐούσας*, above.

λέγεται] Hdt.'s doubts about this story are prob. due to chronological difficulties (Ab.). 'The exact year of Thales' birth and the date of his death cannot be known.' Clinton.

ἐξ ἀριστερῆς] This implies that the army was marching, or that the camp was facing, upstream (i. e. southwards) at the time.

καὶ ἐκ δεξ.] 'Partly on the right hand as well' (§ 6).

§ 5. **ὅκως ἂν...λάβοι**] A common construction in Hdt., as in Homer. Cf. 91. 2; 99. 3; 152. 2. Thuc. has *μὴ ἂν—ἐπιπλεύσειαν*, II. 93. 2. Prob. *ἂν* renders the object in view rather less definite than it would otherwise be, by implying the existence of some condition := 'if possible.' 'With the opt. *ὡς ἄν*, *ὅπως ἄν* = *quomodo* or *ut*. *προμηθοῦνται ὅπως ἂν εὐδαιμονοίης* is derived from the direct interrogative, *πῶς ἂν (εἰ δυνατὸν εἴη) εὐδαιμονοίης;*' Madv. *G. S. App.* 302. Tr. 'that so peradventure (the river) might take the camp, there pitched, in the rear (i. e. might flow on the western side of the camp), having on this side been diverted from its ancient course into the channel.'

§ 6. **καὶ ἐσχίσθη**] '*καί* leads one to expect a second *καί* before *διαβατός* which is omitted.' Kr. More prob. *καί* = 'actually,' the mere purpose (*ὅκως* above) now having the performance superadded.

καὶ τὸ παράπαν] 117. 1, n.

καὶ τὸ ἀρχ.] *καί* belongs to the object of *λέγ.* = 'say this also, viz. that.'

διέβησαν] 'How did they cross (on this supposition)?' i.e. how could they have crossed? Cf. 187. 5, n. Hdt.'s objection is hardly a valid one, since they might have dammed up the new stream and again diverted the river (into its old bed).

[Herodotus. See page 22.]

THE ELECTRA OF

ΗΛ. [*interrupting*] τί τῶν ἀπόντων ἢ τί τῶν ὄντων πέρι;
ΠΡ. [*solemnly*] λαβεῖν φίλον θησαυρόν, ὃν φαίνει θεός·
ΗΛ. ἰδού, καλῶ θεούς.
[*clasping her hands*] ἢ τί δὴ λέγεις, γέρον;
ΠΡ. βλέψον νυν ἐς τόνδ', ὦ τέκνον, τὸν φίλτατον.
[*turning her round to* ORESTES.]
ΗΛ. [*sadly*] πάλαι δέδοικα, μὴ σύ γ' οὐκέτ' εὖ φρονῇς.
ΠΡ. οὐκ εὖ φρονῶ 'γὼ σὸν κασίγνητον βλέπων;
ΗΛ. [*starting suddenly*]
πῶς εἶπας, ὦ γεραί', ἀνέλπιστον λόγον;
ΠΡ. [*emphatically*] ὁρᾶν 'Ορέστην τόνδε τὸν 'Αγαμέμνονος.
ΗΛ. ποῖον χαρακτῆρ' εἰσιδών, ᾧ πείσομαι; [*incredulous*]
ΠΡ. [*pointing at a scar in* ORESTES' *forehead*]
οὐλὴν παρ' ὀφρύν, ἥν ποτ' ἐν πατρός δόμοις
νεβρὸν διώκων σοῦ μέθ' ᾑμάχθη πεσών.
ΗΛ. πῶς φῄς; ὁρῶ μὲν πτώματος τεκμήριον.
[*astounded, but still hesitating.*]
ΠΡ. ἔπειτα μέλλεις προσπίτνειν τοῖς φιλτάτοις;
ΗΛ. [*resolved*] ἀλλ' οὐκέτ', ὦ γεραιέ· συμβόλοισι γὰρ
τοῖς σοῖς πέπεισμαι θυμόν. [*she rushes in a transport of joy into her brother's arms.*] ὦ χρόνῳ φανείς,
ἔχω σ' ἀέλπτως. ΟΡ. κἀξ ἐμοῦ γ' ἔχει χρόνῳ.
ΗΛ. οὐδέποτε δόξασ'. ΟΡ. οὐδ' ἐγὼ γὰρ ἤλπισα.
ΠΡ. ἐκεῖνος εἶ σύ;
ΟΡ. σύμμαχός γέ σοι μόνος,
ἢν ἐκσπάσωμαί γ' ὃν μετέρχομαι βόλον.
πέποιθα δ'. ἢ χρὴ μηκέθ' ἡγεῖσθαι θεούς,
εἰ τἄδικ' ἔσται τῆς δίκης ὑπέρτερα. [*with confidence.*]

[*Scenes from Greek Plays. See page* 18.]

378 *But loose in morals.* Such a one as George Selwyn's chaplain and parasite, Dr Warner. "In letter after letter he (Dr Warner) adds fresh strokes to the portrait of himself, not a little curious to look at now that the man has passed away; all the foul pleasures and gambols in which he revelled, played out; all the rouged faces into which he leered, worms or skulls; all the fine gentlemen whose shoebuckles he kissed, laid in their coffins."—THACKERAY'S *George III.* See also Goldsmith's *Citizen of the World*, No. 58, "A Visitation Dinner;" Knight's *History of England*, vol. vii., p. 109.

384 *Scrawls a card.* Writes his name on a visiting card. Visiting cards in the last century were not the plain bits of pasteboard which we see now-a-days, they had generally some vignette or ingenious device engraved on them. Specimens may be seen at Dresden which Raphael Mengs drew and Raphael Morghen engraved.

385 *Rout.* A crowd or crush, the fashionable term in the last century for what is now called an "at home." For an amusing account of a rout to which Porson was inveigled, see Landor's *Imaginary Conversations*, Southey and Porson.

"*Southey*—Why do you repeat the word *rout* so often?

"*Porson*—Not because the expression is new and barbarous, I do assure you, nor because the thing itself is equally the bane of domestic and polite society."

389 *By infidelity.* "This worthy clergyman takes care to tell us that he does not believe in his religion."—THACKERAY, *loc. cit.*

390 *A sinecure.* Especially applied to a benefice without the cure of souls.

397–408. A free paraphrase and amplification of 1 Tim. iii. 1–11, and Titus i. 7–9.

409 *Rostrum.* More correctly "rostra," the stage or pulpit for speakers in the Roman forum, so called from being ornamented with the beaks of ships taken from the Antians, A.U.C. 416.

410–414 See remarks on Cowper's wit and humour, in Introduction.

420 *Conceit of.* Vanity on account of.

423 *Tropes.* Trope, Greek τρόπος, properly a word turned from its natural sense, then applied more generally to any rhetorical ornament.

430 *Avaunt.* French "avant," Latin "ab ante," move on, begone.

431 *Theatric*; -*ic* is from the French -*ique.* The additional adjectival termination -*al* in the modern theatrical arose from the adjectives in -*ic* (logic, mathematics, or more correctly mathematic, domestic, &c.) acquiring the force of substantives.

435 *Curious.* Inquisitive.

436 *Nasal twang.* A relic of Puritanism, and generally supposed,

their kind, and of every creeping thing of the earth after his kind." Sufficient food was also to be provided: "take thou unto thee of all food that is eaten, and thou shalt gather it to thee, and it shall be for food for thee and for them" [GEN. vi. 19-21].

To make all these preparations required a strong belief in God on the part of Noah. The world around him utterly disbelieved the message which he conveyed to it during many years of preparation as the "preacher of righteousness" [2 PET. ii. 5], while God's longsuffering waited [1 PET. iii. 20]. Our Lord says that "they were eating and drinking, marrying and giving in marriage, until the day that Noah entered into the ark, and knew not until the flood came and took them all away" [MATT. xxiv. 38; LUKE xvii. 26]. But though all the world disregarded, Noah was entitled to be enrolled among the number of St. Paul's "elders who obtained a good report," for his faith made him believe in the things of which God gave him warning "though not seen as yet" [HEB. xi. 7], and it is recorded of him, "Thus did Noah; according to all that God commanded him so did he" [GEN. vi. 22].

The Ark which Noah built in obedience to the Divine command was not a navigable ship, but a great wooden "coffer," or water-tight chest, made so as to float about steadily upon the water.[1]

It was built of cypress or "gopher" wood, and covered with pitch within and without to secure it against leakage from the flood below or the rain above. The size of the ark is distinctly given as being 300 cubits in length by 50 cubits in width, and 30 cubits in height. The cubit is reckoned at about 21 inches, and we are thus able to compare the size of the ark with that of our large iron and wooden ships of modern days.[2]

	Length.	Breadth.	Depth.
The Ark	525 feet	87 feet 6 inches	52 feet 6 inches
Duke of Wellington	240 feet	60 feet	72 feet 4 inches
Great Eastern	680 feet	83 feet	58 feet

[1] Its object being the same as that of the "ark" in which the infant Moses was placed when cast into the Nile in obedience to the edict of Pharaoh.

[2] The proportions of the ark are exactly those of the human body, viz., 10·+1·6+1·; and the capacity of these proportions for stowage has been proved by experiments in Holland and Denmark to be a third greater than that of vessels as built for ordinary sailing purposes. That of the Ark was thus about the same as that of the Great Eastern.

Twenty-ninth Lesson.

CHANTING.

CHANTING is the arrangement of prose in a rhythmical form. The psalms, canticles, &c. are sung or chanted to melodies called CHANTS, which are either SINGLE or DOUBLE.

The melody of a single chant is, for convenience, written in phrases of seven bars of two minims each or their value.

The first half of a chant has three, the second four bars.

The first half is called the *mediation*, the second the *cadence.*

TURNER.

A double chant is simply a single chant form repeated.

ATTWOOD.

A single chant is arranged to fit one verse of the psalms, a double chant two; for the long psalms quadruple chants, of which the phrase or melody is designed to include four verses, have been written.

A changeable chant is one whose key-chord may be either (especially in winter), and only a limited number of troops can march along one road. Thus all roads leading out of a fortress are to some extent like causeways across a marsh, for practical purposes. The difficulty is diminished by acting at night, and by making feints.

24. Fort St. Georges was on the east, La Favorita on the north side, both on the outside of the lakes. A tête-de-chaussée is a fort which commands and "caps" a road, as a tête-de-pont does a bridge.

25. "Considered himself able to obtain."

26. Detached, that is, from the army now under the Archduke Charles. Till this new force, under a new general, should arrive, Melas was left in command of what remained of Beaulieu's army, now in retreat up the valley of the Adige. Beaulieu himself was recalled.

27. The district called the Vorarlberg lies between the Lake of Constance and the Tyrol. The Tyrolese attachment to the House of Austria is famous. In 1809, Napoleon wanted to take the Tyrol from Austria, and give it to Bavaria, setting up the latter as a rival power to Austria. The Tyrolese resisted. [Story of Hofer.]

28. [Why did not Bonaparte cross the Adige, or else ascend it, and make for the Danube?]

29. "Dependent on" (comp. the English "irrelevant") . . . "invested with," i.e. holding. These little domains were only nominally dependent on the empire; in reality they were part of the territory of Genoa, and contributed to its militia. "The empire" had only eight years more to live. When Francis II. saw that he had lost all real power as emperor, he threw it up altogether, and took the title of Emperor of Austria instead.

30. [St. Januarius.]

31. There were also six thousand English in Corsica, who might have reinforced an army attacking Bonaparte from the south. [Have English troops ever been in North Italy? Only once, I believe.]

32. In its lower course, the Po is higher than the surrounding country, thanks to the deposits brought down from the Alps, which raise its bed incessantly. It is walled in by high embankments, kept in order by a staff of engineers, as in Holland. But, in spite of their efforts, the river sometimes breaks through.

33. "Referred the question of peace to."

34. Napoleon had strange good fortune in one respect: his enemies never attacked him at the same moment. In this campaign he could hardly have resisted a flank attack from a Papal and Neapolitan army combined with that of the Austrians. So, when he beat Austria at Austerlitz, Prussia on his left flank was holding back; when he beat Prussia at Jena, Austria on his right flank was passive; when he invaded Russia, neither Prussia nor Austria stirred; when at last they did combine in one attack, they were more than a match for him, and he was ruined in the great battle of 1813.

INDEX

INDEX.