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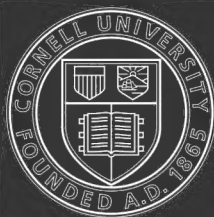
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NOTES ON THE LIFE HISTORY OF BRITISH
FLOWERING PLANTS



Notes on The Life History of British Flowering Plants

BY

THE RIGHT HON. LORD AVEBURY, P.C.

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PREFACE

SOWERBY, Bentham, Hooker, Babington, and others have given us good, and in some cases excellent works, enabling us to determine and name our British plants, but they mostly confine themselves to technical details, with such additional particulars as enable the student to distinguish one species from another. To these, however, in the main they confine themselves, and, no doubt, in great measure, from considerations of space, omit other points often of great interest, nor does it fall within their intention to enter much into the economy and life-history of plants.

Even Sowerby did not to any great extent fill up the gap. He does not, I think, mention the remarkable work of Sprengel, and the interesting researches of Darwin, H. Müller, Hildebrand, Delpino, and others have been made since he wrote.

Kerner's admirable work deals with plants generally, and comparatively little space, therefore, can be devoted to British species.

Knuth's *Handbuch der Blumenbiologie* relates mainly to the relations of flowers and insects, as also does my smaller work, *British Wild Flowers, Considered in Relation to Insects*.

In another book, *Flowers, Fruits, and Leaves*, I have dwelt on the structure and forms of plants, but from a general point of view.

In the present work I endeavour to supplement the various excellent "Florae" which we already possess, not in any way to compete with them: to describe points of interest in the life-history of our British plants; to explain, as far as possible, the reasons for the structure, form, and colour; and to suggest some of the innumerable problems which still remain for solution. I have followed the arrangement adopted in Bentham's *Handbook of the British Flora*, as being one in very general use.

Dr. Rendle has been so kind as to see the proofs through the press for me. This is a guarantee of accuracy, and he has also made many valuable suggestions.

HIGH ELMS, DOWN, KENT,

October 5, 1905.

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GLOSSARY

- Accumbent** (p. 77), of the radicle when lying parallel with the edges of the cotyledons.
- Achene** (p. 47), a one-seeded fruit with a thin dry wall, which does not split open when ripe.
- Albumen**, *see* Endosperm.
- Alien**, a plant which has presumably been introduced by human agency.
- Anatropous** (p. 365), of the ovule, turned through 180° , so that the micropyle points towards the placenta.
- Androdicœcious**, having hermaphrodite and male flowers on different plants.
- Andromonœcious**, having hermaphrodite and male flowers on the same plant.
- Anemophilous** (p. 5), of plants in which the pollen is carried to the stigma by the wind.
- Anther**, that portion of the stamen which contains the pollen.
- Arillus, arilloid, or aril**, a growth on the outside of the seed-coat.
- Berry**, a fruit which, except for the outer skin, is succulent or juicy, as in Grape or Gooseberry.
- Bipinnate** (p. 49), twice pinnate (*q.v.*), the pinnæ again pinnately divided.
- Biternate** (p. 49), with three parts, each of which again divides into three.
- Bract**, a leaf from the axil of which springs a flower or flower-bearing shoot.
- Bracteole** (p. 371), a small bract, situated on the flower-stalk.
- Caducous**, falling early, as the sepals of Poppy.
- Calyx** (p. 3), the outer whorl of the flower.
- Capsule**, a dry many-seeded fruit, opening when ripe to allow the seeds to escape.
- Carpels**, the leaves which make up the gynœcium or pistil.

Carpophore (p. 17), fruit-bearer, applied to the axis of the fruit in Umbellifers which splits lengthwise and bears the two mericarps.

Chlorophyll (p. 32) the pigment to which leaves owe their green colour.

Cleistogamous (p. 8), of plants which, besides the usual conspicuous flowers, have others which are smaller, generally uncoloured, and do not open.

Corolla (p. 3), the second whorl of the flower. In most cases this is the coloured part.

Corymb, an inflorescence in which, owing to the inequality of their stalks, the flowers stand on one level.

Cyme, a definite inflorescence, one in which the main axis ends at once in a flower.

Deciduous, lasting for a time, but ultimately falling, as opposed to persistent.

Decussate, crossing at right angles, like the pairs of leaves in Dead-nettle.

Dehiscent, opening when mature, as an anther or many fruits.

Dichogamous (p. 4), of flowers in which the anthers and stigmas do not mature simultaneously.

Diclinous, having all the flowers on any one plant either male or female; that is to say, either with stamens but no pistil, or pistil but no stamens.

Dicotyledon, having an embryo with a pair of seed-leaves or cotyledons.

Dimorphous, of species in which there are two forms of flowers, differing in the relative position of the anthers and stigma.

Diœcious (p. 4), having the stamens and pistil situated not only in distinct flowers, but also on separate plants.

Disk, an outgrowth of the floral axis, often secreting honey.

Drupe, a fruit the inner wall-layers of which are hard, forming a "stone," as in plum.

Endosperm, the food-store present in many seeds along with the embryo.

Entomophilous (p. 5), of plants in which the pollen is carried to the stigma by insects.

Epidermis, the outermost layer of cells of a leaf or young stem.

Epigynous, situated upon the ovary.

Equitant (p. 378), when leaves are folded one over the other in the bud.

Exalbuminous, without albumen (endosperm), when the embryo occupies the whole seed.

Filament, the stalk of the anther.

Follicle, a several-seeded pod-like fruit, which splits when ripe down one side only, as in Larkspur or Columbine.

Geotropic (p. 45), affected by the stimulus of gravity.

Glabrous, not hairy.

Glume (p. 431), the bract of a grass flower.

Gynodiœcious, having hermaphrodite and female flowers on different plants.

Gynomonœcious, having hermaphrodite and female flowers on the same plant.

Heterogamous, having male, female, and hermaphrodite flowers, or any two of them united in one head, as in Compositæ.

Heteromorphous, having more than one form of flower.

Heterostyly, when two or more forms of flowers are characterised by styles of different lengths.

Homogamous, of flowers in which stigmas and anthers are functional at the same time.

Hypogynous, arising below the ovary on the floral axis.

Incumbent (p. 76), of the radicle when lying parallel with the faces of the cotyledons.

Indehiscent, not opening when mature.

Involucre, an association of bracts round the base of a flower or inflorescence.

Lanceolate, shaped like the head of a lance.

Lenticel (p. 219), a small area of loosely arranged cork cells allowing the passage of air.

Linear, narrow, with parallel sides, like a grass leaf.

Loculicidal dehiscence, of a capsule, splitting down the middle line of each carpel.

Mericarps (p. 17), one-seeded portions of a compound fruit which separate when ripe.

Micropyle, the aperture between the ovule-integuments through which the pollen tube reaches the embryo-sac.

Monœcious, having stamens and pistil in separate flowers, but on the same plant.

Monocotyledon, having an embryo with a single seed-leaf or cotyledon.

Monomorphic, of species in which all the flowers resemble one another in the relative position of the anthers and stigmas.

μ , one-thousandth part of a millimetre.

Nectary, that part of the flower which secretes honey.

Obovate, of a leaf which is egg-shaped (ovate) in outline, but attached at the narrower end.

Orthotropous (p. 364), of the ovule, standing erect, the micropyle being at the opposite end to the stalk.

Palmate, of a leaf, with divisions spreading from a common point.

Panicle, a branched inflorescence with stalked flowers.

Pappus (p. 231), the hairy development which replaces the calyx in Compositæ.

Parenchyma, thin-walled cellular tissue, with cells not much longer than broad.

Pentamerous, with parts in fives.

Pericarp, the wall of the fruit.

Perigynous, situated around the ovary.

Petals, the leaves of the corolla.

Pinnate, of a leaf, with divisions arranged in a series right and left of an axis, as the barbs of a feather.

Pinnatifid, of a leaf, when pinnately cut about half way to the mid-rib.

Pistil, the central organ of the flower. It generally consists of one or more ovaries and stigmas; the stigma is often raised on a stalk, called the style.

Placenta, the part of the ovary on which the ovules are borne.

Plumule, the bud in the embryo which will develop into the stem and leaves of the plant.

Polygamous, having male, female, and hermaphrodite flowers on the same or on distinct plants.

Pome, a fruit in which the succulent floral receptacle surrounds and is completely merged with the pistil, as in Apple and Pear.

Protandrous, of flowers in which the stamens come to maturity before the stigmas.

Protogynous, of flowers in which the stigmas come to maturity before the stamens.

Raceme, an inflorescence consisting of an elongated axis bearing stalked flowers, the youngest at the top.

Radical, of leaves springing from a shortened stem, thus appearing to come from the root.

Radicle, the root of the embryo.

Receptacle, the axis of the flower, generally more or less thickened.

Rhizome, an underground stem, generally more or less thickened.

Rostellum (p. 401), the non-receptive third stigma of an Orchid flower.

Samara, a winged fruit.

Scape, a leafless stem bearing flowers.

Sclerenchyma, hard tissue, for support (mechanical tissue).

Sepals (p. 3), the leaves of the calyx.

Septicidal dehiscence, of a capsule splitting along the septum which separates the constituent chambers.

Silicula or **silicule** (p. 85), a siliqua which is not longer than broad.

Siliqua, the fruit characteristic of Cruciferae, opening longitudinally by two valves which separate from a central septum.

Spike, like a raceme (*q.v.*), but with sessile flowers.

Stamens (p. 4), the parts of a flower which generally stand next the corolla, on the inner side. They usually consist of a stalk or filament, and an anther, containing the pollen.

Staminode, a barren stamen, generally much reduced in size.

Stigma (p. 4), that portion of the pistil on which the pollen must be deposited in order to fertilise the flower.

Stipule, an appendage of the base of the leaf, generally borne in pairs.

Stoma, the mouth or aperture between two adjacent epidermal cells.

Style, the stalk of the stigma.

Testa, the seed-coat.

Tetramerous, with parts in fours.

Transpiration, the giving off of water-vapour by green leaves.

Trimorphous, of species in which there are three forms of flowers, differing in the relative position of the anthers and stigma.

Tricocious (p. 110), having hermaphrodite, male, and female flowers on distinct plants.

Tripinnate (p. 50), thrice pinnate (*q.v.*).

Umbel, an inflorescence in which several stalked flowers spring from one point; the youngest flowers are nearest the centre.

Viviparous (p. 442) when the seed is replaced by a green shoot, as in several Arctic and Alpine grasses.





FIG. 1.—*Geranium sylvaticum*.

CHAPTER I

INTRODUCTION

OUR knowledge of the origin and past history of our British Flora is still very incomplete. The researches of geologists, however, and especially of Mr. Clement Reid, have made it probable that before the glacial period the flora of the British Isles did not materially differ from the present. Some, at any rate, of our northern forms were already here, as well as other more southern species, such as the Hawthorn (*Cratægus*) and some, such as the Spruce Fir, which were driven away, or rather killed out, by the cold, and have never returned. Some of our plants have been introduced by man intentionally, and others, the so-called weeds of cultivation, unintentionally. Some which might be thought to be thoroughly established—the Lime, for instance,—though they produce abundance of fruit, never or scarcely ever reproduce themselves by self-sown seed. Even the Common Elm is said to produce perfect seed two or three times only in a century.

The northern limit of plants is not determined merely by the average temperature; it depends on the respective

summer and winter temperatures, on the amount of sunshine, of moisture, and various other factors. For instance, some plants can stand a severe winter, provided the summers are sufficiently hot; others are satisfied with moderate warmth in summer, but cannot stand a severe winter. Hence some plants will thrive at Paris, but cannot maintain themselves in Kent; while others flourish near London, but are killed by the colder winters of Paris.

Apart from their systematic distribution in natural orders, plants fall into certain great biological groups, differing according to the point of view from which we consider them. Thus they are annual, biennial, or perennial, according as they run through their life-history in one or two seasons, as do many of our herbs, or persist for several or many years, as in the case of some herbaceous plants like the Nettle, and all the larger plants which become shrubs or trees. They may be evergreen, retaining their leaves for more than one season, so that the tree is never bare, as in Holly, Pines, or Yew; or deciduous, shedding at the end of each growing season the leaves which expanded earlier in the same year. Again, while most live on land, many are aquatic. In some the pollen is carried by the wind, in others by animals, especially insects.

ANNUALS AND PERENNIALS

In very dry localities we find an unusual proportion of annual species, which come up during the wet season, if there be one, or after the rains which occasionally occur. According to Boissier, annual species rise to their maximum on the hot coast region of Granada, where, out of 1070 species, 542 are annual, 46 biennial, and 482 perennial.

Alpine and Arctic conditions, on the other hand, favour perennial species. These generally have strong roots which go deep into the ground, and are thus protected from cold, while on the return of more genial conditions they throw out aerial shoots. In the moister

regions of the tropics, also, there is a great preponderance of perennial species, but with this difference, that while in cold regions the persistent parts are underground, in the form of woody stems, or bulbs, tubers, etc. protected by the soil against extreme cold, in hot regions they require no such protection, and are to a great extent aerial.

Uniform climates also appear to favour perennial species. In the Sandwich Islands, for instance, species of Violet and Geranium, of Composites and Caryophyllaceæ, become shrubby.

We owe to Messrs. Bonnier and Flahault a very interesting memoir on the flora of Dauphiné from this point of view. They found—

	Annual.	Perennial.
In the region below the Pine forests .	60 per cent.	40 per cent.
„ Pine and Grass region .	33 „	67 „
„ Upper Alpine „ .	6 „	94 „

As regards the character of the soil, etc., they give the following table :—

	Annual and Biennial.	Perennial.
Stony and sandy places	32 per cent.	68 per cent.
Dry meadows . . .	9·7 „	90·3 „
Damp „ . . .	13·8 „	85·7 „
Woods and bushy places	4 „	96 „
Aquatic . . .	2·6 „	97·4 „
Arable fields . . .	88·8 „	11·2 „

Many plants, as, for instance, Mignonette (*Reseda odorata*), which are habitually annual, become biennial if the flower-buds are pinched off.¹

THE FLOWER

If we examine a common flower, such, for instance, as a Geranium (Fig. 1), we shall find that it consists of, first, an outer envelope or calyx, sometimes tubular, sometimes consisting of separate leaves called sepals; secondly, an inner envelope or corolla, which is generally more or less coloured, and which, like the calyx, is

¹ Hildebrand, in Engler's *Bot. Jahrb.* ii. (1881).

sometimes tubular, sometimes composed of separate leaves called petals; thirdly, of one or more stamens, consisting of a stalk or filament, and a head or anther, in which the pollen is produced; and fourthly, a pistil, which is situated in the centre of the flower, and consists generally of three principal parts—the ovary comprising one or more compartments at the base, each containing one or more ovules; the style; and the stigma, which in many familiar instances forms a small head at the top of the style or of the ovary, and to which the pollen must find its way in order to fertilise the ovule. But though the pistil is thus surrounded by one or more rows of stamens, and though most flowers are capable of fertilisation by their own pollen, still it is a great advantage to a species that the flower should be fertilised by pollen from a different stock. How, then, is self-fertilisation prevented? There are three principal modes. Firstly, in many species the stamens and pistil are in separate flowers, sometimes borne on different plants. Secondly, even when the stamens and pistil are in the same flower, they are in many species not mature at the same time. This was first observed by Sprengel in *Epilobium angustifolium* as long ago as 1790. In some cases the stigma has matured before the anthers are ripe, while in other and more numerous cases the anthers have ripened and shed all their pollen before the stigma has come to maturity. Thirdly, there are many species in which, though the anthers and stigma are contained in the same flower and are mature at the same time, they are so situated that the pollen can hardly reach the stigma of the same flower.

Another circumstance which makes for cross-fertilisation is the prepotence of pollen from another plant of the same species. If plants of several varieties are grown together, the seeds cannot be reckoned on to come true. Even after twenty-four hours Darwin found that pollen from another plant exercised a predominant influence. He placed on several stigmas of a long-styled Cowslip (*Primula veris*) plenty of pollen

from the same plant, and after twenty-four hours added some from a short-styled dark-red *Polyanthus*, which is a variety of the Cowslip. From the flower thus treated thirty seedlings were raised, and all these without exception bore reddish flowers; so that the effect of the plant's own pollen, though placed on the stigmas twenty-four hours previously, was quite destroyed by that of the red variety. In rare cases the pollen, if placed on the stigma of its own flower, acts like a poison!

In most of our trees—Oaks, Beeches, Spanish Chestnuts, Conifers, and many herbaceous plants—the pollen is carried by wind, and the plants are therefore said to be anemophilous. In such cases there is a tremendous waste of pollen. We all know the clouds produced by a Scotch Pine. Wind-fertilised flowers, as a rule, are small, green, and regular; the pollen is dry and dusty, often round and generally smooth. The stigmas are covered with long hairs or papillæ, thus offering a larger surface to the pollen and increasing the chances of fertilisation.

On the other hand, in the great majority of flowering plants the pollen is carried from one flower to another by insects. Such flowers are called entomophilous. They are generally large, and coloured—yellow, white, red, or blue. They often emit scent and produce honey, both of which serve to attract insects. They also present great diversities of form and structure, often being irregular. The pollen is often angular, with teeth, spines, or furrows, and more or less sticky.

Bees and humble bees play a most important part in carrying pollen from flower to flower.

Every one knows how important flowers are to insects; every one knows that bees, butterflies, etc., derive the main part of their nourishment from the honey or pollen of flowers; but it is, on the other hand, only recently that we have realised how much the flowers themselves are dependent on insects. Yet it has, I think, been clearly shown that if insects have been in some respects modified and adapted with a view to the acquirement of honey and pollen, flowers, on the other

hand, owe their scent and honey, their form and colour, to the agency of insects. Thus the lines and bands by which so many flowers are ornamented have reference to the position of the honey; and it may be observed that these honey-guides are absent in night flowers, where they, of course, would not show, and would therefore be useless, as, for instance, in *Lychnis vespertina* or *Silene nutans*. Night flowers, moreover, are generally pale; for instance, *Lychnis vespertina* is white, while *Lychnis diurna*, which flowers by day, is red.¹

It must be borne in mind that, as a rule, each working bee keeps during each journey to a single species of plant. It is interesting that this fact was mentioned by Aristotle. It has been questioned, probably because male bees have been watched, and they are not so constant as the females. For them it is not so important. Male bees take no share in the provision of food, and their time is of no value. Hence neither of the two reasons which influence female bees apply to them. One advantage to the bees is the economy of time resulting from doing the same thing over and over again; but another, no doubt, is that the pollen of different species is kept separate and not mixed together.

Working bees waste no time, and fly quickly. Darwin timed humble bees at 10 miles an hour, and I believe hive bees are considerably more rapid. I have often watched them, and seen them visit some twenty flowers in a minute; and though one would suppose that when flowers are numerous many must be missed, this does not appear to be the case. Darwin, for instance, near Bournemouth, in the course of a long walk examined several hundred flowers of Heath (*Erica Tetralix*), and every one had been visited. Nay, each flower is visited several times a day. In the case of *Dictamnus Fraxinella* he found the visits amounted to thirty in a day. Of course, however, in the case of many species the visits are comparatively few and far between.

¹ Avebury (Lubbock), *Flowers, Fruits, and Leaves*.

Flowers may be divided into groups according to the manner in which the anthers and stigma are protected against wet and cold.

1. Pendent or hanging flowers: as, for instance, some Campanulas, Heaths, Rhododendrons, Rosaceæ (Geum), Solanaceæ (Atropa), Boraginæ (Pulmonaria), Ranunculaceæ (Aquilegia), Liliaceæ (Convallaria), Amaryllidaceæ (Snowdrop, Leucojum), etc.

2. Others are more or less horizontal: as, for instance, Viola, Aconitum, most Labiates, as Lamium (Dead-nettle), Nepeta (Ground Ivy), Stachys, Prunella, etc.; Leguminosæ, Scrophulariaceæ, as Antirrhinum (Snap-dragon), Linaria, Mimulus, etc.

3. Others are upright, but the anthers and stigmas are arched over by the sepals or petals, or both: as, for instance, among Ranunculaceæ, Trollius and Eranthis.

4. Others are protected by the leaves: as, for instance, Tilia (Lime) and Impatiens (Balsam).

5. Another group stand upright, but (*a*) the passage is so narrow that rain and dew cannot enter, or (*b*) it is partly closed by projections or (*c*) by hairs: as, for instance, some Primulas and Geraniums.

6. Some flowers are upright by day or in sunshine, but hang down at night or in rain: as, for instance, some Campanulas (*C. patula*), Scabiosas, Geraniums (*G. Robertianum*), Epilobiums, Anemones, Saxifrages, etc.

Sometimes it is the flower-stalk which bends, sometimes, as in Epilobium, the ovary.

7. In some cases the flowers or flower-heads close: as, for instance, many Composites, Crocus, Gentians, Campanulas, Peonies, Flaxes, Water-lilies, Anemones, Erythræa.

Sometimes the anthers themselves open or close: according to the weather: as, for instance, in Alchemilla (Lady's Mantle), Laurus, Plantago, Thesium, etc. Those of *Thesium alpinum* are said to close in 30 seconds if moistened.

In addition to the ordinary coloured flowers, some

plants have a second kind in which the petals are absent, or at any rate minute, and which do not open. For instance, in some of the Violets—*V. odorata*, *canina* (p. 98), etc.,—besides the blue flowers with which we are all so familiar, there are others almost without petals and stamens, which indeed have scarcely the



FIG. 2.—*Lamium amplexicaule*. Cleistogamous flower.



FIG. 3.—Section of ditto.

appearance of true flowers, but in which numerous seeds are produced. “Cleistogamous” flowers, as these have been called, occur in *Lamium amplexicaule* (Fig. 2), *Oxalis Acetosella*, *Trifolium subterraneum*, and other plants belonging to very different groups.

The flowers of water plants also fall into certain well-marked groups.

In the first we may place those which have a conspicuous coloured flower and are adapted for fertilisation by insects: as, for instance, the Water-lilies, Water Ranunculi, *Limnanthemum*, *Hottonia*, *Utricularia*, *Lobelia Dortmanna*, *Alisma*, *Hydrocharis*, *Stratiotes*.

These project singly, or in terminal bunches, above the water. They have undergone no special modification, though the flower-stalk is more or less strengthened so as to maintain them in an upright position, and the leaves are often arranged so as to serve the same purpose. Hair-like outgrowths are sometimes found in the flower (e.g. *Limnanthemum*) which will prevent the nectar from being flooded by water which may be splashed in. They are generally white or yellow, which makes them more conspicuous against the bluish water. *Lobelia Dortmanna* is the only blue flower in the group, but, as Schenck says,¹ we must remember that blue is in any

¹ *Die Biologie der Wassergewächse*.

case by no means a common colour. Such flowers if kept under water, by flood or otherwise, sometimes become cleistogamous (see above): as, for instance, in *Ranunculus aquatilis*, *Alisma natans*, *Subularia aquatica*, and *Illecebrum verticillatum*.

To a second group belong certain species in which the flowers raise themselves into the air, but which are not large or conspicuous, and which are presumably wind-fertilised: as, for instance, *Myriophyllum*, *Potamogeton* (Pondweed), and some *Sparganiums*.

In a third group the flowers as well as the leaves are submerged. *Callitriche* is an intermediate form; some species have aerial, others submerged flowers. The flowers are very simple, arranged in the axils of the leaves—the males reduced to a single stamen, the females to a pistil.

As typical of this group I may mention *Ceratophyllum demersum*. The flowers are surrounded by a whorl of minute bracts: the female consists of a small ovary with a single style; the male of from 12 to 20 oblong sessile anthers. The pollen, as in all submerged flowers, has no extine.

Zostera, the Grass-wrack of our shallow seas, has the small flowers enclosed in a sheath at the base of certain leaves, which do not materially differ from the rest, but are somewhat smaller. They are arranged in two rows, with alternately male and female flowers. They are protogynous, and the pollen is peculiar, being thread-like, but without motion.

Lastly, there is a small group, of which *Vallisneria* is the best-known form, and which in our flora is represented by *Ruppia*. The flowers are very simple, and consist of two bilocular anthers and an ovary with four carpels. The spadix or stalk on which they grow is at first short. The anthers open first, and eject the pollen, which, being lighter than water, at once rises to the surface. Immediately afterwards the spadix lengthens rapidly, carrying the female flower to the surface, where it meets the floating pollen. In *Vallisneria* the male

flowers are on a separate part of the plant, but are set free and rise to the surface, on which they float in some numbers around the female flowers, one or more of the dehiscing anthers coming in contact with the stigmas.

While some water plants (*Utricularia*, *Hottonia*, and *Lobelia*, for instance) ripen their seeds in the air, by far the larger number after flowering draw the ovary down under water. In many cases the shell of the fruit develops air cavities, which, when the seeds are ripe, carry them up again to the surface, and thus promote dispersal. No doubt in many cases birds carry them from one river or lake to another. It is easy to understand that the seeds and fruits of water plants do not develop wings or parachutes, which in so many land plants serve this purpose; nor do we find cases in which they are thrown or jerked.

It would appear that the chances of the ovule being fertilised and the seed coming to maturity are, on the whole, fewer in water plants than in land plants. On the other hand, the constant supply of water renders the vegetative growth more luxuriant. Hence we find that aquatic plants are generally perennial. In our own flora *Subularia aquatica* and *Najas marina* are the only annual species.

Freshwater plants, for obvious reasons, do not reach high latitudes or great altitudes. In temperate regions, however, the species have, as a rule, very wide ranges, not only in many cases round the world, but even reappearing in islands far from the mainland, mainly, we can hardly doubt, through the agency of water birds. *Najas marina* is a very good instance. Widely spread in the north temperate zone, it occurs also in Australia, the Sandwich Islands, Canaries, Venezuela, Brazil, etc.¹

Another remarkable peculiarity of flowers which I think, as I suggested in a lecture to the British Association at Belfast in 1874, has reference to their

¹ Rendle, *Trans. Linn. Soc. (Bot.) ser. 2, vol. v.*

relations with insects, is the habit of "sleeping," which characterises certain species.

Many flowers close their petals during rain, which is obviously an advantage, since it prevents the honey and pollen from being spoilt or washed away. Everybody, however, has observed that even in fine weather certain flowers close at particular hours. This habit of going to sleep is surely very curious. Why should flowers do so?

In animals we can understand it; they are tired and require rest. But why should flowers sleep? Moreover, some flowers sleep and not others, and those which do sleep keep different hours. The Daisy opens at sunrise and closes at sunset, whence its name "day's-eye." The Dandelion (*Taraxacum officinale*) is said to open about seven and close about five; *Arenaria rubra*, to be open from nine to three; *Nymphaea alba*, from about seven to four; the common Mouse-ear Hawkweed (*Hieracium Pilosella*), from eight to three; the Scarlet Pimpernel (*Anagallis arvensis*), to waken at seven and close soon after two; *Tragopogon pratensis*, to open at four in the morning and close just before twelve, whence its English name, "John-go-to-bed-at-noon." Farmers' boys in some parts are said to regulate their dinner-time by it. Other flowers, on the contrary, open in the evening.¹

Now, it is obvious that flowers which are fertilised by night-flying insects would derive no advantage from being open by day; and, on the other hand, that those which are fertilised by bees would gain nothing by being open at night. Nay, it would be a distinct disadvantage, because it would render them liable to be robbed of their honey and pollen by insects which are not capable of fertilising them. It may be observed also that wind-fertilised flowers do not sleep; and that some of those flowers which attract insects by smell emit

¹ In my own observations the opening and closing were more gradual and more dependent on the weather than I should have expected from the statements quoted above.

their scent at particular hours; thus, *Hesperis matronalis* and *Lychnis vespertina* smell in the evening, and *Habenaria bifolia* is particularly sweet at night.

Besides the means of attracting welcome guests, many plants have adopted various devices for barring access to their stores of honey of insects whose visits would be of no use in transferring pollen. For instance,

in the case of bee flowers, small flying insects are kept from the nectar by barriers of stiff hairs which they are not strong enough to pass—*e.g.* *Tropæolum*. Creeping insects, as ants, are frequently kept back by sticky hairs on the stem or flower-stalk—as in many Saxifrages.

A large proportion of dicotyledonous flowers have five sepals and five petals. Why is this?

It is probably to be explained by the phyllotaxy, or arrangement of the leaves on the stalk.

The petals, as Goethe seems first to have suggested, are modified leaves. Now if we examine a Rose shoot (Fig. 4) we shall find that the leaves are arranged in a spiral round the stem in such a manner that with

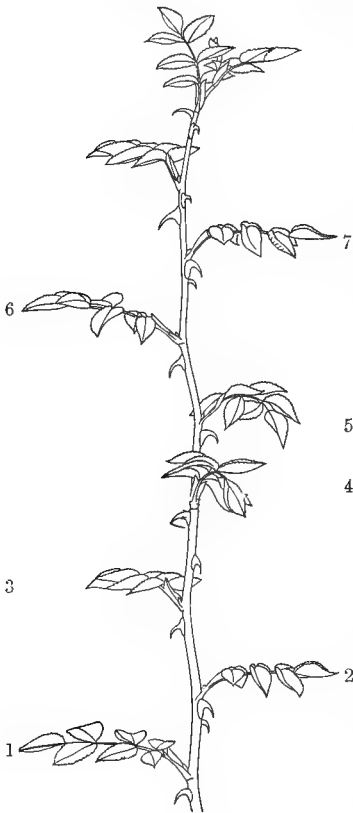


FIG. 4.—Shoot of Rose.

whatever leaf we start the sixth comes directly over it, the seventh over the second, and so on. In fact, the leaves form whorls of five, one over the other. This is still more evident in those species which have a five-

angled stem. If we hold it so that the youngest leaf (1) of the piece of shoot figured sits on the uppermost ridge in Fig. 5, the leaf immediately above (2) rises not from the next ridge, but the next but one, that on the lower left-hand side. The next (3) sits on the ridge on the upper right-hand side. No. 4 is on the left. Finally, leaf No. 5 is on the ridge forming the lower right-hand edge of the stem. I say finally, because this completes the series. Leaf No. 6 is on the same ridge

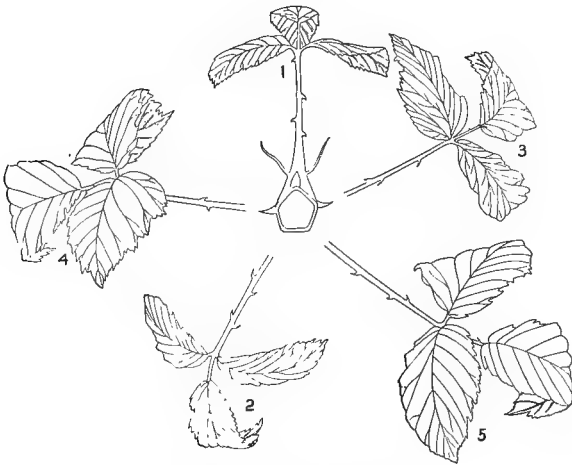


FIG. 5.—Whorl of Bramble leaves.

as, and corresponds to No. 1, leaf No. 7 to leaf No. 2, No. 8 to No. 3, and so on.

The leaves, in fact, are not on the ridge next to the ones immediately above and below, but on the next but one. Thus, then, each whorl consists of five leaves arranged in a double spiral round the stem. This is known as the $2/5$ arrangement. Incidentally it throws light on the pentagonal form of the stem. The arrangement is, however, not quite so obvious as would otherwise be the case—firstly, because the stem is often somewhat twisted, and, secondly, because the petiole of the leaf is itself sometimes bent, so that the leaf may

take the position to secure the fullest amount of light. In Fig. 5 this arrangement is clearly shown. Now if we imagine the intervals between the leaves suppressed, we shall see that they would lie in whorls of five. In fact, the five sepals form one such whorl and the five petals another. We may test this suggestion by taking the case of the Lilac and Privet, which have 4 sepals and 4 petals. Here the leaves are opposite, each pair at right angles to those above and below. Here, therefore, the whorl of leaves would consist, not of five, but of four. There are indeed some exceptions which must be otherwise accounted for. For instance, in genera which contain species of different sizes the number of sepals and petals is often less in the smaller than in the larger ones.

Flowers with parts in fours are also frequently met with in orders where the pentamerous arrangement is the more common. Caryophyllaceæ is a good example. Taking our British genera, we find in the smaller flowered ones—such as *Cerastium*, *Stellaria*, and *Sagina*—the number of parts sometimes 4 instead of 5. Assuming, as we may, that all had a common pentamerous ancestor, we regard the tetramerous forms as resulting from the dropping out of one member from each whorl. In other cases, however, the tetramery is due, not to a loss, but to a fusion of parts. Thus most species of *Veronica* have 4 sepals and a 4-lobed corolla. There is no doubt, however, that the upper petal represents two which have become united. It is very often larger than the others, and sometimes its double origin is indicated by a notch. In some cases, moreover, both petals are developed, and we have a pentamerous corolla, bringing *Veronica* into line with the other members of its family, *Scrophularineæ*, where the corolla is formed on a pentamerous plan. The tetramerous calyx is explained by the loss of the uppermost sepal; in pentamerous species this, however, is developed. In one of our commonest British orders, *Cruciferae*, the flower is built on a 4-plan, but we

cannot correlate this with the leaf-arrangement or derive it in any simple way from a pentamerous flower—it is a remarkably constant type of flower, and the story of its development is lost. Last come such cases as the Lilac and Privet, where the leaves are in pairs, and opposite, so that the whorl would consist of four leaves.

FRUITS AND SEEDS

As regards fruits and seeds, one main point to be considered is the mode in which they are dispersed. From this point of view they may be divided into various classes:—

Seeds or fruits with wings, which are carried by wind.

Seeds or fruits with feathery appendages, carried by wind, and sometimes, as in Willow, floated by water.

Seeds in capsules which open at the top, the seeds being jerked out by wind.

Seeds or fruits with hooks, which are carried by animals.

Fruits which are eaten and the seeds thus carried by animals.

Seeds which are thrown by the plants.

To the first category, viz., those with wings, belong mainly trees: as, for instance, Pines and Firs, Sycamores and Maples, Elms and Birch; while though the fruit of the Lime is not itself winged it is attached to a leafy bract which serves the same purpose. The same is the case with the Hornbeam.

The next class, those with hairy appendages, is very extensive. To it belong the Willows and Tamarisks, many Grasses, Bulrushes, Cotton-grass, Willow-herbs, Dandelion, Thistles, and many other Composites, etc., etc.

Examples of plants in which the fruits or seeds are provided with hooks are found in Agrimony, Burparsley, Burdock, Carrot, Cleavers (*Galium*), Enchanter's

Nightshade (*Circæa*), some Forget-me-nots, etc. That these hooks really serve to attach the seeds to passing animals is shown by the interesting fact that they are characteristic of low plants. In our flora they do not occur on any plant which exceeds 2 or 3 feet in height, nor do they occur on water plants.

On the other hand, this argument does not apply to seeds which are eaten and thus carried by animals, especially by quadrupeds and birds. To this class belong all those popularly known as fruits and nuts, viz., Apple, Pear, Plum, Hazel, Beech, Oak, etc., etc.

It is interesting that while more or less green and inconspicuous when immature, in many cases as they become ripe they assume bright colours, especially orange, red, purple, and dark blue. It seems probable that it is an advantage for fruits which ripen when the leaves are still green to be red, as this gives the greatest contrast. On the other hand, red would not be conspicuous against faded leaves which are brown, or even sometimes themselves reddish. For such fruits, blue or black would be more advantageous, and, as a matter of fact, many heath and moor species have bluish or black fruit, as, for instance, the Bilberry, the allied *Vaccinium uliginosum*, or the Black Bearberry.

In some cases the juicy pulp only is assimilated, and the hard seeds pass through uninjured; but even digestible seeds often pass undigested; moreover, we know that small birds continually fall victims to hawks, etc., and perish from accidents, so that the cases are numerous where undigested seeds have a chance of growing.

The northern birds, as Mr. Reid points out,¹ generally come to us in autumn when the seeds are ripe, and must bring many southwards with them.

Many plants develop their seeds in capsules, which open at the upper end, so that while the seeds lie quiet while it is calm, they are jerked out by a high wind. This is the case, for instance, in Poppies, in

¹ *Origin of the British Flora.*

which the tiny seeds are jerked out through small holes round the upper edge of the capsule. In many *Campanulas* the capsule opens by pores at the base of the capsule, which, however, becomes inverted when mature.

One of the most interesting groups of seeds are those which are thrown by the plants themselves, as, for instance, in the *Geraniums*, *Oxalis*, some *Violets*, *Cardamines*, *Euphorbias*, etc. It is remarkable how much in these cases the mechanism differs.

Some seeds mimic small insects, and are no doubt picked up, and carried some distance before the mistake is discovered, by birds (see, for instance, the *Mallows*), or even by insects, as in the case of *Melampyrum*.

A large number of species have very minute seeds. These, of course, have a larger surface in proportion to their weight, and are readily carried by wind without any special provision for the purpose. Arctic and Alpine species very generally belong to this class.

Many seeds and fruits develop air cavities, which renders them lighter, and thus facilitates dispersal. This is specially the case in water plants, and the seeds are thus enabled to float.

In the great family of *Umbellifers*, as a rule, the "carpophore" splits lengthwise, and the two mericarps, each containing a seed, hang loosely by their upper ends to the two whip-like filaments. The dry plants are very elastic, and sway backwards and forwards in the wind, until at last some strong gust tears the mericarps off and carries them away.

Even when there is no special provision for dispersal, seeds must be often carried about on the feet of animals and the flanks of wallowing quadrupeds.

Another point to be considered with reference to seeds is the character of the surface. Some are smooth and shining, some reticulate, some pitted. Those with hooks or hairs have already been mentioned. Reticulations often, as, for instance, in *Geraniums*, fit into

TREES, SHRUBS, AND CLIMBING SHRUBS NATIVE OR
NATURALISED IN BRITAIN

	Seed or Fruit.			
	Edible.	Hairy.	Winged.	Hooked.
<i>Clematis Vitalba</i>		×		
<i>Berberis vulgaris</i>	×			
Lime (<i>Tilia europæa</i>)			×	
Maple (<i>Acer campestre</i>)			×	
Sycamore (<i>Acer Pseudo-platanus</i>)			×	
Spindle Tree (<i>Euonymus</i>)	×			
Buckthorn (<i>Rhamnus catharticus</i>)	×			
<i>Rhamnus Frangula</i>	×			
Sloe (<i>Prunus</i>)	×			
Rose (<i>Rosa</i>)	×			
Apple (<i>Pyrus Malus</i>)	×			
Pear (<i>Pyrus communis</i>)	×			
Hawthorn (<i>Cratægus</i>)	×			
Medlar (<i>Mespilus</i>)	×			
Ivy (<i>Hedera</i>)	×			
Cornel (<i>Cornus</i>)	×			
Elder (<i>Sambucus</i>)	×			
Guelder Rose (<i>Viburnum</i>)	×			
Honeysuckle (<i>Lonicera</i>)	×			
Arbutus (<i>Arbutus</i>)	×			
Holly (<i>Ilex</i>)	×			
Ash (<i>Fraxinus</i>)			×	
Privet (<i>Ligustrum</i>)	×			
Elm (<i>Ulmus</i>)			×	
Hop (<i>Humulus</i>)			×	
Alder (<i>Alnus</i>) ¹				
Birch (<i>Betula</i>)			×	
Hornbeam (<i>Carpinus</i>)			×	
Nut (<i>Corylus</i>)	×			
Beech (<i>Fagus</i>)	×			
Oak (<i>Quercus</i>)	×			
Willow (<i>Salix</i>)		×		
Poplar (<i>Populus</i>)		×		
Pine (<i>Pinus</i>)			×	
Fir (<i>Abies</i>)			×	
Yew (<i>Taxus</i>)	×			

¹ Some species of Alder have winged fruit.

depressions in the carpels. In other cases, perhaps, they serve to promote dispersal by diminishing the specific gravity of the seeds. It has been suggested that the smooth surface of many seeds is perhaps an advantage by enabling them to pass through the body of an animal without being digested. Another explanation may be that seeds which are thrown by the plant, or jerked by the wind, would no doubt go further if the surface was smooth, because it would offer less resistance to the air.

It may be convenient to say a few words as to the fruits of trees with reference to the dispersal of the seeds. Nature, as we have already seen, has devised several plans for the dispersal of fruits and seeds. For instance, some are edible, and are carried by animals; some are hairy or winged, and are carried by currents of air; some have hooks, and become entangled in fur and hair.

That these differences of structure are really adaptations comes out clearly if we take some definite group, such as our common forest trees, shrubs, and tall climbing plants; not, of course, a natural or botanical group, for they belong to a number of different orders, but a group characterised by attaining to a height of, say, over eight feet. We will in some cases only count genera; that is to say, we will count all the Willows, for instance, as one. These trees and shrubs are plants with which we are all familiar, and are about thirty-six in number. Now of these thirty-six no less than twenty-two have edible fruits or seeds, such as the Plum, Apple, Arbutus, Holly, Hazel, Beech, and Rose; three have seeds which are provided with feathery hairs; and all the rest, namely, the Lime, Maple, Ash, Sycamore, Elm, Hop, Birch, Hornbeam, Pine, and Fir, are provided with a wing. Moreover, as will be seen by the following table, the lower trees and shrubs, such as Cornel, Guelder Rose, Rose, Thorn, Privet, Elder, Yew, and Holly, have generally edible fruits, much eaten by birds. The winged seeds or fruits characterise the great forest trees.

In considering the importance of these provisions we have not only to bear in mind the desirability of the seeds being scattered beyond the shadow of the parent plants, and the soil which has been more or less exhausted by them, but must also remember the vicissitudes of climate through which our islands have passed. Before the glacial period our flora seems to have been, on the whole, very much what it is now. During the glacial period our plants were driven south, a few of the Arctic and Alpine species only remaining in the extreme south and west. During this period there seems to have been certainly one, and possibly several comparatively mild periods, so that the whole, or nearly the whole, of our plants have been compelled at least twice, probably several times, to migrate long distances.¹ Perhaps for this reason our flora is highly specialised for dispersal, or rather the species best organised in this respect are those which have been able to re-establish themselves here.

The methods of packing the embryo in the seed-coat, the germination of the seed, and the characters of the seedling afford interesting subjects for study. Some account of these will be found in my books on *Seedlings*.

LEAVES

The leaf originates as a slight protuberance of the bud. Fig. 6 represents a longitudinal section through the growing point of a winter bud of *Abies pectinata* (Silver Fir), and shows the commencement of two leaves (*b, b*). It also illustrates the cellular structure of young tissue.

The nourishment absorbed by the roots from the soil passes as crude sap into the leaves and is there elaborated. Carbonic acid gas is absorbed from the air by means of the stomata,—minute slit-like apertures between two epidermal cells which guard the entrance (guard-cells), and, by contraction, close it at night and in dull weather. The stomata allow communication

¹ Reid, *Origin of the British Flora*.

between the outside air and the intercellular spaces in the leaf-tissue, which are specially developed on the lower face of the leaf (see Fig. 11 below). Through the stomata also escapes the surplus water in which the nitrogenous and other mineral food has been carried up from the roots to the leaves. Some of the water is required for nutrition and as cell-sap to maintain the turgescence of the tissues, but a large proportion serves only as a carrier, and is ultimately given off, or transpired, through the stomata. They are very numerous.

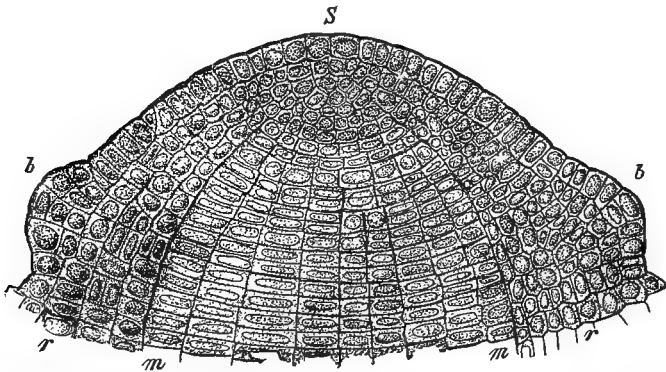


FIG. 6.—Longitudinal section through the growing point of a winter bud of *Abies pectinata*. \times about 200. *S*, apex of growing point; *b*, *b*, youngest leaves; *r*, cortex; *m*, pith.

It is estimated, for instance, that on such a leaf as that of the Oak there are not less than 2,000,000. The carbon is assimilated and the oxygen released, at least in part. It is remarkable that plants do not take up carbonic acid from the soil. It might have been expected that the roots, ramifying as they do in earth more or less saturated with water containing carbonic acid in solution, would absorb what is so important an element in their food. This function is, however, mainly performed by the leaves, and especially under the influence of daylight. It is carried on by protoplasm containing "chlorophyll granules." These are roundish green corpuscles, which give their peculiar

colour to leaves. On them depends the life of plants, and ultimately, therefore, of land animals also.

Every one knows that plants grown in the dark are unable to produce chlorophyll. But though light is necessary for its production, and though the leaves of our plants are, as a rule, arranged so as to secure the greatest amount of light, still it becomes injurious if too intense.

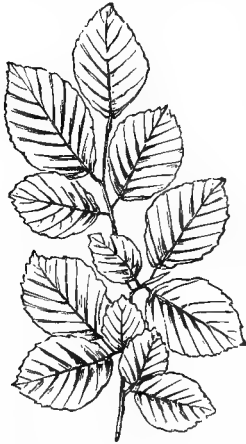


FIG. 7.—Twig of Beech.

In our own country leaves are generally arranged so as to secure the maximum of light and air, as, for instance, those of the Beech (Fig. 7), the Spanish Chestnut (Fig. 8), and the Maple (Fig. 9). We have, however, some shade-loving species, and in hotter regions the tendency becomes greater to avoid the too brilliant sunshine. As familiar examples may be mentioned the leaves of the Black Poplar (Fig. 10) and Eucalyptus, which are vertical, and those of several



FIG. 8.—Twig of Chestnut
(*Castanea*).

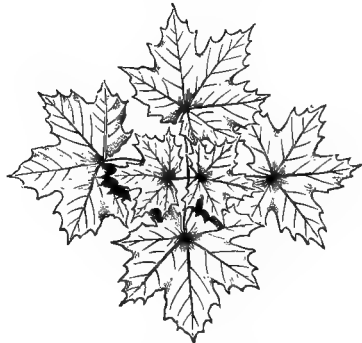


FIG. 9.—Twig of Norway Maple.

New Zealand Veronicas, which are placed in four rows, one under the other. The summer shoots sometimes produced on our forest trees are often pale, the bright

light having checked the formation of chlorophyll. Young shoots, especially, require protection from the action of light, which would otherwise check the formation of chlorophyll. This is afforded in several ways, of which the principal are—by the thick and often glossy epidermis; by the position of the leaf; by the structure of the leaf; by the arrangement of the chlorophyll granules; by change in their form; by hairs, which often fall off when the leaf is fully developed; by stipules—either those of the same leaf, as in the Hop (*Humulus*), or of an older leaf, as in the Pea. The latter safeguards are useful also in other ways; for instance, as a protection against cold, against insects, etc.

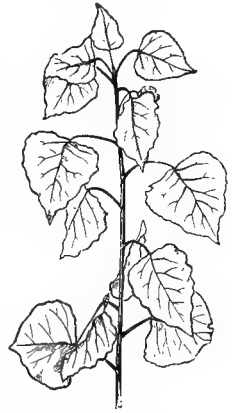


FIG. 10.—Shoot of Black Poplar (*Populus nigra*).

Again, the presence of red colour is very common in young shoots, when it perhaps serves to protect the chlorophyll in the delicate tissues from too much light; and this seems to have been taken advantage of and developed in the corolla and other parts of the flower, as an attraction to insects.

In ordinary parlance, when we speak of a leaf we think only of the leaf blade. The leaf blade is only one part of the leaf, which, if complete, may be regarded as consisting of four parts—the blade, the stalk, the stipules, and the base. One or more of these parts, however, may be wanting. In some cases, for instance, the leaf is sessile; in others the blade is absent.

Stipules are the two small leaflets which often occur just above the base of the leaf, as, for instance, in the Violet, Pea, Rose, etc. Linnæus gave them the name from *stipula*, a little straw. This term happily expresses their appearance in the case of the Beech. In this species they drop early, and in spring make the ground under Beeches almost brown. In this case,

as in many others, they serve to protect the young leaves. Every one who loves a garden knows to his cost how delicate young leaves are; how susceptible to cold, so that often—too often—the bright promise of spring is ruined by a single cold night. Moreover, young leaves require protection not merely from cold but from too great heat, from dryness, moisture, and light, as well as against the attacks of animals.

The principal modes by which they are protected are :—

1. By the preceding leaves, as in *Hypericum*.
2. By the base of the preceding leaf, which persists through the winter, as in *Spartium*, sometimes forming a cup, covering the bud as in *Philadelphus*, the Mock Orange or Syringa of gardens.
3. By scales which represent modified outer leaves, as in *Willows*.
4. By scales which represent leaf-stalks, as in *Maples* and *Ash*.
5. By scales which represent stipules, as in *Beech* and *Oak*. If an *Oak* bud be carefully opened, more than forty scales will be counted before coming to a true leaf.
6. By the two connate stipules of a leaf, as in *Elm* and *Spanish Chestnut*.
7. By two connate stipules belonging to different leaves, as in the *Hop*.
8. By spines.
9. By furry hair.
10. By gum, resin, or mucus.

Leaves may be arranged in various classes: evergreen or deciduous, broad or narrow, opposite or alternate, entire or divided, hairy or smooth, etc. etc.

Deciduous plants keep their leaves on longer as the summers lengthen. The *Cherry* (*Prunus Cerasus*) keeps its leaves longer in Southern Europe, and in Ceylon is evergreen.

Broad leaves are generally horizontal, narrow leaves more or less upright. Thus many trees and herbs, such

as the Daisy, have broad horizontal leaves; while grasses have more or less upright and narrow ones. The Plantain and *Drosera* give good illustrations. *Plantago media* and *Drosera rotundifolia* have broad flat leaves; while in *Plantago lanceolata* and *Drosera anglica* they are narrow and upright.

Hairs on plants fulfil numerous functions: they prevent undue transpiration, hence the hairiness of so many species of hot dry countries, as the Riviera; they also protect the plant from too brilliant sunshine; again, they keep moisture from clogging the stomata, or breathing pores, and are thus useful in cold foggy districts, as, for instance, our northern heaths and moors. Such hairs are dry and contain air; but another sort are juicy and conduct or even themselves absorb moisture, as, for instance, is said to be the case with those on the Chickweed. In some cases hairs protect plants from being eaten by browsing quadrupeds, and in many they prevent ants and other creeping insects from obtaining access to the flowers and robbing them of their honey. Hairs intended to perform this function are often rendered more effective by pointing downwards.

Water plants and those living in damp localities have no need of hairs and are glabrous. Some species, such as *Silene inflata* and *Polygonum amphibium*, are glabrous in damp, and hairy in dry places. Their leaves are also much cut up, often into long linear segments.

I have suggested¹ that the object of this is to expose as large a surface as possible to the action of the water. We know that the gills of fish consist of a number of thin plates, which while in water float apart, but have not sufficient consistence to support even their own weight, much less any external force, and consequently collapse in air. The same thing happens with these thin, finely-cut leaves. In still water they afford the greatest possible extent of surface with the least expenditure of effort in the formation of skeleton. This is, I believe, the explanation of the prevalence of this form in sub-

¹ *Flowers, Fruits, and Leaves.*

aqueous leaves. Again, in still air the conditions, except so far as they are modified by the weight, would approximate to those of water, but the more the plant is exposed to wind the more would it require strengthening. Hence perhaps the fact that herbs, which, of course, are less exposed to wind, so much oftener have finely-cut leaves than is the case with trees. We may instance those of many Geraniums, Umbellifers, Delphiniums, Buttercups.

There are, moreover, many groups of plants which, while habitually herbaceous, contain some shrubby species, or *vice versa*. Let us take some groups of this description in which the herbaceous species have their leaves much cut up, and see what is the character of the foliage in the shrubby species. The vast majority of Umbellifers are herbaceous, and with leaves much divided, the common carrot being a typical example. One European species, however, *Bupleurum fruticosum*, is a shrub attaining a height of more than 6 feet, and has the leaves coriaceous and entire.

Common Groundsel (*Senecio vulgaris*) again is a low herb with much cut leaves. Some species of *Senecio*, however, are shrubby, and their leaves assume a totally different character, *Senecio laurifolius* and *S. populifolius* having, as their specific names denote, leaves respectively resembling the Laurel and Poplar. In the genus *Oxalis*, again, there is a shrubby species, *O. Laureola*, with leaves like those of a Laurel.

One common type of leaf is that of which the Laurel may be taken as an example. Such leaves are more or less oval, somewhat tough, caducous or evergreen, and with the stomata, as a rule, on the lower surface. They are adapted to resist wind, and are characteristic of trees and shrubs. To this type belong, besides those of Laurel, the Laurustinus, the Way-faring tree, Evergreen Oak, Holly, Beech, Hornbeam, Elm, Pear, etc.

In others the leaves are larger, but, perhaps as a protection from the wind, are pinnate, with more or

less oval leaflets, as in Ash, Mountain Ash, Robinia (*Acacia* of gardeners), etc.

Palmate leaves form another type: as, for instance, those of Sycamore, Maple, Plane, Guelder Rose.

Jungner regards the palmate form also as an adaptation to resist wind. He observes that species with palmate leaves are particularly abundant in windy countries and districts. The elastic stalks enable them to arrange themselves so as it were to turn their back to, and fly like flags in, the wind.

As we have seen, the leaves of aquatic plants are in many cases divided into filiform segments, thus exposing a large surface to the action of the water. On the other hand, floating leaves have a tendency to be circular. Some plants have both these forms of leaf,—rounded ones on the surface; others finely divided, below. This is the case, for instance, with some species of *Ranunculus*.

Leaves growing in damp and shady places—shade leaves as they may be called—are large, flat, smooth, and delicate. Those of Petasites, *Lactuca Scariola*, Dentaria, Orobis, Paris, Lunaria, *Mercurialis perennis* (Dog's Mercury), Impatiens (Balsam), etc., belong to this type. In dry, arid regions, such as the Riviera, they would not survive a day.

Another type of leaf may be called ericoid, as the Heaths afford typical and familiar examples. That of *Empetrum* (Fig. 11) is a striking example. They are evergreen, rolled at the edges, leathery, small, and crowded. They suit cold and damp, and hot and dry localities. To the former they are adapted, as they present a smaller surface to the cold air, and especially because, as the stomata open into the space which is more or less completely enclosed by the rolled edges, and are, moreover, also as a rule protected by hairs, they are not liable to be clogged by moisture, but are in a position to fulfil their important function as soon as the sun comes out, and even to some extent during rain. But though it is important that the power of evaporation should be protected, it is, on the other

hand, equally necessary that it should not be too rapid, for in severe weather the frost often checks the supply of water by the roots, even though they go to a considerable depth.

The same safeguards against too rapid evaporation render them suitable to hot dry regions. The leatheriness of the leaves is also, no doubt, a protection against browsing quadrupeds, as also are the aromatic properties of many such species. Besides the Heaths, *Azalea*, *Empetrum* (Fig. 11), *Silene acaulis*, and some Saxifrages belong to this type.

Another northern type is that represented by

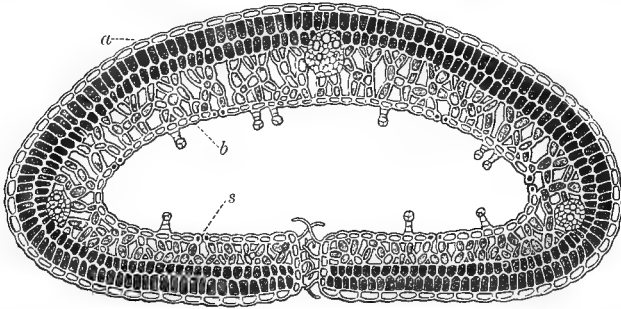


FIG. 11.—Transverse section of leaf of *Empetrum*. *a*, upper face; *b*, under face; *s*, stoma, shown closed by the approximation of the guard-cells.

Cerastium alpinum. The tapering form carries off the moisture, which, moreover, is kept from the stomata by matted woolly hairs. The result is that as soon as the sun comes out transpiration becomes possible. On the other hand, they are less suitable where there is much snow.

Other leaves of the same type are *Salix lanata* and *S. repens* (two of the Arctic Willows), *Gnaphalium supinum* (Arctic or Dwarf Cudweed), *Bartsia alpina*, the Mountain Forget-me-not (*Myosotis silvatica*), *Cotoneaster vulgaris*, and *Hieracium Pilosella*, one of our commonest Hawkweeds.

Another type may be called "snow leaves." Of this group *Viola palustris* is an example. The leaves seem

specially adapted to localities often covered by snow. The stalk enables the leaf to orient itself so as to secure as much sunshine as possible; the crenellations, which, in other plants with the same habit and similar leaves, are often replaced by teeth, probably retain air between them and thus tend to mitigate the temperature. Jungner has shown the probability of this by experiments on *Veronica officinalis*. The more or less circular form is perhaps an advantage from this point of view, as the result is that the teeth or crenellations are nearer together than they would be if the leaf were more elongated. In snowy regions the absence of hair is an advantage.

To the same type belong one of our Arctic Willows (*Salix herbacea*), Arctic Birch (*Betula nana*), Bearberry (*Arctostaphylos alpina*), Whortleberry (*Vaccinium Vitis-Idæa*), Chrysosplenium, some Saxifrages, and, somewhat modified, the Cloudberry (*Rubus Chamaemorus*), and Lady's Mantle (*Alchemilla vulgaris*).

Some species have the radical leaves of this type, while those on the stem are narrow and elongated: as, for instance, the Harebell (*Campanula rotundifolia*), some Composites, and Alpine Penny-cress (*Thlaspi alpestre*).

Thick and fleshy leaves constitute another type. This form reduces the transpiring surface, and affords space for the storage of liquid. Such leaves, therefore, are specially adapted for dry places. When it rains the roots suck up a supply of moisture, which the leaves only part with slowly. They are characteristic, for instance, of the order Crassulaceæ. Thus *Sedum anglicum* lives on dry sandy soil, walls, etc.; other examples occur in *S. dasyphyllum*, *S. album*, *S. villosum*, *S. acre* (Stonecrop), *S. sexangulare*, and *S. rupestre*; also in *Cotyledon Umbilicus*, *Sempervivum tectorum* (Houseleek), and in other families, *Inula crithmoides* and *Crithmum maritimum*, which grow on hot sandy shores, and many foreign species—the Mesembryanthemums and some of the Cacti, for instance.

Many leaves "sleep" at night, that is to say, they assume a position different from that taken in the day. This is, however, a different phenomenon from the sleep

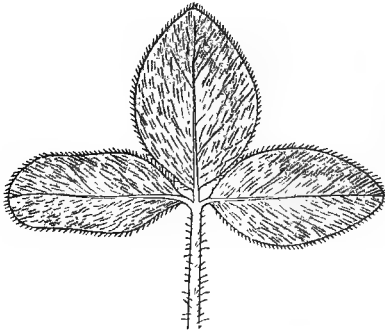


FIG. 12.—Leaf of Clover (*Trifolium repens*).
Position by day.

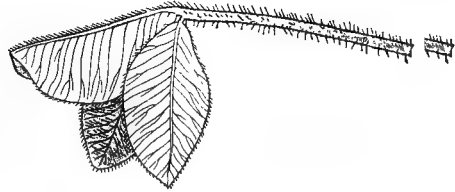


FIG. 13.—Position by night.

of flowers, and due to quite a different cause. As a rule they turn either up or down, thus assuming a more or less vertical position. This serves as a protection against cold, the result being that they expose less surface to the sky. The Acacia (Robinia), Oxalis, Trifolium (Clover), (Figs. 12 and 13) are cases in point.

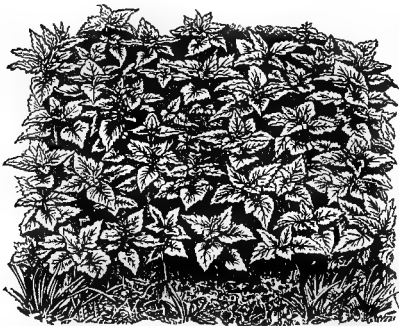


FIG. 14.—Group of Stinging-nettles on the right, and Dead-nettles on the left.

Against the attacks of animals leaves are protected in various ways: by a leathery texture, by spines, by felted hair, by bitter or aromatic sap, etc. Some plants, which are comparatively unprotected, mimic others which are more fortunate. Thus the leaves and general habit of the Dead-nettle closely resemble those of the Stinging-nettle. Fig. 14 represents a group, those on the right being Stinging-nettles, those on the left the white Dead-

nettle, one of them in flower. So close is the resemblance that after getting the photograph I went back to the spot on which they were growing to assure myself that there was no mistake.

There is a remarkable point about some of our forest trees and shrubs, which Vaucher¹ seems to have been the first to notice, namely, that the

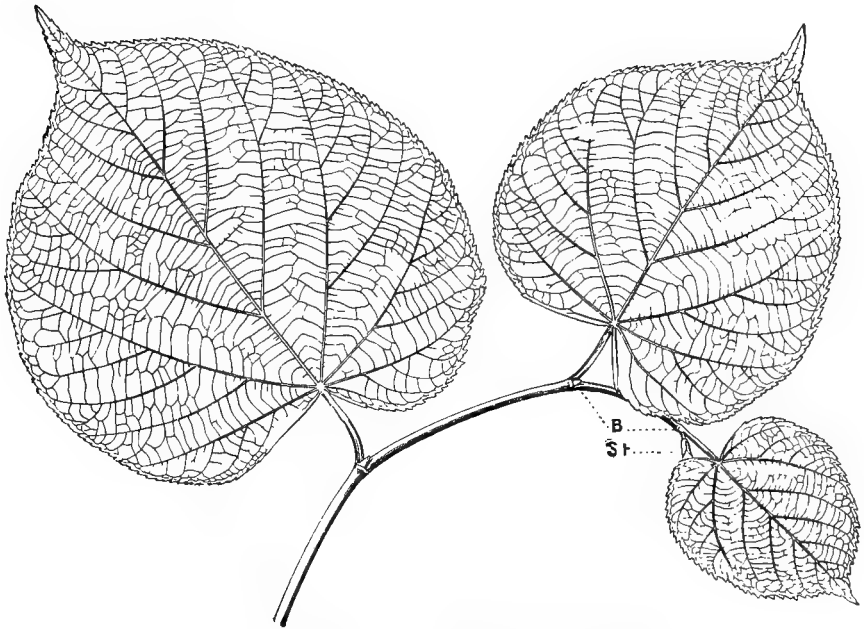


FIG. 15.—Twig of Lime. *St*, terminal bud ; *B*, lateral buds.

terminal buds die, and that very early. Fig. 15 represents a twig of Lime drawn at the end of May ; the terminal bud and stipules (*st*) are very small, and easily drop off. If a branch be examined a little later, it will be found to be terminated by a scar, left by the true terminal bud, which has dropped away, so that the one which is apparently terminal is really axillary. Fig. 16 represents the end of a shoot of Hornbeam (*Carpinus Betulus*) taken in July, and shows how

¹ *Mém. Soc. de Phys. et d'Hist. Nat. Genève*, i. 296 (1822).

snugly the bud nestles between the stump of the terminal shoot and the petiole of the leaf. The same thing occurs in the Elm, Birch, Hazel, Lilac, Willow, and others. In these and many other species the bud situated apparently at the end of the branchlets is in reality axillary, as is shown by the presence of a terminal scar,

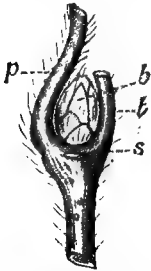


FIG. 16.—Young shoot of Hornbeam. $\times 2$. *p*, base of petiole, the upper part having been cut off; *b*, bud; *t*, terminal shoot, the upper part of which has already dropped off; *s*, scar of stipule.

due to the fall of the true terminal bud. I have found that even at the end of May the terminal buds of the Lime have almost all died and fallen away.

But why do the terminal buds wither away? In some cases the bud contains a definite number of leaves, but in the genera above mentioned the number is indefinite—more than can come to maturity; and yet the rudiments, which are constructed to produce true leaves, cannot modify themselves into bud scales. Thus in

the Ash, Maple, Horse-chestnut, and Oak, which have true terminal buds, there are comparatively few leaves; while in the Elm there are about seven; Hornbeam, eight; Lime, eight; Willow, fifteen; and Lilac, fifteen. In the above species it is generally the uppermost lateral bud or buds which develop, but in some cases, as in *Viburnum Opulus* (Guelder Rose), *Gymnocladus*, and others, these also perish, and as a rule only the lower ones grow, and the upper part of the stem dies back.

The fall of the leaf in autumn is by no means a simple process, or a mere case of death. In the first place, the chlorophyll substance is too valuable to be lost and thrown away. Sachs has satisfied himself that it passes out of the leaf, down the petiole, and thus migrates into the persistent parts of the plant, and is stored up for future use. With the general disappearance of the cell contents, the protoplasm and cell nuclei are dissolved, the chlorophyll corpuscles lose

their normal outlines, the starch disappears, and the colouring matter changes, leaving in many cases a large number of small bright yellow granules, to which the yellow tints of autumn are due. In many cases the cell sap becomes bright red. Sachs has been able by chemical examination to follow the materials (and especially the starch), and also the most valuable chemical materials (especially the potash and phosphoric acid), down the petioles, into the twigs, where

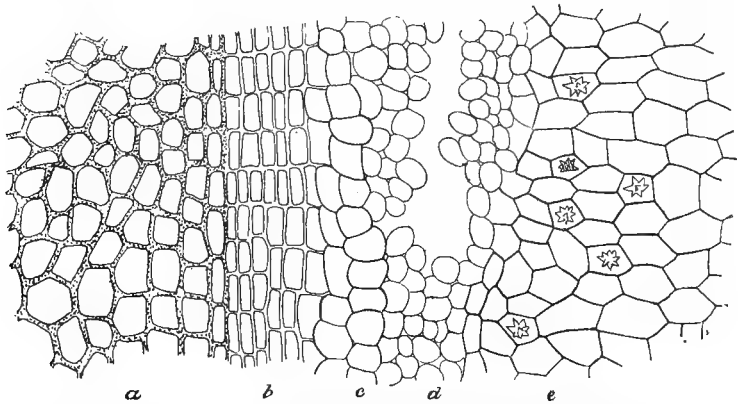


FIG. 17.—Longitudinal section through the junction of stem and leaf of Horse Chestnut in autumn. *a*, parenchyma forming the outer cortex of the twig; *b*, external cork layer of the same; *c* and *e*, parenchymatous tissue at the base of the leaf-stalk; *d*, separating layer, the continuity of which is already broken in the upper part.

they are preserved, evidently to nourish the growing buds of the following spring. While these changes are taking place a new layer of cells is formed across the base of the petiole (Fig. 17, *d*). These cells gradually adhere less and less closely together, so that at last the slightest touch or the gentlest wind brings the leaf to the ground. That this is not a mere case of death of the leaf, but, on the contrary, is a vital process, we may easily convince ourselves by breaking a branch during summer. In that case it is killed, the new layer of cells is not formed, and the leaves remain firmly attached to the twig.¹

¹ Avebury (Lubbock), *Buds and Stipules*.

The first leaves or "cotyledons" generally differ very much from the leaves which follow. Klebs—writing as lately as 1884—refers to these differences, and expressly says that they are "an enigma."

I have suggested¹ as an explanation that the cotyledon develops in the seed, and the leaf in the bud, and that the conditions of the two are very different.



FIG. 18.—*Glaucium corniculatum*. Seedling. (Nat. size.) c, cotyledon; 1-7, successive leaves.

the differences under the Lime, Oak.

In the same work I have in a variety of cases endeavoured to indicate the reasons for the various forms assumed. Fig. 18, which represents the seedling of the Horned Poppy, may be taken as a typical case showing the gradual passage from the simple filiform cotyledon to the fully developed leaves. In other cases the cotyledons themselves are more complex. Examples are mentioned, and reasons suggested for the Violet, Radish, Geranium,

THE STEM

There are two ways in which a prostrate, stemless plant may raise itself into the light and air. One would be by bending itself round so as to form a tube (Fig. 19). We can imitate this by a sheet of paper, which is much less pliable and more rigid if rolled up. In such cases the opposite edges will often unite, or, in botanical language, will become adnate, at any rate below, often remaining free above. Of such a growth an ordinary

¹ Avebury (Lubbock), *A Contribution to our Knowledge of Seedlings*.

Grass (Fig. 20) may be taken as a familiar instance, the axis being supported and enclosed by the rolled leaf sheaths. These plants form the great division of Monocotyledons or Endogens.

In a second series of plants the necessary stiffness is given (Fig. 21) by the thickening and hardening of the midrib. In this case the axis is not enclosed, as in the former, by the rolled-up frond, and the stem, not

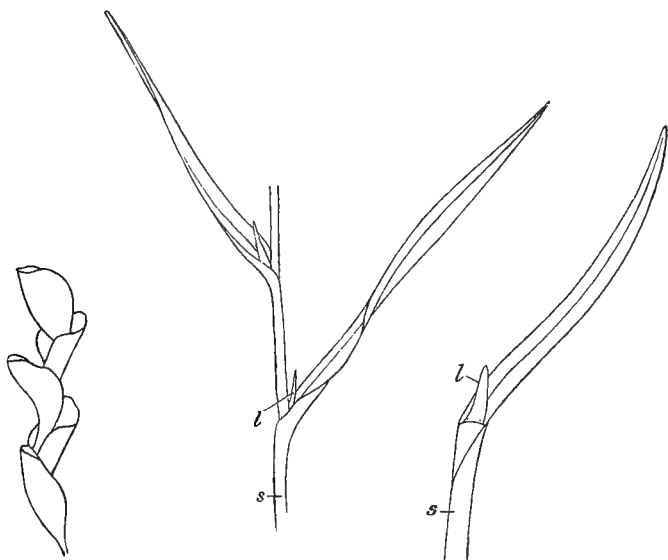


FIG. 19.—Frond, strengthened by rolling.

FIG. 20.—Portion of a grass stem; successive internodes are surrounded by the leaf-sheaths (*s*); *l*, ligule.

being surrounded by the leaves, is able to enlarge and expand by successive additions. Fig. 22 represents diagrammatically part of the stem of such a plant as a Thistle, and it is obvious that the midrib of the leaf is an included part of the stem. Hence arises the characteristic secondary growth of the exogenous stem.

In the first series it is obvious that the leaves are necessarily successive. Consequently the plant is monocotyledonous. On the contrary, in the second, two leaves may, and in seedlings generally do, grow simultaneously,

and hence they are termed dicotyledonous. Herbert Spencer ingeniously suggested that this explains the general connection between monocotyledonous germination and so-called endogenous growth in the stem, on the one hand; dicotyledonous germination and exogenous growth, on the other. The fact that it throws light on these fundamental relations adds very greatly to the probability of the hypothesis, which, however, cannot yet be said to be generally accepted.¹



FIG. 21.—Frond strengthened by midrib.

Considering the sizes of trees, their height and weight, it is really wonderful how they are able to support themselves and resist the force of the wind. The roots fix them firmly in the ground, and the framework of the stem is so constructed as to give immense strength. The hard "bast" cells, from which woody fibres differ but little, are said to have in some trees a bearing capacity equal even to that of steel. Besides the woody fibres, the stem of a tree contains bark, cork, soft tissue or parenchyma, vascular and other bundles, pith, etc. These are by no means arranged at random. The forces acting on and bending the stem of a forest tree tend to extend the tissues on the convex, and compress them on the concave side. In the centre they vanish. The strengthening material must obviously be applied where the force to be resisted is greatest, *i.e.* near the bark. The arrangement may be compared to that by which a girder is strengthened at the side with flanges. In other species there is another or there may be several series of woody bundles, each with a group of vascular cells, always lying on the inner, or central, side.



FIG. 22.

¹ See Herbert Spencer, *Principles of Biology*, vol. ii.

In most cases the stems of plants are round, but in others they are triangular, quadrangular, pentagonal, elliptical, or of other forms. The bare fact is stated in many books of botany, but I have not come across any in which an explanation is given, or even attempted. Yet it will, I suppose, be generally admitted that there must be a reason for all these differences.

If an engineer is constructing a bridge, or an architect is building a house, he must consider how to make it safe, and secondly, how to economise the material as much as possible. The strongest form which can be given to a solid body, in the formation of which a given quantity of material is to be used, and to which the strain is to be applied under given circumstances, is that form which renders it equally liable to rupture at every point. So that when, by increasing the strain to its utmost limit, the solid is nearly breaking at any one point, it may be nearly breaking at every other part. If there are any parts which are not nearly at the eve of rupture it is obvious that from such points some of the material might be removed without increasing the danger of rupture.

If the stem of a plant is acted on by wind, one side will be extended, the opposite compressed, while between them there will be a neutral surface; and both extension and compression will be greatest along the surface furthest from the neutral axis. It follows, therefore, that the material cannot be in the state bordering on rupture at every point of a section at the same time, unless all the material of the compressed side be collected at the same distance from the neutral axis, and likewise all the material of the extended side, *i.e.* unless, in the words of Professor Moseley,¹ "the material of the extended side and the material of the compressed side respectively be collected into two geometrical lines parallel to the neutral axis." The two bars are in practice connected by a cross rod, or web as it is techni-

¹ See Moseley, *Engineering and Architecture*.

cally called. This need not be so strong as the flanges. It has not the same force to resist, and may be a lattice or open work.

The applications of these principles in architecture has led to the well-known "girder" (see Fig. 23), in

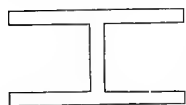


FIG. 23.—Single girder.

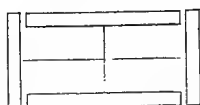


FIG. 24.—Double girder.

which the material is collected in two more or less thin flanges united by a narrow rib. In some substances—in cast iron, for instance—as Mr. Hodgkinson has

shown,¹ the resistance to compression is much greater than the resistance to extension, and in the strongest girder, therefore, the greater flange may be on the extended side. If the forces to be resisted act in two directions at right angles to one another, two girders must be combined, as in Fig. 24. If the forces come in all directions, a series of girders would be required (Fig. 25). This is the case in the stems of trees (see Fig. 26).

Now in the stems of plants the strength is given by tissues known as hard bast, libriform cells, or sclerenchyma, which are collectively termed, in ordinary language, woody fibres. The hard bast of some plants equals steel in its power of resistance. Hence its use for string, ropes, etc. The "web" consists of vascular bundles and parenchymatous cells. Here strength is not required. In some cases—for instance, in many Grasses—the centre is hollow. If the mechanical or woody tissue formed a pillar in the centre of the stem, there would evidently be a great waste of strength (see Fig. 25).

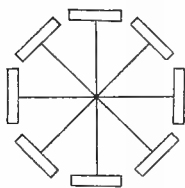


FIG. 25.—Multiple girder.

An erect stem which is liable to wind pressure, sometimes from one side and sometimes from another, must be strengthened in all directions. Hence a series of

¹ *Mem. Manchester Phil. Soc.* vol. iv.

woody bundles arranged round the stem are required, and as a matter of fact we find a series of groups of woody fibres ranged round the stem (Fig. 26). In low-growing herbs they may be widely separated by soft cellular tissue; and the more force the plant has to resist the more they are developed, and the greater proportional space they occupy. In the young shoot they are some distance apart, but gradually approximate (Fig. 27) until at length they are only separated by what are known as the medullary rays.

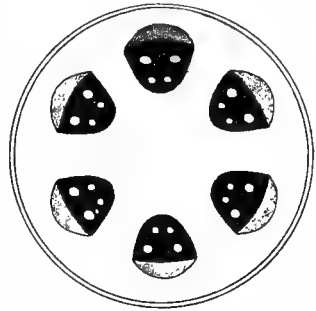


FIG. 26.—Diagram of section of a one-year-old shoot of Lime, showing woody bundles separated by broad bands of soft (parenchymatous) tissue. Mechanical tissue grey; vascular bundles black with white spots.

In dicotyledonous trees a layer of wood is, as we know, laid on, as it were, each year, so that the age of the tree may be estimated by the rings, and the whole form wedge-shaped masses of wood, separated by narrow medullary rays. Being thus arranged at equal distances round the central neutral axis, the stem naturally assumes the prevalent round form. Whatever the size of the plant, whether it is a small herb, or a giant of the forest, the same rule applies.

So far as the structure of round monocotyledonous stems is concerned, the subject is dealt with by Schwendener in a masterly memoir, *Das mechanische Princip in anatomisch Bau der Monocotylen*.

This being so, the question arises, Why do any stems assume other forms? ¹ Let us take first the plants in which it is quadrangular. In a species where the leaves are arranged round the stalk, like the spokes of a wheel, the resistance required is equal all round (see Fig. 25). On the other hand, if the leaves are “decussate” or opposite, each pair being at right angles, this above and that below, then the strain of the wind acts

¹ Avebury, *Rep. Brit. Assoc. Cambridge (1905)*.

mainly in two directions at right angles to one another, and the stem would require additional strength in two directions—in fact, the double girder (Fig. 24). This being so, for plants with opposite decussate leaves

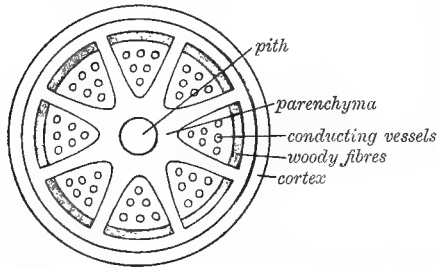


FIG. 27.—Diagram of young dicotyledonous stem, showing approximation of the distinct bundles.

quadrangular stems would be most suitable. Three exceptions, however, at least must be made. In trailing and water plants strength is less required. The first are supported by the ground, and little exposed to the wind. The second are supported by the water in which they live.

As regards trees, the twigs grow in all directions, and the tree therefore, as a whole, has to meet strains in all directions. From this point of view it is interesting that there are some cases of shrubby plants—such as the Box—where the young shoots are quadrangular, but gradually become round. We should expect, therefore, to find quadrangular stems mainly in erect herbaceous plants with opposite leaves. Now let us see how far the facts bear this out. Do quadrangular stems and opposite leaves go together? As a matter of fact all our English flowering plants with square stems have opposite leaves. It is not so invariably the case that plants with opposite leaves have square stems, but for herbaceous plants it is the rule, and the exceptions are susceptible of explanation. Since, then, we find no cases of quadrangular stems without opposite leaves, and that most species which have opposite leaves have quadrangular stems, it is a fair inference that the form of the stem is connected with the arrangement of the leaves. The pentagonal form of the Bramble stem has been already referred to (p. 13).

We now come to the question of triangular stems. They occur principally among Monocotyledons. While among Dicotyledons the number of parts which go to make up a whorl is generally four or five, in Monocotyledons the number is frequently three (Fig. 28). Moreover, the base of the leaf usually encircles or sheathes the stem or base of the next leaf. No doubt, as we have already seen, there is in this arrangement some loss of strength. This is not, however, of supreme importance as the plants in question, being comparatively small, grow in sheltered situations and in close association, so that each is protected by the rest.



FIG. 28.—Arrangement of leaves of *Carex*.

The triangular form prevails among the Rushes, Bulrushes, Sedges, etc. It is not, however, universal in Monocotyledons. Grasses, as we all know, have round stems. In fact, Sedges may generally be known from Grasses in this way. Sedges have triangular stems, Grasses have round stems. While the leaves of Sedges and the parts of the flower are in threes, those of Grasses are often in twos and the leaves are “distichous,” *i.e.* in two rows or ranks (Figs. 28 and 20). It is remarkable, however, that one Grass—a Chinese species of Bamboo—has a quadrangular stem. It is so remarkable that it long ago attracted the attention of the Chinese, who attribute the origin to the fact that one of their holy men had a squared walking-stick made of this Bamboo. He stuck it into the ground, and, in consequence of his sacred character, it at once grew, retaining, out of respect to him, its square form.

The flinty stems of Grasses help to increase their rigidity, and are probably also a protection against snails and other animals.

The stem of trees, as a rule, is thickest at the base, where it requires to be firmly anchored in the ground, then diminishes for a few feet, gradually reaching a

minimum, and soon increasing again and attaining a maximum, after which it tapers to the summit. This conforms to the ideal proportions of a pillar of uniform resistance.

These considerations, then, seem to throw, at any rate, some light on the different forms assumed by the stems of plants. They may seem obvious, but excepting, indeed, as regards the round and compressed forms, I do not find them stated in botanical works, and, indeed, I was myself for a time in some doubt on the subject. Thus, then, we see that plants adopted for themselves, thousands and indeed millions of years ago, principles of construction, adapted to secure the greatest strength with the least expenditure of materials, which have been gradually worked out and applied to our buildings by the skill and science of our architects and engineers.

THE SENSE ORGANS OF PLANTS

We all remember the old aphorism of Linnæus: "Stones grow; plants grow and live; animals grow, live, and feel." Plants, however, feel, though there is no reason to suppose that they can enjoy or suffer. The movements of plants, especially the "sleep" of flowers and leaves, which have been already referred to, and the circumnutation of climbing plants—all such movements imply sensitiveness.

It may seem at first sight somewhat far-fetched to speak of the sensitive organs of plants. We cannot, of course, attribute consciousness to them, but the mechanism which originates and produces movement presents remarkable analogies and similarities in the two kingdoms. As in animals so also in plants, we find papillæ or processes which localise, and thus enhance, the pressure on limited portions of the protoplasm. Any one who has ever suffered from the elevation of a papilla, or a few papillæ, on the skin, will realise the effect produced by confining the pressure, which is generally spread over a comparatively large surface, to a limited area. Again, the transmission of impressions

by hairs or bristles exists, though it is not so general, in the vegetable as in the animal kingdom.

Haberlandt has written several interesting memoirs on what he calls the Sense Organs of Plants.¹ Some plants have papillæ, which, projecting above the general surface, localise and thus intensify the effect of any pressure. In other cases there are special stiff bristles supported by a cellular base, at the side of which is a sensitive tissue, which is, of course, compressed if the bristle is pressed against it, even only slightly. In fact, the concentration of impression is the main principle of these organs. The feeler bristles of *Aldrovanda* were described by Cohn more than thirty years ago.

Sensitive organs are as yet known in a minority of plants only; perhaps because the majority have no need for any such special arrangements. It is not, however, too much to say that the potential power is there, ready to spring into action if the need arises. The sensitiveness of plants is indeed in some cases astonishing.

Darwin² showed that the tentacles of *Drosera* were, affected by a tiny bit of woman's hair $\frac{8}{1000}$ of an inch in length, and weighing $\frac{1}{78705}$ of a grain!—a weight quite imperceptible to our nerves.

The tendrils of climbing plants are amongst the most sensitive organs in the vegetable kingdom. They will react to a piece of cotton-wool or silk weighing only $\cdot0002$ of a milligram, while the most sensitive part of our skin would perceive nothing until the weight reached $\cdot002$ of a milligram. The sensitiveness of the tendril is therefore much greater than ours.

Many of the lower Algæ have a red eye spot. It is probable that the red substance is not the actual perceptive element, but that this property rests rather in the associated colourless plasma, and that the red

¹ His last memoir is "Die Sinnesorgane der Pflanzen," *Ges. Deut. Naturforscher und Arzt*, 1904.

² Insectivorous plants.

colour intercepts the passage of the light and concentrates its effect. Darwin showed that the points of growing Grass leaves were peculiarly sensitive to light, but in this case no special organs have been yet detected. The positions assumed by leaves are also in most cases, no doubt, determined by the influence of light, as Vochting has shown.¹ The cells of the epidermis are to some extent like the lenses of eyes. They are flat below, and more or less convex externally. The middle part of the cell-wall is sometimes itself thickened. In certain plants some cells only of the epidermis project and form lenses, thus increasing the similarity to the "eyes" of some of the lower animals.

We are so accustomed to the fact that the roots of plants grow downwards and the shoots upwards, that it scarcely occurs to most people to ask how this is effected. The classical experiments of Knight called attention to the subject, and showed that it is gravity which enables the plant to orient itself. But in this case how does gravity act? Darwin² showed that the sensitiveness of the root is concentrated in the tip. If this be removed the root cannot properly determine its direction until a fresh tip has been produced.

It was first suggested by Berthold,³ and soon afterwards Haberlandt and Němec⁴ almost simultaneously brought forward strong arguments in support of the view, that this is due to the presence of movable starch grains which lie free in the cells, and naturally fall to, and accumulate on, the lower cell-wall. These starch grains, in fact, perform the same function as the "statocysts" of animals, which were formerly termed "otocysts" and supposed to be auditory organs, but are now generally regarded as enabling the animals to balance themselves. The distribution of these free starch grains is quoted in support of the theory. They occur in all organs

¹ "Über d. Lichtstellung der Laubblätter," *Bot. Zeit.* xlvi. (1888).

² *Movements of Plants.*

³ *Protoplasma mechanik*, 1886.

⁴ *Ber. Deut. Bot. Ges.* xviii. (1900).

capable of bending. They do not occur in stalks, or non-geotropic roots such as those of the Ivy or Mistletoe, while plants which develop starch grains nowhere else, produce them in the root tips. Again, the flowers and leaves of many plants which adopt special positions with reference to the earth develop starch grains; while those of allied species, which assume no definite position do not produce starch grains.¹

CONCLUSION

One result which comes out with increasing clearness from recent investigations is the great amount of variability. In fact, it is becoming more and more a surprise how the older botanists can have regarded species as fixed and invariable. This is not only the case in genera, such as *Rubus* and *Hieracium*, the species of which have long been recognised as extremely variable and difficult to define; but it may almost be said that, as a rule, when plants are studied under dissimilar conditions, or in various parts of their area, they will be found to present considerable differences, so that, as our knowledge advances, the definition and limits of species become, not more easy and definite, as might perhaps have been expected, but more and more difficult and debatable.

Perhaps no part of Botany is more interesting than the manner in which plants adapt themselves to circumstances. The reasons suggested are in some cases more or less hypothetical. Systematic and morphological botany may, no doubt, be treated with scientific precision, by omitting all attempt at explanation. Such works are often models of lucid description, and afford a solid foundation on which to construct the history of plant life. To many, indeed, systematic botany is the most interesting department of the science; to others it is the entrance and outer court

¹ See, for a general discussion on the subject, F. Darwin, *Rep. Brit. Assoc. Cambridge* (1905); also *Nature*, 1904.

of the temple ; and when we realise that for every shade of colour, for all the exquisite beauty of flowers, for the endless difference in the size, forms, and textures of leaves, for the shape and colour of fruits and seeds, there are, if we only knew them, good and sufficient reasons, Nature seems endowed with new and vivid life, with enhanced claims on our love, wonder, and devotion.

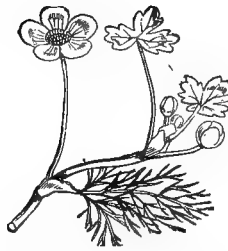


FIG. 29.—*Ranunculus aquatilis*.

CHAPTER II

DICOTYLEDONS

RANUNCULACEÆ

THIS interesting family consists principally of herbs. Clematis, however, is a woody climber. The group is widely extended in temperate and northern regions, but except on the highlands is almost completely absent from the Tropics. Clematis, however, and an allied genus extend into sub-tropical or even tropical districts.

The embryo is generally minute; it is so in all the British species. The petals are sometimes small or absent, in which cases the sepals are often white or coloured (Clematis, Anemone, Caltha, Trollius, Eranthis, Aconitum), generally white or yellow, but sometimes red, blue, or violet. Honey is often absent (Clematis, Thalictrum, Anemone, Adonis), and insects come for the pollen only. The nectaries are sometimes on the ovary (Caltha), sometimes on the stamens (some Anemones), often on the petals (Ranunculus, Helleborus, Trollius, Aquilegia, Aconitum, etc.), rarely on the sepals (some Pæonies).

In Thalictrum the achenes are ribbed, in Ranunculus they are wrinkled (water forms) or smooth, in

some slightly hairy, in others (*R. arvensis*, *R. parviflorus*) covered with tubercles or spines which are often more or less hooked, and no doubt serve to promote the dispersion of the seeds. In some (*R. scapigerus*, *R. multiscapus*, etc.) the style itself is hooked. In other cases dispersion is aided by the presence of wings, or (some species of *Clematis*) by a long feathery process consisting of the persistent style. This probably serves another useful purpose by fixing the seed to the damp soil, thus helping the seedling to escape from the testa.

CLEMATIS

The flowers are honeyless, and are visited by insects for the sake of the pollen. They have white or coloured sepals and no petals. The genus is widely spread over the globe.

Of this genus we have only one species, **C. Vitalba**. It has a woody stem, and climbs by means of the stalks of the leaves, which are opposite, compound, and without stipules. The flowers are sweet, greenish-white, and small, but conspicuous from being collected in clusters, whence Dodonæus gave it the name of *Vitalba*—the White Vine. There are no petals; the sepals are four in number, the stamen and carpels numerous. The persistent style of the one-seeded fruit is produced into a long feathery awn, which, as in other similar cases, assists in the dispersal by wind, and has originated one of its English names—Old Man's Beard. The other, Traveller's Joy, given it, I believe, by Gerard, refers to its partiality for roadside and other hedges. In other species of the genus the style is short and beardless.

Clematis is visited and fertilised by several species of flies and bees which feed on the pollen. Most flowers are visited by small insects for the sake of their pollen, and I only mention such visits when they assist in the fertilisation. It is slightly protogynous. It prefers calcareous soils, and is very luxuriant on chalk,

growing to a height of 20 to 30 feet. It is a southern form, extending to the Mediterranean, and not reaching to our northern counties. It is not regarded as a native of Ireland, but is naturalised there. It flowers in July and August.

THALICTRUM

The species of this genus are also, as a rule, pollen-flowers. Their conspicuousness is due to the numerous stamens. In one species the anthers are yellow; in *T. aquilegifolium* of Southern Europe they are violet. The species are widely dispersed over the temperate and colder regions of the northern hemisphere. They are variable, and botanists differ much as to the number. The most distinct British forms are *T. alpinum*, *T. minus*, and *T. flavum*.

T. alpinum is a graceful little plant 4 to 10 inches high. The leaves are biternate and glaucous beneath; the flowers form a drooping, simple, terminal raceme. The sepals are slightly purplish. The pollen is probably carried by the wind. It is probable that this species once occupied most of the northern hemisphere south of the great glaciers. It grows on the mountains of Wales and Scotland and all over the northern hemisphere as far north as Nova Zembla, descending to lower levels towards the north. In Ireland it is very rare.

T. minus.—In this species also the pollen is probably wind-borne, but the flowers are sparingly visited by flies, beetles, and bees. The flowers are mostly drooping. The leaflets are roundish. It occurs from the Himalayas to Greenland and North Africa, but does not ascend so high or reach so far north as *T. alpinum*, and prefers calcareous districts.

T. flavum.—In this species, on the contrary, the flowers are mostly erect, and the pollen is carried by insects, especially flies. It is 2 to 4 feet high, and not uncommon along the banks of streams. The stem is erect, branched, and furrowed. The leaves are bipin-

nate; the sheathing leaves or stipules serve to protect the bud and also to hold moisture; the leaflets are wedge-shaped or obovate. The anthers open in sunshine and close in rain. According to Edgeworth, *T. flavum* has two forms of pollen. Unfortunately he merely makes the statement and gives no particulars. Fruits of this species are of frequent occurrence in preglacial beds in Norfolk and Suffolk.

ANEMONE

Perennial herbs with radical leaves. There are 4-20 sepals, no petals, and numerous stamens. In some species the petioles of the cotyledons are connate to the summit, or nearly so. One of the most striking features in the genus is the three-leaved involucre, the leaves of which are sometimes stalked, sometimes sessile, sometimes resembling the ordinary leaves, at others quite different. In *A. Hepatica* they are small, undivided, and together resemble a calyx. The fruits are often wind-borne, sometimes by means of a long feathered awn, sometimes by silky hairs; in other cases the fruit is flattened, with a narrow wing (*A. narcissiflora*); lastly, in some the awn is hooked, and catches on to the hair of any passing animal.

A. Pulsatilla (Pasque-flower) is silky, with tri-pinnate leaves, violet sepals, and yellow stamens. The outer series of stamens differ somewhat from the rest, and may possibly be regarded as representing petals. The flowers are protogynous, and remain open two to four days. Honey is secreted by the outer stamens. The flowers are visited by several species of bees and some other insects. Their life-history is curious and interesting. When they open they face the sky, and the stalks are quite short. The stigmas are numerous and ready for fertilisation. After two days the peduncle has elongated, the flower inclines slightly, and the anthers begin to open. The sepals, which are concave, have grown longer, and thus protect the pollen more effectively. The flower closes in the evening, and thus

some of the pollen is deposited on the sepals. After another two days the stalk is ten or even twenty times as long as it was at first, and the flower hangs over by day as well as by night. The sepals have more than doubled in length, and have become convex instead of concave. If not already fertilised, the stigmas are almost sure to receive pollen from the sepals when the flower closes at night.

The achenes have feathery awns, and the peduncles lengthen considerably after flowering, perhaps in order to increase the chances of dispersion of the seeds. The plant grows in high pastures throughout most of Europe, but is rare in England (occurring in certain counties only, on calcareous soils), and does not occur in Scotland, Ireland, or Wales. The root-stock is stout, woody, and penetrates deeply into the ground, thus enabling the plant to maintain itself better in the dry situations where it grows.

A. nemorosa (Wood Anemone) prefers woods and copses. It is one of the few plants which are able to grow under beech trees, probably because it flowers early, and its period of active vegetation is over before the beech leaves are out. It thus escapes the competition of other plants, and is also protected against the wind. The Wood Anemone has a creeping rhizome, which throws up the leaves and flowers. The flower-stalk bears no true leaves, but an involucre of three bracts, which in this species resemble the leaves. The sepals are white, often tinged with pink, or, very rarely, blue. The achenes are downy, without awns. The flowers (March to May), which are honeyless, are visited by pollen-collecting bees, flies, and a few beetles. When they first open they are upright when it is fine, but bend over in wet weather and at night, and gradually become drooping. The bending movement is a not infrequent method of protecting pollen or honey from becoming wetted. According, however, to Van Tieghem, honey is secreted by the receptacle.

The plant prefers calcareous soils, but is spread all

over the northern hemisphere, and in Scotland reaches to 2800 feet.

ADONIS

A. autumnalis.—An annual cornfield weed, 6-8 inches high, glabrous or slightly downy. The leaves are tri-pinnatifid, with fine linear segments. The sepals are 5, petals 5-10, scarlet with black bases, a remarkable combination, for black is a very rare colour in petals, and only occurs in one other English species, curiously enough again associated with scarlet, and in another cornfield weed, the Poppy. The carpels are many, one-ovuled and arranged in a head which sometimes lengthens. It flowers from May to September. According to Knuth, the brown pollen-grain presents remarkable differences in form; there is no honey. The flowers are upright when it is fine, but bend over in wet weather. The only insect visitor recorded is the hive bee. The plant grows in Central and Southern Europe, Western Asia, and North Africa. In Scotland and Ireland it is rare.

MYOSURUS

M. minimus.—This curious little plant is a small annual, only 1-5 inches high, with short, linear leaves dilated at the very base and surrounding the crown. From the axils of the leaves a greater or less number of leafless scapes arise, bearing each a solitary flower. The latter has five, rarely six or seven, sepals, which have a small spur behind, and are appressed to the scape. The small, narrow, greenish-yellow petals are similar in number and have a tubular nectary at the apex of the filiform claw. Inconspicuous as they are, it is yet evident that they serve to attract insect visitors. The flower is almost exclusively visited by small flies. Before the petals have dropped, the receptacle begins to elongate, ultimately reaching a length of $1-1\frac{1}{4}$ inches, and bearing a dense mass of achenes, with short persistent styles.

The plant is a cornfield weed, affects sandy and gravelly soils, and flowers in May and June. It is widely distributed in the temperate regions of the northern hemisphere, but does not extend far north, in our own country not beyond Cumberland. An allied species occurs in America. The name *Myosurus*, or Mouse-tail, is well chosen from the elongated receptacle.

RANUNCULUS

The genus is almost world wide, but the greater number of species belong to the northern hemisphere. It extends far into the Arctic regions, and some species rise to great heights. There are at least 150 well-marked species, but some botanists make many more. When the flower first opens, the anthers are turned towards the centre. Gradually the filaments of the outer whorl twist round, so that the anthers which in the meantime have opened stand just over the nectaries, situated at the base of the petals, and are sure to be brushed by insects coming in search of the nectar. The following day these stamens move outwards and their place is taken by the next whorl. This process continues until all the stamens have had their turn. The leaves, as in many herbaceous species, are much cut up, especially the subaqueous leaves of the aquatic Ranunculi (Fig. 30).

The species of *Ranunculus* are generally perennials. *R. sceleratus* is sometimes annual, sometimes biennial. *R. arvensis* is annual. It is a weed of cultivation, and such plants are generally short-lived.

The genus falls into two divisions—(1) those floating in water or creeping on mud, with white flowers and wrinkled carpels; (2) terrestrial or not floating, with yellow flowers and smooth or tuberculate carpels. The former are often regarded as forming a distinct genus,



FIG. 30.—*Ranunculus aquatilis*. The enlarged petal shows the basal honey-gland.

Batrachium. Like most other water plants they are glabrous, while the land species are generally hairy. The forms are very variable, and some botanists make numerous species, which Bentham and Hooker reduce to two—*R. aquatilis*, in which the lower leaves are finely cut up, and the receptacle is usually hairy; and *R. hederaceus*, in which all the leaves are rounded with broad lobes, and the receptacle is glabrous.

R. aquatilis.—The most interesting feature is the possession of the two kinds of leaves (Fig. 30). Those which float on the surface are rounded in outline and cut more or less into three or six wedge-shaped, obovate or rounded lobes; while the submerged leaves are divided into numerous fine linear segments. It is a very variable species, and has great power of adapting itself to different conditions, such as the depth of the water or the rapidity of the stream. It will also grow on land, in which case, however, the habit is very different. The leaves are so far adapted to their surroundings that the submerged ones cannot live out of, nor the floating ones under, water. The size of the flower varies considerably. The petals are 5 or sometimes more in number, the stamens from 8 to 20. It has a slight scent, and secretes honey in a nectary at the base of each petal; the honey-gland is not protected by a scale. The yellowish base of the petal serves to guide insects towards the honey. It grows and flowers freely, sometimes quite covering small pieces of water. It is visited by many small flying insects, especially flies. If the water is high the flowers remain submerged and closed and fertilise themselves. The plant extends to all temperate regions.

R. hederaceus is smaller, and does not produce the finely divided, submerged leaves. It secretes very little honey, and is not much visited by insects. This species is common in Western and Northern Europe.

Our other species of *Ranunculus* are yellow.

R. sceleratus, so called from its bitter acrid juice, which raises blisters on the flesh, and from the time of the Herbalists is referred to as thus used by beggars to

excite sympathy. It is in some respects an intermediate form between the land and water species of the genus, as the achenes are only slightly wrinkled and furrowed. It grows on muddy banks, often extending into the water. The stem is thick and hollow. The submerged foliage differs from the aerial, and more nearly resembles that of the aquatic species. The flowers are small and pale yellow, the petals scarcely longer than the sepals, which are reflexed. There is no scale over the nectary. The carpels are small, in a dense head which gradually becomes oblong. As an annual it can easily establish itself wherever a suitable situation offers. The species is spread over Europe and temperate Asia, as far south as Bengal. It appears to be visited almost exclusively by Diptera (flies). M. Vesque has made the interesting observation that if it is grown in damp air the stomata become more numerous, and appear on the upper as well as on the lower sides of the leaves.

R. Lingua.—This, which is our largest species, grows to a height of 3 or 4 feet, and has beautiful golden-yellow flowers, some 2 inches in diameter, in a loose panicle. It lives on the edges of lakes and in shallow water. The stem is erect, stout, and hollow. The upper aerial leaves are long, lanceolate, and entire, or with a few small teeth. It has thus adopted one of the forms so characteristic of water plants. The lower submerged leaves are cordate, broad, and obtuse. The flowers are protogynous. At the base of each petal is a large nectary, which secretes a copious supply of honey. Fertilisation is almost exclusively due to flies. Since the anthers open towards the outside of the flower, and also bend outwards as they mature, self-fertilisation is difficult, though not impossible, owing to the oblique position of the flower; it seems to have but little effect. The plant is common in the temperate parts of Europe and Asia.

R. Flammula somewhat resembles *R. Lingua*, but is much smaller and slenderer, with decumbent, rooting stems. It is sometimes hairy and sometimes glabrous.

The upper leaves are lanceolate or linear, the lower ones broader, and all slightly toothed. The flowers are protandrous, the outer stamens opening first, and turning the pollen outwards. The stigma is, however, mature before the innermost stamens have shed their pollen. The insect visitors are not numerous. They comprise the hive bee and some species of *Halictus*, a few beetles, one or two Lepidoptera, and several species of flies.

R. acris, repens, and bulbosus.—These species offer some very interesting problems. *R. acris* is erect and tall; *R. repens*, as the name denotes, is a creeping plant; while *R. bulbosus* has the stem thickened at the base into

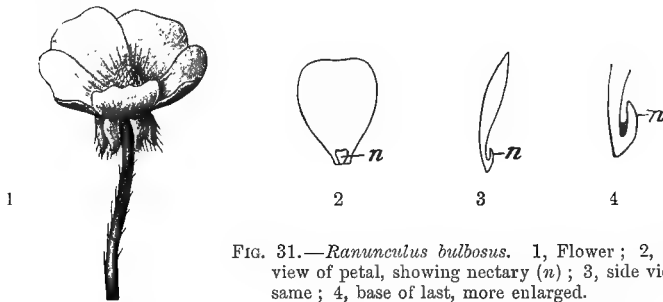


FIG. 31.—*Ranunculus bulbosus*. 1, Flower; 2, front view of petal, showing nectary (*n*); 3, side view of same; 4, base of last, more enlarged.

a sort of bulb. Moreover, it differs from the other two in that the sepals bend downwards in the middle—a character we have just noticed in *R. sceleratus* which recurs in *R. hirsutus* and some foreign species. *R. acris* is softly hairy, the hairs generally spreading, but deflexed on the lower parts of the stem, and appressed on the peduncles. In *R. repens* the hairs are longer and looser. *R. bulbosus* is generally somewhat hairier. In all three the leaves are much divided, but in *R. acris* the divisions are finer. In *R. acris* the outline is rounded, in *R. repens* it is ovate; the leaves of *R. bulbosus* resemble those of *R. acris*, but are broader. The peduncle is glabrous and furrowed in *R. bulbosus*, hairy and furrowed in *R. repens*, hairy but not furrowed in *R. acris*. The carpels are glabrous in *R. acris* and

R. repens. There is a nectary, half concealed by a scale, at the base of each petal. According to Verhoeff, the flowers of *R. repens* secrete more honey than those of *R. acris*; the petals are broader and more brilliant, and they also stand closer together. The arrangements of the flowers are, however, similar, and while, as a rule, the hive bee confines itself to one species of flower in a journey, these three are, according to H. Müller, visited indiscriminately. The sap is very acrid, which protects them and some other species from browsing quadrupeds. They are visited by flies, small bees, the hive bee, Lepidoptera, and beetles, partly for the honey and partly for the pollen. The flower of *R. acris* lasts seven days.

R. auricomus (Goldilocks).—This is a spring species. It grows in woods and copses, flowering before the shrubs and trees are in full leaf. It is perennial, 6-10 inches high, and nearly glabrous, having only a few appressed hairs. The radical leaves have long stalks, and are rounded or reniform; the upper ones are more cut up. H. Müller gives figures of the petals showing considerable variation, and a transition to the condition of those species in which, as in Winter Aconite, they are reduced to mere honey-containing vessels. Where the petals are aborted, the sepals become more petaloid, and are frequently fringed. The carpels are downy. It is visited by bees, flies, a few beetles, and some Lepidoptera. According to Edgeworth, it has two forms of pollen. The plant is found in Northern and Central Europe, and Asia as far south as Northern India.

R. Ficaria (Pilewort or Lesser Celandine).—Also an early spring species, flowering from March to May. It is a glabrous plant, and the root-stock bears oblong or cylindrical root-tubers. The flowers are large, about one inch across, numerous, and golden yellow, each on a separate peduncle, which also bears one or two small leaves. Most of the leaves, however, are radical, cordate, and stalked, thick, smooth, and shining. There are 3 sepals

and 8-12 petals. The carpels are rather large, in a globular head, and smooth. The structure of the flower resembles that of the preceding species and of *R. acris*. The number of stamens varies considerably. The flowers are generally sterile, though the visits of insects are numerous, and the plant generally propagates itself by the tubers. It is a remarkable fact that this species, which flowers so freely, rarely sets its seeds. Some specimens produce purely female flowers. The plant is found throughout Europe and in Western Asia and North Africa.

R. hirsutus has a stem 6-8 inches in height. It agrees with **R. bulbosus** in its foliage, and in having the sepals reflexed, but the flowers are paler, smaller, and more numerous. The hairs are spreading or reflexed; and the achenes have a series of tubercles within a broad margin. The pollen is yellow, round or oval, with three longitudinal furrows, and 30-37 μ in diameter. Warnstorf says that the flower produces no honey.

R. arvensis (Hunger-weed, Starve-acre).—An undesirable cornfield weed, which flowers and seeds with the wheat. It is an erect, branching, glabrous annual, 6-18 inches high. The upper leaves are deeply cut into three linear-lanceolate lobes. The pale yellow flower is very characteristic of this species, which also differs from the preceding species in having the achenes large, few, flattened, and covered on both sides with straight or often hooked prickles, which contribute to the dissemination of the seeds. It varies considerably in the number of stamens and carpels. Some of the flowers contain no stamens.

CALTHA

This genus contains but few species, only one of which is British. The name is derived from the Greek word *κάλαθος*, a cup, suggested by the golden cup-like flower, to which also we owe the common name King-cups.

Caltha palustris (Marsh Marigold or King-cups) is a

glabrous perennial with annual shoots about a foot long. The large kidney-shaped, glossy leaves are long-stalked, and have large membranous stipules. The flowers are 1-2 inches across, with 5 golden-yellow sepals, but no petals. Honey is secreted abundantly in two shallow depressions at the base of each carpel, and the flowers are visited by many beetles, flies, and bees. Besides the ordinary flowers, it is said that in France and the Tyrol some have no pistil. The plants grow in marshy places, and flower from March to May. The species is very widely distributed in temperate and cold regions both of the northern and southern hemispheres.

TROLLIUS

T. europæus (Globe Flower; Old German *Trol*, a globe) is an erect perennial glabrous herb, 1-2 feet high, with large, pale yellow flowers. The leaves are palmately lobed, the lower ones not unlike those of *Ranunculus acris*; the upper ones few, small, and nearly sessile. The sepals, 5-15 in number, are rounded, concave, and converge into a globe, nearly concealing the petals. The flower is slightly scented. It does not open far, so that the stamens and pistil are pretty well protected by the sepals. In wet weather it closes more completely. The insect visitors are not very numerous. The seeds are trigonous, black, usually shining, and smooth but finely dotted. The plant grows in damp mountain pastures in North and Central Europe.

HELLEBORUS

The plants of this genus are coarse perennial herbs. The flowers have 5 large sepals, and 8-10 small, tubular two-lobed honey-containing petals. The stamens are numerous; the carpels few, each becoming when ripe a follicle with several seeds.

Of this genus we have two species—*H. foetidus*, with a large close panicle of drooping flowers, which are green,

often tinged with brown or purple; and *H. viridis*, with three or four yellowish green flowers. Both are protogynous. The petals are modified (Figs. 32, 33, *n*) into remarkable, more or less conical, elongated cups, which serve as nectaries. The hanging position and the close application of the sepals completely protect the honey from rain, and conceal the flowers from many insects. When the flower opens, the styles turn outwards so as to stand just under the nectaries. Subsequently they move inwards, and their place is taken by the stamens, which then, and not till then, open their anthers.

H. foetidus (Stinking Hellebore) is probably protected from grazing quadrupeds by its disagreeable smell and

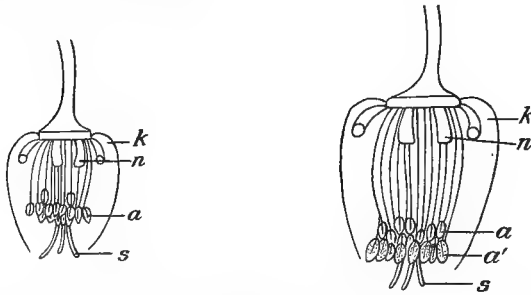


FIG. 32.—*Helleborus foetidus*. Flower in the first (female) condition; the sepals partly removed.

FIG. 33.—*Helleborus foetidus*. Flower in the second (male) condition. *k*, calyx; *n*, nectaries; *a*, unripe anther; *a'*, ripe and open anther; *s*, stigmas.

taste. It grows in stony and calcareous places in Central and Southern Europe, extending some way up the valleys, and occurs in Hampshire and Sussex, but is perhaps a doubtful native.

H. viridis.—The flowers are more open and the nectar is more abundant than in the preceding species. They are, however, less conspicuous on account of their green colour, being indeed the largest green blossoms in our flora. They are visited by bees and humble bees, but not very frequently. The plant is found in woods in calcareous districts throughout Western and Central Europe, and in our southern and south-eastern counties.

DELPHINIUM

Annual or perennial herbs with much-divided leaves. The 5 sepals are coloured, the back one ending in a hollow spur. There are 2-4 small petals, in the British species two, which are joined together, and each lengthened into a spur, lying in that of the calyx. The 1-5 carpels form each a several-seeded dry fruit. The embryo is very small.

D. Ajacis (Common Larkspur).—An annual erect herb, 1 1½ feet high; glabrous or slightly hairy; with branches few and spreading, and leaves divided into fine linear segments. The flowers are blue, reddish, or white, in terminal racemes. The spurs of the two petals are united on the under side into an inner spur, open along its upper surface. The honey is at the base of the spur, and only accessible to the bees which have the longest proboscis, as, for instance, *Bombus hortorum*. The solitary follicle is either glabrous or pubescent. The flowers are protandrous. The seeds are black and angular, with transverse, acute, wavy, and continuous ridges.

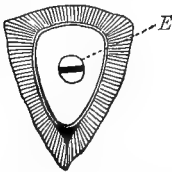


FIG. 35.—Trans. section of seed of *Delphinium Staphysagria*. × 12. *E*, embryo.

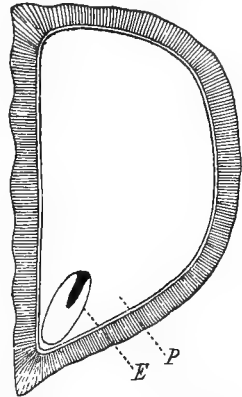


FIG. 34.—Long. section of seed of *Delphinium Staphysagria*. × 12. *E*, embryo; *P*, endosperm.

The plant is a cornfield weed, not a native, and rare except in Cambridgeshire. The name is derived from some marks at the base of the petals which have a fancied resemblance to A I A I.

D. elatum (Fig. 36), a Southern European species, has been well described by H. Müller. The five sepals (*se*) are brightly coloured; the upper one is produced into a long spur (*x*). The two upper petals are also produced

into spurs which lie within the former, and secrete honey. In order to reach this, it is necessary for the bee to press its proboscis between the upper and lower petals (*pe*), through the interval (*m*). The lower wall of this orifice is in front closed by the lower petals,

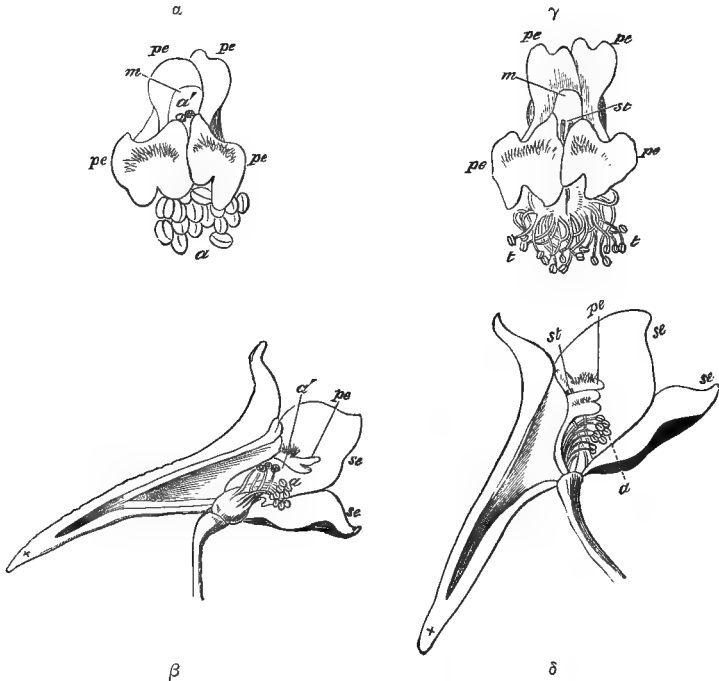


FIG. 36.

Delphinium elatum. *a*, A young flower, seen from the front, after removal of the calyx. *b*, Section of a similar flower, seen from the side; the right half of the calyx and of the corolla has been removed. *c*, An older flower, seen from the front, after removing the calyx. *d*, Section of a similar flower, seen from the side, after removing the right half of the calyx.

which are turned upwards and sideways, so as to form the lower wall of the orifice leading to the nectary, and to cover the stamens and pistil. Immediately behind the entrance to the tube, however, these petals contract so as to leave a space (*m*). The stamens (*a*) and pistil lie below this space, and as the stamens ripen they successively raise themselves and their anthers pass

through this space, as shown in Fig. 36, a, β, a' , so that the proboscis of the bee, in passing down to the honey, can hardly fail to come in contact with them. After shedding their pollen, they turn down again, and when each anther has thus raised itself and again retired, the pistil in its turn takes possession of the place, as shown in Fig. 36, γ, δ, st , and is thus so placed that a bee which has visited a younger flower and there dusted its proboscis can hardly fail to deposit some of the pollen on the stigma. Fig. 36, a , represents a young flower seen from the front after the removal of the calyx; it shows the entrance leading to the nectary, in which are seen the heads of two mature stamens, a' , while the others, a , are situated in a cluster below. Fig. 36, β , represents a section of the same flower. Fig. 36, γ , represents a somewhat older flower in the same position as Fig. 36, a . In this case the stamens have all shed their pollen and retired, while the stigmas st , on the contrary, have risen up, and are seen projecting into the space m . Fig. 36, δ , represents a side view in section of this flower. *Anthophora pilipes* and *Bombus hortorum* are the only two North European insects which have a proboscis long enough to reach to the end of the spur of *Delphinium elatum*. *A. pilipes* is, however, a spring insect, and has already disappeared before the *Delphinium* comes into flower, which in the neighbourhood of Lippstätt appears to depend for its fertilisation entirely on *Bombus hortorum*, though Boissier assures us that in France and in the Alps it is visited by several other species.

The leaves are cut up into linear segments. I have already suggested (*ante*, p. 24) one probable reason for this. Another advantage of leaves being cut up is that they let light through to those below. Of course there must be some shadow; but as the sun moves across the sky, one part of the lower leaves after another is lit up, and this is sufficient for them. Species like the Mulleins, with entire leaves, form a conical pyramid, the lower leaves thus being well lighted; while those

with cut leaves, the Larkspur and Fennel (*Fœniculum*), for example, rise up in cylindrical columns, and the lower leaves are lit through the interstices of the upper ones. *D. elatum* is an Eastern Mediterranean species.

AQUILEGIA

Perennial herbs, with flowers in racemes. The 5 sepals are petaloid. The 5 petals each end in a long horn-shaped spur. The 5 carpels form each a several-seeded follicle.

A. vulgaris (Columbine) is characterised by its large, drooping, blue or pale purple flowers and much-divided leaves. Honey is secreted at the ends of the spurs of the petals, which reach a length of 15-22 mm., and are just wide enough at the entrance to receive the head of a humble bee. Only those, however, with the longest proboscis (*Bombus hortorum* and *B. agrorum*) can reach the honey. Other species, as Sprengel observed long ago, have hit upon the device, adopted also in the cases of many other tubular flowers, of biting a hole through the spur and thus robbing the flower of its honey. This is said to be most frequently done by *B. terrestris*, but other species, including the hive bee, avail themselves of the access thus afforded. H. Müller observed a humble bee (*B. terrestris*) come to one of these flowers and lick the base of the sepals. Finding no honey there, she tried the petal, but her proboscis was too short, and after thrusting her head in as far as it would go, and vainly trying to reach the honey, she gave it up, went round to the end of the spur, bit a hole through, and so was able to suck the honey. After this she visited several other flowers, and, without losing time by trying other means of access, at once bit holes in the spurs. He thinks that each humble bee begins by satisfying herself that she cannot obtain the honey without biting a hole, or using one already made. I have found almost all the Columbines in my garden thus bitten through. The follicles are upright, and open at the top. When agitated by the wind they scatter the seeds in all

directions. The seeds are black, shining and smooth to the naked eye, but with very fine granulations. In seeds which are thrown, smoothness is probably an advantage.

The name *Aquilegia* was given from a fanciful resemblance of the spurs of the petals to the claws of an eagle; *Columbine* from that of its flowers to a nest of doves. The plant grows in Europe, as far north as Scandinavia, and in temperate Asia.

ACONITUM

Perennial herbs, with leaves much divided; the segments are palmate. The 5 sepals are coloured; the large upper helmet-shaped one suggests the common name *Monkshood*. The small petals (2-5) are enclosed in the sepals, the two upper forming small, irregularly-spurred, honey-containing bodies on long stalks (Fig. 37). The stamens are numerous, and the 3-5 carpels form each a several-seeded follicle. The *Aconites* are especially adapted to humble bees, and their distribution on the earth's surface coincides with that of *Bombus*, extending over Europe, Central Asia, and parts of North America.

A. Napellus (*Monkshood* or *Wolfsbane*).—The stem is strong and erect, $1\frac{1}{2}$ -2 feet high. The dark blue flowers are on erect pedicels, forming a handsome terminal raceme. They are protandrous. The large upper hood-like sepal is not only part of the decoration of the flower, but seems to protect the two nectaries, the stamens and the ovary. The three lower sepals combine to protect the inner parts of the flower. The two upper petals are modified into the remarkable nectaries. They secrete a rich supply of honey. The humble bee alights on the lower sepals, and presses into the cavity of the flower, which it just fills. It thus rubs against the anthers and dusts its under surface with pollen. When the anthers have all shed their pollen, the pistil lengthens, so as to rise into the place which the anthers previously occupied. The bee, therefore, can hardly fail to dust

its breast with pollen from the anthers of flowers when just expanded, and to deposit some on the stigmas of older ones. The flowers are fertilised exclusively by humble bees. The species with short proboscis often pierce the spur, and thus obtain access to the honey, as in *Aquilegia*. The plant is very poisonous, and is said to have been formerly used to destroy wolves, whence the name Wolfsbane. Any one who has spent a holiday in Switzerland must have noticed in the Alpine meadows that the cattle leave the clumps of *Aconite* untouched. Darwin¹ quotes from Dr. Ogle a curious illustration of the protection afforded by this poison. Ogle examined 100 stems of the white variety, which is harmless, and found that every single flower had been perforated by humble bees. Flowers so treated are robbed of their honey without being fertilised. The blue flowers of neighbouring plants were, however, none of them perforated. They were being visited by bees in the normal manner, and would therefore set their

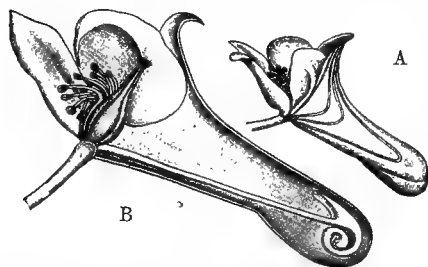


FIG. 37.—*Aconitum Lycoctonum*. A, flower in the second (female) condition, seen from the side. Nat. size. B, longitudinal section. \times about 2. The upper stamens have already fallen.

seeds. The seeds are jerked out of the follicles by the wind. They are triangular, black or deep brown, and much wrinkled. The angles are evidently due to mutual pressure.

The plant is a native of Europe and temperate Asia, and is found wild in Britain only in Wales and a few counties of western England.

In the yellow-flowered *A. Lycoctonum*, which, however, is not British (Fig. 37), the petals are even more remarkable than in *A. Napellus*.

¹ *Cross- and Self-Fertilisation of Plants*, p. 428.

BERBERIDACEÆ

Berberis vulgaris (Berberry) is the only British species of this family, and even this is a doubtful native. It is a glabrous pale-green shrub, with yellow, acid wood, 6 or 8 feet high, with long branches arching over at the ends. The leaves are alternate or in clusters, obovate, and sharply toothed. The primary leaves are changed into seven, five, or three thorns, and the axillary bud develops leaves, which is the reason for their being in clusters. The flowers are yellow, in graceful drooping racemes, with a peculiar smell. The parts are in alternating whorls of three, including 6 sepals, 6 petals, each with two

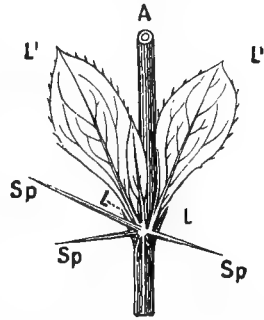


FIG. 38.—Shoot of Berberry (*Berberis vulgaris*), showing three spines, *sp*, representing the leaf. Nat. size. *A*, stem; *L*, *L*, leaves on a lateral shoot arising in the axil of the spiniform leaf, and themselves reduced to short subulate spines; *L'*, *L'*, more perfect leaves on the same lateral shoot.

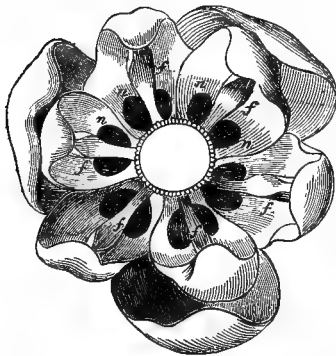


FIG. 39.—*Berberis vulgaris*. Flower seen from above. *n*, nectaries; *f*, stamens. Much enlarged.

orange nectaries at the base, and 6 stamens. The system of fertilisation was well described by Sprengel. The stamens lie close to the petals and almost at right angles to the pistil, as shown in Fig. 39. The honey-glands (*n n*) are twelve in number, situated in pairs at the base of the petals, so that the honey occupies the angle between the bases of the stamens and of the pistil. The papillary edge of the summit of the pistil (Fig. 40, *e*) is the stigma. In open

flowers of this kind it is, of course, obvious that insects will dust themselves with the pollen and then carry it with them to other flowers. In *Berberis*, however, both advantages, the dusting and the cross-fertilisation, are promoted by a very curious contrivance. The



FIG. 40.—*Berberis vulgaris*. Pistil and two stamens, after the visit of an insect. Much enlarged.

bases of the stamens are highly irritable, and when an insect touches them the stamens spring forward to the position shown in Fig. 40 and strike the insect. The effect of this is not only to shed the pollen over the insect, but also in some cases to startle it and drive it away, so that it carries the pollen thus acquired to another flower. It is visited by bees, wasps, flies, and beetles.

The fruits show the characteristic features of those adapted for dissemination of the seeds by serving as food for animals. The fruits themselves are juicy and red, with a pleasant taste. In other cases they are generally sweet, but in the Berberry have a pleasant bitter taste. The seeds have a hardened endosperm and a crustaceous testa, so that they are not digested.

The Berberry had long been suspected by farmers of exercising an injurious influence on wheat, and they generally therefore rooted it out of hedges: The suspicion, however, was regarded as groundless, until it was found that the plant (*Puccinia graminis*) to which "rust" is due passes through two phases: in one it lives on wheat, in the other on the Berberry. The second phase had been regarded as a distinct fungus, *Æcidium berberidis*; it forms yellowish-brown pustules on the leaves and young shoots in the early summer.

NYMPHÆACEÆ (WATER-LILIES)

Perennial, herbaceous, aquatic plants. The very numerous parts of the flower are arranged in a close continuous spiral; sepals passing gradually into petals, and these into stamens. The sepals and petals are on a fleshy disk, which surrounds the many-chambered, many ovuled ovary, and is crowned by the sessile, radiate stigmas. The embryo is very small. In our two British species the carpels develop air-cells, which enable the seeds to float on the surface of the water, and thus ensure their dispersal. The flowers are effectively protected against creeping insects by their aquatic habit. They are large, white, or yellow and more or less scented, yet they are not much visited by insects, principally by flies and a few beetles. The seeds, which are nutritious, and eaten by some birds, are embedded in a slimy mass, so that some of them can hardly fail to adhere to the feathers, and thus be carried from one lake to another. They are crustaceous, deeply cordate, glabrous, shining, and pale yellowish grey. In germination the cotyledons remain in the seed.

In *Nymphæa* the petals are large, without a nectary, and the stamens are inserted on the surface of the ovary. In *Nuphar* the petals are small, with a nectary, and the stamens are inserted below the ovary.

Nymphæa alba (White Water-lily).—The floating leaves are 5-10 inches across. In the leaves of most plants transpiration takes place mainly from the under side, where the majority of the stomata are situated. The under side of the floating leaves of water-plants have, however, lost this power, and have no stomata, transpiration being confined to the upper face. It is interesting that some species of *Nelumbium*, which raise their leaves above the surface, have incomplete stomata on the under side, as if they were making an effort to recover the structure which their ancestors had lost.¹ The upper

¹ Areschoug, "Der Einfluss des Klimas auf die innere Organisation der Pflanzen," in Engler's *Bot. Jahrb.* ii. (1881-82).

surface of the leaf is protected by a covering of wax, and rain falling on it collects in drops. Moreover, the surface of the leaf where it joins the stalk is slightly raised, and the edges are bent up and down in waves. The result is that the raindrops roll away to the edge on the slightest rocking movement. This gives also a peculiar appearance to the shadow of the leaf, which assumes the form of radiating dark strips with intermediate light bands. The leaves are often purple on the under side from the presence of *anthocyan*, which, by changing light rays into heat, promotes the work of the leaf.

The flowers lie on the surface of the water, and are the largest and perhaps the finest of our native flowers. The carpels are embedded in a thick receptacle, radiating from the centre. The flowers open towards the middle of the day, and close in the evening and in wet weather. The anthers open with the flower, or sometimes a day later. They bend over the stigma, and thus in the absence of insects ensure self-fertilisation. The flowers smell of honey, and the stigma exudes a small quantity of fluid, which, however, can hardly be called honey.

The plant occurs throughout Europe, Northern and Central Asia, and North America.

NUPHAR

N. lutea (Yellow Water-lily).—The leaves are of two kinds—floating and leathery, and submerged and membranous. The 5 or 6 yellow sepals are concave and much larger than the petals. The petals and stamens are numerous. The numerous carpels are radiating, fleshy, and united, but separating when ripe; the stigma has 14-20 rays. The flowers have a faint scent resembling brandy. Honey is secreted by the outer surfaces of the petals, and collects in the angle between the petals and sepals. The stigma is ripe when the flowers expand, the anthers a little later, beginning from the outside. The yellow pollen grains are large, ellipsoidal, and rough. The flowers are visited by a few beetles and flies. The geographical range is nearly the same as that of *Nymphæa*.

PAPAVERACEÆ

The Papaveraceæ are herbs, mainly of the north temperate regions. The stem contains a white, yellow, or orange milky juice. The leaves are radical or alternate. The sepals are generally 2, rarely 3, falling when the flower opens. The 4 petals are crumpled in the bud. The stamens are numerous. The ovary is free, really one-celled, but often divided into more or less closed chambers by many-seeded parietal placentas. The fruit is a capsule, opening by pores or valves. The seeds contain albumen and a minute embryo. Papaveraceæ belong mainly to the north temperate zones of both hemispheres.

The British species may be known from those of all other orders by possessing 2 sepals and 4 petals.

PAPAVER

P. Rhœas. — An erect, branched annual, 1-2 feet high, roughened by spreading or adpressed hairs or bristles; the leaves are pinnatifid and finely denticulate. The large flowers have deep scarlet petals, generally black at the base; the capsule is nearly globular and smooth, with 8-12 radiating stigmas. The stamens open in the bud, so that some of the pollen inevitably falls on the stigma, but according to Hoffmann the plant is self-sterile. The pollen is greyish green, in form spherical, or nearly so, freely granular, and 37.5μ in diameter. The plant produces no honey, but is visited for the sake of the pollen. The petals, though large, are thin and weak, so that insects naturally alight on the summit of the ovary, and thus dust themselves with pollen which they carry to another flower. They are visited by bees, flies, and beetles. As Grew quaintly said, the petals in the bud "are crumbed up within the *empalement* by hundreds of little *wrinkles* or *puckers*; as if three or four Cambrick Handkerchiefs were thrust into one's *pocket*." The flower-heads hang down when in bud, but raise

themselves gradually into an upright position before they open. Vöchting¹ found that if the ovary is destroyed this change does not take place. On the other hand, the usual change took place even when all the other parts of the flower were removed. When the capsule is ripe a series of little doors open (Fig. 41) near the summit, through which, when the plant is swung by the wind, the seeds come out, and are thus thrown to some distance. This throws light on the at first sight remarkable fact that in so many plants which have capsules they open, not, as we might perhaps at first sight have expected, at the bottom, but, on the contrary, at the summit. The little doors close when it is wet, and are protected from rain by overhanging eaves.



FIG. 41.—Capsule of a Poppy. *a*, indicates level of apertures.

P. somniferum.—This species is so called because opium is obtained from it. It is a glaucous green erect annual, glabrous or with a few hairs on the peduncles, about 3 feet high. The leaves clasp the stem at the base, and are oblong, toothed or lobed. The large flowers are bluish white, with a purple or nearly black base. The flower remains open for two days. The flat summit of the ovary forms a convenient alighting stage for insects, which dust themselves with pollen. They cannot alight on the petals, which, though large, are thin. The large capsule is globular.

The plant occurs as an escape from cultivation in our southern counties and in the Fens. It is widely cultivated in temperate and warm regions in Europe, Asia, and North Africa. Mr. Reid says it was cultivated in Neolithic times, and its seeds have been found in the Swiss lake-dwellings.

¹ *Die Bewegungen der Blüten und Früchte.* Bonn, 1882.

P. hybridum.—In this species also the capsule is globular, but it is covered with numerous, spreading bristles. The filaments of the stamens are dilated from the middle upwards. It is a native of Central and Southern Europe, North Africa, and Western Asia to North India, and of England except the extreme north.

P. dubium.—The capsule in this species is oblong, glabrous, and narrowed at the base. Its range is rather more northerly than that of the last species.

P. Argemone has a club-shaped capsule. The filaments of the stamens are dilated from the middle upwards, as in *P. hybridum*. Its geographical range is nearly the same as that of *P. hybridum* and *Rhæas*. When ripe the valves detach themselves from the top of the fruit-stalk.

GLAUCIUM

G. luteum (Horned Poppy).—So called from its long curved pods, which are 10-12 inches long. The flower lasts two days. The seeds are brown, with ridges enclosing more or less square areas. It is found on sandy sea-shores all round the Mediterranean and the Atlantic shores as far as Scandinavia, and is common round our shores, but less so in Scotland.

Fig. 42 represents a seedling of a nearly allied species, and shows the gradual development from the simple filiform cotyledons to the comparatively complex leaves.



FIG. 42.—*Glaucium corniculatum*. Seedling. Nat. size. The numbers indicate successive leaves following the cotyledons (c).

CHELIDONIUM

C. majus (Common Celandine) occurs in waste places and hedge-rows, but is a doubtful native. The edges of the leaves sometimes produce buds. The plant is protected by a fœtid yellow sap. The seeds are black, shining, and deeply pitted in longitudinal rows. The ridges, however, are rounded so that when jerked out of the capsule they would offer but little resistance to the air (see p. 65).

In the Welsh Poppy (*Meconopsis cambrica*) the black or deep brown seeds have a close network of rather deep, generally pentagonal alveolæ. In some foreign species of the genus the seeds are covered with papillæ.

The seeds of *Ræmeria hybrida*, a weed of cultivation found in dry soil in the eastern counties, are deeply pitted in lines following the curvature of the outline.

FUMARIACEÆ

FUMARIA

F. officinalis.—The common Fumitory is a glabrous, delicate green, trailing annual, with much-divided leaves

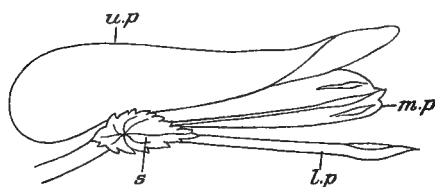


FIG. 43.—*Fumaria officinalis*. Flower much enlarged. *s*, sepal; *u.p.*, upper petal; *l.p.*, lower petal; *m.p.*, median petal.

and white or red flowers in racemes of 1-2 inches. The sepals are small (Fig. 43), 2 in number, lanceolate, and often toothed.¹ The petals are 4. The upper one is produced into a short spur or pouch behind, and in front forms a sort of hood over the rest of the flower. The lower petal is narrow and pointed. The two middle ones are united at the base,

¹ Hildebrand, *Pringsheim's Jahrbuch für Wiss. Botanik*, 1869-70.

and with the others form a tube which encloses the stamens and pistil. They are, moreover, hinged near the base (Fig. 44), and if an insect visits the flower it is thus able to press down the middle petals and thus dust itself with pollen, or deposit pollen on the stigma, as the case may be. When the insect leaves, the petals spring up again into their former position.

The stamens are in two groups of three. The upper group send a glandular process (Fig. 44) or nectary into the pouch of the upper petal. The ovary contains two ovules, only one of which forms a seed.

This occurs in many other groups of plants; perhaps it is an advantage in lightening the fruit, and thus tending to promote dispersion. The flowers appear to be but little visited by insects. Knuth characterises them as bee-flowers. Bees, however, do not seem to take much notice of them. Perhaps they are fertilised by night insects.

The species of *Fumaria* belong mainly to the Mediterranean region. Our common form, which some authorities break up into several species, is now spread almost over the whole world.

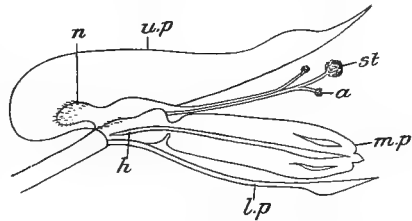


FIG. 44.—*Fumaria officinalis*. Flower from which the sepals have been removed; the petals separated, exposing one of the staminal groups, which consists of a perfect anther (*st*), and two lateral half-anthers (*a*). *h*, hinged base of median petals; *n*, nectary.

CORYDALIS

C. claviculata.—A climbing plant, rising to a height of several feet by the leaves, which end in branched tendrils. Charles Darwin in *Climbing Plants* refers to it as being exactly intermediate between a leaf-climber and a tendril-bearer. The mechanism of the flower resembles that of *Fumaria*. In *C. claviculata*, however, and some other species, the two small petals, when once pressed down, do not spring back. The pistil is

protected by the upper petal. Some species have a more or less rudimentary pouch at the base of the lower petal, and a corresponding trace of a nectary at the base of the lower group of stamens. This seems to indicate that the one-spurred genera, *Corydalis* and *Fumaria*, are descended from two-spurred forms such as *Dielytra*.

The flowers of *C. cava*, according to Hildebrand, are absolutely sterile with their own pollen. The seeds are black and shining, and very finely pitted.

CRUCIFERÆ

This great and important order is distinguished by having 4 sepals, 4 petals, and 6 stamens, 4 longer than the remaining 2. The 4 petals are arranged in a cross, whence the name Cruciferae, or cross-bearers. There are 2 carpels, united to form, when ripened, a pod. There are at least 1200 species, mostly inhabiting the temperate regions of the old world, but forming a considerable part of the vegetation of Arctic regions. They are almost all insect flowers and homogamous. They present great

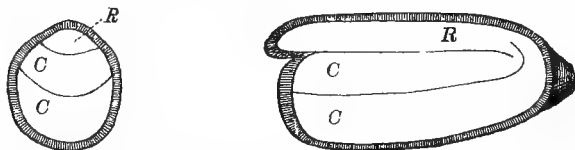


FIG. 45.—Sections of seed of *Hesperis matronalis*. $\times 10$. *R*, radicle; *C*, cotyledons. The radicle is incumbent or parallel with the faces of the cotyledons.

differences in the number and position of the nectaries, and in the position of these in relation to the stamens and the pistil. The great majority, if not all, produce honey. The seeds are oblong, sub-globose, or flattened and margined or winged, and almost always exalbuminous,¹ the embryo occupying the whole seed. The embryo is generally curved, with the radicle incumbent

¹ Except in some species of *Isatis*.

(Fig. 45), or accumbent (Fig. 46), as in the Wallflower (*Cheiranthus Cheiri*).

The order is generally divided into two great groups—(1) those with a dehiscent pod, (2) those with an indehiscent pod, containing one seed or several separated by partitions. The first group again falls into two—Siliquosæ, in which the pod is three to four times as

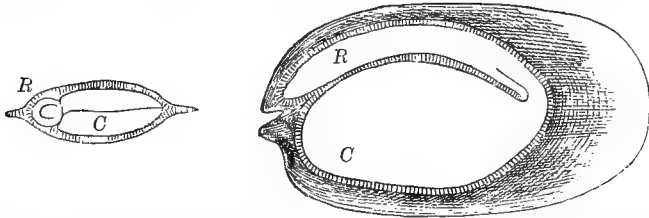


FIG. 46.—Sections of seed of Wallflower (*Cheiranthus Cheiri*). $\times 10$. *R*, radicle; *C*, cotyledon. The radicle is accumbent, or parallel with the edges of the cotyledons.

long as broad, and Siliculosæ, in which it is globular or broad and more or less compressed. The compression is sometimes parallel to the partition, as in *Alyssum* or *Draba*; sometimes at right angles to it, as in *Capsella* (Shepherd's Purse) or *Lepidium* (Cress).

The edges of the leaves in some species (*Cardamine* and *Nasturtium*) produce buds.

CHEIRANTHUS

C. Cheiri (Wallflower) is glabrous, or with adpressed hairs, forked from the base. Forked and stellate hairs are frequent in this family; they afford a better protection from loss of moisture by the plant, and also a more efficient shade from excessive sunlight than would simple hairs. The flowers are rather large, and vary in colour from pale yellow to deep red. There are two nectaries situated at the base of the two short stamens. The honey sinks into the depressions at the base of the sepals. The anthers open inwards, and almost close the mouth of the flower. It is visited by bees and flies; those with short probosces cannot reach

the honey, but must content themselves with pollen. The seed is oblong, oval,¹ much compressed laterally, with the edges produced all round into a thin membranous wing, which probably serves for dispersal. The embryo occupies the whole interior. The cotyledons are broadly ovate, entire, flat, and adpressed face to face. They take, therefore, approximately the form of the seed.

The Wallflower is a native of Central and Northern Europe, and occurs as an alien, growing on old walls, in this country.

BARBAREA

B. vulgaris (Winter-ress or Yellow Rocket).—The yellow flowers attain a diameter of $\frac{1}{3}$ inch. The half-concealed honey is produced in abundance by six nectaries, of which the two at the base of the short stamens are often confluent; it collects in the hollows at the base of the sepals. The insect visitors are bees, flies, and beetles. The leaves are often violet below from presence of anthocyan. The plant, which is very variable, is generally glabrous, but sometimes pubescent. It is widely distributed in the north temperate zone.

NASTURTIUM

The *Nasturtium* of botanists is, I need hardly say, not the *Nasturtium* of gardeners, which is a *Tropæolum*. The true *Nasturtiums* are annual or perennial, with small white or yellow flowers, and a linear or oblong pod. They live by the side of ponds or streams.

N. amphibium.—The flowers are yellow. The six nectaries at the base of the stamens form a ring. The anthers of the four long stamens are about on a level with the stigma, and open inwards, so that insects in search of honey touch the stigma with one side of the head, the anthers, or rather one of them, with the other. According to Warnstorf, however, the anthers, as they open, make a half turn, so carrying the pollen away from the stigma, and making self-fertilisa-

¹ Awebury (Lubbock), *Seedlings*, vol. i.

tion more difficult. The insect visitors are bees, flies, and beetles. The pods are oblong and turgid.

In *N. silvestre* the nectaries do not meet, but form four fleshy glands. The pods are linear, and more or less curved; the seeds are rather less numerous. Why should two plants so similar and so nearly allied have such different pods?

CARDAMINE

C. pratensis (Cuckoo-flower).—The flowers are larger than in most of its allies, and more visited by insects. There are four nectaries—two at the bases of the two shorter stamens, and two smaller ones at the base of the two longer ones. The honey collects at the bowed base of the sepals. The pouches of the two sepals corresponding to the larger nectaries are more roomy than the others. The yellow anthers make a quarter turn when opening. On the contrary, in the case of the two short stamens the anthers open inwards. According to Hildebrand, the plant is self-sterile. In addition to bees, flies, and beetles, the flowers are visited occasionally by butterflies and hawkmoths.

C. amara (Bitter Cress) agrees in many respects with *C. pratensis*, but the anthers are purple.

C. hirsuta is a common weed in gardens, with erect stems about a foot high. The leaves are pinnate, the flowers small and white; the petals are sometimes absent. The name is far from appropriate, as the plant is almost glabrous, having only a few scattered hairs. Though the flowers are so small, they are not entirely deprived of insect visits, in the absence of which, however, as the anthers are close to the stigma, the plant fertilises itself. The inner layers of cells of the walls of the pod gradually come to a condition of great tension, so that when ripe the walls of the pod detach themselves at the slightest touch from below upwards, fly off elastically, and scatter the seeds. In this country it is annual, but plants grown by Kerner in his Alpine garden became perennial. The same change occurred in various other

annual species, and is interesting in connection with the preponderance of perennial species in Alpine and Arctic districts.

C. impatiens.—This species is happily named from its habit of throwing its seeds as in the preceding species.

DENTARIA

A genus of herbs with creeping, scaly root-stock, from which the name is derived (Latin *dens*, a tooth).

D. bulbifera, a rare plant occurring in the south of England, is the only British representative. It grows in damp woods, and like other inhabitants of such localities has large, flat delicate leaves. As, moreover, the leaves inhabit places where, and appear at a season when, the leaf supply is abundant, the plants run their risk, and need no special protection from browsing quadrupeds. In dry, arid regions where the food for goats, sheep, etc., runs short, they would not last a day.

To the same category belong *Lunaria*, *Orobus vernus*, Paris, *Mercurialis* (Dog's Mercury), *Impatiens* (Balsam), *Arum* (Lords and Ladies), and *Petasites* (Butter Bur).

The flowers are large, and honey is formed in four nectaries at the base of the stamens, but insect visits are rare. Knuth never saw any, nor have I been more fortunate. Pods indeed are seldom formed, but small ovoid bulbs grow at the base of the leaves, and by them the plant is generally propagated.

HESPERIS

H. matronalis.—A hairy plant, with violet flowers $\frac{3}{4}$ inch in diameter. The nectaries are two fleshy, green glands at the base of the two short stamens. The long stamens reach just to the opening of the flower, but after shedding their pollen they are said to grow rather longer, which is very unusual. The anthers open inwards, and self fertilisation is easy. The flowers are, however, visited by several insects; about

twenty species have been observed, but this is probably by no means all. I have given (*ante*, p. 76) the embryo of this species as an illustration of an "incumbent" embryo. The genus is named from the Greek *hesperos*, evening, because it becomes specially sweet at night, which generally indicates fertilisation by moths. In support of this I may mention that H. Müller's daughter, Miss Agnes Müller, saw several species of moths visiting the allied species, *H. tristis*. No evening insects, however, are as yet recorded.

The plant is a native of Central and Southern Europe and Russian Asia, except the extreme north; it is found in England only as an escape from gardens.

SISYMBRIUM

S. officinale (Hedge-mustard).—The plant is hairy, and seems to have a peculiar affinity for dust. There is a honey-gland on each side of the two short stamens. When the flower opens, the pistil and the longer stamens project slightly. The shorter stamens are enclosed in



FIG. 47.—*Sisymbrium officinale*. A, Flower in the first stage. B, Flower in the second stage. *k*, sepal; *c*, petal; *a*, anther of one of the longer stamens; *a'*, that of a shorter one; *s*, stigma; *n*, nectary.

the flower, but the anthers are open. All six stamens then grow a little so that the anthers of the shorter ones reach the stigma, while those of the longer ones project slightly beyond it. The flower is therefore adapted for cross-fertilisation, but may also be fertilised by its own pollen. It is visited by bees, flies, and butterflies. It is a native of the north temperate zone of the old world, and has been introduced into the United States.

S. Irio (London Rocket).—So called because it came up in great numbers in the spring after the fire of London.

S. Sophia (Flixweed).—The flowers are small and inconspicuous, the petals only half as long as the sepals, and nearly the same colour. It used to be thought of special value in healing wounds, whence the name Sophia, short for *sophia chirurgorum*, “the wisdom of surgeons.”

ALLIARIA

A. officinalis (Sauce Alone; Jack by the Hedge).—A common hedge-bank plant, with a strong smell of garlic when bruised. There are four glands in the flower, but, according to Knuth, only the two at the base of the short stamens secrete honey. This collects in four drops in the space between the stamens and the pistil. Perhaps it may be connected with the fact that the honey thus passes inwards, and not, as in allied species, outwards between the stamens and the sepals, that the sepals drop early.

ERYSIMUM

E. cheiranthoides.—In this species also the honey is secreted by the nectaries at the base of the short stamens, those belonging to the longer ones being rudimentary. The pod is covered with stellate hairs.

BRASSICA

B. oleracea (Cabbage).—There are four nectaries—two at the base of the inner sides of the two short stamens, the other two between the roots of the longer ones. It seems doubtful, however, whether the latter secrete any honey. The honey accumulates between the bases of the longer stamens, and insects seeking it could therefore not fertilise the flower. Is this perhaps the reason for the diminution or absence of secretion from these glands? The flowers are visited by bees, especially the hive bee, and beetles. The

cabbage is one of those plants in which the stomata are on the upper surface. They are protected by a waxy secretion, so that water runs off in drops as off a duck's back. The plant is found on maritime cliffs round Europe as far as our southern counties. It is the source of many forms of the cabbage, cauliflower, brussels sprouts, etc. The seedling resembles that of the Radish (see p. 91).

B. Sinapis (Charlock).—A cornfield weed with hispid stem and leaves and bright yellow flowers. The bud opens early in the morning, and the stigma is already ripe. The anthers are still closed, so that in this stage the flower must be cross-fertilised if fertilised at all. The next morning the four longer stamens have elongated and twisted round so as to face outwards, away from the stigma. They form a sort of arch over it. The third day the ovary has elongated, thus bringing the stigma up to the anthers, and almost ensuring self-fertilisation.

B. nigra (Black Mustard).—As regards the structure of the flower this species does not materially differ from the preceding. The cotyledons also are similar, and as in the Cabbage, Radish, and other Crucifers they are somewhat kidney-shaped (Fig. 51) and unequal. I will endeavour to explain the reason for this when we come to the Radish.

B. campestris.—This is supposed to be the parent stock of the Turnip (*B. Napus*). It is biennial, and during the first year, when the stem remains very short, the plant occupies itself by laying in a stock of nourishment in the underground root formed from the portion of the original stem (hypocotyl) between the cotyledons and the upper part of the primary root. In the following year the erect leafy and flowering stem is produced at the expense of this store.

DIPLLOTAXIS

The genus is distinguished from *Brassica* by having the seeds arranged in two rows, whence the name.

D. tenuifolia.—Only the two nectaries at the base of the shorter stamens secrete honey. Yet the others are larger. The two sepals outside the secreting glands are upright, the others are spreading. The anthers of the short stamens open inwards. The flowers are visited by flies, bees, and butterflies, but only a few species of each are recorded as visitors.

D. muralis.—In this species all the glands secrete honey, and all the sepals are similarly oblique.

DRABA

D. aizoides.—The flowers are at first golden yellow, gradually becoming white. This is the first flower we have come to which changes colour. I will discuss this interesting point later on. When the flower opens, the stigma projects above the anthers, which are shorter and not yet ripe. They gradually elongate and open when they reach the level of the stigma, over which they bend, so that if it has not been visited by insects the flower fertilises itself. Müller records in the Alps as visitors 13 flies (7 Muscidæ and 6 Syrphidæ), 10 butterflies, and 1 beetle. The plant is not a genuine native; occurring only on rocks and walls at Pennard Castle, near Swansea.

ALYSSUM

Two species occur in Britain, but neither is a true native—*A. calycinum*, in which the calyx is persistent and the seeds two in each cell; and *A. maritimum*, in which the sepals fall off after flowering, and there is only one seed in each cell.

In **A. calycinum** the stamens present differences resembling those which also occur in *Allium*. The shorter ones have a small appendix at each side. This species is also interesting as being one of those in which the petals change colour, being first yellow and then white.

The flowers of **A. maritimum** (Sweet Alison) have a very sweet scent of honey. The seeds are compressed

and winged, which doubtless helps towards dispersion. Moreover, when wetted the cells at the edges of the wing swell up and ultimately burst, liberating a mucilage, which is useful in fixing the seed to the damp earth.

COCHLEARIA

A genus of perennial herbs with small white flowers and inflated pods. There are about twenty-five species in temperate and Arctic regions, chiefly littoral and alpine. Two are British.

C. officinalis, subsp. **danica**.—The subglobose silicule is two-celled, with four to six seeds in each cell, and opens by two turgid valves. The small ellipsoid seeds are somewhat compressed laterally, with a rather deep notch at the base. The deep brown seed-coat is covered with large crystalline, truncate, or slightly funnel-shaped tubercles, in lines following the curvature of the seed. When the seeds are placed in water the truncate tubercles gradually elongate, becoming several times longer than they were in a dry state, and hyaline or transparent, showing striated and filiform thickenings internally; they also lose their truncate form, becoming obtusely conical. They do not burst, even after having been for some time in water. Many of those lying above the water merely become many times larger than they were previously and dome-shaped, showing a very fine internal striation. Such mucilaginous cells when pushed into surrounding soil must serve to fix the seed effectually during germination, but they may also aid in the dispersal of the seeds.

C. Armoracia (Horse-radish) has nectaries at the base of the stamens, but in *C. officinalis* Knuth could find none. The former is, however, visited by a good many insects for the sake of the honey. The plant, which is found on waste ground, is not a native. Its origin is unknown; it is suggested that it is a cultivated form of a Hungarian species, *C. macrocarpa*.

SUBULARIA

S. aquatica (Awlwort).—This is a small aquatic plant generally not more than two, seldom three, inches high. It usually grows entirely under water, and the flowers are cleistogamous. Sometimes, however, it is aerial, in which case the flowers open. The anthers and stigma ripen simultaneously and are closed together. Scott Elliot, in Dumfriesshire, observed a fly on the flower, and this appears to be the only insect visitor on record. It is named from *subula*, an awl, from the shape of the leaves, a form recurring in other submerged herbs, as, for instance, in the Quillwort (*Isoetes*).

SENEBIERA

S. didyma.—The silicule or fruit is so much constricted as to be almost two-lobed, whence the specific name from the Greek *δίδυμος*, twin. It is reniform, much compressed laterally, notched, and deeply and irregularly pitted, ultimately separating into two indehiscent pieces, each containing a solitary seed conforming rather closely to the cavity. The seed is reniform, laterally compressed and rugulose, with longitudinal furrows corresponding to the outline of the folded cotyledons and radicle. The coat is pale yellow, thin, somewhat transparent, and densely and finely rugulose. The notch at the base of the fruit favours its temporary attachment to passing animals, and in this way the seeds may often be carried from the parent plant. The species is a native of temperate South America, but has been introduced into many countries. It is well established on the sea-coast of Hampshire, South and West Wales, South and West Ireland, and appears sporadically elsewhere.

THLASPI (Penny Cress)

The name is derived from the shape of the pods.

T. alpestre.—There are not a few plants in which the petals change colour, but this does not often happen in the case of the anthers. Those of this species, however,

are first yellow, then reddish purple, and finally black. As insect visitors 17 species of bees, 9 flies, 2 butterflies, 2 saw-flies, 1 wasp, and 1 beetle are recorded. The seeds are smooth. The plant grows in mountain districts in Great Britain.

T. arvense.—Nectar is secreted by small green glands on each side of the base of the shorter stamens. The anthers of the four longer stamens open inwards at the same time as, and on the same level with, the stigma, so that in the absence of insect visits self-fertilisation is almost certain to occur. According to Kerner the flower is slightly protogynous. The seeds are covered with concentric striæ.

T. perfoliatum.—The arrangement of the flower agrees with that of the preceding species. The seeds are smooth. The plant is recorded in Great Britain only from limestone in Oxford and Gloucester.

TEESDALIA

T. nudicaulis.—This is one of the species in which the seeds produce a mucous secretion by means of which they adhere to passing animals, and are thus carried about. Possibly also the mucus may tend to fasten them to damp ground, and also prevent them from being eaten.

CAPSELLA

C. Bursa-pastoris (Shepherd's Purse).—The name Capsella was given to this genus from the resemblance of the pod to a small purse. The species is said to be called "shepherd's purse" because there is no money in it. The radical leaves form a rosette on the ground, and are very variable in shape, being sometimes entire, sometimes pinnatifid, with a larger ovate, or triangular terminal lobe; sometimes glabrous, sometimes pubescent. The four nectaries are situated at the two sides of the short stamens. The longer stamens are about as long as the pistil, so that the plant can easily fertilise itself. Willis found gynomonœcious and gynodioecious plants, con-

ditions supposed by some to be due to cold, as the hermaphrodite plants are said to come on later in the season. Warnstorf also remarks that in the earlier flowers the stamens are often incomplete.

LEPIDIUM

From *λεπίς*, a scale, in allusion to the flattened pods. The outer layer of the seed-coat contains a mucilaginous adhesive substance which rapidly absorbs moisture and serves to fix them as soon as they are brought into contact with damp earth.

L. Draba has six small, green nectaries between the bases of the six stamens. The anthers open inwards, but the stamens bend outwards, thus for the time checking self-fertilisation. Insects, therefore, turn different sides of their body to the stamens and the stigma, thus favouring cross-fertilisation. Subsequently the parts close up, so that in the absence of insects the flower fertilises itself. The plant is slightly protogynous. The longer stamens at first place themselves behind the petals, so that insects do not touch them, and after a while move inwards so as to touch and fertilise the stigma. The pollen of the shorter stamens, on the contrary, serves entirely for cross-fertilisation. The plant is a native of South-Eastern Europe and Western Asia, which has been introduced or become established in many places in fields, banks, and railway cuttings.

L. sativum (Cress) has four nectaries. While the true British species of *Lepidium* have entire cotyledons, in the Cress they are divided into three long narrow lobes (Fig. 48). I have suggested the following reason for this in my book on seedlings.¹

Fig. 49 represents a section through the seed of *L. graminifolium*, which may be taken as representing the ordinary arrangement in the genus. The seeds, conforming to the shape of the capsule, are somewhat triangular, with the radicle in the narrow end. The

¹ *On Seedlings*, vol. i.

embryo occupies the whole of the seed, there being no endosperm. In *L. sativum* (Fig. 50) the seed is of the same form, but nearly twice as thick; if, therefore, the cotyledons were to occupy the whole additional

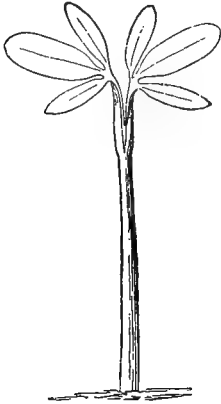


FIG. 48.—Seedling of Cress (*Lepidium sativum*). $\times 3$.



FIG. 49.—Section of seed of *Lepidium graminifolium*. $\times 15$.

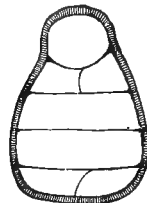


FIG. 50.—Section of seed of *Lepidium sativum*. $\times 15$.

space, they would become extremely thick. In endospermic seeds this would be simply filled by endosperm. In *Lepidium*, however, this device cannot be resorted to; but the two lobes just fill up the vacancy.

CAKILE

C. maritima.—A sea-shore plant. The anthers of the long stamens project above the flower, so that the pollen would fall just on to the stigma. At the same time cross-fertilisation is also provided for. The flower has a sweet scent, and four nectaries, two at the base of the short stamens, two at the base of the longer ones. Some fifty insects are on record as visitors. As in so many other seaside plants, the leaves are fleshy. M. Lesage has found that the leaves of several inland plants tend to become fleshy if they are treated with water containing salt.¹

¹ Constantin, *La Nature tropicale*.

CRAMBE

C. maritima.—This species is peculiar in having the pod apparently stalked, owing to the lower joint being seedless and consequently slender. The flowers have a diameter of 12 mm. and form a large head. The sepals support and enclose the petals, thus forming them into a tube. The claws of the petals, the stamens, and pistil are at first yellowish green, then clear violet red. The anthers, however, are and remain yellow. There are two large green round nectaries at the base of the longer stamens, and two smaller at the base of the shorter ones. The longer stamens terminate in two projections between which the anther is seated. Knuth supposes that they serve to guide the proboscis of visiting insects. The flower is slightly protogynous, and the stigma is ripe when the flower opens. The longer stamens reach rather higher than the stigma. The larvæ of a small beetle (*Meligethes*) are often found in the flower, feeding on the honey. Knuth thinks, however, that the injury thus done is more than compensated by the part they play in fertilisation.

The plant grows on sandy shores and stony places in Western Europe.

RAPHANUS

R. Raphanistrum.—A cornfield plant. The petals are sometimes white with violet veins, sometimes light yellow with dark yellow veins. The stigma is about at the same level as the anthers of the shorter stamens, which open inwards, so that self-fertilisation is ensured in the absence of insects. There are four nectaries. The pods when ripe have no longitudinal septum, but the seeds are separated by a pithy substance. The cotyledons resemble those of *Brassica*. The seed (Fig. 53, *A*) is oblong, thick, and slightly narrower at one end than the other. There is no endosperm, so that the embryo occupies the whole seed, and as this is somewhat deep, the cotyledons, in order to

occupy the whole space, are folded and arranged one over the other, like two sheets of notepaper, as shown



FIG. 51.—*Raphanus sativus*. Seedling. Nat. size.

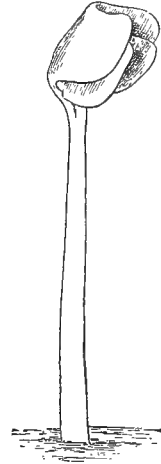


FIG. 52.—*Raphanus sativus*. Germinating seedling, $\times 2$, showing the cotyledons still folded.

in Fig. 53, *B-D*, the radicle being folded along the edge. Fig. *D* represents the embryo a little opened

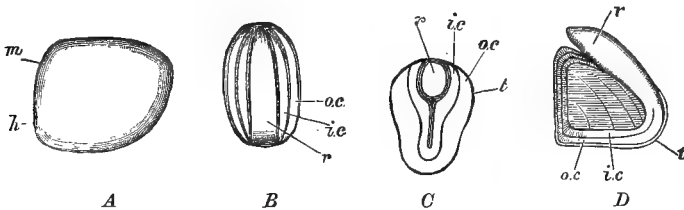


FIG. 53.—*Raphanus sativus*. *A*, outline of seed, $\times 4$; *m*, micropyle; *h*, hilum. *B*, embryo taken from the seed, $\times 4$. *C*, embryo, $\times 4$, vertical section. *D*, embryo, seen from the side, $\times 4$; *o.c.*, outer cotyledon; *i.c.*, inner cotyledon; *r*, radicle; *t*, testa.

out, and Fig. *C* a section showing the radicle and the outer and inner cotyledons. To this folding the emargination is due. If a piece of paper be taken,

folded on itself, cut into the form shown in Fig. 53, *A*, with the fold along the edge from *m* to *h*, and then unfolded, the reason for the form of the cotyledon becomes clear at once.

RESEDACEÆ

RESEDA (Mignonette)

In this genus the flower-bud is open, and the maturity of the flower is indicated by the appearance of honey which is secreted in a cup-shaped cavity of the disk, covered over by the three upper petals, which form a lid completely closing the nectar-holder. It is thus contained within a closed box, the lid of which must be prised up before it can be removed. According to Müller, the most frequent visitor is the bee *Prosopis*, which has a flat trowel-shaped proboscis which it uses in plastering its cell. The nectar-gland bears such an obvious correlation to this form of proboscis as to favour the conclusion that in *Reseda* we have a flower specialised for cross-fertilisation by short-lipped bees.¹ The seeds are black, smooth, and shining, and so much curved as to be nearly circular in outline.

R. lutea.—The flower is scentless and yellowish green. The anthers open at the time when the secretion of honey commences, and the stamens bend towards the pistil. The stigma ripens simultaneously so that self-fertilisation can easily take place. At the same time, according to Darwin,² it has generally little or no effect. The honey, however, attracts many small insects, which bring pollen from other flowers. The petals are peculiar. They consist of three upper lobes, of which the central is narrow and club-shaped, and a lower flap which serves to protect the honey. The leaves are much divided.

R. Luteola (Dyer's Weed) has entire leaves, and the flowers form long, pointed spikes.

¹ Report, British Association, 1883, "On the Nectar Gland of *Reseda*," by Professor A. S. Wilson, M.A.

² He also found the Garden Mignonette (*R. odorata*) to be self-sterile.

CISTACEÆ

HELIANTHEMUM

The name is derived from ἥλιος and ἄνθεμον, sun-flower. In some species the flowers bend over in wet, and follow the sun in fine weather.

Vaucher, in his *Histoire Physiologique des Plantes*, writing on the Rock Roses (*Helianthemum*), observes: "J'indique dans ce genre deux principaux objets de recherche. Le premier est la raison pour laquelle certaines espèces ont des stipules tandis que d'autres en sont privées."

This suggestion started me on the study of stipules. No one, so far as I know, had attempted to answer Vaucher's question, which is one of considerable interest, and might be asked with reference to several other groups besides the genus *Helianthemum*. The results of my observations have been embodied in several Memoirs which the Linnean Society has done me the honour to publish in their Journal, and which have been collected in my book *On Buds and Stipules*.

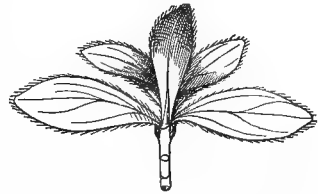


FIG. 54.—Shoot of *Helianthemum aelandicum*. Slightly enlarged.



FIG. 55.—Shoot of *Helianthemum vulgare*. Slightly enlarged.

H. aelandicum (Fig. 54) has none. Now on examining the various species of the genus I found that, where the

are so *privées*." This suggestion started me on the study of stipules. No one, so far as I know, had attempted to answer Vaucher's question, which is one of considerable interest, and might be asked with reference to several other groups besides the genus *Helianthemum*. The results of my observations have been embodied in several Memoirs which the Linnean Society has done me the honour to publish in their Journal, and which have been collected in my book *On Buds and Stipules*. *H. vulgare* (Fig. 55) has stipules,

leaves have broad bases and thus protect the bud in their axil, there are no stipules, while on the other hand where the leaves are narrow the bud is protected by stipules. *H. guttatum* is a very instructive case. The upper leaves have stipules, while the lower ones have none. Now the lower leaves have broad leaf-bases, which effectually protect the bud, and they are exstipulate; the upper leaves, on the contrary, are narrow at the base, but they are provided with stipules. The reason for the presence or absence of stipules seems, then, quite obvious, so far as the Rock Roses are concerned; and the evidence is strengthened by finding similar relations in other genera.

H. vulgare.—The flower is large and bright yellow. Though producing no honey it is visited by a good many insects for the sake of the pollen.

H. polifolium.—In this species the stamens are sensitive. They stand upright, but if touched bend down to a horizontal position, slowly resuming their original attitude in about fifteen seconds.

H. canum.—The flower, according to Briquet, is opened and closed by movements of the sepals. The stamens are not sensitive. The flower is protogynous, and as the anthers open outwards self-fertilisation is almost excluded. The leaves are white underneath and sometimes on both sides.

POLYGALACEÆ

Chiefly tropical and southern. The only European genus is *Polygala*, the Milkwort.

P. vulgaris.—A variable species presenting several forms often regarded as distinct, but from their variability considered by Bentham and Hooker to be varieties. The two inner, coloured, petal-like sepals are termed "wings." They give the flowers a papilionaceous aspect. The petals form a tube to the inside of which the

stamens are attached in two bundles (Fig. 56, *a*), and which contains a number of white hairs pointing downwards, while near the upper end are two groups of finger-like lobes. The pistil (Fig. 56, *st*) occupies the axis of the flower, and ends in a spoon-shaped hollow. The short stamens lie just over this hollow, and shed their pollen into it, after which they withdraw a little to the side. Close behind the hollow is a projection which terminates in a very viscid disk. When the proboscis of an insect is forced down the tube in search of honey, it comes in contact with this viscid disk, and being thus rendered adhesive, when it is withdrawn carries some of the pollen with it, and

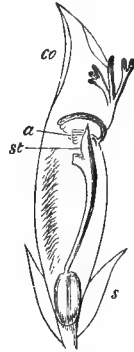


FIG. 56.—Section of *Polygala vulgaris*. *a*, anthers; *co*, petals; *s*, sepals; *st*, stigma.

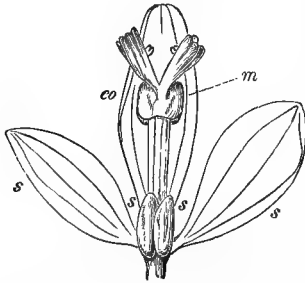


FIG. 57.—*Polygala vulgaris*. Flower opened out. Enlarged. *s*, sepals; *co*, corolla, the median petal ends in a hood (*m*) bearing a pair of fingered processes.

finger-formed processes has not, I think, been satisfactorily explained.

VIOLACEÆ

Nearly world-wide. The northern species are generally herbaceous; those of tropical regions often shrubs

or trees. *Viola* is the only European genus, and extends over most of the world.

VIOLA (Violet)

The flowers are yellow, white, blue, or violet, which indeed has derived its name from the flower. The lower petal is spurred, giving its peculiar form to the flower. The anthers of the two lower stamens, as Sprengel first pointed out, send each (Fig. 58) a projection into the spur of the petal; all five have a membranous

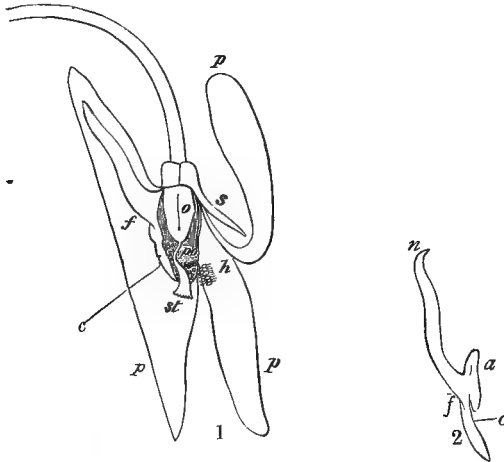


FIG. 58.—*Viola canina*. 1, Section of a flower. 2, Stamen. *a*, anther; *c*, membranous expansion of connective; *f*, filament; *h*, hairs on petal to which pollen grains have become attached; *n*, nectary; *o*, ovary; *p*, petal; *po*, pollen; *s*, sepal; *st*, stigma.

appendage, which together form a cup into which the pollen is shed. The pistil projects upwards and closes the mouth of the flower. The stigma is shaped more or less like a bird's head. Insects only insert their proboscis once in each flower. They naturally touch the stigma first, then dust themselves with pollen and transfer it to the next flower visited. The Violets are as a rule bee-flowers, but some Alpine species (*V. calcarata*, *cornuta*, etc.) have the spur elongated and especially adapted for butterflies, while in

V. lutea it is short and accessible to flies. In addition to the coloured flowers, some species, for instance, *V. canina* and *V. hirta*, produce others (Fig. 61, *a, b*; see also Fig. 62, *a, b*) which do not open, in which the petals are either absent or very imperfectly developed, and the anthers produce very little pollen. When young these cleistogamous flowers resemble the ordinary buds, the central part of the flower being entirely covered by the sepals. They set seed abundantly, much more, it is said, than the coloured flowers.

V. canina.—The stock is at first short, gradually lengthening. Fig. 58 (1) represents a flower cut in half,



FIG. 59.—*Viola canina*. Capsule with seed.

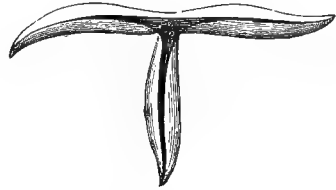


FIG. 60.—*Viola canina*. Capsule after ejecting the seeds.

and Fig. 58 (2) a stamen. It is visited mainly by bees, but also by a few butterflies and one or two pollen-eating beetles. The stamens consist of a short filament, to which the anther is attached, and a terminal membranous expansion, while the two lower stamens also send out each a long spur (Fig. 58, *n*), which lies within the spur of the median petal and secretes honey at its fleshy end. The terminal membranous expansions of the five stamens slightly overlap one another, and their points touch the pistil, so that they enclose a hollow space. The pollen differs from that of most insect-fertilised flowers in being drier and more easily detached from the anthers; consequently, when the latter opens the pollen drops out; and as the flower is reversed and hangs down, the pollen falls into the closed space between the pistil and the membranous termination of the stamens. The

pistil is peculiar, the base of the style not being straight as usual, but thin and bent (Fig. 58). The stigma, *st*, is the enlarged end of the pistil, and shows several small fleshy projections. It will be obvious from the above description that when a bee visits the flower its head will come in contact with and shake the stigma, thus opening, as it were, the box containing the pollen, and allowing it to fall on the head of the bee. It is thus carried away, and some can hardly fail to be

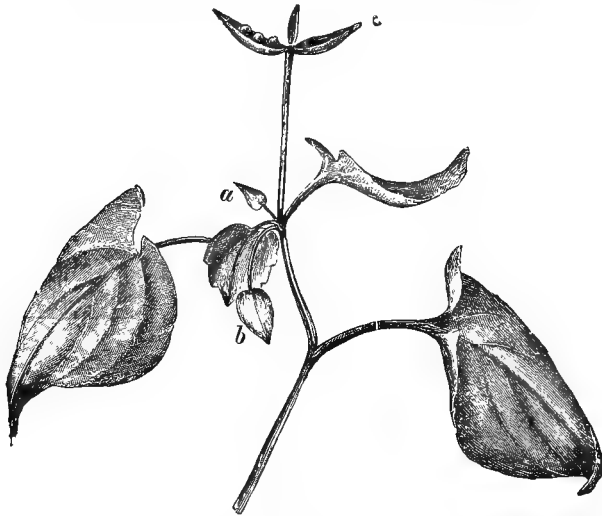


FIG. 61.—*Viola canina*. *a*, bud of cleistogamous flower; *b*, older bud; *c*, capsule open.

deposited on the stigma of the next violet which the bee visits. The capsules are pendent when young, but at maturity they erect themselves (Fig. 61, *c*), stand up boldly above the rest of the plant, and open by the three equal valves (Fig. 59) resembling an inverted tripod. Each valve contains a row of three, four, or five brown, smooth, pear-shaped seeds, slightly flattened at the upper, wider end. The two walls of each valve, as they become drier, contract and approach one another, thus tending to squeeze out the seeds. These resist some time, but at length the attachment of the

seed to its base gives way, and it is ejected several feet, this being, no doubt, much facilitated by its form and smoothness. I have known even a gathered specimen throw a seed nearly ten feet. Fig. 60 represents a capsule after the seeds have been ejected. The pollen is dry, smooth, white, and 44μ long by 25 broad. The hive bee is the most frequent visitor, but the flower attracts several other species of bee, a few flies (*Bombylius*), and butterflies.

V. hirta.—The coloured flowers agree generally with those of *V. odorata*, but have no scent. They are said to be generally infertile. The cleistogamous flowers, on the contrary, are very different (Fig. 62). They are swollen, fleshy, pinkish, and nestle close to the ground. It has been said, as for instance by Vaucher, that the plants actually force these capsules into the ground, and thus sow their own seeds. I have not, however, found this to be the case, though, as the stalk elongates and the point of the capsule turns downwards, if the earth be loose and uneven, it will no doubt sometimes so happen. When the seeds are fully ripe, the capsule opens by three valves and allows them to escape. The leaves of plants growing in shady woods tend to be large, and in *V. hirta* there is a shade-loving variety with enlarged leaves, *V. hirta* var. *macrophylla*.

Now we naturally ask ourselves what is the reason for this difference between the species of violets; why do *V. odorata* and *V. hirta* conceal their capsules among the moss and leaves on the ground, while *V. canina* and others raise theirs boldly above their heads, and throw the seeds to seek their fortune in the world? If this arrangement be best for *V. canina*, why has not *V. odorata* also adopted it? The reason is, I believe, to be found in the different mode of growth of these two species. *V. canina* is a plant with an elongated stem, and it is easy, therefore, for the capsule to raise itself above the grass and other low herbage among which violets grow. *V. odorata* and *V. hirta*, on the contrary, have, in ordinary parlance,

no stem, and the leaves are radical, *i.e.* apparently rising from the root, the stem being very short. Now, under these circumstances, if the Sweet Violet attempted to shoot its seeds, the capsules not being sufficiently elevated, the seeds would merely strike against some neighbouring leaf, and immediately fall to the ground. Hence, I think, we see that the arrangement of the

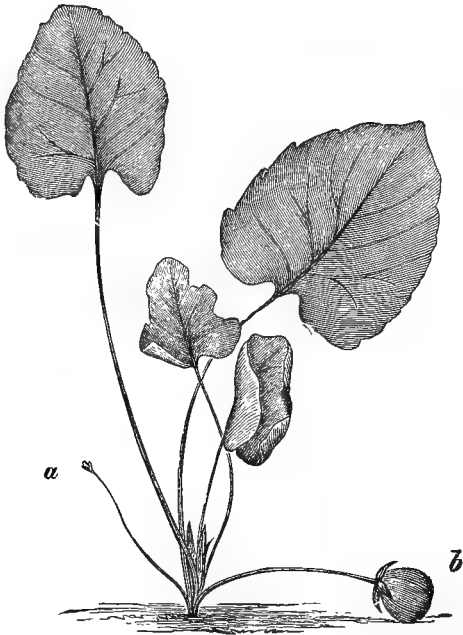


FIG. 62.—*Viola hirta*. *a*, flower-bud ; *b*, full-sized capsule.

capsule in each species is that most suitable to the general habit of the plant.

The species is somewhat variable. Mr. Britton¹ found that “among 1000 flowers gathered indiscriminately by the sides of, and adjacent to, the ancient highway known as Ermyn Street, between Epsom Downs and Leatherhead Downs, 305, or more than 30 per cent, were abnormal. The variations ranged from slight diver-

¹ *Journal of Botany*, 1904, p. 141.

gences in appearance to important modifications in structure. Taking these latter first, 222 flowers showed, in addition to the ordinary spur, saccate protuberances at the base of the petals, suggesting incipient spurs, and 65 flowers two, three, or four spurs each. Of these 65, 3 possessed four spurs, 18 three spurs, and 44 two spurs each. Two of the flowers with four petalline spurs showed traces of a fifth rudimentary spur." Elsewhere, however, he found the proportion of abnormal flowers much smaller.

"On the other hand, in *V. sylvestris*, out of 1000 flowers gathered at the beginning of May 1900, in the wooded country about Farley and Chelsham, where the plant is very distinct in appearance, only 4 flowers were normal, the remaining 996 were distinguished by the appearance at the bases of the petals of the slight protuberances which suggest to my mind incipient spurs. In the case of two flowers an auxiliary spur had been developed from one of these sacs." Again, in *V. Riviniana*, the "examination of 1000 flowers gathered between Bookham and West Humble showed that as many as 890 were marked by the formation of distinct sacs at the base of the petals (in addition to the usual spur). Thirteen of the remainder possessed the common feature that some or all the petals were lobed in a varying degree." Mr. Britton suggests that the tendency to frequent variation in the larger flowers may be due to the fact that they seldom produce seed, and consequently that the tendency to variation is not suppressed by cross-fertilisation.

V. odorata.—The flowers are small, dark, and often more or less concealed by the leaves, but, on the other hand, make their presence known by their sweet scent. According to MacLeod¹ the concavity of the pistil secretes a fluid which moistens the proboscis of the insect, and thus causes the pollen to stick to it. Sprengel, in his description of *V. odorata*, gives the following list of questions and answers as regards this

¹ *Bot. Jaarb.* vi.

species, passing over, however, the more general points, such as the secretion of honey, the colour of the corolla, the radiating lines on the petals, and the smell.

1. Why is the flower situated on a long stalk, which is upright, but curved downwards at the free end?—In order that it may hang down; which, firstly, prevents rain from obtaining access to the honey; and, secondly, places the stamens in such a position that the pollen falls into the open space between the pistil and the free ends of the stamens. If the flowers were upright the pollen would fall into the space between the base of the stamen and the base of the pistil, and would not come in contact with the bee.

2. Why does the pollen differ from that of most other insect-fertilised flowers?—In most of such flowers the insects themselves remove the pollen from the anthers; and it is therefore important that the pollen should not easily be detached and carried away by the wind. In the present case, on the contrary, it is desirable that it should be looser and drier, so that it may easily fall into the space between the stamens and the pistil. If it remained attached to the anther it would not be touched by the bee, and the flower would remain unfertilised.

3. Why is the base of the style so thin?—In order that the bee may be more easily able to bend the style.

4. Why is the base of the style bent?—For the same reason. The result of the curvature is that the pistil is much more easily bent than would be the case if the style were straight.

5. Finally, why does the membranous termination of the upper filament overlap the corresponding portions of the two middle stamens?—Because this enables the bee to move the pistil, and thereby to set free the pollen more easily than would be the case under the reverse arrangement.

V. tricolor (Pansy). — This is a very variable species. The stipules are large, leaf-like, and divided into several more or less narrow lobes. Bentham and

Hooker recognise three well-marked varieties: (1) *V. arvensis*; annual, with small flowers; leaves narrow; a common weed of cultivation. (2) Garden Pansy; much larger, often biennial, or even perennial, and with broader leaves; it easily degenerates, they say, into *V. arvensis*. (3) *V. lutea*; generally perennial; flowers large, often yellow. A plant of mountain pastures. It is annual with us, like so many other weeds of cultivation, but becomes perennial in Alpine districts (see *Cardamine hirsuta*, p. 79).

The Pansies do not produce cleistogamous flowers. The form of the pistil is peculiar, but no reason has, so far as I know, been suggested for the difference. In the absence of insect visits the flowers of No. 2 last two to three weeks, but set no seed, or very little. *V. arvensis*, on the contrary, is self-fertile. The pollen grains are in the form of four- or five-sided prisms. The seeds are pale brown, crustaceous, obovoid, shining, and with a pale corrugated ariloid at the base.

FRANKENIACEÆ

Of this order we have only one species, **Frankenia lævis**. The sepals form a tubular calyx with four or five teeth. The petals also number 4 or 5, with long claws and spreading laminæ. The seeds are very small, with a straight embryo surrounded by albumen. It occurs only on our south-east coasts from Yarmouth to Kent.

CARYOPHYLLACEÆ

This order may be divided into two groups—(1) Sileneæ, in which the sepals are united into a tubular or campanulate calyx; and (2) Alsineæ, in which they

are free, or slightly connected at the base. The petals are distinct, but held together by the sepals so as to form a tube. The flowers generally secrete honey, or a sweet sap, for which insects bore into the tissues. Most of the group are fertilised by insects, but *Silene Otites* is a wind-flower. In many species besides the hermaphrodite, there are female flowers. Some are dioecious. The hermaphrodite flowers are generally the largest, and then the male, while the female are the smallest. The stamens are normally 10, often, however, reduced to 5. They are in two series, and the most usual sequence is that the five outer anthers ripen first, then the inner series, and then the styles. This we should expect from the development of the plant, as the outer are of course the earlier series. In some cases, however, the styles are ripe before the anthers. In many cases the flowers close at night and in bad weather. Some have cleistogamous as well as normal flowers. Others are night flowers. The ovary in most cases forms a capsule which eventually opens generally by five or ten teeth, and the plant, swaying with the wind, ejects the seeds. The dehiscence is due to the fact that the outer cells contract more than the inner layers.

DIANTHUS

The fruit is a capsule, ovoid, and with many seeds. It opens at the summit by four teeth or short valves, and the seeds are jerked out by the wind.

D. prolifer.—The flowers are small, pink, in compact heads, gynodioecious and gynomonœcious; the hermaphrodite flowers are homogamous. The flowers, being small, and the honey sparing, are but little visited by insects, but as the anthers and stigma ripen simultaneously, they easily fertilise themselves. According to Kerner they live two days, and are open from 8 A.M. to 1 P.M. The seeds are black or dark brown, smooth on the concave ventral face, and with obtuse, elevated points on the convex portion.

D. deltoides.—Flowers solitary or two together, on

short peduncles, small, scentless, pink, or spotted with white; sometimes white. The stamens¹ are united with the petals at the base, and form a yellow, fleshy swelling which secretes honey. The tube of the flower is so narrow, and so nearly closed by the stamens and pistil, that the proboscis of Lepidoptera alone can reach the honey, though flies and other insects visit it for the pollen. The upper surface of the flower forms a flat disk. The stamens are ten in number. Soon after the flower opens five of them emerge from the tube, ripen, and the anthers open. When they have shed their pollen the other five do the same. During this period the pistil is concealed in the tube; but after the anthers have ripened and shed most of their pollen, it also emerges, and the two long stigmas expand. Under these circumstances the butterflies can hardly fail to carry the pollen from the anthers of young flowers to the stigmas of older ones. Flies also visit this species to feed on the pollen, and though they cannot obtain any nourishment from flowers in the later condition, still they sometimes come to them, apparently by mistake, and must therefore occasionally fertilise them. This species appears to have lost the power of self-fertilisation.

D. Armeria and **D. cæsius** are also protandrous. In *D. cæsius* (Cheddar Pink), which is very sweet, some plants produce female flowers. This species is found in Great Britain only on limestone rocks at Cheddar in Somerset.

LYCHNIS

L. Githago (Corn Cockle).—The capsule opens by five or ten teeth or short valves at the top. The flower is generally protandrous, but in some districts homogamous. The calyx has long green linear lobes which project beyond the petals. The purple petals have long claws, and are held together by the calyx. The lamina bears no scale. Honey is secreted at the base of the

¹ Avebury (Lubbock), *British Wild Flowers*, p. 65.

tube, which by its length and narrowness is adapted to butterflies. Besides the usual flowers, there are other smaller ones which contain no stamens. It is fertilised by butterflies and moths. It is a weed of cultivation, and, like so many other plants with a similar habit, is annual. Our other species of *Lychnis* are all perennial or biennial. The seeds are large, black, cuneate reniform in shape, with elevated points in lines following the curvature of the seed.

L. Flos-cuculi (Ragged Robin).—The stems are slightly downy below, and viscid above, probably to keep ants from the flowers. The petals are cut into four linear lobes. Why? The calyx is 6-7 mm. long; it has teeth some 3 mm. in length, and keeps the corolla together. Honey is secreted by the bases of the stamens. The plant is protandrous, and the five outer anthers ripen first.

L. Viscaria.—In general arrangements *L. Viscaria* resembles the preceding species. It is glabrous, but each segment of the stem is very sticky in the upper part, which prevents creeping insects from obtaining access to the flowers. The length of the tube and narrowness of the passage render the flower especially adapted for butterflies.

L. vespertina.—This species is also viscid, but only slightly so. The flower, which is white, opens in the evening, generally about six o'clock, when also it becomes very sweet. It closes about nine in the morning, becoming limp and faded, and looking almost dead, till the following evening, though in dark gloomy weather it sometimes remains open all day. The pale colour is probably an advantage, as being the most visible in twilight. These characteristics—white or light yellow colour, and sweetness at night—are characteristic of other species which are specially adapted for fertilisation by moths. The honey is secreted by the base of the ovary. There are three forms of flower—male, female, and hermaphrodite. In the female the tube has a length of 20-25 mm.; in the male, 15-18 mm. The length of the

stamens and pistil also varies. Some plants are hairy, some quite glabrous, and there appear to be in this country¹ no intermediate forms.

L. diurna.—This species in many respects resembles *L. vespertina*, and the two have by many botanists been regarded as varieties. They are no doubt descended from a common ancestor, but while *L. vespertina* has gradually adapted itself to moths, opening at night and closing by day, *L. diurna*, on the contrary, is a bee flower, opening by day and closing by night. It seems probable that the common ancestor was red, which, however, is not a suitable colour for night flowers. Bees, as a rule, have a shorter proboscis than moths, which may perhaps account for the fact that the tube of the flower in *L. diurna* (12-15 mm.) is somewhat shorter than that of *L. vespertina*. The seeds are black or deep brown, large, and covered with points in parallel longitudinal rows.

SILENE

This genus differs from *Lychnis* in having three styles, and the capsules open with six teeth.

S. inflata.—Glaucous green, usually glabrous plants. The flowers are protandrous, with white petals; they are adapted to butterflies and humble bees. In this interesting plant there are, according to Axell,² three forms—those with both stamens and pistils, those with stamens only, and those with pistils only; in the latter the flowers are smaller than in the other two forms. Schulz has pointed out in addition that some are gynomonœcious, and some are andromonœcious. The tube of the flower is 10-12 mm. in depth, and wide enough to admit the proboscis of a humble bee. Another remarkable point about *S. inflata* is that while in most of the allied species the calyx closely surrounds and thus supports the petals, in this it is, as the name denotes, inflated so

¹ Bateson and Saunders, Roy. Soc. Report to Evolution Committee, 1902.

² *Om Anordn för Fan. Växt. Befruktn.* p. 46.

as only to touch them at the base and summit. An eminent French entomologist, M. Fabre, has pointed out that while bees eat their way through the tough cocoon, if this is enclosed in paper—even tissue-paper—they perish, not thinking of eating through a second, even much thinner, obstacle. It has already been mentioned more than once (see p. 64) that bees often rob tubular flowers of their honey by eating through the base of the tube, and it has occurred to me that the inflation of the calyx thus tends to protect the honey. I say tends, because the device is not in all cases successful. The legitimate visitors are butterflies, moths, and the humble bees with long probosces. Kerner doubts whether inflated calyces are in all cases intended to protect the honey, because the proboscis of the average humble bee is at least 8 mm. in length, and the distance between the calyx and corolla is generally less. But his reasoning is, I think, fallacious. In the first place, inside the calyx is the corolla, and this the mandible could not reach.

With us the plant is generally glaucous, and throws off moisture, except in the angles between the leaves, where rain collects, and is no doubt absorbed. There is, however, a variety—*puberula*—with short curly hairs, and in the hot dry climate of the south the plant develops a thick covering of hair, probably as a protection against too rapid transpiration.

S. nutans (Nottingham Catchfly).—This is also a protandrous, nocturnal moth-flower. The life of the flower lasts three days, or rather three nights. The stamens are ten in number, arranged in two sets, the one set standing in front of the sepals, the other in front of the petals. Like other night flowers, it is white, and opens towards evening, when it also becomes extremely fragrant. The first evening, towards dusk, the five stamens in front of the sepals grow very rapidly for about two hours, so that they emerge from the flower; the pollen ripens, and is exposed by the bursting of the anther. So the flower remains through the night, very attractive to, and much visited by, moths.

Towards three in the morning the scent ceases, the anthers begin to shrivel up or drop off, the filaments turn themselves outwards, so as to be out of the way, while the petals, on the contrary, begin to roll themselves up, so that by daylight they close the aperture of the flower, and present only their brownish-green under sides to view, which, moreover, are thrown into numerous wrinkles. Thus, by the morning's light, the flower has all the appearance of being faded. It has no smell, and the honey is covered over by the petals. So it remains all day. Towards evening, however, everything is changed. The petals unfold themselves; by eight o'clock the flower is as fragrant as before, the second set of stamens have rapidly grown, their anthers are open, and the pollen again exposed. By morning the flower is again "asleep," the anthers are shrivelled, the scent has ceased, and the petals rolled up as before. The third evening, again the same process occurs, but this time it is the pistil which grows: the long spiral stigmas on the third evening take the position which on the previous two had been occupied by the anthers, and can hardly fail to be dusted by moths with pollen brought from another flower.¹ Schulz questions this description, which, however, tallies with my own observations; but it is possible that the flowers behave somewhat differently in different localities. They are sometimes visited by insects during the day. The name "Catchfly" has been given it because the upper part of the stem is viscid and small flies are often glued to it. The object, no doubt, is to prevent ants and other creeping insects from robbing the flowers of their honey. After flowering the ovary is at first pendent, but by the time the seeds are ripe has become upright, so that they do not drop out of themselves, but are pushed out and scattered when there is any wind. After fertilisation the plant ceases to be viscid.

S. noctiflora is also a night flower, opening about six in the evening, and is probably fertilised by moths.

¹ Avebury (Lubbock), *Fruits, Flowers, and Leaves*, p. 40.

S. acaulis is tricœcious. It is richly visited by insects.

S. Otites, on the contrary, is said to be generally wind-fertilised. The flowers are yellowish green, small, and numerous. They are dicœcious, the male flowers being the more numerous. Hermaphrodite flowers also sometimes occur. In the north Frisian island Röm, and in the Tyrol, both kinds of flowers secrete honey and are visited by insects. In mid-Germany, according to Schulz, the nectaries of the male flowers secrete no honey, and though the female flowers still produce some, yet from the close adherence of the calyx and corolla it is not accessible to insects in the normal way.

SAPONARIA

While *Lychnis* has 5, or rarely 4, and *Silene* 3 styles, in *Saponaria* there are only 2.

S. officinalis (Soapwort) is a protandrous moth-flower. The calyx forms a tube 18-21 mm. in length. The pink, or white, petals are obcordate, and abruptly contracted into a long narrow claw. The five outer stamens ripen first, and open their anthers just over the flower. When they have shed their pollen they shrivel up and make way for the inner five stamens. When these, in their turn, are exhausted, the two stigmas elongate and take up the same position. The honey is in the base of the long tube, and only accessible to hawkmoths and some moths. The hawkmoths *Sphinx ligustri*, *S. convolvuli*, and *Macroglossa stellatarum* (the Humming-bird hawkmoth) appear to be the most frequent visitors. The flowers are very sweet at night; in the day their scent is faint. The plant is protected by a poisonous ingredient in the sap.

ALSINEÆ

In the second division of the Caryophyllaceæ the sepals are separate, or but slightly connected at the base. The petals therefore can separate, and the honey, which is generally secreted at the base of the stamens,

being thus rendered more accessible, the flowers, though generally small, are much visited by insects, especially flies and the smaller species of bees. The normal number of stamens is 10, but there are often fewer. Generally it is the inner circle, or some of them, which have disappeared; but in some cases not only the inner circle but some even of the outer have disappeared; *Stellaria media* (Chickweed), for instance, has generally only 3 instead of 5. The disappearance is sometimes complete, but sometimes rudiments, more or less developed, still remain. The pistil, however, is always present. In some cases the complete and female flowers are on the same, sometimes on different, plants. As usual, the female flowers are smaller than those which possess stamens. As in the preceding subfamily, the anthers of the outer stamens generally open before those of the inner circle. The pistil generally ripens after the anthers. Most of the species secrete honey at the base of the petals. The flowers have a tendency to close in wet and gloomy weather, and present many gradations towards cleistogamy. *Stellaria media*, var. *pallida*, has in some neighbourhoods become completely cleistogamous.

ARENARIA

A. serpyllifolia.—Bentham and Hooker describe this species as an annual, and so, no doubt, in Britain it is; but on the summit of the Pyrenees it is said to live for several years.

SAGINA

The flowers are small and solitary. The petals are sometimes absent.

S. procumbens has 4, rarely 5, sepals and petals, with a corresponding number of stamens. The stamens have nectaries at the base. The flowers are often, perhaps generally, self-fertilised. They are visited by *Collembola*, ants, and other small insects.

S. Linnæi, on the contrary, is slightly protogynous. It is larger than the preceding species. The petals,

sepals, styles, and valves of the capsule are 5, the stamens 10, in number. The plant is perennial. The flowers are visited by flies and small beetles, but in bad weather they remain closed and fertilise themselves; as also do those of

S. nodosa, which resembles the preceding, though the leaves are shorter and the petals longer in proportion. It forms small perennial tufts. In some of the flowers the stamens are more or less suppressed. The complete flowers are protandrous.

STELLARIA

In most of the species of this genus petals are sometimes wanting.

S. graminea.—The stems are quadrangular and straggling. The petals are narrow and deeply cleft. The nectaries are 5, at the base of the 5 outer stamens. The flowers are protandrous. The five outer stamens just raise themselves over the opening of the flowers, and the anthers open. After a while they bend outwards and downwards, and the inner circle take their place. These then go through the same movements, while the styles elongate, raise themselves, and in their turn eventually curl outwards and downwards. The result is that insects visiting the flower for the sake of the honey can hardly fail to dust themselves with the pollen of flowers in the first two stages and transfer it to the styles of older flowers. In the absence, however, of insect visits, the styles can hardly fail to come in contact with one or other of the anthers, and thus the flower fertilises itself. Besides these complete flowers there are others in which the stamens, or some of them, are more or less incompletely developed. The flowers differ considerably in size in different districts. They are visited by bees, butterflies, moths, beetles, and flies.

S. Holostea (Stitchwort).—This species is larger and stronger than the preceding. The structure and life-history of the flower is similar. The nectaries are yellow. The stems are quadrangular.

S. media (Chickweed).—Some of the stamens are generally more or less suppressed, being thus reduced from 10 to 8, 6, or even 2. The violet anthers ripen about the same time as the stigmas. If not already visited by insects, the flower is almost sure to fertilise itself when it closes. According to Čelakovsky, the variety *Borœana* is cleistogamous. Bateson has made some experiments with seeds from cross-fertilised and self-fertilised flowers. The former were found to be more vigorous in the proportion of 100:91. A remarkable peculiarity of the Chickweed is, that while the rest of the plant is glabrous, there is a line of comparatively large hairs running down the stem, and a few long ones on the leaf-stalks. Bentham says of this line of hairs that they “run down one side of the stem.” This does not exactly express the case. The leaves are opposite decussate, *i.e.* each pair is opposite and at right angles to the pairs immediately above and below. The bases of the two leaves form a small cup. In many cases a flower-stalk rises between the leaves. The line of hairs is always on the side opposite the flower, and changes its place, therefore, at each node. The stalks of the leaves are somewhat hollowed above, and their edges are fringed with long hairs. These and the hairy ridges of the stem are easily wetted, and retain for some time the rain that falls on the leaves. It is said to be absorbed by the lower part of the hairs. It is probable that the line of hairs serves to conduct the rain-water from each cup to the one below.¹ These hairs are full of sap, and act quite differently from the dry hairs, by means of which so many plants protect themselves against too rapid transpiration.

Seeds of *Stellaria media* are among the most common in recent geological strata. Mr. Clement Reid cites it from various localities from preglacial to neolithic times.

¹ Lundström, *Act. Nov. Upsal.* 1884-85.

CERASTIUM

White flowers, with half-concealed honey.

C. arvense.—The general arrangements of the flower agree in the main with those of *Stellaria Holostea*. Besides the complete flowers, there are other smaller ones with more or less rudimentary stamens.

C. vulgare.—Bentham calls this a protean species, and by other botanists it has been divided into several, even as many as 20 to 30. In the facts of their life-history they agree in the main with the preceding species.

SPERGULA

In the preceding genera of the family the leaves have no stipules. They are, as a rule, sessile, and broad at the base, thus protecting the young bud. In *Spergula* and *Spergularia*, however, the base of the leaves is narrow, but provided with two stipules, which, with the base of the leaf, serve the same purpose.

S. arvensis.—A cornfield weed. The stipules are small and scarious. The stamens are normally 5, but often fewer, and in some flowers absent. The flowers remain closed in bad weather and fertilise themselves. The seeds often have a wide, scarious border.

SPERGULARIA

S. rubra.—The stipules are much larger; the arrangement of the flower resembles that of the preceding species. The seeds also are often bordered, especially in the variety *marina*. The plant is found on sand and gravel in waste places, especially near the sea. The stipules develop early; they are connate at the base, scarious, persistent, and inserted just beneath the leaves, completely enclosing them in bud, covering their bases even when fully developed. This is a very unusual arrangement.

HOLOSTEUM

H. umbellatum.—The flowers are protandrous. The stamens vary from 2 to 5—3 being the usual number. Each has a green fleshy nectary at the base. The flower is visited by flies and bees, but often fertilises itself. The flowers are three to eight in number, forming an umbel. They are on long pedicels, erect when flowering, then turned down, but erect again when the seeds are ripe.

POLYCARPON

P. tetraphyllum.—The flowers are very small, and may almost be said to be cleistogamous, as indeed they have been by Wiesner.¹

PORTULACEÆ

MONTIA

M. fontana.—The seeds are comparatively large, black, and somewhat shining. The testa is covered with relatively large tubercles, densely arranged in lines following the curvature of the seed.

CLAYTONIA

C. perfoliata.—This species also has intensely black orbicular seeds. It is a North American plant which has become naturalised in Britain.

HYPERICACEÆ

HYPERICUM (St. John's Wort)

This is the only British genus of the family. The most characteristic feature is the large number of

¹ *Biologie der Pflanzen*, 1889.

stamens, which are united in three or five bundles. The flowers secrete no honey, but are much visited for the sake of the pollen. Hence, perhaps, the advantage of producing so many stamens. They also add considerably to the conspicuousness and beauty of the flowers.

H. calycinum and **H. Androsæmum** (Tutsan) are undershrubs, with large oval leaves, often grown in shrubberies. *H. Androsæmum* is probably native; *H. calycinum* has become naturalised in some of our southern counties.

H. perforatum (Common Hypericum).—The stem is generally round, but sometimes slightly angular. The leaves have numerous pellucid dots, looking like perforations, and giving its name to the plant. There are generally some black dots on the under side of the leaves, and on the petals, but not on the pointed sepals. The stamens are numerous and of different lengths; the shortest ones ripen first, then those of intermediate lengths, and the longest last. These only are as long as the pistil, and fertilise it if it has not already received pollen from another flower. The capsule is erect, and opens at the apex, so that the seeds are scattered by the wind. The seeds are oblong, narrowed at each end. They are dark brown, and strongly reticulated in polygonal areolæ. The flowers are largely visited by pollen-loving insects. H. Müller mentions over forty species, and some others have since been added to the list by Loew, MacLeod, Willis, and others. I do not find any suggestion as to the use of the pellucid dots. They contain an aromatic oily liquid, and may perhaps serve to prevent the plant from being eaten by browsing quadrupeds or by insects.

H. dubium.—The stem is sometimes round, but sometimes slightly quadrangular; it is perhaps in a state of transition. The leaves are nearly destitute of pellucid dots, and the petals and stamens have fewer black dots. The sepals are blunt.

H. quadrangulum.—In this species the stem is dis-

tinctly quadrangular. The leaves have numerous pellucid dots, and a few black ones. The sepals are pointed.

H. humifusum.—The stems are trailing. In bad weather the flowers do not open, and may be described as pseudo-cleistogamous.

H. pulchrum.—The stem is upright and slender; the leaves broadly cordate, and clasping the stem. The broad and obtuse sepals are fringed at the top with black glandular teeth.

H. montanum.—The sepals are fringed with black glandular teeth, and lanceolate. The leaves are ovate or oblong, with or without pellucid dots.

H. hirsutum has downy stems. The leaves are hairy underneath, with pellucid dots. The sepals are narrow, with rather long glandular teeth.

H. Elodes.—This is a small creeping bog plant 6-8 inches long. Like many other species with a similar habit, it is clothed with loose, woolly, whitish hairs, which probably serve to protect the stomata from being clogged with moisture. Each of the petals has at the base a divided scale, which perhaps secretes honey, and at the base of the stamen clusters are small divided glands, which are pressed against the ovary and perhaps also secrete honey.

LINACEÆ

LINUM (Flax)

Homogamous flowers, with concealed honey. The parts are in fives. Each of the five cells of the ovary is divided into two by a nearly complete partition. The seeds, as we know from the familiar linseed poultice, secrete a mucilaginous, adhesive substance, which exudes freely as soon as the seeds are moistened. This is useful to the plant in glueing the seeds to the damp earth. The flowers in many species are dimorphous, in some even trimorphous. In some species they close up at

night and in wet weather. The capsules open by ten longitudinal slits, the lignified part being thinner and less compact along the lines of dehiscence.

L. catharticum.—The anthers and stigma are about at the same height; but at first the stamens are curved outwards. As, however, they gradually turn inwards, and, moreover, as the flower closes at night if it rains, it can easily fertilise itself. The stem is quadrangular; the lower leaves are opposite, the upper alternate.

L. usitatissimum (Common Flax).—An annual, with erect stem and alternate leaves. The sepals are pointed. The flowers are much larger, and of a beautiful blue, but in structure resemble those of the preceding species. They are visited by butterflies and moths, humble bees, and bees, as well as flies. The value of flax fibres for thread is mainly due to the “bast” fibres, the cells of which attain the unusual length of 20-40 mm. They are, moreover, as strong as iron.

L. angustifolium.—Like the preceding, but sometimes perennial; decumbent in habit, and with smaller flowers.

L. perenne.—A perennial, with alternate leaves. The sepals are obtuse, the petals large, but not so large as in the Common Flax. The flowers are dimorphous, as in the case of the Cowslip and Primrose; that is to say, the anthers are in some flowers above the stigma, while in others the stigma is above the anthers. The two forms never occur on the same stock, and the object is to ensure cross-fertilisation; insects carrying the pollen from the long-styled flowers to the short-styled, and *vice versa*. Darwin,¹ since confirmed by Hildebrand, has shown that the long-styled form is sterile, and the short-styled nearly sterile, to pollen of its own form. In the long-styled forms the stigmas first face inwards; but as the insect must insert its proboscis outside the ring of broad filaments, it would not touch the stigma. Subsequently, however, the stigma turns itself round, and thus faces and touches the proboscis.

¹ Darwin, *Forms of Flowers*.

RADIOLA

This genus represented by *R. millegrana*, differs from *Linum* in having the parts of the flower in fours, and the sepals united to near the middle. It is a minute annual, not native in Britain, but not infrequent as an escape from cultivation.

MALVACEÆ

Sepals and petals 5. Below the calyx are three or five bracts forming an involucre. The stamens are numerous, and the filaments are united in a tube round the pistil. The flowers are protandrous.

LAVATERA (Tree Mallow)

Involucre three-lobed. The carpels, 10 or more in number, are arranged in a ring round a common axis; resembling a flat loaf. When ripe they split off singly, and are remarkably like small brown or green caterpillars or centipedes. The effect of this may perhaps be to induce birds to carry them about.

L. arborea.—Very local. Principally on the south and west coasts and on the Bass Rock.

ALTHÆA (Marsh Mallow)

Involucre six- to nine-lobed. The Hollyhock belongs to this genus.

A. officinalis (Marsh Mallow) occurs south of the Clyde in marshes near the sea.

MALVA (Mallow)

M. sylvestris (Common Mallow, Fig. 63).—Honey is secreted at the bases of the petals. When the flower

opens the anthers are arranged in a cone over the as yet undeveloped stigmas. After they have shed their pollen they become limp and droop, as in Fig. 63, 2. The styles then elongate, and take the position previously occupied by the stamens. The flowers are much visited by insects, and as the styles are not ripe until the anthers have shed

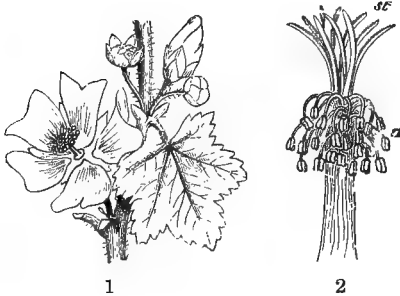


FIG. 63.—1, *Malva sylvestris*; 2, stamens (*a*) and stigmas (*st*) of same.

their pollen, the flower can hardly fertilise itself, which under the circumstances is not necessary. Perhaps for the same reason it does not matter that the honey is not thoroughly protected. Knuth gives a list of over

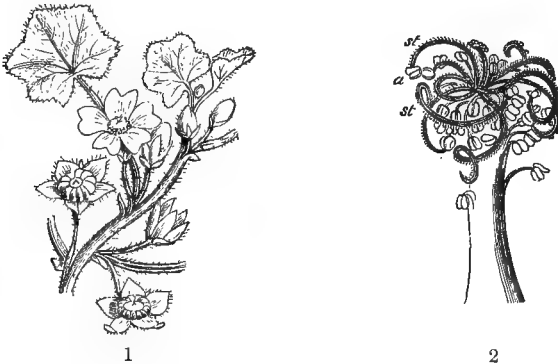


FIG. 64.—1, *Malva rotundifolia*; 2, stamens (*a*) and stigmas (*st*) of same.

fifty insect visitors recorded by H. Müller, himself, and other observers. The bees generally visit the flowers for the sake of the honey, but one species, at any rate, *Chelostoma nigricorne*, comes for the sake of the pollen.

M. rotundifolia is homogamous, or nearly so. The flowers are smaller, and the visits of insects less frequent.

The styles, however (Fig. 64, 2), twine themselves among the stamens, so that the flower can hardly fail to fertilise itself.

M. moschata. — The leaves are more divided, the flowers large and crowded at the summits of the branches. The back of the carpels is rounded and hispid (Fig. 65).

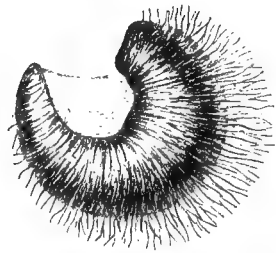


FIG. 65.—Carpel of *Malva moschata*.

The seedlings of Mallow are interesting. I have discussed them and the cause which has determined the form of the cotyledons in my work *On Seedlings*, vol. i. p. 40.

TILIACEÆ

A large tropical and semi-tropical order, represented in Britain by a single species, the beautiful Lime tree. Bentham and Hooker regard it as “truly wild in Southern and Western England, and perhaps in Ireland.” In spite, however, of these high authorities I doubt it.

TILIA (Lime Tree or Linden)

The indigenous form of Northern Europe is the small-leaved species *T. parvifolia*. The species we generally plant, *T. platyphyllos*, which has much larger leaves, is probably of South European origin, though it is considered by some authorities to be truly wild in Herefordshire, Radnorshire, and the West Riding. The flowers are very sweet-scented, smelling strongly of honey. They are pendulous, and so arranged as to lie under and be protected by the broad leaves. The nectaries are at the base of the calyx. The flowers are protandrous, and so richly visited by insects that cross-fertilisation is well assured. Nevertheless, though the visits of insects are so numerous

that the whole atmosphere round a flowering Lime is filled by the "murmurs of innumerable bees," the species of insects visiting it are few, and Knuth only records twenty. The peduncles are bordered or winged half-way up by a long, narrow, leaf-like, persistent bract (Fig. 66). When the fruits drop this catches the wind and thus the seeds are dispersed. The flowers are inconspicuous. The strong scent is quite sufficient to attract insects, and bright colours are therefore unnecessary. A remarkable point about the scent of the Lime is that it is said to be strongest about thirty yards from the tree, as if the strength was brought out by some action of the air as it gradually diffuses. A similar observation has been made in the case of the Vine.¹

The expanding leaf-buds assume a drooping position, so that the leaves look as if they were being poured out.

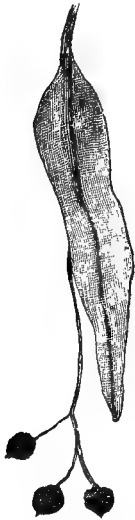


FIG. 66.—Fruits and bract of Lime.

The advantage thus gained is that radiation of heat is much less than it would be if the leaves were to assume at once their permanent position. Darwin has shown that this position really does tend to check the effect of radiation. His experiments, he says, "show that leaves compelled to remain horizontal at night suffered much more injury from frost than those which were allowed to assume their normal vertical position."

The winter buds are described in my *Buds and Stipules*. The foliage leaves are stalked, broadly heart-shaped or nearly orbicular, often oblique, glabrous above, and more or less downy underneath, especially in the angles of the principal veins. The stipules are large and beautiful—a rich crimson or even a bright ruby. On the under side of the leaves at the base where the nerves diverge are more

¹ Step, *Wayside and Woodland Trees*.

or less triangular spaces, enclosed by the under side of the leaf, the walls of the nerves, and a fringe of long hairs. Attention to these was first called by Lundström,¹ who regards them as abodes—"domatia"—for mites. That they are not pathogenic, he proved by growing seedlings and carefully keeping mites away. This was, however, no easy matter, for the mites lay their eggs in the fruit, in which indeed there is, he considers, a special cavity prepared for the purpose. In this way the mites develop *pari passu* with the young plant. During the day the mites remain at home in the domatia, but at night, and sometimes during dull days, they run about all over the leaves, which, however, they do not appear to attack. He suggests—and the theory, though not proved, is probable—that the mites are useful in eating the spores of fungi, which might otherwise grow on and injure the leaves. M. Areschoug thinks he has observed that when the mites are numerous the leaves are specially large and healthy. In certain

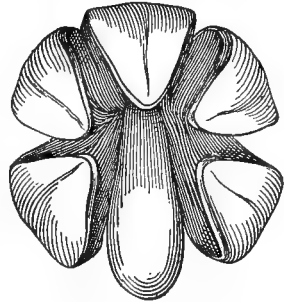


FIG. 67.—Lime embryo.

genera some species have domatia and others not; in the former the leaves are generally smooth, and in the latter protected by hairs. Similar domatia occur on the leaves of many other forest trees, as the Oak, Elm, Sycamore, Alder, Holly, etc.

The seedlings of the Lime (Fig. 68) are interesting² and peculiar. The cotyledons are leafy, and palmately five-lobed, somewhat like a hand. This form is very rare, if not unique. The seeds are obovoid; the embryo is at first straight, but ultimately follows the curvature of the seed (Fig. 67). If the leaf grew continuously in a hollow form, it is obvious that it could not unfold without rupturing itself. If any one will take a common tea-

¹ *Nova Acta Reg. Soc. Sci. Upsala*, ser. 3. xiii. fasc. 2 (1887).

² See Avebury (Lubbock), *On Seedlings*, i. p. 282.

cup and try to place in it a sheet of paper, the paper will, of course, be thrown into ridges. If these ridges

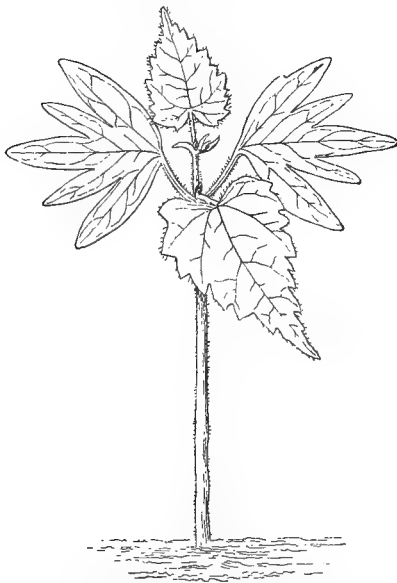


FIG. 68.—Seedling of Lime.

be removed and so much left as will lie smoothly inside the cup, it will be found that the paper has been cut into lobes more or less resembling those of the cotyledons of *Tilia*. Or if, conversely, a piece of paper be cut out into lobes resembling those of the cotyledons, it will be found that the paper will fit the concavity of the cup. The case is almost like that of our own hand, which can be opened and closed conveniently owing to the division of the five fingers. The Lime

flowers freely, but scarcely ever ripens its seeds in our country. Nägeli has calculated that a fine Lime tree contains 20,000,000,000,000 cells.

GERANIACEÆ

GERANIUM

Our twelve British species of this beautiful genus, while presenting considerable differences, agree in so many respects that they may conveniently be considered together. Five are perennial, generally with large flowers; seven are annual, with smaller flowers. They are generally wayside plants or weeds of cultivation.

The large-flowered species are protandrous, the inner row of stamens generally opening first. The flowers are much visited by insects and dependent on them for fertilisation. The species with smaller flowers are less visited by insects and less dependent on them. Honey is richly secreted by five nectaries, generally at the outer side of the base of the inner stamens. It is protected from rain and from creeping insects by a number of fine hairs just above the base of the petals. The presence of these hairs on the petals of *G. sylvaticum* started Sprengel on his classical study of flowers. He argued that the great Creator would have made nothing in vain, and therefore that even these tiny hairs must be of some use.

In the large-flowered species, as, for instance, in *G. pratense* (Figs. 69, 70), all the stamens open, shed their pollen, and wither away before the pistil comes to maturity. The flower cannot therefore fertilise itself, and depends entirely on the visits of insects



FIG. 69.—*Geranium pratense*.

for the transference of the pollen. In *G. pyrenaicum*, where the flower is not quite so large, all the stamens ripen before the stigma, but the interval is shorter, and the stigma is mature before all the anthers have shed their pollen. It is therefore not absolutely dependent on insects. In *G. molle*, which has a still smaller flower, five of the stamens come to maturity before the stigma, but the last five ripen simultaneously with it. Lastly, in *G. pusillum*, which is least of all, the stigma ripens even before the stamens. Thus, then, we have a series more or less dependent on insects, from *G. pratense*, to which they are necessary, to *G. pusillum*, which is

quite independent of them ; while the size of the corolla increases with the dependence on insects. In those species in which self-fertilisation is prevented by the circumstance that the stamens and pistil do not come to maturity at the same time, the stamens generally ripen first.

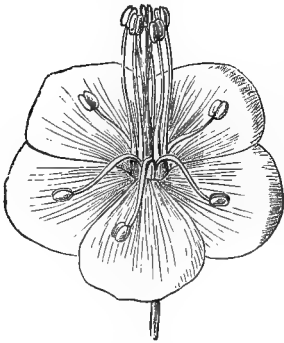


FIG. 70.—*Geranium pratense* (young flower). Five of the stamens are erect.

G. pratense agrees in many respects with *G. sylvaticum* (Fig. 71), but the flowers in the former are larger, and the pedicels of the fruit spreading or reflexed instead of erect. The plant is generally covered with glandular hairs. These species are visited by certain butterflies, moths, flies, and beetles, as well as by bees ; *G. phæum*, on the contrary, almost exclusively by bees, possibly, as Knuth has suggested, because the hanging position of the flower is inconvenient for other insects. *G. dissectum*, *G. columbinum*, and *G. pusillum* are protogynous. In the last species the five outer stamens rarely develop anthers. I have discussed the relations of the Geraniums to insects at somewhat greater length in my *British Wild Flowers considered in relation to Insects*. *G. Robertianum* does not possess the fringes of hairs by which, as already mentioned, the honey is in *G. sylvaticum* protected against the access of rain or creeping insects ; on the contrary, the petals are entirely glabrous. The flowers, however, turn over and hang down in wet weather. Moreover, the flower is less open than usual.



FIG. 71.—*Geranium sylvaticum*.

On the contrary, it forms a distinct tube, the entrance to which is sufficiently protected against rain by the stamens and pistil.

In *G. sylvaticum*, besides the usual complete flowers, there are, according to Lindman, smaller ones in which the stamens are more or less abortive; while Schulz has, in South Tyrol, found others in which the pistil is wanting. These are of large size; but on the higher Scandinavian mountains Eckstam has observed male flowers of small size.

A popular name for the Geranium—Crane's Bill—refers to the long beak of the fruit, which is part of the curious arrangement for the dispersal of the seeds. In *G. Robertianum* (Herb Robert), for instance, after the flower has faded, the central axis gradually elongates (Fig. 72, *c*, *d*, *e*). The seeds, five in number, are situated at the base of the column, each being enclosed in a capsule, which terminates upwards in a rod-like portion, which at first forms part of the central axis, but gradually detaches itself. When the seeds are ripe the ovary raises itself into an upright position (Fig. 72, *e*); the outer layers of the rod-like termination of the seed capsule come to be in a state of great tension, and eventually detach the rod with a jerk, and thus throw the seed some little distance. Fig. 72, *f*, represents the central rod after the seeds have been thrown. In some species, as, for instance, in *G. dissectum* (Fig. 73), the capsule rod remains attached to the central column, and the seed only is ejected. It will be remembered that the capsule opens on its inner side; hence if the carpel merely bursts outwards the only effect will be that the seed will be forced against the outer wall of the carpel and not be ejected, because the opening is not on the outer but on the inner side. This difficulty has been overcome in different ways. In some species, as, for instance, in *G. dissectum*, a short time before the dehiscence, the seed-chamber places itself at right angles to the pillar (Fig. 73, *a*). The edges then

separate, but they are provided with a fringe of hairs just strong enough to retain the seed in its position, yet sufficiently elastic to allow it to escape when the carpels burst away, remaining attached, however, to the central pillar by their upper ends (Fig. 73, *c*). In the common

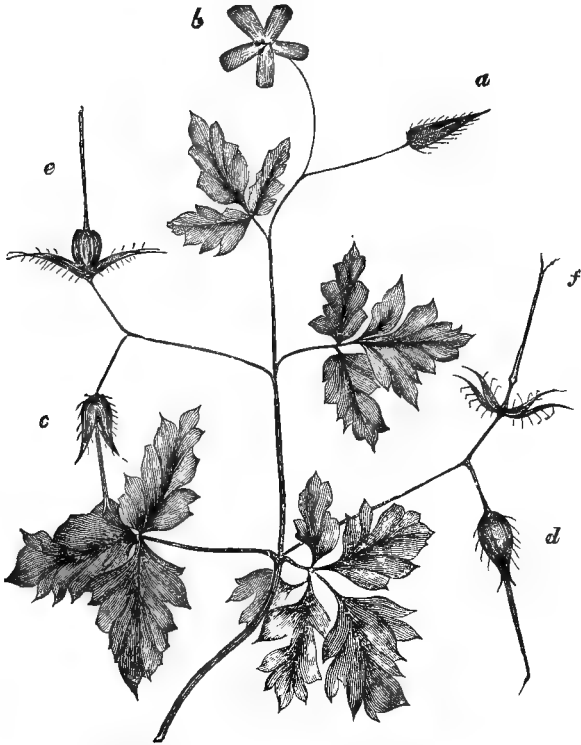


FIG. 72.—Herb Robert (*Geranium Robertianum*). *a*, bud; *b*, flower; *c*, flower after the petals have fallen; *d*, flower with seeds nearly ripe; *e*, flower with ripe seeds; *f*, flower after throwing seeds.

Herb Robert (Fig. 74) and some other species (*G. molle*, *pusillum*, *lucidum*, *pyrenaicum*, etc.) the arrangement is somewhat different. In the first place, the whole carpel springs away (Fig. 74, *b*, *c*). The seed-chamber (*c*) detaches itself from the rod of the carpel (*b*), and when the seed is flung away remains attached to the latter. Under these circumstances it is

unnecessary for the chamber to raise itself from the central pillar, to which, accordingly, it remains close until the moment of disruption (Fig. 74, *a*). The seed-chamber is, moreover, held in place by a short tongue, which projects a little way over its base, while, on the other hand, the lower end of the rod passes for a short distance between the seed-capsule and the central pillar. The seed-capsule has also near its apex a curious tuft of silky hair (Fig. 74, *c*), the use of which I will not here stop to discuss. As the result of all this complex mechanism, the seeds, when ripe, are flung to a distance which is surprising when we consider how small the spring is. In their natural habitat it is almost impossible to find the seeds when once thrown. I therefore brought some into

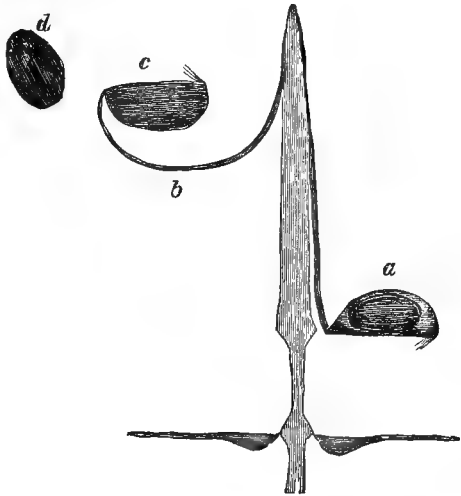


FIG. 73.—*Geranium dissectum*. *a*, just before throwing seed ; *b*, just after throwing seed ; *c*, the capsule still attached to the rod ; *d*, the seed.

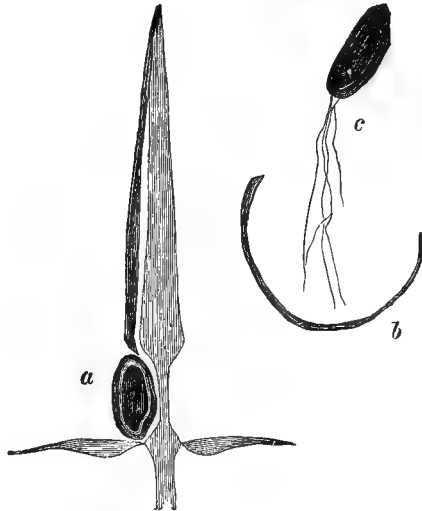


FIG. 74.—*Geranium Robertianum*. *a*, just before throwing the seed ; *b*, the rod thrown off ; *c*, the carpel and seed.

the house and placed them on my billiard-table. They were thrown from one end completely beyond the other, in some cases more than twenty feet. The mechanism by which this is effected has been described by Leclerc du Sablon.¹ He suggests that the fibres forming the rods are thicker and therefore contract more on the outer side, thus throwing the rods into a state of tension, so that eventually they burst away.

In some *Geraniums* the seeds are reticulate, and in others they are smooth. This seems to me to be connected with their relation to the carpel. This is shown in the following table :—

<i>G. sylvaticum</i>	}	Carpels not detached, hairy, not reticulate. Seeds thrown and reticulate.
„ <i>pratense</i>		
„ <i>rotundifolium</i>		
„ <i>columbinum</i>		
„ <i>dissectum</i>		
<i>G. Robertianum</i>	}	Carpels thrown, reticulate. Seeds smooth.
„ <i>lucidum</i>		
„ <i>phæum</i>		
„ <i>molle</i>		
„ <i>pusillum</i>		

In *Erodium*, also, the seeds remain in the carpel, and are practically smooth, the reticulations, if present, being very small.

In the seedlings the

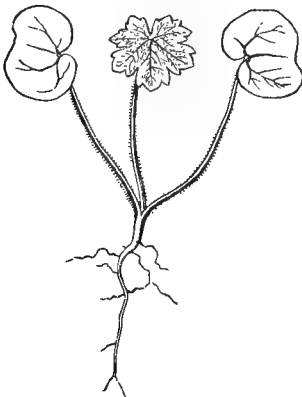


FIG. 75.—Seedling of *Geranium sanguineum*. Nat. size.



FIG. 76.—Section through embryo of *Geranium*, showing the mode of folding of the cotyledons.

two “halves” of each cotyledon are unequal. This is due to the manner in which the cotyledons are

folded. In the Cabbage and Mustard we have seen that

¹ *Ann. Sci. Nat.* ser. 6, xviii. (1884).

one cotyledon is folded inside the other ; in the *Geranium* they are convolute, one half of each being folded inside one half of the other—the inner halves being the smaller, the outer the larger ones.¹

The species differ considerably as regards hairs. In *G. sanguineum* and *G. phæum* they are long and spreading. In *G. sylvaticum*, *G. pratense*, *G. pyrenaicum*, *G. Robertianum*, *G. molle*, and *G. dissectum* those on the upper part of the stem are glandular, while in *G. sylvaticum* the lower part is glabrous or with reflexed hairs. In *G. pratense* those below are appressed ; in *G. pyrenaicum*, soft and short ; in *G. molle*, long, soft, and spreading ; and in *G. Robertianum*, few and soft. *G. dissectum* varies a good deal, but generally has long reflexed hairs ; while *G. lucidum* is glabrous or nearly so. The leaves of *G. sanguineum* assume a vertical position in bright sunlight.

The *Geraniums* of warm regions are generally annuals or biennials. The comparatively few Alpine species are, as usual, perennial.

ERODIUM

Of this genus we have three species : *E. maritimum* has simple ovate leaves, while *E. moschatum* has the leaves pinnate with ovate segments, and *E. cicutarium* pinnate with pinnatifid segments. Nectaries are present as in *Geranium*. The five stamens facing the petals are without anthers.

E. cicutarium.—This species was well described by Sprengel. There are two varieties of *E. cicutarium*, (a) *genuinum* and (b) *pimpinellifolium*. According to Ludwig, in the usual form, *E. cicutarium*, var. *genuinum*, the flower is homogamous or slightly protogynous. The anthers place themselves close to the stigmas, so that self-fertilisation is almost certain. The flower opens about 7 A.M., and by mid-day the petals have fallen. It is perfectly fertile with its own pollen. On the other hand,

¹ Awebury (Lubbock), *On Seedlings*, i. 298.

E. cicutarium, var. *pimpinellifolium*, is protandrous, and fertilised by insects. The flowers are larger, and the two upper petals shorter, broader, and deeper red than the three lower ones, which, being elongated, form a convenient alighting stage for insects. The upper nectaries are larger and secrete more honey than the lower ones. When the flower opens the pistil is short and undeveloped. First the upper and then the lower anthers open on the side turned away from the pistil. Gradually the filaments turn outwards, and on the second day the pistil has elongated and the stigmas are mature. The petals generally fall on the second day. Finally, the stigmas curl over and often come in contact with the anthers, so that in case of need the flower is self-fertilised. It would appear, however, that the flower differs somewhat according to localities. Besides the

complete flowers there are others without anthers, sometimes on the same, sometimes on special stocks. These are generally smaller. The flowers of *E. moschatum* are, according to Ludwig, homogamous or weakly protogynous. *E. maritimum*, according to the same author, is sometimes pseudo-cleistogamous.

The *Erodiums* have a beak like that of *Geranium*, but the action is different. The carpels do not open, but contract over the seeds, which thus remain attached to the awn, which is twisted and hairy, as shown in Fig. 77, which represents a seed of *E. glaucophyllum*. Nägeli has shown that the cell-wall is composed of parallel lamellæ of alternate degrees of density and refractive indices. The first series of lamellæ are seen in transverse sections of elongated woody cells, as concentric shells, alternately



FIG. 77.—Awned fruit of *Erodium glaucophyllum*.

light and dark, traversing the surface of the cell, and are in reality the edges of parallel lamellæ of alternate

densities. There are usually two systems of parallel lamellæ, and they may be inclined to the axis of the cell at almost any angle. Very frequently the two systems wind spirally round the axis in opposite directions. Now, according to Hofmeister,¹ when the tissue of the cell-wall expands during imbibition it is chiefly due to the swelling of the less dense striæ; and we have seen that these striæ are spirally arranged, therefore it is probable that the imbibition of water will result in spiral tension; and spiral tension will result in torsion—just as when a string is fastened to one end of a rod, and is coiled spirally round it, and the free end is pulled, the rod will tend to rotate on its axis.² Francis Darwin found that individual cells rolled themselves up. If this explanation be correct, it would seem to follow that the rods of *Geranium* do not twist, because the striæ are transverse and not inclined. Hildebrand, on the other hand, accounted for the action of the awn by the difference between the contraction of the woody fibres and that of the comparatively soft parenchyma, while Leclerc du Sablon accounts for it by the fact that the outer cells of the rod are more completely lignified, and therefore contract more than the inner ones. The spiral winding he explains by the fact that the woody bands are curved with the concavity outwards. In *Geranium*, when the rods are not spiral, the bands are not curved.

The amount of the spiral twisting in the awn depends upon the degree of moistness; and the seed may thus be made into a very delicate hygrometer, for if it be fixed in an upright position the awn twists or untwists according to the degree of moisture, and its extremity thus may be so arranged as to move like a needle on a register. It is also affected by heat. Now if the awn were fixed instead of the seed, it is obvious that, during the process of untwisting, the seed itself would

¹ *Lehre v. d. Pflanzenzelle* (1867).

² Francis Darwin, "On the Mechanism by which certain Seeds bury themselves in the Ground," *Trans. Linn. Soc. ser. 2, Bot. i.*

be pressed downwards, and, as M. Roux has shown, this mechanism thus serves actually to bury the seed. His observations were made on an allied species, *Erodium ciconium*, which he chose on account of its size. He found that if a seed of this plant is laid on the ground it remains quiet as long as it is dry, but as soon as it is moistened—*i.e.* as soon as the earth becomes in a condition to permit growth—the outer side of the awn contracts, and the hairs surrounding the seed commence to move outwards, the result of which is gradually to raise the seed into an upright position with its point on the soil. The awn then begins to unroll and consequently to elongate upwards, and he suggests that, as it is covered with reversed hairs, it will probably press against some blade of grass or other obstacle, which will prevent its moving up, and will therefore tend to drive the seed into the ground. If, then, the air becomes drier the awn will again roll up, in which action M. Roux thought it would tend to draw up the seed; but from the position of the hairs the feathery awn can easily slip downwards, and would therefore not affect the seed. When moistened once more it would again force the seed further downwards, and so on until the proper depth was obtained.

E. cicutarium is sometimes nearly glabrous, sometimes has glandular hairs; and in *E. moschatum* glandular hairs are always present, giving the plant a strong odour of musk, whence it derives its specific name. In *E. maritimum* the hairs are soft and often glandular.

OXALIS

Of this genus we have two species—*O. Acetosella* with white, *O. corniculata* with yellow flowers. Some of the foreign species are trimorphic (see Primrose and Lythrum), some dimorphic, others, including the two British, monomorphic.

O. Acetosella (Wood-sorrel).—This is one of the plants regarded as the Shamrock. The leaves have a pleasant

acid flavour. They are very delicate, and adapt themselves to differences of light in four ways—by movements of the whole leaf, by change of angle, by movements of the chlorophyll within the leaf, and by changes in the form of the chlorophyll grain. In strong sunshine the leaflets close slightly and move downwards (Fig. 78), so that the rays fall on them less directly; and also at night, serving as a protection against cold. Darwin's experiments clearly showed that leaves which were compelled to remain horizontal at night suffered more from frost than those which were allowed to assume a vertical position.¹

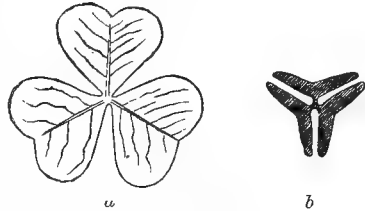


FIG. 78.—*Oxalis Acetosella*. *a*, Leaf seen from above by day. *b*, Leaf seen from above by night.

The motile organs are the very short stalks which connect the leaflets with the common leaf-stalk. Fig. 79 represents a transverse section in *Oxalis carnea*. Beneath the skin or epidermis is a mass of parenchyma surrounding an axial strand, containing the vascular tissue enclosed in a sheath. Fig. 80 gives a longitudinal section. The parenchyma presents no important differences. If the lower part swells and the upper contracts, as in Fig. 78, the leaflet rises; if the reverse, it sinks. The change is rendered possible by the extrusion or absorption of water.

It is remarkable that if the leaves are covered up at night so that they receive no light they will still open in the morning.² The movements are mainly due to the chemical rays. If the yellow, orange, and red rays are excluded, the plant reacts as if in white light; on the contrary, if the violet and blue rays are shut out, and the red end of the spectrum only allowed to pass through, the plant behaves as if in darkness.

Under normal conditions the cell represents a turgid bladder; the watery cell-sap being imprisoned by the

¹ *Movements of Plants*.

² Sachs, *Lectures on Physiology of Plants*.

elastic cell-wall and its lining of living protoplasm. Such an escape of water as is responsible for the movement is rendered possible only by this property of the protoplasmic lining undergoing some change, or, in other words, by the hitherto non-permeable protoplasm becoming permeable in consequence of the stimulus, and thus letting water escape. It must at the same

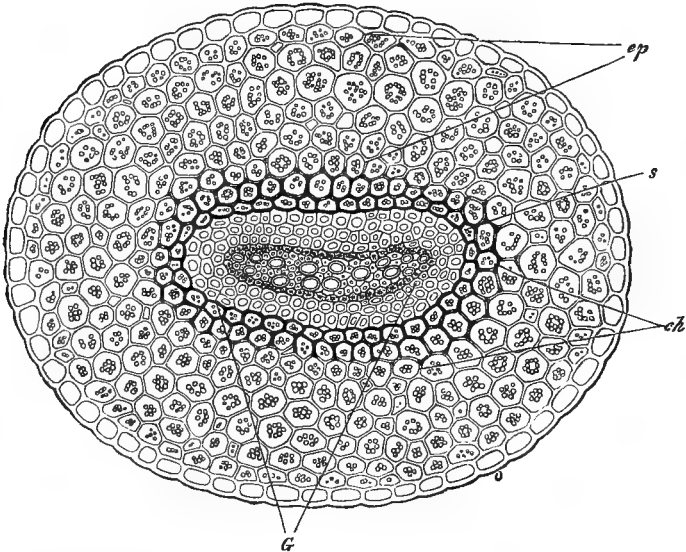


FIG. 79.—Transverse section of the motile organ of a leaflet of *Oxalis carnea*. *G*, axial vascular strand; *o*, epidermis; *ep*, parenchyma; *ch*, inner layers of parenchyma; *s*, sheath of vascular strand.

time be added that we can at present form no idea why this change in the protoplasm occurs in consequence of a stimulus, or with what molecular changes it is connected; all we know at present is that the externally perceptible effects of stimulation so far as described are caused by the change referred to in the protoplasm itself.

The movements of the chlorophyll grains within the cells were first noticed by Bohm. They have been well described by Stahl. The central tissue of

the leaves of *O. Acetosella* consists of three layers. The upper one consists of more or less blunt cones, the two lower ones of star-shaped cells, leaving large intercellular spaces between them. Some healthy leaves were laid flat on a plate and exposed to the rays of the sun falling perpendicularly on them. By pouring

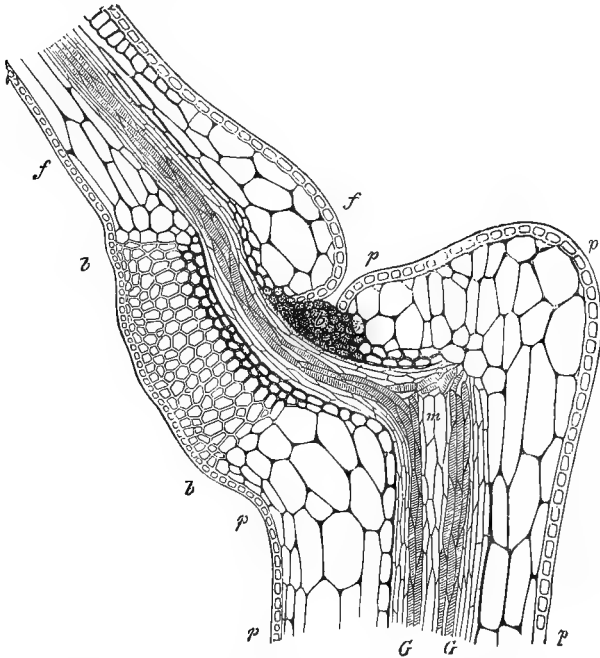


FIG. 80.—Longitudinal section of leaf-stalk and motile organ, *bbb*, of one of the leaflets of *Oxalis carnea* in the day position. *p*, epidermis of leaf-stalk; *f f*, midrib of leaflet; *G G*, vascular bundles; *m*, pith of leaf-stalk.

fresh water over them the leaves were prevented from becoming too warm. Other leaflets were protected from the direct rays of the sun by means of paper shades. After an hour the marked leaflets were placed in alcohol in order to fix the cell-contents in their natural position. The decolorised leaflets were so transparent that mere observation with transmitted light was sufficient to demonstrate the different dis-

tribution of the chlorophyll corpuscles in the shaded leaflets and those exposed to the sun. In diffused daylight the chlorophyll grains arrange themselves so as to receive the largest amount of light (Fig. 81, *a*); if the sunshine becomes stronger they collect on the cell-walls parallel to the rays, so as to receive less (Fig. 81, *b*) and if it continues they finally collect in lumps at the ends of the cells (Fig. 81, *c*).¹ This wonderful power of adaptation only exists in certain species.

The flowers are homogamous. They bend over

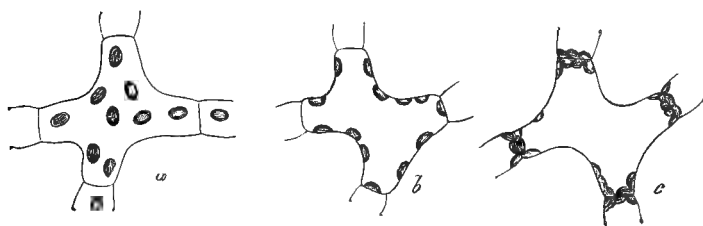


FIG. 81.—Arrangement of the chlorophyll grains from the lower parenchymal layer of *Oxalis Acetosella*: *a*, in diffuse light; *b*, in sunlight; *c*, in long-continued sunlight.

in wet weather. The nectaries are five fleshy projections at the bases of the petals, but the flowers are not much visited by insects. They are open, according to Kerner, from 9 A.M. to 6 P.M. The plant also produces cleistogamous flowers, first observed by Michelet.² The style varies considerably in length, showing perhaps a tendency to dimorphism. As so often happens with cleistogamous flowers, they bury their seeds in the ground.

When the flower fades the peduncle turns downwards, and the flower's head conceals itself among the leaves. When the seeds are ripe it straightens again, and then lifts the capsule well above the leaves.

¹ For a similar case see *Lemna*; for one in which the form of the grains changes see *Potamogeton*; for a change in the structure of the leaf see the *Dandelion* and *Fagus* (the *Beech*).

² Darwin, *Forms of Flowers*.

The species is also interesting as one of those in which the plant throws its seeds to a considerable distance; or rather the seeds throw themselves—a unique case in our English flora. The capsule is five-chambered, and contains two shining black seeds in each cell; the seeds are attached to the central pillar. The walls of the capsule opposite the middle of each chamber are very thin. The outer coat of each seed is a transparent covering, within which is a smooth, hard black testa. The outer coat contains four to five layers of parenchymatous cells. The cells of the inner layer are smaller than those of the outer, closely compressed, and gradually become very turgescient. This is not the case with the outer layer. Finally, the coat splits down one side, the inner cells expand at once, thus turning the coat inside out, the inner and now larger layer coming to the outside, while the originally outer layer is turned inwards. The result of this is that the seed is jerked out to a considerable distance. Owing to the elevation of the capsule the seeds fly clear of the leaves.

In the arrangement of the flower *O. corniculata* does not materially differ from *O. Acetosella*. The pod is more elongated.

IMPATIENS (Balsam)

Of this genus three species now occur wild in Britain: *I. Noli-me-tangere* (Touch-me-not), a rare species with yellow flowers, found in damp woody places in mountainous districts; and two others—*I. fulva*, an American species, with orange flowers, and *I. parviflora*, a Russian species, with very small yellow flowers, which have become naturalised in various places. The flower is very peculiar, and is thus admirably described by Bentham. The sepals and petals are “all coloured, and consist usually of 6 pieces, viz. 2 outer, opposite (sepals), flat, and oblique; the next (upper sepal, although by the twisting of the pedicel it hangs lowest) large, hood-shaped, ending below in a conical spur; the fourth (lower petal, but uppermost from the twisting of

the pedicel) much smaller, but yet very broad and somewhat concave; the 2 innermost (petals) very oblique and irregularly shaped, more or less divided into two unequal lobes.”¹

The flower-buds are at first above the leaves, which are folded and stand up round them like a screen. As the buds open the flower-stalk grows longer and turns down under the leaf from the axil of which it springs. The leaf flattens itself and fixes the flower-stalk in position by one of the lobes of its heart-shaped base. When expanded, the flower hangs horizontally under its leaf, from which the rain rolls off as from a roof

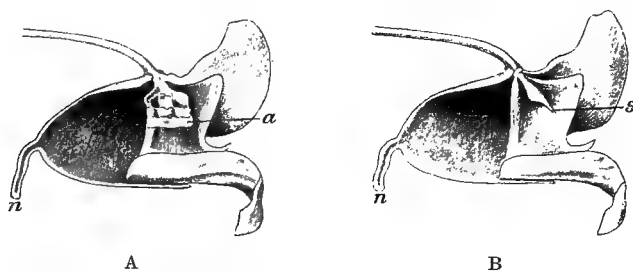


FIG. 82.—Flower of *Impatiens Roylei*. (The Balsam common in gardens, often self-sown.) A, Flower in the first stage. The anthers (*a*) stand over the entrance to the flower. B, Flower in the second stage. The stigmas (*s*) are over the entrance to the flower; *n*, nectary. Nat. size.

The two larger-flowered species are protandrous humble bee flowers. Some of the American species are fertilised by humming-birds. The honey is contained in the spur of the hooded sepal. The stamens are short, with very short thick filaments lying against the roof of the flower, so that a humble bee sucking the honey would necessarily dust its back with pollen. The anthers are ripe when the flower opens (Fig. 82, A). At that time the pistil is immature, but it gradually ripens (Fig. 82, B), and the result is that bees can hardly fail to carry the pollen from younger flowers to older ones.

I. Noli-me-tangere also produces cleistogamous

¹ Bentham, *British Flora*.

flowers; indeed, in the upland valleys of the Tyrol it is said to produce cleistogamous flowers only, in which the pollen grains are separate, not tied together by threads as in the open flowers. In the ordinary ones such a provision would be useless. According to Snyder and Meehan, in the United States *I. fulva* is visited by humming-birds.

The capsule is five-chambered. The dividing walls are thin, and eventually separate themselves from the centre, which thus becomes a pillar standing in the middle of the fruit. As the fruit dries the cells immediately below the epidermis are in a state of gradually increasing tension, more so than the layers below. Moreover, while the carpels of *Geranium* are straight, and thus assume a position like that of a watch-spring, those of *Impatiens* turn slightly to one side (the right), the result of which is that in contracting they resemble a corkscrew. Finally, the fruit bursts, the valves roll up suddenly like a watch-spring, and fly off, carrying the seeds with them. In this case, therefore, the elastic tissue is part of the ovary—not, as in the preceding genus, the outer coating of the seed itself.¹

Moreover, while in *Geranium* the inner cells swell and the valves curve outwards, in this case it is the outer layer which is elastic and the valves curve inwards. It is interesting and suggestive that our genera of this family should present such different modes of arriving at the same object.

The leaves are thin, flat, and delicate, as in other species which inhabit damp and shady localities (see *Dentaria*, p. 80).

¹ Zimmermann explained the dehiscence by the tension of the woody layer; Steinbrinck, by the difference between the tension of the woody layer and of the outer epidermis, which is also Eichholz's view (Pringsheim's *Jahrb. Wiss. Bot.* vol. xvii. (1886)).

ACERACEÆ

ACER

Of this genus two species occur in the British Isles, the Sycamore and the Maple.

A. Pseudo-platanus (Sycamore) has leaves somewhat resembling those of the Plane, whence the name. It is a native of Central Europe, and has no claim to be considered indigenous, though an ancient introduction. In autumn the leaves often present a number of black blotches, looking like drops of tar, each about half an inch in diameter. These are due to a parasitic fungus, *Rhytisma acerinum*. The leaves are opposite, and at an acute angle with the axis of the branch. A glance at Fig. 9 will show how beautifully Maple leaves are adapted to their conditions. The blades of the leaves of the upper pair form an angle with the leaf-stalks, so as to assume a horizontal position, or nearly so; the leaf-stalks of the second pair decussate with those of the first, and are just so much longer as to bring up that pair nearly, or quite, to a level with the first; the third pair decussate with the second, and are again brought up nearly to the same level and immediately to the outside of the first pair, so as to form a somewhat flat arch. In well-grown shoots there is often a fourth pair on the outside of the second. If we look at such a cluster of leaves directly from in front we shall see that they generally appear somewhat to overlap; but it must be remembered that in temperate regions the sun is never vertical. Moreover, while alternate leaves are more convenient in such an arrangement as that of the Beech, it is more suitable in such cases as the Sycamores and Maples that the leaves should be opposite, because if, other things remaining the same, the leaves of the Sycamore were alternate, the sixth leaf would require an inconvenient length of petiole.

If we look at the winter bud of a Maple or Sycamore (and the same is the case with many other trees, as, for instance, the Horse Chestnut), we shall find it covered by a number of brown leathery scales which are, like the leaves, opposite and decussate, so that one might at first sight be disposed to regard them as a simple form of leaf. On looking more closely, however, we shall soon find one which shows a scar or three small teeth at the summit. When the plant begins to grow in spring, some of the scales, especially on certain trees, enlarge somewhat, and show small but



FIG. 83.—Seedling of *Acer Pseudo-platanus*. Half nat. size.

often well-developed leaf-blades at their tip. In the Norway Maple these scales enlarge and assume a beautiful red colour, so that the growing bud looks almost like an opening flower. These bud-scales, therefore, are evidently the bases of leaf-stalks. If, without waiting for the spring, we open a bud in summer, say in July, we shall find five or six pairs of scales, each pair at right angles with the preceding, and then a beautiful little crown of tender green leaves.

The cotyledons are narrow and ribbon-like (Fig. 83). I have suggested the following explanation:—"The fruit (Fig. 84) is winged, the seed somewhat obovoid and exalbuminous—that is to say, the embryo, instead of lying

embedded in food-material, occupies the whole cavity of the seed. Now, if we wish to pack a leaf into a cavity of this form, it would be found convenient to choose one of a long strap-like shape, and then roll it up into a sort of ball. This is, I believe, the reason why this form of cotyledon is most suitable in the case of the Sycamore.”¹



FIG. 84.—Fruit and rolled cotyledons (A, B) of Sycamore. Nat. size.

A. campestre (Maple).

—A common plant in thickets and hedgerows. Native in England, and naturalised in Scotland. Here, as in the Sycamore and other species of the genus, the flowers contain either functional stamens and a central pistil rudiment, or a functional pistil and short stamens, the anthers of which do not open. That is to say, the flowers are functionally male or female. The distribution of the two kinds varies remarkably, sometimes occurring together on the same inflorescence, or at others distributed on different trees.

CELASTRACEÆ

This is a large family, of which we have only one representative.

EUONYMUS

E. europæus (Spindle Tree).—A glabrous shrub 5-15 feet high. The leaves are opposite, and the shoots more or less quadrangular. The flowers are greenish, and

¹ Avebury (Lubbock), *On Seedlings*, vol. i.

protandrous, with exposed honey. They are triœcious. The staminate flowers contain a rudiment of the pistil, and the pistillate rudimentary stamens. According to Darwin's experience, the apparently hermaphrodite flowers are, as a rule, functionally male, and in comparatively few cases produce seed.¹ The flowers are

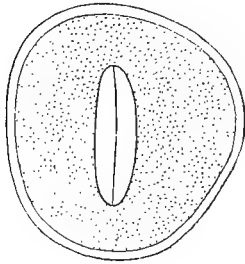


FIG. 85.—Transverse section of seed of *Euonymus*. $\times 8$.

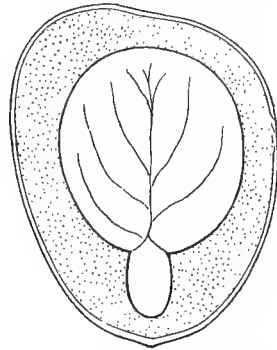


FIG. 86.—Longitudinal section of seed of *Euonymus*. $\times 8$.

principally visited by flies. The capsule, enclosing four to five cells, opens in as many valves along the middle of each cell. The pod is red when ripe, and when opened shows the seeds enclosed in a brilliant orange or red arillus. The embryo is embedded in albumen. It consists of two cotyledons (Fig. 85 and Fig. 86) and the radicle (Fig. 86). The cotyledons, which is very unusual, are quite green.

RHAMNACEÆ

We have only one genus, *Rhamnus*, the Buckthorn, with two species. *R. catharticus*, the Common Buckthorn, has the leaves toothed, and fruit black; while *R. Frangula*, the Alder Buckthorn, has the leaves entire,

¹ *Forms of Flowers*.

and fruit dark purple. The flowers in both species are small and greenish. In *R. Frangula* the petals, teeth of the calyx, and stamens are 5 in number; in *R. catharticus* the parts are in fours.

R. catharticus.—The flowers are dioecious, each containing the rudiments of the other sex; the male is larger than the female. They are sweet-scented, but not much visited by insects. Darwin distinguishes four forms—(1) a long-styled male, (2) a short-styled male, (3) a long-styled female, and (4) a short-styled female.

R. Frangula.—The flowers are complete, and more or less protandrous. Honey is secreted by the inner surface of the calyx. The petals are small, and each covers one of the anthers, forming a sort of small cap. The anthers are at about the same level as the stigma, and as they open inwards insects coming for the honey would touch them with one side of the head, and the stigma with the other, thus probably effecting cross-fertilisation.

According to Warnstorf, the flowers in the neighbourhood of Ruppın are homogamous. Schulz states that in some districts the pistil is longer than in others. They are visited by bees, humble bees, wasps, and flies.

LEGUMINOSÆ

We now come to the great and interesting order Leguminosæ, which falls into three groups, of which one only, the Papilionaceæ, is represented in Britain. Of this we have eighteen genera. The flowers, says Bentham,¹ are “in axillary or terminal racemes or spikes, rarely solitary. Sepals combined into a single calyx, more or less divided into 5 or fewer teeth or lobes. Corolla very irregular, consisting of 5 petals. The upper one, called the standard, is outside of all in the

¹ *Handbook of the British Flora.*

bud, and usually the broadest; the two lateral ones, called wings, are between the standard and the two lower ones, which are inside of all, and united more or less by their outer edge into a single one called the keel, the claws of all five petals remaining free. Stamens, 10; the filaments in the British species either monadelphous, all united in a sheath round the ovary, or diadelphous, when the upper one is free and the other nine united in a sheath. Ovary single, one-celled, with one, two, or more ovules arranged along the inner or upper angle (the one next the standard) of the cavity. Style simple. Fruit a pod, usually opening in two valves. Seeds with two large cotyledons, and no albumen."

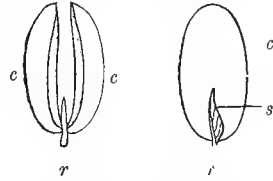


FIG. 87.—Embryo of Bean. *c*, cotyledon; *r*, radicle; *s*, plumule.

It is probable that all flowers which have an irregular corolla are fertilised by insects. The advantage of the irregularity is that it tends to compel the insects to visit the nectary in one particular manner, and thus to fertilise the flower. In the present group the result is that insects necessarily alight on a particular part of the flower, when their weight in many cases causes certain mechanical effects by which the pollen is transferred to the body of the insect, and thus carried from one flower to another. In the Leguminosæ the lower parts of the stamens coalesce into a hollow tube (Fig. 99), the inner walls of which, at their base, secrete honey in some species, though not in all. In the former, one or more of the stamens is detached, as in the Lotus (Fig. 100, *α*), or atrophied, so as to leave a space through which bees can introduce their proboscis into the tube. In those species which do not secrete honey this is unnecessary, and the stamens are all fully developed and united.

The wings often present certain projections or bosses which lock into corresponding depressions in the keel. The result is that if a bee lights on and depresses the

wings, the keel goes with them; and when the weight is removed, all three rise together again.

As a good illustration of the general arrangement of the flowers we may take the Sweet Pea, because, though it is not an English species, it is so common a garden flower, and is of a convenient size. When visiting it for the sake of the honey, insects do not generally alight directly on the keel, but rather on the wings, which are more conveniently situated; the two, however, are relatively so arranged, that when a bee alights on the wings it presses down the keel, which is locked with the two wings by a projection and corresponding depression; thus a portion of the pollen and also the tip of the pistil are forced out at the point of the keel, and against the breast of the bee, until on the removal of the pressure the elasticity of the flower causes the various organs to resume their former position.

The Leguminosæ are, as a rule, adapted for fertilisation by bees, though in some cases by Lepidoptera.

As regards the mechanism of the flower, Delpino has divided the Papilionaceæ into four divisions, which, however, are connected by numerous intermediate stages:—

1. Those in which not only the pollen but also some of the stamens are pressed out. The stamens and the pistil remain outside the keel as long as the pressure of the visiting bee lasts, but afterwards return immediately to their former position. Such blossoms permit several successful visits.

(a) Honey is excreted: *Melilotus*, *Trifolium*, *Galega*, *Onobrychis*, *Astragalus*, *Oxytropis*, *Phaca*, *Ornithopus*, *Hedysarum*.

(b) The sweet juice remains in the cellular tissue, and must therefore be bored for: *Cytisus* (some species of this genus show gradations towards 3 a).

2. Explosive flowers: those in which the flower bursts on pressure and ejects the pollen, the stamens

and the pistil springing out of the keel elastically. Such blossoms permit only one useful visit.

(*a*) Honey-containing flowers: *Medicago*.

(*b*) Honeyless flowers.

(*a*) The bee touches the pollen and the stigma with its under side: *Genista*, *Ulex*.

(*β*) The bee is powdered with pollen and stigma on the back: *Sarothamnus* (Broom).

3. Piston mechanism: those in which the pressure of the bee pumps out, as it were, a certain quantity of pollen; the flower resuming its original form when the pressure is removed. The thickened filaments press the pollen in single portions out of the top of the keel. Frequent insect visits are necessary for its fertilisation.

(*a*) Honey-containing flowers: *Lotus*, *Anthyllis*, *Tetragonolobus*, *Hippocrepis*.

(*b*) Honeyless flowers: *Ononis*, *Lupinus*, *Coronilla*.

4. The brushing arrangement: that in which, on the pressure of the bee, the pollen is swept out by a brush of hairs situated on the end of the pistil. This case does not seem to differ much from the preceding.

(*a*) The top of the pistil is straight: *Lathyrus*, *Pisum*, *Vicia*, *Lens*, *Robinia*.

(*b*) The top of the pistil is twisted in the form of a snail: *Phaseolus*.

The power of self-fertilisation seems to be lost in some species of *Phaseolus*, *Onobrychis*, and *Sarothamnus*; and to be much diminished in others, as in *Trifolium repens* and *Vicia Faba*.

Some species throw their seeds, owing to the elasticity of the pods, which,

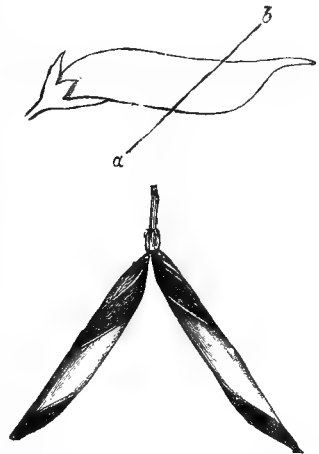


FIG. 88.—1, Pod of Common Vetch. The line *ab* shows the direction of the woody fibres. 2, Pod of Common Vetch after bursting open.

when ripe, open suddenly with a jerk. In *Genista* each valve of the pod contains an outer layer of woody cells, so strongly lignified that their internal cavity is almost obliterated.

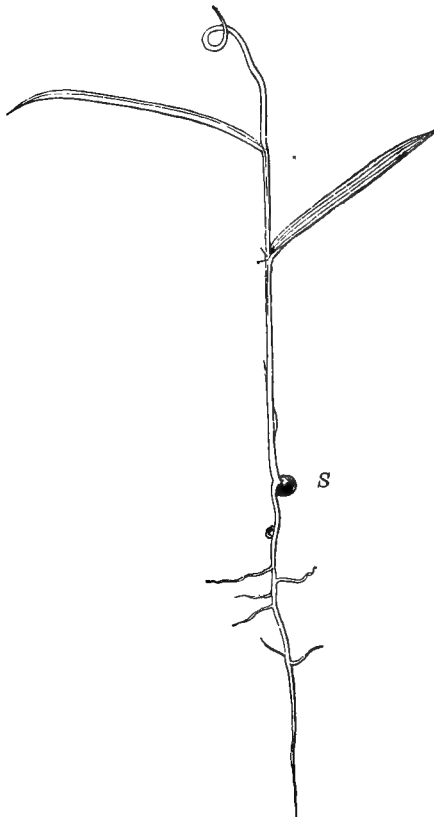


FIG. 89.—*Lathyrus Nissolia*. Seedling. Nat. size
S, seed containing the cotyledons.

The inner layers are less lignified and contract less. In *Vicia*, *Lathyrus*, etc., the fibres do not pass straight up the pod, but are crossed, and consequently when the pod bursts it does not, as in the case of *Cardamine*, roll up like a watch-spring, but twists itself more or less like a corkscrew (Fig. 88).

The seeds, as already mentioned, contain no surrounding albumen, as, for instance, those of *Euonymus* (see Fig. 86), but are entirely occupied by the embryo. If any one will examine the seeds of a Bean, a Pea, or a Laburnum,

for instance, he will find that they fall easily into halves (Fig. 87), the seed-leaves or cotyledons (*c c*); that at one end is the little root or radicle (*r*); while between them is the minute shoot (*s*) which will develop into the future plant. Every one knows split peas. Who split them? Nature. The halves are the two cotyledons. One result of the fleshiness of the coty-

ledons is that frequently the cotyledons are subterranean and do not leave the seed (Fig. 89). In some cases, as, for instance, in the Ground Nut of the West Indies (*Arachis hypogæa*), the plants themselves force the seed-pods into the ground. Some foreign species, but I believe no British, produce also cleistogamous flowers.

SAROTHAMNUS

S. scoparius (Broom).—The stems are wiry and green, having to some extent taken over the functions of the leaves, which are small and sometimes almost absent. The flowers produce no honey, but are visited for the sake of the pollen. Of the ten stamens, five

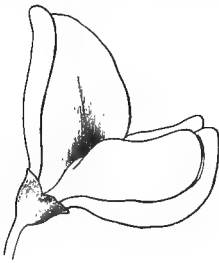


Fig. 90.



Fig. 91.



Fig. 92.

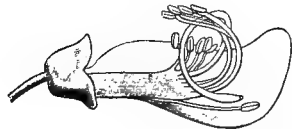


Fig. 93.

FIGS. 90-93.—*Sarothamnus* (the Broom).

FIG. 90.—Flower before explosion.

FIG. 91.—Flower seen from above after removal of the standard and wings.

FIG. 92.—Flower seen from the side after explosion of the short stamens. The standard and wings have been removed.

FIG. 93.—Flower seen from the side after complete explosion.

are long and five short. When a bee alights on an opening bud it presses its head under the standard, and the pressure of its hind feet tends to separate the wings and consequently to open the keel, which at first is closed by the cohesion of the upper edges (Fig. 92). When this is opened to a certain distance the short stamens suddenly appear (Fig. 93). The anthers had already opened in the bud, and they thus dust the under side of the bee with pollen. When the bud is older, or if the bee exercises greater pressure, the split of the edges

of the keel proceeds towards the point, against which the stigma is closely pressed, the pistil being in a state of considerable tension. As soon as the stigma is set free the flower explodes, the pistil bends itself as in Fig. 93 and rubs itself against the bee's back, followed almost immediately by the longer stamens and a shower of pollen.

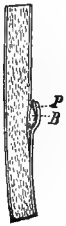


FIG. 94.—Shoot of Broom in vertical section, showing bud *B* protected by pedestal of last year's leaf *p*.

The explosion is facilitated by the narrowness of the claw of the keel, which is reduced to a mere thread. After explosion the keel hangs down, and the flower gapes widely. Humble bees, hive bees, and *Eucera* (one of the solitary bees) are alone capable of exploding the flower, but when this is once effected many insects come to partake of the pollen. Humble bees and hive bees, on the contrary, never descend to visit exploded flowers.

In winter the bud, as in many allied species, is protected by the persistent concave pedestal of the last year's leaf (Fig. 94).

Spartium junceum (Spanish Broom), so often grown in our shrubberies, agrees in most important particulars with the Common Broom.

LOTUS

L. corniculatus (Bird's-foot Trefoil) (Fig. 95), so called from the resemblance of the head of pods to the foot of a bird. As in many other leguminous plants, the leaflets have the power of movement, to which we have already referred; rising and approaching one another at night. The anthers burst and emit their pollen before the flower opens, and indeed before the petals have attained their full size. At this time the ten stamens form two groups, five of them being longer than the others; but by the time the flower opens they are all of the same length, though the five outer ones are somewhat swollen at the end; a difference which subsequently becomes still more marked. The pointed end of the keel is now filled by a mass of pollen

(Figs. 99, 100, *po*), while the anthers, having discharged their contents, begin to shrivel up. The free ends of the five outer stamens continue, however, to increase in size; so that, with the pollen mass, they completely fill up the cavity of the keel. When the flower opens, the pistil, stamens, and pollen occupy the position shown in Figs. 99, 100. The five inner stamens, having discharged their pollen, have become useless, shrivelled up, and lie in the broader part of the keel; the five outer ones, on the contrary (Fig. 99, *f*), which still have an important function to perform, lie behind the pollen mass, and keep it in its place.

Each of the wings has a projection (Fig. 97, *c*) which locks into a corresponding depression of the keel (Fig. 98, *c*), so that if the wings are depressed they carry the keel with them. Now, when an insect alights on the flower, its weight depresses the wings, and as they again carry with them the keel, the latter slips over the column of stamens, thus forcing some of the pollen out at the end of the keel and against the breast of the insect. As soon as the insect leaves the flower this resumes its natural position, and the pollen is again snugly protected. It will be observed (Fig. 99) that one stamen is separated from the rest. The advantage of this is that it leaves a space through which the proboscis of the bee can reach the honey, which is situated inside the tube formed by the united stamens. In those Leguminosæ which have no honey the stamens are all united together. Such flowers are, nevertheless, in spite of the absence of honey, visited by insects for the sake of the pollen.



FIG. 95.—*Lotus corniculatus*.

This is a polymorphic species ; sometimes glabrous, sometimes very hairy ; sometimes erect, sometimes low and spreading. The colour of the flower also varies

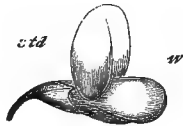


Fig. 96.

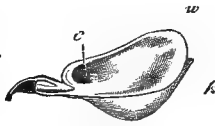


Fig. 97.

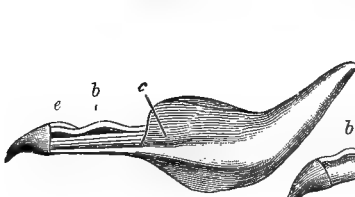


Fig. 98.

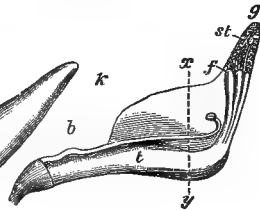


Fig. 99.

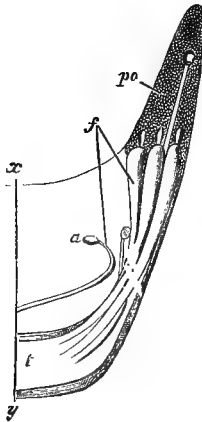


Fig. 100.

FIGS. 96-100.—*Lotus corniculatus*.

FIG. 96.—Flower seen from the side and in front.

FIG. 97.—Ditto, after removal of the standard.

FIG. 98.—Ditto, after removal of the standard and wings.

FIG. 99.—Ditto, after removal of one side of the keel.

FIG. 100.—Terminal portion of Fig. 99 more magnified.

a, the free stamen ; *b*, bend in filament of free stamen ; *c*, the place where the wings lock with the keel ; *e*, entrance to the honey ; *f*, stamens ; *g*, tip of keel ; *k*, keel ; *po*, pollen ; *st*, stigma ; *std*, standard ; *t*, staminal tube ; *w*, wing ; *xy*, in Fig. 99 marks the line of section as shown in Fig. 100.

—sometimes plain yellow, but often more or less streaked or flushed with crimson, becoming a deep rich orange.

GENISTA

This is the "Genet" from which the Plantagenets took their badge and their name. We have three species, but they are much more numerous in Southern

Europe, where some of the species have trifoliate leaves ; ours are all single-leaved. One of our species, *G. anglica*, is spinous. Of the other two, *G. pilosa* has the corolla and pods hairy ; the other, *G. tinctoria*, glabrous. The *Genistas* are pollen flowers, *i.e.* honeyless.

G. tinctoria.—The ten anthers¹ lie in two distinct rows. While the flower is still in the bud, the four upper anthers of the outer row are already on the point of opening, while those of the inner circle have not nearly reached their full size. These four anthers now open and shed their pollen into the space at the apex of the keel, after which they shrivel up. The fifth, although it has attained its full size, remains closed. The next process is that this anther and those of the second row also open, and the pollen occupies the end of the keel between the anthers and the stigma, as in *Lotus*. While, however, in *Lotus*, when the insect leaves the flower and the pressure is thus removed, the keel resumes its position and the stamens and pistil are again protected, in *G. tinctoria*, on the contrary, the flower opens once for all. The keel is at first nearly parallel to the standard (Fig. 101). This position is, however, one of tension ; the keel is retained in it by the union of its upper margins, which enclose and retain the curved pistil, which presses against them like a spring. The sides of the keel have near the base a projecting lobe (Fig. 103, *m*), which locks with one at the corresponding part of the wing. When an insect, alighting on the flower, presses open the keel in search of pollen, as soon as the curved end of the pistil is set free it springs up with a jerk, the keel, on the contrary,



Fig. 101.

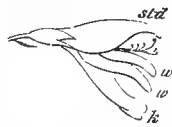


Fig. 102.



Fig. 103.

FIGS. 101-103.—Flower of *Genista tinctoria*.

FIG. 101.—Unopened.

FIG. 102.—Opened.

FIG. 103.—After being visited.

std, standard ; *w*, wing ; *k*, keel ; *m*, projection on keel.

¹ Avebury (Lubbock), *British Wild Flowers*.

springs back (Fig. 103), and the pollen is ejected in a shower. It appears that the flowers do not open of themselves if insects are prevented from visiting them. The plant is sometimes glabrous, sometimes with scattered hairs. The pods are always glabrous, except in the variety *humifusa*, found only in the Lizard district and at St. David's Head, Pembroke.

G. anglica.—The arrangement in this species and in *G. pilosa* resembles that of *G. tinctoria*, but when open the flowers do not gape so widely. The lower branches are converted into short thorns. There are two forms of leaves. Those of the sterile branches are linear or narrow lanceolate; those of the flowering branches obovate and very obtuse. The plant is quite glabrous.

G. pilosa, a prostrate plant found on gravelly heaths in the southern portion of England, but rare, is, as the name implies, hairy.

ULEX (Furze or Gorse)

Of this genus we have two species: *U. europæus*, our common Gorse, with hairy sepals and bracts about half a line long; and the Dwarf Furze, *U. nanus*, with nearly glabrous sepals and scarcely perceptible bracts. The arrangement of the flowers is on the same plan as in *Genista*. In the mature plant the leaves are reduced to spines, but if we examine a seedling (Fig. 104) we shall find that the cotyledons are succeeded by several trifoliate leaves, with ovate leaflets. These gradually become narrower, more pointed, and stiffer, thus passing into spines.

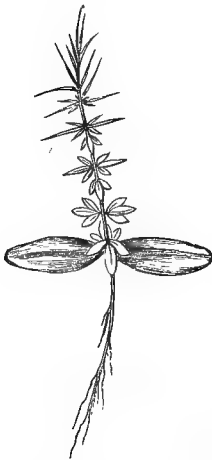


FIG. 104.—Furze Seedling.

Hence we can hardly doubt that the present Furze is descended from ancestors with trifoliate leaves.¹

¹ Avebury (Lubbock), *Flowers, Fruits, and Leaves*.

ONONIS

We have two species—one (*O. arvensis*, Rest-harrow) is perennial, and often thorny; the other (*O. reclinata*) is annual, and the peduncle is jointed beneath the flower. Ononis does not secrete honey, and consequently there is no need for the separation of the upper stamen, which in this genus is attached to the rest. Again, in Ononis all the stamens are thickened at the end; the outer ones, however, much more so than the inner ones. The inner ones, on the contrary, produce much more pollen than the others—a difference of function which is even more marked in the Lupins. The keel forms a tube, closed except at the end, where there is a small orifice through which the pollen is pressed.

Both our species are somewhat variable. *O. arvensis* is sometimes prostrate, sometimes erect, generally clothed with short spreading hairs, and more or less glutinous, but sometimes glabrous. The hairs are either scattered or collected in two opposite lines. The lateral leaflets are sometimes wanting. The plants are usually spiny, but show much variation in this respect, and some forms are unarmed. *O. reclinata* is slightly hairy, often viscid.

MEDICAGO

This is a large genus, of which we have in Britain six species. Two are perennial, *M. sativa* (Lucerne), with purple flowers, and *M. falcata*, with yellow flowers, sometimes passing into blue or violet. The other four species are annual. *M. lupulina* (Black Medick) has one seed in the pod, the others several. *M. minima* is downy, with nearly entire stipules. *M. denticulata* and *M. maculata* are nearly glabrous. In *M. denticulata* the pod has two to three loose spires, in *M. maculata* it is nearly globular. The flowers secrete honey. In some species the pods are round, flattened, and roll along the ground like little green wheels, as in the

curious *M. scutellata* of North Africa; others are covered with hooks, and carried by animals.

M. sativa (Lucerne).—Much cultivated, but not indigenous. It is a native of the Eastern Mediterranean region. It produces honey, and one stamen is detached from the rest. As in *Genista* and the Broom, the flowers open once for all; but the elastic power is confined to the upper stamens. In the Broom and in *Genista* the resistance is obtained by the union of the upper edges of the keel. These are also united in *Medicago*; but even if they are separated no explosion takes place, the flower being still locked together by four processes, two of which point forwards and two backwards. These fit so beautifully that the proboscis of a humble bee is sufficient to unlock them and release the stamens; though, according to Henslow, the hive bee is unable to do so. Hildebrand, however, has observed that in the absence of insects it fertilises itself.¹ The plant is nearly glabrous.

M. falcata.—In this species the pod is merely curved. The flower is easily exploded, even by flies.

M. lupulina (Black Medick).—The flowers are minute, but in general structure resemble those of *M. sativa*. They are mostly fertilised by hive bees, yet how infinitesimal must be the quantity of honey which they can obtain from so small a flower! This species is annual with us, but becomes perennial in Alpine districts. It is more or less hairy.

M. denticulata.—In this species and some others, especially in Southern regions, the pod is edged with rows of hooked or curved prickles. These no doubt serve to catch hold of any passing animal, and thus facilitate dispersal. They may also be useful in other ways. If the pod is rolled about by wind they would help to attach it as soon as it came to any damp earth. They would also tend to deter birds from eating the seeds. It has been suggested² that the larger ones prevent

¹ Avebury (Lubbock), *British Wild Flowers*.

² *Riviera Nature Notes*. By C. C.

the Southern harvesting ants from dragging them down into their nests. I have seen *Medicago* pods lying in little heaps at the entrances to such nests in Italy and Algeria. The plant is slightly hairy, sometimes glandular.

MELILOTUS

Of this genus we have three species. *M. albus* has white flowers, *M. officinalis* and *M. arvensis* yellow; the former has the pods irregularly, the latter transversely, wrinkled. The general structure of the flower resembles that of *Medicago*, but at one place the epidermal cells of the wings are interwoven with those of the keel, so that they may almost be said to have grown together. They therefore move together when pressed down by an insect, but on the removal of the weight resume their original position.

The leaves sleep at night, the leaflets becoming vertical. In doing so the leaflets could, of course, twist so that their upper surfaces should face to either side. As a matter of fact they face north, but as they move at the same time towards the terminal leaflet, the upper surface of the one faces about N.N.W., and that of the other N.N.E. The terminal leaflet, on the other hand, twists to either side, the upper surface sometimes facing east and sometimes west, generally indeed west. It also "moves in another and more remarkable manner, for whilst its blade is twisting and becoming vertical, the whole leaflet bends to one side, and invariably to the side towards which the upper surface is directed; so that if this surface faces the west the whole leaflet bends to the west, until it comes into contact with the upper and vertical surface of the western lateral leaflet. Thus the upper surface of the terminal and of one of the two lateral leaflets is well protected."¹ Darwin proved experimentally that leaves which were forced to remain horizontal suffered more from frost.

¹ Darwin, *Movements of Plants*.

TRIFOLIUM (Clover)

The seed-pods are protected in several ways. In *T. subterraneum* by the rigid, persistent flowers; in *T. fragiferum* by the swollen calyx; in *T. globosum* by large brushes of hairs which completely envelop them. Those of *T. badium* are flattened. In this genus also leaf movements may be observed; for instance, in the common White Clover (*T. repens*). If we take a leaf with an upright stalk and three horizontal leaflets, we find at night that the lateral leaflets twist and approach one another until their upper surfaces come in contact, bending down at the same time at right angles to their original position, until the midribs form an angle of about 45° with the petiole. The terminal leaflet, on the contrary, rises up and turns over so as to form a sort of roof over the other two leaflets, with its lower surface turned upwards. In *T. pratense* the leaflets rise at night, thus presenting a smaller radiating surface, and Darwin found that leaves which were prevented from doing so suffered more from frost. The autonomous movements of the leaflets of *T. pratense* are very considerable; the terminal leaflet may accomplish a movement of 30° - 120° in the course of one and a half to four hours. "If such a plant, previously exposed to daily variation of light, be illuminated in the evening and thenceforth kept continuously in the light, no further closing movement corresponding to the daily period is to be observed even on the following evening, apparently because it is obscured by the autonomous movements, which go on with an amplitude of as much as 100° , and with a rhythm of about two hours. These autonomous movements continued also unchanged while the plant was kept constantly illuminated for two days longer."¹

The stipules offer many points of interest. For

¹ Sachs, *Physiology of Plants*.

instance, the common Red Clover (*T. pratense*) has the strongly veined connate stipules (Fig. 105) ovate, the free part short, triangular, and ending in a setaceous, applied point. The upper ones are somewhat dilated. In White Clover (*T. repens*, Fig. 106) they are all comparatively narrow, and subulate at the free end. This difference may perhaps be accounted for by the different arrangement of the flower-bud. In



FIG. 105.—*Trifolium pratense*. Head of flower-buds with the pair of protecting leaves.

T. pratense the head is sessile (Fig. 105), and the bud is protected by the broad stipules. Hence, also, perhaps the upper ones are more dilated than the others, as they have to cover the young flower-head. In *T. repens*, on the contrary, the peduncle elongates (Fig. 106), while the flower-head is still very undeveloped, indeed scarcely broader than long, and without any projecting corollas. The young flower-head pushes out from the plant and lies flat on the ground, selecting a suitable situation for its development. The figure shows a bud in an early state, the corollas quite uncoloured and enclosed by the calyces, but already with a long peduncle, carrying it far beyond the stipule, *st.* *T. medium* also has stipules, much narrower than those of *T. pratense*.¹

T. repens (White Clover).—According to Darwin, the flowers of White Clover are self-sterile. The wing and keel are at one point grown together. The claw of the wing is very narrow, which greatly facilitates the pumping action. The upper surfaces of the leaflets are glabrous. The cells of the epidermis are thin-walled; they are raised in the middle, and in the depressions are small openings. At the edge of the leaf is a fringe of long hairs. The under side of the leaves, except near

¹ Avebury (Lubbock), *On Buds and Stipules*.

the centre, is coated by a waxy substance which is secreted by glandular hairs, from the bases of which fine lines radiate. The epidermis is quite smooth. The upper part of the leaf is not wetted, even by heavy rain, except just at the outer edges, where it is caught by the teeth and the fringe of hair, and conducted to the under surface, which is soon covered by a film of moisture; and it is interesting to see how rapidly drops falling on the upper are thus conducted to the under

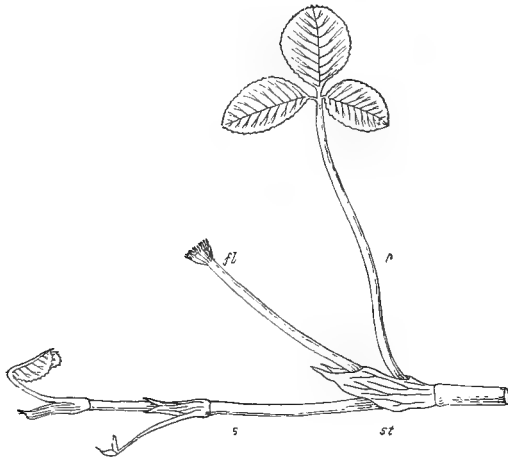


FIG. 106.—*Trifolium repens*. End of creeping shoot. *s*, stem; *st*, stipule; *p*, leaf-stalk; *fl*, very young flower-head. Nat. size.

side. It does not, however, wet the whole surface, but hangs like an hour-glass, suspended from the edges and the midrib, which are wetted, and presumably absorb moisture. This arrangement of the leaf explains the presence of stomata or air pores on the upper surface, as well as below.¹

T. fragiferum (Strawberry Clover).—In this species the arrangement of the flower is similar to that of the preceding species, but after flowering two of the lobes of the calyx become much inflated, and often pink, so that the whole flower-head assumes more or

¹ Lundström, *Acta Nova Upsal.* 1884-85.

less the appearance of a strawberry. This may sometimes lead to the fruit being gathered and carried to a certain distance. The swollen calyx would also serve the same purpose in aiding distribution by the wind.

T. pratense (Purple Clover).—In this species the nine under stamens have coalesced with the claws of the keel and the base of the wings and standard, thus forming a tube 9-10 mm. in length, at the end of which is the honey, inaccessible therefore, excepting to humble bees, hive bees, and Lepidoptera. According to Darwin, it is self-sterile, which, however, Kerner denies. It is said, however, to have produced no seed in New Zealand until the colonists introduced humble bees. Our commonest humble bee, *Bombus terrestris*, has a proboscis just too short to reach the honey, but often obtains access to it by biting a hole through the base of the tube. The breach thus made is utilised by many other insects. Knuth gives a list of those recorded by various observers, amounting to over fifty. In America, according to Robertson,¹ it is much visited by Lepidoptera. In Germany the numbers observed are 8 butterflies out of a total of 25 species; in the United States no less than 13 out of 20. It must, however, be remembered that the United States are very rich in Lepidoptera. The leaves are not wetted by rain, but the moisture collects between the stipules, and is there, probably, in part absorbed.

T. incarnatum and **T. medium** agree in the above points with *T. pratense*, but in the former the tube is a little shorter.

T. arvense (Hare's-foot Clover).—This happily named species begins with a globular flower-head like its allies, which, however, gradually elongates, forming a cylindrical column, like a soft brush, owing to the long fine hairy teeth of the calyx.

T. agrarium.—In this and some allied species the corolla, which is at first yellow, turns brown, shrivels

¹ *Botanical Gazette*, xvii. (1892), p. 177.

up, and forms a sort of balloon serving for the dissemination of the small fruit.

T. subterraneum.—In most clovers the head contains from 50 to over 100 florets. In this, on the contrary, only a few (3-5) florets become complete flowers. The

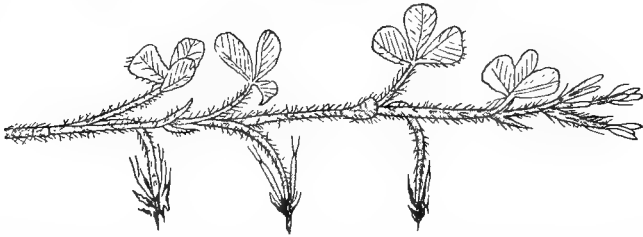


FIG. 107.—*Trifolium subterraneum*. Shoot showing buds at end, and three older flower-heads which are turned down and beginning to bury themselves.

others, proceeding from below upwards, are gradually reduced to stiff spines, forming a rigid pointed head.



FIG. 108.—*Trifolium subterraneum*. Flower-head, slightly magnified.

The complete florets stand upwards, but after they have flowered the peduncle bends over (Figs. 107, 108), turns towards the ground, and grows downwards, sometimes elongating to the extent of 6 or even 9 inches, forcing the flower-head into the ground to a depth of $\frac{1}{4}$ or $\frac{1}{2}$ inch, an operation much facilitated by the peculiar construction and arrangement of the imperfect florets. The florets are, as Darwin has shown, no mere passive instruments. So soon as the flower-head is in the ground they begin, commencing from the outside, to bend themselves towards the peduncle, the result of which, of course, is to drag the flower-head farther and farther into the ground. In most Clovers each floret produces a little pod. This would in the present species be useless, or even injurious; many young plants growing in one place would jostle and starve one another. Hence we see another obvious advantage in the fact that only a few florets perfect their seed.¹

¹ Vaucher, *Hist. Phys. des Plantes d'Europe*, vol. ii.

T. resupinatum.—This is a hive bee flower. It has a strong scent of honey during the day, but is said to become scentless in the evening, when the bees leave off working. The calyx is glabrous, or hairy on the upper side only, which after flowering becomes much inflated, arched, membranous, and veined. The leaves, however, are the most interesting feature of the species, and are very peculiar. The apical halves of the lateral leaflets are covered with bloom, which is wholly absent on the other side, so that if put in water one side of the leaflet is wetted, while the other remains dry.¹

T. hybridum.—The flowers are first white and then red. After flowering they turn down so as to make room for younger ones. The stem is hollow and erect.

ASTRAGALUS

Of this, which is one of the largest genera of flowering plants, and widely distributed in temperate and cold regions, we have three species: *A. alpinus* has the flowers in a raceme and bluish purple, the other two in a head or short spike; *A. hypoglottis*, purple; *A. glycyphyllos*, dingy yellow. The flowers contain honey.

OXYTROPIS

Oxytropis is also a large genus widely distributed in the cooler parts of the northern hemisphere. We have two species, both Scotch alpiners: *O. campestris*, confined to the Clova Mountains, with yellow flowers tinged with purple; and *O. uralensis*, with pale purple flowers.

ORNITHOPUS

O. perpusillus (Bird's-foot); from the resemblance of the fruits to birds' claws. Neither H. Müller nor Knuth could find any honey in this species.

¹ Darwin, *More Letters*.

HIPPOCREPIS

H. comosa (Horse-shoe Vetch) takes its name from the shape of the joints of the seed-pod. The pod forms almost a complete circle, the concave margin of which is continuous, while the convex side is thrown into abrupt undulations (Fig. 109). It might have been supposed that the pod would break up at the narrowest parts. As a matter of fact, however, the lines of dehiscence are in the centre of the thickest parts,

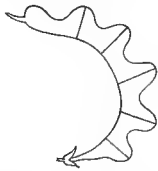


FIG. 109.—Fruit of Hippocrepis.

so that the detached portions have the forms of horse-shoes. Each segment would normally include two seeds, but as a rule one is aborted.

ANTHYLLIS

A. Vulneraria is our only representative of this genus, which contains about twenty species, distributed through the north temperate region of the Old World. It agrees with *Lotus* in its general arrangement. The tube of the flower is, however, elongated; and in consequence this species is only visited by bees with long tongues. In the young flower, though the pistil is in the keel, and necessarily in contact with the pollen, H. Müller has observed that the stigma is dry, and that pollen which falls on it is easily shaken off. Subsequently, however, when most, or all, of the pollen has been removed, the stigma becomes sticky, and pollen adheres closely to it. The pollen grains are short six-sided prisms with striated angles. The dried and swollen calyx helps the dispersion of the fruit. The whole plant is covered with short, appressed silky hairs.

VICIA (Vetch)

The Vetches (*Vicia*) are distinguished from the Peas (*Lathyrus*) by having the style filiform or angular, and

hairy on the outer side or all round; while in the Peas the style is flattened, and hairy on the inner side only. The termination of the staminal tube, moreover, is more or less oblique (Fig. 111), while in the Pea (Fig. 110) it is more abrupt. Several species of the genus have "extra-floral" nectaries. They are situated on the under side of the stipules, and are generally deeply coloured, often black. The object is probably to attract ants,



FIG. 110.—Staminal tube of *Lathyrus*.



FIG. 111.—Staminal tube of *Vicia*.

which then repay the plant by carrying off any small caterpillars, etc.

V. Cracca.—In this beautiful species the connection of the wing and the keel is carried farther than in the preceding genera. In fact, they are doubly interlocked, so that it is difficult to separate without tearing them. The anthers are ripe, and the pollen shed before the flowers open, but according to Knuth the stigma is not capable of impregnation until the delicate papillæ have been scratched and torn by the bee. Though the parts of the flower fit closely to one another, still from the smallness of its size the honey is accessible to most bees, and owing to the conspicuousness of its bunches of bright blue flowers it is much visited by them. From their arrangement and elasticity, the various parts of the flower resume their original position after each visit. The plant is sometimes covered with numerous white silky hairs, sometimes has only a few appressed hairs.

V. sepium (Bush Vetch).—The arrangement of the flowers resembles that in *V. Cracca*, but the pistil, instead of a single brush, bears two separate groups of hairs, one on the inner and the other on the outer side, each about 1 m. in length. That on the inner side

consists of a single row of short hairs pointing outwards. That on the outer side widens towards the stigma, three-quarters of which they surround, and from which they stand out straight, thus forming a sort of flat plate. The longest hairs are in the centre. Access to the honey is more difficult than in *V. Cracca*, and possible only to powerful bees such as *Bombus* and *Anthophora*. *B. terrestris*, therefore, often bites through the base of the flower. The plant creeps about in shady places and among leaves, and the lower part of the stem, which is often covered up, is very weak and thin.

LATHYRUS (Pea)

In this beautiful genus nearly every species offers some special point of interest. The general arrangement of the flower has been already described (see *ante*, p. 148).

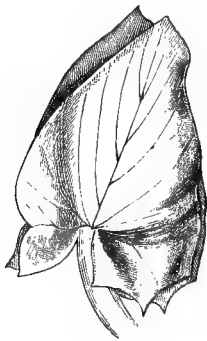


Fig. 112.



Fig. 113.

FIGS. 112, 113.—Stipules of *Lathyrus maritimus*. $1\frac{1}{2}$ nat. size. In Fig. 113 one of the stipules is turned back, revealing the rest of the leaf and bud.

The stipules differ much : they are (1) large and leaf-like, or (2) narrow and sagittate, or (3) narrow and semi-sagittate, or (4) absent.

Lathyrus maritimus belongs to the first category. The stipules (Fig. 112) are large, foliaceous, and develop early.

In *L. grandiflorus* (Fig. 114) they are small, half-

sagittate, narrow, and pointed. The upper and lower limbs, moreover, do not lie in the same plane, but are somewhat twisted relatively to one another. In other species, as, for instance, in *L. pratensis* (Fig. 115), they are sagittate.

Now, if we open the bud of *L. maritimus* (Fig. 113) we find that the young leaves and stipules occupy most of the space between the outer stipules, which cover and protect both the leaves and stipules of all the younger ones, as well as the inflorescences and their own leaf in its earlier stages. They are sessile, cordate, un-

equally sagittate, and glabrous like the rest of the plant, with numerous strong nerves radiating from the point of their insertion on the axis. The smaller auricle is generally ovate or triangular and entire; the larger one has three or four cusps or teeth. The stipules form a very efficient protection to the leaves till they attain a considerable size.

In *L. latifolius* (Figs. 118, 119) the upper limb of the stipule also protects the younger leaves, which, however, have only one pair of leaflets, and not, therefore, occupying so much room, do not require such wide stipules. The stalk, however, being very wide, is not entirely covered by the sheathing stipule. Consequently, if the upper stipule had a lower limb on the outer side, the latter would be exposed. The lower limb, which is on the inner side, lies snugly ensconced between the stem



FIG. 114.—Stipule of *Lathyrus grandiflorus*. $1\frac{1}{2}$ nat. size.



FIG. 115.—Stipule of *Lathyrus pratensis*. $1\frac{1}{2}$ nat. size.

and the older leaf (Fig. 119). Moreover, the function of the stipule being to protect the young bud, it develops early, and when it is full grown the lower limb is equal in length to the internode below. Subsequently, however, the internode becomes much longer, while the stipule remains as before. But though the stipule may



Fig. 116.

Fig. 117.

Fig. 118.

Fig. 119.

FIG. 116.—Stipule of *Lathyrus pratensis*.

FIG. 117.—One of the lower stipules is turned back exposing the next younger leaf with its stipules.

FIGS. 118, 119.—Stipules of *Lathyrus latifolius*. $1\frac{1}{2}$ nat. size. The lower stipule (*st*) has been removed in Fig. 119, exposing the whole of the stipule (*st'*) of the next higher leaf.

be correctly described as half sagittate, it sometimes shows a minute tooth where the other barb would have been, suggesting that it is descended from ancestors which had a barb on each side.

In *L. pratensis* the stipules (Figs. 115-117) are sagittate. Here, however, the petiole is round; the wings lie one on each side of it (Figs. 116, 117), and are fully covered by the stipule of the preceding leaf. Thus, then, the difference between the sagittate and

semi-sagittate stipules appears to depend on the form of the stem and the arrangement of the bud. Where the stem is winged the outer barb of the stipule would be exposed. In such cases the stipule is semi-sagittate. In the Garden Pea (*Lathyrus sativus*, Fig. 120) the stipules are not only large in bud, and in arrangement resemble those of *L. maritimus*, but they continue to grow, reaching a length of fully 3 inches, and $1\frac{1}{2}$ in breadth, and act as a pair of leaflets, which they considerably exceed in size.

L. sativus.—A hardy climbing annual, a native of Southern Europe, cultivated in Britain. The large standard as described by Kirchner¹ has at the base

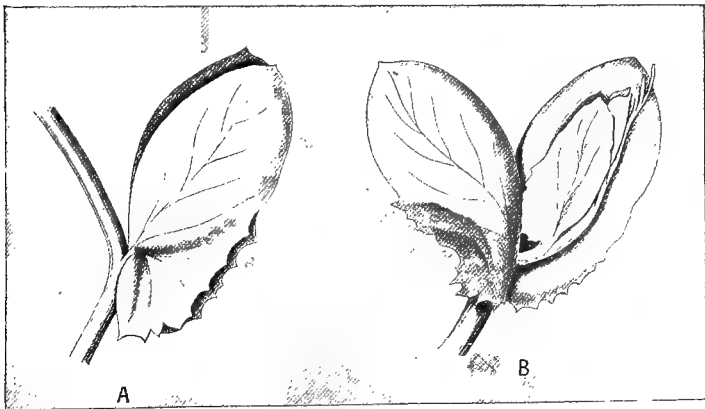


FIG. 120.—Stipules of *Lathyrus sativus*. A, before the unfolding of the leaf in the natural position; B, with one stipule turned back to show the leaf and shoot inside.

two deep folds at right angles to one another, which fit into corresponding depressions of the wing, and thus lock the two closely together. The front edge of the keel is strengthened by a wing-like process, which is bent somewhat into the form of an S, so that the point turns a little to the left. The keel, it will be remembered, consists of two leaves, and the point of the right one is arched outwards, while

¹ Quoted by Knuth.

the left has a deep depression in which the point of the pistil lies. The wings are closely connected with the keel, the right wing, however, when it overlies the point of the keel, has a fold, through which, when the flower is pressed down by an insect, the stigma protrudes. The stigma is widened above, and twisted to an angle of 90° , so that its originally inner side, which bears the brush of hairs, comes to the left side; the smooth, originally outer side, to the right. The anthers open in the bud, and the pollen is swept out by the brush of hairs. It is not easy to make this complicated and unsymmetrical arrangement very clear without an actual specimen. The flower is principally fertilised by the hive bee. The stipules are very large, and partly fulfil the functions of leaves, besides serving to protect their own leaf (Fig. 120) in the young stage and all the rest of the shoot.

L. pratensis.—The arrangement of the flower in this species resembles that of the preceding. The stipules are broadly lanceolate and sagittate.

L. Aphaca.—In this curious species the leaves are reduced to tendrils, and the ordinary functions of the leaf are performed by large, broadly heart-shaped stipules. In the seedling the first and second leaves are scale-like and trifid, with three subulate points corresponding to leaf and stipules. The third and fourth leaves are compound, with one pair of leaflets and obliquely ovate stipules of considerable size, and a tendril represented by a small subulate point. The fifth and succeeding leaves are reduced to a subulate point and a pair of triangular foliaceous stipules. The subulate point develops into a simple tendril on the middle and upper portions of the stem.¹

L. maritimus.—As regards the flower this species also resembles *L. pratensis*, and the stipules are sagittate.

On the other hand, in **L. palustris** the stipules are semi-sagittate. I have suggested that this may be

¹ Avebury (Lubbock), *Buds and Stipules*.

explained by the winged stem, which, being so wide, is not entirely covered by the sheathing stipule. Consequently if there were a lower limb on the outer side it would be exposed. But though the stipule may be correctly described as half-sagittate, it sometimes shows a minute tooth where the other barb would have been, indicating that it is descended from ancestors which had a barb on each side.¹ In *L. pratensis* and *L. maritimus*, on the contrary, the petiole is round, the wings lie one on each side and are fully covered by the stipule of the preceding leaf.

L. sylvestris.—The flower is unsymmetrical. The left honey gland and the passage leading to it are larger than those on the right, and it is remarkable that when bees bite through the flower to get at the honey, which they often do, they always attack the left side. Either, therefore, they have discovered the best place by biting at first at random, or, which seems more probable, having noticed the inequality when sucking the flowers in the normal manner, make the opening on the left. In either case the circumstance is very remarkable, and Darwin regarded it as “the most remarkable case of skill and judgment” on the part of the bees known to him.²

L. Nissolia (Fig. 89) is another curious species. It lives among grass in meadows and waste places, and has lost altogether, not only the leaves, but also the tendrils. Instead, however, of enlarged stipules, the functions of the leaves are assumed by the leaf-stalks, which are elongated, flattened, linear, ending in a fine point, and, in fact, so like the leaves of the grasses among which the plant lives that it is almost impossible to distinguish it except when in flower. The stipules are minute and very slender. For a weak plant growing among close grass a long linear leaf is, perhaps, physically an advantage. Some of the flowers produce seeds, and yet do not open. Sometimes the buds are large, at others quite small. Though they are not true

¹ Avebury (Lubbock), *Buds and Stipules*.

² *Forms of Flowers*.

cleistogamic flowers, Darwin was disposed¹ to regard them as indicating the manner in which cleistogamy may have originated.

ROSACEÆ

Of this great family we have in Britain seventeen genera. Both calyx and corolla consist of separate leaves, and the flowers are open, but in other respects present great differences. They are generally large, but sometimes quite small and greenish; often with honey, secreted by a ring round the base of the calyx, but sometimes without; sometimes single, sometimes in pairs, in close heads, in cymes, panicles, racemes, corymbs, or spikes; mostly fertilised by insects, but in some cases wind-flowers; some are protandrous, some protogynous; some are considerable trees, some small herbs. In many species the flowers protect the pollen by bending over in rain. The fruits present many differences; in some species a pome, in others a drupe, a berry, or an achene. In many of the Rosaceæ belonging to various genera (*Cratægus*, *Geum*, *Pyrus*, *Potentilla*, etc.) the stipules are polymorphic.

PRUNUS

Of this genus we have four species: *P. spinosa*, with the flowers single or in pairs; *P. Cerasus* and *P. Avium*, with flowers in clusters, and *P. Padus*, in axillary racemes. According to H. Müller the flowers are homogamous, but Kirchner says they are protandrous. Each flower lasts seven to eight days. *P. spinosa* and *P. Padus* are protogynous. In *P. spinosa* the young leaves are protected by woody spines.

P. Cerasus (Cherry).—In the wild cherry the fruit is black. It seems probable that it is an advantage for

¹ *Forms of Flowers.*

fruits which ripen when the leaves are still green to be red, as this gives the greatest contrast. On the other hand, red would not be conspicuous against faded leaves which are brown, or even sometimes themselves reddish. For such fruits, blue or black would be more advantageous, and, as a matter of fact, many heath and moor species have bluish or black fruit, as, for instance, the Bilberry, the closely allied *Vaccinium uliginosum*, or the Black Bearberry. *P. Cerasus* keeps its leaves longer in Southern Europe, and in Ceylon is evergreen.

The fruit of **P. Padus** (Bird Cherry) is also black.

SPIRÆA

We have two species of this genus: in one, *S. Ulmaria*, the leaves have a few large segments, and are white underneath; in the second, *S. Filipendula*, they have many small segments.

S. Ulmaria (Meadow-sweet).—The flowers are sweet-scented, yellowish white, homogamous, and honeyless, but a good deal visited by insects for the sake of the pollen. The carpels are twisted, forming a spiral. Can the object be to mimic small caterpillars, and thus inveigle birds to carry them about? The seeds are brown, oblong, and compressed laterally.

DRYAS

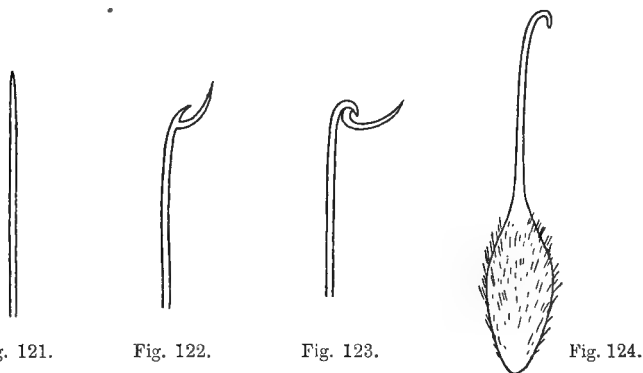
D. octopetala is found in limestone and mountain districts; it has large flowers with concealed honey. The petals, as the name implies, are eight in number. H. Müller describes the flowers as protogynous. When the blossom opens the styles are mature; in a short time the anthers commence to open, beginning with the outer ones, so that at first insects touch the pistil on one side, and the anthers on the other; thus cross-fertilisation is almost sure to take place. If, however, there are no insect visits, the styles bend outwards toward the inner anthers, and the flower is self-fertilised; moreover, the flowers gradually bend over, so that the

stigmas come into the fall line of the pollen. The carpels are numerous, and terminate in a long feathery tail, which obviously serves to disseminate the seeds.

GEUM

We have two species, one (*G. rivale*) with large drooping dull-purplish flowers, and *G. urbanum*, with small upright yellow flowers. Both have honey. The arrangement is very similar to that of the preceding genus (*Dryas*).

G. urbanum is slightly protogynous. Besides the complete flowers there are others, according to Schulz, which are andromonœcious and androdioecious. The



FIGS. 121-124.—*Geum urbanum*. Fig. 121, young style; Fig. 122, older; Fig. 123, still older; Fig. 124, ripe fruit.

carpels are hairy, and terminate in a style which is hairy in the middle and smooth at each end. Immediately below the hairy tract a projection develops (Figs. 122, 123), which gradually elongates and curves. Finally, when the seed is ripe, the upper part of the style detaches itself (Fig. 124), so that the fruit terminates in a hook, which entangles itself in the hair of any passing animal. It will be seen, however, from the arrangement that the fruit cannot be torn away until it is ripe. In other species the achene ends in a feathery tail as in

Dryas. The flower is said to produce honey more abundantly in the North.

G. rivale.—The arrangement and history of the flower are in essentials as in *G. urbanum*.

RUBUS

The species of this genus are richly endowed with honey, secreted by a fleshy ring on the receptacle below the stamens. A more important botanical distinction is in the ovary, which is superior or above the calyx and corolla, while in the Rose it is inferior, the calyx and corolla being above it. The carpels also become succulent, forming a number of "drupelets" on a more or less conical dry receptacle. The division into species is more difficult even than in the Roses. Babington¹ made forty-eight. In the most recent account, Moyle Rogers's *Handbook of British Rubi* (1900), 103 species are recognised! Bentham and Hooker only accept five. Of these two are herbaceous: one (*R. saxatilis*) having trifoliate leaves and small axillary flowers; the other (*R. Chamæmorus*, the Cloudberry) has simple leaves and a large terminal solitary flower. Of the other three, one (*R. fruticosus*, the Blackberry) has 3 or 5 leaflets and a black fruit, without bloom; the second (*R. cæsius*, the Dewberry) has glaucous branches, and fruit covered with a bluish bloom. The fifth is the Raspberry (*R. Idæus*). The Blackberry is especially variable.

R. fruticosus (Blackberry, Bramble).—The flowers are large and widely open; the stamens, though numerous, are not so close as to exclude even insects with a short proboscis from access to the honey. The outer anthers ripen first, and turn their open faces upwards. The stigma ripens at the same time, so that most insect visitors effect cross-fertilisation. Over 100 species of insects are recorded as visitors to the Blackberry. In the late autumn many of the leaves present a pale twining mark like a small serpent, and increasing in

¹ *Manual*. 4th Edition.

width from one end to the other. In parts of England it is, or used to be, believed that these are made by the Devil, and that when a plant is so marked the fruit must be left for him. They are, in fact, the mines of a small moth. The branches form long sweeping curves, and when the ends trail on the ground, roots are developed. After this growth ceases they contract, sometimes as much as 20 to 30 per cent, and thus draw the tip of the branch down into the ground. The older part of the original branch then often dies, while the apex grows upwards and gives rise to a new plant.

R. Idæus (Raspberry).—According to Kerner, the petals in this species remain more upright, thus squeezing the stamens more closely together, the result of which is that only insects with a sufficiently long proboscis can reach the honey. Many are thus excluded, and only about fifty are on record as visitors. The flower lasts two days.

R. cæsius (Dewberry).—According to Knuth, when the flower opens the receptacle is flat, and neither the anthers nor the stigmas are ripe. The stamens arch over the middle of the flower. The outer stamens open first, and as they do so turn outwards towards the petals. In the meanwhile the pistils are gradually elongating, and eventually project above the inner stamens. This arrangement evidently conduces to cross-fertilisation; but the inner stamens gradually grow up, and can hardly fail to touch the stigmas, so that in the absence of insect visits the flower will almost certainly fertilise itself.

R. saxatilis is, according to H. Müller, protogynous, while **R. Chamæmoris** is dioecious. The leaves are adapted to snowy districts (see *Viola palustris*, p. 29). The moisture collects in the sunk nerves, and is absorbed by certain glandular hairs.

FRAGARIA

It is remarkable that in four genera so nearly allied as *Rosa*, *Rubus*, *Fragaria*, and *Potentilla* the fruit should

so greatly differ. In *Rosa* the carpels are enclosed in the fleshy hollowed floral axis; in *Rubus* the carpels become succulent, the convex floral axis being dry; in *Fragaria* the large convex receptacle is succulent, while the ripened carpels are hard, and so closely surround, that they are generally regarded as, the seeds; lastly, in *Potentilla* there is nothing which in common parlance could be termed a fruit, both receptacle and ripened carpels remaining dry.

F. vesca (Strawberry).—The flowers are protogynous, with concealed honey. As Darwin has pointed out, the flowers are of three kinds: (1) female, producing much fruit; (2) complete, which are not so fertile; and (3) male, which, of course, give none. Schulz has observed gynomonœcious on the same umbel, and gynodioœcious on different umbels, andromonœcious and androdiceœcious flowers. The flowers are visited by beetles, flies, and bees, but in the absence of insect visits they are capable of self-fertilisation. The Strawberry is one of the plants in which leaves growing in sunshine and in shade differ considerably.

In *Fragaria* and *Potentilla* the sepals are stipulate; adjoining stipules unite to form, apparently, a set of leaves alternating with the sepals, thus suggesting a double calyx.

POTENTILLA

Potentilla closely resembles *Fragaria*, with which perhaps it should be united, but the receptacle is not fleshy. The flowers are generally homogamous, but in *P. Comarum* protandrous. There are nine British species.

P. Comarum (Marsh *Potentilla*).—When the flower opens, the stamens erect themselves and open gradually. Some of the pollen falls on the stigmas, but has no effect, as they are not mature. When the anthers have dropped, the filaments of the stamens curve downwards towards the petals, while the styles, on the contrary, elongate and take their place. The receptacle makes

some approximation to that of *Fragaria*, as it is slightly spongy, though not succulent.

P. Tormentilla.—This species, like *Geum urbanum*, is said¹ to produce honey abundantly in Norway, but not in Central France. In the North it is visited by humble bees, but not in Germany or France.

P. anserina (Silver Weed) has the leaves silky white on the under side, and sometimes, though less so, on the upper as well. The flowers partly close at night and in wet weather.

P. reptans has cleistogamous as well as the ordinary flowers.

ALCHEMILLA

We have three species: one a small annual (*A. arvensis*), the other two perennial; one (*A. alpina*) has the leaves silvery below, in the other (*A. vulgaris*) they are green on both sides. The calyx is double (as described in *Potentilla*), and there are no petals. The flowers are sometimes complete, but as a rule either the stamens or the pistil are rudimentary. The anthers open when it is fine, and shut again if it rains. The honey is, as usual, secreted by a fleshy ring on the inner side of the calyx, and forms a very thin layer, which gives the flower a yellowish tinge.

A. vulgaris (Lady's Mantle).—The leaves form a small cup, which often contains a comparatively large drop of rain or dew. The rain does not wet the leaf, and only touches it at the base, from which it runs into the small sunk nerves, and is thus retained in place. A tuft of hairs at the base of the leaf prevents it from running off down the leaf-stalk. In the mornings it is often icy cold, and perhaps deters cows and sheep from eating the leaves.

SANGUISORBA

In this genus also petals are absent. It is represented in our flora by

¹ Bonnier, *Ann. Sci. Nat.* ser. 6. viii. (1879).

S. officinale (Great Burnet).—Honey is secreted as usual. The four lobes of the calyx are deeply coloured a rich dark brown. The florets are small, but 50 to 100 are united in an oval or cylindrical head. They expand from below upwards, only one ring being open at once, and are richly visited by insects, especially flies and butterflies.

POTERIUM

P. Sanguisorba (Salad Burnet), on the other hand, has no honey. The flower-heads are greenish, smaller and more globular. The florets are female at the summit, complete in the centre, and male below. The stamens are more numerous, and the pollen is carried by wind, the anthers being exerted on long, slender, pendulous filaments, which are white, yellowish, or red in colour. The anthers are yellow or red. The stigmas are numerous and elongated, so as more effectively to catch the grains of pollen. This is mainly a wind-flower; still the flowers are occasionally visited by flies, solitary wasps, and a few other insects.

The achenes are enclosed in a hollow development of the receptacle, often termed the "calyx tube." There is generally a single achene, but sometimes there are three. It or they fill the receptacle, so that where three are present they are more or less triangular. Each achene contains a single seed. The receptacle is winged, and no doubt serves for the dissemination of the seeds.

AGRIMONIA

A. Eupatoria (Agrimony).—There is a fleshy ring at the base of the pistil which has all the appearance of a nectary, but the presence of honey has not been observed. The flowers open very early in the morning. The "calyx tube" is persistent, and is covered with exquisite little hooks, which fix themselves into the hair of any passing animal or into clothes, and thus ensure the dispersal of the seeds. The flower lasts three days. At first the stigmas are ripe, but

the anthers are not. In the second stage the anthers are open, but turned away from the stigmas; finally, in the third they bend over towards and fertilise them, if they have not been already fertilised from another flower.

ROSA

In this variable genus there are great differences of opinion as to the limits of species. Bentham admits five British species, while other botanists extend the number to fifteen or twenty. I often wonder that the older school of naturalists who regarded species as fixed, aboriginal, and invariable, were not staggered by such genera as *Rosa*, *Rubus*, or *Hieracium*, where the forms are so various and so variable.

The Rose is much visited by insects for the sake of the pollen, but does not produce honey. The numerous stamens ripen at the same time as the pistil; but from the convenient position of the latter, insects very frequently alight upon it, and thus fertilise it with pollen from other flowers, though self-fertilisation probably often occurs. The carpels are numerous, one-seeded, hairy, and embedded in the receptacle, which thus forms a more or less bottle-shaped tube, open at the free end, the walls of which become succulent when ripe, forming the red "hips" which are so great an ornament of our hedge-rows in autumn and winter. Roses are well protected by numerous sharp curved prickles, which in the climbing species are also useful as grapples.

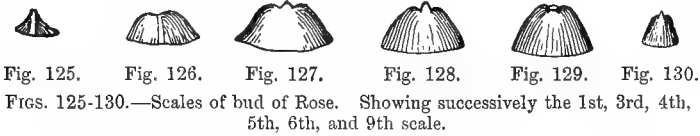
In most cases of upright flowers with separate sepals, the sepals are more or less similar. In the Rose the differences are considerable, and have long been observed. Mr. Landon has kindly called my attention to the following Latin lines, which well describe them:—

Quinque sumus fratres, unus barbatus et alter,
Imberbesque duo, sum semiberbis ego.

The reason, I believe, is to be found in the arrangement of the leaves in the bud. They overlap one another to some

extent. Two have both edges exposed, two have both edges covered, while in the last one side is exposed and one covered. In all cases the exposed edges are bearded.

The fruits do not fall, but remain attached to the shrub. This is perhaps because they are arranged for



dispersal by birds. If they fell to the ground they would be liable to be eaten by mice, etc. On the branches, however, they are sufficiently protected by the thorns and prickles.

If we examine a leaf-bud, say in December (Figs. 125-130), we shall find that it consists of a number of scales with three more or less well-marked projections at the apex. In this case the scale itself represents the leaf-base, while the stipules and upper part of the leaf are indicated by the three points. The outermost scale is the shortest, and they gradually increase in length. After about ten of such scales the little leaf-blade becomes much larger, and the leaf-base smaller in proportion.¹ The expanding bud is shown in Fig. 131.

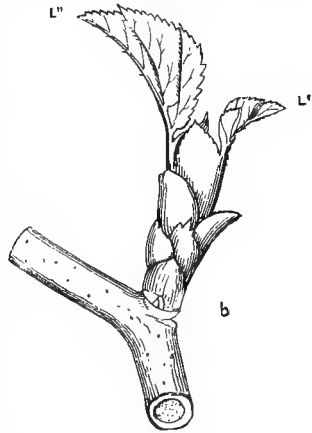


FIG. 131.—Expanding bud of Rose. Stem bearing expanding lateral bud. $\times 2$. One scale has fallen, revealing its axillary bud (*b*); five scales are shown, and two of the first leaves, *L'*, *L''*. — Sketched March 24.

One species of Rose, *R. berberidifolia*, has leaves consisting of a single leaflet only. It is a native of the dry regions of Central Asia, and probably would lose too much moisture if it had the

¹ *Buds and Stipules.*

leaf surface of an ordinary Rose. The stipules also have disappeared. The single leaf appears to represent the terminal leaflet of an ordinary Rose-leaf.¹

PYRUS

Protogynous plants, with half-concealed honey, secreted by the base of the flower.

P. Malus (Apple).—The scent is especially strong at night, and the flower is much visited by moths. According to Waite,² self-fertilisation gives little fruit. When the flower opens the stigmas are ripe. On the second day the anthers begin to open, commencing from the outer rows. The flower lasts five to six days.

P. communis (Pear).—The life-history of the Pear flower is similar to that of the Apple, but the female condition lasts two to four days, and the whole flower life seven to eight days. It is also nearly sterile to its own pollen.

P. Aria (White Beam).—The under side of the leaves is covered with a soft white cotton, and is often turned upwards, so that the tree looks quite white. The cottony down protects the stomata. The buds stand upright, thus exposing a small surface to the sky, and minimising the effect of cold. I have described them at length in my *Buds and Stipules*, p. 140.

CRATÆGUS

C. Oxyacantha (Hawthorn).—The flowers are protogynous, with half-concealed honey secreted by a ring at the base of the flower. The scent is one of the few which we consider pleasant, and which is also very attractive to flies. The anthers do not begin to open until the flower is one or two days old. The plant is protected by modified branches which assume the form of spines. On the lower part of long shoots a long spine and a bud develop together, on the upper part a bud only.

¹ See *Gardeners' Chronicle*, July 6, 1889.

² Waite, *Pollination of Pear Flowers*. Washington, 1894.

The stipules on the leaves of the short lateral spurs and those at the very base of the elongating shoots are minute and tooth-like, or subulate, soon becoming brown and falling early. Those on the upper part of the elongating shoots vary from unilateral, falcate, serrated, small but foliaceous organs, to large, half-cordate, simply or doubly serrate, shortly stalked, foliaceous, much-reticulated organs, with the principal nerves radiating from the base of the lamina and passing into the principal teeth. Thus there are at least three distinct types of stipules.¹ These differences are probably connected with the differences in the shoots. The latter may be described as of two kinds, namely, those which develop into more or less lengthy, leafy shoots, which go to increase the height and breadth of the tree, and those which form short lateral spurs. The latter are very numerous, forming dense rosettes of leaves, and produce clusters of flowers in profusion in adult bushes and trees. Owing to the crowded state of their leaves the bases of their petioles occupy the whole, or very nearly the whole, of the surface of the short axis, thus leaving little or no space for stipules. The lower or outer leaves are very small, and entire or tridentate, or trifid, with short petioles. Very often these have no trace of stipules. The inner or upper leaves of these rosettes are better developed, with elongated petioles, so as to enable them to extend beyond and occupy the space between the short ones. This is obviously a provision to expose every leaf to light. The stipules of these longer-stalked leaves vary from mere points to subulate or linear small brown organs, which, being relatively functionless after the expansion of the leaves, soon shrivel up and fall away.

At or near the base of the elongated leafy shoots fairly well-developed leaves occasionally occur which have no stipules, but as a rule the stipules in this position are also well developed. As these shoots elongate and become vigorous the internodes become

¹ Avebury (Lubbock), *On Buds and Stipules*.

longer and the leaves and stipules larger. The latter, indeed, become quite leafy, and supplement the area of foliage. This is doubtless an advantage, as the leaves themselves do not by any means utilise the area at their disposal, as do those of the Lime, Beech, or Elm.

COTONEASTER

C. vulgaris is a native of Europe and temperate Asia, found wild in Britain only on the Great Orme. The tiny pink flowers are homogamous or protogynous, with concealed honey. This species ascends to the Arctic Circle, and high up in mountain ranges. The leaves are typical of a cold wet district: small, ovate or orbicular, entire, and glabrous on the upper surface, so that wet runs off easily, while below they are covered with a short dense cottony down, which protects the stomata from wet during rain, and renders transpiration possible as soon as the sun comes out again.

MESPILUS

M. germanica (the Medlar), a native of the East Mediterranean area, has become naturalised in hedges and thickets in Central and South England. The flowers are homogamous, with half-concealed nectar. They are remarkable for the great development of the sepals, which are broad and leafy.

ONAGRACEÆ

The flowers are, with a few exceptions, regular, with the parts in twos or fours, and an inferior ovary.

EPILOBIUM (Willow Herb)

We have ten species of this genus. One of them, *E. angustifolium*, has the flowers irregular, the others

regular. Three have the stigma deeply four-lobed, one, *E. hirsutum*, with clasping leaves, while the other two may be distinguished by the form of the leaves, which in one, *E. montanum*, are ovate or ovate-lanceolate, in the other, *E. parviflorum*, are lanceolate. The flowers also are small. Of the five species with a club-shaped stigma, two have the stem marked with two or four raised lines; *E. tetragonum* has sessile leaves, while in *E. roseum* they are shortly stalked. Of the three species with a cylindrical stem, one, *E. alpinum*, is a small Alpine species, not six inches high; *E. alsinifolium* has ovate, *E. palustre* lanceolate leaves. The flowers secrete honey from the summit of the ovary. In wet weather the long ovary bends so that the flowers turn downwards, thus protecting the pollen from rain. The fruit is a long narrow capsule, which splits open from above downwards both between the valves and also along the centre of each, leaving the central axis with the seeds attached to it. The seeds are very numerous, small, oblong, brown, and with a tuft of long white silky hairs at the upper end. The hairs act as a parachute, and facilitate the dispersal of the seeds by wind.

E. angustifolium (Rose-bay) has large purplish flowers in conspicuous heads (Fig. 132), and is much frequented by insects. The flowers, as Sprengel pointed out, are so strongly protandrous that self-fertilisation is almost out of the question. They open soon after sunrise. The lower parts of the filaments are flattened, and form a hollow cone protecting the honey, which lies between them and the ovary. The space between the two is arched over by hairs, which exclude rain while permitting the passage of the probosces of insects. When they have shed their pollen the stamens turn outwards, while the pistil grows up and the stigmas take their place.



FIG. 132.—*Epilobium angustifolium*. Flowering shoot.

Warming, however, as stated by Knuth, found the specimens examined by him to be weakly protogynous, and Schulz found the flowers in mountainous regions less protandrous than those of the lowlands. Kerner also found those examined by him less protandrous than those of Sprengel, and capable of self-fertilisation in the absence of insect visits.

E. parviflorum.—The stigmas are ripe when the flower opens. Gradually the stamens elongate, and the anthers open, so that self-fertilisation becomes possible. The petals close up during the night, but open again the following morning. Some of the anthers now project



FIG. 133. — *Epilobium parviflorum*. Flowering shoot.

beyond the stigma, and the pollen is readily transported to other flowers.

While *E. angustifolium* has conspicuous purplish-red flowers in long terminal bunches or racemes, and is much frequented by insects, this species (Fig. 133), on the contrary, has small solitary flowers, and is seldom visited.

Now, to the former species the visits of insects are necessary, since the stamens ripen before the pistil, and the flower has consequently lost the power of self-fertilisation. In *E. parviflorum*, on the contrary, the stamens and pistil come to maturity at the same time, and the flower can therefore fertilise itself. It is, however, no doubt sometimes crossed by the agency of insects; and, indeed, I am disposed to believe that this is true of all the flowers which are either coloured or sweet-scented. The plant is covered with soft hairs.

E. montanum.—According to Schulz the flowers of this species and of *E. roseum* are homogamous. The stem is glabrous, or bears small woolly hairs.

E. hirsutum.—This species presents considerable differences according to locality. H. Müller seems to have met with homogamous flowers only 25-30 mm. in diameter. Schulz describes three forms:—(1) Large flowers. These

are markedly protandrous, with a long hanging pistil, so that self-fertilisation is precluded. (2) Middle-sized flowers, which are weakly protandrous or even homogamous. The pistil is straight, and self-fertilisation is quite possible. (3) Small flowers. These are homogamous, and regularly fertilise themselves. Female flowers also sometimes occur, in which the anthers produce no pollen. The hairs are of two kinds—some long and spreading, some glandular.

E. roseum is glabrous while young, afterwards covered with woolly hairs, and towards the summit with small spreading articulate hairs. The stigma is sometimes slightly lobed. The stems are more or less quadrangular, and the wings, besides strengthening the stem, probably perform the same function as the rows of hairs of other species in conducting moisture.

ŒNOTHERA (Evening Primrose)

Protandrous moth-flowers, with concealed honey. A large genus, native of temperate North and South America.

Œ. biennis.—Large pale-yellow flowers, which open in the evening, and are then especially sweet-scented. They are adapted to moths, but are also visited during the day by some of the bees which have long probosces. The nectar is protected by woolly hairs. The flowers last two nights; the first evening the anthers open with the flowers, but the lobes of the stigma do not open until the morning. The petals are merely an advertisement, and insects do not alight on them. The hairs are tubercular at the base. This plant is a native of North America, which has become established in various places in this country as a garden escape. A Patagonian species, *Œ. odorata*, has similarly become established on the coasts of Somerset and at Plymouth. I have described the peculiarly interesting cotyledons of this and other genera of the family in my work *On Seedlings*, both in the original and in the popular edition (International Science Series).

LUDWIGIA

L. palustris.—A rare plant, found in boggy pools in Sussex and Hampshire. The minute flowers have no petals.

CIRCÆA

In this genus the leaves are opposite, and the parts of the flowers in twos. We have two species—one hairy, *C. lutetiana*; and one glabrous, *C. alpina*. In both the capsule is pear-shaped, and covered with stiff hooked hairs. The small white honeyed flowers are borne in racemes. The stamens are at first some little distance from the stigma, and at this stage the flower is adapted for cross-fertilisation. In the absence of insect visits, which are not frequent, the stamen gradually curls over and finally touches the stigma.

HALORAGÆ

MYRIOPHYLLUM

We now come to an aquatic genus in which the leaves are, as in so many water plants, divided into long filaments. There are three British species. In one, *M. spicatum*, the bracts are shorter than the flowers; in the second, *M. verticillatum*, they are longer; while in *M. alterniflorum* the bracts are longer than the female, but shorter than the male flowers. The species are more or less amphibious, and the water forms differ considerably from specimens growing on land, especially by the shortening of the internodes.

M. spicatum.—The flowers are in aerial spikes, with small bracts; the upper flowers are male, the lower female. They are wind-fertilised.

M. verticillatum.—This species lives in clear deep water, and the flowers are all immersed; the bracts are pinnate like the leaves.

HIPURIS

The minute flowers are without petals. The leaves are entire.

H. vulgaris (Mare's Tail).—Grenier and Godron mention¹ a specimen in which the leaves were arranged spirally instead of in whorls.

LYTHRARI.EÆ

LYTHRUM

We have two British species—*L. Salicaria*, with upright stems and reddish-purple flowers; and *L. hyssopifolia*, small and decumbent, with minute petals.

L. Salicaria has three distinct forms of flower, which were already recorded by Vaucher, while their functions and relations were first explained by Darwin. He distinguished them according to the length of their style, as long-styled (Fig. 135), mid-styled (Fig. 136), and short-styled (Fig. 137). In this species it is remarkable that the seeds of the three forms differ from one another, 100 of the long-styled seeds being equal to 121 mid-styled or 142 short-styled. The pollen grains also not only differ in size, the long stamens having the largest pollen grains, the middle-sized stamens middle-sized pollen grains, and the short stamens small pollen grains, but also in colour, being green in the longer stamens and yellow in the shorter ones, while the filaments are pink in the long stamens, uncoloured in the shorter ones. Darwin



FIG. 134. — Inflorescence of *Lythrum Salicaria*. Reduced.

¹ *Flore de France*, vol. i.

also proved by experiment that this species does not set its seeds if the visits of insects are prevented; in a state

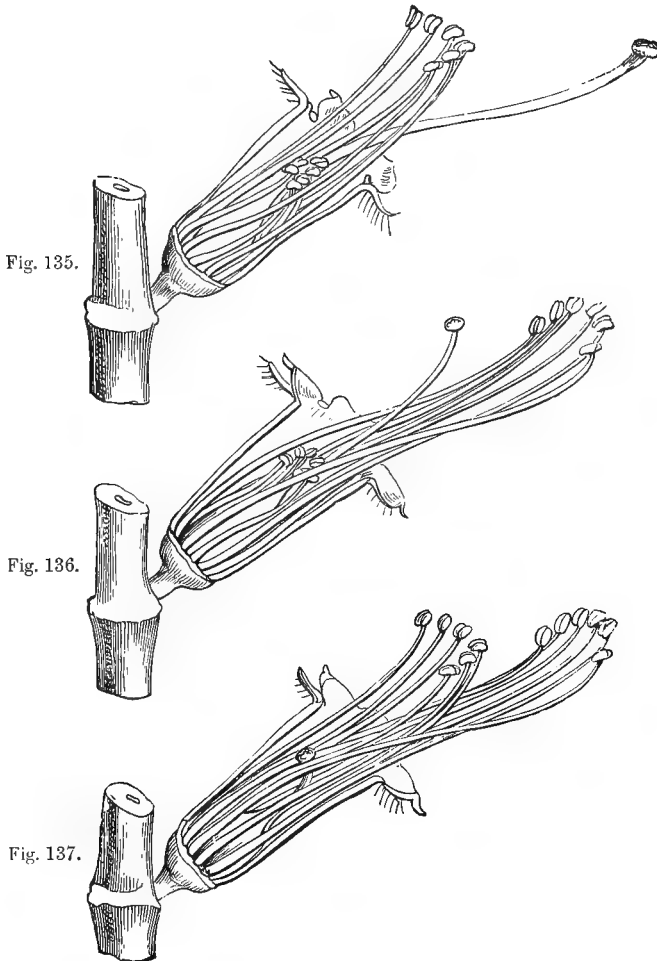


FIG. 135.—Long-styled flower of *Lythrum Salicaria*.

FIG. 136.—Mid-styled flower.

FIG. 137.—Short-styled flower.

of nature, however, the plant is much frequented by bees, humble bees, and flies, which always alight on the upper side of the flowers, on the stamens and pistil.

It was also shown that perfect fertility can only be obtained by fertilising each form with pollen from stamens of the corresponding length. Thus the long-styled form is naturally fertilised by pollen from the long stamens of the two other forms; but it can be so, though imperfectly, by its own two sets of stamens, and by the shorter stamens of the two other forms. It can, therefore, be fertilised, to use Darwin's expression, "legitimately" in two ways, and "illegitimately" in four ways. The same is the case with the other two forms, so that eighteen modes of union are possible, of which six are natural or "legitimate," twelve are "illegitimate" and more or less sterile. This case is, therefore, indeed most complex. The long-styled and short-styled forms are almost sterile if "illegitimately" fertilised; the mid-styled produces about half as much seed as if "legitimately" fertilised. Darwin suggests¹ that the trimorphous condition of this plant may be advantageous, because if it were dimorphous only there would be but an equal chance in favour of any two plants being of different forms, and therefore capable of self-fertilisation; whereas, being trimorphous, the chances are two to one. In the Cowslip and Primrose, where large numbers of plants grow together, this, he thinks, would not be so material. However this may be, the stigma and the two groups of stamens appear to correspond with the three divisions of the body (viz. the head, thorax, and abdomen) of the bee, *Cilissa melanura*, by which it is almost exclusively fertilised.

The genus *Lythrum* is remarkable for the great differences existing between different species. For instance, *L. Græfferi*, like *L. Salicaria*, is trimorphous; while *L. thymifolia* is dimorphous, and *L. hyssopifolia* is homomorphous.

The fruit is a capsule which opens along the centre of each valve. The seeds are numerous, small, plano-convex, yellowish, or testaceous, and nearly smooth. They float in water. *Cilissa melanura*, as already

¹ *Journ. Linn. Soc.* viii. (1864).

mentioned, devotes itself almost exclusively to *L. Salicaria*, which, however, is visited also by many other insects. Knuth suggests that the green colour of the anthers of the longest stamens, which, of course, are most exposed, serves perhaps as a protection against pollen-eating insects.

L. hyssopifolium.—This species is, according to Schulz, protogynous. It is said by Vaucher, though Darwin thinks erroneously, to be dimorphous.

PEPLIS

P. Portula (Water Purslane).—A small weak herb growing in moist places. The very minute flowers sometimes have no petals.

CUCURBITACEÆ

Our only representative is the common Bryony (*Bryonia dioica*), which climbs by means of tendrils. Honey is concealed in the flowers. The plants are dioecious, the female flowers only half as large as the male, in which two pairs of the five stamens are grown together; the fifth is free. The lower parts of the calyx and corolla are grown together, and bear the stamens, the bases of which completely cover the stigma, leaving a passage, however, in the centre and three at the sides which are protected by hairs. Ludwig records a case in which a female plant was fertilised with pollen from a male growing at a distance of about 40 metres. One species of bee, *Andrena florea*, appears to visit this species exclusively. It has been suggested that the flower may have some special odour, very attractive to this particular bee, but which we cannot perceive. Struck by the great attraction which these, to our eyes inconspicuous, flowers have for insects, Knuth suspects that they may possess some attraction not visible to our eye, and suggests that they may emit

ultraviolet rays, which, as I have shown elsewhere,¹ are visible to some insects. In support of this view he finds that they act energetically on photographic plates. The fruit is a globular berry with flat, nearly orbicular seeds.

CRASSULACEÆ

Generally succulent plants with numerous small regular flowers, with usually 5 or sometimes more sepals, petals, and carpels, and the same number of, or twice as many, stamens. They generally have honey, which is secreted by glands at the base of the ovary.

TILLÆA

T. muscosa is probably self-fertilised.

COTYLEDON

C. Umbilicus, Pennywort, so called from the thick, round, peltate leaves. The flowers are protandrous. The only insects recorded as visiting this species belong to the genus Thrips. They do not probably, however, serve to fertilise the flowers. The plants grow on almost bare rocks and walls, especially on our western coasts.

SEDUM

We have nine species of this genus. Two have flat broad leaves, one (*S. Rhodiola*) with 4 sepals and petals, the other (*S. Telephium*) with 5. The other species have leaves as thick, or almost as thick, as they are broad. Four have white or reddish flowers; of these, two have ovoid or globular leaves, one of which (*S. anglicum*) is glabrous, the other (*S. dasyphyllum*) with a few glandular hairs on the calyx and pedicels; the other two have oblong or cylindrical leaves; one (*S. album*) is glabrous, the other (*S. villosum*) is viscidly downy

¹ Avebury (Lubbock), *Ants, Bees, and Wasps*.

Lastly, of the yellow-flowered species, one (*S. rupestre*) is over 6 inches high, the other two not above 3 inches, one (*S. acre*) bitter, the other (*S. sexangulare*) tasteless. The fleshy leaves check transpiration, as the surface is, of course, in a smaller proportion to the volume; the succulent tissues also enable them to lay in a store of water as a reserve in times of drought. In some cases the character of the contained fluid is also an impediment to transpiration; gummy, saline, and resinous fluids evaporate much more slowly than pure water.

It was in species of *Sedum* that Bohm in 1856 observed¹ the movements of the chlorophyll grains under the action of light. In diffused light the grains are scattered, while in bright light they collect into heaps. He did not, however, give details, and the phenomenon is more clearly shown in *Oxalis* (p. 135) and *Lemna*.

S. Rhodiola is dioecious; according to Warming, in Greenland tricecious.

S. acre.—The flowers are protandrous. The five outer stamens, those opposite the sepals, first stand upright and open their anthers. When the pollen is shed they curl outwards and make way for the inner series, which take up the same position. When these also have shed their pollen, they in their turn curve downwards and outwards, while the five carpels grow up, and the small terminal stigmas occupy the same central position. Self-fertilisation would thus be excluded. H. Müller, however, found in Westphalian plants that the second series of stamens and the stigmas ripened together. The bitterness, no doubt, as in other cases, serves as a protection.

S. Telephium.—In this species, on the other hand, H. Müller found that both sets of stamens have shed their pollen before the stigmas come to maturity.

S. album is strongly protandrous.

¹ *Sitzungsb. Akad. Wiss. Wien*, xxii. (1856). See also Frank, *Pringsh. Jahrb.* viii. (1872).

S. dasyphyllum.—This species is also said by some authorities to be protandrous, but the stigmas are said to ripen earlier in mountain districts, and, according to Kerner, the anthers of the stamens opposite the sepals open with the flower and fertilise their own stigmas. Those of the series opposite the petals ripen later, and as the stigmas are then withered, their pollen is, no doubt, intended for cross-fertilisation.

S. villosum.—The flowers of this species are protected by the stalks being clothed with adhesive glands.

SEMPERVIVUM

The leaves are succulent, serving for water-storage, as in *Sedum*.

S. tectorum (House Leek).—The flowers are protandrous, but not so much so as to exclude self-fertilisation.

RIBESIACEÆ

RIBES

There are four British species. One, the Gooseberry (*R. Grossularia*), has prickly stems; *R. alpinum* has diœcious flowers and red fruit. In the last two the flowers are complete; one (*R. rubrum*) has red, the other (*R. nigrum*) black fruit. It is doubtful, however, whether any of them except *R. alpinum* are really native. The flowers are greenish-yellow, yellow, or red, with more or less concealed honey.

R. alpinum.—The petals are very small. The calyx forms an open shallow saucer, which secretes honey. The flowers being diœcious, self-fertilisation is out of the question. As usual, the male flowers are rather larger than the female.

R. rubrum.—The flowers are homogamous and greenish-yellow. The calyx is less widely open than in the preceding species. The anthers are so arranged that an

insect pressing its head to the flower touches them with one side and the stigma with the other. It is a bee-flower, but the flowers often hang in such a manner that the pollen falls on to the stigma and fertilises it.

R. Grossularia (Gooseberry) is slightly protandrous. The cup of the flower is somewhat deeper than in the preceding species, and the honey is also protected by stiff hairs on the pistil which reach across nearly to the petals.

R. nigrum.—The flower is arranged like that of *R. rubrum*, but the calyx is more bell-shaped, and access to the honey is only possible to insects with a proboscis. Insect visits, however, are not numerous, and it is often, perhaps generally, self-fertilised.

SAXIFRAGACEÆ

SAXIFRAGA

The flowers are white or yellow, often sprinkled with purple, more rarely rose or blue. The outer wall of the ovary secretes honey, which is generally quite exposed, in consequence of which the flowers are richly visited by insects. They are, as a rule, protandrous, but a few species are protogynous. The fruit is an upright capsule, and the seeds are jerked out by the wind.

S. Geum.—The stamens are arranged round the flower, with the unripe pistil in the centre. After the anthers have shed their pollen, they shrivel up, while the stigmas separate and occupy the positions previously filled by the stamens.

S. oppositifolia agrees in essentials with *S. Geum*. Engler describes the flowers as sometimes protogynous, sometimes protandrous; Ekstam found them protandrous in Nova Zembla, while, according to Ricca, they are homogamous; according to H. Müller on Piz Umbrail and the Albula, to Warming in Greenland, and Lind-

man in the Dovrefjeld, they are protogynous. In the absence of insect visits they fertilise themselves.

S. stellaris.—This species also is recorded in some districts as protandrous, in others as homogamous, and elsewhere again as protogynous.

S. tridactylites.—According to Sprengel this species is protandrous, while H. Müller describes it as protogynous. The leaves have sticky glandular hairs, which often capture small insects. The glands are absorbent, so that it is quite possible that the plant derives some nourishment from them.

S. umbrosa (London Pride).—In this species also the peduncles and petioles of the leaves bear a certain number of glandular hairs, and the flowers are thus protected against creeping insects.

CHRYSOSPLENIUM

The flowers are greenish or golden-yellow, and inconspicuous, with exposed honey, which is secreted by a band surrounding the base of the pistil. The leaves surrounding the flowers are often golden yellow, thus making the flowers more conspicuous. We have two species, one with a triangular stem and alternate leaves, the other with a quadrangular stem and opposite leaves. These two conditions evidently depend on one another, but which is the determining factor? Besides the complete flowers, there are others with stamens only.

C. alternifolium.—The flowers are homogamous, but apparently with a tendency in some places to become protogynous. The flowers and surrounding leaves are arranged on a plane, which renders them more conspicuous, and also more convenient for small insects. Small snails, especially *Succinea*, also appear to assist in the fertilisation.

C. oppositifolium.—The arrangement of the flowers is similar, but they are protogynous.

PARNASSIA

White protandrous flowers, with half-concealed honey.

P. palustris (Grass of Parnassus).—This species, as its name denotes, inhabits wet and boggy places. It has ten stamens, of which, however, five only bear anthers, while the others secrete honey at the base, and terminate in from eight to seventeen beautiful yellow globular glands. These glands so closely resemble drops of honey that it is difficult to believe they are perfectly dry. They probably serve as sham drops of honey to attract flies. There has been some difference of opinion whether each of these “staminodes” represents a stamen or a group of stamens. I can hardly doubt that the former is the correct view. The five polliniferous anthers ripen, not simultaneously, but successively, and as each ripens it places itself right on the top of the stigma, with its back to it, and the pollen is then discharged from the anther on the side away from the stigma, so that it is scarcely possible for any to fall on it; and this is done by each of the five stamens in succession,¹ each taking a day to itself. When all five have shed their pollen, on the sixth day the pistil takes its turn. The flower smells of honey in bright sunshine, and becomes scentless towards evening.

Parnassia offers another case in which, within the limits of the species, the flowers are sometimes smaller and the number of the parts diminished. In the Alps the flowers are from 13-25 mm. in diameter, and these small flowers often have only three stamens. Knuth mentions that flowers from gathered buds observed by him were often homogamous, confirming the just remark by Sprengel, that it is not always safe to conclude from cultivated specimens as to the behaviour of plants in their natural homes. The seeds are very minute, weighing only 00003 of a grain.

¹ Bennett, *How Flowers are Fertilised* (1873).

DROSERACEÆ

DROSERÆ (Sundew)

We have three species, which, however, do not seem very well marked off from one another. The Common Sundew (*D. rotundifolia*, Fig. 138) has the ends of the leaves obovate or orbicular, as broad as long. In *D. anglica* (Fig. 139) they are linear-spathulate, five or more times longer than broad; but in *D. longifolia* the leaves are almost intermediate in form. *D. rotundifolia* and *D. anglica* produce cleistogamous flowers.

In the species hitherto described the relation between the flowers and insects is one of mutual advantage. The honey of the flowers affords to the insects a rich and nutritious food; and if the latter rob the flowers of some of their pollen, they make ample amends by carrying a portion of the remainder from one flower to another, and thus conferring on the plant the great advantage of cross-fertilisation. In *Drosera* on the contrary, we find a very different state of things, for the plant catches and devours insects. This genus, and the other plants which have this remarkable habit, were the subject of an admirable memoir by Sir Joseph Hooker, read before

the British Association,¹ of a special work by Darwin, and of many subsequent observations. The first observation of insect-eating plants was made about the year 1768 by our countryman Ellis, on *Dionæa*, a North American plant, the leaves of which have a joint in the middle, and close over, kill, and digest any insect which may alight on them. The plant has more

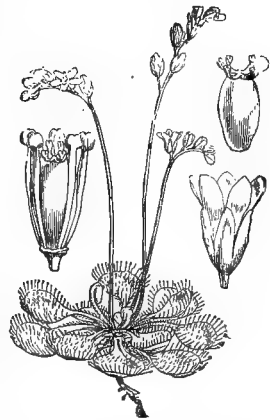


FIG. 138. — *Drosera rotundifolia*. Plant (reduced) with flower and pistil.

¹ *Nature*, September 3, 1874.

recently been studied by an American botanist, Mr. Canby, who found, by feeding the leaves with small pieces of beef, that these were completely dissolved and absorbed; the leaf opening again with a dry surface, and ready for another meal, though with an appetite somewhat jaded. Cheese disagreed with the leaves, turning them black, and finally killing them.

In the case of *Drosera* the leaves are covered with gland-bearing filaments or tentacles. Each gland is



FIG. 139. — *Drosera anglica*.
Plant (reduced) with pistil
and seed.

surrounded by a drop of viscid secretion, which, glittering in the sunshine, have given the plant its poetical name of Sundew. There are about 200 on each leaf. If a small insect—and the victims are mostly small flies—alight on the leaf, it is caught by the viscid secretion. The gland is immediately excited to more active secretion, and the stimulus gradually extends to the whole leaf. The tentacles also bend over towards the insect, which is firmly held (Fig. 140). The secretion becomes more viscid, and the softer parts of the captive are dissolved and

digested. When all the nourishment has been extracted, the secretion dries up, the tentacles resume their original position, the hard parts of the insect are blown away, and the leaf is ready for another meal. On one large leaf Darwin found the remains of no less than thirteen insects. Mr. Francis Darwin has found that plants fed on small bits of meat were more vigorous than others which were kept without animal food and left to depend on their roots alone.

The sensitiveness of the tentacles is marvellous. Darwin found that a minute particle of a woman's hair weighing $\frac{1}{78700}$ of a grain produced a distinct move-

ment. Such a particle would have been entirely imperceptible on the tip of the tongue, which is the most sensitive part of our organisation. Of many stimulants tried carbonate of ammonia was the most energetic. A dose of $\frac{1}{13400}$ of a grain given to a gland produced a marked effect. On the other hand, it is remarkable that though so sensitive the tentacles do not move if struck by drops of rain, even if coming down heavily. Inorganic substances again, such as bits of glass, or sand, or organic substances not containing nourishment, produce little effect, or if the tentacles bend slightly over them they seem soon to find out their mistake.

It seems wonderful indeed how such remarkable contrivances can have originated. Nevertheless some light appears to be thrown on the problem if we bear in mind that we find every gradation. Many plants produce a sticky secretion, which apparently seems only to prevent creeping insects from ascending the plant and eating the leaves or robbing the flowers of nectar. In others, as, for instance, *Saxifraga tridactylites* and *S. umbrosa*, insects are not only occasionally captured, but apparently sucked of their juices. In *Drosera*, and, as we shall see, in *Pinguicula*, the contrivances are more elaborate; and perhaps to this the great success of the genus in the struggle for existence may be due, for there are many species, spread almost over the whole continental world.

D. anglica.—The leaves of this species stand erect, and, as is usual in such cases, are not suddenly widened at the end.

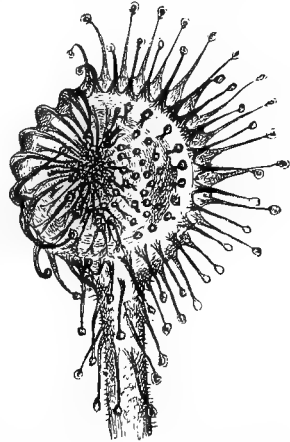


FIG. 140.—*Drosera rotundifolia*.
Leaf enlarged, with the tentacles on one side inflected over a bit of meat placed on the disk.

UMBELLIFERÆ

The Umbelliferæ are generally herbaceous, and the leaves are much subdivided. There are, however, some exceptions. *Hydrocotyle* is a marsh plant growing on wet mud or floating in water, and the leaves are round like those of a small water-lily. *Bupleurum* also has undivided leaves, and one South European species, the only shrubby one in the family, has leathery leaves like those of a Laurel. The fruits are sometimes winged, as in *Angelica*; sometimes covered with spines or hooks, as in the Carrot, *Anthriscus*, or *Sanicula*.

The plants belonging to this group possess two great advantages, namely, first, the association of the



FIG. 141.—Wild Chervil (*Chaerophyllum sylvestre*). Leaf and inflorescence (reduced) with flower and fruit.

numerous small flowers into comparatively large flat heads, by which they are made much more conspicuous; and secondly, they all secrete honey in the centre of the flower on a flat disk (Fig. 142), which is thus accessible to all insects, even those with the shortest lips. This is an advantage, as it effects a considerable saving of time, enabling the insects to visit a given number of flowers more rapidly, and consequently rendering their fertilisation more certain than if they stood singly. But though the order is so rich in genera and species, it is comparatively uniform, and the divisions are for

the most part characterised by the form and structure of the fruit. The flowers are generally small; the petals, 5 in number, are inserted round a little fleshy disk; the stamens, also 5, alternate with the petals.

The self-fertilisation which, in small flowers such as

these, would otherwise naturally occur, is provided against by the fact that the flowers are generally protandrous, the stamens ripening before the pistil, and the latter not being mature until the former have shed their pollen, as, for instance, is shown in the following enlarged figures of the Wild Chervil (*Chærophyllum sylvestre*). Fig. 142 represents a floret in the earlier (male) condition, showing three ripe anthers (*a'*) and two still immature (*a*), while the stigmas have not yet made their appearance; in Fig. 143 the same flower is

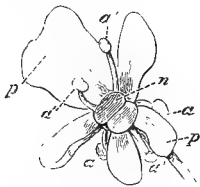


FIG. 142.—Wild Chervil in the first (male) state.

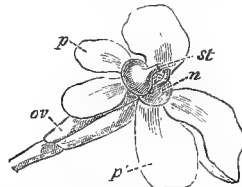


FIG. 143.—Wild Chervil in the second (female) state.

a, immature anther; *a'*, ripe anther; *n*, nectary; *ov*, ovary; *p*, petal; *st*, stigma.

represented in a more advanced condition, the stamens having fallen off, and the stigmas (*st*) being now mature.

In some cases flowers in both conditions may be found in the same head or umbel; in others, as, for instance, in Myrrhis, the flowers of one head are all first in the male condition, and subsequently in that with mature stigmas, none of them arriving at the second stage until they have all passed through the first.

It will be seen that in these florets the petals are not symmetrical, the outer ones being considerably larger than the others, and in many Umbellifers the florets themselves, on the outer edge of the umbel, are considerably larger than the inner ones. This distinction is carried still further in the Compositæ, where also the florets are so closely packed together that the whole flower-head is commonly, though of course incorrectly, spoken of as a flower.

HYDROCOTYLE

Small white flowers with exposed honey, united in a simple head or umbel.

H. vulgaris.—The anthers open one after the other, but the stigmas are ripe before the last have shed their pollen, so that the flower is capable of self-fertilisation. The pollen is pale yellow, forming a pyramid or a double pyramid about 25μ long and 18μ broad.

SANICULA

S. europæa.—The flowers in different localities appear to differ considerably. According to H. Müller there are 1-3 complete protandrous flowers in the centre of the umbel, surrounded by 10-20 later-developing male flowers. Schulz, on the contrary, found male flowers in the centre of the umbels. Kerner and Francke describe the complete flowers as protogynous, but Kerner agrees with Müller that the older flowers in the middle of the umbels are complete. The stigmas are so long that it is possible for them to touch the anthers of neighbouring flowers. The flowers are principally visited by small flies and beetles.

ASTRANTIA

White or reddish flowers with concealed honey. Of this beautiful genus one species, *A. major*, a native of Central and South Europe, has become naturalised in woods in Herefordshire. Besides the complete flowers, male flowers occur either on the same umbel (andromonoëcious) or on different plants (androdioëcious). The bracts are white and shining like broad silvery plates, reminding one very much of some of the simple and pretty Norwegian peasant jewellery. Almost every head contains a few outer complete and central male flowers, which are somewhat later in coming to maturity. According to Kerner the complete flowers are protogynous, and may be fertilised by neighbouring male flowers.

ERYNGIUM

Whitish or amethystine protandrous flowers with concealed honey, which is secreted by a ten-rayed disk at the base of the flower. The bracts are coloured, and add considerably to the conspicuousness of the flowers. The close flower-heads and stiff spiny leaves give the plants some resemblance to a thistle, for which, indeed, they are often taken. We have two species—one common on our coasts—*E. maritimum*, with the scales of the receptacle three-lobed, and the leaves with plaited and rounded lobes; the second, *E. campestre*, which is very local and not a true native, has the leaves pinnately divided, with pinnatifid lobes.

E. maritimum (Sea Holly).—The spiny leaves and bracts form an effective protection. The petals (Fig. 144) are turned down in a long lobe, which with the filaments close the opening of the flower, though they are easily pushed on one side by the proboscis of an insect. The proboscis must, however, have a length of 4 mm. to reach the honey.

E. campestre.—The arrangement of the flower agrees closely with that of the Sea Holly.

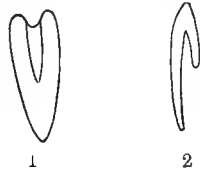


FIG. 144.—1, Petal seen in front; 2, petal seen from the side. Enlarged.

BUPLEURUM

This genus is somewhat peculiar, having entire leaves with parallel veins, but the flowers and fruit resemble those of other Umbellifers. The flowers are yellow. We have four species. *B. rotundifolium* has perfoliate leaves, which perhaps prevent creeping insects from obtaining access to the flowers; *B. falcatum* is a perennial, with grass-like leaves. Of the other two, *B. tenuissimum* has very minute bracts, while in *B. aristatum* the bracts are longer than the flowers. The flowers are protandrous. The leaves are adapted to

dry conditions. The cuticle is more or less thickened, and there are often stomata on both sides.

In the remaining genera of this family the flowers form a corymbose umbel, *i.e.* a head consisting of several branches which start from the same point, and, though of different lengths, reach the same height, so that the flowers form a plane. They are generally white, sometimes greenish, and in a few species yellow or reddish. The honey is exposed.

CONIUM

C. maculatum (Hemlock).—This is a very typical Umbellifer. The flowers are several hundred in an umbel, protandrous, small, white, and conspicuous from their numbers. The plant is about 3 feet high, with much-divided leaves, which if crushed have a nauseous scent, though the actual flowers have a sweet smell of honey. The petals are turned over at the tip, but not so much so as in *Eryngium*, and perhaps with the object of protecting the honey till the flower is mature. At the opening of the bud the anthers are scarcely ripe, but they soon arrive at maturity, and raise themselves so as to stand directly over the still immature stigma. When each anther has shed its pollen it turns outwards and another takes its place. When they have all had their innings, and generally not until all the pollen has fallen, the stigmas themselves grow upwards and take their turn. The honey being open to all, the flowers are visited by many small insects.

Tittmann¹ long ago remarked on the power possessed by plants of drawing themselves down under the protection of the ground in winter by means of the contraction of the roots. This is well shown in several Umbelliferæ, in some Compositæ, in *Dipsacus*, *Beta*, etc. In this species, according to De Vries,² it amounts to as much as 8 per cent.

¹ *Flora*, ii. (1819).

² *Bot. Zeitung*, xxxvii. (1879).

PETROSELINUM

P. sativum (Parsley) occurs as a garden escape. The flowers are greenish yellow, whereas

P. segetum, a native in Central and South England, has white flowers.

TRINIA

T. vulgaris.—A rare plant, found on limestone rocks in Devon and Somerset, has dioecious flowers; the males have narrower petals than the females.

APIUM

We have three species. *A. nodiflorum* has ovate or lanceolate leaflets, while in *A. inundatum* they are almost filiform, probably in consequence of being submerged. Both species have partial involucre of several bracts. *A. graveolens*, on the contrary, has none.

A. nodiflorum.—According to Knuth this species is markedly protandrous, and the secretion of honey ceases when the anthers have shed their pollen, commencing again when the stigmas reach maturity.

ÆGOPODIUM

A. Podagraria (Goutweed).—According to Warnstorf the umbels of the first order have complete flowers, while those of the second have male flowers in the centre and complete ones round the outside. Over a hundred insects are recorded as visitors of this species, which is a doubtful native occurring in waste places near buildings or gardens.

CARUM

Of this genus we have three species—*C. tuberosum*, with tubers; *C. verticillatum*, with leaves apparently in whorls; and *C. Carui*, the Caraway; the last not native, but naturalised in waste places.

C. Carui.—According to Warnstorf, in some of the flowers the anthers produce no pollen.

PIMPINELLA

We have two species—*P. Saxifraga*, which is very common in pastures; and *P. magna*, which is less frequent and larger, preferring mountainous and shady places.

SIUM

This genus is represented by two species—*S. latifolium*, which has the umbels all terminal, and *S. angustifolium*, in which many of them are lateral.

S. latifolium.—Some of the flowers are complete, some male, and the arrangement seems to differ in different localities. The flower-heads, which are at first upright, gradually turn to the side, and in this position the pollen of the upper flowers may fall on and fertilise the lower ones. This happens in many Umbellifers.

CENANTHE

We have four well-marked species. Two have long linear leaves; one, *C. fistulosa*, with hollow, the other, *C. pimpinelloides*, with nearly solid stems. The other two have broadly cuneate leaves, one, *C. crocata*, with large terminal umbels, while the other, *C. Phellandrium*, has most of them opposite to the leaves.

C. fistulosa has andromonœcious, and also almost homogamous complete flowers, which are generally central. Some plants appear to produce male flowers only.

C. aquatica.—Flowers resembling those of the preceding species.

ÆTHUSA

Æ. Cynapium.—The flowers have been described by Kerner and Schulz, who, as in so many other cases, give quite different accounts. According to Schulz the complete flowers are homogamous or slightly protandrous, while Kerner found them protogynous. It is probable, therefore, that they differ in different localities.

FŒNICULUM

F. vulgare (Fennel).—A tall glabrous herb with finely divided leaves, and large umbels of small yellow flowers; it occurs on some of our southern sea-cliffs, but is a doubtful native.

MEUM

M. athamanticum.—An Alpine plant found in Wales, the North of England, and Scotland. It is, according to Schulz, andromonœcious; the hermaphrodite flowers being markedly protandrous.

CRITHMUM

C. maritimum (Samphire).—Like so many other seaside plants, this has succulent leaves. The flowers are markedly protandrous. According to Kirchner, the pistil does not begin to develop till the anthers have all shed their pollen.

ANGELICA

A. sylvestris.—In some of the flowers the anthers are rudimentary.

PEUCEDANUM

We have three species. *P. Ostruthium*, which has become naturalised in the North of England and Scotland, has broad leaves; the other two, narrow. Of these, *P. officinale*, a very rare plant, has yellowish flowers; *P. palustre*, white flowers.

PASTINACA

P. sativa (Wild Parsnip) is easily identified by its yellow flowers. The umbels of the first order, according to Schulz, are hermaphrodite, with one or a few male flowers in the centre; those of the second order are hermaphrodite, sometimes with some male flowers in the centre; those of higher orders contain more male flowers. Warnstorff found no male flowers in the umbels of the first order.

HERACLEUM

H. Spondylium (Hogweed).—This appears in some localities to have complete flowers only. In others the umbels of the second order are said to have male flowers on the circumference, and those of higher orders to be entirely male, or in some cases female. No less than 118 species of insects are on record as visitors of this flower. In this respect it is pre-eminent. An allied genus, *Ferula*, is supposed to have supplied Prometheus with the rod or “ferule” in which he brought down fire from heaven.

SILER

S. trilobum.—Andromonœcious, with protandrous hermaphrodite flowers. The male flowers are numerous, and occupy the centre of the umbels. The plant is not a native of Britain, but has become naturalised at Cherry Hinton, near Cambridge.

DAUCUS

D. Carota (Carrot).—The flowers are white; one or a few in the centre, however, generally, but not always, red. No satisfactory explanation of this has yet been given. They do not appear to be of any functional importance, and Darwin was disposed to regard them “as a remnant of a former and ancient condition.”¹ A somewhat similar case of the appearance of red colour occurs in the ray florets of *Yarrow* and the *Daisy*. Darwin’s suggestion of a primitive condition in *Carrot* seems unlikely, as red is a rare colour in *Umbelliferæ*. The red colour would tend to increase the attractiveness, but it is so small that this hardly seems a sufficient explanation. The flowers vary considerably in size, those at the circumference, and especially the petals on the outside, being the largest. *Schulz* describes in *Mid-Germany* two forms: the commoner has complete and male flowers on the same

¹ *Forms of Flowers.*

head, the latter occupying the centre. The second form has greenish or reddish flowers; the umbels have only female, or female and sexless flowers. The anthers often contain normal pollen grains, but the grains are often smaller and irregular in form; moreover, the anthers rarely open, and even then remain in the same position which they occupied in the bud. Warnstorff found the umbels of the first order hermaphrodite; those of the second complete at the outside, and with a few male flowers in the centre; those of the third all male. Here again, therefore, we find very curious and as yet unexplained differences. The flower-heads are upright during the day, but curve over at night, thus protecting the flowers from rain and from too rapid radiation. Irmsch long ago observed that after the seedlings have made a certain amount of growth the root contracts and draws the stem down under ground.

CHÆROPHYLLUM (Chervil)

We have three species. One, *C. Anthriscus*, has short hispid fruit. Of the other two, one, *C. temulum*, has the fruit ribbed; in the other, *C. sylvestre*, it is smooth, without ribs.

C. sylvestre (Figs. 141-143).—The flowers are andromonœcious, complete, and protandrous. The male flowers are central. According, however, to Schröter, all the flowers are complete and protandrous. The honey is exposed, and the list of visitors very long.

C. temulum.—The arrangement of the flowers is as in the preceding species.

ANTHRISCUS

A. vulgaris.—According to Schulz the flowers are homogamous, and fertilise themselves. They are not much visited by insects. The fruits are covered with short hooked bristles, and narrow at the top into a short smooth beak.

SCANDIX

S. Pecten-Veneris (Venus's Comb).—This prettily and cleverly named species has andromonœcious, or homogamous, or weakly protandrous, complete flowers. The male flowers are generally central, but not always present; while the umbels of the third order are often exclusively male. Before fertilisation the involucre consists of five small, simple leaves. If fertilisation is not effected they remain in this condition, but if even a single flower of the umbel is fertilised they grow and ramify considerably. The upper part of the ovary also elongates rapidly, attaining a length of 2 inches. When ripe the fruits spring open elastically.

PHYSOSPERMUM

P. cornubiense.—An extreme West of England species, characterised by its bladdery fruit, whence its generic name. It is an example of an element of the South-west European flora subsisting under the mild climatic conditions of the West of England. The Cornish heath, *Erica vagans*, affords another example.

MYRRHIS

M. odorata.—A doubtful native. Most of the flowers are complete and protandrous, but the later ones male only.

CAUCALIS

There are five British species. One, *C. nodosa*, has the umbels opposite the leaves, and short fruit. In the other four the umbels are terminal. Two have short fruits not two lines long; in one, *C. Anthriscus*, the general involucre has several bracts; in the other, *C. arvensis*, only one. Of the last two, one, *C. latifolia*, has simple pinnate leaves; while in the other, *C. daucoides*, the leaves are twice or thrice pinnate.

C. daucoides.—According to Schulz, is andromonœcious, and also has protandrous complete flowers. The male flowers are central. Kerner, however, describes

the complete flowers as protogynous. It is not much frequented by insects.

C. latifolia.—Andromonœcious, with complete flowers, which are homogamous according to Kerner, protogynous according to Schulz. A rare plant in cornfields in the South of England, and not native.

C. Anthriscus.—Flowers generally white, but often reddish. Schulz describes them as resembling those of *C. daucoides*. The plant is covered with short appressed hairs.

ARALIACEÆ

This family agrees with the Umbelliferæ in many respects, differing principally in the fruit, which forms a berry, or berry-like "drupe." The flowers are greenish, protandrous, or homogamous, with free honey secreted by a band surrounding the pistil.

HEDERA

H. Helix (Ivy).—A woody evergreen climber. The main stems adhere to walls, trees, etc., by small modified roots, which, unlike the ordinary ground roots, arise along the length of the stem between the leaves. They act solely as hold-fasts, and show a strong negative response to the light, tending to grow away from it into cracks or crannies of walls, bark, etc. The ivy, like other green plants, derives its food from the air by means of its leaves, and from the ground by means of the ground roots, which arise only at the leaf insertions. A plant cut off from connection with the ground withers. The flowering branches project freely from their support, and, instead of the typical three- to five-lobed "ivy" leaves, have ovate leaves. They are so distinct that they are often supposed by those who are not botanists to belong to different plants. Other species with a similar habit have two forms of leaves, as, for instance, *Ficus repens*. The reason I believe to be as follows. It is

important to the leaves to secure as much light and air as possible, and when growing on a flat surface the ivy shape enables the leaves to fit into one another, and to cover the whole surface. On the other hand, the flowering branches grow up into the air. The leaves are arranged round the stem, and under these conditions an oval form is more suitable, as, for instance, is also seen in the Black Poplar. The structure of the leaf differs according to the amount of light to which it is exposed. In the sun two layers of palisade cells are developed under the upper epidermis, while in the shade leaves the whole interior consists of rounded cells. The difference is very like that which exists in the Dandelion (see p. 250). The ivy is almost, if not quite, the last of our plants to flower. The peduncles are covered with stellate hairs. The five united carpels form a pistil projecting about 1 mm. above the sepals. According to Delpino the flowers are protandrous, while H. Müller and Kirchner describe them as homogamous. Honey is abundant, and the flowers are very attractive to insects—especially flies. They appear to be sterile to their own pollen. The fruit, which is set during the late autumn, remains almost, if not quite, dormant during the winter, and does not ripen until the following spring.

LORANTHACEÆ

Shrubby or half-succulent evergreens, parasitic on trees.

VISCUM

V. album (Mistletoe).—This interesting species is the subject of many folklore tales. The traditionary connection with the Druids is more or less doubtful. Its favourite tree appears to be the Black Poplar. It also does well on the Apple, and some Conifers, as the Silver Fir. It attains an age of forty years. The berry is white, enclosing a single seed, surrounded by a very

sticky pulp. The seed is carried by birds, and when dropped adheres firmly to the bark, into which the young plant drives its suckers, which ultimately become thickened to wooden pegs. Unlike many other parasites, the Mistletoe is partly green. This has been accounted for by suggesting¹ that it only takes the ascending sap, while the brown parasites make use of the descending, elaborated sap, and consequently can dispense with green leaves. This, however, is probably incorrect, for not only does the Mistletoe root become firmly fixed in the wood of its host, thereby tapping the stream of water and dissolved substances rising from the roots, but also develops secondary branches which make their way along the bast, that is, the path of the descending sap. The evergreen leaves well serve for the construction of carbohydrate in the winter, when in most cases the host plant will have shed its leaves. Hence the relation between Mistletoe and host becomes one of symbiosis, involving, that is, a certain mutual advantage.

The leaves have no palisade cells, the tissue between the upper and lower epidermis being fairly uniform throughout.

It is fertilised by insects (bees and flies), and is therefore interesting as a species which is dependent on both birds and insects.

CORNACEÆ

CORNUS

We have two species—*C. suecica*, a low herb, with 4 petal-like bracts; and *C. sanguinea*, a shrub, without bracts. The flowers are homogamous, with free-lying honey secreted by the base of the pistil.

C. sanguinea.—The anthers open inwards, and at the same level as, but some little distance from, the pistil; so that an insect visiting the flower is almost sure to dust itself with pollen on one side, and to touch

¹ Constantin, *La Nature Tropicale*.

the stigma with the other. Gradually, however, the stamens rise and turn inwards, so that in the absence of insect visits the flower would fertilise itself. The pollen is large, rounded, and 63-75 μ in diameter. The fruits are black (see Wild Cherry, p. 175).

C. suecica.—The four white red-veined bracts fulfil the purpose of petals, and surround an umbel of about twenty minute flowers. The true petals are minute, purple, and reflexed, as are the sepals.

CAPRIFOLIACEÆ

This family presents great differences as regards fertilisation. The Elder has no honey, and is visited for the pollen; *Adoxa* and *Viburnum* have quite exposed honey; in *Linnæa* it is accessible to insects even with short probosces; *Symphoricarpus* is a wasp flower; *Lonicera nigra* is adapted to bees with a short proboscis; *L. cærulea* to humble bees; *L. Periclymenum* only to a few of those with the longest proboscis, and to moths; and lastly, *L. Caprifolium*, with a tube almost an inch long, only to hawkmoths.

ADOXA

Inconspicuous greenish flowers, with exposed nectar.

A. Moschatellina.—The flowers have a scent of musk, as suggested by the specific name. The anthers stand at the same level as the stigma. According to Kerner the flowers are protogynous; the anthers at first turned from, and afterwards towards, the pistil.

SAMBUCUS

We have two species. *S. Ebulus* is a herb with stipules, or lobes resembling stipules; *S. nigra*, a small tree without stipular lobes.

S. Ebulus (the Dwarf Elder, or Danewort) is supposed to have been introduced by the Danes. The honey is free-lying, secreted by the summit of the ovary.

S. nigra (Elder) has the flowers honeyless, sweet-smelling, homogamous, and united in large corymbs, which makes them very conspicuous. They are, however, not much visited by insects, and the anthers open outwards, but the stigma comes in the fall line of the pollen from at any rate one of the anthers. The flowers are principally visited by flies. The scales protecting the bud are petioles; the outer ones are very small; the third pair often terminate in more or less rudimentary leaves.

The bark of the younger shoots is a good subject for the study of lenticels. These are oval spots where the cork cells are loosened and separated sufficiently to allow free passage of air, as shown in the above figure (Fig. 145). Lenticels replace the stomata of the young green shoots as respiratory organs.

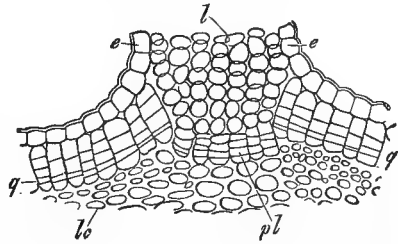


FIG. 145.—Lenticel from a branch of *Sambucus nigra* in the summer of the second year. *e*, epidermis; *l*, loosely arranged cork cells forming the lenticel; *lc*, parenchyma of cortex; *pl*, formative layer by the transverse division of the cells of which the lenticel is formed; *g*, formative layer giving rise to the ordinary closely packed cork cells.

VIBURNUM

We have two very distinct species. *V. Opulus* has three- to five-lobed glabrous leaves, and red berries; *V. Lantana*, entire leaves, downy underneath, and purplish-black berries. The honey is free-lying, or half concealed, and *V. Opulus* has nectaries on the leaf-stalks.

V. Opulus (Guelder Rose) (Fig. 146).—This is the wild form of the Guelder Rose. As in many of the Umbelliferæ the outer flowers are larger than the central ones. In this species, indeed, they serve merely to make the flower-head more conspicuous, for they have neither stamens nor pistil, as Sprengel long ago observed. The flowers are homogamous. They are visited by bees for

the pollen, while flies come principally to lick the layer of honey. From the position of the flowers pollen must often fall from one flower on to the stigma of another.

I was long puzzled as to the reason for the great difference in the form of the leaves of our two species of *Viburnum*, but it may perhaps be explained by the following suggestions, which I brought forward in a paper read before the Linnean Society in 1890,¹ and in my book *On Buds and Stipules*. *V. Lantana* has



FIG. 146.—*Viburnum Opulus*. Shoot, with flower and fruit.

leathery leaves, tomentose on the nerves, which, moreover, are when young protected by a thick felt of stellate hairs. *V. Opulus*, on the contrary, has more delicate leaves, glabrous above, pubescent beneath. They are protected in the bud by the lower leaves, which are leathery, and serve merely for this purpose. For facility of packing in the confined space of the bud they are folded up, and hence the lobed form. They also present curious stipules or stipuliform appendages, which fill up and thus utilise a space at the base of the bud which would otherwise be empty.² The leaf-stalks bear one or more cups which secrete nectar. This is also

¹ *Journal Linnean Soc. (Bot.)* xxviii.

² This is described more fully in my *Buds and Stipules*, p. 40.

perhaps connected with the tender delicate texture of the leaves, and especially of the young leaves, which afford a tempting food to many caterpillars and other insects. The ants and wasps which are attracted by the honey tend to keep them down, and thus to serve as a bodyguard. Indeed, it has appeared to me that on specimens of *V. Opulus* which are much frequented by wasps and ants the leaves are less eaten than in other cases where they are not so protected. It is said to emit a peculiar odour in the evening.¹

V. Lantana (Wayfaring Tree) (Fig. 147).—In addition to the differences from *V. Opulus* already mentioned, the flowers of

V. Lantana are all complete, the peripheral flowers are not much larger than the others, the quantity of honey is less, and according to Schulz the flowers are protogynous.



FIG. 147.—*Viburnum Lantana*. Shoot, with flower and young and ripe fruit.

LONICERA

Honey is secreted at the surface of, or in a cup at, the base of the corolla tube.

L. Periclymenum (Honeysuckle).—The first flowers expand, and become strongly scented about seven o'clock in the evening, and by eight most of them are open. The buds stand more or less perpendicularly. The tube is rather more than an inch in length, so that the honey is only accessible to Lepidoptera. Soon after opening the flowers turn downwards and become horizontal. The flowers are homogamous, but in the first state of the

¹ Rev. H. Friend, in *Science Gossip*, Sept. 1896.

flower, while the stamens project straight in front, the pistil is turned somewhat downwards; moreover, it projects beyond the anthers, so that self-fertilisation is doubly precluded. The next day the appearance of the flower is quite altered. If it has been, as usual, visited by insects, the pollen is gone, and the stamens gradually turn downwards, while the pistil rises and takes their place. This change has generally taken place before the evening (seven to eight). During the first night, therefore, an insect visitor would rub its breast against the anthers, during the second against the stigma. Between the two stages yet other changes take place. The tube commences to arch itself, and the upper and under lip to roll up, so that the flower becomes less conspicuous. Nor is this all. The colour changes: having been white internally and reddish outside, it becomes a clear yellow. This change is completed before the second evening, at which time, therefore, all the flowers of this age are yellow. A change of colour takes place in several other plants, as in *Polemonium* and *Myosotis*, and in a Brazilian species of *Lonicera* there are even two changes, so that the flower presents successively three different colours. The advantage probably is that moths naturally fly first to the more conspicuous flowers, thus dusting themselves with pollen, and then passing on to the others to deposit some of it on the stigma. But this is not all. In the next stage the flowers become darker, and finally dirty orange, the corolla rolls up still more, and the scent ceases, so that the flower becomes less conspicuous, and less and less attractive to insects. On the other hand, Kerner and Warnstorf consider that in the absence of insect visits the flowers fertilise themselves. The production of honey is so considerable that the tube is sometimes filled up half way. In such cases it is accessible to humble bees with the longest probosces, especially to *Bombus hortorum*. The feast is, however, not arranged for them; there is no convenient alighting stage, and they waste time in clumsy struggles to get at the honey. The true friends are hawkmoths—

especially *Sphinx convolvuli* and *S. ligustri* (the Privet and Convolvulus hawkmoths). Some flies visit the flowers for the sake of the pollen, but do not fertilise them.

L. Caprifolium agrees in essentials with the preceding, but the tube is even longer, reaching 30 mm., so that the honey is effectually reserved for hawkmoths—and even of them, only those with the longest probosces. Kerner describes the flowers as weakly protogynous, H. Müller as homogamous. The flower is first rose outside and white within, and subsequently yellow. Its life continues for three days. The uppermost leaves are united and form a cup round the stem, which, according to Kerner, forms an unclimbable barrier and prevents creeping insects from reaching the flower and robbing it of its honey.¹

L. Xylosteum.—Homogamous. The tube is only 3-4 mm. in length. This species affords an instance of synanthly, or greater or less union of two or more flowers. The two flowers of the cyme are united for about half their length; the two red berries are, however, nearly distinct. In *L. alpigena*, which is not found in Britain, the union is nearly complete in the flower, while in the globose berry the distinction between the two ovaries of which it is made up has been completely lost.²

The two last species are not native, but have become naturalised in some of our southern and eastern counties.

LINNÆA

Homogamous flowers with concealed honey, which is secreted between the bases of the shorter stamens.

L. borealis.—The honey is protected by the hanging position of the flowers. The petals are also lined with hairs, which perhaps serve to exclude both rain and small creeping insects. The pistil projects considerably

¹ We find a similar provision in *Chlora*.

² See Arber in *Journ. Linn. Soc.* (Botany) xxxv.

beyond the stamens, so that insects are almost sure to touch it before reaching the anthers. This delicate little plant is sometimes glabrous, sometimes covered with fine glandular hairs, which are specially developed on two bracts which stand immediately below, and almost close over the fruit, thus probably assisting in its dissemination. The plant was named by Gronovius in honour of Linnæus; a spray is generally introduced in portraits of the great naturalist.

RUBIACEÆ

A large world-wide order which is represented in Britain by the tribe

STELLATÆ

The tribe is so named because the leaves appear to be in whorls. There are, however, in reality only two leaves at each node with buds in their axils. These are opposite one another. The others are stipules, and have no buds in their axils. Where there are six leaflets, these correspond to two leaf-blades and their four stipules. Where there are only four leaflets, this is considered to be due to a coalescence of stipules by pairs, as occurs also in the case of the Hop.

SHERARDIA

Honey is secreted by the fleshy base of the pistil, and concealed in a short narrow tube.

S. arvensis is gynodioecious. The complete flowers are slightly protandrous and rather larger than the female. Kirchner, however, describes the flowers as homogamous. In any case the flower is self-fertile. Knuth observes that from the narrowness of the tube *Sherardia* would appear to be especially adapted to small butterflies. As a matter of fact, however, I do not find that any are recorded as visiting it. It seems

to be chiefly frequented by flies. The calyx teeth enlarge after flowering, and the fruit is covered with bristles, which probably assist in dissemination.

ASPERULA

We have two species—*A. cynanchica*, with glabrous, and *A. odorata*, with hispid, fruit.

A. cynanchica (Squinancy-wort).—The flowers secrete a rich supply of honey. H. Müller describes two forms—one with smooth, white, rather blunt petals, while in the other the petals are rough, pointed, and with three red lines. The pollen easily drops from the anthers on to the stigma.

A. odorata (Woodruff).—The flowers are larger, but resemble those of *A. cynanchica*. They are very sweet. The leaves are extremely sensitive to light, and while healthy green in the shadow of a thick wood, soon turn sickly yellow if the trees are cut down and the plant is exposed to the full sunlight. They are larger and more delicate than those of most of their allies, no doubt from living in localities which are shady and moist. (See *Dentaria*, p. 80, and *Petasites*, *Butter-bur*, p. 236.)

GALIUM

The small flowers have free-lying honey. Insects probably carry the pollen from flower to flower very often on their feet. The anthers and stigma are, however, so close that no doubt the flowers frequently fertilise themselves. We have ten or eleven species.

G. Aparine (Cleavers), takes its common name from the recurved hooks on the angles of the slender four-sided stem, by means of which the plant clings, and is able to scramble over other vegetation. The leaves are also hispid, and similar hooked bristles occur on the rather large fruit and aid in its distribution.

G. Cruciata.—According to Darwin the flowers are andromonœcious; the lower ones male, the upper complete. Schulz, however, gives a different account. He found the earlier flowers of each shoot complete, the

later ones male; the complete ones were generally protandrous. The plant is covered with long white spreading hairs. The specific name recalls the leaf arrangement, four in a whorl, crosswise.

G. Mollugo.—At first the stamens stand upright, and the anthers are covered all round with pollen, while the two stigmas are close together, though mature. Gradually the stamens turn outwards, and eventually bend quite out of the flower, while the two stigmas separate.

G. saxatile agrees with *G. Mollugo* as regards the flowers, and so does **G. verum**, the common Lady's Bedstraw. The last-named is glabrous or pubescent. In some localities the flowers are said to vary considerably in size, while Knuth found them on the North Friesian islands all approximately of the same size.

VALERIANACEÆ

In this order honey is secreted in a cup or spur of the corolla.

VALERIANA

The flowers have 3 stamens, and the calyx forms a feathery pappus in the fruit.

We have three species—one, *V. dioica*, is dicecious; *V. pyrenaica* has large cordate, the other, *V. officinalis*, pinnate, leaves.

V. officinalis.—The flowers are protandrous. As honey guides there are five purple lines, which gradually fade. The honey is protected by some hairs on the inner side of the corolla tube. In the first stage the stamens, with open anthers, project above the corolla; in the second the three stigmas. The anthers develop one after the other.

V. dioica.—Sprengel long ago pointed out that as the male flowers were larger than the female, insects are likely to visit them first. According to Kerner the

female flowers open before the male. In some cases, though rarely, complete flowers occur.

V. pyrenaica.—A native of the South of France and Spain which has become naturalised in plantations. The flowers resemble those of *V. officinalis*.

CENTRANTHUS

Tube of the corolla spurred. 1 stamen.

C. ruber.—The corolla tube is divided into two unequal parts by a thin membrane: the smaller contains the pistil; the larger is produced into a spur, but is so narrow that the honey is only accessible to Lepidoptera. The stamen is connate with the corolla, and only becomes free at the base of the lobe; when the flower opens it projects. When the anther has shed its pollen the pistil elongates and takes its place. According to Knuth, self-fertilisation is therefore excluded, but the stamen gradually curls over so much that the anther might often fertilise a neighbouring flower. It is a Central and South European species often grown in gardens, which has become naturalised, especially in the South of England.

VALERIANELLA

Homogamous or protogynous flowers with concealed honey. There are 3 stamens, but the calyx is not pappose.

We have four species, which are most easily distinguished by the fruits. They consist of three cells, but only one has a seed in it, the other two remain empty. A more or less similar arrangement occurs in other plants, and perhaps serves a useful purpose by reducing the specific gravity of the fruit and thus enabling it to be more easily carried by wind. In some of the foreign species the fruits are provided with hooks. In *V. discoidea* they are winged. The germinating seedling of *V. coronata*¹ (Fig. 148) shows an interesting contrivance for fixing the fruit to the soil and thus

¹ Avebury (Lubbock), *On Seedlings*.

enabling the cotyledons to make their escape. The embryo swells up and the radicle usually bursts through the side of the fruit beneath the calyx limbs; it then pierces the latter, entering by the outer face, and pushing on through both sides, enters the ground, thus pinning the fruit to the soil, while the cotyledons are pulled out in a comparatively short time into the light.

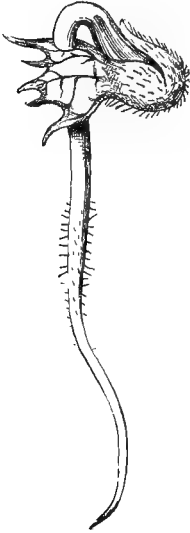


FIG. 148.—Seedling of
Valerianella coronata. $\times 4$.

In *V. olitoria* the fruit is laterally compressed. The chamber containing the seed is in the middle, with the two empty chambers on one side and a corky mass on the other.

In *V. carinata* the fruit is not flattened laterally, but compressed rather from front to back, so as to be almost boat-shaped.

In *V. auricula* the two hollow cells are much larger than that containing the seed.

Lastly, in *V. dentata* the hollow cells are smaller than the fertile one, and each lies in a separate projection of the fruit wall, which is also produced at the two ends.

DIPSACEÆ

Each floret is surrounded by an involucre; they are rendered conspicuous by being collected into a head. Our species are protandrous. Honey is secreted by the upper part of the ovary, and concealed in the tube of the corolla.

DIPSACUS

Stiff bristles prevent insects from walking on the flower-heads, so that they must touch the anthers and stigmas with their heads rather than with their feet.

We have two species, or forms—*D. sylvestris*, with ovoid heads, and very prickly; and *D. pilosus*, with globular heads, and very hairy.

D. sylvestris.—One of the stigmas is generally atrophied. H. Müller suggests that as the tube of the corolla is narrow, if both stigmas were retained there would be no room for the proboscis of the bee, and that fertilisation being secured, a second stigma is unnecessary. The leaves are sessile and broadly connate at the base, forming a water-collecting cup round the stem, which effectually prevents creeping insects from reaching the flowers. The water thus collected is also probably useful as affording the plant a supply in dry weather. The Fuller's Teazel, in which the scales of the receptacle terminate in hooks, is sometimes regarded as a variety of *D. sylvestris*, sometimes as a separate species, *D. Fullonum*.

SCABIOSA

We have three species. One, *S. succisa*, has entire leaves. In the other two the leaves are divided; one, *S. Columbaria*, has the florets five-lobed, the other, *S. arvensis*, four-lobed.

S. arvensis.—When the flower opens the stamens project 4-5 mm. above the corolla, and the anthers open one after the other, so that this stage lasts several days. When they have all shed their pollen they shrink up. The pistil now elongates, and the ripe stigmas take up the position previously occupied by the anthers. The florets open from the circumference towards the centre, but the central florets have all shed their pollen before the stigmas of the outer ones are ripe; so that not only each floret, but the whole head, is at first male, and subsequently female. Self-fertilisation is therefore excluded; but this is immaterial as the flowers are so richly visited by insects—something over 100 species are recorded. Some plants also have female flowers, especially early in the season. In Kent, Darwin found the female flowers much less numerous than the others. According to

Willis, on the contrary, in Cambridgeshire they are more numerous. The plant bears hairs of three kinds—(1) long and simple; (2) long and seated on a dark gland; (3) short ones, sometimes very numerous.

S. succisa (Devil's Bit).—Fifty to eighty deep-blue florets are united in one hemispherical head. The corolla has generally 4, but sometimes 5 lobes, of which the outer one is larger than the rest. The life-history of the flower resembles that of *S. arvensis*. Some plants have flowers in which the stamens are more or less atrophied, and which are smaller than the complete ones. These appear to be much more numerous in some places than in others; near Homburg Magnus estimated them at 10 per cent, Schulz in Brunswick and Halle at 30 per cent. Turner¹ describes the plant as trimorphous—with hermaphrodite, and two female forms, one with a straight and the other with a bent style. The flower-heads are much visited by insects. The stem is pubescent.

S. Columbaria.—The heads contain 70-80 pale purplish florets. The life-history, which is similar to that of the two preceding species, was well described by Sprengel. The outer florets are half again as large as those of the next and inner rows. Plants with female flower-heads appear to be less common than in the preceding species. The insects recorded as visitors are much less numerous. When young the flower-heads turn over at night, thus protecting the florets from rain and cold. The stem is clothed, especially on the upper part, with downward-pointing hairs.

COMPOSITÆ

The Compositæ agree with the Dipsacæ in having flower-heads composed of a large number of florets. The stamens which are 5, or rarely 4, in number,

¹ *Nature*, xl. (1889).

are united in a tube. The flower-head is surrounded by an involucre, consisting of more or less numerous bracts. It serves in some cases to support the florets; if these are taken away from the flower-head, say of a Thistle or a Centaurea, the involucre contracts and closes together, showing how closely it compresses the florets. In other cases, as in *Carlina*, it contributes much to the conspicuousness of the flower-head. The calyx is absent, or represented either by a narrow ring or by a pappus, often of long feathery hairs. The corolla is tubular, with a four- or five-toothed border. The ovary is inferior, with a filiform style, divided at the top into two short branches bearing the stigmas. Honey is secreted at the base of the style. Hildebrand has pointed out that while the small disk flowers fade, as usual, when fertilised, the ray flowers remain fresh until all the florets of the disk are impregnated, clearly showing their relation to the flower-head as a whole. This is the most extensive and widely distributed family of plants. There are over 10,000 known species. We have in Britain no less than 40 genera. It is hardly necessary to say that what we call a "flower" in, say, a Daisy is really a combination of many small flowers or florets. In many the heads close up in wet weather, thus protecting the pollen and stigma, as, for instance, in *Hieracium*, *Bellis*, and *Carlina*. It is said that when once closed, even if the sun comes out again they will not reopen till the next morning.

We may take *Chrysanthemum Parthenium* (Fever-few) (Fig.

149) as a type of the order. It has been well described by Ogle.¹ The flower-heads consist of an outer row of



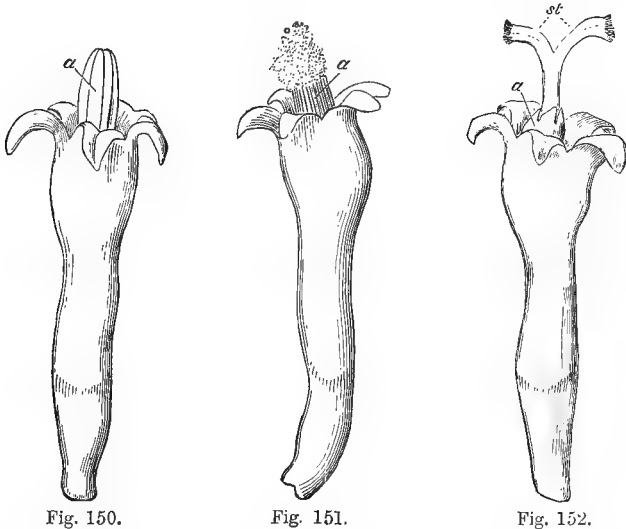
FIG. 149.—*Chrysanthemum Parthenium*, with enlarged ray and disk florets and fruit.

¹ *Pop. Sci. Rev.* April 1870.

female florets, in which the tubular corolla terminates on the outer side in a white leaf or ray, which is useful in making the flower conspicuous. The inner florets are also tubular, but are small, yellow, and without a ray. Each of these florets has stamens as well as a pistil. The anthers are united at their sides so as to form a closed tube, within which the pistil lies. They ripen before the pistil, and open on their inner sides, so that the pollen is discharged into the upper end of the tube above the head of the pistil. When the flower opens the pollen is already ripe, and fills the upper part of the stamen tube. A floret in this condition is represented in Fig. 150. The style, however, continues to elongate, and at length pushes the pollen against the upper end of the tube, which gives way, and thus the pollen is forced out of the tube, as shown in Fig. 151. The style itself terminates in two branches, which at first are pressed closely to one another, and each of which terminates in a brush of hairs (Fig. 152). As the style elongates, this brush of hairs sweeps the pollen cleanly out of the tube, and it is then removed by insects. When the pistil has attained its full length, the two branches open and curve downwards, so as to expose the stigmatic surfaces (Fig. 152, *st*) which had previously been pressed closely to one another, and thus protected from the action of the pollen. From this arrangement it is obvious that any insect alighting on the flower-head would dust its under side with the pollen of the younger flowers, which then could not fail to be brought into contact with the stigmatic surfaces of the older ones. As the expansion of the flowers begins at the outside, and thence extends to the centre, it is plain that the pollen of any given floret cannot be used to fertilise one situated on its inner side. Consequently, if the outer row of florets produced pollen, it would in the great majority of cases be wasted. I have, however, already mentioned that these florets do not produce pollen, while the saving thus effected enables them to produce a larger corolla. It is also interesting to observe that

in these outer flowers the branches of the pistil do not possess the terminal brush of hairs, which in the absence of pollen would be useless.

When the fruits are ripe the involucre press strongly inwards. If the fruits are removed it will be found that the bracts quickly close in. On the other hand, when it is dry they open out and thus allow the fruits to escape. This is well seen in *Centaurea*. The dispersal

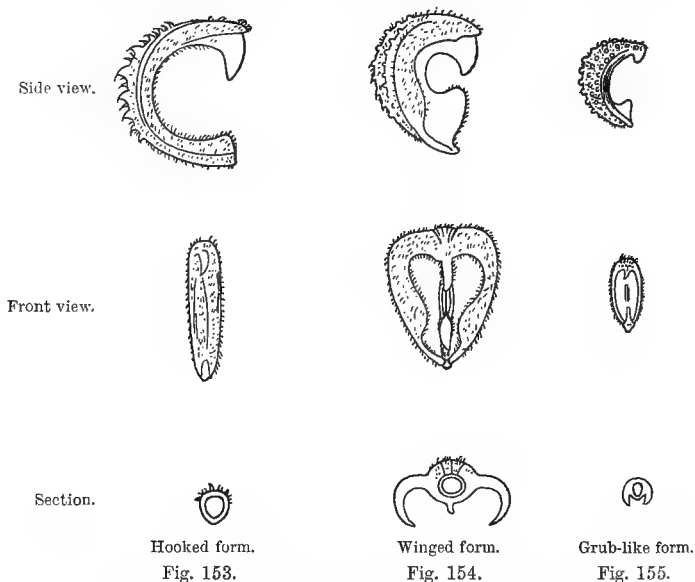


FIGS. 150-152.—*Chrysanthemum Parthenium*. Successive stages in the life of the flower. *a*, anthers; *st*, stigmas.

of the fruits has been specially studied by Hildebrand.¹ In some there is no special provision, but they are small and easily carried by the wind. In many cases they are surmounted by a ring of simple or plumose hairs, or flat scales. In *Dahlia* the floral bracts or paleæ are long, membranous, and attached to the fruit, thus forming a wing; in *Melampodium* the corolla is persistent, and serves the same purpose. In other cases (*Bidens*, *Lappa*) they are covered with hooks, or are sticky, and attach themselves to animals. In one genus (*Wulffia*)

¹ "Ueber die Verbreitungsmittel der Compositen-früchte," *Bot. Zeit.* xxx. (1872).

they are fleshy. In *Silybum marianum* the involucre contracts, compressing the achenes more and more until at last they detach themselves and are scattered in all directions. The common *Calendula* (Marigold) of our gardens is a very interesting case. Three devices for dispersal are united in each head. The outer achenes (Fig. 153) are narrow, and bent into a curve forming three parts of a circle, and well adapted to hang on to



FIGS. 153-155.—Seeds of *Calendula officinalis*, showing various forms.

the hair of any passing animal. Then follow a certain number which are puffed out with wide wings (Fig. 154), and are evidently intended for dispersal by wind. Towards the centre the achenes are smaller, and much resemble small green or brown caterpillars (Fig. 155). These, it has been suggested, are picked up by birds, and then dropped when they discover their mistake. Between the extreme types there are many intermediate forms.

EUPATORIUM

Flower-heads of few florets. Protandrous. The branches of the stigma are as long as the flower-tubes, and for three-quarters of their length clothed with hair.

E. cannabinum (Hemp Agrimony).—The plant is so named from the form of the leaves. There are generally only about 5 florets to a head. They are of a reddish purple, and as the flower-heads themselves are numerous and in compact terminal corymbs, they are very conspicuous in spite of the small size of the individual florets. The corolla tube has a length of $4\frac{1}{2}$ mm., of which $2\frac{1}{2}$ form a tube and the upper 2 are expanded into a bell. The anther tube does not project beyond the bell of the corolla. The anthers open on the inner side, and the pollen fills the upper part of the tube. When the flower opens the upper part of the branches of the pistil elongate and carry up the pollen on their hairy surface. The lower parts constituting the stigma are still in the corolla. In the second stage of the flower the papillary part of the stigma also protrudes and is ready for fertilisation. The long pollen-covered hairy branches of the stigma must often serve to fertilise neighbouring florets.

TUSSILAGO

T. Farfara (Coltsfoot) has the flower-heads solitary and yellow; while in *T. Petasites* they form a compound raceme, and are white or pinkish. The flower was well described by Sprengel. It is monœcious. The ray flowers are female; those of the disk, male; both being yellow. The pistil of the ray flowers has a pollen brush, which would appear to be useless, and in most Composites is not developed in the female flowers. The male flowers are about 40, the female about 300 in number. The male flowers only produce honey. The flower-heads close up at night and in bad weather. Burkill¹ remarks that the female

¹ *Journal of Botany*, 1897.

flowers do not fade as soon as they are fertilised, but retain their clear colour until the male flowers, which do not open till several days after the female, have shed their pollen. The flowers are succeeded by the soft white pappus. The plant is perennial, developing its flowers early in the spring, and later the leaves, which are often very large. It spreads widely by means of burrowing stolons. The stem is somewhat woolly. The stomata are on the under side of the leaves, and are protected by a loose white cottony wool.

T. Petasites (Butter-bur).—In this species the male and female flowers are, as a rule, on different plants. There are sometimes, however, a few female florets on the male and a few male florets on the female plant. The male has smaller flower-heads and a looser panicle. The male flowers are tubular below and expand into a bell above. They secrete honey. They have a pistil, which is necessary to brush out the pollen, but which has no stigma. The female flowers are tubular and honeyless. They have not a trace of stamens, and the outer sides of the stigmas have some short hairs which, however, can hardly be said to amount to a brush. The stem is somewhat woolly. The leaves are characteristic, and perhaps our most remarkable example, of those adapted to situations in which the supply of water is considerable, the air moist, and the light not too strong. They are very large, sometimes almost a yard across, flat, smooth, delicate, and glabrous. As, moreover, they grow where leaves are abundant the plants have comparatively little to fear from browsing quadrupeds. In dry arid regions such as the Riviera such leaves would not last a day. To the same type belong those of *Dentaria* (p. 80), *Orobus*, *Paris*, *Lunaria*, *Mercurialis perennis* (Dog's Mercury), *Arum* (Lords and Ladies), *Impatiens* (Balsam).

The Butter-bur is often separated as a distinct genus, *Petasites*, when it is known as *Petasites vulgaris*.

ASTER

The ray flowers in a single row, female ; sometimes absent. We have two species—*A. Tripolium*, with ray flowers ; *A. Linosyris*, without.

A. Tripolium (Sea Aster) is common in salt marshes along our coasts. As in so many shore plants, the plant is glabrous and the leaves are succulent. The ray florets number 20-30, are purplish violet, and female ; the disk florets are yellow, with stamens and pistil. The disk florets are tubular below and bell-shaped above. In the first stage the anther tube projects, and the pollen is pushed out by the brush of the pistil. The lobes of the corolla are horizontal. In the second the anther tube has retired into the cup of the flower, the lobes of the corolla are upright, and the stigmas protrude, exposing the stigmatic surface.

A. Linosyris has no ligulate ray flowers. The life-history of the florets is much the same as in *A. Tripolium*.

ERIGERON

Ray flowers in several rows, female, narrow or almost filiform. Disk flowers often but few, complete. The pistil of the female flowers is without a terminal brush, which would be useless in the absence of pollen. We have two species—*E. acre*, which is annual or biennial, and *E. alpinum*, which is perennial. *E. canadense*, which has thoroughly established itself, differs from the other two in having the outer florets filiform.

E. alpinum is gynomonœcious. According to H. Müller there are two forms of female flowers—in the one the ray is conspicuous, in the other it is absent ; so that there are three kinds of flowers in each head. The complete flowers also produce honey. According to Kerner the stigmas of the female flowers are mature some days before the pollen of the complete flowers in the same head.

E. acris (Fleabane).—The life-history of the flower resembles that of *E. alpinum*.

SOLIDAGO

S. Virgaurea (Golden Rod).—The flowers are gynomonœcious and freely visited by insects, and the pollen also may easily drop from the stamens of the upper flowers on to the pistil of the lower ones.

INULA

Ray flowers in a single row, female; disk flowers complete. We have five species. Elecampane (*I. Helenium*) has large flowers, and only occurs here and there, if indeed it is truly native. Two species have the rays much longer than the involucre: one, *I. crithmoides*, is succulent and glabrous; the other, *I. dysenterica*, is downy. Of the last two, *I. Pulicaria* is annual, *I. Conyza* perennial.

I. Helenium.—The leaves are nearly glabrous above; white and cottony below.

I. dysenterica is gynomonœcious.—The heads contain about 100 ray and 600 disk flowers. The leaves are rough above, more or less downy or cottony underneath.

I. Conyza is a downy plant with the under sides of the leaves soft and cottony.

I. crithmoides, a seaside plant, is glabrous, with succulent leaves.

I. Pulicaria.—Like *I. dysenterica*, but smaller, with short ray florets, less woolly leaves, and a fœtid smell.

BELLIS

The ray flowers are in a single row, are female, and do not have the pollen brush, which is present in the disk flowers. On the other hand, the stigmatic papillæ are rather larger.

B. perennis (Daisy) is gynomonœcious.—The flower-heads vary somewhat in size. After fertilisation the stigmas draw back into the bell of the flower. The flowers close at sunset, whence the name, and also in wet

weather. The tips of the petals are coloured red with anthocyanin on the side which is turned towards the ground when the head is open, and towards the sky when it is closed (see *ante*, p. 212). The leaves are closely applied to the ground, and, as in so many similar cases, are broad. The result is that no seedlings can grow up under them, and the plant is very injurious in meadows and lawns. The fruits have no pappus. It has occurred to me whether, as they would fall on the flat plane of the leaves, the wind carries them a sufficient distance. The plant is generally clothed with white jointed hairs.

CHRYSANTHEMUM

We have four species. *C. segetum* is yellow, the other three are white. Of these *C. Leucanthemum* has the leaves toothed, while in *C. Parthenium* and *C. inodorum* they are pinnate; in the former the flower-heads are in corymbs, in the latter they are terminal, and the lobes of the leaves are narrow or filiform.

I took this genus (see p. 231) as typical of the order, and need not therefore repeat the description of *C. Parthenium* (Fever-few), which has been already given.

C. Leucanthemum (the Oxe-eye Daisy) is sometimes glabrous, sometimes downy; **C. Parthenium** is pubescent.

C. segetum (Corn Marigold).—The upper side of the corolla lobes of both disk and ray flowers is covered with microscopic papillæ. The plant is glabrous.

C. inodorum.—The receptacle gradually rises in the middle, becoming convex or hemispherical, though not so much so as in *Matricaria*. Kerner suggests that the advantage of this is to bring the stigmas of the outer florets into the fall line of the pollen of the inner ones. This species, and still more the next, closely resembles *Anthemis Cotula*. That species is protected by a very bitter taste, and these two benefit perhaps by resembling it so closely. The plant is glabrous.

MATRICARIA

M. Chamomilla (Wild Chamomile).—The receptacle, as just mentioned, becomes considerably lengthened. The plant can hardly be distinguished from *A. Cotula*, except by the absence of scales between the florets. It is glabrous. The achenes secrete mucus, which helps to fix them to the ground and to ensure a definite position for the seedling.

ANTHEMIS

This genus closely resembles the two preceding, but is distinguished by the curious character that it has a scale between each two florets.

There are four British species—three with white flowers, and one, *A. tinctoria*, with yellow. In *A. Cotula* the ray florets have no stigma; *A. arvensis* has the scales narrow and pointed; while in *A. nobilis* they are oblong and obtuse.

A. Cotula.—As already mentioned, this species has a disagreeable taste and smell, which probably serve to protect it from browsing quadrupeds. The receptacle is conical from the commencement. The ray florets have neither stamens nor pistils. They are only for show. The plant is generally glabrous.

A. nobilis (Chamomile) is downy and aromatic. **A. arvensis** has minute silky hairs. **A. tinctoria** is more downy than the other species. It is not a native, but occurs on ballast heaps and in similar places.

ACHILLEA

The flowers are gynomonœcious.

A. Millefolium (Milfoil or Yarrow).—This species differs from our only other *Achillea* in having the leaves much divided, while in *A. Ptarmica* they are linear and serrated. The flower-heads are numerous, small, often over 100 in number, and collected into a dense terminal corymb. Each flower-head comprises about 20 disk florets, surrounded by generally 5 ray florets.

The ray itself is broad and short. The list of insect visitors is very long. H. Müller observed over 120, and others have been added since. The plant is sometimes glabrous, sometimes densely covered with white woolly hairs.

A. Ptarmica.—The flower-heads are larger than those of *A. Millefolium*, but not so numerous. They appear to be especially attractive to bees of the genus *Prosopis*. The plant is nearly glabrous.

DIOTIS

D. maritima.—The plant is covered with a dense white cottony wool. It is a native of the shores of the Mediterranean and sandy shores in our eastern and southern counties, but very rare in this country. The hairs are no doubt a provision corresponding to the hot, dry climate.

TANACETUM

The flowers are all tubular, or if the outer ones are ligulate, they are scarcely any longer than the others.

T. vulgare (Tansy).—Flower-heads in a large corymb, which is very conspicuous in spite of the small size of the individual florets. It is evident that in a plant so arranged ray flowers are unnecessary, and indeed, except at the edge of the corymb, the rays would be inconvenient. It is a nearly glabrous plant, found in waste places, but probably not a true native.

ARTEMISIA

Wind- or pollen-flowers. The florets are small, and combined in small heads. The branches are easily swayed by the wind. There are four British species. Two have the leaf-segments narrow linear, while in the other two they are broader. Of the former, *A. maritima* has the stem and leaves cottony white, while in *A. campestris* they are green or reddish. Of the two latter, *A. Absinthium* (Absinth), has the leaves silky and whitish on both sides, while in *A. vulgaris* they are green above.

GNAPHALIUM

Wind-flowers, with small flower-heads. Ray florets female, filiform, in several rows. Disk flowers complete, tubular. Achenes with a silky pappus. There are four British species. The name of the genus recalls the woolly habit of the plants. Edelweiss belongs to a closely allied genus, *Leontopodium*. *G. supinum* is typical in this respect (see p. 28).

SENECIO

Ray flowers female, sometimes wanting; disk flowers complete. Achenes with silky pappus. We have eleven species. The genus is very large, and widely distributed.

S. vulgaris (Groundsel).—The florets are almost always all tubular; there are 60-80 in a head. The honey is abundant, but from the smallness of the flower-heads insect visits are not numerous. Bateson has experimented with this species, and found that seeds which were the result of cross-fertilisation produced more vigorous plants than those resulting from self-fertilisation. The plant is annual with us, but becomes perennial in Alpine districts (see *Cardamine hirsuta*, p. 79). It is glabrous, or with a little cottony wool. The sides of the achenes have short appressed hairs, as also have those of *S. sylvaticus*. These hairs secrete a mucus, which serves to attach the achenes to damp soil.

S. viscosus.—This is one of the species in which the access of creeping insects is precluded by the presence of a sticky secretion. The plant is covered with a short, viscous, unpleasantly smelling down. The achenes are glabrous.

S. Jacobæa (Ragwort).—This species is perennial. It has an unpleasant odour. The flower-heads are large, showy, and much visited by insects. The plant is glabrous, or with a loose woolly down. The achenes of the disk have short hairs, those of the ray are glabrous. This is also the case with those of *S. aquaticus*.

S. erucaefolius has the habit of *S. Jacobæa*, but is more pubescent. The achenes are all equally hairy.

S. squalidus.—A Southern European species which has become naturalised on old walls at Oxford and elsewhere. The achenes all bear silky hairs.

S. paludosus.—A native of the Fens in the eastern counties. It has glabrous achenes.

S. saracenicus.—A South European plant which has become naturalised by river-sides and in moist meadows. The achenes are glabrous.

S. palustris.—Native in the Fens district, but very rare. The achenes are glabrous, with strong ribs.

S. campestris occurs on dry banks and chalk downs in York, Lincoln, and southwards. The achenes are downy, with faint ribs.

DORONICUM

Disk flowers complete. Ray flowers female, without any pollen brush on the stigma. Two species occur in Britain, naturalised in plantations. Sometimes glabrous, sometimes hairy, and generally glandular towards the summit.

D. Pardalianches.—The ray flowers have rudiments of stamens, and are as richly supplied with honey as the disk flowers. A native of Central and Southern Europe.

BIDENS

Ray flowers sometimes absent; when present, without either stamens or pistil. The achenes terminate in a few (2-5) stiff awns, covered with reflexed prickles. The generic name was suggested by the two stiff awns of some species. We have two species: one, *B. cernua*, with undivided leaves, while in *B. tripartita* they are deeply cut into 3-5 segments. They grow in watery places, and are both nearly glabrous.

B. cernua.—The ray florets are sometimes wanting. The achenes have 2-3, rarely 4 awns.

XANTHIUM

The male and female florets are in different heads on the same plant. The female flowers open some time before the males. The males are in several rows; the females in pairs. The involucre is covered with hooked hairs, which very effectively secure the dispersal of the achenes.

X. strumarium.—Though generally included in our English lists, this is not a true native.

ARCTIUM

A. Lappa (Burdock).—The achenes are large, with a short pappus of stiff hairs, but the dispersal is perhaps more effectively secured by the strong hooks at the ends of the involucreal leaves. The leaves are green above, more or less covered with loose cottony wool beneath.

SERRATULA

S. tinctoria.—Gynodioecious, with, according to Kirchner, intermediate forms. The hairs of the pappus are simple and unequal. This is one of the genera in which there are scales between the florets. Sir J. E. Smith pointed out that the seeds of the female are larger than those of the hermaphrodite form.

SAUSSUREA

This genus is closely allied to *Serratula*, but the hairs of the pappus, at least the inner ones, are feathery, and the anthers have hair-like appendages at their lower ends. The florets are all tubular and complete.

S. alpina.—The florets are protandrous. The plant is covered with loose cottony hairs. It is an Alpine species, found in North Wales, the Lake district, the Highlands, and Donegal.

CARDUUS (Thistle)

Florets tubular, complete, with scales. Achenes with a pappus, which is sometimes simple, sometimes

feathery. The thistles are more or less effectively protected by the spiny leaves and flower-heads. There are eleven British species. Several of them hybridise freely. The species with a feathery pappus are often placed under another genus, *Cnicus*.

C. acanthoides.—In this species the leaf surface is supplemented by green wings which run down from the base of the leaves. Similar wings occur in *C. nutans*, *C. pycnocephalus*, *C. lanceolatus*, *C. palustris*, and *C. arvensis*.

CARLINA

Receptacle with scales. Florets all tubular and complete. The white inner bracts take the place of the ray florets and make the flower-heads very conspicuous; they also seem to protect the florets, as they close over in bad weather and at night. The outer ones are very prickly, the inner ones smooth and shining.

C. vulgaris is the only British species. The leaves are green above, cottony below.

ONOPORDON

Receptacle with scales. Florets tubular, complete.

O. Acanthium.—The filaments are sensitive. The plant is covered with a loose cottony wool. This is the so-called Scotch thistle, and, though not a Scotch plant, has been adopted by heralds as the special emblem of that country.

In most Composites the pollen is pushed out of the anther tube by the growth of the pistil, as already described (p. 232). In *Onopordon* and *Centaurea* a different plan is adopted. The filaments of the stamens are sensitive; they protect the pollen, but if touched by an insect, rapidly contract, carrying down, of course, the anthers with them, and as the stigma is stationary the pollen is squeezed out. This arrangement is perhaps connected with the fact that in *Onopordon* the heads are unable to close up.

CENTAUREA

Herbs, sometimes spiny. Receptacle with scales. The bracts are often curiously and beautifully fringed. The outer row of florets is generally without stamens or pistil. The disk flowers are complete. Achenes glabrous, generally with a pappus of short hairs. The pollen-brush is not situated at the summit of the stigmas, but forms a ring round the pistil just below where it bifurcates. When the flower opens, the pollen has already been shed into the hollow space between the pistil and the hood formed by the anther-heads. It is not, as in most Composites, pushed up by the growing pistil, but the stamens are sensitive, as in the previous genus, and when touched by the proboscis of an insect they contract, thus exposing the pollen. This interesting process can easily be seen if the stamens are gently touched by a hair. The sensitive part appears to be that covered by the hairs. If the stamen be touched above or below the hairs no movement takes place.¹ Eventually the stigmas open and curl over, so that if insect visits are delayed the flower can hardly fail to fertilise itself. We have six species. Two are prickly, one, *C. Calcitrapa*, with purple, the other, *C. solstitialis*, with yellow florets. Of the other four, two have the involucrel bracts ending in small teeth; one, *C. Cyanus*, is bright blue; the other, *C. aspera*, is purple. The last two have the involucrel bracts with a broad black or brown fringed border, one, *C. Scabiosa*, with deeply pinnatifid leaves, while in *C. nigra* they are nearly entire or toothed. The stamens contract to from one-tenth to one-fifth of their length. They take about ten minutes to return to their original state. They are very elastic, and can be stretched to double their usual length, contracting again to their former size when the force is removed. The contraction appears to affect the whole parenchyma, but not the spiral vessels, which consequently are waved. The tension, however, must

¹ Haberlandt, *Sinnesorgane im Pflanzenreiche*.

be different in different parts of the tissue, for if a stamen is cut vertically it at once rolls up. When the pistil is full grown, and the stigmas open, the stamens lose their power of contraction.¹

C. nigra (Knapweed).—According to Knuth ray flowers are always wanting; in England they occur, though not generally, yet not infrequently. Hairs are few and small; the leaves are rather cottony underneath.

C. Scabiosa.—A stouter plant than the preceding, which, however, it much resembles. The flower-heads always have an outer row of longer, sterile flowers.

C. Cyanus (Corn-flower).—A corn-field weed. It is covered with a loose cottony down.

C. Calcitrapa.—A rare plant, found in dry waste places in the South of England. It is sometimes covered with loose cottony down; as is also **C. solstitialis**, a rare plant, found in fields in the East and South of England, but not native; it is a native of the Mediterranean area which has become widely naturalised.

TRAGOPOGON

The leaves are long and grass-like. Achenes narrowed at the top into a long beak, and bearing a pappus of feathery hairs. We have one species, *T. pratensis*, with yellow florets. *T. porrifolius*, which has purple florets, occasionally occurs as an "escape."

T. pratensis (Goat's-beard, John-go-to-bed-at-noon).—The heads contain 20-50 golden-yellow florets. They close in wet weather, and about noon, whence the name. At Upsala, according to Linnæus, they open at 3 to 5 in the morning and close as early as 8 to 10. The plant is glabrous.

HELMINTHIA

Characterised by the outer bracts, which are leafy and broadly cordate. The achenes are narrowed into a short beak.

¹ Colm. "Ueber contractile Gewebe im Pflanzenreiche," *Jahresb. Schlesischen Ges.* 1861.

H. echioides.—The plant is covered with stiff, bristly, often hooked hairs.

PICRIS

Achenes not beaked, with a whitish pappus.

P. hieracioides.—The plant is covered with short, stiff, generally hooked hairs.

LEONTODON (Hawkbit)

Achenes tapering into a short beak. Hairs of pappus feathery. We have three species: in one, *L. hirtus*, the achenes of the outer row have a pappus of very short simple hairs; in the other two all the achenes have a feathery pappus—one, *L. hispidus*, is hairy, the other, *L. autumnalis*, glabrous.

L. autumnalis.—The heads contain from 50 to 80 florets. They are much visited by insects. The plant is glabrous or with a few stiff hairs.

L. hispidus.—The plant has short, stiff, erect hairs, often forked or stellate at the top.

L. hirtus.—This is often regarded as a separate genus—*Thrinacia*—and with some reason. It is an interesting example of a plant with two kinds of fruit. The achenes of the outer row of florets are curved, taper slightly at the top, and have a short scaly pappus. Those of the other florets are long, striate, and rugose, tapering at the top, and have a pappus of long brown feathery hairs. These could be easily carried away by the wind, while the former could grow close at home. The plant is glabrous, or hispid with forked hairs.

HYPOCHÆRIS

A few, but by no means all the florets, have palææ, or flat membranous outgrowths of the receptacle, representing the floral bracts. We have three species: one, *H. maculata*, has the involucre hairy; of the other two, *H. radicata* has achenes ending in a slender beak, while in *H. glabra* they have no beak.

H. maculata.—According to Linnæus, at Upsala the

flowers open at 6 A.M. and close between 4 and 5 ; while at Innsbruck, Kerner found them opening about 7 to 8 and closing at 6 to 7. The plant is scabrous and hairy.

H. glabra, on the other hand, is glabrous ; while **H. radicata** has the leaves rough, with stiff hairs.

LACTUCA (Lettuce)

There are but few florets in each flower-head. The achenes taper into a slender beak, and have a pappus of many white silky simple hairs. There are four British species: *L. muralis* has the beak shorter than the achene, and leaves on long stalks ; in *L. virosa* and *L. Scariola* the beak is about as long as the achene ; in *L. saligna*, twice as long.

L. Scariola.—The plant is glabrous, but with a few stiff bristles or prickles on the edges and midribs of the leaves in the lower part of the plant, and on the stem. This is a shade-loving species, and the leaves are very delicate. While most English plants have the leaves so arranged as to receive a maximum of light, in this species they change their position so as to avoid it. In the morning and evening, when it is faint, they are ranged perpendicularly to it, *i.e.* east and west. When, however, the sun becomes strong they turn themselves north and south, so as to receive as little light as possible. For the same reason they are horizontal in the shade, more or less perpendicular in sunshine. The involucreal scales are smooth, tense, and full of a sticky juice. The investing membrane is so delicate that it is pierced by the claws of insects, such as ants, which thus become smeared by the sticky juice. The result is that they do not attempt to reach the flowers. It is a rare plant in waste places in some of our southern and eastern counties.

L. virosa, a commoner plant, is closely allied to the above, but is never generally scabrous.

SONCHUS (Sowthistle)

Achenes not beaked ; pappus sessile, of numerous simple hairs ; leaves clasping the stem at the base.

There are four British species: one, *S. alpinus*, with blue, the others with yellow flowers; of these *S. oleraceus* is annual, the other two perennial; one, *S. palustris*, has the auricles of the leaves narrow and acute; the other, *S. arvensis*, short and broad.

S. arvensis is a "Sunflower," turning round so as to face the light. The flower-heads and peduncles are hispid with black or brown glandular hairs. The stem is hispid and glandular above, glabrous below.

S. palustris.—A marsh plant in our eastern counties, and now almost extinct. It is glabrous, as is also **S. oleraceus**, a weed of almost world-wide distribution.

S. alpinus, is found on Alpine rocks in the North of Scotland. It has the panicle hispid with jointed glandular hairs; the leaves are glabrous.

TARAXACUM (Dandelion)

Bracts of the involucre in two sets: outer ones imbricated; inner row, equal, erect.

T. officinale.—A glabrous plant, taking its common name from the teeth of the leaves. These are very large in some cases, and pointing backwards, while in

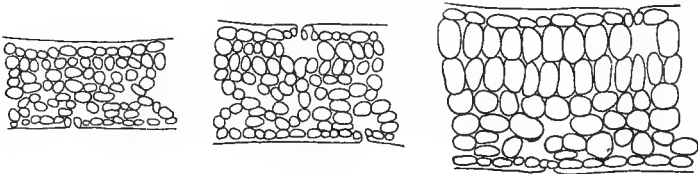


Fig. 156.

Fig. 157.

Fig. 158.

FIG. 156.—Section of part of a leaf of Dandelion grown in shade.

FIG. 157.—Section of part of a leaf grown in diffused light.

FIG. 158.—Section of part of a leaf grown in sunshine.

other plants, especially in shady places and rich soil, the leaves are often almost entire. The flower-heads close at night and in wet weather. At Upsala, according to Linnæus, they open at 5-6 in the morning, and close between 8 and 10; at Innsbruck, according to Kerner, they open between 6 and 7, and close between 2 and 3.

Each flower-head consists of 200-300 florets. The list of insect visitors is a long one, extending to considerably over 100 species. The pollen presents several crystalline forms in the same anther. Self-fertilisation, in the absence of insect visits, is ensured by the same means as described under *Centaurea*. In the last stage of the flower the stigmas bend over among the collecting hairs at the end of the style. This is one of the plants in which the structure of leaves grown in the sun differs considerably from those in shade. Fig. 156 represents a section of a leaf grown in shade, Fig. 157 represents a section of a leaf grown in diffused light, Fig. 158 a corresponding section of a leaf grown in sunshine. The last is the thickest, and has two rows of palisade cells in the upper part.

CREPIS

The pappus is very white. We have six British species, all with yellow flowers. Two have slender beaks to the achenes: in one, *C. taraxacifolia*, all the achenes have a long slender beak; in the other, *C. fœtida*, the achenes of the outer row are only short-beaked. Of the other four, two have the lower leaves pinnatifid; one, *C. virens*, with the outer bracts of the involucre narrow linear, while in the other, *C. biennis*, they are oblong linear, with a whitish edge. The last two have mostly oblong leaves, coarsely toothed or entire; one, *C. paludosa*, with about 10, the other, *C. hieracioides*, with about 20 ribs to the achenes.

C. virens is a nearly glabrous annual, while

C. biennis—as the name implies, a biennial—is more or less hispid.

C. fœtida is also hairy. The interior of the bracts of the involucre bears appressed hairs.

C. paludosa—growing in damp places—is, as we might expect, glabrous. The access of creeping insects to the flowers is prevented by glandular hairs on the bracts of the involucre.

C. hieracioides is glabrous or slightly hairy.

HIERACIUM (Hawkweed)

Pappus of simple hairs. This is one of those genera which are undergoing rapid change. The forms run into one another, and no two botanists are agreed as to the species.

Bentham and Hooker accept seven principal forms as regards Britain.

H. Pilosella (Mouse-ear Hawkweed).—There are about 50 florets to a head. According to Linnæus, in fine weather it is open from 7 to 3. The flowers are much visited by insects. The leaves have a few long stiff hairs above, and are protected underneath by a white felt of stellate hairs (see *Cerastium alpinum*, p. 28). In very dry weather the leaf rolls up, so that the white felt comes uppermost and protects the whole leaf.

H. alpinum is shaggy, with woolly, glandular, and stellate hairs, as in so many mountain plants. It is a rare plant in Britain, occurring in North Wales, the North of England, and Scotland. It is regarded by some as an Alpine variety of *H. murorum*.

H. murorum.—The stem is glabrous, or with long white woolly hairs on the lower part, getting more dense towards the base. The leaves are slightly hairy above, glaucous green below. Grenier and Godron give a somewhat different account. They describe the leaves as “couvertes sur les deux faces ou au moins sur l'inférieure de longs poils mous, sans poils étoilés”; and the stem as “plus ou moins pubescente ou herissée munie vers le haut de poils glanduleux qui manquent quelquefois, un peu rameuse, rarement naine et uniflore.”¹

H. anglicum.—Sometimes glabrous, sometimes with long white, and other, glandular, hairs.

H. umbellatum.—The leaves are glabrous, or hairy underneath; the stems have long loose hairs, especially towards the base.

H. boreale is more hairy than the last.

H. prenanthoides.—The involucre and peduncles bear

¹ *Flore de France*, vol. ii.

short down, and black glandular hairs. The leaves are glabrous above, glaucous and pubescent below. The stem is sometimes glabrous, sometimes slightly hairy.

CICHORIUM

C. Intybus (Chicory).—A stiff woody perennial, with sessile, lateral, and terminal, blue flower-heads. The achenes are crowned with a ring of minute erect scales. The stem is hispid, the leaves are more or less hairy, especially above. According to Linnæus, the flowers at Upsala open at 5 and close at 10; at Innsbruck, according to Kerner, they are open from 6-7 to 2-3.

ARNOSERIS

The achenes are crowned by a minute raised border.

A. pusilla is found in dry pastures and fields on the east side of Britain. Watson regarded it as a colonist. The plant is nearly or quite glabrous.

LAMPSANA

Achenes without any pappus or border.

L. communis (Nipplewort).—The flower-heads are small and inconspicuous. According to Kerner, they are open from 6-7 to 10-11, but keep closed in bad weather. According to Warnstorf, at New Ruppin they are open from 6-7 to 3-4. The stem is nearly glabrous, with a few stiff hairs below.

CAMPANULACEÆ

The Campanulaceæ¹ are protandrous, and secrete honey. In many species (*Campanula glomerata*, *Trachelium*, *rotundifolium*, etc.) the flowers are hanging; in others (*C. patula*) they are upright by day, but pendent at night and in wet weather; while in a third series (*C.*

¹ A good account of the family is given by Kirchner, *Wurtemb. Naturwiss. Jahreshfte*, 1897.

glomerata, etc.), which have short stalks, and cannot therefore turn over, the flowers themselves close. In the absence of insect visits the greater number are capable of fertilising themselves; the pollen reaching the stigmas partly through the folding of the corolla, partly by the rolling back of the stigmas themselves.

LOBELIA

The corolla is irregular, open on the upper side. The pollen is shed into the anther-tube, as in *Compositæ*, and is swept out by the brush of the stigma. We have two species—one, *L. Dortmanna*, an aquatic plant with drooping flowers; the other, *L. urens*, a heath plant with erect flowers. They do not seem to be much visited by insects, but have not been carefully watched.

In *L. urens* the stem is angular, and the plant puberulent. It is a South-west European species, which finds its northern limit of distribution in the West of England.

L. Dortmanna is aquatic and glabrous. The leaves are doubly fistular; that is to say, they are divided into two longitudinal tubes.

JASIONE

Corolla regular, deeply divided into five narrow lobes. The anthers form a tube into which the pollen is shed.

J. montana (Sheep's-bit).—This species has been well described by Sprengel. The heads consist of 100-200 pale-blue florets. It is one of the flowers most richly visited by insects, being, indeed, surpassed only by a few Umbellifers and Composites. The association of the florets into heads, the convenient position and rich supply of nectar, and the arrangement of the flower, all contribute to this result, and about 150 species of insect visitors are on record, of which over 50 are bees, 30 butterflies and hawkmoths, and 30 flies. Perhaps in consequence, the power of self-fertilisation is apparently

almost lost. The plant is sometimes, though rarely, glabrous, sometimes clothed with simple, sometimes with long, stiff hairs.

PHYTEUMA (Rampion)

The anthers shed their pollen in the bud, as in the Compositæ, but the tube into which it is received is not enclosed by the anthers themselves, but by the lobes of the corolla. The upper part of the pistil also resembles that of the Compositæ, in being provided with a brush, and terminating in two branches. It acts in the same manner, first sweeping out the pollen, after which the two branches diverge, and thus expose the stigmas. They are long enough eventually to reach some of the neighbouring florets, and thus in the absence of insect visitors the flower fertilises itself. There are two British species: one, *P. orbiculare*, has rounded, the other, *P. spicatum*, oblong, and finally cylindrical, heads.

P. spicatum.—Flower-heads with about 100 florets, pale blue or yellowish white, with green tips. The plant is glabrous or pubescent. It is found, in this country, only in Eastern Sussex.

P. orbiculare.—Flower-heads, with 15-30 florets, deep blue. A native of the chalk downs in our south-eastern counties.

CAMPANULA (Bell-flower)

The corolla is regular, or nearly so, and bell-shaped, as the name denotes. The lower parts of the filaments are swollen and cover the honey; the anthers are distinct; the styles 2, 3, or 5. The flowers are especially adapted for bees. The life-history of the flower falls into four periods. Even before the opening the anthers shed their pollen on to the hairy pistil, against which they are pressed by the folded corolla (Fig. 159). This is the first stage. Soon after the flowers open, the anthers and upper part of the filaments shrivel up; the lower portions, however, swell, and form a covering for the honey. The hairs on the pistil gradually draw themselves in, thus

exposing the pollen, which is gradually carried off by the insects visiting the flowers for the sake of the nectar (Fig. 160). This is the second stage. When the hairs are all withdrawn the stigmas open out, and are ready to receive pollen (Fig. 161). This is the third stage. Fourthly and finally, in the absence of insect visits the stigmas bend over and dust themselves with any pollen which may be remaining on the pillar of the pistil.

The fruit is a three-celled capsule. The seed capsules are in some species erect, in others hanging. The former open at the apex, the hanging ones at

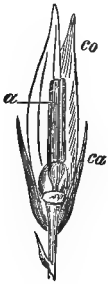


Fig. 159.

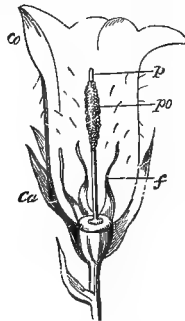


Fig. 160.

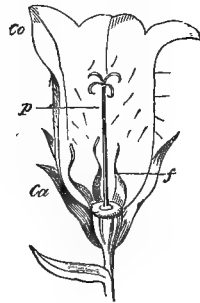


Fig. 161.

FIGS. 159-161.—*Campanula medium*. Fig. 159, section of bud ; Fig. 160, section of flower in first (male) condition ; Fig. 161, section of flower in second (female) condition. *a*, anthers ; *ca*, calyx ; *co*, corolla ; *f*, filaments of stamens ; *p*, style with stigmas ; *po*, pollen.

the base. Thus in both cases the opening is at the actual upper part of the capsule. I have suggested that the object is to provide for the dispersal of the seeds. The result is, that they do not fall directly out of the capsules, but remain in them until on some windy day the capsules are swung backwards and forwards, and eventually scatter the seeds. In the hanging capsules the method by which the valves at the base open is very peculiar. In *C. medium*, for instance, the inner face is very much thickened and lignified. The thickened portion is ovate, and drawn out into a long, acuminate neck, extending up into the capsule ; the broader end is at the base of the capsule, and corresponds

to the outline of the valve. Along the centre is a shallow groove. At maturity this process becomes convex on the inner face, and deeply concave on the outer, breaking away from the rest of the capsule, while at the same time the thin edges turn outwards. The seeds are of large size for the genus, oblong, often broader at the opposite end from the hilum, biconvex, and frequently surrounded at the edges by a narrow, thin margin, especially when not over well filled. The testa is bright reddish brown, polished, smooth, and shining.

C. rotundifolia (Harebell).—The rounded radical leaves (see *Viola palustris*, p. 29), from which this beautiful plant has received its name, are generally withered before the flowers open. The upper leaves are narrow. The plant is glabrous or pubescent.

C. rapunculoides.—The flowers are borne in long terminal racemes. The capsules are hanging, but small doors open near the base, and therefore at the upper part, through which the seeds are jerked during wind. They close if it rains, and open again when the sun comes out. The plant is glabrous or pubescent.

C. Trachelium has the flowers in clusters. According to Kerner, at Innsbruck the flower is open from 6-7 in the morning to 6-7 at night. On the Brenner the flowers are white. The leaves are scabrous, with short hairs; the stem hispid.

C. Rapunculus.—The flowers are in long terminal racemes. The plant is hairy and rather rough; rarely glabrous.

C. glomerata.—The flowers are sessile, in compact clusters. The plant is glabrous or pubescent.

C. latifolia (Giant Campanula).—The blue or white flowers are solitary in the axils of the upper leaves. They were well described long ago by Pontedera.¹ The capsule is hanging.

C. patula is pubescent. The flowers are in a spreading panicle, more open than in the other species. They

¹ *Anthologia*, 1720.

are upright in sunny weather, pendulous at night and when it rains.

SPECULARIA

Remarkable for the long triangular ovary. Flowers sessile. Corolla blue, very open.

S. hybrida.—A corn-field weed, chiefly in the eastern counties. The flowers are protandrous. The style is clothed with hairs, on which the pollen is deposited. It is used by insects as an alighting stage, and they can hardly fail to carry off some of the pollen. Every evening the corolla folds up longitudinally, and the five projecting angles also dust themselves. The three stigmas open out when mature, and insects coming from another flower deposit pollen on them. When the flower folds up at night they come in contact with the pollen on the projecting ridges of the corolla.

WAHLENBERGIA

The pistil secretes a viscid fluid, to which the pollen adheres.

W. hederacea.—A graceful, prostrate plant, glabrous, with delicate ivy-shaped leaves. The flowers are on long stalks, and pale blue, with darker veins. The filaments widen gradually downwards, and after the anthers have shrivelled up the broad base remains as a protection to the honey. A South-western European plant, found in bogs and damp woods in our southern and especially in the western counties.

ERICACEÆ

Stamens sometimes equal in number to, but generally twice as many as, the divisions of the calyx or corolla; cells of ovary as many, sometimes apparently twice as many. Fruit a capsule or berry. Flowers, as a rule, with honey.

ANDROMEDA

A. polifolia is a small glabrous bog plant, seldom above 6 inches high. The leaves are evergreen, glaucous below, and with their edges rolled up—a provision found in many plants growing in peat bogs in cold climates. The air is often saturated with moisture for weeks, and the summers are short. If the stomata or breathing pores, which are on the under side of the leaves, were liable to be clogged with moisture, it might often happen that, even when the sun appeared, it would take so long to free the passages that dew and rain might come on again before they were open. Under these circumstances it is of great importance to protect the stomata, and one way in which this is effected is by rolling the leaves. We find this arrangement in some of the Silenes, Heaths (see p. 27), in Azalea, Cranberry (*Vaccinium Oxycoccus*), Crowberry (*Empetrum*) (see Fig. 11, p. 28), Ledum, some Willows, and some of the grasses associated with them. Certain grasses have the leaves flat in fine weather, but are able to roll them up if it is wet.

LOISELEURIA (Azalea)

L. procumbens is a low trailing moorland shrub, found in the Scotch mountains, with evergreen leaves rolled back at the edges. The small rose-coloured flowers are borne in terminal clusters. The anthers open inwards and surround the pistil, so that insects dust themselves on one side with pollen, and touch the stigma with the other. Gradually, however, they bend over towards and fertilise the stigma.

VACCINIUM

Honey is secreted by a ridge on the ovary. The anthers have lateral appendages. We have four species. Two are deciduous, with black or bluish berries; of these *V. Myrtillos* has toothed, *V. uliginosum* entire leaves. The other two are evergreen, with red berries; one, *V.*

Vitis-Idæa, with a bell-shaped, the other, *V. Oxycoccus*, with a spreading corolla. The pollen is dry and pulverulent. The anthers are provided with appendages as in *Erica*, and also have an orifice at the tip, but the pollen is prevented from falling by the anthers being applied against the pistil—not, as in *Erica*, against one another. When the ring of anthers is dislocated by the bee the pollen falls on the insect.

V. Myrtillus (Bilberry or Whortleberry).—The stems are glabrous, angular, green, and supplement the leaves as organs of carbon-assimilation. The flowers, which hang down, are a pale greenish white, rich in honey, supplied by a ridge which surrounds the base of the ovary. The corolla is swollen at the base and contracted at the summit so as to leave a comparatively narrow entrance. The stigma projects a little, but the anthers remain in the bell. This is the favourite flower of *Vespa rufa*.¹ The berries are nearly black, which probably is more conspicuous against the surrounding vegetation than red would be.

V. uliginosum.—A smaller plant, but more woody, and with nearly cylindrical branches. The flowers are smaller, but redder and more conspicuous. They are also more open, and therefore accessible to a larger number of insects. The berries are nearly black. The plant is common in the Highlands and our northern counties.

V. Vitis-Idæa (Cowberry).—The stems are glabrous, procumbent, and straggling. The flowers are in terminal drooping racemes. The corolla is white or a pale flesh colour, with spreading, but not reflexed, lobes. The filaments are hairy. The anthers are elongated, and almost as long as the filaments. According to Warming the flowers are protogynous, and in some cases the pistil is wanting. On the under sides of the leaves are small depressions, each of which is nearly filled by a club-shaped structure composed of thin-walled cells. These absorb the water which collects in the little pits. See also *Viola palustris* (p. 29).

¹ Evans, *Entomologists' Monthly Mag.* 1903.

V. Oxycoccus (Cranberry).—The procumbent stem is much more slender than in the other species. The leaves are lanceolate, evergreen, glaucous below, and with the edges rolled back. The flowers are on long slender peduncles; the corolla is red with reflexed lobes, exposing the stamens, which are widened, and thus form a tube protecting the honey. Their whole outer side is rough with short hairs, but those on the edges are longer and so interlocked that no insect can get at the honey through them, but must push its proboscis between the anthers. No insect visitors have yet been recorded, but some bees are very early risers, and work short hours, so that they may easily be missed. The flowers, moreover, are long-lived, lasting, according to Sprengel, no less than eighteen days.

ARCTOSTAPHYLOS

A. Uva-Ursi (Bearberry).—The flowers are 4-6 together, in compact terminal drooping racemes. The honey does not remain on the nectary, but runs into ten cups at the base of the corolla. It is prevented from running down any further by the hairs on the outer side of the stamens and the inner side of the corolla. The stamens (Fig. 162) are narrow at the base, then expand suddenly, forming a closed ring round the ovary, then again diminish into a cylindrical filament. At the base of the anther are two long tail-like appendages. Hive bees and humble bees seem alone to be able to reach the honey. The fruit is red. The leaves are shining, evergreen, obovate or oblong.

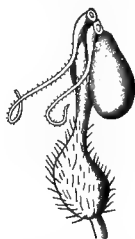


FIG. 162. — Stamen of *Arctostaphylos Uva-Ursi* seen from the side. $\times 15$.

A. alpina (Fig. 163).—This is, strictly speaking, a Northern, not an Alpine species. The flowers are generally 2-3, in compact terminal drooping racemes. The appendages of the anthers are much smaller, and in Greenland are said to be altogether wanting.

The fruit is black, which is probably more conspicuous among the brown leaves of autumn. The leaves, which are ciliated, are thin, strongly veined, and toothed at the top. It occurs in Britain only on Ben Nevis and the northern Highlands.

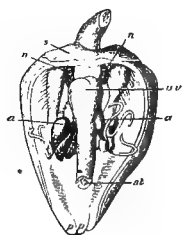


FIG. 163.—Section of flower of *Arctostaphylos alpina*. $\times 7$. *a*, anther; *n*, nectary; *p* *p*, lobes of the corolla; *s*, sepal; *st*, stigma; *ov*, ovary

fours, the edges are fringed with long and often glandular hairs. The flower is in the form of a bell (Fig. 164), which hangs with its mouth downwards, and is almost closed by the pistil, and stigma (*st*), which represents

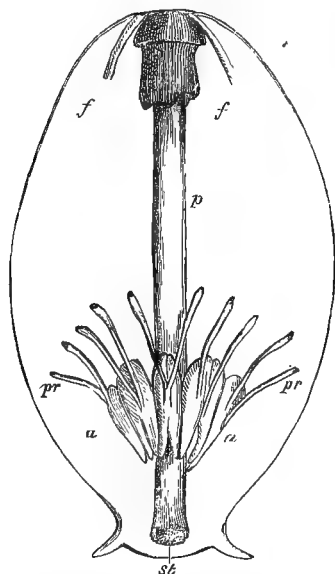


FIG. 164.—Section of flower of *Erica Tetralix*. *a* *a*, anthers; *f* *f*, base of filaments; *p*, style; *pr*, appendages of anther; *st*, stigma.

end of the anther cells

ERICA

The parts of the flower are in fours. The fruit is a capsule with 4 cells, opening with either 4 or 8 valves.

E. Tetralix (Cross-leaved Heath) is pubescent. The leaves are in

fours, the edges are fringed with long and often glandular hairs. The flower is in the form of a bell (Fig. 164), which hangs with its mouth downwards, and is almost closed by the pistil, and stigma (*st*), which represents

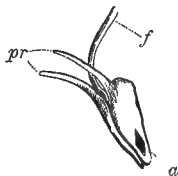


FIG. 165.—Stamen of *Erica Tetralix*. *a*, anther; *f*, filament; *pr*, appendages of anther.

the clapper. The stamens are 8 in number, and each terminates in 2 cells, which diverge slightly, and have at their lower end an oval opening (Fig. 165). But though this opening is at the lower end of the anther cells the pollen cannot fall out,

because each cell, just where the opening is situated, rests against the next anther cell, and the series of anthers thus form a circle surrounding the pistil and not far from the centre of the bell. Each anther cell also sends out a long process (*pr*), which thus form a series of spokes standing out from the circle of anthers. Under these circumstances, a bee endeavouring to suck the honey from the nectary cannot fail, firstly, to bring its head in contact with the viscid stigma (Fig. 164, *st*), and thus to deposit upon it any pollen derived from a previous visit; and, secondly, in thrusting its proboscis up the bell it inevitably comes in contact with one of the processes (*pr*), which then acts like a lever and dislocates the whole chain of anther cells, when a shower of pollen falls on to its head.

E. cinerea (our Common Heath).—The arrangement of the flower agrees with that of *E. Tetralix*; the leaves are, however, glabrous, and in whorls of three.

E. carnea.—In this species—which is a native of Ireland, but not of Great Britain—the plant is rendered additionally conspicuous by the redness of the stem. The anthers have no processes, and project a little beyond the corolla. The style is still longer, so that insects visiting the flower must touch the stigma first, and then the anthers. It cannot fertilise itself, as the stigma is not widened out, but is, as it were, cut sharp off. The pollen grains are united in fours. From the narrowness of the entrance H. Müller looks on this as a butterfly flower. The bright red colour also points in this direction. He found it, in fact, almost exclusively visited by *Vanessa cardui*. The flower-buds are fully formed in the summer for the succeeding year.

CALLUNA

Calluna vulgaris (Ling).—This species was formerly described as a species of *Erica*, but is now regarded, and, as it seems to me, correctly, as a distinct genus.

The corolla is small, and the red colour is due to the calyx, which has four small bracts at the base. The appendages of the anthers are covered with rough hairs. The leaves are glabrous, and somewhat concave below. It is a Northern and Alpine species, especially adapted to resist cold (see p. 27). The leaves are, as a rule, closely appressed to the stem, but in shady places diverge from it so as to receive more light.

PYROLA (Wintergreen)

Low herbs, sometimes rather woody; some with, others without, honey. We have five species. One, *P. uniflora*, has a single flower, the others several. *P. secunda* has small flowers in a one-sided raceme, and pointed leaves. In *P. rotundifolia* the style is much longer than the corolla and curved; in *P. intermedia* it is longer and straight; in *P. minor* it is not longer than the corolla. The pollen grains remain coherent in fours. This fact, which we have noted in other species, is simply the persistence of an earlier stage of development. The pollen grains are formed by division of a mother cell into four as a result of successive bipartition. In so-called powdery pollen the separation of the daughter pollen grains is complete, but not infrequently they remain aggregated in the original tetrad.

P. secunda.—The flowers are protogynous, and crowded on a one-sided spike; the petals are greenish white. This species may be taken as typical of the genus. Honey is secreted at the base of the corolla. The anthers open near the base, which, however, is brought upwards by a curvature of the stamens. The anthers are kept in this position, with the pore upwards, by the petals, but when an insect pushes into the flower and presses back one of the petals, the anther at once drops down, and some of the pollen falls out.

P. uniflora.—The flowers are large, but honeyless; the general arrangement is as in *P. secunda*. The

pores of the anthers are produced into short tubes (Fig. 166). The pistil at first stands out so that it is well beyond the stamens, but the flower gradually curves down so that the stigmas come within the fall line of the pollen. The leaves form little saucers, thus probably retaining a store of water as a provision for dry weather. The seeds are very minute.

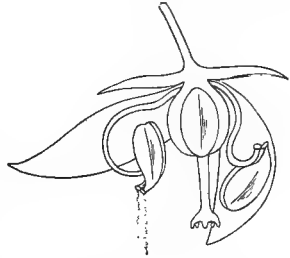


FIG. 166.—*Pyrola uniflora*. Section of flower; the left-hand anther is shedding its pollen.

P. minor.—The flowers are homogamous, drooping, and borne in a short loose raceme on an erect peduncle 4-9 inches high. The sepals and petals are broad and rounded, the latter concave, closing over the stamens. There is no honey, but the five lobes of the stigma secrete a sticky fluid which is licked up by insects.

P. rotundifolia has larger and sweet-scented flowers, but without honey; homogamous according to Knuth, protandrous according to Warnstorf. Knuth mentions that in a peat-moss near Kiel he had the opportunity of watching many specimens of this plant intermixed with *Parnassia palustris*. The flowers of the latter, though smaller, were much visited by insects, while the former were quite neglected.

P. media.—The pistil is at first upright, but finally bends over, and, as some of the pollen generally falls into the saucer-shaped petal below, is able to fertilise itself.

MONOTROPA

Homogamous flowers, with concealed honey.

M. Hypopitys.—This curious plant is 6 or 8 inches high, with a few flowers in a terminal raceme. It is of a pale brownish or dingy yellow colour, and lives in woods. The roots are short and fleshy. They are embedded in humus, and enveloped in a thick mantle

of fungus mycelium, by means of which the plant is able to feed on the nutritive matter in the humus. It is a case, therefore, of a flowering plant living at the expense of a fungus, reversing the usual rule. Probably, however, the fungus also derives some advantage from its association with the *Monotropa*. The terminal flower is in fives, the rest are in fours; the former, according to Kirchner, having 10, the others 8 nectaries at the base of the ovary, which project into corresponding hollows in the corolla. The anthers open transversely. The style is hairy, which tends to prevent the pollen from reaching the stigma of the same flower.

PRIMULACEÆ

The flowers in this beautiful family offer considerable variety in their arrangement. The corolla, indeed, is in all cases the invitation to the feast. Some, however, are merely pollen flowers, though the majority secrete honey. *Samolus* has a "sham" nectary. In some species the honey is accessible to bees with a short proboscis, in others only to those with a long one, while there are some—*Primula farinosa*, for instance—which are adapted to Lepidoptera. Many species of *Primula* and *Hottonia* are dimorphous. The flowers of some species are upright and apparently unprotected, but the mouth is narrow, so that rain-drops cannot enter, but roll off the surface.

PRIMULA

Honey is secreted by the base of the ovary. The capsule dehisces by ten valves. The outer epidermis is passive; the cells within are lignified and contract on drying, while the inner epidermis forms the layer of resistance (Fig. 167). At the lines of fissure the inner epidermis only is lignified, while elsewhere this is the case with the whole of the inner tissue. We have four species.

Three are yellow-flowered : the Primrose, with peduncles one-flowered and apparently radical; and the Cowslip and Oxlip, in which the peduncles bear an umbel of several flowers. The limb of the corolla in the Cowslip is small and concave, in the Oxlip broad and flat. These three were considered by Linnæus and Bentham as varieties of one species. Lastly, *P. farinosa* is pale lilac, and is covered in parts with a white meal. All four are dimorphous; that is to say, if a number of specimens are examined it will be found that about half of them have the stigma at the top of the tube, and the stamens half-way down (as is shown in Fig. 168); while the other

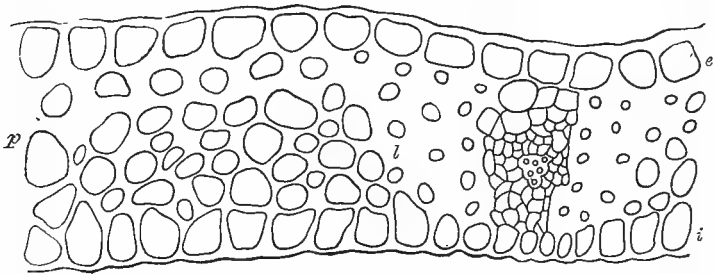


FIG. 167.—*Primula elatior*. Section through the wall of a capsule. *e*, external epidermis; *i*, internal epidermis, partly lignified; *l*, line of dehiscence; *p*, parenchyma.

half have, on the contrary, the stamens at the top of the tube, and the stigma half-way down (as shown in Fig. 169). Corresponding differences occur in *Polyanthus* and *Auricula*. They have long been known to gardeners, and even to school children, by whom the two forms are distinguished as “pin-eyed” and “thrum-eyed.” As already mentioned, plants which present these differences are known as heteromorphous (in opposition to those which are homomorphous, or have only one kind of flower). Heteromorphous species with two forms are called dimorphous; those with three, trimorphous. Sprengel himself had noticed a case of dimorphism in *Hottonia*, and shrewdly observed that there was probably some reason for it, but was unable to suggest any explanation. In *Lythrum* the existence of different forms had

been observed by Vaucher in 1841, and in the genus *Oxalis* by Jacquin, who regarded them as indicative of different species; but it was reserved for the genius and perseverance of Charles Darwin to explain¹ the significance of this curious phenomenon, and the important part it plays in the economy of the flower. Now that it has been pointed out, it is sufficiently obvious.

An insect thrusting its proboscis down a Primrose of the long-styled form (Fig. 168) would dust its proboscis at a part which, when it visited a short-styled flower (Fig. 169), would come just opposite the head of

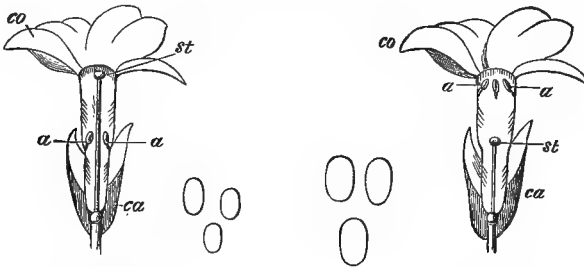


Fig. 168.

Fig. 169.

Fig. 168.—*Primula farinosa*. Long-styled form and pollen.

Fig. 169.—Short-styled form and pollen.

a, anthers; ca, calyx; co, corolla; st, stigma. Pollen $\times 250$.

the pistil, and could not fail to deposit some of the pollen on the stigma. Conversely, an insect visiting a short-styled plant would dust its proboscis at a part further from the tip, which, when the insect subsequently visited a long-styled flower, would again come just opposite the head of the pistil. Hence we see by this beautiful arrangement, insects must carry the pollen of the long-styled form to the short-styled, and *vice versa*.

There are other points in which the two forms differ from one another; for instance, the stigma of the long-styled form is globular and rough, while that of the short-styled is smoother and somewhat depressed. The pollen of the two forms (Figs. 168 and 169) is also dis-

¹ *Journ. Linn. Soc. (Bot.)* vi. (1862).

similar, that of the long-styled being considerably smaller than the other— $\frac{7}{1000}$ of an inch in diameter against $\frac{19.11}{7000}$, or nearly in the proportion of three to two—a difference the importance of which is probably due to the fact that each grain has to give rise to a tube which penetrates the whole length of the style, from the stigma to the base of the flower; and the tube which penetrates the long-styled pistil must therefore be nearly twice as long as in the other. Darwin showed that much more seed is set if pollen from the one form be placed on the pistil of the other than if the flower be fertilised by pollen of the same form, even when taken from a different plant. Nay, what is most remarkable, such unions in *Primula* are more sterile than crosses between some nearly allied though distinct species of plants. Darwin's explanation has been generally accepted by botanists. It has, however, been questioned by the late Mr. E. Bell in a special work (*The Primrose and Darwinism*, by a Field Naturalist), and again in a paper "On the Pollination of the Primrose," in *Nature Notes* for April. This paper has a pathetic interest, as the author, who had been for some time in bad health, died before it was published. Mr. Bell scarcely appreciated, I think, the cases of insect visits which are on record, and the fact that while Darwin attributed the fertilisation to night-flying moths, most of the observations have been made by day. The length of the pistil varies very much both in the Cowslip and the Primrose, and both sometimes produce equal-styled varieties.

P. veris (Cowslip) is visited by humble bees and solitary bees in the day, and by moths at night.

P. vulgaris (Primrose) is rarely visited by the larger humble bees, and not often by the smaller ones. It appears to be mainly fertilised by moths, but is sometimes visited by *Bombus hortorum*.

P. farinosa.—In the Alps this species is visited principally by butterflies; in lower districts by humble

bees. The leaves are glabrous above; the under side is covered by a waxy secretion, which protects the stomata from being clogged by rain or dew.

H. Müller gives the following list of insect visitors—twelve in number:—Coleoptera: *Omalium florale*, numerous, creeping about in the flowers. Diptera: *Bombylius discolor*, numerous; *B. major*, rarer, and probably not often getting to the honey. Hymenoptera: Bees: *Anthrena gwynana*, female, frequent on the short-styled flowers; *Anthophora pilipes*, both male and female, very numerous; the hive bee, sucking busily; *Bombus confusus*, female; *B. hortorum*, female, very numerous; *B. lapidarius*, female; *B. silvarum*, female; *B. terrestris*, robbing the flower of its honey after biting through the corolla; *Osmia rufa*, male.

HOTTONIA

This genus resembles *Primula* in the position of the honey, and in being dimorphous. It is sometimes cleistogamous.

H. palustris (Water Violet).—As in so many other water plants the leaves are cut up into numerous narrow linear lobes. That the plant was originally terrestrial is indicated by the aerial flowers. The observations made by Darwin on *Primula* were repeated and confirmed as regards *Hottonia* by John Scott and subsequently by H. Müller.

CYCLAMEN

C. europæum.—The flowers produce no honey, but it is supposed that insects pierce the delicate tissues inside the flower and thus obtain a sweet sap. The flowers are pendent, and being smooth and slippery, Kerner has suggested that creeping insects are unable to get round the lip, but slip off and fall down. The flowers are protandrous, and the pollen is at first sticky, but gradually becomes dry and pulverulent. The anthers open at the apex. When the flowers first open, the flower-stalk is bent nearly at a right angle, so that as

it opens, the pollen which drops, and which from its stickiness is but little, falls (Fig. 170) clear of the pistil. Gradually the stalk bends downwards (Fig. 171), moving about 10 per cent a day, and finally (Fig. 172) hangs almost perpendicularly, so that the pollen, which has now become dry and pulverulent, drops on to the stigma. The leaves are glabrous and oval, but in the species or variety known as *C. hederæfolium* they are ivy-leaf in form. No explanation of the difference, so far as I know, has been suggested. The flower is said to last ten days. When the flower is fertilised the stem contracts into a spiral, and carries the fruit down to, and even into, the ground. The seeds gradually ripen during the winter, while the lower part of the stalk rots away, the upper portion remaining as a hook attached to the capsule and facilitating its dispersal.

LYSIMACHIA

The parts of the flower are generally in fives, but sometimes in sixes. The flowers, as in the preceding genus, are honeyless. We have four species. Two have erect stems: *L. vulgaris*, with short terminal panicles; and *L. thyrsiflora*, with flowers in axillary racemes. The other two are trailing plants: one, *L. Nummularia*, with large flowers and broad calyx segments; the

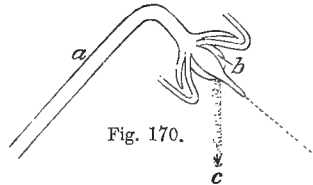


Fig. 170.

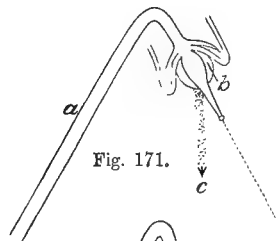


Fig. 171.

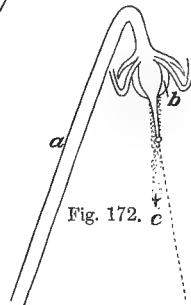


Fig. 172.

FIGS. 170-172.—*Cyclamen europæum*.

FIG. 170.—Position of flower as it opens.

FIG. 171.—Position of flower when fully open.

FIG. 172.—Final position of flower.

a, flower-stalk; b, cone formed by the anthers; c, fall line of the pollen.

other, *L. nemorum*, with small rotate flowers and narrow calyx segments.

L. vulgaris appears to be in special relation with one species of bee—*Macropis labiata*. This insect does not appear to exist where *L. vulgaris* does not occur. Besides the usual large flowers there are other smaller ones, slightly modified, so as to favour self-fertilisation. The stem is sub-quadrangular, and the leaves pubescent below, with black spots.

L. Nummularia (Moneywort).—From the structure of the flower the pollen must often fall on the stigma, but, according to Darwin, it has little effect, and Kerner refers to the species as self-sterile. The plant is glabrous, with a quadrangular stem.

L. thysiflora has protogynous flowers.

TRIENTALIS

The parts of the flower are generally in sevens, which is a very unusual number. There is no honey, but a juicy fleshy ring surrounding the ovary, and bearing the stamens, is probably pierced by the insects for the sake of the sweet juice. This and other similar cases seem to indicate the manner in which honey may have been gradually evolved.

T. europæa is generally protogynous, but the plants observed by Schulz in the Riesengebirge were homogamous, or very slightly protogynous. When the anthers open, an insect visiting the flower would touch them on one side and the stigma on the other. The pistil somewhat elongates while the flower is open, so that eventually the stigma is raised a little above the anthers. Finally, the flower closes, pressing the anthers against the stigma, and thus, it would seem, ensuring self-fertilisation.

GLAUX

A small decumbent seaside plant, without any corolla, the function of which is taken over by the reddish calyx. Honey is secreted, though only in small

quantity, by the base of the flower. The single species, *G. maritima*, is widely spread in the temperate parts of the northern hemisphere.

ANAGALLIS

Creeping herbs. The flowers are homogamous and without honey. The capsule opens transversely by a circular fissure across the middle. Along the line of dehiscence the cells are elongated transversely (Fig. 173, *c*), and are but slightly attached, while above and below they present irregular outlines, which tend to keep them together. We have two species: one perennial, with a campanulate pale-pink corolla, *A. tenella*; the other annual, with a rotate deep-red, pink, blue, or white corolla, *A. arvensis*. The seeds are dark brown, biconvex, flattened on the dorsal aspect by pressure against the wall of the pericarp, and covered with obtuse, broad-based teeth, which give them the appearance of being deeply pitted.

A. arvensis.—The flower is open from about 9 A.M. to 3 P.M., and it is interesting from this point of view that the only insect visitor yet recorded (*Halictus morio*) belongs to a genus which also goes to rest early. When the corolla closes, the stigma would probably come in contact with the anthers. Moreover, the corolla drops early, and in slipping over the pistil can hardly fail to dust the stigma with pollen. The blue form, which, though rarer with us, is equally common in the South of Europe, is often considered, as, for instance, by Bentham and Hooker, to be merely a variety. Clos, however, finds that the two are infertile together, in which

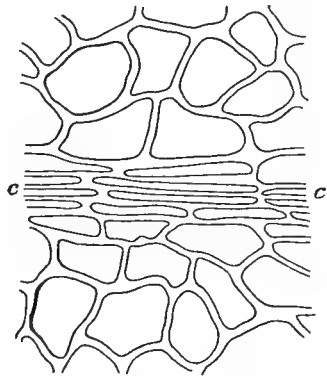


FIG. 173.—*Anagallis arvensis*. Wall of the capsule. *c c*, elongated cells along the line of dehiscence.

case they must no doubt be regarded as distinct species. The plant is glabrous, with a quadrangular stem; the leaves bear black dots. The stem has water furrows, which start from the intervals between the leaves.

A. tenella.—Here the pistil projects beyond the anthers, so that self-fertilisation seems unlikely. The tube of the flower is almost filled by the woolly hairs of the stamens. The stem is quadrangular and glabrous.

CENTUNCULUS

The capsules open transversely, as in *Anagallis*.

C. minimus.—The flowers, according to Kerner, are only open between 10 and 11. In the island of Föhr, Knuth found them to be cleistogamous. The plant is glabrous.

SAMOLUS

The capsule opens in five valves.

S. Valerandi.—A glabrous plant growing in Britain, generally near the sea. The ovary has a ring at the base which resembles a nectary, but apparently secretes no honey. The anthers are at the same height as the stigma, and open inwards, so that the flower can easily fertilise itself.

LENTIBULARIACEÆ

Corolla two-lipped. Stamens 2.

UTRICULARIA (Bladderwort).

Calyx deeply two-lobed. Corolla spurred. Capsule globular, opening in two valves. Our species of the genus are all floating plants, without roots, and with leaves divided into capillary branches, bearing little bladders or utricles, whence the name. As in so many

aquatic plants, the flowers rise above the water, an

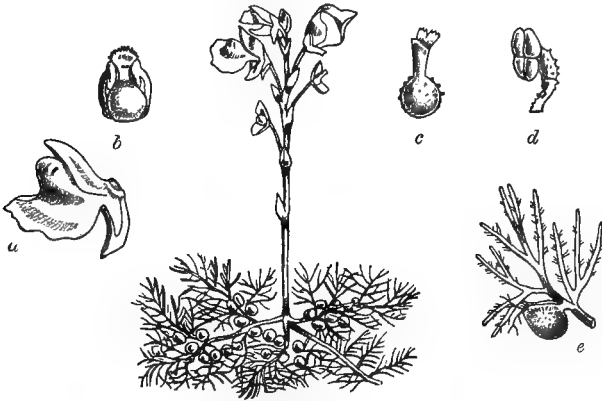


FIG. 174.—*Utricularia vulgaris*. *a*, flower seen from the side; *b*, flower seen from the front; *c*, ovary and pistil; *d*, stamen; *e*, part of leaf showing a bladder.

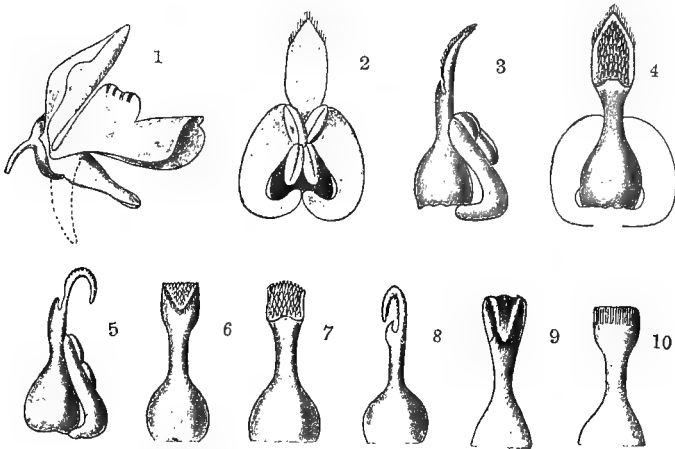


FIG. 175.—*Utricularia vulgaris*. 1, The flower, natural size. The dotted line shows the position which the spur takes on the downward pressure of the under lip. 2, Stamens and pistil shortly before the opening of the bud, viewed from underneath. 3, The same, viewed from the side. 4, The same, viewed from above. 5, The same, from a newly opened bud, viewed from the side. The lobe of the stigma is bent downwards. 6, The same, viewed from underneath. 7, The same, viewed from above. 8-10, The pistil, after an outward irritation upon the lobe of the stigma, and after the withdrawal of the corolla, in consequence of which the stigma lobe, unimpeded by the corolla, has strongly turned itself upwards.

indication of their originally aerial condition. We have

three species: *U. intermedia* is distinguished by the bladders being on separate branches; in *U. vulgaris* the spur is conical; in *U. minor* it is very short. They are said to be fly flowers, the entrance of the corolla being too narrow for bees. It is seldom that flies show sufficient intelligence to avail themselves of a flower so complicated. The remarkable bladders, from which the genus derives its name, have been specially studied by Cohn¹ and Darwin.² Darwin worked mainly with *U. neglecta*. The bladders, he says, "are supported on short foot-stalks. When fully grown they are nearly one-tenth of an inch (2.54 mm.) in length.

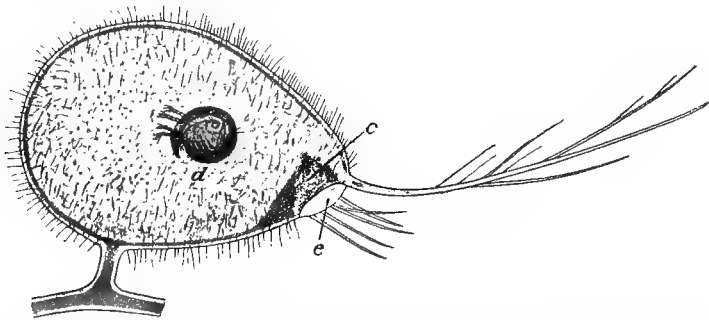


FIG. 176.—*Utricularia vulgaris*. Bladder much enlarged. *c*, collar indistinctly seen through the walls; *e*, entrance; *d*, a small Crustacean (*Chydorus*) which has been captured.

They are translucent, of a green colour, and the walls are formed of two layers of cells. The exterior cells are polygonal and rather large; but at many of the points where the angles meet, there are smaller rounded cells." The interior is lined with a serried mass of absorbent processes, in groups of four, two long and two short. The general form is shown in Fig. 176. The lower side is nearly straight, the upper much arched, and terminates in some long processes, two of which are larger than the rest and branched, giving the whole organ a curious resemblance to a *Daphnia*. At the angle is an entrance

¹ Cohn, "Ueber d. function der Blasen von *Aldrovanda* u. *Utricularia*," *Beitr. Biol. Pflanzen*, i. Heft 3 (1875).

² Darwin, *Insectivorous Plants*.

closed by a flap (Fig. 177, 178, *c*), which plays freely on a rim or collar. This flap is easily pressed inwards, but then springs back into place. Minute fresh-water Crustacea and insects seem to have a singular fascination for entering, and once in, as they cannot open the flap from inside, they are doomed. Darwin found in one bladder as many as ten minute Crustacea. The walls of the entrance (Fig. 177, *a*) are slightly contracted in the centre like (though not so much as) an hour-glass; and the flap (*b*), shown by the dotted line, being nearly semi-circular, can open inwards, but not outwards.

U. vulgaris.—

The arrangement of the flower in some respects resembles that of

Antirrhinum (Snapdragon). The two lips of the corolla completely close the flower. The upper lip is simple: the lower consists of three parts (Fig. 175, 1) —(1) the spur which contains the honey; (2) the arched prominence which abuts against the upper lip and closes the flower; and (3) the lateral projecting lobes. These serve as an alighting stage for the



FIG. 177.—*Utricularia vulgaris*. Opening of bladder, seen in front; much enlarged. *a*, wall of opening; *b*, outline of the flap; *c*, opening.

fly, the weight of which presses down the lower lip, and thus opens the way to the honey. As in *Antirrhinum* the pistils and stamens lie close underneath the upper lip. The pistil consists of two lobes—an upper one, quite short and pointed; and a lower one, which is longer, spatulate, and bears the stigma on its upper surface (Fig. 175). The stigma projects beyond the anthers, so that it is first touched by any entering insect. The anthers open downwards, so that the head of the insect necessarily touches them and takes up a fresh supply of pollen. The stigmatic surface, as already mentioned, is on the upper side of the stigma, and lies, therefore, against the upper lip of the corolla.

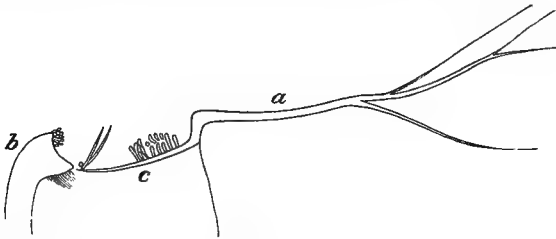


FIG. 178.—*Utricularia vulgaris*. Mouth of bladder, seen sideways. *a*, antenna; *b*, strengthened margin of fore-court; *c*, flap.

When the flower opens, however, it turns downwards (Fig. 175) so as to touch the head of any insect visitor. It is, moreover, sensitive, and as soon as it is touched it rises again, and resumes its original position, so that the retreating insect cannot dust it with any of its own pollen. The edge of the stigma is furnished with a row of hairs, which, according to Heinsius,¹ serve to brush the pollen from the head of the visitor. The pollen grains lend themselves to this, being provided with several longitudinal ridges. The visitors appear to be especially flies belonging to the family Syrphidæ.

The flowers of *U. minor* and *U. intermedia* are formed on the same general plan.

In autumn most of the plant decays away, but the

¹ *Bot. Jaarb.* iv. (1892).

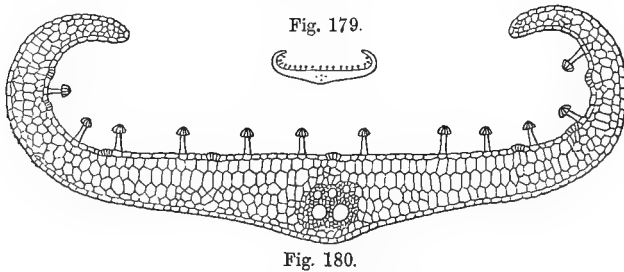
terminal part grows into a compact bud, and thus passes the winter.

PINGUICULA (Butterwort).

The corolla is spurred as in *Utricularia*, but with a broad open mouth. There are three British species: *P. vulgaris*, with violet-purple, *P. alpina* and *P. lusitanica*, with yellow flowers. In *P. alpina* the spur is very short, and nearly straight, while in *P. lusitanica* it is longer and curved. The plant grows in damp places. "It bears on an average eight, rather thick, oblong, light green leaves, having scarcely any foot-stalk. A full-sized leaf is about $1\frac{1}{2}$ inch in length and $\frac{3}{4}$ inch in breadth. The young central leaves are deeply concave, and project upwards; the older ones towards the outside are flat or convex, and lie close to the ground, forming a rosette from 3 to 4 inches in diameter. The margins of the leaves are incurved (Figs. 179, 180). Their upper surfaces are thickly covered with two sets of glandular hairs, differing in the size of the glands and in the length of their pedicels (Fig. 181). The larger glands have a circular outline as seen from above, and are of moderate thickness; they are divided by radiating partitions into sixteen cells, containing light-green homogeneous fluid."¹ The glands secrete a colourless fluid which is so viscid that Darwin was able to draw out a thread to a length of no less than 18 inches. It has been calculated that an ordinary rosette of leaves bears about 500,000 of such glands. Any small insect alighting on the leaves is thus caught: the edge curves over, which appears to be an advantage in two ways, partly in preventing the victim from being blown away, and partly by pushing it slightly towards the centre of the leaf, where there are more glands. Seeds, small fruits, pollen, etc., are also caught. Thirty-two leaves examined by Darwin had 142 insects adhering to them, or rather more than four each.

¹ Darwin, *Insectivorous Plants*.

P. vulgaris.—As regards arrangement the flowers of *Pinguicula* differ from those of *Utricularia* principally in being adapted to small bees, in being open, and in not having a sensitive stigma. The latter is in the present genus pushed back by the retreating head of the bee.



FIGS. 179, 180.—Transverse section through the leaf of a Butterwort (*Pinguicula alpina*). Fig. 179, nat. size. Fig. 180, $\times 50$.

P. alpina.—This species has protogynous flowers, and is mainly visited by flies, which creep into the flower until their head reaches the base of the spur. In almost all cases the presence of a spur or a tube in flowers indicates that of honey. *P. alpina*, however, is said to be honeyless, but the inner side of the spur is clothed with glandular juicy hairs the contents of which are very attractive to insects. As the flower is protogynous, the flies necessarily effect cross-fertilisation, carrying the pollen from older flowers

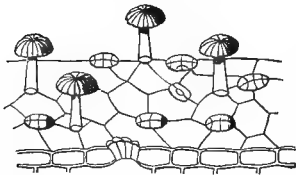


FIG. 181.—Piece of the epidermis of a leaf of Butterwort, showing the two kinds of gland, sessile and stalked. $\times 180$.

to those more recently opened. The bristles give an easy entrance, but are supposed to make the withdrawal of the head more gradual, and in other cases prevent it altogether, the fly being thus treacherously captured. Thus *P. alpina* is doubly an insect-capturing plant.

AQUIFOLIACEÆ

ILEX

Parts of the flower in fours. Calyx sometimes with 5 teeth. Flowers often subdioecious; with exposed honey.

I. Aquifolium (Holly). — Generally dioecious. The male flowers possess the rudiment of a pistil. The female flowers are larger than the male. The honey is but sparing. As in so many small trees, the dispersal of the seed is due to the fruit being attractive to birds; and the ripeness is indicated by the colour.

The leaves are spiny, glossy, and twisted. The teeth are a protection against browsing quadrupeds. It is interesting that the upper ones which are out of reach tend to lose their spines, and old trees are often almost entirely without them. As Southey well said,—

Below, a circling fence, its leaves are seen
Wrinkled and keen;
No grazing cattle through their prickly round
Can reach to wound;
But as they grow where nothing is to fear,
Smooth and unarm'd the pointless leaves appear.

Some evergreen oaks also when young have prickly leaves. The leaves are also protected by a thick cuticle, and their generally tough, leathery character enables them to withstand conditions of dryness and cold which would be fatal if they were less well-protected. The glossiness is perhaps an advantage in throwing off snow, which might otherwise accumulate and break down the branches. Other evergreens—the Common Laurel, Portugal Laurel, Ivy, Pines, etc.—also have the leaves glossy. The twisted character of the leaves has the effect of presenting spines in every direction. We find a similar character in the leaves of many thistles. I have sometimes thought also that the absence of flat surfaces is another protection against snow. The stipules are black, and reduced to minute points. They are now perhaps functionless, the rudiments of once larger organs.

OLEACEÆ

The flowers are small, but rendered conspicuous by association. The honey is at the base of the corolla tube. *Fraxinus* is wind-fertilised.

FRAXINUS

Flower polygamous. Corolla 2-4-fid or wanting. Fruit, as in so many other high trees, provided with a wing, which assists in the dispersal by wind.

F. excelsior (Ash).—The leaves, as in so many other plants with large leaves, are divided into leaflets. This renders them less liable to be injured by hail or wind.

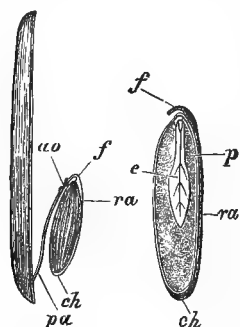


Fig. 182.

Fig. 183.

FIG. 182.—*Fraxinus excelsior*. Samara with half removed and the seed pulled out. Nat. size. *ao*, aborted ovules; *ch*, chalaza; *f*, funicle; *pa*, placental axis; *ra*, raphe.

FIG. 183.—Longitudinal section of seed. $\times 2$. *ch*, chalaza; *e*, embryo; *f*, funicle; *p*, endosperm; *ra*, raphe.

The leaf-stalk has a deep groove on the upper side, with openings opposite the leaflets, and in it the rain which falls on the leaves is retained for some time. There are special hairs by which the moisture is said to be absorbed. The fruits, commonly called keys, are thin, flat, and an inch and a half long. The flowers come out early, before the leaves. This is generally the case with wind-flowers, and is an advantage, as the leaves do not get in the way of the pollen. Some of the flowers are complete, some have rudimentary stamens, others a rudimentary pistil, and intermediate forms occasionally occur, indicating that the transition is not yet fully accomplished. Schulz has

observed that the same tree, and even the same branch, differs in these respects in different years. They are protogynous, the stigma being ripe two to four days before the anthers. The anthers when ripe arrange themselves so as to open on the upper side. The ovary,

as characteristic of the order, is 2-celled with 2 ovules in each chamber. During development of the fruit, however, three ovules become atrophied, and the samara is one-seeded. The septum between the ovary chambers becomes separated, and bears as on a long funicle the three atrophied ovules and the perfect seed (Fig. 182).

The bud-scales are modified leaf-stalks, and generally show more or less rudimentary leaflets at the tip. The outer scales are thick, and rather furry on the inner side. The second pair are furry on the outer side, and especially on the edges. The third pair still more so. The outer scales are not dead, like those of so many trees, but increase more or less in size. They are olive green, so dark as to be almost black. Tennyson, in *The Gardener's Daughter*, describes Juliet's hair as—

More black than ash-buds in the front of March.

The dark colour is due to a layer of black, more or less angular bodies, which are flattened hairs, containing a dark resinous secretion, and do not increase in size or number. As the scale grows they are, therefore, carried further and further apart, and occupying a smaller relative portion of the surface, the general colour becomes lighter and greener.

LIGUSTRUM (Privet)

Flowers homogamous, with concealed honey, in compact panicles.

L. vulgare.—The honey is at the base of the tube, which is about 3 mm. in length. The corolla has generally 4, but sometimes 5 lobes. The stamens are generally 2, but sometimes 3. The anthers open widely; their position also varies. Sometimes they are far apart, so that an insect would touch the stigma on one side and an anther on the other; sometimes they incline over the stigma, so that the flower would fertilise itself. The flowers are visited by various butterflies, bees, flies, and beetles. As in Ash, the

ovary contains 4 ovules, whereas the fruit contains only one or two seeds. In the Privet, however, the pericarp becomes fleshy, forming a berry.

APOCYNACEÆ

Chiefly a tropical family of trees or shrubs, with a milky juice, and opposite leaves. We have only one genus.

VINCA (Periwinkle)

Homogamous flowers, with concealed honey, secreted at the base of the ovary. We have two species: *Vinca major*, which has become naturalised in copses and hedges, with broad leaves, large flowers, and a fringed calyx; and *V. minor*, a doubtful native, with narrower leaves, smaller flowers, and the calyx quite glabrous.

V. minor.—The curious structure of this flower (Figs. 184-186) was described independently by Darwin and Delpino. The flower forms a tube 11 mm. in length. The honey is secreted by two yellow nectaries at the base of the ovary, and is protected from rain by a number of hairs at the opening of the corolla. The stamens are attached to about the middle of the tube, are bent like a knee, and the anthers, which are hairy, lie over the stigma. The stigma is conical, expanding upwards, and terminating in a curious flat plate. The edges of this are sticky and constitute the stigma, while the upper surface is hairy. The pollen is shed into the space above the stigma, which, however, it cannot reach on account of the brush of hairs. Insects are able to force their heads into the upper part of the tube, so that a proboscis 8 mm. long is able to reach the honey. It becomes smeared by the sticky secretion, and on being withdrawn some of the pollen adheres to it and consequently is carried to another flower and deposited on the stigma.

Bees and some flies, especially *Bombylius discolor*, are frequent visitors.

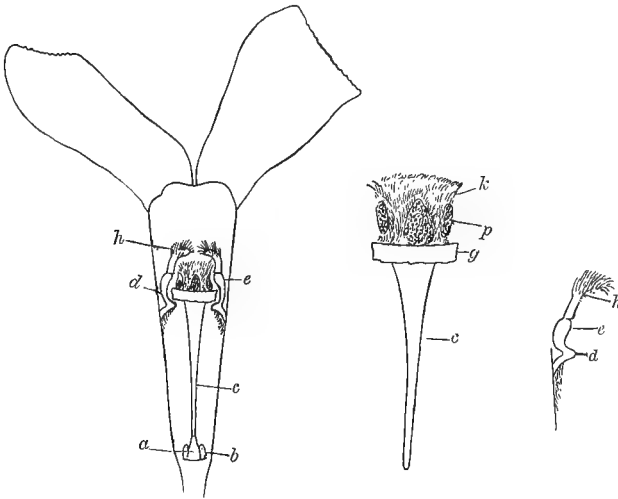


Fig. 184.

Fig. 185.

Fig. 186.

FIG. 184.—*Vinca minor*. Flower after the removal of the front part of the corolla. $\times 2$.

FIG. 185.—Pistil. $\times 3$.

FIG. 186.—Stamen. $\times 3$.

a, ovary ; *b*, yellow honey-gland ; *c*, style ; *d*, stamens bent in the form of a knee ; *e*, anther opening towards the inside ; *g*, flat plate at the summit of the style supplied with sticky stuff round the edge, and whose under edge acts as stigma ; *h*, hairy connective of anther ; *k*, the brush of hair which sits on the top of the style, and receives the pollen which comes out of the anthers ; *p*, pollen.

V. major.—The structure of the flower agrees with that of *V. minor* ; but the tube is 15-16 mm. long, and it requires a proboscis 11 mm. in length to reach the honey.¹

GENTIANACEÆ

The leaves are opposite. *Chlora* and *Erythræa* have quadrangular stems, as also have some *Gentians*.

¹ See Baillon, *Bull. Soc. Linn.*, Paris, 1882.

CICENDIA

Parts of the flower in fours. There are two British species: *C. filiformis*, with broad, the other, *C. pusilla*, with linear, calyx teeth.

ERYTHRÆA

Parts of the flower in fives. There is no honey, but the flower is sweet and juicy, and it would appear that insects pierce the tissue and suck out the sap. They only open in fine weather, and close again if it rains.

E. Centaurium. — A variable species, the forms of which are regarded by some botanists as distinct species, while others consider them to be mere varieties. The flowers are homogamous, but the stamens and pistil at first bend away from, afterwards, however, approaching, one another. Wilson¹ found them to be heterostylic, with corresponding differences in the pollen. This has been confirmed by Loew. German botanists have not altogether accepted this view, though they found that the pistil varies in length. According to Kerner, the life of the flower lasts five days. They open, according to Warnstorf, from 5-7 A.M., and begin to close about mid-day.

GENTIANA

Blue, yellow, or red flowers, with the parts in fours or fives. They have honey secreted at the base of the ovary and of the corolla, and from the length of the tube generally accessible to humble bees and Lepidoptera only. In many Gentians the leaves are so arranged as to hold water, retaining it for some time, during which it can be absorbed by special club-shaped hairs. Some species are protected from browsing quadrupeds by a bitter sap. The stamens are adnate to the corolla, projecting in the form of ridges, and thus divide the hollow of the flower into four or five separate tubes.

G. Pneumonanthe. — The flowers are protandrous. They close at night and in wet weather. The

¹ *Nature*, xviii. (Sept. 5, 1878).

corolla-tube is 25-30 mm. long, and 8-10 wide at the mouth. Beneath the middle the tube suddenly narrows, as the filaments of the stamens are soldered to the corolla. To this point a bee can enter, and touches with its head the pollen in young flowers, the stigma in older ones. In this stage the stigma projects above the anthers. Gradually, however, the tube elongates, and brings the anthers to the level of the stigma, so that in the absence of insect visits the flower fertilises itself.

G. verna.—This species is fertilised principally by butterflies.

G. nivalis.—This species appears to be generally self-fertilised. The flowers open and close rapidly—occasionally, according to Kerner, several times in an hour.

G. Amarella.—The flower-tube is 16-18 mm. in length, but is 6 mm. wide, so that humble bees, by which the flowers are principally visited; can push their heads some 6 mm. down. At the entrance to the tube are a number of hairs, which exclude unwelcome visitors, especially flies, and, in combination with the contraction of the flower, also serve to exclude rain. The anthers open upwards and at the same time as the flower. The two stigmas project somewhat farther, so that an approaching insect must almost inevitably, in the first instance, touch the stigma, and then dust itself with pollen.

G. campestris.—This species differs from the preceding in having 4 sepals and 4 corolla-lobes. Two of the sepals are wider than, and overlap the others. In some districts it is said to be slightly protogynous, in others protandrous. It appears also to differ in these respects somewhat according to the season. In bad weather the flowers are said to be cleistogamous. In Norway the stigmas are at the same level as the anthers, or even lower; in the Alps, according to H. Müller, they project beyond the anthers, but finally bend over to them and so fertilise themselves. They are visited by humble bees and butterflies. An interesting point

about the species is that while it is annual in the plains, in Alpine districts it becomes biennial.¹

CHLORA (Yellow-wort)

The calyx and corolla are eight-lobed. The flowers produce no honey.

C. perfoliata.—The flowers close at night. The leaves are glabrous and connate, forming a smooth collar round the stem, which creeping insects cannot get over.

MENYANTHES (Buckbean)

Honey secreted by the base of the ovary. Flowers generally dimorphous.

M. trifoliata.—The upper surface of the corolla is clothed with beautiful white filaments. According to Knuth these render the flower more conspicuous, and also serve as a protection against rain and unwelcome

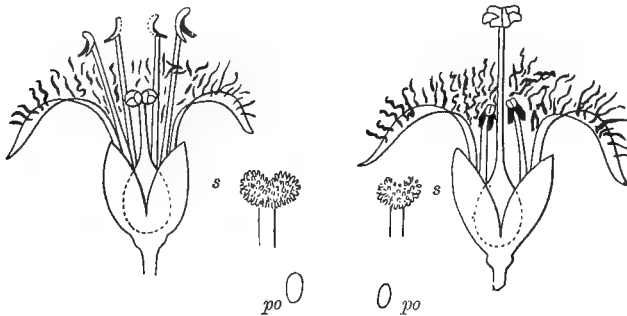


Fig. 187.

Fig. 188.

FIG. 187.—*Menyanthes trifoliata*. Short-styled form, after the removal of the front part of the corolla and front stamens (nat. size).

FIG. 188.—long-styled form (as before).

po, pollen from the stamens of each form ($\times 70$); s, papillæ of the stigma of the two forms ($\times 4$).

intruders. I am not satisfied that this is a sufficient explanation. This curious and beautiful flower is dimorphous in some places and not in others. Sprengel knew only the homomorphous form. Warming in West Greenland plants found the stamens and pistil of

¹ Grisebach, *Die Vegetation der Erde*.

equal length. Knuth, near Kiel, and other observers, found two forms, one long-styled and one short-styled, as in *Primula*. In England also they are dimorphous. As in *Primula*, the papillæ of the stigma (Figs. 187, 188) and the pollen of the two forms differ in size. The flowers are very little visited by insects—at least by day.

LIMNANTHEMUM

Dimorphous flowers, with concealed honey, secreted by five nectaries between the roots of the stamens.

L. nymphæoides.—This is a floating water plant, well named from its resemblance to a water-lily. Flies are much attracted to the flowers by a sap which exudes from the cells of the corolla. The entrance to the flower-tube is occupied by numerous filaments. The pistil of the long-styled is about one and a half times as long as that of the short-styled form. The bud forms under water, the flower emerges as it opens, and after it fades the stalk turns down again and the seed matures below the surface. This is a most unusual arrangement. When ripe the seed rises; it is lenticular, the surface is smooth, and not wetted by water, so that it floats and is carried about by currents; the edge, moreover, bears a row of stiff roughened hairs, which no doubt sometimes attach themselves to animals—perhaps, also, they tend, in conjunction with the lens-like form, to make the seed float.

POLEMONIACEÆ

POLEMONIUM

Protandrous flowers, with concealed honey, which is secreted at the base of the ovary. The filaments of the stamens are dilated into hairy scales.

P. cæruleum.—A glabrous or slightly pubescent plant, the flowers of which are united in a beautiful terminal corymb or panicle. The access to the honey

is concealed by the woolly hairs on the inner side of the corolla, and the dilated filaments of the stamens. When the bud opens, the anthers are ripe, but not the stigmas, which, moreover, project considerably. Self-fertilisation is therefore at first excluded, but eventually the flower bends over, and the stigmas come within the fall line of the pollen (see *Pyrola*, p. 265).

In Nova Zembla, according to Ekstam, the plant is protogynous. The flowers bend over in wet weather. The capsule is upright, and at maturity it ruptures along the middle of the dissepiments, so that the outer cell-walls break away from the central axis. The seeds thus lie in a cup, and are jerked out by the wind. They are dark brown, elliptical, convex on the back, flattened on the ventral aspect, and more or less finely rugose.

CONVOLVULACEÆ

CONVOLVULUS

Flowers brightly coloured and adapted to various insects; generally only open for a single day. Corolla plaited in the bud, and rolling inwards when it fades. Honey secreted at the base of the ovary. Many of the exotic species have extrafloral nectaries. As in other climbers, the growing part of the shoot revolves or "circumnutates" from right to left (*i.e.* against the course of the sun), and in this species makes a revolution in about two hours. Other plants move more rapidly. The vine revolves in about an hour, *Cobæa scandens* (a member of the preceding order) in only twenty-five minutes. We have three species of *Convolvulus*. *C. arvensis* has small, the other two have large bracts, and are sometimes separated as the genus *Calystegia*; *C. sepium* has the leaves angular at the base, and the corolla white; while in *C. Soldanella* the leaves are rounded, and, as in so many other seaside plants, fleshy, and the corolla pink.

C. arvensis (Bindweed).—The leaves are ovate-sagittate; the flowers are sweetly scented, and open from about 7 A.M. to 10 P.M., closing at night and in bad weather. Honey is secreted by the base of the ovary, and the swollen bases of the five stamens (which are adnate to the corolla) leave only five narrow entrances to it. The filaments are woven together by short stiff projections at their edges, so that an insect cannot insert its proboscis between them. The anthers open outwards, and the stigmas project beyond them, and must therefore be first touched by any visiting insect. The flowers, as in so many cases, present numerous differences. In Belgium, MacLeod found four forms: (1) that above described; (2) one with larger flowers, the corolla surrounded by a red band; (3) a form with small flowers; (4) a female form, with shortened stamens and rudimentary anthers. After flowering the ovary curves downwards and thus protects itself. The flowers are often infested by a spider, *Thomisus onustus*, which seizes the unsuspecting insects which come for the honey. The plant is sometimes glabrous, sometimes hairy.

C. Soldanella.—The general arrangement of the flower agrees with that of *C. arvensis*. The relative lengths of the stamens and pistil vary considerably. Besides the complete plants, MacLeod found at Blankenberge some that were gynodioecious. It is a plant of sandy sea-shores; its slender root-stock helping to bind the sand.

C. sepium.—This species has no scent, but in other respects the arrangement of the flower is much the same as in *C. arvensis*. On moonlight nights, however, it remains open. Though sometimes visited by other insects, it is especially adapted to the *Convolvulus* hawkmoth, and seldom sets its seeds where that insect does not occur. The ovary does not curve downwards after the flowering—perhaps, as Dutrochet long ago suggested,¹ because it is sufficiently protected by the large bracts. The plant is glabrous.

¹ *Recherches Anatomiques, etc.*

CUSCUTA (Dodder)

This curious genus is annual, leafless, and parasitic, with thread-like, delicate, pinkish, twining stems, bearing clusters of small homogamous flowers, with concealed honey, which is secreted by the base of the ovary. They are often cleistogamous. The seeds germinate in the soil, developing a slender root and thread-like stem, but no cotyledons. When, as a result of its circumnutation, the stem has come in contact with its future host, it curls round it like a tendril and develops suckers, which penetrate to the vascular tissue of the host-plant. The root then withers, and the Dodder is henceforth a parasite. There are three British species. In *C. europæa* and *C. Epilinum* the corolla-lobes are short and broad—the latter grows only on flax, and is not a true native; in *C. Epithymum* the corolla-lobes are spreading and pointed.

C. Epithymum.—This species grows on heath, thyme, and other small shrubs. The flower parts are generally in fives, but sometimes in fours, threes or even twos. The honey is protected by small scales growing from the inside of the corolla. The stigma and anthers ripen simultaneously, and an insect would naturally touch the stigma on one side and the anthers on the other.

C. europæa resembles *C. Epithymum* in the general arrangement, but is larger.

BORAGINEÆ

Generally rough, with coarse hairs. Nectar is generally secreted at the base of the ovary, and often protected by scales at the summit of the corolla-tube. The flowers are especially adapted for and visited by bees, and are often bent in a manner well adapted to suit the proboscis. Blue is the predominant colour.

ECHIUM

E. vulgare (Viper's Bugloss) has generally protandrous flowers. The honey is abundant. From the size and bright colour of the flowers, and their association in a long one-sided inflorescence, they are very conspicuous, and much visited by insects, nearly 100 species being on record. The lower parts of the filaments are soldered to the corolla-tube, and where they detach themselves the tube suddenly enlarges, so that even the largest humble bee can conveniently insert its head and thorax. Four of the stamens lie along the under side of the flower; one, on the contrary, is separate, and divides the tube into two parts. The anthers open with the flower, and turn the pollen upwards. When the flower opens, the pistil is somewhat shorter than the corolla-tube, but it soon elongates and projects beyond the stamens. This is one of the flowers which changes colour;¹ from reddish purple they become bright blue. Besides these complete flowers, plants occur with smaller flowers, in which the stamens are short and the anthers without pollen. Intermediate forms also occur. The plant is effectively protected by stiff, spreading, almost prickly leaves.

E. violaceum, which occurs in Cornwall, is of interest from its geographical distribution. It belongs to that Southern European element, examples of which occur in our flora only in the West of England.

PULMONARIA

Nectar secreted by the base of the ovary, and protected by hairs on the inside of the corolla. Corolla-tube straight.

P. officinalis is a European species, rare in Britain, where it has become naturalised in woods and copses in the South of Scotland and England. The flowers, which are borne in a terminal forked cyme, are first red, then blue-violet; they are dimorphous; the tube is 10-12 mm. long, but as it is large enough at the summit to admit

¹ See p. 84.

the head of a bee, the honey is accessible to insects with a proboscis 8 mm. in length. As in other cases, the pollen of the short-styled is larger than that of the long-styled form.¹ From the size of the flowers, the brightness of the colours, the early season at which they open, and the abundance of honey, they are richly visited by insects, especially by bees and butterflies. Hildebrand has shown² that the long-styled flowers are utterly sterile to their own pollen, and even to pollen from other plants of the same form. The short-styled flowers, on the contrary, under such circumstances produce some seed, though only about half as much as they do if properly fertilised. The plant is covered with spreading hairs.

MERTENSIA

This genus is glabrous, which is unusual in the present family, but frequent among maritime plants.

M. maritima.—A Northern and Arctic plant found on our sea-shores in Wales, North England, and Scotland.

LITHOSPERMUM

Nectar secreted by the base of the ovary, and concealed at the base of the corolla-tube. Generally humble bee flowers. We have three species: two have white or pale yellow flowers; one, *L. arvense*, is annual, with wrinkled nuts; the other, *L. officinale*, perennial, with smooth nuts; the third, *L. purpureo-cæruleum*, has bright blue flowers. The name is derived from the extreme hardness of the nuts (*λίθος*, stone, and *σπέρμα*, seed).

L. arvense.—Flowers small and white, or on the Continent sometimes blue. The nectar is protected by hairs in the upper part of the corolla-tube. The anthers open inwards and even before the flower, though the flowers examined by Kerner were slightly protogynous. The pistil ends in two short lobes, beneath which is a ring of papillæ, which are at the level of the anthers,

¹ See p. 288.

² *Bot. Zeit.* xxiii. (1865).

and with them fill the corolla-tube. To arrive at the honey an insect must therefore press its proboscis between the anthers and the stigmas. The leaves are rough with appressed hairs.

L. purpureo-cæruleum.—The arrangement of the flower resembles that of the preceding species. The colouring curiously repeats that of *Pulmonaria*, being first purple and then blue. The plant is pubescent.

L. officinale.—The leaves are rough, green above, pale below.

MYOSOTIS

Flowers in one-sided cymes, generally blue, homogamous, with concealed honey. Corolla-tube straight. Nuts attached by the narrow end. There are five British species: *M. palustris* has the calyx with short teeth and appressed hairs; in the other four the calyx has long teeth and spreading or hooked hairs. *M. sylvatica* and *M. arvensis* have the pedicels longer than the calyx, the first being perennial with rather large flowers, the second annual with small ones. The last two have the pedicels less than a line long—*M. collina*, with blue flowers; *M. versicolor*, with flowers first yellow, then blue, and finally violet.

M. sylvatica.—The anthers are contained in the corolla-tube a little above the stigma, but open at the same time as the latter is ripe. They open inwards, so that an insect touches the stigma on one side and dusts itself with pollen on the other. At first the flower is horizontal, but it gradually becomes upright, so that the anthers are just over the stigma, and in the absence of insect visits the flower is almost sure to fertilise itself. The leaves are pubescent.

M. versicolor.—This is another case in which the flower changes colour. When it opens it is of a clear yellow colour, and the pistil projects beyond the anthers, so that it is adapted for cross-fertilisation. Gradually, however, the colour changes to blue; the corolla elongates, carrying the anthers, which are attached to it,

up to the level of the stigma, so that in the absence of insects it fertilises itself. The leaves are bright green, with spreading hairs. Fig. 189 represents a flower of

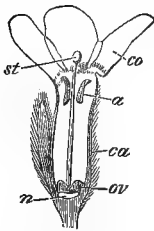


Fig. 189.

FIG. 189.—*Myosotis versicolor*. Young flower.

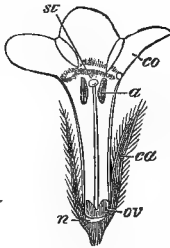


Fig. 190.

FIG. 190.—Older flower; much enlarged.
a, anther; ca, calyx; co, corolla; n, nectary; ov, ovary; st, stigma.

M. versicolor when just opened. It will be observed that the pistil projects above the corolla and stamens, so that it must be touched first by any insect alighting on the flower. Gradually, however, the corolla elongates, carrying up the stamens with it, until at length they come opposite the stigma, as shown in Fig.

190. Thus, if the flower has not already been fertilised by insects, it is almost sure to fertilise itself.

ANCHUSA

Homogamous bee flowers. Corolla-tube straight, with honey at the base. Nuts attached by the broad end. Two species occur in Britain, but both are rare, and have presumably been introduced by human agency. *A. officinalis* has terminal forked spikes, *A. semper-virens* short axillary spikes.

A. officinalis.—The corolla is at first violet, then deep blue. The entrance to the tube is guarded by five hairy, closely fitting scales. Immediately below them is the stigma, and about the middle of the tube are the anthers, so that visiting insects touch the stigma first and then the anthers. The corolla eventually detaches itself and falls off, carrying some of the pollen with it, and thus, in the absence of insects, fertilising the stigma. In some places, besides the usual complete flowers, others occur in which the stamens are rudimentary. The flowers differ also in size and in the exact position of the stamens, which, according to Schulz and Warming,

are sometimes at the same level with, sometimes even below, the stigma. In that figured by Bentham the anthers are at the summit of the tube. The flowers are much visited by bees, and sometimes by butterflies and moths. The stem is rough with stiff downward-pointing, and the leaves with spreading, hairs.

A. sempervirens.—According to Loew, the anthers and stigma are at the same height. The nuts have a small convex appendage on the inner side of the base. The plant is rough.

LYCOPSIS

Resembles *Anchusa*, but the tube is bent.

L. arvensis (Bugloss).—The arrangement of the flower agrees closely with that of the common form of *Anchusa officinalis*. The plant is rough.

BORAGO (Borage)

Flowers protandrous, in loose forked cymes. Corolla rotate. Tube short, closed by scales at the mouth. Filaments forked. Nectar secreted by the base of the ovary, and concealed in a short tube formed by the bases of the stamens.

B. officinalis.—Flowers drooping, sky-blue. Anthers nearly black, forming a cone round the stigma, and opening gradually from the tip to the base. Each anther is said to contain 60,000 pollen grains. They are smooth, dry, and pulverulent, and fall into the conical space round the pistil. The stamen has a prolongation (Fig. 191) which touches, or almost touches, the wall of the corolla-tube. The arrangement, therefore, somewhat resembles that in the hanging flowers of the Heath. An insect in search of honey must press its proboscis between two of the stamens, thus dislocating the anther-tube, when some of the pollen drops on to it, and is thus carried to another flower. Gradually the pistil elongates and the stigmas ripen.



FIG. 191. —Anther of Borage; enlarged.

If any pollen is left some might easily fall on it, but, according to Darwin, the flowers are not very susceptible to their own pollen. They are principally visited by bees, and Darwin says by more than in the case of any other plant he knew. The plant is rough, with stiff hairs on tubercles. It is not a native, but occurs in waste ground near dwellings.

SYMPHYTUM (Comfrey)

Flowers homogamous. Corolla tubular, enlarged above the middle. Nectar secreted by the base of the ovary. According to Kerner, the flowers gradually bend down, so that the stigma comes into the fall line of the pollen. There are two British species—*S. officinale*, with decurrent leaves; *S. tuberosum*, with leaves not, or only very slightly, decurrent.

S. officinale.—The corolla is white or purple-violet. The arrangement of the stamens resembles that of Borage, but the flower-tube is longer—14 mm. The upper swollen part, however, occupies 6 mm., but a proboscis 11 mm. in length is required to reach the honey, because when the tube contracts the entrance is still further protected by five triangular scales and by the stamens. *Bombus terrestris* and other humble bees, however, often bite through the corolla, and thus rob the flower of its honey. The leaves are rough, with short scattered hairs, and longer ones on the ribs.

S. tuberosum is less roughly hairy than the preceding. It is not found in the South of England.

ASPERUGO

The calyx enlarges after the flower fades, and becomes flattened and veined. The flowers are homogamous, with nectar secreted by the base of the ovary.

A. procumbens.—The flowers are small and blue. The plant is rough, with hooked hairs turned downwards. It is not common in Britain, but is occasionally found in waste places.

CYNOGLOSSUM

Flowers in one-sided cymes. Corolla-tube short, with scales at the mouth closing the aperture, and forming a roof to the chamber containing the honey, stamens, and pistil. The dispersal of the nuts is ensured by the presence of numerous short hooked prickles. There are two British species: *C. officinale*, with soft appressed hairs, and *C. montanum*, with rough scattered hairs.

C. officinale.—Corolla dullish purple. The stamens are longer than the pistil. The leaves are soft, with fine appressed down.

C. montanum.—The leaves are thin, semi-transparent, glabrous above, rough below, with scattered hairs on tubercles. The stem bears soft spreading hairs.

SOLANACEÆ

DATURA

Homogamous moth-flowers. Nectar secreted by the base of the ovary. Not indigenous, but sometimes found wild in Britain.

D. Stramonium (Thorn-apple).—The pure white flower has a strong smell of musk, which is specially strong at night; it opens about seven in the evening, and, according to Kerner, only lasts one day. In bad weather the corolla folds up and closes. The tube has a length of about 60 mm. The stamens are attached to the corolla by their centres, but the sides widen out, so that they touch one another, and leave five narrow tubes leading down to the honey. The stigma is about at the same height as the anthers. It is a North American plant, which has become widely introduced in the Old World.

HYOSCYAMUS

Homogamous humble bee flowers. Nectar secreted by the base of the ovary. The capsule is enclosed in the enlarged persistent calyx. The seeds are jerked out by the wind.

H. niger (Henbane).—The plant is hairy and viscid, with a nauseous smell. The corolla is dingy yellow with purplish veins. The stamens are hairy. The stigma rises above the anthers at first, but gradually the corolla-tube grows, bringing them up to the level of the stigma, and thus, in the absence of insect visits, facilitating self-fertilisation. According to Ludwig, the terminal flowers are cleistogamous. The seeds are numerous, compressed, dirty gray or pale brown, moderately deeply pitted all over, and divided into roundish or oblong areas by more or less conspicuously toothed ridges.

SOLANUM

There is no honey. The anthers, which are almost sessile, form a cone round the pistil, and each opens by a pore at the end. Fruit, a berry. We have two species : *S. Dulcamara*, a climber ; *S. nigrum*, erect.

S. Dulcamara (Bitter-sweet).—The flowers are blue, with violet veins and yellow anthers. The base is bluish black, and so shiny that it looks as if covered by a film of liquid. At the base of the corolla-lobes are greenish knobs which surround the flower in a ring, and also look as if covered with fluid, so that H. Müller calls them sham nectaries. Flies have, in fact, been seen exploring the flower, evidently expecting to find nectar. Delpino, however, refers the plant to the same type as Borage, and regards it as a bee flower. Hoffer has suggested that the juicy greenish knobs are pierced and sucked by the insects. The fruit is a berry, pulpy and red when ripe. The seeds are somewhat reniform, tapering to one end, white, cartilaginous, and smooth to the naked eye, but in reality very finely, though deeply, pitted and rugose. It is probable that birds scatter the seeds

while eating the juicy pulp. Moreover, if swallowed they would probably not be digested. The leaves have short appressed hairs, and are sometimes woolly.

S. nigrum.—This species on the Continent has the stems covered with short appressed hairs; with us they are generally glabrous or nearly so. The flowers close at night. They are small and white, sometimes with a blue spot at the end of each corolla-lobe.

ATROPA

Protogynous humble bee flowers. Nectar secreted by the base of the ovary.

A. Belladonna (Deadly Nightshade).—The corolla is a pale purplish blue. Knuth, however, describes it as brownish red above, dingy yellowish green below. As regards size and form, the flower is adapted to middle-sized humble bees. The nectar is protected by stiff hairs on the stamens. The pistil projects some distance beyond the anthers. When the flower opens the stigma is mature, but the anthers are still closed. The filaments are bent below the anthers. Finally, the latter burst open and become covered with pollen; the filaments also elongate somewhat, but still remain bent and overtopped by the stigma. The stem is finely glandular at the summit.

Below each leaf, and on the same side of the stem, is a smaller one. This seems to fill up the interval. The arrangement is peculiar, and is supposed to be due to displacement, the leaf-stalk being connate with the following shoot, and thus seeming to arise from it.

OROBANCHACEÆ

Parasitic plants, brown or purplish, never green. The parts of the flower in twos or fours; flowers sometimes with, sometimes without, nectar.

OROBANCHE (Broomrape)

We have seven species. The embryo shows no differentiation into root and stem, and has no cotyledons. It is a delicate simple filament, and the end which corresponds to the shoot remains in the seed. The other end works its way down into the earth in a spiral line. If it does not meet with a suitable host it soon dies, and indeed the vast majority perish. The seeds, however, are very numerous. If the rootlet finds a suitable host it adheres to it and thickens, the upper part perishing. The thickened part drives pegs into the root to which it has attached itself, sucks out sap, and forms a bud which grows into a short, thick, strong stem. The plant also throws out rootlets, which probably derive a certain amount of nourishment from the soil.

O. caryophyllacea.—The flowers are homogamous; sweet-smelling, and with nectar. The corolla-tube is somewhat bent, gradually widening to the middle; the underlip is trifid and thrown into folds, which so much diminish the width of the tube that insects are almost certain to touch the anthers and stigma. The latter projects beyond the stamens. The four anthers are grown together at the sides, and each chamber is provided with a long stiff horn directed downwards. If these are shaken by an insect the dry pulverulent pollen falls on its head or proboscis. The flower does not fertilise itself. The plant is parasitic on species of *Galium*, *Rubus*, etc.

O. elatior.—The flowers are scentless and without nectar. The stigma at first projects beyond the anthers, which, however, gradually grow up to it, so that self-fertilisation is possible. The stem is glandular-pubescent. The plant, which is parasitic on *Centaurea Scabiosa*, is rare, and found chiefly in the eastern counties.

O. ramosa.—Pale straw colour. The arrangement of the flower resembles that of *O. elatior*. According to Kirchner and Warnstorff, it is slightly protogynous.

The stem is covered with glandular hairs. The plant is parasitic on Hemp, and is occasionally found in Britain, but not native.

LATHRÆA

Parasitic on the roots of trees. Protogynous humble bee flowers. Nectar secreted by a gland on the under side of the ovary.

L. Squamaria (Toothwort).—The plant is flesh-coloured or slightly bluish, with red or purple streaks. The flowering stems and the rhizome bear scales, those underground thick and fleshy. The flowers are in a one-sided spike, which is at first bent and does not become straight until the uppermost flower is ready to open. The stigma then projects beyond the flower-tube, within which lie the still unripe anthers, so that, as the honey is abundant and humble bees assiduously visit the flowers, cross-fertilisation is effectively provided for. For a short time after the



Fig. 192.



Fig. 193.

FIG. 192.—Piece of an underground shoot of *Lathræa*. $\times 2$.

FIG. 193.—Longitudinal section through the same.

anthers open the stigma remains fresh, yellow, and capable of impregnation. Soon, however, it dries and shrivels up. The dry pollen falls from the anthers, but is supported by a thick brush of hairs. If, however, the short points of the anthers are pressed aside by the proboscis of the bee the pollen drops out on to the insect's head. In the meanwhile the corolla-tube lengthens and eventually covers the stigma. The stamens also elongate, and project at last beyond the tube; the dry pollen is carried away by the wind, and as the plants generally grow in patches, some must occasionally reach the stigmas of younger flowers. The underground scales resemble those on the stem in outline. At first sight they seem to be squarely mounted on a short

foot-stalk. In reality they are folded back on themselves, and what seems to be the lower is really part of the upper surface, so that the true lower surface is very small and not visible in the usual positions of the leaf (Figs. 192-194). In the thickness of the leaf are from 5 to 13, generally about 10 chambers, which have irregularly undulating outlines. The interior of the

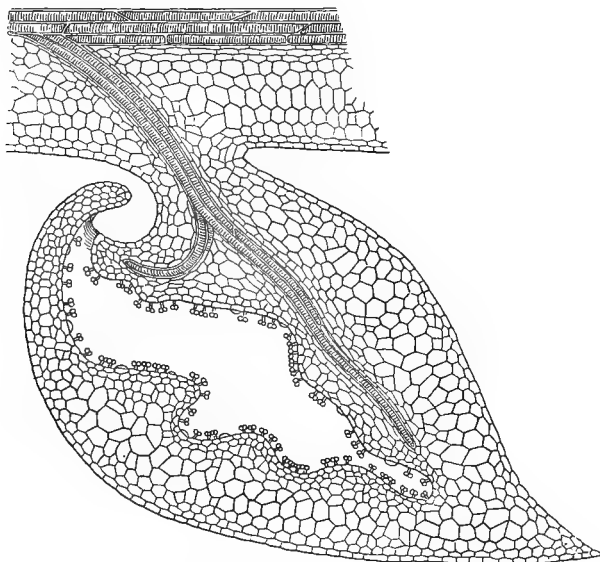


FIG. 194.—Longitudinal section through a leaf of *Lathrea*. $\times 60$.

cavities bears two forms of glands (Fig. 195). The first are in the form of a little head, consisting of two cells on a short stalk. In the other the cells of the head form a flattened dome. Both kinds of cells emit delicate protoplasmic filaments exactly like those of *Rhizopoda* (Fig. 196). When any small animals penetrate into the chambers the projecting cells begin to emit filaments which entangle and capture them, and by degrees suck out all that can be digested, leaving only the claws, hairs, and other hard parts. Several naturalists have

expressed their surprise that so many animalcules should enter these traps and those of *Utricularia*, etc., but we

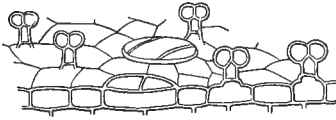


FIG. 195.—Piece of the wall of a cavity.
× 200.



FIG. 196.—Plasmic threads radiating from
the cells of the little heads. × 540.

must remember that they press into any small crevice in search of food and shelter.¹

SCROPHULARIACEÆ

The prevailing colours are yellow and red. In many species they are different in different localities. The flowers generally secrete nectar at the base of the ovary, or in *Pentstemon* at the base of the stamens. Most of the *Verbascums*, however, are without nectar. Some species have opposite and some alternate leaves. The latter have round stems. Among the former the stems of some species of *Scrophularia*, *Rhinanthus*, *Melampyrum*, *Veronica*, and *Mimulus* have quadrangular stems.

VERBASCUM (Mullein)

The flowers are yellow, white, or (rarely) purple. They are in some species rendered more conspicuous by the brightly coloured stamens. Most species have a thick covering of woolly, sometimes branched hairs. These probably serve three purposes. Firstly, they protect the plant from grazing quadrupeds: they would be unpleasant in the mouth, and probably injurious in the stomach. Secondly, they prevent the access of creeping insects; and thirdly, they prevent too rapid transpiration.

¹ See also Præger, *Open-air Studies in Botany*, p. 32.

We have six species. *V. Thapsus* may be recognised at once by its decurrent leaves; two are nearly glabrous or slightly glandular-hairy—*V. Blattaria*, with pedicels mostly longer, *V. virgatum* shorter, than the calyx.



FIG. 197.—*Verbascum nigrum*.

Of the other three, *V. nigrum* has the leaves cordate, the others narrow at the base; of these, *V. Lychnitis* has white flowers; *V. pulverulentum*, yellow.

Crosses are not infrequent in this genus. Gaertner found that taking the produce of *V. Lychnitis* with pollen of its own species as 100 seeds, when fertilised with pollen from *V. phæniceum* it produced 90 seeds, with that of *V. nigrum* 63, of *V. Blattaria* 62. On the other hand, the ovary is quite sterile to pollen of the same flower.¹

Kerner calls attention to the beautiful manner in which the rain is collected and carried down to the roots. The upper part of the leaves hangs downwards, and consequently the rain drops off at the tip. But as the leaves are shorter the higher their position on the stem, the drops fall on that part of a lower leaf which shelves towards the stem. Thus all the rain-water received by the plant is eventually conducted to the tap-root.

V. Thapsus.—Two of the stamens are longer than the other three, which have hairy filaments. The leaves have stomata on both sides, and a hairy covering which it is impossible to wet. The whole plant is tomentose.

V. Blattaria.—The flowers are homogamous, generally yellow, but sometimes white. According to Kerner the corolla secretes nectar, but this is denied by Kirchner. The pistil projects beyond the anthers. Eventually the corolla drops off and slips down the

¹ Darwin, *Forms of Flowers*.

pistil, hanging to it, however, for some time. As the stamens are inserted on the corolla, the result of this is that the anthers are almost sure to touch the stigma, and thus, in the absence of insect visits, to fertilise the flower. The leaves are glabrous and shining.

V. nigrum.—The filaments are clothed with bright purple hairs. The flowers are homogamous; they secrete nectar, but very sparingly. The uppermost stamen is the shortest, the two lowest are the longest. The anthers open outwards. The pistil is somewhat shorter than the lowest stamens, but generally bent a little downwards, so that an insect visiting the flower would generally touch it first. According to Gaertner, confirmed by Darwin, the plant is absolutely sterile to its own pollen. The leaves are pubescent above, tomentose below. The seeds are brown, subquadrate, obtuse at both ends, with wavy longitudinal and transverse ridges, between which are deep oblong pits. They are light, and readily adhere to any surface with which they come into contact.

V. Lychnitis.—The flowers are homogamous, white, or sometimes pale yellow, without nectar. The stamens are clothed with yellowish, somewhat clubbed hairs. The pistil projects rather beyond the stamens. This species is also sterile to its own pollen. The leaves are pubescent above, shortly tomentose below.

ANTIRRHINUM (Snapdragon)

Homogamous bee and humble bee flowers. The upper and under lip close the corolla-tube, but the latter opens by a spring. Nectar is secreted by the base of the ovary. The stamens lie along the upper lip; they are in pairs, the anthers of the two longer ones lying in front of the others. The anthers deposit their pollen on the back of the bee. We have two species—*A. majus* is perennial, with large flowers; *A. Orontium* annual, with small ones.

A. majus.—This is especially a humble bee flower. The corolla is purple, rarely white, with yellow gums.

The lower lip has two projections which fit into hollows in the upper lip. It completely closes the entrance, and excludes small insects. Humble bees, however, are able to press it down and creep into the corolla, which they nearly fill, so that their back presses against the open anthers. *Bombus terrestris*, however, and *B. lucorum* bite through the base of the corolla, and thus rob the flower of its nectar. The hive bee, according to Douglas,¹ also pierces the corolla for the nectar; but if only in search of pollen, presses down the door and collects pollen without actually entering. He does not suggest any reason, but is it not possible that if she once entered she might be unable to get out again? According to Darwin, the red form is self-sterile, the white variety less so. The flowers are sometimes "peloric," that is, depart from the characteristic irregular form, becoming regular. The seeds are black or dark brown, oblong ovoid, with high longitudinal ridges. The plant is glabrous, but with the upper part of the stem pubescent and slightly glandular. It is not a native, but occurs as an alien on old walls.

A. Orontium.—The flowers are much smaller, red or (seldom) white. The arrangement of the flower resembles that of *A. majus*. They are visited by the hive bee as well as by humble bees. The plant is nearly glabrous, or with long spreading glandular hairs.

LINARIA

This genus differs from *Antirrhinum* chiefly in having the corolla produced into a spur. There are seven British species. The effect of the habit of the plant on the form of the leaf is well shown in this genus. Five species are erect, with upright linear leaves; three trailing, with ovate, orbicular, or ivy-shaped leaves.

L. vulgaris (Toadflax).—The flowers are large in a terminal panicle, yellow with an orange palate. The tight closing of the lips and the length of the spur debar all insects excepting bees with a long proboscis from

¹ *Entom. Month. Mag.* Nov. 1886.

access to the honey. For such insects, however, the flower is admirably arranged. When they have opened the door they find on each side of the lower lip a band or ribbon of close orange-coloured hairs, between which is a clear space leading directly to the honey. The fruit is a capsule. The cells of the outer wall are thickened, and contract more than the inner layer. The result is that the walls curve outwards, thus opening the upper end of the capsule. The seeds are jerked out by the wind; they are brown or black, somewhat rounded in form, with a notch at the base, laterally compressed, winged, and finely reticulate. The plant is glabrous, pubescent and glandular above. In some cases there are traces of the posterior stamen.

L. minor.—The arrangement is much the same as in the last species, but the parts are smaller, and no doubt adapted to smaller insects. They are not, however, much visited.

L. supina has glaucous and glabrous yellow flowers, but the plant is pubescent-glandular above.

L. spuria has a trailing stem, with leaves orbicular or nearly so. The upper lip is purplish brown, the lower lip yellowish. Some of the lower flowers are cleistogamous, and these are said to be more numerous in shade. The stem has two sorts of hairs, long and soft, and short and glandular.

L. Cymbalaria also has the stem trailing. The leaves are ivy-shaped; the flowers lilac with a yellowish palate. They stand up in the sunlight, but when they fade the flower-stalk turns down and inserts the growing seed-pod, if possible, into some hole or crevice. The seeds are globular and longitudinally ridged. The plant is quite glabrous. Like *Antirrhinum majus*, it is not a native, but an alien found on old walls.

L. Elatine.—A corn-field weed, the short stem bearing long prostrate slender branches; hairy as in *L. spuria*.

L. repens.—A rare plant, but occasionally found in waste places. It is quite glabrous, and is a perennial with many slender creeping stems.

SCROPHULARIA

Protogynous wasp flowers. Nectar secreted by a ring at the base of the open corolla. Cleistogamous flowers also occur. There are four British species. Two have the leaves glabrous; in two they are downy. Of the former, *S. aquatica* has the stem four-winged; in *S. nodosa* it is four-angled, but not winged. Of the downy-leaved species, *S. Scorodonia* has purple flowers, *S. vernalis* yellow. One of the stamens is barren, and usually forms a scale under the upper lip. The reason or use of this peculiar arrangement is not known.

S. nodosa (Figwort).—The flowers are small (Fig. 198) and generally reddish brown, which seems to be a favourite colour with wasps. The tube of the corolla is



FIG. 198.—*Scrophularia nodosa*.

a pale greenish purple. The flower has a scent, pleasant no doubt to wasps, but disagreeable to us. In the first stage of the flower, which lasts two days, the stigma projects, and the anthers are not ripe; in the second, which also lasts two days, they open and expose the pollen. The stigma and anthers lie on the lower side of the flower, and the upper (fifth) stamen being useless, the anther is not developed, but forms a widened end to the stamen. This, however, is so well formed that I cannot help suspecting it has some function which has not yet been observed. The style, after fertilisation, gradually curves down.¹ In bee flowers the lower blossoms generally open first, and bees begin below and work their way up. Wasps, on the contrary, begin at the top. The flowers open irregularly, but the general result is that the younger flowers are fertilised with

¹ T. W. Fulton "On *Scrophularia*," *Trans. Bot. Soc. Edinb.* xvi. (1886).

pollen brought from older flowers of another stock. In America also, wasps are the special visitors of this species. There appear, however, to be remarkable differences. Knuth, like Sprengel and other observers, found the flowers in Holstein to be, at first, specially attractive to wasps. Later in the season, however, they were neglected by wasps, and much visited by bees. Robertson, in Illinois, confirms this, but adds that the wasps gradually returned. It may be possible that these differences might be explained if we knew what other plants were in flower at the same time. Knuth remarks that the brown of the corolla and the yellow anthers closely reproduce the colouring of the wasps. *Epipactis latifolia*, which is also a dingy purple, is almost the only other British plant which is visited by wasps. The plant is glabrous.

S. aquatica.—The flower agrees in the main points with that of *S. nodosa*. The stem is distinctly winged, and the plant is glabrous.

S. Scorodonia, on the other hand, is pubescent, or sometimes hairy. It is a native of the West of England and Kerry.

S. vernalis.—A bee flower with a sweet smell. There is no barren stamen. The anthers all project beyond the corolla-tube. The plant is glandular-pubescent. It is a rare plant, occasionally found in waste places, but is not native.

MIMULUS

Homogamous bee flowers with a sensitive stigma.

M. luteus.—A native of North America, now thoroughly naturalised in Britain. The pistil lies over the stamens, and the bee first touches the stigma. This has two sensitive lips which close over the pollen like a forceps. If none is enclosed they reopen, ready for another chance.

According to Edgeworth, *M. moschatus* has two kinds of pollen. The seeds are brown, very minute, biconvex and oblong or elliptical.

LIMOSELLA

A small floating annual.

L. aquatica.—According to Kerner, if the small pink flowers are submerged they become cleistogamous.

DIGITALIS

(Foxglove, *i.e.* Folksglove or Fairy's-glove)

Protandrous humble bee flowers, with nectar secreted by a ring surrounding the base of the ovary.

D. purpurea.—Beautiful purple flowers in, as Bentham well says, “a long stately raceme.” The flowers hang downwards, and are thus protected against rain. The posterior sepal is small, a step towards its complete suppression in the next genus (*Veronica*). The interior of the corolla is lined with hairs, which Kirchner regards as intended to prevent the entrance of small creeping insects. Knuth doubts this, and suggests that they perhaps rather serve to give a foothold to the friendly visitors. May they not be useful for both purposes? The size of the flower is well adapted to that of humble bees. The anthers and stigma are not spread out round the circumference of the corolla, but are arranged together on the upper side. The fifth stigma, which was fully developed and useful in *Verbascum*, and has lost its anther in some species of *Scrophularia*, in this and the following genera of the family has entirely disappeared. The pistil lies along the centre of the upper lip between the anthers, which are in two pairs, one in front of the other, so that they must be touched by the back of an insect entering the flower. The anthers of the two longer stamens open first, then those of the shorter ones, after which the two stigma lobes open. If humble bees are abundant the pollen may be removed before the stigmas are ripe; if any pollen remains the flower might easily fertilise itself. According to Darwin, however, it is self-sterile. The anthers (Figs. 199-201) are at first horizontal, but as they ripen

they become vertical, so as to be more closely in the centre of the flower. According to Kerner the life of the flower lasts six days. Ludwig found on some of the plants examined by him small female flowers with rudimentary stamens. The capsule is upright. The reddish brown seeds are thrown out by the wind; they are small, numerous, oblong, and variously compressed. The plant is covered with fine spreading hairs. The fruit normally splits along the septa. The lignified layer of the inner epidermis is composed of horizontal fibres, and the sub-epidermal layer of isodiametric cells, which contract more than those of the epidermis, and thus open the fruit.

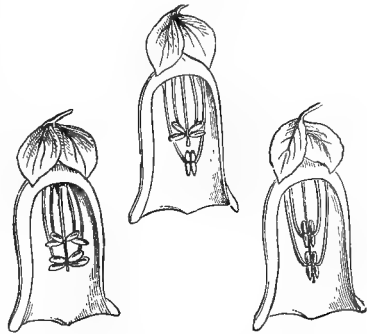


Fig. 199. Fig. 200. Fig. 201,

FIG. 199.—*Digitalis purpurea*. Section of flower, showing the anthers unripe and horizontal.

FIG. 200.—The same, more advanced. The upper anthers vertical, the lower as before.

FIG. 201.—The same, still more advanced. All the anthers ripe and vertical.

VERONICA

Flowers generally blue or white, with nectar, specially adapted to flies, which gather up, as it were, the two stamens under the body to act as a support while they sip the honey. Other stamens would, under the circumstances, only be in the way. The calyx is 5 or 4 cleft, the lobe representing the posterior lobe being suppressed. The corolla is deeply 4-cleft, two of the lobes being united. There are sixteen British species. The fruit is a capsule. The seeds fall into two series. In some species they are smooth, flattened, and winged. This is the case, as a rule, in species living in or close to water. To this series belong *V. Beccabunga*, *V. Anagallis*, *V. scutellata*, and among land species *V. serpyllifolia*, *V. Chamædryas*, *V. montana*, *V. officinalis*,

V. arvensis, and *V. triphyllos*. In the second the seeds are hollowed out on the ventral side and wrinkled, as in *V. Buxbaumii*, *V. agrestis*, *V. polita*, and *V. hederæfolia*.

V. Chamædrys.—This species is remarkable for having the hairs collected in two rows running down the stem from between each pair of leaves. The flowers are homogamous and adapted to flies. They are blue, or sometimes smaller and pinkish, with darker lines, and are collected into showy racemes. The nectar is protected by hairs. The pistil projects straight from the flower, while the two stamens diverge on each side. The lower lobe of the corolla forms a convenient alighting stage for insects, which must inevitably touch the stigma. The fly clasps the stamens and presses



FIG. 202.—*Veronica Chamædrys*.

the anthers against its body, dusting itself with pollen, some of which it would probably deposit on the stigma of the next flower visited. The stamens become thinner towards the base, and thus yield more easily to the pressure of the insect. According to Kerner, the flowers open from 5 to 6 A.M. and close from 5 to 6 P.M.

V. montana.—The arrangement resembles that of *V. Chamædrys*. The plant is softly hairy.

V. officinalis.—The flowers are small, nearly sessile, blue with darker lines, or sometimes pale pink. The stamens are even thinner at the base than in the preceding species. The general arrangement is as in *V. Chamædrys*. Stapley found some of the flowers protandrous. On the other hand, Kirchner found those near Stuttgart distinctly protogynous, and Warnstorff says the same of those at Ruppin. The plant is hairy. It seems probable that some plants have entire leaves, in order to facilitate the removal of rain and dew; while others have the edges toothed when the object is to retain moisture. The teeth seem to be an advantage

in snowy districts, as they serve to retain small reserves of comparatively warm air; while the absence of teeth is an advantage in rainy districts, because the wet runs more quickly off a smooth edge. Jungner tested¹ the effect of this form on leaves of *V. officinalis*. In this species the same plant has some entire leaves, some with toothed edges. He chose some smooth and some toothed, and surrounded them by a freezing mixture. The former froze soonest, and melted after the toothed ones.

V. serpyllifolia.—The flowers are small, pale blue or white, sometimes protandrous, at others homogamous or protogynous. The leaves are glabrous, the stem finely pubescent.

V. arvensis.—A variable plant; covered with jointed hairs, arranged on the lower part of the stem in two rows.

V. agrestis has a pale blue or white corolla, and is pubescent, as is also **V. hederæfolia**.

V. spicata.—The flowers are protogynous, blue, or sometimes pale pink, in a dense terminal spike. They open from below, and the undermost are in fruit while the upper ones are still in the bud, so that a spike may show in descending order—buds, flowers in the female state, in the male state, flowers faded, and at the base young fruit. H. Müller, however, found some plants protogynous, others protandrous. He also found some in which the pistil was rudimentary. The plant is pubescent, and generally slightly glandular.

V. saxatilis has homogamous flowers, rather large, and bright blue.

V. alpina, a rare plant, found in the highest Scotch Alps, has flowers homogamous or slightly protogynous, small and blue. The plant is glandular-pubescent in the upper part.

V. scutellata, not a very common plant, found in bogs and on edges of ditches, is glabrous or glandular-pubescent.

V. Buxbaumii, a field species, with large bright-blue flowers, is pubescent, but not glandular.

¹ "Klima und Blatt in der Regio Alpina," *Flora*, lxxix (1894).

V. verna has a small deep-blue corolla, with darker lines, and small stamens not narrowed at the base. The flowers are homogamous. The stem is hairy, and glandular above.

V. Beccabunga (Brooklime) is a glabrous succulent plant, found on margins of brooks and ditches. The flowers are protogynous, and a deep sky-blue. The specific name comes from an old German word meaning "brook-loving."

V. Anagallis is also a glabrous succulent plant, found in watery places. The sepals are glabrous or slightly glandular. The small corolla is pale lilac or white.

We now come to a series of parasitic or semi-parasitic genera.

RHINANTHUS (Yellow Rattle)

This is a semi-parasitic plant, which attaches itself by means of suckers to the roots of grasses. The suckers are comparatively large, and often surround more than half of the root attacked. They are homogamous, humble bee, or in some cases butterfly, flowers. The general arrangement of the flower agrees with that of *Euphrasia*, but is on a larger scale. The calyx is swollen, not so much, in Knuth's opinion, to protect the flower from being bitten into by humble bees, as to give the wind more purchase, so that the winged seeds may be thrown out with more force.

R. Crista-galli.—The corolla is yellow, with beautiful violet teeth, and the tube 9-10 mm. in length. Each anther is opposite the corresponding one on the other side of the flower, and the two are connected by matted hairs, thus enclosing a space into which the pollen is shed. The filaments of the stamens are waved, leaving a space between them through which the bee thrusts its proboscis, and thus separating the anthers sets free the pollen. The stigma projects beyond the corolla. According to H. Müller, the Alpine form *R. hirsutus* is adapted both to butterflies and humble bees. Close to

the extremity of the flower is a small orifice, suited to the narrow proboscis of a butterfly, and nearer the middle a second and larger one, for that of a humble bee. The corolla gradually elongates, and thus carries the anthers up to the stigma, so that in the absence of insect visits the flower fertilises itself. This is more especially the case in certain flowers which are smaller than the others, thus presenting a first stage in the direction of cleistogamy. The stem is quadrangular, and bears narrow opposite leaves. The capsule included in the bladderly calyx-tube suggests a rattle, whence the popular name of the plant—Yellow Rattle.

BARTSIA

Semi-parasitic herbs. Flowers homogamous or protogynous, adapted to humble bees, and containing nectar secreted by the under part of the ovary. There are three British species: *B. viscosa*, with yellow flowers; *B. Odontites*, with flowers in paniced spikes, and pink; and *B. alpina*, with dull purple flowers in simple short spikes.

B. alpina.—The flowers are slightly protogynous. The mode of fertilisation in some respects resembles that of *Melampyrum pratense*, but the position of the stigma and anthers that of *Rhinanthus Crista-galli*. When the flower opens the corolla-tube has a length of 12-16 mm., and the pistil projects beyond it. Gradually the tube elongates to 19-20 mm., while the pistil remains almost stationary, so that the anthers are carried close to the stigma. After the stigma has shrivelled up the dry pollen may still be carried by the wind in small clouds, and may serve to fertilise another flower. This species not only derives some nourishment from the earth and some parasitically from other plants, but it also puts the animal kingdom under contribution and is insectivorous. The subterranean winter buds bear scales which leave recesses between them (Figs. 203, 204). These bear glands of two kinds (Fig. 205) somewhat resembling those of *Lathræa* (p. 303), and probably with the same

function. It is a glandular-pubescent sub-Alpine plant, found in the North of England and Scotland. The

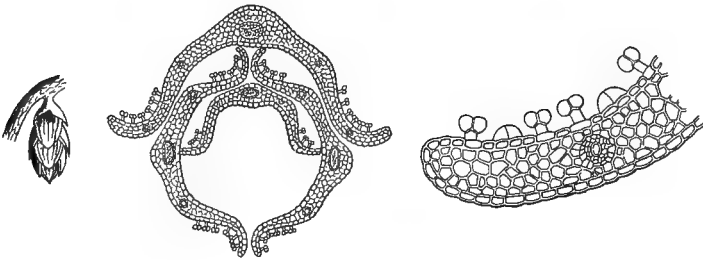


Fig. 203.

Fig. 204.

Fig. 205.

FIG. 203.—*Bartsia alpina*. Subterranean bud. Nat. size.
 FIG. 204.—Cross section through part of this bud. $\times 60$.
 FIG. 205.—The margin of a bud scale in section. $\times 200$.

leaves are typical of plants growing in cold, wet regions (see *Cerastium alpinum*, p. 28).

B. Odontites.—The flower forms a tube 4-5 mm. long, at the base of which is the honey, while the entrance is protected against rain by the four hairy anthers. These lie close together; but immediately below them the filaments of the stamens separate, so as to leave a space (Fig. 206, *e*) through which bees can insert their proboscis and thus reach the honey. In doing so they naturally dust themselves with pollen, some of which

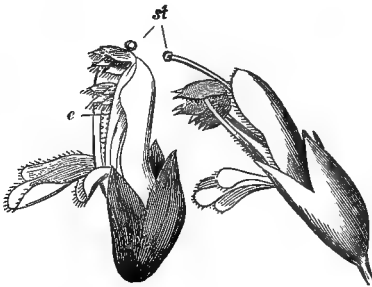


Fig. 206.

Fig. 207.

FIG. 206.—*Bartsia Odontites*. Flower with short pistil.

FIG. 207.—Flower with long pistil.

e, entrance to flower; *st*, stigma.

they transfer to the stigma (Figs. 206, 207, *st*) of the next flower they may visit. In warm and sunny places, where insect visits are numerous, the stigma projects well above the anthers (Fig. 207); in cold and shaded places, where insects are comparatively few, it scarcely projects beyond the anthers.

MELAMPYRUM (Cow-wheat)

Flowers unsymmetrical, with nectar secreted by a gland at one side of the ovary. Semi-parasitic like *Bartsia* and *Rhinanthus*. The suckers resemble those of *Rhinanthus*, with which it also agrees in the general arrangement of the flower. The conspicuousness of the flowers is in some species enhanced by the presence of coloured bracts. There are four British species. Two have yellow flowers; one, *M. pratense*, with the upper bracts toothed at the base, while in the other, *M. sylvaticum*, they are entire. The other two species have yellow flowers variegated with purple; one, *M. cristatum*, has the bracts finely toothed, while in *M. arvense* they have long slender teeth.

M. pratense.—The corolla-tube has a length of 14-15 mm., but as humble bees can press their head a short way into the entrance a proboscis 10-11 mm. long is sufficient to reach the nectar. This, however, excludes the hive bee and *Bombus terrestris*, which often bite through the corolla and thus rob the flower of its nectar. The flowers are horizontal, and the stigma hangs over the entrance. Inside the tube the anthers touch at their edges and thus form a pollen-box. At their lower ends are projecting teeth, which are pressed on one side by the bee, thus unlocking the box and setting free the pollen. In the absence of insects the filaments gradually become flaccid, in consequence of which the anthers separate, and as in the meanwhile the style has bent downwards, some of the pollen generally drops on the stigma. In most flowers the secretion of nectar ceases when the flower fades. *Melampyrum*, however, is an exception, and the reason is interesting. The result of the continued secretion of nectar is that the plants are visited by ants (*Formica fusca*). The seeds of *Melampyrum* (Fig. 208) curiously mimic the chrysalis of a common



FIG. 208.—1, Seed of *Melampyrum*; 2, chrysalis of *Formica fusca*.

ant (*F. fusca*). They resemble it in size and colour and in the possession of a black spot at one end. As a rule, our English ants take no notice of seeds. But, as I have proved by actual experiment, they take up and carry off the seeds of *Melampyrum*, mistaking them apparently for the chrysalises, which they so much resemble.¹ The stem is quadrangular, pubescent, or nearly glabrous; the leaves, as throughout the genus, being narrow and opposite. It bears two rows of hairs; the lateral horizontal branches have one row on the lower side.

M. arvense.—The general arrangement resembles that of *M. pratense*, but the tube of the corolla is bent in a manner which makes it peculiarly convenient for the proboscis of a humble bee. The lower lip is also slightly bent, so that, as in *Antirrhinum*, it closes the orifice and excludes small creeping insects. The plant is covered with short stiff hairs.

M. cristatum.—This species differs in colour in different districts. In the Southern Tyrol the bracts are pale yellow; in Lower Austria and Hungary, red. The plant is pubescent, especially near the summit. It is a rare British plant, occurring in fields and copses in our eastern counties.

M. sylvaticum is also rare, occurring in sub-Alpine woods in the North of England and Scotland. The leaves are glabrous or finely puberulent.

PEDICULARIS (Lousewort)

Semi-parasitic annual or perennial herbs with homogamous, or rarely protogynous, flowers. Nectar secreted by a ridge at the base of the ovary. The general arrangement of the flowers is as in the preceding genera. There are two British species. *P. palustris* is erect, and the calyx has 2 broad jagged lobes. *P. sylvatica* is prostrate, and the calyx has 4 or 5 lobes or teeth.

¹ *Ants, Bees, and Wasps.* Lundström (*Pflanzen-Biol. Studien*) has independently made the same suggestion.

P. sylvatica.—This curious flower is unsymmetrical and compressed laterally. The corolla-tube is 10-14 mm. in length. The under lip falls from right to left, so that the right half is 2-8 mm. higher than the left. The tube is contracted about 1 mm. below the opening and then expands again, so that it consists of a very short and a longer lower part connected by a very narrow passage. The stigma projects slightly, as usual. The anthers are arranged so as to form a pollen-box, and the lower edges are fringed with long hairs which direct the pollen on to the bee. The edges of the upper lip of the corolla are rolled back, and the inner edge is armed with projecting teeth. The plant is glabrous.

P. palustris.—The corolla-tube is rather shorter than in the last species, and the anthers have not the lower fringe of long hairs, which H. Müller suggests are not in this case required, because the anthers are so close to the bee's head that the pollen needs no guidance. The plant is an annual, and glabrous or sparingly hairy.

EUPHRASIA (Eye-bright)

This genus is semi-parasitic on the roots of grasses. The suckers are tiny little nodules which only just penetrate into the root of the host. Euphrasia is an annual, and Kerner makes the interesting suggestion¹ that the useful substances existing in the green leaves of the Eye-bright may, before it withers, be transferred to the host plant. If so, then it would be unjust to Euphrasia to call it a parasite, for the two plants would be mutually beneficial, as occurs in other cases (see p. 217). Dichogamous, generally protogynous bee flowers, with concealed nectar, secreted by the lower part of the ovary. This is one of the genera with reference to the species of which there has been much difference of opinion. Bentham and Hooker consider that there is probably but one in the northern hemisphere. Wettstein, in a recent memoir,² makes about fifty, fourteen

¹ *Nat. Hist. of Plants*, vol. i.

² *Monographie der Gattung Euphrasia*. Leipzig, 1896.

of which, according to Mr. Frederick Townsend, occur in Britain.¹ No doubt the plants vary wonderfully in the size and form of the leaves, in the size, colour, and arrangement of the flowers, and if one district or country is considered alone they may be divided into well-marked forms. I have, however, examined the plant in France and Switzerland as well as in England, and believe that if we take a sufficiently large area, such as Western Europe, intermediate forms can be found between all the varieties, so that I cannot but accept, at any rate provisionally, the view of the two great English botanists whom I have quoted.

E. officinalis.—H. Müller distinguishes two principal forms: one with large flowers adapted for cross-fertilisation, one with smaller ones for spontaneous self-fertilisation.

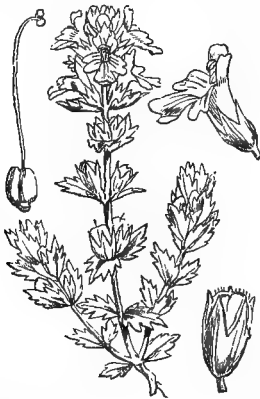


FIG. 209.—*Euphrasia officinalis*. Shoot, with flower, pistil, and fruit; enlarged.

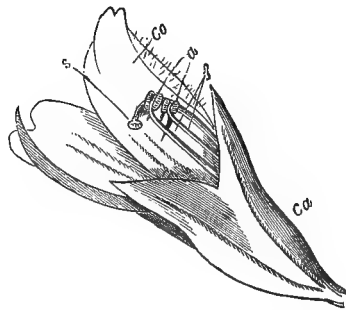


FIG. 210.—*Euphrasia officinalis*. Partial section of flower, enlarged. *a*, anthers; *ca*, calyx, uncut; *co*, corolla; *f*, filaments of stamens; *s*, stigma.

tion. The upper lip (Fig. 210) protects the anthers and nectar from rain. The ripe stigma projects from the flower even before it opens. The corolla gradually elongates so as eventually to reach the stigma, thus bringing the anthers close to it. In this respect, how-

¹ Monograph of the British species of *Euphrasia*, *Journal of Botany*, 1897. See also Babington, *Manual of British Botany*, ed. ix., H. and J. Groves, 1904.

ever, there are several differences, and Schulz describes no less than seven forms of the flower. In any case, however, when the anthers first open they are behind the stigma. The stamens are 4 in number, so that there are 8 anthers (Fig. 210). The lower chambers of the upper or outer anthers coalesce with the upper chambers of the inner or lower anthers, and the two upper are firmly connected. The lower surface of each anther has a stiff pointed process. The two lower points are distinctly longer than the upper ones and project into the mouth of the flower, while the upper ones end in a brush of hairs which prevent the pollen from being scattered at the sides, so that they are sure to be touched by the bee, which thus dislocates them, the result of which is that some of the pollen drops on to it. The plant is pubescent, and more or less glandular, especially near the summit.

LABIATÆ

Herbs, or rarely shrubs, with quadrangular stems and opposite leaves.¹ Flowers generally protandrous. Corolla tubular, generally forming two lips. Stamens, probably for the reason already suggested (see p. 313), 4 or sometimes 2. Nectar secreted at the base of the ovary. Fruit enclosed in the persistent calyx, separating into 4 one-seeded, seed-like nuts. The upper lip of the corolla protects the anthers and stigma, and the lower lip forms a convenient alighting stage for insects. The corolla-tube often assumes the curve convenient for the proboscis of a humble bee. The flowers often vary in size, sometimes even on the same plant. Sometimes there are two distinct forms, sometimes two

¹ I have attempted to show (Brit. Assoc. Cambridge, 1904) that it is an advantage for herbs with opposite leaves to have quadrangular stems, and that the two generally go together.

extremes with intermediate gradations. Many species have female as well as complete flowers, generally on special, but sometimes, though rarely, on the same plants. The female flowers are always smaller than the others, though they vary considerably in size. The nectar is generally protected from rain by hairs. The capsules are generally upright, and the nutlets are jerked out by the wind or by passing animals. In a few genera the flower is nearly regular.

MENTHA (Mint)

Complete flowers, protandrous, generally less numerous than the smaller female ones. Some species dimorphous. Calyx regular or slightly two-lipped. Corolla nearly regular. Stamens equal and erect.

M. arvensis.—The corolla is lined with hairs which protect the nectar; the leaves are glabrous or hairy.

M. aquatica includes a number of varieties and forms, some of which are more or less glabrous, others more or less hairy.

M. rotundifolia has cut leaves, hairy above, tomentose below, with branched hairs.

M. Pulegium (Pennyroyal).—With us it is nearly glabrous, but in the hot dry regions in the South of Europe it develops a thick covering of hair as a protection against too rapid transpiration.

THYMUS (Thyme)

In this genus the corolla is two-lipped, but not very markedly so.

T. Serpyllum.—The stamens and pistil project freely from the flower. Besides the complete there are small female flowers. In these, indeed, stamens occur, but without fertile anthers. The filaments vary greatly in length. Delpino found the plants near Florence trimorphic—hermaphrodite, female, and male. Darwin, however, in spite of careful search, never found any male flowers in this country. The leaves are flat, ciliated at

the base, sometimes glabrous, sometimes hairy; the stems bear reflexed hairs.

ORIGANUM (Marjoram)

Protandrous. Besides the complete there are often small female flowers.

O. vulgare.—The corolla-tube of the complete flowers is 7 mm. long, of the female 4-5 mm. long. The small female flowers open some eight days before the others. The leaves are hairy underneath; the stem bears soft hairs.

LAMIUM (Dead-nettle)

We now come to the typical Labiates in which the corolla is distinctly two-lipped. I take *Lamium* as a type, because it is very characteristic, very common, and known to every one. They are red, white, or yellow homogamous bee or humble bee flowers, with nectar secreted at the base of the ovary, and protected by a ring of hairs round the corolla. We have five species. Two are annual: *L. amplexicaule*, with the bracts sessile and orbicular; while in *L. purpureum* they are stalked and ovate. Of the three perennial species, one, *L. maculatum*, has red flowers; one, *L. Galeobdolon*, yellow; and the third, *L. album*, white.

L. album (Fig. 211).—In few flowers is the use of the various arrangements more clearly and beautifully shown. The honey occupies the lower contracted portion of the tube, and is protected from the rain by the arched upper lip and by a rim of hairs. Above the narrower lower portion the tube expands, and throws out a broad lip (Fig. 213, *m*), which serves as an alighting place for large bees, while the length of the narrow tube prevents the smaller species from obtaining access to the honey, which would be injurious to the flower, as it would remove the source of attraction for the bees, without effecting the object in view. At the base of the tube, moreover, at the point marked *ca* (Fig. 213), there is a ring of hairs which prevents

small insects from creeping down the tube and so getting at the honey. *Lamium*, in fact, like so many of our other wild flowers, is especially adapted for humble bees. They alight on the lower lip, which projects at the side, so as to afford them a leverage, by means of which they may press the proboscis down the tube to the honey; while, on the other hand, the arched upper lip, in its size, form, and position, is admirably adapted not only as a protection against rain,



Fig. 211.



Fig. 212.

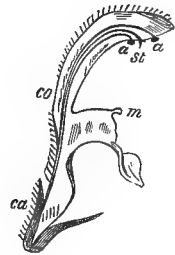


Fig. 213.

FIG. 211.—*Lamium album*. White Dead-nettle.

FIG. 212.—Flower magnified.

FIG. 213.—Section of flower magnified. *a a*, anthers; *ca*, calyx; *co*, corolla; *m*, lower lip of corolla; *st*, stigmas.

but also to prevent the anthers (*a a*) and pistil (*st*) from yielding too easily to the pressure of the insect, and thus to ensure that it should press the pollen, which it has brought from other flowers, against the pistil. The stamens do not form a ring round the pistil, as is so usual. On the contrary, one stamen is absent or rudimentary, while the other four lie along the outer arch of the flower, on each side of the pistil. They are not of equal length, but one pair is shorter than the other; the inner pair in some species, the outer pair in others, being the longest. Now, why is this? Probably, as Dr.

Ogle has suggested, because if the anthers had lain side by side they would have formed a too broad surface, and the pollen would have adhered to parts of the bee's head which do not come in contact with the stigma, and would therefore have been wasted; perhaps also partly, as he suggests, because it would have been deposited on the eyes of the bees, and might have so greatly inconvenienced them as to deter them from visiting the flower. Dr. Ogle's opinion is strengthened by the fact that there are some species, as, for instance, the Foxglove, in which, as shown in Figs. 199-201, the anthers are transverse when immature, but become longitudinal as they ripen.

But to return to the Dead-nettle. From the position of the stigma, which hangs down below the anthers (Fig. 213, *st*), the bee comes in contact with the former before touching the latter, and consequently generally deposits upon the stigma pollen from another flower. The small processes (*m*) on each side of the lower lip are the rudiments of the lateral petals with which the ancestors of *Lamium* were provided. Thus, then, we see how every part of this flower is either—like the size and shape of the arched upper lip, the relative position of the pistil and anthers, the length and narrowness of the tube, the size and position of the lower lip, the ring of hairs, and the honey—adapted to ensure the transference, by bees, of pollen from one flower to another, or, like the minute lateral points (*m*), an inheritance from more highly developed organs of ancestors. If we compare *Lamium* with other flowers we shall see how great a saving is effected by this beautiful adaptation. The stamens are reduced to 4, the stigma almost to a point. How great a contrast to the Pines and their clouds of pollen, or even to such a flower as that of *Nymphæa*, where the visits of insects are secured, but the transference of the pollen to the stigma is, so to say, accidental. Yet the fertilisation of *Lamium* is not less effectually secured than in either of these.

The Dead-nettle is so called because in the form of the leaf and in general habit the plant so closely resembles young plants of the Stinging-nettle, although the two species belong to very different families. How close the similarity is may be seen by the following illustration taken from a photograph. The plants on the right are true Stinging-nettles; those on the left are the white Dead-nettle, one of which is in flower. So close was the resemblance that after getting the photograph I went back to the spot on which they were growing to assure myself that there was no mistake. It

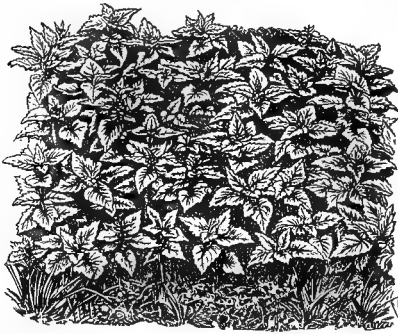


FIG. 214.—Group of Dead-nettles and Stinging-nettles.

cannot be doubted that the true Nettle is protected by its power of stinging; and that being so, it is scarcely less clear that the Dead-nettle must be protected by its likeness to the other. Moreover, though I was fortunate in lighting on so good an illustration as that shown in the figure,

just when I had an opportunity of photographing it, still every one must have observed that the two species are very commonly found growing together. Assuming that the ancestor of the Dead-nettle had leaves possessing a faint resemblance to those of the true Nettle, those in which the likeness was greatest would have the best chance of survival and consequently of ripening seeds. There would be a tendency, therefore, according to the well-known principles of Darwin, to a closer and closer resemblance. I am disposed to suggest whether these resemblances may not serve as a protection, not only from browsing quadrupeds, but also from leaf-eating insects. On this part of the subject we have as yet, however, I think, no sufficient observations on record.

L. maculatum.—The corolla-tube is rather longer than in *L. album*—15-17 mm.,—so that it is adapted to bees with a somewhat longer proboscis. As they can press their head into the tube, 10-12 mm. is sufficient. The leaves are hairy or pubescent; the stem hairy or glabrous.

L. purpureum.—In this species, on the contrary, the flower-tube is shorter—10-11 mm.,—and a proboscis 6-7 mm. long is sufficient. The leaves are hairy.

L. amplexicaule.—The length of the tube is about the same as in the preceding. The ring of hairs is wanting—perhaps being unnecessary, as the flower closes in wet weather, and is, indeed, often cleistogamous. In the latter flowers there are no petals; and the anthers do not open, but the pollen tubes pierce the walls and reach the stigma. The leaves are pubescent.

L. Galeobdolon.—The corolla-tube is 8 mm. in length, and yellow. This difference of colour in the three perennial species—red, white, and yellow—is perhaps of use in enabling the bees easily to distinguish them. The leaves are hairy.

CALAMINTHA

Protandrous bee or humble-bee flowers. The two upper teeth of the calyx are more or less connected at the base into an upper lip. There are three British species: one, *C. Acinos*, annual; the other two perennial—*C. officinalis* many-flowered, the other, *C. Clinopodium*, with few flowers in close cymes.

C. Acinos.—The corolla is a little longer than the calyx. The stem bears reflexed hairs.

C. Clinopodium.—The complete flowers, according to Müller, fall into two distinct forms—(1) large-flowered, protandrous; (2) small-flowered, almost homogamous. The leaves are more or less hairy.

NEPETA

The upper or central stamens project beyond the outer ones (Fig. 215), while in most Labiates the reverse

is the case (Fig. 216). Some species are adapted to butterflies. We have two species: *N. Glechoma*, creeping; *N. Cataria*, upright.

N. Cataria (Catmint).—The flowers are pale blue or nearly white. The stigma sometimes projects beyond the anthers, and at others is on a level with them; but this does not lead to self-fertilisation, as the plant is distinctly protandrous. The complete flowers are 7-8 mm. long. There are also female flowers 5-6 mm. long. These are generally on the same plants as the complete ones. A pubescent species, rare in England, and found as an introduction in Scotland.

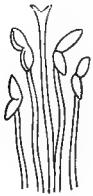


Fig. 215.

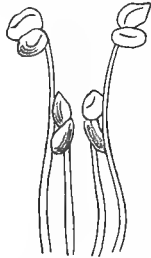


Fig. 216.

FIG. 215.—Diagram to show arrangement of stamens in *Nepeta*.

FIG. 216.—Diagram to show position of stamens in most Labiates.

N. Glechoma (Ground Ivy).

—The flowers are blue-violet, rarely white or rose, with purple and white spots. The corolla-tube is lined on its lower side with stiff hairs; in the large complete flowers it is 13-16 mm. in length. That of the small female flowers is only $6\frac{1}{2}$ -8 mm. long. Willis, in Cambridgeshire, found one year at the beginning of the flowering time 86 per cent female, towards the end 24 per cent; another year 50 per cent and 28 per cent. A polymorphous plant, glabrous or hairy. In summer it sends out creeping runners, from which the flowering shoots rise in the following spring.

PRUNELLA OR BRUNELLA

Calyx distinctly two-lipped. The stamens have a process or lobe beyond the anthers. The processes on the longer stamens are much longer than those on the shorter ones.

P. vulgaris.—Besides the complete flowers, there are smaller ones with more or less rudimentary stamens. In Belgium, MacLeod found cleistogamous flowers.

SCUTELLARIA

We have two species: *S. galericulata*, blue, and *S. minor*, pink.

S. galericulata (Fig. 217).—The flower is protandrous. The upper lip is three-lobed and laterally compressed, so as to leave a small orifice (Fig. 218, *a*), which it has been suggested by Kirchner¹ is especially adapted to butterflies; while the larger one between

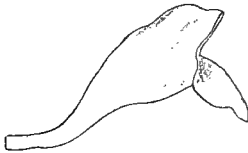


Fig. 217.

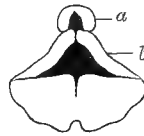


Fig. 218.

FIG. 217.—*Scutellaria galericulata*. Side view of flower.

FIG. 218.—Front view. *a*, entrance for butterflies; *b*, entrance for humble bees.

the upper and under lip is used by bees. According to Warnstorff the longer stamens have only one anther chamber. Besides the complete flowers, there are others with rudimentary anthers, which are sometimes on the same, sometimes on distinct plants. When the corolla has faded the calyx closes tightly over the ovary, forming the helmet-shaped hood, and protecting the young seeds.

S. minor has the habit of the former species, but is a smaller, slenderer plant, with much smaller pale pink-purple flowers.

LEONURUS

Protandrous or homogamous bee flowers represented by

L. Cardiaca, a pubescent plant now established, though rare, in this country.

¹ *Neue Beobachtungen über d. Bestäubungs-Einrichtungen einheimischer Pflanzen.* Stuttgart, 1886.

MELITTIS

Protandrous. Adapted to humble bees and moths.

M. Melissophyllum.—In some districts the corolla is white, in others pale purple, in others red or white with purple spots. The flowers are very sweet. The corolla-tube is 25-35 mm. in length and sometimes half filled with nectar. It varies in colour in different countries, being white in Southern Tyrol, purplish white in Lower Austria and Hungary.

MARRUBIUM (Horehound)

M. vulgare.—The ten teeth of the calyx curve back, forming hooks, which facilitate the scattering of the nutlets. The plant bears long soft hairs.

STACHYS (Woundwort)

S. sylvatica has protandrous flowers. The corolla-tube, 11 mm. long, is often filled with nectar to a depth of 2-3 mm.

S. palustris is also protandrous. The corolla-tube is 7-9 mm. long. The anthers of the outer stamens are open first and lie in front of the others. After shedding their pollen they turn outwards, while the inner stamens elongate and their anthers open at the same place. Then the pistil elongates and the stigma presses itself between the anthers. The leaves are finely hairy. The stem bears reflexed hairs on the edges.

S. arvensis is homogamous. According to Kirchner there is very little, if any nectar. The corolla-tube is only 4 mm. in length.

S. annua, an alien which has become established in corn-fields in Kent, has homogamous flowers. The corolla-tube is 8-10 mm. in length. The leaves are glabrous or slightly hairy.

S. germanica.—Besides the complete flowers this species has others in which the stamens are rudimentary. These are often on special plants. The plant is covered with a white tomentum.

GALEOPSIS

Homogamous or slightly protandrous bee flowers. Kerner describes the anthers as boxes closed with a lid which is pushed open by the humble bees, though only by those which correspond to the size of the flower. These only, therefore, are dusted by the pollen. There are three British species. One, *G. Tetrahit*, has long stiff hairs, and the stem swollen at each node. Of the other two, *G. Ladanum* has purple, *G. ochroleuca* yellow flowers; the leaves bear soft hairs.

G. Tetrahit.—The corolla-tube varies between 11 and 17 mm. in length; but the upper part is widened, so that for small humble bees a proboscis of 12 mm. is sufficient. Besides the complete there are small female flowers, which seem to be more frequent in the south than in the north. The two forms sometimes occur on the same plant. The stem bears rough jointed hairs.

Briquet in his Monograph of Galeopsis says:—

“Les renflements sont des portions d’entre-nœud différenciées en organes spéciaux, sur lesquels se localise l’action du géotropisme, et de l’héliotropisme, et qui, dans les mouvements effectués par l’axe sous l’influence de ces forces, jouent le rôle de charnière, tandis que les entre-nœuds proprement dits ne jouent qu’un rôle passif.

Une expérience très simple suffit pour constater cette localisation. Couchons, dans les mêmes conditions de température et de lumière, une tige de *G. Ladanum* et une tige de *G. Tetrahit* dans du sable humide. Au bout de quelque jours, les deux tiges se sont relevées et même complètement érigées; mais tandis que chez le *G. Ladanum* la courbure affecte les entre-nœuds tout entiers, on constate que le *G. Tetrahit* s’est érigé uniquement sur ses renflements qui sont fortement courtes, et que les entre-nœuds sont restés droits.”¹

And further on he adds:—

“Le rôle des renflements se révèle comme étant d’une utilité incontestable pour la plante dans une quantité de

¹ J. Briquet, *Monographie du Genre Galeopsis*, p. 74.

cas. Nous avons d'abord celui dans lequel les pieds sont couchés par le vent ou par une cause accidentelle de ce genre ; on constate que dans l'immense majorité des cas sous l'action du géotropisme, les tiges s'érigent avec une grande rapidité et rattrapent ainsi en fort peu de temps les dommages que leur a causés la tempête. Dans les haies et les taillis, que les Galeopsis du groupe des Tetrahit affectionnent, la sensibilité phototropique fait rapidement prendre aux tiges qui se courbent sur leurs renflements une position favorable à l'optimum d'éclairage."

BETONICA

Protandrous to homogamous bee flowers.

B. officinalis (Wood Betony).—The corolla is 7 mm. in length, and is not widened at the mouth, perhaps because a tube of this length is accessible to all the humble bees.

BALLOTA

Protandrous bee flowers.

B. nigra.—The corolla-tube has a length of about 7 mm., and is slightly widened at the mouth, so that the nectar is accessible to a proboscis 6 mm. long. The flower is protandrous, and if not carried away by insects the pollen falls on to the lip of the corolla. Finally the pistil elongates, and the stigma touches the lip, taking up some of the pollen. The leaves are hairy.

AJUGA

Nectar protected by a ring of hairs. The upper lip of the corolla is very short, but the anthers and stigma are protected by the bract of the flower above. There are three British species. One, *A. Chamæpitys*, has yellow flowers, with much-divided leaves ; the other two blue or ash-coloured, with nearly entire leaves ; one, *A. reptans*, is glabrous or nearly so, with creeping scions ; the other, *A. pyramidalis*, very hairy, and without creeping scions.

A. reptans (Bugle).—The flower is generally homogamous; sometimes, however, the anthers open a little before the stigma is ripe, while at others the reverse happens. MacLeod, in Belgium, found a distinctly protandrous form with large flowers. The stem is alternately hairy on two faces, and glabrous on the other two. In this species, as in many others, the leaves are coloured red, especially on their under sides, by anthocyanin. The use of the pigment seems to be to turn the light- into heat-rays. The object of the lower side being coloured is apparently that some of the light would otherwise pass through the leaf and be lost to the plant. It is found especially in plants which grow in shady places, in Alpine plants, water plants, and many sea-weeds, especially those found at greater depths and not exposed at the ebb-tide. There are other cases in which the anthocyanin is on the upper surface. Here it probably serves as a screen, and protects the plants against too intense illumination by turning part of the light into heat. This view seems strongly supported by some of King's experiments. For instance, he placed some chlorophyll in intense sunshine, part, however, protected by a screen of anthocyanin extracted from Beetroot. The part so sheltered remained green, the rest was decomposed by the light. It is also borne out by the frequent presence of the red colouring-matter in young leaves in which the delicate epidermis forms an inadequate protection from strong light.

A. pyramidalis has the stem hairy all round, and very hairy leaves.

A. Chamæpitys.—The leaves are deeply divided into three lobes. It is a southern form, and I have found it on the Riviera growing with *Euphorbia Cyparissias*, which it so much resembled that I could not but think it was a case of mimicry. The *Euphorbia* is protected by its acrid sap, and the similarity may be a distinct advantage to the present species, which itself has an unpleasant taste. The leaves are rather viscous; the stem is hairy all round.

TEUCRIUM

Protandrous bee flowers. The upper lip is apparently absent, as in *Ajuga*. We have four species. *T. Scordium* and *T. Botrys* have axillary flowers. In the other two they are in terminal one-sided spikes; *T. Scordonia* has pale yellow, *T. Chamædrys* red flowers. When the flower opens the anthers stand out at the orifice; afterwards they bend up, and their place is taken by the stigma.

T. Scordonia (Wood Sage).—The corolla-tube is 9-10 mm. long, sometimes nearly half filled with nectar. When the lower flowers of a raceme have reached the



Fig. 219.

Fig. 220.

FIG. 219.—*Teucrium Scordonia*. Flower in the first state, with anthers erect. Enlarged.

FIG. 220.—Flower in the second state, with recurved anthers and exposed stigmas.

second (female) condition (Fig. 220), the upper ones are still male (Fig. 219), so that a bee first visits female flowers, and then dusts itself with pollen, which it probably carries to another plant. The plant is pubescent.

T. Chamædrys.—According to H. Müller the pistil is only as long as the shorter stamens, while according to Schulz it exceeds the longer ones. The leaves are pubescent; the stem hairy. It is not a British plant, but found, rarely, as a garden escape on old walls.

LYCOPUS

In this genus the stamens are reduced to two. The complete flowers are protandrous; there are also smaller ones which are female. The corolla-tube is only 3-4 mm. long, and the nectar is therefore accessible even to insects with a very short proboscis.

It is represented in our flora by **L. europæus**, a

glabrous or slightly pubescent plant; found in ditches or on river banks, with small bluish-white flowers.

We now come to a genus which presents us with one of the most remarkable pieces of mechanism to be found in the whole vegetable kingdom.

SALVIA

Two of the stamens are rudimentary or absent. In the other two the halves of the anthers, instead of being close together, are united by a more or less long connective (Fig. 224), and one half produces little or no pollen. In several of the species the access of creeping insects is precluded by the presence of glutinous hairs. There are two British species: one, *S. pratensis*, with a large flower and leaves mostly radical; the other, *S. Verbenaca*, with a leafy stem and small flowers.

I take *S. officinalis*, the common garden Sage, as an example, because it is accessible to any one. The flowers were well described by Sprengel, and more recently by Hildebrand and Ogle.¹ Fig. 221 represents a young flower of *S. officinalis* in which the stamens (*a*) are mature, but not the stigma (*p*), which, moreover, from its position is untouched by bees visiting the flower, as shown in Fig. 222. The anthers, as they shed their pollen, gradually shrivel up; while, on the other hand, the pistil increases in length and curves downwards until it assumes the position shown in Fig. 223, *st*, where, as is evident, it must come in contact with a bee visiting the flower, and would touch just that part of the back on which pollen would be deposited by a younger flower. In this manner self-fertilisation is effectually provided against. The general form of the flower is very similar to that of other Labiates. We find that, as generally, the corolla has the lower lip adapted as an alighting board for insects, while the arched upper lip covers and protects

¹ *Pop. Sci. Rev.* July 1869.

the stamens and pistils. In *S. officinalis*, however, the back of the upper lip shows an arch at the part *x*, and the front portion of the lip, containing the stamens, is loftier than in *Lamium*, and does not therefore come in contact with the back of the bee (Fig. 222). This is evidently correlated with the difference in the stamens

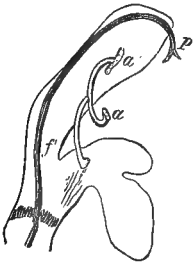


Fig. 221.

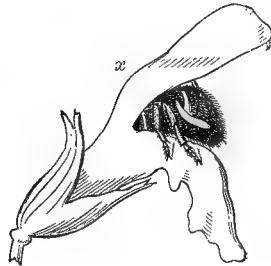


Fig. 222.

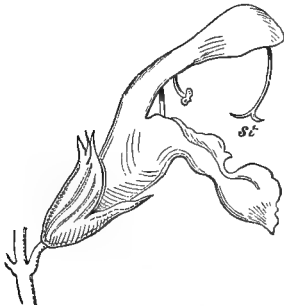


Fig. 223.

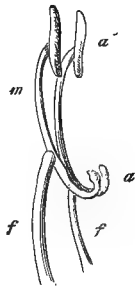


Fig. 224.

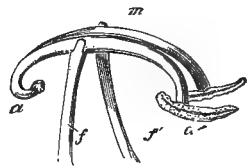


Fig. 225.

FIG. 221-225.—*Salvia officinalis*. Fig. 221, section of a young flower; Fig. 222, flower visited by a bee; Fig. 223, older flower; Fig. 224, stamens in their natural position; Fig. 225, stamens when moved by a bee. All enlarged. *a*, sterile, *a'*, fertile half of anther; *f*, filament of functional stamen; *f'*, position of aborted stamen; *m*, connective; *p*, pistil; *st*, stigmas; *x*, arch of corolla.

(Fig. 221), two of which (*f'*) are minute and rudimentary, while in the other pair the two anther cells (*a a'*) are separated by a long connective. Moreover, the lower anther cells (*a a*) contain very little pollen; sometimes, indeed, none at all. This portion of the stamen, as shown in Fig. 223, hangs down and partially stops up the mouth of the corolla-tube.

When, however, a bee thrusts its head into the tube in search of the honey, this part of the stamen is pushed into the arch (Fig. 222, *x*), the connectives of the two large stamens revolve on their axis, and consequently the fertile anther cells (*a'*) are brought down on to the back of the bee, as shown in Fig. 225.

In this country we have only two species of *Salvia*, but the foreign species are numerous, and differ considerably in their mechanism for fertilisation. For instance, in *S. verticillata*¹ the arrangement is quite different. The lower anther is rudimentary. The connective does not move, but the hood is connected with the tube of the corolla by a narrow part which acts as a hinge. The flower is much smaller, and the bee dusts itself with pollen by pressing back the movable hood. In fact, in this species it is the hood of the corolla, and not the anther, which is movable. Connected with this change in the structure of the stamen is an alteration in the position of the pistil. If it occupied the usual position it would impede, if not prevent, the raising of the hood. At first it lies close to the lower lip, which it about equals in length. Gradually, however, it elongates, projects beyond the corolla, and generally raises itself a little, so that it can scarcely fail to touch the head of the bee. Besides the large complete flowers, some species have plants with small female flowers.

S. Verbenaca.—This is our common species. The flowers are small. There are also cleistogamous flowers.

S. pratensis.—A very rare British plant, found in dry fields in a few of our southern counties. The pericarp is thick, crustaceous, deep brown, not shining, and the epidermis is rugulose. When placed in water it emits long colourless filaments, which are at first spirally coiled, but gradually open out.

In **S. Horminum** these mucilaginous threads attain a considerable relative length, and for some time wriggle about like small worms.

¹ Hildebrand, *Pringsh. Jahrb.* vol. iv. (1865-66).

VERBENACEÆ

VERBENA (Vervain)

Homogamous bee flowers. Nectar secreted by the base of the ovary, and protected by a ring of hairs.

V. officinalis is the only representative of the family in the British flora. The flowers are small, but are rendered less inconspicuous by being collected into a long slender spike. The corolla-tube is 3-4 mm. long. The lower half is turned upwards, the upper outwards, thus protecting the stigma, anthers, and nectar. The stem is quadrangular, and bears opposite leaves.

PLUMBAGINACEÆ

The flowers are small, but conspicuous by association. Calyx and corolla tubular; nectar secreted by the base of the flower.

ARMERIA (Thrift)

Small red or sometimes white flowers collected in a terminal globular head. The calyx has a petal-like border.

A. vulgaris.—The flowers are sweet-scented. The calyx is 5 mm. long, the upper part thin, violet, and supported by five ribs ending in short teeth. The corolla-tube is lined with hairs which protect the nectar. When the flower opens the five stigmas are in the centre surrounded by the anthers, which are over the honey. Subsequently they change places, the stigmas moving outwards, the anthers approaching the centre of the flower. Finally the stigmas wind spirally, and touch the anthers. The membranous calyx serves as a parachute for the dispersal of the seed. This species has two well-chosen haunts—mountains and the seaside.

STATICE (Sea Lavender)

Flowers in a dichotomous or trichotomous panicle. Nectar secreted by the base of the flower. The calyx is membranous above and coloured, as in *Armeria*. We have three species. One, *S. Limonium*, has leaves several inches long; in the other two they are short; in *S. auriculæfolia* all the branches are flowering; the other has a number of short barren branches.

S. Limonium is protandrous. Some of the flowers have rudimentary anthers. A glabrous plant found on muddy shores round England and the South of Scotland.

S. auriculæfolia is a Southern European plant, found in Britain as far north as Lincoln on the east and Wigtown on the west.

S. reticulata occurs in salt-marshes in Norfolk, Suffolk, and Cambridge.

PLANTAGINEÆ

Parts of the flower in fours. As a rule protogynous wind flowers, with long movable stamens, and the stigmas feathery, which, of course, increases their chance of receiving some of the pollen. They are also long-lived.

PLANTAGO

Flowers in heads or spikes; complete. The anthers are somewhat conspicuous, and the plants are sometimes visited by insects for the sake of their pollen. This is especially the case with *P. media*. The filaments of the stamens are long and thin, so that they are easily shaken by the wind. The orifice of the anthers is small, so that the pollen only comes out if they are somewhat violently shaken. They open when it is fine, and close again if it rains. The anthers open on the side turned to the sky, and it takes a couple of days to

disperse the pollen.¹ As in many other wind flowers the pollen is dry and dusty, but the bees moisten it with honey from their proboscis, which makes it easy to collect. The Plantains illustrate the difference between broad leaves, which tend to be horizontal, and narrow ones, which tend to be vertical.

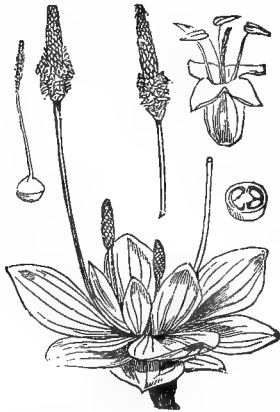


FIG. 226.—*Plantago media*.

Thus *P. media* (Fig. 226) has broad leaves, which lie flat on the ground, and *P. lanceolata* has narrow ones, which point upwards (see also *Drosera*, p. 203). The seeds secrete a mucilaginous adhesive substance, which exudes freely as soon as they are moistened, and serves to fasten them if they meet with damp earth. We have five species. One, *P. maritima*, has narrow linear leaves; one, *P. Coronopus*, deeply toothed or pinnatifid leaves; in the other three they are broad and entire. *P. lanceolata* has short round heads; the last two, slender spikes; *P. major* with reddish brown, yellowish, or white, *P. media* with pink or purple anthers.

P. major.—Anthers reddish brown, but according to Ludwig sometimes yellow, greenish yellow, or white. The plant is glabrous or bears appressed hairs. The seeds are small, faintly rugose, somewhat flat, and covered by a layer of mucilage.

P. media.—Anthers pink or purple. This species forms a passage from a wind flower to an insect flower. The long flexible filaments and feathery stigma are characteristic of a wind flower; while the violet anthers and the scent serve to attract insects. Some flowers have anthers only, and others only the pistil. These also are sometimes monœcious, sometimes dioecious, so that there are five forms of flower. The plant is covered with short hairs.

¹ Kerner, *Natural History of Plants*, vol. ii.

P. lanceolata.—This species also presents female as well as complete flowers. It is visited by hive bees, which moisten the anthers with honey, then force them open, and collect as much of the pollen as they can. The plant is glabrous, or, in the maritime variety, with appressed hairs. The seeds are comparatively large, shining, smooth, with a deep furrow on one side; they have a thin layer of mucilage.

P. maritima has glabrous leaves. The peduncles bear an appressed pubescence. The seeds are like those of *P. lanceolata*.

P. Coronopus.—This species grows in sandy situations, generally near the sea. The lobes of the leaves are so arranged that the rosette offers a smooth surface, over which the sand blows, and on which it finds no ledge or hollows in which it might accumulate. The seeds are small, with narrow white expansions at each end, and covered with a layer of mucilage.

LITTORELLA

This genus differs from *Plantago* in the flowers being few and monœcious.

L. lacustris.—This is a small plant, $1\frac{1}{2}$ to 3 inches high, and grows in shallow ponds. It often goes some years without flowering, till a dry summer comes, when the water contracts and the ground is laid dry. The stamens are sometimes $\frac{1}{2}$ inch long. The plant is glabrous or minutely hairy.

CHENOPODIACEÆ

The flowers are inconspicuous, and appear to be generally self-fertilised. Perhaps the pollen is carried by creeping insects. Sprengel regarded them as wind flowers, and no doubt this may sometimes be the case, but they do not present the special characteristics of wind-fertilised flowers.

SALICORNIA

Leafless herbs, with cylindrical succulent jointed stems; found in salt-marshes. The minute bisexual flowers are sunk in pits at the nodes, and contain no honey.

S. herbacea and **S. radicans** occur in Britain, the latter only south of Yorkshire.

SALSOLA (Saltwort)

This genus is represented by **S. Kali**, another succulent maritime species. It is homogamous or protogynous. The plant is glabrous or with rough hairs. The leaves are fleshy, and somewhat awl-shaped.

CHENOPODIUM (Goosefoot)

Generally protogynous wind flowers; without nectar. Some, however, have nectar. Though insect visits are few and far between, it must be remembered that the flowers are very numerous and long-lived.

C. Vulvaria (Stinking Goosefoot).—This species, according to Kirchner, produces nectar. The very unpleasant smell is perhaps a protection against browsing quadrupeds. Kirchner describes it as distinctly protogynous, but Hildebrand found it protandrous in his neighbourhood. The plant is covered with powdery dust-like hairs.

C. album.—More or less mealy white, from the numerous small globular hairs. The flowers are protogynous. In this species also Kirchner found nectar. The young leaves rise vertically at night. The stem has alternate bands of white and green.

C. rubrum is a glabrous shining plant, the stem having alternate bands of green and white or red.

C. glaucum.—In this species the leaves are green above, white, glaucous, and mealy below.

C. polyspermum.—Leaves entire and scentless.

C. hybridum.—Maple-leaved Goosefoot; with a heavy odour.

C. murale, a nearly glabrous plant, found in waste places near houses. The leaves are mealy when young.

C. Bonus-Henricus (Good King Henry).—Stem with bands of green and red, papillose, as is also the under face of the succulent triangular leaves.

C. urbicum.—The stem has alternate bands of green and white.

BETA (Beet)

B. maritima.—A glabrous plant with fleshy shining leaves, and small protandrous flowers in clusters of two or three. This is the origin of the Beetroot and Mangel Wurzel.

ATRIPLEX (Orache)

According to Bentham,¹ “the flowers are small and numerous, clustered in axillary spikes or terminal panicles as in Goosefoot, but always of two kinds; in some, which are usually males only, the perianth is regular and 5-cleft, as in Goosefoot, with 5 stamens; in the females the perianth consists of two flat segments (or rather, bracts replacing the real perianth), either free or more or less united at the edges, enclosing the ovary. After flowering this false perianth enlarges, is often toothed at the edge, and covered with wart-like excrescences. Seeds usually vertical. In some species there are also a few regular female real perianths, which ripen without enlarging, and contain a horizontal seed, as in Goosefoot.” The species, of which we have five, are found on shores and in waste places. The plants are generally more or less covered with mealy hairs.

A. hortensis.—The fruit is an utricle, much compressed, and concave on the sides, one-celled, one-seeded. It is enclosed in two orbicular, or nearly orbicular, bracts, which are connate at the base, aurescent, and probably serve to disperse the seeds. The seeds are of two kinds. Some are small and black, with a rather thick, crustaceous, smooth, and shining coat; the others are larger, brown, and more orbicular, with a thin,

¹ *Handbook of the British Flora*, vol. ii.

membranous, smooth, but not shining coat. They are mixed indiscriminately on the panicle. The large brown ones germinate much more quickly than the small black ones, which would seem, under natural conditions, to be more adapted to remain in a resting condition in the ground during the winter and germinate in spring. If such is the case they would enable the plant to exist in a colder climate than the large ones would.¹ The plant occurs in Britain as a garden escape.

POLYGONACEÆ

In this family also the flowers are small, but contain nectar, and are often conspicuous by association. They generally contain both anthers and pistil. Many species are dimorphous.

RUMEX (Dock)

The British species are all perennials. The flowers are generally reddish. The parts of the flower are in threes. The Sorrels have hastate leaves. The true Docks are generally distinguished by the form of the perianth segments and the tubercles on them. The function of these tubercles is not known, nor has any suggestion been offered as to why some species (*R. aquaticus*) should have none; others (*R. crispus* and *R. sanguineus*), one on one at least of the perianth segments, while *R. conglomeratus*, as a rule, has one on each segment.

R. crispus.—The leaves are much waved or crisped at the edges. The flowers are protandrous, and the pollen is wind-borne. Some are complete, some are male, some female; these last are generally small.

R. obtusifolius.—Kirchner describes the flowers of this species as resembling those of *R. crispus*. Kerner, however, found those examined by him to be protogynous.

¹ Avebury (Lubbock), *On Seedlings*, vol. ii.

R. sanguineus.—Schulz describes this species as slightly protandrous; Kerner as protogynous. Some flowers have no pistil; these may be on the same or on special plants. The perianth bears only one tubercle, which is bright red, and on the midrib of the uppermost segment round the drooping fruit.

R. conglomeratus.—In this species there are two tubercles.

R. maritimus is a local British plant. The flowers are homogamous.

R. Acetosella.—According to Lindman the flowers early in the season are protogynous, the later ones homogamous. Besides the complete, there are some female dicecious flowers.

POLYGONUM

The species differ much in habit. Nectar is secreted in some cases. Some species have cleistogamous flowers.

P. Bistorta (Bistort).—The flowers are protandrous. Though small they are brightly coloured, and being collected into a long spike are fairly conspicuous, and being well supplied with nectar are much visited by insects. The nectar is secreted by eight glands at the base of the stamens. According to Schulz, besides the complete there are also female flowers, which are more numerous on the mountains than in the plains. The spike is composed of small two-flowered groups—one flower complete, the other male with a small style and rudimentary ovary. The complete flowers open first, and are protandrous. Gradually the anthers fall off, the styles elongate, and the plant is adapted for fertilisation by pollen from another flower. In the absence of insect visits the anthers often touch their own stigmas.

P. viviparum.—The length and relations of the stamens and pistil differ considerably in different districts. The plant does not set its seed easily, and is principally increased by bulbils, into which the lower and sometimes all the flowers are modified.

P. amphibium.—This species secretes honey by five orange-yellow glands at the base of the ovary. The flowers are dimorphous; some with a long pistil and short stamens, others with long stamens and a short pistil. There are also female flowers. The plant grows sometimes on land and sometimes in water. And here we find also another interesting adaptation. The land form is more or less hairy, while plants growing in water are entirely glabrous. One form changes into the other if the plant is moved from dry land into water or *vice versa*.

P. Hydropiper.—The flowers are small and without nectar. Of the eight stamens two are generally rudimentary. Some of the flowers in this and the following species are cleistogamous, especially those which receive little light. The plant is protected from browsing quadrupeds by a bitter juice, whence the name.

P. minus is very near the preceding. It has no bitter flavour, but is probably protected by its great similarity to *P. Hydropiper*. Bentham regards it as a mere variety.

P. Aviculare (Knot-grass).—A creeping plant with small green, white, or purple flowers which have no scent or honey. Five of the eight stamens bend outwards towards the corolla; the other three towards the stigma, which, as they are at the same level, and ripe at the same time, they can scarcely fail to fertilise. The young leaves rise up vertically at night.

P. Fagopyrum (Buckwheat).—This is an Asiatic species, but familiar to us as being so often cultivated. The flowers are markedly dimorphous. According to Richer they are quite sterile when self-pollinated, or with pollen from flowers of the same form on the same plant. They are very slightly fertile after cross-pollination between flowers of the same form on distinct plants. They are, on the contrary, highly fertile after cross-pollination between flowers of different form on distinct plants.¹

¹ *Comptes Rendus*, cxxxviii. (1904).

P. Convolvulus.—This species much resembles a *Convolvulus* in habit. Though the secretion of nectar is slight, the flowers are occasionally visited by bees. The stem is angular.

THYMELÆACEÆ

DAPHNE

Homogamous flowers with nectar secreted by the base of the ovary. In species which have the corolla-tube short the flowers are fertilised mainly by flies; when it is longer, by bees; and the longest, by butterflies. There are 8 stamens, inserted in the upper part of the corolla-tube.

We have two species only—*D. Mezereum*, which is deciduous, with red berries, and *D. Laureola* (Spurge Laurel), which is evergreen, with black ones.

D. Mezereum.—The flowers are sweet-scented, well supplied with nectar, and much visited by insects. Ludwig considered the flower to be sterile to its own pollen; Schulz, however, came to the opposite conclusion. Perhaps, as Ludwig suggests, this is one of the cases where plants differ in different localities; or perhaps different plants are differently constituted in this respect. Some of the flowers have no anthers.

ELÆAGNACEÆ

Dioecious wind flowers.

HIPPOPHÆ

H. rhamnoides (Sea Buckthorn).—The leaves of this species are the food of a special hawkmoth, the large caterpillars of which have orange patches curiously

resembling the fruits in size and colour. This does much to render them inconspicuous. The leaves are grey, with red scales on the under side.

SANTALACEÆ

THESIUM

Homogamous flowers. Nectar secreted at the base of the flower. The anthers remain open some time; in wet weather, or if moistened, they close rapidly—according to Kerner, in *T. alpinum* in about half a minute.¹

T. linophyllum.—A glabrous green woody perennial, 6-8 inches high. Generally dispersed over Europe, but in England only found on some of our south-eastern downs. It is semi-parasitic, and derives some, at least, of its nourishment from the roots of other plants. The suckers are little white knobs on the sides of the roots.

ARISTOLOCHACEÆ

Protogynous trap flowers secreting nectar at the base of the flower.

ASARUM

A. europæum.—The flowers are greenish brown, about half an inch long on a short recurved stalk, and on the ground or often concealed among dead leaves. They have a scent resembling camphor. The flower-tube ends in three long pointed lobes; these are at first curled over so that the entrance to the flower is formed by three narrow slits. The stigmas are 6 in number, and ripe when the flower opens. The stamens are 12, in two rows, and end in a long point. As the flower hangs down the pollen may easily drop on the stigmas. The

¹ *Nat. Hist. of Plants*, vol. ii.

insect visitors are principally small flies. A Southern European plant found in several English counties, but regarded by Watson as a denizen.

EUPHORBIACEÆ

EUPHORBIA

The plants are protected by a milky acrid juice. The flowers secrete nectar, which lies quite exposed. The apparent flowers are really flower-heads. The cup-shaped involucre has 4 or 5 rounded or moon-shaped glands, which secrete a thin covering of nectar. It contains 10-15 stamens, each of which is jointed, showing that it represents a stalk bearing a flower which is reduced to a single stamen,¹ and in the centre is a single female flower consisting of a 3-celled ovary and 3 styles, each terminating in 2 stigmas. The flower-head is protogynous. The flowers are occasionally visited by bees and wasps, but fertilisation is almost exclusively due to flies. According to Kerner the anthers close in wet weather. The seeds differ considerably. Some are smooth (*E. hyberna*, *E. Paralias*, *E. amygdaloides*); some pitted (*E. Peplus*, *E. peploides*, *E. Helioscopia*, *E. segetalis*); some wrinkled (*E. exigua*, *E. Lathyris*); others dotted, or tubercular. The capsule, as a rule, opens both loculicidally and septicidally, so that each valve consists of one half of a carpel.

MERCURIALIS (Dog's Mercury)

Wind flowers; generally dioecious.

We have two species—one annual, the other perennial. In both, male flowers sometimes, though rarely, occur on the female plants. There are only two carpels. The outer skin of the fruit of *M. annua*,² which is

¹ An interesting confirmation of this view is afforded by a foreign genus, *Anthostema*, which has a distinct perianth.

² Leclerc du Sablon, *Ann. Sci. Nat.* xviii. (1834).

formed of soft parenchyma, has no part in the opening of the valves. The inner lignified layer, according to Le Clerc du Sablon, is composed of three divisions, each of one layer of cells. The internal epidermis consists of fibres at an angle of 45° to the axis of the fruit; then comes a layer elongated radially, and finally one of cells at right angles to those of the epidermis. The result of this is that the valves open outwards. The structure of *M. perennis* is very similar, but the rows of cells are more numerous.

M. perennis.—The dust-like pollen is conveyed to the stigmas by the wind; and the stigmas are said to be capable of fertilisation at least two days before the pollen is ripe. The leaves, which are glabrous or hairy, are opposite, and provided with stipules. They thus form a sort of cup which holds the rain. In it is a rounded ridge, with a row of hairs. This is readily wetted and probably absorbs moisture.

M. annua.—Like the preceding, this species is dioecious. But female plants cultivated in pots by themselves have long been known to give fertile seeds. This result is so unusual and so remarkable that it has been suggested either that there may have been one or two male flowers which had been overlooked or that a few grains of pollen might have come from a distance. Ramisch, however, and subsequently Kerner, have grown female plants in districts where the plant does not occur wild, and yet they set fertile seeds. The plant is glabrous. Like so many other weeds of cultivation it is annual. According to Kerner it throws its seeds.

BUXUS (Box)

Monœcious wind flowers, with free-lying nectar in both sexes.

B. sempervirens.—The Box flowers early, and is sometimes visited by bees for its pollen, the more so, no doubt, as there are not then many other plants in flower. The male and female flowers are associated in the same cluster, the former below, and the latter

above. The former have one bract, the latter three. The clusters are slightly protogynous. The pollen, like that of wind flowers generally, is dry and dusty, but the hive bee, having separated the pollen from the anther, moistens it with nectar from its mouth, and then brushes it on to its hind legs. The leaves are evergreen, and well protected against extremes of temperature and drought. The epidermis is thick, the stomata are sunk, and there are no less than four rows of palisade cells. The polished surface, which occurs in several other evergreen species, is perhaps a provision to throw off snow.

EMPETRACEÆ

EMPETRUM (Crowberry)

Generally dioecious. Warming and Knuth consider them as wind flowers. Lindman regards them as fertilised by insects, especially flies. They have nectar, but very little.

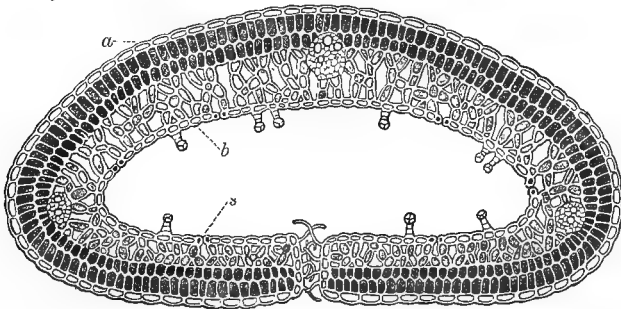


FIG. 227.—Transverse section of leaf of *Empetrum*. Much enlarged. *a*, upper epidermis; *b*, lower epidermis; *s*, stoma.

E. nigrum.—The male flowers are rose, the female purple. The pistil is short, with 6-9 diverging black shining stigmas. Besides the dioecious, Lindman found some protandrous complete flowers.

The leaves are evergreen and conform to the heath

type (Fig. 227, also p. 28). The upper face is protected by a strong smooth cuticle; the stomata are on the under face, and communicate with an almost closed chamber formed by the rolling back of the leaf margins. This arrangement serves to check excessive loss of water in the exposed situations in which the plant is found, and also prevents clogging of the stomata by the dew or rain which is deposited on the upper face only, and owing to the smooth surface is got rid of as quickly as possible.

CALLITRICHINEÆ

Aquatic floating herbs.

CALLITRICHE

Inconspicuous monœcious protogynous flowers. The pollen is probably in some cases carried by insects, in others by wind, and sometimes by water.

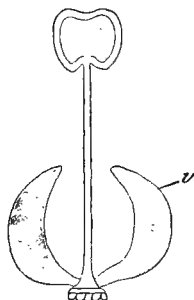


FIG. 228.—Male flower, consisting of one stamen subtended by a pair of bracts, *v*.

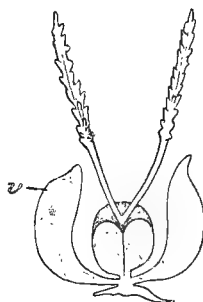


FIG. 229.—Female flower, consisting of a 4-lobed ovary with 2 styles; bracts as in male, *v*.

C. aquatica.—The pollen grains, as in some other aquatic plants, have no outer coat (extine). They are lighter than water, and thus may easily be carried to the female flowers.

CERATOPHYLLACEÆ

As in so many submerged plants the leaves are divided into many linear divisions (see p. 25). The flowers are monœcious. The plants float freely, having no roots.

C. demersum.—The flowers are sessile; male and female in different whorls, the female generally below. The males are the more numerous, containing 12-20 anthers, and produce much pollen. The female flowers consist of an ovoid ovary with a filiform sticky pistil. Ludwig¹ points out that though several marine phanerogams flower under water, this is the only European fresh-water species which does so. He has, however, overlooked *Najas*, four species of which occur in European fresh waters. The anthers terminate in two points, and contain a tannin-like substance which Ludwig suggests protects them from water snails. They also contain air chambers, so that they float on the surface of the water. When they ripen they slightly contract, squeezing the pollen into the water, which it equals in specific gravity. The diffusion of the pollen is increased by the peculiar movements of the plant itself, which were first noticed by Rodier.² Sometimes in seven hours an angle of 120° is passed through. The pollen is so plentiful that some of it is almost sure to come in contact with the sticky stigmas.

URTICACEÆ

Leaves rough and often stinging. Flowers unisexual.

URTICA

Wind flowers. Male with 4-lobed perianth and 4 stamens. Female perianth with 2 lobes, or if 4, the

¹ "Süßwasserflora," in Zacharias, *Tier- u. Pflanzenwelt d. Süßwassers*, i.

² *Comptes Rendus*, lxxxiv. (1877).

2 inner ones larger than the outer. There are three British species. *U. dioica*, the Common Nettle, is perennial; the other two annual; one *U. urens*, with the flowers in nearly sessile short clusters; the other,

U. pilulifera, with the male flowers in loose spikes, the female in stalked globular heads.

U. urens and *U. pilulifera* are monoëcious, with stinging hairs.

U. dioica (Common Stinging-nettle) is generally dioëcious. The plant is protected by stinging hairs (Fig. 230). These point forwards, so that the plant may safely be grasped from below, as they are merely compressed. If, however, taken from above, they are sure to run into the skin. Each hair sits on a cushion of delicate tissue, contains an acid fluid, and terminates in a small rounded head set on at an angle. The silicified tissue at the base of the head is very thin, and breaks through with the slightest touch.

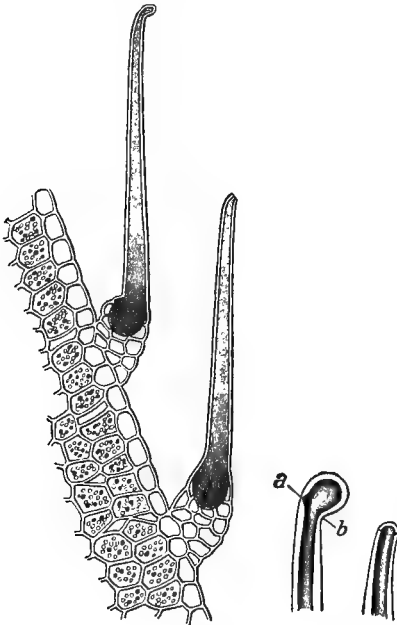


Fig. 230.

Fig. 231. Fig. 232.

FIG. 230.—*Urtica dioica*. Vertical section through part of the leaf of a Stinging-nettle, showing two hairs, from the lower one of which the head has been broken. $\times 35$.

FIG. 231.—Top of hair more magnified, entire. $\times 150$. *a b*, line of fracture.

FIG. 232.—Top of hair more magnified, after removal of the head. $\times 150$.

As the fracture is oblique (Fig. 231, *a b*) the point is very sharp, so that it easily penetrates into the flesh. Our British Nettles can make themselves very unpleasant, but some of the foreign species produce serious results.

Borscow¹ has described the movements of the proto-

¹ *Bull. Acad. Sci. St. Pétersburg*, xii. (1868).

plasm in the stinging hairs. He found that it was repelled by red light, and attracted by blue. No doubt, however, the protoplasm would react differently in different species. The filaments bearing the anthers are coiled in the bud and suddenly spring up at the moment the anthers open, thus ejecting the pollen in little puffs. This happens on bright summer mornings as soon as they are touched by the sun, and the cannonade lasts about half an hour.

PARIETARIA (Pellitory)

There are three forms of flower—complete, male, and female. Male flowers as in the Nettle. Female, with a tubular or campanulate four-lobed perianth and a brush-like stigma. The complete flowers are protogynous.

P. officinalis is the only British species. The stamens explode as in *Urtica*. The name is derived from the habit of the plant to grow on old walls. The stem and leaves are pubescent, with curled hairs.

HUMULUS (Hop)

Diœcious wind flowers. A climber.

H. Lupulus.—The stigmas of the female flowers are ripe at least two days before the anthers of the male plants open. The orifice of the anther is small, so that the pollen is gradually scattered. The stipules (Fig. 233) are interesting: they are connate, but the two which have joined belong to opposite leaves. This explains the deep notch at the end. The leaves are smooth above and rough below. The upper part of the shoot, as in other climbers, revolves in a circle or ellipse, the object being to find some support up which to climb. The direction is always towards the right, and on an average a revolution takes 2 hours and



FIG. 233.—End of shoot of Hop, showing connate stipules in pairs.

8 minutes.¹ The surface is covered with hairs, shaped like an anvil with a broad top. These climbing hooks help to attach it to its support. The persistent bracts serve as parachutes to disperse the seeds.

ULMACEÆ

ULMUS (Elm)

Flowers generally complete, protogynous, with long-lived stigmas. Pollen carried by the wind. Perianth of 4-6 lobes and as many stamens (Fig. 234). According to Kerner the filaments double their length very shortly before the opening of the anthers. These close in wet weather. The fruit, as in the case of that of so many other trees, is thin, flat, and easily carried by wind. We have two species. The Wych Elm (*U. montana*) has the fruit slightly, the other, the Common Elm (*U. campestris*), deeply notched. There are, however, considerable differences of opinion as to the number of species, and *U. campestris* may perhaps represent a group of allied forms rather than a single species. The hairs are sometimes poisonous.

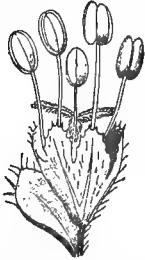


FIG. 234.—Flower of the Elm. Enlarged.

The buds of the Common Elm (*U. campestris*) are covered and protected by scales, each of which represents a pair of stipules.² This is shown by the position and arrangement of the scales. The leaves are in two ranks, as in the Beech. Hence, as there are two stipules to each leaf, it follows that if each scale corresponded to a stipule they must be in four ranks, as, in fact, they are in the Beech (Fig. 253). Those of the Elm, however (Fig. 235), are in two rows, showing that

¹ Darwin, *Climbing Plants*.

² Avebury (Lubbock), *Buds and Stipules*, p. 144.

each consists of two connate stipules. This is further suggested by the fact that they are sometimes bifid at the summit, as shown in Fig. 244. The young leaf, moreover, is situated, not between two scales, as in the Beech, but within and opposite the middle of the often bifid scale. The outer four stipular scales are coriaceous, dark brown, brittle, and more or less ciliate towards the apex. Owing to their being connate, however, the single piece occupies the central position of the leaf, the

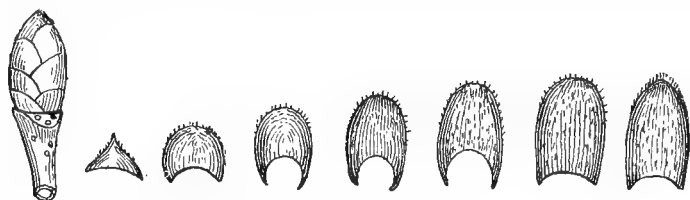


Fig. 235. Fig. 236. Fig. 237. Fig. 238. Fig. 239. Fig. 240. Fig. 241. Fig. 242.



Fig. 243. Fig. 244. Fig. 245. Fig. 246. Fig. 247. Fig. 248.

FIG. 235.—Elm. Terminal bud, showing seven scales.

FIG. 236.—The first scale.

FIG. 237.—The second scale.

FIG. 238.—The third scale.

FIG. 239.—The fourth scale.

FIG. 240.—The fifth scale.

FIG. 241.—The sixth scale.

FIG. 242.—The seventh scale.

FIG. 243.—The eighth scale.

FIG. 244.—The ninth scale, showing fusion, which is unusual.

FIG. 245.—Members at the tenth node. *o. st.*, outer stipule, with a portion removed to show the leaf, *l*, which comes next in order; *i. st.*, inner stipule.

Figs. 246-248.—Members at nodes 11 to 13. *o. st.*, outer stipule; *l*, leaf; *i. st.*, inner stipule. All are separated to show outline.

blade of which, if present, would be between them. These four scales do not elongate in spring, being practically dead; they often split at the apex into four or five teeth. In Figs. 236-248 I have given an analysis of a terminal bud.

Though the Elm flowers so freely the seeds seldom ripen. Mr. Boulger states¹ that this is the case also on the continent of Europe and in Asia.

¹ *Familiar Trees.*

AMENTACEÆ

This order comprises many of our forest trees—the Oak, Beech, Hornbeam, Birch, Poplars, Willows, etc. The flowers are generally monœcious or dicecious; they generally precede the leaves. Perianth none, or forming a mere border to the ovary. In some the fruits are winged (Birch), or carried on winged bracts (Hornbeam), or the seeds are provided with silky hairs (Willow, Poplar), and dispersed by the wind, an arrangement especially suitable in the case of trees; in others (Beech, Spanish Chestnut, Hazel, Oak) they are carried by animals. In several, for instance in the Hornbeam, Birch, Hazel, Willow, etc., as in the case of the Lime (*ante*, p. 31), the bud situated apparently at the end of the branchlets is in reality axillary, as is shown by the presence of a terminal scar, due to the fall of the true terminal bud. The genera here included in Amentaceæ are separated in recent systems of classification under the orders Myricaceæ (Myrica), Corylaceæ (Alnus, Betula, Corylus, Carpinus), Fagaceæ (Fagus, Quercus, Castanea), Salicaceæ (Salix, Populus).

In my *Flowers, Fruits, and Leaves* I have devoted some space to the consideration of the arrangement and forms of the leaves in this family, and it will perhaps be more convenient to consider them here as a group than under the separate species. In the first place, let us consider the size of the leaf. On what does this depend? In herbs we very often see that the leaves decrease towards the end of the shoot, while in trees the leaves, though not identical, are much more uniform in size. If we take a twig of Hornbeam, we shall find that the six terminal leaves have together an area of about 14 square inches, and the section of the twig has a diameter of $\cdot 06$ of an inch. In the Beech the leaves are rather larger, six of them having an area of perhaps 18 inches, and corresponding with this greater leaf-surface we find that the

twig is somewhat stouter, say $\cdot 09$ of an inch. Following this up, we shall find that, *cæteris paribus*, the size of the leaf has relation to the thickness of the stem.

Of course, however, this is only approximate. Other things have to be taken into consideration. Strength, for instance, is an important element. If, for example, we compare the Beech and Hornbeam with the Lime (p. 31), the general plane of the leaves is again that of



FIG. 249.—Beech.



FIG. 250.—Spanish Chestnut.

the branch (Fig. 249); but the leaves themselves are ovate in form, and smaller, being only from 2 to 3 inches in length. On the other hand, the distance between the nodes is also smaller, being, say, $1\frac{1}{4}$ inch against something less than 2 inches. The diminution in length of the internode is not, indeed, exactly in proportion to that of the leaf, but, on the other hand, the leaf does not make so wide an angle with the stem. To this position is probably due the difference of form. The outline of the basal half of the leaf fits neatly to the branch, that of the upper half follows the edge of the leaf beyond, and the form of the inner edge being thus determined decides the outer one also. But it may be

said that the Spanish Chestnut (*Castanea sativa*, Fig. 250) also has alternate leaves in a plane parallel to that of the branch, and with internodes of very nearly the same length as the Beech. That is true; but, on the other hand, the terminal branches of the Spanish Chestnut are stouter in proportion. Thus, immediately below the sixth leaf, the Chestnut stalk may be $\cdot 15$ of an inch in thickness, that of the Beech not more than half as much. Consequently, the Chestnut could, of course, supposing the strength of the wood to be equal, bear a greater weight of leaf; but, the width of the leaf being determined by the distance between the nodes, the leaf is, so to say, compelled to draw itself out. Moreover, not only do the leaves on a single twig thus admirably fit in with one another, but they are also adapted to the ramification of the twigs themselves. Fig. 249 shows a bough of Beech seen from above, and it will be observed that the form of the leaves is such that, while but little space is lost, there is scarcely any overlapping. Each fits in perfectly with the rest.

The form of the Oak leaf is so familiar that it does not strike us as anything peculiar, and comparatively few of us, perhaps, have ever asked why it should be as it is; and yet it is peculiar, unlike that of any of our forest trees, and those of the evergreen Oaks so abundant in hotter countries. In botanical phraseology it is "deciduous, oblong-ob lanceolate, or oblong-elliptical, sinuated, with blunt lobes extending not more than half-way down to the midrib." The sinus between the lobes is generally rounded off at the bottom. Again, though I have not seen this mentioned in the botanical works which I have consulted, they are rarely symmetrical, the lobes of the two sides not corresponding. The three points, then, which give the Oak leaf its peculiar form are—

1. The deep rounded sinuses.
2. The want of symmetry of the two sides.
3. The obovate or oblanceolate outline.

The explanation which I have suggested is as follows:—The leaves of the evergreen Oak are entire, and small in comparison with those of the English Oak. During the winter and early spring they are protected by a series of brown scales, inside which they lie, forming the familiar buds, which are both small and short in proportion to the size of the leaves themselves. In cooler and moister regions, on the contrary, there is, as we know, a tendency for leaves to become larger and deciduous. These influences do not, however, affect the outer scales, which remain as before, without any increase of size. But as the leaves have increased in size and the buds have not, the leaves can no longer retain their original arrangement in the bud. If, for instance, we compare the buds of the Oak and of the Beech, we see that while the leaf of the Oak is longer than that of the Beech, the bud of the Oak (Fig. 271) is, on the contrary, shorter than that of the Beech (Fig. 253). Under these circumstances, what must happen? The leaf grows and becomes longer than the bud; it is therefore necessarily bent into a curve. But an entire leaf, if thus thrown into a curve, would necessarily fall into folds, the number being determined by the number of ribs or veins. For such folds, however, there would be no room within the narrow limits of a bud, or rather, perhaps, they would be inconvenient because they would leave more or less empty spaces. This may be rendered more clear by taking a piece of cloth or paper, folding it up, and then throwing it into a curve. It will then necessarily fall into one or more folds. If it were strengthened, as an Oak leaf is, by three or four side ribs, there would be a fold between each two ribs. As a matter of fact, however, from the absence of space the membrane where the fold would be is not actually developed. We may imitate this by removing them. If this be done, the result will be the formation of sinuses, rounded at the base, closely resembling those so characteristic of the Oak leaf. These sinuses are due,

then, as I believe, to the curvature of the leaf, owing to the shortness of the bud in comparison with the length of the leaf. The young leaf is not only curved, it is wrapped round the interior leaves. The result of this is that one side of the leaf is folded within the other; the one therefore has more space than the other. The two sides of the leaf are, in fact, differently situated, and this, I believe, accounts for the second point—namely, the want of symmetry. The obovate form is an advantage in consequence of the way the leaves diverge from the stalk. I think, then, that the explanation I have suggested accounts for all these points, and beautifully explains the peculiar form assumed by the leaf.

The arrangement of the seeds is also very interesting. Fig. 252 is a diagram of a Nut with the parts somewhat separated from one another so as to show the relations more clearly. The micropyle (*m*) is at the apex of the seed.¹ The ovule, however, is not straight and orthotropous, which would be, or at any rate seem to be, the simplest arrangement. Quite the contrary, for we find a long placental axis (*pl*), which extends to the apex of the Nut, and from which starts a raphe (*r*), which returns about half-way back again to the place where the true attachment or chalaza (*ch*) is situated. I have in vain endeavoured to discover or imagine any circumstances which would render this complex arrangement specially adapted to present conditions. It would seem as if it would be simpler, and give Nature less trouble, if the ovule sat directly with its base on the stalk, thus doing away with both the placental axis (*pl*) and the raphe (*r*).

This view is strengthened by the fact that such an arrangement has actually been nearly attained by the Oak. The ovule in this genus is theoretically anatropous, but the placental axis and the raphe are both greatly shortened (Fig. 251), so that the distance which the nourishment has to traverse is much less,

¹ Avebury (Lubbock), *On Seedlings*, ii.

though the actual place of attachment remains the same. The Oak, in fact, seems to have appreciated the difficulties of the situation, and to have in great measure neutralised them. Is it fanciful to imagine that some ages hence the Oak may be practically orthotropous?

But why should these species be anatropous if it is an advantage to be orthotropous? On this question some light is thrown by the fact that while one seed only comes to maturity, the ovary contains originally



FIG. 251.—Fruit and seed of Oak.
a, placental axis; *ch*, chalaza;
m, micropyle; *o*, abortive ovule.

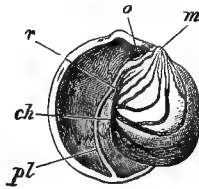


FIG. 252.—Fruit and seed of Nut. Nat. size. *ch*, chalaza; *m*, micropyle; *o*, abortive ovule; *pl*, placental axis; *r*, raphe.

several cells, each with one or two ovules, though none of the others comes to anything. They can, however, easily be seen, either at the apex of the seed, as in the Nut (Fig. 252) and Beech (*Fagus*), or, as in the Oak (Fig. 251), near the base. Their presence appears to indicate that these species are descended from ancestors the fruit of which was composed of several cells, each with more than one seed—a state of things, therefore, very unlike the present, and in which the anatropous condition would be an advantage. If this view be correct, the structure of the fruit in the Nut, Beech, and others becomes peculiarly interesting, because it represents a case in which the present arrangements are not those in all respects most convenient to the plant, and renders it probable that the same explanation may apply to other cases of difficulty.

MYRICA

Shrubs. Generally dioecious. The catkins hang down, thus protecting the pollen from wet.

M. Gale (Sweet Gale or Bog Myrtle).—The flowers are sometimes complete, but the stamens and pistils are generally on separate plants. Each male flower has 4 stamens. The pollen is pulverulent, and when it falls is held by the scales of the catkins until it is shaken by the wind. The leaves are glabrous or slightly hairy.

ALNUS (Alder)

Generally monoecious, but sometimes also with complete flowers. Pollen wind-borne.

A. glutinosa.—The male catkins are cylindrical; the female, ovoid. According to Kirchner the plants are protandrous, according to Kerner protogynous, while Macleod, in Belgium, found the male and female flowers appearing simultaneously. The petioles and under sides of the leaves are hairy. The young leaves are also protected by being sticky, whence the name.

FAGUS (Beech)

Monoecious protogynous wind flowers in globular catkins; the male pendulous, with 8-12 stamens, the female almost sessile. Nuts generally 2, enclosed in a hard prickly involucre, composed of the combined inner and outer bract-scales of the catkin. When they are ripe the involucre opens. The nuts are larger than those of the Hornbeam, and are intended to be carried by squirrels and other animals. Hence they differ from the fruit of the Hornbeam, which the Beech so much resembles—first, in the absence of a wing, which would be useless; secondly, in having a less hard coat; and thirdly, in being larger.

The bud of the Beech is very complex.¹ It is elongated, spindle-shaped, in winter half to three-quarters of

¹ Avebury (Lubbock), *Buds and Stipules*.

an inch in length ; on the outside are four closely imbricating rows of stipules, arranged apparently in opposite decussate pairs (Fig. 253). I say apparently, because, as the leaves are alternate, it is possible that each pair of these stipules are really alternate, though so compressed as to appear to be opposite. The first pair (Fig. 254) are small, triangular, and pointed. The five following are also triangular, each rather larger than the preceding and more convolute, till they almost enclose the upper part of the bud. The lower ones are brown and coriaceous ; the upper membranous, and furnished with numerous straight, longitudinal, parallel slender veins running from the base to the apex. The covered parts are white, the exposed brown. The upper ones are fringed with long, recurved, silvery or satiny hairs. They are sometimes a brilliant pink or rose colour after expansion, but less often than those of the Hornbeam. The fifth and sixth pairs (Fig. 255) are ciliate with short hairs, and rolled round a considerable part of the bud. The seventh pair are half as long as the bud, but otherwise like the sixth ; the eighth pair, two-thirds as long as the bud ; the ninth, nearly as long as the bud, with silky hairs directed downwards, and the outer one of the two distinctly overlaps the inner. The tenth pair are as long as the bud, and each is convolute, so as to cover nine-tenths of the bud, or even more. The eleventh pair (Fig. 256) are similar, and almost meet at their edges. These eleven pairs of stipules show no traces of a leaf. Fig. 258 represents a bud after the removal of the first eleven pairs of stipules. About the twelfth pair there is a material change ; they (Fig. 259) are smaller, and between them is a leaf-blade ; this is about one-third as long as its stipules, concave on the inner face, and plicate along the course of the ascending lateral nerves. The thirteenth pair of stipules (Fig. 260) are rather narrower, especially at the base. The leaf is about half as long as the stipules. The fourteenth pair (Fig. 261) are much smaller, thinner, narrower, and unequal, the inner one being the smaller. The leaf



Fig. 253.



Fig. 254.



Fig. 255.

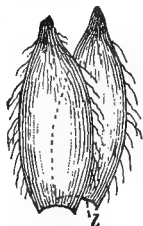


Fig. 256.



Fig. 257.

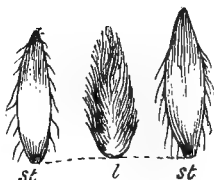


Fig. 259.



Fig. 258.

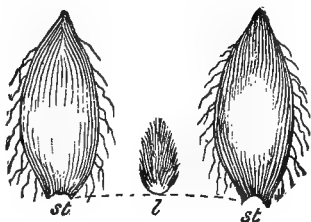


Fig. 260.

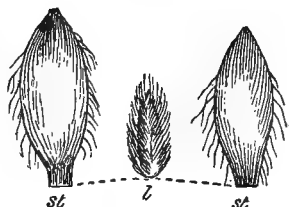


Fig. 261.



Fig. 262.



Fig. 263.



Fig. 264.

- FIG. 253.—The Beech. Winter bud.
 FIG. 254.—First or lowest pair of stipules.
 FIG. 255.—Sixth pair of stipules, overlapping at the corners.
 FIG. 256.—Eleventh pair of stipules, showing how one is rolled within the other; *l*, position where the leaf should be, though it is yet absent.
 FIG. 257.—Diagrammatic transverse section of the stipules, showing the extent to which they overlap.
 FIG. 258.—The bud after eleven pairs of stipules have been removed; *l*, the first leaf; *st st*, the twelfth pair of stipules; *ee*, the edges of the outer one of the twelfth pair.
 FIG. 259.—*st st*, the twelfth pair of stipules flattened out; *l*, the first leaf belonging to the same.
 FIG. 260.—*st st*, the thirteenth pair of stipules; *l*, the second leaf.
 FIG. 261.—*st st*, the fourteenth pair of stipules; *l*, the third leaf.
 FIG. 262.—*st*, the only stipule of the fifteenth pair discernible in this bud; *l*, the fourth leaf.
 FIG. 263.—No stipule discernible in the bud examined; *l*, the fifth and last leaf discernible, occupying the centre of the bud.
 FIG. 264.—Junction of the wood of two seasons' growth; *sc. st*, scars of the outer eleven pairs of stipules that covered the winter bud and which were unaccompanied by leaves.

is three-fourths as long as its stipules. The leaf (Fig. 262) belonging to the fifteenth pair is longer and more bulky than the stipule. The next leaf (Fig. 263) is large, deeply concave, or rolled into a cylinder occupying the centre of the bud, and densely covered with silky hairs on both surfaces, but particularly on the back, as are all the others.

The above description may be regarded as giving the average composition of the winter or resting bud of the Beech. Larger buds have a greater number of leaves and stipules; smaller buds, fewer. Strong shoots on vigorous young trees have more leaves, though the inner ones are small or but slightly developed in winter.

The buds gradually elongate. Before unfolding, they turn slightly upwards, but afterwards bend down. The long, narrow, pale-brown or straw-coloured stipules are thrown off when the leaves expand, and sometimes quite colour the ground under the tree. If the branch is examined, the scars where the stipules were inserted may be seen forming rings (Figs. 264) round the base of each annual shoot. The shoot elongates considerably between the leaves, but not between the leafless stipules, so that the stipular rings remain close together; they are very persistent, and can be traced for twenty-five years or more.

The Beech is one of the most interesting cases of the difference of structure of leaves in sunshine and in shade. They have been carefully studied by Stahl.¹ The leaf consists of an upper epidermis, of one or more layers of palisade cells, of a layer or layers of spongy parenchyma, and a lower epidermis. Fig. 265 represents a transverse section of a leaf grown in sunshine. There are two layers of long palisade cells. Fig. 266 represents a similar section of a leaf grown in shade. There is only one layer of palisade cells, which, moreover, are broader and much shorter. The parenchyma is also much reduced in thickness. The leaf is more delicate,

¹ *Jenaischer Zeitschr. f. Naturwiss.* xvi. (1882-83).

larger, and thinner, being 0.22 mm. in thickness against 0.35 mm.

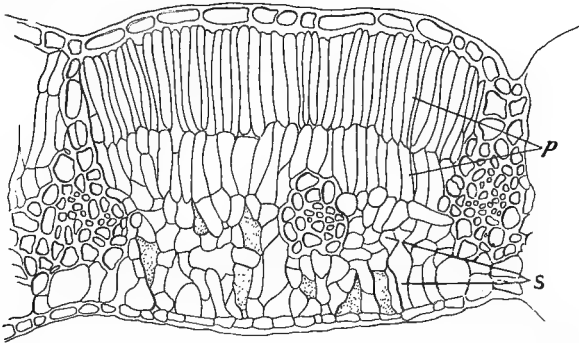


FIG. 265.—Transverse section of a Beech leaf grown in sunshine. Much enlarged. *p*, palisade layers; *s*, spongy parenchyma.

M. de Lamartière gives the following measurements as showing the contrast between leaves exposed to the sun and those growing in shade :—

	MICROMETRIC DIVISIONS, EACH CORRESPONDING TO $\frac{1}{1000}$ OF A MILLIMETRE.			
	OAK.		BEECH.	
	In sunlight.	In shade.	In sunlight.	In shade.
Upper epidermis	3	2	3	2
First layer of palisade	12	7	10	5
Second "	5	0	6	0
Spongy tissue	12	9	9	6
Lower epidermis	2	2	2	2
Total	34	20	30	15

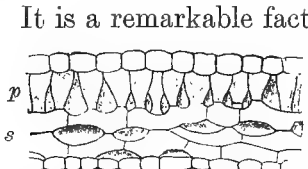


FIG. 266.—Transverse section of a Beech leaf grown in shade. *p*, palisade layer; *s*, spongy parenchyma.

It is a remarkable fact that the roots of many trees are covered by an evenly woven generally thin, but in some cases comparatively thick layer (Fig. 267), of mycelial filaments known as a mycorrhiza. This is not only no injury, but a positive benefit to the tree. There is, indeed,

some reason to doubt whether it could live without the assistance of the fungus. At any rate, attempts to rear seedlings of Beech and Fir in nutrient solutions have failed; and it seems fairly well established that the roots of the Beech and of many other trees suck up moisture and nutriment by help of the mycelium; and, on the other hand, the mycelium, no doubt, is nourished by taking toll of the sap of the Beech. To what species of fungus the mycelium belongs has not yet been ascertained.

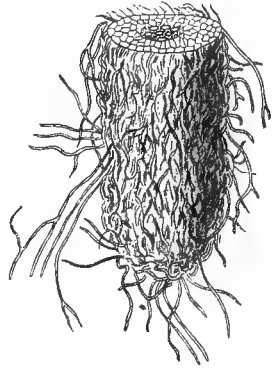


FIG. 267.—Tip of the root of a Beech with closely adherent mycelial mantle.



Fig. 268.

FIG. 268.—Buds of Spanish Chestnut. $\frac{1}{2}$ nat. size.



Fig. 269.

FIG. 269.—The second scale detached. $\times 4$.

The cupule forms a single chamber surrounded by four or five valves which open at their upper ends. The walls are composed of two distinct layers of woody cells. Those of the inner layer are elongated vertically, those of the outer are isodiametric. They therefore contract more, and thus open the valves.

CASTANEA (Spanish Chestnut)

The erect catkins, which flower when the tree is in full leaf, bear a few groups of female flowers at the base, and the male flowers above. Each female group consists of 3 flowers, the whole enveloped, as in Beech, by a cupule, formed from the four bracteoles. In the fruit the cupule forms a spiny envelope around the three nuts.

The Eating or Spanish Chestnut (*Castanea sativa*) has been cultivated in England since the Roman period.

The scales which protect the bud of *Castanea* are connate stipules. This is indicated by the indentation at the apex (Fig. 269), and the bud at the base.

QUERCUS (Oak)

Monœcious. Male flowers in slender pendulous catkins, with 6-12 stamens; female flowers solitary or clustered. Pollen wind-borne. According to Kerner the trees are protogynous.

Q. Robur.—Two forms are often regarded as distinct species—(1) *Q. Robur*, var. *pedunculata*, which has the leaves sessile or shortly stalked, and the fruits above the middle of a peduncle from 1 to 5 or 6 inches long; and (2) *Q. Robur*, var. *sessiflora*, with leaves on foot-stalks half an inch to one inch long, and fruits either sessile or on a peduncle rarely attaining an inch in length.

The leaves are pubescent when young, but afterwards glabrous. There are said to be about 500 species of insects which live on the Oak, in which connection we may mention the familiar Oak-apples, the result of an irritation set up



FIG. 270.—Shoot of Oak. Nat. size.

by a gall-insect. The cotyledons are subterranean, and the first few leaves are small scales. This is probably an advantage, as enabling the stem to grow longer and thus carry up the first foliaceous leaves above the surrounding herbage. The same reduction of the first few leaves to scales occurs in several other

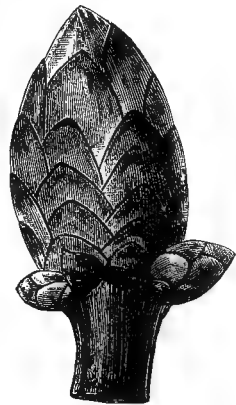


FIG. 271.—Oak bud. $\times 6$.

plants which have large seeds and subterranean cotyledons.

The buds of the Oak¹ (*Quercus pedunculata*) (Figs. 270, 271) are even more complicated than those already described. They are a rich brown, and make a beautiful contrast with the greyish-black of the stems. They are



Fig. 272. Fig. 273. Fig. 274. Fig. 275. Fig. 276. Fig. 277. Fig. 278. Fig. 279. Fig. 280.



Fig. 281. Fig. 282. Fig. 283. Fig. 284. Fig. 285. Fig. 286. Fig. 287.

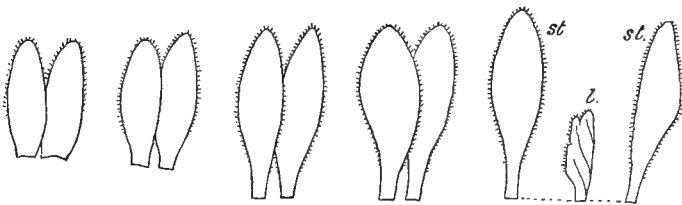


Fig. 288. Fig. 289. Fig. 290. Fig. 291. Fig. 292.

FIGS. 272-285.—*Quercus pedunculata*. Pairs of stipules forming the scales of the winter bud, sketched in the first week of May; some of them had small lateral buds between them, but no leaf; the bud had resumed growth, was oblong, and 16.5 mm. in length. $\times 2$.

FIGS. 286-292.—Stipules which had elongated when growth was resumed in spring. $\times 2$. *st.* stipules; *l.* leaf, conduplicate in bud, but not likely to attain any great size if it had been allowed to develop.

short and conical, and the colour, together with the arrangement of the scales, gives them a curious similarity to a miniature cone of a Pine. The buds differ considerably in size, but are comparatively short, broadest above the base but somewhat below the middle, covered with dry brown stipules arranged in five imbricating rows. The buds are slightly pentangular, each of the five angles being made up of one stipule from each of two contiguous and successive pairs. The pentangular

¹ Avebury (Lubbock), *Buds and Stipules*.

character of the bud is due to the leaves being on the two-fifths plan of arrangement. The centres of the stipules correspond with the angles, while the leaves lie in the middle of the flat surfaces. Figs. 272-292 show the succession of bud scales, of which, as will be seen, there are some forty before the first leaf is produced. For the form of the leaf, see *ante*, p. 362.

The three genera *Fagus*, *Castanea*, and *Quercus* have in the female flower three united carpels, forming

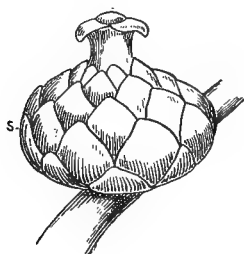


FIG. 293.—Young female flower of Oak enveloped by an involucre of scales, *s*, from which protrude the three stigmas. Much enlarged.



FIG. 294.—The same, cut lengthwise. Two of the ovary chambers have been opened by the section, exposing one ovule in each.

a three-chambered ovary, with two ovules in each chamber. The fruit is, however, one-seeded, as five of the six ovules do not form a seed. These genera are often placed in a separate order—*Fagaceæ*—from the following four, in which the pistil contains only two carpels, and which comprise the order *Corylaceæ*.

The cup surrounding the base of the acorn is formed from the union of a number of scales borne on the floral axis below the flower (Figs. 293, 294).

BETULA (Birch)

Flowers monœcious and protogynous. The pollen is wind-borne. The male and female catkins are not simple spikes, but compound inflorescences, each bract on the main axis subtending a group of three flowers. The fruits are surrounded by a scarious wing, and rest,

in groups of three, on the scales of the cone-like fruit. Each of the hardened cone-scales is formed by the union of the three bracts which subtend the group of female flowers (see Figs. 295, 296). We have two species—the Common Birch, a tree with pointed leaves (*B. alba*); and *B. nana*, a shrub with small orbicular leaves (see *Viola palustris*, p. 28). The colouring is rich and varied: the stems white and black, boughs coppery,

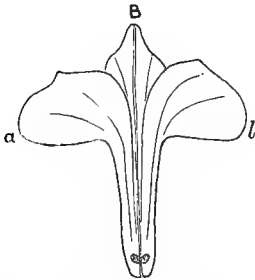


FIG. 295.—Cone-scale of Birch, formed by union of the bract *B*, and the pair of bracteoles, *a*, *b*. Much enlarged. See next figure.

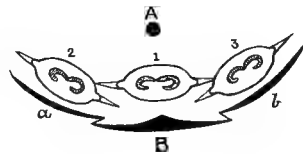


FIG. 296.—Diagram of a three-flowered group from the female catkin of Birch. *A*, position of axis of catkin; *B*, bract subtending the group of flowers; *a*, *b*, bracteoles; 1, median; 2 and 3, lateral flowers.

twigs purple, and leaves green or gold according to the variety and the season of year. The pleasant smell of Russian leather is said to be given by an oil distilled from the Common Birch.

CARPINUS (Hornbeam)

Monœcious wind flowers; males with about 12 stamens. The fruit is small, one-seeded, and very hard, attached to a long, leafy, unequally three-lobed bract, so that it is easily carried by wind.

C. Betulus.—A group of two flowers is borne in the axil of each bract of the female catkin (Figs. 297, 298). This group of two is comparable with the three-flowered group in Birch, the central flower being suppressed. The main bract *B*, subtending the group, plays no part in the formation of the cupule; the pair of three-lobed

wings, each with its fruit shown in Fig. 297, is homologous with a single cone-scale with its three-winged fruits in Birch. The bracteoles a' , b' are undeveloped in Birch. The leaves are pubescent below, on the nerves. The stem is somewhat flattened, and has a considerable

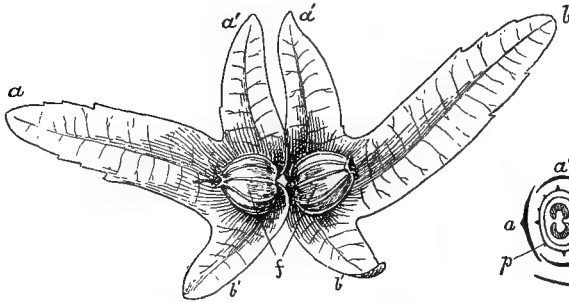


Fig. 297.

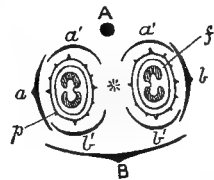


Fig. 298.

FIG. 297.—Pair of fruits of Hornbeam. a , b , a' , b' , bracteoles forming the wing; f , fruit. Somewhat enlarged.

FIG. 298.—Diagram of a pair of female flowers of Hornbeam. A , position of axis of catkin; B , bract subtending the pair of flowers; a , b , a' , b' , bracteoles enveloping each flower; p , rudimentary perianth; f , pistil of two carpels.

tendency to form buttresses. Bentham describes it as a small tree, but it often attains a considerable size. It is the most characteristic tree in Epping Forest, where, however, owing to exercise of ancient lopping rights, the individuals are generally much distorted.

CORYLUS (Hazel)

C. Avellana.—In this species some individuals are protandrous, and others protogynous. These, therefore, would naturally fertilise one another. The same arrangement also occurs in the Walnut (*Juglans*). The floral arrangement is the same as in Hornbeam (see Fig. 298), but the bracts a , a' , b' , and b , a' , b' , instead of forming a three-lobed wing, unite to form the characteristic cupule.

In the male flower the half-anthers in each stamen are distinct, giving the appearance of 8 stamens.

They are placed on a three-lobed scale formed by the union of the main bract *B* and the pair of secondary

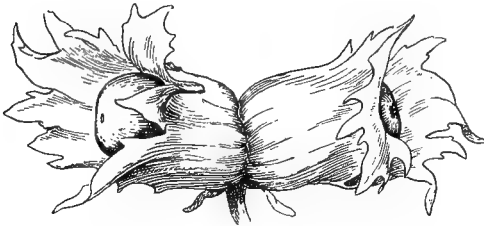


Fig. 299.

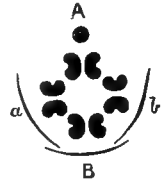
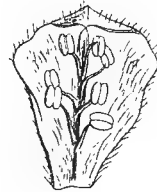


Fig. 300.

FIG. 299.—Pair of fruits of Hazel, each in its involucre.

FIG. 300.—Plan of arrangement of a male flower of Hazel. *A*, position of axis of catkin; *B*, bract subtending the flower; *a*, *b*, bracteoles.

bracts *a*, *b*. Compared with the arrangement in the female catkin, we may regard the single male flowers as

FIG. 301.—*Corylus Avellana*. Female flower.FIG. 302.—*Corylus Avellana*. Male flower

representing the lost median flower in the female group; in the male the lateral flowers are undeveloped.

The leaves are pubescent below.

SALIX (Willow)

A vast genus, particularly in the north. The flowers are dioecious, with half-concealed nectar, which is so abundant that the trees are much visited by insects. The flowers are very variable. The stipules are persistent or deciduous, and vary much in form. The arrangement of the leaves of the Willow is very instructive. They are in spiral whorls, and so shaped

that each whorl occupies the whole circumference. For instance, *S. herbacea* has a whorl of 3 nearly circular leaves; *S. Caprea*, with broad leaves, 5 in a whorl; *S. pentandra*, with lanceolate foliage, and 8, and *S. incana*, with 13 linear leaves arranged in 5 spirals. In several species the ascent of ants and other unwelcome visitors is prevented by a waxlike, smooth, and slippery secretion which they cannot scale. The seeds have a tuft of long white silky hairs which enable the wind or water to carry them about, and when at length they fall on damp earth serve to fasten them to it. The nectary bears in many cases a single large water-gland at the end, through which the nectar exudes.

I have described the buds of the Willow and Poplar in my *Buds and Stipules*. It is curious that in some species the young leaves are convolute, while in others they are "equitant." The more the genus is studied the more difficult, I might say the more impossible, does it become to divide it into well-marked species. The difficulty is increased by the facts that the male and female flowers are on different trees, which are often dissimilar, and that the leaves and flowers are out at different seasons of the year, and also by the readiness with which the species hybridise.

S. viminalis.—The stomata on the under side of the leaf are protected by silky hairs. The young stem is hairy, afterwards glabrous.

S. Caprea.—In this case the stomata are protected by short crisp, but not silky, down. The leaves are glabrous and shining above, tomentose below. The stems are at first tomentose, afterwards glabrous.

S. pentandra.—In this species stipules are sometimes present, sometimes absent.

S. herbacea.—The leaves of this species, which, like the two following, is an Alpine and Arctic form, are typical "snow-leaves" (see *Viola palustris*, p. 28).

S. reticulata.—This species also has rounded leaves, but the edges are entire. It is possible that this difference is due to the prevalence of rain rather than of

snow. The advantage of a toothed edge in snowy regions has been already indicated. On the other hand, teeth would retain moisture, and in wet regions, therefore, an entire edge tapering to the stalk is an advantage, because it carries off the moisture more rapidly. (See also *Cerastium alpinum*, p. 28.)

S. lanata.—This is also an Arctic and Alpine species. The stomata are protected by thick, soft, silky wool. This not only serves to prevent the stomata from becoming clogged, but also keeps a layer of comparatively warm air, thus protecting the leaf from extreme cold.

POPULUS (Poplar)

Diœcious, and, as a rule, wind flowers; they are, however, visited by bees for the sake of the pollen. We have three species. In *P. alba* the under side of the leaves is white, while in the other two both sides are green. *P. tremula* (Aspen) has orbicular or rhomboidal leaves with large teeth. In *P. nigra* (Black Poplar) the leaves are ovate triangular, tapering to a point, and with small teeth. It is not a true native. The seeds have a tuft of silky hairs which serve the same purposes as in the Willows. While in most species the stipules are caducous, or fall with the leaf, those of the terminal leaf in the Poplar are persistent, and assist in protecting the bud during winter. In *P. alba* and *P. tremula* the young shoots are downy, the female catkins dense, the bracteal scales fringed with hairs, and the stamens 4-12 in number. On the other hand, the leaves of *P. alba* are white and cottony underneath; those of *P. tremula* silky or smooth.

P. tremula (Aspen).—The leaves are green and glabrous underneath. There are two kinds. Those on the upper part of the tree have long petioles,



FIG. 303. — *Populus nigra*. Terminal winter bud, showing a pair of persistent stipules (*st*) belonging to a leaf of last season. $\times 2$.

and rounded blades with somewhat sinuate margins. Those on the radical shoots have shorter stalks and subtriangular laminæ; and the whole leaf is so arranged that the rain falling on it runs down towards the petiole. Here are two small cups which catch and hold it. The cells lining the cups have thin walls, and secrete a resinous substance which swells up when moistened. The thin-walled cells then absorb the moisture, but in dry weather are protected by the resinous varnish.

The mediæval explanation of the tremulousness of the leaves was the touching legend that the Cross was made of Aspen wood, and that the tree shivered ever afterwards at the recollection. It has been suggested that the movement helps to pump up the sap. Herbert Spencer suggested that in all cases the movement of leaves and branches by the wind was of use in this way, but the object of the tremulousness of the leaves in Poplars does not seem to be as yet clearly explained. It is due to the insertion of the blade on the vertically flattened leaf-stalk, as on a knife-edge.

P. nigra (Black Poplar).—The leaves are orbicular or rhomboidal, and rather coarsely toothed. They are ciliate, and silky on the under side when young, afterwards glabrous. The female catkins are lax, with scales nearly smooth; the male flowers have 12-20 stamens.

In most trees the stomata are situated mainly, if not entirely, on the under side of the leaves. In the Black Poplar, on the contrary, they are nearly as numerous on one side of the leaves as on the other. Now, why is this? If we compare the leaves of the Black and White Poplar, we shall be at once struck by the fact that, though these species are so nearly allied, the leaves are very different. In the White Poplar the upper and under sides are very unlike both in colour and texture, the under side being thickly clothed with cottony hairs. In the Black Poplar the upper and under surfaces are—which is not frequent—very similar in colour and texture. The petioles or leaf-stalks, again, are unlike

those of *P. nigra*, presenting the peculiarity of being much flattened at the end towards the leaf. The effect of the unusual structure of the petiole is that the leaf, instead of being horizontal, as in *P. alba* and most trees, hangs vertically; and this, again, explains the similarity of the two surfaces, because the result is that both surfaces are placed under nearly similar conditions as regards light and air. Again, it will be observed that if we attempt to arrange the leaves of the Black Poplar on one plane, they generally overlap one another; the extent is larger than can be displayed without their interfering with one another. In foliage arranged like that, for instance, of the Beech, Elm, Sycamore, or, in fact, of most of our trees, this would involve a certain amount of waste; but in the Black Poplar, as Fig. 304 shows, the leaves, when hung in their natural position, are quite detached from one another.

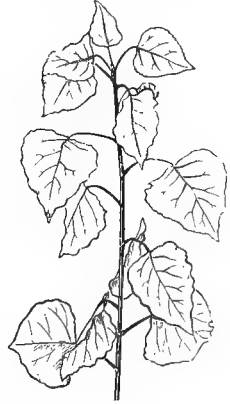


FIG. 304.—Black Poplar shoot.

Another peculiarity of the Black Poplar is that it not only sheds its leaves, but also some of the twigs or small branches. That these are thrown off, and not merely broken, is clear, because they are thickened at the base. It is said to have been only introduced into England in 1758.

CONIFERÆ

Wind flowers. The quantity of pollen is very considerable, and may be seen falling from the trees in yellow clouds. The grains are sometimes lightened by the presence of two air-sacs. The flowers are sometimes red in colour. This is perhaps a protection against cold. The seeds of the Pines and Firs are generally

winged and dispersed by wind. The berries of the Juniper are globular and of a dark purple blue; the seeds of the Yew are imbedded in a pulpy cup of a brilliant scarlet. Both are, no doubt, carried by birds.

The young cone makes its appearance, and the pollen is shed in the spring. The pollen is long-lived, and the development of the seed very slow. The pollen of *Pinus* remains dormant, or rather completing its development, for more than a year, and the ovule is not fertilised till the following July, more than twenty months after its commencement. The same occurs also in the Juniper. Two embryos start from each fertilised egg, so that several may be developed together in the early stages. Only one, however, comes ultimately to maturity. The cones open in dry weather, often at considerable intervals, so that the seeds are dispersed by the wind in various directions. A cone placed in a glass of water will soon become tightly closed.

The leaves are round (*Pinus monophylla*), semi-circular, or triangular. Some are much longer than others. Why is this? I puzzled over it for some time. The governing consideration is, I believe, to secure a suitable amount of leaf surface. They are all evergreen, but in some cases the leaves of one year fall soon after those of the next are developed. In others they are longer lived. In the Scotch Pine they last three or even four years; in the Norway Fir eight or ten; in the Pinsapo even as many as sixteen to eighteen. Now, speaking roughly, and having regard also to the stoutness of the terminal shoots, it will be found that the shorter leaves have longer lives, and *vice versa*. The longest-lived leaves amongst the Coniferæ which I know are those of *Abies Pinsapo*, which last some eighteen or twenty years. Those of *Welwitschia*, a member of the order Gnetaceæ, however, are said to reach even a century. This remarkable genus¹ is represented by a single species inhabiting the desert country in south-west tropical Africa. It has a short thick stem like a

¹ Described by Sir J. Hooker in *Trans. Linn. Soc.* xxiv. (1863).

huge wooden radish, and bears only one pair of long ribbon leaves a yard or more in length.

The cotyledons are long and narrow, varying in number from two to nearly twenty; when numerous they seem to form a tuft. The Conifers are a very ancient group, dating back to the later Palæozoic periods.

PINUS

This genus includes those Abietinæ in which both shoots and leaves are dimorphic; or, as regards the leaves, polymorphic.¹ There are about seventy species, spread mainly over the north temperate region, and nearly equally divided between the New and the Old World. The extension shoots grow rapidly, and during the season more or less continuously, and are elongated. The lateral shoots are either elongate or short and thick, forming "spurs." These are axillary shoots, which grow slowly and are soon arrested in their growth, so that they do not materially lengthen between the nodes, and probably serve as store-places for reserve food or for water. They are surrounded by bud scales. There are three principal forms of leaves: the cotyledons; the primordial leaves, which are often mere scales; and the adult leaves, which are sometimes single (*P. monophylla*), but generally arranged in tufts of two, three, or five (rarely more), on the ends of the spurs. The number in a tuft is, as a rule, constant in each species.

P. sylvestris (Scotch Pine).—The leaves are borne in pairs on the dwarf shoots. The seeds have a wing, formed by the separation of a layer from the upper face of the mature cone scale. The pollen grains, which are carried by the wind, are lightened by having a hemispherical bladder at each end. The upper side of each stamen is saucer-shaped, and, as the stamens are one over the other, when the anther opens the pollen falls into the saucer of the stamen below, where it remains till it is jerked out by the next gust of wind. The quantity of pollen produced by Pine

¹ Masters, "A General View of the Genus Pinus," *Journ. Linn. Soc. (Bot.)* xxxv. (1904).

trees is amazing. It is formed in the spring, remains dormant in the mouth of the ovule all through the summer, autumn, and winter, and rouses itself to fertilise the ovule in the following spring. The fruits open under the influence of dry winds, which carry off and scatter the winged seeds.

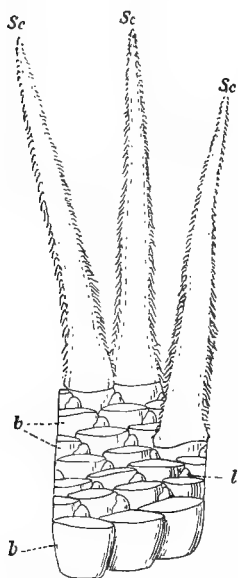


FIG. 305.—*Pinus sylvestris*. Fragment of terminal bud representing seven tiers of scales of the winter bud, $\times 6$. *sc*, three scales with their fringed membranous margin, the rest have been removed; *b*, persistent bases of scales; *l*, buds of secondary leaves in the axils of the primary.

The bud¹ is covered by brown elongated scales, which are spirally arranged on the axis, and represent the primary leaves. They rest on a pedestal or base (Figs. 305, 306), which in the winter is green, and from which they are easily stripped off, leaving a whitish scar. The bud may be divided into three parts (Fig. 307). The lower, which occupies from one-fifth to one-tenth of the length, is somewhat narrower than the rest (*sc'*). No needles are developed on this part of the bud. The middle portion (*sc*) is the longest, and, when the brown portion of the primary leaves has been stripped off, has, from their spiral arrangement, very much the appearance of an elongated cone. At the base of each pedestal is a small axillary bud, bearing the secondary leaves or needles in pairs (Fig. 305, *l*). At the apex are the terminal (*tb''*) and lateral buds (*lb*) for next year.

The brown terminal part of the primary leaves is thrown off in spring, and these secondary leaves form the needles. The brown primary leaves are thicker towards the centre, and thin off towards the edges. They consist of diverging fibres



FIG. 306.—*Pinus sylvestris*. A detached scale-base.

¹ Avebury (Lubbock), *On Buds and Stipules*.

connected by a thin membrane. Towards the edges the fibres turn suddenly backwards, and are frayed at the edges, forming an interlacing tissue which helps to strengthen the bud (Fig. 305, *sc*). These scales are very numerous. Some of the outer ones are truncate (Fig. 308). These are followed by a few that are triangular-subulate and acuminate. Succeeding scales pass quickly from triangular to decidedly subulate forms, which are more or less revolute at the tip. They are followed by a few more which are linear, with a subulate base, and revolute at the tip. These scales with revolute tips are followed by a dense mass of others which are subulate-linear, acuminate, straight, and closely appressed to the bud. If a large terminal bud (Fig. 308, *t*) is taken, and the scales removed, it will be seen that the bud includes the whole

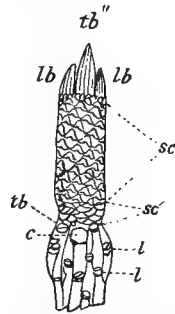


FIG. 307.—*Pinus sylvestris*. Terminal bud. *c*, point of insertion of a female cone; *l*, base of pair of needles; *lb*, lateral bud; *sc*, bases of primary leaf scales which have been removed, revealing the axillary foliage-leaf buds; *sc'*, lower portion of bud in which no needles are developed; *tb*, extreme base of terminal bud; *tb''*, terminal bud of next year.



FIG. 308.—Apex of branch. $\times 2$. *t*, terminal bud; *a*, axillary buds at the base of the terminal; *l*, base of pair of secondary leaves or needles.

of the plan of growth for the two succeeding years (Fig. 307).

The scales themselves are the primary leaves of next summer's shoot; and their obovate persistent bases constitute the persistent scales upon the primary axis. In the axils of these persistent portions, which are green in winter, we find the axillary buds which go to form the secondary shoots upon the resumption of growth in spring. In those buds containing male catkins, the latter are

equivalent to axillary shoots, and occupy the lower portion of the axis of the bud; while the perfect leaves

are similarly accommodated, but higher up the axis of the large resting winter bud.

PICEA

P. excelsa (Spruce or Norway Fir).—Commonly planted in Britain, but not native. In this species the true bud scales are inserted on a “common ringlike wall of tissue investing the base of the bud; when the bud bursts, this ring separates off below, and the whole mass of scales is carried up on the elongating bud, like a cap.”¹ There are about twenty species, all in the north temperate region. This is well named *excelsa*, as it is said to be the loftiest of European trees, reaching a height of 150, or even 180 feet. The cones contain from 300 to 350 seeds. After fertilisation they become pendent, and in the following spring the scales open, the seeds drop out and are wafted away by the wind, after which the rest of the cone drops off whole, and does not break up like that of the Silver Fir.

The winter buds (Fig. 309) vary greatly in size, those at the apex and immediately beneath it being strongest on the leading branches; they are also the first to resume growth in the spring. All are covered with numerous scales, which consist of modified leaves. The actual number of scales varies greatly, according to the size of the bud. The accompanying figures would represent buds and scales about the middle of April, after growth has recommenced. The outer scales are the most coriaceous, and elongate slightly or not at all; the inner ones are transparent and membranous, elongating considerably in spring. The true leaf (Fig. 310) consists of a lamina, which becomes disarticulated, when about to fall, from a short persistent portion or pedestal surmounting a basal portion which is decurrent upon the axis. Fig. 311 shows a small, slightly modified leaf—a form which occurs but sparingly. The basal portion of the bud is covered with broad, triangular, acuminate scales (Figs. 312, 313), with a more

¹ Marshall Ward, *Trees*, pt. i.

or less evident midrib, which seem to consist of the whole leaf modified. These are followed by a few oblong obtuse, or subacute scales (Figs. 314, 315) which

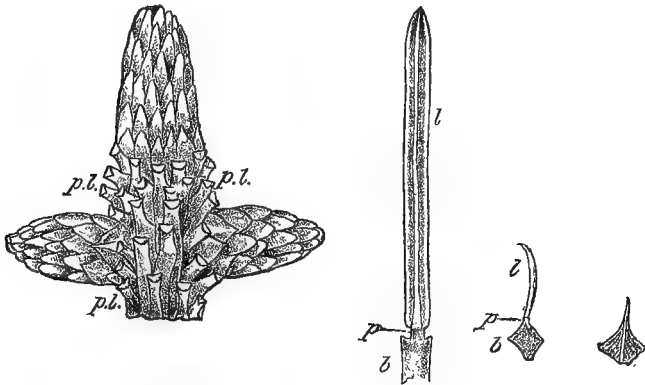


Fig. 309.

Fig. 310. Fig. 311. Fig. 312.

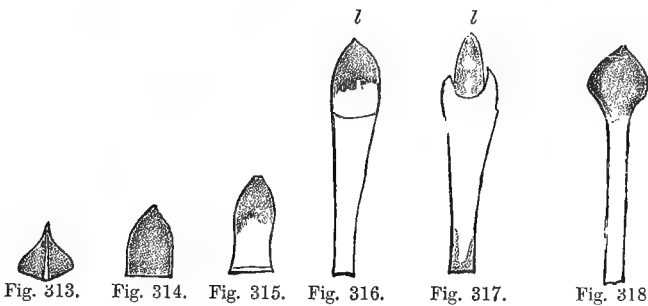


Fig. 313.

Fig. 314.

Fig. 315.

Fig. 316.

Fig. 317.

Fig. 318.

FIG. 309.—Apical and two lateral buds. *p.l.*, pedestals of leaves after the green portion has been removed.

FIG. 310.—Normal and perfect leaf. *l*, leaf; *p*, pedestal; *b*, basal portion decurrent upon the axis.

FIG. 311.—Slightly modified small leaf. *l*, leaf; *p* and *b*, pedestal and base merged in one another.

FIGS. 312, 313.—Leaves now modified to triangular acuminate scales with a midrib. FIGS. 314, 315.—Succeeding forms of scales.

FIGS. 316-318.—Inner scales after they have elongated, about the middle of April.

l, l, in Figs. 316, 317, would seem to represent the lamina, surmounting elongated pedestals; the same portion in Fig. 318 is hooded over the apex of the bud; the lower portions are membranous and transparent.

are still coriaceous; the inner ones elongate slightly in spring.¹

The innermost scales (Figs. 316-318) are as long

¹ Awebury, *On Buds and Stipules*.

as the bud, or nearly so; but after the resumption of growth they soon extend beyond the coriaceous ones, keeping pace for a time with the elongated axis, and completely enclosing the young true leaves. These inner scales elongate chiefly in the lower portion, which seems to correspond to the pedestal. They are, on the whole, more or less spatulate, but vary in form, and the apical portion may be regarded as corresponding to the lamina, because there is generally a trace of a joint or articulation. This apical portion is slightly more coriaceous and browner than the long and very membranous lower portion. Some of the inner scales are more or less evidently trifid (Fig. 317) or tridentate, the lateral lobes appearing to correspond to the shoulders seen below the pedestal of the normal and perfect leaf. The innermost scales (Fig. 318) are suddenly widened at the apex, forming a hood or cap rolled round the apex of the bud, and completely covering and protecting the young leaves. The stomata are arranged in two series on the under side of the leaf, and are protected by a waxy secretion, which gives rise to two white stripes. The seeds take two seasons to ripen.

The "witches' brooms" which sometimes appear on Silver Firs are caused by the growth of a fungus, *Æcidium elatinum*.

JUNIPERUS (Juniper)

J. communis.—In this species also the stomata are arranged in two series and protected by a waxy secretion, so that the leaves have two white stripes on the upper surface. The leaves are linear, spreading and ending in a stiff point. In hot dry countries many species have scale-like leaves closely appressed to the stem, and partly covered by other leaves, which diminishes the transpiring surface. That the narrow spreading leaves are the original form is shown by the fact that in the species with scale-like appressed leaves the seedlings have linear spreading ones, and only afterwards produce the other form. In some species,

J. chinensis, for instance, the two tendencies are so nearly balanced, that while the general form is broad and appressed, some branches or twigs, generally in the lower and shaded parts of the tree, bear narrow spreading leaves.

The tube of the pollen grain branches, and fertilises several egg cells. This is very unusual.

Botanists variously estimate from twenty-five to fifty species, mainly in the Mediterranean region and the North Atlantic Islands.

TAXUS (Yew)

There are six to eight species, all in the north temperate zone. The name is said to be derived from a Celtic word *Jw* = green.

T. baccata.—When the anthers open the pollen falls into a sort of pocket, where it lies quietly till there is some wind, when it is thrown out. Generally it is dioecious, but occasionally male and female flowers occur on the same tree, and even on the same branch.¹

MONOCOTYLEDONS

TYPHACEÆ

TYPHA (Bulrush)

Monœcious wind flowers. We have two species. In one, *T. latifolia* (Reed-mace), often called Bulrush, the flowers are in an almost continuous spike; in the smaller species, *T. angustifolia*, there is a distinct interval between the upper (male) and lower (female) flowers. The minute one-seeded fruits are raised on a long thread-like stalk which bears long silky hairs, ensuring the ready dispersal of the fruit by the wind.

The "Bulrushes" in which Moses was concealed

¹ Lowe, *The Yew Trees of Great Britain*.

were probably the Papyrus (*Papyrus antiquorum* a member of the Cyperaceæ), which would be plentiful in the river Nile.

SPARGANIUM

Protogynous, monœcious wind flowers, in globular heads. We have three species. One, *S. ramosum*, has the inflorescence branched; in the other two it is simple—one, *S. simplex*, has short, the other, *S. minimum*, long styles.

AROIDEÆ

ARUM

Monœcious, protogynous fly-trap flowers. The spike is half concealed in the large leaf or spathe, only the purplish or yellow club-shaped top appearing. The spike supports a number of pistils (Fig. 319, *p*) near the base, and of anthers (*a*) somewhat higher. Now in this case nothing would at first sight seem easier or more natural than that the pollen from the anthers should fall on, and fertilise, the pistils. This, however, is not what occurs. The stigmas mature before the anthers, and by the time the pollen is shed, have become incapable of fertilisation. It is impossible, therefore, that the plant should fertilise itself. Nor can the pollen be carried by wind. When it is shed it drops to the bottom of the tube, where it is so effectually sheltered that nothing short of a hurricane could dislodge it; and although *Arum* is common enough, still the chances against any of the pollen so dislodged being blown into the tube of another plant would be immense.

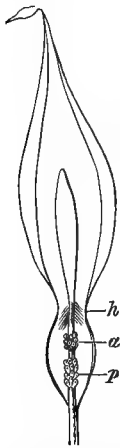


FIG. 319.—Diagrammatic section of inflorescence of *Arum*. *a*, anthers; *h*, hairs; *p*, pistils.

As, however, in *Aristolochia*, so also in *Arum*, small flies, especially those belonging to the genus *Psychoda*, attracted by the showy central spadix, the peculiar smell, the prospect of honey, and perhaps of shelter, enter the tube while the stigmas are mature, and find themselves imprisoned by the fringe of hairs (Fig. 319, *h*), which, while permitting their entrance, prevent them from returning. After a while, however, the period of maturity of the stigmas is over, and each secretes a drop of honey, thus repaying the insects for their captivity. The anthers then ripen and shed their pollen, which falls on and adheres to the insects. Then the hairs gradually shrivel up and set the insects free, which carry the pollen with them, so that those which then visit another plant can hardly fail to deposit some of it on the stigmas. Often more than a hundred small flies will be found, and in one case Knuth counted no less than 4000 in a single *Arum*.

Another explanation of the floral mechanism in *Arum maculatum* has recently been suggested by Father Gerard.¹ He considers that the honey secreted by the stigmas has a stupefying effect on the insects, which are killed and ultimately digested in the interior of the spathe. The insectivorous habit is deduced from the presence of dried remains of flies on the walls of the cavity. Schnetzler² had previously claimed a similar insectivorous habit for *Arum crinitum*. Self-pollination is not, he thinks, precluded in *A. maculatum*, some of the stigmas being still functional when the anthers dehisce.

The Aroids are mainly tropical. As regards the leaves, see *Dentaria* (p. 80) and *Petasites* (p. 236).

A. italicum appears to be the plant of our flora in which the temperature relatively to that of the atmosphere rises highest. The evolution of heat which accompanies the vigorous activity of vital processes connected with flowering, was noticed in this species by Lamarck, and quantitative experiments have been made

¹ *Journ. Bot.* August 1905.

² *Ann. and Mag. Nat. Hist.* Ser. 5, iv. 1879, p. 399.

by various workers in plant physiology.¹ Kerner records that when the outside air was 15° C. the interior of the spathe rose to 40° or even 44°.

ACORUS (Sweet Flag)

Protogynous, complete flowers forming a spike. Perianth consisting of 6 short scales, with 6 stamens.

A. Calamus.—The spike contains many hundred flowers. It never, however, produces ripe fruit in Europe, though it does so in Asia. It is probable that this is due to the absence of the proper insects for fertilisation. Ludwig, on the other hand, accounts for it by suggesting that all our European plants are descended from a specimen brought from the east by Clusius. Bentham, however, regards it as native in some of our eastern counties.

LEMNACEÆ²

Small floating plants of remarkably simple structure, consisting of repeatedly branching so-called "fronds," which show no distinction of stem and leaf. In *Wolffia* there are no roots, or vascular tissue, the plant consisting of little green cellular cushions. The flowers, which are very rare, appear in a fissure at the edge of the shoot. They are reduced to a small spathe-like bract enclosing one or two stamens, and a pistil (Fig. 320).

LEMNA (Duckweed)

We have four species. *L. polyrhiza* has the roots in clusters. In the other three they are single. *L. trisulca* has the fronds very thin, oblong, or narrowed at one end. In the other two they are broadly ovate, in *L. minor* nearly flat, in *L. gibba* very thick and convex underneath. *L. trisulca* is submerged, the others float on the surface of the water.

¹ Vines, *Physiology of Plants*, p. 304.

² Hegelmaier, *Die Lemnaceen*. Leipzig, 1868.

L. minor is protogynous. The anthers, however, are ripe before the stigma has faded. Ludwig¹ believes that the pollen is carried by the small insects which are so abundant on the surface of still waters. The structure of the pollen, which is covered with small projections, favours this view. The plant generally increases by division of the fronds, but when it blossoms a number of flowers generally come out at once. This flowering in pulses occurs in other species in which the pollen is carried by wind or water.

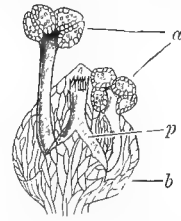


FIG. 320. — Flower of *Lemna trisulca*; much enlarged. *a*, anther; *b*, bract; *p*, pistil.

We have seen in the case of some preceding species that the leaves are arranged, and shaped, with reference to the supply of light and air. In this respect the transparent fronds of *Lemna* are very instructive, not indeed as regards their form or position, but with reference to the arrangement of the chlorophyll granules.

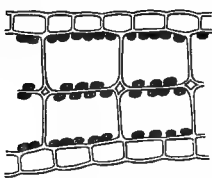


Fig. 321.

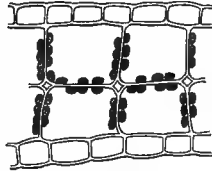


Fig. 322.

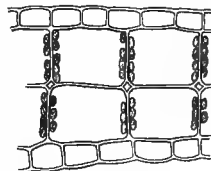


Fig. 323.

FIGS. 321-323. — Position of the chlorophyll granules in the cells of the ivy-leaved *Lemna* (*Lemna trisulca*). Fig. 321, in darkness; Fig. 322, in diffused light; Fig. 323, in direct sunlight.

In the dark (Fig. 321) the granules of chlorophyll arrange themselves on the side and inner walls of the cells; in direct sunlight, on the side walls (Fig. 323), so as to receive as little of the light as possible; while in diffused light (Fig. 322) they are placed so as to receive the maximum amount of light.²

Wolffia arrhiza, which occurs in ponds in the Home Counties, is the smallest known flowering plant; the shoots are only $\frac{1}{20}$ inch long.

¹ *Susswasserflora*.

² See *ante*, p. 138, *Oxalis*.

NAIADACEÆ

Floating or submerged plants, with very simple flowers. Pollen without extine.

ZOSTERA (Sea-grass)

Marine grass-like herbs, with flowers enclosed in a sheath near the base of the leaves, and always submerged. The pollen forms long slender thread-like tubes, the so-called confervoid pollen from its resemblance to an algal filament. The thin hair-like styles are exerted from the spathe to catch the pollen. We have two species—*Z. marina* with ribbed seeds, common in muddy and sandy estuaries, and *Z. nana* with smooth seeds, a much smaller and rare plant.

NAJAS

Small submerged herbs growing in fresh or brackish water, with a slender stem and small opposite leaves with a narrow blade and basal sheath. The flowers are unisexual. The male flower consists of an anther, closely surrounded by a thin membranous sac-like perianth. The pollen is spherical or oblong. The female flower is a more or less ellipsoidal ovary, produced into a narrow style with usually three stigmas.

We have two species, both very local. *N. marina* is diœcious, and *N. flexilis* monœcious.

N. marina is almost world-wide; but in Britain occurs only in one or two localities in the Norfolk Broads, though in prehistoric times it was more widely distributed.

N. flexilis is a North American species which has been found in several localities in Ireland, Scotland, and on the Continent.

Mr. Clement Reid's discovery of fossil seeds in recent beds indicates that these species were once more generally distributed in Britain, and also the presence of two other species—*N. minor*, which is now widely spread in Europe and Asia, and *N. graminea*,

common in the tropics of the old world, and finding its present northern limit in the Mediterranean area.¹

ZANNICHELLIA

Z. palustris (Horned Pondweed) is more or less common in fresh or brackish water, in temperate and tropical regions all over the world. The plants are submerged. The long-stalked male flowers consist merely of one or two stamens; the female, of single free or shortly-stalked carpels, collected in groups of four or fewer, and surrounded by a cup-like or entire spathe. The pollen is spherical.

RUPPIA

R. maritima is widely distributed in salt and brackish water in the temperate and tropical zones. The simple hermaphrodite flowers are enclosed in the broad swollen sheaths of the two uppermost foliage leaves up to the time of flowering, but are then raised to the surface by elongation of the peduncle, which lengthens still further after fertilisation, and often becomes spirally coiled. The pollen is bow-shaped and floated by the water to the stigmas.

POTAMOGETON (Pondweed)

Protogynous wind flowers. Parts of the flower in fours. The flowers are borne in spikes which rise above the water. Some botanists make fifty species, of which no less than twenty-one are British. Others, however, reduce the number considerably; Bentham reduces ours to nine—probably too low an estimate.

In *P. crispus* shoots with short leaves quite unlike the usual form are developed in autumn at the ends of some of the branches, detach themselves from the mother plant, sink to the bottom, and root in the mud.

P. natans.—This species affords a good illustration of the way in which the chlorophyll grains adapt

¹ Rendle, "British Species of *Najas*," in *Journal of Botany*, 1900.

themselves to changes in the intensity of light by altering their shape. Figs. 324, 326 are two palisade cells, seen in section in Figs. 325, 327. In diffused light the grains are hemispherical or even somewhat contracted at the base. In sunshine they flatten themselves out, and thus receive less light.¹

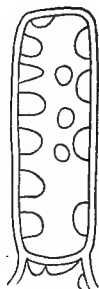


Fig. 324.

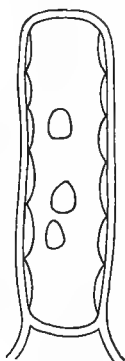


Fig. 326.

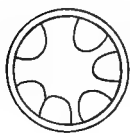


Fig. 325.

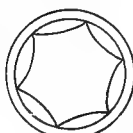


Fig. 327.

FIG. 324.—Palisade cell of *Potamogeton natans* in diffused light.

FIG. 325.—Section of same.

FIG. 326.—A similar palisade cell in sunshine.

FIG. 327.—Section of same.

ALISMACEÆ

Perianth of 6 segments; stamens 6, 9, or indefinite; ovary with 3, 6, or many carpels.

BUTOMUS (Flowering Rush)

Nectar abundant, secreted by the base of the ovary.

B. umbellatus.—The flowers are large, rose-coloured, often 20-30 in an umbel, and about an inch in diameter, with 6 perianth leaves, 9 stamens, and 6 carpels. According to Sprengel the anthers all shed their pollen before the stigma is ripe, so that self-fertilisation is impossible. On the other hand, H. Müller says that the anthers are still covered with pollen when the stigma is ripe. Schulz near Halle found the anthers and stigma ripe simultaneously. In the plants examined by Knuth the six anthers which alternate with the segments of the perianth ripen first and shed their pollen. Then the other three anthers open, and soon after the stigmas are ripe. These are all such good observers that the plants probably differ in different localities or seasons.

¹ See also *Oxalis*, *Lemna*, *Fagus*.

SAGITTARIA

Monœcious pollen flowers without nectar.

S. sagittifolia (Arrowhead).—There are three kinds of leaves. Those which are submerged are ribbon-shaped; the swimming ones, heart-shaped; those which rise into the air, arrow-shaped. The submerged leaves are very thin, and, as Frank has shown,¹ the chlorophyll grains arrange themselves in the cell according to the light, almost as in Lemna (see *ante*, p. 393). Moreover, they are somewhat flat, and with the same object alter their angle according to circumstances. The seeds are shining, and are not wetted by water; the result is that they float on the surface and are dispersed by currents.

ALISMA

White or reddish flowers with half-concealed nectar, secreted by a ring at the base of the stamens. There are three British species. *A. Plantago* has numerous flowers in a loose panicle. The other two have few flowers. *A. ranunculoides* is an erect or creeping plant; *A. natans* floats.

A. Plantago.—The flowers are homogamous; the anthers open outwards. They are principally visited by flies.

A. ranunculoides.—The secretion of nectar is less abundant.

A. natans.—A delicate floating plant very rare in Britain. Owing to its difference in habit it has been regarded by some botanists as a distinct genus, *Elisma*.

DAMASONIUM

D. stellatum (Star-fruit).—So called from the spreading fruits. It is a Western Mediterranean plant, which is sometimes found in gravelly ditches and pools in the South of England.

¹ Pringsheim's *Jahrbucher*, 1872.

TRIGLOCHIN

Perianth of 6 nearly equal segments. Stamens 6; carpels 3 or 6. Protogynous wind flowers. There are two British species—*T. palustre* with 3, *T. maritimum* with 6 carpels. The stigmas precede in maturity the anthers by two or three days. Underneath each stamen is a deeply concave perianth leaf, into the hollow of which, when the anther opens, the pollen falls. There it rests till the wind rises and it is thrown out. As in so many other wind flowers, the stigma is brush-like. The fruits are sharply pointed, diverging, and turned downwards, being attached by their summits to a stiff erect axis, so that they are easily brushed off by, and run into the fur or skin of, any passing animal.

HYDROCHARIDÆ

ELODEA

Tricecious water plants.

E. canadensis (Water-thyme).—This is a Canadian plant. It was introduced into Ireland about 1836, appearing in England in 1841, and became so well established as often to choke canals and streams. This rapid propagation was a purely vegetative one of the female plant. In Britain the male has only been found near Edinburgh.

HYDROCHARIS (Frogbit)

Dicecious plant, with half-concealed honey.

H. Morsus-ranæ.—The petals have a nectar scale at the base. The plant has no fixed roots, but floats loose on the water. The flowers rarely produce seeds; the plant throws off short shoots, which sink to the bottom, but rise again and develop in the following spring.

STRATIOTES (Water Soldier)

Diœcious, with half-concealed honey.

S. aloides.—The plant is protected from aquatic animals by sharp teeth along the edges of the leaf. The male flowers have about 12 fertile stamens, and 15–30 others which serve as honey glands. The female flowers have similar honey glands. It is said that in Northern Europe there are no male flowers, while in Holstein they are not infrequent. The increase is even with us mainly by offshoots. During the winter the plant remains at the bottom of the water. In spring it rises to the surface, producing fresh leaves, flowers, and floating roots. After flowering it again sinks. The seeds ripen in safety, and young plants are also produced at the end of long stalks which spring from between the leaves. Towards the end of August the plant rises a second time, and is at first surrounded by the young ones. The connecting stalks, however, die and decay, thus setting them free. Finally they all descend to the bottom for the winter.

ORCHIDACEÆ

This is one of the largest, most varied, most interesting, and most beautiful families in our whole flora. The homologies of the flowers were first pointed out in 1831 by our great botanist, Robert Brown.¹ The perianth consists of two whorls of 3 leaves; those of the outer whorl and two of the inner often form a sort of hood protecting the inner parts of the flower. The other petal is known as the labellum, and forms an alighting stage for insects. This petal would normally be uppermost, but the ovary is generally twisted, so that it becomes a lower lip. The stamens (represented only by the anthers) are normally 3, reduced, however, to 1,

¹ *Trans. Linn. Soc.* xvi.

or rarely 2. There are also normally 3 stigmas, the upper and central one of which is modified into a remarkable organ known as the rostellum (Figs. 328, 331). The anther and stigmas are borne in close proximity on a prolongation of the floral axis known as the column. The stigma is sticky. The pollen is generally

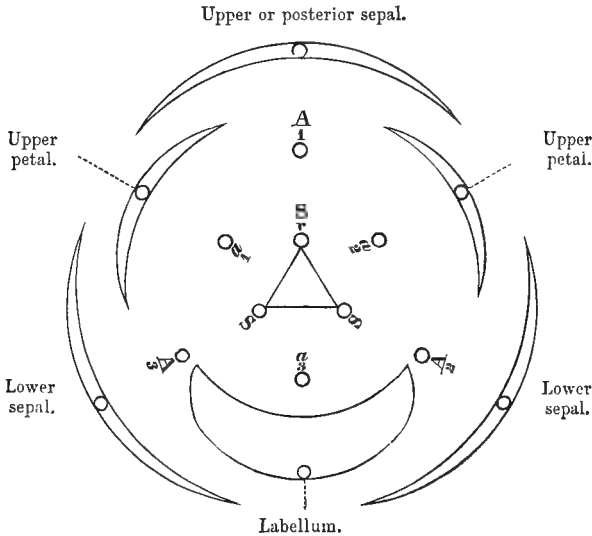


FIG. 328.—Section of the flower of an Orchid. *SS*, stigmas; *S_r*, stigma modified into the rostellum; *A₁*, fertile anther of the outer whorl; *A₂*, *A₃*, anthers of the same whorl sometimes present in the form of barren outgrowths (staminodes) of the column (as in *Orchis*), but generally absent; *a₁*, *a₂*, rudimentary anthers of the inner whorl fertile in *Cypripedium*, generally forming staminodial outgrowths of the column; *a₃*, third anther of the same whorl, normally suppressed, but occasionally present in abnormal flowers.

united by elastic threads, and forms one or two oblong or globular pollen masses. The flowers as a rule produce nectar, often contained in a spur.¹ In some cases (*Orchis*) the nectar does not transude, but the tissue must be bored to obtain the sweet juice. The flowers are very long-lived. Those of our wild orchids are said to retain their beauty often for a month, and some foreign ones for twice or even nearly three times as

¹ In one species, *Angraecum sesquipedale*, of Madagascar, the spur reaches a length of 18 inches.

long. Some foreign species have more than one kind of flower. The above diagram (Fig. 328) illustrates the structure of an orchid flower. The seeds are numerous, and very minute.

In some species the ovules are undeveloped or very rudimentary when the plant is in flower. According to Hildebrand,¹ in *Dendrobium* the formation of the ovules has not yet commenced, even the placentæ are not fully developed, and it is not till four months after the deposition of the pollen that the formation of the embryo begins.

ORCHIS

Of this genus we have ten species, of which *Orchis mascula* (Early Purple Orchis, Fig. 329) is perhaps the commonest, and I have therefore taken it as the type. It occurs in Southern and Central Europe as far as South Scandinavia. It is sometimes, but not always, scented. The leaves are spotted and broad. The flowers vary from pinkish purple to flesh-colour, sometimes pale or even white. They form a loose spike 3 to 6 inches long. Fig. 330 represents the side view of a flower from which all the petals and sepals have been removed, except the lip (*l*), half of which has been cut away, as well as the upper portion of the near side of the nectary (*n*). The pollen forms two masses (Figs. 331, *α*, and 332), each attached to a tapering stalk, which gives the whole an elongated pear-like form, and is attached to a round sticky disk (Fig. 332, *d*), which lies loosely in a cup-shaped envelope, the rostellum (*r*). This envelope is at first continuous, but the slightest touch



FIG. 329.—*Orchis mascula*.

¹ "On the Impregnation in Orchids," *Ann. of Nat. Hist.* xii. (1863).

causes it to rupture transversely, and thus to expose the two viscid balls (*dd*). Now suppose an insect visiting this flower: it alights on the lip (*l*), and pushing its proboscis down the spur it can hardly fail to bring

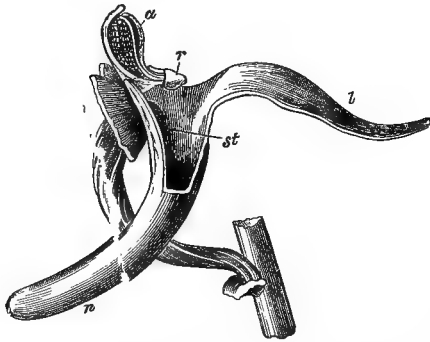


FIG. 330.—*Orchis mascula*. Side view of flower with petals and sepals cut off except the lip, of which the near half is cut away, as well as the upper portion of the near side of the nectary.

a, the pair of anther cells; *l*, labellum; *n*, nectary; *r*, rostellum; *st*, stigma.

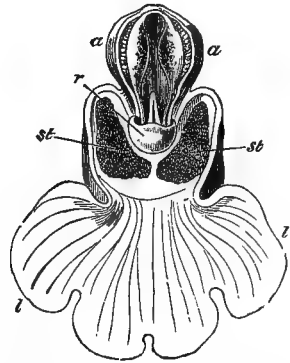


FIG. 331.—Front view of flower, with all sepals and petals removed except the lip.

the base of the proboscis into contact with the two viscid disks, which at once adhere to it, so that when the insect withdraws, it carries away the two pollen masses. It is easy to imitate this

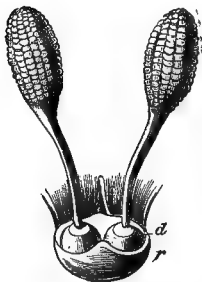


FIG. 332.—The two pollinia. *d*, viscid disc; *r*, ruptured rostellum.

with a piece of grass, and to carry away on it the two pollen masses and their stalks. If, however, the pollinium retained this erect position when the insect came to the next flower, it would simply be pushed into or against its old position. Instead, however, of remaining upright, the pollinia, by the contraction of the minute disk of membrane to which they are attached, gradually turn downwards and forwards, and thus when the insect sucks the next flower, the thick end of the club exactly strikes the stigmatic surfaces (*st, st*). The pollinium or pollen

mass consists of packets of pollen grains, fastened together by elastic threads. The stigma, however, is so viscid, that it pulls off some of these packets, and ruptures the threads, without removing the whole pollinium, so that one pollinium can fertilise several flowers.¹

This description applies in essentials not only to *Orchis mascula*, but also to *O. Morio*, *O. fusca*, *O. maculata*, and *O. latifolia*, as well as to *Aceras anthropophora* (Man Orchis) in all of which the pollinia undergo, after removal from the anther cells, the curious movement of depression which is necessary in order to place them in the right position to strike the stigmatic surface.

O. pyramidalis differs from the above group in several important points. The two stigmatic surfaces are quite distinct, and the rostellum is brought down so as to overhang and partly close the entrance to the nectary. The viscid disks which support the pollen masses are united into a single saddle-shaped body. The lower lip bears two prominent ridges, which serve to guide the proboscis of the insect into the orifice of the nectary. It is of course important that the proboscis should not enter obliquely, for in that case the pollen masses would not occupy exactly the right position. In this species the spur is too long and slender for bees, and the plant is specially adapted to butterflies and moths. It is sweet-scented. Darwin gives a list of twenty-three Lepidoptera which visit this species. One of them (*Caradrina*) had no less than eleven pairs of pollinia attached to its proboscis.

Following Darwin and other botanists, I have applied to the spur of *Orchis* the term "nectary." As a matter of fact, however, the flowers of this genus produce no honey; whence Sprengel applied to them the term *Scheinsaftblumen* or "Sham-honey-flowers." Darwin does not, however, think that moths (by which the flowers of this group are principally fertilised) could be so deceived for generation after generation; and as he has observed that the membrane of the interior of

¹ Avebury (Lubbock), *British Wild Flowers considered in relation to Insects*.

the spur is very delicate, and the cellular tissue extremely juicy, he suspected that insects possibly pierce the membrane, and suck the juicy sap lying beneath. His suggestion has been confirmed by H. Müller, and he himself in a subsequent memoir¹ speaks confidently on the point. Delpino, on the contrary, is confident that the species examined by him (*O. sambucina*, *O. Morio*, *O. mascula*, and *O. maculata*) do not secrete honey either on or under the epidermis. The weight of evidence, however, seems to be on the side of the suggestion made by Darwin. Considering, he observes, the incalculable number of plants which have been fertilised, "we cannot believe in so gigantic an imposture." The case of some flies is different, as they appear to be very stupid. To test the intelligence of moths he tried an ingenious experiment. He cut off about half the spur of six flowers out of twenty-one on a spike, and found that while thirteen out of the fifteen intact flowers had the pollinia removed, this was only the case with half of those with their nectaries removed. The result, however, though suggestive is not conclusive; and to make out a strong case the experiment would have to be tried on a larger scale.

However this may be, there is no doubt that the tissues between the two membranes of the nectary in *O. pyramidalis* contain a copious fluid; on the other hand, in allied species the spur of which contains abundance of nectar, as, for instance, *Gymnadenia conopsea* and *Habenaria bifolia*, the two membranes are close to one another. Darwin makes an ingenious suggestion to account for the difference. In the two latter species the disk is naked and remains permanently viscid. On the other hand, in *O. pyramidalis* the disk is covered with a pouch. When this is pushed away by an insect the disk rapidly becomes viscid, and gets hard in a few minutes. It would therefore be an advantage that the proboscis should be retained in place for a short time, so that the viscid matter might have time

¹ *Ann. and Mag. of Nat. Hist.*, 1869.

to set. Hence, perhaps, the reason which accounts for the insects being compelled to pierce the tissues, and suck out the sweet sap more slowly.

The seeds are small and numerous. Darwin states that one spike of *O. mascula* would produce over 186,000; and he calculates that if they all grew, the great-grandchildren of a single plant would be sufficient to clothe the entire earth with one uniform green carpet!

O. hircina (Lizard Orchis).—Though common in some parts of Europe, this species is very rare in England. It has been found in Kent and Surrey, but often only a single plant. Through the kindness of Mrs. Drax I saw one in 1899 at Ollantigh Towers, near Wye in Kent, but though a careful search was made only a single plant was found.

GYMNADENIA

G. conopsea.—This species has an even longer spur than *Orchis pyramidalis*, and is even more sweet-scented. The flowers are red or white; the red ones probably adapted to butterflies, the white ones to moths (see Lychnis, p. 107). It secretes so much nectar that the spur is sometimes half full. H. Müller records no less than twenty-six species of butterflies which he saw visiting this Orchid.

HABENARIA

This genus, in which *Gymnadenia* is generally included, hardly seems to me to be sufficiently distinct from *Orchis*. The main difference, says Bentham, is that "the anther cells, instead of converging at the base, are either parallel or more or less diverging."

H. chlorantha.—The flowers are greenish, and the spur is 23-43 mm. in length. The anther cells are widely separated; the pollinia slope backwards, and are much elongated; the viscid disk is circular, and prolonged on its imbedded side into a short drum-like pedicel. When exposed to the air this drum contracts on one

side, and alters the direction of the pollen mass, thus bringing it (as in *Orchis mascula*) into such a position, that it comes in contact with the stigmatic surface of the flower to which it is carried. The pollinia attach themselves at the side of the insect's face.

H. bifolia.—This is one of the white species which is especially adapted to moths, and is particularly sweet-scented at night. The spur is 13-20 mm. in length. It is regarded by Bentham and other high authorities as a mere variety of the last. Yet, as Darwin points out, it differs in many important particulars. The viscid disks are oval, and almost touch; the viscid matter itself is of somewhat different character; the drum-like pedicel is rudimentary; the stalk of the pollen mass is much shorter; the packets of pollen shorter and whiter; and the stigmatic surface more distinctly tripartite. It would certainly seem, therefore, that the two species are distinct. The pollinia attach themselves at the base of the proboscis, not on the side of the face.

H. albida.—In this species the spur is very short, but so narrow that it is probably adapted to small moths.

ACERAS

A. anthropophora (Man Orchis).—The arrangements of the flower resemble those of *O. mascula*.

HERMINIUM

The perianth has no spur, and the anther cells are distant at the base.

H. Monorchis.—The pollen masses are short and the disks large. It does not produce honey, but is very sweet-scented at night, so that it is probably a moth flower. G. Darwin, however, and H. Müller found it visited during the day by ichneumons and small beetles. The pollinia attach themselves to the joint between the femur and the trochanter of the first pair of legs.¹

¹ Darwin, *More Letters*.

OPHRYS

This genus resembles *Orchis*, but has no spur. We have three species. *O. apifera* resembles a bee in form, and generally has more or less pink sepals; while in *O. aranifera* they are green. *O. muscifera* has small, narrow, very dark flowers resembling a fly.

O. muscifera.—The lip is long and dark purple, and when the flower is just open secretes minute drops of nectar, becoming gradually covered by a thin layer, which, however, soon disappears. At each side of the base there are also two spots with a bright metallic lustre, which closely resemble drops of nectar, and are supposed by Sprengel and some observers to deceive flies and other small insects. Darwin observes that if he “could in any case believe in Sprengel’s ‘sham nectaries,’ I should believe it in this instance.”¹ I myself do so. The visits of insects are, however, very few. The plant is sometimes abundant in my woods, but I have never seen an insect visiting them. In one case there were a group of over a hundred all within five yards of one another, and I watched them for an hour in the middle of a bright summer’s day, but not a single insect came. It is certain, however, that they are visited by insects. Darwin found that out of 207 flowers which he examined, 88 had had one or both of their pollinia removed. Moreover, the plant is not self-fertile, and the result is that but few flowers set seeds.

O. apifera (Bee Orchis, Fig. 333).—This species is so named from its curious likeness to a humble bee. Robert Brown first observed that the Bee Orchis is adapted for self-fertilisation.² The stalks of the pollen masses are long, thin, flexible, and too weak to stand upright. The distance of the pollen masses from one another, and the shape of the pollen grains is, moreover, variable. The anther cells open soon after the flower expands, and the pear-shaped pollen masses drop out, so as to hang directly over the stigma, with which a breath of air is

¹ *Fertilisation of Orchids.*

² *Trans. Linn. Soc.* xvi. (1833).

sufficient to bring them in contact. While, therefore, in most species of *Orchis* and *Ophrys* self-fertilisation appears to be impossible, in the Bee *Orchis* it is carefully provided for. Darwin has examined hundreds of flowers, and has never seen reason in a single instance to believe that pollen had been brought from one flower to another; and he has met with very few cases in which the pollen mass failed to reach its own stigma. He has never seen an insect visit the flowers of this species, and R. Brown suggested that the resemblance of the flower to bees was to deter insects from visiting them. Darwin does not think this probable. Can it be to deter browsing quadrupeds? He believes also that, though this species habitually fertilises itself, the curious arrangements which



FIG. 333.—*Ophrys apifera*.

it possesses in common with other allied species are of use in securing an occasional cross, even if only at very long intervals.

MALAXIS

M. paludosa.—One of our smallest Orchids. As already mentioned the labellum is theoretically the upper petal, but assumes the position of a lower lip by the twisting of the ovary. In *Malaxis* it is in the normal position as an upper lip. That *Malaxis* has descended from Orchids in which the labellum was below, is, however, shown by the curious fact that it has taken its present place by a double twist, so that it now occupies the position it would have held had there been no twist at all. When ripe, the ovary gradually untwists. The edges of the leaves produce cellular bulbils, hence the leaves if placed in the ground develop new plants.

LIPARIS

L. Loeselii (Fen Orchis).—A small orchid with green flowers, found in spongy bogs in the eastern counties.

CORALLORHIZA

C. innata.—Brown or yellow plants without green leaves. They live in leaf-mould under trees, and have no true roots. The underground stem or rhizome consists of a number of short, thick, fleshy, nearly white branches, resembling a piece of coral. Rhizomes of this character occur in other genera, which are denizens of similar situations. They are associated with a mycorrhiza (see p. 371), which plays the part of root hairs in absorbing food from the humus.

NEOTTIA

A genus with brown stems and flowers, scales instead of leaves, and thick succulent rhizomes. The species live, like *Corallorhiza*, under trees, and root among the dead leaves. The flowers have free or half-concealed honey. The apex of the root, after forming rudimentary leaves, throws off the root cap and grows onwards as a stem.¹

N. Nidus-avis (Birds'-nest Orchis).—The flower agrees in essential points with *Listera* (see below, p. 411).

EPIPACTIS

We have two species—*E. palustris* with narrow, *E. latifolia* with broad leaves.

E. palustris.—The sepals are lanceolate and pale greenish purple, the petals white, streaked with pink. The long lip is in two parts connected by a narrow hinge. In the natural position the outer part of the lip partly closes the opening of the flower; when, however, an insect alights on it, it is pressed down.

E. latifolia.—The flowers vary from green to dingy purple. The free part of the lip is smaller than in the preceding species, and the connecting part is broader.

¹ Irmisch, *Biol. d. Orchideen*, 1853.

It is principally¹ visited by wasps; yet, according to Webster,² the visits are few and far between. My experience is the same.

EPIPOGUM

E. Gmelini.—This also is a brownish, leafless species, living among decaying leaves, and with a rhizome consisting of short, thick, fleshy branches, as in *Neottia* and *Corallorhiza*; the flower, however, differs considerably. The plant often goes several years without flowering. The flowers have a spur, secrete nectar, smell of *Vanilla*, and appear to be principally fertilised by humble bees. It is remarkable in not having its flowers inverted. It is one of our rarest British plants (a native of Herefordshire), but spread all over Europe from Sweden to North Italy.

CEPHALANTHERA

Flowers more or less erect, with incurved sepals and petals. We have three species—



FIG. 334.—*Cephalanthera grandiflora*.

C. rubra is red, the other two white; *C. grandiflora* (Fig. 334) with broad, *C. ensifolia* with sword-shaped leaves. The genus differs from those hitherto described in not possessing a rostellum, and in having the pollen grains single. The flower stands upright, and the labellum is formed of two portions: a base, and a small triangular flap, which at first closes the tube, then turns back, thus forming a small landing-place in front of a triangular door, situated half-way up the tube, and, lastly, rises up again and closes the

entrance. The pollen mass is extremely friable; it is

¹ Darwin says "exclusively," *Fertilisation of Orchids*.

² "On the Fertilisation of *Epipactis latifolia*," *Trans. Bot. Soc. Edinb.* xvi. (1886).

situated just above the stigma ; and while the flower is in bud, or at any rate before it becomes quite open, the anther opens and expels the pollen, which stands in two almost free columns, resting on the sharp edge of the stigma, and emits a number of tubes which deeply penetrate the stigmatic tissue. These serve partially, but, as Darwin has shown, only partially, to fertilise the flower ; he suggests that the principal use of this closing of the flower and emission of the pollen tubes is probably to support the pollen, which would otherwise fall out of the flower. In this curious manner, however, they are retained in a proper position until the flower is visited by insects, to which they readily adhere ; and which are necessary to ensure the perfect fertility of the plant. Darwin found that plants which were covered up only ripened one-seventh of the usual quantity of seeds.

C. ensifolia.—According to Delpino this species is always fertilised by insects. While sucking the nectar, or as the proboscis is drawn back, the insect slightly smears itself with the sticky fluid which clothes the stigma, and then pressing the anther, carries off some of the pollen, which it deposits on the stigma of the next flower it visits.

LISTERA (Twayblade)

A raceme of small greenish flowers, over a pair of leaves, which in *L. ovata* are 2-4 inches long, in *L. cordata* less than an inch.

L. ovata.—In the centre of the lip is a narrow nectar-secreting tract. The pollen is friable, and would not of itself adhere to insects, but the moment the rostellum is touched a drop of viscid fluid exudes on each side, and when the insect retires it is sure to touch the anther and carry off the pollen. It is principally visited by ichneumons, small beetles, and flies. Darwin several times saw insects enter the flower and afterwards retire with a pair of bright yellow pollinia sticking to their foreheads. The number of insect visitors is so large, having regard to the inconspicuousness of the flower,

that some naturalists have supposed it may have a scent which we do not perceive.

L. cordata.—The structure is essentially the same as in the previous species.

SPIRANTHES

We have three species. *S. autumnalis* has the radical leaves ovate or oblong; in the other two they are narrow. *S. æstivalis* has the flowers in one row, *S. cernua* in three.

S. autumnalis (Ladies' Tresses).—The flowers are upright, with a scent like that of a Hyacinth.

S. æstivalis.—Occurs in Britain only in bogs in the New Forest, and in Wyre Forest, Worcester.

S. cernua.—Only found in a peat bog near Castle-town in Cork County.

GOODYERA

G. repens.—Agrees generally with *Epipactis* in the arrangements for fertilisation. The seeds are numerous and very minute, only weighing $\cdot 00002$ of a gram.

CYPRIPEDIUM

Flowers few, large, with an inflated lip.

C. Calceolus (Ladies' Slipper).—The lower lip has the form of a slipper, whence the name. This genus has two fertile anthers, which are rudimentary in other Orchids, while the one which is functional in them is here represented by a singular shield-like body. The opening into the slipper is small, and partly closed by the stigma and this shield like body which lies between the other two anthers. The result is that the opening into the slipper has a horse-shoe-like form, and that bees or other insects which have once entered the slipper (Figs. 335, 336) have some difficulty in getting out again. While endeavouring to do so they can hardly fail to come in contact with the stigma, which lies under the shield-like representative of the middle anther. As the margins of the lip are inflected (*q*), the easiest exit

is at the two ends of the horse-shoe, and by one or other of these (Fig. 336, *e*) the insect generally escapes, in doing which, however, it almost inevitably comes in contact with, and carries off some of the pollen from the corresponding anther. The pollen of this genus is immersed in a viscid fluid, by means of which it adheres first to the insect, and secondly to the stigma, while in most Orchids it is the stigma which is viscid.

In a Trinidad species, *Coryanthes macrantha*,¹ the basal part of the lip forms a bucket, which secretes a copious

fluid which wets the wings of the bees, and by rendering them temporarily incapable of flight, compels them to creep out through the small passages close to the anther and stigma, thus securing, though by different means, the object which in *Cypripedium* is effected by the inflected margins of the labellum.

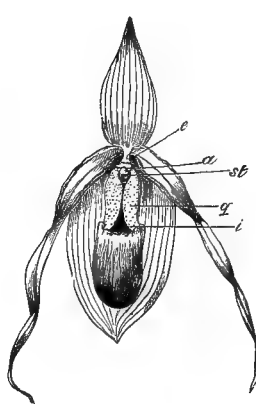


Fig. 335.

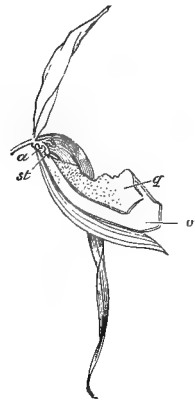


Fig. 336.

FIG. 335.—Flower of *Cypripedium Calceolus*. Front view.

FIG. 336.—Side view.

a, anther; *e*, exit; *i*, entrance; *o*, interior of lip; *q*, incurved edge of lip; *st*, stigma.

IRIDACEÆ

The conspicuousness of the flowers is sometimes considerably enhanced by the coloured styles and stigmas. Perianth 6-leaved, petaloid; springing from the top of the ovary. Stamens 3.

¹ See Crüger in *Journ. Linn. Soc.* viii. (1864).

CROCUS

Protandrous butterfly flowers. We have two species—one *C. vernus*, flowers in spring; the other, *C. nudiflorus*, in autumn.

C. vernus.—The flowers are white or purple, with stigmas of a rich orange. Nectar is secreted by the ovary, and is protected by hairs. The tube is much too long for the proboscis of any insects except Lepidoptera, but the nectar sometimes reaches so far up as to be accessible to some of the humble bees. There are two forms of the flower. A small flowered one, with stigmas as long as, or shorter than, the stamens; and a large flowered one with longer stigmas. The leaves in *Crocus* are arranged round the stem, not in two rows as usual in the order, and also, unlike those which characterise most of the genera, have a distinct upper and lower face, and the tissues of the leaf are markedly differentiated into palisade cells above, and spongy parenchyma below. When the leaves are young and tender they are rolled up, and do not flatten themselves till they are stronger, and in less danger from frost.

C. nudiflorus.—Areschoug and Massart have published¹ interesting memoirs on the means by which plants keep to a convenient depth. Plants of *Crocus* placed on the surface develop fleshy roots, which eventually contract and draw the corm down to a suitable level. On the other hand, if the light is excluded no such contraction takes place. As Raunkler says, "la plante est complètement désorientée dans l'obscurité."²

IRIS

The flowers are large and showy—the 3 outer perianth-segments large, spreading, and reflexed; the 3 inner ones much smaller and erect. The style bears 3 large flattened branches, each with an appendage

¹ Areschoug, "Beitr. z. Biol. der geophilen Pflanzen," *Act. Reg. Soc. Phys. Lund.* 1896. Massart, "Comment les plantes vivaces maintiennent leur niveau souterrain," *Bull. Jard. Bot. Bruxelles*, 1903.

² Overs, det K. Danske Vid. Selsk. Forh., 1904.

resembling a petal, which arches over the corresponding stamen and outer segment of the perianth (Fig. 337). In order to reach the honey, which is secreted at the base of the flower, insects have to force their way between this segment and the over-arching style-arm. In so doing the back will rub against the outwardly dehiscent anther. The receptive surface is the upper face of a small ledge (*st*) on the under side of the style-arm. In backing out of the flower a bee would only come in contact with the non-receptive lower face, thus avoiding self-fertilisation; on entering the flower with pollen obtained on a previous visit it will deposit some of the pollen on the upper receptive face. We have two species—*I. Pseud-acorus*, with yellow, and *I. fœtidissima*, with blue flowers.

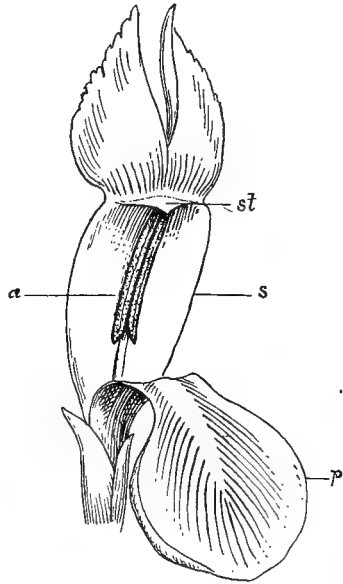


FIG. 337.—*Iris Pseud-acorus*. *p*, one of the large outer petals; *a*, anther of the corresponding stamen; *s*, the corresponding style-arm arching over the stamen; *st*, ledge-like stigma. Nat. size.

GLADIOLUS

Flowers in a one-sided spike. Protandrous humble bee flowers. Some of the flowers are female, the others complete. The genus is represented in Britain by *G. illyricus*, a Southern European species found in the New Forest and the Isle of Wight.

SISYRINCHIUM

S. Bermudiana.—This is a North American species, but is found in the South and West of Ireland.

ROMULEA

R. Columnæ (or *Trichonema Bulbocodium*) is a native of the Mediterranean area, which is also found in the Channel Islands, and near Dawlish, in Devon.

AMARYLLIDACEÆ.

This order differs from Iridaceæ in having 6 stamens.

NARCISSUS

This genus has a cup-shaped or tubular crown at the mouth of the flower tube. Nectar is secreted at the base of the flower tube.

There are two species in Britain. *N. Pseudo-narcissus* has yellow solitary flowers; *N. biflorus* (a Western European plant which has become naturalised) has white or yellowish-white flowers generally in pairs.

N. Pseudo-narcissus (Daffodil).—The flower tube is about an inch long, wider at the top, so that insects can enter it, and a proboscis 6 mm. long can reach the honey. There are 3 nectaries. The pistil is a little longer than the anthers.

LEUCOJUM

There is no free nectar, but the tissues of the flower appear to contain a sweet sap.

L. æstivum (Snow-flake).—The flowers are bell-shaped, hanging in a cluster of 2-6. The pistil is rather longer than the stamens. Knuth found traces of sugar in the tissues under the green spots on the perianth-leaves.

GALANTHUS

G. nivalis (Snowdrop).—The flowers are homogamous. The pistil is longer than the stamens. Sprengel found that nectar was secreted by the green

parts of the perianth-leaves, and this has been confirmed by Delpino and Knuth. It is not, however, abundant. The flowers are principally visited by hive bees. They are pendulous; the anthers form a cone, and terminate in rigid points, which can hardly fail to be touched by the bee, which thus shakes the stamens so that some of the pollen drops down. In the absence of insect visits the filaments relax, the anthers separate, and some of the pollen drops on the viscid stigma.

DIOSCOREACEÆ

Climbing plants, with net-veined leaves. Flowers on the same plan as in Amaryllidaceæ. Fruit, a berry in the British genus.

TAMUS

T. communis (Black Bryony).—The plant is dioecious; the flowers are small, yellowish-green, in slender racemes. The berries are scarlet. Darwin found that the growing shoot revolves or circumnutates in $2\frac{1}{2}$ to 3 hours.¹

LILIACEÆ

Plants of various habit, often growing from a bulb or rhizome. Perianth 6-leaved, petaloid; stamens 6, below the ovary.

Some produce nectar, others are visited for the pollen only. Some (Paris) appear to attract flies by mock nectar. In several genera (Fritillaria, Allium, Gagea, Ornithogalum, and Hyacinthus), the leaves sometimes produce buds. Some 2500 species are known.

¹ Darwin, *Climbing Plants*, p. 25.

TULIPA (Tulip)

Some with, some without nectar.

T. sylvestris.—The flowers are yellow, homogamous, and sweet-scented. Nectar is secreted at the base of the stamens, and protected by a tuft of hairs. The yellow stigma projects beyond the stamens, and secretes drops of sweet fluid. The flowers are principally visited by small bees (*Andrena* and *Halictus*) which lick up the fluid on the stigma before they explore the recesses of the flower. The flower gradually droops, so that finally the stigma comes within the fall line of the pollen.

LLOYDIA

Protandrous flowers with free honey.

L. serotina.—Nectar is secreted by a ridge at the base of the perianth. In Britain it only occurs on some of the Welsh mountains.

GAGEA

Scentless flowers with exposed or half-concealed nectar, secreted at the base of the flower. According to Schulz sometimes the stamens, and sometimes the pistil, fail to develop.

G. lutea.—The flowers are slightly protogynous. According to Kerner the stamens contract after shedding their pollen.

ORNITHOGALUM

Flowers with half-concealed honey, secreted by 3 glands contained in the septa of the ovary.

Three species occur in Britain: *O. umbellatum* has the flowers in a corymb, the other two in racemes; in *O. nutans* they are few and large, in *O. pyrenaicum* many and small.

O. umbellatum (Star of Bethlehem).—The flowers are protogynous and borne in a corymb; the spreading perianth segments are white, with an outer broad green band. The stigma is ripe when the flower expands, then, accord-

ing to Kirchner, the three outer anthers open, and afterwards the inner ones. In the flowers, however, observed by Kerner the inner stamens opened a day before the outer ones, and this was also the case with those examined by Knuth. After shedding their pollen the upper half of each stamen bends outwards, while the lower half remains close to the ovary, thus forming 6 narrow canals, of which the 3 corresponding to the septal glands are nectariferous. Finally, the stamens turn inwards, and the shorter ones deposit pollen on the stigma. In the afternoon, and in wet weather, the flowers close.

O. nutans.—The flowers are protandrous; at first upright, then horizontal, finally hanging. When the bud expands the anthers of the 3 stamens standing in front of the nectaries also open, and in such a position as to be touched by any insect coming for the nectar. Subsequently they bend outwards, the stigma ripens, the other 3 anthers open, and the flower becomes horizontal. Finally, the flower droops, the anthers contract, and press out the pollen, which falls on the stigma, so that in the absence of insect visits the flower fertilises itself.

O. pyrenaicum occurs in woods in some of our southern counties, and is very common near Bath. It is an undoubted native, whereas the other two species are naturalised in Britain.

SCILLA

Flowers generally violet, sometimes white or pink, with free or half-concealed nectar, secreted by glands in the septa of the ovary. We have three species—*S. nutans* with hanging, the other two with erect flowers; *S. verna* having a bract under each pedicel; *S. autumnalis* without bracts.

S. nutans (Bluebell).—This beautiful flower often carpets our woods with a sheet of blue, bringing, as Ruskin said, the heavens down to earth. It is remarkable that it does not occur in parts of Central Europe, as for instance in Switzerland.

MUSCARI

Bee flowers; the tissues at the base of the flower containing a sweet juice. Flowers in a spike; those at the apex sometimes only for show. Perianth contracted at the mouth, with 6 lobes.

M. racemosum has dark violet protogynous flowers. It occurs in sandy fields in some of the eastern counties.

ALLIUM (Onion)

Flowers in a terminal head or umbel, with concealed nectar surrounded by a spathe of 2 or 3 bracts. Perianth of 6 segments. Stamens, 6, in two sets of 3. It is a genus with many species, of which eight are British.

A. ursinum.—The flower is snowy white and protandrous. The anthers of the 3 inner stamens open before those of the outer ones. During this time the pistil lengthens from 2–3 mm. to 6 mm. and the stigmas ripen. Finally, in the absence of insect visits, the stigmas touch the anthers, and the flower fertilises itself. The visitors are principally bees, humble bees, and flies. The leaves are reversed, so that the morphologically upper side is turned downwards, and develops stomata.

Scott Elliot in his *Nature Studies* gives an interesting account of this species. The seed begins to develop on the surface of the earth, but as soon as germination begins the growing embryo becomes buried in the soil through a peculiar elongation of the stalk of the cotyledon, which carries plumule and radicle to a depth of 3–4 mm. Its subsequent yearly history is as follows:—“In April a circle of peculiar fleshy roots is formed; they grow obliquely downwards, and when they are firmly fixed by root hairs at their ends, they contract, losing about 30 per cent of their original length; in so doing they draw the bulb downwards into the soil. From May to July the green leaves perform their work, and the flowers and fruit are

formed. In September another series of roots grow, not downwards, but outwards; these are thin, they have no power of contraction, and simply absorb nourishment like those of ordinary plants. From November to April is the winter rest, and in April another circle of stout contracting roots is produced, which again drag the bulb downwards. Eventually it comes to lie at a depth of 10–15 cm.”

A. oleraceum.—The flowers, according to Bentham, are pale brown; Knuth describes them as at first greenish white, and gradually becoming rose colour. They are protandrous, and usually few in number; some are replaced by bulbils.

A. Schœnoprasum (Chives).—A very rare plant in Britain; found in rocky pastures in a few counties. This is one of the species with fistular leaves—an arrangement which is useful as a protection against undue transpiration, and also probably against wind.

A. triquetrum is a South west European species which occurs in Britain only in Cornwall.

In the other British species the 3 inner stamens are flattened and three-cleft (Fig. 338, *c*). I have seen no suggestion as to the purpose of this curious arrangement.

A. sphærocephalum

(Fig. 338) has a globular, dense umbel. It is found in Britain only on St. Vincent's Rocks, Bristol.

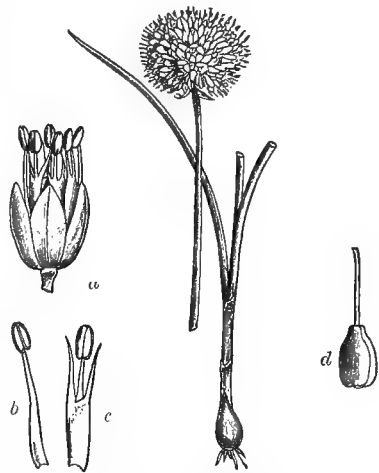


FIG. 338.—*Allium sphærocephalum*. Figure of plant reduced. *a*, flower; *b*, an outer, *c*, an inner stamen; *d*, pistil; enlarged.

SIMETHIS

S. bicolor.—The filaments of the stamens are very woolly. It occurs in Britain only near Bournemouth, and in a locality in Kerry, Ireland.

NARTHECIUM

N. ossifragum (Bog Asphodel).—The stamens are like those of *Simethis*. The flowers are homogamous, and have a scent like that of *Habenaria bifolia*, but no honey. They are, however, visited by insects for the sake of the pollen. Possibly also the juicy sap may be an inducement. The fruit is a narrow, oblong, glabrous, dark yellow capsule, with 6 longitudinal ridges separated by furrows. It contains a number of pale yellow minute seeds (Fig. 339) only about 1 mm. in length.

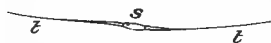


FIG. 339.—Seed of *Narthecium ossifragum*. *s*, body of seed; *t*, thread-like appendage. Enlarged.

The testa, however, is prolonged at each end into a thin thread (*t t*) 8–9 mm. long.

PARIS

Protogynous flowers without honey. Perianth of 8 or sometimes 10 segments. Stamens as many. Styles 4 or sometimes 5.

P. quadrifolia.—Leaves, generally 4, but sometimes 5, in a whorl. In the first case the parts of the flower are in fours; but when there are 5 leaves, the parts of the flower are also in fives. Flies are supposed to be attracted by the dull reddish colour of the ovary, which looks not unlike a piece of decaying meat. Flowers sometimes occur without stamens. They are said to be very long-lived.

MAIANTHEMUM

M. Convallaria.—The flowers are protogynous and sweet-scented. A very rare plant, found in woods in a few counties.

POLYGONATUM

Homogamous bee and humble bee flowers, richly supplied with nectar, which is secreted by septal glands in the ovary. There are three British species; *P. verticillatum* has the leaves in whorls; *P. officinale* has 1 or 2 flowers in each axil, and glabrous filaments; *P. multiflorum* several flowers in each axil and hairy filaments.

P. verticillatum.—A very rare British plant, only found in woods in Northumberland and Perth.

P. officinale.—The flower has the scent of bitter almonds. The flower-tube has a length of 14–17 mm., and is only accessible to humble bees with a long proboscis. No honey is secreted, but the tissues contain a sweet sap. The flower is often bitten into by *Bombus mastrucatus*. A rare plant, found in woods in England.

P. multiflorum (Solomon's Seal).—This species, on the contrary, is said to secrete honey, though in Sweden Almquist found none. Warnstorf was also unable to find any. Also a rare plant, in woods in England and Scotland.

CONVALLARIA (Lily of the Valley)

Slightly protandrous pollen flowers. The tissues contain a sweet sap, but there is no free nectar.

C. majalis.—The flowers are drooping, pure white, and very sweet-scented. The pistil projects beyond the anthers.

ASPARAGUS

Flowers diœcious, or rarely complete, and occasionally with intermediate forms. They secrete nectar.

A. officinalis.—The male flowers, as usual, are larger than the female, and first visited by insects. The fruit is a berry, globose, smooth, shining, red, and three-celled with 3–6 seeds. The seeds are large, flattened on the ventral aspect, hard, black, and smooth to the naked

eye. They are evidently adapted for transport by birds. Only native on our western and south-western shores, and the coasts of Waterford and Wexford. The plant has been cultivated since Roman times.

RUSCUS (Butcher's Broom)

R. aculeatus.—The place of leaves is taken by flattened branches (cladodes) which are generally twisted at the base, so that the lower surface is turned upward. The small white flowers are solitary; each on the true upper (actually the lower) surface of a cladode, the flower stalk being adnate to it. The berries are red. The flattened branches are tough, woody, and further protected by running out into a fine point. It is a rare plant, in copses and woods in the southern half of England.

FRITILLARIA (Fritillary)

Large protogynous hanging flowers with concealed nectar, which is secreted by the leaves of the perianth.

F. Meleagris.—Flowers of a dull red, chequered with more brightly coloured lines and spots. According to Kerner they last 5 days.

COLCHICUM

This genus closely resembles *Crocus*, but has 6 stamens instead of 3, and the perianth springs from below the ovary. The flowers are protogynous, with concealed honey, secreted by the lower ends of the free part of the staminal filaments, and protected by woolly hairs.

C. autumnale (Meadow Saffron).—The leaves appear in spring, and wither before the flowers open.

The arrangements of the flower in this species are very complicated. Three of the petals are longer than the others, and all elongate during the life of the flower. It is hetero-styled, as in the case of *Lythrum* (see *ante*, p. 192), having three forms—long-styled,

mid-styled, and short-styled flowers, and the elongation of the corolla is by no means the same in the three forms. In the long-styled, according to Kerner, the longer petals grow 9 mm. and the shorter 12·6; in the mid-styled the longer grow 13·5 mm. and the shorter 18·5; in the short-styled the longer grow 10 mm. and the shorter 15 mm. The anthers open outwards, which also tends to cross-fertilisation, but the stigmas remain fresh, and in the absence of insects the flower fertilises itself. It opens about 9 A.M. and closes about 6 P.M.

What appears to be the flower stalk is really the tube of the corolla, and the ovary is underground. Perhaps the advantage of this is that as the plant is an autumn flower, and lives in northern and mountainous districts, the seeds would not have time to ripen before the cold weather sets in. The seed capsule remains, however, underground all the winter, rising to the surface and ripening its seeds in the following spring.



FIG. 340. — *Colchicum autumnale*. Styles and ovary. About $\frac{2}{3}$ nat. size.

JUNCACEÆ

Perianth regular, dry, in 6 segments. The Juncaceæ are wind flowers, almost invariably protogynous. The female condition may last a few minutes (*J. squarrosus*), a few hours, or several days. Cleistogamous flowers occur in some species; in such cases the three inner stamens are generally absent.

A remarkable feature in the flowering of rushes is

that it occurs in pulses. For some days, perhaps, no flowers will be open; then suddenly, without apparently any change in the weather to account for it, the flowers will all open together. This feature is especially marked in the species which have single, or few flowers. For wind-fertilised species the arrangement is obviously advantageous. The flowers open once for all.

There are 15 British species, mostly perennial. Buchenau¹ makes altogether 176, but many of these vary considerably in certain districts, and he observes that the more he studied these variations, the more he was disposed to diminish the number of species.

JUNCUS (Rush)

J. articulatus.—Each flower lasts a day. It is female in the morning, then hermaphrodite. The species is supposed to flower in pulses. The leaves are hollow and divided by partitions of pith, giving them a jointed appearance, whence the name.



FIG. 341.—Flower of
Juncus articulatus.
Enlarged.

Leaves formed on the model of the rush have several advantages in northern regions. They are flexible, and not liable to be broken in storms; their thick epidermis protects them from cold; they resist evaporation; and they catch the low light which would not, as in temperate regions, fall on the upper side of the leaf. They would also be well suited to benefit by the low light glinting from the surface of the shallow water in which they so often grow.

The fruit is an upright capsule from which the seeds are jerked by the wind. It has three chambers, opening by three valves which alternate with the walls. The exterior walls of the pericarp are strongly lignified, and their contraction causes the dehiscence.

J. balticus.—This species flowers in pulses.

J. bufonius.—Annual. In some districts—as, for in-

¹ "Monographia Juncacearum," Engler's *Bot. Jahrb.* xii.

stance, in parts of Russia¹—all, elsewhere some, flowers are cleistogamous and have 3 stamens only. The flowers open between 5 and 6 in the morning, and the stigma is ripe about 2 hours before the stamens open. Towards mid-day the flowers close.

J. capitatus.—Annual. In this species the stamens are generally reduced to 3. The flowers are sometimes cleistogamous.

J. castaneus.—The life of the flowers lasts 2-3 days : they do not open wide.

J. compressus.—This species generally flowers in pulses. The flowers only last one day.

J. communis.—This species has two forms which are often regarded as separate species—*J. conglomeratus*, with flowers in close heads, and *J. effusus*, in which they are much looser. But though the difference is generally well marked, every gradation may be found between them. They generally flower in pulses, and are open from about 7 to 3. The anthers open a few hours after the stigmas are ripe. There are generally only 3 stamens.

J. filiformis.—Flowers short-lived, protogynous. Pulses not so marked as in the previous species. The flower opens, and the stigma is ripe between 5 and 6 A.M. The anthers open later, and the flower closes about mid-day.

J. glaucus.—The flowering is like that of *J. effusus*, but the flowers remain open longer, and there are generally 6 stamens. The pulse is very marked. Some flowers are cleistogamous.

J. maritimus.—The female condition lasts for a day ; the whole flower-life being 36 hours.

J. obtusiflorus.—Pulses well marked, with 3-4 days' intervals, in which scarcely any, if any, flowers open. The flower-life is only one day ; the female condition lasting 2-4 hours.

J. squarrosus.—The flowering pulses are well marked. The flowers open early, by 8 A.M. the anthers are ripe,

¹ Ascherson, *Bot. Zeit.* xxix. (1871) p. 551.

and they close soon after mid-day. In wet weather they are almost cleistogamous.

J. trifidus.—The female condition lasts 2 days, the whole flower-life is probably 4.

LUZULA (Wood-rush)

This genus has softer and more grass-like leaves, often with a fringe of hairs. We have five species—three with flowers in panicles, two in compact heads.

L. campestris.—The perianth segments are very pointed. As soon as the bud begins to open the three stigmas push out, and soon wither. Several days (5-9) then elapse before the flower is completely open, and another, making 6-10, before the anthers are ripe. The flower remains fully open for about 36 hours. From the long interval between the withering of the stigmas and the ripening of the anthers, it is evident that the flower can never fertilise itself.

L. pilosa.—In this species the stigmas remain fresh for 4-5 days, during which the perianth is only partially open. It then expands for some hours, the anthers open, and finally the flower closes.

L. sylvatica.—This is the largest of our species. The female condition lasts one or two days. Then the flower and the anthers open. In this case, however, they do so while the stigmas are still fresh.

L. arcuata is an Arctic and Alpine plant found in Britain only on the Scotch alps.

ERIOCAULEÆ

Small herbs with a dense tuft of narrow grass-like radical leaves, and a scape bearing a dense head of minute sessile flowers, subtended by an involucre of bracts, and suggesting a Composite. It is almost restricted to the warmer parts of the earth; it is represented in Europe by the following species.

ERIOCAULON

E. septangulare.—A North American species which is also found in lakes in one or two of the Hebrides, and near Connemara in West Ireland.

CYPERACEÆ

Wind flowers, with a few exceptions protogynous. They resemble grasses superficially, though the flowers are very different, but may be at once distinguished by having generally a triangular stem, sometimes with very sharp edges, while that of grasses is round,¹ or compressed. Perianth absent or replaced by six bristles or minute scales representing the six leaves. In some cases the number of bristles is indefinite. Stamens, generally 3, sometimes 2. Style, with two or three branches. The fruit is flat, or with two ridges, in species with two styles, triangular when there are three. The embryo is embedded in the endosperm, while in grasses it is outside. The plants are visited, though not very frequently, by pollen-eating insects, which sometimes cross the species.

ERIOPHORUM (Cotton-grass)

A North Temperate and Arctic genus, represented in Britain by four species. It derives its name from the long cotton-like hairs which represent the perianth, and reach their full development in the fruiting stage; they form a light envelope in which the nut is carried. The plants grow in wet moss or in bogs.

CAREX (Sedge)

The largest genus of the order in temperate climates. It is also the largest genus, as regards number of

¹ I have suggested (Brit. Ass. Cambridge, 1904) that this is because the leaves of Carex are in threes, while those of grasses are distichous.

species, in our flora, numbering about sixty species.



Fig. 342.

FIG. 342.—Sedge (*Carex acuta*). Male flower, consisting of three stamens in the axil of a bract, *b*.



Fig. 343.

FIG. 343.—Female flower. The bract subtends a compressed ovary surrounded by a sac from which project the two hairy stigmas.

Mr. Reid records fruits of nine species from pre-glacial and interglacial beds in various parts of the country.

In some species the male and female florets are on different plants (*C. dioica*); in those which are regarded as most typical there are one or more spikelets, consisting of male flowers above, and one or more of female flowers

below; sometimes, however, the male and female florets are in the same spike, either the male above and the female below, or *vice versa*. In some species (Fig. 343) there are 2 stigmas, in others 3. The form of the one-seeded fruits or "utricles" also gives good specific characters.

In some species, as, for instance, in *C. paludosa*, the stomata are protected by a series of cuticular pegs (Fig. 344). These hold the air, thus keeping the stomata clear and dry. Even if the leaf be immersed in water it is not wetted, but looks like a sheet of silver.

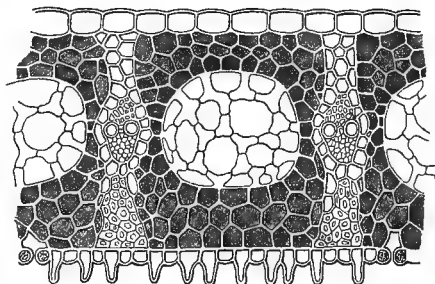


FIG. 344.—Vertical section through part of a leaf of *Carex paludosa* ($\times 200$), showing protection of stomata from moisture by papilla-like outgrowths of the under-surface.

C. pulicaria.—In this species and in *C. pauciflora* the fruits are narrow, pointed, and spreading or reflexed, so that they would readily be carried away by any passing animal.

GRAMINEÆ¹

Wind flowers. Generally protandrous. Stem round or compressed, generally hollow. The flower, or floret, of grasses is enclosed in two bracts or glumes, one slightly above the other; it consists of two "glumelles," the lower one of which is often termed the flowering glume, the upper the pale. Above these two leaves are two very minute scales known as lodicules or glumellules, followed by the stamens and pistil. The lodicules swell and separate the pale and glume, thus enabling the stamens and stigmas to protrude. Theoretically the flower may be regarded as consisting normally of one carpel with 2 styles, and 3 stamens (exceptionally 2-6), without any perianth. On this view the lodicules are bracteoles, enclosed in a second pair—the pale, and the flowering glume. Another view regards the lodicules as representing two members of a perianth. The "awn," which is sometimes present, stands to the palea in the relation of a leaf-blade to its sheath.

Hildebrand thinks² that while the awns in some cases promote dispersal, because their roughness enables them to attach themselves to animals, their principal use is that they move the seeds by hygroscopic changes, and by serving as wings. No doubt they are



FIG. 345.—Diagram of a spikelet of Wheat dissected (\times about 5), showing—from below upwards—the 2 barren glumes, the flowering glume (right) and pale (left), 2 lodicules, 3 stamens, and the pistil.

¹ H. Marshall Ward has recently published a small but very useful book on the family. *Grasses* (Cambridge Nat. Sci. Manual). See also Lowe, *British Grasses*.

² *Bot. Zeit.* 1872, p. 890.

useful in these ways, but is not an even more important service that they tend to prevent the seeds being eaten?

Fig. 346 gives a diagram of a spikelet of *Anthoxanthum*, and Fig. 345 of Wheat.



FIG. 346.—Diagram of a spikelet of *Anthoxanthum* dissected (\times about 8), and showing—from below upwards—2 outer and 2 (awned) inner barren glumes, fertile glume and pale, stamens, and pistil. There are no lodicules.

The flowers open only once, generally in the morning, through the swelling of the lodicules. As usual in wind flowers the filaments are very thin, so that the anthers are easily shaken by the wind. Some species have cleistogamous flowers. The flowers are generally complete, but sometimes, as in Maize, unisexual. The leaves consist of two parts—a sheath which encloses and strengthens the stem, and a free blade (Fig. 347). The sheath is generally split open on the side opposite the blade. At the point where the blade quits the sheath is a small, scariosus appendage known as the ligule. Its probable use is to serve as a dam, and prevent the rain which runs down the blade from getting between the sheath and the culm, and to turn the little stream on each side down a groove, and so to the exterior of the sheath. Species which grow in the shade of woods have thin flat leaves; those of moor and heath grasses are thicker, stronger, setaceous, or rolled in at the edges (Fig. 349). This is effected by “motorcells,” which are thin-walled, vary in turgescence, and are seated on each side of the mid-rib.

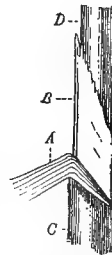


FIG. 347.—*Poa trivialis*, showing parts of leaf. A, base of blade; B, ligule; C, upper part of sheath; D, culm. \times about 3.

In some of the species the points of the roots are covered with hard scales, which enables them to force their way. The common Couch-grass has thus been known to bore through the roots of trees.

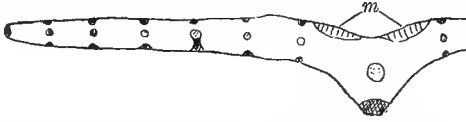


FIG. 348.—Transverse section of half of leaf of *Poa annua* including the median keel. \times about 50. Six vascular bundles are represented in the half of the blade, the strongest one is girdered with sclerenchyma. *m*, lines of motor cells on upper face above the median vascular bundle.

The flowers of Grasses have as a rule definite hours for opening. *Poa*, *Koeleria*, and *Avena elatior* take the lead between 4 and 5 A.M.; *Briza media*, *Aira cæspitosa*, and Barley, are a little later, between 5 and 6; a good many species, Rye, some *Festucas*, *Andropogon*, *Dactylis*, between 6 and 7; *Alopecurus*, *Phleum*, and *Anthoxanthum*, between 7 and 8. Then comes an interval. At 11 *Agrostis* opens; between 12 and 1 *Melica*, *Molinia*, *Nardus*, *Elymus*, *Sclerachloa*, and some species of *Calamagrostis*. Some species of *Bromus* open about 2, some of *Avena* about 3, *Agropyrum* at 4, and, lastly, *Aira flexuosa* between 5 and 6. *Holcus* is peculiar. It opens under favourable circumstances twice, at 6 in the morning, and 7 in the evening. Each flower takes from 15 to 20 minutes.

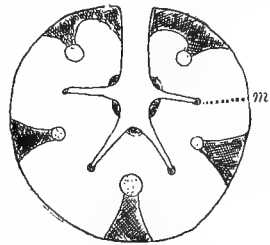


FIG. 349.—Transverse section of leaf of *Nardus stricta*. \times about 50. The shaded portions represent supporting tissue (sclerenchyma). *m*, traces of motor cells at base of furrow in upper face.

Wheat is said to open at any time of the day. The anthers scatter about two-thirds of their pollen, and drop one-third in their own flower, which, however, gives better results if cross-fertilised. Rye is said to be quite sterile to its own pollen.

The seeds are not free, but are combined with the wall of the ovary, thus forming a one-seeded fruit, known as the "grain." The embryo is outside the endosperm, not within it.

The dissemination of the seeds is provided for in several ways.¹ Sometimes they are very minute, as, for instance, in *Eragrostis*; generally, however, when leaving the plant they carry with them parts of the spikelet, which act as a balloon. In the quaking grass, *Briza*, the glumes fulfil this function, and the same is the case with species of *Poa*, *Dactylis*, *Holcus*, *Festuca*, and *Phalaris*. In many cases the awns attach themselves to animals; and in some the dissemination is due to hygroscopic movements.

Perhaps the most remarkable case is that of a South European species, *Stipa pennata* (Fig. 350), the structure of which has been described by Vaucher, and more recently, as well as more completely, by Francis Darwin. The grain is enveloped in the persistent glume which is continued below into a sharp point, and bears stiff short hairs pointing backwards. The upper end is produced into a fine twisted corkscrew-like rod, which is followed by a plain cylindrical portion, attached at an angle to the corkscrew, and ending in a long and beautiful feather, the whole being more than a foot in length.

The long feather no doubt facilitates dispersion by wind; eventually, however, they sink to the ground, which they tend to reach, the fruit being the heaviest portion, point downwards. So the fruit remains as long as it is dry; but if a shower comes on, or when the dew falls, the spiral unwinds, and if, as is most probable, the surrounding herbage or any other obstacle prevents the feather from rising, the fruit itself is forced down and so driven by degrees into the ground.²

¹ Hildebrand, "Über d. Verbreitungsmittel der Gramineen Früchte," *Bot. Zeit.* 1872.

² Aveyary (Lubbock), *Flowers, Fruits, and Leaves*, p. 90.

The flinty epidermis not only serves as a support

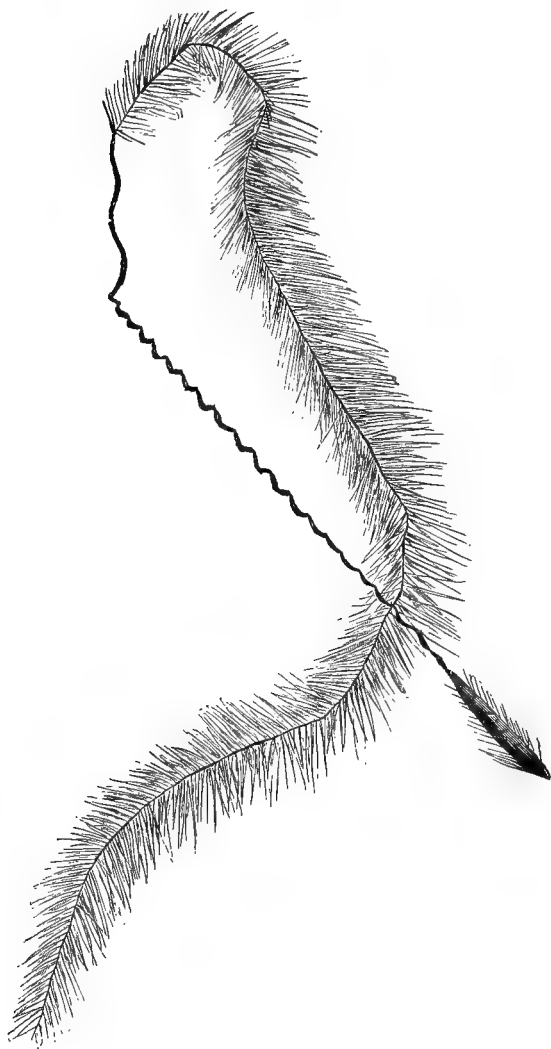


FIG. 350.—Floret of *Stipa pennata*.

to the stem, but no doubt protects the plants against snails and other herbivorous animals.

The leaves of some species of *Festuca* present a

good illustration of plants which are protected by barbs at the edges of the leaves, converting them into fine saws. If loose pieces of such a leaf are shaken on a flat surface they will move in the direction opposed to the points of the barbs. Such leaves are awkward to eat, and if they are stroked the wrong way they cut like a knife.

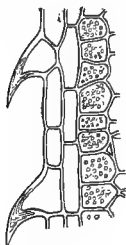


FIG. 351.—Margin of a leaf of *Festuca setacea* with barbs. $\times 180$.

There are some 3500 species. Ours are all small, but some of the bamboos reach a height of over 100 feet. This is one of the largest, and perhaps the most useful, of all the orders of plants.

ZEA

Z. Mays (Maize).—This widely cultivated plant is not a British species, but I mention it because the male and female flowers are on different heads, sometimes, however, with a few male flowers among the female, and female among the male. The male flowers smell of cumarin, the female are scentless. It is only partially self-fertile.

LEERSIA

L. oryzoides.—Besides the usual, there are cleistogamous flowers, which are very small, and do not generally emerge from the sheaths of the leaves.¹ The perfect flowers are rare, and still more rarely produce seeds.

MILIUM

M. effusum is slightly protogynous.

SETARIA

S. verticillata—which is sometimes found in culti-

¹ Douval-Jouve, *Bull. Soc. Bot. France*, 1863.

vated fields though not a native—has small spikelets interspersed with numerous barbed bristles, which would easily attach themselves to any passing animal.

ANTHOXANTHUM

A. odoratum.—This is the species which contributes the most to the delightful scent of new-made hay. It is markedly protogynous; the anthers are not ripe till the stigma is quite faded, so that the flower cannot fertilise itself. The flowers open between 7 and 8 in the morning. The anthers are generally yellow, sometimes red.

PHALARIS

P. canariensis (Canary Grass).—The flowers open in the afternoon. The plant is often found as an escape in fields and waste places.

DIGRAPHIS

D. arundinacea.—This is slightly protogynous, so that a flower can at first only be fertilised by the pollen of an older flower; it is, however, long-lived, so that it may afterwards be fertilised by its own pollen, and lastly by that of a younger flower.

PHLEUM

P. pratense.—According to Axell and Kirchner the flowers are markedly protogynous, but Warnstorff found the plants homogamous. The anthers are yellow or violet.

P. alpinum is, according to Schröter, protogynous.

ALOPECURUS (Fox-tail)

A. pratensis.—This species is markedly protogynous. The anthers are white or grey, turning to red. The flowers open, according to Kerner, from 7 to 8 A.M., but

Warnstorf found those near Ruppin did not do so till between 10 and 11.

A. agrestis.—The flower arrangements are as in the preceding species.

LAGURUS

L. ovatus.—In this species the long silky hairs do not fall with the fruit, but Hildebrand suggests that they catch the wind, with the result that the plant is violently waved about, and thus the fruits are thrown to some distance.

APERA

A. Spica-venti.—The flowers, which are borne in a large pyramidal panicle, open about 6 A.M.

GASTRIDIDIUM

The genus derives its name from the inflated base of the barren glumes.

G. lendigerum occurs in maritime sandy marshes in South Wales and the southern portion of England.

PSAMMA (Marram Grass)

P. arenaria.—This is the common grass of our sand dunes. It is very valuable in binding the sand together by its long creeping stems, and thus preparing for other plants.

AIRA

A. cæspitosa opens, according to Kerner, between 6 and 7 A.M.

A. flexuosa.—The flowers are homogamous, with bluish-black anthers.

A. canescens.—In this species the awn is pointed, and has a minute tuft of hairs about the middle.

AVENA (Oat)

A. sativa (Oat).—The flowers are homogamous, and open between 2 and 4 P.M. According to Godron the stamens turn downwards before the anthers open, so that the flower could not often fertilise itself. Other observers, however, dispute this. Körnicke found that in some varieties, a few of the flowers open in the morning, and the rest in the afternoon. In wet weather the flowers are almost cleistogamous.

The awns are very hygroscopic, thus moving the fruits and making them seem almost alive. Hildebrand explains¹ the mechanism as follows. The awn contains two kinds of tissues—(1) long, thick-walled cells; and (2) more rounded parenchymatous cells. The long cells form a pillar in the shape of a T, with the upper arms turned down, and a very large foot. As the upper part presents a larger proportionate surface it contracts more rapidly than the foot. It is probable that the twisting of the awn is due to the same cause as in *Erodium* (see *ante*, p. 132).

A. fatua (Wild Oat), a common weed of cultivation in all corn countries, has been regarded as the original form of the cultivated Oats. It is annual, while our two other British species, *A. pratensis* and *A. pubescens*, are perennial.

ARRHENATHERUM

A. avenaceum.—Each spikelet contains two flowers; one male and one complete. They open simultaneously. The stamens then elongate rapidly, so that in ten minutes they have increased their length three- or even four-fold, growing from 2-4 mm. in a minute. They are at first stiff, but as they elongate they become flexible, and when ripe they hang down, and the anthers open at the point. The anthers curl outwards at the tips, thus forming little cups, in which a certain quantity of pollen accumulates. As long as the weather is calm,

¹ Pringsheim's *Jahrb.* ix. (1873-4).

here it rests ; but when there is any wind it is thrown out, and a fresh supply drops down, to be scattered in its turn. The plant is protected against browsing quad-

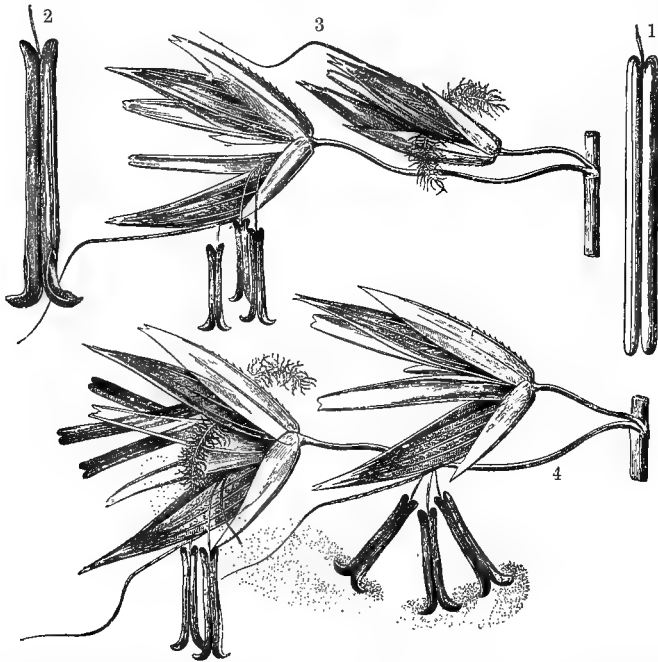


FIG. 352.—*Arrhenatherum avenaceum*. 1, 2 $\times 12$. 3, 4 $\times 5$. 1, A closed anther ; 2, an open anther ; 3, spikelets on a calm day with glumes distended, and anthers pendulous ; 4, spikelets in a wind. The pollen escaping from the pendulous anthers in the spikelet to the right ; in that to the left (and below) the anthers (two only remaining) have shed their pollen ; in a third flower (in the same spikelet as the last mentioned) the anthers are still closed and in process of being exerted.

rupeds by the scabrid leaves. Kerner, however, saw thousands of the tufts on the meadows near Oberiss in the Tyrol, which cattle had torn up, as he supposes, so as to get at the edible plants growing near them.

HOLCUS

H. lanatus.—The floral arrangements resemble those of *Arrhenatherum*. According to Kerner some florets open in the morning about 6 A.M. and others about 7 P.M.

Körnicker confirms this, but says that comparatively few open in the morning. Hildebrand, on the contrary, says that they open about mid-day.

CYNODON

C. Dactylon.—A widely distributed grass, forming the chief pasture of many dry climates. It occurs on sandy shores in the south-west of England.

NARDUS

N. stricta.—A low-growing species with very slender, rigid, erect stems, found on heaths and in dry pastures. The flowers are protogynous. The spikelets open at the apex for the protrusion of the stamens and single stigma.

ELYMUS (Lyme Grass)

E. arenarius is found on sandy sea-shores; its creeping stems help to bind the sands.

HORDEUM (Barley)

The spikelets are in threes: one or two either empty or with a male or rudimentary flower; the other two or one, as the case may be, contain each a complete flower.

H. vulgare.—The flowers open between 5 and 6 A.M., and, according to Lindau, even at a temperature of $12\frac{1}{2}^{\circ}$ C. The flowers of the middle row, according to Delpino, never open, but are cleistogamous. Those of the four outer rows are homogamous. Godron, however, found the flowers of all the rows open. The awns attach themselves to animals and thus promote the dissemination of the fruits.

TRITICUM (Wheat)

Flowers in a simple spike, the side of the spikelet being next the axis. *T. sativum* (Wheat) is probably derived from a species belonging to the subgenus *Ægilops*. *T. repens* (Couch-grass) has a long creeping root-stock, and is a troublesome weed in cultivated land.

LOLIUM

This genus resembles *Triticum*, but the face of the spikelet is applied to the axis.

L. perenne (Ray-grass).—The flowers are slightly protogynous or homogamous; they open in the early morning. This species is common in waste places and is also a valuable pasture-grass.

L. temulentum (Darnel) resembles the last species, but differs in being an annual. It occurs in cornfields, and is probably not a genuine native. The fruit is very poisonous.

BRACHYPODIUM

B. pinnatum.—The flowers open before 6 A.M., and the anthers between 6 and 7.

BROMUS

B. erectus, which occurs in fields and waste places in dry soil, has homogamous flowers. The anthers are orange yellow.

B. sterilis occurs in similar localities to the last species. Warnstorff found only cleistogamous flowers.

B. arvensis, a continental species, is classed as a casual in Britain. The flowers rarely open.

FESTUCA

As to the number of British species there is much difference of opinion. Bentham admitted five, others make several more. The genus is closely connected with *Poa* and *Bromus*, differing from the former in the sharp-pointed or awned flowering glume, and from the latter in absence of hairs on the top of the ovary.

F. ovina is often viviparous, especially in mountain regions.

DACTYLIS

D. glomerata (Cock's-foot).—A coarse grass common in waste places. The flowers are slightly protogynous, with a long-lived stigma. The stamens do not turn

down as in so many other grasses. The flowers open, according to Kerner, between 6 and 7 A.M., according to Warnstorf, between 6 and 9.

CYNOSURUS (Dog's-tail)

C. cristatus.—A slender species with almost filiform leaves. The flowers are homogamous, with anthers yellow or violet.

BRIZA (Quaking Grass)

B. media.—The flowers are homogamous, and open once in the morning and once in the evening between 6 and 7. The glumes are large, concave, and serve as a wing to the small fruit.

POA (Meadow Grass)

P. pratensis.—A common meadow grass. The flowers are homogamous; the anthers open about mid-day.

P. annua.—Though annual with us, this species is said to be perennial on the summits of the Pyrenees.¹ Similarly in the *Flora of British India*, where it appears as an alpine on the hills of Northern and Southern India, it is described as annual or perennial. In the Swiss Floras it is given as an annual. This is the commonest grass in our parks and by our roadsides.

P. alpina.—This species is often viviparous, the spikelets being converted into buds. The association of the viviparous condition generally with an alpine or arctic habit is a point of interest.

MELICA

Our two species of this genus, *M. nutans* and *M. uniflora*, occur in woods. The spikelets are two-flowered; in *M. nutans* both flowers are hermaphrodite, while in *M. uniflora* the upper is male.

¹ See *Cardamine hirsuta*, p. 79, and Constantin, *Les végétaux et les milieux cosmiques*, p. 30.

TRIODIA

The genus takes its name from the three-toothed flowering glume. Our one species, *T. decumbens*, is found in dry pastures and on moors.

KÆLERIA

K. cristata has a slender silvery panicle. The flowers are homogamous; the anthers bluish-black. The genus is named after Koeler, a German writer on Grasses.

SESLERIA

S. cœrulea.—A Central and South European species found in hilly pastures, especially in limestone districts. The flowers are protogynous. The genus takes its name from Sesler, an Italian botanist.

Sesleria is one of the plants which has stomata on the upper surface of the leaf. In the morning, or if the weather is damp, the leaf is flat; but as the sun rises and the air becomes drier, the sides rise and at last the two edges almost meet, thus protecting the leaf from too rapid transpiration. The movement is effected by a special tissue of motor cells on each side of the mid-rib, comparable to those illustrated on p. 433. Many other grasses protect themselves in a more or less similar manner.

PHRAGMITES

P. communis (Reed).—As a rule the florets in a spikelet are close together, but in this species there is a slight interval, clothed with long silky hairs, forming a parachute. The stem is round, and, as well as the leaf-sheath, quite smooth at the surfaces of contact. The result is, that in a high wind the leaf turns partly round, so as to fly with the wind, like a pennon. Even if the sheath splits a little, this does not injure the plant.

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