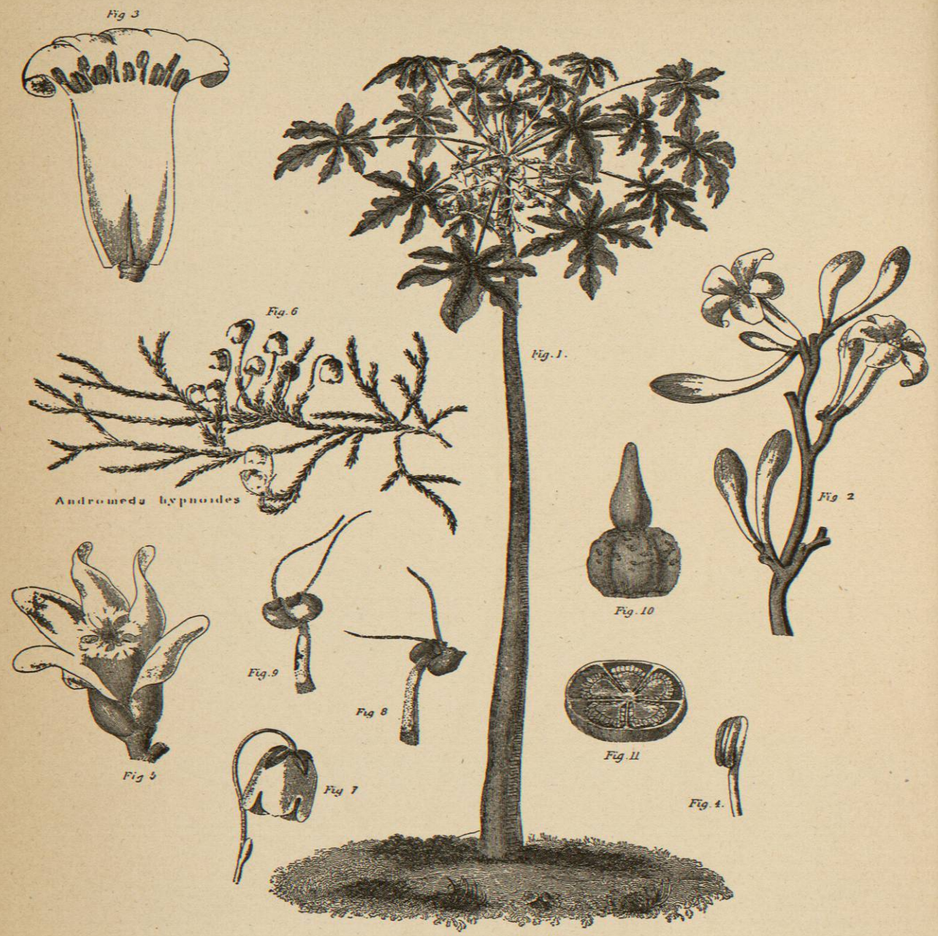
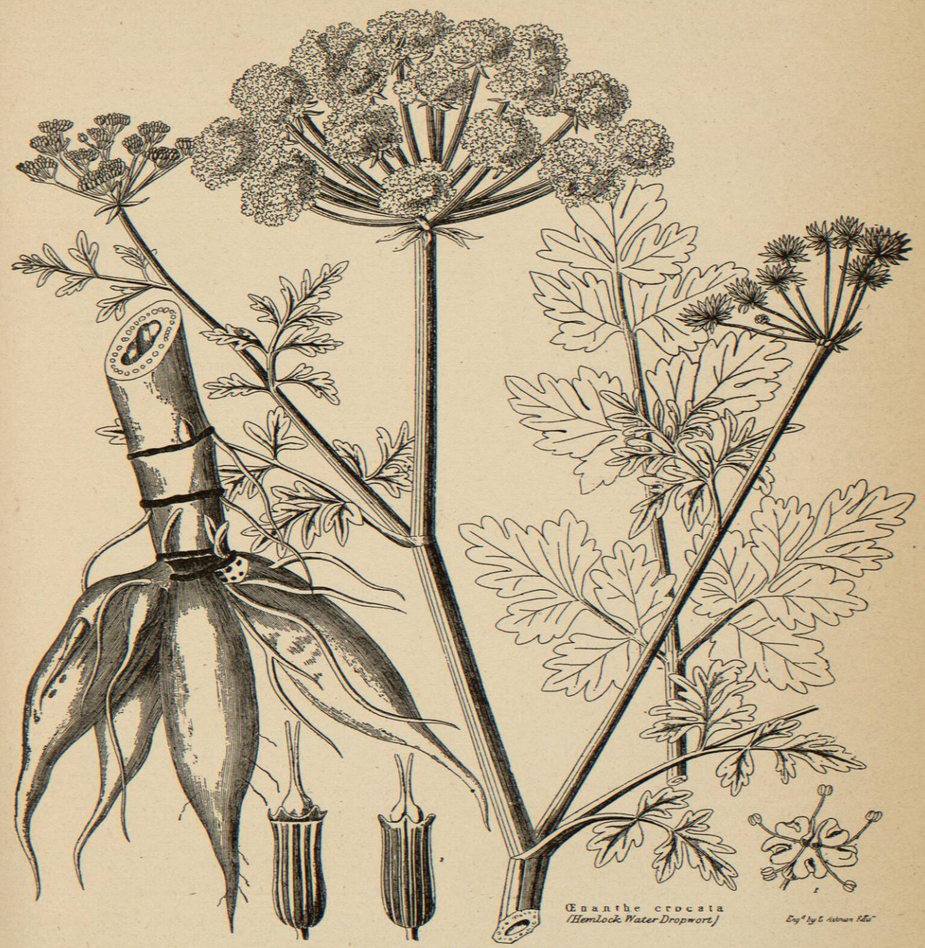


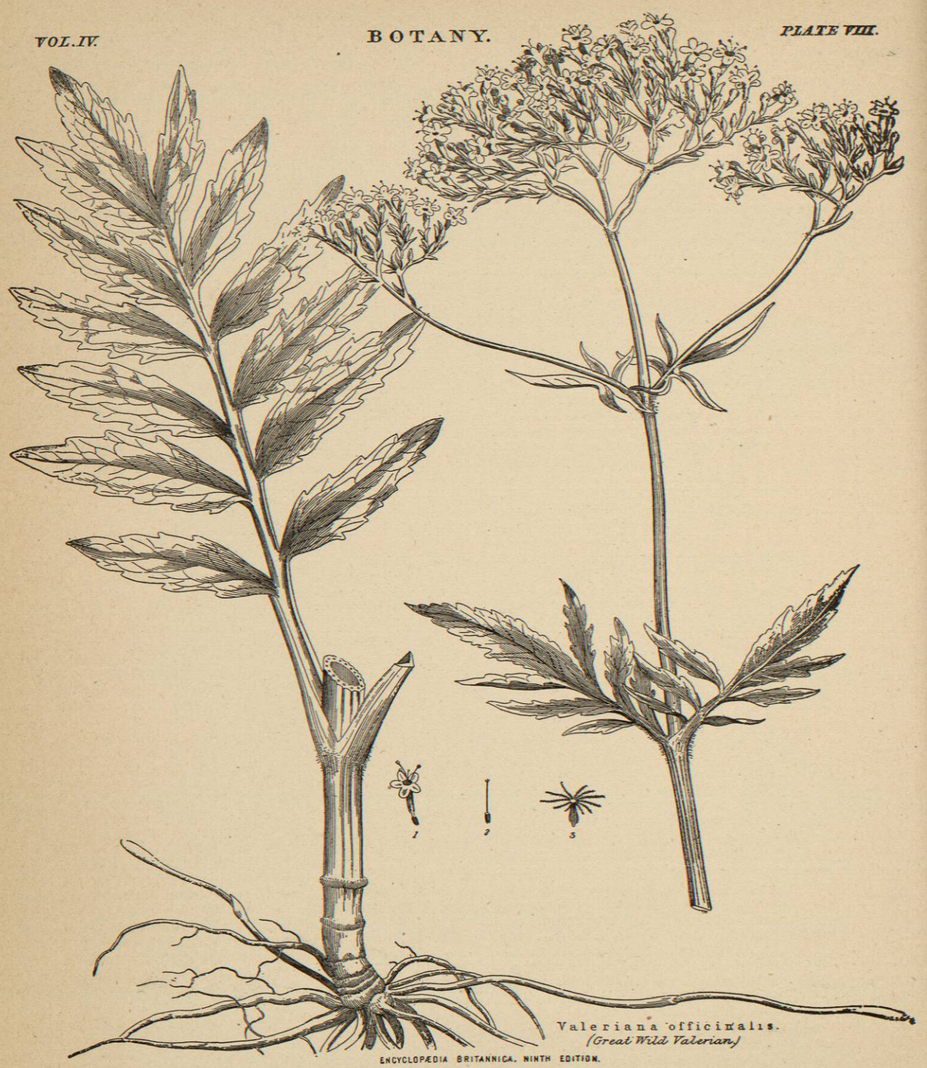
Carica Papaya
(Papaw Tree.)

Engd by G. Aikman, Edin.



Œnanthe crocata
(Hemlock Water Dropwort.)

Engd by G. Aikman, Edin.



Valeriana officinalis.
(Great Wild Valerian.)

branch becomes embedded and hardened among the woody layers of the stem.

The mode in which branches come off from the stems gives rise to various forms of trees, as pyramidal, spreading, or weeping,—the angles being more or less acute or obtuse. In the Italian Poplar and Cypress the branches are erect, forming acute angles with the upper part of the stem; in the Oak and Cedar they are spreading or patent, forming nearly a right angle; in the Weeping Ash and Elm they come off at an obtuse angle; while in the Weeping Willow and Birch they are pendulous from their flexibility. The comparative length of the upper and under branches also gives rise to differences in the contour of trees, as seen in the conical form of Spruce, and the umbrella-like form of the Italian Pine (*Pinus Pinea*). The branching of some trees is peculiar. In the Amazon district many Myristicaceæ and Monimiaceæ have verticillate branches coming off in fives. This is also seen in the Chili Pine. Some Amazon trees taper downwards, so as to have a form like an inverted cone or pyramid, as in the Mulatto tree (Eukylista Spruceana), one of the Cinchonaceæ.

Branches are sometimes long and slender, and run along the ground, producing buds with roots and leaves at their extremity or apex. This is seen in the *runner* (*flagellum*) of the Strawberry. In the Houseleek (Sempervivum) there is a similar prostrate branch of a shorter and thicker nature, producing a bud at its extremity capable of independent existence. It receives the name of *offset* (*propagulum*). In many instances the branch decays, and the young plant assumes a separate existence. Gardeners propagate plants by the process of *layering*, which consists in bending a twig, fixing the central part of it into the ground, and, after the production of roots, cutting off its connection with the parent. A *stolon* differs from these in being a branch which curves towards the ground, and, on reaching a moist spot, takes root and forms an upright stem, and ultimately a separate plant. This is a sort of natural layering, and the plant producing such branches is called *stoloniferous*. In the Rose and Mint a subterranean branch arises from the stem, which runs horizontally to a certain extent, and ultimately sends up an aerial stem, which becomes an independent plant. Such branches are denominated *suckers*, and the plants are *surculose*. The gardener divides the connection between the sucker and the parent stem, in order to propagate these plants. In the case of Asparagus and other plants which have a perennial stem below ground, subterranean buds are annually produced, which appear above ground as shoots or branches covered with scales at first, and ultimately with true leaves. The young shoot is called a *turio*. These branches are herbaceous and perish annually, while the true stem remains below ground ready to send up fresh shoots next season. In Bananas and Plantains the apparent aerial stem is a shoot or leaf-bud sent up by an underground stem, and perishes after ripening fruit. Branches are sometimes arrested in their development, and, in place of forming leaves, become transformed into *spines* or *thorns*, as in the Hawthorn. Plants which have spines in a wild state, as the Apple and Pear, often lose them when cultivated, in consequence of their being changed into branches; in some cases, as in the Sloe (Prunus spinosa), (fig. 65), a branch bears leaves at its lower portion, and terminates in a spine. Plants bearing thorns (modifications of branches or leaves) are denominated *spiny*, *spinose*, or *spinescent*. A bud is sometimes developed as a slender spiral or twisted branch, called a *tendril* or *cirrus*. In the Passion-flower the lateral buds are thus altered, with the view of enabling the plant to climb. In the Vine the tendrils are looked upon as the terminations of separate axes, or as transformed terminal buds, and are sometimes called *sarmenta*. In the Vine there are no young buds seen in the angle between the stem and leaves, nor between the stem and tendrils; and the latter are not axillary.

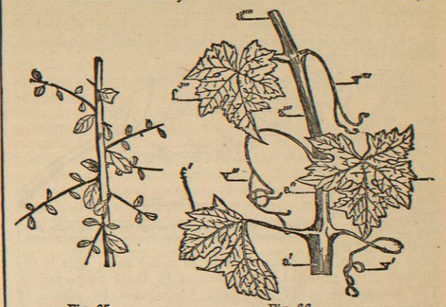


Fig. 65. Fig. 66.

FIG. 65.—Branch of the Sloe (*Prunus spinosa*) producing spines or thorns which are abortive branches, as shown by their bearing leaves.
FIG. 66.—Portion of a branch of the Vine (*Vitis vinifera*), on which the terminal buds are converted into tendrils.

Fig. 66 represents the branch of a Vine, in which a' is the primary or first formed axis, ending in v', a tendril or altered terminal bud, and having a leaf f' on one side. Between this leaf and the tendril, which represents the axis, a leaf-bud was formed at an early date, producing the secondary axis, or branch a'', ending in a tendril v'', with a lateral leaf f'', from which a tertiary axis or branch a''' was developed, ending in a tendril v''', and so on. The tendrils of Ampelopsis Veitchii are terminated by disks which secrete a sticky matter, by means of which they adhere to walls, &c. The tendrils, like those of the Vine, are modifications of the axis. Tendrils twist in a spiral manner, and enable the plants to rise into the air by twining round other plants. The direction of the spiral frequently differs from that of the climbing stem which produces the tendril. In the Vine the lower part of the stem is strong, and needs no additional support; the tendrils therefore occur only in the upper part, where the branches are soft, and require aid to enable them to support the clusters of fruit. In the Bryony the tendril in the first part of its course twines from right to left, and in the last from left to right.

In some instances lateral buds are found without being in the axil of leaves. In this case they are *extra-axillary*. Such buds are produced after the stem and leaves have been formed, and in certain circumstances they are developed like normal buds. What have been called *embryo-buds* are woody nodules seen in the bark of the Beech, Elm, and other trees. They are partially developed adventitious or abnormal buds, in which the woody matter is pressed upon by the surrounding tissue, and thus acquires a very hard and firm texture. When a section is made, they present woody circles arranged around a central pith, and traversed by medullary rays. The nodules sometimes form *knots* on the surface of the stem, at other times they appear as large *excrescences*, and in some cases twigs and leaves are produced by them.

Buds sometimes become extra-axillary in consequence of the non-appearance or abortion of one or more leaves, or on account of the adhesion of the young branch to the parent stem. In place of one bud there are occasionally several accessory ones produced in the axil, giving origin to numerous branches. Such an occurrence is traced to the presence of latent or adventitious buds. By the union of several such buds, branches are produced, having

a thickened or flattened appearance, as is seen in the Fir, Ash, and other trees. These *fasciated* branches, in some cases, however, are owing to the abnormal development of a single bud. Occasionally adventitious buds are produced on the edges of leaves, as in Bryophyllum calycinum (fig. 67), Malaxis paludosa, and various species of Asplenium, and on the surface of leaves, as in Ornithogalum thyrsoideum. These are capable of forming independent plants. Similar buds are also made to appear on the leaves of Gesnera, Gloxinia, and Achimenes, by wounding various parts of them, and placing them in moist soil; this is the method often pursued by gardeners in their propagation. The Ipecacuan plant has been propagated by means of leaves inserted in the soil. In this case the lower end of the leaf becomes thickened like a corm, and from it roots are produced, and ultimately a bud and young plant. Leaves bearing buds on their margin are called *proliferous*.

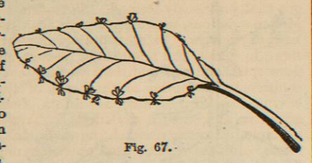


Fig. 67.

Leaf of *Bryophyllum calycinum*, producing buds along the margin, at the extremities of the primary veins.

The typical form of stems is rounded. They are sometimes compressed or flattened laterally, while at other times they are angular: being *triangular*, with three angles and three flat sides; *trigonous*, with three convex faces; *triquetrous*, with three concave sides; *quadrangular* or square; *quinquangular* or five-angled; *octangular* or eight-angled, &c. Various terms are applied to the forms of stems, as *cylindrical* or *terete*, *jointed* or *articulated*, &c. The following are some of the more important modifications of stems:—The *crown of the root* is a shortened stem, often partially under ground, which remains in some plants after the leaves, branches, and flower-stalks have withered. In this case the internodes are very short, and the nodes are crowded together, so that the plant appears to be stemless. It is seen in perennial plants, the leaves of which die down to the ground annually. A *rhizome* or *root-stock* (fig. 68) is a stem which runs along the surface of the ground, being partially covered by the soil, sending out roots from its lower side and leaf-buds from its upper. It occurs in Ferns, Iris, Hedychium, Acorus or Sweet Flag, Ginger, Water-lily, many species of Carex, Rushes, Anemone, Lathræa, &c. By many the term *rhizome* is applied to stems creeping horizontally, whether they are altogether or only partially subterranean. In rhizomes called definite, the terminal bud gives off flowers, and the lateral buds form the stem; while in indefinite rhizomes the terminal leaf-bud is formed annually. A rhizome such as occurs in Solomon's Seal (fig. 68) is not a single stem, *i.e.*, the product of a single bud, but is composed of portions of successive axes, the leaves of which have died off and remain as scars (fig. 68, *c*, *c*); it is thus an indefinite rhizome. Rhizomes are well seen in British Ferns. A rhizome sometimes assumes an erect form as in Scabiosa succisa, in which the so-called *præmorse* root is in reality a rhizome, with the lower end decaying. The erect rhizome of Cicuta virosa shows hollow internodes, separated by partitions.

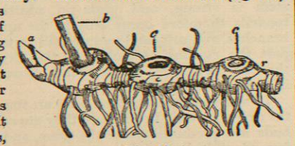


Fig. 68.

Rhizome *r* of *Polygonatum multiflorum* (Solomon's Seal), forming buds and adventitious roots. *a*, young bud; *b*, bud developed as a branch; *c*, *c*, cicatrices or scars of old branches.

A *pseudo-bulb* (fig. 62) is an enlarged bulbous-like aerial stem, common in Orchidaceous plants. It is succulent, often contains numerous spiral cells and vessels, and is covered with a thick epidermis. A *soboles* is a creeping underground stem, sending roots from one part and leaf-buds from another, as in Couch-grass, Carex arenaria, and Scirpus lacustris. It is often called a creeping root, but is really a rhizome with narrow elongated internodes. A *tuber* is a thickened stem or branch produced by the approximation of the nodes and the swelling of the internodes, as in the Potato. The eyes of the Potato are leaf-buds. Tubers are sometimes aerial, occupying the place of branches. The ordinary herbaceous stem of the Potato, when cut into slips and planted, sends off branches from its base, which assume the form of tubers. Tubers frequently store up a quantity of starch as in Maranta arundinacea, whence arrowroot is derived. Another form of thickened underground stem is the *corm*, as seen in the Autumn Crocus (Colchicum, fig. 69), Gladiolus, &c. Structurally it is composed of a solid more or less rounded axis covered by a layer of thin membranous scales (fig. 70, *h*, *h*). A

Fig. 69.

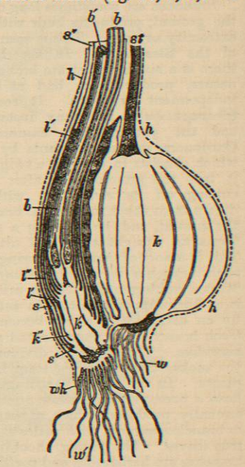


Fig. 70.

Fig. 69.—Corm of Meadow Saffron (*Colchicum autumnale*). *a*, old corm shrivelling; *b*, young corm produced laterally from the old one.

Fig. 70.—Corms of *Colchicum autumnale* in autumn when the plant is in flower. *k*, oldest corm; *h*, *h*, brown scales covering it; *w*, its roots; *st*, its withered flowering stem; *k'*, younger corm produced from *k*; *wh*, roots from *k'*, which grows at expense of *k*; *s*, *s'*, *s''*, sheathing leaves; *l'*, *l''*, foliage leaves; *b*, *b*, flowers; *k''*, young corm produced from *k'* in autumn, and which in succeeding autumn will produce flowers. (*Sachs.*)

corm is only of one year's duration, giving off buds annually in the form of young corms. In autumn the young corm gives origin to leaves, the lower of which (*s*, *s'*, *s''*) form sheaths round the corm and flower-stalk, the upper (*l'*, *l''*) remaining very small; and in the axil of the uppermost leaves the flowering-stem develops and bears the flowers (*b*, *b'*). Meanwhile in the axil of the middle leaves on the corm, a bud—the rudiment of a new corm—appears (*k'*). The flowering-stem dies down, and the corm from which it arose enlarges greatly during the winter at the expense of its parent corm (*k*), which thus becomes shrivelled. In spring the leaves produced on it (*l'*, *l''*), which were merely rudiments in autumn, appear above ground as conspicuous

large leaves. At the end of spring these leaves die down, the bases of the lower ones alone remaining, and constituting thin brown scales around the corm (as at *h*). Meanwhile, the young bud corm (*k'*) in the axil of the middle leaves grows rapidly at the expense of its parent corm (*k'*), but it does not attain a great size. In autumn it produces new leaves, which remain small, but from the axil of the two upper the flowering stem rises up and bears flowers; whilst in the axil of its middle leaves a new bud-corm appears, which will the following autumn produce young leaves, flowering stem, and a new bud-corm, and thus the cycle goes on. The buds or new corms formed from the old corms may be produced either laterally, as in Colchicum autumnale, or terminally, as in Crocus and Gladiolus. The *bulb* is another form of underground stem or bud. The axis in this case is much shortened, and the internodes are hardly developed. The bases of the leaves rising from the stem are quite close together, and become succulent and enclose the axis. In the Lily the thick and narrow scales are arranged separately in rows, and the bulb is called *scaly*; while in the Leek, Onion, Squill, and Tulip the scales are broad, and enclose each other in a concentric manner, the outer ones being thin and membranous, and the bulb is *tunicated*. In the axils of these fleshy scales new lateral shoots arise, forming new bulbs. The lateral buds or *cloves* sometimes remain attached to the axis, and produce flowering stems, so that apparently the same bulb continues to flower for many years, as in the Hyacinth and Tulip; at other times the young bulbs are detached, and form separate plants. In the axil of the leaves of Lilium bulbiferum, Dentaria bulbifera, and some other plants, small conical or rounded bodies are produced, called *bulbils* or *bulblets* (fig. 71, *b*). They resemble bulbs in their aspect, and consist of a small number of thickened scales enclosing a growing-point. These scales are frequently united closely together, so as to form a solid mass. Bulbils are therefore transformed leaf-buds, which are easily detached, and are capable of producing young plants when placed in favourable circumstances. The scales in bulbs vary in number. In Gagea there is only one scale; in the Tulip and Fritillaria imperialis they vary from two to five; while in Lilies and Hyacinths there are a great number of scales. In the Tulip a bud is formed in the axil of an outer scale, and this gives rise to a new flowering axis, and a new bulb, at the side of which the former bulb is attached in a withered state.

Fig. 71.

Stem of Bulbiferous Lily (*Lilium bulbiferum*), showing bulbils or bulblets *b*, produced in the axils of the leaves.

The forms of the stem having been considered, we now proceed to examine its anatomical structure. This structure consists of the elementary tissues combined and arranged in various ways. The arrangement of the fibro-vascular bundles in the mature stem or root is not the same in all plants. But we find that in most plants which have two seed-lobes in the embryo, *i.e.*, Dicotyledons, a characteristic structure is apparent, quite distinct from what is found in the majority of plants in which only one seed-lobe is present in the embryo, *i.e.*, in Monocotyledons; and these, again, have a different structure from that found in Acotyledons, or plants with no seed-lobe in their embryo. The three forms of stem here referred to have been usually distinguished as follows:—(1.) *Exogenous* stem, in which the fibro-vascular bundles are produced indefinitely in an outward direction, and the stem increases in diameter by the annual formation of a new layer of woody matter on the outside of the preceding layers. This is the form found in most Dicotyledons, and they have hence been called *Exogens*, or Outward-growers. Ordinary trees, such as the Oak and Ash, furnish instances. (2.) *Endogenous* stem, in which the fibro-vascular bundles are definite, and are formed towards the centre, which becomes filled up with them in the progress of growth, so that the diameter of the stem increases in a great measure by the new matter pushing out that previously formed. This stem characterizes many Monocotyledons, which have thus been called *Endogens*, or Inward-growers. Palms supply examples. (3.) *Acrogenous* stem, in which the bundles of vessels are simultaneously developed, and the additions to the stem take place at the summit by the union of the bases of the leaves. Plants having this kind of stem are called *Acrogens*, or Summit-growers, and are Acotyledons. Tree-ferns furnish an example. Recent research, however, has shown that these terms cannot always be used as synonymous with Dicotyledon, Monocotyledon, and Acotyledon, as we find amongst Dicotyledons stems where the formation of new fibro-vascular bundles is distinctly endogenous, and again amongst Monocotyledons stems with a provision for exogenous growth, and also amongst Acotyledons examples are not wanting in which a continuous increase in diameter is provided for.

We shall consider the structure of the stem in Dicotyledons, Monocotyledons, and Acotyledons successively.

In the young stem of a Dicotyledon the fibro-vascular bundles first appear as a circle of wedge-shaped masses, by which the stem is divided into a central cellular portion, the *pith*, and a peripheral *cortex*,—the space between the bundles being occupied by cellular tissue constituting the *medullary rays*, and uniting the pith and cortex. Each fibro-vascular bundle increases by division of its own cambium cells. If eventually all the cambium cells become permanent tissue then the bundle becomes closed, and all further growth ceases. This is the complete structure of an annual herbaceous dicotyledonous stem, which thus consists of a central cellular pith, a circle of fibro-vascular bundles, a cellular cortex united with the pith by medullary rays, and outside all an epidermis (fig. 72). In trees and shrubs with permanent woody stems, the young shoots given out annually have a structure similar to that of annual herbaceous stems; but as the shoot grows, further changes occur by which the diameter is increased, and the stem becomes more dense. After the first year's growth, the cells of the medullary rays, stretching between the fibro-vascular bundles and continuous with their cambium cells, become converted into *secondary meristem*, and then an *interfascicular* cambium is formed, which eventually coalesces with the cambium cells of the fibro-vascular bundles, and thus a complete *cambium ring* is formed (fig. 73). From this cambium ring new xylem or wood is formed on the inside, whilst new cortex

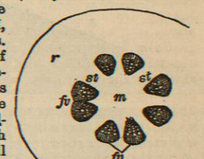


Fig. 72.

Young Dicotyledonous stem. *m*, pith; *fv*, wedge-shaped fibro-vascular bundles; *st*, medullary rays; *r*, cortex. Outside all is the epidermis. (*Sachs.*)

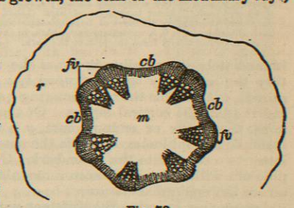


Fig. 73.

Young Dicotyledonous stem; *m*, pith; *fv*, fibro-vascular bundles; *cb*, connecting band of meristem, by which a cambium ring is formed; *r*, cortex. (*Sachs.*)