occur occasionally; but the other cryptogamous plants are entirely without them. These vessels are sometimes called *air vessels*, because their slender spiral tubes are always found filled with a kind of air, which contains seven or eight times more oxygen than the common air we breathe. *Ducts* are cylindrical tubes closely resembling those which enclose the air vessels; only the spiral vessels they contain appear to have been broken into rings, or short corkscrew-like curves, which sometimes cross each other in a reticulated manner. These rings and curves are, however, quite different from the true spiral vessels, as they have no power of unrolling, and appear only intended to keep the slender membrane which forms the duct distended. Similar rings are found in the windpipe of animals, which appear also only intended to keep that membrane distended. The ducts in plants are always found to contain liquid.

44. *Pitted tissue*, sometimes called *dotted ducts*, or *vasiform tissue*, consists of tubes which, when held up to the light, appear full of holes, from the numerous dots in the lining of their sides. The mouths of these tubes are very conspicuous in the wood of the rattan when cut across; they are also to be seen in sections of the oak and the vine; and, indeed, in most other kinds of wood, as well as in the stems of herbaceous plants. Being the channels through which the ascending sap is conveyed, the dotted ducts are larger than the vessels of the other tissues, and are distinctly visible in many kinds of wood, even when dry. Modern botanists consider them as belonging to cellular tissue, and as consisting only of elongated cells placed end to end, and opening into each other so as to form a kind of tube. The dots are supposed to be formed by deposition of earthy matter, like that in the cellular tissue which forms the stones of fruits, and which botanists call *sclerogen*.

45. *Lactiferous tissue*, which is the same as the proper vessels of the older botanists, consists of tubes, which are

58. Describe the spiral ducts.
59. What of the pitted tissue, with examples?
60. What is the nature and use of the lactiferous tissue?

distinguished from all other kinds of tissue by being branched. They are filled with a mucilaginous fluid called the *latex*, which is, in fact, the descending sap, and is full of numerous small specks, like that which is the germ of the future chicken in the egg of a hen. These specks are always in motion while they remain in the vessels of the latex, and whenever they are deposited, they expand into cells of different kinds of tissue. From the latex, also, is formed gum, sugar, tannin, or other secretions, according to the nature of the plant. The vessels of the latex are found on the under sides of leaves, and within the inner bark, which they may be said to line: hence the peculiar secretions of a tree are generally strongest in the bark, and what are not deposited there, are in most cases carried down to the root.

46. *Most kinds of tissue* may be traced in all the compound organs of plants, though in different proportions, except the vessels of the latex, which are only found in the under part of the leaves, and lining the inner surface of the liber, or inner bark.

COMPOUND ORGANS, AND THEIR FUNCTIONS.

47. The compound organs of plants are composed of several of the simple ones; as, for example, a leaf has woody and vascular tissue in its veins, and cellular tissue in its pulpy part; and in like manner, these elementary organs are found in the stem, flower, fruit, and, in fact, in every part of the plant. The compound organs are divided into three kinds; namely, the *general organs*, which are common to every part of a plant, such as the *epidermis*, or skin, and the hairs; *the organs of nutrition*, through which the plant takes and digests its food, such as the root, stem, and leaves; and *the organs of reproduction*, which are the flowers, fruit, and seeds.

61. How are the compound organs of plants divided?

48. THE EPIDERMIS, OR SKIN, is a thin membrane, which covers every part of a terrestrial plant, except the stigma and the spongioles, but which is sometimes entirely or partly wanting in plants which live under water. It is composed of a kind of cellular tissue; but the cells are pressed so closely together, as to make it appear homogeneous to the naked eye; and they are filled with air instead of water. The use of the epidermis is to retain a sufficiency of moisture in plants; for, should the delicate membrane of which the cells of their tissue are composed become so dry as to lose its elasticity, the different organs would be unable to perform their proper functions. On this account, its thickness is curiously adapted to the conditions under which a plant grows. In ordinary cases, the epidermis consists of two layers, the outer one of which, called the *cuticle*, is extremely thin, and consists of cells of oblong shape and large size, pressed closely together, and filled with air: while the secondary layer is formed of cells of a different shape and size, but still closely pressed together. In the plants of very hot countries, it consists of three, or even four layers, in order that the moisture may be retained, notwithstanding the excessive heat and dryness of the climate. The oleander being a native of a country subject to hot drying winds, has an epidermis which consists of four layers. Those plants which have numerous pores, or stomata, in their epidermis, require watering oftener than others, and are more easily affected by the heat of the sun. Thus, we often see the leaves of the common lilac droop, as though the plant were suffering for want of water; while those of the apple or pear tree which grows beside it are perfectly unaffected by the heat—the latter tree not having above twenty thousand pores in the square inch, while the lilac has one hundred and sixty thousand in the same space. The epidermis of aquatic plants is extremely thin; and, indeed, it is entirely wanting on the under side of floating

62. Describe the epidermis of plants and its use.
63. What of its layers and pores?

leaves, as also on the stigma of the flower, and on the spongioles of the roots. The cuticle, being composed of cells so firmly pressed together that it is longer in decomposing than any other part, is often found on leaves of which all the pulpy part is decayed. While in a healthy state, the epidermis adheres so closely to the pulpy part of the leaf, that it cannot be separated without laceration of the cells, however easily it may appear to peel off.

49. *The stomata* are valve-like openings in the epidermis, which communicate with the intercellular passages, and which seem intended to regulate evaporation. Sometimes these openings are partially closed with hairs; and succulent and aquatic plants have either no stomata, or have them so imperfectly formed, as scarcely to be capable of action. They have never been discovered upon roots, nor upon the ribs or veins of leaves. The word *stomata* signifies mouths; and each *stoma*, or mouth, consists of two kidney-shaped cells, which, when open, leave a delicate little slit between them, but which have the power of closing entirely when necessary. The stomata are so extremely small, that one hundred and sixty thousand have been counted in every square inch on the under side of the leaf of the common lilac. They are generally most abundant on the under side of the leaf, and in the lilac there are none on the upper side; but in some plants—for example, in the carnation—the numbers are equal on both sides, and do not amount to more than forty thousand in the square inch in each. In other plants, the numbers are very limited; as, for example, the mezereon has no stomata on the upper side of the leaf, and only four thousand in the square inch on the under. The use of the stomata is to enable the plant to throw off its superfluous water, and

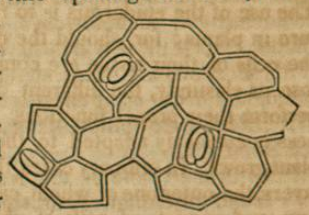

Fig. 6.—Stomata of a Leaf.

64. What of the stomata or mouths of the epidermis?
65. Their number and peculiarities.

this it does with great rapidity when exposed to the heat of the sun. The vessels of plants are so extremely small, that all the solid substances they take must be reduced to an impalpable form by solution in water before they can be absorbed; thus, a great deal more moisture is taken up by a plant than is wanted for its nourishment; and the superfluous water would distend the vessels, and bring on a kind of dropsy, if it were not evaporated through the stomata. This occasionally happens with plants that have very few or no stomata; such, for example, as the different kinds of cactus, and all those which have succulent or fleshy leaves. If these plants are over-watered, their vessels become diseased, and decay soon ensues.

50. *Hairs* are minute expansions of the epidermis, and are found almost upon every part of a plant. Sometimes they cover the whole of the leaf, and sometimes they are only found on the lower surface. They are of two kinds; namely, *lymphatic* and *glandular*.

51. *Lymphatic hairs* are of various kinds, but they may be divided into short and long. Of the short, the most remarkable are, *down*, or *pubescence*, when the hairs are very short and very soft; *tomentum*, when they are closely pressed to the surface of the epidermis, and appear entangled; *velvet*, when they are very short, dense, and rather rigid; and *bristles*, when they are short, stiff, and wiry. *Hooks* and *barbs* are bristles hooked or barbed at the point. Of the long hairs the principal are those called *hirsute*, which are moderately long and rigid; *pilose*, of the same kind, but longer: *villous*, long and soft; *crinose*, very long and loose; and *silky*, long, but pressed closely to the surface. Besides these kinds, hairs, whether long or short, are said to be *ciliate* when they surround the margin of a leaf or petal, like the lashes of the eye; *bearded* when they grow in erect tufts; and *stellate* when they grow in similar tufts, but are spread out like little stars.

52. *The use of lymphatic hairs* is partly to protect the surface of the leaf from the heat of the sun and from drying winds, and partly to collect moisture from the atmosphere. It is now known that plants take in nourishment from the atmosphere as well as from the ground; and it is supposed that part of this nourishment is absorbed through the lymphatic hairs. It has been observed, that the hairs, when they do not cover the entire surface of the leaf, always grow either upon the veins or in the angles where the veins cross each other. It is thus evident that they have a direct communication with the vessels containing the sap. Lymphatic hairs are most abundant on the under surface of the leaves, which is, indeed, very rarely entirely devoid of them.

66. Describe the hairs of the epidermis.
67. The varieties of hairs, and how designated?

53. *Glandular hairs* are hollow, generally open at the point, and with a receptacle of secretion at the base. Of this nature are the stings of the nettle, and the hairs of the sweet-brier, &c., which are filled with a fragrant volatile oil. In both these cases, glandular hairs seem to act as organs of excretion, through which the plant is enabled to exude certain fluids.

54. *The position of hairs* is generally perpendicular to the surface on which they grow; but in some plants they are attached by the middle; as, for example, in all the cabbage tribe.

55. *Scurf* is the name given to a rough and spotted appearance on the leaves of plants, which is also an expansion of the epidermis.

56. *Glands* are organs of secretion, or cells containing liquid different from that in the cells of the common tissue of the plant, as in the flowers of the *Hypericum*, or St. John's wort, which give out a red liquid when pressed. Sometimes glands assume a wart-like appearance; thence the stems or leaves on which they appear are said to be *verrucose*, or *warty*; and sometimes they take the form of little watery blisters, in which case the plant is said to be *papillose*.

57. *Prickles* may be called hardened hairs, as they are merely indurated expansions of the epidermis, without any

68. What functions do they perform in plants?
69. What other organs are named?

woody fibre; and they may be detached from the branch which bears them without laceration. Occasionally the side veins or lateral ribs of a leaf end in sharp points, which are called *prickles*, as in the leaves of the holly; but these are, in fact, spines, as they are expansions of woody fibre.

58. *Thorns* differ from prickles in being formed partly of woody fibre; and they cannot be detached from the branch which bears them without lacerating its vessels. They are, in fact, abortive, or imperfectly developed buds, and are formed instead of leaves and branches.

59. *Spines* resemble thorns in every respect, except in being found on the leaves and stems of herbaceous plants, while thorns only grow on the trunk and branches of woody plants. When spines grow on leaves, they are always found on the nerves or veins, which are extensions of the woody fibre. Spines serve to protect the leaves; and, in some instances, when the plant has risen above the reach of animals, it produces its leaves without spines.

60. *Of the general organs*, the epidermis is the only one that is sure to be found on every plant, and even of this the cuticle cracks and peels off in the case of old trees. The stomata, it has been already observed, vary exceedingly in numbers, according to the nature of the plant, and in some they are entirely deficient. The hairs are also sometimes wanting, in which case the surface of the leaf is said to be *glabrous*, or smooth.

ORGANS OF NUTRITION—ROOT, STEM, LEAF-BUDS, AND LEAVES.

61. THE ORGANS OF NUTRITION are the root, the stem and branches, and the leaves; and of these organs, the root and the leaves, or some modification of them, must exist in every flowering plant, as the vital functions could not be carried on without them.

62. THE ROOT is that part of the plant which grows

70. Define the technicals italicized.
71. What is said of the universality of the epidermis?
72. Name the organs of nutrition.
73. Describe the root.

downwards from the vital knot, or collar, which divides it from the stem.

63. *There are two kinds of roots*; namely, the main root, or *caudex*, and the fibrous roots, or *fibrils*.

64. *The uses of roots* are to give stability to the plant, which is done by the main root; and to supply it with nourishment, which is done by the fibrils.

65. *To give stability to the plant*, the main root either descends to a considerable depth into the ground, or spreads over a sufficient extent of surface, to afford a proper base to the head. When the main root descends perpendicularly, it is called a *tap-root*; and when it divides just below the collar, it is called a *branching root*.

66. *To supply the plant with food from the soil*, the main roots are furnished with a great number of slender fibres, each ending, as the main root does itself, in a soft porous part called a *spongiole*, from its resemblance to a little sponge. This organ imbibes what moisture it can find, and the moisture is thence transmitted through the other parts of the root to the stem and leaves.

67. *Roots elongate* chiefly by fresh tissue forming at the extremity of the fibrils. Thus the spongioles being always the latest formed part of the root, the tissue composing them is looser in its texture than that of the other parts, and more readily absorbs water. The whole root, except the spongioles, is also covered with an epidermis, or skin, which is destitute of pores, and which, in trees and shrubs, become thickened by age into a cortical integument like bark.

68. *A tap-root is always sent down first* by a seedling plant; but as the plant increases in size and strength, the tap-root seems to disappear, as it either changes its form, or is surrounded by other roots, which soon attain such a size and thickness as to render the original root no longer distinguishable.

69. *As plants increase in age their roots enlarge.* Trees and shrubs have, after the first few years, in most cases a

74. Varieties and uses of roots.
75. What change by age?

branching root, as shown in fig. 7. Herbaceous plants have generally either fibrous roots, that is, a number of roots of the same thickness descending perpendicularly, or extending horizontally from the collar; or they have thickened roots, in which a store of feculent or mucilaginous matter is laid up for the use of the plant, should it be required. Of this nature are the spindle-shaped or fusiform roots of the parsnip (*a* in fig. 8), and the truncated root shown in *b*, the moniliform or granulated root of the meadow saxifrage (fig. 9), fasciculated tubers of the dahlia and peony (fig. 10), and the tuberous roots shown in figs. 11 and 12.

Fig. 7.—Branching Root.

Fig. 8.—Spindle-shaped or Fusiform Root (*a*); Truncated Root (*b*).

Fig. 9.—Moniliform Roots.

Fig. 10.—Fasciculated Root of the Peony.

76. Describe the various roots of herbaceous plants, with examples.

Fig. 11.—Tuberous Roots.

Fig. 12.—Twin Roots.

70. *Roots have no natural buds*, and on this account those roots which produce buds, such as the potato, are generally called underground stems. Some botanists include under this name the fleshy roots of the turnip and carrot; but, as all the buds produced by these roots, and even those found on the tubers of the potato, are always irregular or adventitious (see fig. 13), and as all roots are found occasionally to produce adventitious buds, the mere fact of fleshy roots producing buds does not appear a sufficient reason for calling them stems; particularly where the collar is above the fleshy part of the root, as is decidedly the case with the carrot (see *a* in fig. 14), as all botanists allow that to be the point of division between the ascending and descending axes of the plant, or, in other words, between the stem and the root.

Fig. 13.—Longitudinal Section of a Potato.

Fig. 14.—Section of Fleshy Root, with Collar.

77. What of buds upon roots?

71. *The mode in which plants obtain nourishment from the soil,* is by absorbing the various substances they want in a state of solution. It is well known that a considerable quantity of inorganic matter is taken up by the roots, the particles of which must be in a state of most minute division, and dissolved in many times their own bulk of water, before they can pass through pores so exceedingly minute as those of the spongioles. The same may be said of carbon, which is a solid substance, and which constitutes at least one-half of every vegetable. On this account, the quantity of moisture taken up by every healthy plant is very great in proportion to its size; and it was found, by experiment, that four plants of the common mint, which were grown for fifty-six days with their roots in water, took up during that time seven pints of the fluid, though their own weight was only four hundred and three grains. The fact, that water is imbibed only by the spongioles, has been proved by bending a fleshy root, and placing it in water so as to leave the spongioles dry, when it is said that no water is absorbed, and it is certain that the root withers. If, on the contrary, the fleshy part of the root be kept dry and only the tips of the spongioles immersed in water, the root is maintained in a vigorous and healthy state.

72. *The root elongates much more rapidly than it increases in thickness;* and hence the roots of the largest timber trees are extremely slender in proportion to their trunks. The reason for this seems to be, that a very thick root is not wanted to give stability to a ligneous plant, as it would require an enormous depth of soil to sustain such lofty trunks, were they dependent upon a single root. In tap-rooted trees and herbaceous plants, on the contrary, the main root is as thick as the stem, and sometimes thicker; as in that case the plant is steadied only by the root descending into the ground, and the stem would be apt to be broken off by high winds, if the main root were not of corresponding dimensions. Another reason for the great elongation of the branching roots is, the necessity which

78. Describe the process of obtaining nutriment from the soil, and its chemical processes.
79. Proportion of growth in the roots of plants.

trees, and other plants intended to last many years, are under of finding fresh soil. This is not felt by annuals, as they cannot in one year exhaust the soil within their reach of all the nutritious substances they may require; and thus even forest trees have generally tap-roots the first year, though their roots afterwards soon become branched.

73. *The construction of roots* differs in many respects from that of stems; though, as in other cases, the characteristic differences appear in some examples to melt so gradually into each other, that it is difficult to draw a distinction between them. It has been before observed, that though plants and animals are really quite distinct, there are some organized forms which it is difficult to class with either, as they appear to belong to both. In like manner, there are some roots that appear to be stems, and some stems that can hardly be distinguished from roots. Of the first kind are the aërial roots sent down by palm and other similar trees, apparently for the purpose of strengthening their stems, which are often very small at the base, in proportion to the height of the tree. The roots sent out by cabbages and cauliflowers from above the collar, when they are transplanted to a rich soil, are of the same kind. Many herbaceous plants send out roots in a similar manner when they are earthed up; and trees which grow in unnatural situations, as on a wall or bare rock, send down roots in quest of soil and moisture, which afterwards take the appearance of stems. The maple, the gooseberry, and some others, may have their roots converted into stems by reversing the plants, and burying the tips of the shoots in the earth, so as to leave the roots in the air. In this case, the branches will soon send out fibrous roots from the joints which have been buried in the earth, and the fibrous part of the old roots withering, the roots themselves will gradually assume the character of branches. With regard to stems being mistaken for roots, the instances are still more common. What are generally called creeping roots, are all underground stems; the rhizoma, or root-stalk, of the water lily, and those of several kinds of ferns, are of a similar nature.

80. Singular construction of roots.

The tubers of the potato and arrowroot are also called underground stems, which are said to have become so distended and overgrown by an excess of cellular tissue, as to bury the buds and to distort them out of their proper position. This is exemplified in what are called the pine-apple potato, the buds of which are said to be arranged with as much regularity as those of any aërial stem. Bulbs, which were formerly classed with roots, are, in fact, underground stems and distended leaf-buds.

74. *The structure of the woody part of roots* corresponds in a great measure with that of the stem, with the exceptions that no pith exists in roots, and that there are no regular joints, or nodes, for the production of buds. In the place of pith, there is in the centre a bundle of vascular tissue and woody fibre, which is carried on by branches from the main roots through the whole of the fibrous roots, and even through the spongioles; though in the fibrous roots it is only covered by a sheath of transparent cellular tissue, and in the spongioles by tissue of a still softer and looser nature. This bundle of fibre and vessels, forming a kind of cord, may be seen distinctly through the transparent sheath with which it is covered; and as the descending sap is conveyed by it downwards, a portion of that sap, containing the peculiar secretions of the plant, is frequently discharged by it from the roots: hence the ground in which poppies have been grown has been found to contain a portion of opium, and that in which oaks have grown, tannin, &c. On this account, the roots, like the bark, are often found to contain a great portion of the secretions of the plant.

75. *The collar*, or *vital knot*, also called the *collet*, *neck*, or *crown*, is that part which divides the stem from the root. It is sometimes scarcely perceptible, as in most kinds of herbaceous plants; but in trees and shrubs, it is generally marked by a roughness round the stem, just above the surface of the ground. In the elephant's foot, or Hottentot

81. What of under-ground stems, bulbs, etc.?
82. Nature and functions of the woody part of roots.
3. What of the collar of plants?

bread, it is exceedingly enlarged, and covered with a hard woody substance (see fig. 15). De Candolle, and other continental botanists, have regarded the collar as the most vital and important part of a plant; and though the majority of modern botanists appear to think that its importance has been overrated, it is quite certain, that if the collar be uninjured, the stem of most plants will grow again when cut down; but no art can make the roots produce another stem where the collar is removed, unless it should be from an adventitious bud. Thus, the tubers of the dahlia, when separated from each other with a portion of the collar attached, will produce separate plants; but if no part of the collar be attached to the separated tuber, though it may continue to live, and even grow, no art can ever make it produce a stem.

Fig. 15.—Elephant's Foot.

76. The stem is the ascending axis of the plant, always growing above the collar, as the root grows below it. It is furnished with joints or nodes at regular distances, where the fibres and vessels take a curved direction, so as to form a little recess, plainly discernible when the branch is split in two, in the centre of which the bud is formed that afterwards expands into a branch furnished with leaves, and sometimes producing flowers and fruit.

77. *Stems are either ligneous*, *herbaceous*, or *suffruticose*. *Ligneous stems* are those of trees and shrubs, which, being composed principally of woody tissue, are hard and durable. *Herbaceous stems*, on the contrary, being composed chiefly of cellular tissue, are green and succulent, and of short duration, generally dying down to the ground every winter, even when the root survives. *Suffruticose stems* are those which are partly ligneous and partly herbaceous;

84. Importance of the collar in transplanting.
85. Define the stem and its varieties.
86. Varieties of ligneous stems, and define.

the lower part of the stem being woody, and the young shoots succulent.

78. *Ligneous stems differ in their construction* according as they are Exogenous, Endogenous, or Acrogenous.

79. *Exogenous ligneous stems* increase by successive layers of new wood, deposited within the bark on the outside of the old wood: hence they are called *exogenous*, which signifies to increase on the outside. In external aspect, the ligneous exogens are easily distinguished by the branching and leafy nature of their trunks, which, in the case of forest trees, often present a lofty and commanding appearance (see fig. 16). As shrubs and trees, they yield at once beauty and shelter to the landscape, while their timber, from its strength and durability, is of most essential service to man in the construction of houses, ships, implements, and machinery.

Fig. 16.—Pine.

80. *The stem of a seedling exogenous tree* consists at first only of cellular tissue, surrounded by an epidermis; but as soon as the leaves have expanded, some bundles of woody fibre are deposited, so as to have the appearance of a dotted circle just within the skin. As the tree advances in growth, the cellular tissue in the centre becomes what is called *pith*, and rays of it extend to the epidermis between the bundles of woody fibre. A membrane, or rather layer of vascular tissue, then forms round the pith, so as to separate it entirely from the bundles of woody fibre, and the pith takes the form of a star, with rays diverging from a centre. The pith was called by the older botanists the *medulla*, from the resemblance of its position in the tree to that of the medulla, or spinal marrow of an animal; and for the same reason, the layer of vessels round the central pith is called the *medullary sheath*, and the rays the *medullary rays*. In the second year of a tree's life, the rays and the central pith both contract as fresh layers of woody fibre are deposited, and they

87. Define the technicals here italicised.

continue to do so every year till the tree is full-grown. In the second year's growth of a seedling tree, a complete layer of wood is formed round the pith just within the epidermis, and this is called the *alburnum*, or *sap-wood*. Another layer of vessels, like those in the medullary sheath, afterwards forms round the sap-wood, so that when a second layer of wood is deposited, a distinct ring of vessels remains between the two. This process is continued every year, and, as the layers of vascular tissue have always a different appearance from the tissue of the wood, the rings of vessels between the layers of wood, which are called *concentric circles*, and the medullary rays diminished to fine lines, may be always traced in a section of the trunk of a tree (see *a* in fig. 17). The medullary rays become changed in time into thin hard plates, which still radiate from the centre to the outer circumference of the tree, and which form what is called by the carpenters the *silver grain* of the wood. The central pith, in the meantime, has diminished to a mere speck in the middle of the tree, or, as is frequently the case, it has entirely disappeared. The layer of wood which is deposited every summer, always appears soft and white for the first year; and it is called the *sap-wood*, because the ascending sap rises through it the following spring. This wood is of no value as timber, and carpenters, in their contracts for houses, always agree not to use it, promising, that their wood shall be free from sap, &c. The inner layers of wood in the tree form what is called the *heart-wood*, or *duramen*, which is extremely hard and durable. As the layers of wood are thus distinct, and as one is generally deposited in temperate climates every year, it has been supposed the age of a tree may be found by counting the number of concentric circles; but this rule does not always hold good, for the reasons before explained (par. 32). Sometimes, but rarely, concentric circles are not formed at all; as in the Menispermum, in which, after the first year, the wood appears to be in one mass; as in the trunks of the woody species of Aristolochia, in which

88. What changes indicate the age.
89. What of the sap-wood in various trees?

the wood is divided into wedge-shaped portions by the medullary rays; and as in old trunks of Calycanthus, in the wood of which four distinct axes, or central points, may be traced. The sap-wood of regularly-formed wood is always white, but some secretions are conveyed by the returning sap through the medullary rays into the heart-wood, which changes its colour to brown of various shades, dark red, green, or even black, according to the nature of the tree.

81. *The bark of exogenous trees* consists of three, and sometimes four parts; namely, the *cuticle*, or outer skin; the *cortical integument*, or solid part; and the *liber*, or inner bark. Of these, the cuticle, or outer skin, soon cracks, and partially peels off; as from the closeness of its texture, it cannot dilate so as to give space for the bark beneath it, when that organ increases in thickness. The cortical integument is what is properly called *bark*, and this in some trees attains a considerable thickness; as, for example, in the cork-tree, which is a variety of Spanish oak, and in several kinds of elm. This bark, or cortical integument, is occasionally in two layers, the inner one of which increases so rapidly in diameter, that the outer often cracks; and in some trees, as, for example, in the Oriental plane, it falls off in large plates as the part below it expands. The liber, or inner bark, which is quite distinct from the two layers of cortical integument, is very thin, though a layer of it is deposited every year within that of the preceding year. It was supposed by Linnæus that the inner bark became wood the second year, but this is now proved to be incorrect. It is generally very elastic, and dilates as the stem of the tree increases in thickness; but in a few ligneous plants, such as the vine and the honeysuckle, a portion even of the liber is thrown off annually. In the Menispermum and its allies, it is only formed the first year, and then buried in the trunk, where it is found near the pith. In some trees, as, for example, the Lagetto, or lace-bark tree of Jamaica, the liber is capable of extraordinary distension; and in others, as the lime tree, it is remarkable

90. Describe the varieties of bark, examples.

for its toughness, as is shown in the bast mats which are made of it.

82. *The nodes of exogenous trees and shrubs* are the parts destined to produce buds; and in some shrubs, as, for example, in the vine and the lilac, they are very distinct. They are generally called *joints*, but this is an incorrect mode of speaking, as the stem is not jointed where they occur. When a branch or stem of a ligneous plant is split open, it will be found that at every node there is a peculiar arrangement of the fibres, so as to form a little hollow or cell, in the centre of which the germ of the young bud forms. From some nodes, two buds are produced opposite each other; and in some herbaceous plants, four leaves or flowers spring from each node; but buds are very rarely produced from any other part of the tree, and when they are, they

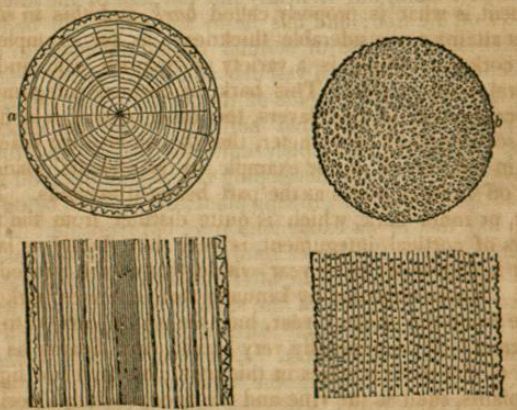

Fig. 17.—Sections of Exogenous and Endogenous Stems.

are said to be adventitious, or irregular. The spaces between the nodes are called *internodes*.

83. *Endogenous ligneous stems* have neither pith, medul-

91. What are nodes of trees and shrubs?
92. Peculiarities of endogenous ligneous stems.