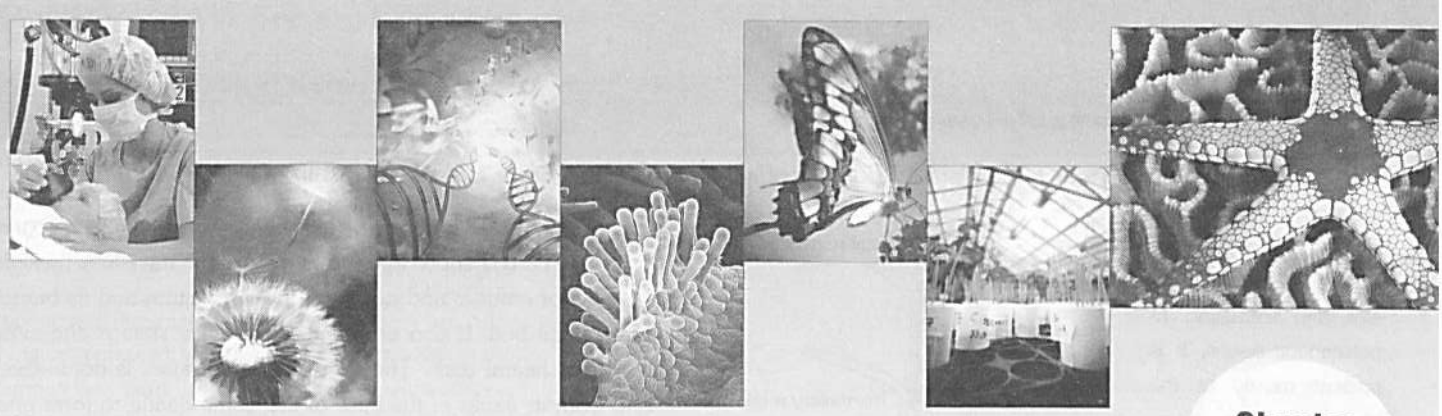


Chapter

2.2

Anatomy of Flowering Plants

A group of cells performing a particular function is collectively called as tissue. A tissue may be defined as, "a group of similar or dissimilar cells having common origin and performing specific function".

Tissues are mainly divided into three categories : Meristematic tissues or Meristems, Permanent tissues and Secretory tissues

Meristematic tissues or Meristems

The word "Meristem" originated from "*Meristos*" (Greek = continuous division) and the term meristem was introduced by Nageli (1858). A group of cells which are much active and capable of showing continuous divisions and redivisions, is called as meristematic tissue. The various characteristic features of the meristems are discussed below :

(1) They contain immature and young cells and are capable of repeated divisions.

(2) Intercellular spaces are not present in meristematic tissue.

(3) They contain a homogeneous thin cellulosic wall.

(4) They contain large nuclei associated with abundant cytoplasm.

(5) They are metabolically very active but they do not store food material and further no plastids in them.

(6) Vacuoles are small or absent.

(7) Meristematic cells are isodiametric in shape.

(8) Undifferentiated tissue in which cells divides continuously $G_1 \rightarrow S \rightarrow G_2 \rightarrow M$.

Types of meristems

The meristems may be classified on the basis of their mode of origin, position or function :

According to origin and development : On the basis of origin, meristematic tissues are of three types :

(1) **Promeristem or Primordial meristem :** The promeristem originates from embryo and therefore, called primordial or embryonic meristem. It is present in the regions where an organ or a part of plant body is initiated. A group of initial cells that lay down the foundation of an organ or a plant part, is called promeristem. It occupies a small area at the tips of stem and root. The promeristem gives rise to all other meristems including the primary meristem.

(2) **Primary meristem :** A primary meristem originates from promeristem and retains its meristematic activity. It is located in the apices of roots, stems and the leaf primordia. Primary meristem gives rise to the primary permanent tissue.

(3) **Secondary Meristem :** They always arise in permanent tissues and have no typical promeristem. Some living permanent cells may regain the meristematic nature. This process in which permanent tissue regains meristematic nature is called dedifferentiation. The secondary meristems are so called because they originate from permanent cells. The phellogen or cork cambium arising from epidermis, cortex or other cells during secondary growth, is an important example of secondary meristem. The secondary meristems produce secondary tissues in the plant body and add new cells for effective protection and repair.

According to position : On the basis of their position in the plant body meristems are classified into three categories :

(1) **Apical meristem :** This meristem is located at the growing apices of main and lateral shoots and roots. These cells are responsible for linear growth of an organ. Solitary apical cells occur in ferns and other Pteridophytes while apical initials are found in other vascular plants.

(2) **Intercalary meristem :** These are the portions of apical meristems which are separated from the apex during the growth of axis and formation of permanent tissues. It is present mostly at the base of node (*e.g.*, *Mentha viridis*, Mint), base of internode (*e.g.*, stem of many monocots *viz.*, Wheat, Paddy, Grasses, Pteridophytes like *Equisetum*) or at the base of the leaf (*e.g.*, *Pinus*). The intercalary meristems ultimately disappear and give rise to permanent tissues.

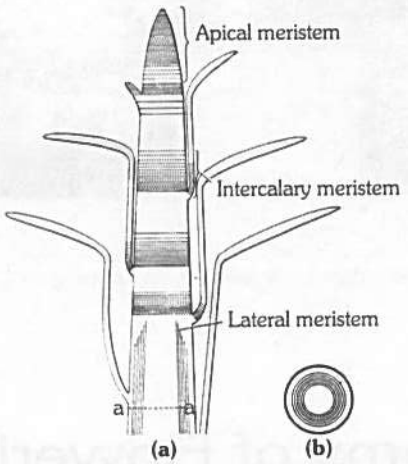


Fig : 2.2-1 Various meristematic tissue

(3) **Lateral meristem :** These meristems occur laterally in the axis, parallel to the sides of stems and roots. This meristem consists of initials which divide mainly in one plane (periclinal) and results in increase in the diameter of an organ. The cambium of vascular bundles (Fascicular, interfascicular and extrastelar cambium) and the cork cambium or phellogen belongs to this category and are found in dicotyledons and gymnosperms.

According to function : Haberlandt in 1890 classified the primary meristem at the apex of stem under the following three types :

(1) **Protoderm :** It is the outermost layer of the apical meristem which develops into the epidermis or epidermal tissue system.

(2) **Procambium :** It occurs inside the protoderm. Some of the cells of young growing region which by their elongation and differentiation give rise to primary vascular tissue, constitute the procambium.

(3) **Ground meristem :** It constitutes the major part of the apical meristem which develops ground tissues like hypodermis, cortex, endodermis, pericycle, pith and medullary rays.

According to plane of cell division : On the basis of their plane of cell division meristem are classified into three categories :

(1) **Mass meristem :** The cells divide anticlinally in all planes, so mass of cells is formed. *e.g.*, formation of spores, cortex, pith, endosperm.

(2) **Plate meristem :** The cells divide anticlinally in two planes, so plate like area increased. *e.g.*, formation of epidermis and lamina of leaves.

(3) **Rib or File meristem :** The cells divide anticlinally in one plane, so row or column of cells is formed. *e.g.*, formation of lateral root.

Structure and organisation of apical meristem

(1) **Vegetative shoot apex :** Shoot apex was first recognized by Wolff (1759) shoot apex is derived from meristem present in plumule of embryo and occurs at the tip of stem and its branches as terminal bud. It also occurs in the inactive state in the axils of leaves as lateral buds. The tip of the shoot apex is dome-shaped and from its flanks at the base of the dome divide to form one or more leaf primordia. This continues throughout the vegetative phase. Many theories have been put forward to explain shoot apex, such as :

(i) **Apical cell theory :** This theory was proposed by Nageli (1858). According to this theory, shoot apical meristem consists of single apical cell. This theory is applicable in case of higher algae, bryophytes and in many pteridophytes but not in higher plants (*i.e.*, gymnosperms and angiosperms).

(ii) **Histogen theory :** It was proposed by Hanstein (1870). According to this theory, the shoot apical meristem consists of three distinct meristematic zones or layers (or histogens).

(a) **Dermatogen :** Outermost layer and it forms epidermis and epidermal tissue system.

(b) **Periblem :** It is the middle layer which gives rise to cortex and endodermis.

(c) **Plerome :** The innermost layer forms pith and stele.

(iii) **Tunica corpus theory :** This theory was proposed by Schmidt (1924). According to this theory, the shoot apex consists of two distinct zones.

(a) **Tunica :** It is mostly single layered and forms epidermis. The cells of tunica are smaller than corpus. The tunica shows only anticlinal division and it is responsible for surface growth.

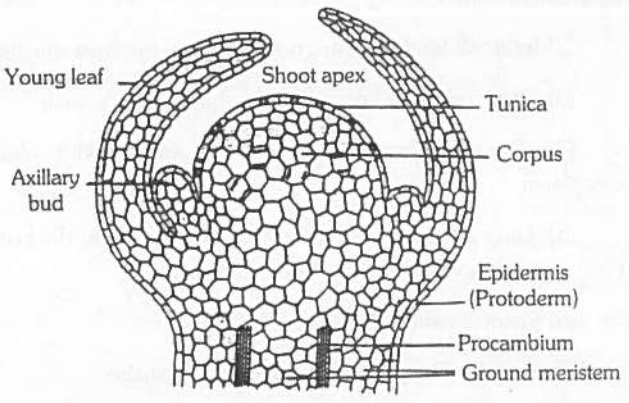


Fig : 2.2-2 L.S. Vegetative shoot apex

(b) **Corpus :** It represents the central core with larger cells. Corpus shows divisions in all planes and it is responsible for volume growth.

Popham and Chan (1950) introduced the term mantle for tunica and core for corpus.

(2) **Root apex :** A group of initial cells, present at the subterminal region of the growing root tip, which is protected by a root cap, is called root apical meristem or root apex. It is embryonic in origin and formed from the radicle part of embryo. However, in adventitious roots it is produced from derivatives of root apex. According to Hanstein (1870) root apex of most of the dicotyledons also consists of three meristematic zones - plerome, periblem and dermatogen (fourth meristem calyptrogen to form root cap only in monocots).

(i) **Dermatogen :** It gives rise to epiblema or piliferous layer or rhizodermis.

(ii) **Periblem :** It gives rise to cortex including endodermis..

(iii) **Plerome :** It gives rise to vascular tissue including pith.

Regarding the apical organisation of root following theories have been put forward.

Korper-Kappe theory : It was proposed by Schuepp (1917). This theory is comparable with the tunica and corpus theory of shoot apex. Korper means body and Kappe means cap.

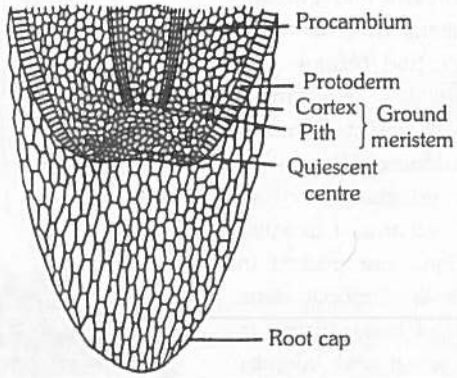


Fig : 2.2-3 L.S. Root apical meristem

Quiescent centre theory : It was proposed by Clowes (1961) in maize. According to him, in addition to actively dividing cells, a zone of inactive cells is present in the central part of the root apex called quiescent centre.

The cells in this region have light cytoplasm, small nuclei, lower concentration of DNA, RNA and protein.

(3) **Reproductive apex :** During reproductive phase, the vegetative apices are converted into reproductive apices. Before conversion, the apex stops producing leaf primordia. The summit of the apex which remained inactive during the vegetative phase, starts dividing. As a result of cell divisions, the apical meristem undergoes change in shape and increase in size. The apex may develop into a flower or an inflorescence.

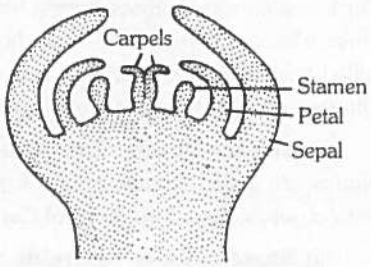


Fig : 2.2-4 L.S. Reproductive apex (diagrammatic)

Permanent tissues

Permanent tissues are made up of mature cells which have lost the capacity to divide and have attained a permanent shape, size and function due to division and differentiation in meristematic tissues. The cells of these tissues are either living or dead, thin-walled or thick-walled. Permanent tissues are of following types :

Simple permanent tissues

Simple tissues are a group of cells which are all alike in origin, form and function. They are further grouped under three categories :

(1) **Parenchyma :** Parenchyma is most simple and unspecialized tissue which is concerned mainly with the vegetative activities of the plant.

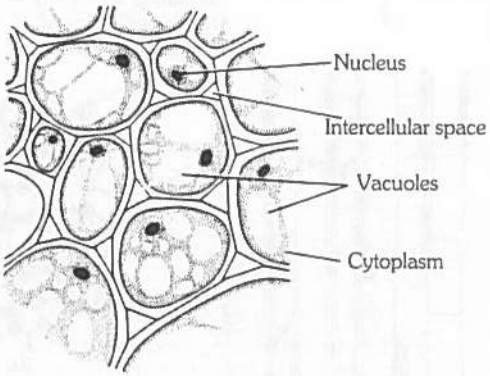


Fig : 2.2-5 Parenchyma in T.S.

The main characteristics of parenchyma cells are :

(i) The cells are isodiametric, living, thin walled, soft, possess a distinct nucleus, having well developed intercellular spaces, vacuolated cytoplasm and cellulosic cell wall.

(ii) The shape may be oval, spherical, cylindrical, rectangular and stellate (star shaped) in leaf petioles of banana and canna and some hydrophytes.

(iii) This tissue is generally present in roots, stems, leaves, flowers, fruits and seeds.

(iv) If they enclose large air spaces they are called as aerenchyma; if they develop chlorophyll, they are called as chlorenchyma and if they are elongated cells with tapering ends, they are called as prosenchyma.

Functions : They perform the following functions :

(i) Storage of food materials. *e.g.*, Carrot, Beetroot etc.

(ii) Chlorenchyma helps in photosynthesis. Aerenchyma helps in floating of the aquatic plants (Hydrophytes) and also helps in gaseous exchange during respiration and photosynthesis. *e.g., Hydrilla.*

(iii) In turgid state they give rigidity to the plant organs.

(iv) In emergency they behave like meristematic cells and help in healing of the various plant injuries.

(v) Sometimes they store secretory substances (ergastic substance) such as tannins, resins and gums and they are called as idioblasts.

(2) **Collenchyma :** The term collenchyma was coined by Schleiden (1839). It is the tissue of primary body. The main characteristics of collenchyma are given below :

(i) The cells of this tissue contain protoplasm and are living without intercellular spaces. The cell walls are thickened at the corners and are made up of cellulose, hemicellulose and pectin.

(ii) They are compactly arranged cells, oval, spherical or polygonal in outline. The tissue is elastic, extensible and have capacity to expand.

(iii) Collenchyma occurs chiefly in the hypodermis of dicotyledonous stems (herbaceous, climbers or plants *e.g. Cucurbita, Helianthus*) and leaves. They are usually absent in monocots and in roots.

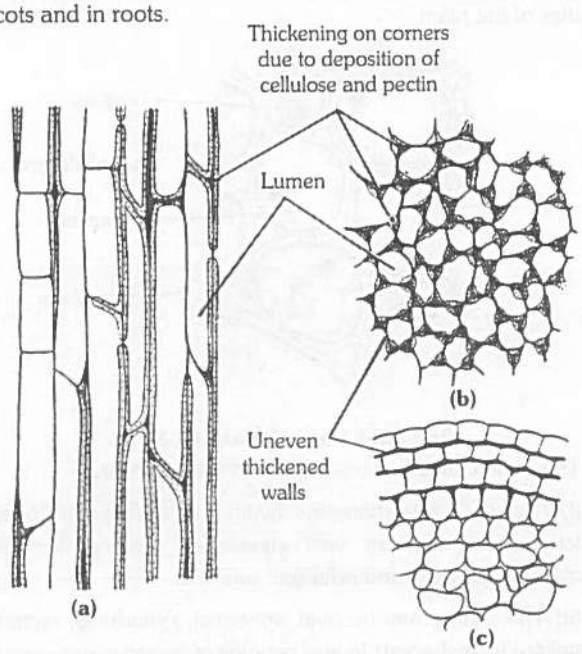


Fig : 2.2-6 (a) Collenchyma L.S. (b) and (c) T.S. of the same

Types of collenchyma : Majumdar (1941) divided collenchyma into three types on the basis of thickening :

(i) **Angular collenchyma :** When the thickening of the cells is confined to the corners of the cells. *e.g., Tagetes*, Tomato, *Datura*, Potato, etc.

(ii) **Plate or Lamellar collenchyma :** When the thickenings are present in the tangential walls. *e.g.* hypodermis of sunflower stem.

(iii) **Lacunar or Tubular collenchyma :** If the thickened cell wall is associated with intercellular spaces of the adjacent cells. *e.g.* leaf petioles of compositae (asteraceae) and malvaceae etc. hypodermis of *Cucurbita* stem, *Salvia, Malva*.

Functions

(i) Provide mechanical support to petiole, pedicels, branches of stem, roots and fruits.

(ii) If they contain chlorophyll they help in photosynthesis.

(iii) It is present at the margins of some leaves and resists tearing and bending effect of the wind.

(3) **Sclerenchyma :** It was discovered and coined by Mettenius (1805).

The main features of sclerenchyma are :

(i) It consists of thick-walled dead cells.

(ii) The cells vary in shape, size and origin.

(iii) In the beginning the cells are living and have protoplasm but due to deposition of impermeable secondary walls (lignin) they become dead, thick and hard.

Types of sclerenchyma : They are of two types :

(i) **Sclerenchymatous fibres :** These are greatly elongated and tapering at both the ends. The fully developed fibre cells are always dead. They are polygonal in transverse section and walls are highly lignified. Intercellular spaces are absent and lumen is highly obliterated. The walls show simple and oblique pits. They provide mechanical strength to the plant. Some of the longest fibre yielding plants are *Linum usitatissimum* (Flax or Alsi), *Corchorus, Cannabis*, etc. The fibres are present in hypodermis of monocot stem, in pericycle of many dicots, in secondary wood and vascular bundle sheath in monocot stems. There are three different kinds of fibres :

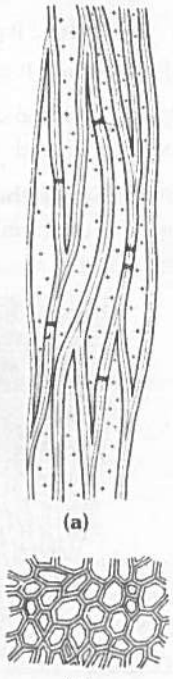


Fig : 2.2-7 Sclerenchymatous fibres (a) L.S. (b) T.S.

(a) **Bast fibres :** The fibres present in the pericycle (*e.g., Cannabis sativa* / Hemp or Bhang), *Linum usitatissimum* and phloem (*e.g., Corchorus capsularis* (Jute), *Hibiscus cannabinus* (Patsan), *Calotropis, Nerium*, Sunn hemp etc.). These fibre are also known as extraxylary fibres.

(b) **Wood fibres :** Those fibres which are associated with wood or xylem have bordered pits are known as wood fibres. Thick walled wood fibres having simple pits are called libriform fibres whereas thin walled wood fibres having bordered pits are called fibre-tracheids. A specific type of wood fibre is produced by *Quercus rabra* and is called gelatinous or mucilagenous fibres.

(c) **Surface fibres :** The fibres present over surface of plant organs are called surface fibres. *e.g.*, Cotton fibres found in the testa of seeds, mesocarp fibres of Coconut (*Cocus nucifera*).

(ii) **Stone cells or Sclereids :** They are lignified, extremely thick walled so that the lumen of the cells is almost obliterated and may be spherical, oval, cylindrical, T-shaped and even stellate. They are generally found in hard parts of the plant, *e.g.*, endocarp of Walnut and Coconut. The sclereids provide mechanical support and hardness to the soft parts.

Kind of sclereids : They are of five types :

(a) **Brachysclereids or stone cells :** These are small and more or less isodiametric in shape. They occur in the cortex, pith, phloem, and pulp of fruits (*e.g., Pyrus*).

(b) **Macrosclereids or rod cells :** These are rod-shaped elongated sclereids usually found in the leaves, cortex of stem and outer seed coats.

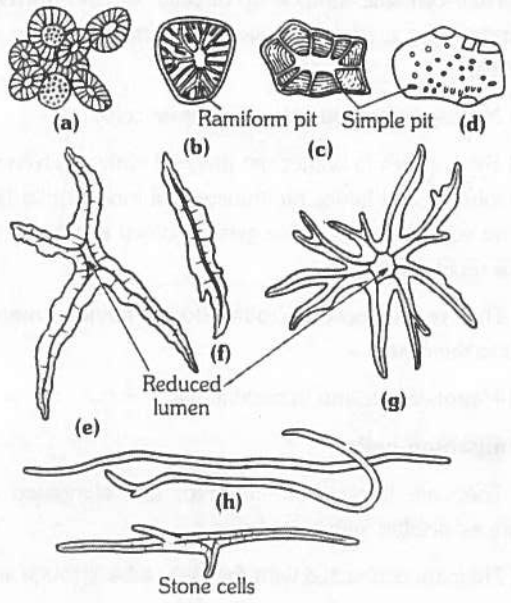


Fig : 2.2-8 Stone cells (a, b) from pulp of pear, (c, d) from stem cortex of Hoya, (e, f) from petiole of *Camelia*, (g) from stem cortex of *Trochodendron*, (h) from mesophyll cells of fig leaf

(c) **Osteosclereids or bone cells :** These are bone or barrel-shaped sclereids dilated at their ends. *e.g.*, leaf of *Hakea*.

(d) **Astrosclereids or stellate cells :** These are star-shaped sclereids with extreme lobes or arms. *e.g.*, leaf of *Nymphaea*.

(e) **Trichosclereids or internal hairs :** These are hair-like sclereids found in the intercellular spaces in the leaves and stem of some hydrophytes.

Complex permanent tissues

A group of more than one type of cells having common origin and working together as a unit, is called complex permanent tissue. The important complex tissues in vascular plants are : xylem and phloem. Both these tissues are together called vascular tissue.

(1) **Xylem :** The term xylem was introduced by Nageli (1858). Xylem is a conducting tissue which conducts water and mineral nutrients upwards from the root to the leaves. It is also know as hadrome (Haberlandt).

On the basis of origin xylem is of two types :

(i) **Primary xylem :** It is derived from procambium during primary growth. It consists of protoxylem and metaxylem.

(ii) **Secondary xylem :** It is formed from vascular cambium during secondary growth.

Xylem is composed of four types of cells :

(i) **Tracheids :** Term "Tracheids" was given by Sanio (1863). The tracheids are elongated tubelike cells with tapering or rounded or oval ends with hard and lignified walls.

The cells are without protoplast and are dead on maturity. Tracheids possess bordered pits. Maximum bordered pits are formed in gymnospermous tracheids. They also possess various kinds of thickenings, *e.g.*, annular, spiral, scalariform, reticulate or pitted tracheids. All the vascular plants have tracheids in their xylem. The main function of tracheids is to conduct water and minerals from the root to the leaf. They also provide strength and mechanical support to the plant.

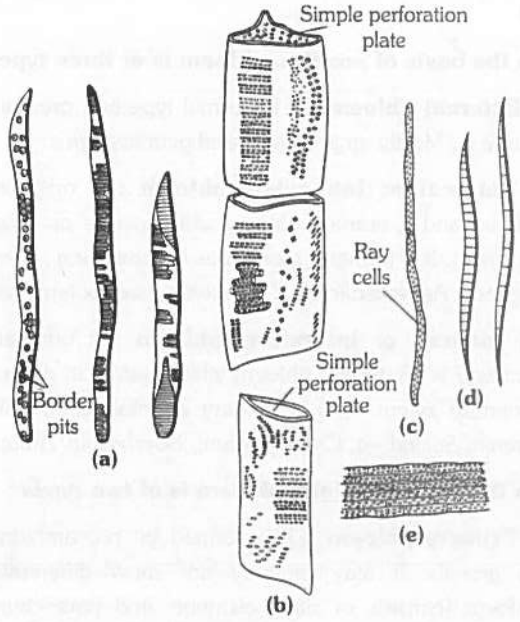


Fig : 2.2-9 Xylem-(a) Tracheids, (b) Tracheae, (c) and (e) Xylem parenchyma (d) Wood fibres (wood sclerenchyma)

(ii) **Xylem vessels or Tracheae :** Vessels are rows of elongated tube-like cells, placed end to end with their end walls dissolved. Vessels are multicellular with wide lumen. The vessels may be annular, spiral, scalariform, reticulate or pitted. Vessels are absent in pteridophytes and gymnosperms (except *Ephedra, Gnetum, Selaginella, Pteridium*). In angiosperms (porous wood) vessels are always present (Vessels are absent in family - Winteraceae, Trochodendraceae and Tepacenpaceae of Angiosperm *i.e.* Lotus, *Wintera, Trochodendron*). It also provide mechanical support to the plant and help in conduction. On the basis of distribution and size of vessels, porous wood is of two types :

(a) **Diffuse porous wood (Primitive) :** Vessels of same size are uniformly distributed throughout the growth or annual ring *e.g., Pyrus, Azadirachta, Eucalyptus, Mangifera sp., Betula*. They are characteristics of plants growing in tropical region.

(b) **Ring porous wood (Advanced) :** Large vessels are formed in early wood when the need of water is great and small vessels are formed in late wood *e.g. Quercus, Morus, Cassia, Delbergia, Tilea sp.*

(iii) **Wood (xylem) parenchyma :** These are the living parenchymatous cells. As found associated with xylem they are known as wood parenchyma. They serve for the storage of reserve food and also help in conduction of water upwards through tracheids and vessels.

(iv) **Wood (xylem) fibres :** The long, slender, pointed, dead and sclerenchymatous cells found associated with xylem are termed wood fibres. They aid the mechanical strength of xylem and various organs of plant body.

(2) **Phloem (bast) :** Term "Phloem" was given by Nageli. Its main function is the transport of organic food materials from leaves to stem and roots in a downward direction. It is also known as leptome.

On the basis of position phloem is of three types :

(i) **External phloem :** It is normal type and present outside the xylem *e.g.*, Mostly angiosperms and gymnosperms.

(ii) **Internal or Intraxylary phloem :** It originates from procambium and is primary phloem which occurs on innerside of primary xylem. It is primary anomalous structure. *e.g.*, Members of Apocynaceae, Asclepiadaceae, Convolvulaceae, Solanaceae.

(iii) **Induced or Interxylary phloem :** It originates from cambium and is secondary phloem which occurs in groups within the secondary xylem. It is secondary anomalous structure. *e.g.*, *Leptadaenia, Salvadora, Chenopodium, Boerhaavia, Amaranthus.*

On the basis of origin, phloem is of two types :

(i) **Primary phloem :** It is formed by procambium during primary growth. It may or may not show differentiation in protophloem (consists of sieve elements and parenchyma) and metaphloem (develop after protophloem and consists of sieve elements, parenchyma and fibre).

During the primary growth the protophloem elements are crushed by the surrounding tissues and disappear. This process is known as obliteration.

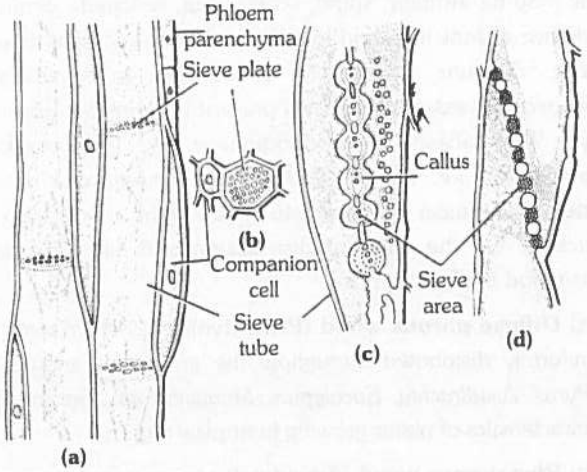


Fig : 2.2-10 Parts of Phloem (a) L.S. of phloem tissue, (b) T.S. of phloem tissue, (c) Sieve tubes of *Vitis*, (d) L.S. of sieve plate

(ii) **Secondary phloem :** It is produced during secondary growth by vascular cambium.

It consists of the following elements :

Sieve element

(i) They are long tube-like cells placed end to end, forming a continuous channel in the plant parts.

(ii) Their cell wall is made up of cellulose and transverse wall is perforated like a normal sieve and hence they are called as sieve tubes.

(iii) Nucleus is not found in the mature cells.

(iv) Sieve pores in winter get plugged with a substance called callose (soluble) and hence the transport of food is retarded. But in spring and summer, this callose gets dissolved and hence transport of food is rapid again.

(v) Their main function is to translocate the food material from one part to the other.

(vi) *P*-protein is found in sieve tubes.

Companion cells

(i) They are thin-walled, more or less elongated cells and which are associated with sieve tubes.

(ii) They are connected with the sieve tube through sieve pore.

(iii) They contain nucleus and are therefore, living in nature.

(iv) They are not found in pteridophytes and gymnosperms but are always present in angiosperms.

Phloem parenchyma : The parenchyma associated with the phloem is called phloem parenchyma. The cells are elongated with rounded ends and possess cellulosic cell walls. These cells are living and store food reserves in the form of starch and fats. They are present in pteridophytes and most of dicotyledonous angiosperms. They are absent in monocots and few dicots like *Ranunculus*.

Phloem or Bast fibres : The sclerenchymatous fibres associated with the phloem are called as phloem fibres or bast fibres. The fibres are elongated lignified sclerenchymatous cells with tapering ends and with simple pits. They are non-living cells that provide mechanical support to the organs. Commercial jute fibres are obtained from phloem fibres.

Special or Secretory tissues

These tissue perform special function in plants, *e.g.*, secretion of resins gum, oil and latex.

These tissues are of two types :

(1) **Laticiferous tissues :** They are made up of thin walled, elongated, branched and multinucleate (coenocytic) structures that contain colourless, milky or yellow coloured juice called latex. These occur irregularly distributed in the mass of parenchymatous cells. Latex is contained inside the laticiferous tissue which is of two types :

(i) **Latex cells :** A laticiferous cell is a highly branched cell with long slender processes ramifying in all directions in the ground tissue of the organ. They do not fuse and do not form network. Plants having such tissues are called simple or non-articulated laticifers. *e.g., Calotropis* (Asclepiadaceae) *Nerium, Vinca* (Apocyanaceae), *Euphorbia* (Euphorbiaceae), *Ficus* (Moraceae).

(ii) **Latex vessels :** They are formed due to fusion of cells and form network like structure in all directions. At maturity, they form a highly ramifying system of channels full of latex inside the organ. Plants having such tissues are called compound or *articulated laticifers. e.g., Argemone, Papaver* (Papaveraceae), *Sonchus* (Compositae), *Hevea, Manihot* (Euphorbiaceae).

(2) **Glandular tissue :** This is a highly specialized tissue consisting of glands, discharging diverse functions, including secretory and excretory. Glands may be external or internal.

(i) **External glands :** They generally occur on the epidermis of stem and leaves as glandular hair in *Plumbago* and *Boerhaavia*, stinging hair secrete poisonous substance in *Urtica dioica*, nectar secreting glands in flowers or leaves. *e.g.,* Rutaceae and Euphorbiaceae. Digestive enzyme secreting glands in insectivorous plants *e.g., Drosera* (Sundew), *Nepenthes* (Pitcher plant).

(ii) **Internal glands :** These are present internally and are of several types *e.g.,* oil glands in *Citrus* and *Eucalyptus*, resinous ducts in *Pinus,* these resin canals are schizogenous in nature. mucilage canals in *Cycas*. Water secreting glands (hydathodes) in *Colocasia* (present at the tip of leaves), *Tropaeoleum* (along margin), etc. The glands which secrete essential oil are called osmophores (osmotrophs).

The tissue system

Several tissues may collectively perform the same function. A collection of tissues performing the same general function is known as a "Tissue System". According to Sachs (1975) there are three major tissue systems in plants as follows :

(1) **Epidermal tissue system :** The tissues of this system originate from the outermost layer of apical meristem. It forms the outermost covering of various plant organs which remains in direct contact with the environment.

Epidermis : Epidermis is composed of single layer of cells. These cells vary in their shape and size and form a continuous layer interrupted by stomata. In some cases epidermis may be multilayered *e.g. Ficus, Nerium, Peperomia, Begonia* etc.

The epidermal cells are living, parenchymatous, and compactly arranged without intercellular spaces.

Certain epidermal cells of some plants or plant parts are differentiated into variety of cell types :

(i) In aerial roots, the multiple epidermal cells are modified to velamen, which absorbs water from the atmosphere (*e.g.,* Orchids).

(ii) Some of the cells in the leaves of grasses are comparatively very large, called bulliform or motor cells. It is hygroscopic in nature. *e.g., Ammophila.* They are thin-walled and contain big central vacuoles filled with water. They play an important role in the folding and unfolding of leaves.

(iii) Some members of Gramineae and Cyperaceae possess two types of epidermal cells : the long cells and the short cells. The short cells may be cork cells or silica cells.

Cuticle and Wax : In aerial parts, epidermis is covered by cuticle. The epidermal cells secrete a waxy substance called cutin, which forms a layer of variable thickness (the cuticle) within and on the outer surface of its all walls. It helps in reducing the loss of water by evaporation. Usually the cuticle is covered with wax which may be deposited in the form of granules, rods, crusts or viscous semiliquid masses. Other substances deposited on the cuticle surface may be oil, resin, silicon and salts (cystoliths are crystals of calcium carbonate, *e.g., Ficus*. Druse and Raphides, *e.g., Pistia* are crystals of calcium oxalate). Thick cuticle are found in leaves of dry habitats plants.

Stomata : Stomata are minute apertures in the epidermis. Each aperture is bounded by two kidney shaped cells, called guard cells. Stomata are absent in roots. In xerophytes the stomata are sunken in grooves due to which rate of transpiration is greatly reduced (*e.g. Nerium*). Usually there is a large air cavity below each aperture, it is called substomatal cavity. In some species the guard cells are surrounded by subsidiary cells or accessory cells which differ morphologically as well as ontogenitally from the other epidermal cells. In monocots subsidiary cells and guard cells originated from same cell. *e.g.,* Doob, Maize guard cells are dumb bell shape. Stomata are scattered in dicot leaves but they are arranged in rows in monocots.

Trichomes : These are epidermal outgrowths present temporarily or permanently on almost all plant parts. They may be unicellular or multicellular and vary in size and shape in different species. They may be of different types : stellate hair, glandular hair, short glandular hair, floccose hair, urticating hair and stinging hair. The trichomes serve for checking excess loss of water and for protection.

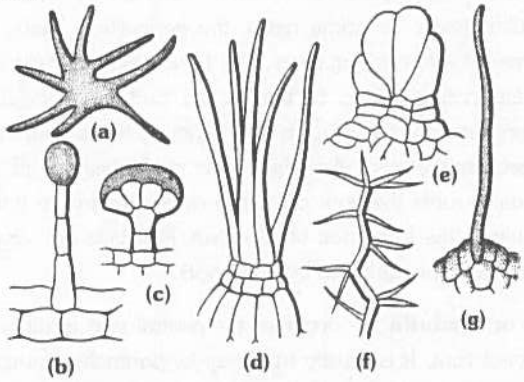


Fig : 2.2-11 Appendages of epidermis of leaves (a) Stellate hair of *Alyssum*, (b) Glandular hair of *Pelorgonium* (c) Short glandular hair of *lavandula*, (d) Floccose hair of *Malva*, (e) Glandular hair of *Solanum*, (f) Urticating hair of *Verbascum*, (g) Stinging hair of *Cestus*

Root hairs : They are enlargements of special epiblema cells called trichoblasts and occur in a particular zone of young root called root hair zone. A root hair cell has vacuolated protoplast with nucleus present towards the apical part of hair. They are specialised to absorb water from soil crevices. They also hold soil particles.

(2) **Ground or Fundamental tissue system :** Ground tissue system includes all the tissues of plant body except epidermal tissue system and vascular tissues. It forms the bulk of body. This tissue system mainly originates from ground meristem. The ground tissues constitute the following parts :

Cortex : It lies between epidermis and the pericycle. The cortex is distinct in dicotyledons but not in monocotyledons where there is no clear demarcation between cortex and pith. It is further differentiated into :

Hypodermis : It is collenchymatous in dicot stem and sclerenchymatous in monocot stem. It provides strength.

General cortex : It consists of parenchymatous cells. Its main function is storage of food.

Endodermis (Starch sheath) : It is mostly single layered and is made up of parenchymatous barrel shaped compactly arranged cells. The inner and radial or transverse wall of endodermal cells have casparian strips of suberin. In roots thick walled endodermal cells are interrupted by thin walled cells just outside the protoxylem patches. These thin walled endodermal cells are called passage cells or transfusion cells. A fully developed endodermis is found in all types of roots. Endodermis with characteristic casparian bands is absent in woody dicot stem, monocot stem and leaves of angiosperms.

Endodermis behaves as water tight dam to check the loss of water and air dam to check the entry of air in xylem elements. Endodermis is internal protective tissue.

Pericycle : It is a single layered or multilayered cylinder of thin-walled or thick-walled cells present between the endodermis and vascular tissues. In some cases, the pericycle is made up of many layers of sclerenchymatous cells (*Cucurbita* stem) or in the form of alternating bands of thin-walled and thick-walled cells (Sunflower stem). In case of roots, the pericycle is made up of thin-walled parenchymatous cells which later on gives rise to lateral roots. In dicot roots the cork cambium originates in the pericycle which results in the formation of periderm. Pericycle also gives rise to a part of vascular cambium in dicot roots.

Pith or Medulla : It occupies the central part in dicot stem, and monocot root. It is mostly made up of parenchymatous cells. In dicot root pith is completely obliterated by the metaxylem elements. In dicot stem the pith cells between the vascular bundles become radially elongated and known as primary medullary rays or pith rays. They help in lateral translocation.

(3) **Vascular tissue system :** The central cylinder of the shoot or root surrounded by cortex is called stele. The varying number of vascular bundles formed inside the stele constitute vascular tissue system. Xylem, phloem and cambium are the major parts of the vascular bundle. Vascular bundle may be of following types :

Radial : The xylem and phloem strands alternate with each other separated by parenchymatous cells. Such kinds of vascular bundles are called radial and found mainly in roots.

Conjoint : A vascular bundle having both xylem and phloem together, is called conjoint. Normally the xylem and phloem occur in the same radius. They occur in stems.

Collateral : A vascular bundle in which the phloem lies towards outer side and xylem towards inner side, is called collateral, *e.g.*, Sunflower.

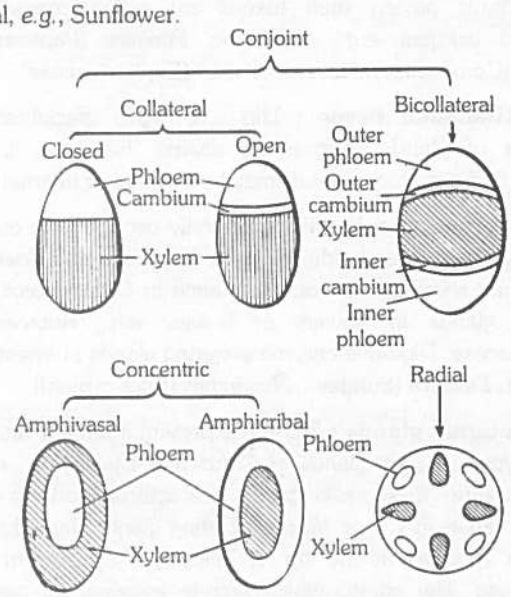


Fig : 2.2-12 Different types of vascular bundles

Collateral bundle having a cambium between xylem and phloem is said to be of the open type, *e.g.*, Dicot stem.

Collateral bundle lacking a cambium between xylem and phloem is said to be of the closed type, *e.g.*, Monocot stem.

Bicollateral : A vascular bundle having the phloem strands on both outer and inner side of xylem, is called bicollateral. *e.g.*, *Cucurbita*, *Lagenaria*. Bicollateral vascular bundles are found in family Cucurbitaceae, Solanaceae and Myrtaceae.

Concentric : A vascular bundle in which one tissue is completely surrounded by the other, is called concentric. The concentric bundles are of two types :

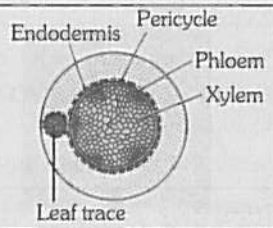
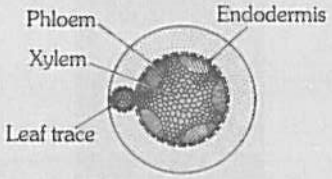
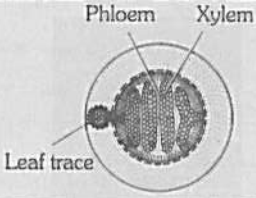
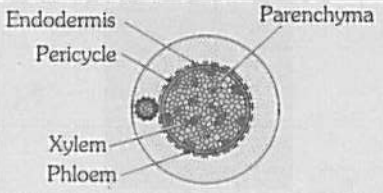
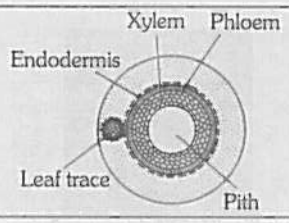
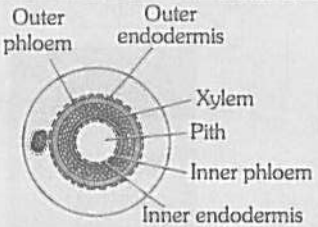
(i) **Amphivasal (Leptocentric) :** The phloem lies in the centre and remains completely surrounded by xylem. *e.g.*, *Dracaena*, *Yucca*.

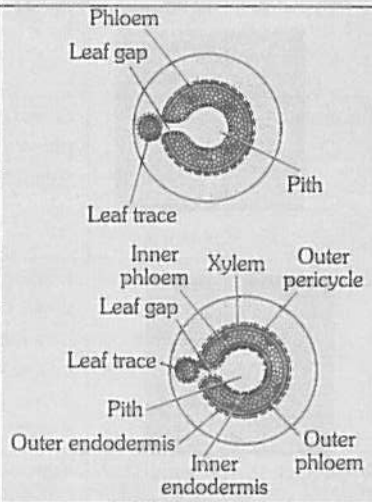
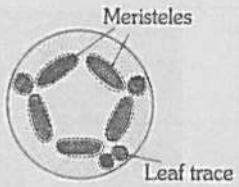
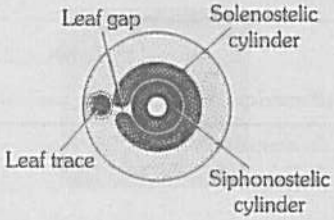
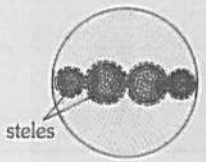
(ii) **Amphicribal (Hadrocentric) :** The xylem lies in the centre and remains completely surrounded by phloem. *e.g.*, Ferns.

Stelar system

Stelar theory was proposed by Van Tieghem and Douliot (1886). According to this concept primary body of root and stem are basically alike anatomically *i.e.* each consists of a central stele surrounded by cortex. Stele includes the vascular tissues and the ground tissue like pericycle and pith, when present.

Table : 2.2-1 The types of steles are

Types of stele	Diagrammatic representation
(1) **Protostele :** This term was given by Jeffrey. It is the simplest and most primitive type of stele in which central core of xylem surround by phloem.	
(i) **Haplostele :** It consists of a smooth core of xylem which is surrounded by a ring of phloem. *e.g., Rhynia, Selaginella, Lycopodium*, etc.	
(ii) **Actinostele :** Protostele having star shaped xylem core with many radiating arms called actinostele. *e.g. Psilotum, Lycopodium* etc.	
(iii) **Plectostele :** A protostele in which xylem core broken into a number of parallel plates is known as plectostele. *e.g., Lycopodium clavatum.*	
(iv) **Mixed protostele :** A protostele in which xylem is broken into small group or patches is known as mixed protostele. *e.g., Lycopodium cernuum, Hymenophyllum demissum*, etc.	
(2) **Siphonostele :** A protostele with central pith is called siphonostele or medullated stele. It is considered to be derived phylogenetically from protostele and thus represents an advance form. It is of two types :	
(i) **Ectophloic siphonostele :** When phloem occurs on the outer side of xylem. *e.g., Osmunda, Equisetum.*	
(ii) **Amphiphloic siphonostele :** When phloem is present on both external and internal sides of the xylem. *e.g., Marsilea, Adiantum.*	

Modification of siphonostele	
(i) **Solenostele :** A siphonostele with non-overlapping leaf gaps is known as solenostele. It may be ectophloic or amphiphloic.	
(ii) **Dictyostele :** A siphonostele with overlapping leaf gaps is known as dictyostele. It has many scattered vascular strands called as **meristeles**. *e.g., Dryopteris, Pteris Ophioglossum.*	
(iii) **Polycyclic stele :** When vascular tissue is present in the form of two or more concentric cylinders. *e.g., Pteridium aquilinum, Marattia.* It may be polycyclic solenostele or polycyclic dictyostele.	
(iv) **Polysteles :** Sometimes more than one steles are present in the axis of some pteridophytes. *e.g.*, 2 steles in *Selaginella kraussiana*, 16 steles in S. *laevigata.*	

Internal structure of root, stem and leaf

Table : 2.2-2 Functions of different organs and tissues of a plant tissue system

	Roots	*Stems*	Leaves
(i) **Functions**	(i) Absorb water and minerals. (ii) Anchor plant. (iii) Store materials.	(i) Transport water and nutrients. (ii) Support leaves. (iii) Help to store materials.	Carry on photosynthesis.

(ii) **Tissues**			
(a) Epidermis	Root hairs absorb water and minerals.	Protect inner tissues.	Stomata carry on gas exchange.
(b) Cortex	Store products of photosynth-esis and water.	Carry on photosynthesis if green.	
(c) Endodermis	Regulates passage of minerals into vascular cylinder.	Regulates passage of minerals also into vascular tissue, if present.	Regulates passage of minerals into vascular tissue if present.
(d) Vascular bundle	Transport water and nutrients.	Transport water and nutrients.	Transport water and nutrients.
(e) Pith	Store products of photosynth-esis and water.	Store products of photosynthesis.	
(f) Mesophyll (i) Spongy layer (ii) Palisade layer			Carry on gaseous exchange and photosynthesis.

Table : 2.2-3

Difference between internal structure of root and stem

Description	Root	Stem
(i) Epidermis or Epiblema	Epiblema or piliferous layer without cuticle.	Epidermis usually with cuticle.
(ii) Epidermal Hairs	Unicellular.	Usually multicellular.
(ii) Hypodermis	Absent	Present – Collenchymatous or sclerenchymatous.
(iv) Chlorenchyma in cortex	Absent.	Usually present in young stems but absent in old stem.
(v) Endodermis	Very distinct.	Poorly developed or absent.
(vi) Vascular bundle	Radial.	Conjoint collateral or bicollateral or concentric.
(vii) Xylem	Exarch.	Endarch.

Origin of Lateral roots : Lateral roots arise endogenously *i.e.*, form the cells inside the endodermis. They arise from pericycle cells.

Table : 2.2-4 Difference between dicot and monocot leaf

Character	Dicot leaf	Monocot leaf
(i) Type of leaf	Dorsiventral (bifacial).	Isobilateral.
(ii) Stomata	Usually more on lower epidermis.	Equal on lower and upper epidermis (amphistomatic).
(iii) Mesophyll	Made up of two types of tissues (a) Palisade parenchyma. (b) Spongy parenchyma with large intercellular spaces.	Only spongy parenchyma is present which has very small intercellular spaces.
(iv) Bundle sheath	Made up of parenchyma. Just above and below the vascular bundle some parenchymatous cells or collenchymatous cells are present (upto epidermis).	Made up of parenchyma but just above and below the vascular bundles are found sclerenchymatous cells (upto epidermis).
(v) Bulliform or motor cells	Absent.	Present on upper epidermis.

Kranz type anatomy occurs in both monocot and dicot leaves of some tropical and arid areas. Kranz anatomy is characteristic feature of C_4 plants. The mesophyll is undifferentiated and occurs in concentric layers around vascular bundles. Cells of bundle sheath possess large chloroplast.

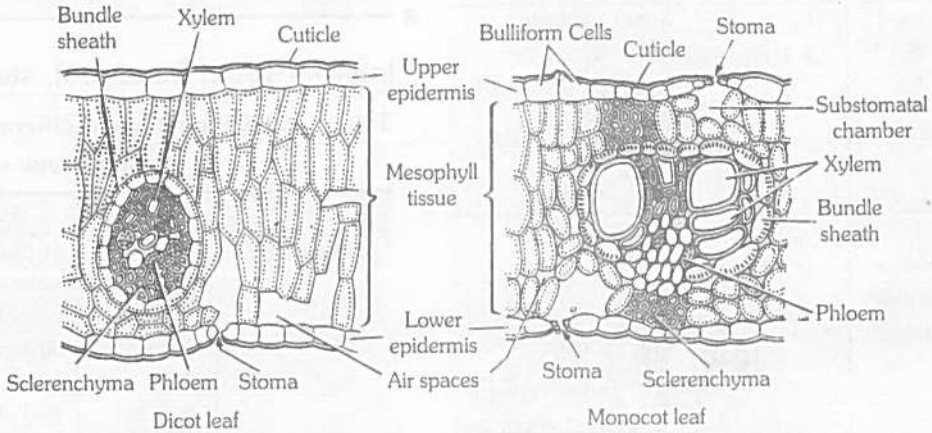


Fig : 2.2-13 Comparison of T.S. of a dicot and monocot leaf

Table : 2.2-5 Difference between dicot and monocot stem

Characters	Monocotyledonous Stem	Dicotyledonous Stem
(i) Epidermis	Present, cells comparatively smaller and without hair.	Present, cells larger and with hair.
(ii) Hypodermis	Sclerenchymatous (non-green)	Collenchymatous (green).
(iii) Cortex	Absent, but ground tissue is present from hypodermis to the centre of stem.	Made up of several layers of parenchymatous tissue.
(iv) Endodermis	Absent	One layered, starchy sheath which is usually not well differentiated.
(v) Pericycle	Absent	Made up of 1 or more layers of parenchymatous and sclerenchymatous cells.
(vi) Medullary rays	Absent	Found in between vascular bundles.
(vii) Pith (Medulla)	Absent	Abundant, made up of parenchymatous cells situated in the centre of stem.
(viii) Vascular bundles	Scattered Conjoint, Collateral and closed. Larger towards centre. Oval Bundle sheath present. Phloem parenchyma absent. Xylem vessels either Y or V shaped.	Vascular bundles in a ring Conjoint, collateral and open. All of same size. Usually wedge-shaped. Bundle sheath absent. Phloem parenchyma present. Xylem vessels more radial.

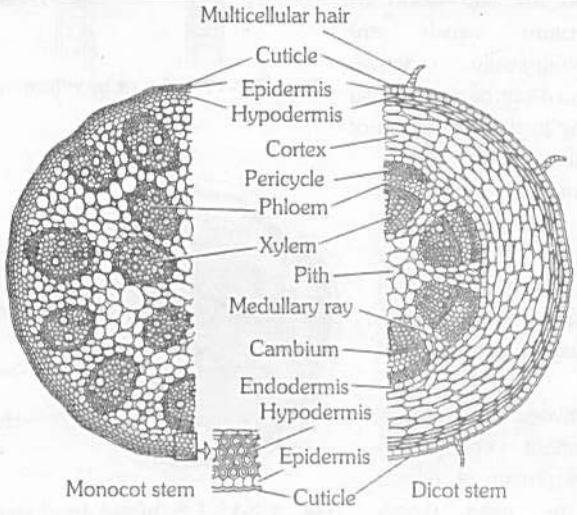


Fig : 2.2-14 Comparision of the T.S. of monocot and dicot stem

Table : 2.2-6 Difference between dicot and monocot root

Character	Dicot Root	Monocot Root
(i) Pericycle	Gives rise to secondary roots and lateral meristem	Gives rise to lateral roots only
(ii) Vascular bundles	Diarch to hexarch	Hexarch to polyarch (It is more than 6 in number)
(iii) Cambium	Develops at the time of secondary growth	Absent
(iv) Pith	Absent or poorly developed	Abundant and fully developed
(v) Secondary growth	Takes place	Does not take place
(vi) Cortex and Endodermis	Narrow cortex. Endodermis is less thickened and casparian strips are more prominent	Cortex wide. Casparian strips are visible only in young root. Later on endodermal cells become highly thickened

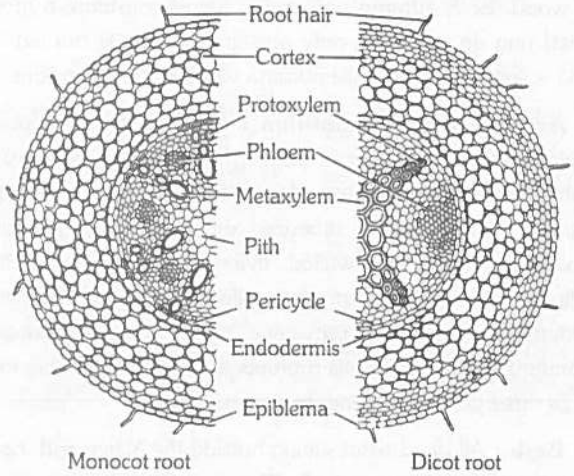


Fig : 2.2-15 Comparision of the T.S. of monocot and dicot root

Secondary growth

The increase in thickness or girth due to the activity of the cambium and the cork cambium is known as secondary growth.

(1) **Secondary growth in stem :** On the basis of the activities of cambium and cork-cambium, secondary growth in stem can be discussed under the following heads :

Activity of cambium : The vascular cambium in between xylem and phloem is called intrafascicular or fascicular cambium which is primary in origin. At the time of secondary growth the parenchymatous cells of medullary rays between the vascular bundles become meristematic and form strip of cambium called as interfascicular cambium which is secondary in origin. Both inter and intrafascicular cambium joins together and form cambium ring which is partly primary and partly secondary in origin. By anticlinal divisions the circumference of the cambium increase. By periclinal division cambium produces the secondary xylem and phloem tissues on innerside and outerside. The amount of sec. xylem produced is 8-10 times greater than sec. phloem. Cambium cells are rectangular, thin walled, full of protoplasm and having meristematic activity. The cambium has two types of cells :

The fusiform initials : Which are elongated and form fibres, sieve cells, sieve tubes, tracheids.

Ray initials : Which produce parenchyma cells of the rays in wood and phloem. Certain cells of cambium form some narrow bands of living parenchyma cells passing through secondary xylem and secondary phloem and are called secondary medullary rays. These provide radial conduction of food from the phloem, and water and mineral salts from the xylem.

Annual rings : Activity of cambium is not uniform in those plants which grow in the regions where favourable climatic conditions (spring or rainy season) alternate regularly with unfavourable climatic conditions (cold water or dry hot summer). In temperate climates, cambium becomes more active in spring and forms greater number of vessels with wider cavities; while in winter it becomes less active and forms narrower and smaller vessels. The wood formed in the spring is known as spring wood and that formed in the dry summer or cold winter autumn wood or late wood. Both autumn and spring wood constitute a growth or annual ring. In one year only one growth ring is formed. Spring wood is light in colour while autumn wood is dark in colour.

Activity of cork cambium : Cork cambium or phellogen develops from outer layer of cortex. It produces secondary cortex or phelloderm on innerside and cork or phellem on outerside. The cells of phellem are dead, suberized and impervious to water. Cells of phelloderm are thin walled, living and store food. Phellem, phellogen and phelloderm are collectively called as periderm. Periderm is secondary protective tissue. Due to pressure of secondary xylem, epidermis ruptures and cortex is largely lost after two or three years of secondary growth.

Bark : All dead tissues lying outside the active cork-cambium are collectively known as bark. This includes ruptured epidermis, hypodermis and cork. When cork-cambium appears in the form of a complete ring, it is known as ring bark, *e.g., Betula* (Bhojpatra). If the cork cambium occurs as separate strips and the resulting bark appears in the form of scales, such a bark is known as scaly bark. *e.g., Eucalyptus, Psidium guava.* The outermost layer of bark is dead and called as rhytidome.

Lenticels : These are aerating pores formed in the cork through which gaseous exchange takes place. They are formed as a result of the action of phellogen. A lenticel appears as a scar or protrusion on the surface of the stem and consists of a radial row of thin-walled cells, known as complementary cells or filling tissue. They are found in old dicot stem, main function is gas exchange.

Cork : It consists of dead cells with thick walls heavily impregnated with suberin. These cells are compactly arranged in radial rows without intercellular spaces. Cork is impervious to water and prevents its loss from the plant surface. It also protects the inner tissues from the attack of fungi and insects. There is no differentiation of bark, sap wood and heart wood of Date palm. Commercial cork is obtained from *Quercus suber* (Oak).

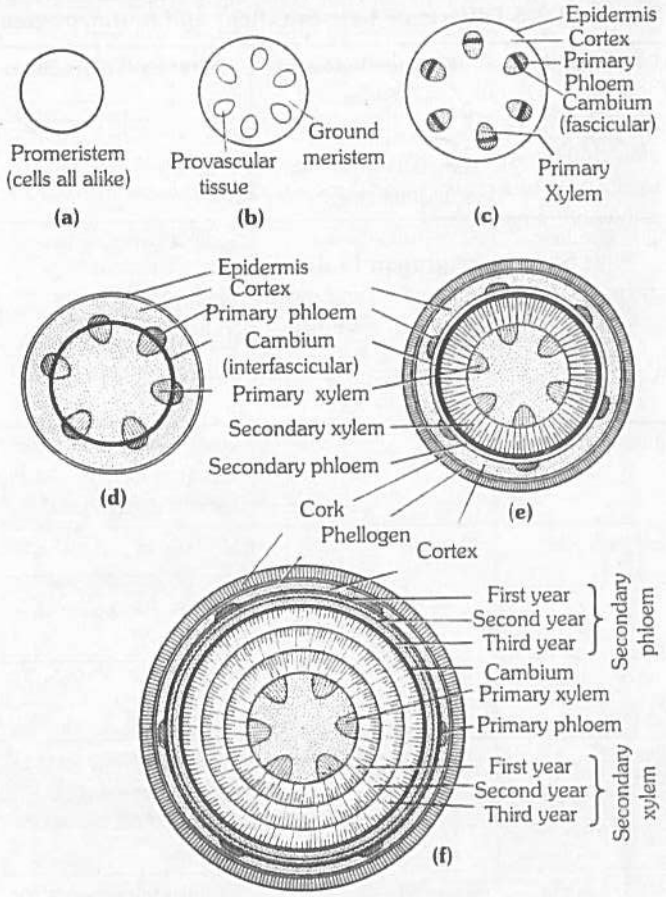


Fig : 2.2-16 Stages of secondary growth in stem

Heart wood and sap wood : In old trees, secondary wood is differentiated into a centrally situated darker and harder wood called the heart wood or duramen which are physiologically inactive (almost dead)and an outer light coloured zone called the sap wood or alburnum which are physiologically active. Dark colour of heart wood is due to the deposition of tannins, resins, gums, essential oils, etc. in the cell walls and cell cavities. The water conduction takes place through sap wood. During the conversion of sap wood into heartwood the most important change is development of tyloses in the heart wood. Tyloses are balloon like

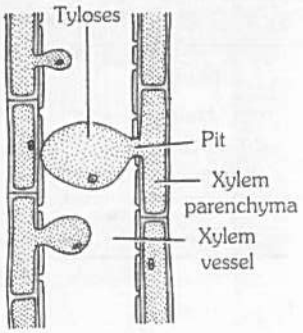


Fig : 2.2-17 Tyloses in xylem vessels

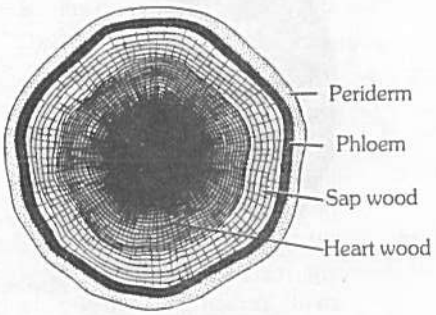


Fig : 2.2-18 T.S. of old dicot stem showing heart wood and sap wood

structures, develop from xylem parenchyma. These tyloses block the passage of xylem vessels so also called as tracheal plug. The heart wood is commercially used as wood. When the plant is made hollow, it will not die because the water conduction takes place through sap wood. The heart wood is well developed in *Morus alba* (Mulberry). The heart wood is absent in *Populus* and *Salix* plant. As a tree grows older thickness of heartwood increases and sap wood remains same.

(2) **Secondary growth in dicot roots :** Vascular bundles in dicot roots are radial, exarch and mostly triarch. Vascular cambium is formed secondarily from conjunctive parenchyma cells lying just below each phloem strand. Thus the number of cambium strips form equal the number of phloem strands. The cells of pericycle lying outside the protoxylem also become meristematic to form part of strips of cambium. These cambial strips join the first formed cambium strips to form complete but wavy ring of vascular cambium. This cambium ring produces secondary xylem on inner side and secondary phloem on outer side. In roots, the growth rings are not distinct because there is no seasonal variation under the soil. From the outer layers of pericycle arises the phellogen which cuts phellem (cork) on the outer side and secondary cortex or phelloderm toward the inner side.

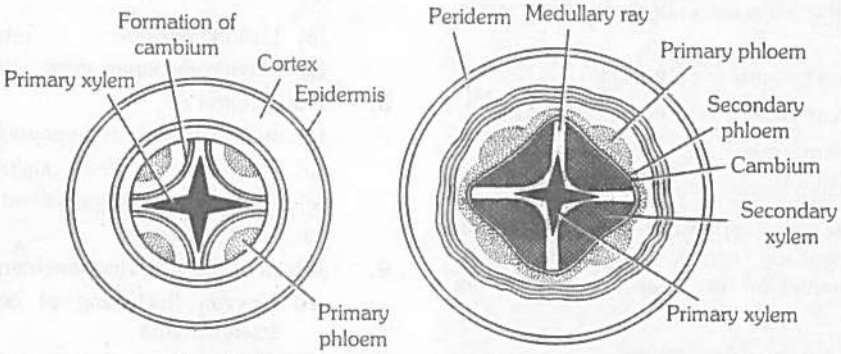


Fig : 2.2-19 Secondary growth in dicot

Tips & Tricks

- N.Grew is the father of anatomy (1682) and coined the term tissue and parenchyma.
- Haberlandt (1914) proposed the names of protoderm (for dermatogen), ground meristem (for periblem) and procambium (for plerome)
- Haberlandt (1914) gave the terms Leptome for soft walled conducting part of phloem and hadrome for conducting part (tracheary elements) of xylem.
- Strasburger discovered albuminous cells instead of companion cells in the phloem of non-flowering plants.
- In sugarcane there is no distinction of tunica and corpus.
- In the roots the meristem is subterminal due to the presence of terminal cap.
- Reproductive apex is elongated in *Sagittaria* but it can be 400 times broad in *Chrysanthemum*.
- Sieve cells or sieve tube elements resemble RBCs in being without nucleus in the mature state.
- The wood of *Tectona grandis* is termite resistant.
- Cavities are of three types :

  (1) Schizogenous : They are formed by enlargement of intercellular spaces or separation of cells *e.g.*, oil cavities of Sunflower.

  (2) Lysigenous : They are formed by degeneration of cells, *e.g.*, oil cavity of Citrus and protoxylem lacunae or water cavity in monocot stem vascular bundles.

  (3) Schizolysigenous : They are formed partly by separation and partly by degeneration of cells. *e.g.*, protoxylem cavity.
- Pith cavity often present in monocot stems (*e.g.*, grass) and occassionally in dicot stems (*e.g.*, *Ricinus*).
- Wood without vessels is called homoxylous, *e.g.*, Ranales (winteraceae, tetracentraceae, trochodendraceae). Whereas with vessels is called heteroxylous.
- The bottle cork is prepared from cork of *Quercus suber* (Oak tree).
- Lightest wood is of *Ochroma pyramidate* (*O.lagopus*).
- Heaviest wood is of *Guaiacum officinale*. In India heaviest wood is of *Acacia sundra*.
- Most durable soft wood is of *Cedrus deodara*.
- Reaction wood is a wood formed in bending stems. When reaction wood is formed on the lower side, it is called as Compression wood *e.g.*, conifers. When it is formed on the upper side, it is called as tension wood *e.g.*, Dicots.
- Wound periderm is similar to natural periderm. But it is restricted to the place of injury and is used in producing the commercial cork.
- Maceration is a method of separation of various tissues by disintegration of middle lamella.
- In some plants primary structure is abnormal such as presence of medullary bundles in pith *e.g.*, *Boerhaavia*, *Mirabilis*, *Achyranthes*, *Bougainvillea* or presence of cortical vascular bundles (inverted) *e.g.*, *Casuarina* and *Nyctanthus*.
- A protective tissue found in roots of some plants (Rosaceae, Myrtaceae) having alternate layers of endodermal and parenchyma cells are called periderm.
- Knots are the bases, scars/wounds of fallen branches which get covered by growth of secondary tissues. They form knots in the wood.

✍ Abscission layer is a special layer of parenchymatous cells, appears at the base. Abscission is premature fall of plant parts from the plant without causing the injury. A protective layer of suberised thick walled cork cells is formed below the abscission layer to prevent infection or dessication (sometimes it is corky layer).

✍ Metaxylem consists of two larger and rounded vessels situated on the sides with the pitted tracheids in between them.

✍ Protoxylem consists of two smaller vessels situated towards the centre. The vessels of metaxylem are pitted and those of protoxylem are annular and spiral.

✍ Depending upon the relative position of protoxylem; xylem is of four types :

(1) Exarch : Protoxylem towards the outerside.

(2) Endarch : Protoxylem towards innerside of metaxylem.

(3) Mesarch : Protoxylem surrounded by metaxylem.

(4) Centrach : Protoxylem in the centre of metaxylem.

✍ Endarch xylem is also called centrifugal as xylem matures from inside to outside. Similarly, exarch xylem is known as centripetal because differentiation of xylem proceeds from outside to inside *e.g.* roots.

✍ Root hairs are found in zone of maturation.

✍ In the leaf, vascular bundles are found in the veins.

✍ An example of monocots showing secondary growth in stems is *Yucca* or *Draceana*.

✍ Safranine stains lignified elements of the tissue.

✍ The longitudinal section of a root have four zones which occur in the following order (from the tip upward) : Root cap, cell division, cell enlargement, cell maturation.

✍ Sequence of secondary tissues from outside : Cork → Cork cambium → Secondary cortex → Primary phloem → Older secondary phloem → Younger secondary phloem → Cambium → Younger secondary xylem → Older secondary xylem → Primary xylem → Pith.

Ordinary Thinking

Objective Questions

Tissue (General)

1. A group of cells alike in form, function and origin is called **[NCERT; CMC Vellore 1994; MP PMT 1999]**

(a) Organ (b) Organella
(c) Tissue (d) None of these

2. Shoot apical meristem is found on the tip of **[Odisha JEE 2008]**

(a) Plumule (b) Radicle
(c) Root (d) Apex

3. Companion cells are closely associated with **[NCERT; CBSE PMT (Pre.) 2012; WB-JEE 2016]**

Or

Transport of food material in higher plants takes place through **[CBSE PMT (Mains) 2010]**

(a) Sieve elements (b) Vessel elements
(c) Trichomes (d) Guard cells

4. Tunica corpus theory was proposed by **[MP PMT 2001]**

(a) Schmidt (b) Strasburger
(c) Nageli (d) Hofmeister

5. Histogen theory was proposed by **[RPMT 1995]**

(a) Bailey (b) Haberlandt
(c) Hanstein (d) Schmidt

6. Parenchymatous cells filling the space between dermal and vascular tissue is **[Odisha JEE 2008]**

(a) Ground tissue (b) Epidermal tissue
(c) Pith (d) Vascular bundles

7. Tracheids differ from other tracheary elements in **[CBSE PMT 2014]**

(a) Lacking nucleus (b) Being lignified
(c) Having casparian strips (d) Being imperforate

8. Parenchyma is

(a) A fundamental tissue physiologically and morphologically
(b) A fundamental tissue phylogenetically
(c) Progenitor of all specialised tissues
(d) All of the above

9. Which of the following statements is/are true

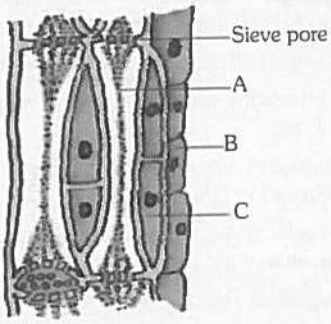
(A) Uneven thickening of cell wall is characteristic of sclerenchyma
(B) Periblem forms the cortex of the stem and the root
(C) Tracheids are the chief water transporting elements in gymnosperms
(D) Companion cell is devoid of nucleus at maturity
(E) The Commercial cork is obtained from *Quercus suber* **[Kerala PMT 2008]**

(a) A and D only (b) B and E only
(c) C and D only (d) A, B and C only
(e) B, C and E only

10. Specialised parenchyma cells which store tannins, oils and crystals of calcium oxalate are called

(a) Sclereids (b) Idioblasts
(c) Stone cells (d) Conjunctive tissue

11. See the following figures and identify the types of simple tissue marked by alphabets **[NCERT]**



(a) A – Sieve tube, B – Companion cell, C – Phloem parenchyma
(b) A – Sieve tube, B – Phloem parenchyma, C – Phloem fibre
(c) A – Vessel, B – Xylem parenchyma, C – Companion cell
(d) A – Sieve tube, B – Phloem parenchyma, C – Companion cell

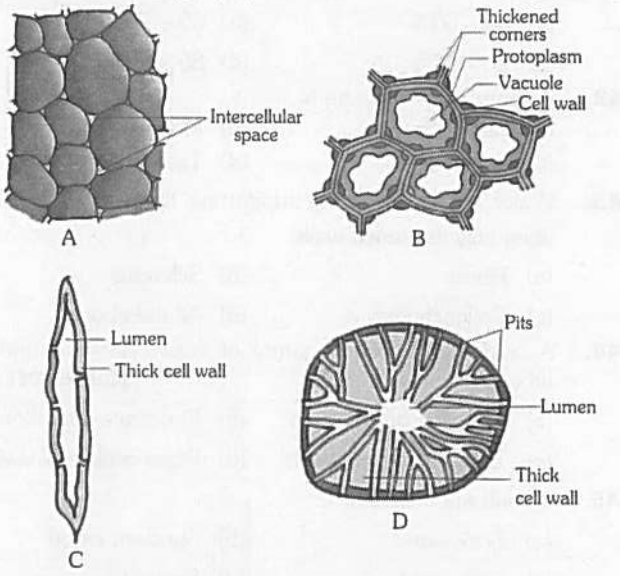
12. A simple mechanical tissue devoid of lignin is

Or

Which one of the following is an effective tissue of growing organs with sufficient elasticity

(a) Parenchyma (b) Collenchyma
(c) Sclerenchyma (d) Chlorenchyma

13. See the following figures and identify the types of simple tissue indicated by A, B, C and D **[NCERT]**



(a) A – Collenchyma, B – Parenchyma, C – Sclereid (Sclerenchyma), D - Fibre (Sclerenchyma)
(b) A – Parenchyma, B – Collenchyma, C – Sclereid (Sclerenchyma), D - Fibre (Sclerenchyma)
(c) A – Collenchyma, B – Parenchyma, C – Fibre (Sclerenchyma), D – Sclereid (Sclerenchyma)
(d) A – Parenchyma, B – Collenchyma, C – Fibre (Sclerenchyma), D – Sclereid (Sclerenchyma)

14. A mature sieve tube differs from vessel in
(a) Being nearly dead
(b) Lacking cytoplasm
(c) Lacking a functional nucleus
(d) Absence of lignified walls

15. From evolutionary point of view, tracheids and sieve cells are more primitive than tracheae and sieve tubes respectively. The angiosperms have **[EAMCET 2009]**
(a) Tracheae and sieve tubes
(b) Tracheids, tracheae and sieve tubes
(c) Tracheids, sieve cells and sieve tubes
(d) Tracheids, tracheae and sieve cells

16. In pteridophyta and gymnosperms which cells are present in place of companion cell
(a) Sclereids (b) Albuminous cells
(c) Idioblasts (d) None of the above

17. Wood is a common name of **[J & K CET 2002; MP PMT 2004, 05]**
(a) Phloem (b) Secondary xylem
(c) Cambium (d) Vascular bundles

18. At maturity the sieve plates become impregnated with **[Kerala PMT 2009]**
(a) Cellulose (b) Pectin
(c) Suberin (d) Lignin
(e) Callose

19. Consider the following statements and choose the correct option
(i) The thread like cytoplasmic strands, running from one cell to other is known as plasmodesmata
(ii) Xylem and phloem constitute the vascular bundle of the stem
(iii) The first form xylem elements are described as metaxylem
(iv) Radial vascular bundles are mainly found in the leaves **[Kerala PMT 2009]**
(a) (i) is true, but (ii), (iii) and (iv) are wrong
(b) (ii) is true, but (i), (iii) and (iv) are wrong
(c) (iii) is true, but (i), (ii) and (iv) are wrong
(d) (iv) is true, but (i), (ii) and (iii) are wrong
(e) (i) and (ii) are true, but (iii) and (iv) are wrong

20. Which of the following statement is true **[Kerala PMT 2010]**
(a) The collenchyma occurs in layers below the epidermis in monocotyledonous plants
(b) Sclerenchyma cells are usually dead and without protoplasts
(c) Xylem parenchyma cells are living and thin walled and their cell walls are made up of lignin
(d) The companion cells are specialized sclerenchymatous cells
(e) Phloem fibres are generally present in the primary phloem

21. Intraxylary phloem may also be called
(a) Internal phloem (b) Included phloem
(c) Vestigeal phloem (d) None of the above

22. Interfascicular cambium develops from the cells of **[NCERT; NEET 2013]**
(a) Pericycle (b) Medullary rays
(c) Xylem parenchyma (d) Endodermis

23. Active division takes place in the cells of **[MP PMT 1998]**
(a) Xylem (b) Phloem
(c) Cambium (d) Sclerenchyma

24. The only plant cells without nuclei among the following are **[NCERT; CPMT 1998, 2009; KCET 1999, 2001; RPMT 2002]**

Or

The tissue which is living but does not possess nucleus in mature stage is **[RPMT 1995; CBSE PMT 1997; BHU 2008]**
(a) Cambium cells (b) Cells of pericycle
(c) Xylem parenchyma (d) Sieve tubes

25. Cork tissue arises from **[AFMC 2005]**
(a) Periderm (b) Phellogen
(c) Pelloderm (d) Phellem

26. Collenchyma differs from sclerenchyma
(a) Retaining protoplasm at maturity
(b) Having thick walls
(c) Having wide lumen
(d) Being meristematic

27. Walls of sclerenchyma are
(a) Rigid (b) Lignified
(c) Pactinised (d) Suberised

28. Tunica corpus theory is related with **[Odisha JEE 2009]**
(a) Root apex
(b) Lateral meristems
(c) Root cap
(d) Shoot apex (apical meristem)

29. The baloon like outgrowth of parenchyma in the lumen of a vessel is known as **[BHU 1994; NEET (Phase-II) 2016]**
(a) Histogen (b) Tyloses
(c) Phellogen (d) Tunica

30. Vessels differ from tracheids **[MHCET 2011]**
(a) In being derived from single cell
(b) In having vertical rows of cells with dissolved cross walls
(c) In being living
(d) They help in the conduction of water

31. Vascular cambium and cork cambium are examples of **[CBSE PMT 1990; AIIMS 1999; J & K CET 2002; KCET 2009]**
(a) Lateral meristem
(b) Apical meristem
(c) Elements of xylem and phloem
(d) Intercalary meristem

32. Laticiferous vessels instead of laticiferous cells are found in
(a) *Ficus* (b) *Calotropis*
(c) *Poppy* (d) *Nerium*

33. The histogen layer present at the apex of the root tip is called **[BHU 2008]**
(a) Dermatogen (b) Procambium
(c) Calyptrogen (d) Plerome

34. Radial conduction of water takes place by **[AMU (Med.) 2012]**
(a) Vessels (b) Vessels and trachieds
(c) Phloem (d) Ray parenchyma cells

35. Sieve tubes are better suited for translocation, because **[NCERT]**
(a) Possess broader lumen and perforated cross walls
(b) Are broader than long
(c) Possess bordered pits
(d) Possess no end walls

36. Collenchyma differs from parenchyma in having
(a) Living protoplasm (b) Cellulose walls
(c) Vacuoles (d) Pectin deposits at corners

37. Cystoliths sometimes deposited in plant cells are crystals of (aggregation of) **[AIIMS 1999; BVP 2004; RPMT 2006; MP PMT 2010; Odisha JEE 2010]**
(a) Calcium oxalate (b) Calcium carbonate
(c) Magnesium carbonate (d) Glucosides

38. Trachea, tracheids, wood fibres and parenchyma tissues are found in **[CPMT 2003]**
(a) Xylem (b) Phloem
(c) Cambium (d) Cortex

39. In the following pairs where do you get lignin in both the element **[WB JEE 2008]**
(a) Trachid and Collenchyma
(b) Sclerenchyma and sieve tube
(c) Sclerenchyma and trachea
(d) Parenchyma and endodermis

40. Tyloses are **[BHU 1995, 2000]**
(a) Wound healing secretions
(b) Responsible for plugging the lumen of vessels
(c) Special epidermal hairs covering stomata in xerophytes
(d) Callus secretion on sieve plates

41. Plant tissues, which are actively growing have water content of
(a) 40 – 50% (b) 65 – 75%
(c) 20 – 40% (d) 85 – 95%

42. A component of xylem is **[MP PMT 1999]**
(a) Sieve tube (b) Medullary ray
(c) Sclereids (d) Tracheid

43. Which of the following supporting tissues have cells with unequally thickened walls
(a) Fibres (b) Sclereids
(c) Collenchyma (d) All the above

44. A common structural feature of vessel elements and seive tube elements is **[CBSE PMT 2006]**
(a) Presence of *p*-protein (b) Enucleate condition
(c) Thick secondary walls (d) Pores on lateral walls

45. Vessels are absent in
(a) Teak wood (b) Shisham wood
(c) Chir wood (d) Sal wood

46. All the following statements regarding sieve tube elements are true except **[Kerala PMT 2007]**
(a) Their end walls have perforated sieve plates which become impregnated with lignin at maturity
(b) They possess a peripheral cytoplasm as well as a large vacuole
(c) Distinct proteinaceous inclusions, the *P*-proteins are seen evenly distributed throughout the lumen
(d) Long, slender, tube-like structures arranged in longitudinal series
(e) They are devoid of nucleus at maturity

47. Xylem fibre is
(a) Bast fibre (b) Wood fibre
(c) Heart wood (d) Libriform fibre

48. The casparian strips of root endoderm contain a mixture of **[CBSE PMT 1994; BHU 1994; HP PMT 2005; Kerala PMT 2008]**
(a) Cellulose and cutin (b) Cellulose and lignin
(c) Lignin and suberin (d) Cellulose and suberin

49. Parenchymatous cells are found in **[Manipal 2005]**
(a) Pulp of fruit (b) Seeds
(c) Endocarp (d) Skin of fruit

50. Meristematic cells have **[Manipal 2005]**
(a) Thick cell wall and large intercellular spaces
(b) Thick cell wall and no intercellular space
(c) Thin cell wall and large intercellular spaces
(d) Thin cell wall and no intercellular spaces

51. The root apex is subterminal because it **[NCERT; Kashmir MEE 1995]**
(a) Is covered by tunica cells (b) Is covered by root hairs
(c) Has many corpus cells (d) Is covered by root cap

52. Root cap in dicots is formed from
(a) Protoderm (b) Ground meristem
(c) Calyptrogen (d) Procambium

53. One of the characteristic of sieve tube is **[WB JEE 2008]**
(a) It is a part of phloem
(b) Function is transport of inorganic solutes
(c) It is dead cell
(d) Sieve plate is not present

54. Interfasicular cambium is a **[WB JEE 2010]**
(a) Primary meristematic tissue
(b) Primordial meristem
(c) Type of protoderm
(d) Secondary meristematic tissue

55. Which of the following is a complex tissue **[CPMT 2010]**
(a) Parenchyma (b) Collenchyma
(c) Xylem (d) Schlerenchyma

56. Safranine stains which elements of the tissue
(a) Starch elements (b) Lignified elements
(c) Protein elements (d) Hard bast

57. Laticiferous vessels are found in **[CPMT 1993]**
(a) Xylem tissue (b) Phloem tissue
(c) Cortex (d) None of the above

58. Term 'Leptome' is a synonym of
(a) Companion cells (b) Sieve elements
(c) Phloem fibres (d) Phloem parenchyma

59. The calyptrogen of the root apex forms **[MP PMT 2003]**
(a) Rhizoids (b) Root nodule
(c) Root hairs (d) Root cap

60. Histogen theory is more applicable for **[CPMT 1999]**
(a) Root apex (b) Shoot apex
(c) Meristematic tissue (d) None of these

61. Meristematic tissue in vascular bundle is **[MP PMT 2007]**
(a) Phellem (b) Procambium
(c) Interfasicular cambium (d) Fasicular cambium

62. In which of the following phloem parenchyma is absent
(a) Maize (b) Sunflower
(c) Guava (d) Banyan

63. Meristematic tissue responsible for increase in girth of tree trunk is **[RPMT 2002; NEET (Karnataka) 2013]**
(a) Lateral meristem (b) Intercalary meristem
(c) Primary meristem (d) Apical meristem

64. Function of storage is performed by **[BHU 1999]**
(a) Parenchyma (b) Sclerenchyma
(c) Phloem (d) All the above

65. On the basis of origin, meristematic tissues can be classified under how many groups
(a) 2 (b) 3
(c) 4 (d) 5

66. Which of the following are primary meristems
(a) Pleurome (b) Protoderm
(c) Intercalary meristem (d) All the above

67. Collenchymatous tissue is found in **[CBSE PMT 1990]**
(a) Climbing plants
(b) Aquatic plants
(c) Woody climbers
(d) Herbaceous climbers

68. Parenchymatous tissue is characterised by the **[JIPMER 2002; MP PMT 2004]**
(a) Presence of uniform thickening
(b) Presence of thickening in the corners
(c) Presence of intercellular spaces
(d) Presence of lignified walls

69. The histogens are classified on the basis **[Manipal 2005]**
(a) Cells they contain
(b) Cells they give rise to future tissue
(c) Meristematic activity
(d) Cell division

70. Which of the following are simple tissues **[CPMT 2000]**
(a) Parenchyma, xylem and phloem
(b) Parenchyma, collenchyma and sclerenchyma
(c) Parenchyma, xylem and collenchyma
(d) Parenchyma, xylem and sclerenchyma

71. Bordered pits are found in
(a) Phloem (b) Protoxylem
(c) Metaxylem (d) Pith

72. The plant tissues commonly found in fruit walls of nuts and pulp of some fruits like guava are termed as **[NCERT; AMU (Med.) 2009]**

Or

Pear fruits are gritty due to the presence of **[J & K CET 2012]**

Or

Tissue composed of non-parenchymatous cells and have isodiametric or irregular shape is called
(a) Fibres (b) Tracheids
(c) Sclereids (d) Vessels

73. Promeristem gives rise to which meristem **[MP PMT 1997]**
(a) Secondary (b) Lateral
(c) Primary (d) Apical

74. Starch sheath is another name of **[AMU (Med.) 2009]**
(a) Hypodermis (b) Epidermis
(c) Casparian strip (d) None of these

75. Sieve tubes have
(a) Apical and oblique septa
(b) Perforated and longitudinal septa
(c) Perforated and oblique septa
(d) Simple oblique wall

76. Which one of the following statements pertaining to plant structure is correct **[AIIMS 2005]**
(a) Cork have no stomata, but lenticels carry out transpiration
(b) Passage cells help in transfer of food from cortex to phloem
(c) Sieve tube elements possess cytoplasm but not nuclei
(d) The shoot apical meristem has a quiescent centre

77. 'Protoderm' and 'procambium' terms were coined by
(a) Haberlandt (b) Hanstein
(c) Schmidt (d) Nageli

78. Which of the following tissues consist of living cells **[MP PMT 2009]**
(a) Vessels (b) Tracheids
(c) Companion cell (d) Sclerenchyma

79. Tyloses thickenings are seen in **[CPMT 2001]**
(a) Phloem cells
(b) Ray parenchyma only
(c) Collenchyma
(d) Ray parenchyma and xylem cells

80. Name the tissue from which procambium and primary structures of plant originates
(a) Phellogen (b) Promeristem
(c) Calyptrogen (d) None of these

81. The function of a vessel is **[BHU 1995; Pb. PMT 2004]**
(a) Conduction of food
(b) Conduction of water and minerals
(c) Conduction of hormones
(d) All the above

82. The outermost primary meristem gives rise to **[CPMT 2001]**
(a) Epidermis (b) Procambium
(c) Ground meristem (d) All of the above

83. The long plants are capable of standing erect due to presence of **[BHU 2012]**
(a) Sclerenchyma (b) Collenchyma
(c) Parenchyma (d) Prosenchyma

84. Epiblema in roots is derived from **[BHU 2002]**
(a) Protoderm (b) Procambium
(c) Ground meristem (d) Calyptrogen

85. In a woody dicotyledonous tree, which of the following parts wall mainly consist of primary tissues **[CBSE PMT 2005]**
(a) Stem and root (b) All parts
(c) Shoot tips and root tips (d) Flowers, fruits and leaves

86. Tunica differs from corpus in
(a) Position (b) Rate of growth
(c) Plane of division (d) Region of activity

87. Histogen theory states that epidermis is derived from the **[AMU (Med.) 2006]**
(a) Periblem (b) Cambium
(c) Cortex (d) Dermatogen

88. What is meristems **[MP PMT 2005]**
(a) Dividing cells (b) Non dividing cells
(c) Permanent cells (d) Complex tissues

89. Bordered pits are found in **[CPMT 1993; BVP 2000]**
(a) Gymnosperms (b) Bryophytes
(c) Monocots (d) Hydrilla

90. The tip of the root apical meristem is proceeded by root pocket in
(a) *Brassica* (b) *Eichhornia*
(c) *Petunia* (d) Wheat

91. Which one of the following pairs is an example for lateral meristem **[CPMT 1998; KCET 2010]**
(a) Procambium and phelloderm
(b) Interfascicular cambium and phellem
(c) Phellogen and phelloderm
(d) Phellogen and fascicular cambium

92. Match the followings in column I with column II and choose the correct combination

	Column I		Column II
A.	Xylem vessels	1.	Store food materials
B.	Xylem trachieds	2.	Obliterated lumen
C.	Xylem fibre	3.	Perforated plates
D.	Xylem parenchyma	4.	Chisel–like ends

[Kerala PMT 2006]
(a) A – 4, B – 3, C – 2, D – 1 (b) A – 3, B – 2, C – 1, D – 4
(c) A – 2, B – 1, C – 4, D – 3 (d) A – 1, B – 2, C – 3, D – 4
(e) A – 3, B – 4, C – 2, D – 1

93. Bamboo and grasses elongate by the activity of --------- **[KCET 2004]**
(a) Secondary meristem (b) Lateral meristem
(c) Apical meristem (d) Intercalary meristem

94. Which is present in vascular bundles of gymnosperms **[RPMT 1999]**
(a) Tracheids (b) Vessels
(c) Companion cells (d) All of these

95. Root cap is absent in **[BHU 1994, 99; RPMT 2002, 06; Manipal 2005; CPMT 2009]**
(a) Lithophytes (b) Hydrophytes
(c) Xerophytes (d) Mesophytes

96. Axillary bud and terminal bud are derived from the activity of **[NCERT; CBSE PMT 2002]**
(a) Parenchyma (b) Lateral meristem
(c) Apical meristem (d) Intercalary meristem

97. Vessels are found in **[CBSE PMT 2002]**
(a) All pteridophyta (b) All angiosperms
(c) Some gymnosperm (d) Both (b) and (c)

98. The meristem of root is **[MHCET 2001]**
(a) Apical (b) Sub apical
(c) Intercalary (d) Lateral

99. Which one of the following is not a lateral meristem **[NCERT; CBSE PMT (Pre.) 2010]**
(a) Intercalary meristem (b) Intrafascicular cambium
(c) Interfascicular cambium (d) Phellogen

100. Lignin is the main constituent of **[CPMT 1993]**
(a) Woody tissues (b) Growing tissues
(c) Phloem (d) Cortex

101. Which of the following is absent in phloem of *Pinus* **[BVP 2001]**
(a) Phloem parenchyma (b) Sieve cells
(c) Companion cells (d) None of these

102. The plant which reproduces by apical meristem is **[Manipal 2005]**
(a) Gymnosperm (b) Pteridophyte
(c) Angiosperm (d) Algae

103. *P* – protein is found in **[CPMT 2005]**
(a) Collenchyma (b) Parenchyma
(c) Xylem (d) Sieve tube

104. Function of companion cells is **[NCERT; MP PMT 1998, 2000; AIIMS 2004; CBSE PMT (Mains) 2011]**
(a) Loading of sucrose into sieve elements by passive transport
(b) Loading of sucrose into sieve elements
(c) Providing energy to sieve elements for active transport
(d) Providing water to phloem

105. Companion cells are part of angiospermic **[MHCET 2000; MP PMT 2010]**
(a) Xylem (b) Phloem
(c) Pith (d) Collenchyma

106. Which of the following cell is totipotent **[BHU 1999; CBSE PMT 1999; KCET 2000; AFMC 2000]**
(a) Meristem (b) Sieve tube
(c) Collenchyma (d) Xylem vessel

107. The following diagrams show the types of secondary thickenings in the xylem vessels. Identify the types labelled from A to F. Choose the correct option from those given **[KCET 2006]**

(a) A= spiral, B= annular, C= reticulate, D= scalariform, E= pitted with border, F= pitted simple
(b) A= annular, B= spiral, C= scalariform, D= reticulate, E= pitted with border, F= pitted simple
(c) A= annular, B= spiral, C= scalariform, D= reticulate, E= pitted simple, F= pitted with border
(d) A= spiral, B= annular, C= scalariform, D= reticulate, E= pitted with border, F= pitted simple

108. The xylem fibres are classified into
(a) Protoxylem and metaxylem
(b) Primary and secondary fibres
(c) Fibre tracheids and fibres
(d) Long and short fibres

109. The trees have in them a large amount of
(a) Starch (b) Lignocellulose
(c) Cellulose (d) Chitin

110. Meristems are found in
(a) *Cycas* stem (b) Fern leaf
(c) Pollens of *Pinus* (d) Fern rhizome

111. Rod shaped elongated sclereids found in the seed coats of pulses are known as
(a) Astrosclereids (b) Macrosclereids
(c) Trichosclereids (d) Brachysclereids

112. The process by which plants becomes woody is
(a) Impregnation (b) Lignification
(c) Fossilization (d) Calcification

113. Casparian strips are present in the _____ of the root **[NCERT; KCET 2011]**
(a) Epiblema (b) Cortex
(c) Pericycle (d) Endodermis

114. Promeristem is found in **[JIPMER 1994]**
(a) Embryo (b) Root apex
(c) Shoot apex (d) Intercalary region

115. Meristematic tissues include **[AFMC 1994]**
(a) Leaf tips, cork cambium and vascular cambium
(b) Stem and root apices, cork cambium and mature fruits
(c) Stem and root apices, vascular cambium and cork cambium
(d) Mature fruits and leaf tips

116. The complex tissues include **[MP PMT 1993]**
(a) Scleroids (b) Sclerenchyma
(c) Secretory tissues (d) Collenchyma

117. Which of the following elements has its end walls perforated **[AIEEE Pharmacy 2004]**
(a) Tracheid (b) Vessel
(c) Fiber (d) Scleried

118. Epidermis in stem is produced from **[NCERT; BHU 2002]**
(a) Protoderm (b) Procambium
(c) Ground meristem (d) Calyptrogen

119. The tissue which perpetuates itself by active cell division is **[Kerala PMT 2004]**
(a) Permanent tissue (b) Ground tissue
(c) Meristematic tissue (d) Vascular tissue
(e) None of these

120. Vascular cambium of the root is an example of **[BHU 2000; AIIMS 2000, 13]**
(a) Apical meristem (b) Intercalary meristem
(c) Secondary meristem (d) Root apical meristem

121. Intercalary meristems are present in the
(a) Nodal region
(b) Internodal region
(c) Bryophytes
(d) Nodal region close to base of plant

122. Intercalary meristem is seen in
(a) Paddy (b) *Ficus*
(c) Cabbage (d) *Cucurbita*

123. Intercalary meristem results in **[Kerala PMT 2004]**
(a) Secondary growth (b) Primary growth
(c) Apical growth (d) Secondary thickening
(e) Secondary over growth

124. Chlorenchyma cells are chlorophyll containing
(a) Sclerenchyma cells (b) Epidermis
(c) Parenchyma (d) Phloem

125. The loosely arranged nonchlorophyllous parenchyma cells present in lenticels are called **[KCET 2011]**
(a) Complementary cells (b) Passage cells
(c) Water stomata (d) Albuminous cells

126. From which of the following tissue the protoderm is derived
(a) Procambium (b) Cambium
(c) Promeristem (d) All the above

127. In a longitudinal section of a root, starting from the tip upward, the four zones occur in the following order **[CBSE PMT 2004]**
(a) Cell division, cell enlargement, cell maturation, root cap
(b) Cell division, cell maturation, cell enlargement, root cap
(c) Root cap, cell division, cell enlargement, cell maturation
(d) Root cap, cell division, cell maturation, cell enlargement

128. Healing of wound in plants takes place by the activity of **[CPMT 1998; CBSE PMT 2000; DPMT 2004]**
(a) Ground tissue (b) Callus deposition
(c) Secondary meristem (d) Permanent tissue

129. Which of the following statement is true about parenchymatous cells **[MP PMT 2006]**
(a) Presence of thickening at corner
(b) Presence of uniform thickening
(c) Presence of intercellular space
(d) Presence of lignified wall

130. Lateral meristem is responsible for **[MP PMT 2004]**
(a) Growth in length (b) Growth in parenchyma
(c) Growth in thickness (d) Growth in cortex

131. The commercial jute fibres are obtained from **[MP PMT 2004]**
(a) Interxylary fibres (b) Xylem fibers
(c) Phloem fibers (d) None of these

132. Root cap is not found in
(a) Hollyhock (b) *Pistia*
(c) Sunflower (d) China rose

133. Lignin is the important constituent in the cell wall of **[MP PMT 1994, 98, 2002]**
(a) Phloem (b) Parenchyma
(c) Xylem (d) Cambium

134. Which of the following is absent in the primary and secondary structure of stem of *Pinus* **[AIIMS 2000]**
(a) Sieve tubes (b) Mucilage duct
(c) Companion cells (d) Phloem parenchyma

135. Xylem position in secondary xylem is **[RPMT 1995]**
(a) Exarch (b) Endarch
(c) Mesarch (d) None of these

136. Dead cells of root are supplied by **[RPMT 1995]**
(a) Calyptrogen (b) Protoderm
(c) Phallogen (d) Dermatogen

137. Quiescent centre is found in **[CPMT 1993, 2002, 05; RPMT 2005, 06; WB JEE 2010]**
(a) Stem tip (b) Root tip
(c) Leaf tip (d) None of these

138. The fibres associated with phloem are known as **[MP PMT 2006]**
(a) Wood fibre (b) Surface fibre
(c) Bast fibre (d) Hard fibre

139. The cell wall of xylem cells is rich in **[MP PMT 1995]**
(a) Lipid (b) Protein
(c) Lignin (d) Starch

140. Porous wood contains mainly **[AIIMS 2001]**
(a) Fibres (b) Vessels
(c) Trachieds (d) Solid secretions

141. Conducting part of phloem according to Haberlandt (1914) is **[J & K CET 2002]**
(a) Hadrome (b) Leptome
(c) Sterom (d) Bark

142. The difference in phloem of gymnosperms and angiosperms is due to **[RPMT 2002, 06]**
(a) Parenchyma (b) Sieve cell
(c) Companion cell (d) Fibres

143. Starch is mainly manufacture by **[JIPMER 2002]**
(a) Palisade parenchyma (b) Spongy parenchyma
(c) Guard cells (d) Vascular bundle

144. Fibres are obtained from **[BHU 1994; JIPMER 2002]**
(a) Xylem, phloem and sclerenchyma
(b) Xylem, phloem, sclerenchyma and epidermis
(c) Xylem, parenchyma, epidermis
(d) Xylem, parenchyma, endodermis

145. Aerenchyma is formed in the tissue of **[MP PMT 1997]**
(a) Sclerenchyma (b) Parenchyma
(c) Phloem (d) None of the above

146. The chief water conducting elements of xylem in gymnosperms are **[CBSE PMT (Pre.) 2010]**
(a) Tracheids (b) Vessels
(c) Fibres (d) Transfusion tissue

147. Which tissue makes up the embryo of a seed
(a) Meristematic tissue (b) Permanent parenchyma
(c) Collenchyma (d) Sclerenchyma

148. The meristem which develops into a primary vascular tissue is **[MP PMT 1999; Odisha JEE 2008; WB JEE 2009]**

Or

Portion of apical meristem that gives rise to xylem tissue is called **[WB JEE 2012]**
(a) Protonema (b) Promeristem
(c) Ground meristem (d) Procambium

149. Tracheids differs from vessels in having **[RPMT 2006]**
(a) Thick wall
(b) Bordered pits
(c) Discontinuous intercalary wall
(d) Spiral thickening

150. Hard lignified thick walled long and pointed cells a plant are **[MP PMT 1999]**
(a) Parenchyma (b) Sclerenchyma
(c) Collenchyma (d) Sclereids

151. Which tissue is derived from tunica
(a) Epidermis (b) Endodermis
(c) Pericycle (d) Vascular tissue

152. Which of the following plants grow by a single "apical cell"
(a) Monocots (b) Dicots
(c) Gymnosperms (d) Bryophytes

153. Which structure is not found in the leaves of a bean plant
(a) Guard cell (b) Chloroplast
(c) Phloem (d) Lenticel

154. Histogens are component of or The histogens are differentiated in
(a) Apical meristem (b) Intercalary meristem
(c) Lateral meristem (d) Secondary meristem

155. How many histogens are present at the apex of root
(a) 1 (b) 2
(c) 3 (d) 4

156. The vascular cambium normally gives rise to **[NEET 2017]**
(a) Phelloderm (b) Primary phloem
(c) Secondary xylem (d) Periderm

The tissue system

1. Star shaped stele devoid of pith termed as **[Odisha JEE 2012]**
(a) Actinostele (b) Solenostele
(c) Dictyostele (d) Plectostele

2. A stele with a central core of xylem surrounded by phloem is called or Actinostele is a modification of

Or

Pith is absent in **[Odisha JEE 2009; AFMC 2012]**
(a) Protostele (b) Siphonostele
(c) Solenostele (d) Dictyostele

3. The arrangement of xylem in stem is **[Odisha JEE 2010]**
(a) Endarch (b) Exarch
(c) Mesarch (d) Both (a) and (b)

4. Reduction in vascular tissue mechanical tissue and cuticle is characteristic of **[CBSE PMT 2009]**
(a) Xerophytes (b) Mesophytes
(c) Epiphyttes (d) Hydrophytes

5. The length of different internodes in a culm of sugarcane is variable because **[CBSE PMT 2008]**
(a) Size of leaf lamina at the node below each internode
(b) Intercalary meristem
(c) Shoot apical meristem
(d) Position of axillary buds

6. Vascular bundles in which phloem is found on both sides of xylem are called (In which of the following phloem occurs in two patches) **[CBSE PMT 1992; BVP 2003]**
(a) Collateral (b) Bicollateral
(c) Radial (d) Amphicribral

7. Amphivasal or leptocentric vascular bundles are found in

Or

An example of monocots showing secondary growth in stems is
(a) *Cycas* and *Dryopteris* (b) *Dracaena* and *Yucca*
(c) *Helianthus* and *Cucurbita* (d) Maize and wheat

8. A root hair is formed by **[EAMCET 1995]**
(a) Epidermal cell (b) Endodermal cell
(c) Cortical cell (d) Pericycle cell

9. The layer of cells outside the phloem meant for giving rise to the root branches is called **[Kerala CET 2003]**
(a) Cambium (b) Carpus
(c) Endodermis (d) Pericycle

10. The root cap is not used in absorption of water due to **[Odisha JEE 2011]**
(a) Presence of root hairs
(b) Absence of root hairs
(c) Its presence in elongation zone
(d) None of these

11. In root, pericycle gives rise to
(a) Branch root and cork cambium
(b) Cortex and pith
(c) Epidermis and vascular bundles
(d) Xylem and phloem

12. Vascular bundles in the stem of *Cucurbita* or *Lagenaria* are **[AIIMS 1992; KCET 1999; BHU 2001]**
(a) Collateral (b) Bicollateral
(c) Radial (d) Inverted

13. Periblem gives rise to **[MP PMT 2001; RPMT 2005]**
(a) Pericycle (b) Cortex
(c) Medulla (d) Epidermis

14. Cuticle is secreted by **[CPMT 2002]**
(a) Epidermis (b) Endodermis
(c) Both (a) and (b) (d) Hypodermis

15. Vascular bundles are derived from (originate from)
(a) Dermatogen
(b) Periderm
(c) Endogenous tissue the procambial strand or plerome
(d) Cortex

16. The composition of stele is **[Odisha JEE 2011]**
(a) Pith, vascular bundle
(b) Pericycle, pith
(c) Endodermis, pericycle
(d) Endodermis, pericycle, pith

17. Bulliform or motor cells are present in
(a) Dicot stem
(b) Upper epidermis of dicot leaves
(c) Lower epidermis of monocot leaves
(d) Upper epidermis of monocot leaves

18. Ground tissue includes **[NCERT; CBSE PMT (Pre.) 2011]**
(a) All tissues internal to endodermis
(b) All tissues external to endodermis
(c) All tissues except epidermis and vascular bundles
(d) Epidermis and cortex

19. Radial vascular bundle can be seen in **[CPMT 1996; MP PMT 2005]**
(a) Leaf (b) Dicot root
(c) Stem (d) Flower

20. Water stomata are found in
(a) Plants inhabiting humid region
(b) Plants inhabiting dry regions
(c) All plants
(d) Plants lacking normal stomata

21. Raphides are found in **[MP PMT 1996]**
(a) *Citrus* (b) *Colocasia*
(c) *Nerium* (d) Mango

22. Mesarch xylem is common in **[Pb. PMT 1999]**
(a) Ferns (b) Bryophytes
(c) Dicots (d) Monocots

23. In plants like *Nymphaea* which is attached emerged hydrophyte, the stomata are present on
(a) Adaxial (upper) surface of leaf
(b) Abaxial (lower) surface of leaf
(c) On both surface of leaf
(d) None of the above

24. Multiple epidermis on dorsal and ventral side of the leaf is found in **[CBSE PMT 1990; BHU 1994]**
(a) *Zea mays* (b) *Ficus benghalensis*
(c) *Mangifera indica* (d) *Nerium oleander*

25. Amphiphloic (bicollateral) condition of stele means that **[RPMT 1997; BVP 2003]**
(a) Phloem is surrounded by xylem
(b) Phloem is on both sides of xylem
(c) Phloem is internal to xylem
(d) Phloem is external to xylem

26. When formation of metaxylem is in a centripetal manner, the xylem is **[BHU 1994]**
(a) Endarch (b) Exarch
(c) Mesarch (d) Radial

27. Druse is a crystal or deposit of
(a) Calcium oxalate (b) Calcium carbonate
(c) Starch (d) Silica

28. The most primitive type of stele is **[CPMT 2001]**
(a) Eustele (b) Solenostele
(c) Protostele (d) Siphonostele

29. Match the items in Column – I with Column – II and choose the correct option

Column – I		Column – II	
A.	Radial Vascular Bundle	1.	*Cucurbita pepo*
B.	Collateral Vascular Bundle	2.	*Dracaena*
C.	Bicollateral Vascular Bundle	3.	Roots of angiosperms
D.	Amphicribal Vascular Bundle	4.	Sunflower stem
E.	Amphivasal Vascular Bundle	5.	Fern

[Kerala PMT 2007]
(a) A – 3, B – 4, C – 1, D – 5, E – 2
(b) A – 2, B – 3, C – 1, D – 5, E – 4
(c) A – 3, B – 4, C – 5, D – 1, E – 2
(d) A – 4, B – 5, C – 1, D – 2, E – 3
(e) A – 3, B – 1, C – 2, D – 4, E – 5

30. Passage cells are found in **[AIIMS 2002]**
(a) Dicot stem (b) Aereal root
(c) Monocot root (d) Monocot stem

31. Trabaculae is the transformation of **[MP PMT 2003]**
(a) Pericycle (b) Endodermis
(c) Xylem (d) Phloem

32. A bicollateral vascular bundle has the following arrangement of tissues **[KCET 2004]**
(a) Outer phloem – outer xylem – middle cambium – inner xylem – inner phloem
(b) Outer cambium – Outer phloem – middle xylem – inner phloem – inner cambium
(c) Outer phloem – outer cambium – middle xylem – inner cambium – inner phloem
(d) Outer xylem – outer cambium – middle phloem – inner cambium – inner xylem

33. Amphivasal vascular bundle possess **[RPMT 2006]**
(a) Xylem around phloem
(b) Phloem around xylem
(c) Phloem on both sides of xylem
(d) Phloem towards centre and xylem towards periphery

34. A dicot plant in which scattered vascular bundles are present in stem is **[AFMC 2012]**
(a) *Yucca* (b) *Peperomia*
(c) *Dolichos* (d) *Helianthus*

35. Vascular tissue is well developed in **[MHCET 2001]**
(a) Hydrophytes (b) Mesophytes
(c) Xerophytes (d) None of these

36. Vascular bundle in monocotyledons are considered closed, when **[Odisha JEE 2004; AFMC 2010; CBSE PMT (Pre.) 2012; AIPMT (Cancelled) 2015]**
(a) Cambium present (b) Cambium absent
(c) Pericycle absent (d) None of these

37. In the leaf vascular bundles are found in the **[Kerala CET 2003]**
(a) Veins (b) Palisade tissue
(c) Lower epidermis (d) Upper epidermis

38. Protosteles are found in **[MP PMT 2002]**
(a) Bryophyta (b) Gymnosperms
(c) Pteridophyta (d) Angiosperms

39. Which of the following have sunken stomata **[RPMT 2002]**
(a) *Nerium* (b) *Mangifera*
(c) *Hydrilla* (d) *Zea mays*

40. Some vascular bundles are described as open because these **[NCERT; CBSE PMT (Mains) 2011]**
(a) Possess conjunctive tissue between xylem and phloem
(b) Are not surrounded by pericycle
(c) Are surrounded by pericycle but no endodermis
(d) Are capable of producing secondary xylem and phloem

41. Vascular cambium in dicot root develops from **[DPMT 2004]**

Or

In dicot root, initiation of lateral root and vascular cambium during secondary growth takes place from **[NCERT]**
(a) Endodermis (b) Pericycle
(c) Conjunctive parenchyma (d) Both (b) and (c)

42. The large, empty and colourless cells present at intervals on the upper surface of grass leaf are called **[Kerala PMT 2006, 11]**
(a) Bulliform cells (b) Palisade parenchyma
(c) Spongy parenchyma (d) Accessory cells
(e) Passage cells

43. Amphicribal or hadrocentric vascular bundles are present in the stem of
(a) *Selaginella* (b) *Dracaena*
(c) *Cucurbita* (d) *Zea mays*

44. In free floating plant, the stomata are **[AFMC 2000]**
(a) Absent
(b) Present on upper surface
(c) Present on both the surface
(d) Present on lower surface

45. Pith cells are found in **[RPMT 1995]**
(a) Epidermis (b) Endodermis
(c) Pericycle (d) Lenticels

46. Dorsiventral leaf has **[Kerala CET 2002]**
(a) Stomata on both side (b) Stomata on lower surface
(c) Stomata on upper surface (d) No stomata

47. Root hairs are found **[NCERT; Kerala CET 2003; NEET 2017]**
(a) In the zone of maturation (b) Adventitious roots
(c) On the root cap (d) Apical meristem

48. Raphides are needle-like crystals of calcium oxalate which are specially found in **[Bihar MDAT 1995; MP PMT 1996; CPMT 2000; Odisha JEE 2004]**
(a) *Pistia* (b) Rose
(c) *Asparagus* (d) *Dahlia*

49. Which of the following do not have stomata **[AIIMS 2000]**
(a) Xerophytes (b) Mesophytes
(c) Hydrophytes (d) Submerged hydrophytes

50. Passage cells are present in **[KCET 2000]**
(a) *Epidermis* (b) *Endodermis*
(c) *Xylem* (d) Lenticels and hydathodes

51. When xylem and phloem are separated by a strip of cambium it is called **[KCET 1998]**
(a) Collateral and open (b) Collateral and closed
(c) Bicollatoral and open (d) Concentric and closed

52. Cortex is the region found between **[NEET (Phase-II) 2016]**
(a) Endodemis and vascular bundle
(b) Epidermis and stele
(c) Pericycle and endodermis
(d) Endodermis and pith

Internal structure of root, stem and leaf

1. Exarch and polyarch vascular bundles occur in **[MP PMT 2000, 06]**
(a) Monocot stem (b) Monocot root
(c) Dicot stem (d) Dicot root

2. Bicollateral conjoint vascular bundles have **[Kerala PMT 2006]**
(a) Xylem and phloem, which are arranged in an alternate manner on different radii
(b) Xylem and phloem, which are situated at the same radius and it has two groups of phloem along the two sides of xylem (inside and outside)
(c) Xylem and phloem in same radius but it has only one group phloem outside the xylem
(d) Phloem surrounds the xylem tissues
(e) Xylem surrounds the phloem tissues

3. Velamen tissue in orchids is found in **[RPMT 2002]**
(a) Shoot (b) Root
(c) Leaves (d) Flowers

4. Casparian thickenings are found in the cells of **[CPMT 1999; KCET 2006; Odisha JEE 2011]**

Or

In dicot roots, cells of which region show casparian strips **[RPMT 1997; CBSE PMT 1999; Odisha JEE 2005]**
(a) Pericycle of the root (b) Endodermis of the root
(c) Pericycle of the stem (d) Endodermis of the stem

5. In monocot leaf **[CBSE PMT 1990]**
(a) Bulliform cells are absent from the epidermis
(b) Veins form a network
(c) Mesophyll is well differentiated into these parts
(d) Mesophyll is not differentiated into palisade and spongy parenchyma

6. Find out the wrong statement about angiosperm roots **[KCET 2012]**
(a) Cuticle is absent in young stages
(b) The apex is protected by root cap
(c) Vascular bundles are collateral
(d) Xylem is centripetal in growth in the young roots

7. A major characteristic of the monocot root is the presence of **[AIPMT (Cancelled) 2015]**
(a) Scattered vascular bundles
(b) Vasculature without cambium
(c) Cambium sandwiched between phloem and xylem along the radius
(d) Open vascular bundles

8. The correct situation of mesophyll in isobilateral grass leaf is shown by
(a) Palisade towards adaxial surface
(b) Palisade towards abaxial surface
(c) Undifferentiated mesophyll
(d) Palisade along both the surface

9. Leaf mesophylls are composed of **[Odisha JEE 2008]**
(a) Pallisade parenchyma (b) Spongy parenchyma
(c) Both of them (d) None of these

10. Vascular bundles are scattered in **[Kerala CET 2002; CPMT 1990]**
(a) Bryophytes (b) Dicot root
(c) Dicot stem (d) Monocot stem

11. Generally hypodermis in monocots is composed of
(a) Parenchyma (b) Sclerenchyma
(c) Collenchyma (d) Chlorenchyma

12. Kranz anatomy is found in **[CPMT 1998]**
(a) Monocots (b) Dicots
(c) Both (a) and (b) (d) None of these

13. Which of the following is not a characteristic feature of the anatomy of dicotyledonous root
(a) Radial vascular bundles
(b) Secondary growth
(c) Pith little or absent
(d) Vascular bundles 15 – 20

14. Origin of lateral root of secondary root is
(a) Exogenous (b) Endogenous
(c) Lysigenous (d) Schizogenous

15. In a vertical section of a dorsiventral leaf, the protoxylem in its midrid bundle **[BHU 1994]**
(a) Faces the dorsal epidermis of the leaf
(b) Faces the ventral epidermis of the leaf
(c) Is not distinct
(d) Is surrounded by metaxylem

16. The annular and spirally thickened conducting elements generally develop in the protoxylem when the root or stem is **[CBSE PMT 2009]**

(a) Maturing (b) Elongating
(c) Widening (d) Differentiating

17. In barley stem vascular bundles are **[CBSE PMT 2009]**

(a) Open and scattered
(b) Closed and scattered
(c) Open and in a ring
(d) Closed and radial

18. Anatomically fairly old dicotyledonous root is distinguished from the dicotyledonous stem by **[CBSE PMT 2009, 14; Odisha JEE 2011]**

(a) Absence of secondary xylem
(b) Absence of secondary phloem
(c) Presence of cortex
(d) Position of protoxylem

19. Palisade parenchyma is absent in leaves of **[CBSE PMT 2009]**

(a) Sorghum (b) Mustard
(c) Soybean (d) Gram

20. Exarch xylem is found in **[CBSE PMT 1990; KCET 1999]**

(a) Root (b) Stem
(c) Leaf (d) Rachis

21. The vascular cambial ring of a dicot stem is

(a) Primary in origin (b) Secondary in origin
(c) Embryonic in origin (d) Tertiary in origin
(e) Partly primary and partly secondary in origin

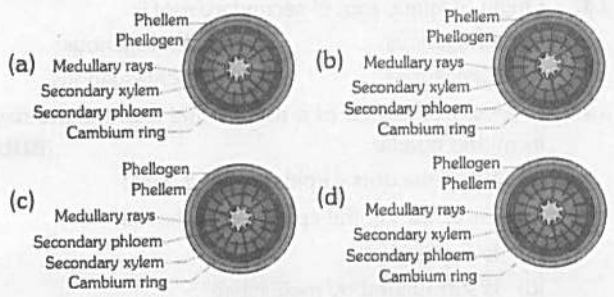
22. Consider the following statements

(A) In a dicot root, the vascular bundles are collateral and endarch
(B) The inner most layer of cortex in a dicot root is endodermis
(C) In a dicot root, the phloem masses are separated from the xylem by parenchymatous cells that are knwon as the conjunctive tissue

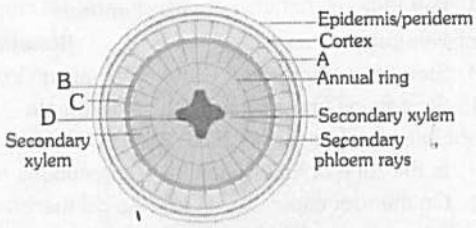
Of these statements given above **[Kerala PMT 2008]**

(a) A is true, but B and C are false
(b) B is true, but A and C are false
(c) A is false, but B and C are true
(d) C is false, but A and C are true
(e) C is true, but A and B are false

23. Which of the following figure of dicot stem is correctly labelled **[NCERT]**



24. The following figure is old typical dicot root. Identify A, B, C and D **[NCERT]**



(a) A – Secondary phloem, B – Primary xylem, C – Primary phloem, D – Vascular cambium
(b) A – Primary phloem, B – Primary xylem, C – Secondary phloem, D – Vascular cambium
(c) A – Secondary phloem, B – Vascular cambium, C – Primary phloem, D – Primary xylem
(d) A – Primary phloem, B – Vascular cambium, C – Secondary phloem, D – Primary xylem

25. Vascular bundles in dicot stem are **[MHCET 2001; Odisha JEE 2012; PET (Pharmacy) 2013]**

(a) Conjoint and collateral
(b) Conjoint and closed
(c) Conjoint, collateral and open
(d) Collateral and open

26. Which of the following is correct sequence of layers in typical monocot root (from outer surface to inside) **[CPMT 2005]**

(a) Pericycle, cortex, endodermis, epiblema
(b) Epiblema, endodermis, cortex, pericycle
(c) Epiblema, cortex, endodermis, pericycle
(d) Epiblema, pericycle, cortex, endodermis

27. Monocot root differs from dicot root in **[NCERT; AMU (Med.) 2005; CBSE PMT (Mains) 2012]**

(a) Presence of more than six xylem bundle
(b) Well developed pith
(c) Absence of secondary growth
(d) All of these

28. Pith is a central part of the ground tissue generally made up of **[J & K CET 2005]**

(a) Parenchyma (b) Collenchyma
(c) Chlorenchyma (d) Sclerenchyma

29. In a dorsiventral leaf, location of palisade tissue and phloem respectively are **[NCERT; RPMT 1999]**

(a) Abaxial and abaxial (b) Adaxial and abaxial
(c) Adaxial and adaxial (d) Abaxial and adaxial

30. T.S. of stem of *Cucurbita* can be identified from the T.S. of sunflower stem by the presence of

(a) Bicollateral vascular bundles
(b) Conjoint vascular bundles
(c) Scattered vascular bundles
(d) Cambium in the vascular bundles

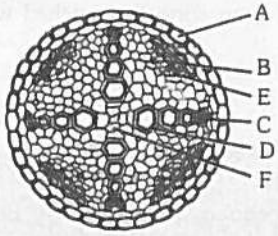
31. Which of the following is seen in a monocot root

(a) Large pith (b) Vascular cambium
(c) Endarch xylem (d) Medullary ray

32. In monocot stem, following is absent **[DPMT 2004]**

(a) Endodermis (b) Hypodermis
(c) Cortex (d) Both (a) and (b)

33. In the diagram of T.S. of Stele of Dicot Root, the different parts have been indicated by alphabets; choose the answer in which these alphabets correctly match with the parts they indicate **[KCET 2004]**



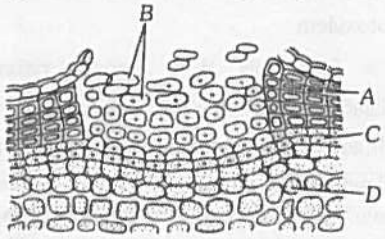
(a) A = Endodermis
B = Conjunctive tissue
C = Metaxylem D = Protoxylem
E = Phloem F = Pith

(b) A = Endodermis B = Pith
C = Protoxylem D = Metaxylem
E = Protoxylem
F = Conjunctive tissue

(c) A = Pericycle
B = Conjunctive tissue C = Metaxylem
D = Protoxylem E = Phloem

(d) A = Endodermis
B = Conjunctive tissue
C = Protoxylem D = Metaxylem
E = Phloem F = Pith

34. In the diagram of lenticel identify the parts as *A, B, C, D*



[KCET 2007]

(a) *A* – phellem, *B* – periderm, *C* – phellogen, *D* – phelloderm

(b) *A* – phellem, *B* – complementary cells, *C* – phelloderm, *D* – periderm

(c) *A* – complementary cells, *B* – phellogen, *C* – phelloderm, *D* - periderm

(d) *A* – complementary cells, *B* – phellem, *C* – periderm, *D* – phelloderm

35. Centripetal xylem is the characteristic of

(a) Roots (b) Stems
(c) Leaf (d) Petiole

36. In monocot roots which types of vascular bundles are found **[BHU 2003]**

(a) Collateral, conjoint and closed
(b) Radial V.B. with exarch xylem
(c) Bicollateral, conjoint and closed
(d) Radial V.B. with endarch xylem

37. Conjoint, collateral and closed vascular bundle is found in **[RPMT 1995, 2002; CPMT 1998; BHU 2002; BCECE 2005; AMU (Med.) 2009]**

(a) Monocot stem (b) Monocot root
(c) Dicot stem (d) Dicot root

38. Collenchyma tissue is present in **[RPMT 1995]**

Or

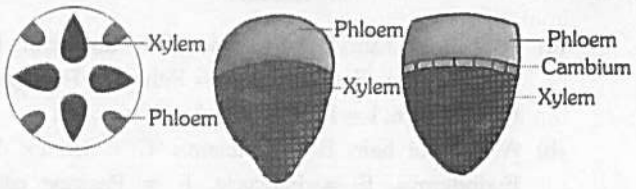
Collenchymatous hypodermis is characteristics of

(a) Dicot stem (b) Monocot stem
(c) Dicot root (d) Flowers

39. Largest number of chloroplast is found in **[CPMT 2004]**

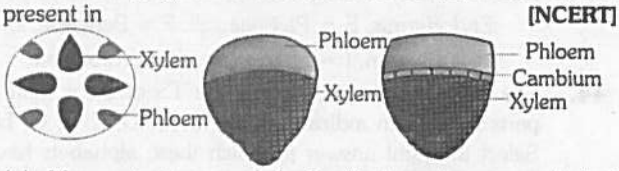
(a) Palisade tissue (b) Spongy tissue
(c) Transfusion tissue (d) Bundle sheath cells

40. Which type of vascular bundles are found in A, B and C **[NCERT]**



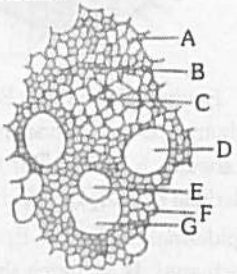
(a) Bicollateral; Concentric; Radial
(b) Open collateral conjoint; Close collateral conjoint; Radial
(c) Close collateral conjoint; Open collateral conjoint; Radial
(d) Radial; Close collateral conjoint; Open collateral conjoint

41. The following types of vascular bundles (A, B and C) are present in **[NCERT]**



(a) Monocot stem and leaf, dicot root, monocot leaf respectively
(b) Root, monocot stem and leaf, dicot stem respectively
(c) Root, stem, leaf respectively
(d) Stem, root, leaf respectively

42. The following diagrams shows the cross-section of the vascular bundle of monocot stem given aside, different parts have been indicated by alphabets; choose the option in which these alphabets have been correctly matched with the parts which they indicate **[NCERT]**



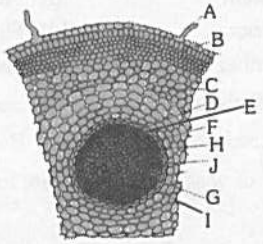
(a) A = Bundle cap, B = Metaxylem, C = Metaphloem, D = Protoxylem, E = Protophloem, F = Lysigenous cavity, G = Xylem parenchyma

(b) A = Bundle sheath, B = Primary phloem, C = Secondary phloem, D = Primary xylem, E = Secondary xylem, F = Xylem fibres, G = Hydathode

(c) A = Bundle cap, B = Metaphloem, C = Protophloem, D = Protoxylem, E = Metaxylem, F = Lysigenous cavity, G = Xylem parenchyma

(d) A = Bundle sheath, B = Broken phloem, C = Metaphloem, D = Metaxylem, E = Protoxylem, F = Xylem parenchyma, G = Lysigenous cavity

43. The following diagram illustrates the TS of monocot root in which certain parts have been indicated by alphabets, choose the right answer in which these alphabets have been correctly matched with the parts which they indicate **[NCERT]**



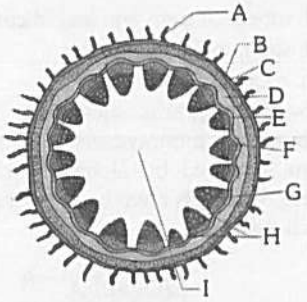
(a) A = Root hair, B = Cortex, C = Epiblema, D = Pericycle, E = Endodermis, F = Pith, G = Passage cell, H = Phloem, I = Protoxylem, J = Metaxylem

(b) A = Root hair, B = Epiblema, C = Cortex, D = Endodermis, E = Pericycle, F = Passage cell, G Phloem, H = Pith, I = Protoxylem, J = Metaxylem

(c) A = Root hair, B = Epiblema, C = Cortex, D = Endodermis, E = Passage cell, F = Pith, G = Pericycle, H = Metaxylem, I = Phloem, J = Protoxylem

(d) A = Root hair, B = Epiblema, C = Cortex, D = Endodermis, E = Passage cell, F = Pericycle, G = Pith, H = Phloem, I = Metaxylem, J = Protoxylem

44. The following diagram shows the TS of dicot stem, certain parts have been indicated by A, B, C, D, E, F, G, H and I. Select the right answer in which these alphabets have been correctly matched with the parts which they indicate **[NCERT]**



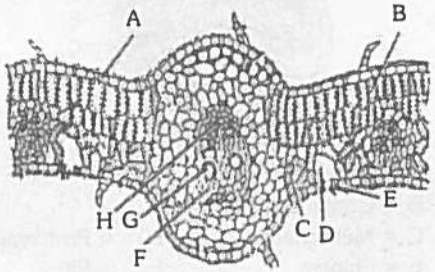
(a) A = Epidermal hairs, B = Epidermis, C = Parenchyma, D = Hypodermis (Collenchyma), E = Starch sheath, F = Vascular bundle, G = Bundle cap, H = Medulla or pith, I = Medullary rays

(b) A = Epidermal hairs, B = Epidermis, C = Hypodermis (Collenchyma), D = Starch sheath, E = Parenchyma, F = Vascular bundle, G = Bundle cap, H = Medulla or pith, I = Medullary rays

(c) A = Epidermal hairs, B = Epidermis, C = Hypodermis (Collenchyma), D = Parenchyma, E = Starch sheath, F = Bundle cap, G = Vascular bundle, H = Medullary rays, I = Medulla or pith

(d) A = Epidermis, B = Epidermal hairs, C = Parenchyma, D = Starch sheath, E = Hypodermis (Collenchyma), F = Vascular bundle, G = Bundle cap, H = Medulla or pith, I = Medullary rays

45. The following diagram shows the TS of dicot leaf passing through the midrib, some parts have been indicated by alphabets. Choose the answer in which A, B, C, D, E, F, G and H have been correctly matched with the parts which they indicate **[NCERT]**



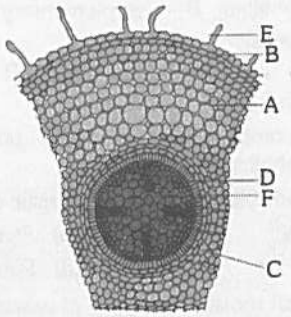
(a) A = Epidermis, B = Palisade parenchyma, C = Spongy parenchyma, D = Stomata, E = Guard Cells, F = Phloem, G = Metaxylem, H = Protoxylem

(b) A = Epidermis, B = Palisade parenchyma, C = Spongy parenchyma, D = Stomata, E = Guard cells, F = Endodermis, G = Xylem, H = Phloem

(c) A = Epidermis, B = Palisade parenchyma, C = Spongy Parenchyma, D = Sub stomatal cavity, E = Guard cells, F = Phloem, G = Metaxylem, H = Protoxylem

(d) A = Epidermis, B = Spongy parenchyma, C = Palisade parenchyma, D = Stomata, E = Guard cells, F = Phloem, G = Metaxylem, H = Protoxylem

46. The following diagram shows the TS of dicot root, certain parts have been indicated by letters, select the option in which these letters have been correctly matched with the parts which they indicate **[NCERT]**



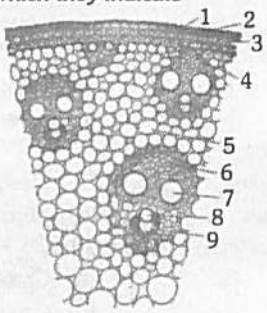
(a) A = Cortex, B = Epiblema, C = Pith, D = Endodermis, E = Root hair, F = Pericycle

(b) A = Epiblema, B = Endodermis, C = Cortex, D = Root hair, E = Pith, F = Pericycle

(c) A = Cortex, B = Pith, C = Epiblema, D = Endodermis, E = Root hair, F = Pericycle

(d) A = Epiblema, B = Root hair, C = Cortex, D = Endodermis, E = Pith, F = pericycle

47. The given below diagram shows the T.S. of monocot stem, some parts have been indicated by numbers. Select the answer in which these numbers have been correctly matched with the parts which they indicate **[NCERT]**



(a) 1 - Cuticle, 2 - Epidermis, 3 - Sclerenchymatous hypodermis, 4 - Sclerenchymatous sheath, 5 - Parenchymatous sheath, 6 - Protoxylem, 7 - Metaxylem, 8 - Phloem, 9 - Water cavity

(b) 1 - Cuticle, 2 - Epidermis, 3 - Sclerenchymatous hypodermis, 4 - Sclerenchymatous sheath, 5 - Parenchymatous sheath, 6 - Phloem, 7 - Protoxylem, 8 - Metaxylem, 9 - Water cavity

(c) 1 - Cuticle, 2 - Epidermis, 3 - Sclerenchymatous sheath, 4 - Sclerenchymatous hypodermis, 5 - Parenchymatous sheath, 6 - Phloem, 7 - Metaxylem, 8 - Protoxylem, 9 - Water cavity

(d) 1 - Cuticle, 2 - Epidermis, 3 - Sclerenchymatous hypodermis, 4 - Sclerenchymatous sheath, 5 - Parenchymatous sheath, 6 - Phloem, 7 - Metaxylem, 8 - Protoxylem, 9- Water cavity

Secondary growth

1. In dicot stem, the secondary growth takes place by
(a) Primary cambium
(b) Secondary cambium
(c) Development of cambium in stele region
(d) Development of cambium in stele and in the cortical region

2. Which one of the following is not correct **[AMU (Med.) 2010]**
(a) Early wood is characterized by large number of xylary elements
(b) Early wood is characterized by vessels with wider cavities
(c) Late wood is characterized by large number of xylary elements
(d) Late wood is characterized by vessels with narrower cavities

3. Conduction of sap in plants occurs through
(a) Heartwood (b) Sapwood
(c) Xylem (d) All the above

4. "*Sap wood*" is otherwise called **[J & K CET 2008; Kerala PMT 2009]**
(a) Duramen (b) Alburnum
(c) Pith (d) Medullary rays

5. The function of cork cambium (phellogen) is to produce **[Odisha JEE 2010]**
(a) Cork and secondary cortex
(b) Secondary xylem and secondary phloem
(c) Cork
(d) Secondary cortex and phloem

6. Vascular tissues in flowering plants develop from **[KCET 1998; CBSE PMT 2008]**
(a) Periblem (b) Dermatogen
(c) Phellogen (d) Plerome

7. In dicot roots, cork cambium is derived from
(a) Epidermis (b) Hypodermis
(c) Cortex (d) Pericycle

8. Periderm is made up of **[MP PMT 1995, 2010]**
(a) Phellem (b) Phellogen
(c) Phelloderm (d) All the above

9. If four radial vascular bundles are present, then the structure will be **[CBSE PMT 2002]**
(a) Monocot stem (b) Monocot root
(c) Dicot stem (d) Dicot root

10. Secondary growth is absent in
(a) Dicot stem (b) Gymnosperms
(c) Monocot stem (d) Dicot root

11. Complementary cells are found in **[Odisha JEE 2012]**
(a) Pericycle (b) Endodermis
(c) Lenticels (d) Pith

12. Fascicular cambium found in dicot stem is a
(a) Secondary meristem (b) Primary meristem
(c) Intercalary meristem (d) Apical meristem

13. Which of the following meristems is responsible for extrastelar secondary growth in dicotyledonous stem **[CBSE PMT 1998]**
(a) Phellogen (b) Intrafascicular cambium
(c) Interfascicular cambium (d) Intercalary meristem

14. Heartwood differs from sapwood in **[CBSE PMT (Pre.) 2010]**
(a) Being susceptible to pests and pathogens
(b) Presence of rays and fibres
(c) Absence of vessels and parenchyma
(d) Having dead and non-conducting elements

15. Youngest layer of secondary xylem in wood of dicot stem is located just **[CPMT 1993]**
(a) Outside the cambium (b) Inside the cambium
(c) Outside pith (d) Inside the cortex

16. Annual rings are distinct in plants growing in
(a) Tropical regions (b) Arctic region
(c) Grasslands (d) Temperate region

17. Read the different components from (A) to (D) in the list given below and tell the correct order of the components with reference to their arrangement from outer side to inner side in a woody dicot stem **[AIPMT 2015]**
(A) Secondary cortex (B) Wood
(C) Secondary phloem (D) Phellem
(a) (A), (B), (D), (C) (b) (D), (A), (C), (B)
(c) (D), (C), (A), (B) (d) (C), (D), (B), (A)

18. Growth rings are well marked in trees growing in
(a) Shimla (b) Bombay
(c) Madras (d) Calcutta

19. As secondary growth proceeds, in a dicot stem, the thickness of **[KCET 2006]**
(a) Sapwood increases
(b) Heartwood increases
(c) Both sapwood and heartwood increases
(d) Both sapwood and heartwood remains the same

20. External protective tissues of plants are (of dicot stem are)
(a) Cork and pericycle (b) Cortex and epidermis
(c) Pericycle and cortex (d) Epidermis and cork

21. Cork cambium is a **[MHCET 2000]**
(a) Secondary meristem (b) Apical meristem
(c) Intercalary meristem (d) Primary meristem

22. The cambium which produces cork is known as **[EAMCET 1993; RPMT 1997; CPMT 1999; HPMT 2005]**

Or

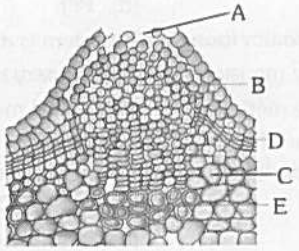
The common bottle cork is a product of **[NCERT; CBSE PMT (Pre.) 2012]**

Or

The meristem that is parallel to the longitudinal axis of the plant is
(a) Phelloderm (b) Phellogen
(c) Periblem (d) Periderm

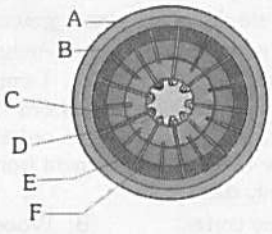
23. The cork cambium, cork and secondary cortex are collectively called **[NCERT; Kashmir MEE 1995; CBSE PMT (Pre.) 2011]**
(a) Phellem (b) Phelloderm
(c) Phellogen (d) Periderm

24. Identify the correct combination of labelling a lenticel **[NCERT]**



(a) A – pore, B – complimentary cells, C – cork, D – cork cambium, E – secondary cortex
(b) A – pore, B – cork, C – complimentary cells, D – cork cambium, E – secondary cortex
(c) A – pore, B – cork cambium, C – secondary cortex, D – cork, E – complimentary cells
(d) A – pore, B – secondary cortex, C – cork cambium, D – cork, E – complimentary cells

25. The following figure showing secondary growth in dicot stem. Identify A, B, C, D, E and F **[NCERT]**



(a) A – Phellem, B – Phellogen, C – Cambium ring, D – Secondary xylem, E – Secondary phloem, F – Medullary rays
(b) A – Phellogen, B – Phellem, C – Medullary rays, D – Secondary xylem, E – Secondary phloem, F – Cambium ring
(c) A – Phellem, B – Phellogen, C – Medullary rays, D – Secondary phloem, E – Secondary xylem, F – Cambium ring
(d) A – Phellem, B – Phellogen, C – Medullary rays, D – Secondary xylem, E – Secondary phloem, F – Cambium ring

26. In dicot stem secondary growth is due to the activity of **[Pb. PMT 2004, 05]**
(a) Apical meristem (b) Lateral meristem
(c) Cork (d) Back

27. The cell wall is impermeable to water and deposition of suberin is also found in **[CPMT 1998]**
(a) Bast (b) Cork
(c) Bark (d) Xylem

28. Secondary growth is absent in **[CPMT 1998]**
(a) Hydrophytes (b) Mesophytes
(c) Halophytes (d) Xerophytes

29. Girth of a dicot stem is increased by **[Pune CET 1998]**
(a) Xylem (b) Cambium
(c) Phloem (d) Ground tissue

30. Tyloses are found in **[MP PMT 1996; KCET 2010; Odisha JEE 2012]**
(a) Secondary xylem (b) Secondary phloem
(c) Callus tissue (d) Cork cells

31. Fusiform initials form **[MP PMT 2007]**
(a) Vascular rays (b) Treacheary elements
(c) Ray parenchyma (d) Phloem parenchyma

32. In the primary tissues of the stem, the cambium separating xylem and phloem is called
(a) Procambium (b) Fascicular cambium
(c) Cork cambium (d) Interfascicular cambium

33. The trees growing in desert will
(a) Show alternate rings of xylem and sclerenchyma
(b) Have only conjunctive tissue and phloem formed by the activity of cambium
(c) Show distinct annual rings
(d) Not show distinct annual rings

34. The bark of tree comprises **[NCERT; CPMT 1996; Pune CET 1998]**
(a) All the tissues outside the vascular cambium
(b) All the tissues outside the cork cambium
(c) Only the cork
(d) The cork and secondary cortex

35. Knots in stems are formed due to
(a) Tumors formed due to bacterial infection of wounds
(b) Outgrowth of seconday tissue over wounds
(c) Injury caused by insects
(d) None of the above

36. The vascular cambium in dicots is **[EAMCET 1995]**
(a) Lateral (b) Apical
(c) Intercalary (d) Secondary

37. Secondary cortex is also known as **[KCET 2012]**
(a) Phellem (b) Phelloderm
(c) Phellogen (d) Bark

38. Annual growth rings are formed due to activity **[CPMT 2004; MP PMT 2006]**
(a) Extrastelar cambium (b) Intrastelar cambium
(c) Interstelar cambium (d) Both (b) and (c)

39. As a tree grows older, which increases rapidly in thickness
(a) Its heart wood (b) Its cortex
(c) Its sap wood (d) Its phloem

40. The axillary buds arise **[MP PMT 2013]**
(a) Endogenously from the pericycle
(b) Exogenously from the tissues of the main growing point
(c) Endogenously from the cambial tissues
(d) Exogenously from the innermost cortex

41. Lenticel develops through the activity of
(a) Vascular cambium (b) Dermatogen
(c) Phellogen (d) Intercalary meristem

42. In a stratified cambium, the fusiform initials are **[CBSE PMT 1994]**
(a) Long and overlap each other at the ends
(b) Short and overlap each other at the ends
(c) Short and arranged in horizontal tiers
(d) Short or long and overlap each other at the ends

43. Intrafascicular cambium is situated in **[BVP 2003]**
(a) Outside the vascular bundles
(b) In medullary rays
(c) Inside the vascular bundles
(d) In between the vascular bundles

44. Lenticels are **[NCERT; Odisha JEE 2009]**
(a) Loose cells on leaves
(b) Subsidiary cells of stomata
(c) Cells for respiration in epiphytes
(d) Some loose cells on bark meant for aeration

45. In an annual ring, the light coloured part is known as **[DUMET 2009]**
(a) Early wood (b) Late wood
(c) Heartwood (d) Sapwood

46. In old dicot stems, a major part of the wood is filled up with tannins, resins, gums etc. This part of wood is called
(a) Hard wood (b) Heart wood
(c) Sap wood (d) Soft wood

47. In summer, cambium
(a) Dies (b) Is more active
(c) Is less active (d) Is not active

48. What is/are true about heart wood
A. It does not help in water conduction
B. It is also called alurnum
C. It is dark in colour but very soft
D. It has tracheary element which are filled with tannin, resin, etc. **[NCERT; KCET 2009]**
(a) B, C and D (b) A and D
(c) B and D (d) A, B and C

49. Identify the correct statement **[KCET 2009]**
(a) Because of marked climatic variations, plants growing near the sea shore do not produce annual rings
(b) The age of the plant can be determined by its height
(c) Healing of damaged tissue is because of the activity of sclerenchyma cells
(d) Grafting is difficult in monocot plants as they have scattered vascular bundles

50. For a critical study of secondary growth in plants, which one of the following pairs is suitable **[CBSE PMT 2007]**
(a) Sugarcane and sunflower
(b) Teak and pine
(c) Deodar and fern
(d) Wheat and maiden hair fern

51. Vascular cambium is a meristematic layer that cuts off **[CBSE PMT 1990]**
(a) Primary xylem and primary phloem
(b) Xylem vessels and xylem tracheids
(c) Primary xylem and secondary xylem
(d) Secondary xylem and secondary phloem

52. The waxy substance associated with cell walls of cork cells is or cork cells are impervious to water because of the presence or what is deposited on cork cells **[NCERT; AIIMS 1992, 2004; CBSE PMT 1994; MP PMT 2000]**
(a) Cutin (b) Suberin
(c) Lignin (d) Hemicellulose

53. Which of the following statements is / are not true
A. Cork cambium is otherwise called phellogen
B. Cork is otherwise called phellem
C. Secondary cortex is otherwise called periderm
D. Cork cambium, cork and secondary cortex are collectively called phelloderm **[Kerala PMT 2006, 07]**
(a) C and D only (b) A and B only
(c) B and C only (d) B and D only
(e) A and D only

54. The functional xylem of dicot tree is **[AFMC 2001]**
(a) Sap wood (b) Hard wood
(c) Heart wood (d) Autumn wood

55. Which will decay faster if exposed freely **[CBSE PMT 1993]**
(a) Soft wood (b) Heart wood
(c) Sap wood (d) Wood with lots of fibres

56. In dicot stem, vascular bundles are **[NCERT; Odisha JEE 2004]**
(a) Numerous scattered
(b) Arranged in a ring
(c) Without cambium
(d) Surrounded by bundle sheath

57. The best method to determine the age of tree is **[MP PMT 2004; NEET 2013]**
(a) To find out the number of branches
(b) To count the number of annual rings
(c) To measure its diameter
(d) To count the number of leaves

58. Removal of ring wood of tissue outside the vascular cambium from the tree trunk kills it because **[RPMT 2005]**
(a) Water cannot move up
(b) Food does not travel down and root become starved
(c) Shoot become starved
(d) Annual ring and not produced

59. After the secondary growth the youngest layer of secondary phloem in a dicot stem is located
(a) Just outside the vascular cambium
(b) Just inside the vascular cambium
(c) Just inside the primary phloem
(d) Just outside the secondary xylem

60. Cork is a derivative of
(a) Cork cambium (phellogen) or extra fascicular cambium
(b) Vascular cambium
(c) Fascicular cambium
(d) Interfascicular cambium

61. Which of the following is known as wood **[AFMC 2003]**
(a) Primary xylem (b) Secondary xylem
(c) Secondary phloem (d) Cambium

62. Heart wood or duramen is **[KCET 2001; BHU 2006]**
(a) Outer region of secondary xylem
(b) Inner region of secondary xylem
(c) Outer region of secondary phloem
(d) Inner region of secondary phloem

63. One cannot age a tree by its rings if that tree is located in which of the following forests
(a) Tropical deciduous (b) Tropical evergreen
(c) Temperate deciduous (d) Temperate evergreen

64. Commercial cork is obtained from **[BHU 2003; MP PMT 2012]**
(a) Mango (b) Oak (*Quercus suber*)
(c) *Ficus religiosa* (d) *Pinus*

65. The pores present in the wall of plant's stem *i.e.*, called **[NCERT; CPMT 1994]**

Or

In a plant organ which is covered by periderm and in which the stomata are absent, some gaseous exchange still takes place through **[AIIMS 2004]**
(a) Lenticels (b) Bark
(c) Dalipore (d) All the above

66. Lenticels are found in **[RPMT 1995]**
(a) Young dicot stem (b) Old dicot stem
(c) Monocot root (d) Young root

67. Secondary growth or increase in diameter is due to **[NCERT]**
(a) Ground meristem (b) Procambium
(c) Cork and phelloderm (d) Vascular cambium

68. In the following how the sap wood is converted into heart wood **[RPMT 2006]**
(a) By degeneration of protoplast of living cells
(b) Tylosis formation
(c) By deposition of resins, oil, gums
(d) All of the above

69. Identify the wrong statement in context of heartwood **[NEET 2017]**
(a) Organic compounds are deposited in it
(b) It is highly durable
(c) It conducts water and minerals efficiently
(d) It comprises dead elements with highly lignified walls

70. Which of the following is made up of dead cells **[NEET 2017]**
(a) Xylem parenchyma (b) Collenchyma
(c) Phellem (d) Phloem

NCERT Exemplar Questions

1. A transverse section of stem is stained first with safranin and then with fast green following the usual schedule of double staining for the preparation of a permanent slide. What would be the colour of the stained xylem and phloem **[NCERT]**
(a) Red and green (b) Green and red
(c) Orange and yellow (d) Purple and orange

2. Match the following and choose the correct option from below

A. Meristem	i. Photosynthesis, storage
B. Parenchyma	ii. Mechanical support
C. Collenchyma	iii. Actively dividing cells
D. Sclerenchyma	iv. Stomata
E. Epidermal tissue	v. Sclereids

Options: **[NCERT]**
(a) A-i, B-iii, C-v, D-ii, E-iv
(b) A-iii, B-i, C-ii, D-v, E-iv
(c) A-ii, B-iv, C-v, D-i, E-iii
(d) A-v, B-iv, C-iii, D-ii, E-i

3. Match the following and choose the correct option from below

A. Cuticle	i. Guard cells
B. Bulli form cells	ii. Single layer
C. Stomata	iii. Waxy layer
D. Epidermis	iv. Empty colourless cell

Options **[NCERT]**
(a) A-iii, B-iv, C-i, D-ii
(b) A-i, B-ii, C-iii, D-iv
(c) A-iii, B-ii, C-iv, D-i
(d) A-iii, B-ii, C-i, D-iv

4. Identify the tissue system from among the following **[NCERT]**
(a) Parenchyma (b) Xylem
(c) Epidermis (d) Phloem

5. Cells of this tissue are living and show angular wall thickning. They also provide mechanical support. The tissue is **[NCERT]**
(a) Xylem (b) Sclerenchyma
(c) Collenchyma (d) Epidermis

6. Epiblema of roots is equivalent to **[NCERT]**
(a) Pericycle (b) Endodermis
(c) Epidermis (d) Stele

7. A conjoint and open vascular bundle will be observed in the transverse section of **[NCERT]**
(a) Monocot root (b) Monocot stem
(c) Dicot root (d) Dicot stem

8. Interfascicular cambium and cork cambium are formed due to **[NCERT]**
(a) Cell division (b) Cell differentiation
(c) Cell dedifferentiation (d) Redifferentiation

9. Phellogen and Phellem respectively denote **[NCERT]**
(a) Cork and cork cambium
(b) Cork cambium and cork
(c) Secondary cortex and cork
(d) Cork and secondary cortex

10. In which of the following pairs of parts of a flowering plant epidermis is absent **[NCERT]**
(a) Root tip and shoot tip
(b) Shoot bud and floral bud
(c) Ovule and seed
(d) Petiole and pedicel

11. How many shoot apical meristems are likely to be present in a twig of a plant possessing, 4 branches and 26 leaves **[NCERT]**
(a) 26 (b) 1
(c) 5 (d) 30

12. A piece of wood having no vessels (trachea) must be belong to **[NCERT]**
(a) Teak (b) Mango
(c) Pine (d) Palm

13. A plant tissue, when stained, showed the presence of hemicellulose and pectin in cell wall of its cells. The tissue represents **[NCERT]**
(a) Collenchyma (b) Sclerenchyma
(c) Xylem (d) Meristem

14. Fibres are likely to be absent in **[NCERT]**
(a) Secondary phloem (b) Secondary Xylem
(c) Primary phloem (d) Leaves

15. When we peel the skin of a potato tuber, we remove **[NCERT]**
(a) Periderm (b) Epidermis
(c) Cuticle (d) Sapwood

16. A vesselless piece of stem possessing prominent sieve tubes would belong to **[NCERT]**
(a) *Pinus* (b) *Eucalyptus*
(c) Grass (d) *Trochodendron*

17. Which one of the following cell types always divides by anticlinal cell division **[NCERT]**
(a) Fusiform initial cells (b) Root cap
(c) Protoderm (d) Phellogen

18. What is the fate of primary xylem in a dicot root showing extensive secondary growth **[NCERT]**
(a) It is retained in the centre of the axis
(b) It gets crushed
(c) May or may not get crushed
(d) It gets surrounded by primary phloem

Critical Thinking

Objective Questions

1. Match the following and choose the correct combination

(A) Endodermis	(1) Companion cells
(B) Stomata	(2) Lenticels
(C) Sieve tube	(3) Palisade cells
(D) Periderm	(4) Passage cells
(E) Mesophyll	(5) Accessory cells

[Kerala PMT 2009]

(a) A – 4, B – 5, C – 2, D – 1, E – 3
(b) A – 5, B – 3, C – 1, D – 2, E – 4
(c) A – 4, B – 5, C – 1, D – 2, E – 3
(d) A – 2, B – 5, C – 3, D – 4, E – 1
(e) A – 4, B – 2, C – 5, D – 3, E – 1

2. In woody dicotyledons, the arrangement of vessels is either diffuse porous or ring porous. Based on these data, which one of the following statements is correct **[BHU 1994]**
(a) Ring porous vessels are specialised and are used for conducting more water for a shorter period only, when tyloses occur early in the vessels
(b) Although diffuse porous vessels are not so specialized as ring porous vessels, they conduct more water at all periods and through new xylem vessels added gradually during development
(c) Diffuse porous vessels carry more water and also faster because of a greater number of small vessels having greater capillary force
(d) Ring porous vessels conduct more water as they are formed early during development, when the need for water is great

3. The quiescent centre in root meristem serves as a **[AIIMS 2003]**
(a) Site for storage of food, which is utilized during maturation
(b) Reservoir of growth hormones
(c) Reserve for replenishment of damaged cells of the meristem
(d) Region for absorption of water

4. For a successful graft, the adhesion between stock and scion is a must. Which one of the following is the earliest event towards a good graft **[CBSE PMT 1990]**
(a) Production of plasmodesmata in the cells at the interface of stock and scion
(b) Coordinated differentiation of vascular tissue between the stock and scion
(c) Regeneration of cortex and epidermis over the union of stock and scion
(d) Production of callus tissue between the cells of stock and scion

5. If there is more than one tunica layer in a stem apex, which among the following is most likely to happen
(a) All the layers will develop into epidermal cells
(b) Only the outer layer will develop into epidermal cells
(c) All the layers will develop into cortex
(d) Inner layer develops into cortex

6. Water containing cavities in vascular bundles are found in **[NCERT; CBSE PMT (Pre.) 2012]**
(a) Sunflower (b) Maize
(c) *Cycas* (d) *Pinus*

7. A nail is driven into the trunk of a 30 year old tree at a point 1 meter above the soil level. The tree grows in height at the rate of 0.5 meters a year. After three years, the nail will be **[Kerala PMT 2004]**
(a) 1 meter above the soil (b) 1.5 meter above the soil
(c) 2 meters above the soil (d) 2.5 meters above the soil
(e) 3 meters above the soil level

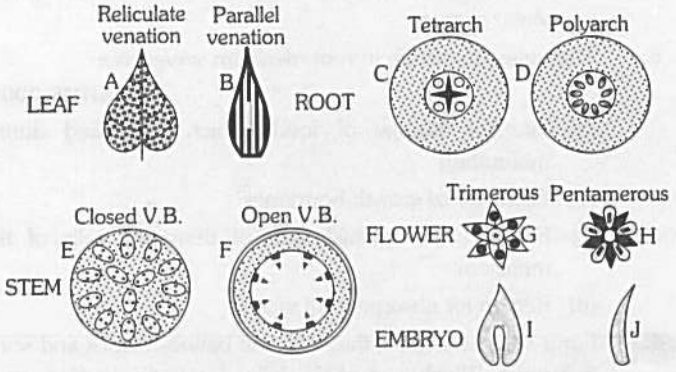
8. Grafting is not possible in monocots because they **[BHU 1995; MP PMT 1996; AFMC 2010]**

(a) Have scattered vascular bundles
(b) Have parallel venation
(c) Are herbaceous
(d) Lack cambium

9. Trees at sea do not have annual rings because

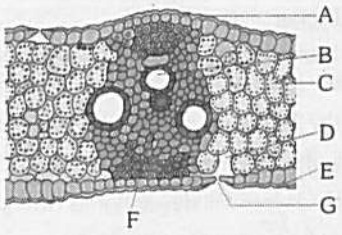
(a) Soil is sandy
(b) There is climatic variation
(c) There is no marked climatic variation
(d) There is enough moisture in the atmosphere

10. See the following figures and identify the characters of Dicot and Monocot respectively **[NCERT]**



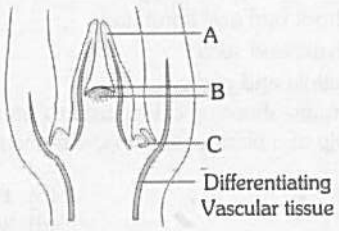
(a) B, C, F, H, I; and A, D, E, G, J
(b) A, C, E, G, I; and B, D, F, H, J
(c) A, D, F, H, I; and B, C, E, G, J
(d) A, C, F, H, I; and B, D, E, G, J

11. The following diagram shows the T.S. of monocot leaf, certain parts have been indicated by alphabets. Select the option in which A, B, C, D, E, F and G have been correctly matched with the parts which they indicate **[NCERT]**



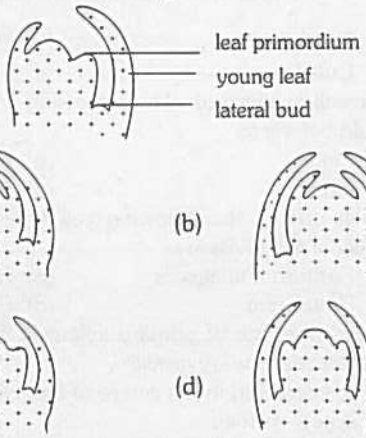
(a) A – Adaxial epidermis, B – Xylem, C – Stoma, D – Sub-stomatal cavity, E – Abaxial epidermis, F – Phloem, G – Mesophyll
(b) A – Adaxial epidermis, B – phloem, C – Mesophyll, D – Sub-stomatal cavity, E – Abaxial epidermis, F – Xylem, G – Stoma
(c) A – Abaxial epidermis, B – Xylem, C – Mesophyll, D – Sub-stomatal cavity, E – Adaxial epidermis, F – Phloem, G – Stoma
(d) A – Adaxial epidermis, B – Xylem, C – Mesophyll, D – Sub-stomatal cavity, E – Abaxial epidermis, F – Phloem, G – Stoma

12. Identify the following points A, B and C in the given diagram **[NCERT]**



(a) A – Root hair primordium, B – Root apical meristem, C – Terminal bud
(b) A – Root hair primordium, B – Root apical meristem, C – Axillary bud
(c) A – Leaf primordium, B – Shoot apical meristem, C – Apical bud
(d) A – Leaf primordium, B – Shoot apical meristem, C – Axillary bud

13. The following diagram opposite illustrates a longitudinal section through a shoot apex. Which of the figures given below shows the correct appearance of this shoot apex at the formation of the next leaf primordium **[NCERT]**



14. A few drops of sap were collected by cutting across a plant stem by a suitable method. The sap was tested chemically. Which one of the following test results indicated that it is phloem sap **[NEET (Phase-II) 2016]**

(a) Absence of sugar (b) Acidic
(c) Alkaline (d) Low refractive index

AR Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : All tissues lying inside vascular cambium are called as bark.
Reason : Bark is made up of phellogen, phellem and phelloderm lying inside secondary phloem. **[AIIMS 1994]**

2. Assertion : Stomata are absent in submerged hydrophytes.
Reason : Respiration occurs by means of air chambers in submerged plants. **[AIIMS 1997]**

3. Assertion : Cambium is a lateral meristem and cause growth in width.
Reason : Cambium is made up of fusiform and ray initials in stem. **[AIIMS 1998]**

4. Assertion : Higher plants have meristematic regions for indefinite growth.
Reason : Higher plants have root and shoot apices. **[AIIMS 1999]**

5. Assertion : In collateral vascular bundles phloem is situated towards inner side.
Reason : In monocot stem, cambium is present. **[AIIMS 2000]**

6. Assertion : Thick cuticle is mostly present in disease resistant plants.
Reason : Disease causing agents cannot grow on cuticle and cannot invade the cuticle. **[AIIMS 1997]**

7. Assertion : Quiescent centre is found in the centre of the root apex.
Reason : It consists of actively dividing cells.

8. Assertion : Sclerenchyma cells do not have plasmodesmata.
Reason : The cell walls of some permanent tissues are heavily lignified. **[KCET 2010]**

9. Assertion : Intercalary meristem increase length of plant like apical meristems.
Reason : Intercalary meristem originates from the apical meristems.

10. Assertion : Apical and intercalary meristems contribute to the growth in length, while the lateral meristems bring increase in girth in maize.
Reason : Apical and intercalary meristems always increase the height of plants. **[EAMCET 2009]**

11. Assertion : Xerophytic leaves may contain stomatal crypts or sunken stomata.
Reason : Spongy parenchyma is more in xerophytic leaves.

12. Assertion : Xylem and phloem are also called as leptome and hadrome respectively.
Reason : Xylem and phloem form conducting tissue of the plant.

13. Assertion : The upper surface of the leaf is darker than the lower surface.
Reason : Spongy mesophyll contains less chloroplasts than palisade mesophyll cells.

14. Assertion : Tyloses plug the tracheids and vessels.
Reason : Tyloses are in growths of xylem cells.

15. Assertion : Cuticle is also present in lower epidermal region of the leaf.
Reason : The lower epidermis contains a large number of stomata.

16. Assertion : Bulliform cells are useful in the unrolling of leaf.
Reason : Bulliform leaves store water.

17. Assertion : In grasses and cereals, intercalary meristems are not present.
Reason : Intercalary meristems form permanent tissues.

18. Assertion : Sapwood is less durable than the heartwood.
Reason : Hollow tree trunks are due to the disappearance of sapwood.

19. Assertion : Idioblasts are derived from parenchyma.
Reason : Secretory cells are modified parenchyma.

20. Assertion : Growth rings are also called as annual rings.
Reason : Generally growth ring is formed in each year.

Answers

Tissue (General)

1	c	2	a	3	a	4	a	5	c
6	a	7	d	8	d	9	e	10	b
11	d	12	b	13	d	14	d	15	b
16	b	17	b	18	e	19	e	20	b
21	a	22	b	23	c	24	d	25	b
26	a	27	b	28	d	29	b	30	b
31	a	32	c	33	a	34	d	35	a
36	d	37	b	38	a	39	c	40	b
41	d	42	d	43	c	44	b	45	c
46	a	47	b	48	c	49	a	50	d
51	d	52	a	53	a	54	d	55	c
56	b	57	c	58	b	59	d	60	a
61	d	62	a	63	a	64	a	65	b
66	d	67	a	68	a	69	b	70	b
71	c	72	c	73	c	74	c	75	c
76	c	77	a	78	c	79	d	80	b
81	b	82	d	83	a	84	a	85	d
86	c	87	d	88	a	89	a	90	b
91	d	92	e	93	d	94	a	95	b
96	c	97	d	98	b	99	a	100	a
101	c	102	b	103	d	104	b	105	b
106	a	107	b	108	c	109	c	110	a
111	b	112	b	113	d	114	a	115	c

116	c	117	b	118	a	119	c	120	c
121	a	122	a	123	b	124	c	125	a
126	c	127	c	128	b	129	c	130	c
131	c	132	b	133	c	134	c	135	d
136	a	137	b	138	c	139	c	140	b
141	b	142	c	143	a	144	b	145	b
146	a	147	a	148	d	149	b	150	b
151	a	152	d	153	d	154	a	155	c
156	c								

The tissue system

1	a	2	a	3	a	4	d	5	b
6	b	7	b	8	a	9	d	10	b
11	a	12	b	13	b	14	a	15	c
16	a	17	d	18	c	19	b	20	a
21	c	22	a	23	a	24	d	25	b
26	b	27	a	28	c	29	a	30	c
31	b	32	c	33	a	34	b	35	c
36	b	37	a	38	c	39	a	40	d
41	d	42	a	43	a	44	b	45	b
46	b	47	a	48	a	49	d	50	b
51	a	52	b						

Internal structure of root, stem and leaf

1	b	2	b	3	b	4	b	5	d
6	c	7	b	8	c	9	c	10	d
11	b	12	c	13	d	14	b	15	a
16	a	17	b	18	d	19	a	20	a
21	e	22	c	23	b	24	d	25	c
26	c	27	d	28	a	29	b	30	a
31	a	32	a	33	d	34	a	35	a
36	b	37	a	38	a	39	a	40	d
41	b	42	d	43	d	44	c	45	c
46	a	47	d						

Secondary growth

1	d	2	c	3	b	4	b	5	a
6	d	7	d	8	d	9	d	10	c
11	c	12	b	13	a	14	d	15	b
16	d	17	b	18	a	19	c	20	d
21	a	22	b	23	d	24	a	25	d
26	b	27	b	28	a	29	b	30	a
31	b	32	b	33	d	34	b	35	b
36	a	37	b	38	d	39	a	40	d
41	c	42	c	43	c	44	d	45	a
46	b	47	d	48	b	49	d	50	b
51	d	52	b	53	a	54	a	55	a
56	b	57	b	58	b	59	a	60	a
61	b	62	b	63	b	64	b	65	a
66	b	67	d	68	d	69	c	70	c

NCERT Exemplar Questions

1	a	2	b	3	a	4	a	5	c
6	c	7	d	8	a	9	b	10	a
11	c	12	c	13	a	14	d	15	a
16	d	17	d	18	a				

Critical Thinking Questions

1	c	2	d	3	c	4	d	5	b
6	b	7	a	8	d	9	c	10	d
11	d	12	d	13	a	14	c		

Assertion and Reason

1	d	2	b	3	b	4	a	5	d
6	a	7	c	8	a	9	a	10	d
11	c	12	e	13	a	14	c	15	b
16	b	17	e	18	c	19	b	20	a

AS Answers and Solutions

Tissue (General)

3. (a) Companion cells are connected with sieve elements by complex plasmodesmata. The sieve tubes are syncytes and allow free diffusion of soluble organic substances. The callose also plays important role. Usually the perforations in the sieve plates are surrounded by callose. The callose is soluble and disappears when the solute is dilute so that the solute can pass from one cell to another cell through the pores.

4. (a) This theory was proposed by Schmidt (1924). This theory recognizes only two zones in the apical meristems.

5. (c) This concept was given by Hanstein (1870). According to this, there are 3 groups of initials in the shoot apex.

7. (d) Vessel is a long cylindrical tube like structure made of many cells, called vessel members, each with lignified walls and a large central cavity. Vessel members are interconnected through perforation in their common walls.

10. (b) *Idioblasts* : Those parenchymatous cells in which waste products *e.g.*, gum, resin, sugar, starch is accumulated.

12. (b) Collenchyma is never lignified but may possess simple pits.

14. (d) The walls of vessels are lignified and hard and not very thick. Sieve tubes have thin cellulose walls.

16. (b) Albuminous cells : These cells are storage cells which are found in pteridophytes and gymnosperms stem, they store minerals as well as starch.

17. (b) Technically, wood is secondary xylem formed by vascular cambium during secondary growth.

21. (a) Internal or intraxylary phloem : It originates from procambium and is primary phloem which occurs on inner side of primary xylem. It is primary anamolous structure. *e.g.*, Members of Apocynaceae, Solanaceae.

23. (c) Cambium represents lateral meristem of plant which has actively dividing cells.

24. (d) In sieve tubes, nucleus is present only in young stage and without nuclei at maturity.

25. (b) It is a secondary permanent tissue developed from cork cambium (phellogen) by periclinal division in the extra stellar region.

26. (a) The cells of collenchyma contain protoplasm and are living without intercellular spaces. When sclerenchyma consist of thick-walled dead cells. In the beginning the cells are living and have protoplasm but due to deposition of impermeable secondary walls (lignin) they become dead, thick and hard.

27. (b) They posses hard and extremely thick secondary walls due to uniform deposition of lignin.

28. (d) This theory was proposed by Schmidt (1924). According to this theory, shoot apex consists of two distinct zones – (1) Tunica (2) Corpus.

29. (b) Tyloses are balloon like structures develop from xylem parenchyma.

31. (a) Lateral meristems occur laterally in the axis, parallel to the sides of stems and roots. The cambium of vascular bundles (fascicular, interfascicular and extrastelar cambium) and the cork cambium (phellogen) belongs to this category.

32. (c) Latex vessels found in Poppy (*Papaver*).

36. (d) In collenchyma cell walls show localized thickenings due to presence of approximately 45% pectin, 35% hemicellulose and 20% cellulose.

37. (b) Cystolith : In the epidermal cells of *Ficus bengalensis* leaves, the crystals of $CaCO_3$ accumulate in a grape manner, called as cystolith.

38. (a) The term xylem was introduced by Nageli (1858). Xylem is a conducting tissue. Xylem consists of Tracheids, Trachea (Xylem vessels), wood fibres and xylem parenchyma.

43. (c) Collenchyma tissue is made up of elongated cells with thickening at corners.

45. (c) Chir is gymnosperm plant which belongs to family pinaceae of gymnosperm.

47. (b) Those fibres which are associated with wood or xylem have bordered pits are known as wood fibres.

48. (c) In endodermis (starch sheath) the inner and radial or transverse wall of endodermal cells have casparian strips of suberin.

51. (d) A group of initial cells, present at the subterminal region of the growing root tip, which is protected by a root cap is called root apical meristem or root apex.

52. (a) Protoderm is the outermost layer of the apical meristem which develops into the epidermis or epidermal tissue system.

54. (d) Parenchymatous cells present between two vascular bundles give rise to interfascicular cambium after dedifferentiation.

56. (b) Saffranine stains lignified elements of the tissue.

58. (b) Haberlandt (1914) gave the term Leptome for soft walled conducting part of phloem (sieve-element).

62. (a) Maize is a monocot so phloem parenchyma absent in maize.

63. (a) These meristems occur laterally in the axis, parallel to the sides of stems and roots. This meristem consists of initial which divide mainly in one plane (periclinal) and result increase in the diameter of an organ.

64. (a) Parenchyma storage of food materials *e.g.*, Carrot, Beet root etc.

65. (b) On the basis of origin, meristematic tissue can be classified into promeristem, primary meristem and secondary meristem.

66. (d) All are involved in primary growth of plant.

67. (a) Because such plants need much flexibility.

68. (a) The parenchymatous cells are isodiametric (all sides equal) and thinwalled.

71. (c) Metaxylem consist of two larger and rounded vessels situated on the sides with the pitted tracheids in between them.

72. (c) Sclereids is composed of sclerenchymatous cells, lignified walls and long tubular pits. The sclereids may be spherical, oval, cylindrical, T-shaped, dumbell-shaped or even stellate is size.

76. (c) Sieve tube formed by end to end fusion of cells and nuclei get degenerated at maturity.

77. (a) Haberlandt in 1890 classify the primary meristem at the apex of stem of three types : Protoderm, Procambium and Ground meristem. Haberlandt (1914) introduced the new terminology for meristematic zones derived from apical meristem. They are protoderm instead of dermatogen, ground meristem instead of periblem and procambium instead of plerome.

79. (d) A bladder like structure are formed during the secondary growth and blocks the continuity of the conducting system. It is known as tyloses which found in xylem cells and ray parenchyma.

86. (c) Plane of division in tunica is anticlinal and in corpus it is periclinal.

87. (d) Dermatogen is the outermost layer and it forms epidermis and epidermal tissue system.

89. (a) Tracheids possess bordered pits. Maximum bordered pits are formed in gymnospermous tracheids (helps in conduction of water).

90. (b) *Eichhornia* (water hycianth) is a hydrophytes. So root pocket present instead of root cap.

93. (d) Intercalary meristem is responsible for increase in length. This meristem is present at the base of internodes or at the base of leaves or at the base of nodes.

94. (a) Trachieds are mainly found in gymnosperms while vessels are found in angiosperms.

95. (b) Root cap is absent in adventitious epiphytic roots of orchids, aquatic plants, parasites.

100. (a) Lignin is a deposition of cell wall.

101. (c) Companion cells are not found in pteridophytes and gymnosperms (*Pinus*) but are always present in angiosperms.

103. (d) A sieve tube is analogous to RBC, both being living but enucleated at maturity. A network of fibres of P_1 and P_2 protein is present in the central part of lumen of sieve tube which controls movement of materials and with callose, the sealing of pores after injury.

106. (a) Meristem posses the capacity of division. That is why plants keep growing in length whole life time.

108. (c) Xylem fibres are two lypes : libriform fibres (thickwalled with simple pits) and fibre tracheids (thin walled with reduced bordered pits).

111. (b) Macrosclereids or rod cells are rod shaped elongated sclereids usually found in the leaves, cortex of stem and outer seed coats.

112. (b) Lignification makes the xylem cells thick.

114. (a) The promeristem originates from embryo and therefore, called primordial or embryonic meristem.

117. (b) The opening in vessel element walls are called perforations, which may be simple perforation or multiple perforations.

119. (c) Meristematic tissue or meristem is a group of cells which has power of continuous division.

121. (a) Intercalary meristems are present mostly at the base of node (nodal region) (*e.g.*, *Mentha viridis*, Mint), base of internode (*e.g.*, stem of wheat, grasses), and the base of the leaf (*e.g.*, *Pinus*).

122. (a) Because paddy is monocot plant.

123. (b) This is present away from apical meristem in primary permanent tissue. Some workers consider it as a part of apical meristem which is separated from it by means of primary permanent tissue.

124. (c) Chlorenchyma is the modification of parenchyma or specialized parenchyma.

126. (c) Promeristem is outer primary meristem.

128. (b) When wound is deep it is healed as follows healthy cells adjacent to the wound form a mass of parenchymatous cells called callus. This callus covers the wound entirely. Thus wound in healed.

130. (c) Lateral meristem present on the lateral sides. It divides only periclinally or radially and responsible for increase in girth or diameter of stem.

131. (c) Commercial jute fibres are obtained from phloem fibres. These are sclerenchymatous fibres but because of their presence in phloem they are called phloem fibres. They are used in making ropes.

132. (b) *Pistia* is a aquatic plant in which roots are not well developed.

133. (c) Most of the xylem cells have deposition of lignin on their cell wall.

134. (c) Companion cells are found in angiosperms only. In gymnospermic plants albuminous cells are found in place of companion cells.

135. (d) Because there is no variation in protoxylem and metaxylem in cells of secondary xylem.

137. (b) At the apex of roots some cells are not dividing, this region is called quiescent centre.

140. (b) Porous wood (In angiosperms) contains mainly vessels.

143. (a) Palisade parenchyma are elongated columnar cells without intercellular spaces. These have chloroplast in them and generally arranged in two layers.

145. (b) Parenchyma containing air spaces is known as aerenchyma. It provides buoyancy to hydrophytes.

147. (a) Embryo has rapidly dividing cells.

149. (b) In tracheids if the entire surface is thickened leaving unthickened circular areas known as 'bordered pits'. The vessels lack the bordered pits.

151. (a) Tunica is outermost layer and it becomes change into epidermis.

152. (d) Bryophytes grow by a single apical cell. Position of apical cells may either be strictly terminal or subterminal.

153. (d) Lenticels are some loosely arranged areas in the periderm. Lenticels are characteristics of woody stem. Lenticels are not found in leaves.

155. (c) According to histogen theory, apex of root is made up of dermatogen, periblem and pleurome.

The tissue system

2. (a) Protostele term was given by Jeffrey. It is the simplest and most primitive type of stele in which central core of xylem surrounded by phloem.

6. (b) Bicollateral vascular bundle is present in members of cucurbitaceae.

7. (b) When phloem is surrounded by xylem on all sides, such V.B. are called amphivasal or leptocentric. These are found in *Yucca* and *Dracaena*.

8. (a) Root hair is outgrowth of epidermal cell.

9. (d) Branching of root is endogenous. During the branching pericycle of root becomes meristematic and protrudes to outside.

12. (b) In bicollateral vascular bundle, phloem is found on both the sides of xylem.

13. (b) Periblem is the middle layer gives rise to cortex and endodermis.

14. (a) Waxy outermost lining, which is secreted by epidermis.

17. (d) In the upper epidermis, there are some large cells found in groups, which are known as motor cells or bulliform cells.

18. (c) Ground tissue system includes — cortex, endoderm, pericycle and pith.

20. (a) Water stomata are usually present in leaves of aquatic plants.

21. (c) Raphides are found below the upper epidermis in *Nerium*.

22. (a) Protoxylem surrounded by metaxylem are called mesarch.

23. (a) Inner wall of stomatal guard cell is thick and outer wall is thin. This type of structure helps in opening and closing of stomata.

24. (d) Because *Nerium oleander* is xerophytic plant and multiple epidermis is formed to check the loss of water from leaves.

25. (b) When phloem is present on both external and internal sides of the xylem. *e.g.*, *Marsilea, Adiantum*.

27. (a) Calcium oxalate substances deposited on the cuticle surface. Druse and Raphides (*e.g.*, *Pistia*) are crystals.

30. (c) In monocot roots a thick walled endodermal cells. Just outside the protoxylem. They help in passage of water from cortex to xylem.

31. (b) Trabeculated endodermis is the characteristic feature of *Selaginella*.

32. (c) A vascular bundle having the phloem strands on both outer and inner sides of xylem is called bicollatoral.

33. (a) In amphivasal vascular bundle, phloem is surrounded by xylem *e.g.*, *Dracaena*.

35. (c) Vascular tissue is well developed in xerophytes. These plants grows in areas where water supply is inadequate. Hence they have well developed root system and vasculature.

36. (b) When cambium is absent between xylem and phloem, it is said to be closed type.

39. (a) Sunken stomata found is xerophytic plants which is adaptation for decrease the rate of transpiration.

41. (d) Vascular cambium is formed secondarily from conjuctive parenchyma cells lying just below each phloem strand. The cells of pericycle lying out side the protoxylem also become meristematic to form part of strips of cambium.

43. (a) Amphicribal (Hadrocentric) : The xylem lies in the centre and remains completely surrounded by phloem. *e.g.*, Ferns. (*Selaginella*).

44. (b) Free floating plants float freely upon the surface of water. Stomata present on upper epidermis. *e.g.*, *Wolffia, Lemna, Pistia* etc.

46. (b) Dorsiventral leaves are found in dicots. In dicots stomata are present in lower epidermis.

49. (d) The whole plant body is enclosed by water. Submerged plants (*e.g.*, *Hydrilla, Vallisneria, Potamogeton*) do not have stomata.

50. (b) In roots thick walled endodermal cells are interrupted by thin walled cells just outside the protoxylem patches. These thin walled endodermal cells are called passage cells or transfusion cells.

Internal structure of root, stem and leaf

3. (b) Velamen tissue is water-absorbing tissue which can absorb atmospheric humidity. It is present in aerial root of orchids.

4. (b) Endodermis is mostly single layered and is made up of parenchymatous barrel shaped compactly arranged cells. The inner and radial or transverse wall of enedodermal cells have casparian strips of suberin.

5. (d) In between upper and lower epidermis, there is present mesophyll tissue which is undifferentiated into palisade and spongy parenchyma, but all the cells are alike.

7. (b) In monocot root, Cambium is absent in the vasculature.

11. (b) Hypodermis is collenchymatous (green) in dicot stem and sclerenchymatous (non-green) in monocot stem.

12. (c) Kranz type anatomy occurs in both monocot leaves (*e.g.*, Sugarcane, Maize and Sorghum etc.) and some dicot leaves (*e.g.*, *Amaranthus-edulis*, *Atriplex rosea* etc).

13. (d) In dicots vascular bundles are 2 to 6.

18. (d) In stems, the protoxylem lies towards the centre (pith) and the metaxylem lies towards the periphery of the organ. This type of primary xylem is called endarch. In root, the protoxylem lies towards periphery and metaxylem lies towards the centre, such arrangement is called exarch.

25. (c) Conjoint : A vascular bundle having both xylem and phloem together, is called conjoint. Collateral : A vascular bundle in which the phloem lies towards outer side and xylem towards inner side, is called collateral *e.g.*, Sunflower.

Collateral bundle having a cambium between xylem and phloem is said to be of the open type. *e.g.*, Dicot stem.

28. (a) Pith is generally having thin walled parenchymatous cells, which help in storage.

30. (a) In vascular bundles of *Cucurbita* (family-cucurbitaceae), phloem is present in two patches.

31. (a) In monocot root large pith, made up of loosely arranged parenchymatous cells with abundant starch grains.

39. (a) Palisade tissue are elongated columnar cells without intercellular spaces. These cells have chloroplasts. They take part in photosynthesis.

Secondary growth

1. (d) At the initial stage of secondary growth, cambium forms a ring like structure known as cambium ring. This ring is present in stelar and cortical region both.

3. (b) Cells of sapwood are alive and because of abundant pore spaces, movement of sap takes place through these tissues.

4. (b) Alburnum is an outer light coloured zone called the sap wood which are physiologically active.

5. (a) Cork cambium (phellogen) develops from outer layer of cortex. It produces secondary cortex (phelloderm) on inner side and cork (phellem) on outer side.

7. (d) Cork cambium aries as a result of the tangential division of the outer cells of pericycle.

8. (d) *Periderm* : During secondary growth in dicot stems towards the outer side cork cambium produces cork outer side and secondary cortex to inner side. The three layers (Phellem, Phellogen, and phelloderm) collectively called as periderm.

10. (c) Vascular bundles are scattered and cambium is absent in monocot stem.

13. (a) The extrastelar regions grow simultaneously. The growth of extrastelar region is initiated by the formation of cork cambium or phellogen.

16. (d) Annual rings are formed due to variation in climatic conditions of any region. Spring season and autumn season occur in temperate region, thus clear annual rings are formed.

17. (b) The correct sequence from outerside towards inner side in a wood dicot stem is

Phellem → secondary cortex → Secondary phloem → wood
(D) (A) (C) (B)

18. (a) Growth rings (Annual rings) are distinct or sharply demarcated in the plants of temperate (cold) regions (as shimla).

23. (d) Phellem, phellogen and phelloderm are collectively called periderm.

28. (a) Hydrophytes mean plant grow in water. Hydrophytes do not show secondary growth because the vascular cambium is absent.

31. (b) Treacheary elements such as tracheids, vessels, fibres, sieve tubes formed by fusiform initials.

33. (d) Because climatic variations (autumn and spring seasons) are absent in deserts.

34. (b) All dead tissues lying outside the active cork cambium are collectively known as bark.

35. (b) *Knots* : When wounds around cells undergo rapid cell division, then wound is covered by cells but the wound is not completely healup, so in adult stem knots are established.

36. (a) Vascular cambium is a lateral meristem.

39. (a) Heartwood (duramen) is a hard and dark wood which are physiologically inactive (almost dead).

52. (b) After actual falling of leaf, the scar is exposed to air, which develops a primary protective layer by deposition of lignin and suberin on their wall.

54. (a) During the secondary growth, centrally located xylem become nonfunctional due to deposition of tannins etc. the function of conduction of water and dissolved minerals from roots is now performed by outer younger rings of secondary xylem is called sap wood or alburnum.

58. (b) Vascular cambium forms phloem tissue outside. Food synthesisted in the leaves move to different parts of the plant through the phloem.

61. (b) Secondary xylem is made up of scalariform and pitted vessels, tracheids and sclerenchymatous fibres (wood fibres) along with xylem parenchyma.

64. (b) In Oak (*Quercus suber*) which yields bottle cork, the cavities of cork cells are filled with air which makes the cork light in weight. It also provides thermal insulating qualities.

65. (a) Lenticels are some loosely areas in the periderm. Lenticels are characteristics of woody stem. Lenticels helps in gaseous exchange and transpiration.

66. (b) Pore like small openings are present on bark of old stem.

67. (d) Vascular cambium is made up of lateral meristem.

Critical Thinking Questions

3. (c) Quiescent centre having low rate of cell division and acts as reservoir of active initials.

4. (d) New cells form a mass of parenchymatous cells known as callus.

5. (b) Because tunica shows only anticlinal division and it is responsible for surface growth.

6. (b) Stem of maize has water containing cavities in vascular bundles.

7. (a) The nail will be 1 meter above the soil because when tree grows in height it will not effect the base level (Tree grows in height from the apical region).

8. (d) A new variety is produced by joining parts of two different plants (with the help of cambia) is called grafting. In monocots cambium is absent hence the parts of two different plants are unable to joint each other.

9. (c) Because in sea shore area being isothermal zones, temperature is constant throughout the year, so their will be no annual ring formation.

14. (c) Alkaline pH (7.8 – 8.0) is present in phloem sap where as xylem sap is acidic

Assertion and Reason

1. (d) Bark consists of all tissues out side the vascular cambium. Phellem, phellogen and phelloderm constitute periderm.

2. (b) Stomata are absent in submerged hydrophytes. Air chambers help in gaseous exchange, O_2 liberated during photosynthesis is stored in these chambers and used in respiration, CO_2 released during respiration also remain in these chambers. CO_2 is used in photosynthesis.

3. (b) Cambium is a lateral meristem. Its activity causes increase in width. It is composed of fusiform and ray initial.

4. (a) Higher plants have root and shoot apices where cells are in continuous state of division. Here they can grow indefinitely. Such regions are not found in animals.

5. (d) In collateral vascular bundles phloem is situated towards outer side and xylem towards inner side and both are found on same radii, but in monocot stem vascular bundle are closed, *i.e.*, cambium is absent.

6. (a) Disease resistant plants possess thick cuticle. Infectious organisms can not grow or invade cuticle.

7. (c) Quiescent centre is found in the centre of the root apex. Cell divisions are very few in the quiescent centre as there is very little synthesis of new proteins, RNAs and DNA. Quiescent centre may function as reserve meristem.

8. (a)

9. (a) Intercalary meristems are intercalated in-between the permanent tissues. The activities of these meristems also add to the length of the plant or its organs. They originate from the apical meristems when their portions get detached due to the growth of the organs. For example, in the grasses when the internodes complete their elongation, some cells at the base retain their meristematic activity and function as intercalary meristems. They lie just above the node.

10. (d) Apical and intercalary meristems always increase in the height of plant and lateral meristem is responsible for secondary growth (increase in girth) but secondary growth doesn't occur is monocots.

11. (c) In xerophytic leaves, spongy parenchyma is reduced. Palisade parenchyma may occur on both upper and lower sides with spongy parenchyma sandwitched between the two, *e.g.*, *Nerium*. In *Nerium* or Oleander, the lower surface bears deep depressions called crypts (stomatal crypts). The crypts possess a number of cutinised hair and stomata. In other xerophytic plants, stomata occur individually and are sunken below the surface due to their being overtopped by accessory or subsidiary cells.

12. (e) Phloem transports organic food inside the body of the plant. Xylem performs the function of transport of water or sap inside the plant. Thus they form the conducting elements in the plant. Haberlandt used the term leptome for phloem and hadrome for xylem.

13. (a) The palisade mesophyll lies below the upper epidermis. The spongy parenchyma or spongy mesophyll lies between the lower epidermis and the palisade parenchyma. The spongy mesophyll cells contain chloroplasts but fewer than present in the palisade parenchyma. As the chloroplasts are more abundant in the compact palisade mesophyll cells than the loosely arranged mesophyll cells, the upper surface of the leaf appears deeper green as compared to the lower surface.

14. (c) The tracheids and vessels of the heart wood get plugged by in growth of the adjacent parenchyma cells into their cavities through the pits. These in growths are called tyloses. Ultimately, the parenchyma cells become lignified and dead.

15. (b) A distinct layer of cuticle is present in the lower epidermis. The cuticle is, however, less developed than at the upper epidermis. The lower epidermis contains a large number of pores called stomata or stomates. They lead internally into substomatal cavities.

16. (b) In isobilateral leaves, the upper epidermis contains specialized cells, *i.e.*, bulliform or motor cells. They are highly vacuolate and can store water, if available. However, in case of water deficiency the bulliform cells lose water and become flaccid. As a result the leaf gets rolled upto reduce the exposed surface. the bulliform cells are also useful in the unrolling of leaf during its development.

17. (e) Intercalary meristems are intercalated in between the permanent tissues. They may be present either at the base of the internode as in the stems of various grasses and wheat; or at the base of the leaf as in *Pinus*; or at the base of a node as in mint (*Mentha viridis*). Usually the intercalary meristems differ from other meristems in that they ultimately get fully used up in the formation of permanent tissues.

18. (c) Various types of plant products like oils, resins, gums and tanins are deposited in the cells of the heartwood. They are antiseptic. The heartwood is, therefore, stronger and more durable than the sapwood. It is, however, liable to be attacked by wood rotting fungi. Hollow tree trunks are due to their activity. Sapwood (outer light coloured wood) is less durable because it is susceptible to attack by pathogens and insects.

19. (b) Secretory cells are specialized parenchyma cells that produce nectar, oil, etc. Idioblasts are specialized nongreen large-sized parenchyma cells which possess inclusions or ingredients like tannins, oils, crystals, etc.

20. (a) The activity of the cambium is commonly periodic in the temperate regions and the xylem produced during one growth period constitutes a growth layer. In transverse sections of stems and roots, autumn wood (summer wood) and spring wood appear in the form of distinct concentric circles known as the annual rings. Spring wood circle and autumn wood circle constitute an annual rings. Like this, year after year, such rings in the oldest part of the tree corresponds to its age.

Anatomy of Flowering Plants

SET Self Evaluation Test

1. When strong wind blows, the plants bend down and then again become erect. This flexibility in plants is due to

Or

Whose living cells provide tensile and mechanical strength **[AIIMS 1992; MP PMT 1997]**

(a) Sclerenchyma (b) Parenchyma
(c) Collenchyma (d) Chlorenchyma

2. Quiescent centre is the zone of **[CPMT 1995; Manipal 2005]**
(a) Least mitotic activity in the root apex
(b) Least mitotic activity in the shoot apex
(c) Maximum mitotic activity in the root apex
(d) Maximum mitotic activity in the shoot apex

3. In the tropics there is no sharp distinction of season and the wood contains vessels of the same size in late wood and early wood. Such wood is called **[JIPMER 1994]**
(a) Porous (b) Ring porous
(c) Ring and diffuse porous (d) Diffuse porous

4. Cuticle is absent in **[DUMET 2009]**
(a) Mesophytes (b) Young roots
(c) Mature stems (d) Leaves

5. Cytologically vascular cambium (lateral meristem) differs from apical meristem by **[MP PMT 2013]**
(a) Presence of vacuoles, storage materials and thin cell wall, isodiametric cells
(b) Presence of vacuoles, storage materials and thick cell wall, isodiametric as well as radially elongated cells
(c) Presence of vacuoles, storage materials and thick radial cell wall, isodiametric as well as radially elongated cells
(d) Presence of vacuoles, storage materials and thin protoplasm, isodiametric cells

6. Vascular bundles are arranged in a ring in the member of family **[Kerala CET 2005]**
(a) Orchidaceae (b) Iridaceae
(c) Euphorbiaceae (d) Liliaceae
(e) Palmae

7. The stems of hydrophytic plants are soft and weak because of the poor development of **[JIPMER 2002]**
(a) Pith and supporting parenchyma
(b) Phloem and companion cells
(c) Xylem and supporting tissue
(d) Cortex and endodermis

8. A concentric amphivasal (leptocentric) vascular bundle is one in which **[CPMT 1993; MP PMT 2001]**
(a) Centrally located phloem is surrounded by the xylem or xylem surrounds phloem
(b) Centrally located xylem is surrounded by phloem
(c) Xylem is flanked by phloem on the interior and exterior side only
(d) Phloem is flanked by the xylem on interior side only

9. Which combination of tissues act together to provide the support to the hypocotyl of a seedling **[BVP 2003]**
(a) Xylem and phloem fibres
(b) Epidermis and parenchyma
(c) Xylem and parenchyma
(d) Epidermis and collenchyma

10. The bicollateral vascular bundle is the characteristic feature of plants belonging to the family **[MP PMT 1994; CPMT 1998; KCET 1999; BHU 2001]**
(a) Cruciferae (b) Liliaceae
(c) Cucurbitaceae (d) Malvaceae

11. In a dicotyledonous stem, the sequence of tissues from the outside to the inside is **[AIIMS 2003]**
(a) Phellem – Pericycle – Endodermis - Phloem
(b) Phellem – Phloem - Endodermis - Pericycle
(c) Phellem - Endodermis - Pericycle - Phloem
(d) Pericycle – Phellem - Endodermis - Phloem

12. The distinct cavities (lacunae) found in a mature vascular bundle of maize stem are formed due to
(a) Disruption of protoxylem as well as lysis of adjacent xylem parenchyma
(b) Disruption of protoxylem alone
(c) Lysis of xylem parenchyma
(d) Dissolution of common wall between a few metaxylem elements and their consequent coalition

13. After preparing a transverse section out of a cut piece of a plant axis, it was seen that it has a C shaped open arch of endarch collateral vascular bundles with secondary growth. This indicates that it is a transverse section of
(a) A dicotyledonous petiole
(b) A dicot stem at the node
(c) A dicot root at the point where a root branch is coming out
(d) A phylloclade

14. Annual rings are the bands of **[NCERT]**
(a) Secondary cortex and cork
(b) Secondary vascular tissues
(c) Secondary xylem and medullary rays
(d) Secondary phloem and medullary rays

15. If you cut the old trunk of a tree transversely, you will observe that the outer region of secondary wood is lighter in colour. This region of wood is known as
(a) Autumn wood (b) Sap wood
(c) Heart wood (d) Spring wood

16. Which of the following is true for the origin of epidermis and hypodermis
(a) Epidermis from corpus and hypodermis from tunica
(b) Epidermis from tunica and hypodermis from corpus
(c) Both from tunica
(d) Both from corpus

17. Which of the following is not a part of epidermal tissue system **[Kerala PMT 2010]**
(a) Companion cells (b) Trichomes
(c) Root hairs (d) Guard cells
(e) Subsidiary cells

18. Pericycle in roots is responsible for **[CBSE PMT 1990; CPMT 1994; BHU 1994, 2000, 04; MH CET 2001; DPMT 2003; KCET 2000 07; Kerala PMT 2011]**
(a) Formation of lateral roots
(b) Providing mechanical support
(c) Formation of vascular bundle from cortex
(d) Formation of vascular bundle from endodermis

19. Medullary rays are made up of **[AMU (Med.) 2010]**
(a) Parenchymatous cells (b) Sclerenchymatous cells
(c) Tracheids (d) Fibres

Answers and Solutions

1	c	2	a	3	d	4	b	5	c
6	c	7	c	8	a	9	d	10	c
11	c	12	b	13	a	14	b	15	b
16	b	17	a	18	a	19	a		

1. (c) Collenchyma tissue is elastic, extensible and have capacity to expand.

2. (a) A zone of inactive cells is present in the central part of the root apex called quiescent centre.

3. (d) Diffuse porous wood (primitive) : Vessels of same size are uniformly distributed throughout the growth or annual ring. *e.g.*, *Pyrus, Azadirachta, Eucalyptus, Magnifera* sp., *Betula*.

7. (c) The stems of hydrophytic plants are soft and weak, spongy which can bend easily in each and every direction because mechanical tissue is either absent or reduced and conductive tissue is poorly developed.

9. (d) Mechanical strength to hypocotyl of seedling is provided by epidermis and collenchyma tissues.

10. (c) Bicollateral : In such vascular bundles there are two patches of phloem one on each side of xylem. In such a vascular bundles there are two strips of cambium one on each side of xylem. Cucurbitaceae (*e.g.*, *Cucurbita*).

12. (b) In a completely mature vascular bundle a schizolysigenous cavity is formed by disintegration of protoxylem. These cavities are filled with water.

14. (b) Spring wood + Autumn wood of a year constitute annual ring. Spring and Autumn wood is the part of secondary xylem formed during spring and autumn. The amount of wood is affected by the activity of cambium.

15. (b) The outer young and functional part of xylem is called sap wood. The functions of conduction of water and dissolved mineral from roots is now performed by outer younger rings of secondary xylem which constitute the sapwood.

16. (b) According to the tunica – corpus theory epidermis is derived from outer layer of tunica and the remaining tissues are derived from remaining layer of tunica and entire corpus.

18. (a) In dicotyledonous roots, a well developed pericycle lies below endodermis which gives rise to lateral roots, part of vascular cambium and whole cork cambium. Pericycle functions as the site of lateral root initiation.

* * *