TISSUE AND TISSUE SYSTEM

Introduction

The higher plants have highly complex bodies made up of different types of cells. All cells are of same origin but afterwards they gets differentiated into different types of cells. Cells of similar shape and size constitute a group which perform diverse functions. 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 a specific functions*."

Tissues are mainly divided into three categories :

(1) Meristematic tissues or Meristems

(2) Permanent tissue

(3) Secretory tissue

2.1 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 :

- They contain immature and young cells and are capable of repeated divisions.
- Intercellular spaces are not present in meristematic tissue.
- They contain a homogeneous thin wall.
- They contain large nuclei associated with abundant cytoplasm.
- They are metabolically very active but they do not store food material.
- Only proto-plastids are present instead of plastids, chloroplast absent.
- Dense cytoplasm is present which contains several premature mitochondria.
- Vacuoles are absent.
- Meristematic cells are isodiametric in shape.
- Undifferentiated tissue in which all divides continuously $G_1 \rightarrow S \rightarrow G_2 \rightarrow M$.

(1) **Types of meristems :** The meristems may be classified on the basis of their mode of origin, position or function :

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

(a) **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**. This group consists of a limited amount of cells, which divide repeatedly to give rise primary meristem. It occupies a small area at the tips of stem and root. The promeristem gives rise to all other meristems including the primary meristem.

(b) **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.

(c) **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.

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

(a) **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. The initiating cells may be single or in groups. Solitary initial cells are known as apical cells whereas those occurring in groups are called apical initials. Solitary apical cells occur in ferns and other Pteridophytes while apical initials are found in other vascular plants. The apical initials may occur in one or more tiers. Position of apical cells may either be strictly terminal or terminal and subterminal.

(b) **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, Grasses, Pteridophyts like *Equisetum*) or at the base of the leaf (*e.g., Pinus*). The intercalary meristems ultimately disappear and give rise to permanent tissues.

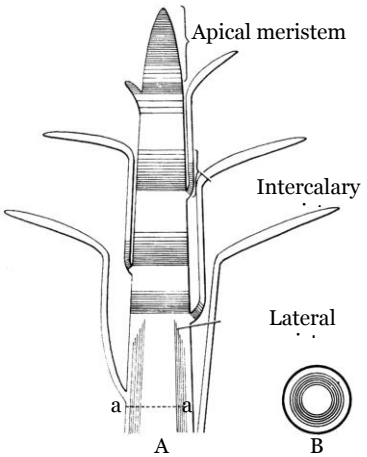


Fig : Various meristamatic tissue

(c) **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 result increase in the diameter of an organ. The cambium of vascular bundles (Fascicular, interfascicular and extrastelar cambium) and the cork cambium or phellogen belong to this category and are found in dicotyledons and gymnosperms.

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

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

(b) **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.

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

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

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

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

(c) **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.

(2) **Structure and organisation of apical meristem**

(i) **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 :

(a) **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).

(b) **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).

- **Dermatogen** : Outermost layer and it forms epidermis and epidermal tissue system.
- **Periblem :** It is the middle layer gives rise to cortex and endodermis.
- **Plerome :** Innermost layer forms pith and stele.

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

- **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

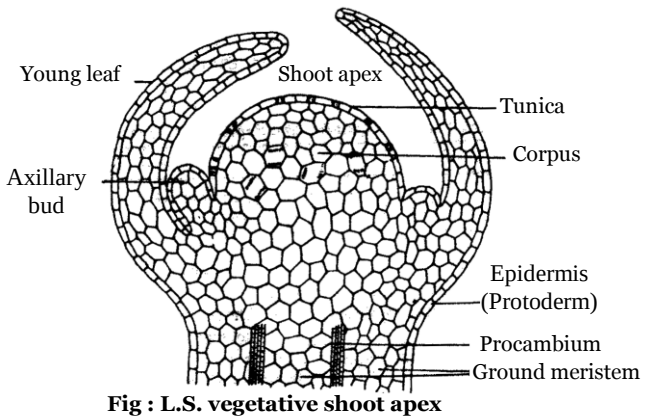


Fig : L.S. vegetative shoot apex

responsible for surface growth.

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

(ii) **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. The root apex differs from shoot apex as it is short and more or less uniform due to complete absence of lateral appendages (leaves and branches) and differentiation of nodes and internodes. 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). Regarding the apical organisation of root following theories have been put forward.

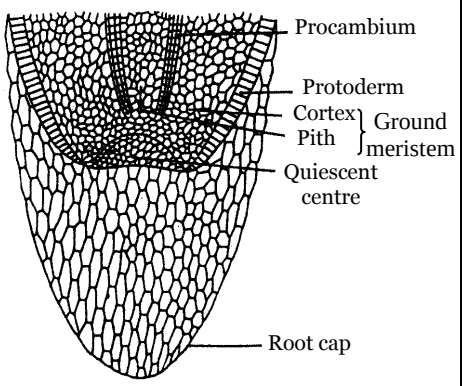


Fig : L.S. root apical

(a) **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.

(b) **Quiescent centre theory :** It was proposed by Clowes (1961). 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 quiscent centre.

The cells in this region have light cytoplasm, small nuclei, lower concentration of DNA, RNA and protein. These cells also contain fewer number of mitochondria, less endoplasmic reticulum and small dictyosomes.

Types of root apex : It is divided into following four types :

- **Ranunculus type :** Root apex is made up of only one type of histogen layer. *e.g.*, Plants of family - Ranunculaceae, Leguminosae and Amentiferae.
- **Casuarina type :** Root apex is made up of two types of histogen layers. *e.g,* Plants of family - Casurinaceae, Leguminosae and Proteaceae.
- **Common dicot root :** Root apex is made up of three layers of histogen.
- **Common monocot root :** Root apex is made up of four layers of histogen.

(iii) **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. When the apex is to develop into a single flower, the cells at the flanks of the apex produce sepals and petals while the cells in the centre of summit produce stamens and carpels.

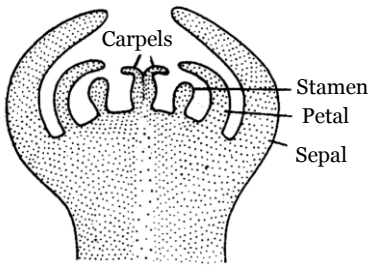


Fig : L.S. Reproductive apex (diagrammatic)

2.2 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 three types :

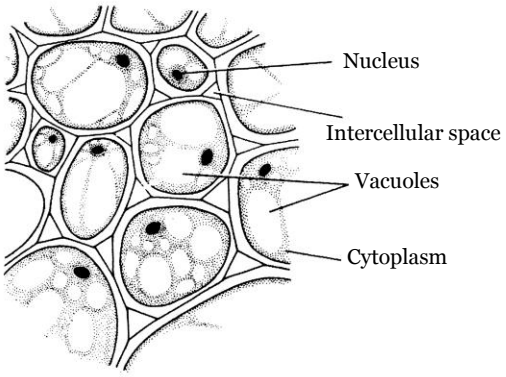


Fig : Parenchyma in T.S.

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

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

The main characteristics of parenchyma cells are :

(a) The cells are thin-walled and soft.

(b) The cells usually are living and possess a distinct nucleus.

(c) The cells contain well-developed intercellular spaces amongst them.

(d) The cytoplasm is vacuolated and cell wall is made up of cellulose.

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

(f) This tissue is generally present in almost all the organs of plants, *i.e.*, roots, stems, leaves, flowers, fruits and seeds.

(g) 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 :

- Storage of food materials. *e.g.,* Carrot, Beetroot etc.
- Chlorenchyma helps in photosynthesis.
- Aerenchyma helps in floating of the aquatic plants (Hydrophytes) and also help in gaseous exchange during respiration and photosynthesis. *e.g., Hydrilla*.
- In turgid state they give rigidity to the plant organ.
- In emergency they behave like meristematic cells and help in healing of the various plant injuries.
- Sometimes they store secretory substances (ergastic substance) such as tannins, resins and gums and they called as idioblasts.

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

- The cells of this tissue contain protoplasm and are living.
- The cell walls are thickened at the corners and are made up of cellulose, hemicellulose and pectin.
- They are never lignified but may posses simple pits.
- They are compactly arranged cells, oval, spherical or polygonal in outline.

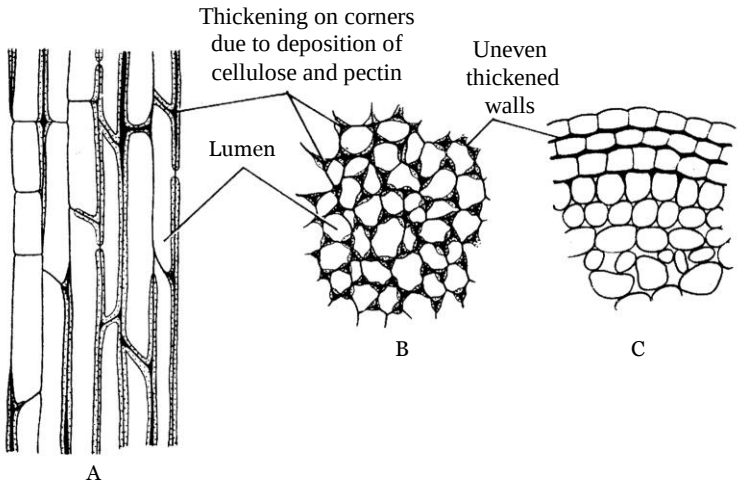


Fig : (A) Collenchyma L.S. (B) and (C)T.S. of the same

- No. intercellular spaces are present.
- The tissue is plastic, extensible and have capacity to expand.
- They provide mechanical strength to younger part where xylum is less developed.

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

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

- **Angular collenchyma :** Where the thickening of the cells is confined to the corners of the cells. *e.g.*, *Tagetes*, Tomato, *Datura*, Potato, etc.
- **Plate or Lamellar collenchyma :** When the thickenings are present in the tangential walls. *e.g.* hypodermis of sunflower stem.
- **Lacunar or Tubular collenchyma :** If the thickened cell wall is associated with intercellular spaces of the adjacent cells. *e.g.* leaf petioles of compositae and malvaceae etc. hypodermis of *Cucurbita* stem, *Salvia, Malva*.

(b) **Functions**

- Provide mechanical support to petiole, pedicels, branches of stem, roots and fruits.
- If they contain chlorophyll they help in photosynthesis.
- It is present at the margins of some leaves and resists tearing effect of the wind.

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

The main feature of sclerenchyma are :

- It consist of thick-walled dead cells.
- The cells vary in shape, size and origin.

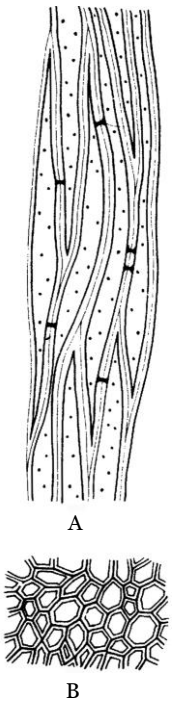


Fig : Scalerenchymatous fibres (A) L.S. (B) T.S.

- They possess hard and extremely thick secondary walls due to uniform deposition of lignin.
- In the beginning the cells are living and have protoplasm but due to deposition of impermeable secondary walls they become dead.

Types of sclerenchyma : They are of two types :

(a) **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 :

- **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.
- **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**.
- **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*).

(b) **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. They form part of seed coat in some members of leguminosae. The sclereids provide mechanical support and hardness to the soft parts. Sclereids may be :

- **Brachy-sclereids 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*).
- **Macrosclereids or rod cells :** These are rod-shaped elongated sclereids usually found in the leaves, cortex of stem and outer seed coats.
- **Osteosclereids or bone cells :** These are bone or barrel-shaped sclereids dilated at their ends. *e.g.*, leaf of *Hakea*.

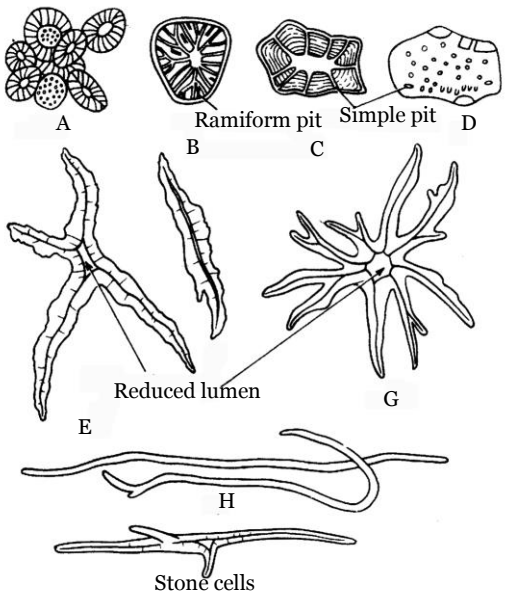


Fig : Stone cells (A, B) from pulp of pear, (C,D) from stem cortex of Hoya, (E, F) from petiole of *Camelia*, (G) from stem cortex of *Trochodendron*, (H) from mesophyll cells of fig leaf.

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

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

(2) **Complex 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.

(i) **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.

On the basis of origin xylem is of two types

- **Primary xylem :** It is derived from procambium during primary growth. It consists of protoxylem and metaxylem.
- **Secondary xylem :** It is formed from vascular cambium during secondary growth.

Xylem is composed of four types of cells

(a) **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 walls are not much thickened. The cells are without protoplast and are dead on maturity. The tracheids of secondary xylem have fewer sides and are more sharply angular than the tracheids of primary xylem. The cell cavity or lumen of a tracheid is large and without any contents. 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.

(b) **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 classified into several types according to the thickening developed in their wall. They 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*). Vessels along with tracheids forms the main tissue of xylem of vascular bundles of the angiosperms and help in conduction. It also provide mechanical support to the plant.

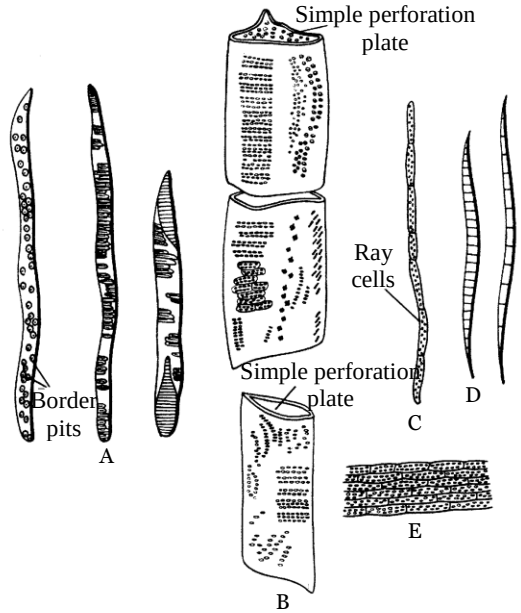


Fig : Xylem-A Tracheids, B. Tracheae, C and E. Xylem parenchyma D. Wood fibres (wood sclerenchyma)

On the basis of distribution and size of vessels, porous wood is of two types :

- **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.
- **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*.

(c) **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.

(d) **Wood (xylem) fibres :** The long, slender, pointed, dead and sclerenchymatous cells found associated with xylem are termed wood fibres. They possess mostly thickened walls and few small pits. These pits are found abundantly in woody dicotyledons. They aid the mechanical strength of xylem and various organs of plant body.

(ii) **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.

On the basis of position phloem is of three types :

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

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

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

On the basis of origin phloem is of two types

(a) **Primary phloem :** It is formed by procambium during primary growth. It may or may not show differentiation of in protophloem (consists of sieve elements and parenchyma) and **metaphloem** (develop after protophloem and consists of sieve elements, parenchyma and fiber). During the primary growth the protophloem elements are curshed by the surrounding tissues and disappear. This process is known as obliteration consists of sieve elements, parenchyma and fibre.

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

It consists of the following elements :

Sieve element

Companion cells

Phloem parenchyma

Phloem fibres or bast fibres

(1) **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.

(iii) Their transverse wall is perforated like a normal sieve and hence they are called as sieve tubes.

(iv) Nucleus is not found in these cells.

(v) Each sieve tube has a lining of cytoplasm near its periphery.

(vi) Callus pad may be visible in the winter season.

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

(2) **Companion cells**

(i) They are thin-walled cells which are associated with sieve tubes.

(ii) They are more or less elongated.

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

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

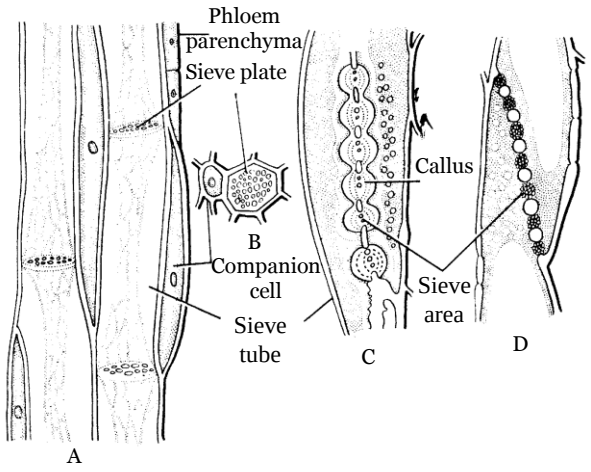


Fig : Parts of Phloem (A) L.S. of phloem tissue, (B) T.S. of phloem tissue, (C) Sieve tubes of *Vitis*, (D) L.S. of sieve plate

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

(3) **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.

(4) **Phloem or Bast fibres :** The sclerenchymatous fibres associated with the phloem are called as phloem fibres. These are also known as bast fibres. The fibres are elongated lignified cells with simple pits. The ends of these cells may be pointed, needle like or blunt. They are non-living cells that provide mechanical support to the organs.

2.3 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

(2) Glandular tissues

(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 very 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 are generally occur on the epidermis of stem and leaves as glandular hair in *Plumbago* and *Boerhaavia*, stinging hair secrate 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*, 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).

Tissues

Meristematic tissue

Acc. to origin and development

1. **Promeristem :** Gives rise to primary meristem.

2. **Primary meristem :** Gives rise to primary permanent tissue.

3. **Secondary meristem :** Produce secondary tissues *e.g.,* phellogen or cork cambium, interfascicular cambium, cambium etc.

Acc. to position

1. **Apical meristem :** Responsible for secondary growth of an organ.

2. **Intercalary meristem :** Present at the base of node (e.g., Mint) or internode (e.g., stems of many monocots, *i.e.* Wheat, Grasses etc) or at the base of leaf *e.g., Pinus*.

3. **Lateral meristem :** Increases diameter of an organism.

Acc. to function

1. **Protoderm :** It develops into the epidermis or epidermal tissue system.

2. **Procambium :** Gives rise to primary vascular tissue, constitute procambium.

3. **Ground meristem :** Develops ground tissue *e.g.,* hypodermis, cortex, endodermis, pericycle, pith, medullary rays.

Acc. to plane of cell division

1. **Mass meristem :** Forms mass of cell *e.g.,* formation of spores, cortex, pith, endosperm etc.

2. **Plate meristem :** Increase plate like area *e.g.* formation of epidermis and lamina of leaves.

3. **Rib or file meristem :** Form row or column of cells *e.g.,* formation of lateral roots.

Permanent tissue

Simple tissue

1. **Parenchyma :** Cells are living, soft with thin cellulosic wall and intercellular spaces. Present in all the plant organs *e.g.,* roots, stems, leaves, fruit, seeds etc.

2. **Collenchyma :** Compactly arranged living cells with thick wall of pectin and hemicellulose and no intercellular spaces.

- **Angular** e.g., *Tagetus*, Tomato, *Datura*, Potato etc.
- **Plate or lamellar** e.g., hypodermis of Sunflower stem.
- **Lacunar or tubular** e.g., hypodermis of *Cucurbita* stem.

3. **Sclerenchyma :** Thick walled dead cells due to uniform deposition of lignin.

- **Sclerenchymatous fibres :** Elongated and tapering at both the ends e.g., *Cannabis Sativa, Linum, Corchorus, Cocus etc.*
- **Stone cells or tracheids :** May be spherical, oval or cylendrical e.g., endocarp of Walnut and Coconut, occur in pulp of some fruits, part of seed coat.

Complex tissue

Xylem

Conducting element which conducts water and mineral nutrients upwards from the root to the leaves.

1. **Tracheids :** Elongated tube like cells with tapering or rounded or oval ends, with hard and lignified walls. *e.g.,* present in xylem of all vascular plant.

2. **Xylem vessels or trachae :** Elongated tube like cells, placed end to end. *e.g.,* always present in angiosperms (except lotus, *Winifera, Trochodendron*) and absent in pteridophytes and Gymnosperms (except *Ephedra, Gnetom, Selaginella*

3. **Wood parenchyma :** Living parenchymatous cells associated with xylem.

4. **Wood or xylem fibres :** Long, slender, pointed, dead and sclerenchymatous. *e.g.,* found in woody dicotyledons.

Phloem

Food conducting elements which transport the organic food material downward from leaves to stems and roots.

Sieve elements : Nucleus is not found. In angiosperm it occurs as sieve plate while in pteridophytes and gymnospermum as sieve cells (have nuclei).

Companion cells : Contain nucleus. Not found in pteridophytes and gymnosperms but always present in angiosperms.

Phloem parenchyma : Parenchymatous living cells with cellulosic cell wall and nucleus. *e.g.,* present in pteridophytes and some of dicotyledonous angiosperms but absent in monocotyledons.

Phloem or Bast fibres : Sclerenchymatous fibres associated with phloem abundantly found in sec. phloem *e.g.,* Jute, Hamp.

Special or secretory tissue

Glandular tissue : Highly specialized tissue consisting of glands including secretory or exretory.

1. **External glands :** Occurs in epidermis of stems and leaves as glandular hair in *Plumbago* and *Boerhaavia*, stinging hair secrete poisonous substance in *Utrica dioica*, nector secreting glands in flowers or leaves of Rutaceae, Euphorbiaceae, digestive secreting glands in sectivorous plants *e.g., Nepenthes* (Pitcher plant), *Drosera* (Sundew).

2. **Internal glands :** Present internally *e.g.,* oil glands in *Citrus* and *Eucalyptus*, resinous ducts in *Pinus*, schizogenous canal and mucilage canals in *Cycas*, water secreting glands hydathodes in *Colocasia* (present at the tip of leaves); *Tropaeoleum* (along margin), etc.

Laticiferous tissue : Thin walled branched, elongated and multinucleate structure that contain latex.

1. **Latex cells :** Very highly branched cell which do not fuse and do not form network. *e.g.,Calotropis, Nerium, Vinca, Euphorbia, Ficus.*

2. **Latex vessels :** Formed due to fusion of cells and form network like structure in all directions *e.g., Argemone Papaver, Sonchus, Hevea,*

2.4 The tissue system

The various types of tissues present in the body of a plant perform different functions. 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 (2) Ground or fundamental tissue system (3) Vascular tissue system

(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.

(i) **Epidermis :** Epidermis is composed of single layer 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 :

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

(b) 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.

(c) 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.

(ii) **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.

(iii) **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 from the other epidermal cells. In monocots *e.g.,* Doob, Maize guard cells are dumb bell shape. Stomata are scattered in dicots leaves but they are arranged in rows in monocots.

Depending upon distribution of stomata, the leaves are :

(a) **Apple-mulberry type :** *e.g. Oxalis, Mulberry, Apple*.

(b) **Potato type :** *e.g.* Bifacial (dorsiventral leaves of pea, bean, tomato).

(c) **Oat type :** *e.g.* Suberect (isobillateral) leaves of most grasses and cereals (monocotyledens).

(d) **Nymphea type :** *e.g.* Floating leaves of *Nelumbo, Nymphia,* water lily.

(e) **Potamogeton type :** *e.g.* Submerged plants like *Hydrilla, Vallisneria, Potamogeton*.

(iv) **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.

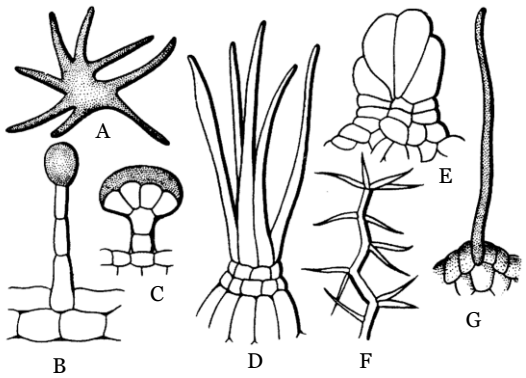


Fig : Appendages of epidermis of leaves A. Stellate hair of Alyssum, B. Glandular hair of Pelorgonium C. Short glandular hair of lavandula, D. Floccose hair of Malva, E. Glandular hair of Solanum, F. Urticating hair of Verbascum, G. Stinging hair of Cestus

(v) **Root hairs :** They are enlargements of special epiblema cells called **trichoblasts** and occurs 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 :

(i) **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 :

(a) **Hypodermis :** It is collenchymatous in dicot stem and sclerenchymatous in monocot stem. It provides strength.

(b) **General cortex :** It consists of parenchymatous cells. Its main function is storage of food.

(c) **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 pathches. 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. The young stems of angiosperms show a layer with abundant starch deposition. This layer occurs in the position where endodermis would have been situated which is called as starch sheath. In *Selaginella* trabeculate endodermis is found due to formation of air spaces between two endodermal cells.

Endodermis behave 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.

(ii) **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.

(iii) **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 :

(i) **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.

(ii) **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. Such vascular bundles are of two types :

(a) **Collateral :** A vascular bundle in which the phloem lies towards outerside 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.

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

(b) **Bicollateral :** A vascular bundle having the phloem strands on both outer and inner side of xylem, is called bicollateral. *e.g.*, *Cucurbita*.

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

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

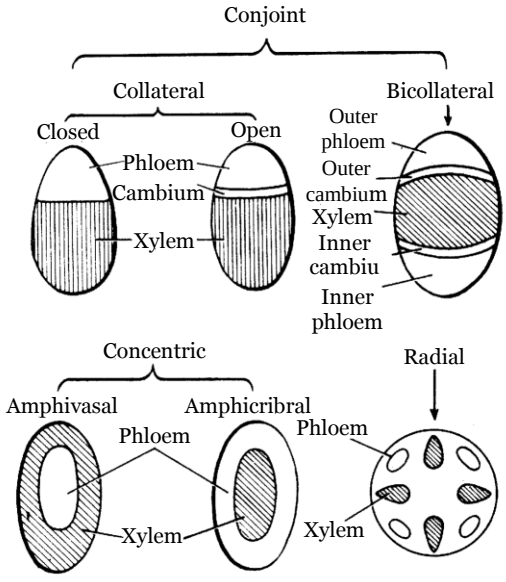
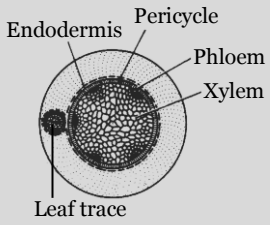
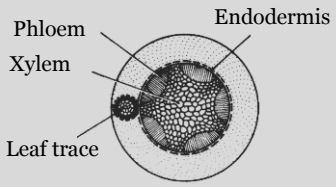
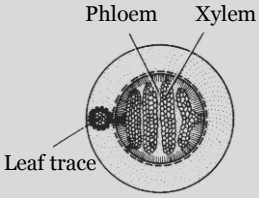
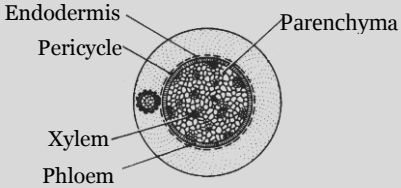


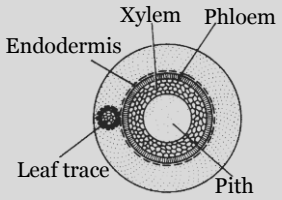
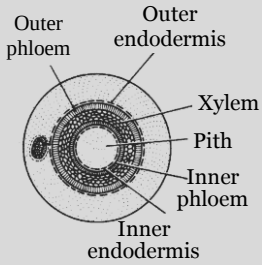
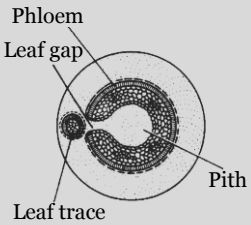
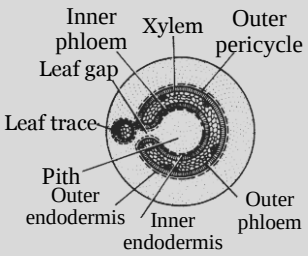
Fig : Different types of vascular bundles

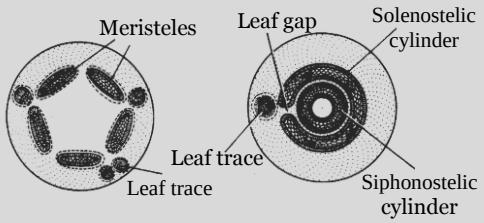
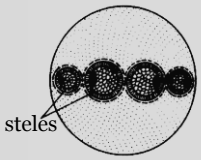
(b) **Amphicribal (Hadrocentric) :** The xylem lies in the centre and remains completely surrounded by phloem. *e.g.,* Ferns.

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. Different types of steles were recognised, a brief review of which are given in table :

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, Lyco podium*, etc.	
(ii) **Actinostele :** Protostele having star shaped xylem core with many radiating arms called actinostele. *e.g. Psilotum, Lycopodium* etc. It may be of two types :	
(a) **Plectostele :** A protostele in which xylem core broken into a number of parallel plates is known as plectostele. *e.g., Lycopodium clavatum.*	
(b) **Mixed protostele :** A protostele in which xylem 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*.	
(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.	
	

2.5 INTERNAL STRUCTURE OF ROOT, STEM AND LEAF

(1) **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 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 photosynthesis 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.	Regulate passage of minerals into vascular tissue if present.
(d) Vascular	Transport water and nutrients.	Transport water and nutrients.	Transport water and nutrients.
(e) Pith	Store products of photosynthesis and water.	Store products of photosynthesis.	

(f) Mesophyll (i) Spongy layer (ii) Palisade layer			Carry on gaseous exchange and photosynthesis.

(2) **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) Hairs	Unicellular.	Multicellular.
(iii) Chlorenchyma in cortex	Absent.	Usually present in young stems but absent in old stem.
(iv) Endodermis	Very distinct.	Poorly developed or absent.
(v) Vascular bundle	Radial.	Conjoint collateral or bicollateral or concentric.
(vi) Xylem	Exarch.	Endarch.

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

(3) **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 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.

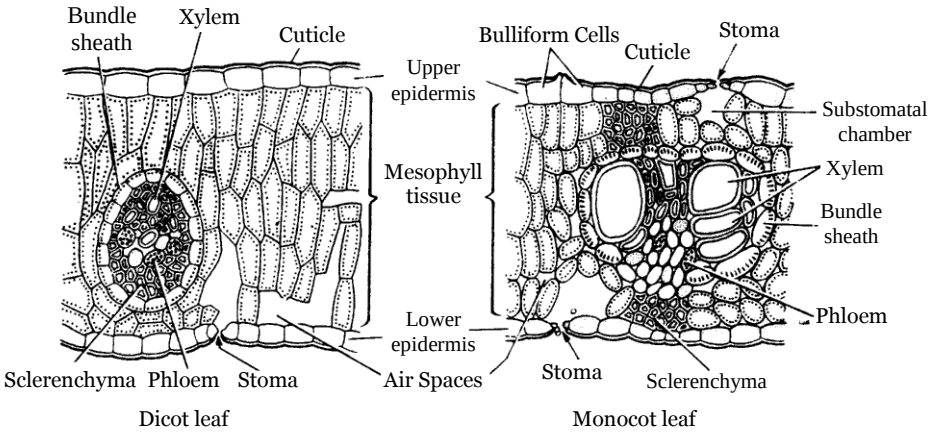


Fig : Comparison of T.S. of a dicot and monocot leaf

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

(4) **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	Vascular bundles in a ring Conjoint, collateral and open

	Larger towards centre Oval Bundle sheath present Phloem parenchyma absent Xylem vessels either Y or V shaped	All of same size Usually wedge–shaped Bundle sheath absent Phloem parenchyma present Xylem vessels more radial

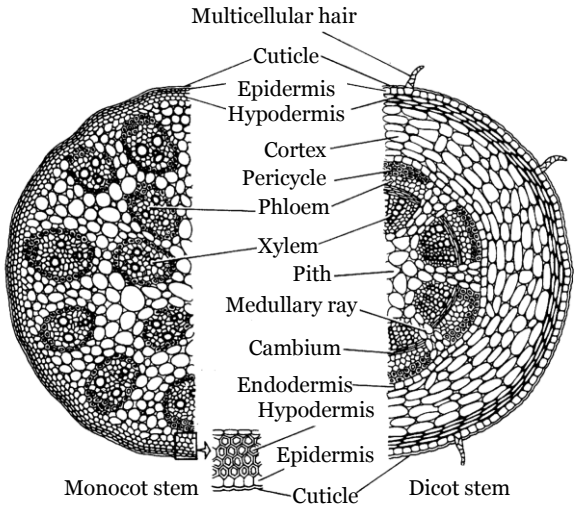


Fig : Comparision of the T.S. of monocot and dicot stem

(5) **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
(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
	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.

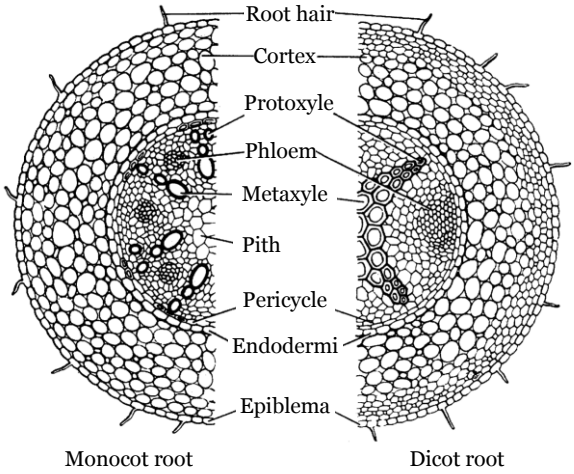


Fig : Cmparision of the T.S. of monocot and dicot root

2.6 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 :

(i) Activity of cambium (ii) Activity of cork-cambium

(i) **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 produced the secondary xylem and phloem tissues on innerside and outerside. The amount of sec. xylem produced is 8-10 times greater than sec. phloem. The cambium has two types of cells :

(a) **The fusiform initials** which are elongated and form fibres, sieve cells, sieve tubes, tracheids.

(b) **Ray initials** which produce parenchyma cells of the rays in wood and phloem. Ray initials are much shorter than fusiform initials. 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. Thus by counting the number of annual rings in the main stem at the base we can determine the age of a tree.

This branch of science is known as dendrochronology. Age is determined by an instrument increment borer. Growth rings are distinct or sharply demarcated in the plants of temperate regions where as in tropical climate (near equator) they are not distinct or sharply demarcated in the trees.

(ii) **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 phellum 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 collectively called as **periderm**. Periderm is secondary protective tissue. Due to pressure of secondary xylem, epidermis raptures and cortex is largely lost after two or three years of secondary growth.

(a) **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.

(b) **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 **guttation**.

(c) **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.

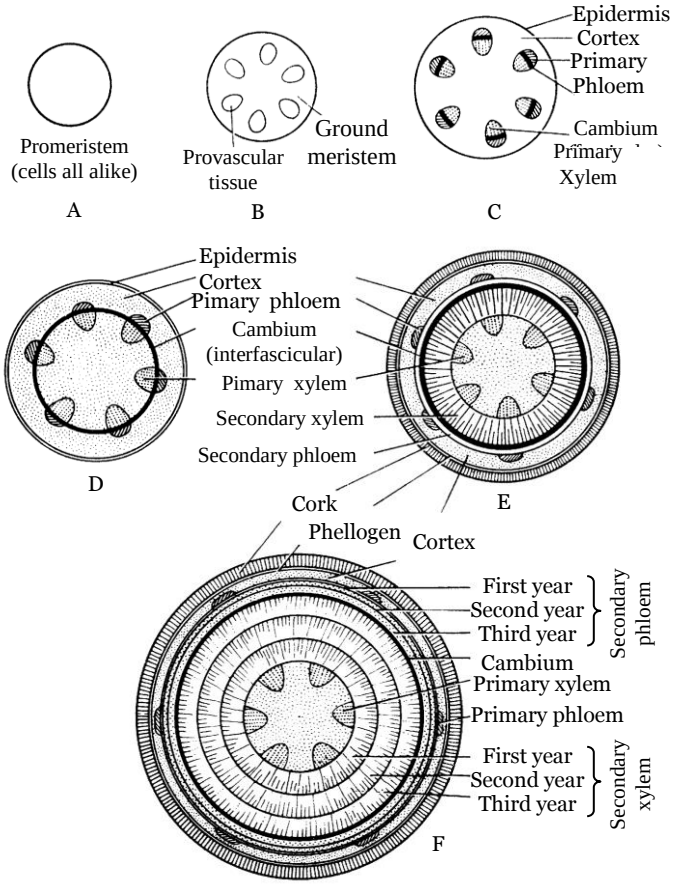


Fig : Stages of secondary growth in stem

(d) **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 ballon like 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.

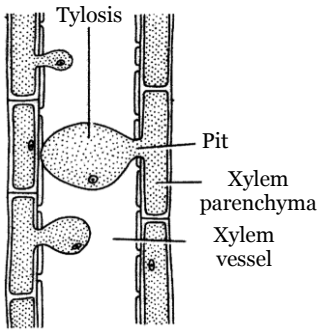


Fig : Tyloses in xylem vessels

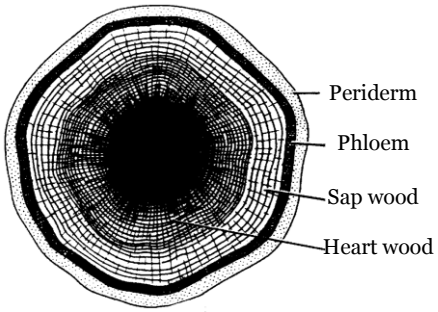


Fig : T.S. of old dicot stem showing heart wood and sap wood

(2) **Secondary growth in dicot roots :** Vascular bundles in dicot roots are radial, exarch and mostly triarch. Vascular cambium is formed secondarily from conjuctive parenchyma cells lying just below each phloem strand. Thus the number of cambium strips formed equals 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 produced 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.

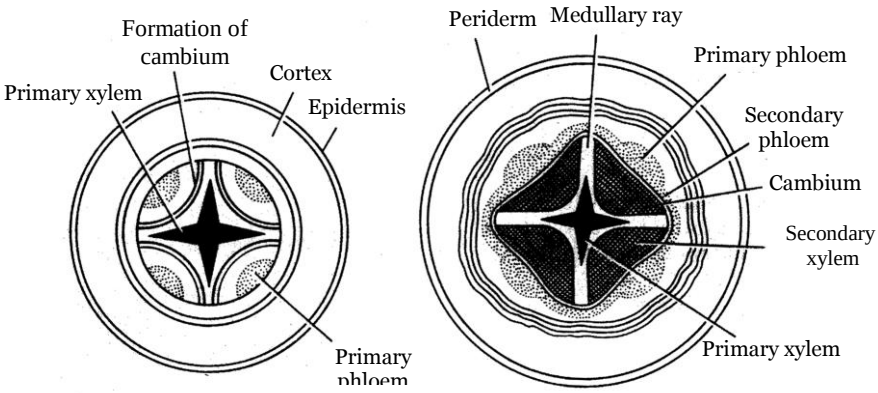


Fig : Secondary growth in dicot root

Important Tips

- N.Grew is the father of anatomy (1682) and coined the term tissue and parenchyma.
- **Haberlandt** proposed the names of **protoderm** (for dermatogen), **ground meristem** (for periblem) and **procambium** (for plerome)
- **Haberlandt** (1914) gave the terms lepton for soft walled conducting part of phloem and hadrom 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**.
- Reproductive apex is elongated in **Sagittaria** but it can be 400 times broad in **Chrysanthemum**.
- Seive cells or seive tube elements resemble RBCs in being without nucleus in the mature state.
- Cavities are of three types :

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

  (ii) **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.

  (iii) **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 wood of Tactona grandis is termite resistance.
- 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.
- Latex for chewing or chickle gum obtained from Achras sapota, Gutta percha (insulating material) from palaquium gutta alkaloid opium from Papaver sominiferum (poppy), papain (enzyme) from carica papayas, Rubber from Hevea brasiliensis, Ficus elastica.
- **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 get covered by growth of secondary tissues. They form knots in the wood.
- **Abscission** 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 consist of two larger and rounded vessels situated on the sides with the pitted tracheids in between them.
- Protoxylem consists of two smaller vessels situated to wards 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 :

  (i) **Exarch :** Protoxylem towards the outerside.

  (ii) **Endarch :** Protoxylem towards innerside of metaxylem.

  (iii) **Mesarch :** Protoxylem surrounded by metaxylem.

  (iv) **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 cap is absent in hydrophytes.
- 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.

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ASSIGNMENT

TISSUE

Basic Level

1. A group of cells alike in form, function and origin is called
(a) Organ (b) Organelle (c) Tissue (d) None of these

2. According to Histogen theory, the plerome gives rise to
(a) Epidermis (b) Hypodermis (c) Vascular bundles (d) External hair

3. The meristem which develops into a primary vascular tissue is
(a) Protonema (b) Promeristem (c) Ground meristem (d) Procambium

4. Which of the follwing is a secondary meristem
(a) Phelloderm (b) Primary cambium (c) Cork cambium (d) Promeristem

5. The cambium is an example of
(a) Lateral meristem (b) Intercalary meristem (c) Apical meristem (d) Primary meristem

6. Fibres are obtained from
(a) Xylem, phloem and sclerenchyma
(b) Xylem, phloem, sclerenchyma and epidermis
(c) Xylem, parenchyma, epidermis (d) Xylem, parenchyma, endodermis

7. The quiescent centre in root meristem serves as a
(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

8. The outermost primary meristem gives rise to
(a) Epidermis (b) Procambium (c) Ground meristem (d) All of the above

9. Meristem is defined as a plant tissue where
(a) Cell conserves food and supply it to new ones
(b) Cells mature and add to the bulk of a plant
(c) Cells elongate and add to the growth of a plant
(d) Cells divide continuously to give rise to new ones

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

11. Dermatogen is a tissue formed by apical meristem and develops into
(a) Cortex (b) Vascular bundle (c) Epidermis (d) Ground tissue (pith)

12. Histogen theory is more applicable for
(a) Root apex (b) Shoot apex (c) Meristematic tissue (d) None of these

13. Root cap regenerates or produced from
(a) Calyptrogen (b) Pleurome (c) Periblem and histogen (d) Dermatogen

14. The length of a plant axis increases by
(a) Apical meristem (b) Lateral meristem (c) Dermatogen (d) Pleurome

15. Tunica corpus theory was proposed by
(a) Schmidt (b) Strasburger (c) Nageli (d) Hofmeister

16. Dermatogen, periblem and plerome are
(a) Permanent tissues (b) Meristematic tissues (c) Intercalary tissues (d) Secondary tissues

17. Vascular cambium of the root is an example of
(a) Apical meristem (b) Intercalary meristem
(c) Secondary meristem (d) Root apical meristem

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

19. Vascular cambium and cork cambium are examples of
(a) Lateral meristem (b) Apical meristem
(c) Elements of xylem and phloem (d) Intercalary meristem

20. Quiescent centre is found in
(a) Stem (b) Root (c) Leaves (d) None of these

21. Tunica corpus theory is related with
(a) Root apex (b) Lateral meristems
(c) Root cap (d) Shoot apex (apical meristem)

22. Grass stem elongates by the activity of
(a) Primary meristem (b) Secondary meristem (c) Intercalary meristem (d)Apical meristem

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

24. Histogen theory states that epidermis is derived from the
(a) Periblem (b) Cambium (c) Cortex (d) Dermatogen

25. Histogen theory was proposed by
(a) Bailey (b) Haberlandt (c) Hanstein (d) Schmidt

26. Dead cells of root are supplied by
(a) Calyptrogen (b) Protoderm (c) Phellogen (d) Dermatogen

27. The calyptrogen of the root apex forms
(a) Rhizoids (b) Root nodule (c) Root hairs (d) Root cap

28. Collenchyma generally occurs
(a) Scattered in dicot roots (b) In a ring in monocot roots
(c) In patches under epidermis in dicot stem (d) In all of the above

29. Aerenchyma is found in
(a) Lithophytes (b) Hydrophytes (c) Sciophytes (d) Xerophytes

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

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

32. Hard lignified thick walled long and pointed cells a plant are
(a) Parenchyma (b) Sclerenchyma (c) Collenchyma (d) Sclereids

33. Mechanical tissue consisting of living cells is
(a) Sclerenchyma (b) Collenchyma (c) Chlorenchyma (d) Parenchyma

34. Function of storage is performed by
(a) Parenchyma (b) Sclerenchyma (c) Phloem (d) All of the above

35. Parenchymatous tissue is characterised by the
(a) Presence of uniform thickening (b) Presence of thickening in the corners
(c) Presence of intercellular spaces (d) Presence of lignified walls

36. A parenchyma cell which stores ergastic materials or waste substances is
(a) Phragmoplast (b) Conidioblast (c) Idioblast (d) Blastomere

37. Aerenchyma is formed in the tissue of
(a) Sclerenchyma (b) Parenchyma (c) Phloem (d) None of these

38. The difference in phloem of gymnosperms and angiosperms is due to
(a) Parenchyma (b) Sieve cell (c) Companion cell (d) Fibres

39. Cork cambium is a
(a) Secondary meristem (b) Apical meristem (c) Intercalary meristem (d) Primary meristem

40. Tracheids of angiosperms are recognised by the presence of
(a) Bordered pits (b) Scalaiform thickening
(c) Scalaiform perforation plates (d) All of the above

41. The complex tissues include
(a) Scleroids (b) Sclerenchyma (c) Secretory tissues (d) Collenchyma

42. Laticiferous vessels are found in
(a) Xylem tissue (b) Phloem tissue (c) Cortex (d) None of these

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

44. The cell wall of xylem cells is rich in
(a) Lipid (b) Protein (c) Lignin (d) Starch

45. Root cap is absent in
(a) Lithophytes (b) Hydrophytes (c) Xerophytes (d) Mesophytes

46. Which meristem helps in increasing girth
(a) Lateral meristem (b) Intercalary meristem (c) Primary meristem (d) Apical meristem

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

48. Vessels are the major conducting element mainly found in
(a) Xylem of angiosperms (b)Xylem of gymnosperms
(c) Both (a) and (b) (d)None of these

49. Which is present in vascular bundles of gymnosperms
(a) Tracheids (b) Vessels (c) Companion cells (d) All of these

50. Tracheae, tracheids, wood fibres and parenchyma tissues are found in
(a) Xylem (b) Phloem (c) Cambium (d) Cortex

51. Trachieds and vessels related to
(a) Xylem (b) Phloem (c) Both (d) None of these

52. Companion cells are usually seen associated with
(a) Fibres (b) Vessels (c) Tracheids (d) Sieve tubes

53. Collenchyma is found in stems and petioles of
(a) Hydrophytes (b) Herbaceous climbers (c) Xerophytes (d) Lianas

54. Walls of sclerenchyma are
(a) Rigid (b) Lignified (c) Pectinised (d) Suberised

55. Meristematic activity occurs at
(a) Bud (b) Stem apex (c) Leaf (d) Root hair

56. Promeristem is found in
(a) Embryo (b) Root apex (c) Shoot apex (d) Intercalary region

57. The meristem in the root is
(a) Terminal (b) Sub-apical or sub-terminal
(c) Intercalary (d) Absent

58. Passage cells are found in
(a) Dicot stem (b) Aerial root (c) Monocot root (d) Monocot stem

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

60. Vessels are found in
(a) All pteridophyta (b) All angiosperms (c) Some gymnosperm (d) Both (b) and (c)

61. Which is not the characteristic of xerophytic plants
(a) Thick stomata (b) Developed root (c) Aerenchyma (d) All of the above

62. All xylem elements when mature are dead except
(a) Tracheids (b) Vessels (c) Xylem parenchyma (d) Xylem fibres

63. Fascicular, interfascicular and extra-stelar cambium together constitute
(a) Lateral meristem (b) Apical meristem (c) Intercalary meristem (d) Ground meristem

64. The tip of the root apical meristem is capped by the histogen known as
(a) Periblem (b) Dermatogen (c) Plerome (d) Calyptrogen

65. Axillary bud and terminal bud are derived from the activity of
(a) Parenchyma (b) Lateral meristem (c) Apical meristem (d) Intercalary meristem

66. Meristems are found in
(a) Cycas stem (b) Fern leaf (c) Pollens of pinus (d) Fern rhizome

67. Intraxyllary phloem may also be called
(a) Internal phloem (b) Included phloem (c) Vestigeal phloem (d) None of these

68. Cells of quiescent centre are characterised by
(a) Dense cytoplasm and prominent nuclei (b) Light cytoplasm and small nuclei
(c) Dividing regularly to add to the corpus (d) Dividing regularly to add to tunica

69. Apical meristem of root is present
(a) Only in radicles (b) Only in tap roots
(c) Only in adventitious roots (d) In all the roots

70. The activity of intercalary meristems add to
(a) Primary growth (b) Secondary growth (c) Both (a) and (b) (d) None of these

71. Vessels occur in
(a) All angiosperms, all gymnosperms and some pteridophytes
(b) All angiosperms, and some gymnosperms
(c) Most angiosperms, a few gymnosperms and pteridophytes
(d) All pteridophytes

72. Which is correct
(a) Tracheids are unicellular with wide lumen (b) Vessels are multicellular with wide lumen
(c) Tracheids are multicellular with narrow lumen (d) Vessels are unicellular with narrow lumen

73. Plants yielding latex is
(a) *Ficus* (b) *Sonchus/Euphorbia* (c) *Calotropis* (d) All of the above

74. Which of the following are simple tissues
(a) Parenchyma, xylem and phloem (b) Parenchyma, collenchyma and sclerenchyma
(c) Parenchyma, xylem and collenchyma (d) Parenchyma, xylem and sclerenchyma

75. Diffuse porous woods are characteristics of plants growing in
(a) Alpine regions (b) Cold winter regions (c) Temperate regions (d) Tropical regions

76. Porous wood contains mainly
(a) Fibres (b) Vessels (c) Trachieds (d) Solid secretions

77. When protoxylem develops towards the periphery, it is called
(a) Centripetal xylem (b) Centrifugal xylem (c) Endarch (d) None of these

78. When formation of metaxylem is in a centripetal manner, the xylem is
(a) Endarch (b) Exarch (c) Mesarch (d) Radial

79. Bordered pits are very common in
(a) Monocotyledons (b) Gymnosperms (c) Dicotyledons (d) Pteridophytes

80. Bordered pits are found in

(a) Phloem (b) Protoxylem (c) Metaxylem (d) Pith

81. Which of the following is known as wood

(a) Primary xylem (b) Secondary xylem (c) Secondary phloem (d) Cambium

82. Conducting part of phloem according to Haberlandt (1914) is

(a) Hadrom (b) Leptom (c) Sterom (d) Bark

83. Xylem position in secondary xylem is

(a) Exarch (b) Endarch (c) Mesarch (d) None of these

84. Water secreting glands or tissues are known as

(a) Tyloses (b) Hydathodes (c) Cork (d) Phellogen

85. Epidermis in stem is produced from

(a) Protoderm (b) Procambium (c) Ground meristem (d) Calyptrogen

86. Trabaculae is the transformation of

(a) Pericycle (b) Endodermis (c) Xylem (d) Phloem

87. Periblem gives rise to

(a) Pericycle (b) Cortex (c) Medulla (d) Epidermis

88. Angular collenchyma occurs in

(a) *Cucurbita* (b) *Helianthus* (c) *Althaea* (d) *Salvia*

89. 'Patua' of *Hibiscus sabdarifa* is

(a) Secondary phloem (b) Collenchymatous hypodermis

(c) Pericycle (d) Epidermis

90. Two adjacent vessels and tracheids exchange sap through

(a) Perforated end walls (b) Pits

(c) Intercellular spaces (d) Intercellular spaces and parenchyma

91. Which one yields Sunn hemp

(a) *Corchorus* (b) *Hibiscus* (c) *Crotalaria* (d) *Cannabis*

92. Fibres associated with phloem are

(a) Hard fibres (b) Wood fibres (c) Surface fibres (d) Bast fibres

93. Which of the following is absent in the primary and secondary structure of stem of *Pinus*

(a) Seive tubes (b) Mucilage duct (c) Companion cells (d) Phloem parenchyma

94. Lignified cell wall is the characteristic feature of

(a) Phloem cells (b) Epidermal cell (c) Cambial cells (d) Xylem cells

95. Stelar region (vascular tissue, pericycle and pith) are formed from

(a) Periblem (b) Plerome (c) Dermatogen (d) Tunica

96. Epiblema in roots is derived from

(a) Protoderm (b) Procambium (c) Ground meristem (d) Calyptrogen

97. A cap like region of slowly dividing or inactive cells in the middle of highly meristematic cells (between meristem and root cap) is

(a) Somatic zone (b) Vegetative zone (c) Quiescent centre (d) Corpus centre

98. Which tissue makes up the embryo of a seed

(a) Meristematic tissue (b) Permanent parenchyma

(c) Collenchyma (d) Sclerenchyma

99. Xylem fibres is

(a) Bast fibre (b) Wood fibre (c) Heart wood (d) Libriform fibre

100. Bast fibres are frequently found in

(a) Secondary xylem (b) Secondary phloem (c) Primary phloem (d) Primary xylem

101. Tunica is a rib meristem because it divides in

(a) Anticlinal plane only (b)Periclinal plane only

(c) Both the above (d)Several different planes

102. A nectar secreting gland cell has

(a) Vacuolated cytoplasm with large nucleus

(b) Granular nonvacuolated cytoplasm

(c) Peripheral granular cytoplasm with small nucleus

(d) Granular nonvacuolated cytoplasm with a conspicuous nucleus

103. Tunica corpus theory is based on

(a) Rate of shoot tip growth (b) Plane of cell division

(c) Rate of cell division (d) Regions of meristematic activity

104. Meristematic cells contains more of

(a) Sugar (b) Salts (c) Proteins (d) Fats

105. A single apical cell constitutes the apical meristem in

(a) Dicots (b) Gymnosperms (c) Bryophytes (d) Monocots

106. Lodged cereals become erect due to

(a) Intercalary meristem (b) Apical meristem (c) Lateral meristem (d) Secondary meristem

107. More activity occurs on the flanks in

(a) Vegetative shoot apex (b)Reproductive shoot apex

(c) Lateral meristem (d)Root apex

108. Apical meristem divides to form three meristematic regions

(a) Dermal, vascular and ground (b) Calyptrogen, periblem and plerome

(c) Protoderm, procambium and ground meristem (d) Lateral, intercalary and sub apical

109. Concept envisaging three zones of cells in root and stem apices is

(a) Histogen theory (b) Tunica corpus theory (c) Meristem theory (d) Dermatogen theory

110. Apical, intercalary and lateral meristems are differentiated on the basis of

(a) Development (b) Origin (c) Function (d) Position

111. Procambium forms

(a) Only primary vascular bundles (b) Only vascular cambium

(c) Only cork cambium (d) Primary vascular bundles and vascular cambium

112. Periblem produces

(a) Cortex (b) Pericycle (c) Vascular strand (d) Both (b) and (c)

113. Which is not a primary meristem

(a) Promeristem (b) Protoderm (c) Periblem (d) Ground tissue

114. Active divisions occur in the cells of

(a) Xylem (b) Phloem (c) Cambium (d) Collenchyma

115. Monocot leaves possess

(a) Intercalary meristem (b) Lateral meristem (c) Apical meristem (d) Mass meristem

116. Flesh of fruits is mostly made of

(a) Parenchyma (b) Collenchyma (c) Sclereids (d) Meristem

117. Which one is not a plant fibre

(a) Coir (b) Flax (c) Hemp (d) Silk

118. Longest fibres are found in

(a) Jute (b) Cotton (c) Sunn hemp (d) Coir

119. Which one yield fibres

(a) Coconut (b) Oak (c) Teak (d) Sisso

120. Epidermal fibres of economic importance belong to

(a) Cotton (b) Flax (c) Hemp (d) Coir

121. Cells taking part in conduction of sap are

(a) Sieve tubes (b) Tracheae (c) Sieve cells (d) Stone cells

122. Chief function of phloem is conduction of

(a) Food (b) Minerals (c) Water (d) Air

123. Early formed xylem is

(a) Uniseriate (b) Multiseriate (c) Protoxylem (d) Metaxylem

124. Anatomically jute fibres are

(a) Xylem fibres (b) Cortical fibres (c) Pith fibres (d) Phloem fibres

125. Transport of water and dissolved minerals occurs through

(a) Phloem (b) Xylem (c) Sieve tubes (d) Sclerenchyma

126. Function of vessels is

(a) Conduction of water and mineral (b) Conduction of food

(c) Mechanical strength (d) All of the above

Advance Level

127. Starch is mainly manufacture by

(a) Palisade parenchyma (b)Spongy parenchyma

(c)Guard cells (d)Vascular bundle

128. Simple pits occur in

(a) Parenchyma alone (b) Simple tissue alone

(c) Parenchyma and sclerenchyma (d) All types of tissue

129. Which is present in vascular bundles of gymnosperms

(a) Tracheids (b) Vessels (c) Companion cells (d) All of the above

130. A leaf that possess stomata exclusively its upper side is called

(a) Oat type (b) Mulberry type (c) Lotus type (d) Cactus type

131. 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

132. In which of the following ways is the parenchyma, the basic of fundamental type of tissue

(a) Morphologically (b) Physiologically (c) Phylogenetically (d) All of the above

133. The root apex (apical meristem) is subterminal because it

(a) Is covered by root hairs (b)Is covered by root cap

(c) Has many corpus cells (d) Is covered by tunica cells

134. Why cambium is considered as lateral meristem

(a) Because it gives rise to lateral branches (b) Because it increases the girth of a plant

(c) Because it increases the length of a plant (d) None of these

135. The vessel elements of angiosperms differ from other elements of xylem in having

(a) Simple pits on their radial walls (b) Bordered pits on their lateral walls

(c) Simple and bordered pits on their end walls (d) Simple perforation on their end walls

136. Quiescent centre is the zone of

(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

137. Meristematic tissues include

(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

138. Aerenchyma is helpful in plants by

(a) Providing buoyancy in hydrophytes (b) Promoting photosynthesis

(c) Giving mechanical strength to plants (d) Giving flexibility to plants

139. Thick-walled and lignified with simple pits in walls and non-prosenchymatous cells without living protoplasm usually isodiametric or irregular in shape are

(a) Parenchyma (b) Collenchyma (c) Fibres (d) Sclereids

140. When strong wind blows, the plants bend down and then again become erect. This flexibility in plants is due to

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

141. The chief function of sieve tubes is

(a) To translocate the organic materials manufactured in the leaves

(b) To conduct minerals

(c) To transport water from root to leaves

(d) To help the plant in forming wood

142. At maturity, which of the following is non-nucleated

(a) Sieve cell (b) Companion cells (c) Palisade cell (d) Cortical cell

143. Vessels differ from tracheids

(a) In being derived from single cell

(b) In having vertical rows of cells with cross walls dissolved

(c) In being living (d) They help in the conduction of water

144. Sieve tubes are better suited for translocation, because

(a) Possess broader lumen and perforated cross walls (b)Are broader than long

(c) Possess bordered pits (d)Possess no end walls

145. Which combination of tissues acts together to provide the support to the hypocotyl of a seedling

(a) Xylem and phloem fibres (b)Epidermis and parenchyma

(c) Xylem and parenchyma (d)Epidermis and collenchyma

146. Which one of the tissue is formed in stems from cells cut off by the cambium on its inner side

(a) Wood fibres (b) Bast fibres (c) Sieve tubes (d) Companion cells

147. A mature sieve tube differs vessel in

(a) Being nearly dead (b) Lacking cytoplasm

(c) Lacking a functional nucleus (d) Absence of lignified walls

148. The organisation of the shoot apex into tunica and corpus is determined largely on the basis of

(a) Rate of shoot tip growth (b) Rate of cell division

(c) Planes of cell division (d) Regions of meristematic activity

149. In woody dicotyledons, the arrangement of vessels is either diffuse porous or ring porous.

Based on the these data, which one of the following statements is correct

(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 specialised 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

150. 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

(a) Porous (b) Ring porous

(c) Ring and diffuse porous (d) Diffuse porous

151. Senescence and death are essential in the functioning of

(a) Sieve tubes (b) Companion cells

(c) Both (a) and (b) (d) Xylem and Sclerenchyma cells

152. As compared to other parts of root apical meristem. DNA content of quiescent centre is

(a) Low (b) High (c) Same (d) Very high

THE TISSUE SYSTEM

Basic Level

153. 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

154. Which one of the following is a type of tissue system

(a) Parenchyma (b) Sclerenchyma (c) Vascular (d) All of the above

155. The layer of cells outside the phloem meant for giving rise to the root branches is called

(a) Cambium (b) Corpus (c) Endodermis (d) Pericycle

156. The lateral roots generally originate in

(a) Endodermal cells lying against phloem (b) Cortex

(c) Pericycle cells lying against protoxylem (d) Cork cambium

157. Secondary roots arise from

(a) Pericycle (b) Sap wood (c) Endodermis (d) Hypodermis

158. In free floating plant, the stomata are

(a) Absent (b) Present on upper surface

(c) Present on both the surface (d) Present on lower surface

159. A root hair is formed by

(a) Epidermal cell (b) Endodermal cell (c) Cortical cell (d) Pericycle cell

160. Adventitious roots in a dicot stem originate from

(a) Radicle (b) Pericycle or interfascicular parenchyma

(c) Cortex (d) None of these

161. Water stomata are found in

(a) Plants inhabiting humid region (b) Plants inhabiting dry regions

(c) All plants (d) Plants lacking normal stomata

162. Multiple epidermis on dorsal and ventral side of the leaf is found in

(a) *Zea mays* (b) *Ficus benghalensis* (c) *Mangifera indica* (d) *Nerium oleander*

163. The casparin strips of root endoderm is contain a mixture of

(a) Cellulose and cutin (b) Cellulose and lignin

(c) Lignin and suberin (d) Cellulose and suberin

164. Cuticle is secreted by

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

165. Which of the following do not have stomata

(a) Xerophytes (b) Mesophytes

(c) Hydrophytes (d) Submerged hydrophytes

166. Which of the stomata wall is thick

(a) Inner (b) Outer (c) Lateral (d) Upper

167. Passage cells are present in

(a) Epidermis (b) Endodermis

(c) Xylem (d) Lenticels and hydathodes

168. Thick cuticle on leaves are typical of plants growing in

(a) Wet habitats (b) Warm habitats (c) Dry habitats (d) Cool habitats

169. Epidermal outgrowths are known as

(a) Stomata (b) Leaves (c) Trichomes (d) Flower buds

170. 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

171. Who coined the term 'tissue'

(a) Grew (b) Nageli (c) Hanstein (d) Wolff

172. 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 these

173. Velamen is needed for

(a) Respiration of plants (b)Protection of tissue

(c) Absorption of moisture (d) None of these

174. Velamen tissue in orchids is found in

(a) Shoot (b) Root (c) Leaves (d) Flowers

175. Which of the following have sunken stomata

(a) *Nerium* (b) *Mangifera* (c) *Hydrilla* (d) *Zea mays*

176. The function of a vessel is

(a) Conduction of food (b) Conduction of water and minerals

(c) To provide strength (d) None of these

177. Vascular bundles in the stem of *Cucurbita* or *Lagenaria* are

(a) Collateral (b) Bicollateral (c) Radial (d) Inverted

178. Amphivasal or leptocentric vascular bundles are found in

(a) *Cycas and Dryopteris* (b)*Dracaena and Yucca*

(c) *Helianthus and Cucurbita* (d) *Maize and wheat*

179. The bicollatoral vascular bundle is the characteristic feature of plants belonging to the family

(a) Cruciferae (b) Liliaceae (c) Cucurbitaceae (d) Malvaceae

180. Radial vascular bundle can be seen in

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

181. When xylem and phloem are separated by a strip of cambium it is called

(a) Collateral and open (b) Collateral and closed

(c) Bicollateral and open (d) Concentric and closed

182. Vascular bundles having xylem and phloem sit at the same radius is termed as

(a) Concentric (b) Radial (c) Collateral (d) Amphicribral

183. Passage cells occur in

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

184. Stomata in Water Lily and Podostemon occur respectively

(a) Lower leaf surface and absent (b) Upper leaf surface and absent

(c) Both leaf surface and upper part (d) Absent in both

185. Most common type of stomata is

(a) Apple-Mulberry type (b)Potato type (c) Oat type (d) Nymphaea type

186. In floating leaved hydrophytes (*e.g.*, *Nymphaea*) stomata

(a) Occur on both the surface (b) Present on only the lower surface

(c) Present on only the upper surface (d) Absent

187. In submerged hydrophytes/*Vallisneria* the functional stomata are found

(a) On the upper leaf surface (b) On the lower leaf surface

(c) Both leaf surfaces (d) No where on the plant

188. Match items of column I and column II

	Column I		Column II
a	Collateral and open	*p*	Cucurbita stem
b	Radial	*q*	Fern
c	Bicollateral	*r*	Maize root
d	Concentric	*s*	Sunflower
		t	Maize stem

(a) *a – t, b – s, c – r, d – p* (b)*a – s, b – r, c – p, d – q*

(c) *a – s, b – p, c – r, d – q* (d)*a – s, b – r, c – q, d – p*

189. Root hairs are found

(a) In the zone of maturation (b) Adventitious roots

(c) On the root cap (d) Apical meristem

190. Epidermal cells are

(a) Guard cells (b) Root hairs (c) Trichomes (d) All of the above

191. Casparian strips occurs in

(a) Exodermis (b) Passage cells (c) Endodermis (d) Pericycle

192. The number of stomata per square *cm* of leaf is

(a) Less than one hundred (b)Less than one thousand

(c) Less than one million (d)None of these

193. Velamen cells are found in epiphytes

(a) Just outside the cortex (b) Below the endodermis

(c) Just outside the exodermis (d) Below the epidermis

194. Undifferentiated ground tissue is met with in

(a) *Pisum* stem (b) Sunflower stem (c) Cucurbita stem (d) Maize stem

195. In moncots, guard cells are

(a) Dumb-bell shaped (b) Reniform (c) Spherical (d) Isodiametric

196. Layer of cells between endodermis and vascular bundles is called

(a) Epidermis (b) Pericycle (c) Hypodermis (d) Pith

Advance Level

197. A concentric amphivasal (leptocentric) vascular bundle is one in which

(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

198. Vascular bundles in which phloem is found on both sides of xylem are called (in which of the following phloem occurs on two patches)

(a) Collateral (b) Bicollateral (Amphiphloic)

(c) Radial (d) Amphicribral

199. Pericycle in roots is responsible for

(a) Formation of lateral roots (b)Providing mechanical support

(c) Formation of vascular bundle from cortex

(d) Formation of vascular bundle from endodermis

200. Mature wood stem has a peripheral water proof tissue with opening in the form of scars on its surface. They are

(a) Epidermal cells (b) Guard cells (c) Lenticels (d) Stomata

201. The axillary buds arise

(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

202. In dicot roots, cells of which region show casparian strips

(a) Cambium (b) Endodermis (c) Pericycle (d) Hypodermis

INTERNAL STRUCTURES OF ROOT, STEM AND LEAF

Basic Level

203. Monocot stem has

(a) Bicollateral closed vascular bundles (b) Bicollateral open vascular bundles

(c) Collateral open vascular bundles (d) Collateral closed vascular bundles

204. In monocot roots which types of vascular bundles are found

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

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

205. Abundant pith is characteristic of

(a) Monocot root and monocot stem (b) Monocot root and dicot stem

(c) Dicot stem and dicot root (d) Dicot root and monocot stem

206. Collenchymatous hypodermis is characteristics of

(a) Dicot stem (b) Monocot stem

(c) Monocot as well as dicot stem (d) Hydrophytes

207. Exarch and polyarch vascular bundles occur in

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

208. The endodermis in dicot stem is also called

(a) Starch sheath (b) Mesophyll (c) Pili (d) Bundle sheath

209. Polyarch condition is seen in

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

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

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

211. Well developed pith is found in

(a) Monocot stem and dicot root (b) Monocot and dicot stems

(c) Dicot stem and dicot root (d) Dicot stem and monocot root

212. Sclerenchymatous sheath is present in vascular bundles

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

213. The vascular bundles in the stem of monocots are typically

(a) Collateral (b) Bicollateral (c) Concentric (d) Radial

214. Vascular bundles are scattered in

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

215. Monocot root differs from dicot root in having

(a) Open vascular bundles (b) Scattered vascular bundles

(c) Well developed pith (d) Radially arranged vascular bundles

216. In root, xylem is

(a) Mesarch (b) Exarch

(c) Placed at different places in different plants (d) Endarch

217. Phloem parenchyma is absent in

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

218. Kranz anatomy is found in

(a) Monocots (b) Dicots (c) Both (a) and (b) (d) None of these

219. Dorsiventral leaf has

(a) Stomata on both side (b)Stomata on lower surface

(c) Stomata on upper surface (d) No stomata

220. In the leaf vascular bundles are found in the

(a) Veins (b) Palisade tissue (c) Lower epidermis (d) Upper epidermis

221. In a dicotyledonous stem, the sequence of tissues from the outside to the inside is

(a) Phellem – Pericycle – Endodermis – Phloem (b) Phellem – Phloem – Endodermis – Pericycle

(c) Phellem – Endodermis – Pericycle– Phloem (d) Pericycle – Phellem – Endodermis – Phloem

222. Hypodermis in monocotyledonous stem is

(a) Parenchymatous (b) Chlorenchymatous (c) Collenchymatous (d) Sclerenchymatous

223. In a dorsiventral leaf, location of palisade tissue and phloem respectively are

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

224. In leaves, protoxylem (xylem) elements

(a) Face towards the adaxial side (b) Face towards the abaxial surface

(c) Are surrounded by metaxylem (d) Are scattered in the middle

225. In a dorsiventral leaf, protoxylem and metaxylem are located respectively

(a) Abaxial and adaxial sides (b) Adaxial and abaxial sides

(c) Adaxial and adaxial sides (d) Abaxial and adaxial sides

226. Dicot root can be identified by

(a) Exarch xylem (b) Absence of pith and endodermis

(c) Presence of more than 8 radial bundles (d) Occurrence of 2-6 radial bundles

227. Dicot isobilateral shaded leaves are called

(a) Mesophytic (b) Sciophytic (c) Heliophytic (d) Xerophytic

228. In isobilateral leaves chloroplasts are present in

(a) Only palisade parenchyma (b) Only spongy parenchyma

(c) Both (a) and (b) (d) All of the above

229. The similarity between palisade and spongy parenchyma of dorsiventral leaf lies in their

(a) Arrangement (b) Function (c) Shape (d) Size

230. The roots of angiosperms show exarch xylem and their stems have endarch bundles. The xylem being continuous throughout, the change in them occurs in

(a) Lower part of stem (b) Upper part of root (c) Hypocotyle region (d) Epicotyle region

231. A T.S. of dicot stem shows

(a) Vascular bundles arranged in a ring (b) Scattered vascular bundles

(c) Closed vascular bundles (d) Radial vascular bundles

Advance Level

232. 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

233. Bulliform 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

234. In monocot leaf

(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

235. In isobilateral leaf more plastids are found in

(a) Upper epidermis (b) Lower epidermis (c) Mesophyll cells (d) Pericycle

236. 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

237. In a vertical section of a dorsiventral leaf, the protoxylem in its midrib bundle

(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

238. In a longitudinal section of a root, starting from the tip upward, the four zones occur in the following order

(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

SECONDARY GROWTH

Basic Level

239. Vascular cambium is a meristematic layer that cuts off

(a) Primary xylem and primary phloem (b) Xylem vessels and xylem tracheids

(c) Primary xylem and secondary xylem (d) Secondary xylem and secondary phloem

240. Growth rings (annual rings) are formed by activity of

(a) Cambium (b) Xylem

(c) Phloem (d) Both xylem and phloem

241. Annual rings are distinct in plants growing in

(a) Tropical regions (b) Arctic region (c) Grasslands (d) Temperate region

242. Intrafascicular cambium is situated in

(a) Out side the vascular bundles (b) In medullary rays

(c) Inside the vascular bundles (d) In between the vascular bundles

243. Annual rings are the bands of

(a) Secondary cortex and cork (b) Secondary vascular tissues

(c) Secondary xylem and medullary rays (d) Secondary phloem and medullary rays

244. The collective name for cork cambium and phelloderm is

(a) Phellogen (b) Periderm (c) Endoderm (d) Secondary tissue

245. An example of monocots showing secondary growth in stem is

(a) *Lilium* (b) *Cocos* (c) *Asparagus* (d) *Yucca or Dracaena*

246. 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

(a) Cutin (b) Suberin (c) Lignin (d) Hemicellulose

247. Active division takes place in the cells of

(a) Xylem (b) Phloem (c) Cambium (d) Sclerenchyma

248. Lenticels are found in

(a) Young dicot stem (b) Old dicot stem (c) Monocot root (d) Young root

249. Secondary growth is absent in

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

250. Tyloses are found in

(a) Secondary xylem (b) Secondary phloem (c) Callus tissue (d) Cork cells

251. If four radial vascular bundles are present, then the structure will be

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

252. The balloon like outgrowth of parenchyma in the lumen of a vessel is known as

(a) Histogen (b) Tyloses (c) Phellogen (d) Tunica

253. The functional xylem of dicot tree is

(a) Sap wood (b) Hard wood (c) Heart wood (d) Autumn wood

254. Tyloses thickenings are seen in

(a) Phloem cells (b) Ray parenchyma only

(c) Collenchyma (d) Ray parenchyma and xylem cells

255. Lenticel develops through the activity of

(a) Vascular cambium (b) Dermatogen (c) Phellogen (d) Intercalary meristem

256. In dicot roots, cork cambium is derived from

(a) Epidermis (b) Hypodermis (c) Cortex (d) Pericycle

257. The pores present in the wall of plant's stem i,e. called

(a) Lenticels (b) Bark (c) Dalipore (d) All the above

258. Main function of lenticel is

(a) Transpiration (b) Guttation (c) Bleeding (d) Gaseous exchange

259. Bhojpatra is got from bark of

(a) *Dalbergia* (b) *Cinchona* (c) *Piper* (d) *Betula*

260. Periderm is made up of

(a) Phellem (b) Phellogen (c) Phelloderm (d) All the above

261. Secondary growth is absent in

(a) Hydrophytes (b) Mesophytes (c) Halophytes (d) Xerophytes

262. Heart wood or duramen is

(a) Outer region of secondary xylem (b) Inner region of secondary xylem

(c) Outer region of secondary phloem (d) Inner region of secondary phloem

263. Cork cells are

(a) Dead (b) Photosynthetic

(c) Elongated and participate in movement (d) Meristematic

264. Cork is a derivative of

(a) Cork cambium (phellogen) or extra fascicular cambium

(b) Vascular cambium

(c) Fascicular cambium (d) Interfascicular cambium

265. Cork cambium is otherwise called

(a) Phellem (b) Phelloderm (c) Periderm (d) Phellogen

266. Which structure is not found in the leaves of a bean plant

(a) Guard cell (b) Chloroplast (c) Phloem (d) Lenticel

267. In which of the following there is no differentiation of bark, sap wood and heart wood

(a) Ashok (b) Neem (c) Mango (d) Date palm

268. The xylem which is functional in a dicot tree is

(a) Spring wood (b) Sap wood (c) Autumn wood (d) Heart wood

269. Wood is a common name of

(a) Phloem (b) Secondary xylem (c) Cambium (d) Vascular bundles

270. Which one yields drug for malaria

(a) *Penicillium* (b) Algae (c) Bacteria (d) *Cinchona* bark

271. As a tree grows older which increases rapidly in thickness

(a) Its heart wood (b) Its cortex (c) Its sap wood (d) Its phloem

272. Fusiform initials form

(a) Vascular rays (b) Treacheary elements (c) Ray parenchyma (d) Phloem parenchyma

273. Which of the following meristems is responsible for extrastelar secondary growth in dicotyledonous stem

(a) Phellogen (b) Intrafascicular cambium

(c) Interfascicular cambium (d) Intercalary meristem

274. Cork cambium produces

(a) Pith (b) Secondary xylem

(c) Phellogen (d) Secondary cortex and cork

275. Which of the following is responsible for the growth in circumference or girth of stem and root in plants (in crucifers)

(a) Xylem (b) Phloem

(c) Cortex (d) Cambium (Meristematic tissue)

276. Fascicular cambium found in dicot stem is a

(a) Secondary meristem (b) Primary meristem (c) Intercalary meristem (d) Apical meristem

277. Cambium is most active in

(a) Summer (b) Winter (c) All seasons (d) Snow areas

278. The abscission layer is covered by a leaf scar which is composed of

(a) Pectose and cellulose (b)Resin (c) Pectin (d) Cutin

279. Which would do maximum harm to a tree ? The loss of

(a) Half of its branches (b) All of its leaves (c) Half of its flowers (d) Its bark

280. Secondary growth occurs through

(a) Formation and division of meristematic cells (b) Vascular region

(c) Cortical region (d) Both (b) and (c)

281. 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

282. In roots and stems, secondary growth takes place after the formation of

(a) Cambium (b) Sclerenchyma (c) Cork (d) Bark

283. Secondary growth or increase in diameter is due to

(a) Ground meristem (b) Procambium (c) Cork or phelloderm (d) Vascular cambium

284. Which will decay faster if exposed freely

(a) Soft wood (b) Heart wood

(c) Sap wood (d) Wood with lots of fibres

285. The interfibrillar material of the secondary wall is chiefly made up of

(a) Fat (b) Wax (c) Lignin (d) Glucose

286. No secondary growth occurs in monocot stems because

(a) Vascular bundles are scattered (b)Vascular bundles are closed

(c) Vascular bundles are enclosed by bundle sheath (d)None of the above

287. Bulliform cells are also called

(a) Motor cells (b) Latex cells (c) Stone cells (d) Rod cells

288. Lenticels are

(a) Scars on old stems (b) Special stomata

(c) Aerating pores in bark (d) Special stomata on hydrophytic plants

289. Age of a tree can be determined by counting

(a) Number of nodes and internodes (b) Number of annual rings near the base

(c) Number of annual rings near the tip of trunk (d) Number of branches

290. Sap-wood is

(a) Outer functional part of secondary xylem (b) Inner nonfunctional part of secondary xylem

(c) Outer as well as inner part of secondary xylem (d) None of the above

291. Exchange of gases in old stems takes place from

(a) Stomata (b) Hydathodes (c) Lenticels (d) Passage cells

292. Abnormal secondary growth due to accessory cambia occurs in

(a) *Helianthus* (b) *Dracaena* (c) *Dalbergia* (d) *Cucurbita*

293. A nail inserted some years back at 1.5 metre height on a tree trunk shall

(a) Remain where it was (b)Move upwards (c) Move downwards (d) Move laterally

294. Vascularisation in plants occurs through

(a) Differentiation of procambium followed by primary phloem and then primary xylem

(b) Differentiation of procambium followed by development of xylem and phloem

(c) Simultaneous differentiation of procambium, xylem and phloem

(d) Differentiation of procambium is immediately followed by development of secondary xylem and secondary phloem

295. Hard wood have

(a) More of parenchyma (b)Vessels in abundance (c)Tracheids mainly (d) Nonporous nature

296. Each annual ring or growth ring consists of two strips of

(a) Autumn wood and spring wood (b) Heart wood and sap wood

(c) Xylem and phloem (d) Cork and cortex

297. Compact wood with little parenchyma is

(a) Heart wood (b) Hard wood (c) Pycnoxylic (d) Manoxylic wood

298. The process by which the plants becomes woody is called

(a) Calcification (b) Lignification (c) Impregnation (d) Fossilization

299. Growth rings are formed due to the activity of

(a) Intrastelar cambium (b) Intercalary cambium

(c) Extrastelar cambium (d) Primary cambium

300. In dicot root

(a) Vascular bundles are scattered and with cambium

(b) Vascular bundles are arranged in a ring and have cambium

(c) Xylem and phloem radially arranged (d) Xylem is always endarch

301. Dendrochronology is the study of

(a) Height of a tree

(b) Diameter of a tree

(c) Age of a tree by counting the number of annual rings in the main stem

(d) None of these

302. Innumerable vascular bundles, lack of cambium and lack of well demarcated pith are found in

(a) Sugar cane (b) Sunflower (c) Pea (d) Tomato

303. Growth rings are well marked in trees growing in

(a) Simla (b) Bombay (c) Madras (d) Calcutta

304. Hollow trunks in trees lead to

(a) Death of shoot (b) Normal growth (c) Death of root (d) Death of plant

305. A T.S. of stem is stained first with safranin and then fast green. What would be the colour of phloem

(a) Red (b) Green (c) Orange (d) Purple

306. Which one contain vascular bundles in a ring

(a) Wheat (b) Lily (c) Cotton (d) Onion

307. Conduction of sap in plants occurs through

(a) Heartwood (b) Sapwood (c) Xylem (d) All the above

Advance Level

308. Knots in stems are formed due to

(a) Tumors formed due to bacterial infection of wounds

(b) Outgrowth of secondary tissue over wounds

(c) Injury caused by insects (d) None of the above

309. In a stratified cambium the fusiform initials are

(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

310. After the secondary growth, the oldest 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 vascular phloem (d) Just outside the secondary xylem

311. Tyloses are

(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

312. 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

313. The bark of tree comprises

(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

314. Youngest layer of secondary xylem in wood of dicot stem is located just

(a) Outside the cambium (b) Inside the cambium

(c) Outside pith (d) Inside the cortex

315. 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

316. 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

317. After two or three years of the secondary growth, the cortex in dicot root

(a) Remains intact (b) Is completely sloughed away

(c)Is largely lost (d) Is converted into cork

318. 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

319. No secondary growth appears in monocot roots because

(a) They have single cotyledon per seed (b) They possess adventitious roots

(c) They lack cambium (d) Vascular bundles are open

320. Leaves fall from the branches on account of

(a) Completing their duration of life

(b) Formation of abscission layer external to cork

(c) Shortening of day time

(d) Fall in atmospheric temperature

321. A hundred year old tree of temperate area will show

(a) Irregular number of rings which show increase or decrease along the length

(b) More than 100 rings at the base and less than 100 near the top

(c) 100 rings at the base and progressive decrease towards the top

(d) 100 rings from base to top

322. Removal of ring wood of tissue outside the vascular cambium from the tree trunk kill it because
(a) Water can not move up
(b)Food does not travel down and root become starved
(c) Shoot become starved (d) Annual ring are not produced

323. When secondary growth in thickness is initiated in dicot root, which of the following happens first
(a) Cambial initials between xylem and phloem divide
(b) Pericycle strands outside the primary xylem divide
(c) Anticlinal Divisions take place so that the cambium become circular
(d) Parenchymatous cells between xylem and phloem become meristematic

324. Vascular cambium forms xylem on inner side and phloem on outer side due to
(a) Effect of gravity (b) Shearing force of wind
(c) Intrafascicular nature (d) Differential action of hormone

325. Common features between lenticels and hydathodes are
(a) Allow exchange of gases
(b) Always remain closed
(c) There is no regulation of their opening and closing
(d) They occur on the same organ of the plant

MISCELLANEOUS PROBLEMS

Basic Level

326. Branch of botany which deals with the study of internal organization of plants is
(a) Physiology (b) Ecology (c) Anatomy (d) Cytology

327. Leaves are situated on
(a) Nodes (b) Internodes (c) Tip (d) None of these

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

329. Which of the following cell is totipotent
(a) Meristem (b) Sieve tube (c) Collenchyma (d) Xylem vessel

330. Lignin is the main constituent of
(a) Woody tissues (b) Growing tissues (c) Phloem (d) Cortex

331. Which of the following cells is not totipotent
(a) Pollen grain (b) Sieve cell (c) Epidermal cell (d) Pith cell

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

333. The undifferentiated cells are present in
(a) Sepals of *Geranium* flower (b) Cambium of oak
(c) Maple tree root system (d) Root of *Raphanus*

334. Raphides are needle-like crystals of calcium oxalate which are specially found in
(a) *Pistia* (b) Rose (c) *Asparagus* (d) Dahlia

335. Where would you look for an active cell division in a plant
(a) In cortex (b) In pith
(c) At tip of the stem (d) In the internodal region

336. Commercial cork is obtained from
(a) Mango (b) Oak (*Quercus suber*) (c) *Ficus religiosa* (d) *Pinus*

337. Wound healing is due to
(a) Primary meristem (b) Secondary meristem (c) Ventral meristem (d) All of the above

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

339. Who is the father of anatomy
(a) Grew (b) Haberlandt (c) Nageli (d) Strasburger

340. Root hairs are present on
(a) Radish (b) Wheat (c) Maize (d) None of these

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

342. Raphides are found in
(a) *Citrus* (b) *Potato* (c) *Nerium* (d) *Mango*

343. Cystoliths sometimes deposited in plant cells are crystals of (aggregation of)
(a) Calcium oxalate (b) Calcium carbonate (c) Magnesium carbonate (d) Glucosides

344. Which of the following tissues is present in the leaves of *Pinus* to conduct water and food
(a) Xylem (b) Phloem (c) Transfussion tissue (d) Conducting tissue

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

346. Mesarch xylem is common in
(a) Ferns (b) Bryophytes (c) Dicots (d) Monocots

347. Exarch xylem is found in
(a) Root (b) Stem (c) Leaf (d) Rachis

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

349. Resin canals are
(a) Schizogenous (b) Lysigenous (c) Schizolysigenous (d) None of these

350. In trees, the death of protoplasm is essential for a vital function such as
(a) Food transport (b) Water transport (c) Both (a) and (b) (d) Stomatal movement

351. Protosteles are found in
(a) Bryophyta (b) Gymnosperms (c) Pteridophyta (d) Angiosperms

352. Centripetal xylem is the characteristic of
(a) Roots (b) Stems (c) Leaf (d) Petiole

353. The most primitive type of stele is
(a) Eustele (b) Solenostele (c) Protostele (d) Siphonostele

354. Eustele is characteristic of
(a) Monocots (b) Dicots (c) Pteridophytes (d) Bryophytes

355. A stele consisting of numerous fascicular bundles is
(a) Eustele (b) Dictyostele (c) Atactostele (d) Solenostele

356. Stele consists of
(a) Phloem (b) Xylem (c) Pericycle (d) All the above

357. Origin of vegetative branch is
(a) Schizogenous (b) Endogenous
(c) Exogenous (d) Internal from intercalary meristem

358. Lightest wood is
(a) *Cereus giganteus* (b) *Ochroma lagopus* (c) *Hardwickia binata* (d) *Cycas*

359. A stele with a central core of xylem surrounded by phloem is called
(a) Protostele (b) Siphonostele (c) Solenostele (d) Dictyostele

360. Periclinal division in a cell takes place by
(a) Vertical cleavage (b) Transverse cleavage
(c) Perpendicular cleavage (d) Tangential cleavage

361. Inulin and raphide crystals are which type of plant products
(a) Excretory (b) Inorganic (c) Respiratory (d) Reserve material

362. Which one of the following shows origin and evolution of steles
(a) Bryophytes (b) Pteridophytes (c) Gymnosperms (d) Angiosperms

363. Stelar theory was given by
(a) Van Tieghem and Douliot (b) Zimmerman
(c) Huxley (d) Hanstein

364. Grafting is not possible in monocots because they
(a) Have scattered vascular bundles (b) Have parallel venation
(c) Are herbaceous (d) Lack cambium

365. The stems of hydrophytic plants are soft and weak because of the poor development of
(a) Pith and supporting parenchyma (b) Phloem and companion cells
(c) Xylem and supporting tissue (d) Cortex and endodermis

366. Why soil particles remain adhered to root hair even after adequate washings? Because the wall of root hair have a predominance of
(a) Lignin (b) Pectin (c) Suberin (d) Chitin

367. 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

368. The total time in which growth occurs is called
(a) Phase of maturation (b) Phase of cell division
(c) Phase of elongation (d) Grand period of growth

369. Wilting of plants takes place when one of the following takes place
(a) If few roots are damaged (b) Light is cut to 50%
(c) Xylem is blocked (d) Phloem is blocked

370. Plant fibres can originate from

(a) Phloem, xylem, epidermis and sclerenchyma tissues

(b) Phloem, xylem and sclerenchyma tissues

(c) Phloem, xylem and epidermis tissues (d) Xylem, epidermis and sclerenchyma tissues

371. 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

372. Girdling experiment cannot be performed with sugarcane plant because

(a) Its stem is thin

(b) Its vascular are not arranged in a sequential order

(c) Its stem surface is coated with wax (d) None of the above

ANSWER

ASSIGNMENT (BASIC & ADVANCE LEVEL)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
a	c	d	c	a	a	c	d	d	a	c	b	a	a	a	b	c	b	a	b
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
d	c	c	d	c	a	d	c	b	a	d	b	b	a	c	c	b	c	a	d
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
c	c	c	c	b	a	b	a	a	a	a	d	b	b	b	a	b	c	b	d
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
c	c	a	d	c	a	a	b	d	a	c	b	d	b	d	b	a	b	b	c
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
b	b	d	b	a	b	b	a	a	b	c	d	c	d	b	a	c	a	b	b
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
a	d	b	b	c	a	a	c	a	d	a	a	d	c	a	a	d	a	a	a
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
b	a	c	d	b	a	a	d	a	c	b	d	b	b	d	a	c	a	d	c
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
a	a	c	a	d	a	d	d	d	d	d	a	b	c	d	c	a	b	a	b
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
a	d	c	a	d	a	b	c	c	a	a	a	c	b	a	b	b	b	c	b
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
a	c	d	b	b	c	d	b	a	d	c	b	c	d	a	b	a	b	a	a
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
d	b	d	b	b	a	b	a	b	a	d	d	a	d	b	b	c	c	a	a
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
c	d	b	a	b	d	c	b	b	c	a	d	d	d	c	c	a	c	d	a
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
d	c	b	b	d	b	c	b	c	a	d	b	a	d	c	d	a	b	d	d
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
a	b	a	a	d	d	d	b	b	d	a	b	a	d	d	b	a	b	d	a
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
d	a	d	a	c	a	a	c	b	a	c	b	a	b	b	a	a	b	a	c
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320

c	a	a	b	b	c	b	b	c	c	b	a	a	b	b	c	c	d	c	b
321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
c	b	d	d	c	c	a	b	a	a	b	c	b	a	c	b	a	b	a	a
341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
a	c	b	c	d	a	a	b	a	b	c	a	c	b	c	d	c	b	a	d
361	362	363	364	365	366	367	368	369	370	371	372								
d	b	a	d	c	b	b	d	c	a	a	b								

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