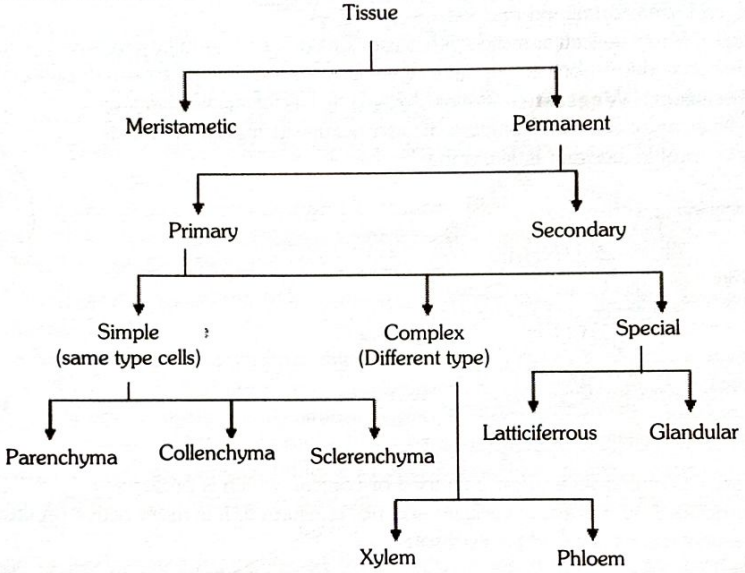
6. Anatomy of Flowering Plants

1. Anatomy

Anatomy is study of internal structure''' (with naked eye). N.Grew known as father of plant anatomy. K.A. Chaudhary known as father of Indian plant anatomy. In plants not much internal structure is visible to naked eye. Histology is the study of tissues with the help of microscope. N. Grew is called the father of plant anatomy, he coined the terms tissue and parenchyma.

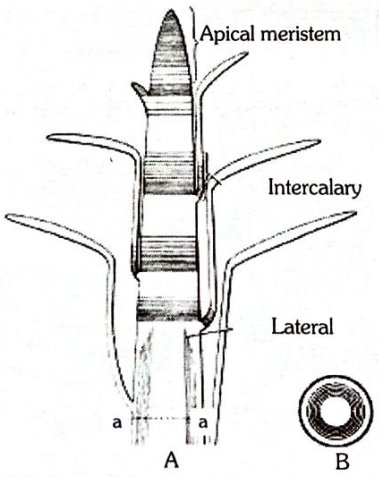
2. Plant Tissues

Tissue is group of cells having a common origin & helping to perform same or similar functions. Based on their capacity to divide plant tissues has classified into two fundamental types, meristematic & permanent



2.1. Meristematic Tissue

Simple living tissues, which are capable of division and formation of new cells. Meristematic cells are, Small, isodiametric, Compactly arranged intercellular spaces are absent. Wall is thin and cellulosic, Cytoplasm dense, Nucleus large, Proplastids present. Metabolic activity high.



Various meristametic tissue

(1) On the basis of origin

- **Promeristem (mother of other meristem) :** Part of apical meristem and their most recent derivatives.
- **Primary Meristems :** Meristems derived directly from meristems of embryo and retaining the ability to divide from very beginning, *e.g.*, apical meristem, intercalary meristem, intrafascicular cambium.
- **Secondary Meristem :** It formed from permanent tissues by dedifferentiation, *e.g.*, interfascicular cambium, cambium of root, phellogen, wound cambium.

(2) On the basis of Position

- **Apical Meristems :** Present at tips of stem and root. It take part in initial growth or elongation of roots and stems.
- **Intercalary Meristems :** They are derived from the apical meristems and separated from same by permanent cells.
- It occur at leaf bases and above or below the nodes *(e.g.,*Grass, Mint). It help in elongation of leaves and internodes, prostrate stems to become erect.
- **Lateral Meristems :** Occur on the sides and helpful in increasing girth of stem and root, *e.g.*, vascular cambium, phellogen (cork cambium).

2.2. Theories Explaining the Meristem

(1) Apical Cell Theory (Hofmeister): All tissues of plant body are derived from a single apical cell. It is found in some lower plants like algae, bryophytes and pteridophytes.

(2) Tunica Corpus Theory (Schmidt): Shoot apex has two zones, outer tunica and inner corpus. Tunica forms epidermis by anticlinal divisions but also forms ground tissue if multilayered. Corpus is inner mass, where cells undergo divisions in different planes to form vascular tissues and cortex, endodermis and pith.

(3) Histogen Theory (Hanstein): Promeristem forms three meristematic regions or histogens -
Dermatogen: Outermost forms epidermis or epiblema (in root),
Periblem: Middle histogen forms cortex and endodermis.
Plerome: Central histogen, forms vascular strand (pith, vascular/bundles, medullary rays and pericycle).
Haberlandt gave names protoderm (for dermatogen), ground meristem (for periblem) & procambium (for plerome)

- **Stem Apical Meristem (Vegetative Shoot Apex):** It lies in active form as terminal bud of shoot apex and its branches. It also occurs in inactive state as lateral buds in the axils of leaves and it is terminal.

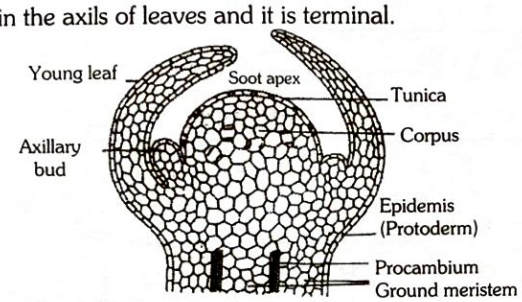


Fig : L.S. vegetative shoot apex

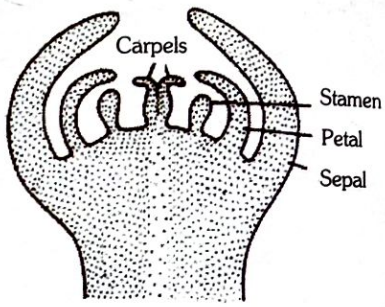


Fig. L.S. Reproductive apex (diagrammatic)

Vegetative shoot apex is multicellular, dome-shaped or conical, which is protected by young leaves produced by it. It show cyclicity and not consumed. It is more active on flanks than summit. Period between origin of two successive leaves is called plastochron.

- **Reproductive Shoot Apex:** It is multicellular, wide and nearly flattened meristem. It does not show cyclicity & get consumed in formation of various floral organs. It is more active on summit than flank.

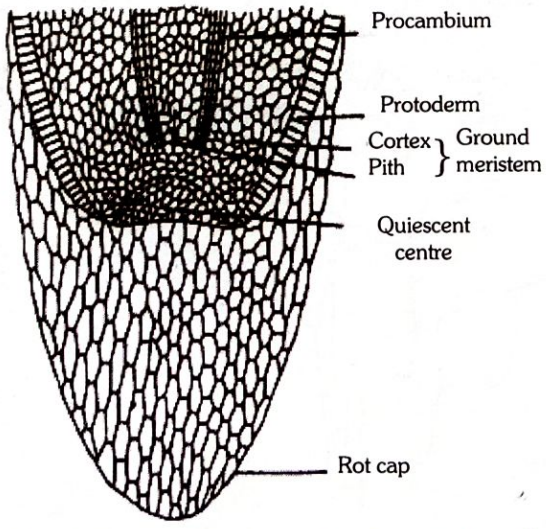


Fig : L.S. root apical meristem vegetative shoot apex

Order of organ formation: Sepal---Petal---Stamen---Carpels.

- **Root Apex:** It lies below root cap and is hence subterminal. It is rounded but appears to be inverted cup-shaped due to presence of a quiescent centre (Clowes in maize). Quiescent centre is reserve meristem where divisions are very few as it has more RNA and less DNA Root apical meristem forms 3 or 4 structures - protoderm, procambium, ground meristem and calyptrogen. Calyptrogen occurs in monocot roots. It forms root cap. Protoderm produces epiblema. In dicots it also forms root cap. Procambium gives rise to vascular strand. Cortex, pith, endodermis are formed by ground meristem.

2.3. Permanent Tissue

Cells have lost capacity to divide, have become mature and attained a permanent shape, size. Depending upon their origin, permanent tissues are of two types, primary and secondary. Primary tissues are derived from primary meristems. Secondary tissues derived from secondary meristem. Primary tissues add to primary growth of the plant. Secondary tissues usually add to the diameter of the plant. Permanent tissues are simple (one type of cells), complex (more types of cells) and specialised.

(1) Simple Permanent Tissue

Having permanent cells that are similar in structure, origin, function. It is of three types - parenchyma, collenchyma and sclerenchyma.

- **Parenchyma**

  Living tissue made of isodiametric cells having thin walls. Cells are either closely packed or have small intercellular spaces. It is most common and abundant tissue. It is morphologically & physiologically unspecialised. The tissue takes part in the storage of food, slow conduction and turgidity of softer parts. Common modifications are

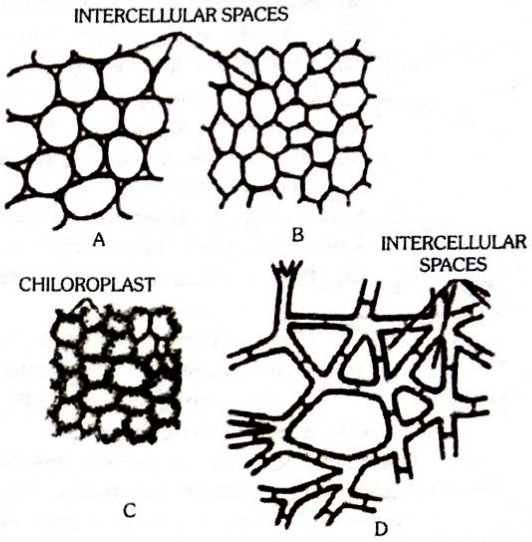
  (a) Chlorenchyma : Cells having chloroplasts and hence taking part in photosynthesis. Chlorenchyma of leaf is called mesophyll.

  (b) Aerenchyma : Network of cells enclosing large air cavities, *e.g.*, aquatic plants.

  (c) Epidermis : Cutinised parenchyma cells forming covering layer.

  (d) Guard Cells : They are a pair of specially thickened small reniform or dumb-bell shaped cells.

  (e) Idioblasts : Specialised parenchyma cells containing inclusions like crystals, tannins, oil.



Types of Parenchyma (A & B) C. Chlorenchyma D. Aerenchyma

Fig: Types of Parenchyma cells

Functions of Parenchyma

Their main function is to repair. In leaves, they form the mesophyll and are responsible for photosynthesis and the exchange of gases,parenchyma cells in the mesophyll of leaves are specialised parenchyma cells called chlorenchyma cells (parenchyma cells with chloroplasts). Storage of starch, protein, fats. oils and water in roots, tubers (e.g. potatoes), seed endosperm (e.g. cereals) and cotyledons (e.g. pulses and peanuts). Secretion (e.g. the parenchyma cells lining the inside of resin ducts). Wound repair and the potential for renewed meristematic activity. Other specialised functions such as aeration (aerenchyma) provides buoyancy and helps aquatic plants in floating. Chlorenchyma cells carry out photosynthesis and manufacture food.

- **Collenchyma**

  Living tissue made of isodiametric or elongated living cells having thickening pectocellulosic nonlignified primary walls. Collenchyma provides both mechanical strength and elasticity, so called living mechanical tissue. It is found in hypodermis of dicot stems and petioles. It is abundant in climbing stems.

  Functions of Collenchyma-

  It provides mechanical strength to the petiole, leaves and stem of young dicot plants. Collenchyma confers flexibility to various parts of the plant like petiole and stem, allowing for easy bending without breakage. It allows for growth and elongation of plant organs. Collenchyma present in leaves also prevents them from tearing. The living cells of collenchyma store food. Collenchyma when containing chlorophyll performs the function of photosynthesis.

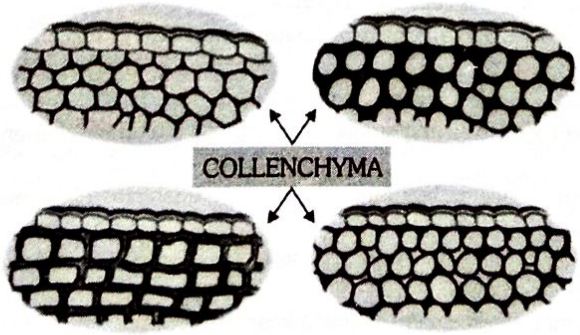


Fig: Cross section of Collenchyma cells

- **Sclerenchyma**

  Mechanical tissue formed of dead cells (exception Tamarix aphylla). Thickening is usually of lignin but can be cellulosic *(e.g.*Cotton, Flax).

  Sclerenchyma is of two types - Fibres and sclereids.

  Sclerenchyma Fibres: Elongated, spindle-shaped cells with pointed end walls. Found in hypodermis of monocot stem, around vascular bundle, in pericycle, phloem & xylem.

  Commercial Fibres- According to their origin commercial fibres are divided into following types.

(a) **Surface Fibres :** Fibres obtained from surface of seeds, *e.g.* Cotton, *Calotropis,* Coconut (coir). Cotton fibers are cellulosic, which are long (lint) and short (fuzz).

(b) **Extraxylery Fibres :** Present in stem in pericycle (soft bast) or phloem (hard bast), *e.g., Cannabis* (Hemp), *Linum* (Flax, from pericycle), *Corchorus* (Jute), *crotalaria* (Sunn Hemp), *Hibiscus* (Patua).

(c) **Xylery :** From xylem or wood.

(d) **Leaf Fibres :** Fibres extracted from leaves, *e.g.. Agave* (Sisal Hemp), *Musa* (Manila Hemp).

Sclerenchyma Sclereids : Broad cells which may be many shaped. They formed from parenchyma. Sclereids are of Five types :

(a) **Brachysclereids (Stone cells) :** Isodiametric and rounded, *e.g.,* grit of pear and apple.

(b) **Macrosclerids :** Columnar, *e.g.,* epidermis of legume seeds.

(c) **Osteosclereids :** Elongated with ends swollen like bones, *e.g.,* subepidermis of legume seeds.

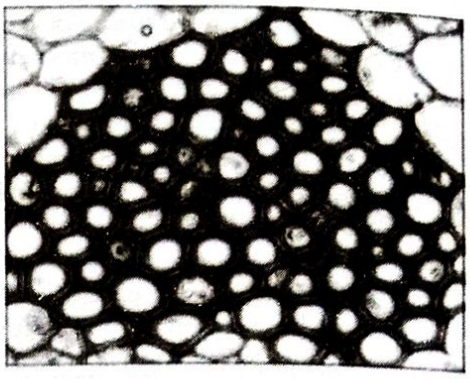


Fig: Cross section of sclerenchyma fibres

Functions of Sclerenchyma

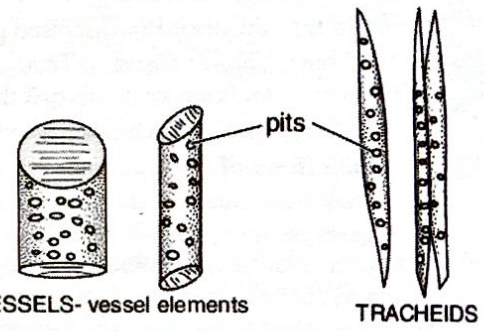
These cells provide mechanical strength to the plant body and are supporting tissues. These cells provide hardness and strength to the seed coat. Sclereids are responsible for the hardness of date seeds and walnuts shells. Young living fibres store starch granules.

Fibres probably play role in the transport of solutes to the plants. Long, rigid fibres have potential of fibres of commercial importance.

Grittiness in guava is due to presence of sclereids

(2) Complex Permanent Tissue

Made up of more than one type of cells, helping to perform a similar function *e.g.* conducting tissue Conducting or vascular tissues conduct materials within the plant body. They occur in vascular plants (pteridophytes, gymnosperms & angiosperms), called tracheophyta. Vascular tissues are of two types- xylem and phloem.



- **Xylem / Hadrom (Nageli)**

It conducts sap, hormones and provides mechanical strength. Xylem is made of four types of cells - tracheids, vessels, xylem fibres and xylem parenchyma. Conduction of sap is performed by only tracheids and vessels. So, called tracheary elements.

(a) Tracheids : Dead, elongated tube-like cells with wide lumen and lignified walls. Ends are tapering. In transverse section tracheids can be circular, polygonal or polyhedral. In gymnosperm & pteridophyte, they forms chief water transporting elements .

(b) Vessels : Formed by end to end fusion of tracheids with perforations in end walls. (called syncyte). Exceptionally long vessels occur in *Eucalyptus*. Commonly they are of the size of 10 - 20 cm. Vessels occur only in angiosperm. They are circular/oval in T.S. in monocots & angular in dicots. Vessel less angiosperm are Drymis, Australobelia, Wintria, Trochodendron, Tetracentron. Vessels also occur in some pteridophytes and gymnosperms. e.g.Selleginella, Gnetum. Vessels are more efficient than tracheids in conduction of sap. They provide mechanical support.

(c) Xylem or Wood Fibres : Sclerenchyma fibres .Primitive Xylem. Tracheids with annular or spiral thickenings. Old xylems are blocked by parenchyma cells called tyloses.

(d) Xylem Parenchyma : Stores food and helps in lateral conduction of sap.

Primary Xylem : Primary xylem is derived from procambium during primary growth. It consists of protoxylem and metaxylem.

(a) Protoxylem is first formed xylem having smaller and narrow tracheary elements because lignification starts before the completion of growth.

(b) Mataxylem or later formed xylem, has larger and wider tracheary elements, because lignification starts only after completion of growth.

Secondary Xylem : Secondary xylem is formed from vascular cambium during secondary growth. It is not differentiated in protoxylem and metaxylem.

Depending upon relative position of protoxylem, xylem is of four types

(a) Exarch(centripetal): Protoxylem towards the outer side.

(b) Endarch(centrifugal): Protoxylem towards the inner side of metaxylem.

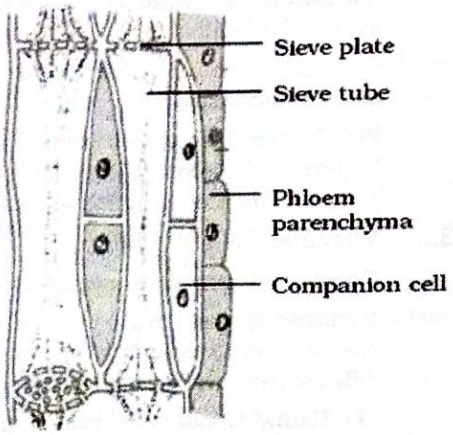
(c) Mesarch: Protoxylem surrounded by metaxylem.

(d) Centrarch: Protoxylem in the centre of metaxylem. Inside to outside and exarch xylem is known centripetal because differentiation of xylem proceeds from outside to inside.

- **Phloem**

Phloem or bast is a complex permanent vascular tissue, which conducts organic food in plant. It has four types of cells - sieve tubes (sieve cells in nonflowering plants), companion cells (albuminous cells in nonflowering plants), phloem parenchyma and phloem fibres. Conducting part of phloem has been called leptone by the Haberlandt.

(a) **Sieve Tubes :** Tubular elements of phloem, which are formed by end to end union of cells. The septa between indivi dual sieve tube cells or sieve elements are bulged out. They are called sieve plates because they possess a number of perforations called sieve pores or sieve pits. Common type of sieve plate is called simple sieve plate (sieve pores are uniformly distributed). In non flowering plants, sieve cells do not form tubes. Nucleus degenerates in mature sieve tube cell. Central part has a network of cytoplasmic strands. Tonoplast is absent, so cytoplasm and cell sap mixed called nyctoplasm. Microscopic fibrils of p-protein occur in sieve tube. Some time p–protein blocks sieve pore called slime plug. In winter the sieve tube elements may become blocked with deposition of callose (a carbohydrate, β 1 - 3 glucan).



(b) **Companion Cells :** Elongated cells, which are connected with sieve tube through plasmodesmata. They control metabolic activities of sieve tube cells by means of their nuclei. Companion cells and sieve tube elements develop from common mother cells. Death of one brings about the death of other as well, so called sister cell. In non flowering plants, companion cell and sieve tube are replaced by albuminous cell and sieve cell (Strasburger).

(c) **Phloem Parenchyma :** It takes part in storage as well as slow lateral conduction of food. Besides food, the cells may also store resin, mucilage and latex, etc.

(d) **Phloem Fibres (Bast Fibres) :** It is only non living component of phloem (sclerenchyma fibres).

2.4. Secretory Special Tissue

They are commonly secretory or excretory tissues, *e.g.*, laticiferous, glandular

(1) Lacticiferous Tissue

They has branched tubes lined by secretory protoplasm. It is of two types :

(a) Latex Cells (Nonarticulated Laticifers) : Independent coenocytic tubes, *e.g., Euphorbia, Cannabis, Calotropis,* Banyan, Oleander.

(b) Latex Vessels (Articulated Laticifers) : Reticulate tubular system formed by fusion of latex cells, *e.g., Hevea* (rubber), Papaya (papain), Poppy (opium), Achras (chickle or chewing gum).

(2) Glandular Tissue

Glands are isolated secretory structures. Glands can be external or internal.

(a) External Glands

(i) Nectar Glands (Nectaries): Occur in flowers and floral parts.

(ii) Digestive Glands: Occur in insectivorous plants.

(b) Internal Glands

(i) Secretory Cells: They are specialised individual cells present here and there producing oil (magnoliaceae), tannin (tannin cells), resin (meliaceae), mucilage (cactaceae) and crystals.

(ii) Secretory Glands: They are multicellular internal regions which pour their secretion in cavities formed lysogenously *(e.g., Citrus)* or schizogenously *(e.g., Eucalyptus).*

3. Plant Tissues System

A tissue system is a tissue or a group of tissues formed from the same derivative of meristem and performs the same function irrespective of its position in the plant body. According to function, tissue systems are - protective, mechanical, photosynthetic, fundamental and vascular. Three types of tissue systems are recognised on the basis of their location (Sachs) - epidermal (dermal), ground (fundamental) and vascular (= fascicular).

3.1. Epidermal Tissue system

The cells of epidermis are parenchymatous having protoplasm and nucleus without intercellular spaces. Epidermis possesses numerous minute openings called stomata. Main function of stomata is exchange of gases between the internal tissues and the external atmosphere. Cuticle is present on the outer wall of epidermis to check evaporation of water. Epidermis forms a Protective layer in leaves, young roots, stem, flower, fruits etc.

3.2. Ground Tissue System

It includes all the tissues of the plant body except epidermal and vascular tissues. It constitutes the interior of organs except vascular system. Ground tissue system of the leaves is called mesophyll. In dicot stem, it is differentiated into hypodermis, cortex, endodermis, pericycle, and medulla

Hypodermis-It is situated below the epidermis. It is multilayered and made up of parenchymatous and sclerenchymatous cells.

General Cortex-This consists of parenchymatous cells with or without chloroplasts.

Endodermis - Endodermis is single layered made up of parenchymatous cells. The radial and internal walls of endodermal cell are thickened; a band of lignin or suberin knows as casparian strip is sometimes found on the radial and transverse wall of every cell.

Pericycle - It is single or multilayered and is situated in between endodermis and vascular bundles. It is made up of sclerenchymatous and parechymatous cells.

Pith-The central portion in stems and roots is called pith or medulla. It is made up of parenchymatous cells with intercellular spaces. In dicot stem the pith is large and well developed; in dicot roots the pith is either absent or small; in monocot roots large pith is present; in monocot stem the vascular bundles are scattered and the ground tissue is not marked into different parts.

3.3. Vascular Tissue System

Consists of a vascular strand or cylinder

It consists of xylem and phloem tissues which are found as strands termed as vascular bundles. The main function of xylem is to conduct water, materials to different parts of the plant body. The main function of phloem is transportation of food materials in different parts of the plant. Distinct patches of vascular tissue which are separated from one another by non-vascular areas

(1) Radial Bundles : Phloem & xylem occur as distinct bundles present on alternate radii, *e.g.,* roots.

(2) Conjoint Bundles : Has both xylem and phloem. They are of three types - collateral, bicollateral and concentric,

- **Collateral :** Conjoint bundles having phloem on the outside and xylem on the inner side. These are open, if fascicular/intrafascicular cambium found between xylem & phloem (dicot & gymnosperm stem) They are closed if cambial strip is absent, *e.g.,* monocot stems.
- **Bicollateral:** Phloem both on the outer and inner sides of xylem, *e.g., Cucurbita.* Inner cambium is active.

(3) Concentric Bundles: One type of vascular tissue surrounds the other completely. Two kinds, amphivasal and amphicribal.

- In amphivasal/leptocentric bundle, phloem forms a core, around which xylem is present, *e.g., Dracaena, Yucca.*
- In amphicribal/hadrocentric bundle, xylem forms a central core & phloem is present all around, *e.g.,* staminal bundles.

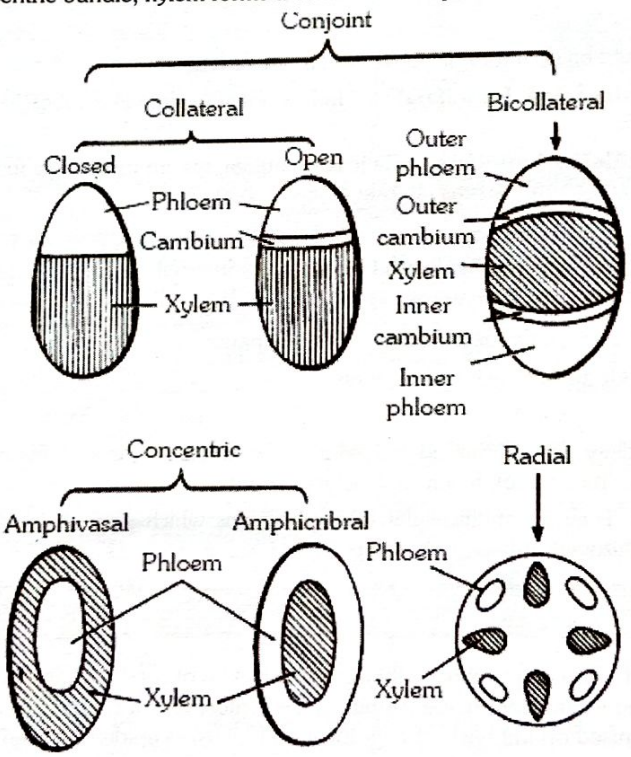


Fig. Different types of vascular bundles

4. Anatomy of Dicotyledonous and Monocotyledonous Plants

4.1. Internal Structure of Root

(1) Dicot Root

It is covered on outside by a layer of uncutinised epiblema or piliferous layer. Some cells of this layer form root hairs. Epiblema is followed by several layers thick parenchymatous cortex. Cortex is followed by endodermis. It has some barrel-shaped cells that has ligno-suberin thickenings called casparian strips. Endodermis functions as check post. Cells without casparian strips called passage cells (for entry of water). One or more layered pericycle lies below endodermis. Pericycle forms lateral roots, part of vascular cambium. Vascular strand has 2-6 alternate and radial bundles of xylem and phloem (diarch to hexarch). Xylem is exarch or centripetal. Pith is absent or small. Phloem occurs as oval patches below the pericycle in between the xylem strands. Conjunctive parenchyma occurs between xylem and phloem bundles.

- **Secondary Growth**

It occurs with help of vascular cambium (Intrastelar) and phellogen (Extrastelar) like stem.

(a) Intrastelar : Vascular cambium is formed secondarily from conjunctive parenchyma and part of pericycle. Vascular cambium becomes active initially below the phloem bundles and then above the xylem. When whole of vascular cambium becomes active, it appears wavy in outline. Vascular cambium becomes circular quite late. Vascular cambium derived from pericycle forms primary vascular rays. At other places it forms secondary xylem on the inner side and secondary phloem on the outside. Secondary xylem consists of vessels, xylem parenchyma and a few fibres. Previous phloem gets crushed when the new secondary phloem becomes operational. Secondary xylem as well as primary xylem persist. Annual rings are absent because there is little seasonal variation in soil temperature.

(b) Extrastelar : Cork cambium or phellogen is formed from outer pericycle. It produces phellem or cork on outside and secondary cortex or phelloderm on inner side. All three are together called periderm. Cortex and epiblema peel off. Cork or phellem is made of dead cells.

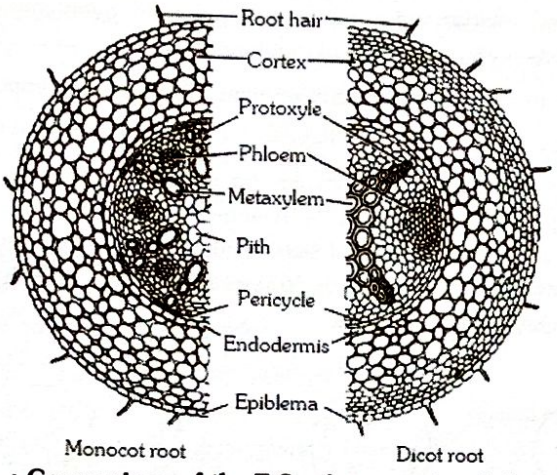


Fig. : Comparison of the T.S. of monocot and dicot root

(2) Monocot Root

Outer layer is uncutinised epiblema. Some cells give rise to tubular root hairs. Cortex is many layered thick, which has parenchymatous colourless cell. They store food. In older parts, outer layers of cortex become cutinised and form protective exodermis. Endodermis is a single layer of barrel-shaped cells. Cell has ligno-suberised casparian strips, except opposite proloxylem points, called passage cells. Pericycle is made of many parenchymatous layers. It forms outer boundary of stele. Vascular strand has a large number of alternate radial bundles of xylem and phloem (polyarch). Xylem is exarch or centripetal. Xylem has oval or rounded vessels. Secondary growth is absent. Rarely vascular bundles is less than 8, *e.g.*, 6 in Onion, Garlic.

4.2. Internal Structure of Stem

(1) Dicot Stem

On the outside, epidermis having multicellular, unbranched cutinised hair and stomata (kidney shaped). Inner to epidermis is a collenchymatous hypodermis of a (3 - 4) layers. Hypodermis is outer most cortex. Hypodermis is followed by parenchymatous cortex. Cells of hypodermis and cortex may have chloroplasts. Cortex is followed by endodermis (starch sheath). Endodermis is inner most cortex. Endodermis is followed by pericycle. Pericycle is heterogeneous and made of a few layers. Parenchyma and sclerenchyma occur alternatively. Sclerenchymatous pericycle occurs as bundle caps. Vascular bundles lie in a ring (eustele). They are wedge shaped, conjoint, collateral and open. Xylem lies inner side and phloem lies on the outside. In between the vascular bundles medullary rays are present. Pith (medulla) lies in the centre.

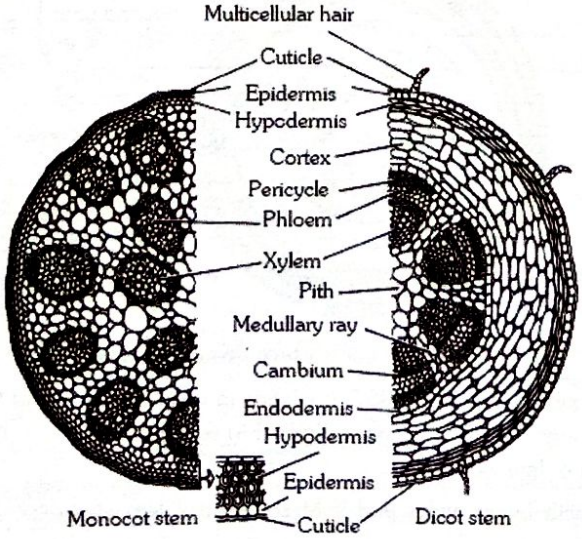


Fig. : Comparison of the T.S. of monocot and dicot stem

(2) Monocot Stem

On the outside, epidermis with silica and cuticle is present. Stomata (dumb-bell shape) present. Hypodermis is 2-3 layered, sclerenchymatous. Ground tissue is undifferentiated. So, endodermis, pericycle, cortex and pith are not differentiated. Numerous oval, conjoint, collateral and closed vascular bundles are found. They are scattered (atactostele) and of variable size with outer ones being smaller than the inner ones. Vascular bundles are surrounded by sclerenchymatous sheaths (fibrovascular bundles). Phloem has sieve tubes and companion cells but parenchyma is absent. Protoxylem has a schizo-lysigenous cavity called protoxylem cavity/lysigenous cavity.

- **Secondary Growth**

It is of two types – Intrastelar (by vascular cambium)and Extrastelar(by phellogen).

(a) Intrastelar : In side endodermis by vascular cambium. Vascular cambium is formed by strips of fascicular cambium (primary meristem) and interfascicular cambium formed by dedifferentiation of medullary ray cells. (secondary meristem) Vascular cambium has two types of divisions-

(i) Anticlinal divisions (at right angles to surface): It increases circumference of vascular cambium.

(ii) Periclinal divisions (parallel to surface): It produces xylem, phloem and vascular rays.

Vascular cambium produces secondary phloem on outside and secondary xylem on inner side. Phloem is not persistent. Older one is crushed as soon as the new one becomes functional. Secondary xylem or wood is persistent. So, it grows with age and increases girth of stem. Youngest secondary xylem occurs just inner to vascular cambium, while oldest just outside primary xylem /pith. Youngest secondary phloem lies just outside vascular cambium, while oldest just inner to primary phloem /pericycle.

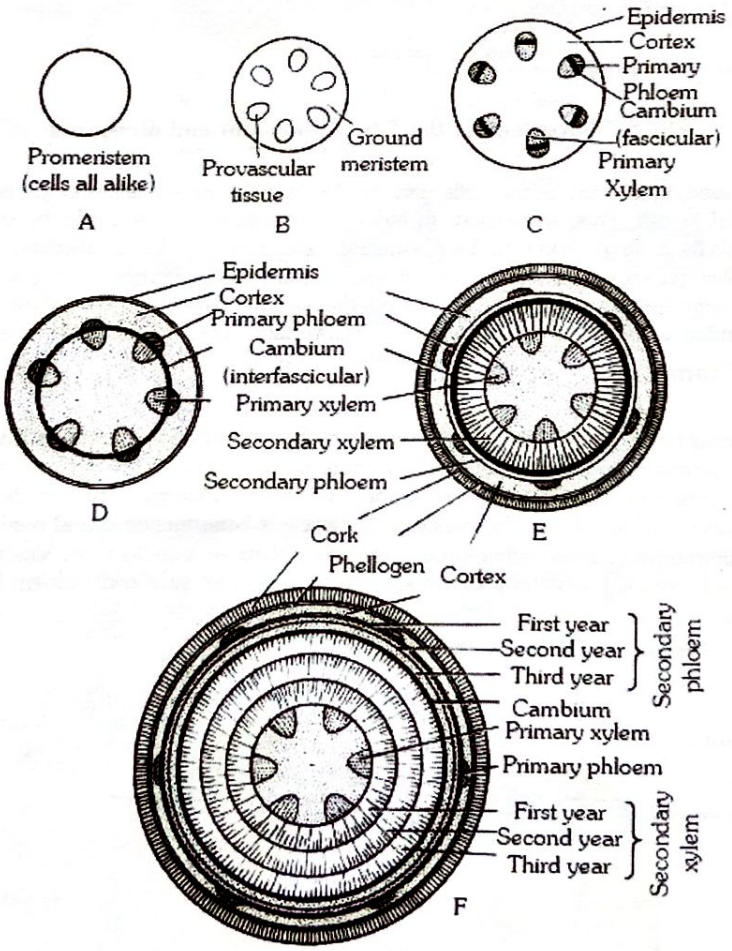


Fig. : Stages of secondary growth in stem

Wood - Formed of secondary xylem. 90-95% tracheids in gymnosperms and 90-95% vessels in angiosperms. Amount of secondary xylem is roughly 8-10 times as compared to secondary phloem. Each annual ring has two parts, spring or early wood and autumn or late wood.

Spring wood is wider with larger wider and light coloured xylem elements. Autumn wood has smaller, narrow and darker xylem elements.

Transition from spring to autumn wood is gradual, while transition from autumn to spring wood of next year is sudden. In temperate and tropical areas with wet and dry seasons, secondary xylem shows annual or growth rings. Each annual ring has one autumn wood and one spring wood. Number of annual rings present at base of stem indicates age of tree. Growth rings do not develop in area, where temperature & rain are uniform throughout year, *e.g.* sea coast, equator/tropical area.

Dendrochronology is determination of age of trees by study (counting) of annual rings. Wood of gymnosperms is called nonporous and soft wood (absence of vessels and fibres) It is porous and hard wood in case of dicots, where vessels and fibres are abundant.

Dicots have large sized vessels arranged in two ways - ring porous (vessels in early wood, *e.g., Dalbergia, Morns)* and diffuse porous (vessels distributed throughout, *e.g., Azadirachta).*

Ring porous is more efficient for translocation of water. In old trees, secondary xylem or wood gets differentiated into outer light coloured functional sapwood or alburnum and inner dark coloured nonfunctional heartwood or duramen. Heartwood is stronger and durable. Its size increases with time because of conversion of inner alburnum into it. Duramen/heart wood is nonfunctional part of secondary xylem as the tracheids and vessels of heart wood get plugged by tyloses (lignified and dead outgrowths of adjacent parenchyma cells), oils, resins, gums and tannins.

Heart Wood is maximum percentage in Morus alba and absent in Populus and Salix.

Lightest Wood is Ochroma pyranidale (O. Lagopus).

Heaviest Wood is Guaiacum officinalae. Heaviest wood of India belongs to Acacia sundra

Most Durable Wood is Tectona grandis (Teak).

Strongest Soft Wood is Cedrus deodar (Deodara, a gymnosperm).

Wooden Sports Articles: (i) Cricket Bat-Saliz (Willow). (ii) Violin-Picea (Spruce). (iii) Billiard Ball – Phytelephas (Ivory Palm) (iv) Hockey Blade – Morus (Mulberry). Hockey Handle-Salix.

(b) Extrastelar - Out side endodermis by cork cambium. Phellogen or cork cambium develops secondarily from some outer layer of cortex. Cells of phellogen/cork cambium divide on the outside as well as inside to form respectively cork or phellem and secondary cortex or phelloderm. Cork, cork cambium & secondary cortex are together called periderm. Cork or phellem is made up of dead suberised cells, which are filled with air and tannin. Commercial cork is obtained from *Quercus suber* (Cork Oak, Bottle cork). Cork has aerating pores or lenticels. It has loose suberinised complementary cells.

Bark is technically cork of dead cells outside phellogen. In nontechnical usage it means all tissues outside vascular cambium. The outer dead part of bark is then called rhytidome. The inner living part of bark comprises phellogen, secondary cortex and phloem. Outer part of bark is peeled off either in sheets (sheet or ring bark, e.g., Eucalyptus) or irregular strips (scaly bark, e.g., Guava == Psidium, Acacia). Sheet bark of Betula (Bhojpatra) was used as paper in ancient India. Bark of Cinchona gives quinine while that of Cinnamon provides spice (Dalchini). Bottle cork: It is peeled after every four years when plant (Quercus suber) becomes 20 years old (cork is cut vertically.)

Anomalous Secondary Growth

Monocots like *Dracaena, Yucca, Agave, Aloe,* etc may show abnormal secondary growth. A circular accessory cambium develops in the ground tissue just outside the original vascular bundles. It forms conjunctive tissue and a number of secondary vascular bundles.

In storage roots of Beet and Sweet Potato, accessory cambial rings are formed which cut out less/little secondary xylem and more of storage parenchyma in secondary phloem. Anomalous vascular bundles are those which occur in addition to normal ones like cortical (in cortex, *e.g., Nyctanthes)* or medullary (in pith, *e.g., Boerhaavia).*

Vascular bundles are scattered irregularly in dicot stems of Anemone and Thalictrum.

4.3. Internal Structure of leaf

(1) Dicot leaf

Upper surface is darker green as compared to lower surface. Both surfaces have a layer of epidermis. Epidermal cells are rectangular-barrel shaped. They are cutinized. Outer surface also bears a layer of cuticle. Hair and stomata occur at some places but commonly on lower side. Stomata are kidney/ reniform/ bean shaped, having chloroplast (absent in epidermal cells). Mesophyll occurs in between the upper epidermis and lower epidermis. Mesophyll is differentiated into upper palisade parenchyma and lower spongy parenchyma. Palisade parenchyma has 1 - 3 layers of closely placed columnar cells rich in chloroplasts. Spongy parenchyma is formed of rounded chloroplast having cells with large intercellular spaces. Vascular bundles present in between palisade and spongy parenchyma. Vascular bundle is surrounded by a thick walled parenchymatous bundle sheath. Vascular bundles are conjoint and collateral with xylem towards upper side and phloem towards the lower side.

Secondary growth is absent as the bundles are closed. In midrib region, the mesophyll is absent.

(2) Monocot leaf

Found in monocots where both surfaces are equally green. Both the surfaces are covered by a layer of epidermis. Epidermal cells are cutinized and possess deposit of silica. Cuticle also occurs on the outside. Epidermis has stomata having two dumb-bell shaped guard cells with associated accessory or subsidiary cells. Their leaves are amphistomatic as stomata occur on both the surface. Upper epidermis has large sized vacuolate bulliform or motor cells.(help in rolling of leaves during drought.) Mesophyll is undifferentiated and consists of isodiametric small circular cells enclosing small intercellular spaces. Vascular bundles are surrounded by one (panicoid) or two (festucoid) bundle sheaths.

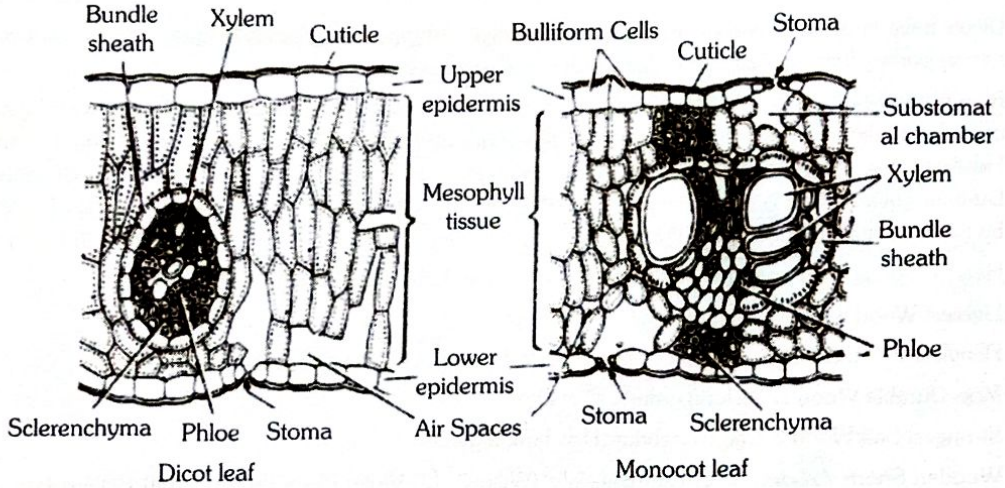


Fig. : Comparison of T.S. of a dicot and monocot leaf

Large vascular bundles have bundle sheath extensions, which may be sclerenchymatous. Midrib region has no mesophyll. It has a number of parallel vascular bundles partially embedded in sclerenchyma. Vascular bundle is conjoint, collateral, endarch and closed with phloem towards lower side & xylem towards upper. In larger bundles, the xylem may have protoxylem or lysigenous cavity. The latter lies towards upper surface.

4.4. Important notes

(1) Bicollateral Vascular Bundles : Having phloem both towards outer and inner side of xylem, e.g, Cucurbita. A strip of cambium occurs between the two on both outer and inner side in Cucurbita.

(2) Unusual Chlorenchyma : Roots of some epiphytic and aquatic plants possess chloroplasts for photosynthesis. Leaves and stems of aquatic plants and some shade plants possess chloroplasts in the epidermis as well.

(3) Abscission : A parenchymatous layer called abscission/ separation layer appears at the base. A suberised thick protective layer is formed below it. Cells of abscission layer gelatinize or degenerate causing the leaf/fruit to fall.

(4) Wound Healing : Exposed cells die. Wound cambium develops below it. It forms cork (wound cork) towards outer side and callus (mass of parenchyma cells) below.

(5) Knots : Bases, scars/wounds of fallen branches get covered by growth of secondary tissues. They form knots in wood.

(6) Cavities : Elongated cavities are called ducts. Depending upon origin, cavities are of three types :

(i) Schizogenous : Cavity formed by separation of cells or enlargement of intercellular spaces, e.g., resin ducts (Pinus), oil ducts (Sunflower).

(ii) Lysigenous : Breakdown or degeneration of cells, e.g., oil cavities in Citrus and Eucalyptus.

(iii) Schizolysigenous : By both separation and degeneration of cells, e.g., protoxylem cavity of Maize stem.

6. Anatomy of Flowering Plants – Multiple Choice Questions

1. Tissue (General)

1. Trachea, tracheids, wood fibres and parenchyma tissues are found in
   (a) Xylem (b) Phloem
   (c) Cambium (d) Cortex
2. Function of storage is performed by
   (a) Parenchyma (b) Sclerenchyma
   (c) Phloem (d) All the above
3. The plant tissues commonly found in fruit walls of nuts and pulp of some fruits like guava are termed as

   Or

   Pear fruits are gritty due to the presence of

   Or

   Tissue composed of non-parenchymatous cells and have isodiametric or irregular shape is called
   (a) Fibres (b) Tracheids
   (c) Sclereids (d) Vessels
4. Starch sheath is another name of
   (a) Hypodermis (b) Epidermis
   (c) Casparian strip (d) None of these
5. The function of a vessel is
   (a) Conduction of food
   (b) Conduction of water and minerals
   (c) Conduction of hormones
   (d) All the above
6. The meristem of root is
   (a) Apical (b) Sub apical
   (c) Intercalary (d) Lateral
7. Root cap is absent in
   (a) Lithophytes (b) Hydrophytes
   (c) Xerophytes (d) Mesophytes
8. Promeristem is found in
   (a) Embryo (b) Root apex
   (c) Shoot apex (d) Intercalary region
9. Tunica corpus theory was proposed by
   (a) Schmidt (b) Strasburger
   (c) Nageli (d) Hofmeister
10. From evolutionary point of view, tracheids and sieve cells are more primitive than tracheae and sieve tubes respectively. The angiosperms have
    (a) Tracheae and sieve tubes
    (b) Tracheids, tracheae and sieve tubes
    (c) Tracheids, sieve cells and sieve tubes
    (d) Tracheids, tracheae and sieve cells
11. At maturity, which of the following is non-nucleated
    (a) Palisade cell (b) Sieve cell
    (c) Companion cell (d) Cortical cell
12. Cork tissue arises from
    (a) Periderm (b) Phellogen
    (c) Pelloderm (d) Phellem
13. The histogen layer present at the apex of the root tip is called
    (a) Dermatogen (b) Procambium
    (c) Calyptrogen (d) Plerome
14. Radial conduction of water takes place by
    (a) Vessels (b) Vessels and trachieds
    (c) Phloem (d) Ray parenchyma cells
15. Laticiferous vessels instead of laticiferous cells are found in
    (a) Ficus (b) Calotropis
    (c) Poppy (d) Nerium
16. 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
17. Plant tissues, which are actively growing have water content of
    (a) 40 – 50% (b) 65 – 75%
    (c) 20 – 40% (d) 85 – 95%
18. The calyptrogen of the root apex forms
    (a) Rhizoids (b) Root nodule
    (c) Root hairs (d) Root cap
19. Sieve tubes have
    (a) Apical and oblique septa
    (b) Perforated and longitudinal septa
    (c) Perforated and oblique septa
    (d) Simple oblique wall
20. Which of the following tissues is present in the leaves of *Pinus* to conduct water and food
    (a) Xylem (b) Phloem
    (c) Transfusion tissue (d) Conducting tissue
21. Epidermis in stem is produced from
    (a) Protoderm (b) Procambium
    (c) Ground meristem (d) Calyptrogen
22. Which of the following elements has its end walls perforated
    (a) Trachieds (b) Vessel
    (c) Fiber (d) Sclereids
23. 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
24. Starch is mainly manufacture by
    (a) Palisade parenchyma (b) Spongy parenchyma
    (c) Guard cells (d) Vascular bundle
25. Fibres are obtained from
    (a) Xylem, phloem and sclerenchyma
    (b) Xylem, phloem, sclerenchyma and epidermis
    (c) Xylem, parenchyma, epidermis
    (d) Xylem, parenchyma, endodermis
26. The long plants are capable of standing erect due to presence of
    (a) Sclerenchyma (b) Collenchyma
    (c) Parenchyma (d) Prosenchyma

2. The tissue system

1. 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

2. 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
3. A stele with a central core of xylem surrounded by phloem is called
   (a) Protostele (b) Siphonostele
   (c) Solenostele (d) Dictyostele
4. A root hair is formed by
   (a) Epidermal cell (b) Endodermal cell
   (c) Cortical cell (d) Pericycle cell
5. Periblem gives rise to
   (a) Pericycle (b) Cortex
   (c) Medulla (d) Epidermis
6. Pith is absent in
   (a) Protostele (b) Siphonostele
   (c) Solenostele (d) Cladosiphonostele
7. A dicot plant in which scattered vascular bundles are present in stem is
   (a) *Yucca* (b) *Peperomia*
   (c) *Dolichos* (d) *Helianthus*
8. When formation of metaxylem is in a centripetal manner, the xylem is
   (a) Endarch (b) Exarch
   (c) Mesarch (d) Radial
9. Medullary rays are made up of
   (a) Parenchymatous cells (b) Sclerenchymatous cells
   (c) Tracheids (d) Fibres

3. Internal structure of root, stem and leaf

1. Epiblema in roots is derived from
   (a) Protoderm (b) Procambium
   (c) Ground meristem (d) Calyptrogen
2. 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
3. Grafting is not possible in monocots because they
   (a) Have scattered vascular bundles
   (b) Have parallel venation
   (c) Are herbaceous
   (d) Lack cambium
4. In a vertical section of a dorsiventral leaf, the protoxylem in its midrid 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
5. Collenchymatous hypodermis is characteristics of
   (a) Dicot stem
   (b) Monocot stem
   (c) Monocot as well as dicot stem
   (d) Hydrophytes
6. Which of the following is seen in a monocot root
   (a) Large pith (b) Vascular cambium
   (c) Endarch xylem (d) Medullary ray

4. Secondary growth

1. Cork cambium is a
   (a) Secondary meristem (b) Apical meristem
   (c) Intercalary meristem (d) Primary meristem
2. 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
3. The vascular cambium in dicots is
   (a) Lateral (b) Apical
   (c) Intercalary (d) Secondary
4. In an annual ring, the light colored part is known as
   (a) Early wood (b) Late wood
   (c) Heartwood (d) Sapwood
5. 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
6. Which of the following is known as wood
   (a) Primary xylem (b) Secondary xylem
   (c) Secondary phloem (d) Cambium
7. 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
8. 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
9. Which one of the following is not correct
   (a) Early wood is characterized by large number of xylary elements
   (b) Early wood is characterized by vessels with wider cavities
   (c) Late wood is characterized by large number of xylary elements
   (d) Late wood is characterized by vessels with narrower cavities
10. Annual rings are distinct in plants growing in
   (a) Tropical regions (b) Arctic region
   (c) Grasslands (d) Temperate region
11. Growth rings (annual rings) are formed by activity of
   (a) Cambium (b) Xylem
   (c) Phloem (d) Both xylem and phloem

5. NEET AIPMT

1. Companion cells are closely associated with **[2012]**

   Or

   Transport of food material in higher plants takes place through **[2010]**
   (a) Sieve elements (b) Vessel elements
   (c) Trichomes (d) Guard cells
2. Axillary bud and terminal bud are derived from the activity of **[2002]**
   (a) Parenchyma (b) Lateral meristem
   (c) Apical meristem (d) Intercalary meristem

3. Vessels are found in [2002]
(a) All pteridophytes (b) All angiosperms
(c) Some gymnosperm (d) Both (b) and (c)

4. Transport of food material in higher plants takes place through [2010]
(a) Companion cells (b) Transfusion tissue
(c) Tracheids (d) Sieve elements

5. Tunica corpus theory is related with [1988]
(a) Root apex
(b) Lateral meristems
(c) Root cap
(d) Shoot apex (apical meristem)

6. Sieve tubes are better suited for translocation, because [1989]
(a) Possess broader lumen and perforated cross walls
(b) Are broader than long
(c) Possess bordered pits
(d) Possess no end walls

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

8. The casparian strips of root endoderm contain a mixture of [1994]
(a) Cellulose and cutin (b) Cellulose and lignin
(c) Lignin and suberin (d) Cellulose and suberin

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

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

11. Healing of wound in plants takes place by the activity of [1998; 2000]
(a) Ground tissue (b) Callus deposition
(c) Secondary meristem (d) Permanent tissue

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

13. The tissue which is living but does not possess nucleus in mature stage is [1997]
(a) Companion cell (b) Vessels
(c) Sieve tube (d) Sclerenchyma

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

15. Tracheids differ from other tracheary elements in [2014]
(a) Lacking nucleus (b) Being lignified
(c) Having casparian strips (d) Being imperforate

16. Ground tissue includes [2011]
(a) All tissues internal to endodermis
(b) All tissues external to endodermis
(c) All tissues except epidermis and vascular bundles
(d) Epidermis and cortex

17. Casparian thickenings are found in the cells of [2011]
Or
In dicot roots, cells of which region show casparian strips [1999]
(a) Pericycle of the root (b) Endodermis of the root
(c) Pericycle of the stem (d) Endodermis of the stem

18. In dicot roots, cells of which region show casparian strips [1999]
(a) Cambium (b) Endodermis
(c) Pericycle (d) Hypodermis

19. Water containing cavities in vascular bundles are found in [2012]
(a) Sunflower (b) Maize
(c) *Cycas* (d) *Pinus*

20. The lateral roots originate from [1994]
(a) Endoderm cells
(b) Pericycle cells
(c) Epiblema
(d) Cortical cells below root hairs

21. The bicollateral vascular bundle is the characteristic feature of plants belonging to the family [1998]
(a) Cruciferae (b) Liliaceae
(c) Cucurbitaceae (d) Malvaceae

22. Pericycle in roots is responsible for [1990]
(a) Formation of lateral roots
(b) Providing mechanical support
(c) Formation of vascular bundle from cortex
(d) Formation of vascular bundle from endodermis

23. Reduction in vascular tissue mechanical tissue and cuticle is characteristic of [2009]
(a) Xerophytes (b) Mesophytes
(c) Epiphytes (d) Hydrophytes

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

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

26. Multiple epidermis on dorsal and ventral side of the leaf is found in [1990]
(a) Zea mays (b) Ficus benghalensis
(c) Mangifera indica (d) Nerium oleander

27. Vascular bundle is closed, when [2012; 2015]
(a) Cambium presents (b) Cambium absent
(c) Pericycle absent (d) None of these

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

29. In barley stem vascular bundles are [2009]
(a) Open and scattered (b) Closed and scattered
(c) Open and in a ring (d) Closed and radial

30. Conjoint, collateral and closed vascular bundle is found in **[1998]**
(a) Monocot stem (b) Monocot root
(c) Dicot stem (d) Dicot root

31. The distinct cavities (lacunae) found in a mature vascular bundle of maize stem are formed due to **[1988]**
(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

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

33. The annular and spirally thickened conducting elements generally develop in the protoxylem when the root or stem is **[2009]**
(a) Maturing (b) Elongating
(c) Widening (d) Differentiating

34. Exarch xylem is found in **[1990]**
(a) Root (b) Stem
(c) Leaf (d) Rachis

35. Palisade parenchyma is absent in leaves of **[2009]**
(a) Sorghum (b) Mustard
(c) Soybean (d) Gram

36. Anatomically fairly old dicotyledonous root is distinguished from the dicotyledonous stem by **[2009]**
(a) Absence of secondary xylem
(b) Absence of secondary phloem
(c) Presence of cortex
(d) Position of protoxylem

37. Monocot root differs from dicot root in **[2012]**
(a) Presence of more than six xylem bundle
(b) Well developed pith
(c) Absence of secondary growth
(d) All of these

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

39. The cambium which produces cork is known as **[1999]**
Or
The common bottle cork is a product of **[2012]**
Or
The meristem that is parallel to the longitudinal axis of the plant is
(a) Phelloderm (b) Phellogen
(c) Periblem (d) Periderm

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

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

42. Cork is a derivative of **[1988]**
(a) Cork cambium (phellogen) or extra fascicular cambium
(b) Vascular cambium
(c) Fascicular cambium
(d) Interfascicular cambium

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

44. Vascular tissues in flowering plants develop from **[2008]**
(a) Periblem (b) Dermatogen
(c) Phellogen (d) Plerome

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

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

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

48. The cork cambium, cork and secondary cortex are collectively called **[2011]**
(a) Phellem (b) Phelloderm
(c) Phellogen (d) Periderm

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

50. Which of the following cell is totipotent **[1999]**
(a) Meristem (b) Sieve tube
(c) Collenchyma (d) Xylem vessel

51. Which one of the following is not a lateral meristem **[2010]**
(a) Intercalary meristem (b)Intrafascicular cambium
(c) Interfascicular cambium (d)Phellogen

52. Secondary xylem and phloem in dicot stem are produced by **[2018]**
(a) Axillary meristems (b) Phellogen
(c) Vascular cambium (d) Apical meristems

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

6. AIIMS

1. Walls of sclerenchyma are **[1990]**
(a) Rigid (b) Lignified
(c) Pactinised (d) Suberised

2. Collenchyma differs from parenchyma in having **[1990]**
(a) Living protoplasm
(b) Cellulose walls
(c) Vacuoles
(d) Pectin deposits at Corners

3. The abscission layer is covered by a leaf scar which is composed of **[1992]**
(a) Pectose and cellulose (b) Suberin
(c) Pectin (d) Cutin

4. Function of companion cells is [2011]
(a) Loading of sucrose into sieve elements by passive transport
(b) Loading of sucrose into sieve elements
(c) Providing energy to sieve elements for active transport
(d) Providing water to phloem

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

6. When strong wind blows, the plants bend down and then again become erect. This flexibility in plants is due to [1992]

Or

Whose living cells provide tensile and mechanical strength [1992]

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

7. Cystoliths sometimes deposited in plant cells are crystals of (aggregation of) [1999]
(a) Calcium oxalate (b) Calcium carbonate
(c) Magnesium carbonate (d) Glucosides

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

9. Histogen theory states that epidermis is derived from the [1989]
(a) Periblem (b) Cambium
(c) Cortex (d) Dermatogen

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

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

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

13. Vascular bundles in the stem of *Cucurbita* or *Lagenaria* are [1992]
(a) Collateral (b) Bicollateral
(c) Radial (d) Inverted

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

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

16. In a dicotyledonous stem, the sequence of tissues from the outside to the inside is [2003]
(a) Phellem – Pericycle – Endodermis - Phloem
(b) Phellem – Phloem - Endodermis - Pericycle
(c) Phellem - Endodermis - Pericycle - Phloem
(d) Pericycle – Phellem - Endodermis – Phloem

17. 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 [2004]
(a) Cutin (b) Suberin
(c) Lignin (d) Hemicellulose

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

Or

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

19. Fusiform initials form [1987]
(a) Vascular rays (b) Treachery elements
(c) Ray parenchyma (d) Phloem parenchyma

20. In a plant organ which is covered by periderm and in which the stomata are absent, some gaseous exchange still takes place through [2004]
(a) Aerenchyma (b) Trichomes
(c) Pneumatophores (d) Lenticels

7. Assertion & Reason

1. Assertion : Stomata are absent in submerged hydrophytes.
Reason : Respiration occurs by means of air chambers in submerged plants.

2. Assertion : Higher plants have meristematic regions for indefinite growth.
Reason : Higher plants have root and shoot apices.

3. Assertion : Thick cuticle is mostly present in disease resistant plants.
Reason : Disease causing agents cannot grow on cuticle and cannot invade the cuticle.

4. Assertion : Apical and intercalary meristems contribute to the growth in length, while the lateral meristems bring increase in girth in maize.
Reason : Apical and intercalary meristems always increase the height of plants.

5. Assertion : All tissues lying inside vascular cambium are called as bark.
Reason : Bark is made up of phellogen, phellem and phelloderm lying inside secondary phloem.

6. Assertion : Cambium is a lateral meristem and cause growth in width.
Reason : Cambium is made up of fusiform and ray initials in stem.

7. Assertion : In collateral vascular bundles phloem is situated towards inner side.
Reason : In monocot stem, cambium is present.

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

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