XI
6

ANATOMY OF FLOWERING PLANTS

SYLLABUS

Tissues; Anatomy of different parts of flowering plants: Root, stem, leaf

KEY CONCEPTS

PLANT ANATOMY

The branch of botany which deals with study of internal structures and organization of plants is known as plant anatomy.

* N. Grew is known as father of plant anatomy.
* K.A. Chaudhary is known as father of Indian plant anatomy.
* Book - "The anatomy of seed plants" was written by Katherine Esau. It was published in 1960. It is referred to as Webster's of plant biology.

TISSUE

* A group of cells which is similar or dissimilar in shape, having a common origin and usually performing a common function is called **tissue.**
* The term tissue was coined by Nehemiah Grew.
* The tissues are divided into two groups by Karl Nageli

Tissues (On the basis of stage of development) :

(i) Meristematic tissues (undifferentiated) :

* Cell have capacity of division. Growth in plants is largely restricted to specialised regions of active cell division called meristem.
* A meristem is a localised region in which actual cell division occurs.

(ii) Permanent tissue (fully differentiated tissue)

* Cells have no capacity to divide actively, so it is composed of mature cells.

Characteristics of Meristematic tissues

* It is an undifferentiated tissue.
* Cell cycle of meristem is in continuous state of division. Thus, meristematic tissue is composed of immature cells.
* Meristematic cells have only primary cell wall which is thin and flexible (elastic) and made up of cellulose.
* Secondary cell wall is absent.
* Cells of meristem are small and **isodiametric.**
* They have dense cytoplasm.
* Normally vacuoles are absent in meristematic cells but if present then they are small in size.
* Meristematic cells are metabolically highly active so reserve food is absent in these cells.
* Plastids are absent in meristems. If they are present, then only in the proplastid stage.
* They do not have intercellular spaces. Cells are closely fitted (packed) together, so it is a compact tissue.
* Ergastic (non living) substances are absent.

Classification of Meristematic tissue

1. Meristamic tissue based on origin and development :

On the basis of origin and development meristems can be divided into following three types :

(a) Promeristem/Embryonic meristem / Urmeristem

* This meristem develops in beginning during embryonic stage.
* It forms primary meristem.

(b) Primary meristem :

* Meristematic cells developed from promeristem are known as primary meristem.
* It appears early in the life of a plant and contribute to the formation of the primary plant body.
* Cells are always in division phase and form primary permanent tissue by the process of differentiation.

  eg. **Apical meristem, intercalary meristem, intrafascicular cambium (Fascicular vascular cambium)**

(c) Secondary Meristem :

* Develops from primary permanent tissues by the process of dedifferentiation.
* Secondary meristem appears later than primary meristem.
* By the activity of secondary meristems, secondary growth takes place.
* Eg. Interfascicular cambium and cork cambium of dicot stem,vascular cambium and cork cambium of dicot root.
* Promeristem → Primary meristem

  $\xrightarrow{\text{Differentiation}}$ Primary permanent tissue

  $\xrightarrow{\text{Dedifferentiation}}$ Secondary meristem

  $\xrightarrow{\text{Redifferentiation}}$ Secondary permanent tissue.

2. Meristamtic tissues based on location in plant body:

(a) Apical Meristem :

* It is an example of primary meristem.

  The meristems which occur at the tips of roots and shoots and produce primary tissues are called apical meristems.
* They are responsible for increase in the length of plant organs.
* They are responsible for primary growth.
* Example : Root apex. shoot apex.
* Root apical meristem occupies the tip of a root while the shoot apical meristem occupies the distant most region of the stem axis.
* During the formation of leaves and elongation of stem, some cells 'left behind' from shoot apical meristem, constitute the **axillary bud**.
* Such buds are present in the axils of leaves and are capable of forming a branch or a flower.

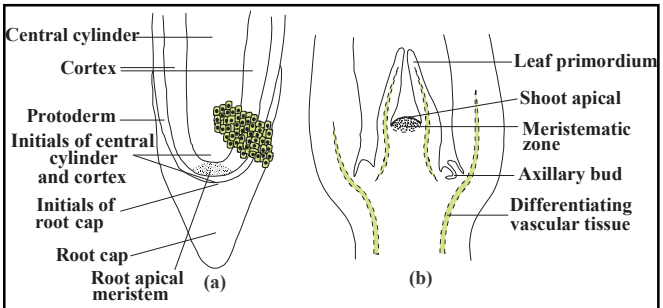


Figure : Apical meristem: (a) Root (b) Shoot

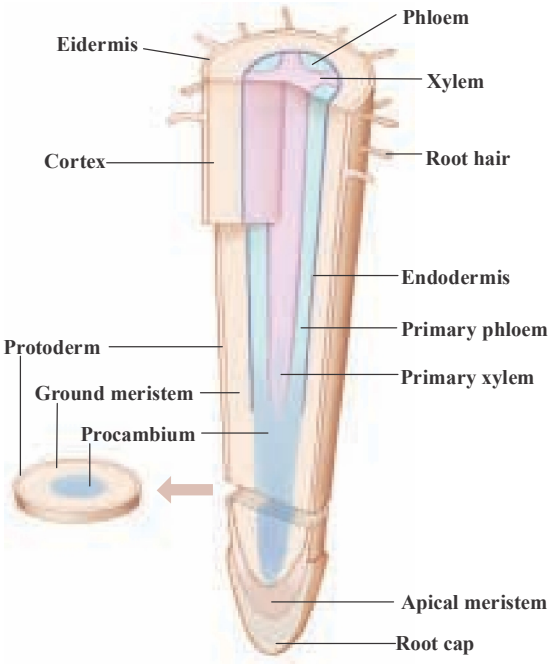
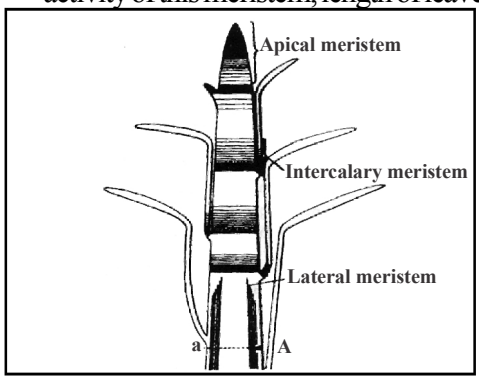


Figure : An apical root meristem.
This diagram of meristems in the root shows their relation to the root tip.

(b) Intercalary Meristem :

* It is an example of primary meristem.
* The meristem which occurs between mature tissues.

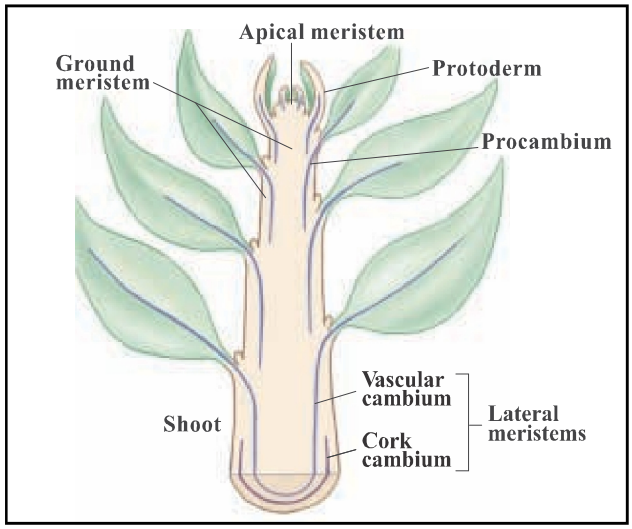
* By the activity of this meristem length of the plant organs increases.
* Present either at the base of internode of monocots stems e.g. grasses, bamboo, sugarcane and *Equisetum* (Pteridophyte) etc, or at the base of node e.g. Mint. They are also present at the base of leaves e.g. *Pinus* (Gymnosperm). By the activity of this meristem, length of leaves increases.



* They occur in grasses and regenerate parts removed by the grazing herbivores.
* Both apical meristems and intercalary meristems are primary meristems because they appear early in life of a plant and contribute to the formation of the primary plant body.

(c) Lateral Meristem :

* Lateral meristem occurs in **lateral side** of plant organ.
* Activity of lateral meristem increases the **girth/ thickness of plant** organ.
* All secondary meristems are lateral meristems.
* Lateral meristems are both primary and secondary in origin **(mostly secondary in origin)**.



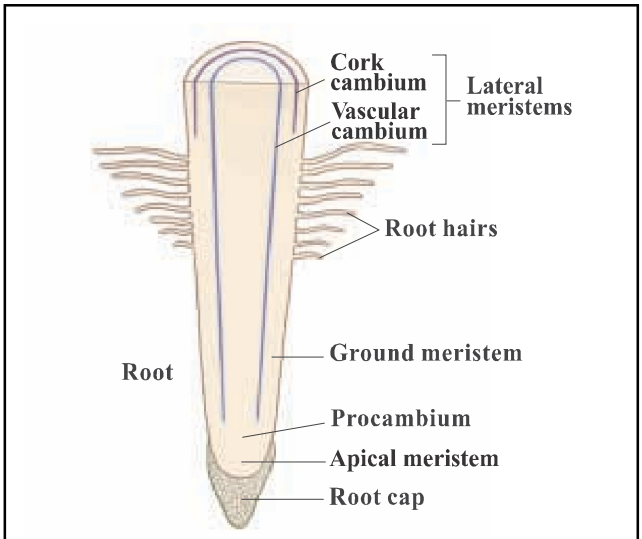
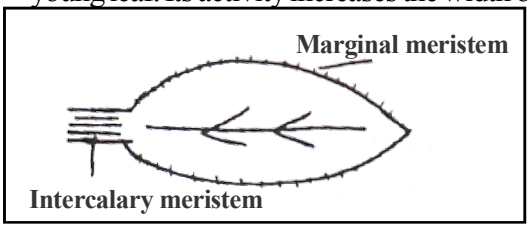


Figure : Apical and lateral meristems. Apical meristems produce primary growth, the elongation of the root and stem. In some plants, the lateral meristems produce an increase in the girth of a plant. This type of growth is secondary because the meristems were not directly produced by apical meristems.

* **Primary lateral meristem :**
  (a) Marginal meristem
  (b) Intrafascicular cambium
* **Marginal meristem :** It occurs at the margin of young leaf. Its activity increases the width of leaf.



* For total growth of leaf only primary meristems are responsible.
* **Intra fascicular cambium or fascicular cambium :** This cambium occurs inside the vascular bundle of dicot stems and gymnospserms stems.
* Intrafascicular cambium is only primary meristem which is responsible for secondary growth.
* **Secondary lateral meristems :** Cork cambium and vascular cambium of dicot roots and interfascicular cambium and cork cambium/ phellogen of dicot stem and gymnosperm stem.

3. On the basis of function

(a) Protoderm. These are outermost meristematic cells. They form skin or epidermis of plant and epidermal tissue system.

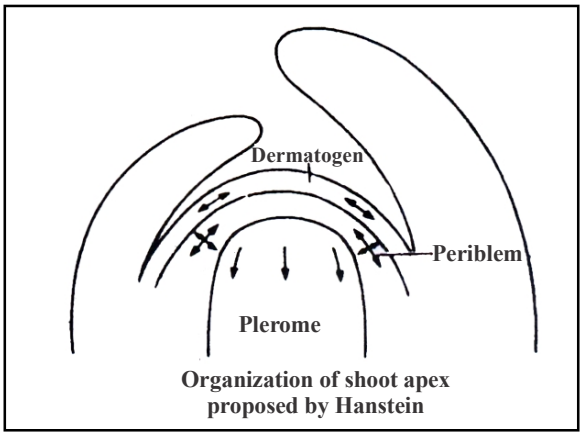
(b) Procambium. These are innermost meristematic cells. They form primary xylem, primary phloem and cambium.

(c) Ground meristem. They form ground or fundamental tissue such as hypodermis, cortex, pith, pericycle, etc.

Composition of Apical meristem

* Apical meristem is absent in most of the algae and fungi. All the cells of these plants are divisible, so they do not show apical growth. Thus such type of growth in these plants is called diffused growth. Diffused growth also occur in animals.
* In some algae (eg brown algae) bryophytes and some pteridophytes one meristematic cell is present at the apex.Generally the shape of apical cell is pyramid like.
* In Ferns, gymnosperms and angiosperms apical meristem consist of many cells.
* **Histogen Theory :** It was proposed by Hanstein (1870).

The apical meristem (root and shoot apices) are distinguished into three meristematic regions or three layers of histogen cells.



Organization of shoot apex proposed by Hanstein

(i) Dermatogen : This is the outermost single layer of cells. These cells forms uniseriate epidermis.

(ii) Periblem : This region is situated just below the dermatogen. It forms cortex (Hypodermis, general cortex and endodermis).

(iii) Plerome : This is the innermost region. Stele formation takes place by division of these cells. It means formation of pericycle, vascular bundles, pith rays or medullary rays and pith .

* This theory is only true for root apex. It is not applicable for shoot apex of higher plants because in most of the gymnosperms and angiosperms, shoot apex does not have distinct differentiation of three histogen.
* Except above described three histogens, a fourth type of histogen is present in monocotyledons. This is known as **Calyptrogen.** Root cap is produced by Calyptrogen in monocots. Root cap and epiblema/epidermis is produced by dermatogen in dicotyledons.
* Due to presence of root cap, position of **root apex is sub terminal/sub apical**. so maximum growth in root takes place **behind the apex**.

Note :

(i) In hydrophytes root cap is absent, eg. Pistia. In place of root cap, root pocket are present.

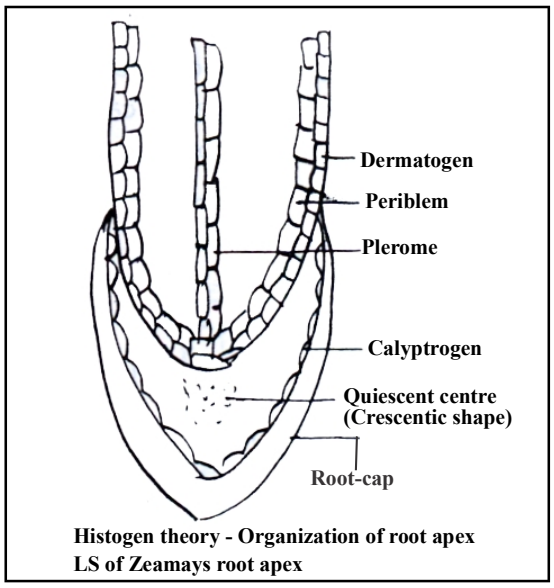
(ii) Generally root cap is single layered but in *pandanus* (screw pine) root cap is multilayered.

(iii) Root cap contain more amount of golgi body which secrete mucilage which make the root slimy.

* In monocot root epidermis and calyptrogen and derived from dermatogen.

Type of root	Number of histogens	Outer most histogen	Root cap is formed by
Dicot root	3	Dermatogen	Dermatogen
Monocot root	4	Calyptrogen	Calyptrogen

* Root cap is formed by calyptrogen (If dicot or monocot is not given)
* **Quiscent centre :** A group of inactive cells or less active cells present between the dermatogen and calyptrogen is called quiescent Centre.
* These cells contain less amount of DNA, RNA and synthesis of protein is also less.
* Quiescent centre term was coined by Clowes.
* Quiescent centre was discovered in Maize root.



Histogen theory - Organization of root apex
LS of Zeamays root apex

Function :

* The quiescent centre in the root meristem serves as a reserve for replenishment of damaged cells of the meristem
  or inactive cells of quiescent centre become active when previously active initials of calyptrogen get damaged.
* Quiescent centre is crescentic shaped.

Tunica-Corpus theory

* It was proposed by **Schmidt** (1924). It is based on plane of division of cells.
* According to this theory, shoot apex consists of two distinct layers as

(a) **Tunica :** It is mostly single layered and forms epidermis. The cells of tunica are smaller than corpus and divide by anticlinal divisions mostly.

(b) **Corpus :** It represents central core with larger cells. The cells divide in all planes (anticlinal and periclinal) .

* Sometimes, tunica is multilayered, then only outer layer forms epidermis and the remaining layers with corpus form cortex of shoot.

Cyto-Histological zonation theory

* According to **Foster**, shoot apical meristem is classified into two regions on the basis of rate of division : (a) Summit, (b) Flanks

Vegetative shoot apex :

(i) **Summit :** The rate of division is slow in this region. This region is located at the apex.

(ii) **Flanks :** The rate of division is very fast in this region. This region lies behind/below the summit and leaf primordia are formed by this region.

* Time period between initiation of two successive leaf primordia is called "**Plastochron**".
* Shape of vegetative shoot apex → Dome (mainly) or conical shaped
* Shape of reproductive shoot apex → Broad & flat
* Shoot apex is **terminal** in position
* Growth of leaf primordium → First apical then marginal.
* Function of leaf primordium → Provide protection to shoot apex.

Reproductive shoot apex

* During reproductive phase i.e., at the time of flowering, vegetative shoot apex transforms into reproductive shoot apex. This change of shoot apex is induced by **florigen** & **light**.
  In reproductive shoot apex, summit zone is more active (rate of cell division fast) and it forms stamens (androecium) & carpels (gynoecium) and flanks zone is less active (rate of cell division slow) and it forms sepals (calyx)and petals (corolla).

PERMANENT TISSUES

* Permanent tissues are composed of cells which have lost the power of division temporarily or permanently. They are formed by division and differentiation of meristematic tissues.
* Their cells may be living or dead. Permanent tissues are of three types :
  (a) Simple tissue (Homogenous tissue)
  (b) Complex tissues (Heterogenous tissue)
  (c) Special tissue (Secretory tissue)

Simple tissue

These tissues are made up of similar cells that perform a common function. Simple tissues are of three types : 1. Parenchyma 2. Collenchyma 3. Sclerenchyma

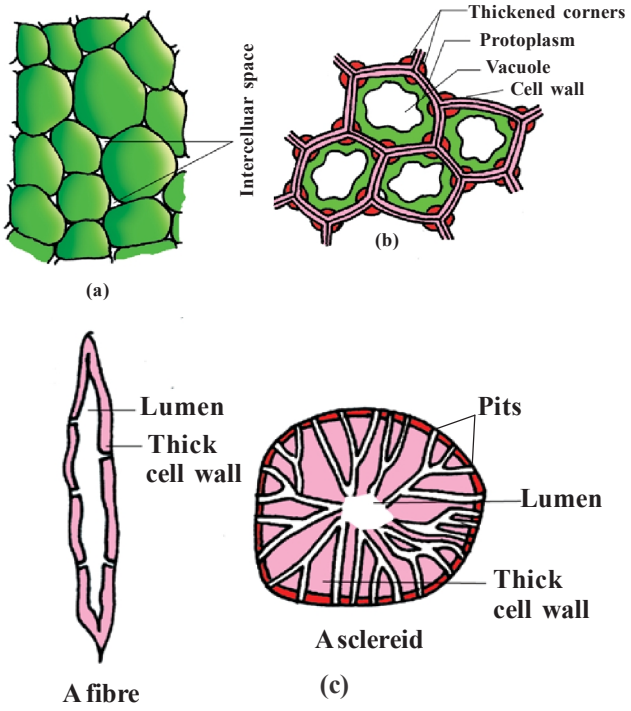


Figure : Simple tissues :
(a) Parenchyma, (b) Collenchyma, (c) Sclerenchyma

1. Parenchyma (Para means "beside" and chyma means "infilling") :

* Parenchyma name was coined by Grew.
* It is very primitive type of tissue. It is first evolved tissue. Remaining all different types of tissues are derived from this tissue, so it is also called as **fundamental tissue.**
* Parenchyma forms the major component within organs.

Characteristic features :

* It is a living tissue.
* It is first differentiated tissue.
* It is a universal tissue.
* Pulp of a fruit is mainly composed of parenchyma.
* Body of bryophyte plants is composed of parenchyma.
* The cells of parenchyma are thin walled. Cell wall is made up of pectocellulose (**mainly cellulose**). So parenchyma is a soft tissue.
* Each cell contains large central vacuole. So the main function of a parenchyma cell is storage of food.
* Parenchyma cells may either be closely packed or have intercellular spaces.

  Note : Intercellular spaces are usually **schizogenous** (due to separation of cells) in origin.
* It is found in cortex, pericycle, medullary rays, pith and mesophyll etc. It forms major component within organs.
* **Shape :** The cells of parenchyma are **usually isodiametric**.They may be spherical (rounded),oval,elongated or polygonal in shape.
* Each parenchymatous cell contains**14** planes/ sides.These cells are known as **tetrakoidecahedron cells**.

Modifications of Parenchyma

(i) Prosenchyma : The cells of this parenchyma are long, thick walled with pointed ends. This parenchyma forms the **pericyle of roots**. Function : Provide support to plant organ.

(ii) Aerenchyma : This parenchyma is made up of rounded cells. These cells surround the large air chambers. Air chambers are **lysigenous** (due to disintegration of cells) in origin. Aerenchyma is found in cortex region. It provides **buoyancy** to **hydrophyte** plants.

(iii) Stellate parenchyma : The cells of this tissue are stellate and branched. Air spaces are also present. Main function of this parenchyma is to provide **mechanical support**/mechinical strength to leaf bases (pseudo stem) of banana.

(iv) Chlorenchyma : Such type of parenchyma in which abundant quantity of chloroplasts are found. It is found in the leaves. Its function is to perform **photosynthesis**.

(v) Mucilage Parenchyma : In the mucilage parenchyma large vacuoles and mucilage are present. e.g. Succulent (fleshy) xerophytic plants. e.g. ***Aloe, Opuntia***. Function **-storage of water**.

Functions of Parenchyma

* The parenchyma performs various functions like storage, photosynthesis, secretion etc.
* The main function of this tissue is **storage of food.**

* Some cells of parenchyma **store waste materials**. They are called "**idioblast cells**".
* Idioblast cells store oils, tannin and crystals.
* **Photosynthesis** (by chlorenchyma)

2. Collenchyma

* Term was coined by **Schleiden**.

Main Characteristics

* Collenchyma is a **living mechanical tissue.**
* It is made up of more or less elongated (In transverse section cells are oval, spherical or polygonal in shape) cells.
* Localized deposition of **pectin,** cellulose & hemi cellulose are the main characteristics of collenchyma.
* Usually intercellular spaces are absent.
* Chloroplast may be found in the cells of collenchyma. These cells assimilate food when they contain chloroplasts.

Occurrences :

* Collenchyma is not a universal tissue. It is found in the **stems of herbaceous dicotyledons (young dicot stem)** below epidermis either as a homogenous layer (in sunflower stem)or in patches(in *Cucurbita* stem).
* Collenchyma is absent in woody plant parts (After secondary growth in plant parts), roots and monocotyledons.
* Collenchyma forms the **hypodermis of dicotyledon stems**. Cells of collenchyma are **flexible** due to hydrophilic nature of pectocellulose so flexibility occurs in dicotyledonous/dicot stems.
* **Lamina margins** and **petiole of leaves** also bear collenchyma. It protects the cracking of lamina margins from the action of wind.

Functions :

* It provides **tensile strength for extensibility** of various growing plant organs/provide tensile strength/provide tensile strength against bending & swaying **(mechanical function)**.
* Due to the presence of chloroplast, **photosynthesis** process takes place in collenchyma **(vital function)**.

3. Sclerenchyma

* Term was coined by **Mettenius**.

Main features :

* Sclerenchyma is the **main mechanical tissue**. It is **dead mechanical tissue**.
* Cells of sclerenchyma are long, narrow, thick walled, **lignified without protoplasts** and dead (cells become dead at maturity).
* Sclerenchyma is found in the **hypodermis of monocot stem**.

Functions :

* It provide mechanical support/mechanical strength to plant organs.
* Various types of pits are formed due to the **deposition of lignin on the walls.**

Types of Sclerenchyma

On the basis of variation in form, structure, origin & development. Sclerenchyma cells are of **two types: (i) Sclereids (ii) Sclerenchymatous fibres/**

I. Sclereids :

* These cells are small, extremely thick walled and their ends are not pointed.
* Sclereids are isodiametric or irregular in shape. Sclereids cells have simple pits(usually branched) and **lumen(cavity) is almost very small**.
* Sclereids are found in fruit walls of nuts,pulp of guava, pear and sapota (Stone cells or Brachysclereids or Grit cells),seed coats of legumes (Macro sclereids or Rod cells) and leaves of tea (astro sclereids or star like cells).

II Sclerenchymatous Fibres

* These cells are fibrous.
* They are **longest cells in plant body.** Their both ends are pointed (tapering). Due to thick cell wall, **lumen is reduced**.
* Their cell wall contains **simple** and **bordered** pits.

* On the basis of **position**, fibres are divided into three types -

A. **Surface fibres :** They are present on the surface of plant. These fibres also called as filling fibres.

(i) **Seed surface fibre -**

* **Example 1 : Cotton fibres** - Cotton fibres are **out growth of seed coat/out growth of testa**. Cotton fibres are composed of **cellulose.** They are **non-lignified.** So cotton fibres are **not true fibres**. Two types of fibres are found in cotton. Long fibres are called '**lint**' and small fibres are known as **'fuzz'.** Lint fibres are used in cloth industry. Fuzz are filling fibre.
* **Example 2 :** Red silk cotton (Semal fibre) - Obtained from ***Salmalia malabaricum***
* **Example 3 :** White silk cotton (Kapok) - Obtained from ***Ceiba pentendra*** (Both red and white silk cotton fibres are not true fibres and they are also an example of seed surface fibre.)

(ii) **Coir of coconut** is also a type of surface fibre.

* They are derived from the **fibrous mesocarp**.
* These are **true fibres**, because they are **lignified**.

B. **Xylary or wood fibres :**

* These are hard fibres.
* These fibres are not flexible.
* They can not be knitted (weaved) easily so they are not more useful.
* These are obtained from xylem. Ex. Munj fibre (***Saccharum munja)***

C. **Bast fibres/Extra xylary fibres/Phloem fibre**

* These are also known as **commercial fibres**.
* These fibres are flexible and can be knitted (weaved) easily.
* They have great economic value.
* These fibres are obtained from the **phloem** and **pericycle** of plants.
* The bast fibres of ***Corchorus capsularis*** (Jute),***Crotalaria juncea*** (Sunn hemp) and **Hibiscus sabdariffa** (patua) are obtained from the secondary **phloem** of stem.
* The bast fibres of hemp **(Cannabis sativa)** and **Linum usitatissimum**(flax) are obtained from the **pericycle**. Fibres which are obtained from pericycle are called **perivascular fibres.**
* Fibres are longest plant cell. **Longest fibres (phloem fibres)** occur in ***Boehmeria nivea* (Ramie fibre)** length–**55 cm**.
* In plant kingdom hardest, thickest and **Largest leaves** are found in ***Victoria regia.*** Due to presence of astrosclereids these leaves are hardest. Diameter (1–1.5 m)
* **Longest leaves** are found in ***Raphia vinifera***. Length 10 – 15 m.
* Longest commercial fibres – Jute fibres

Complex permanent tissue

* The complex tissues are made of more than one type of cells and these work as a unit. Complex tissue are heterogenous
* Complex tissues are absent in gametophytes.
* During vascularisation in plants differentiation of procambium is followed by the formation of primary phloem and primary xylem simultaneously.
* They are also known as **vascular tissue** or **conducting tissue**.
* Complex tissues are of two types - (a) Xylem (b) Phloem.

Xylem

* The term Xylem was coined by **Nageli.**
* The function of xylem is to conduct water & minerals salts upwards from the roots to stem & leaves and to give mechanical strength to the plant parts.

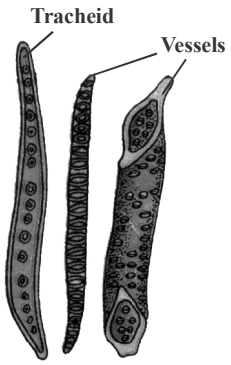


Figure : Xylem

* For conduction of water death of protoplasm is must. Dead tissues are more developed in water scares condition.
* In hydrophytes xylem is poorly developed while in xerophytes xylem is well developed.
* On the basis of **origin**, xylem is divided into primary xylem and secondary xylem.

(i) **Primary xylem** originates from procambium during vascularisation.

Xylem which is formed first in the life of a plant is known as primary xylem.

On the basis of development primary xylem divided into two parts/types.

(a) Protoxylem (b) Metaxylem

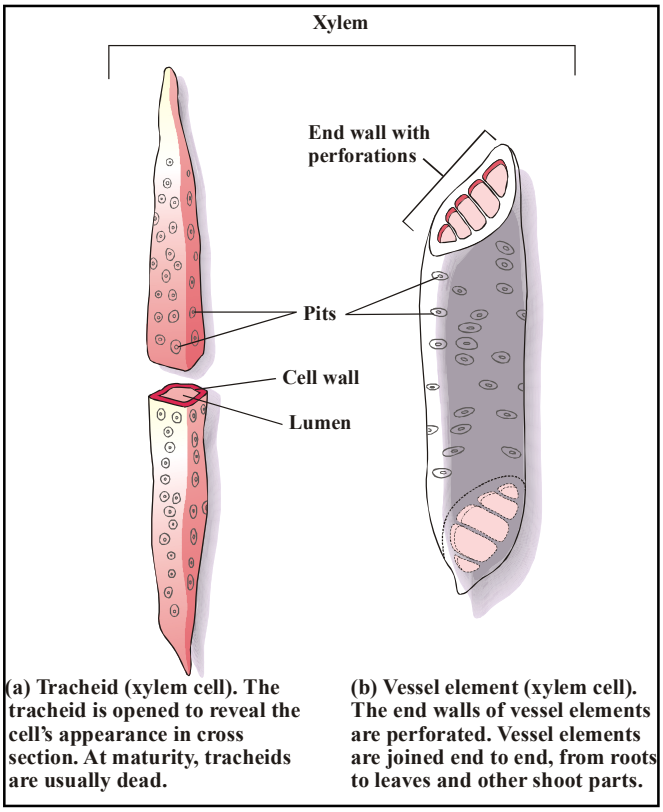
* Cells of protoxylem are small as compare to metaxylem.
* The first formed primary xylem elements are called **protoxylem** and the later formed primary xylem is called **metaxylem**.
* In stems, the protoxylem lies towards the centre (pith) and the metaxylem lies towards the periphery of the organ. This type of primary xylem is called **endarch**.
* In roots, the protoxylem lies towards periphery and metaxylem lies towards the centre. Such arrangement of primary xylem is called **exarch**.

(ii) **Secondary xylem** originates from vascular cambium during secondary growth. Secondary xylem is not differentiated into protoxylem and metaxylem.

* **The elements of xylem are**

(1) Tracheids
(2) Vessels or tracheae } Dead elements
(3) xylem fibres

(4) Xylme parenchyma : Living element



(a) Tracheid (xylem cell). The tracheid is opened to reveal the cell's appearance in cross section. At maturity, tracheids are usually dead.

(b) Vessel element (xylem cell). The end walls of vessel elements are perforated. Vessel elements are joined end to end, from roots to leaves and other shoot parts.

1. Tracheids:

* Tracheids are **primitive conduting elements of xylem**. Tracheids are found in **pteridophytes, gymnosperms** & **angiosperms**.
* A single tracheid is elongated cell with hard, thick and lignified wall and a **narrow lumen**. The ends of tracheids are tapering or chisel like.
* The tracheids found one above the other and are separated by cross wall/end wall which bears bordered pits.
* The deposition of lignin on cell wall is responsible for the formation of different types of thickenings.i.e., annular (primitive type), spiral, scalariform, reticulate and pitted.
* Usually **bordered pits** are present in tracheids. **The maximum bordered pits are found in the tracheids of Gymnosperm plants.**
* Maximum deposition of lignin is found in pitted type of thickening and pits are formed in this type of thickening.
* **Annular** and **Spiral** type of thickening of lignin is found in **protoxylem**.
* **Reticulate** and **Pitted** (mainly) type of thickening of lignin is found in **metaxylem**.
* **Scalariform** (ladder like) type of thickening is found in metaxylem tracheids of **pteridophytes** and in metaxylem tracheids of ***Cycas (gymnosperm)***.
* End wall of tracheids are **imperforated / pitted**. Tracheids are **unicellular**.
* **Pits** are unlignified areas on lignified walls

2. Vessels (Tracheae)

* Vessel is an **advanced conducting element of xylem.** Vessel is a long cylindrical, tube like structure with lignified walls and, **a wide central lumen/cavity**.
* Vessel is multicellular, it is made up of many cells called vessel member or vessel elements.
* **End wall is perforated.** Due to presence of perforated end wall, vessels **work as a pipe line** so, vessels are more capable for conduction of water than tracheids.
* Vessel members are interconnected through perforation in their common walls. The perforation may be **simple** (only one pore) or **multiple** (several pores).

* Vessels contain **usually simple pits** on their lateral walls**.** Types of thickening on the walls of vessels is the same as tracheids.
* Vessels are **found in most of the angiosperm** but also present in **some gymnosperms like *Ephedra, Gnetum*** and ***Welwitschia*** (order Gnetales).
* Vessels are **absent in some *angiospermic* plants** such as ***Dracaena, Yucca, Dagenaria, Drimys.*** There are some angiosperm families in which vessel less angiosperms are included. e.g.***Winteraceae***, ***tetracentraceae*** and ***trochodendraceae***.
* Vessels are example of **dead syncyte.(Syncyte: Structure which is formed by fusion of cells)** Vessels are **multicellular** (made up of vessel members or vessel elements).
* Tracheids and vessels are called tracheary elements of xylem/ Tracheids & vessels are collectively known as hadrom. Hadrom term was given by **Haberlandt.**

3. Xylem fibres(Wood Fibres) :

* Xylem fibres provides strength to the tracheids and vessels. Mainly to the vessels.
* They may be either septate or aseptate.
* They have **obliterated central lumen.**
* They are **abundantly** found in **secondary xylem(wood)**.
* They are generally not found in gymnosperm wood (so gymnosperms are also called soft wood spermatophytes)

4. Xylem Parenchyma :

* Cells living and thin walled and their cell wall is made up of cellulose.
* **Function : Storage of food materials** in the form of starch, fats and storge of tannin also.

Note : Function of ray paranchymatus cells - radial conduction of water.

Hadrom :

Tracheids and **Vessels** are collectively known as **water conducting elements** or **"Hadrom".** Hadrom term was proposed by **Haberlandt.**

Phloem

* The term 'Phloem' was coined by **Nageli**.
* The main function of the phloem is to conduct of food materials, usually from the leaf to other plant parts (eg. storage organ and growing regions)
* On the basis of origin, phloem is classified into two categories primary and secondary phloem.

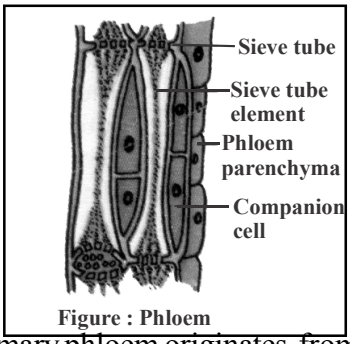
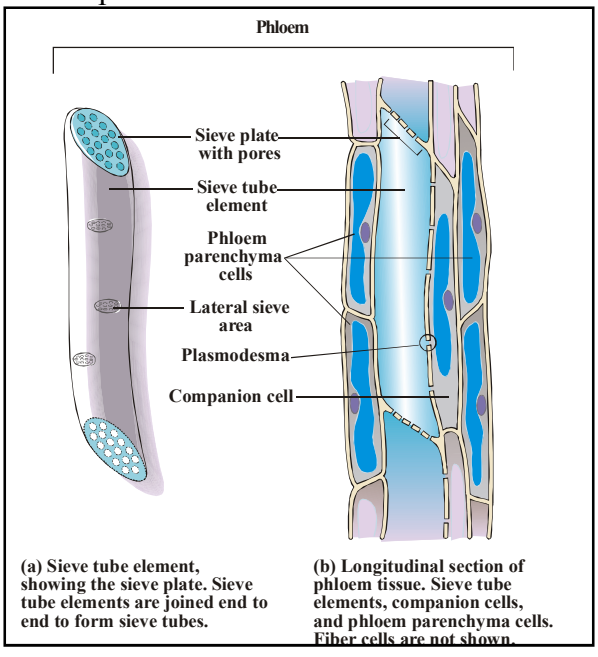


Figure : Phloem

* Primary phloem originates from procambium and secondary phloem originates from vascular cambium. On the basis of development primary phloem categorised into protophloem and metaphloem.
* The protophloem (first formed primary phloem) has narrow sieve tubes whereas metaphloem (later formed primary phloem) has bigger sieve tubes.
* Phloem remains active for less duration as compared to xylem.
* Phloem in angiosperms is composed of sieve tube elements, companion cells, phloem parenchyma and phloem fibres.



(a) Sieve tube element, showing the sieve plate. Sieve tube elements are joined end to end to form sieve tubes.

(b) Longitudinal section of phloem tissue. Sieve tube elements, companion cells, and phloem parenchyma cells. Fiber cells are not shown.

Phloem consists of **4 types** of cells :-

1. Sieve cell (In Gymnosperms and pteridophytes) / Sieve tube (In Angiosperms)

* Sieve element (sieve tube) was discovered by **Hartig**.
* Sieve cells and sieve tube elements are **living** and thin walled.
* Mature sieve tube elements are enucleated living cells (enucleated means without nucleus).
* Central vacuole is present in each sieve cell and sieve tube element and around the central vacuole thin layer of cytoplasm is present.
* **In Angiosperm plants,** sieve tube elements are joined from their ends and form **sieve tube.** Their end walls are perforated (Sieve Pores) in a sieve like manner to form the sieve plates. Translocation of food material takes place through these pores.
* Sieve tube is an example of **living syncyte**.
* **Callose** deposition takes place on the radius of sieve pores during dropping season/falling season of leaves (autumn) to form a thick layer. This is called callus pad.
* Sieve plate is protected by callus pad. It protects from bacterial infection and drought.
* Callose dissolves during spring season. Callose is a polymer of **b-1, 3-glucan.**
* Sieve elements contain special type of protein- **P-protein**. Most likely function of p-protein is sealing mechanism on wounding along with callose and it is also related with conduction of food.

Note : In **Gymnosperms** and **pteridophytes** sieve cells are arranged irregularly. Sieve cell have less conspicuous sieve areas which are located laterally. So, food conduction takes place in Zig-Zag manner. They are narrow elongated cell. They taper at the ends or have inclined walls.

2. Companion cells :

* These are thin walled, living, **specialised parenchymatous cells.**
* The sieve tube elements and companion cells are connected by pit fields present in their longitudinal walls, which is common wall for both.
* The companion cells and sieve tube elements maintain close **cytoplasmic connections** with each other through **plasmodesmata**.
* A companion cell is laterally associated with each sieve tube element in Angiospermic plants.
* **Sieve tube element and companion cell** originates together. Both of them originates from a single mother cell. So they are called **sister cells**.
* Companion cell is a **living cell** with **large elongated nucleus**. This nucleus also controls the activity of sieve tube element.
* Companion cells are only found in **Angiosperms.** *(exception - Austrobaileya-* It is angiosperm plant without companion cells)**.**

Note : Special type of cells are attached with the sieve cells in **gymnosperm (mainly) and in pteridophytes** in place of companion cells. These cells are called as **albuminous cells.**

* Albuminous cells in conifers are analogous to companion cells of angiosperms.
* The companion cells play an important role in the maintenance of a pressure gradient in the sieve tubes.

3. Phloem fibres / Bast fibres :

* These are made up of **sclerenchymatous** cells.
* These are much elongated and have pointed ends.
* These fibres are generally not found in primary phloem but are found in the secondary phloem.
* These fibres **provide mechanical support** to sieve elements.
* At maturity fibres lose their protoplasm and become **dead**.

4. Phloem Parenchyma :

* It's cells are elongated, tapering cylindrical, **living** and thin walled.
* The wall is composed of cellulose & has pits through which plasmodestmatal connection exist between the cells.
* It **stores food material** and various materials. eg. Resin, Latex, Mucilage etc.
* The main function of phloem parenchyma (**ray parenchyma**) is **conduction of food in radial direction** and **storage of food**.

* The conducting element of pholem is called **Leptom**.
* **Leptom** term was given by **Haberlandt**.
* **Phloem parenchyma** is **absent** in the **stems** of most of the **monocotyledon plants**.
* Phloem Parenchyma is absent in the stems of Ranunculaceae plants (dicot family).e.g. *Thallictrum.*

TISSUE SYSTEM

* In higher plants several tissues work together in form of a unit to perform a particular function.
* These tissues have the same origin. Such tissues form a system which is called tissue system.
* On the basis of division of labour tissue categorised by Sachs into three different system.
* Each system usually consist of an association of tissues which perform specific function.

Epidermal tissue system

* The epidermal tissue system forms the outer-most covering of the whole plant body and comprises epidermal cells, stomata and the epidermal appendages – the trichomes and hairs.
* It is made up of elongated, compactly arranged cells, which form a continuous layer. Epidermis is usually singlelayered.
* Epidermal cells are parenchymatous with a small amount of cytoplasm lining the cell wall and a large vacuole.
* The outside of the epidermis is often covered with a waxy thick layer called the **cuticle** which prevents the loss of water.
* Cuticle is absent in roots.
* **Stomata** are structures present in the epidermis of leaves. Stomata regulate the process of transpiration and gaseous exchange.
* Each stoma is composed of two beanshaped cells known as **guard cells** which enclose stomatal pore.
* In grasses, the guard cells are dumb-bell shaped. The outer walls of guard cells (away from the stomatal pore) are thin and the inner walls (towards the stomatal pore) are highly thickened.
* The guard cells possess chloroplasts and regulate the opening and closing of stomata. Sometimes, a few epidermal cells, in the vicinity of the guard cells become specialised in their shape and size and are known as **subsidiary cells**.
* The stomatal aperture, guard cells and the surrounding subsidiary cells are together called **stomatal apparatus.**

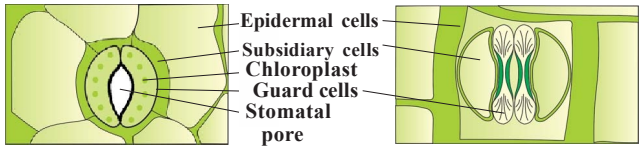


Figure : Diagrammatic representation: (a) stomata with bean-shaped guard cells (b) stomata with dumb-bell shaped guard cell

* **Trichomes :** The cells of the epidermis give rise to a number of protuberances which vary markedly in their shape, structure and function. These are known as trichomes. These appendages can be unicellular or multicellular. The unicellular trichomes are usually simple, unbranched (sometimes also branched) and elongated structures. On the other hand, the multicellular trichomes and glands are made up of several layers of cells. In shoot system, trichomes are usually multicelluar.
  Function: The trichomes help in protection, dispersal of seeds and fruits, and reduction of water loss.

* **Root hair :** The root hairs are formed due to the elongation of the epidermal cells and are not protuberances or appendages. These have a vacuolated protoplasm and the nucleus moves towards the apical part of the cell. The thin wall is made up of cellulose and pectic materials.
  Function: Root hairs play an important role in anchoring the plant body in the soil besides absorbing water and mineral solution from it.

Ground tissue system

* It is the largest tissue system.
* All tissues except epidermis and vascular bundles constitute the **ground tissue**.

* It consists of simple tissues such as parenchyma, collenchyma and sclerenchyma.
* Parenchymatous cells are usually present in cortex, pericycle, pith and medullary rays, in the primary stems and roots.
* In leaves, the ground tissue consists of thin-walled chloroplast containing cells and is called **mesophyll**.
* **Main function :**
  – Manufacture and storage of food material.
  – Mechanical support (additional work).

Vascular/stele/conducting tissue system

* This tissue system originates from pro-cambium. It consists of xylem and phloem.
* Xylem and phloem are collectively termed as **vascular bundles.**

Types of development of primary xylem

I. **Centrifugal :** In this type of development, the protoxylem formed near the central axis and metaxylem is formed away from the centre, it means towards the periphery. In this condition xylem is known as **endarch**. ex. **Stem of angiosperms & gymnosperms**

II. **Centripetal:** In this type of development protoxylem is formed away from the centre it means near the pericycle and metaxylem is formed towards the centre. In this condition xylem is called **exarch**. ex. **Roots.**

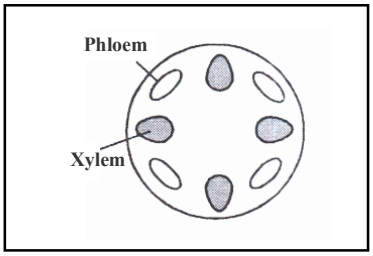
III. **Centrifugal and Centripetal :** Elements of metaxylem are formed on both sides of the elements of protoxylem. In this type of development protoxylem is surrounded by metaxylem. In this condition xylem is known as **mesarch**. ex. **Fern rhizome**.

Types of Vascular Bundles

On the basis of arrangement of different parts, vascular bundles are divided into three categories.

1. **Radial vascular Bundles :**

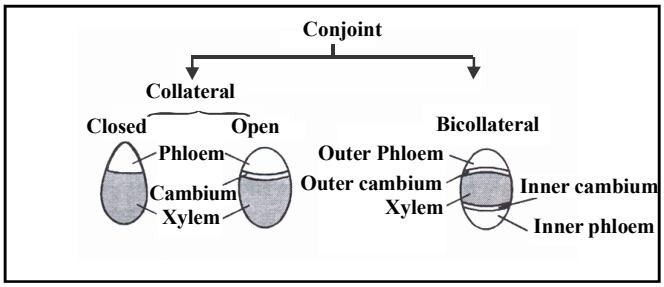
* When the xylem and phloem are present separately on different radii in alternate manner, then vascular bundles are called radial vascular bundle.



* The order of development of xylem in these vascular bundle is centripetal. Thus, these vascular bundles are called exarch.Example : Most of the roots (Dicot, monocot, gymnosperm, fern root) **Exception :** Radish, carrot, turnip, sugarbeet/ Beet root/conjoint-collateral vascular bundles are present.

2. **Conjoint vascular bundles :** In this type of vascular bundle xylem and phloem are present on the same radius and combine into a bundle. These are of two types

(i) **Conjoint collateral:** In this type of vascular bundle xylem and phloem are present on the same radius and phloem present towards the periphery.



These are two types

(a) **Open :** If the cambium is present between the xylem and phloem then it is said to be open vascular bundle. Ex. Stem of dicotyledons and gymnosperm.

(b) **Closed :** When cambium is absent between the xylem and phloem of conjoint vascular bundle then it is called closed vascular bundle. Ex. Monocotyledons stem and leaves of angiosperms.

* In this type of vascular bundle, order of development of xylem is centrifugal. So endarch condition is found in xylem.

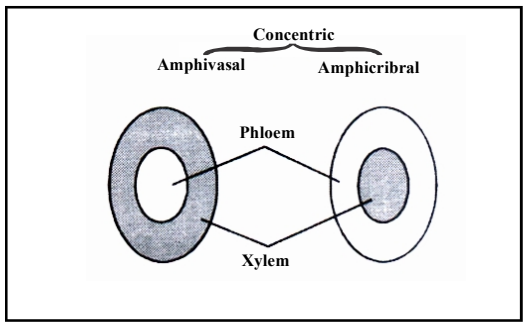
(ii) Conjoint bicollateral and Open Vascular bundle :

* In this type of vascular bundle two patches of phloem, one on each side of xylem are found.
* There are two strips of cambium (outer and inner), one on each side of xylem, are found. Only outer cambium is functional.
* Order of development of xylem is centrifugal so endarch condition is found.
  Ex. stem of family cucurbitaceae (Ex. *Luffa cylindrica, Cucurbita pepo & Lagenaria stem*) and some plants of family Apocynaceae and Solanaceae.

3. Concentric vascular bundles : In this type of vascular bundle either xylem surrounds the phloem or phloem surrounds the xylem. Concetric vascular bundles are always closed. They are of two types

(i) Amphicribral or Hadrocentric :

* In this type of vascular bundle xylem is completely surrounded by phloem. It means xylem is present in the centre of vascular bundle.
* The order of development of xylem in these vascular bundles is of both centripetal and centrifugal and xylem is mesarch.
* Such types of vascular bundles are found in stem of ferns and rhizome (underground stem)



(ii) Amphivasal or Leptocentric :

* In this type of vascular bundle phloem is completely surrounded by xylem.
* It means phloem is present in the centre of the vascular bundle.
* In this type of vascular bundle, xylem is endarch. e.g. stem of *Dracaena, Yucca* etc.

Stele

* The stele is the whole central mass of vascular tissue with or without pith surrounded by endodermis.
* Van tieghem and Douliot put forward the hypothesis about stele. According to him stele is the central part or core of the axis of the plant which includes the vascular system and its related structures.
* The tissues which lies inside the stele is called intrastelar tissues and the tissues which lies out side the stele is known as extra stelar tissues. Stele surrounded by endodermis but endodermis is originally the part of cortex. It is not a part of stele. Stelar system started from pteridophytes.

* **Table : Types of vascular bundles in dicots and monocots**

	Roots	Stems
Dicots	* Radial vascular bundles. * Vascular cambium absent but develops at the time of secondary growth.	* Conjoint open vascular bundles. * Vascular cambium present.
Monocots	* Radial vascular bundles. * Vascular cambium absent.	* Conjoint closed vascular bundles. * Vascular cambium absent.

Table : Tissue Systems, Tissues, and Cell Types of Flowering Plants

Tissue System	Tissue	Cell Types	Main Functions of Tissue
Ground tissue system	Parenchyma tissue	Parenchyma cells	Storage, secretion, photosynthesis
	Collenchyma tissue	Collenchyma cells	Support
	Sclerenchyma tissue	Sclerenchyma cells (sclereids or fibers)	Support, strength
Vascular tissue system	Xylem	Tracheids	Conduction of water and nutrient minerals, support
		Vessel elements	Conduction of water and nutrient minerals, support
		Xylem parenchyma cells	Storage
		Fibers (sclerenchyma cells)	Support, strength
	Phloem	Sieve tube elements	Conduction of sugar in solution, support
		Companion cells	May control functioning of sieve tube elements, loading sugar into sieve tube elements
		Phloem parenchyma cells	Storage
		Fibers (sclerenchyma cells)	Support, strength
Dermal tissue system	Epidermis	Epidermal cells	Protective covering over surface of plant body
		Guard cells	Regulate stomata
		Trichomes	Variable functions
	Periderm	Cork cells	Protective covering over surface of plant body
		Cork cambium cells	Meristematic (form new cells)
		Cork parenchyma cells	Storage

ANATOMY OF DICOTYLEDONOUS AND MONOCOTYLEDONOUS PLANTS

Dicotyledonous Root

Internal structure of a typical dicotyledon root shows following features :-

1. Epiblema / Epidermis :-

* It is **uniseriate** (single layered) outermost layer.
* **Cuticle and stomata are absent. Unicellular root hairs** are formed due to elongation of some cells of epiblema. Epiblema is also known as **Rhizodermis** or **Piliferous layer**.
* Root hairs are present in maturation zone of root. Root hairs are short lived.
* Hypodermis is absent in the roots.

Note: Cells of epiblema which develop root hairs are called **trichoblast cells**.

2. Cortex :

* It is made up of **parenchymatous** cells.
* Chloroplast is absent, so they are non-photosynthetic but chloroplasts are present in the **roots of *Tinospora*** and ***Trapa*** so they are **photosynthetic**.

Note : As the epiblema dies off, a few outer layer of the cortex become suberized or cutinized and form the **exodermis**. Exodermis is found in some dicotyledon roots and most of the monocotyledon roots.

3. Endodermis :

* This layer of **barrel shaped cells** or tobular cells is situated between the pericycle and cortex.
* **Casparian strips** are present on radial and tangential walls of endodermis. These strips are made up of **ligno suberin (mainly suberin)**.
* Casparian strips were discovered by **Caspari**.
* The cells of endodermis which are situated infront of protoxylem cells are devoid of casparian strips. These are called **passage cells/path cells**.
* Passage cells provide path to absorbed water from cortex to pericycle.
* Casparian bands and passage cells are well developed in monocot root in comparison to dicot root.
* Intercellular spaces are absent between the cells of endodermis of root.
* **Endodermis** acts as a **water tight jacket** which **prevents leakage of water from stele**.

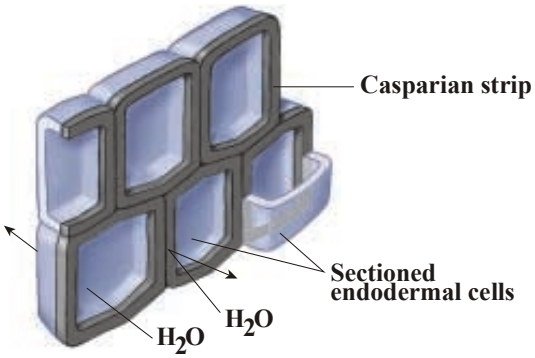


Figure :The Casparian strip is a water-proofing band that protects cells inside the endodermis from flooding.

4. Pericycle :

* It is **single or few layers of thick walled parenchymatous cells .(It is composed** of prosenchyma).
* **Lateral roots** usually originate from the part of pericycle which is lying opposite to protoxylem. Thus lateral roots are **endogenous** (because these are originated from stelar region) in origin.

Note :

(i) The **branches of stems** are **exogenous** in origin because these are originated from extra stelar region .

(ii) **Adventitious roots** are also **endogenous** because these are originated from stelar region .

5. Vascular Bundles :

* Vascular bundles are **radial** and **exarch.**
* Xylem and phloem are separate and equal in number.
* The number of xylem patches / xylem bundles are usually two to four but they may be two to six (**diarch** to **hexarch**).
* Tetrarch condition is found in gram and sunflower.
* But exceptionally, *Ficus bengalensis* (Banyan tree) root is polyarch**.**
* Parenchyma which is found between the xylem and phloem is called **Conjunctive tissue**.
* In dicot root xylem vessels appear angular / polygonal in T.S.

6. Pith :

* In dicot root pith is **small (less developed)** or **inconspicuous or absent**.

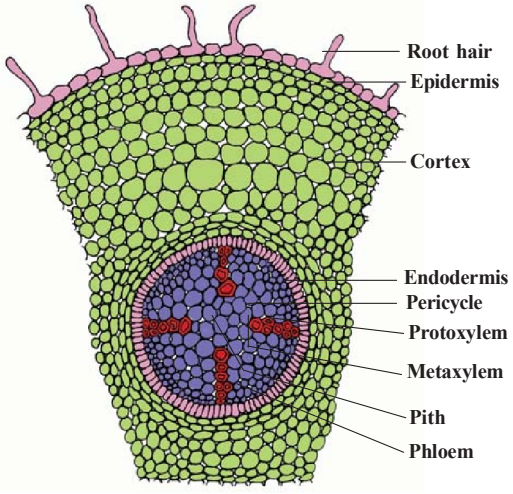


Figure : T.S. of Dicot root (Primary)

Monocotyledonous root

* The internal structure of a typical monocotyledon root is similar to dicotyledon root except some differences.

(1) Number of **xylem bundles** are u**sually more than six (Polyarch)** in monocotyledon root (exceptionally the number of xylem bundles are two to six in onion).

(2) **Pith is large and well developed** in monocotyledon root

(3) **Xylem vessels** appear circular or oval shaped in T.S.

Velamen : This tissue is found in aerial or hanging roots of some epiphytes (eg. **orchid**).

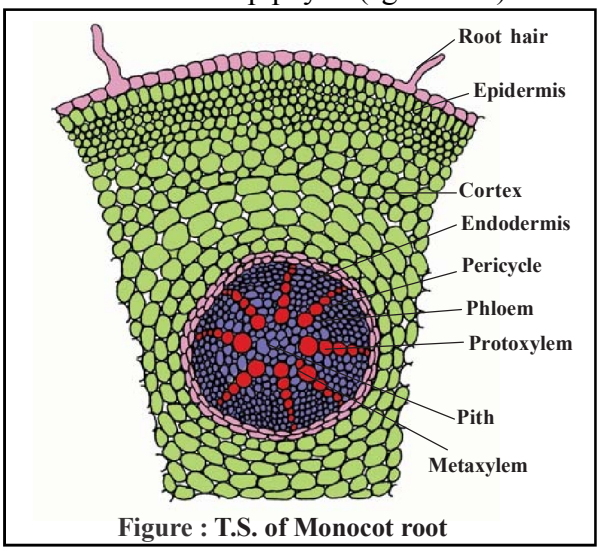


Figure : T.S. of Monocot root

* It is an example of multilayered epidermis
* It absorbs atmospheric moisture by imbibition.
* Monocotyledonous roots do not undergo any secondary growth.

Table : Dicot and monocot root anatomy

S.N.	Character	Dicot root	Monocot root
1.	Pericycle	Gives rise to secondary (lateral) roots and vascular cambium both.	Gives rise to lateral roots only.
2.	Vascular bundles	Diarch to hexarch, *i.e.,* vascular bundles are 2 to 6 in number.	Polyarch, *i.e.,* more than 6 vascular bundles are present.
3.	Cambium	Develops at the time of secondary growth.	Cambium is absent. No secondary growth.
4.	Pith	Small and inconspicuous.	Large and well developed.

Dicotyledonous Stem

Internal structure of a typical dicot stem shows following features :

1. Epidermis :

* Epidermis is the outermost protective layer of the stem.
* It is **single layered** and lacks chloroplast.
* Stomata, **multicellular hairs (trichomes)** are present on epidermis. Thin **Cuticle** is present on epidermis.
* Epidermis plays a significant role in protection.
* Trichomes help in preventing water loss due to transpiration.

2. Cortex :

* In dicotyledon stem cortex is divided into three parts :

(a) Hypodermis : It is present just below the epidermis. It is thick and multilayered. It is **composed of collenchyma** and their cells often contain **chloroplasts**.

(b) General Cortex : This part is composed of **parenchyma**. Storage of food is the main function of the cortex.
Resin canals/mucilage canals are present in it. These are **schizogenous** (due to separation of cells) in origin. The innermost layer of the cortex is called **endodermis**.

(c) Endodermis : It is single celled thick layer. The cells of endodermis accumulate starch grains, thus it is known as **"starch sheath"**.

3. Pericycle :

* Pericycle is situated below the endodermis.
* The pericycle of stem is **multilayered** and made up of **sclerenchyma**.
* In **sunflower** stem, **pericycle** is made of alternate bands of **parenchymatous** and **sclerenchymatous** cells.
* The part of pericycle which is present infront of the vascular bundle is made up of sclerenchyma and remaining part is composed of parenchyma.
* Part of pericycle which is situated in front of vascular bundle is known as **Bundle cap**.
* In sunflower stem, pericycle is **heterogenous** in nature.
* Sclerenchymatous pericyle is also known as **Hard bast.**
* Pericycle is present above the phloem in the form of semilunar patches of sclerechyma.

4. Vascular Bundles : The vascular bundles **(wedge shaped)** are **arranged in a ring**. Each vascular bundle is **conjoint, collateral** and **open** and **xylem is endarch**.

5. Pith : This is **well developed** region, present in the centre. The cells of this region are made up of **parenchyma**.
The part of pith which is radially arranged between the vascular bundles, called **pith rays or medullary rays.** The main function of pith rays is radial conduction of food and water.

Cucurbita stem :

* It contains **five ridges** and **five furrows**. The vascular bundles are arranged in **two rings**. Each ring has five vascular bundles. In this way the **total 10** vascular bundles are present.
* The vascular bundles of outer ring are **small** in size and situated in front of **ridges** while the vascular bundles of inner rings are **large** in size and located **below** the furrows.
* Vascular bundles are **conjoint**, **bicollateral and open** and **xylem is endarch**. Outer cambium is functional.
* Hypodermis is present in ridge region and it is absent or less developed in furrows region.
* General cortex contains chloroplast.
* In *Cucurbita* stem **pericycle is sclerenchymatous**.

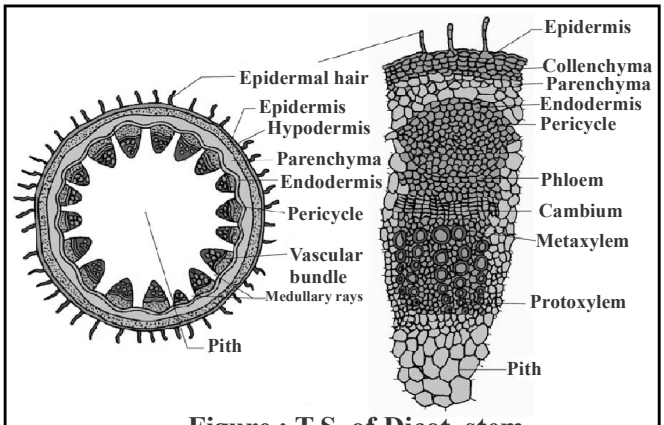


Figure : T.S. of Dicot stem

Monocotyledonous Stem

1. Epidermis :

* Epidermis is the outer most single celled thick layer.
* It is covered with thick cuticle. Multicellular hairs are absent .

2. Hypodermis :

* Hypodermis of monocotyledon stem is made up of sclerenchyma.
* It is 2-3 layered thick.
* In monocot stem rigidity is more in hypodermis whereas in dicot stem elasticity is more.
* It provides mechanical support to the plant.

3. Ground tissue :

* There is no differentiation of ground tissue in monocotyledon stem.
* It means ground tissue is not differentiated into endodermis, cortex, pericycle etc.

Note : Sometimes in some grasses, wheat etc. the central portion of ground tissue becomes hollow and is called pith cavity (pith cavity is also found in Cucurbita, Ricinus amongst dicots).

4. Vascular Bundle :

* Many vascular bundles are **scattered** in the ground tissue and V.B. are generally **oval** shaped.
* Vascular bundles which are situated towards the **centre** are **large** in size and **less** in number.
* Vascular bundles which are situated towards the **periphery** are **small** in size but **more** in number.
* Each vascular bundle is **conjoint, collateral and closed** and **xylem is endarch**.
* Each vascular bundle is surrounded by fibrous **sclerenchymatous bundle sheath**, So vascular bundles are called **fibro vascular bundles**.

(a) Xylem :

* In xylem number of **vessels** is less.
* In **metaxylem** there occurs **two large vessels** while in **protoxylem** there occurs **one** or **two small vessels**. Vessels are **arranged** in **V** or **Y shape**.
* Just beneath protoxylem vessels, there occurs a **water cavity** which is **schizolysigenous** in origin.
* Major part of water cavity is **lysigenous**. This cavity is formed mainly by disintigration of the elements present below the protoxylem and neighbouring parenchyma and some part of water cavity is **schizogenous**.

Exception : In *Asparagus* water cavity & bundle sheath are absent.

(b) Phloem : It consists of sieve tube elements and companion cells.

* **Phloem parenchyma** is absent.

5. Pith: Pith is **undifferentiated** in monocotyledon stems or lack of well demercated pith.

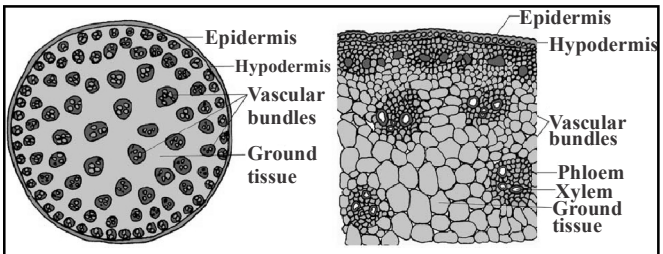


Figure : T.S. of Monocot stem

Table : Dicot and monocot stem anatomy

S.N.	Character	Dicot stem	Monocot stem
1.	Ground tissue	Differentiated into cortex and pith.	Not differentiated into cortex and pith.
2.	Hypodermis	Collenchymatous	Sclerenchymatous
3.	Endodermis	Single layered	Absent
4.	Pericycle	Made up of parenchymatous and/or sclerenchymatous cells.	Absent
5.	Vascular bundles	• Almost all are of uniform size. • Arranged in a ring. • Conjoint and open. • Bundle sheath absent. • Phloem parenchyma present. • Water-containing cavities are absent.	• Larger towards centre and smaller towards periphery. • Scattered • Conjoint and closed . • Bundle sheath present. • Phloem parenchyma absent. • Water-containing cavities are present.
6.	Pith (medulla)	Made up of parenchymatous cells, situated in the centre.	Absent
7.	Medullary rays	Found in between the vascular bundles.	Absent

* **Table : Internal structure of angiospermic stem and root**

S.N.	Character	Root	Stem
1.	Epidermis	Without cuticle	Usually with cuticle.
2.	Hypodermis	Absent	Present - collenchymatous or sclerenchymatous.
3.	Endodermis	Distinct	Poorly developed
4.	Vascular bundles	Radial	Conjoint
5.	Xylem	Exarch	Endarch

Internal Structure of Leaf

* Generally leaves are divided into two categories - Dorsiventral leaves and isobilateral leaves.
* The differences in between them are as follows :

S.N.	Dorsiventral or Bi–facial	Iso–bilateral or Equifacial
1.	Present at **right angle to stem**	Arranged **parallel to stem**.
2.	Upper surface of leaf receive more sun light as compared to lower surface, so there occur **difference** between internal structure of upper and lower surfaces. Example : **Dicots** Exception - *Eucalyptus and Nerium* leaves are Iso-bilateral.	Both surfaces of leaf receive equal amount of sun light so there occur **no difference** between internal structure of upper & lower surfaces. Example : **Monocots** Exception - *Lilium longiflorum* leaves are dorsiventral

Dorsiventral (Dicotyledonous) Leaf

* The vertical section of a dorsiventral leaf through the lamina shows three main parts, namely, epidermis, mesophyll and vascular system.
* The **epidermis** which covers both the upper surface (adaxial epidermis) and lower surface (abaxial epidermis) of the leaf has a conspicuous cuticle.
* The abaxial epidermis generally bears more stomata than the adaxial epidermis. The latter may even lack stomata.
* The tissue between the upper and the lower epidermis is called the **mesophyll**. Mesophyll, which possesses chloroplasts and carry out photosynthesis, is made up of parenchyma. It has two types of cells – the **palisade parenchyma** and the **spongy parenchyma**.
* The adaxially placed palisade parenchyma is made up of elongated cells, which are arranged vertically and parallel to each other.
* The oval or round and loosely arranged spongy parenchyma is situated below the palisade cells and extends to the lower epidermis. There are numerous large spaces and air cavities between these cells.

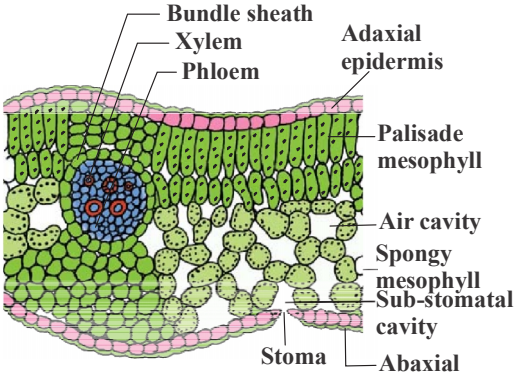


Figure : T.S. of Dicot leaf

* **Vascular system** includes vascular bundles, which can be seen in the veins and the midrib. The size of the vascular bundles are dependent on the size of the veins. The veins vary in thickness in the reticulate venation of the dicot leaves.
* The vascular bundles are surrounded by a layer of thick walled bundle sheath cells.

Isobilateral (Monocotyledonous) Leaf

The anatomy of isobilateral leaf is similar to that of the dorsiventral leaf in many ways. With the following differences:

* In an isobilateral leaf, the stomata are present on both the surfaces of the epidermis; and the mesophyll is not differentiated into palisade and spongy parenchyma.
* In grasses, certain adaxial epidermal cells along the veins modify themselves into large, empty, colourless cells. These are called **bulliform cells**. When the bulliform cells in the leaves have absorbed water and are turgid, the leaf surface is exposed.

When they are flaccid due to water stress, they make the leaves curl inwards to minimise water loss.

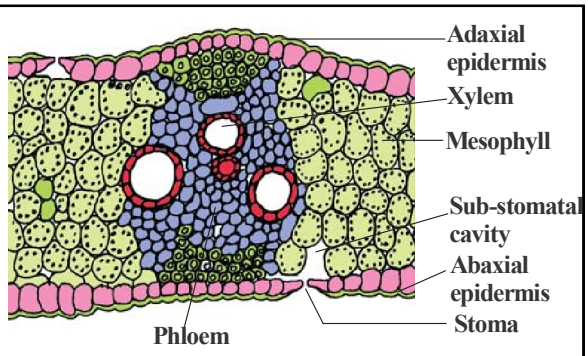


Figure : T.S. of Monocot leaf

* The parallel venation in monocot leaves is reflected in the near similar sizes of vascular bundles (except in main veins) as seen in vertical sections of the leaves.
* **Table : Anatomy of dicot and monocot leaf**

S.N.	Character	Dicot leaf	Monocot leaf
1.	Type of leaf	Dorsiventral	Isobilateral
2.	Stomata	Usually more in number on lower epidermis.	Equal in number on lower and upper epidermis.
3.	Mesophyll	Differentiated into two types of tissues-palisade and spongy parenchyma.	Not differentiated into palisade and spongy parenchyma.
4.	Bulliform cells	Absent	Present, particularly in grasses.
5.	Vascular bundles	Differ in size due to presence of reticulate venation.	Nearly similar in size due to presence of parallel venation.

NOTE

* In **isobilateral leaf**, two distinct patches of **sclerenchyma** are present above and below the large vascular bundle and extend up to the upper and lower epidermal layers.These are called bundle sheath extensions.
* In **dorsiventral leaf**, two distinct patches of **parenchyma (mainly)**/collenchyma are present above and below the large vascular bundle and extend up to the upper and lower epidermal layers. Chloroplasts are absent in bundle sheath extensions.

VASCULAR BUNDLES OF LEAVES

* Similar types of vascular bundles are found in both dorsiventral and isobilateral leaves.
* Vascular bundles of leaves are **conjoint, collateral** and **closed**.
* **Protoxylem** is situated **towards the adaxial** surface and **protophloem towards the abaxial** surface in the vascular bundle. Leaves are **devoid** of **endodermis** and **pericycle**.
* Vascular bundles are surrounded by a **bundle sheath**. It is made up of **parenchyma** (mostly) or sclerenchyma.

NOTE

1. In the leaves of C_4**-plants**, **bundle sheath is chlorenchymatous.**
2. **In grasses**, certain adaxial epidermal cells along the veins modify themselves into large, empty, colourless cells. These are called **bulliform cells or motor cells .** When the bulliform cells in the leaves have absorbed water and are turgid, the leaf surface exposed. When they are flaccid due to water stress, they make the leaves curl inwards to minimise water loss.
   Example :- ***Ammophila, Poa, Empectra*** and ***Agropyron*** etc. (**Psammophytic grasses**).
3. Both upper & lower **epidermis of *Nerium* leaves** are **multilayered** and in *Ficus* leaves upper epidermis is multilayered. This is an adaptation to reduce transpiration.
   Dicot xerophytes with isobilateral leaves contain palisade tissue on both sides of leaf.
   Example : ***Eucalyptus*** & ***Nerium***.
4. The stomatal aperture, guard cells and the surrounding subsidiary cells are together called stomatal apparatus.
5. The size of vascu!ar bundles are dependent on the size of the veins. The veins vary in thickness in the reticulate venation of the dicot leaves.
6. The parallel venation in monocot leaves is reflected in the near similar sizes of vascular bundles (except in main veins) as seen in vertical sections of the leaves.

7.

Leaf	Stomata position	Examples
Epistomatic leaf	Stomata are present only on upper surface.	Roating leaves Examples -Lotus (*Nelumbium) Victoria regia, Nymphaea*
Hypostomatic leaf	Stomata are present on lower surface.	Mostly dicot leaves
Amphistomatic leaf	Stomata are present on both surfaces.	Mostly monocot leaves
Astomatic leaf	Stomata are absent or non functional.	Submerged leaves Exmples - *Vallisneria, Hydrilla*

SECONDARY GROWTH

* The growth of the roots and stems in length with the help of apical meristem is called the **primary growth**.
* By the activity of laterel meristems (vascular cambium and cork cambium), **increase in the girth/ thickness** of the plant organs due to the formation of secondary tissues in stelar & extra stelar regions, called secondary growth.
* Normally secondary growth takes place in **roots and stems of dicotyledons** & **gymnosperms**.
* Due to lack of cambium in monocotyledons, secondary growth is absent. But **exceptionally** secondary growth takes place in **some monocotyledons**. Such as - ***Palm, Yucca, Dracaena, Kingia, Sansiviera, Smilax, Agave, Coconut*** *etc*. These plants show **abnormal secondary growth**.
* The tissues involved in secondary growth are the two **lateral meristems: vascular cambium and cork cambium.**

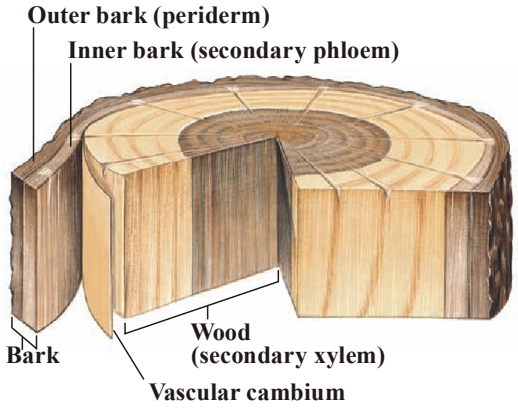


Figure : Secondary growth

The vascular cambium, a thin layer of cells sandwiched between the wood and bark, produces the secondary vascular tissues: the wood, which is secondary xylem, and the inner bark, which is secondary phloem. The cork cambium produces the periderm, the outer bark tissue that replaces the epidermis in a plant with secondary growth.

Secondary Growth in Dicot stem

[A] Secondary growth in stelar region (by vascular cambium) :

Secondary growth in stelar region begins earlier than the extrastelar region.

I. Formation of ring of vascular cambium :

* A cambium which is present inside the vascular bundle is called **intrafascicular- cambium**. This is a type of primary lateral meristem.
* First of all, cells of medullary rays become meristamatic to form **interfascicular cambium** which is a secondary lateral meristem.
* Intrafascicular and interfascicular cambium are collectively known as **vascular cambium**. Vascular cambium is formed in the form of a complete ring which is made up of single layer of cells.
* In diocot stem, the **vascular cambium is partly primary and partly secondary** in origin.
* Two types of cells are found in the ring of this vascular cambium.
  (i) **Fusiform initials** (ii) **Ray initials**.
* Fusiform initials are long with pointed ends, whereas ray initials are spherical/rounded or oval in shape.
* Fusiform initials are more in number in vascular cambium.

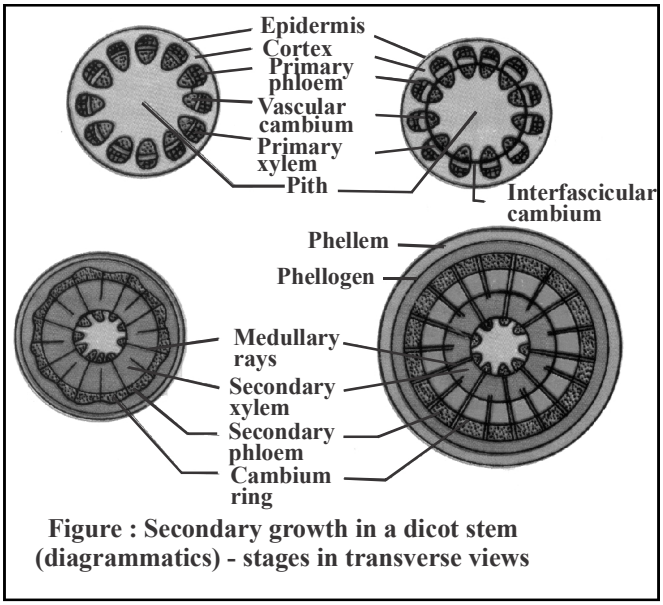


Figure : Secondary growth in a dicot stem (diagrammatics) - stages in transverse views

II Activity of vascular cambium :

(a) Activity of fusiform initials :

* Continuous periclinal divisions (parallel to longitudinal axis or parallel to surface) takes place in fusiform initials. Then few cells are formed towards the periphery and these cells are differentiated into **secondary phloem or bast** and the cells which are formed towards the centre are differentiated into **secondary xylem or wood**.
* Normally **more secondary xylem** is formed as compared to the secondary phloem **due to unequal distribution of hormones**. (**Secondary xylem** is formed **8-10 times more** as compared to the sec. phloem).
* By the pressure of secondary phloem, **primary phloem** is pushed towards the outside and **gets crushed**.
* By the pressure of secondary xylem, the primary tissues- such as **primary xylem,** is pushing towards centre.
* The **primary xylem** however remains **more or less intact** in or around the centre.
* The primary and secondary phloem of the earlier get gradually crushed due to the continued formation and accumulation of secondary xylem.

(b) Activity of Ray initial :

* Due to periclinal divisions ray initials cuts off parenchymatous cells. These are called **Vascular rays** or **Secondary medullary rays** which passes through the secondary xylem and secondary phloem in the radial direction.
* They **conduct water** and **food** in **radial direction**. An order of development of vascular rays are both centripetal and centrifugal.

(III) Formation of Annual Rings

* Annual rings are formed due to unequal activity of vascular cambium.
* The activity of cambium does not remain same, it is changeable in the whole year. Activity of vascular cambium is affected by physiological and environmental factors.
* In temperate regions, the climatic conditions are not uniform throughout the year.
* In the spring season, vascular cambium is very active and produces a large number of secondary xylem elements having vessels with wider lumen. The wood formed during this season is called **spring wood** or **early wood.**
* In winter, the vascular cambium is less active and forms fewer secondary xylem elements that have vessels with narrow lumen and this wood is called **autumn wood** or **late wood.**
* The spring wood is lighter in colour and has a lower density whereas the autumn (or winter) wood is darker and has a higher density.

NOTE

* The **autumn** and **spring wood** are formed in the form of concentric rings, called **growth rings**.
* A **ring of autumn wood** and a **ring of spring wood** are collectively known as **Annual ring**. The number of annual rings, formed in a tree give the idea of the age of the tree. The study of determination of age of a tree/plant by this technique is called **Dendrochronology**.
* The annual rings are counted from the **base of the stem** because basal part has maximum annual rings and upper part has less. Therefore, counting from the basal region can give the correct idea.
* A piece is taken from the stem up to central region from the base of stem with the help of **increment borer** instrument. The annual rings are counted from that piece and again inserted (fitted) into the same stem at the same place.
* More distinct/clear annual rings are formed in that regions where climatic variations are sharp.

* **More distinct annual rings** are formed in **temperate plants**. In temperate regions, the climatic condition are not uniform through the year.
* Distinct annual rings are not formed in tropical plants. **Distinct/clear annual rings are not formed in India except Himalayan regions (Shimla, Nainital).**
* Least distinct annual rings are formed in seashore regions/coastal regions because the climate remains the same through out the year.
* More clear annual rings are formed in deciduous plants as compared to evergreen plants.(In temperate region)
* In deserts annual rings are less distinct.
* In **Annual rings bands of secondary xylem and xylem rays (rays parenchyma) are present.**

HEART WOOD AND SAP WOOD

* The organic compounds such as tannin, resin, gums, oil, and aromatic substances etc. are filled in lumen of tracheids and vessels of secondary xylem.
* Due to this, **central region** of secondary xylem becomes **dark brown**. It is called **Heart wood or Duramen**.
* The **peripheral region** of secondary xylem which is **light** in colour, called **Sap wood or Alburnum**.
* The function of sap wood is conduction of water and minerals.

Heart wood does not conduct water because:

1. Cavities of tracheids and vessels are progressively filled with waste materials.
2. The bladder/balloon like ingrowth of parenchyma cells which enter in the lumen of vessels (mainly) & tracheids through the pits in their wall.Such bladder like ingrowth are called **tyloses**. Tyloses block the **lumen of tracheary elements (vessels and tracheids)**

* Heart wood provides stiffness to the stem. The waste materials of heart wood are **antiseptic** in nature. Heart wood is resistant to the attacks of micro organisms and insects and in rainy season it does not imbibe water. Thus it is the best quality of wood.
* Study of wood is known as **Xylotomy**. The wood is actually a **secondary xylem**.
* Position of youngest secondary phloem is just outside the vascular cambium.
* Position of oldest secondary phloem is just inside the primary phloem.
* Position of youngest layer of secondary xylem is just inside the vascular cambium.
* Position of oldest layer of secondary xylem is just outside the primary xylem.
* As the time passes amount of heart wood increases more as compared to sap wood.

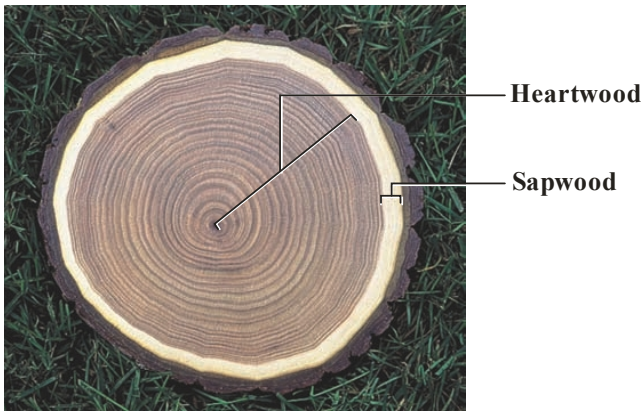


Figure : Heartwood and sapwood
The wood of older trees consists of a dense central heartwood and an outer layer of sapwood. The sapwood is the functioning xylem that conducts water and dissolved minerals. The annual rings in the heartwood are very conspicuous.

CLASSIFICATION OF WOOD

* On the basis of **amount of parenchyma** wood is classified into two groups :

1. **Manoxylic wood :** Such type of wood contains **more amount of living parenchyma**. It is soft and loose wood. eg. **Cycas**
2. **Pycnoxylic wood :** Such wood contains **less amount of living parenchyma**. It is hard wood. Such type of wood are **found in most of the plants**.

Example :- ***Pinus (Chir)*****, Mango,** ***Acacia (Babool)*****,** ***Tectona (Sagwan)*****,** ***Dalbergia (Shisham). Shorea robusta (Sal)***

Classification based on vessels

* On the basis of presence or absence of vessels, wood is classified into two categories -

1. ***Non-porous wood*** *:* **Vessels are absent** in this type of wood.
Example :- Mostly **Gymnosperms**

2. ***Porous wood*** *:* **Vessels are present** in this type of wood. e.g **Dicots (Angiosperms).**

* On the basis of arrangement of vessels porous wood is divided into two groups.

(i) **Ring porous wood** *:* Vessels are arranged in the form of a ring in this type of wood. Such wood conducts water more efficiently. Example :- *In temperate region plants*. Ex. *Dalbergia*

(ii) **Diffused porous wood**:- Asymmetrical distribution of vessels is found in this type of wood. Example :- In tropical region plants. Ex. ***Azadirachta.***
Note : Non-porous wood also called as **homoxylous wood** and **porous wood** also called as **hetero xylous wood**.

* **Lightest wood** → ***Ochroma pyramidale*** or ***Ochroma lagopus (*****Balsa*****)***
* **Most durable wood** → ***Tectona grandis (*****Teak = Sagwan*****)***

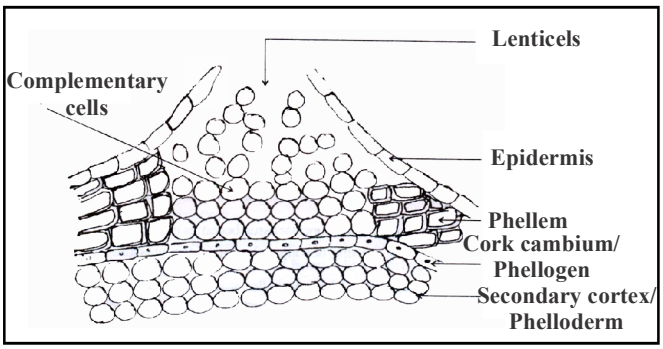
[B] Secondary growth in Extra stelar region (By cork cambium)

* Secondary growth takes place in extra stelar region **due to the activity of cork cambium**.
* Cork cambium is also known as **Phellogen** or **Extrastelar cambium**. The cells of the cork cambium are narrow, thin walled and nearly rectangular.
* Cork cambium develops usually in cortical region of hypodermis.
* As the stem continuous to increase in girth due to activity of vascular cambium the outer cortical and epidermal layers get broken and need to be replaced to provide new protective cell layers. Hence sooner or later another meristematic tissue called cork cambium develops.
* Cork cambium is derived from the **hypodermis** or from the **outer layer of cortex** by dedifferentiation. Cork cambium is formed in the form of a **single** or **a couple of layers thick(mainly)**.
* It forms sec. tissue in extra stelar region.
* Cork cambium divides periclinally. It forms some cells towards the outside (towards epidermis) and some cells towards the inside (towards general cortex). Those cells which are formed towards outside, become suberized. Due to this, these cells become dead. These cells are known as **Cork or Phellem**. Those cell formed towards the inside, are differentiated into parenchyma and may contain chloroplasts. These are called **secondary cortex or Phelloderm**.
* Phellem, phellogen and phelloderm are collectively known as periderm.
* The **cork is impervious to water** due to **suberin deposition** in the cell wall.
* **Commercial cork** is obtained from ***Quercus suber*** **(oak)**
* Cork is formed in high quantity and secondary cortex is in less quantity because, activity of Cork cambium is more towards outside. The highest activity of cork cambium is in winter /Autumn season.
* Due to activity of the cork cambium,pressure builds up on the remaining layers peripheral to phellogen and ultimately these layers die and slough off.
* Ring of cork cambium remains living and active only for one year.
* Each year, a new cork cambium is formed below the previous cambium. This new cambium is derived from the secondary cortex or phelloderm.
* All the tissues which occur outside the innermost cork cambium are collectively termed as **rhytidome**. Rhytidome includes cork and tissues which become dead due to the pressure of cork.

Lenticels

* At certain regions, the phellogen (cork cambium) cuts off closely arranged parenchymatous cells on the outer side instead of cork cells.
* These thin walled, rounded, colourless, parenchymatous cells are called **complimentary cells.** These cells are **not suberized.**
* As the complementary cells increase in number, pressure is exerted on the epidermis due to which it ruptures, forming a lens-shaped openings called **lenticels.**

* Lenticels are generally formed beneath the stomata or group of stomata of the epidermis.
* Complimentary cells are formed by the activity of **phellogen** (cork cambium).



Functions

1. The main function of lenticels is exchange of gases between plant and atmosphere. Rows (vertical or longitudinal) of lenticels may occur opposite the medullary rays, facilitating the free exchange of gases.
2. Transpiration also takes place through the lenticles, is known as Lenticular transpiration.
3. Adventitious roots on cutting originates from the living cells of lenticels in vegetative reproduction.

Note:

* Lenticels are found in most of the woody trees but absent in woody dimbers.
* Lenticels are mainly found on wood stems and they are never found on leaves. Lenticels are present all over the plant body They are also present on fruits.

Bark

There are two views about the bark.

1. **Old view :** All the tissues situated out side the cork cambium is called bark. According to old view bark includes mainly dead tissues.
2. **Modern view : Bark** is a non-technical term that refers to **all tissues exterior to the vascular cambium**, therefore including secondary phloem. According to modern view bark includes both living and dead tissues.

Kinds of Bark

1. **Ring Bark :**

* Continuous bark of equal thickening is called ring bark.
* It is formed around the stem in the form of a complete ring. In ring bark cork cambium is continuous.
* **Example : Bhojpatra (Betula) -** A complete distinct ring bark is formed in this plant. Its bark was used as a writing material /as a paper in ancient period. Ring bark is also formed in ***Eucalyptus***.

2. **Scaly Bark :**

* Discontiuous bark of unequal thickening is called scaly bark.
* This bark is formed around the stem in the form of **pieces** or **fragments**.
* In scaly bark the ring of cork cambium is not continuous.
* Scaly bark is formed in **Guava (Psidium guajava)**. **Neem *(Azadirachta),* Mango *(Mangifera indica)*** and ***Tamarind* = *Imli* *(Tamarindus)*** etc plants.
* Highly distinct scaly bark is formed in *Psidium guajava* (Guava)
* Scaly bark is found in most of the woody plants.
* Secondary phloem & periderm are included in bark.
* Bark refers to a number of tissue types, viz., periderm and secondary phloem.
* Bark that is formed early in the season is called **early** or **soft bark**.
* Towards the end of the season, **late or hard bark** is formed.

Note:

(i) If complete bark of tree is removed then paint become dead due to excessive water loss.

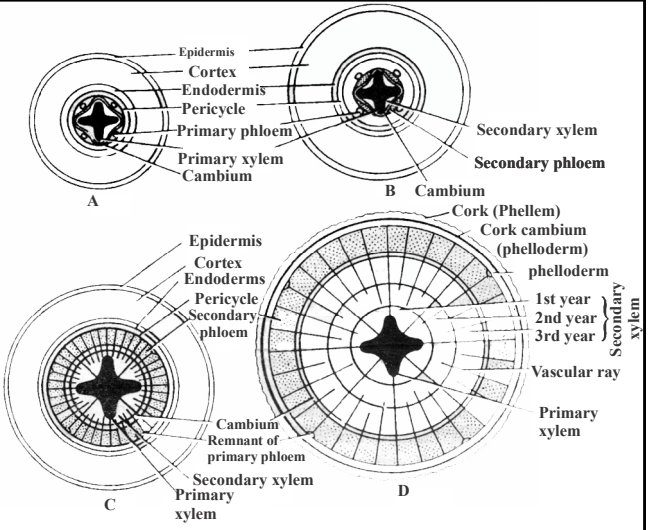
(ii) If bark is removed in the form of ring (Girdling) at the base of main stem then root will die first due to lack of food.

* Girdling is not possible in monocot stem because vascular bundles are scattered.

Secondary growth in Dicot root

* First of all, conjunctive tissue becomes meristematic during the secondary growth in a dicotyledon root and form separate curved strips of vasular cambium below phloem bundles. Then after, the cells of pericycle lying opposite to protoxylem also becomes meristematic to form additional strips of cambium.

* In this way a complete ring of vascular cambium is formed.
* The portion of vascular cambium formed by pericycle is less. The main portion of vascular cambium is formed by conjunctive tissue.
* The shape of ring of vascular cambium is wavy in the beginning, but later on it becomes circular due to the pressure of secondary xylem.
* The portion of vascular cambium formed by conjunctive tissue becomes meristematic first and form the secondary xyelm towards the centre. Ultimately the ring becomes circular by the pressure of secondary xylem (Pushing outwards).
* In the dicot root the **vascular cambium is completely secondary in origin.**
* The activity of vascular cambium of root is the same as the activity of vascular cambium of stem.
* **Secondary xylem** is formed towards the inner side and **secondary phloem** is formed towards the outer side by vascular cambium.
* The portion of vascular cambium which is formed by pericycle is responsible for the formation of **pith rays.** These are made up of parenchyma.
* These pith rays are known as **primary medullary rays (Multiseriate)**.



Different stages in secondary growth of dicot root

* A few medullary or pith rays are also formed from remaining vascular cambium. These are called **secondary medullary rays (uniseriate).** Thus two types of medullary rays are found in the secondary structure of roots.

Note : The presence of two types of medullary rays is basic characteristic feature of roots. Only secondary medullary rays are found in dicot stem during the secondary growth. Both of them conduct water and food in radial direction.

* Cork cambium is developed from the pericycle in roots.
* Cork is formed towards the outside and secondary cortex is formed towards the inner side by the cork cambium. Lenticels are also found in roots but less in number as compared to stem. Cortex completely degenerate in roots after the secondary growth of one or two years. This falls down due to the pressure of cork, whereas in stem, it degenerates after the long duration.

(i) Secondary growth is essential in roots to provide strength to the growing aerial parts of the plants and fulfill the requirement of water and minerals.

(ii) Generally clear annual rings are not seen in roots because roots are not effected by the changes of environment.

(iii) Secondary growth is not found in monocot roots.

(iv) In dicot roots, all cambia and pith rays (medullary rays) are secondary in origin.

Functions of secondary meristem

1. Healing of wounds :

* It occurs by the activity of wound cambium (inducible cambium).
* By the activity of wound cambium wound cork is formed towards the outside which covers the wound entirely.

2. Abscission :

* Falling of leaf is called abscission.
* Abscission takes place due to formation of abscission layer at the base of petiole and it is composed of parenchyma.
* ABA induces the formation of abscission layer.

Note : Formation of protective layer (suberized) at the site of abscission.

3. Formation of knots :- Knot is formed when bases of branches are embedded inside the main stem.

4. Help in grafting :- Grafting is not possible in monocots due to absence of cambium.

CONCEPT REVIEW

* Anatomically, a plant is made of different kinds of tissues. The plant tissues are broadly classified into meristematic (apical, lateral and intercalary) and permanent (simple and complex).
* Assimilation of food and its storage, transportation of water, minerals and photosynthates, and mechanical support are the main functions of tissues.
* There are three types of tissue systems - epidermal, ground and vascular.
* The epidermal tissue systems are made of epidermal cells, stomata and the epidermal appendages.
* The ground tissue system forms the main bulk of the plant. It is divided into three zones cortex,pericycle and pith.
* The vascular tissue system is formed by the xylem and phloem.
* On the basis of presence of cambium, location of xylem and phloem, the vascular bundles are of different types. The vascular bundles form the conducting tissue and trans locate water, minerals and food material.
* Monocotyledonous and dicotyledonous plants show marked variation in their internal structures. They differ in type, number and location of vascular, bundles.
* The secondary growth occurs in most of the dicotyledonous roots and stems and it increases the girth (diameter) of the organs by the activity of the vascular cambium and the cork cambium.
* The wood is actually a secondary xylem. There are different types of wood on the basis of their composition ,and time of production.
* **Complex Tissues :**

(a) **Xylem :** Xylem consists of tracheids, vessels, xylem fibres and xylem parenchyma. It conducts water and minerals from roots to other parts of plant.

Protoxylem : The first formed primary xylem elements.

Metaxylem : The later formed primary xylem.

Endarch : Protoxylem lies towards the centre and metaxylem towards the periphery of the stems.

Exarch : In roots,the protoxylem lies towards periphery and metaxylem lies towards the centre.

(b) **Phloem :** Phloem consists of sieve tube elements, companion cells, phloem fibres and phloem parenchyma. Phloem transports the food material from leaves to various parts of the plant.

Protophloem : First formed phloem with narrow sieve tubes.

Metaphloem : Later formed phloem with bigger sieve tubes.

* **Types of Meristems**

S.N.	Apical meristem	Intercalary meristem	Lateral meristem
1	Occurs at the tips of roots and shoots.	Occurs between mature tissues.	Occurs in the mature regions of roots and shoots.
2	Primary meristem.	Primary meristem.	Secondary meristem.
3	Increase the length of plant.	Capable of forming branch and flower.	Appears later than primary meristem and responsible for secondary growth.

* **Simple Tissues :**

Ground Tissue	Parenchyma Tissue	Collenchyma Tissue	Sclerenchyma Tissue
Function	• Photosynthesis • Food storage • Healing and tissue regeneration	• Support in young stems, roots, and petioles	• Rigid support • Protection
Cell	Parenchyma cells Thin walled cells, with intercellular spaces, cell wall is made up of cellulose.	Collenchyma cells closely packed cells which are thickened at the corners due to deposition of cellulose, hemicelluloses and pectin.	Sclereid cells & fiber cells dead cells with thick and lignified cell walls with pits.

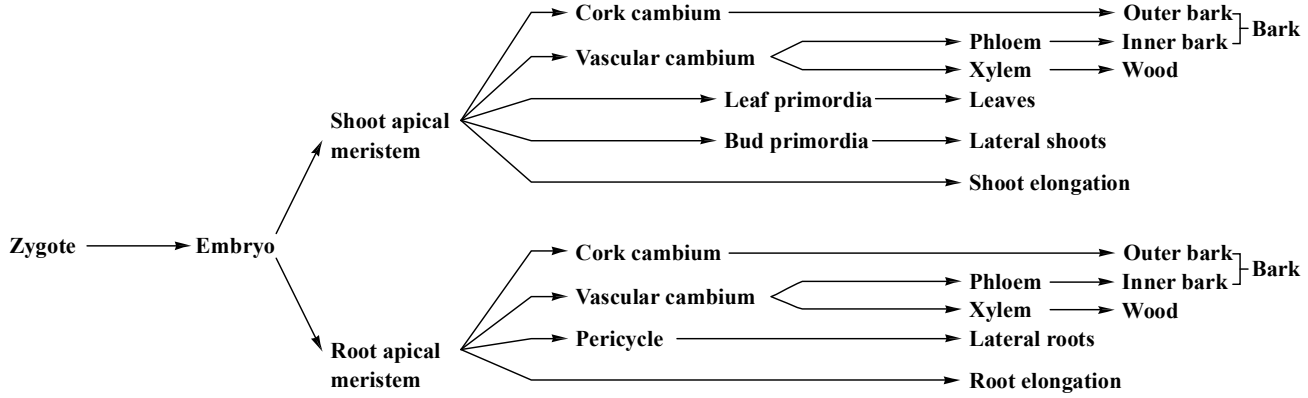
IMPORTANT POINTS

* In case of dicot roots the cork cambium is derived from pericycle.
* Collenchymatous hypodermis is present in dicot stem.
* In leaves, protoxylem (xylem) elements face towards the adaxial side.

* Centripetal xylem is found in root.
* Pericycle of roots produces lateral roots.
* Functional xylem of a dicot tree is sap wood.
* Cotton contains vascular bundles in a ring.
* Fascicular cambium of dicot stem is primary meristem.
* Kranz anatomy is found in case of leaf.
* Periderm is produced by phellogen.
* Endodermis is part of cortex.
* Hard wood have vessels in abundance.
* Secondary growth is absent in hydrophytes.
* A monocot showing secondary growth is yucca.
* Secondary xylem is wood.
* Main function of lenticel is gaseous exchange.
* Lysigenous cavity occurs in stem of Zea mays.
* The correct match of species with type of wood:
  Tectona grandis – Hardwood
  Cedrus deodara – Softwood
  Shorea robusta – Hardwood
  Dalbergia sisso – Hardwood
* Sugarcane plant has dumb-bell shaped guard cells.
* In dicot root phloem and xylem bundles are separated by conjuctive tissue.
* The sequence order of the location from periphery to centre in the entire dicotyledonous plant body –
  Trichoblasts – Collocytes – Fusiform cells – Tylosis
* An old trunk of Shisham (*Dalbergia sisso*) tree would have the maximum amount of secondary xylem.
* Albuminous cells occurs in phloem.
* Tracheids differ from vessels in having discontinuous lumina due to presence of end walls.
* Epidermal outgrowths are known as trichomes.
* Most common type of stomata is potato type.
* Collenchyma occurs in climbing stems.
* Lignin occurs in tracheids.
* Collateral and open = Sunflower.
  Radial = Maize root
  Bicollateral = *Cucurbita stem*
  Concentric = Fern
* Medullary rays does not occur in xylem.
* Parenchyma tissue is characterised by the presence of intercellular spaces.
* Pith or central part of ground tissue is made of parenchyma.
* Xylem vessels = Perforated plates
  Xylem tracheids = Chisel-like ends
  Xylem fibre = Obliterated lumen.
  Xylem parenchyma = Store food material.
* Xylem produced through centrifugal differentiation is centrarch.
* Cambium produces growth in girth.
* Dermatogen, plerome and periblem are meristematic tissues.
* Lateral meristem are responsible for growth of thickness.
* Meristem which forms primary vascular tissue is procambium.
* Cambial cells are formed from promeristem.
* Vascular cambium of dicot stem is lateral meristem.
* Shoot apical meristem occurs over the tip of plumule.
* Length of different internodes in culm of sugarcane is variable due to intercalary meristem.
* Meristem that is parallel to the longitudinal axis of the plant is phellogen.
* Portion of apical meristem that gives rise to xylem tissue is called procambium.
* The sclerenchyma cells are thick walled, dead, often lignified whose function is mechanical strength.
* Sclerenchyma takes dark red stain with Safranln.
* The sclerenchyma fibres are very long, narrow, thick and lignified cells usually tapering at both ends.
* Xylem conducts water and mineral nutrients from the root to the leaves.
* In Angiosperms vessels are present along with tracheids.
* In Gnetum (Gymnosperm) vessels are also present.
* In sieve tube nucleus is absent.
* Companion cells occur only in Angiosperms and are absent in Pteridophytes and Gymnosperms.
* Phloem parenchyma is absent in monocots.
* Tyloses are balloon-like outgrowths of xylem parenchyma and ray parenchyma into the tracheary elements.

* Passage cells allow the entry of water from cortex to stele.
* If xylem and phloem are present at different radii, they are called radial vascular bundles, e.g., Roots.
* In amphivasal vascular bundles, xylem surrounds the phloem, e.g. Secondary V.B. of Dracaena stem.
* In stems vascular bundles are conjoint, collateral or sometimes bicollateral or concentric.
* In dicot stem vascular bundles are open (i.e., cambium Is present) and they are arranged in a ring or rings.
* In monocot stem vascular bundles are closed (i.e., cambium Is absent) and scattered.
* In secondary growth the youngest or latest formed secondary xylem and secondary phloem lie closer to the vascular cambium. i.e., sec. xylem just on inner side and sec. phloem just on outside of cambium.
* The age of plant can be determined by counting the number of annual growth rings. Annual rings are in the plants growing in areas of uniform seasons, e.g., Bombay, Madras, Calcutta etc.
* Heartwood (duramen) provides only mechanical support to tree. It is nonconducting in nature.
* Sap wood or alburnum is the only conducting part of xylem in older stems.
* Periderm is formed due to the activity of phellogen.
* Periderm is made up of phellogen, phellem and phelloderm.
* The dead tissue outside the cork cambium is called cork or phellem.
* All the tissues lying outside the vascular cambium constitute bark.
* Ring bark is present in Bhojpatra (Betula utilis).
* Lenticels are minute pore-like openings which are present in the cork and help in exchange of gases.
* In deciduous ,plants leaves fall due to the formation of abscission layer.
* Knots are formed due to branches get buried in the stem.
* Normally no secondary growth in monocot stems except anomalous secondary growth in Dracaena, Yucca, etc.
* In monocots grafting is not successful due to closed and scattered vascular bundles.
* In a hollow hearted plant the growth of the plant is not affected.

* **Stages in the differentiation of plant tissues.**



Undifferentiated	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5: Fully differentiated

QUESTION BANK

EXERCISE - 1 (LEVEL-1) [NCERT EXTRACT]

SECTION - 1 (VOCABULARY BUILDER)

Choose one correct response for each question.
For Q.1-Q.5
Match the column I with column II.

Q.1

	Column I	Column II
a.	Cork	1. Phellogen
b.	Secondary cortex	2. Phellem
c.	Cork cambium	3. Phelloderm

Codes
(A) a-1, b-2, c-3 (B) a-3, b-2, c-1
(C) a-3, b-1, c-2 (D) a-2, b-3, c-1

Q.2

	Column I	Column II
a.	Sclereids	1. Spherical, oval, cylindrical
b.	Fibre	2. Highly thickened dead cells
		3. Narrow lumen
		4. Thick walled
		5. Elongated and pointed cells

Codes
(A) a = 1, 2 ; b = 3, 4, 5
(B) a = 1, 2, 3 ; b = 4, 5
(C) a = 4, 5 ; b = 1, 2, 3
(D) a = 3, 4, 5 ; b = 1, 2

Q.3

	Column I	Column II
a.	Hypodermis	1. Collenchymatous cells
b.	Cortical layers	2. Parenchymatous cells
c.	Endodermis	3. Rich in starch

Codes
(A) a-3, b-2, c-1 (B) a-3, b-1, c-2
(C) a-1, b-2, c-3 (D) a-1, b-3, c-2

Q.4 Match the following columns.

	Column I	Column II
a.	Early Wood	1. spring wood
b.	Late Wood	2. autumn wood
		3. Lighter in colour
		4. Darker in colour

Codes
(A) a-1, 2 ; b-4, 3 (B) a-1, 3 ; b-2, 4
(C) a-3, 4 ; b-1, 2 (D) a-2, 3 ; b-1, 4

Q.5 Match the following columns.

	Column I	Column II
a.	Endodermis	1. Companion cells
b.	Stomata	2. Lenticels
c.	Sieve tube	3. Palisade cells
d.	Periderm	4. Passage cells
e.	Mesophyll	5. Accessory cells

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

SECTION - 2 (BASIC CONCEPTS BUILDER)

For Q.6 to Q.39 :
Choose one word for the given statement from the list.

Intercalary meristem, thin, thick, vascular cambium, parenchyma tissues, Radial, protoxylem; phellogen, metaxylem, cortex, tracheids, lenticels, xylem, periphery, Lateral meristem, Quiescent centre, tip, stem, secondary meristem, suberin, endodermis, Bulliform cells, pith, Stele, axillary bud, root hairs, Meristems, Collenchyma, Ray initials, periderm, cuticle.

Q.6 Specialised regions of plants having active cell division are called ____.

Q.7 The meristem found intercalated between permanent tissues is called ____.

Q.8 The meristem that is required for increase in girth of plant body is _____.

Q.9 First formed primary xylem elements are called ____. Later formed primary xylem elements are called ____.

Q.10 Simple tissues which occurs in layers below the epidermis in dicotyledonous plants are ____.

Q.11 The outer walls of guard cells (away from stomatal pore) are ____ While the inner walls (towards the stomatal pore) are ____.

Q.12 Inverted cup like structure in root apex is called _____ .

Q.13 Type of vascular bundles, when the xylem and phloem are arranged on different radii,alternating with each other is ____.

Q.14 _____ of vascular cambium are isodiametric and form ray parenchyma.

Q.15 Conducting tissue for the transport of water and minerals from the roots to the stems and leaves is called _____.

Q.16 A branch or a flower develops in the axil of the leaves by the activity of ____.

Q.17 Roots apical meristem occupies the ___ of roots, while shoot apical meristem occupies the distant most region of the ___ axis.

Q.18 The surface area of leaves in monocotyledon plant can be regulated by the help of ____.

Q.19 The merismatic tissue responsible for the cutting of vascular tissue (xylem and phloem) is called ____.

Q.20 Elongation of epidermal cells which helps in the absorbtion of water and minerals from the soil are called ____.

Q.21 New protective layers formed after the crushing or breaking of cortical and epidermal layers due to increase in the girth of stem by vascular cambium. These new layers collectively called as ____.

Q.22 Aerating pores are present at places on the cork cambium. These are called ____.

Q.23 During secondary growth new meristematic tissues arising in the cortical region of the stem are called ____.

Q.24 The innermost layer of cortex is called ____.

Q.25 Water impermeable, waxy material secreted by endodermal cells is called ____.

Q.26 All the tissues on the inner side of the endodermis constitutes together to form ____.

Q.27 Simple permanent living tissues which are made up of thin-walled similar isodiametric cells are called ____.

Q.28 Central part of root occupied by parenchymatous (thin or thick walled) cells is called ____.

Q.29 Epidermis is often covered with a waxy thick layer called ____.

Q.30 The chief water conducting elements of xylem in the gymnosperm are ____.

Q.31 The cells arranged in multiple layers between the epidermis and pericycle is called ____.

Q.32 In dicot stem, secondary xylem lie towards the ___ and secondary phloem lie towards the ____.

Q.33 The meristem which is particularly present in the mature regions of roots and shoots and produce woody axis and appear later than the primary meristem is called ____.

Q.34 Ergastic substances are absent in meristem cells. **[True / False]**

Q.35 Secondary meristem arises directly from primary meristem. **[True / False]**

Q.36 Main function of general cortex is storage of food. **[True / False]**

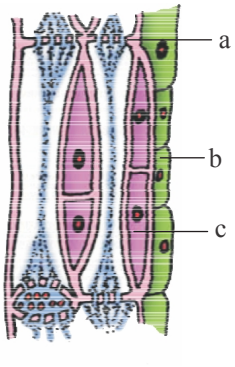
Q.37 Bicollateral vascular bundles are present in the stem of sunflower. **[True / False]**

Q.38 Complimentry cells are cut off by phellogen towards outside. **[True / False]**

Q.39 Meristematic layer that is responsible for cutting off xylem and phloem is called vascular cambium. **[True / False]**

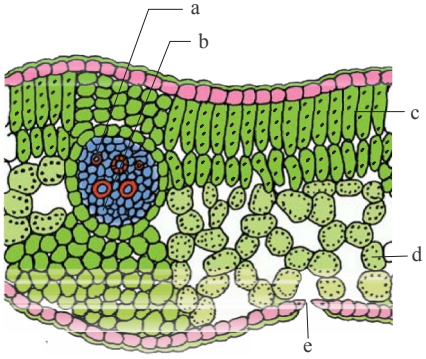
SECTION - 3 (ENHANCE DIAGRAM SKILLS)

Q.40 In the given diagram of phloem tissue, identify a, b and c.



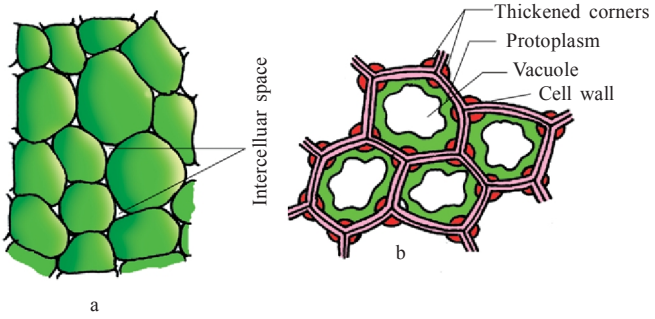
(A) a-Sieve tube cells, b-Xylem parenchyma, c-Companion cell
(B) a-Seive tube cells, b-Phloem parenchyma, c-Companion cell
(C) a-Sieve pore, b-Xylem parenchyma, c-Companion cell
(D) a-Sieve pore, b-Phloem parenchyma, c-Companion cell

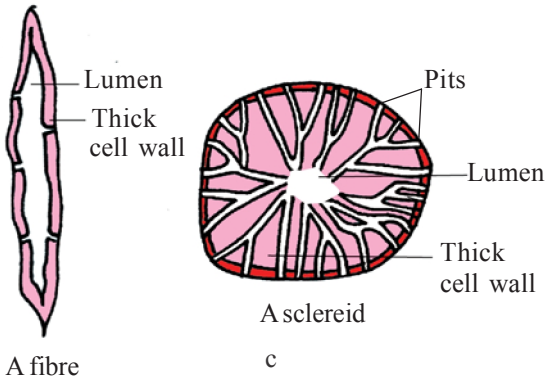
Q.41 In the given TS of dicot leaf, identify a to e and choose the correct option.



(A) a-Phloem, b-Xylem, c-Palisade mesophyll, d-Spongy mesophyll, e-Stomata
(B) a-Phloem, b-Xylem, c-Palisade mesophyll, d-Spongy mesophyll, e-Stomata
(C) a-Xylem, b-Phloem, c-Palisade mesophyll, d-Spongy mesophyll, e-Stomata
(D) a-Xylem, b-Phloem, c-Palisade mesophyll, d-Spongy mesophyll, e-Hydathodes

Q.42 Identify the types of simple tissue given in the diagram a, b and c.

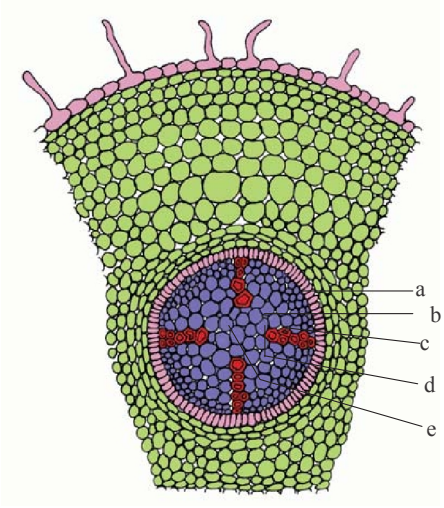




(A) a-Parenchyma, b-Sclerenchyma, c-Collenchyma

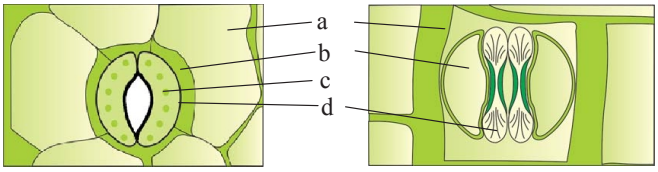
(B) a-Parenchyma, b-Collenchyma, c-Sclerenchyma
(C) a-Sclerenchyma, b-Collenchyma, c-Parenchyma
(D) a-Sclerenchyma, b-Parenchyma, c-Collenchyma

Q.43 Identify a to e in the given diagram. (T.S. of dicot root)



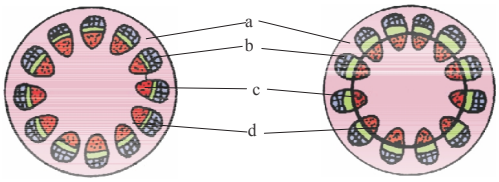
(A) a-Endodermis, b-Pericycle, c-Protoxylem, d-Metaxylem, e-Pith
(B) a-Endodermis, b-Pericycle, c-Protoxylem, d-Pith, e-Metaxylem
(C) a-Endodermis, b-Pericycle, c-Pith, d-Protoxylem, e-Metaxylem
(D) a-Endodermis, b-Pith, c-Pericycle, d-Protoxylem, e-Metaxylem

Q.44 Identify a to d in the given diagram and choose the correct option.



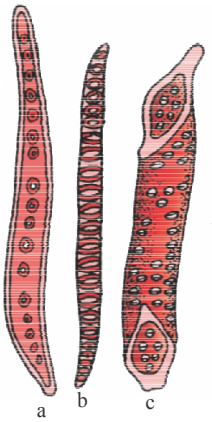
(A) a-Epidermal cell, b-Guard cell, c-Subsidiary cell, d-Chloroplast
(B) a-Epidermal cell, b-Subsidiary cell, c-Chloroplast, d-Guard cell
(C) a-Epidermal cell, b-Chloroplast, c-Subsidiary cell, d-Guard cell
(D) a-Guard cell, b-Chloroplast, c-Subsidiary cell, d-Epidermal cell

Q.45 Given below the diagram of secondary growth in dicot stem (diagrammatic). Identify a to d.



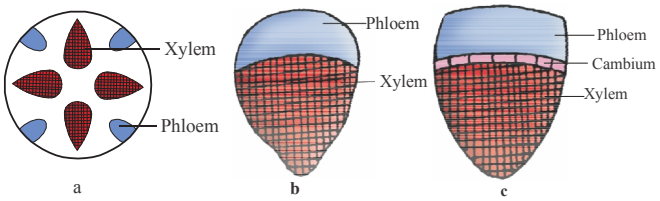
(A) a-Cortex, b-Secondary xylem, c-Secondary phloem, d-Vascular cambium
(B) a-Cortex, b-Primary phloem, c-Vascular cambium, d-Primary xylem
(C) a-Cortex, b-Primary xylem, c-Vascular cambium, d-Primary phloem
(D) a-Cortex, b-Primary xylem, c-Vascular cambium, d-Primary phloem

Q.46 Identify a, b and c in the given diagram.



(A) a-Tracheid, b-Vessels, c-Vessels
(B) a-Vessels, b-Tracheid, c-Companion cell
(C) a-Companion cell, b-Vessels, c-Tracheid
(D) a-Xylem fibre, b-Vessels, c-Vessels

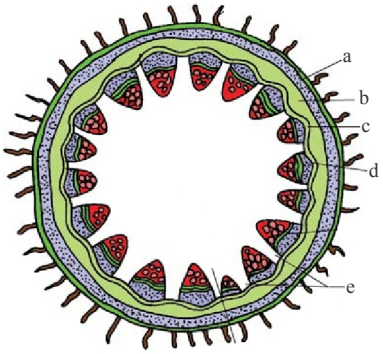
Q.47 Identify type of vascular bundle with respect to



(A) a-Conjoint closed, b-Conjoint open, c-Radial
(B) a-Radial, b-Conjoint open, c-Conjoint closed
(C) a-Radial, b-Conjoint closed, c-Conjoint open

(D) a-Conjoint open, b-Conjoint closed, c-Radial

Q.48 Identify a to e in the given TS of dicot stem and choose the correct option.



(A) a-Hypodermis, b-Chlorenchyma, c-Endodermis, d-Pericycle, e-Medullary rays
(B) a-Hypodermis, b-Parenchyma, c-Endodermis, d-Pericycle, e-Medullary rays
(C) a-Hypodermis, b-Sclerenchyma, c-Endodermis, d-Pericycle, e-Medullary rays
(D) a-Hypodermis, b-Sclerenchyma, c-Endodermis, d-Pericycle, e-Parenchyma

SECTION - 4 (ENHANCE PROBLEM SOLVING SKILLS)

Choose one correct response for each question.

PART - 1 : TISSUE

Q.49 Apical meristems are present at the
(A) tips of roots
(B) tips of shoots
(C) lateral sides of roots and shoots
(D) Both (A) and (B)

Q.50 Intercalary meristem is related to all, except –
(A) Present between permanent cells.
(B) Part of apical meristem.
(C) Increasing the girth of axis.
(D) Regenerates part of grasses removed by grazing herbivores.

Q.51 Which of the above following are simple tissues?
I. Parenchyma II. Collenchyma
III. Sclerenchyma
(A) I and II (B) II and III
(C) I and III (D) I, II and III

Q.52 Which of the following would be present in insignificant amount in xylem sap?
(A) Sugar (B) Nitrates
(C) Phosphates (D) Water

Q.53 Example of secondary meristem is
(A) fascicular vascular cambium
(B) interfascicular cambium
(C) cork cambium
(D) All of the above

Q.54 Interxylary phloem is not found in
(A) Potato (B) *Leptadaenia*
(C) *Salvadora* (D) *Chenopodium*

Q.55 Which component is not found in phloem of angiosperms?
(A) Albuminous cells (B) Sieve tube
(C) Companion cell (D) Bast fibre

Q.56 Primary meristem is
(A) apical meristem
(B) intercalary meristem
(C) root apical meristem and shoot apical meristem
(D) Both (A) and (B)

Q.57 Meristamatic tissue helps in the
(A) absorption of water
(B) growth of plant
(C) absorption of minerals
(D) transpiration

Q.58 In roots the
(A) protoxylem lies towards the periphery
(B) metaxylem lies towards the pith (centre)
(C) Both (A) and (B)
(D) endarch condition is found

Q.59 Thickening material in collenchyma is
(A) Pectin, cellulose, hemicellulose
(B) Lignin, cellulose, hemicellulose
(C) Hemicellulose, suberin, cellulose
(D) Suberin, pectin, cellulose

Q.60 Long hair like sclereids found in aerial roots of Monstera are known as
(A) Brachysclereids (B) Trichosclereids
(C) Macrosclereids (D) Astrosclereids

Q.61 Cells of collenchyma have thickened corners due to the deposition of
(A) cellulose (B) hemicellulose
(C) pectin (D) All of these

Q.62 Sclerenchyma mainly provides
(A) storage tissue to the plants.
(B) mechanical support to the organs of plants.
(C) secretory tissue to the plants
(D) strength to monocot plants, specially their abundance in the layers below the epidermis

Q.63 Major xylary element in wood of a gymnospermic plant is –
(A) Vessel (B) Tracheid
(C) Xylem fibre (D) Xylem parenchyma

Q.64 Which of the following cell helps in maintaining the pressure gradient in the sieve tubes?
(A) Phloem parenchyma (B) Bast fibre
(C) Companion cell (D) Wood fibre

Q.65 Xylem fibres are made up of
(A) sclerenchyma cells with thin walls
(B) sclerenchyma cells with thick wall
(C) parenchyma cells with thin wall
(D) sclerenchyma cells with no obliteration in central lumen

Q.66 Meristem responsible for the production of secondary tissues–
(A) Primary meristem
(B) Root apical meristem
(C) Shoot apical meristem
(D) Secondary meristem

Q.67 Axillary bud originates from
(A) meristem
(B) shoot apical meristem
(C) root apical meristem
(D) secondary meristem

Q.68 Quiescent centre is found in plants at the
(A) root tip (B) cambium
(C) shoot tip (D) tip

Q.69 Select the correct statement from the following.
(A) The cells of the permanent tissue do not generally divide.
(B) Permanent tissues having all cells similar in structure and function are called simple tissues
(C) Permanent tissues having many different types of cells are called complex tissues
(D) All of the above

Q.70 The most abundant tissues in plants are
(A) meristematic tissues (B) parenchyma tissues
(C) collenchyma tissues (D) sclerenchyma tissues

Q.71 On the basis of variation in form, structure, origin and development, sclerenchyma may be
(A) fibres (B) sclereids
(C) Both (A) and (B) (D) None of these

Q.72 Xylem tissue is composed of
(A) four same kinds of elements
(B) three same kinds of elements
(C) four different kinds of elements
(D) three different kinds of elements

Q.73 The functions of sieve tubes are controlled by
(A) cytoplasm of sieve tube cells.
(B) nucleus of sieve tube cells.
(C) nucleus of companion cells.
(D) cytoplasm of companion cells.

Q.74 Sclerenchyma fibres are
(A) thick-walled (B) elongated
(C) pointed cells (D) All of these

Q.75 In flowering plants, the main water transporting elements are
(A) tracheids (B) vessels
(C) fibres (D) Both (A) and (B)

Q.76 Which of the following cells are studied during translocation of solutes?
(A) Sieve tube cells (B) Companion cells
(C) Phloem fibre (D) Xylem fibre

Q.77 Cells having no power of cell division are formed by –
(A) primary meristem (B) fascicular cambium
(C) cork cambium (D) All of these

PART - 2 : TISSUE SYSTEM

Q.78 Primary function of epidermis is
(A) photosynthesis
(B) protection
(C) conduction of water and solutes
(D) mechanical support

Q.79 Shape of guard cells in monocot plants is-
(A) Kidney shape
(B) Bean seeds shape
(C) Dumb-bell shape or bone shape
(D) Oval

Q.80 Cambium is present in between
(A) phloem and xylem
(B) permanent mature cells
(C) collenchyma and sclerenchyma
(D) collenchyma and parenchyma

Q.81 I. Epidermal cells II. Stomata.
III. Trichomes IV. Root hairs
These are the attributes of
(A) epidermal tissue system
(B) ground tissue system
(C) fundamental tissue system
(D) vascular tissue system

Q.82 Cambium is a type of
(A) apical meristem
(B) intercalary meristem
(C) lateral meristem
(D) permanent or mature meristem

Q.83 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 cells of xylem, phloem and medullary rays

Q.84 Trichomes are epidermal hairs of
(A) primary root (B) primary stem
(C) primary leaves (D) secondary root

Q.85 Ground tissue does not include
I. epidermis II. vascular bundle
III. sclerenchyma IV. collenchyma
V. parenchyma
Select the right combination from the above given options.
(A) I and II (B) III and IV
(C) I and V (D) I and IV

Q.86 Which cells possess chloroplast and regulate the opening and closing of stomata?
(A) Cuticle cell (B) Stomatal cell
(C) Guard cell (D) Subsidiary cell

Q.87 Open vascular bundles
(A) have cambium in between the primary and secondary xylem.
(B) have cambium in between the primary and secondary phloem.
(C) have cambium in between the xylem and phloem.
(D) don't have cambium in between xylem and phloem.

Q.88 Cuticle is absent in which part of plant?
(A) leaves (B) root
(C) stem (D) pneumatophores

Q.89 Stomatal apparatus consists of
(A) stomatal aperture (B) guard cell
(C) subsidiary cells (D) All of these

Q.90 Vascular system consists of
I. xylem II. phloem
III. ground meristem IV. epidermal meristem
Select the correct combination from the given options.
(A) I and II (B) I, II and III
(C) I, II and IV (D) I, III and IV

PART - 3 : ANATOMY OF DICOTYLEDONOUS AND MONOCOTYLEDONOUS PLANTS

Q.91 Conjuctive tissue is made up of
(A) parenchymatous cells, i.e., in between the xylem and phloem.
(B) sclerenchymatous cells, i.e., in between the xylem and phloem.
(C) collenchymatous cells, i.e, in between the xylem and phloem.
(D) merismatic cells, i.e, in between the xylem and phloem

Q.92 Epidermis covered with cuticle, bearing trichomes and few stomata is the characteristic feature of
(A) root (B) dicot stem
(C) vascular bundle (D) monocot stem

Q.93 Carsparian strips are found on radial and inner walls of –
(A) Stem endodermis (B) Root endodermis
(C) Pericycle (D) Outer cortex

Q.94 Amphistomatic leaf is
(A) dicotyledonous leaf
(B) monocotyledonous leaf
(C) Both (A) and (B)
(D) None of these

Q.95 Border parenchyma or bundle sheath is made up of
(A) parenchymatous cell
(B) sclerenchymatous cell
(C) chlorenchymatous cell
(D) All of these

Q.96 In monocotyledonous stem, the vascular bundles are
(A) conjoint and open
(B) conjoint and closed
(C) scattered through out the ground tissue
(D) Both (B) and (C)

Q.97 The outermost layer of dicotyledonous root is called
(A) cortex (B) epidermis
(C) cambium (D) periderm

Q.98 Dicot root is similar in all given characters with monocot root, except
(A) Radial, exarch vascular bundles
(B) Unicelled root hairs
(C) Pericycle forms the lateral roots
(D) Well developed pith

Q.99 In dicotyledonous roots, cambium develops in between
(A) xylem and cortex
(B) phloem and meristem .
(C) xylem and phloem
(D) two xylem strands

Q.100 Medullary rays are formed by the
(A) radially placed parenchymatous cells between vascular bundles.
(B) longitudinally placed parenchymatous cells between vascular bundles.
(C) laterally placed parenchymatous cells between vascular bundles.
(D) obliquely placed parenchymatous cells between vascular bundles.

Q.101 Stem of barley is related to
(A) Presence of collenchyma in hypodermis.
(B) Scattered vascular bundles.
(C) Presence of parenchymatous pericycle.
(D) Presence of wedge shaped vascular bundles

Q.102 Conjoint, collateral, endarch and closed vascular bundles are found in –
(A) Monocot root (B) Monocot stem
(C) Dicot root (D) Dicot stem

Q.103 Bulliform cells are the modification of
(A) abaxial epidermis cell
(B) adaxial epidermis cell
(C) mesophyll
(D) vascular tissue

Q.104 Bulliform cells are
(A) Empty (B) Colourless
(C) Found in grass leaves (D) All of these

Q.105 Initiation of lateral roots and vascular cambium during secondary growth occurs due to activity of
(A) endodermis (B) pericycle
(C) casparian strip (D) periderm

Q.106 Abaxial surface of the leaf generally bears
(A) less stomata than adaxial epidermis.
(B) more stomata than adaxial epidermis.
(C) equal stomata than adaxial epidermis.
(D) hairs to absorb the minerals.

Q.107 Polyarch condition is found in which of the following?
(A) Monocotyledonous stem
(B) Monocotyledonous leaves
(C) Monocotyledonous roots
(D) Dicotyledonous stem

Q.108 In dicotyledonous root, the cortex consists of
(A) sclerenchymatous tissue
(B) collenchymatous tissue
(C) parenchymatous tissue
(D) endodermis tissue

Q.109 The ring arrangement of vascular bundle is the characteristic feature of
(A) dicot root (B) monocot root
(C) monocot stem (D) dicot stem

PART - 4 : SECONDARY GROWTH

Q.110 Intrafascicular cambium is present in between the
(A) primary xylem and secondary xylem.
(B) secondary phloem and primary xylem.
(C) primary xylem and primary phloem.
(D) primary xylem and secondary phloem.

Q.111 Vascular cambium in dicot stem is
(A) Primary meristem in origin
(B) Secondary meristem in origin
(C) Promeristem in origin
(D) Both primary and secondary meristem in origin

Q.112 Narrow bands of parenchymatous tissue which passes through the secondary xylem and phloem radially are called
(A) pith
(B) stele
(C) primary medullary rays
(D) secondary medullary rays

Q.113 Tissues involved in secondary growth is/are
I. intercalary stem
II. vascular cambium
III. cork cambium
Select the correct options from below
(A) I and II (B) II and III
(C) I and III (D) I, II and III

Q.114 Heart wood is characterised by all, except
(A) Presence of tyloses
(B) Presence of tannins, resins, oils, gums etc.
(C) Its commercial importance for timber
(D) Active in water conduction

Q.115 Bark includes
I. phellogen II. phellem
III. secondary phloem IV. secondary xylem
Select the correct combination.
(A) only I (B) I, II and III
(C) ony III (D) All of these

Q.116 Large number of xylary elements having vessels with wider activity are produced in
(A) spring wood (B) autumn wood
(C) early wood (D) (A) or (C)

Q.117 Bark is a non-technical term that does not include
(A) Secondary xylem (B) Secondary phloem
(C) Phellem (D) Secondary cortex

Q.118 In young stem, the vascular cambium is
(A) single layered (B) bilayered
(C) trilayered (D) does not exist

Q.119 Exchange of gases between the outer atmosphere and internal tissue of the stem takes place by (in dicot stem)
(A) lenticels (B) stomata
(C) hydathodes (D) pneumatophores

Q.120 Interfascicular cambium is formed by the joining of
(A) medullary rays to xylem cambium.
(B) medullary rays to intrafascicular cambium.
(C) medullary rays to lateral fascicular cambium.
(D) endodermis to intrafascicular cambium.

Q.121 Heart wood and sapwood of dicot plants are respectively, called as
(A) duraman and alburnum
(B) alburnum and duraman
(C) alburnum and phellogen
(D) duraman and phellogen

Q.122 Which of the following tissue makes phellogen during the secondary growth in dicot roots?
(A) Endodermis (B) Hypodermis
(C) Epidermis (D) Pericycle

Q.123 Periderm includes
I. Phellem II. Phellogen
III. Phelloderm
Select the correct option.
(A) I and II (B) II and III
(C) III and I (D) I, II and III

Q.124 In dicot root, the cork cambium is formed with the help of
(A) cortex (B) pericycle
(C) epidermis (D) endodermis

Q.125 In any dicot root having secondary growth, the cork is the
(A) outer to endodermis and inner to primary cortex.
(B) inner to endodermis and external to primary phloem.
(C) inner to endodermis and external to primary xylem.
(D) outer to endodermis and external to primary phloem.

Q.126 Cambium activity is
(A) more active towards the periphery of stem.
(B) more active towards the lateral sides of stem.
(C) more active towards the inner side of stem.
(D) same on the both sides.

Q.127 When cut horizontally both spring and autumn wood apear in concentric rings known as –
(A) heartwood (B) latewood
(C) sapwood (D) annual ring

Q.128 Early wood is formed in dicot plant during
(A) spring season (B) winter season
(C) autumn season (D) summer season

Q.129 Secondary phloem of a dicot root is made up of
I. sieve tube
II. companion cell
III. phloem parenchyma
Select the correct option for given statement.
(A) I and II (B) II and III
(C) I and III (D) All of these

Q.130 In the annual ring of wood, the light coloured part is known as –
(A) early wood (B) late wood
(C) heartwood (D) sapwood

Q.131 Secondary phloem remains functional generally
(A) for one year
(B) for less than one year
(C) for many years
(D) as long as plant is alive

Q.132 Continuous ring of cambium is formed by
(A) intrafascicular cambium
(B) interfascicular cambium
(C) lateral meristem
(D) Both (A) and (B)

Q.133 The age of tree can't be determined by annual rings if the tree belongs to the
(A) temperate evergreen
(B) temperate deciduous
(C) xerophyte condition
(D) tropical forest

EXERCISE - 2 (LEVEL-2)

Choose one correct response for each question.

Q.1 The layer between the primary cell wall of adjacent plant cells is the _____
(A) middle lamella (B) protoplast
(C) secondary cell wall (D) vascular cambium

Q.2 Which of the following is NOT a primary meristem?
(A) ground meristem (B) procambium
(C) protoderm (D) vascular cambium

Q.3 A _____ shoot produces flowers and, ultimately, fruits.
(A) floral (B) nodal
(C) reproductive (D) vegetative

Q.4 Which of the following structures is/are present in a matured xylem?
(A) Cell wall only
(B) Cell wall and cytoplasm
(C) Cell membrane and a nucleus
(D) Cell membrane, cytoplasm and a nucleus

Q.5 The tissue responsible for growth in diameter of a plant is _____.
(A) lateral mersitem
(B) root apical meristem
(C) shoot apical meristem
(D) B and C

Q.6 Which cell type is most likely to be photosynthetic?
(A) collenchyma (B) parenchyma
(C) sclerenchyma (D) stone cell

Q.7 Which of the following tissues has a protective function in plants?
(A) Epithelial (B) Epidermal
(C) Cortex (D) Phloem

Q.8 Which type of cell assists in the functioning of sieve tube cells?
(A) companion cells (B) endodermal cells
(C) pith cells (D) stone cells

Q.9 The self-perpetuating embryonic cells of plants is called ____ tissue.
(A) dermal (B) ground
(C) meristematic (D) vascular

Q.10 The distance between two leaves on a stem is known as a(n) ____.
(A) axil (B) internode
(C) leaf gap (D) node

Q.11 Which will decay faster if exposed freely to the air –
(A) Heart wood (B) Sap wood
(C) wood with lots of fibres (D) soft wood

Q.12 Periderm is formed from –
(A) Vascular cambium
(B) Phellogen
(C) Fascicular cambium
(D) Interfascicular cambium

Q.13 Abnormal secondary growth is observed in –
(A) Dracaena (B) Wheat
(C) Ginger (D) Rice

Q.14 Compact wood with little parenchyma is termed
(A) Heart wood (B) Hard wood
(C) Pycnoxylic wood (D) Manoxylic wood

Q.15 The process by which the plant becomes woody is called
(A) Calcification (B) Lignification
(C) Impregnation (D) Fossilization

Q.16 Dendrochronology is the study of -
(A) Height of a tree
(B) Diameter of a tree
(C) Age of a tree with the help of annual rings
(D) Counting of the number of branches

Q.17 A timber merchant told his customer that log of wood which he was purchasing comes from a 20 years old tree, he told so by inspecting the –
(A) Diameter of log
(B) Thickness of the heart wood
(C) Number of cork layers
(D) Growth rings

Q.18 How many growth rings should be developed per year in a plant grown in Rajasthan with four distinct seasons (Viz, summer, rains, winter and spring) –
(A) Four (B) Two
(C) one (D) none

Q.19 Annual rings are well demarcated in trees growing in -
(A) Shimla (B) Delhi
(C) Madras (D) Udaipur

Q.20 The trees growing in deserts will -
(A) Show alternate rings of xylem and sclerenchyma
(B) Show distinct annual rings
(C) Not show distinct annual rings
(D) have only conjunctive tissue and phloem formed by the activity of cambium

Q.21 Which of the following characters belong to sclerenchyma?
I. Consists of long narrow cells with thick lignified cell walls.
II. Having few or numerous pits.
III. They are usually dead and without protoplasm.
(A) I and II (B) II and III
(C) I and III (D) I, II and III

Q.22 A meristem may be defined as the group of cells which –
(A) Add to the bulk of the Plants.
(B) Conserve food
(C) Divide continuously to give rise to new cells.
(D) Elongate and add to the group of cells.

Q.23 Embryo of a seed is made up of –
(A) Meristematic tissue (B) Parenchyma
(C) Collenchyma (D) Sclerenchyma

Q.24 Meristems are not found in –
(A) Cycas stem (B) Pollen of pinus
(C) Fern leaf (D) Fern rhizome

Q.25 Bamboo, grass and mint stem elongate by the activity of
(A) Primary meristem
(B) Secondary meristem
(C) Intercalary meristems
(D) Apical meristems

Q.26 Protective layer found at the site of abscission is
(A) Parenchymatous (B) Collenchymatous
(C) Sclerenchymatous (D) Suberized

Q.27 In trees, the growth rings represent –
(A) Primary xylem (B) Secondary xylem
(C) Secondary phloem (D) Cambium

Q.28 Annual rings are the bands of-
(A) Secondary cortex and cork
(B) All secondary vascular tissue
(C) Secondary xylem and xylem rays
(D) Secondary phloem and medullary rays

Q.29 Annual rings and growth rings are formed due to the fluctuations in the activity of
(A) xylem (B) phloem
(C) xylem and phloem (D) cambium

Q.30 Growth rings are formed due to the activity of-
(A) Intrastelar Cambium
(B) Intercalary Cambium
(C) Extrastelar cambium
(D) Primary cambium

Q.31 In plants maximum growth occurs during which season
(A) Summer (B) Winter
(C) Autumn (D) Spring

Q.32 The tracheids differ from vessels in having –
(A) Thick wall
(B) Bordered pit
(C) Presence of pitted end wall
(D) Spiral thickening

Q.33 In Cucurbita stem vascular bundles are –
(A) Radial (B) Collateral
(C) Concentric (D) Bicollateral

Q.34 The commercial cork is obtained from :
(A) Quercus suber (B) Calotropis
(C) Pine (D) Peepal

Q.35 "Bast-fibers" obtained from which part of woody stem –
(A) Cork (B) Cortex
(C) Xylem (D) Phloem

Q.36 Thickness of stem increase due to activity of –
(A) Cambium (B) Xylem
(C) Phloem (D) Shoot apex

Q.37 Non-porous wood is found in which plants –
(A) Dicots (B) Monocots
(C) Gymnosperm (D) Cactus

Q.38 In dorsiventral leaf phloem is found in which side
(A) Adaxial (B) Abaxial
(C) Lateral (D) Adaxial & Abaxial both

Q.39 The leaves having equal stomata on both the surfaces are called as –
(A) Amphistomatic (B) Hypostomatic
(C) Epistomatic (D) Astomatic

Q.40 Most distinct annual rings are formed in which region –
(A) Tropical (B) Temperate
(C) Arctic (D) Equatorial

Q.41 Kranz anatomy is found in
(A) dicotyledonous leaves
(B) monocotyledonous leaves
(C) Both (B) and (D)
(D) isobilateral leaves

Q.42 Cambium is a lateral meristem, as it –
(A) Increases girth
(B) Forms lateral branches
(C) lies on nodes
(D) Increases length

Q.43 Root apex has a zone of slow dividing cells in the middle of rapidly dividing cells, it is –
(A) Quiescent centre
(B) Sluggish centre
(C) Dormant centre
(D) Nonmeristematic zone

Q.44 Root apex is subterminal because it is –
(A) Covered by root hairs
(B) Covered by root cap
(C) Covered by epidermis
(D) Under the soil

Q.45 Apical, intercalary and lateral meristems are differentiated on the basis of –
(A) Development (B) Origin
(C) Function (D) Position

Q.46 Active divisions occur in the cells of –
(A) Xylem (B) Phloem
(C) Cambium (D) Collenchyma

Q.47 Plant growth in length is due to activity of –
(A) Apical meristem (B) Dermatogen
(C) Periblem (D) Lateral meristem

Q.48 Leaf primordium grows into adult lamina by means of –
(A) Marginal meristem
(B) Lateral meristem
(C) First apical and then marginal meristem
(D) Apical meristem

Q.49 Meristem which forms primary vascular tissue is
(A) Protonema (B) Promeristem
(C) Ground meristem (D) Procambium

Q.50 Meristematic tissue occurs in –
(A) Stems (B) Roots
(C) All growing tips (D) Both A and B

Q.51 Totipotency is present in :
(A) Meristem (B) Xylem
(C) Phloem (D) Cork

Q.52 In monocots, root cap is formed by :
(A) Dermatogen (B) Calyptrogen
(C) Wound cambium (D) Vascular cambium

Q.53 Procambium form :
(A) Vascular cambium
(B) Vascular tissues
(C) Cork cambium
(D) Intercalary meristem

Q.54 Periblem form –
(A) Endodermis (B) Cortex
(C) Both A and B (D) Epidermis

Q.55 A living mechanical tissue having pecto cellulosic wall thickening is –
(A) Sclerenchyma (B) Collenchyma
(C) Parenchyma (D) Aerenchyma

Q.56 Extrastelar secondary growth takes place by:
(A) Vascular cambium (B) Phellogen
(C) Phellem (D) Phelloderm

Q.57 Growth of leaf primordia is –
(A) First apical then marginal
(B) Only apical
(C) Only marginal
(D) Lateral

Q.58 Transition of exarch bundles of root to endarch bundles of stem occurs in –
(A) Epicotyl (B) Hypocotyl
(C) Apical bud (D) Coleoptile

Q.59 Casparian bands are present in :
(A) Endodermis (B) Pericycle
(C) Periderm (D) Cortex

Q.60 What happens in plants during vascularisation :
(A) Differentiation of procambium, formation of primary phloem followed by formation of primary xylem.
(B) Differentiation of procambium followed by the formation of primary phloem and xylem simultaneously.
(C) Formation of procambium, primary phloem and xylem simultaneously.
(D) Differentiation of procambium followed by the formation of secondary xylem.

Q.61 Annual rings seen in cross section of trees consist of –
(A) Spring wood and autumn wood
(B) Summer wood and winter wood
(C) Heart wood and sap wood
(D) Porous wood and non-porous wood

Q.62 Subsidiary cells are the specialised cell in the
(A) vicinity of guard cell
(B) vicinity of stomatal cell
(C) absence of stomatal cell
(D) absence of guard cell

Q.63 Collenchyma is present in –
(A) Herbaceous monocots
(B) Herbaceous dicots
(C) All herbaceous plants
(D) Pteridophytes and monocots

Q.64 Xylem fibre is –
(A) Bast fibre (B) Wood fibre
(C) Heart wood (D) Libriform fibre

Q.65 Cortex and pith are not distinguished in
(A) Monocot stem (B) Monocot root
(C) Dicot stem (D) Dicot root

Q.66 Monocot leaves are characterised by
(A) lack of differentiation between palisade & spongy tissue
(B) Permanently opened stomata
(C) Bulliform cells absent
(D) Phloem on the abaxial side

Q.67 Monocot leaves grow by –
(A) Apical meristem (B) Lateral meristem
(C) Intercalary meristem (D) Dermatogen

Q.68 Food is transported by –
(A) Xylem (B) Phloem
(C) Cortex (D) Pith

Q.69 Collenchyma is found in
(A) Herbaceous climbers (B) Hydrophytes
(C) Woody climbers (D) Xerophytes

Q.70 Xylem in root is –
(A) Endarch
(B) Exarch
(C) Mesarch
(D) Different in different roots

Q.71 If a stem is girdled
(A) Root dies first
(B) Shoot dies first
(C) Both die together
(D) None of the above would die

Q.72 In submerged hydrophytes, stomata are found –
(A) On upper surface of leaf
(B) On lower surface of leaf
(C) On both surface of leaf
(D) Nowhere on the plant

Q.73 When a meristematic tissue cambium is present inside a vascular bundle, the bundle is said to be
(A) Conjoint (B) Open
(C) Closed (D) Collateral

Q.74 Which of the dorsiventral leaf has a multilayered epidermis
(A) Mulberry (B) Banyan
(C) Nerium (D) Eucalyptus

Q.75 A nectar secreting gland cell characteristically contains
(A) Granular cytoplasm filling the cell & a small nucleus.
(B) Granular cytoplasm lining a central vacuole and a small nucleus.
(C) Granular cytoplasm filling the cell and a large conspicuous nucleus.
(D) Vacuolated cytoplasm but with a large nucleus.

Q.76 When xylem and phloem are on same radii, the vascular bundles are said to be –
(A) Radial (B) Conjoint/Collateral
(C) Concentric (D) Exarch/centripetal

Q.77 A concentric amphivasal vascular bundle is that in which
(A) Centrally located xylem is surrounded by phloem
(B) Centrally located phloem is surrounded by xylem
(C) Phloem is flanked by xylem on interior sides only
(D) Both (B) and (C)

Q.78 In a graft between stock and scion, the structure first developed is –
(A) Vascular tissue (B) Wall
(C) Callus (D) Plasmodesmata

Q.79 Polyarch, exarch vascular bundles are the characteristics
(A) Dicot stem (B) Dicot root
(C) Monocot stem (D) Monocot root

Q.80 In trees the growth rings represent
(A) Primary xylem (B) Secondary xylem
(C) Secondary phloem (D) Cambium

Q.81 The vascular cambium produces xylem on one side and phloem on other because –
(A) Its interfascicular position
(B) Its multicellular nature
(C) Gravitation force
(D) Difference in supply of hormones on two sides

Q.82 Undifferentiated ground tissue is met within-
(A) Maize stem (B) Cucurbita stem
(C) Sunflower stem (D) Pisum stem

Q.83 Quiescent centre with a zone of slowly dividing cells in the middle of highly meristematic cells in root apex was recognized by –
(A) Schmidt (B) Clowes
(C) Hanstein (D) Eames

Q.84 Apical, intercalary and lateral meristems are differentiated on the basis of-
(A) Origin (B) Function
(C) Position (D) Development

Q.85 Which is not the primary meristem-
(A) Protoderm (B) Periblem
(C) Ground meristem (D) Promeristem

Q.86 Lenticels help in –
(A) Food storage (B) Gaseous exchange
(C) Photosynthesis (D) Mineral absorption

Q.87 The only plant cells without nuclei among following are
(A) Cambium cells (B) Xylem vessels
(C) Root hairs (D) Companion cells

Q.88 Healing of wound in plants takes place by activity of –
(A) Intercalary meristem
(B) Secondary meristem
(C) Apical meristem
(D) Lateral meristem

Q.89 In monocot stem, vascular bundle is-
(A) Closed and collateral (B) Open collateral
(C) Bicollateral (D) Radial

Q.90 A vascular bundle in which the protoxylem is pointing to periphery is called-
(A) Endarch (B) Exarch
(C) Radial (D) Closed

Q.91 When phloem and cambium are present on both sides of xylem, the vascular bundle is called-
(A) Bicollateral (B) Radial
(C) Concentric (D) Collateral

Q.92 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

Q.93 A leaf primordium grows into adult leaf lamina by means
(A) At first by apical meristem and later largely by marginal meristems
(B) Apical meristem
(C) Lateral meristem
(D) Marginal meristems

Q.94 The roots of angiosperms show exarch xylem and their stems have endarch bundles. These are continuous throughout, the change occurs in-
(A) Epicotyl region (B) Hypocotyl region
(C) Upper part of root (D) Lower part of stem

Q.95 In Cucurbita, which type of vascular bundles are found in stem-
(A) Collateral (B) Bicollateral
(C) Radial (D) None of these

Q.96 Collenchyma differs from parenchyma in-
(A) Corners are thickened by lignin
(B) Corners are thickened by pectocellulose
(C) Both (A) and (B)
(D) None of the above

Q.97 Which of the following is true for a dicot leaf-
(A) Mesophyll is differentiated into pallisade and spongy parenchyma.
(B) Mesophyll is not differentiated into pallisade and spongy parenchyma.
(C) Stomata on both surface (Amphistomatic).
(D) None of the above

Q.98 Numerous vascular bundles are scattered in the ground tissue of –
(A) Monocot stem (B) Dicot stem
(C) Monocot root (D) Dicot root

Q.99 I. Usually cortex of stem is formed during secondary growth of the stem.
II. It is a couple of layer thick.
III. It is made up of thin walled rectangular cells.
Select the incorrect statements.
(A) I and II (B) II and III
(C) I and III (D) None of these

Q.100 In the leaf, vascular bundles are found in the-
(A) Veins (B) Palisade tissue
(C) Lower epidermis (D) Upper epidermis

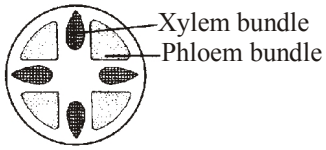
Q.101 All the xylem elements, when mature, are dead except
(A) tracheids (B) vessels
(C) xylem parenchyma (D) xylem fibres

Q.102 Which of the following tissues has dead cells with thick and lignified cell walls, having a few or numerous pits?
(A) Sclerenchyma (B) Collenchyma
(C) Xylem (D) Phloem

Q.103 Select the incorrect pair out of the following.

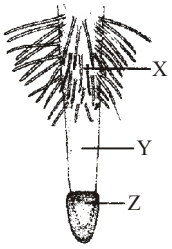
	Type of tissue	Function
(A)	Parenchyma -	Storage, photosynthesis
(B)	Sclerenchyma -	Mechanical strength
(C)	Xylem -	Ascent of sap
(D)	Phloem -	Conduction of water and minerals

Q.104 Identify the type of vascular bundle as shown in the figure and select the incorrect statement regarding this.



(A) Figure represents radial vascular bundles in which xylem and phloem occur in the form of separate bundles.
(B) Xylem bundles and phloem bundles occur on different radii.
(C) These are the characteristic of monocot and dicot leaves.
(D) None of these

Q.105 Identify the different zones of a typical root shown in figure and select the correct answer regarding these.



(A) X-Zone of cell differentiation, Y-Zone of cell maturation, Z-Meristematic zone
(B) X-Zone of cell elongation, Y-Zone of cell maturation, Z-Meristematic zone
(C) X-Meristematic zone, Y-Zone of cell elongation, Z-Zone of cell maturation
(D) X-Zone of cell maturation, Y-Zone of cell elongation, Z-Meristematic zone

Q.106 Vascular bundle is enclosed within a well developed sclerenchymatous sheath in
(A) monocot stem (B) dicot stem
(C) monocot root (D) dicot root

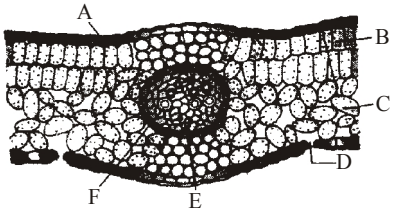
Q.107 Which of the following conditions of xylem is present in both monocot and dicot stems?
(A) Endarch (B) Polyarch
(C) Mesarch (D) Exarch

Q.108 Which plant part possesses polyarch condition of vascular bundles with a well developed pith?
(A) Dicot root (B) Monocot root
(C) Dicot stem (D) Monocot stem

Q.109 As compared to spring wood, autumn wood has
(A) more number of xylary elements with wider vessels
(B) more number of xylary elements with narrow vessels
(C) fewer xylary elements with wider vessels
(D) fewer xylary elements with narrow vessels.

Q.110 Which of the following tissue systems constitute bulk of the plant body?
(A) Epidermal tissue system
(B) Ground tissue system
(C) Vascular tissue system
(D) Both (A) and (C)

Q.111 The given figure shows T.S. of *Helianthus* leaf with various parts labelled as A, B, C, D, E, F and G. Identify the parts and select the correct option.



(A) A-Epidermis, B-Spongy parenchyma, C-Palisade parenchyma, D-Stomata, E-Phloem, F-Xylem
(B) A-Epidermis, B-Palisade parenchyma, C-Spongy parenchyma, D-Stomata, E-Xylem, F-Phloem
(C) A-Epidermis, B-Palisade parenchyma, C-Spongy parenchyma, D-Stomata, E-Endodermis, F-Xylem
(D) A-Epidermis, B-Palisade parenchyma, C-Spongy parenchyma, D-Stomata, E-Phloem, F-Xylem

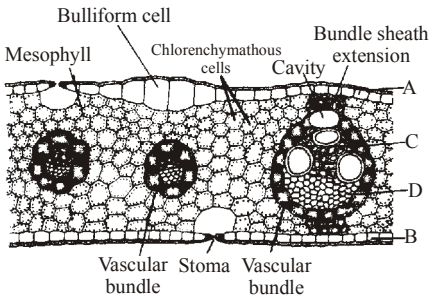
Q.112 Which out of the following is a vessel-less angiosperm
(A) *Tetracentron* (B) *Trochodendron*
(C) *Wintera* (D) All of these

Q.113 The terms 'wood' and 'bast' respectively refer to
(A) xylem and cork (B) phloem and xylem
(C) xylem and phloem (D) phloem and cork.

Q.114 Epidermal tissue system is derived from
(A) protoderm (B) procambium
(C) periblem (D) plerome

Q.115 Well developed pith is found in
(A) monocot root and monocot stem
(B) monocot stem and dicot root
(C) monocot root and dicot stem
(D) dicot root and dicot stem.

Q.116 Identify A, B, C and D in the given transverse section of leaf of *Zea mays*.



(A) A-Abaxial epidermis, B-Adaxial epidermis C-Xylem, D-Phloem
(B) A-Adaxial epidermis, B-Abaxial epidermis C-Xylem, D-Phloem
(C) A-Adaxial epidermis, B-Abaxial epidermis C-Phloem, D-Xylem
(D) A-Abaxial epidermis, B-Adaxial epidermis C-Phloem, D-Xylem

Q.117 I. Made up of elongated, tapering cylindrical cells which have dense cytoplasm and nucleus.
II. Cell wall composed of cellulose.
III. Stores food materials.
The above mentioned characters belong to which attribute of phloem?
(A) Sieve tube elements (B) Companion cell
(C) Phloem parenchyma (D) Phloem fibre

Q.118 Root apical meristem is derived from the
(A) plumule part of embryo
(B) scutellum part of embryo
(C) radical part of embryo
(D) endosperm part of embryo

Q119 I. Made up of sclerenchymatous cells.
II. Generally absent in primary phloem.
III. Much elongated and pointed.
Given above characters belongs to which of the following?
(A) Phloem fibre (B) Xylem fibre
(C) Companion cells (D) Sieve cells

Q.120 In leaves, the ground tissues consists of
(A) epidermis (B) vascular tissue
(C) mesophyll cells (D) medullary rays

Q.121 The protoxylem and metaxylem in the stem lies towards
(A) the pith and root centre, respectively
(B) the periphery and root centre, respectively
(C) the root centre and periphery of organ, respectively
(D) the pith and periphery of organ, respectively

Q.122 Intercalary meristem is found between the
(A) mature tissue (B) apical root meristem
(C) shoot meristem (D) two nodes

Q.123 Grass elongates after cutting (moving) due to
(A) primary meristem
(B) secondary meristem
(C) apical meristem
(D) intercalary meristem

Q.124 Gymnosperms lack which of the following structure?
(A) tracheids (B) vessels
(C) xylem (D) phloem

Q.125 In old trees, the greater part of secondary xylem is dark brown due to the –
(A) deposition of inorganic material
(B) deposition of organic material
(C) activity of cambium
(D) activity of secondary xylem

Q.126 Which of the three sub-zones of cortex of dicot stem performs the function of providing mechanical strength to young stem?
(A) Hypodermis (B) Cortical layers
(C) Endodermis (D) Both (A) and (C)

Q.127 Apical meristem and intercalary meristem are called primary meristem because
(A) they appear early in plant and contributes to the formation of primary plant body.
(B) they make secondary tissue
(C) they make the whole plant body
(D) All of the above

Q.128 Viral infection is usually absent in which of the following?
(A) Phloem cells (B) Xylem cells
(C) Pith cells (D) Apical meristem

Q.129 As compared to the dicot root, monocotyledon root have
(A) more xylem bundles
(B) more phloem bundles
(C) less phloem bundles
(D) less xylem bundles

Q.130 Tracheids –
(A) are the dominant cell types of xylem in an angiosperm.
(B) are primarily found in mosses and liver worts.
(C) are responsible for water conduction and provide support in many land plants.
(D) first appear during palaeozoic era.

Q.131 Which of the following statement are not true?
I. Cork cambium is otherwise called phellogen.
II. Cork is otherwise called phellem.
III. Secondary cortex is otherwise called periderm.
IV. Cork cambium, cork and secondary cortex are collectively called phelloderm.
(A) III and IV (B) I and II
(C) II and III (D) II and IV

Q.132 In monocot stem, the hypodermis is
(A) parenchymatous
(B) sclerenchymatous
(C) collenchymatous
(D) meristematic

EXERCISE - 3 (LEVEL-3)

Choose one correct response for each question.

Q.1 Most of the photosynthesis in a leave takes place in the
(A) guard cells (B) lower epidermis
(C) palisades mesophyll (D) spongy mesophyll

Q.2 The annual rings that form in trees in temperate climates are formed by alternating layers of –
(A) fusiform initials and ray initials.
(B) heartwood and sapwood.
(C) pericycle and endodermis.
(D) spring wood and summer wood.

Q.3 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 specialized as ring porous vessels, they conduct more water at all periods and through new xylem vessels added gradually during development.
(C) Diffuse porous vessels carry more water and also faster because of a greater number of small vessels having greater capillary force.
(D) Ring porous vessels conduct more water as they are formed early during development, when the need for water is great.

Q.4 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.

Q.5 For a successful graft, the adhesion between stock and scion is a must. Which one of the following is the earliest event towards a good graft –
(A) Production of plasmodesmata in the cells at the interface of stock and scion.
(B) Coordinated differentiation of vascular tissue between the stock and scion.
(C) Regeneration of cortex and epidermis over the union of stock and scion.
(D) Production of callus tissue between the cells of stock and scion.

Q.6 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

Q.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

For Q.8-Q.19
(A) Statement-1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement - 1 is True, Statement-2 is False.
(D) Statement -1 is False, Statement-2 is False.

Q.8 **Statement 1 :** Apical meristem of root is subterminal.
Statement 2: At the terminal end of root, root cap is present.

Q.9 **Statement 1 :** In stem, pericycle take active part in secondary growth.
Statement 2 : In root, pericycle take active part in secondary growth.

Q.10 **Statement 1 :** Annual ring do not occur in dicot trees growing on sea shore.
Statement 2 : There is little climate variation.

Q.11 **Statement 1 :** Tyloses are more abundant in Duramen.
Statement 2: They provide rigidity & strength to heart wood.

Q.12 **Statement 1 :** Radial vascular bundles are found in roots.
Statement 2 : Xylem & phloem occur in separate bundles and lie on different radii alternating with each other.

Q.13 **Statement 1 :** Open vascular bundles are found in dicot stem & gymnosperm.
Statement 2: Cambium is absent in between xylem & phloem

Q.14 **Statement 1 :** Amphivasal vascular bundles are found in some monocots.
Statement 2 Xylem lie in centre surrounded by phloem.

Q.15 **Statement 1 :** All the endodermal cells of root don't contain casparian thickening on their radial and transverse walls.
Statement 2 : Passage cells are formed in root endoderrnis

Q.16 **Statement 1 :** Aerenchyma help in buoyancy to hydrophyte plants.
Statement 2: The large air chambers are present in aerenchyma.

Q.17 **Statement 1 :** Apical and intercalary meristems contribute to the growth in length while the lateral meristem helps in increasing the girth in maize plant.
Statement 2 : Apical and intercalary meristems always increases the height of plant.

Q.18 **Statement 1 :** The quiescent centre acts as a reservoir of relatively resistant cells, which constitutes a permanent source of active initials.
Statement 2 : The cells of the inactive region of quiescent centre become active when the previous active initials get damaged.

Q.19 From evolutionary point of view tracheids and sieve cells are more primitive than tracheae and sieve tube respectively. The angiosperms have which of the following attributes of xylem?
(A) tracheae and sieve tube
(B) tracheids, tracheae and sieve tube
(C) tracheae, sieve cells and sieve tube
(D) tracheids, tracheae and sieve cells

Q.20 In dicot stems, cambium present between primary xylem and primary phloem is
(A) fascicular cambium
(B) intrafascicular cambium
(C) interfascicular cambium
(D) both (A) and (B)

Q.21 Select the correct pair out of the following.
(A) Hypostomatic leaf - Dicots
(B) Epistomatic leaf - Monocots
(C) Amphistomatic leaf-Free-floating hydrophytes
(D) Presence of sunken stomata in leaf - Submerged hydrophytes

Q.22 Match Column-I with Column-II and select the correct option from the codes given below.

	Column-I	**Column-II**
a.	Bulliform cells	(i) Regulate opening and closing of stomata
b.	Guard cells	(ii) Aerating pores in the bark of plant
c.	Lenticels	(iii) Rolling in and out of leaves
d.	Subsidiary cells	(iv) Accessory cells

(A) a-(iii), b-(i), c-(ii), d-(iv)
(B) a-(i), b-(ii), c-(iii), d-(iv)
(C) a-(iv), b-(iii), c-(i), d-(ii)
(D) a-(ii), b-(iv), c-(iii), d-(i)

Q.23 Three types of tissue systems have been recognized in plants on the basis of their functions. Select the correct option regarding this.
(A) Epidermal tissue system consists of epidermis and epidermal appendages, which provide protection to the internal tissues.
(B) All tissues except epidermis and vascular bundles constitute the ground tissue, which forms the major part of a plant's body.
(C) Vascular tissue system consists of complex tissues i.e., xylem and phloem.
(D) All of these.

Q.24 Match Column-I with Column-II and select the correct answer from the codes given below.

	Column-I	**Column-II**
a.	Hard wood	(i) Duramen
b.	Soft wood	(ii) Alburnum
c.	Heart wood	(iii) Non-porous wood
d.	Sap wood	(iv) Porous wood

(A) a-(iv), b-(iii), c-(ii), d-(i)
(B) a-(iv), b-(iii), c-(i), d-(ii)
(C) a-(iii), b-(iv), c-(i), d-(ii)
(D) a-(iii), b-(iv), c-(ii), d-(i)

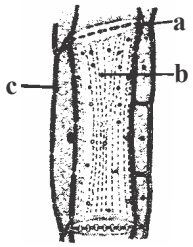
Q.25 A typical monocotyledonous root is characterized by
(A) usually more than six xylem bundles
(B) large and well developed pith
(C) no secondary growth
(D) all of these

Q.26 In old trees, central dark coloured, non-conducting part of secondary xylem is referred to as
(A) heartwood (B) sapwood
(C) softwood (D) hardwood.

Q.27 Read the following statements regarding meristematic cells and select the correct ones.
(i) Cells possess the ability to grow and divide.
(ii) Cells have dense cytoplasm with prominent nucleus.
(iii) Well developed ER and mitochondria are present.
(A) (i) and (ii) (B) (ii) and (iii)
(C) (i) and (iii) (D) (i), (ii) and (iii)

Q.28 Bone shaped sclerenchymatous cells found in hypodermal layers of some seeds and fruits are called
(A) osteosclereids (B) macrosclereids
(C) brachysclereids (D) trichosclereids

Q.29 Identify the given figure and select the correct option for the parts labelled as a, b and c.



(A) c represents the cells which are replaced by albuminous cells in non-flowering plants such as gymnosperms.
(B) a represents phloem parenchyma, which is absent in most monocots.
(C) b represents the cells which become dead on maturity.
(D) All of these

Q.30 What is/are true about heart wood?
I. It does not help in water conduction.
II. It is also called alburnum.
III. It is dark in colour but very soft.
IV. It has tracheary elements, which are filled with tanin, resin etc.
(A) II, III and IV (B) I and IV
(C) II and IV (D) I, II and III

Q.31 Choose the incorrect statement.
(A) Medullary rays connects the pith with pericycle and cortex.
(B) Medullary rays make intimate contact with the conducting cells of both phloem and xylem.
(C) Medullary rays help in radial conduction
(D) All of the above

Q.32 I. Long tube-like structure, arranged longitudinally and associated with companion cells.
II. End wall perforated in a sieve like manner to form sieve plates.
Given above two character belongs to which attribute of phloem.
(A) Sieve tube elements (B) Companion cells
(C) Phloem parenchyma (D) Tracheid

Q.33 I. During secondary growth, a complete ring is formed by vascular cambium.
II. Interfascicular cambium originates from medullary ray cells.
III. Vascular cambium form xylem on the inside and phloem on the outside due to differential action of hormones.
Select the correct combination of option
(A) I and II are correct
(B) II and III are correct
(C) I and III are correct
(D) I, II and III

Q.34 'Exarch' is the condition of vascular bundles in which
(A) protoxylem lies toward the outside and metaxylem lies inward.
(B) metaxylem lies toward the outside and protoxylem lies inward.
(C) metaxylem lies toward the lateral side and protoxylem lies inward.
(D) protoxylem lies toward the lateral side and metaxylem lies inward.

Q.35 I. Annual rings are formed as a result of seasonal environmental conditions.
II. Tracheids/vessels elements are larger during periods when water is abundant.
III. Tracheids/vessels elements have thicker wall during periods of water deprivation.
IV. Wood formed in the previous years is darker than newer wood.
Select the combination of correct statements from the options given below.
(A) I and II (B) II and IV
(C) I, II and III (D) II, III and IV

Q.36 Which one of the following is the correct sequence of tissue present in a dicot stem during secondary growth?
(A) Phellogen, cork, primary cortex, secondary cortex.

(B) Cork, primary cortex, secondary cortex, phellogen.
(C) Primary cortex, secondary cortex, phellogen, cork.
(D) Secondary cortex, cork, phellogen, primary cortex.

Q.37 Which of the following statements are true?
I. Uneven thickening of cell wall is a characteristic of sclerenchyma.
II. Periblem forms the cortex of stem and root.
III. Tracheids are the chief water transporting elements in gymnosperms.
IV. Companion cell is devoid of nucleus at maturity.
V. The commercial cork is obtained from *Quercus suber*.
(A) I and IV (B) II and V
(C) III and IV (D) II, III and V

Q.38 Match the following columns.

	Column I	Column II
a.	Spring wood	1. Lighter in colour
b.	Autumn wood	2. Density high
		3. Density low
		4. Darker in colour
		5. Large xylem vessel
		6. Lesser xylem vessel

Codes
(A) a = 1, 3, 5 ; b = 2, 4, 6
(B) a = 2, 4, 6 ; b = 1, 3, 5
(C) a = 2,3,4 ; b = 1, 5, 6
(D) a = 6, 5, 1 ; b = 2, 3, 6

EXERCISE - 4 (PREVIOUS YEARS AIPMT/NEET EXAM QUESTIONS)

Choose one correct response for each question.

Q.1 Perisperm differs from endosperm in –
(A) its formation by fusion of secondary nucleus with several sperms. **[NEET 2013]**
(B) being a haploid tissue
(C) having no reserve food
(D) being a diploid tissue

Q.2 Age of a tree can be estimated by **[NEET 2013]**
(A) diameter of its heartwood
(B) its height and girth
(C) biomass
(D) number of annual rings

Q.3 Interfascicular cambium develops from the cells of – **[NEET 2013]**
(A) Pericycle (B) Medullary rays
(C) Xylem parenchyma (D) Endodermis

Q.4 Lenticels are involved in : **[NEET 2013]**
(A) Photosynthesis (B) Transpiration
(C) Gaseous exchange (D) Food transport

Q.5 You are given a fairly old piece of dicot stem and a dicot root. Which of the following anatomical structures will you use to distinguish between the two? **[AIPMT 2014]**
(A) Secondary xylem (B) Secondary phloem
(C) Protoxylem (D) Cortical cells

Q.6 Tracheids differ from other tracheary elements in: **[AIPMT 2014]**
(A) Having casparian strips (B) Being imperforate
(C) Lacking nucleus (D) Being lignified

Q.7 In a ring girdled plant : **[AIPMT 2015]**
(A) The root dies first.
(B) The shoot and root die together.
(C) Neither root nor shoot will die.
(D) The shoot dies first.

Q.8 A major characteristic of the monocot root is the presence of – **[AIPMT 2015]**
(A) Scattered vascular bundles.
(B) Vasculature without cambium.
(C) Cambium sandwiched between phloem and xylem along the radius.
(D) Open vascular bundles.

Q.9 Vascular bundles in Monocotyledons are considered closed because: **[AIPMT 2015]**
(A) Cambium is absent.
(B) There are no vessels with perforations.
(C) Xylem is surrounded all around by phloem.
(D) A bundle shealth surrounds each bundle.

Q.10 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
(a) Secondary cortex (b) Wood
(c) Secondary phloem (d) Phellem
The correct order is: **[RE-AIPMT 2015]**
(A) (a), (b), (d), (c) (B) (d), (a), (c), (b)
(C) (d), (c), (a), (b) (D) (c), (d), (b), (a)

Q.11 Roots play insignificant role in absorption of water in: **[RE-AIPMT 2015]**
(A) Pistia (B) Pea
(C) Wheat (D) Sunflower

Q.12 Cortex is the region found between **[NEET 2016 PHASE 2]**
(A) Epidermis and stele
(B) Pericycle and endodermis
(C) Endodermis and pith
(D) Endodermis and vascular bundle

Q.13 The balloon-shaped structures called tyloses **[NEET 2016 PHASE 2]**
(A) Originate in the lumen of vessels.
(B) Characterize the sapwood.
(C) Are extensions of xylem parenchyma cells into vessels.
(D) Are linked to the ascent of sap through xylem vessels.

Q.14 Identify the wrong statement in context of heartwood. **[NEET 2017]**
(A) Organic compounds are deposited in it.
(B) It is highly durable.
(C) It conducts water and minerals efficiently.
(D) It comprises dead elements with highly lignified walls.

Q.15 Which of the following is made up of dead cells? **[NEET 2017]**
(A) Xylem parenchyma (B) Collenchyma
(C) Phellem (D) Phloem

Q.16 The vascular cambium normally gives rise to **[NEET 2017]**
(A) Phelloderm (B) Primary phloem
(C) Secondary xylem (D) Periderm

Q.17 Stomata in grass leaf are **[NEET 2018]**
(A) Rectangular (B) Kidney shaped
(C) Dumb-bell shaped (D) Barrel shaped

Q.18 Secondary xylem and phloem in dicot stem are produced by **[NEET 2018]**
(A) Phellogen (B) Vascular cambium
(C) Apical meristems (D) Axillary meristems

Q.19 Casparian strips occur in **[NEET 2018]**
(A) Cortex (B) Pericycle
(C) Epidermis (D) Endodermis

Q.20 Plants having little or no secondary growth are **[NEET 2018]**
(A) Conifers (B) Deciduous angiosperms
(C) Grasses (D) Cycads

Q.21 Grass leaves curl inwards during very dry weather. Select the most appropriate reason from the following **[NEET 2019]**
(A) Closure of stomata
(B) Flaccidity of bulliform cells
(C) Shrinkage of air spaces in spongy mesophyll
(D) Tyloses in vessels

Q.22 Which of the statements given below is not true about formation of Annual Rings in trees? **[NEET 2019]**
(A) Annual ring is a combination of spring wood and autumn wood produced in a year.
(B) Differential activity of cambium causes light and dark bands of tissue early and late wood respectively.
(C) Activity of cambium depends upon variation in climate.
(D) Annual rings are not prominent in trees of temperate region.

Q.23 Phloem in gymnosperms lacks : **[NEET 2019]**
(A) Albuminous cells and sieve cells.
(B) Sieve tubes only.
(C) Companion cells only.
(D) Both sieve tubes and companion cells.

ANSWER KEY

EXERCISE-1 (SECTION-1&2)

(1) (D) **(2)** (B) **(3)** (C)
(4) (B) **(5)** (C)
(6) Meristems **(7)** Intercalary meristem
(8) Lateral meristem
(9) Protoxylem; metaxylem. **(10)** Collenchyma
(11) thin, thick **(12)** Quiescent centre
(13) Radial **(14)** Ray initials
(15) Xylem **(16)** Axillary bud
(17) Tip, stem **(18)** Bulliform cells
(19) Vascular Cambium **(20)** Root hairs
(21) Periderm **(22)** Lenticels
(23) Phellogen **(24)** Endodermis
(25) Suberin **(26)** Stele
(27) Parenchyma **(28)** Pith
(29) Cuticle **(30)** Tracheids
(31) Cortex **(32)** Pith, Periphery
(33) Secondary meristem **(34)** True
(35) False **(36)** True
(37) False **(38)** True
(39) True

EXERCISE - 1 [SECTION-3 & 4]

Q	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
A	D	C	B	A	B	B	A	C	B	D	C	D	A	D	A	A	D	B	C	A	B	D	B	B	C
Q	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
A	B	D	B	A	D	B	C	C	C	D	D	A	D	B	C	A	A	C	D	B	A	C	C	B	D
Q	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
A	A	A	B	B	B	C	D	B	D	C	A	B	B	B	D	B	B	C	C	D	C	D	D	B	D
Q	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133						
A	B	D	A	A	A	B	A	D	D	B	B	C	D	A	D	A	D	D	D						

EXERCISE - 2

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	A	D	C	A	A	B	B	C	C	B	B	B	A	C	B	C	D	B	A	C	D	C	A	C	C
Q	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
A	D	B	C	D	A	D	C	D	A	D	A	C	B	A	B	C	A	A	B	D	C	A	C	D	C
Q	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
A	A	B	B	C	B	B	A	B	A	B	A	A	B	B	A	A	C	B	A	B	A	D	B	C	C
Q	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
A	B	D	C	D	B	A	A	B	C	D	B	B	B	A	B	A	A	A	B	B	B	A	A	A	A
Q	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
A	C	A	D	C	D	A	A	B	D	B	D	D	C	A	C	B	C	C	A	C	D	A	D	B	B
Q	126	127	128	129	130	131	132																		
A	A	A	D	A	C	A	B																		

EXERCISE - 3

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	C	D	D	C	D	B	C	A	D	A	A	A	C	C	B	C	D	B	B	D	A	A	D	B	D
Q	26	27	28	29	30	31	32	33	34	35	36	37	38												
A	A	A	A	A	B	D	A	B	A	C	C	D	A												

EXERCISE - 4

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
A	D	D	B	C	C	B	A	B	A	B	A	A	C	C	C	C	C	B	D	C	B	D	D

SOLUTIONS

EXERCISE-1

(1) **(D).**
(i) Cork cambium is also called phellogen.
(ii) Cork is also called phellem.
(iii) Secondary cortex is also called phelloderm.

(2) **(B).** On the basis of variation in form, structure, origin and development, sclerenchyma may be fibres or sclereids. The fibres are thick walled, elongated and pointed cells, generally occuring in groups, in various parts of the plant. The sclereids are spherical oval or cylindrical, highly thickened dead cells with very narrow cavity (lumen). These are commonly found in the fruit wall of nuts, pulp of fruit like guava, pear and sapota, seed coats of legumens and leaves of tea. Sclerenchyma provides the mechanical support to organs.

(3) **(C).** Hypodermis : Collenchymatous
Cortical layers : Parenchymatous
Endodermis : Rich in starch

(4) **(B).** Bark that is formed early in the season is called early or soft bark. Towards the end of season late or hard bark is formed early formed wood is lighter in colour, while the late wood is dark in colour.

(5) **(C).** Endodermis : Passage cells
Stomata : Accessory cells
Sieve tube : Companion cells
Periderm : Lenticels
Mesophyll : Palisade cells

(6) **Meristems.** Growth in plants is largely restricted to specialised regions of active cell division called meristem. (Gk *meristos*-divide). Plants have different kind of meristems. The meristems, which occur at the tips of roots and shoots and produce primary tissues are called apical meristems.

(7) Intercalary meristem

(8) Lateral meristem

(9) **protoxylem; metaxylem.** Primary xylem is of two types. First, formed primary xylem is called protoxylem and later formed is called metaxylem. The position of protoxylem and metaxylem is towards pith and periphery, respectively in case of stem and vice versa in roots.

(10) **Collenchyma.** The collenchyma occurs in layers below the epidermis in dicotyledonous plants. It is found either as a homogeneous layer or in patches. It consists of cells which are much thickened at the corners due to the deposition of cellulose, hemicellulose and pectin. Collenchymatous cells may be oval, spherical or polygonal and often contain chloroplasts. These cells assimilate food when they contain chloroplasts. Intercellular spaces are absent. They provide mechanical support to the growing parts of the plant such as young stem and petiole of a leaf.

(11) thin, thick **(12)** Quiescent centre

(13) Radial **(14)** Ray initials

(15) **Xylem.** Xylem is a complex tissue which performs the function of transport of water or sap inside the plant. Simultaneously, it also provides mechanical strength. Xylem is also known as wood. It consist of four types of cells. Tracheids, vessels (both tracheary elements), xylem fibres parenchyma.

(16) Axillary bud

(17) **Tip, stem.** The root apical meristem occupies the tip of root, while shoot apical meristem occupies region of stem apex.

(18) **Bulliform cells.** In monocotyledons epidermis have bulliform cells, which regulate the surface area of leaves.

(19) **Vascular Cambium.** The meristematic layer that is responsible for cutting off vascular tissues (xylem and phloem) is called vascular cambium. In the young stem. It is present in patches as a single layer between the xylem and phloem. Later, it forms a complete ring.

(20) **Root hairs.** Roots have unicellular root hairs, which arises as tubular unbranched outgrowth of the cells of piliferous layers of epiblema (epidermis). They increases the absorptive surface of the roots.

(21) **Periderm.** As the stem continues to increase in girth due to the activity of vascular cambium, the outer cortical and epidermis layers get broken

and need to be replaced to provide new protective cell layers. Hence, sooner or later another meristematic tissue called cork cambium or phellogen develops, usually in the cortex region, which forms new layers, which is called periderm.

(22) **Lenticels.** At certain regions, the phellogen cuts off closely arranged parenchymatous cells on the outer side instead of cork cells. These parenchymatous cells soon rupture the epidermis, forming a lens-shaped openings called lenticels. Lenticels permit the exchange of gases between the outer atmosphere and the internal tissue of the stem. These occur in most woody trees.

(23) **Phellogen.** Phellogen or cork cambium is the meristematic tissue which arises in the cortical region. Phellogen is a couple of layers thick. It is made of narrow, thin-walled and nearly rectangular cells.

(24) **Endodermis.** The innermost layer of cortex is called endodermis. It comprises a single layer of barrel-shaped cells without any intercellular spaces. The tangential as well as radial walls of the endodermal cells have a deposition of water impermeable, waxy material called suberin in the form of casparian strips.

(25) **Suberin.** Ater impermeable, waxy material secreted by endodermal cells is called suberin.

(26) **Stele** is the innerside of endodermis, such as pericycle, vascular bundles and pith.

(27) **Parenchyma** forms the major component within organs. The cells of the parenchyma are generally isodiametric. They may be spherical, oval, round, polygonal or elongated in shape. Their walls are thin and made up of cellulose. They may either be closely packed or have small intercellular spaces. The parenchyma performs various functions like photosynthesis, storage, secretion, etc.

(28) **Pith.** The centre of monocot root or dicot root is occupied by pith. It consists of parenchymatous (thin-walled thick-walled) cells which may be rounded or angular. Intercellular spaces are present in the pith cells. The pith cells stores food. Pith is small or inconspicuous in dicots and large, conspicuous in monocots.

(29) **Cuticle.** The outside of the epidermis is often covered with waxy thick layer called cuticle, which prevents the loss of water. Cuticle is absent in roots.

(30) **Tracheids.** The tracheids are elongated, angular dead cells with hard lignified wide lumen and narrow end walls. The walls of tracheids possesses different types of thickenings and the thickened areas of its wall allows the rapid movement of water from one tracheid to another. Tracheids are the characteristic cell type of xylem tissue in gymnosperm and pteridophytes, where they are the chief elements of water conduction.

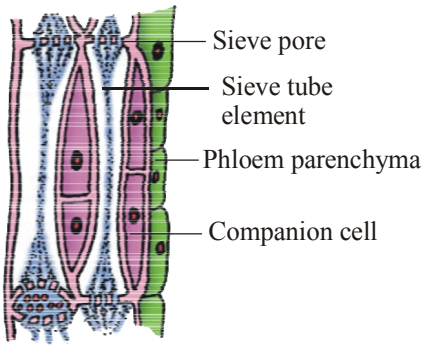
(31) **Cortex.** The cells arranged in multiple layer between epidermis and pericycle constitutes the cortex (dicot stem). It consists of three zones
(i) Hypodermis (ii) Cortical layer
(iii) Endodermis

(32) **Pith, Periphery.** The cambial ring becomes active and begins to cut off new cells, both towards the inner and the outer sides. The cells cut off towards the pith, mature into secondary xylem and the cells towards the periphery mature into secondary phloem.

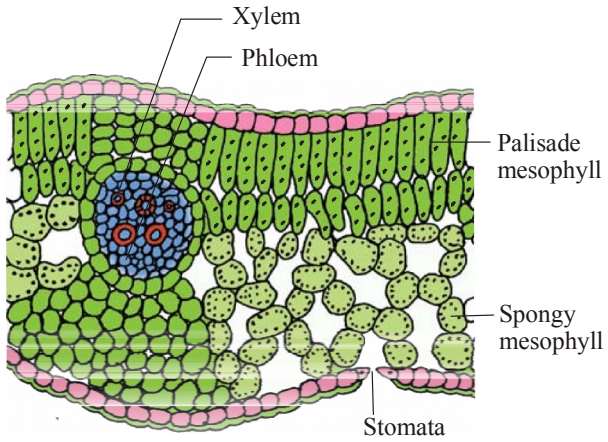
(33) **Secondary meristem.** The meristem that occurs in both roots and shoots and produce the woody axis and appear later than the primary meristem is called the secondary meristem.

(34) True **(35)** False
(36) True **(37)** False
(38) True **(39)** True

(40) **(D).** Phloem tissue have following attributes
(i) Sieve tube
(ii) Phloem parenchyma
(iii) Companion cell
(iv) Phloem fibres



(41) **(C).** TS of dicot leaf Palisade and spongy mesophyll tissue are the characteristic of dicot leaves.



T.S. of dicot leaf

(42) (B). a-Parenchyma, b-Collenchyma, c-Sclerenchyma

(43) (A).

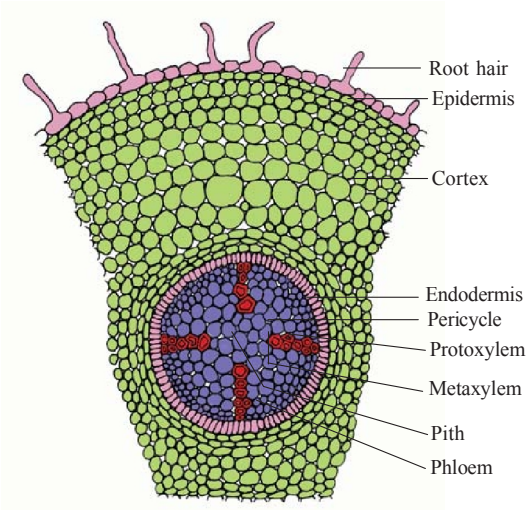
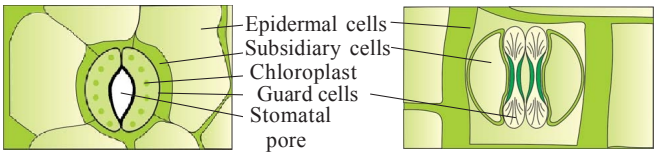


Figure : T.S. of Dicot root (Primary)

(44) (B).

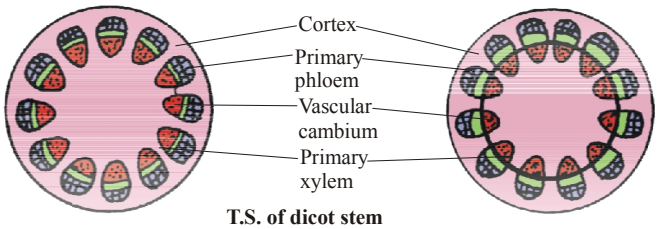


(I) (II)

Diagram (I) Represents the dicotyledon plant because of having bean-shaped guard cells.

Diagram (II) Represents the monocotyledon plant because of having dumb-bell shaped guard cells.

(45) (B).



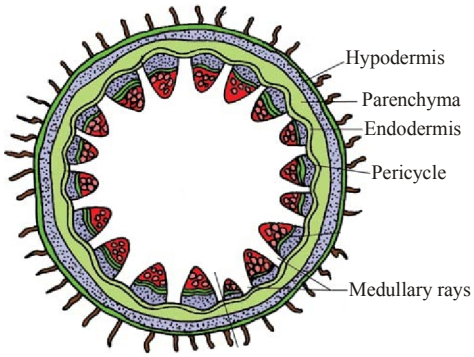
T.S. of dicot stem

(46) (A). Tracheids and vessels are the characteristics of xylem vascular bundle and the a, b and c are tracheid, vessels and vessels, respectively.

(47) (C). a-radial, b-conjoint closed, c-conjoint open

- Radially arranged vascular tissue found in the dicot root.
- When vascular bundle is present in between xylem and phloem it is called open otherwise close-vascular bundle.

(48) (B).



TS of dicot stem showing various region. Secondary growth (vascular bundle) is the characteristic feature of dicot stem.

(49) (D). The meristem which occurs generally at the tip of either roots or shoots are called apical meristem.

(50) (C)

(51) (D). Simple tissues are : Parenchyma, Collenchyma and Sclerenchyma

(52) (A). In plants, xylem conducts the water and minerals. Thus in xylem sap, sugar would be in insignificant amount.

(53) (D). The secondary meristem i.e., fasicular vascular cambium, interfascicular cambium and cork cambium are examples of secondary or lateral meristem and are responsible for producing secondary tissue.

(54) (A) **(55)** (A)

(56) **(D).** Both apical meristem and intercalary meristem are primary meristems because they appear early in life of plants and contributes to the formation of primary plant body.

(57) **(B).** Both primary and secondary meristems contributes to the growth of plants. Shoot apical meristem and root apical meristem helps the plant to grow in length while the lateral meristem helps the plant to grow in width.

(58) **(C).** In roots the protoxylem lies towards the periphery and metaxylem lies toward the centre. Such arrangement is called exarch.

(59) (A) **(60)** (B)

(61) **(D).** Cells of collenchyma have thickened comers due to the deposition of cellulose, hemicellulose and pectin.

(62) **(B).** The sclerenchyma cells are commonly found in the fruit walls of nuts; pulp of fruits like guava, pear and sapota; seed coats of legumes and leaves of tea. Sclerenchyma provides mechanical support to organs.

(63) (B) **(64)** (C)

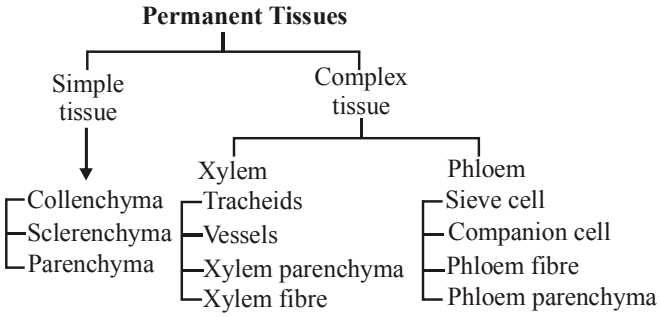
(65) **(B). Xylem or Wood fibres :**
They are sclerenchymatous fibres associated with xylem. Xylem fibres are mainly mechanical in function.
Xylem fibres have highly thickened walls and obliterate central lumens. These may either be septate or aseptate.

(66) **(D).** Secondary meristem is responsible for the production of secondary tissues.

(67) **(B).** During the formation of leaves and elongation of stem, some cells 'left-behind' from shoot apical meristem. These constitute the axillary buds. Such buds are present in the axis of leaves and are capable of forming a branch of flower.

(68) **(A).** Quiescent centre found in plant's root tip between the root cap region is inactive and often called reserve meristem.

(69) **(D).** The cell of the permanent tissues do not generally divide further. Permanent tissues having all cells similar in structure and function are called simple tissues. Permanent tissues having different types of cells together are called complex tissues.



(70) **(B).** Parenchyma is the most abundant and common tissue of the plants. Parenchyma forms ground tissue in the non-woody or soft areas of the stem, leaves, roots, flowers, fruit, etc. The typical parenchyma is meant for storage of food. It is modified to perform special functions.

(71) **(C).** On the basis of variation in form, structure origin development sclerenchyma may be fibre, i.e., thick, elongated and pointed cells or sclereids, i.e., spherical oval or cylindrical.

(72) **(C).** Xylem is composed of four types of tissue

(i) **Tracheids :** Elongated or tube like cells with thick lignified walls and tapering ends. These are main water transporting elements.

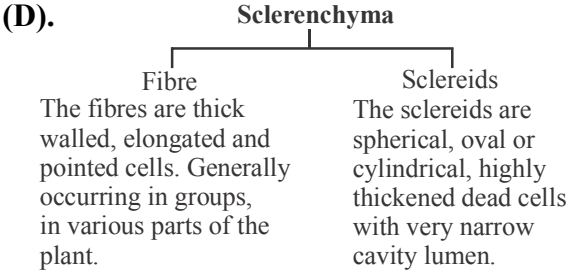
(ii) **Vessels :** A long cylindrical tube with lignified walls and large central cavity. It is a characteristic feature of angiosperms.

(iii) **Xylem fibres** have thickened walls and obliterated central lumen either septate or aseptate.

(iv) **Xylem parenchyma** is a thin, cellulosic and used to store food in the form of starch or fat.

(73) **(C).**

(74) **(D).**



(75) (D)

(76) **(A).** Sieve tube cells are studied during the translocation of solutes because they have interconnected lumen. Sieve tubes takes part in the conduction of organic food.

(77) **(D).** Permanent or mature cells don't have the power of division. They are formed by the division of both types of meristems i.e., primary meristem (shoot apical meristem, root apical meristem) and secondary/lateral meristems (fascicular, cork; cambium).

(78) **(B).** Generally, the epidermis layer does the function of protection but it modifies to the different structures to give the various structures(like-root hairs, trichomes, stomata etc) to perform the various functions in an organism.

(79) (C)

(80) **(A).** The cambium lies in vascular bundles of dicot and gymnosperm stem in between phloem and xylem.

(81) **(A).** Epidermal cells are elongated compactly arranged and form continuous layer called epidermis. Stomata are present in epidermis of leaves and regulate process of transpiration and gaseous exchange. The epidermal hairs, i.e., root hairs, unicellular elongations and trichomes, multicellular elongation of epidermis on root and shoot helps in absorbing water and preventing water loss, respectively.

(82) **(C).** **Lateral Meristem :** The meristem occurs on the sides and take part in increasing girth of the plant. Only one type of primary lateral meristem is found in plants. It is intrafascicular cambium. The cambium lies in vascular bundles of dicot and gymnosperm stem in between phloem and xylem.

(83) (D)

(84) **(B).** The cells of epidermis bear a number of hairs. The root hairs are unicellular elongations of the epidermal cells and helps to absorb water and minerals from the soil. On the stem the epidermal hairs are called trichomes. The trichomes in the shoot system are usually multicellular. They may be branched or unbranched and soft or stiff. They may even be secretory. The trichomes help in preventing water loss due to transpiration.

(85) **(A).** All tissue except epidermis and vascular bundles constitutes ground tissue. It consists of simple tissues such as parenchyma, collenchyma and sclerenchyma.

(86) **(C).** The guard cells possesses chloroplast and regulate the opening and closing of stomata.

(87) **(C).** Cambium is present between xylem and phloem. Such vascular bundles because of the presence of cambium, possesses the ability to form secondary xylem and phloem tissue and hence, is called open vascular bundles.

(88) **(B).** Cuticle is absent in root of plant

(89) **(D).** The stomatal aperture, guard cells and the surrounding subsidiary cells are together called stomatal apparatus.

(90) **(A).** The vascular system consists of complex tissues, the phloem and the xylem. The xylem and phloem together constitutes the vascular bundles.

(91) **(A).** The parenchymatous cells which lies between the xylem and the phloem are called conjuctive tissue.

(92) **(B).** The transverse section of a typical young dicotyledonous stem shows that the epidermis is the outermost protective layer of the stem covered with a thin layer of cuticle. It may bear trichomes and a few stomata.

(93) (B)

(94) **(B).** The isobilateral monocot leaves usually do not show a distinction into petiole and lamina. The leaf base is commonly sheathing, that is covering the stem partially or completely. The venation is parallel. Amphistomatic leaf have stomata on both the surface.

(95) **(C).** Each vascular bundle is surrounded by a sheath of parenchymatous cells called bundle sheath. They are chloren chymatous in nature.

(96) **(D).** In monocotyledon, the vascular bundles are scattered throughout the ground tissue. They are conjoint and closed (not having vascular cambium).

(97) **(B).** In dicotyledonous root, the outermost layer is epidermis. Many of the epidermal cells protrude in the form of unicellular root hairs which absorb water and minerals and increases the surface area.

(98) (D)

(99) **(C).** The initiation of vascular cambium during secondary growth phase takes place in pericycle which is present between xylem and phloem.

(100) **(A).** **Dicot stem :** In between the vascular bundles, there are few layers of radially placed parenchymatous cells. These parenchymatous cells are called medullary rays.

(101) (B) **(102)** (B)

(103) **(B).** In grasses, certain adaxial epidermal cells along the veins modify themselves into large, empty, colourless cells. These are called bulliform cells. When the bulliform cells in the leaves have absorbed water and are turgid, the leaf surface is exposed. When they are flaccid due to water stress, they make the leaves curl inwards to minimise water loss.

(104) (D)

(105) **(B).** Next to the endoderm is lies a few layers thick-walled parenchymatous cells referred to as pericycle. Initiation lateral roots and vascular cambium during secondary growth takes place in these cells.

(106) **(B).** The abaxial epidermis generally bears more stomata than the adaxial epidermis. The latter may even lack stomata. The tissue between the upper and the lower epidermis is called mesophyll.

(107) (C)

(108) **(C).** In dicotyledous root, the cortex consists of several layer thin walled parenchyma cells. These parenchyma cells have intercellular space. The inner most layer of the cortex is called endodermis. It surrounds the vascular tissue.

(109) **(D).** The 'ring' arrangement of vascular bundles is a characteristic of dicot stem. Each vascular bundle is conjoint, open and with endarch protoxylem.

(110) **(C).** In dicot stems, the cells of cambium present between primary xylem and primary phloem are intrafascicular cambium. The cells of medullary cells, adjoining these intrafascicular cambium becomes meristematic and form the interfascicular cambium. Thus, a continuous ring of cambium is formed.

(111) (D)

(112) **(D).** Narrow bands of parenchymatous tissue which passes through the secondary xylem and phloem radially are called secondary medullary rays.

(113) **(B).** The tissue involved in secondary growth are two lateral meristems.
(i) Vascular cambium (ii) Cork cambium.

(114) (D)

(115) **(B).** Bark refers to a number of tissue types viz., periderm and secondary phloem.

(116) **(D).** In winter, the cambium is less active and forms fewer xylary elements that have narrow vessels, and this wood is called autumn wood or late wood.

(117) (A)

(118) **(A).** In young stem, the vascular cambium is single layered.

(119) **(A).** Exchange of gases between the outer atmosphere and internal tissue of the stem takes place by (in dicot stem) lenticels.

(120) (B) **(121)** (A) **(122)** (D)

(123) **(D).** Phellogen, phellem and phelloderm are collectively known as periderm.

(124) **(B).** Cork cambium is formed by pericycle in the dicotyledonous roots. It is absent in monocot root that's why secondary growth does not take place in the monocots.

(125) **(B).** In dicot root, during the secondary growth, the cork is formed. This cork is inner to the endodermis and external to the primary phloem.

(126) **(C).** Cambium is generally more active on the inner side than the outer. As a result the amount of secondary xylem produced is more than the secondary phloem and soon forms a compact mass.

(127) **(D).** The spring wood is lighter in colour and has a lower density whereas the autumn wood is darker and has higher density. The two kinds of woods that appear as alternate concentric rings, constitutes an annual ring. Annual rings seen in a cut stem give an estimate of the age of the tree.

(128) **(A).** The activity of cambium is under the control of many physiological and environmental factors. In temperate regions, the climatic conditions are not uniform through the year. In the spring season, cambium is very active and produces a large number of xylary elements having vessels with wider cavities. The wood formed during this season is called spring wood or early wood.

(129) **(D).** The secondary phloem is made up of sieve tubes, companion cells and phloem parenchyma. Sclerenchyma fibres are rare. The secondary xylem is formed of vessels, tracheids and xylem parenchyma.

(130) **(A).** Spring wood plus autumn wood of a year constitutes the annual ring. The spring wood (also called early wood) is lighter in colour and constitutes a major part of annual ring. The autumn wood (also called late wood) is darker in colour.

(131) **(D).** Secondary phloem remains functional as long as plant is alive.

(132) **(D).** Interfascicular and intrafascicular both cambium join each other and form a continuous ring of cambium for the secondary growth of dicots.

(133) **(D).** If the plants belongs to the tropical forest then the age of tree can't be determined by annual rings because the physiological and environmental factors remains the same throughout the year and due to this, the fluctuation of cambial activity does not take place.

EXERCISE-2

(1)	(A)	**(2)**	(D)	**(3)**	(C)	**(4)**	(A)
(5)	(A)	**(6)**	(B)	**(7)**	(B)	**(8)**	(C)
(9)	(C)	**(10)**	(B)	**(11)**	(B)	**(12)**	(B)
(13)	(A)	**(14)**	(C)	**(15)**	(B)	**(16)**	(C)
(17)	(D)	**(18)**	(B)	**(19)**	(A)	**(20)**	(C)

(21) **(D).** Sclerenchyma consists of long, narrow cells with thick and lignified cell walls having a few or numerous pits. They are usually dead and without protoplasts. On the basis of variation in form, structure, origin and development, sclerenchyma may be either fibres or sclereids.

(22)	(C)	**(23)**	(A)	**(24)**	(C)	**(25)**	(C)
(26)	(D)	**(27)**	(B)	**(28)**	(C)	**(29)**	(D)
(30)	(A)	**(31)**	(D)	**(32)**	(C)	**(33)**	(D)
(34)	(A)	**(35)**	(D)	**(36)**	(A)	**(37)**	(C)
(38)	(B)	**(39)**	(A)	**(40)**	(B)		

(41) **(C).** In maize leaf (monocot), the undifferentiated mesophyll occurs in the concentric layers around the vascular bundles having large centrifugal chloroplasts in its large bundle sheath cells. Such an arrangement is called Kranz anatomy.

(42)	(A)	**(43)**	(A)	**(44)**	(B)	**(45)**	(D)
(46)	(C)	**(47)**	(A)	**(48)**	(C)	**(49)**	(D)
(50)	(C)	**(51)**	(A)	**(52)**	(B)	**(53)**	(B)
(54)	(C)	**(55)**	(B)	**(56)**	(B)	**(57)**	(A)
(58)	(B)	**(59)**	(A)	**(60)**	(B)	**(61)**	(A)

(62) **(A).** Sometimes, a few epidermal cells, in the vicinity of the guard cells become specialised in their shape and size and are known as subsidiary cells.

(63)	(B)	**(64)**	(B)	**(65)**	(A)	**(66)**	(A)
(67)	(C)	**(68)**	(B)	**(69)**	(A)	**(70)**	(B)
(71)	(A)	**(72)**	(D)	**(73)**	(B)	**(74)**	(C)
(75)	(C)	**(76)**	(B)	**(77)**	(D)	**(78)**	(C)
(79)	(D)	**(80)**	(B)	**(81)**	(A)	**(82)**	(A)
(83)	(B)	**(84)**	(C)	**(85)**	(D)	**(86)**	(B)
(87)	(B)	**(88)**	(B)	**(89)**	(A)	**(90)**	(B)
(91)	(A)	**(92)**	(A)	**(93)**	(A)	**(94)**	(B)
(95)	(B)	**(96)**	(B)	**(97)**	(A)	**(98)**	(A)

(99) **(A).** Cells arranged in multiple layers between epidermis and pericycle constitutes the cortex. It is divided into three regions.

(i) Hypodermis, few layer of collenchymatous cells.

(ii) Cortical layer cells, rounded thin walled parenchymatous cells.

(iii) Endodermis.

(100) (A)

(101) **(C).** Xylem is made up of three types of dead cells (vessels, tracheides, xylem fibres).

There are only one type of living cells (xylem parenchyma). It stores food and helps in the lateral conduction of water or sap.

(102) (A). Sclerenchyma is a simple supportive tissue of highly thick-walled cells with little or no protoplasm. Sclerenchyma cells are generally dead, these cells are empty. Wall thickening is uniform which can be made up of cellulose, lignin or both. Pits are usually simple and oblique, they may be branched.

(103) (D). Phloem is a complex permanent tissue that transports organic food inside the plant. Xylem is a complex permanent tissue that performs the function of ascent of sap i.e., transport of inorganic nutrients (water and minerals) inside the plant.

(104) (C). The given figure represents radial vascular bundles. Here xylem and phloem occur in the form of separate bundles called xylem bundles and phloem bundles. The two types of bundles usually alternate with each other. They occur on different radii. Radial bundles are characteristic of monocot and dicot roots.

(105) (D). Root hair zone (or Zone of cell maturation) also represents the zone of differentiation because different types of primary tissues differentiate or mature in this region (viz., xylem, phloem, pericycle, endodermis, cortex, epiblema, etc.).

Zone of elongation is about 4-8 mm in length. It lies behind the growing point. The cells of this region are newly formed cells which lose the power of division. They elongate rapidly.

Meristematic zone is about 1 mm in length. The growing point of the root is subterminal and lies protected below the root cap. It is made up of compactly or closely arranged small thin walled isodiametric and meristematic cells which have dense protoplasm.

(106) (A). In most monocot stems, a sclerenchymatous bundle sheath is generally present on the outside of each vascular bundle.

(107) (A). Based on position of protoxylem in relation to metaxylem, the xylem may be exarch/ centripetal, endarch/centrifugal, mesarch and centerarch. In endarch condition, protoxylem lies on the inner side of metaxylem e.g., dicot and monocot stems.

(108) (B). Vascular bundles in monocot roots are radial, polyarch and exarch. Large number (more than 6) of xylem and phloem groups alternate with each other. A well developed pith is present in monocot root.

(109) (D). The activity of cambium is under the control of many physiological and environmental factors. In temperate regions, the climatic conditions are not uniform throughout the year. In the spring season, cambium is very active and produces a large number of xylary elements having vessels with wider cavities. The wood formed during this season is called spring wood or early wood. In winter, the cambium is less active and forms fewer xylary elements that have narrow vessels, and this wood is called autumn wood or late wood. The spring wood is lighter in colour and has a lower density whereas the autumn wood is darker and has a higher density. The two kinds of woods that appear as alternate concentric rings, constitute an annual ring.

(110) (B). Ground tissue system includes all the tissues of plant body except epidermal tissue system and vascular tissues. It forms the bulk of body and consists of mainly parenchymatous, collenchymatous, sclerenchy-matous, glandular and laticiferous tissues.

(111) (D).

(112) (D). Vessels are present in almost all angiosperms, but there are 10 woody genera belonging to 5 families viz Winteraceae (e.g., *Wintera*), Tetracentraceae (e.g., *Tetracentron*), Trochodendraceae (e.g., *Trochodendron*), Amborellaceae (*Amborella*) and Chloranthaceae in which vessels are absent.

(113) (C). Xylem is also known as wood. It consists of four types of cells,viz, tracheids, vessels (both tracheary elements), xylem or wood parenchyma and xylem or wood fibres. Phloem is also called bast. It consists of four types of cells, vis, sieve tubes, companion cells, phloem parenchyma and fibres.

(114) (A). Protoderm (Gk. *protos*-first, *derma*-skin) is the outer layer of apical meristem that gives rise to epidermal tissues. Epidermal tissue system is derived from protoderm. Ground tissue system is derived partly from periblem and partly from plerome. Vascular tissue system is derived from procambium.

(115) (C). In a dicot stem, a well developed pith (made of parenchymatous or occasionally sclerenchymatous cells) is present whereas in a monocot stem, pith is absent. In a dicot root, pith is poorly developed whereas in a monocot root, a well developed pith is present.

(116) (B).

(117) (C). Phloem parenchyma is made up of elongated, tapering cylindrical cells which have dense cytoplasm and nucleus. The cell wall is composed of cellulose and has pits through which plasmodesmatal connections exist between the cells. The phloem parenchyma stores food material and other substances like resins, latex and mucilage. Phloem parenchyma is absent in most of the monocotyledons.

(118) (C). Root Apical Meristem : It is found at the tip of the main root and its branches. In case of tap root system, the root apical meristem is formed from radicle part of the embryo or its derivatives. In adventitious root, the root apical meristem is produced from the derivatives of shoot apex.

(119) (A). Phloem fibres (bast fibres) are made up of sclerenchymatous cells. These are generally absent in the primary phloem but are found in the secondary phloem These are much elongated, unbranched and have pointed, needle like apices. The cell wall of phloem fibres is quite thick. At maturity, these fibres lose their protoplasm and become dead. Phloem fibres of jute, flax and hemp are used commercially.

(120) (C). Ground tissue system occupies the whole of the interior of plant organs with the exclusion of vascular system. Ground tissue system of leaves is called mesophyll. Mesophyll is made up of two types of photosynthetic cells, palisade and spongy.

(121) (D). In stems, the protoxylem lies towards the centre (pith) and the metaxylem lies toward the periphery of organ. This type of primary xylem is called endarch.

(122) (A). The meristem which occurs between mature tissues is known as intercalary meristem. They occurs in grass and regenerate the parts removed by grazing herbivores.

(123) (D).

(124) (B). Gymnosperm lacks vessels in their xylem tissue. Vessels are also absent in pteridophytes. Their tracheary element comprise only tracheids. Flowering plants possesses, both vessels and tracheids but latter are comparatively fewer and moreover vessels are the characteristic features of angiosperms.

(125) (B). In old trees, the greater part of secondary xylem is dark brown due to the deposition of organic compounds like tanins, resins, oils, gums, aromatic substances and essential oils in the central or innermost layers of the stem. These substances make it hard, durable and resistant to the attacks of microorganisms and insects. The region comprises dead elements with highly lignified walls and is called heart wood.

(126) (A). Hypodermis consists of a few layers of collenchymatous cells just below the epidermis, which provides mechanical strength to the young stem. Cortical layers below the hypodermis consists of rounded thin-walled parenchymatous cells with conspicuous intercellular spaces.

(127) (A). Both apical meristems and intercalary meristems are called primary meristems because they appear early in life of a plant and contributes to the formation of primary plant body.

(128) **(D).** The apical meristems are present at the apices of primary and secondary shoots and roots of the plant. The cells of apical meristem are under very active stage of division, have dense cytoplasms, thin cell wall and remains virus free.

(129) **(A).** The anatomy of the monocot root is similar to the dicot root in many respects. It has epidermis, cortex, endodermis, pericycle, vascular bundles and pith compared to the dicot root, which have fewer xylem bundles, there are usually more than six (polyarch) xylem bundles in the monocot root. Pith is large and well developed.
Monocotyledonous roots do not undergo any secondary growth.

(130) **(C).** Tracheids are elongated cells and their cell walls are usually extensively thickened by the deposition of lignin. Water flows from one tracheids to another through unthickened regions (pits) in the cell wall.

(131) **(A).** III and IV

(132) **(B).** The monocot stem has a sclerenchymatous hypodermis, a large number of scattered vascular bundles, each surrounded by a sclerenchymatous bundle sheath, and a large, conspicuous parenchymatous ground tissue. Vascular bundles are conjoint and closed. Peripheral vascular bundles are generally smaller than the centrally located ones. The phloem parenchyma is absent and water-containing cavities are present within the vascular bundles.

EXERCISE-3

(1) (C) **(2)** (D) **(3)** (D) **(4)** (C)
(5) (D)

(6) **(B).** Because tunica shows only anticlinal division and it is a responsible for surface growth.

(7) **(C).** Because in sea shore area being isothermal zones, temperature is constant throughout the year, so their will be no annual ring formation.

(8) (A) **(9)** (D) **(10)** (A) **(11)** (A)
(12) (A) **(13)** (C) **(14)** (C)

(15) **(B).** The characteristic feature of endodermal cells of roots is the presence of casparian thickenings on their radial and transverse walls but all cells of endodermis don't have casparian thickenings instead they have simple permeable cell wall. Those cells are called passage cells, which remain in contact with the protoxylem cells.

(16) (C)

(17) **(D).** Apical and intercalary meristem always increases the height of plant and lateral meristem is responsible for the secondary growth (increase in girth) but secondary growth does not occur in monocots, e.g., maize.

(18) **(B).** Quiescent centre was discovered by Clows in root. It is the inactive region which have the active initials. The cells of this region have low concentration of DNA, RNA and protein. It is present between root cap and active meristematic region of root.

(19) **(B).** In angiosperms, xylem consists of tracheids, vessels or tracheae, xylem fibres and xylem parenchyma. Tracheae are absent in pteridophytes and gymnosperms. In angiospermic phloem, sieve elements are sieve tubes while in gymnosperms and pteridophytes, sieve cells are found.

(20) **(D).** Intrafascicular or fascicular cambium is present in the form of a narrow strip of primary meristematic cells in between the phloem and the xylem of a vascular bundle. Intrafascicular cambium is primary lateral meristem which helps in increasing girth of the plant. It lies in the vascular bundles of dicot and gymnosperm stems.

(21) **(A).** In dicot leaves, stomata are generally present on lower epidermis (hypostomatic), whereas in monocot leaves, they are present on both the surfaces (amphistomatic). In free-floating hydrophytes, stomata are restricted to upper epidermis (epistomatic) whereas in submerged hydrophytes, stomata are either non-functional or absent. In algae and fungi, stomata are totally absent. Stomata are sunken (deep seated) in case of xerophytes.

(22) **(A).** In some grasses, on epidermis, there are some larger, thin-walled cells with vacuoles called bulliform cells or motor cells or bubble like cells, which in dry conditions lose water and thus the rolling up of leaves occurs, e.g., in *Psamma, Poa, Agropyron, Amophilla*, etc.

Each stoma or pore is guarded by two specialized kidney shaped or dumb-bell shaped guard cells, which regulate opening and closing of stomata. The guard cells are also surrounded by other specialized epidermal cells called subsidiary cells or accessory cells.

Lenticels are some loosely arranged areas in the periderm. These are the aerating pores present in the bark of plants. Due to more activity of certain portions of phellogen, the phellem cells are cut off very rapidly and hence these cells are loosely arranged with much intercellular spaces.

(23) **(D).** Epidermal tissue system forms outer covering of plant, which is in direct contact with external environment. The tissue system consists of the epidermis derived from protoderm and its associated structures; epidermal outgrowths. The cells perform different functions like protection, absorption, excretion, gaseous exchange, secretion and control of transpiration, etc.

The tissue present between epidermis and vascular tissue system constitutes ground tissue system. It forms the major part of a plant's body.

Vascular tissue system is composed of a number of vascular bundles, present in the central cylinder or column of the axis of root and stem which is known as stele. The vascular bundle is composed of primary xylem, primary phloem and cambium.

(24) **(B).** Soft wood is the technical name of gymnosperm wood. Because it is devoid of vessels it is also called as nonporous wood. Several of the soft woods are very easy to work with (e.g., Cedrus, Pinus species), however all of them are not 'soft'. The softness depends upon the content of fibres and vascular rays. 90-95% of wood is made of tracheids. Vascular rays constitute 5-10% of the wood. Hard wood is the name of dicot wood which possesses abundant vessels. Due to the presence of vessels, the hard woods are also called porous woods. Content of tracheids is very low (less than 5%).

(25) **(D).** There is no such distinction between a young and an old root of monocotyledonous plant. This is due to the absence of secondary growth in the monocot roots. The centre of monocot root is occupied by the pith. It consists of parenchymatous (thin-walled or thick-walled) cells which may be rounded or angular. Intercellular spaces are present amongst the pith cells. The pith cells store food. Xylem and phloem bundles are numerous and are 8 or more in number. Xylem vessels are oval or rounded.

(26) **(A).** Heart wood (duramen) is the central wood of an old stem. It is dark coloured. Living cells are absent. Heart wood is the part of secondary xylem. The tracheary elements are plugged by tyloses. Tracheary elements have deposition of tannins, resins, gums, etc. Heart wood is heavier. It is more durable due to its little susceptibility to the attack of pathogens and insects. Heart wood is mechanical in function. The outer or peripheral portion of the trunk is lighter in colour and soft which performs the functions of conduction of water and minerals and it is known as sap wood or alburnum.

(27) **(A).** Meristematic cells are small immature cells, which possess ability to grow and divide rapidly. Cytoplasm of these cells is dense with conspicuous nucleus. Walls are thin, elastic and made of cellulose, rate of respiration is very high. ER is small, poorly developed mitochondria have simple structure and proplastids are present instead of plastids.

(28) **(A).** Osteosclereids are a type of sclereids, which are bone-like or columnar with swollen ends, present in sub-epidermal covering of some legume seeds.

(29) **(A).** In the given figure, companion cells are labelled as 'c'. These cells are narrow, elongated and thin walled living cells. They lie on the sides of sieve tubes and are closely associated with them through compound plasmodesmata. Companion cells are replaced by modified parenchyma cells (albuminous cells) in nonflowering plants. 'a' represents sieve plate and 'b' represents sieve tube cell. Vessels are absent in gymnosperms and pteridophytes with some exceptions e.g., *Selaginella*,etc.

(30) **(B).** Heartwood is also called duramen. It represents the central wood of the plant. It is dark in colour and heavier in weight. Living cells are absent. It represents non-functional part of secondary xylem (wood).

(31) **(D).** Medullary ray or pith rays They are the radial strips of parenchyma cells present between the adjacent vascular bundles. The medullary rays connects the pith with pericycle and cortex. The ray cells make intimate connection with the conducting cells of both xylem and phloem through pits.
The medullary rays help in the radial conduction of food and water. They also transport gases from pith to cortex and vice-versa.

(32) **(A).** **Sieve tube elements** are long, tube-like structures, arranged longitudinally and are associated with the companion cells. Their end walls are perforated in a sieve-like manner to form the sieve plates. A mature sieve element possesses a peripheral cytoplasm and a large vacuole but lacks a nucleus. Functions of sieve tubes are controlled by the nucleus of companion cells.

(33) **(B).** During the secondary growth, the continuous ring of cambium is formed by joining of intrafascicular cambium and interfascicular cambium not by vascular cambium. Vascular cambium form xylem on its inside and phloem on outside due to differential action.

(34) **(A).** **Exarch :** It is the condition of vascular bundles in which the protoxylem (earlier formed xylem) lies toward the outside and metaxylem (later formed xylem) lies toward inward.
Endarch : It is the condition of vascular bundles in which the protoxylem (earlier formed xylem) lies toward the inner side and metaxylem (later formed xylem) lies outside.

(35) **(C).** In the formation, of the heart wood and sap wood,. it is not necessarily that the wood formed in previous years is darker than newer wood.

(36) **(C).** The correct sequence of tissue from cambium present in dicot stem during secondary growth is primary cortex, secondary cortex, phellogen and cork.

(37) **(D).** Sclerenchyma is composed of dead cells, The cell wall is heavily thickened due to the deposition of lignin.
According to Histogen theory, periblem is the middle dermatogen which give rise to cortex of root and stem.
Tracheids are most primitive type of conducting elements in xylem. The xylem of gymnosperm consists of tracheids only.
Companion cells are thin-walled elongated cells in phloem. They are living cells and contain dense protoplasm and a large elongated nucleus.
Cork is produced by the number of plants. However it is commercially obtained from cork oak tree (*Quercus suber*).

(38) **(A).** Spring wood : Light in colour ; Density low Large xylem vessels.
Autumn wood : Density high ; Darker in colour, Lesser xylem vessels

EXERCISE-4

(1) **(D).** Perisperm is remnants of nucellus which is diploid (2n) but endosperm is triploid (3n).

(2) **(D).** Number of annual rings = Number of Years

(3) **(B).** At the time of secondary growth interfascicular cambium is formed by parenchymatous medullary rays.

(4) **(C).** Lenticels are found on the outersurface of old dicot stem & mainly involved in gaseous exchange.

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

(6) **(B).** Tracheids are elongated, dead cells with hard lignified walls, wide lumens and narrow walls with spiral, annular, reticulate, scalariform and pitted thickening but without perforated end walls of septa. That is, they have intact end walls unlike vessels.
Vessel is a long cylindrical tube like structure made of many cells, called vessel members, each with lignified walls and a large central cavity. Vessel members are interconnected through perforation in their common walls.

(7) **(A).** In a ring girdled plant, the root dies first. A ring of bark is cut from the stem. It also removes phloem. Nutrients collect above the ring where the bark also swells up and may give rise to adventitious roots. Growth is vigorous above the root. The tissues below the ring not only show stoppage of growth but also begin to shrivel (contract). Roots begin to starve first if the ring is not healed, after sometime roots will die, which will kill the whole plant.

(8) **(B).** In monocot root, Cambium is absent in the vasculature.

(9) **(A).** Vascular bundles of Monocots are closed due to absence of cambium.

(10) **(B).** The correct sequence from outerside towards inner side in a wood dicot stem is Phelluum (d) → Secondary cortex (a) → Secondary phloem (c) → Wood (b)

(11) **(A).** Pistia is hydrophyte where absorption of water by root is insignificant.

(12) **(A).** Cortex is the region present between epidermis & stele.

(13) **(C).** Tyloses are balloon - shaped structures in xylem vessels developed by xylem parenchyma cells.

(14) **(C).** Heartwood is physiologically inactive due to deposition of organic compounds and tyloses formation, so this will not conduct water and minerals.

(15) **(C).** Cork cambium undergoes periclinal division and cuts off thick walled suberised dead cork cells towards outside and it cuts off thin walled living cells i.e., phelloderm on inner side.

(16) **(C).** During secondary growth, vascular cambium gives rise to secondary xylem and secondary phloem.
Phelloderm is formed by cork cambium.

(17) **(C).** Grass being a monocot, has Dumb-bell shaped stomata in their leaves.

(18) **(B).** Vascular cambium is partially secondary.
* Form secondary xylem towards its inside and secondary phloem towards outsides.
* 4 – 10 times more secondary xylem is produced than secondary phloem.

(19) **(D).** Endodermis have casparian strip on radial and inner tangential wall. It is suberin rich.

(20) **(C).** Grasses are monocots and monocots usually do not have secondary growth.
Palm like monocots have anomalous secondary growth.

(21) **(B).** Bulliform cells become flaccid due to water loss. This will make the leaves to curl inward to minimise water loss.

(22) **(D).** Growth rings are formed by the seasonal activity of cambium. In plants of temperate regions, cambium is more active in spring and less active in autumn seasons. In temperate regions climatic conditions are not uniform throughout the year. However in tropics climatic conditions are uniform throughout the year.

(23) **(D).** Phloem in Gymnosperms lacks both sieve tube and companion cells.

(24) **(B).**

(25) **(D).**