DAY SIX

Anatomy of Flowering Plants

Learning & Revision for the Day

- Plant Tissues
- Tissue Systems
- Anatomy of Stem and Root
- Anatomy of Leaves
- Secondary Growth
- Wood

- Plant anatomy is the branch of biological science, which deals with the study of gross internal structure of plants.
- **N Grew** (1682) is known as **Father of Plant Anatomy**.
- Plants have cell as the basic unit. Cells are organised into tissues and in turn the tissues are organised into organs.
- Different organs in a plant show differences in their internal structure.
- Internal structures also show adaptations to diverse environment.

Plant Tissues

Tissue is a group of similar or dissimilar cells of common origin that have same method of development and similar structure and function. The study of tissues is called **Histology.** Tissues can be conveniently grouped under three categories

1. Meristematic Tissues

- It represents a group of cells that are in a continuous state of division to produce new cells or retain their power of division. Meristematic cells have abundant, dense cytoplasm and large conspicuous nucleus.
- These cells remain in active state of metabolism.
- There are no intercellular spaces, crystals and vacuoles in meristematic cells.

Classification of Meristematic Tissues

1. On the basis of origin and development of initiating cells meristem can be
   - **Promeristem** (e.g. tip of plumule and radicle)
   - **Primary meristem** (e.g. apical meristems, intrafascicular cambium, intercalary meristem)
   - **Secondary meristem** (e.g. vascular cambium in dicot root, interfascicular cambium, cork cambium, wound cambium and accessory cambia of monocots).
2. On the basis of position in the plant body meristems can be divided into three parts
   - **Apical meristems** are present at the apices of primary and secondary shoots and roots of the plants. Apical meristem lacks vascular tissue. It is free from virus and is used as explant in tissue culture to get virus-free plants. Apical meristems are responsible for increase in length.
   - **Intercalary meristems** help in the elongation of organs and also allows the fallen stems of cereals to become erect. It lies between the regions of permanent tissues. Grasses grow by intercalary meristem and lack apical meristem, that is why cutting causes no damage to their growth.
   - **Lateral meristems** are present along the sides of organs. Lateral meristems are responsible for increase in girth of stems and roots.
3. On the basis of their functions, meristem can be divided into three parts
   - **Protoderm** The outermost meristematic layer of young growing region, develops into epidermis, stomata and root hairs.
   - **Procambium** It is composed of narrow elongated cells. It develops into primary vascular tissue.
   - **Ground meristem** The precursor of ground tissue system, has large and thin-walled cells. These develop into hypodermis, cortex, pericycle, pith and medullary rays.

Theories Related to Shoot and Root Apical Meristems

Various scientists have given different theories in the context of shoot and root apical meristems. These are described as:

Shoot Apical Meristem (SAM) Theories

- **Tunica-corpus theory** (Schmidt; 1924) It states that, there are two distinct zones present in shoot apices–tunica (outer) and corpus (inner).
- **Histogen theory** (Hanstein; 1870) According to this, there are three distinct meristematic layers called as **dermatogen** (epidermis), periblem (cortex) and pleurome (vascular cylinder).This theory is used to explain shoot as well as root growth.
- **Apical cell theory** (Hofmeister; 1857) It states that a single apical cell is the structural and functional unit of apical meristems and it regulates the whole process of primary growth.

Root Apical Meristem (RAM) Theories

- **Korper-kappe theory** (Schuepp; 1917) According to this, the root apices divide in two planes. First a cell divide transversally then two daughter cells divide longitudinally. This sequence is termed as T-division.
- **Apical cell theory** (Nageli; 1858) He observed a single tetrahedral apical cell in the root apices of a number of vascular cryptogams like algae, bryophytes, etc.

NOTE **Clowes** discovered the quiescent centre in root-promeristerm which acts as a reserve meristem.

Differences between Shoot and Root Apical Meristem

Shoot Apical Meristem	Root Apical Meristem
Terminal in position.	Sub-terminal in position due to the presence of root cap.
Conical (dome-shaped).	Cup-shaped (roughly hemispherical) due to the presence of quiescent centre.
No quiescent centre.	Quiescent centre in most of the root apices.
Protected by young (juvenile) leaves.	Protected by root cap.
Lateral appendages produced.	Lateral appendages not produced.
Branch-primordia appear in the axils of leaves.	Branch-primordia formed far behind the root-apices.
Exogenous origin of branches.	Endogenous origin of branches.
The most favoured theory to explain the organisation is tunica-corpus theory.	The most favoured theory to explain the organisation is histogen theory.

2. Permanent or Mature Tissues

These are composed of mature cells that after undergoing complete growth have acquired a definite shape, size and function.

Permanent tissues can be of two types, i.e. simple tissue and complex tissue.

Characteristics of Various Types of Permanent Tissues

Tissue	Main Function	Living or Dead	Wall Material	Cell Shape	Distribution
1. **Simple Tissues** : These tissues have one type of cells only. They can be further classified as follows					
(i) **Parenchyma**	Acts as packing tissue, support in herbaceous plants. Metabolically active. Intercellular air spaces allow gaseous exchange, food storage. Transport of materials through cells or cell walls.	Living	Cellulose or calcium pectate.	Roughly spherical to elongated.	Cortex, pith, medullary rays in wood and packing tissue in xylem and phloem.
Modified Parenchyma					
(a) Epidermis	Protection from dessication and infection. Hairs and glands may have additional functions.	Living	Cellulose, pectins and hemicellulose and covering of cutin.	Elongated and flattened.	Single layer of cells covering entire primary plant body.
(b) Mesophyll	Photosynthesis (contains chloroplasts), storage of starch.	Living	Cellulose, pectins and hemicellulose.	Roughly spherical, irregular (spongy) or column-shaped (palisade) depending on location.	Between the upper and lower epidermis of leaves.
(c) Endodermis	Selective barrier to movement of water and mineral salts (between cortex and xylem in roots). Starch sheath possibly plays role in gravity response in stems.	Living	Cellulose, pectins, hemicellulose and deposits of suberin.	As epidermis	Around vascular tissue (innermost layer of cortex).
(d) Pericycle	In roots, it retains meristematic activity producing lateral roots and contributing to secondary growth if this occurs.	Living	Cellulose, pectins and hemicellulose.	As parenchyma	In roots, between central vascular tissue and endodermis.
(ii) Collenchyma	Support (a mechanical function).	Living	Cellulose, pectins and hemicellulose.	Elongated and polygonal with tapering ends.	Outer regions of cortex, e.g. angles of stems, midrib of leaves.
(iii) Sclerenchyma					
(a) Fibres	Support (purely mechanical).	Dead after maturity	Mainly lignin. Cellulose, pectins and hemicellulose also present.	Elongated and polygonal with tapering interlocking ends.	Outer regions of cortex, pericycle of stems, xylem and phloem.
(b) Sclereids	Support or mechanical protection.	Dead	As fibres	Roughly spherical or irregular.	Cortex, pith, phloem, shells and stones of fruits, seed coats.
2. **Complex Tissues** : These are made up of tissues which differ from each other in structure. They constitute					
(i) **Xylem**	Consists of living as well as dead cells. Xylem contains tracheids, vessels, fibres and parenchyma.				
(a) Tracheids and vessels	Support in translocation of water and mineral salts.	Dead at maturity	Mainly lignin. Cellulose, pectins and hemicellulose also present.	Elongated and tubular.	Vascular system
(b) Xylem parenchyma	Helps in lateral conduction of water or sap and stores food.	Living	Cellulose	Small thin or thick-walled parenchymatous cells	Vascular system
(c) Xylem fibres	Mechanical strength	Dead	Walls are lignified	Have highly thickened walls and central lumen	Vascular system

Tissue	Main Function	Living or Dead	Wall Material	Cell Shape	Distribution
(ii) **Phloem**	Made up of living and dead cells. It also contains fibres and sclereids.				
(a) Sieve tubes	Translocation of organic solutes (food).	Living	Cellulose, pectins and hemicellulose.	Elongated and tubular	Vascular system
(b) Companion cells	Works in association with sieve tubes.	Living	Cellulose, pectins and hemicellulose.	Elongated and narrow	Vascular system

Features of Xylem

Some additional features related with **xylem** elements are as follows:

- Tracheids and vessels are tracheary elements. Vessels are absent in pteridophytes, gymnosperms and Winteraceae, Tetracentraceae and Trochodendraceae families of angiosperms.
- First formed xylem is **protoxylem** and later formed xylem is **metaxylem**.
- On the basis of position of protoxylem in relation to metaxylem, xylem can be of four types, i.e. exarch, endarch, mesarch and centrarch.
- In exarch condition, protoxylem lies towards periphery of metaxylem.
- Protoxylem is on inner side in the endarch, middle of metaxylem in the mesarch condition and at the centre of metaxylem in centrarch xylem.

3. Special Tissue (Secretory Tissue)

These tissues perform special functions, e.g. secretion of resin, gum, oil and latex in plants. Secretory tissue are of two types:

(i) **Laticiferous tissues** These tissues contain colourless, milky or yellow coloured fluid called latex. They can be composed of uninucleated cells (branched/unbranched), i.e. **latex cells** (e.g. *Euphorbia, Thevetia,* etc.) or **latex vessels** in which cells are placed end to end to form long vessels, e.g. *Papaver, Hevea* (rubber plant), etc.

(ii) **Glandular tissues** These tissues include different types of glands which secrete oils, gums, mucilage, tannins and resins.

They may be **external glands** (e.g. glandular hair in *Utricularia*, digestive enzyme secreting glands in *Drosera*, *Nepenthes*) or **internal glands** (e.g. oil glands in *Citrus* and *Eucalyptus*, resinous ducts in *Pinus*).

All these above discussed tissues combinedly result into tissue system in plants. These tissues system performs coordinated activities in plants.

Tissue Systems

On the basis of their structure and location, there are three types of tissue systems. These are described as below

1. Epidermal Tissue System

- It forms the outermost covering of the whole plant body and comprises epidermal cells, stomata and the epidermal appendages, i.e. the trichomes and hairs.
- Epidermal cells are parenchymatous with a small amount of cytoplasm lying below the cell wall.
- Epidermal cells in some monocot leaves, become enlarged thin-walled, having vacuole and are called **bulliform cells**.
- These cells bring about rolling of leaves during dry season, thus reducing the rate of transpiration, e.g. *Ammophila*.
- The stomatal aperture, guard cells and the surrounding cells all together form **stomatal apparatus**. Guard cells in dicots are kidney-shaped and in monocots (grasses) are dumb-bell-shaped.
- The trichomes in the shoot system are usually multicellular. They prevent water loss due to the transpiration. The cells of epidermis bear a number of hairs.

2. Ground Tissue System

- This system constitutes all tissues except epidermis and vascular bundles.
- It consists of simple tissues such as parenchyma, collenchyma and sclerenchyma.
- In leaves, the ground tissue consists of thin-walled chloroplast containing cells and is called **mesophyll**.

The ground tissue system is differentiated into three main zones

(i) **Cortex** (main zone lying between epidermis and pericycle)

(ii) **Pericycle** (present between endodermis and stele)

(iii) **Pith** or **Medulla** (central core of the stem and root)

NOTE **Casparian strips** are the thickenings present on the walls of endodermal cells of roots.

3. Vascular Tissue System

- This system is derived from procambium. It consists of varying number of strands or bundles called **vascular bundles**.
- Each vascular bundle is primarily made up of xylem and phloem. It also contains a cambium in dicots.
- Depending upon arrangement of xylem and phloem vascular bundles can be classified as follows
  - (i) **Radial** Xylem and phloem are arranged alternately along the circumference.
  - (ii) **Conjoint** Xylem and phloem are situated at the same radius.
  - (iii) **Concentric** Either xylem sorrounds phloem completely or *vice-versa*.

Anatomy of Stem and Root

Anatomically, stem and root of dicot and monocots are very different. The tissue organisation of stems and roots can be studied better and conveniently by studying the internal structure.

Anatomical Differences between Stem and Root

Stem	Root
Chloroplasts may be present in some outer cells of the cortex.	Chloroplast almost absent.
Cuticle or cutinised outer walls of epidermal cells present.	Cuticle or cutinised outer walls absent.
Epidermis is protective in function.	Epidermis (young) is absorptive in function. It is called epiblema or rhizodermis.
Stomata present in epidermis.	Stomata absent in epiblema.
Stem hairs are additional cells, i.e. they do not arise as outgrowths of epidermal cells.	Root hairs are tubular outgrowths of the epiblema (epidermal) cells.
Hypodermis (collenchymatous or sclerenchymatous) present below the epidermis.	Hypodermis generally absent particularly in young roots, thick-walled exodermis occurring in some cases, e.g. *Smilax*, *Iris*, etc.
Cortex narrow.	Cortex broad.
Endodermis unconspicuous.	Endodermis conspicuous.
Pericycle, when present is mostly multilayered (multiseriate) and is not involved in secondary growth.	Pericycle usually single-layered (uniseriate) and is actively involved in root branches formation and in secondary growth.
Vascular bundles collateral and conjoint.	Vascular bundles are radial.
Xylem characteristically endarch.	Xylem characteristically exarch.
Xylem and phloem fibres present.	Xylem and phloem fibres usually absent.
Secondary growth, if occurs, takes place by primary cambium, which is both interfascicular and intrafascicular.	Secondary growth, if present, takes place by secondary cambium.

Anatomy of Dicot and Monocot Stem

The internal structures of monocot stem and dicot stem are very different. It is as follows

Dicot Stem

- They may be circular or angular. The various primary tissues of dicot stem are arranged in concentric fashion.
- Epidermis is uniseriate and is made up of compactly arranged, rectangular and barrel-shaped parenchymatous cells.
- Kidney-shaped guard cells in stomata.
- Ground tissue differentiated into cortex, endodermis, pericycle and pith.
- Vascular bundles are conjoint, collateral and of open type. They are arranged in a ring.
- Xylem vessels are polygonal and arranged in a row.

Monocot Stem

- They may be solid, fistular with central cavity.
- Epidermis is made up of compactly arranged, barrel-shaped cells.
- Dumb-bell-shaped guard cells in stomata.
- Ground tissue is uniform and there is no differentiation.
- Vascular bundles are conjoint, collateral and closed. They are scattered throughout the ground tissue.
- Xylem vessels are oval and arranged in a Y-shaped manner.

Anatomy of Dicot and Monocot Root

Anatomically, dicot roots are very different from monocot roots.

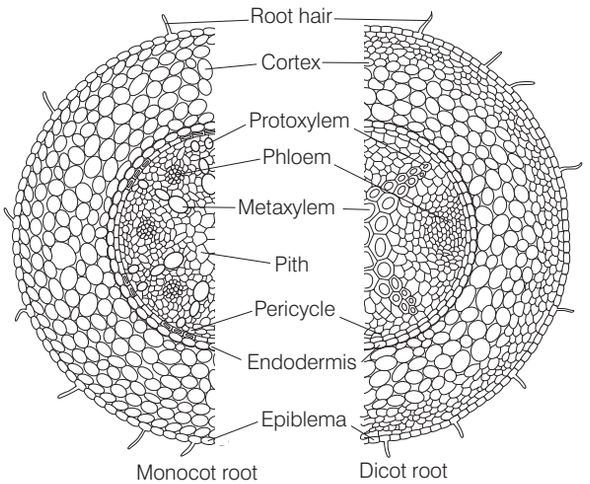
Dicot Root

- Epiblema is short-lived, uniseriate with unicellular root hairs.
- Cortex is comparatively narrow, endodermis is less thickened and lacks passage cells.

- It contains prominent Casparian strips.
- Pericycle gives rise to lateral root and cork cambium and pith is small or absent.
- Vascular bundles are radial, xylem is exarch where diarch to hexarch (2-6) condition is seen, e.g. sunflower (*Helianthus*), pea (*Pisum*).

Monocot Root

- Epiblema is generally persistant, uniseriate with unicellular root hairs.
- Cortex is wide, endodermis is highly thickened at a later stage and passage cells generally occur.
- Casparian strips are only visible in young roots.
- Vascular bundles are radial, xylem is exarch and polyarch (8 or more) condition is seen, e.g. maize (*Zea mays*), orchid (*Vanda*).



Comparison of TS of dicot root and monocot root

Anatomy of Leaves

Based on the internal structure, angiospermic leaves can be dorsiventral (bifacial), isobilateral (equifacial) and concentric (unifacial).

Differences between Dorsiventral and Isobilateral Leaf

Dorsiventral (Dicot) **Leaf**	**Isobilateral** (Monocot) **Leaf**
Stomata usually absent or less abundant in upper epidermis, while numerous in lower epidermis.	Stomata almost equally distributed in upper and lower epidermis.
Guard cells are kidney-shaped.	Guard cells are dumb-bell shaped.
Bulliform cells (motor cells) absent.	Bulliform cells (motor cells) present.
Mesophyll is differentiated into palisade and spongy parenchyma.	Mesophyll is undifferentiated.
Vascular bundles are arranged irregularly.	Vascular bundles are arranged in a row.
Bundle sheath cells are colourless and parenchymatous.	Bundle sheath cells are chlorophyllous and sclerenchymatous.

- Most of the **dicot leaves** are dorsiventral having reticulate venation, in which, mesophyll is differentiated into palisade and spongy parenchyma.
- Most of the **monocot leaves** are isobilateral, in which, there is no differentiation of mesophyll into palisade and spongy parenchyma.

NOTE

- Multilayered epidermis is found in the leaves of *Ficus, Bignonia, Nerium,* etc. The multiple epidermis of *Peperomia* has as many as 14-15 layers.
- **Lithocytes** are the specialised epidermal cells containing cystoliths, the crystals of calcium carbonate. Lithocytes are frequently found in Apocyanaceae, Acanthaceae, Moraceae (e.g. *Ficus*), Cucurbitaceae and Urticaceae families.

Secondary Growth

It is the growth in the girth of stems and roots in dicots, produced by division of secondary meristem, resulting in the formation of woody tissues.

The cambium is involved in secondary growth.

Cambium

- The increase in the diameter or thickness is due to the formation of secondary tissues as a result of the activities of primary and secondary lateral meristems, namely vascular cambium (**fascicular cambium**) and cork cambium (**phellogen**), respectively.
- The secondary growth begins by the formation of a continuous cambial ring.
- In stems, there is already a fascicular cambium between the xylem and phloem of the vascular bundles, which becomes joined up by interfascicular cambium.

Cork Cambium or Phellogen

- It cuts off cells both on outer side and inner side. The cells that cut off on outer side are phellem or cork cells and that on the inner side are phelloderm or secondary cortex. Phellem, phellogen and phelloderm collectively constitute periderm.
- The phellem or cork cells are dead, which have deposition of a fatty substance called suberin (i.e. cork cells are suberised). Suberin is impervious to water.

- The commercial cork is obtained from the cork tissue of *Quercus suber*, which yields bottle cork.

Vascular Cambium

- It is the meristematic layer that is responsible for cutting off vascular tissues, i.e. xylem and phloem.
- In young stems, it is present in patches as a single layer between the xylem and phloem. Later, it forms complete ring.

Differences between Intrafascicular and Interfascicular Cambium

Intrafascicular Cambium	Interfascicular Cambium
This meristem is primary in origin. It is present between the primary phloem and primary xylem of the vascular bundle.	This meristem is secondary in origin. It originates only at the time of secondary growth between the vascular bundles.
Fascicular cambium originates from procambium of the apical meristem of the stem.	The permanent cells of medullary rays change into interfascicular cambium due to the dedifferentiation.

Secondary Xylem and Phloem

The cells of the cambium ring divide periclinally and result in the formation of new cells both outside and inside. The cells that cut off outside constitute secondary phloem, while those on inner side form secondary xylem. Secondary growth is the characteristic feature of dicots. It remains absent in monocots.

NOTE The deviating type of secondary growth is called **anomalous secondary growth**. Anomalous or Abnormal secondary growth is found in some monocot stems such as *Yucca, Dracaena, Aloe, Agave, Sensiviera,* etc.

Wood

Wood is cellular and contains all tissues inner to cambium, i.e. secondary xylem and pith.

The central, hard, tough and darker region of wood constitutes heartwood, while peripheral portion constitutes the sapwood.

Differences between Sapwood and Heartwood

Sapwood	Heartwood
It is also called alburnum.	It is also called duramen.
Sapwood represents the outward wood of the plant.	Heartwood represents the central wood of the plant.
It is light in colour and lighter in weight.	It is dark in colour and heavier in weight.
Consists of living cells.	Living cells absent.
Represents functional part of the secondary xylem (wood).	Represents non-functional part of the secondary xylem (wood).
Tannins, resins, gummy substances not deposited in tracheary elements.	Tannins, resins, gummy substances deposited in tracheary elements.
Economically not important because of being easily attacked by pathogens and insects. Thus is non-durable.	Economically very important because of being resistant to pathogens and insects. Thus, durable.

Dicot wood is extremely variable; certain species lack some of these cell types, other species have them all. The relative amount of each cell varies greatly. The wood of gymnosperms is called **softwood** or **non-porous wood**, whereas wood of angiosperms is called **hardwood** or **porous wood**.

Differences between Softwood and Hardwood

Softwood (Non-porous)	**Hardwood** (Porous)
Gymnospermic wood is the softwood.	Angiospermic wood is the hardwood.
It chiefly constitutes of tracheids.	It constitutes of both tracheids and vessels.
Since, the vessels are absent, the wood is called non-porous wood.	Due to the presence of vessels, it is called porous wood.
Tracheid-percentage ranges 90-95%.	Tracheid-percentage ranges only less than 5%. Xylem fibres are plenty.
Easily workable.	Difficult workability.

- Springwood plus autumnwood of a year constitute **annual ring**. Annual rings are conspicuous in temperate (cold) regions.
- The age of tree can be determined by counting annual rings in basal portion of tree trunk. The calculation of age of the tree by counting annual rings is called **dendrochronology**.

Differences between Springwood and Autumnwood

Springwood	Autumnwood
It is also called early wood.	It is also called late wood.
It is formed during spring season.	It is formed during winter season.
It constitutes the major part of the annual ring.	It constitutes as a narrow strip in the annual ring.
Springwood is present in the beginning of an annual ring.	Autumnwood is present at the end of an annual ring.
Forms plenty of xylem vessels with wider-cavities.	The cavities of xylem vessels are narrower.
Xylem fibres are fewer in number.	Abundant xylem fibres are produced.
Wood is lighter in colour.	Wood is darker in colour.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 Who among the following is regarded as the Father of Plant Anatomy?
(a) N Grew and M Malpighi (b) Hofmeister
(c) B Schmidt (d) Nageli

2 Meristem responsible for increase in girth or diameter is
(a) apical meristem (b) intercalary meristem
(c) lateral meristem (d) None of these

3 The meristem derived from the promeristem is
(a) primary meristem (b) apical meristem
(c) lateral meristem (d) secondary meristem

4 The permanent tissues possessing a single type of cells are known as
(a) complex permanent tissue
(b) simple permanent tissue
(c) simple meristematic tissue
(d) complex meristematic tissue

5 Quiescent centre is found in root. The concept of quiescent centre was proposed by
(a) Clowes in maize (b) Schmidt in rice
(c) C Nageli in oats (d) Buvat in *Arabidopsis*

6 Which one of the following is an example of meristem?
➝ CBSE-AIPMT 2010
(a) Dermatogen (b) Periblem
(c) Phellogen (d) Plerome

7 Meristematic cells have
(a) thick cell wall and large intercellular spaces
(b) thick cell wall and no intercellular spaces
(c) thin cell wall and large intercellular spaces
(d) thin cell wall and no intercellular spaces

8 Intercalary meristem is present at the base of
(a) internodes in grasses (b) leaves in *Pinus*
(c) nodes in *Mentha* (d) All of these

9 Which one of the following is not a lateral meristem?
(a) Intrafascicular cambium (b) Interfascicular cambium
(c) Phellogen (d) Intercalary meristem

10 Which of the following is not correctly matched?
(a) Father of Plant Anatomy — N Grew
(b) Term 'meristem' — C Nageli
(c) Apical cell theory — C Nageli
(d) Histogen concept — N Grew

11 Tracheids differ from other tracheary elements in
➝ CBSE-AIPMT 2014
(a) having Casparian strips (b) being imperforate
(c) lacking nucleus (d) being lignified

12 The procambium develop into
(a) primary vascular tissue (b) pericycle
(c) medullary rays (d) cortex

13 Casparian strips occur in ➝ NEET 2018
(a) cortex (b) pericycle
(c) epidermis (d) endodermis

14 In a woody dicotyledonous tree, which of the following parts will mainly consist of primary tissues?
(a) Stem and root (b) All parts
(c) Shoot tips and root tips (d) Flowers, fruits and leaves

15 The presence of intercellular spaces is the usual conspicuous feature of
(a) parenchyma (b) sclerenchyma
(c) collenchyma cells (d) Both (b) and (c)

16 Sclerenchyma is thick-walled tissue, which has depositions of
(a) lignin on their cell walls (b) suberin on their cell walls
(c) pectin on their cell walls (d) cellulose on their cell walls

17 Specialised epidermal cells surrounding the guard cells are called ➝ NEET-I 2016
(a) subsidiary cells (b) bulliform cells
(c) lenticels (d) complementary cells

18 Cortex is the region found between
(a) epidermis and stele
(b) pericycle and endodermis
(c) endodermis and pith
(d) endodermis and vascular bundle

19 In *Eichhornia,* parenchyma develops air spaces, such parenchyma with air cavities is known as
(a) collenchyma (b) chlorenchyma
(c) aerenchyma (d) sclerenchyma

20 Consider the following statements.
I. In monocot stem, ground tissue system is a continuous mass of parenchymatous tissue in which vascular bundles are found scattered.
II. In leaves, the ground tissue consists of thin-walled chloroplast containing cells called bundle sheath.
Which of the statements given above is/are correct?
(a) Only I (b) Only II
(c) Both (a) and (b) (d) None of these

21 Which of the following is made up of dead cells? ➝ NEET 2017
(a) Xylem parenchyma
(b) Collenchyma
(c) Phellem
(d) Phloem

22 Companion cells are absent in the phloem of
(a) angiosperms and bryophytes
(b) pteridophytes and gymnosperms
(c) angiosperms and gymnosperms
(d) bryophytes and angiosperms

23 What do you mean by closed vascular bundle?
(a) Cambium present (b) Cambium absent
(c) Periderm absent (d) None of these

24 Monocot stem lacks
(a) tracheids (b) sieve tube
(c) cambium (d) None of these

25 Jute fibre, sunhemp (hemp fibres) are obtained from the region of
(a) phloem (b) pericycle
(c) xylem (d) pith

26 Lateral meristem is present in
(a) vascular cambium (b) cork cambium
(c) xylem and phloem (d) Both (a) and (b)

27 Which of the following statements is true?
(a) Vessels are multicellular and with wide lumen
(b) Tracheids are multicellular and with narrow lumen
(c) Vessels are unicellular and with narrow lumen
(d) Tracheids are unicellular and with wide lumen

28 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? ➜ CBSE-AIPMT 2014
(a) Secondary xylem (b) Secondary phloem
(c) Protoxylem (d) Cortical cells

29 A major characteristic of the monocot stem is the presence of
(a) open vascular bundles
(b) scattered vascular bundles
(c) vasculature without cambium
(d) cambium sandwiched between phloem and xylem along the radius

30 Endarch is a condition in which
(a) the protoxylem lies towards the centre (pith)
(b) the protoxylem lies towards the periphery
(c) the metaxylem present in the centre of protoxylem
(d) protoxylem surrounded by metaxylem

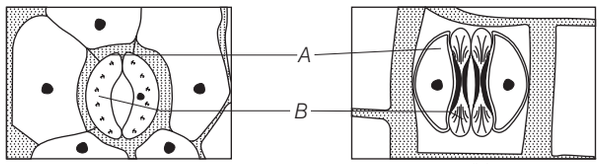
31 Which of the following cells helps in maintaining the pressure gradient in the sieve tubes?
(a) Phloem fibres
(b) Phloem parenchyma
(c) Companion cells
(d) Sieve tube

32 Stomata in a grass leaf is ➜ NEET 2018
(a) rectangular (b) kidney-shaped
(c) dumb-bell-shaped (d) barrel-shaped

33 Multilayered epidermis is found in
(a) Apocyanaceae (b) Moraceae
(c) Urticaceae (d) Acanthaceae

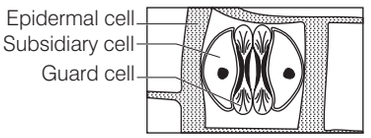
34 Consider the following statements.
I. *Nerium* has sunken stomata in leaf, which is an adaptive structure in xerophytic plants for reducing the water loss during transpiration.
II. Cork is rich in lipid which is wax-like called suberin.
III. *Pinus* leaf is evergreen due to the growth of apical meristem present at the base of leaf.
Which of the statements given above are correct?
(a) I and II (b) I and III
(c) II and III (d) I, II and III

35 Given figures (a and b) represent the stomatal apparatus of dicot and monocot, respectively. Select the option which correctly lebels *A* and *B*.



(a) *A*–Stomatal cell *B*–Guard cell
(b) *A*–Guard cell *B*–Subsidiary cell
(c) *A*–Epidermal cell *B*–Epidermal cell
(d) *A*–Subsidiary cell *B*–Guard cell

36 Identify the plants which possess the given type of guard cells (as shown in the diagram) in their leaves.



(a) Banana
(b) Lily
(c) Grasses
(d) All of the above

37 Match the following columns.

	Column I		Column II
A.	Apple and mulberry type	1.	Stomata on lower surface.
B.	Potato type	2.	Stomata more on lower surface and less on upper surface.
C.	Oat type	3.	Stomata equally distributed on both the surfaces.
D.	Potamogeton type	4.	Stomata absent or vestigial.

Codes

	A	B	C	D		A	B	C	D
(a)	2	4	1	3	(b)	1	2	3	4
(c)	2	3	4	1	(d)	1	3	2	4

38 Cork cambium results in the formation of cork, which becomes impermeable to water due to the accumulation of
(a) resins (b) suberin
(c) lignins (d) tannins

39 Plants having little or no secondary growth are ➝ NEET 2018

(a) conifers (b) deciduous angiosperms
(c) grasses (d) cycads

40 Secondary xylem and phloem in dicot stem are produced by ➝ NEET 2018

(a) phellogen (b) vascular cambium
(c) apical meristems (d) axillary meristems

41 Interfascicular cambium develops from the cells of

(a) xylem parenchyma (b) endodermis ➝ NEET 2013
(c) pericycle (d) medullary rays

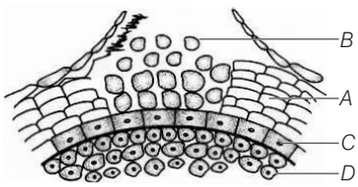
42 What is the fate of primary xylem in a dicot root showing extensive secondary growth?

(a) It is retained in the centre of the axis
(b) It gets crushed
(c) May or may not get crushed
(d) It gets surrounded by primary phloem

43 Anomalous secondary growth is found in

(a) *Yucca* (b) *Dracaena*
(c) *Aloe* (d) All of these

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



(a) *A*–Phellem *B*–Complementary cell
C–Phellogen *D*–Phelloderm
(b) *A*–Phellem *B*–Complementary cells
C–Phelloderm *D*–Periderm
(c) *A*–Complementary cells *B*–Phellogen
C–Phelloderm *D*–Periderm
(d) *A*–Complementary cells *B*–Phellem
C–Periderm *D*–Phelloderm

45 Consider the following statements about vascular cambium ring in secondary growth

I. In vascular bundles, the cambium present in between the primary xylem and primary phloem is called interfascicular cambium.
II. Along with interfascicular cambium, some medullary ray cells also become active forming intrafascicular cambium.
III. Both interfascicular and intrafascicular cambium join together and form a vascular cambial ring.

Which of the statements given above are incorrect?

(a) I and II (b) I and III (c) II and III (d) I, II and III

46 Consider the following statements.

I. Anomalous or abnormal secondary growth is found in *Yucca*, *Dracaena* and *Aloe*.
II. The secondary xylem of wood is distinguishable as springwood and autumnwood by the presence of annual rings.
III. The large empty and colourless cells present at intervals on the upper surface of grass leaf are called passage cells.

Which of the statements given above are correct?

(a) I and II (b) I and III
(c) II and III (d) I, II and III

47 Softwood is known as

(a) porous wood
(b) heartwood
(c) sapwood
(d) non-porous wood

48 Age of a tree can be estimated by ➝ NEET 2013

(a) biomass (b) number of annual rings
(c) diameter of its heartwood (d) its height and girth

49 Lenticels are involved in ➝ NEET 2013

(a) gaseous exchange (b) food transport
(c) photosynthesis (d) transpiration

50 Tyloses are an outgrowth from ray or axial parenchyma cell into the lumen of a vessel, which partially or completely blocks the cavity are present in

(a) periderm (b) heartwood
(c) sapwood (d) secondary cortex

51 The ballon-shaped structures called tyloses ➝ NEET-II 2016

(a) originate in the lumen of vessles
(b) characterise the sapwood
(c) are extensions of xylem parenchyma cells into vessels
(d) are linked to the ascent of sap through xylem vessels

52 Which one of the following statements is false for heartwood?

(a) Made up of living cells
(b) Forms central cylinder of wood
(c) Solid and hard
(d) Contains gums and resins

53 Consider the following statements regarding heartwood.

I. It does not help in water conduction.
II. It is also called alburnum.
III. It is dark in colour and physiologically active.
IV. It has tracheary elements, which are filled with tanin, resin, etc.

Choose the incorrect statements.

(a) I and IV (b) I and II
(c) II and III (d) III and IV

54 Consider the following statements.

I. Dendrochronology is the science dealing with age of tree by counting annual rings at the base of main stem.
II. Age of twig is known by counting internodes.
III. Increment borer is used to count annual rings in intact tree.

Which of the statements given above are correct?

(a) I and II (b) I and III
(c) II and III (d) All of these

55 Identify the correct order of the components with reference to their arrangement from outerside to innerside in a woody dicot stem.

I. Secondary cortex II. Autumnwood
III. Secondary wood IV. Phellem

(a) II, III, I and IV (b) III, IV, II and I
(c) IV, I, III and II (d) I, II, IV and III

56 Consider the following statements.

I. Usually the vessels remain plugged with tyloses.
II. It looks black or dark brown.
III. Generally the vessels are not plugged with tyloses.
IV. It consists of recently formed xylem elements.

Which of the above statements belongs to the heartwood and sapwood?

	Heartwood	Sapwood
(a)	I and III	II and IV
(b)	II and IV	I and III
(c)	I and II	III and IV
(d)	III and IV	I and II

57 Match the following columns.

	Column I		Column II
A.	Meristem	1.	Photosynthesis, storage
B.	Parenchyma	2.	Mechanical support
C.	Collenchyma	3.	Actively dividing cells
D.	Sclerenchyma	4.	Stomata
E.	Epidermal tissue	5.	Sclereids

Codes

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

58 Match the following columns.

	Column I		Column II
A.	Stomata	1.	Contains chloroplasts
B.	Mesophyll	2.	Light colour
C.	Lenticels	3.	Dark colour
D.	Springwood	4.	Epidermis of leaves
		5.	Exchange of gases

Codes

	A	B	C	D
(a)	4	1	5	2
(b)	2	1	3	5
(c)	5	4	2	1
(d)	1	2	3	4

59 Select the correctly matched pair.

(a)	Springwood	—	Late wood
(b)	Autumnwood	—	Alburnum
(c)	Heartwood	—	Duramen
(d)	Sapwood	—	Early wood

Directions (Q. Nos. 60-63) *In each of the following questions a statement of Assertion is given followed by a corresponding statement of Reason just below it. Of the statements, mark the correct answer as*

(a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion
(b) If both Assertion and Reason are true, but Reason is not the correct explanation of Assertion
(c) If Assertion is true, but Reason is false
(d) If both Assertion and Reason are false

60 **Assertion** Permanent tissue is composed of mature cells.

Reason Meristematic tissue is a group of actively dividing cells.

61 **Assertion** Xerophytic leaves have sunken stomata.

Reason Spongy parenchyma is more in xerophytic leaves.

62 **Assertion** Fascicular vascular cambium, interfascicular cambium and cork cambium are examples of lateral meristems.

Reason These are responsible for producing secondary tissues.

63 **Assertion** The lenticel is meant for gaseous exchange.

Reason Lenticel checks excessive evaporation of water.

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 Amount of secondary xylem is more than secondary phloem because
(a) cambium is more active on the outer side
(b) cambium is more active on inner side
(c) cambium has no role
(d) cambium is active equally on both sides but xylem is required

2 Correct sequence of layers from outside to typical monocot root is
(a) epiblema, endodermis, cortex, pericycle
(b) pericycle, cortex, endodermis, epiblema
(c) epiblema, cortex, endodermis, pericycle
(d) epiblema, pericycle, cortex, endodermis

3 Wheat and grass stems elongate by the activity of
(a) intercalary meristem (b) apical meristem
(c) lateral meristem (d) secondary meristem

4 Identify the group of glandular tissues.
(a) Cortex cells, xylem (b) Hydathodes, stinging hairs
(c) Protophloem, oil glands (d) Digestive gland, latex vessels

5 In angiosperms, pericycle gives rise to
(a) primary roots (b) lateral roots
(c) secondary growth (d) cork cells

6 A cut trunk shows 26 concentric rings of springwood and autumnwood in alternate rows. The age of trunk would be
(a) 13 years (b) 26 years (c) 52 years (d) 104 years

7 The cells of tunica undergo anticlinal divisions and give rise to
(a) epidermis (b) cortex (c) endodermis (d) pericycle

8 Histogens capping root apical meristem is
(a) dermatogen (b) calyptrogen
(c) periblem (d) plerome

9 Centripetal xylem (exarch) arrangement occurs in
(a) roots (b) stems
(c) Both (a) and (b) (d) None of these

10 Generally epidermis is single layered but in certain leaves, multilayered upper epidermis is present such as
(a) *Nerium* (b) *Ficus*
(c) *Pepromea* (d) All of these

11 Which of these characters does/do not apply to the vascular bundles of monocot stems?
I. Conjoint
II. Endarch protoxylem
III. Open
IV. Phloem parencyma is absent
Select the correct answer using the codes given below
(a) I and II (b) II and III
(c) III and IV (d) Only III

12 In dicotyledonous stem, which of the following is the sequence of tissues from inside to outside?
(a) Pith, phloem, cambium, protoxylem, metaxylem, pericycle, parenchyma, collenchyma, endodermis and epidermis
(b) Pith cambium, phloem, protoxylem, metaxylem, pericycle, endodermis, parenchyma, collenchyma and epidermis
(c) Pith, cambium, phloem, protoxylem, metaxylem, pericycle, endodermis, parenchyma, collenchyma and epidermis
(d) Pith, protoxylem, metaxylem, cambium, phloem, pericycle, endodermis, parenchyma, collenchyma and epidermis

13 A meristem in which the cell division takes place in all planes resulting in an increase in volume is called
(a) rib meristem (b) plate meristem
(c) mass meristem (d) None of these

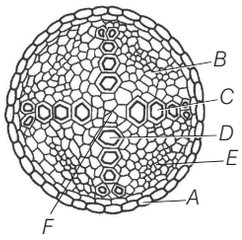
14 Transport proteins of endodermal cells are control points where a plant adjusts the quantity and types of solutes that reach the xylem. Root endodermis is able to actively transport ions in one direction only because of the layer of
(a) actin (b) lignin (c) suberin (d) cellulose

15 The internal structure of a plant stem is observed. There is discontinuous ring of angular collenchyma below the epidermis. Type of vascular bundles are of the same type as in the stems of solanaceous plants. Sieve tube elements possess simple sieve plates, identify the plant.
(a) *Helianthus* (b) *Cucurbita* (c) *Zea mays* (d) *Hydrilla*

16 Consider the following statements.
I. The central cylinder of the shoot or root surrounded by cortex is called stele.
II. Xylem, phloem and cambium form the major part of the vascular bundle.
III. In concentric bundles, xylem and phloem combine in the same bundle and are present on the same radius.
Choose the incorrect statement(s).
(a) Only I (b) Only II (c) Only III (d) All of these

17 Consider the following statements.
I. In a dicot root, the vascular bundles are collateral and endarch.
II. The innermost layer of cortex in a dicot root is endodermis.
III. In a dicot root, the phloem masses are separated from the xylem by parenchymatous cells that are known as the conjunctive tissue.
Which of the following options is correct regarding above statements?
(a) I is true, while II and III are false
(b) II is true, while I and III are false
(c) I is false, while II and III are true
(d) III is false, while I and II are true

18 In the diagram of TS of stele of dicot root, the different parts have been indicated by the alphabets. Choose the correct combination.



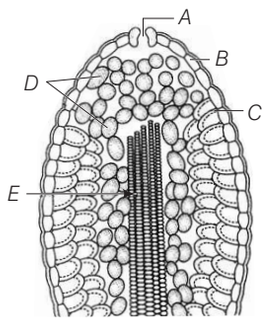
(a) *A*–Pericycle, *B*–Conjunctive tissue, *C*–Metaxylem, *D*–Protoxylem, *E*–Phloem, *F*–Pith

(b) *A*–Endodermis, *B*–Conjunctive tissue, *C*–Protoxylem, *D*–Metaxylem, *E*–Phloem, *F*–Pith

(c) *A*–Endodermis-*B*–Conjunctive tissue, *C*–Metaxylem, *D*–Protoxylem, *E*–Phloem, *F*–Pith

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

19 Choose the correct combinations of labelling of hydathode.



(a) *A*–Guard cells *B*–Epithem *C*–Mesophyll *D*–Epidermis *E*–Vascular tissue

(b) *A*–Guard cells *B*–Epidermis *C*–Mesophyll *D*–Epithem *E*–Vascular tissue

(c) *A*–Water pore *B*–Epidermis *C*–Mesophyll *D*–Epithem *E*–Vascular tissue

(d) *A*–Ostiole *B*–Epidermis *C*–Mesophyll *D*–Epithem *E*–Vascular tissue

20 Match the following columns.

	Column I		Column II
A.	Cuticle	1.	Guard cells
B.	Bulliform cells	2.	Single layer
C.	Stomata	3.	Waxy layer
D.	Epidermis	4.	Empty colourless cell

Codes

	A	B	C	D		A	B	C	D
(a)	3	4	1	2	(b)	1	2	3	4
(c)	3	2	4	1	(d)	3	2	1	4

Directions (Q. Nos. 21 and 22) *In each of the following questions a statement of Assertion is given followed by a corresponding statement of Reason just below it. Of the statements, mark the correct answer as*

(a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion

(b) If both Assertion and Reason are true, but Reason is not the correct explanation of Assertion

(c) If Assertion is true, but Reason is false

(d) If both Assertion and Reason are false

21 **Assertion** The quiescent centre acts as a reservoir of relatively resistant cells, which constitute a permanent source of active initials.

Reason The cells of the inactive region of quiescent centre become active, when the previous active initials get damaged.

22 **Assertion** In collateral vascular bundles, phloem is situated towards inner side.

Reason In monocot stem, cambium is present.

ANSWERS

SESSION 1

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

SESSION 2

1 (c)	**2** (c)	**3** (a)	**4** (b)	**5** (b)	**6** (a)	**7** (a)	**8** (b)	**9** (b)	**10** (d)
11 (d)	**12** (d)	**13** (c)	**14** (c)	**15** (b)	**16** (c)	**17** (c)	**18** (b)	**19** (c)	**20** (a)
21 (a)	**22** (d)								