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Course Code: 22PGBOTCC102

UNIT -I

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Permanent Tissues

- The Permanent tissues develop from apical meristem. They lose the power of cell division either permanently or temporarily.
- They are classified into two types:
    1. Simple permanent tissues.
    2. Complex permanent tissues.

Simple Permanent Tissues:

- Simple tissues are composed of one type of cells only. The cells are structurally and functionally similar. It is of three types.
    1. Parenchyma
    2. Collenchyma
    3. Sclerenchyma

1. Parenchyma (Gk: Para-beside; enehein- to pour)

Parenchyma is generally present in all organs of the plant. It forms the ground tissue in a plant. Parenchyma is a living tissue and made up of thin walled cells. The cell wall is made up of cellulose. Parenchyma cells may be oval, polyhedral, cylindrical, irregular, elongated or armed. Parenchyma tissue normally has prominent intercellular spaces. Parenchyma may store various types of materials like, water, air, ergastic substances. It is usually colourless. The turgid parenchyma cells help in giving rigidity to the plant body. Partial conduction of water is also maintained through parenchymatous cells.

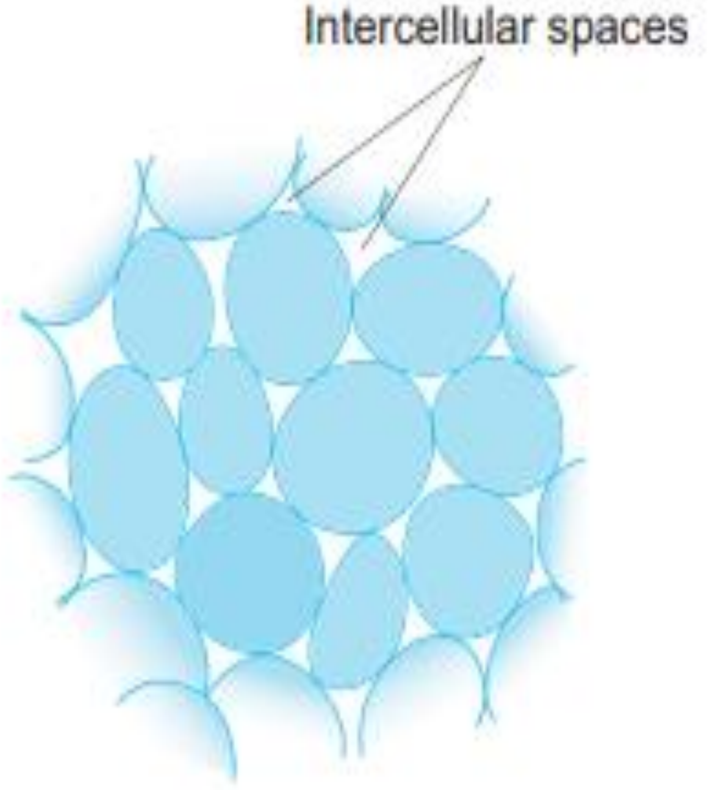


Figure 9.4: Parenchyma

- Occasionally, Parenchyma cells which store resin, tannins, crystals of calcium carbonate, calcium oxalate are called idioblasts. Parenchyma is of different types and some of them are discussed as follows.

Types of Parenchyma

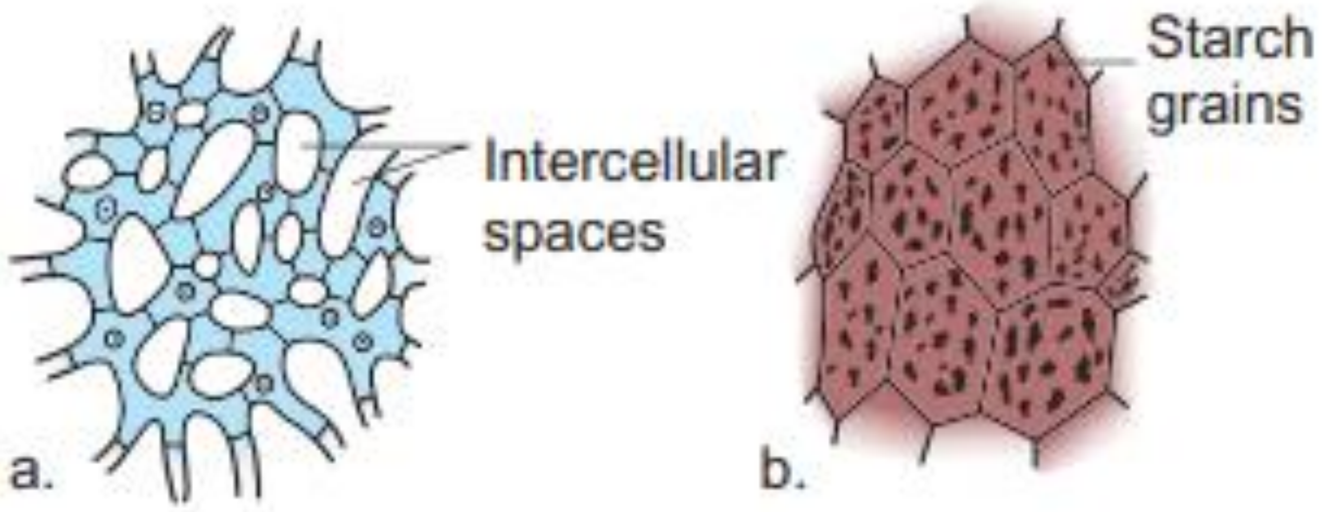


Figure 9.5: Types of Parenchyma
a) Aerenchyma, b) Storage parenchyma

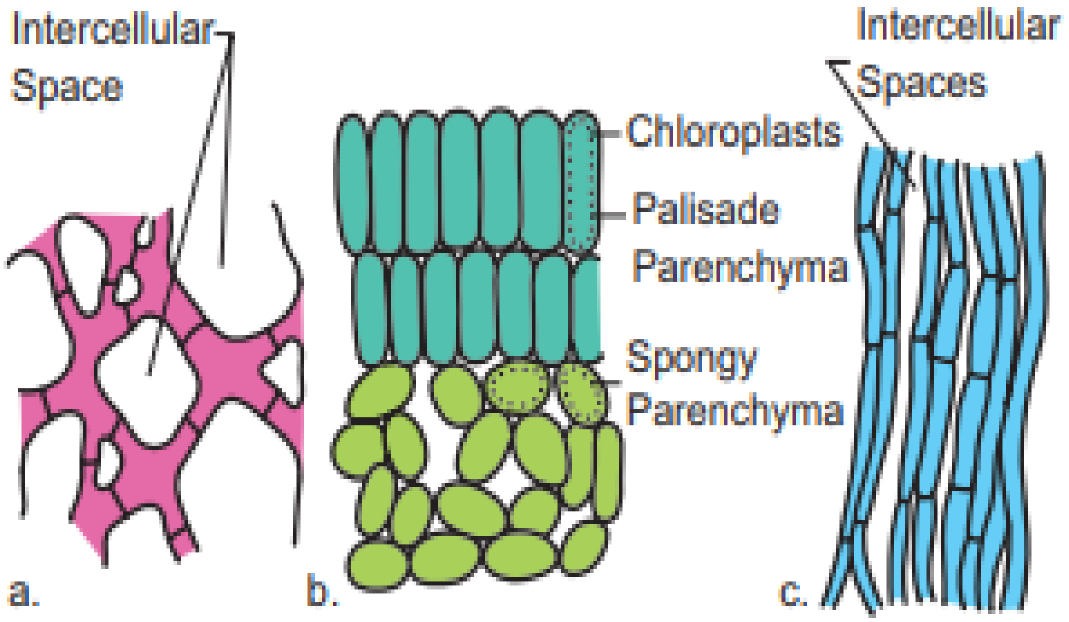


Figure 9.5: c) Stellate parenchyma,
d) Chlorenchyma, e) Prosenchyma

Parenchyma

1. Aerenchyma:
Parenchyma which contains air in its intercellular spaces. It helps in aeration and buoyancy. Example: *Nymphae and Hydrilla*.

2. Storage Parenchyma:
Parenchyma stores food materials. Example: Root and stem tubers.

3. How?.... Stellate Parenchyma
Star shaped parenchyma. Example: Petioles of *Banana and Canna*.

4. Chlorenchyma
Parenchyma cells with chlorophyll. Function is photosynthesis. Example: Mesophyll of leaves.

5. Prosenchyma:
Parenchyma cells became elongated, pointed and slightly thick walled. It provides mechanical support.

Collenchyma (Gk. Colla-glue; enchyma – an infusion)

Collenchyma is a simple, living mechanical tissue. Collenchyma generally occurs in hypodermis of dicot stem. It is absent in the roots and also occurs in petioles and pedicels. The cells are elongated and appear polygonal in cross section. The cell wall is unevenly thickened. It contains more of hemicellulose and pectin besides cellulose. It provides mechanical support and elasticity to the growing parts of the plant. Collenchyma consists of narrow cells. It has only a few small chloroplast or none. Tannin maybe present in collenchyma. Based on pattern of pectinisation of the cell wall, there are three types of collenchyma.

1. Angular collenchyma

It is the most common type of collenchyma with irregular arrangement and thickening at the angles where cells meets. Example:Hypodermis of *Datura* and *Nicotiana*

2. Lacunar collenchyma

The collenchyma cells are irregularly arranged. Cell wall is thickening on the walls bordering intercellular spaces. Example:Hypodermis of *Ipomoea*

3. Lamellar collenchyma

The collenchyma cells are arranged compactly in layers(rows). The Cell wall is thickening is at tangential walls.These thickening appear as successsive tangential layers. Example:Hypodermis of *Helianthus*

Diagramatic structures

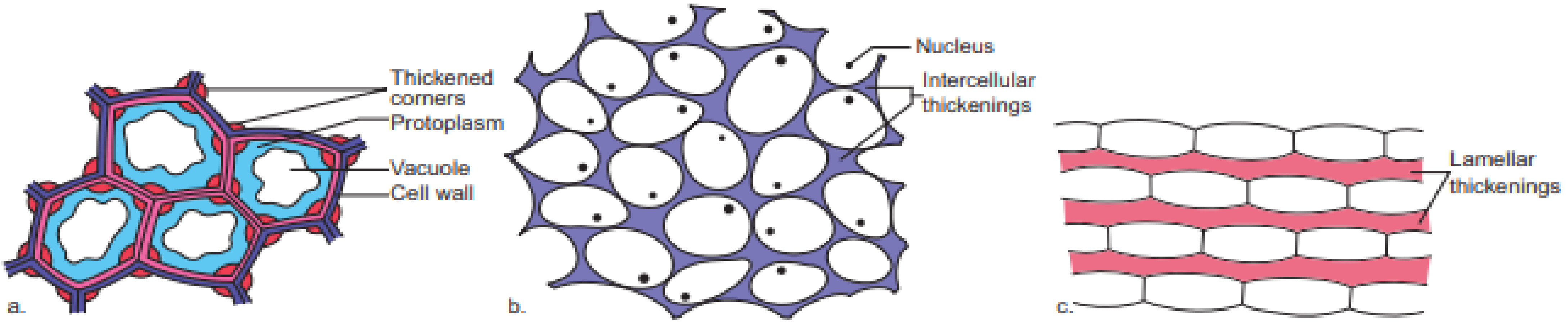


Figure 9.6: Types of Collenchyma a) Angular collenchyma, b) Lacunar collenchyma, c) Lamellar collenchyma

Sclerenchyma (Gk. Sclerous- hard: enchyma-an infusion)

The sclerenchyma is dead cell and lacks protoplasm. The cells are long or short, narrow thick walled and lignified secondary walls. The cell walls of these cells are uniformly and strongly thickened. The sclerenchymatous cells are of two types:

1. Sclereids
2. Fibres

1. Sclereids (Stone Cells):

Sclereids are dead cells, usually these are isodiametric but some are elongated too. The cell wall is very thick due to lignification. Lumen is very much reduced. The pits may simple or branched. Sclereids are mechanical in function. They give hard texture to the seed coats, endosperms etc., Sclereids are classified into the following types.

Types of Sclereids

1. Branchysclereids or Stone cells:
Isodiametric sclereids, with hard cell wall. It is found in bark, pith cortex, hard endosperm and fleshy portion of some fruits. Example: - Pulp of *Pyrus*.

2. Macrosclereids:
Elongated and rod shaped cells, found in the outer seed coat of leguminous plants. Example: *Crotalaria and Pisum sativum*.

3. Osteosclereids (Bone cells):
Rod shaped with dilated ends. They occur in leaves and seed coats. Example: seed coat of *Pisum and Hakea*

4. Astrosclereids:
Star cells with lobes or arms diverging form a central body. They occur in petioles and leaves. Example: *Tea, Nymphae and Trochodendron*.

5. Trichosclereids:
Hair like thin walled sclereids. Numerous small angular crystals are embedded in the wall of these sclereids, present in stems and leaves of hydrophytes. Example: *Nymphaea leaf* and Aerial roots of *Monstera*.

Diagramatic Structures

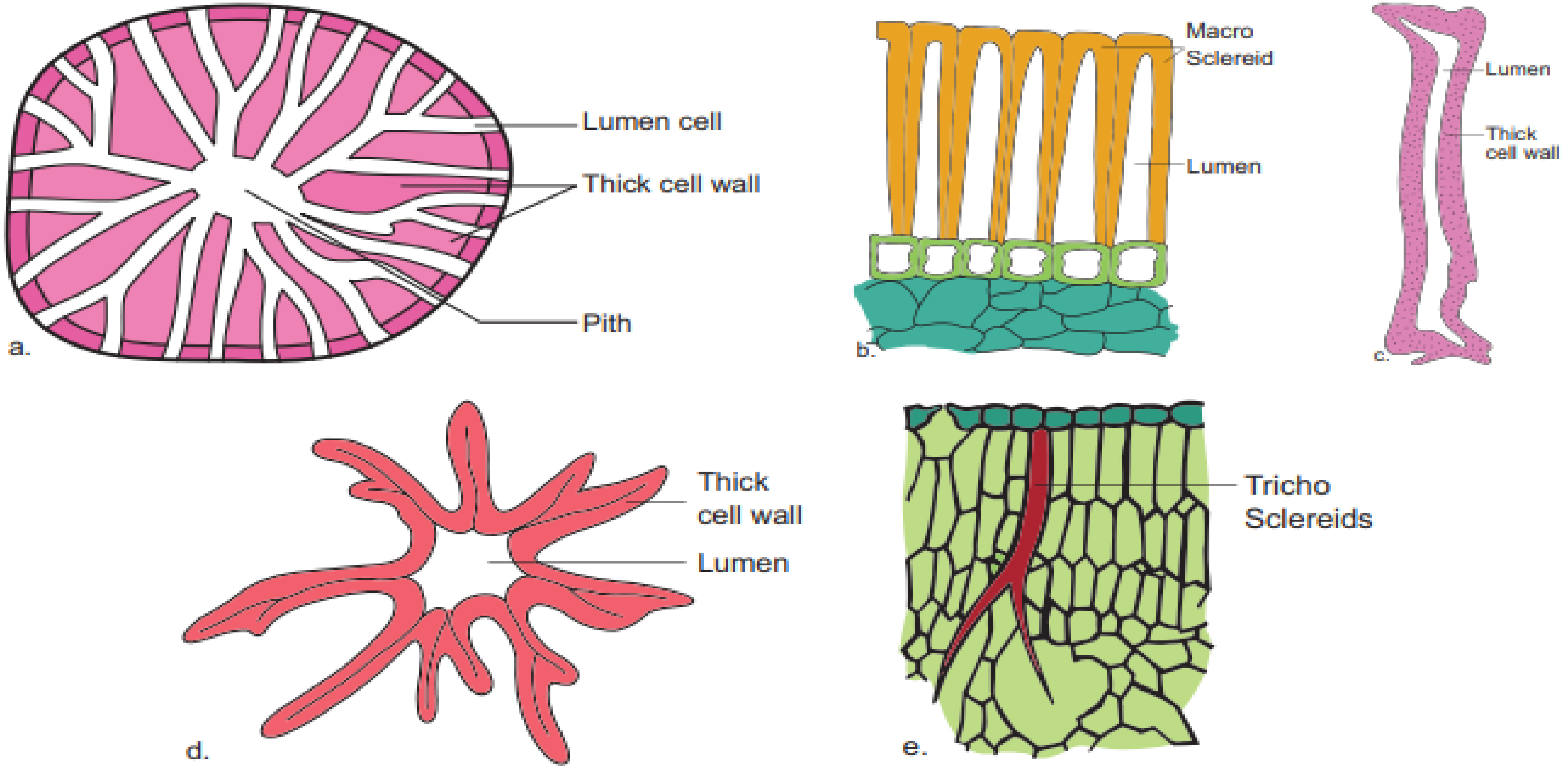


Figure 9.7: Types of Sclereids a) Brachysclereids, b) MacroSclereids, c) Osteosclereids, d) Astrosclereids, e) Trichosclereids

Complex Tissues

A complex tissue is a tissue with several types of cells but all of them function together as a single unit. It is of two types – **xylem and phloem.**

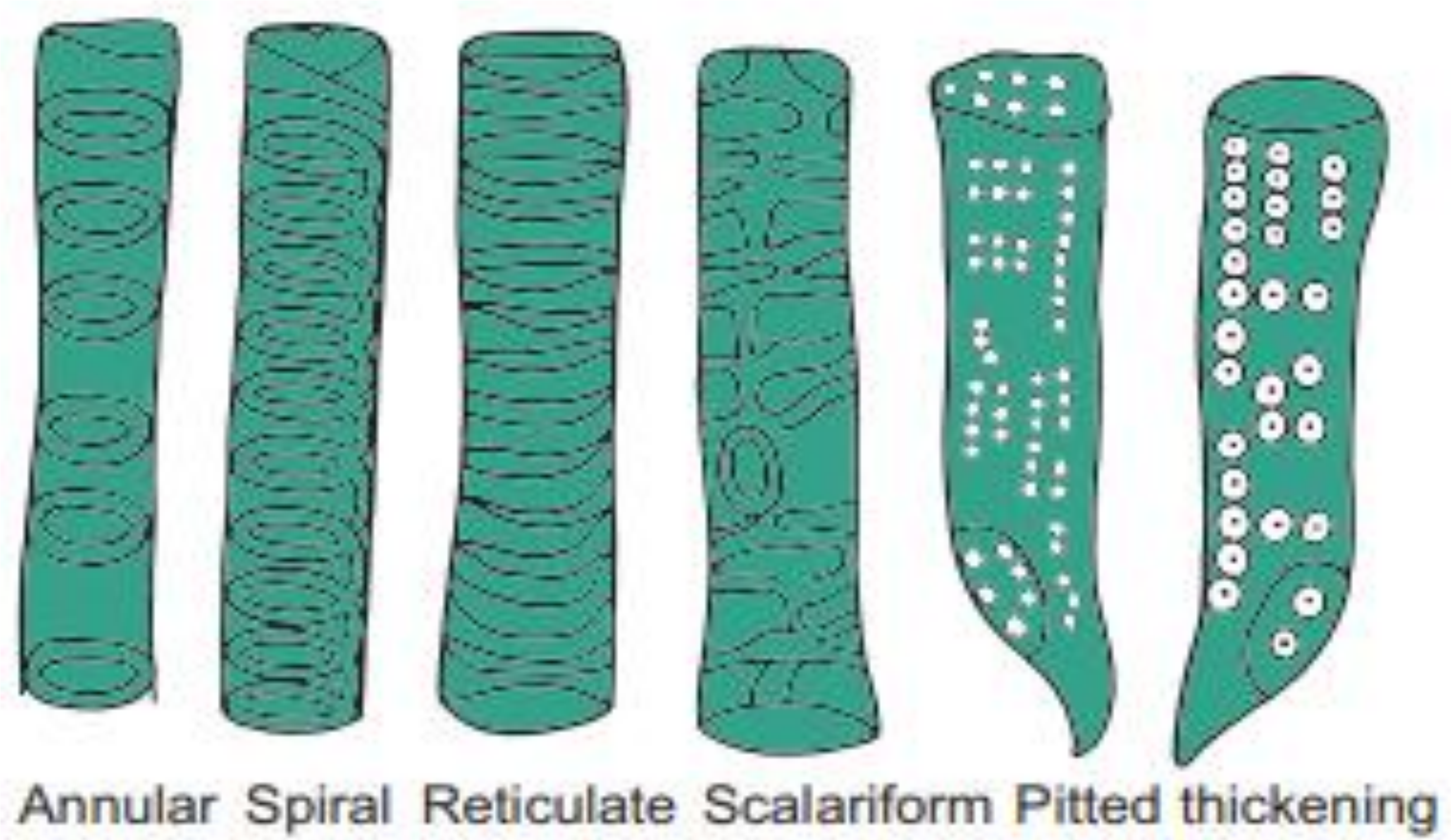
Xylem:

The xylem is the principal water conducting tissue in a vascular plant. The term xylem was introduced by Nageli (1858) and is derived from the Gk. Xylos – wood. The xylem which is derived from Procambium is called primary xylem and the xylem which is derived from vascular cambium is called secondary xylem. Early formed primary xylem elements are called protoxylem, whereas the later formed primary xylem elements are called metaxylem. Xylem Consists of Four Types of Cells –

1. Tracheids
2. Vessels or Trachea
3. Xylem Parenchyma
4. Xylem Fibres

1. Tracheids:

Tracheids are dead, lignified and elongated cells with tapering ends. Its lumen is broader than that of fibres. In cross section, the tracheids are polygonal. There are different types of cell wall thickenings due to the deposition of secondary wall substances. They are -



2. Vessels or Trachea:

- Vessels are elongated tube like structure. They are dead cells formed from a row of vessel elements placed end to end. They are perforated at the end walls. Their lumen is wider than Tracheids. Due to the dissolution of entire cell wall, a single pore is formed at the perforation plate. It is called simple perforation plate, Example: Mangifera. If the perforation plate has many pores, it is called multiple perforation plate. Example Liriodendron.

- Vessels are chief water conducting elements in Angiosperms and absent in Pteridophytes and Gymnosperms. In Gnetum of Gymnosperm, vessels occur. The main function is conduction of water, minerals and also offers mechanical strength.

3. Xylem Fibre:

The fibres of sclerenchyma associated with the xylem are known as xylem fibres. Xylem fibres are dead cells and have lignified walls with narrow lumen. They cannot conduct water but being stronger provide mechanical strength. They are present in both primary and secondary xylem. Xylem fibres are also called libriform fibres.

4. Xylem Parernchyma:

The parenchyma cells associated with the xylem are known as xylem parenchyma. These are the only living cells in xylem tissue. The cell wall is thin and made up of cellulose. Parenchyma arranged longitudinally along the long axis is called axial parenchyma. Ray parenchyma is arranged in radial rows. Secondary xylem consists of both axial and ray parenchyma, Parenchyma stores food materials and also helps in conduction of water.

Phloem:

Phloem is the food conducting complex tissues of vascular plants. The term phloem was coined by C. Nageli (1858) The Phloem which is derived from procambium is called primary phloem and the phloem which is derived from vascular cambium is called secondary phloem. Early formed primary phloem elements are called protophloem whereas the later formed primary phloem elements are called metaphloem. Protophloem is short lived. It gets crushed by the developing metaphloem.

Phloem Consists of Four Types of Cells

1. Sieve elements
2. Companion cells
3. Phloem parenchyma
4. Phloem fibres

1. **Sieve Elements:** Sieve elements are the conducting elements of the phloem. They are of two types, namely sieve cells and sieve tubes.

Sieve Cells: These are primitive type of conducting elements found in Pteridophytes and Gymnosperms. Sieve cells have sieve areas on their lateral walls only. They are not associated with companion cells.

Sieve Tubes

Sieve tubes are long tube like conducting elements in the phloem. These are formed from a series of cells called sieve tube elements. The sieve tube elements are arranged one above the other and form vertical sieve tube. The end wall contains a number of pores and it looks like a sieve. So it is called as sieve plate. The

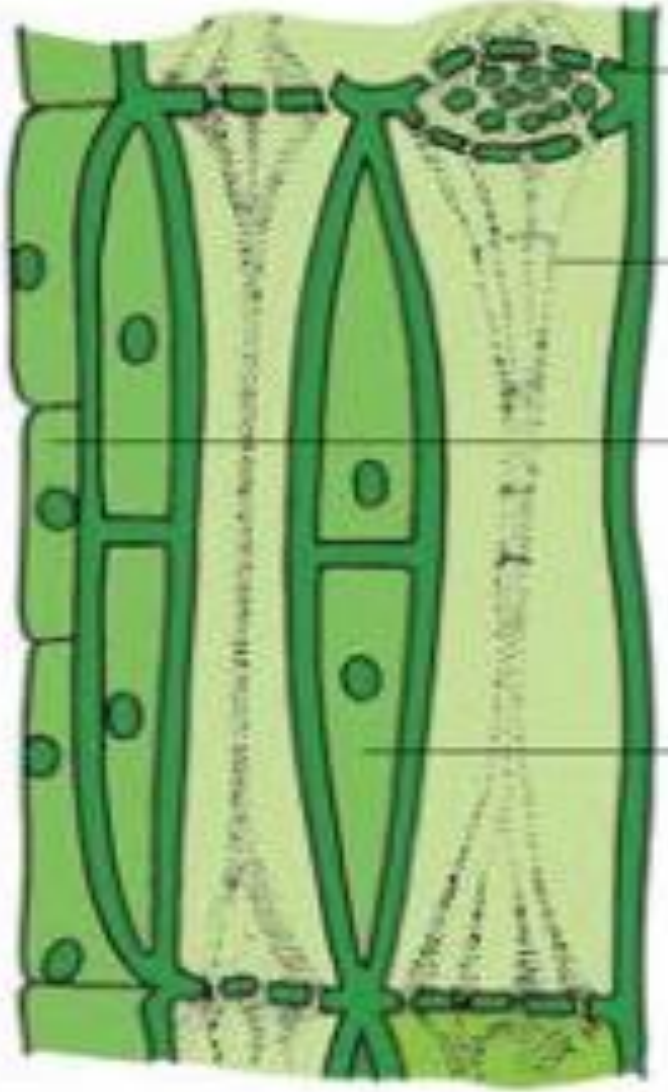
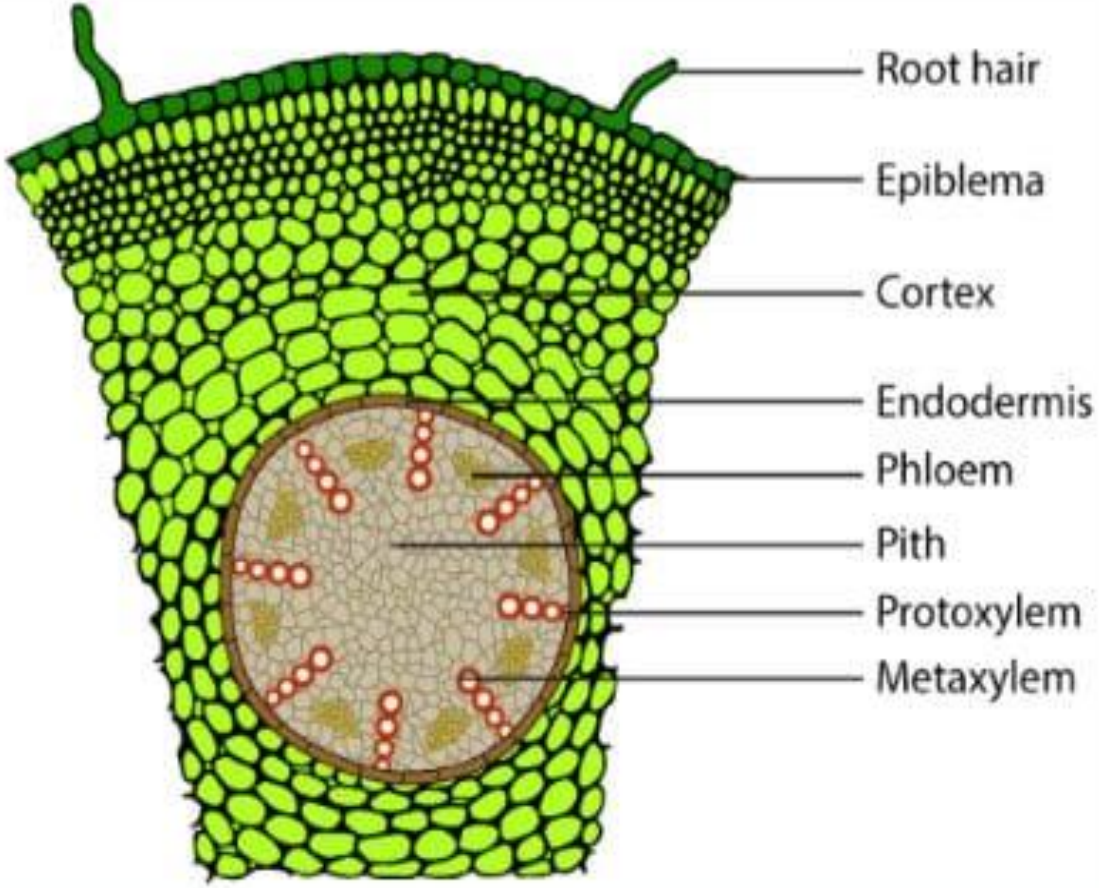


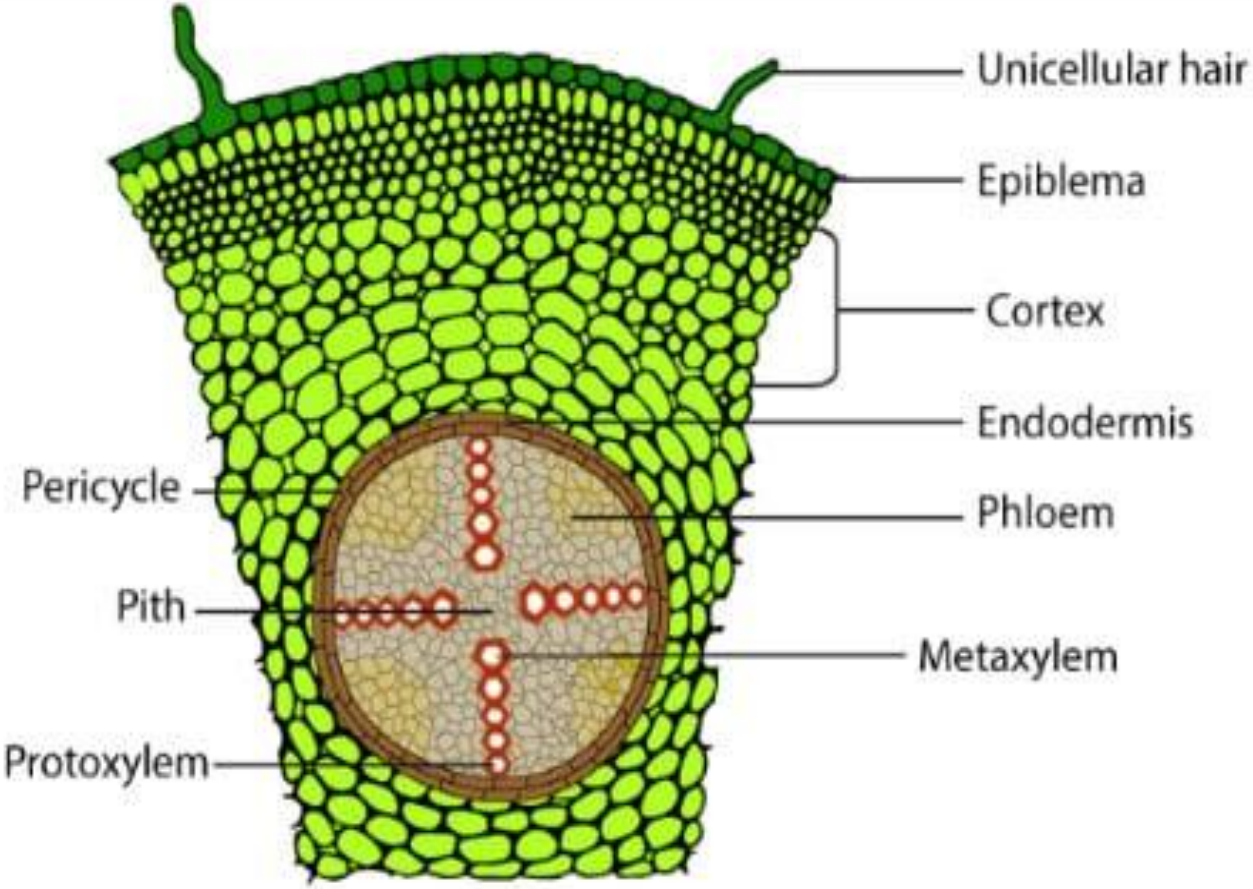
Figure 9.11: Different types of phloem elements

Monocot and Dicot Roots

Definitions, Structure, 18 Differences, Examples



Monocot Root



Dicot Root

Definition of Monocot Root

Monocot roots are fibrous or adventitious roots consisting of a wide network of thin roots and root fibers that originate from the stem.

- Monocot roots are highly variable depending on the plant species and the age of the plant. But most of the monocot plants are herbaceous with weak cambium that cannot hold woody tissues.

- The monocot root system consists of various roots characterized by their growth and complexity. The root system has a primary or taproot with associated lateral roots.

- Besides, seminal roots are present that are preformed in an ungerminated seed. Shoot-borne roots or adventitious roots are characteristic of monocot plants as well. The adventitious roots develop other regions of the seed than the radical.

•The adventitious roots in monocots are of two types; roots that originate at nodes present on the germinating seedling axis below the soil and roots that originate at nodes that are present above the soil. The second type of adventitious roots usually are observed at the lowermost 2-3 nodes and are often referred to as prop or brace roots.

•The roots of monocot plants lack cambium which prevents the formation of strong woody plants and limits the sufficient growth of the plant.

•The lack of cambium in the roots is replaced by the formation of adventitious roots or shoot-borne roots that provide stability and strength to the plant.

•The formation of primary roots of monocot plants begins during early embryogenesis and forms a distinct region within 10-15 days.

•It is then followed by vascular development during which the primary root is enclosed in a protective sheathing structure.

Definition of Dicot Root

Dicot roots are taproots consisting of a single primary root from which secondary and tertiary roots develop and grow vertically downwards through the soil.

•The roots are a non-green part of the plan that is present below the soil and do not have any nodes or internodes.

•The roots in dicot plants are mostly similar in structure but the length, thickness complexity of the root system might differ.

•Some dicot plants might have modified roots for different purposes like respiration, food storage, and mechanical support.

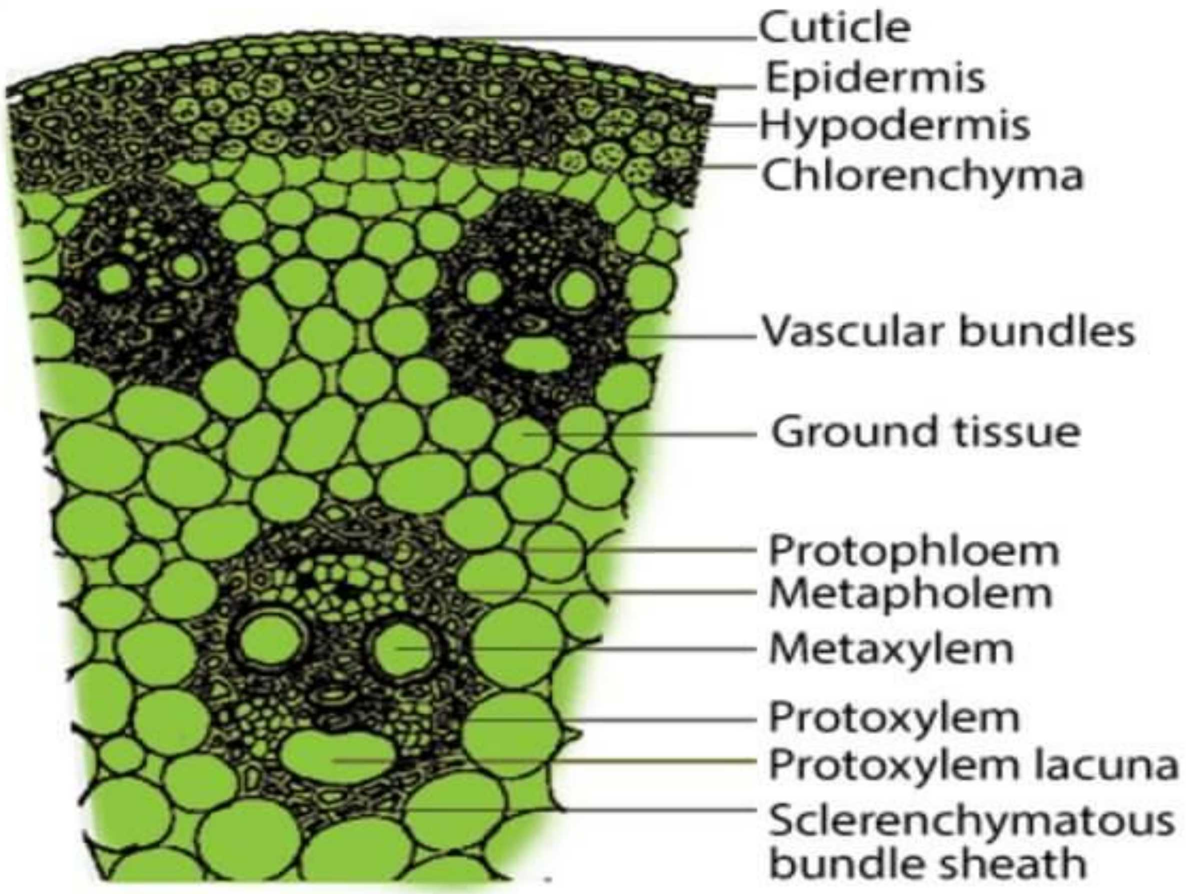
•A typical root consists of different parts; root cap, meristematic zone, the zone of elongation, and zone of maturation.

- The primary root of the dicot root system is the taproot which grows vertically downwards to great depth. From the taproot, secondary roots arise which might grow sidewards as well as downwards.

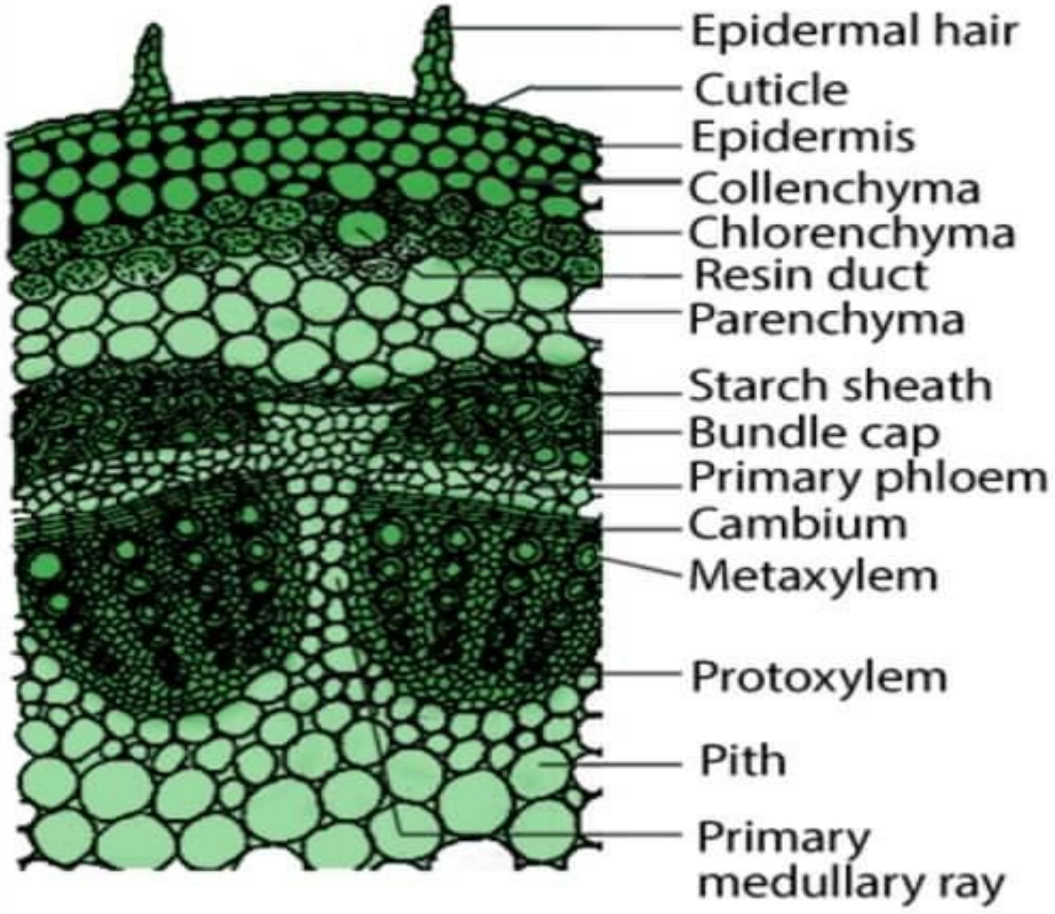
- Tertiary roots might arise from the secondary roots in order to reach greater depth and enable absorption of water and minerals. Tiny root hairs are also present in the dicot root system.

- Dicot roots can be both herbaceous and woody depending on the plant species. The woody root system has cambium which enables the growth of large plants with thick stems.

MONOCOT AND DICOT STEM



T.S. of Monocot Stem



T.S. of Dicot Stem

Definition of Monocot Stem

Monocot stem is a circular-shaped hollow axial part of the plant which gives rise to nodes, internodes, leaves, branches, flowers with roots at the basal end.

•The size of stems varies in different species of monocots, but the size is barely ever as large as dicots.
•Monocot stems are herbaceous as they lack secondary growth due to the absence of cambium in their internal tissue system.

•However, some plants like Palms and Bamboo might have woody stems as a result of anomalous secondary growth.

•Many monocot stems are hollow as the tissues in the stem are not arranged in an orderly fashion.

•Monocot stems arise from the plumule of the embryo and often have a terminal bud at the tip of the shoot. The stem is positively phototropic, unlike the roots.

•The stem gives off leaves and branches at structures called nodes that are present at regular intervals on the stem. In monocots, the leaves develop from the nodes without any petiole, surrounding the stem at the base.

•Monocot stems can exist in different forms depending on the characteristics of the plant species.

•Monocots like coconut and palms have caudex or columnar type of stem which is unbranched, erect, cylindrical, and stout with a crown of leaves at the tip. This type of stem is characterized by scars of fallen leaves throughout the trunk.

•Culm type of stem can be observed in monocot plants like bamboo where the stem is composed of solid nodes and hollow internodes. The nodes are often swollen with tiller branching.

•In some monocots like onions, a scape type of stem is found which is characterized by the absence of aerial stem during the vegetative phase of the plant. A reproductive shoot is observed during later stages which are unbranched and cylindrical with an inflorescence at the tip.

•Monocot stems are essential as they carry most of the parts of the plant from photosynthetic leaves to branches and flowers.

Definition of Dicot Stem

Dicot stem is the solid cylindrical axial part of a plant consisting of nodes and internodes givin rise to leaves, branches, and flowers.

•The most distinguishing feature of dicot stems is the hard and woody trunk as a result of th secondary growth of the plant.

•The diameter of the stem ranges from few millimeters to several centimeters depending on th type of plant species and the age of the plant.

•The stem of dicots is green and somewhat photosynthetic when young, but it becomes har and woody as the plants continue to grow.

•Dicot stems are exogenous in origin as these originate from the lateral branches of the cortica zones.

• Dicot stems also arise from the plumule of the embryo and are positively phototrophic. Unlik roots, the stems have stomata which enable the exchange of gases.

- The stem consists of nodes which are slightly swollen structures present throughout the stem and the space between two nodes are the internode. The nodes give rise to branches and leaves.

- In the dicot stem, the leaves develop with a petiole, and the number of leaves or branches on the stem differ in different species.

- Most dicot stems remain erect and ascending, but some might lie prostrate on the ground like in sweet potato or strawberries.

- Like in monocots, dicot stems are also modified in different species to give different structure and function to the plant.

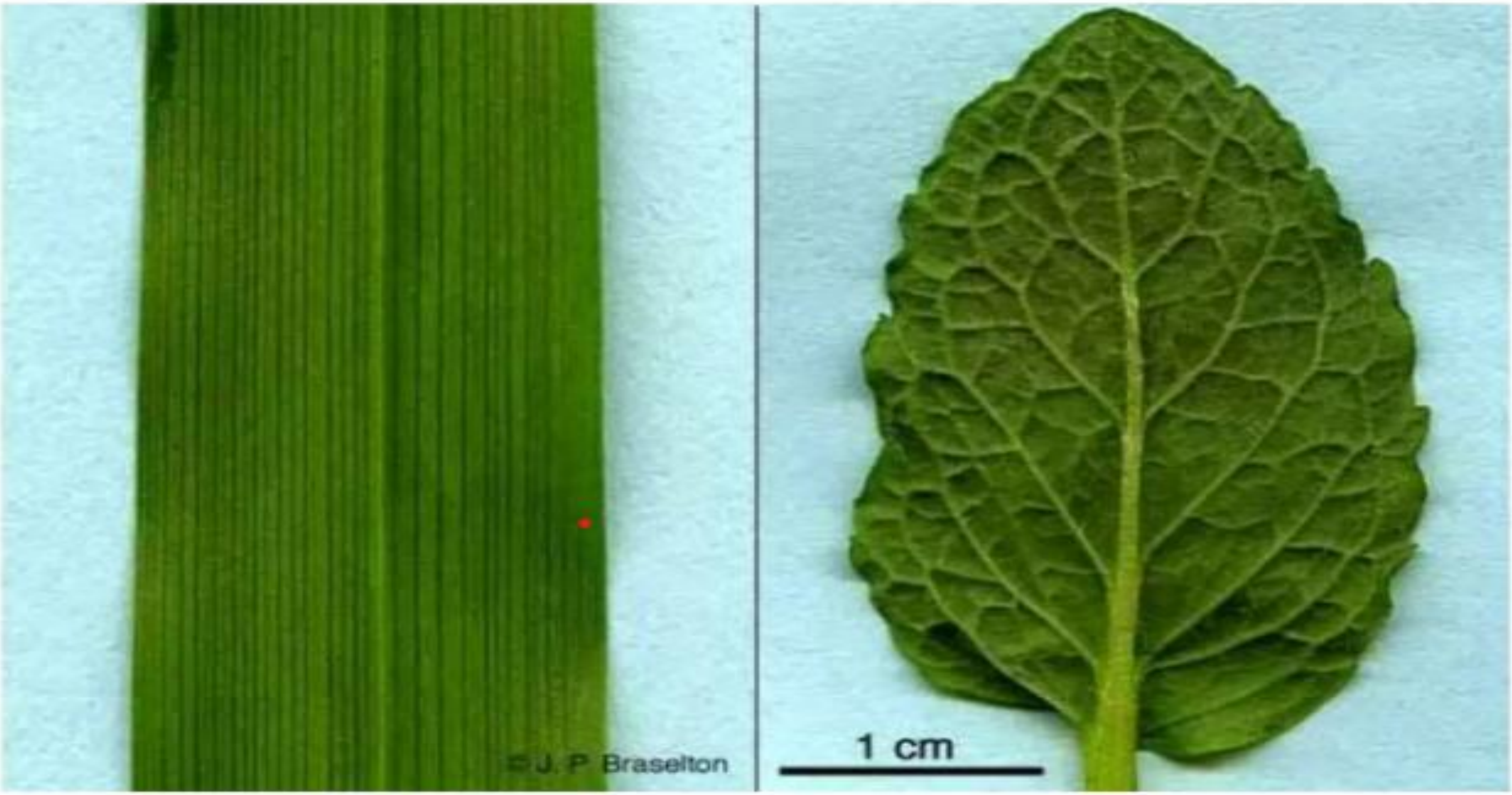
- A common form of the stem in dicots is the deliquescent form where the main stem grows for some time and then stops growing.

- It continues to give out branches resulting in a dome or umbrella-shaped structure of the plant.

- Some dicots might be climbers with soft, flexible stems to enable the plant to grow and move through hard surfaces.

DICOT AND MONOCOT LEAF ANATOMY

MORPHOLOGY

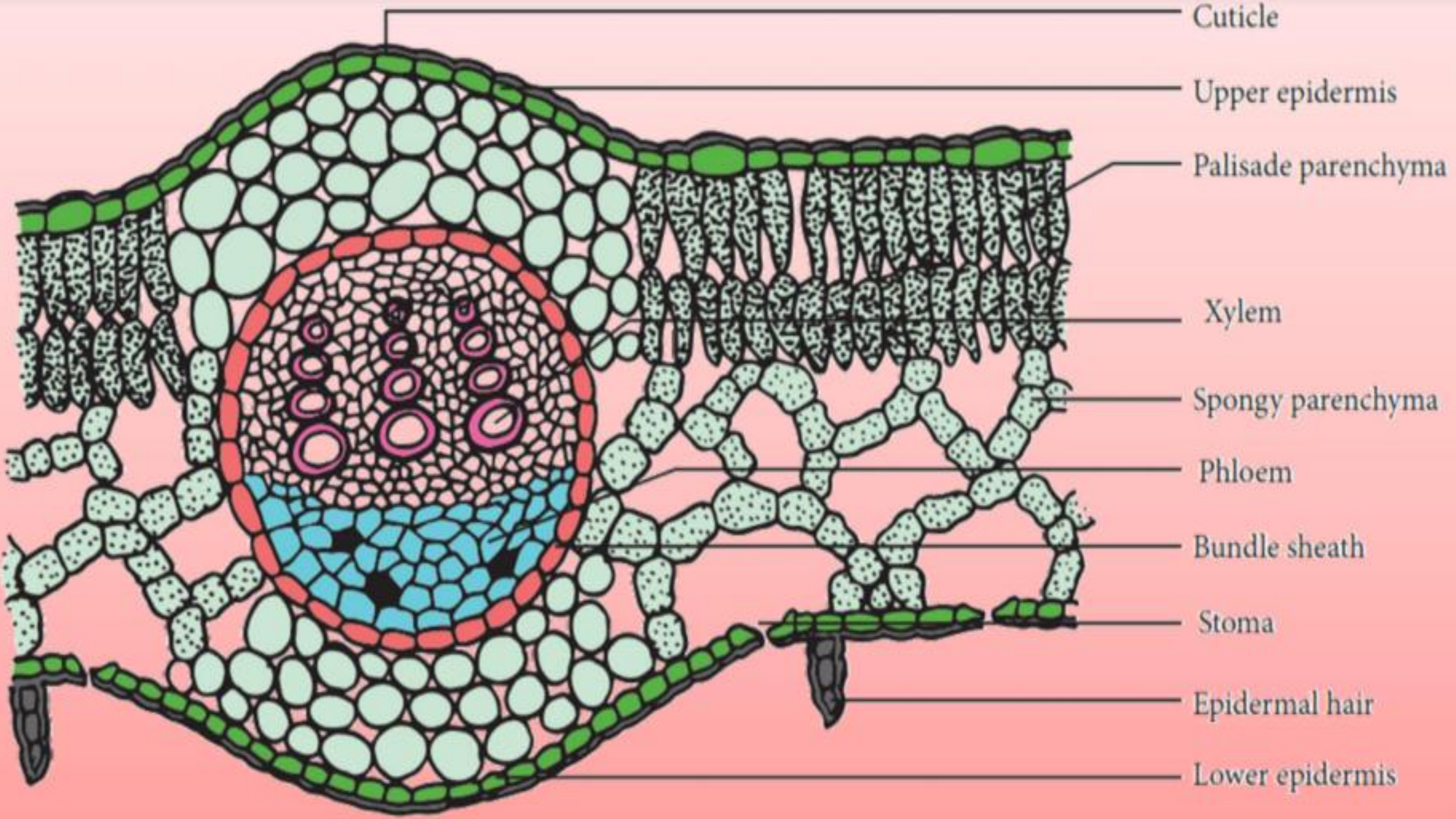


Dicotyledonous leaf

- Typical dorsiventral leaf
- T.S of leaf lamina show three main parts
  - Epidermis
  - Mesophyll
  - Vascular system

Epidermis

- It covers both upper(adaxial epidermis) and lower surface(abaxial)
- Cuticle is present


Cuticle
Upper epidermis
Palisade parenchyma
Xylem
Spongy parenchyma
Phloem
Bundle sheath
Stoma
Epidermal hair
Lower epidermis

MESOPHYLL

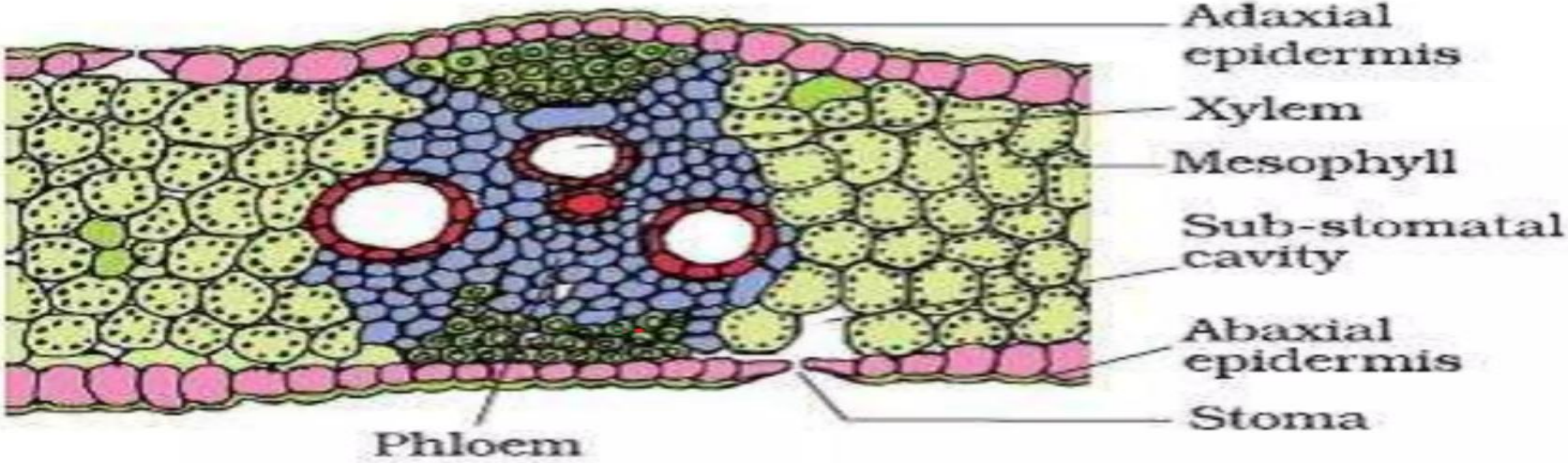
- Tissues between upper and lower epidermis
- It posses chloroplast –photosynthesis
- Two type- palisade parenchyma, spongy parenchyma
- Palisade parenchyma
- Adaxially placed
- Elongated cells
- Vertically arranged and parallel to each other

VASCULAR SYSTEM

- It seen in the veins and mid ribs
- Size of vascular bundle depend on the size of the vein
- It is surrounded by a thick walled bundle sheath cells

MONOCOTYLEDONOUS LEAF

- Typical isobilateral leaf
- Three main parts
  - ❖ Epidermis
  - ❖ Mesophyll
  - ❖ Vascular system



- Stomata present on both epidermis
- Mesophyll is not differentiated in to palisade and spongy parenchyma
- Bulliform cells- modified adaxial epidermis cells and veins
- It absorb water and become turgid-leaf surface exposed
- It become flaccid due to water stress-leaves curl inward

characters	Dicot leaf	Monocot leaf
Nature of orientation	Dorsi ventral	isobilateral
stomata	Upper epidermis	Both upper and lower
mesophyll	Palisade and spongy parenchyma	Spongy parenchyma
Bundle sheath	Made up of collenchyma	made up of sclerenchyma

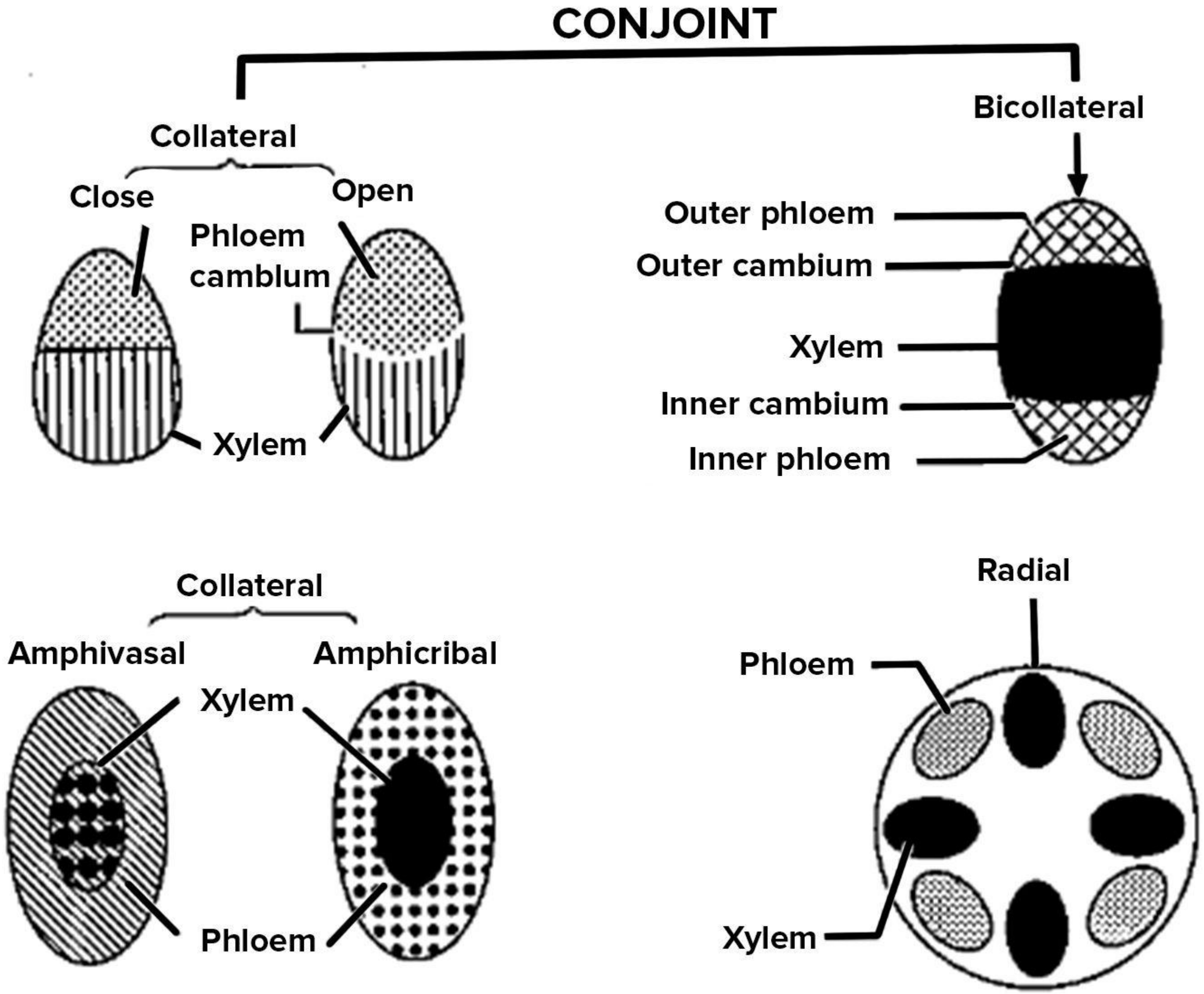
Vascular bundle: The part of the transport system that runs through the plant and carries water, minerals, and nutrition to different parts of the plant.

Different types of vascular bundles:

The vascular bundles are classified into three types accordingly as per the relative location of xylem and phloem:-
(1) Radial vascular bundle
(2) Conjoint vascular bundles
(3) Concentric vascular bundles

(1) **Radial vascular bundle:**

1.In these types of vascular bundles, xylem and phloem tissues occur at alternate radial locations in different groups.
2.This can be seen at the roots. This is the most primitive type.


CONJOINT
Collateral
Close
Open
Phloem
cambium
Xylem
Bicollateral
Outer phloem
Outer cambium
Xylem
Inner cambium
Inner phloem
Collateral
Amphivasal
Amphicribal
Xylem
Phloem
Radial
Phloem
Xylem

- (2) **Conjoint vascular bundles:**

1. In conjoint vascular bundles, the xylem and phloem tissues are present on the same radius and only opposed to each other.
2. In dicot stems, this is a common phenomenon. Conjoint vascular bundles are of two forms, depending on the number and the location of the phloem group.

- The two sub-types are:-
- (i) Collateral (ii) Bi-collateral

- (i) **Collateral type** –

1. Except for the members of Cucurbitaceae and certain members of Convolvulaceae, vascular bundles are of a very specific nature and are found in dicotyledon stems.
2. Cambium can be present or absent in between xylem and phloem patches that open or close the vascular bundle, accordingly.

- (ii) **Bi-collateral type** –

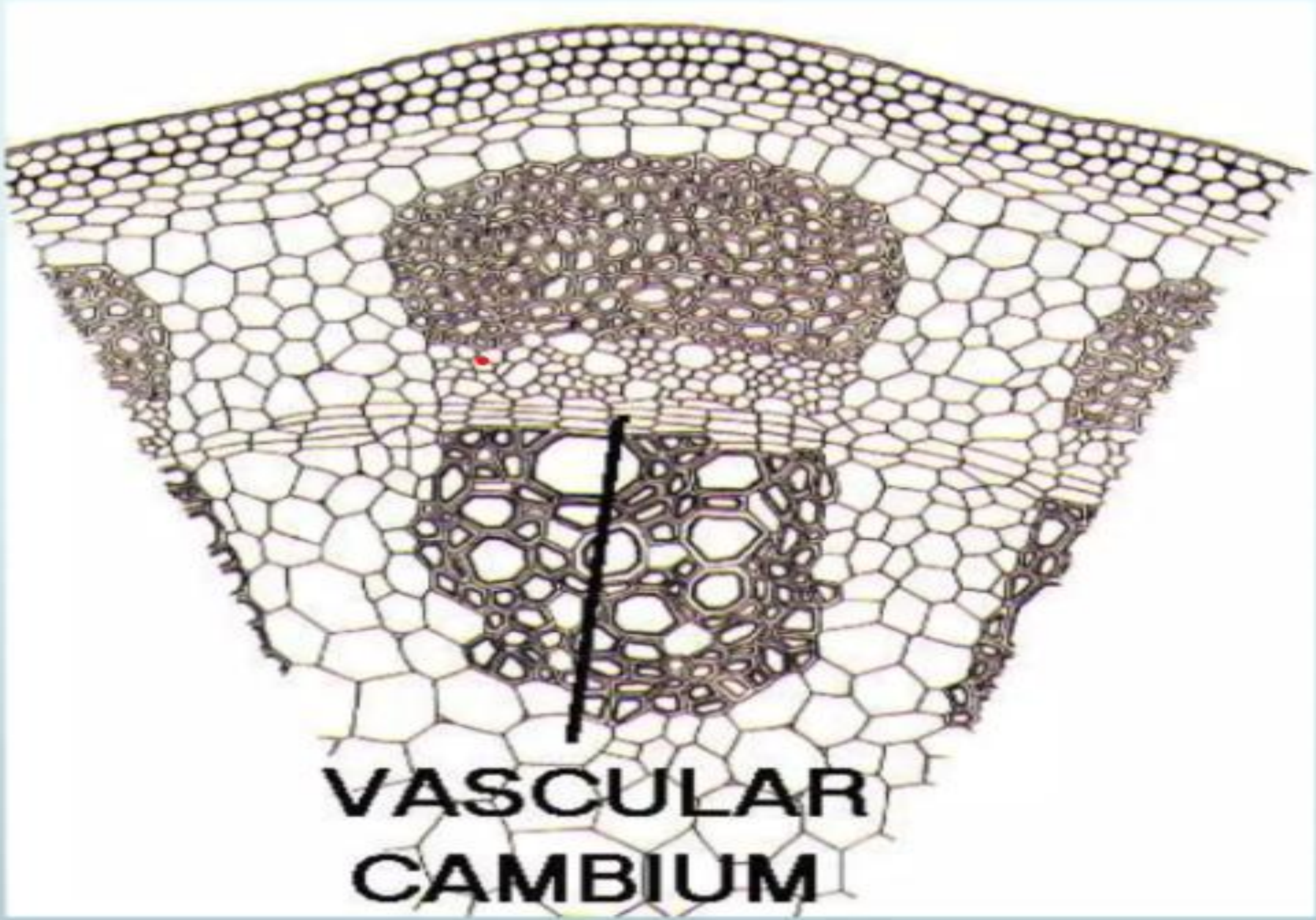
1. Vascular bundles comprise two patches of phloem in the same area on each side of the xylem.
2. The outer phloem remains to the central cylinder periphery and the inner phloem remains toward the middle.

1. Those vascular bundles consist of two patches of cambium.
2. The external cambium distinguishes the outer phloem from the xylem, whereas the internal cambium distinguishes the xylem from the internal phloem.
3. The outer cambium is concave in shape and much more active than the internal planoconcave cambium strips which are less active.

- (3) **Concentric vascular bundles**:

1. The either xylem surrounds the tissue of the phloem occasionally or vice versa.
2. Such bundles of vascular substances are called concentered vascular bundles.
3. When xylem surrounds the phloem tissue from all sides, the vascular bundle is called amphivasal vascular bundle (leptocentric type).
4. Such bundles are seen after secondary growth in monocot plants like *Dracaena*.
5. The vascular bundle is called amphicribal vascular bundle (hadrocentric type) when phloem covers the xylem tissue altogether.
6. These vascular bundles occur in pteridophytes such as *Selaginella* etc.

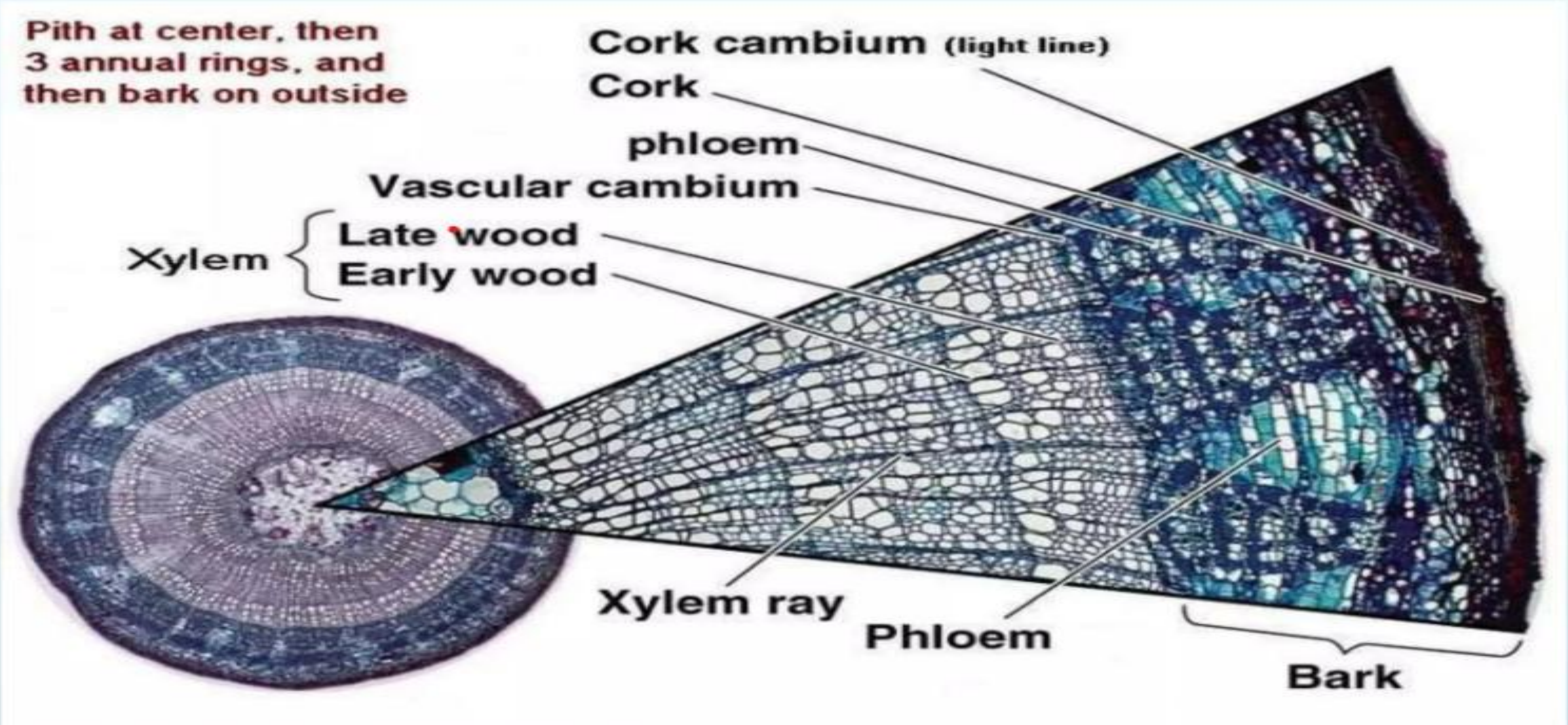
Vascular Cambium



LOCATION OF VASCULAR CAMBIUM

In Dicots:

The **vascular cambium** is in dicot stems and roots, located between the xylem and the phloem in the **stem** and root of a **vascular** plant, and is the source of both the **secondary** xylem **growth** (inwards, towards the pith) and the **secondary** phloem **growth** (outwards).


Pith at center, then
3 annual rings, and
then bark on outside
Cork cambium (light line)
Cork
phloem
Vascular cambium
Xylem
Late wood
Early wood
Xylem ray
Phloem
Bark

In Monocots:

Monocot stems, such as corn, palms and bamboos, **do** not **have a vascular cambium** and **do** not exhibit secondary growth by the production of concentric annual rings. They cannot increase in girth by adding lateral layers of cells as in conifers and woody dicots.

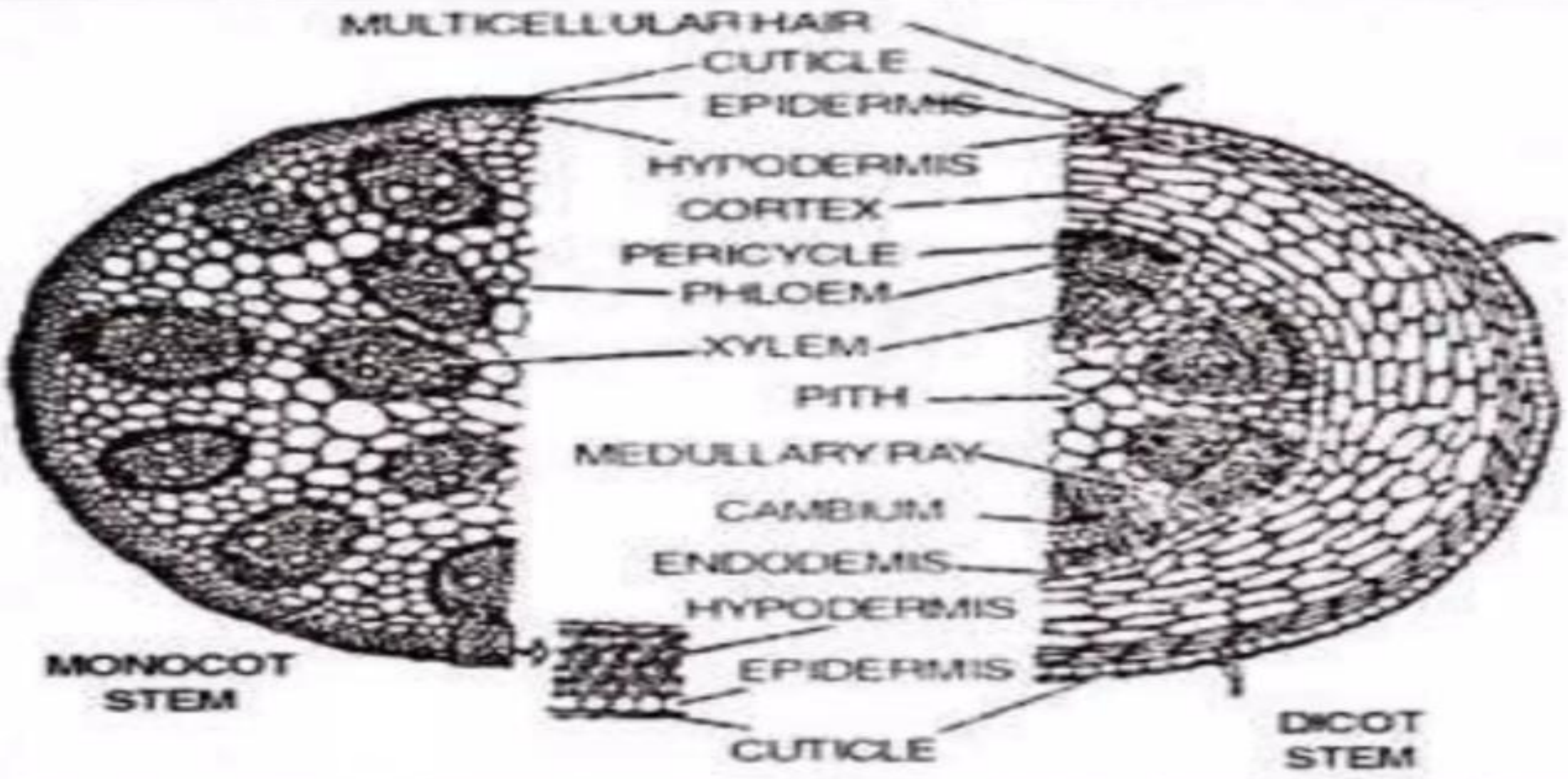
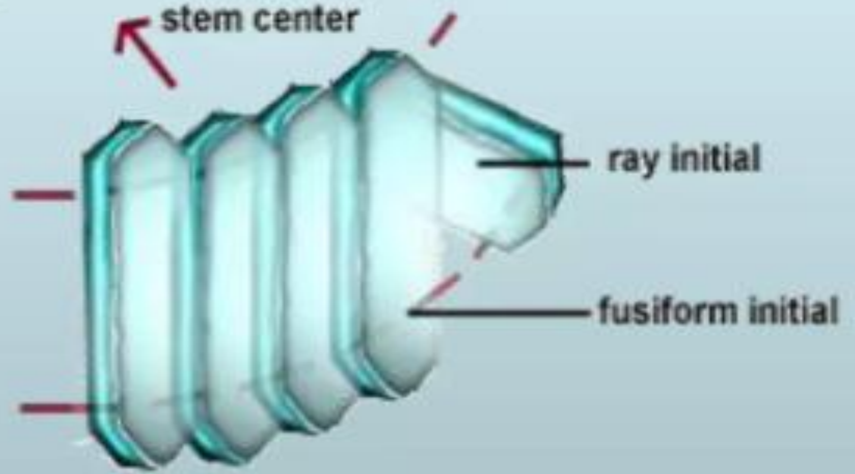


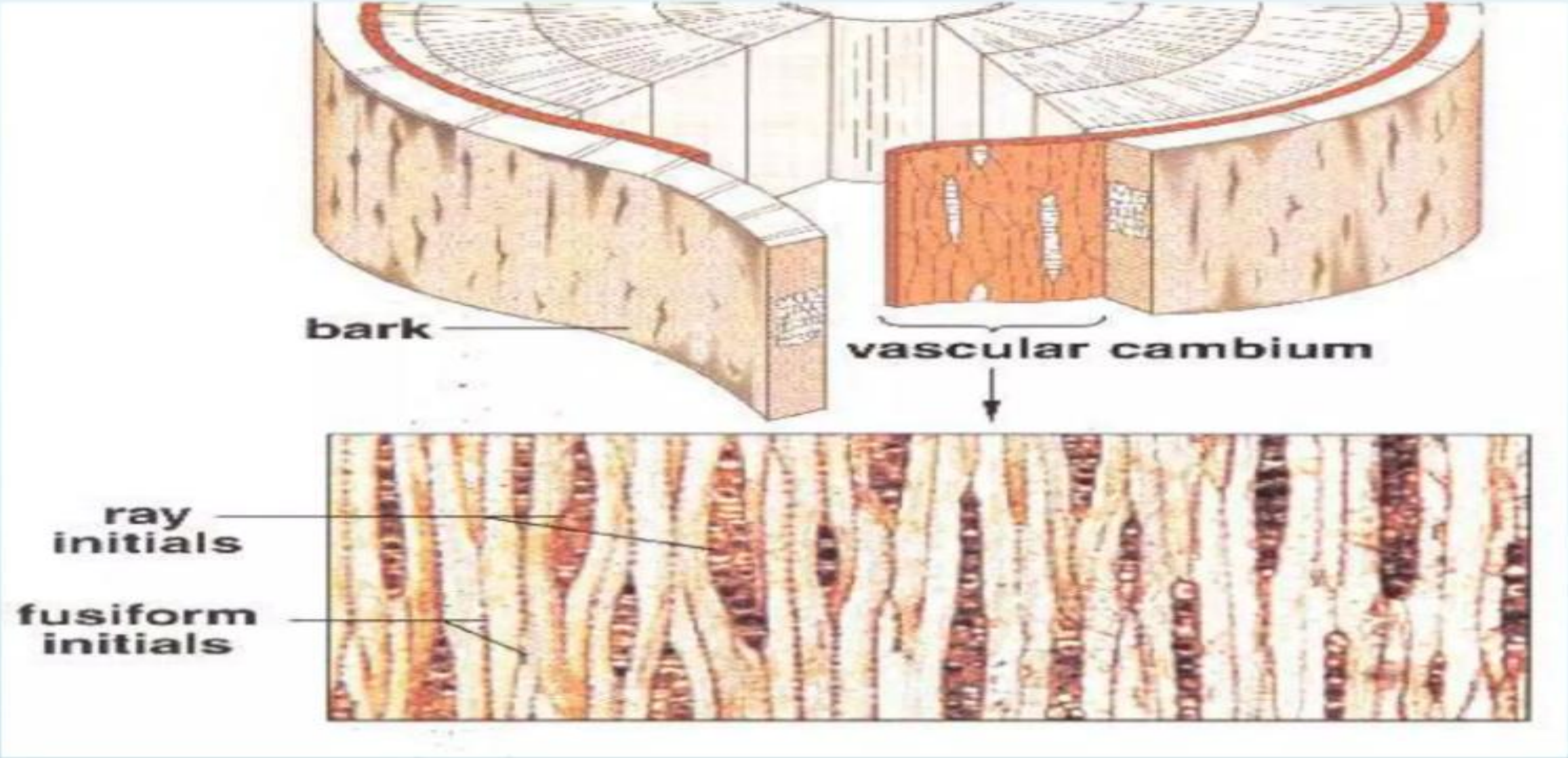
Figure 9.17 Comparison of the T.S. of monocot and dicot stem.

TYPES OF CELLS

Vascular cambium is a very thin layer that lies between the primary xylem inside and primary phloem on outside. They contain meristematic cells that can form the secondary xylem inside and secondary phloem outside. There are two kinds of meristematic cells called **fusiform initials** which are vertically elongated and **ray initials** which are horizontally elongated.



Fusiform initials & Ray initials



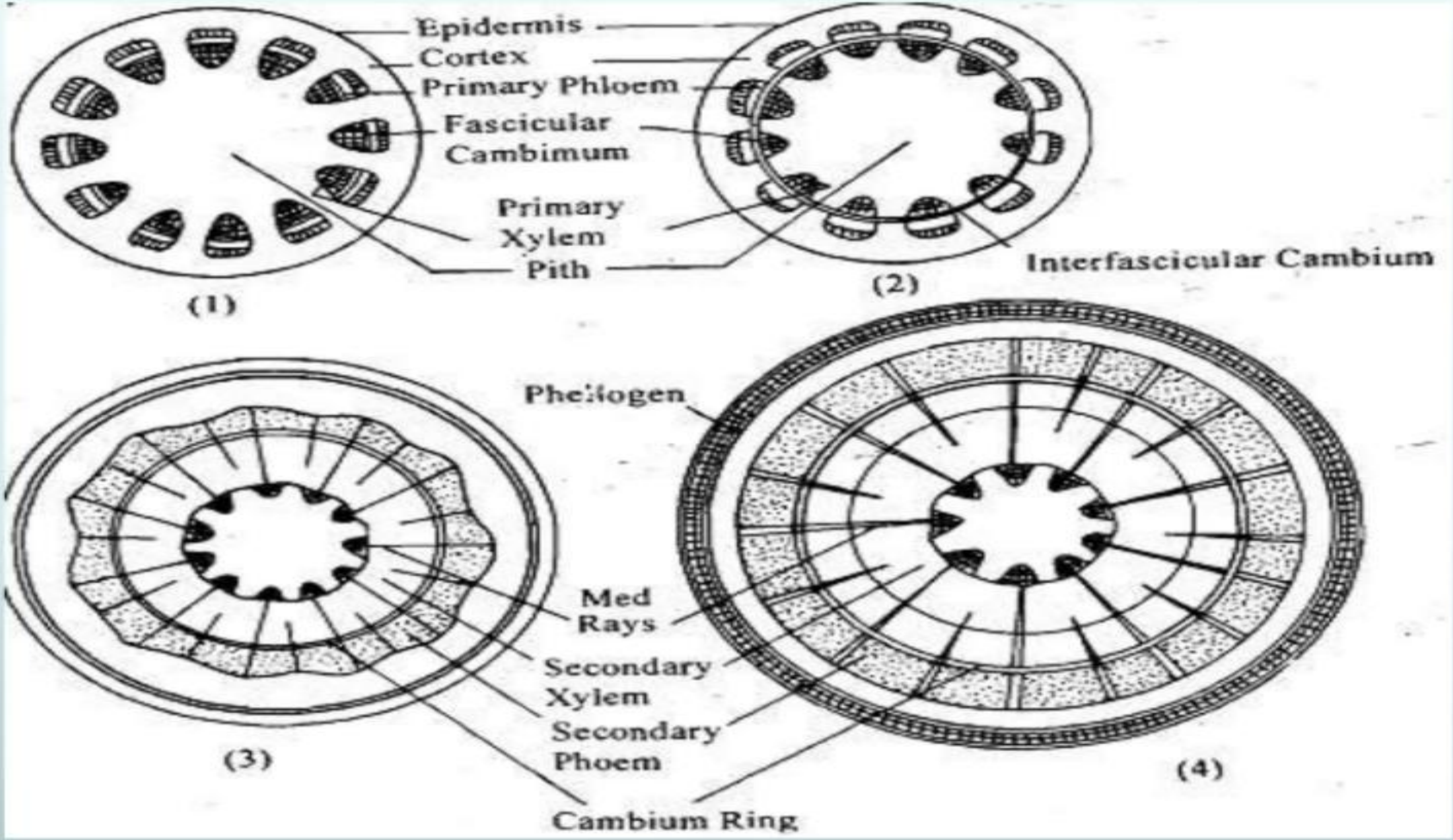
Seasonal activity of cambium

- Cambium of some plants remains active for the entire period of their life, i.e., cambial cells divide and resulting cells mature to form xylem and phloem elements.
- This type of seasonal activity usually found in the plants present in the tropical regions, and not all plants show cambial activity.
- Percentage of ringless trees in the rain forests of;
  India : 75%
  Amazon : 43%
  Malaysia : 15%

- In regions with definite seasonal climate; seasonal activity of cambium ceased with onset of unfavorable conditions; In Autumn, it enters the dormant state and lasts for the end of summer; In Spring, cambium again becomes active.
- Duration of cambial activity is also affected by day-length, e.g., In ***Robinia pseudoacacia,*** cambium is dormant under short-day condition.

SECONDARY GROWTH IN STEM

- The cambium cells formed in circular in cross section from the beginning onwards.
- The cambial ring is partially primary (fascicular cambium) and partially secondary (interfascicular cambium).
- Periderm originates from the cortical cells (extra stelar in origin).
- In Dicot stem, for mechanical support xylem is with comparatively smaller vessels, greater fibers and less parenchyma.
- More amount of cork is produces for protection.
- Lenticels on periderm are very prominent.



Epidermis
Cortex
Primary Phloem
Fascicular
Cambimum
Primary
Xylem
Pith
(1)
(2)
Interfascicular Cambium
Phellogen
Med
Rays
Secondary
Xylem
Secondary
Phoem
(3)
(4)
Cambium Ring

SECONDARY GROWTH IN ROOT

- The cambial ring formed is wavy in the beginning and later becomes circular.
- The cambium ring is completely secondary in origin.
- Periderm originates from the pericycle (intra stelar in origin).
- In Dicot root, xylem is with big thin walled vessels with few fibers and more parenchyma.
- Less amount of cork is produced as root is underground.
- Lenticels on periderm are not very prominent.

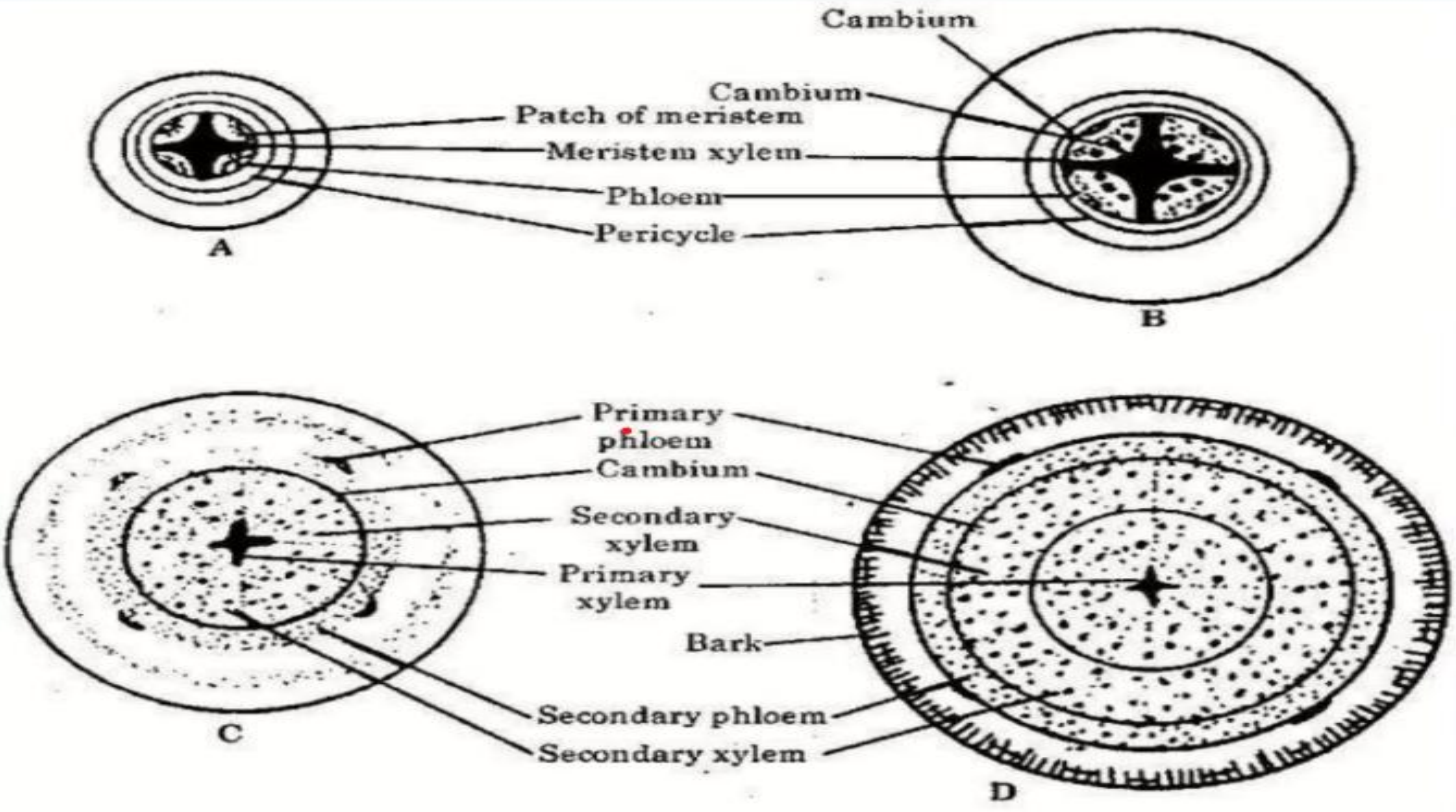


Fig. 6.9. Stages in Secondary Growth of Dicot Root (A—D).