# TISSUE

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**Tissue:**

Tissue is the group of cells of the same type or the mixed type, having a common origin and performing an identical function.

**Classification of Tissue:**

Tissues may primarily be grouped into two groups (on the basis of power of cell division)-

1. **Meristematic tissue,** and
2. **Permanent tissue**

## MERISTEMATIC TISSUE / MERISTEMS

**Meristematic tissue / Meristems:**

Meristematic tissue, commonly called 'Meristem', which consists of a group of cells which remain in a continuous state of division or they retain their power of division. They not only add the new cells to the plant body but also perpetuate themselves. That is some of the products of division in the meristems do not develop into adult cells but remain meristematic.

**The characteristic features of meristematic tissue:**

i) They are composed of immature cells which are in a state of division and growth.
ii) Usually the intercellular spaces are not found among these cells.
iii) The cells may be rounded, oval or polygonal in shape.
iv) They are always living and thin- walled.
v) Each cell possesses abundant cytoplasm and one or more nuclei in it.
vi) The vacuoles in the cell may be quite small or altogether absent.

**Classification of meristematic tissue:**

**a) Based on Origin and development –** meristematic tissues are classified into three types,

i) Promeristem or primordial meristem- It consists of a group of meristematic cells representing the earliest of **youngest stage** of a growing organ. The promeristem by cell divisions gives rise to the primary meristem. As soon as the cells begin to show tendency of differentiation, they have passed the earliest promeristematic condition.

ii) Primary meristem- The primary meristems are those that build up the primary part of the plant. They are composed of the cells, which are direct descendants of the embryonic cells and are retained meristematic nature. The chief primary meristems are the **apices** of stems, roots, leaves and similar appendages.

iii) Secondary meristem- Primary meristems gradually differentiate into permanent tissues. Sometimes some of the **permanent tissues may regain the power of division**. These tissues constitute the secondary meristems as they originate from permanent tissues. The cork cambium or phellogen is an example of secondary meristem.

**b) Based on the Position in the plant body –**

i) Apical meristem- Apical meristems occur at the **apices of the stems, roots, main and lateral of vascular plants**. Due to the activity of these meristems the organ increases in length.

ii) Intercalary meristem- These are the portions of apical meristem which are separated from the apex during the growth of the axis. They are located in **between the permanent tissues** either at the **leaf base or at the base of internode**. Such meristems are commonly found in the stems of grasses and other monocots.

iii) Lateral meristem - These meristems occur **laterally** in the **axis, parallel** to the **sides of stems and roots**. These tissues are responsible for growth in **thickness** of plant body. The **cambium and the cork cambium** are the examples of this type.

**c) Based on their function-**

i) Protoderm - The protoderm is the outermost tissue, which develops into epidermis.

ii) Procambium - The procambium develops into primary vascular tissue.

iii) Ground or fundamental meristem - The ground or fundamental meristem develops into ground tissue and pith. The cells of this region are large, thin walled, living and isodiametric.

**d) Based on the planes of division-**

i) Mass meristem - The cells of mass meristem divide in **all planes**, so that the bodies formed are either isodiametric or have no definite shapes. This type of growth found in reproductive organs during the formation of spores, sperms and endosperm and in young embryos of some plants.

ii) Plate meristem - The cells of plate divide chiefly in **two planes** so that new cells are formed but number of layers does not increase.

iii) Rib meristem/ File meristem – Rib meristem, divides anticlinally to the long axis and gives rise to longitudinal files or row of cells. Rib meristem found in developing cortex and pith.

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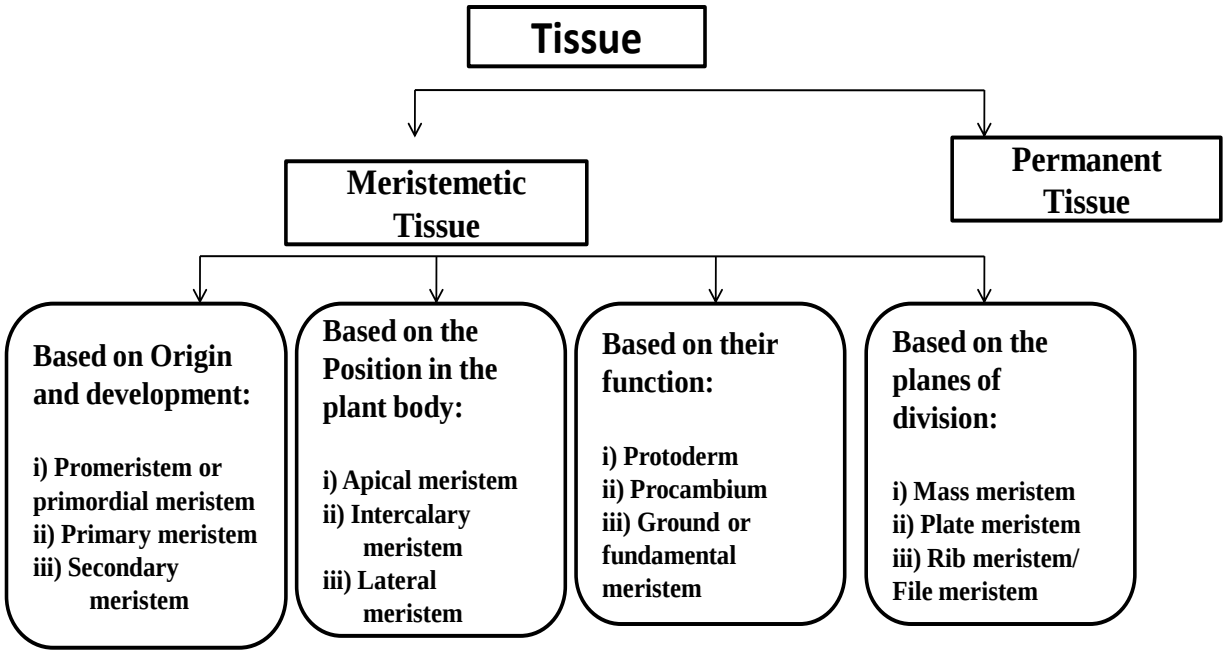
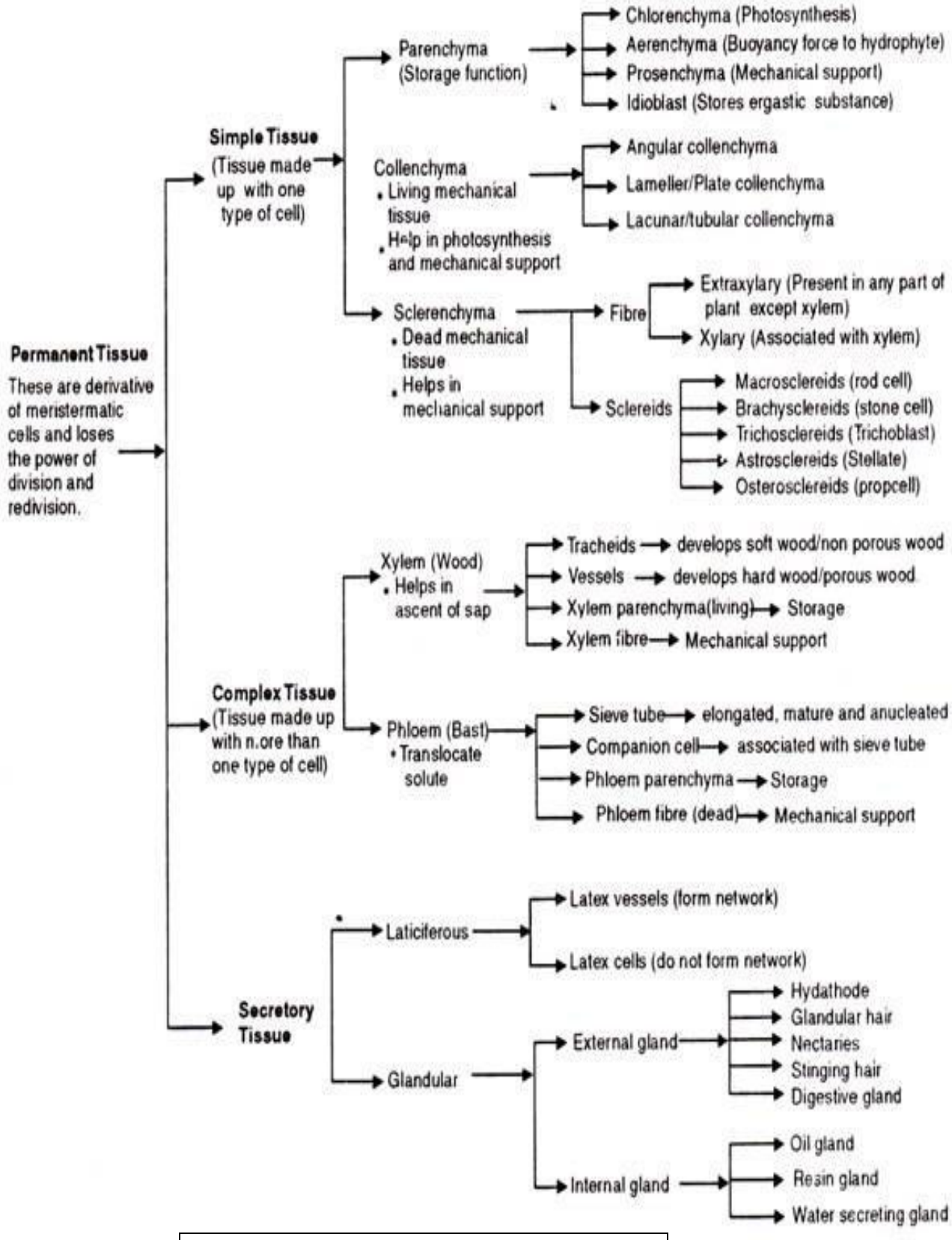



Types of Meristematic Tissue




Types of permanent tissue

# PERMANENT TISSUE

**Permanent tissue:**

Permanent tissues are composed of cells that have lost the power of dividing, having attained their definite form and size.

**Features of permanent tissues:**

- Composed of cells that have usually lost the power of dividing
- The cells of these tissues may be living or dead.
- Generally thick walled except some parenchyma.
- Vacuole usually large.
- Nucleus comparatively small.

**Types of Permanent Tissue:** Permanent tissues are of three types:

**A. Simple tissue-** composed of only one type of cells. e.g.: parenchyma, collenchyma, schlerenchyma, etc.

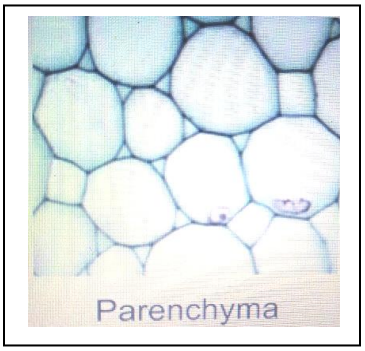
**B. Complex tissue-**composed of more than one type of cells. e.g.: xylem and phloem.

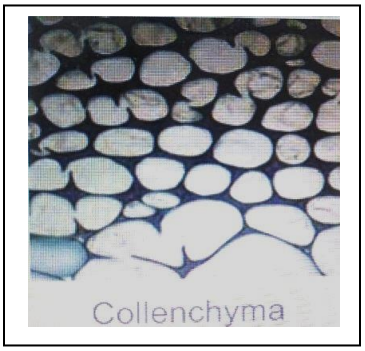
**C. Special tissue or Secretory tissue-** laticifers and gandular tissues

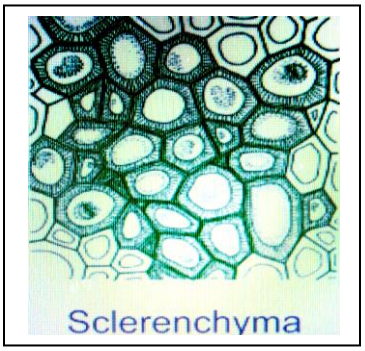
## A. Simple tissue:

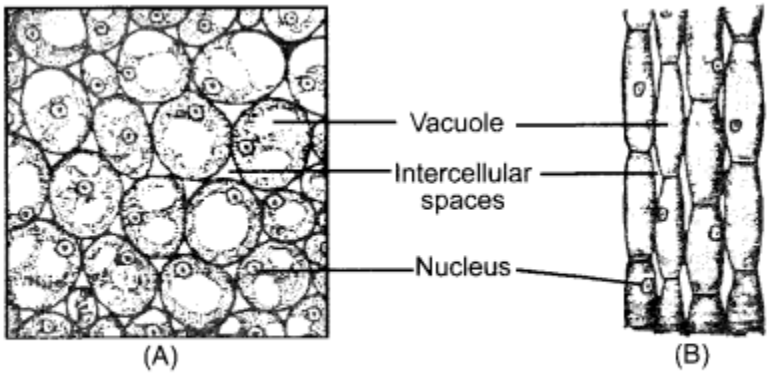
The common simple permanent tissues are -

i) Parenchyma tissue
ii) Collenchyma tissue
iii) Sclerenchyma tissue



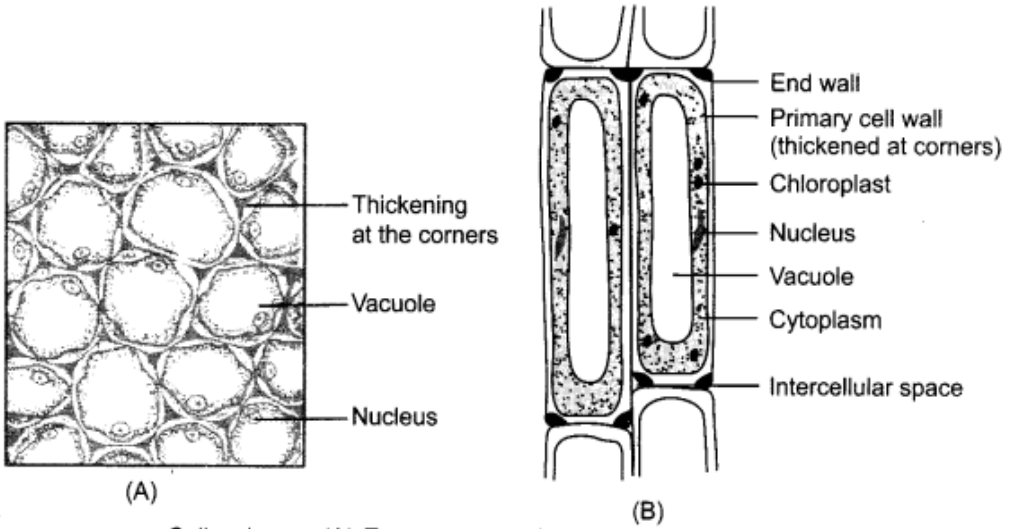





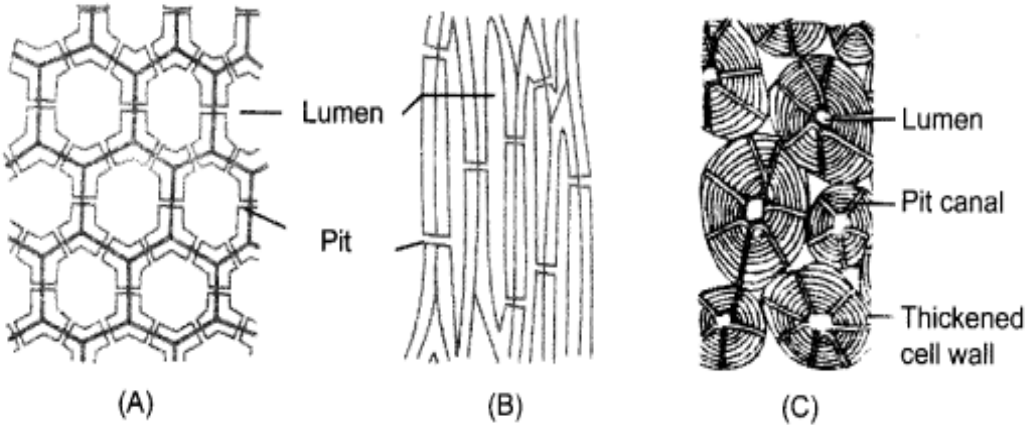

Parenchyma: (A) Transverse section and (B) Longitudinal section

**Fig. 6.1.**




Collenchyma: (A) Transverse section and (B) Longitudinal section

**Fig. 6.2.**




Sclerenchyma: (A) Transverse section, (B) Longitudinal section and (C) Sclereids (Stone cells)

**Fig. 6.3.**

**Table : Difference among parenchyma, collenchyma and sclerenchyma**

| Features | Parenchyma | Collenchyma | Sclerenchyma |
|---|---|---|---|
| 1. Cell shape | Isodiametric cells which are oval, spherical or polygonal in shape | Circular, oval or polyhedral | Variable in shape. Fibers and sclereids |
| 2. Cell wall | Thin and made up with cellulose, secondary thickening of cell wall is not found | Uneven thickening on the cell wall | Lignified secondary cell wall is present |
| 3. Cytoplasm | Abundant | Present | Absent |
| 4. Nucleus | Present (Living tissue) | Present (Living tissue) | Absent (Dead tissue) |
| 5. Vacuoles | Large vacuole | Vaculated | Absent |
| 6. Intercellular spaces | Present | Absent | Absent |
| 7. Occurrence | Basically packing tissue. Found in soft part of plant, pith, cortex, medullary rays | Dicot stem, petiole and beneath the epidermis. Absent in monocot and roots | Dicot hypodermis, bundle sheath, pericycle, seed, pulp of fruits |
| 8. Functions | Food storage, photosynthesis, air storage or others | Provide tensile strength, mechanical support, sometimes photosynthesis | Mechanical strength, protection from stress and strain |

**i) Parenchyma tissue:** It is composed of living cells which are usually isodiametric, thin walled and equally expanded cells. These cells are oval, rounded or polygonal in shape with well developed intercellular spaces. The cells have active protoplast. Pith, mesophyll of leaves, endosperm of seeds, cortex of stems and roots and other organs of plants consist mainly of parenchyma. The parenchyma cells also occur in xylem and phloem. Some parenchyma form air space known as aerenchyma. Some parenchyma perform the function of mechanical support which is known as prosenchyma.

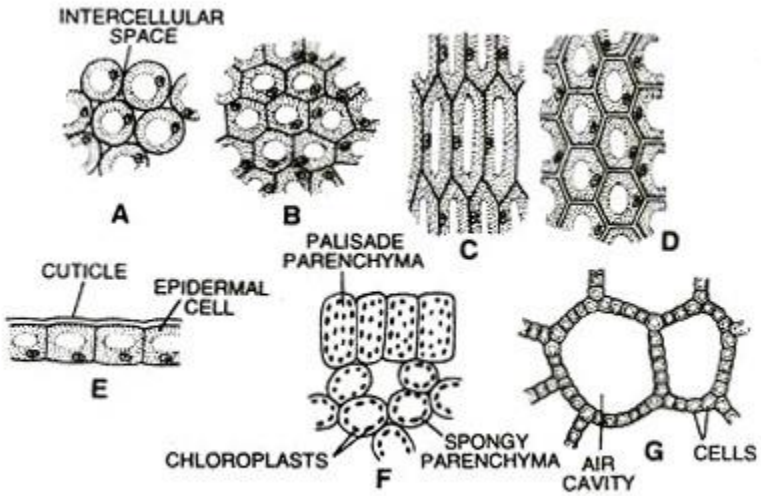



Fig. 6.7. Types of Parenchyma Cells. A–B, normal parenchyma cells; A, rounded; B, angular; C, prosenchyma; D, xylem parenchyma; E, epidermal cells; F, mesophyll; G, aerenchyma

**ii) Collenchyma tissue:**

Collenchyma is a living tissue composed of somewhat elongated cells with unevenly thickened cell wall. There are different methods of thickening, but commonly thickenings are confined to the corner of the cells. Collenchyma may be present beneath the epidermis of herbaceous dicotyledonous plant. On the basis of the thickening of cell wall and arrangement of cells, three forms of collenchyma have been found, such as –

I. **Angular collenchyma:** Thickening occurs at the junction between the cells or in the corner and cells are irregularly arranged without intercellular spaces.

II. **Tabular / Lacunate collenchyma:** When the intercellular spaces are present and thickening occurs to the wall of the bordering of the spaces.

III. **Lamellar / Plate collenchyma :** Thickening occurs at the tangential walls on the two opposite sides, resulting the cells appear like the plates/bands.

**iii) Sclerenchyma tissue:**

The Sclerenchyma consists of thick walled cells and lignified. Sclerenchyma cells do not possess living protoplasm at maturity. The walls of these cells are uniformly and strongly thickened. Its main function is to give mechanical support. Generally sclerenchyma cells are classified into two groups –

**I. Fibres:** Fibres are very much elongated cells usually with pointed ends. The wall is usually hard, uniformly thickened and lignified. Sometimes the lumen or cell cavity is reduced very much. At maturity these cells lose protoplast and become dead.

**II. Sclereids:** Sclereids are usually not much longer than they are broad. The secondary walls of the sclereids are typically lignified and vary in thickness. Commonly pits are simple and sometimes the lumens are almost filled with the deposition. At the mature stage it becomes dead.

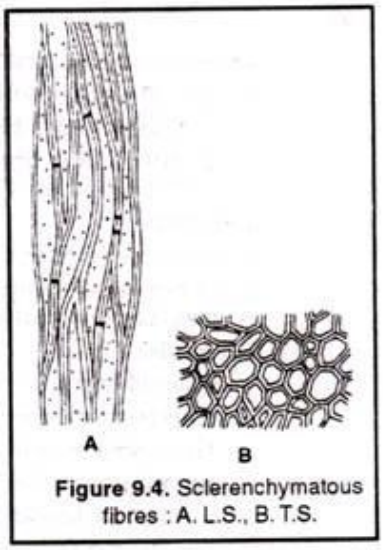



**Figure 9.4.** Sclerenchymatous fibres : A. L.S., B. T.S.

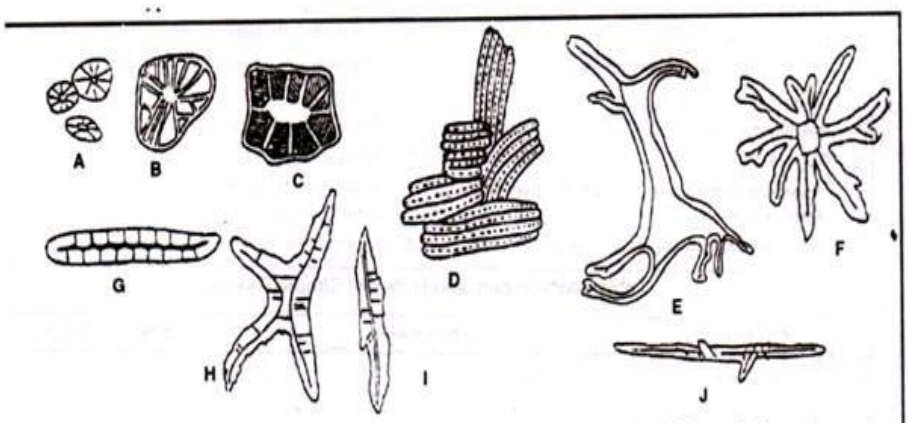



**Figure 9.5** Various types of Sclereids. A — C **Brachysclereids** ; A. B from pulp of *Pyrus* ; C. from stem cortex of *Hoya* ; D and G **Macrosclereids** or **rod-cells** from the endocarp of fruit of apple; E. **Columnar sclereid** with branched ends from *Hakea* ; F. **Astro-sclereid** ; H — I **Branched sclereid** ; J. **Filiform** sclereid from leaf of *Olea*. (After Esau).

## B. Complex tissue

They are permanent tissues which contain more than one type of cells. All the types of cells of a complex tissue work as a unit. The common complex permanent tissues are conducting tissues:

i. Xylem
ii. Phloem

**i. Xylem:**

Xylem is a complex tissue which transports water or sap inside the plant. Simultaneously, it also provides mechanical strength. Xylem is also known as **wood**. It consists of four types of cells:

a. Tracheids
b. Vessels
c. Xylem or wood parenchyma
d. Xylem or wood fibres

Out of these only **tracheids and vessels** take part in the **transport of sap**. They are hence called **tracheary elements**. **Vessels** are the **main tracheary elements of angiosperms**. They are **absent** in **gymnosperms and pteriodophytes**. In the last two groups, conduction of sap is carried out by **tracheids**. The conducting elements of the xylem have been called hadrome by Haberlandt (1914).

a. Tracheids:

The tracheids are elongated (5-6 mm dead cells with hard lignified walls, wide lumen and narrow end walls. In outline they are circular, polygonal or polyhedral. The inner walls of tracheids have various types of thickenings for mechanical strength. The un-thickened areas allow the rapid movement of water from one tracheid to another. Tracheids constitute 90-95% of wood in gymnosperms while in angiosperms they hardly form 5% of the wood.

b. Vessels:

Vessels take part, like tracheids, in the conduction of water or sap and provide mechanical support. They are much elongated tubes (3-6 metres in Eucalyptus) which are closed at either end and are formed by the union of several short, wide and thickened cells called vessel elements or members.

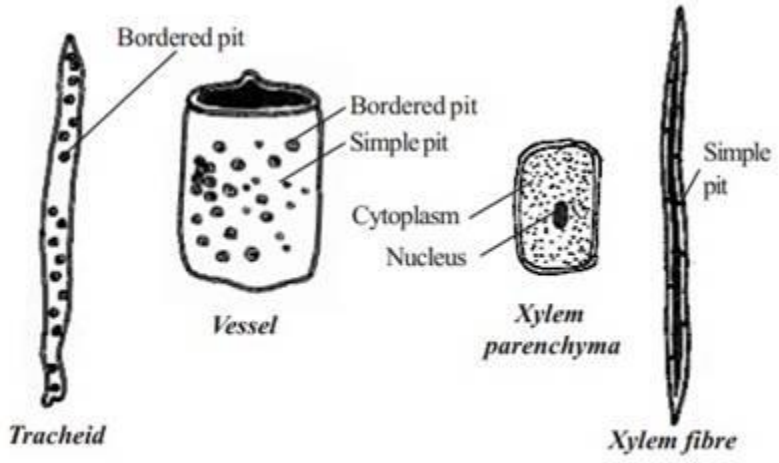



*Fig. Kinds of xylem cells*

Vessels help in quick movement of water in the plant. The walls of the xylem vessels are lignified. They are thickened variously— annular, spiral, reticulate, scalariform and pitted. The pitted condition is more common.

Vessels are absent in gymnosperms and pteridophytes with the exceptions of a few (e.g., Selaginella species, Gnetum). Their tracheary elements comprise tracheids only. Flowering plants possess both vessels and tracheids but the latter are comparatively fewer.

c. Xylem or Wood Parenchyma:

It is made of generally small thin or thick walled parenchymatous cells having simple pits. The wood parenchyma stores food (starch, fat) and sometimes tannins. It helps in the lateral conduction of water or sap. Ray parenchyma cells are specialized for this.

d. Xylem or Wood Fibres:

They are sclerenchyma fibres associated with xylem. Xylem fibres are mainly mechanical in function.

***Protoxylem and Metaxylem***:

Depending upon the time of origin in relation to the growth of the plant organ, the xylem is of two types, protoxylem and metaxylem. **Protoxylem** (Gk. protos— **first**, xylem— wood) is the **first**

**formed** xylem, where lignification begins before the completion of elongation. It is made up of **small tracheids and vessels** which possess annular or spiral thickenings.

The later formed xylem is described as **metaxylem** (Gk. meta— **after**, xylem— wood). It consists of **bigger tracheids and vessels** which have reticulate, scalariform or pitted thickenings. Lignification occurs in them after completion of elongation.

Depending upon the **position of protoxylem in relation to metaxylem**, xylem can be of four types— **exarch, mesarch, centrarch and endarch.**
**Exarch:** Protoxylem is found toward the outside and metaxylem toward the inside.
**Endarch:** Protoxylem is found toward the inside and metaxylem toward the outside.
**Centrarch:** In centrarch development there is one vascular strand and the protoxylem is located in the center surrounded by the metaxylem.
**Mesarch:** In mesarch development, there are several vascular strands and in each of these protoxylem is located in the center surrounded by the metaxylem.

**ii. Phloem:**
It is a complex tissue which transports organic food inside the body of the plant. Phloem is also called bast. It consists of four types of cells, viz., sieve tubes, companion cells, phloem parenchyma and fibres.

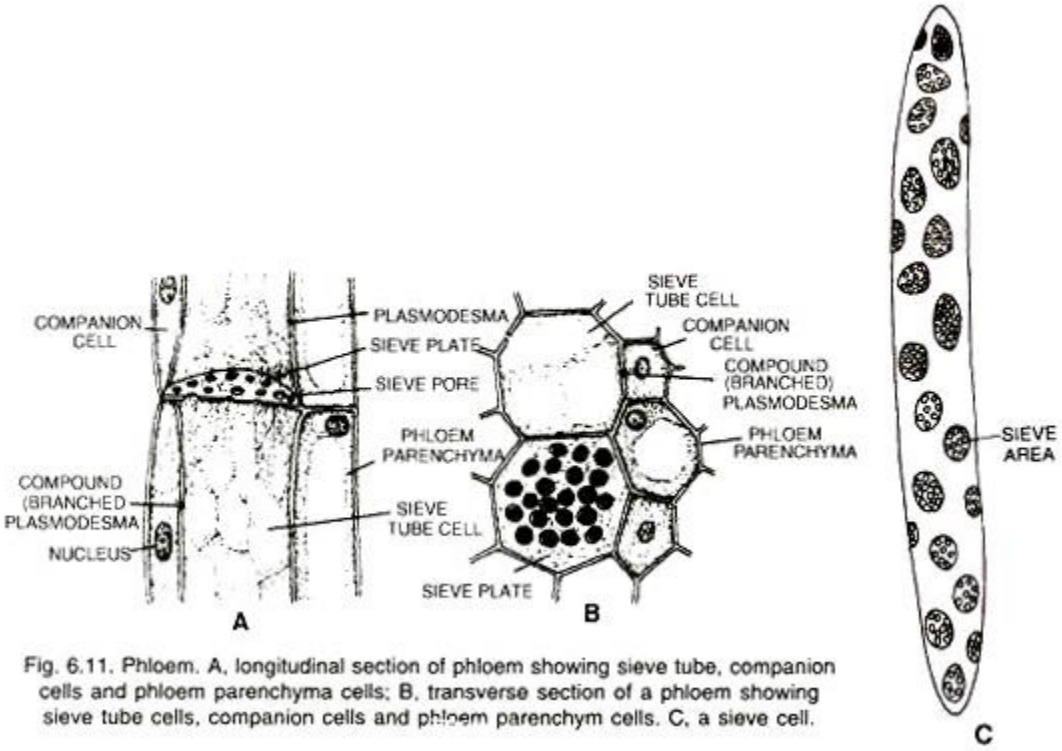



Fig. 6.11. Phloem. A, longitudinal section of phloem showing sieve tube, companion cells and phloem parenchyma cells; B, transverse section of a phloem showing sieve tube cells, companion cells and phloem parenchym cells. C, a sieve cell.

a. Sieve Tubes:
**Sieve tubes** are **elongated tubular conducting channels of phloem**. Each sieve tube is formed of several cells called sieve tube elements or members, sieve tube cells or sieve elements. Sieve tube members/cells are placed end to end. They have many small pores or sieve pits between two cells. Due

to the presence of sieve pits the end walls are commonly called sieve plates. Internally a sieve tube member or cell has peripheral layer of cytoplasm **without any nucleus** in mature cell. Sieve tube takes part in the conduction of organic food.

b. Companion Cells:
Companion cells are narrow, elongated and thin walled living cells. They lie on the sides of the sieve tubes and are closely associated with them through compound plasmodesmata. The cells have dense cytoplasm and a prominent nucleus. It is supposed that the nuclei of the companion cells control the activities of the sieve tube through plasmodesmata. Companion cells also help in maintaining a proper pressure gradient in the sieve tube elements.

c. Phloem Parenchyma:
They are ordinary living elongated parenchyma cells having abundant plasmodesmata. They store food, resins, latex, mucilage, etc. The cells help in slow conduction of food, especially to the sides. Phloem parenchyma is absent in most of the monocots and some herbaceous dicots.

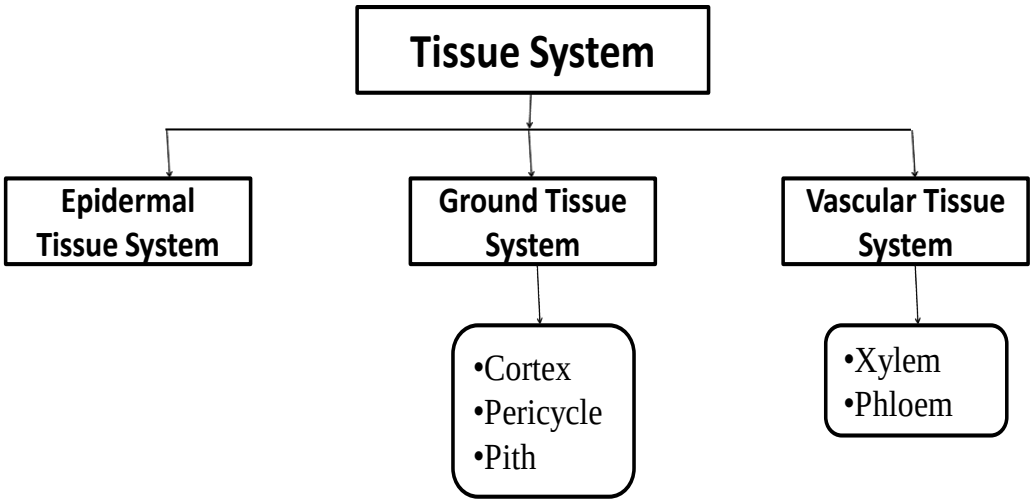
d. Phloem or Bast Fibres:
Sclerenchyma fibres found in the phloem are called phloem or bast fibres. They are generally absent in primary phloem but are quite common in secondary phloem where they occur more abundant in secondary phloem as compared to primary phloem. The fibres occur in sheets or cylinders. Phloem fibres provide mechanical strength. The textile fibres of flax, (Linum usitatissimum), hemp (Cannabis) and jute (Corchorus species) are phloem fibres.

***Protophloem and Metaphloem:***
**Protophloem is the first formed** part of phloem which develops in parts that are undergoing enlargement. It consists of **narrow enucleate sieve elements** which may occur singly or in groups amongst cells that often grow later into fibres. Companion cells may or may not be associated with protophloem. During elongation the protophloem elements (sieve elements) get stretched and become non-functional.
**Metaphloem** is part of primary phloem that differentiates in plant organs after they have stopped enlargement. The sieve elements are **wider and longer**. Companion cells are regularly associated. Fibres are absent but parenchyma cells may later become sclerified.

# TISSUE SYSTEM IN PLANTS

All the different type of tissues in a plant that perform similar basic function, irrespective of their location is known as Tissue system. **Sachs (1875) recognized three types of tissue system in plants:**

1. Epidermal or Dermal Tissue System
2. Cortical or Fundamental or Ground Tissue System
3. Vascular Tissue System




# 1. Epidermal or Dermal Tissue System:

It forms the outer protective covering of the plant body. During primary growth the covering of plant body is known as epidermis (in root it is known as epiblema) but in secondary growth the epidermis may be replaced by periderm.

**Epidermis:**

i. It is the outermost, usually one cell thick continuous layer without intercellular spaces, but in leaf it is interrupted by tiny pores, known as **stomata**.

ii. Epidermis can be multilayered in some cases. e.g.: Multilayered epidermis of some xerophytes (plants of desert area).

iii. The walls of epidemis are unevenly thick and inner radial walls are thick. The additional thickening of epidermal cell is due to deposition of **cutin and suberin**.

iv. It is heavily circularized (Cuticle is thick in **xerophytes**/desert plants. It is formed by waxy deposition, secreted by epidermal cells) with frequent interruption of pores known as stomata. It helps in gas exchange as well as transpiration.

iv. Outer most layer of root is known as **epiblema** or piliferous layer or rhizodermis. It is **devoid/absence of lenticel** and **stomata**. **Unicellular root** hair develops from epiblema.

v. Stem or leaf epidermis in some plants may contain hairs which are unicellular or multicellular.

vi. In some cases, stomata of leaf are covered by numerous hairs which hide stomata from direct contact of air and this reduce transpiration water loss.

vii. Epidermal cells contain **leucoplast, chromoplast (chloroplast or chromatoplast) and anthocyanin**.

viii. Leaf is protected by **upper and lower epidermis**.

ix. Epidermis can contain gland having differential purposes in different plants.

x. Bulliform cells or motor cells are large, bubble-shaped epidermal cells that occur in groups on the upper surface of the leaves of many monocots/grass type plants. Bulliform cells have the capacity to uptake and release water rapidly. These cells are supposed to regulate folding and unfolding of leaf tissue to control light intensity and reduce overall water loss.

**Function of Epidermal Tissue System:**

i. It is mainly an outer **protective covering** of underlying soft tissue.

ii. It prevents **excessive evaporation of water** from internal tissue, due to presence of cuticle, wax, or trichomes (stem hairs).

iii. Upper epidermis of monocot leaf carries large, thin walled, vaculated, living motor or bulliform cell. It helps in rolling of leaf to reduce the rate of transpiration.

iv. It also protects the plant against the attack of herbivorous animals.

v. Acts as a storehouse of water as in desert plants.

vi. It also has some minor functions such as photosynthesis, secretion etc.

# 2. Cortical or Fundamental or Ground Tissue System:

Ground tissue system consists all the tissues which are present **inside the epidermis except vascular or complex tissue**. It forms the main bulk of the plant body and it extends from below the epidermis to the central core of a plant. It includes hypodermis, cortex, endodermis, pericycle and pith.

1. In **dicot stem**, cortex is differentiated into three parts i.e., **hypodermis** (Collenchymatous), **middle cortex** (thin walled parenchymatous) and **endodermis**. In young dicot stem endodermis is known as starch sheath because it contains mucilage, tannin and high amount of starch.

2. In **monocot stem**, cortex is differentiated into two parts: **Hypodermis** (Sclerenchymatous) and **inner cortex**. Endodermis is absent.
3. **Ground tissue** of leaf is known as **mesophyll tissue**. It is enclosed by upper and lower epidermis. It is undifferentiated in monocot leaf but differentiated into **pallisade parenchyma and spongy parenchyma** in dicot leaf.
4. **Endodermis of root** present opposite to phloem tissue becomes thick due to more deposition of suberin and less lignin known as **Casparian Strip** or Bands. It was first observed by Caspary (1865). This band checks the flow of water towards phloem. The thin walled cells in endodermis of root present opposite to **protoxylem are known as passage cells or transfusion cells**. They help in translocation of water from cortex to xylem. Endodermis of young stem lacks casparian strips and passage cells. But bears starch grains. So, often called as starch sheath.
5. **Pericycle** is composed of thin walled, **parenchymatous** or sometimes thick-walled **sclerenchymatous cells** (e.g., Cucurbita); ranging in width from single layer of cells to a few layers. In some stems, e.g., Sunflower, the pericycle is composed of alternating bands of thin- walled and thick-walled cells (heterogenous pericycle). Parenchymatous pericycle stores food but mechanical support to the plant is given by thick walled pericycle. In angiosperms, **lateral root** originates from pericycle.
6**. Pith or Medulla** forms the central core of the stem and the root. It is made up of large, thin- walled, **parenchyma** with inter cellular spaces. It is well developed in dicot stem and monocot root. It is absent in monocot stem and feebly developed in dicot root. It helps in storage of food.

# 3. Vascular Tissue System:

Vascular tissue system is associated with conduction of water, minerals and food materials. This system includes the vascular bundles (group of xylem and phloem). These are located inside the stele in all vascular bundles. (Fig.).

**There are three types of vascul bundles mainly. Such as:**

A. Radial Vascular Bundles
B. Conjoint Vascular Bundles
C. Concentric Vascular Bundles

These can be grouped into different other types as follows.

**A. Radial Vascular Bundles:**

Xylem and phloem occur in separate patches on alternate radii. Radial vascular bundles are the characteristic of all types of root. 11 dicot root xylem patch is 2 – 6 (Diarch to hexarch). In monocot root xylem patch is 7 or more (polyarch).

**B. Conjoint Vascular Bundles:**

Xylem and phloem are associated with each other and together form a bundle. They are present on the same radius. These are usually found in stem.

**It is of two types:**

**(a) Collateral:**

In this type of vascular bundle, xylem is located towards the inner side and phloem towards the outer periphery of xylem.

i**) Collateral-open:** In dicot stem cambium is present between xylem and phloem; such vascular bundles are called open. Cambium is responsible for secondary growth or thickening/increase in diameter of plant.

**ii) Collateral-closed:** In monocotstems, the cambium is absent; such vascular bundles are called closed.

**(b) Bicollateral:**

In these vascular bundles, there are two patches of phloem, one on each side of xylem. Here, there are two strips of cambium one on each side of xylem. Thus the arrangement is outer phloem →outer cambium → xylem → inner cambium and inner phleom, e.g., cucurbitaceae, some members of Solanaceae and Convolvulaceae etc.

**C. Concentric Vascular Bundles:**

In this vascular bundle either xylem surrounds the phloem or phloem surrounds the xylem. **Concentric vascular bundles are of two types:**

**(a) Amphicribral (hadrocentric):**

The xylem is in the centre surrounded on all sides by phloem e.g., Ferns, aquatic angiosperms and the staminal bundles of many dicots (e.g., Prunus).

**(b) Amphivasal (leptocentric):**

The xylem completely surrounds the phloem e.g., Dracaena, Yucca.

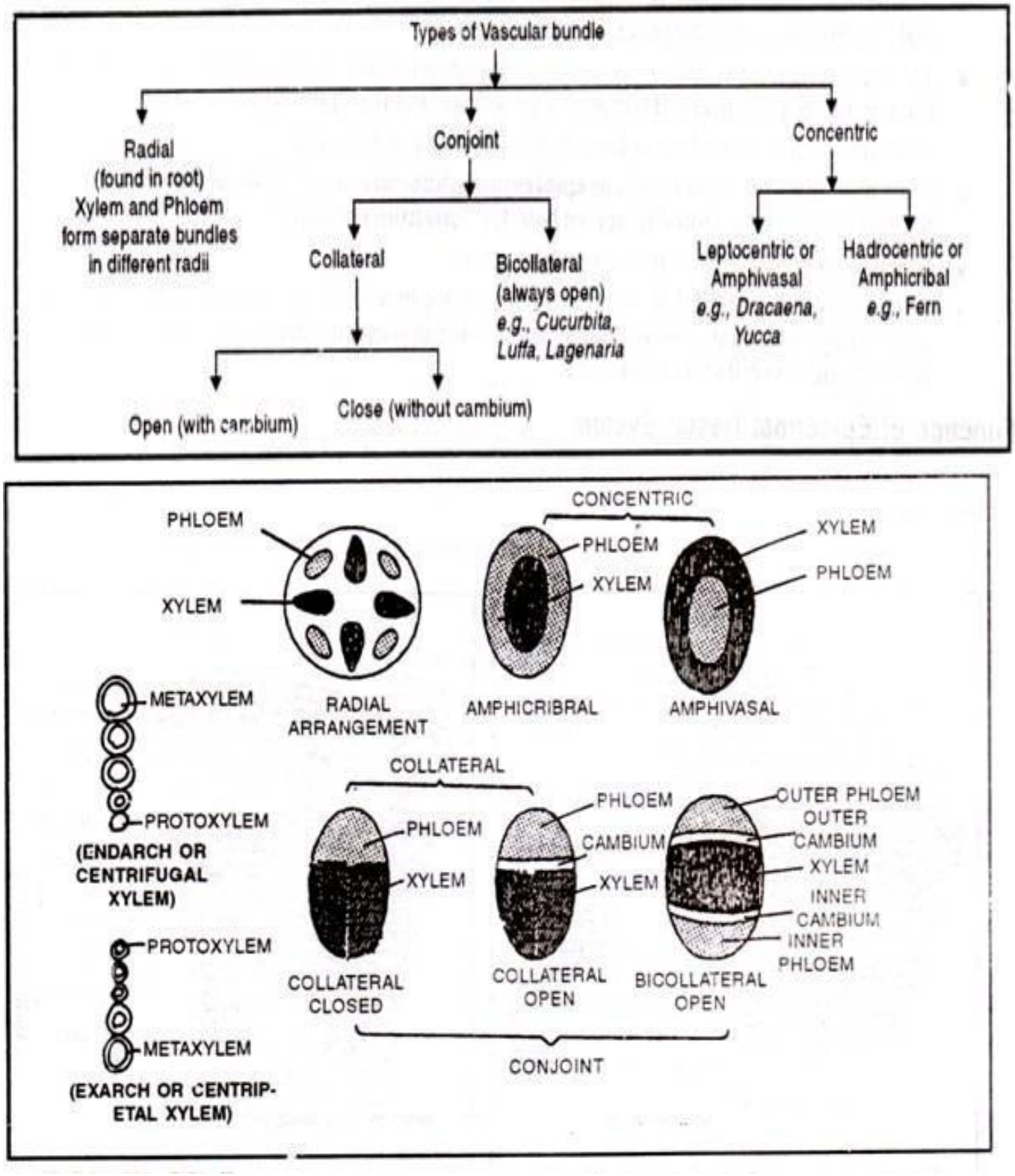
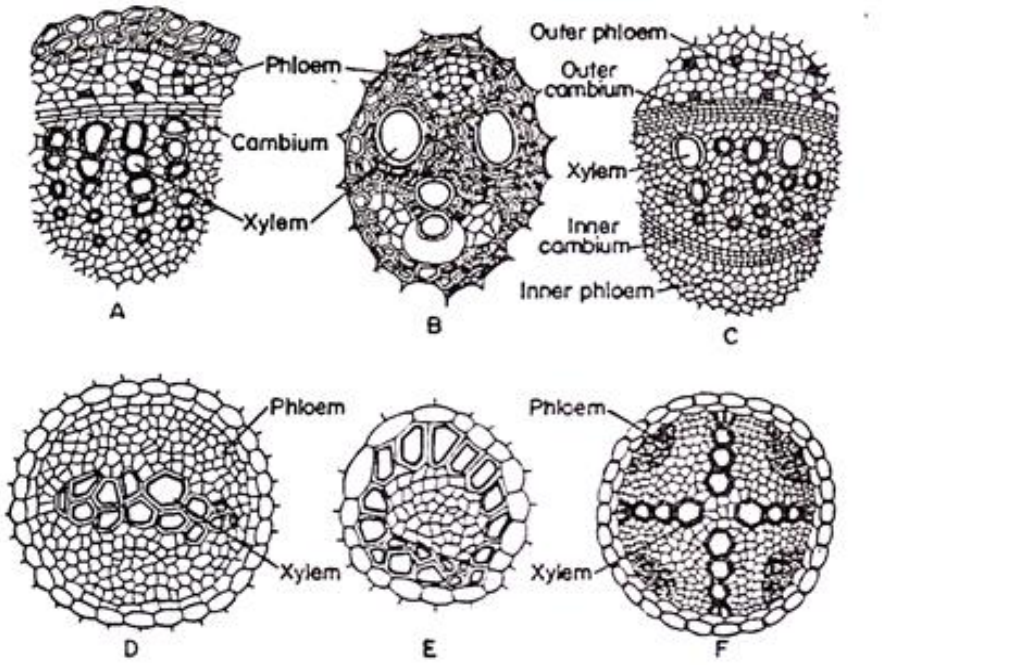



Fig: Different types of vascular bundle




Types of Vascular Bundles : (A) Collateral open type in *Helianthus;* (B) Collateral close type in *Zea*; (C) Bicollateral open type in *Cucurbita*; (D) Concentricamphicaribal in *Pteris*; (E) Concentricamphivesal in *Dracena* and (F) Radial in *Cicer*

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