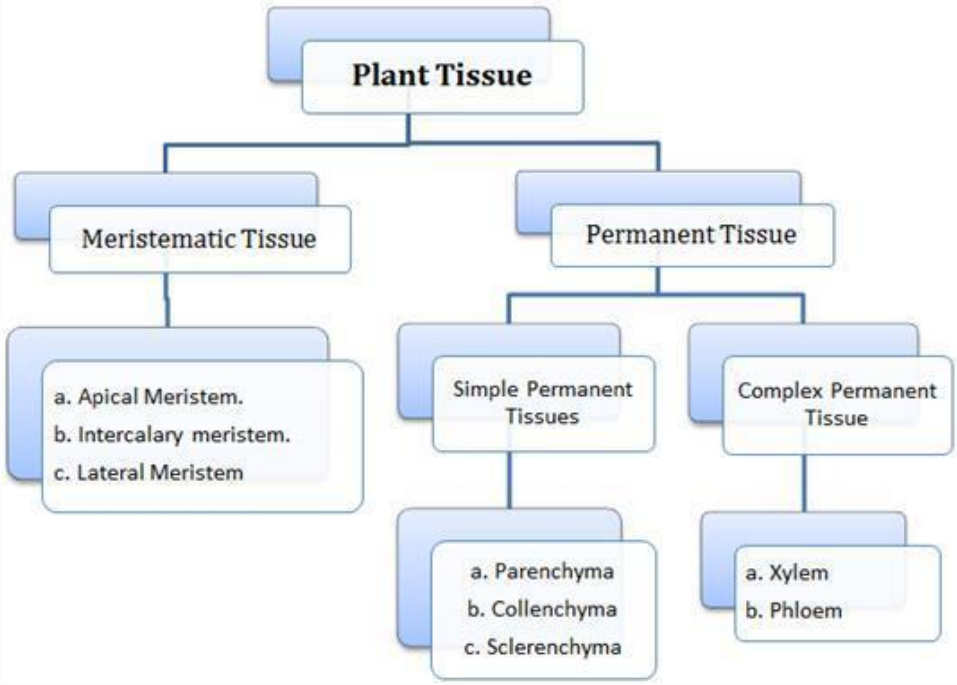
CHAPTER-06

ANATOMY OF THE FLOWERING PLANTS

Anatomy is the study of the internal structure of an organism. The study of plant anatomy includes histology- the study of organization and structure of tissues. Anatomy helps in knowing the structural peculiarities of a different group of plants and indicates the structural adaptation to diverse environments.

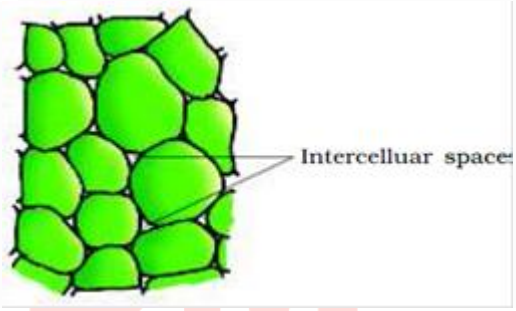
The tissue

A group of cells having a common origin and usually performing common functions is called tissues.

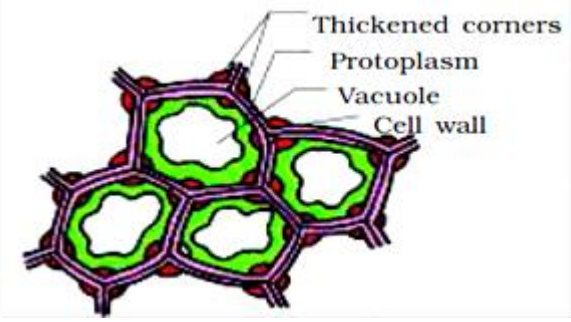


- Meristematic tissue is a simple tissue composed of a group of similar and immature cells that can divide and form new cells. The meristem which occurs at the tips of roots and shoots are called **apical meristem**.
- **An intercalary meristem** occurs between mature tissues, especially in grasses. Both apical meristems and intercalary meristems are primary meristems because they appear early in the life of a plant and help to form the primary plant body.

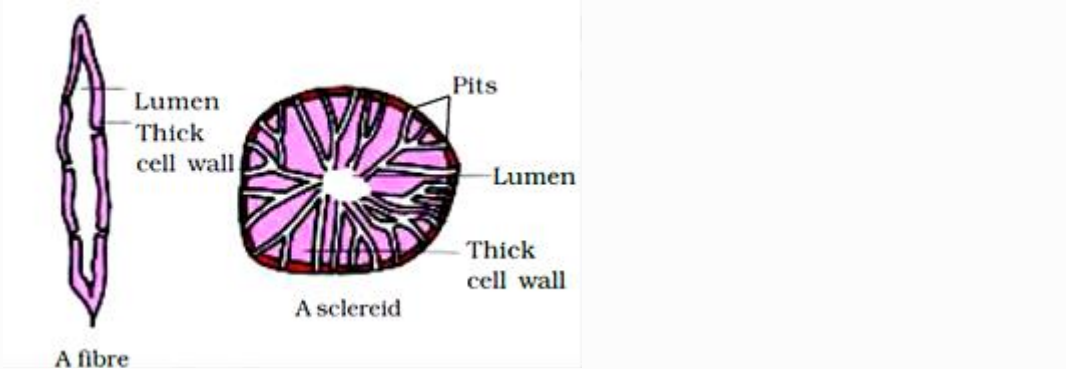
- The meristem which occurs on the sides and takes part in increasing girth of the plants is called **Lateral meristem**. Intrafascicular cambium in the primary lateral meristem. Vascular cambium, cork cambium are secondary meristem.
- The cells that have become structurally and functionally specialized and lose the ability to divide are called permanent tissue. Permanent tissues having all cells similar in structure and function are called **simple permanent tissues** and those having different kinds of cells are called **complex tissue**.
- **Parenchyma** is a simple permanent living tissue that is made up of thin-walled isodiametric cells. Each cell encloses a large central vacuole and peripheral cytoplasm containing the nucleus. They are found in non-woody and soft areas of stem, root, leaves, fruits, and flowers. They store the food and provide turgidity to softer parts of the plant.



- **Collenchyma** consists of cells that are much thickened at the corner due to cellulose, hemicellulose, and pectin. Oval, spherical or polygonal often contains chlorophyll. They provide mechanical support to the growing parts of the plants like the young stem.



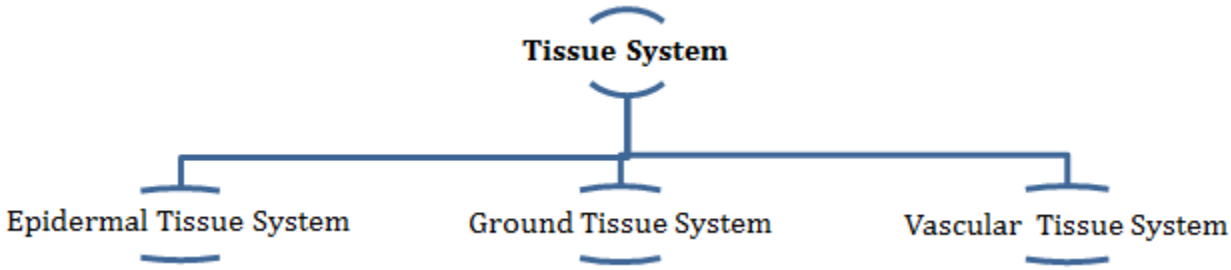
- **Sclerenchymas are** supportive tissue having highly thick-walled cells with little or no protoplasm due to the deposition of cellulose or lignin. They are of two types: fibres and sclereids. They provide mechanical support to mature plant organs to tolerate bending, shearing, compression, etc.



Complex Tissues– Xylem and phloem constitute the complex tissues in plants and work together as a unit.

Xylem	Phloem
1. It conducts water or sap. 2. Xylem is found deep in the plant. 3. Xylem provides mechanical strength. 4. is made up of vessels, tracheid, xylem fibre, and xylem parenchyma.	1. Phloem conducts organic food. 2. It is situated towards the outer side. 3. It has no mechanical functions. 4. Phloem is made up of a sieve tube, companion cells, phloem parenchyma, and phloem fibres.

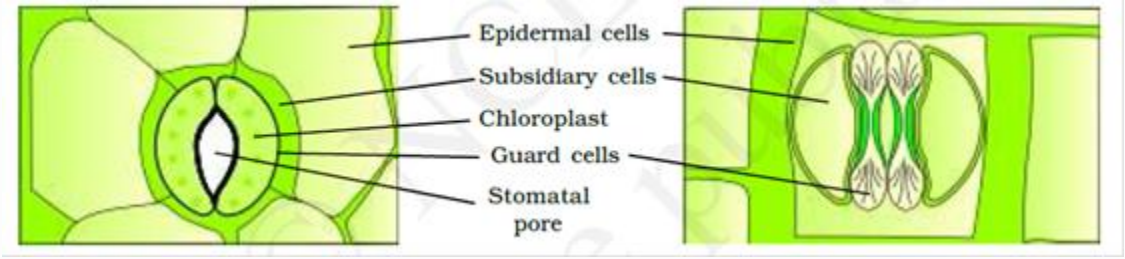
- Primary xylem is of two types- protoxylem and metaxylem. In the stem, the protoxylem lies in the center and the metaxylem towards the periphery. This type of primary xylem is called **endarch**.
- In roots, the protoxylem lies in the periphery and the metaxylem lies towards the center. This type of primary xylem is called an **exarch**.
- In gymnosperms, albuminous cells and sieve cells lack sieve tubes and companion cells.



Epidermal Tissue System

- It forms the outermost covering of the whole plant body, which consists of epidermal cells, stomata, epidermal appendages (trichomes and hairs).

- The epidermis is single-layered, parenchymatous with waxy thick layers of the cuticle to prevent water loss.
- Stomata is present in the epidermis of leaves. It regulates the transpiration and gaseous exchange. In dicots, stomata are bean-shaped having two guard cells closing the stomatal pore. In monocots, the stoma is dumbbell-shaped. Guard cells contain chloroplasts and help in the opening and closing of stomata.
- Guard cells are surrounded by subsidiary cells. The stomatal aperture, guard cells, and the surrounding subsidiary cells are together called **stomatal apparatus**



Dicots (Bean shaped) Monocots (Dumb-bell shaped)

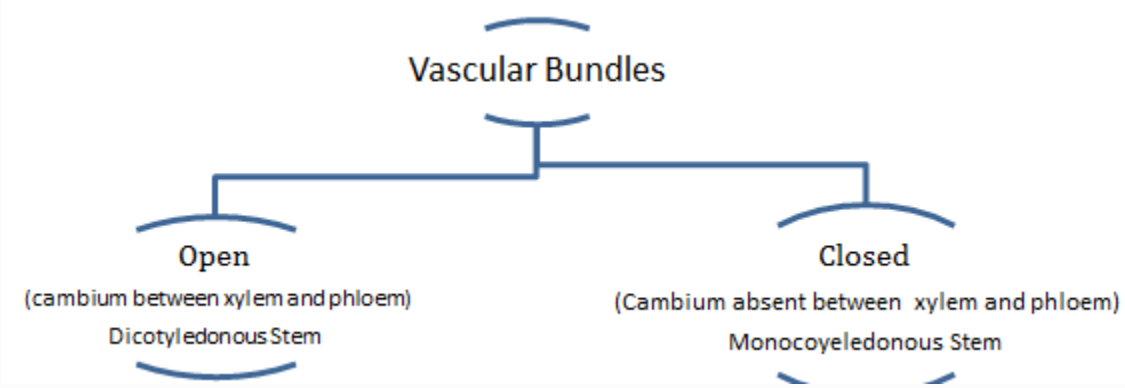
- Epidermis also contains some hairs. Root hairs are a unicellular elongation of epidermal cells. Trichomes are present on stems, which are multicellular, branched, or un-branched preventing water loss due to transpiration.

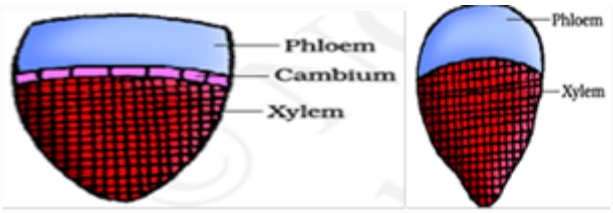
The ground Tissue System

- All the tissue between the epidermis and vascular bundle forms the ground tissues. It consists of simple permanent tissues. Parenchyma is present in pericycle, cortex, pith, and medullary rays in stem and roots.
- In leaves, the mesophyll, chloroplast containing cell, forms the ground tissues.

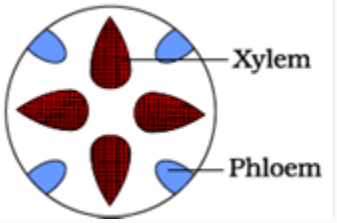
The Vascular Tissue System

- The vascular system consists of complex tissues, xylem, and phloem that together form vascular bundles.





- When xylem and phloem within a vascular bundle are arranged alternately on different radii, the arrangement is called **radial** as in roots. When xylem and phloem are situated at the same radius of the vascular bundle, it is called **conjoint** as in stem and leaves.



The radial arrangement of vascular bundle

Dicotyledonous Root

- The outermost layer of the dicot root is the **epidermis** containing unicellular root hairs.
- The **cortex** consists of several layers of thin-walled parenchyma cells.
- The innermost layer of the cortex is called **endodermis** having waxy material suberin as **Casparian strips**, which is impermeable to water.

Monocotyledonous Root

- The anatomy of the monocot root is similar to the dicot root in many respects. It has an epidermis, cortex, endodermis, pericycle, vascular bundles, and pith. As compared to the dicot root which has fewer xylem bundles

Dicotyledonous Stem

- Epidermis: is covered with a thin layer of cuticle and may have Trichomes and stomata.
- Cortex: The cortex is made up of the multiple layers of cells including hypodermis, the middle layer of parenchyma cells, and an innermost layer called endodermis.
- Endodermis cells are rich in starch grains and are called the starch sheath. The pericycle is present on the inner side of the endodermis. Layers of radially placed parenchyma between the vascular bundles are called medullary rays.

- A large number of vascular bundles are arranged in a ring. Each vascular bundle is conjoint, open. Protoxylem is endarch

Monocotyledonous Stem

- The hypodermis is made up of sclerenchyma. Vascular bundles are conjoint, closed, and scattered. Each vascular bundle is surrounded by a sclerenchymatous bundle sheath.
- Phloem parenchyma is absent. Water-containing cavities are present within the vascular bundles.

Dorsiventral (Dicotyledonous) Leaf

- The leaf lamina of a dorsiventral leaf has 3 parts: epidermis, mesophyll, and vascular system.
- The upper epidermis is called the adaxial epidermis and the lower one is called the abaxial epidermis. More number of stomata are present on the abaxial epidermis.
- There are two types of cells in the mesophyll: palisade parenchyma and spongy parenchyma. The palisade parenchyma is placed adaxially.
- The spongy parenchyma is situated below the palisade parenchyma and extends to the lower epidermis. There are numerous large spaces and air cavities between the cells of spongy parenchyma.
- Vascular bundles are surrounded by a layer of thick-walled bundle sheath cells.

Isobilateral (Monocotyledonous) Leaf

- Stomata are present on both the surfaces of an isobilateral leaf. The mesophyll is not differentiated into palisade and spongy parenchyma.
- Some adaxial epidermal cells in grasses are modified into large, empty cells called bulliform cells. When the bulliform cells absorb water, they become turgid. So the leaf surface is exposed. During water stress, when the bulliform cells become flaccid, the leaves curl inwards to minimize water loss.

SECONDARY GROWTH

The increase in girth of a plant body is called secondary growth. The tissues involved in secondary growth are vascular cambium and cork cambium.

Vascular Cambium: In the case of the young stem, vascular cambium is present in patches as a single layer between the xylem and phloem. It forms a complete ring at a later stage.

The activity of the Cambial Ring:

- The cambial ring becomes active and begins to cut off new cells, both towards the inner and the outer sides.

- The cells which are cut off towards pith mature into secondary xylem. The cells which are cut off towards periphery mature into secondary phloem.
- The cambium is more active on the inner side than on the outer. As a result, the amount of secondary xylem produced is more than the secondary phloem. The primary and secondary phloems get gradually crushed due to the continued formation and accumulation of secondary xylem.
- At some places, the cambium forms a narrow band of parenchyma, which passes through the secondary xylem and the secondary phloem in the radial directions. These are the secondary medullary rays

Springwood and autumn wood:

- Cambium is very active during the spring season, but less active during the winters. Hence, during spring; a large number of xylem elements are formed having wider vessels. During winter, fewer xylem elements are formed having narrow vessels.
- The wood formed during summer is called springwood. The wood formed during winter is called autumn wood.
- The two kinds of wood appear as alternate concentric rings in transverse section of a trunk of a tree. These are called annual rings and provide information about the age of the tree.

Heartwood and sapwood:

- In old trees, the greater part of secondary xylem is dark in colour, hard, and resistant to attacks by microorganisms and insect. This region is made of dead elements with highly lignified walls. This wood is called heartwood. The heartwood gives mechanical support but does not conduct water.
- The peripheral part of the secondary xylem is lightly coloured. This is known as sapwood. It helps in conduction of water and minerals.

Cork Cambium

- Meristematic tissue which develops in the cortex region is called cork cambium or phellogen.
- The phellogen cuts off cells on both sides. The outer cells differentiate to form cork or phellem while the inner cells differentiate into secondary cortex or phelloderm.
- Phellogen, phellem and phelloderm are collectively called periderm.
- Due to the activity of the cork cambium, pressure builds up on the remaining layers peripheral to the phellogen. These layers gradually die and fall off.

Lenticels

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

Secondary Growth in Roots

- The vascular cambium of the dicot root originates from the tissue located just below the phloem bundles. A portion of pericycle tissue present above the protoxylem forms a continuous wavy ring. It gradually becomes circular. Rest of the steps are similar as in dicot stem.
- Secondary growth takes place in stems and roots of gymnosperms. No secondary growth occurs in monocots.

IMPORTANT TERMS

Sl No.	Terms	Explanation
1	**Meristematic Tissues**	The meristem is a type of tissue found in plants. It consists of undifferentiated cells (meristematic cells) capable of cell division
2	**Intercalary meristem**	The meristem which occurs between mature tissues
3	**Interfascicular cambium**	The cambium occupy between two vascular bundles is called the interfascicular cambium
4	**Fascicular cambium**	Fascicular cambium definition, cambium that develops within the vascular bundles, producing secondary xylem and phloem
5	**Complex tissues**	Complex plant tissue is made up of more than one type of simple permanent cells cells
6	**Fibres**	Fibres originate from meristematic cells and are elongated cells
7	**Sclereids**	Sclereids are formed by the secondary wall thickening of parenchyma cells and are broad cells
8	**Primary xylem**	Primary xylem is the xylem that is formed during the primary growth from procambium of apical meristems.
9	**Secondary xylem**	Secondary xylem consists of tracheids and vessels that are shorter and

		wider than those of primary xylem. It is richer in xylem fibres rings
10	**Protoxylem**	The first-formed xylem developing from procambium and consisting of narrow cells with annular, spiral, or scalariform wall thickenings
11	**Metaxylem**	The part of the primary xylem that differentiates after the protoxylem and that is distinguished typically by broader tracheids and vessels with pitted or reticulate walls
12	**Endarch**	Endarch is the arrangement in which the protoxylem is directed towards the centre and metaxylem elements towards the periphery
13	**Exarch**	Exarch is the arrangement in which the metaxylem is directed towards the centre and protoxylem elements towards the periphery
14	**Mesarch**	The condition in which protoxylem in a primary xylem strand develops first in the centre of the strand and continues to develop both centrifugally
15	**Companion cells**	Are specialised parenchymatous cells, which are closely associated with sieve tube elements
16	**Subsidiary cells**	A plant epidermal cell that is located next to a guard cell in the stoma of a leaf and differs in structure from other epidermal cells
17	**Trichomes**	a small hair or another outgrowth from the epidermis of a plant, typically unicellular and glandular
18	**Cambium**	A cellular plant tissue from which phloem, xylem, or cork grows by division, resulting (in woody plants) in secondary thickening
19	**Vascular bundles**	A strand of conducting vessels in the stem or leaves of a plant, typically with phloem on the outside and xylem on the inside
20	**Epiblema**	Epiblema is a tissue that replaces the epidermis in most roots and stems of submerged aquatic plants. It is usually located between the epidermis and cortex in the root or stem of a plant
21	**Casparian strips**	Casparian strips are specially modified primary carbohydrate cell walls, in which the radial parts of the cell walls are characterized by the deposition of lignin and suberin in the primary cell wall and middle lamella
22	**Stele**	The stele is the central part of the root or stem containing the tissues derived from the procambium. These include vascular tissue, ground tissue (pith) and a pericycle, which, if present, defines the outermost boundary of the stele. Outside the stele lies the endodermis, which is the innermost cell layer of the cortex.
23	**Bulliform cells**	Bubble-shaped epidermal cells that occur in groups on the upper surface of the leaves of many monocots

24	**Secondary growth**	Secondary growth is the result of the activity of the two lateral meristems, the cork cambium and vascular cambium. Arising from lateral meristems, secondary growth increases the girth of the plant root or stem, rather than its length.
25	**Medullary rays**	The elongate and horizontal parenchymatous cells arranged in radial planar structures, perpendicular to the growth rings
26	**Annual ring**	Arrangement of new cells in concentric circles called annual rings or annual growth rings
27	**Phellogen**	Phellogen is defined as the meristematic cell layer responsible for the development of the periderm
28	**Phelloderm**	A part of the periderm made up of cells produced inwardly by the cork cambium supplement. In woody plants, the epidermis is eventually replaced by a tougher, protective layer called bark.
29	**Phellem**	the layer of dead, corky cells produced externally by the cork cambium in the bark of woody plants
30	**Lenticels**	Raised circular, oval, or elongated areas on stems and roots; it appears as rough, cork-like structures on young branches. Underneath them, porous tissue creates some large intercellular spaces between cells meant for gaseous exchange.