

ANATOMY OF FLOWERING PLANTS

Points To Remember :

- Study of internal structure of plant is called **anatomy**.
- In plants cells are the basic unit.
- Cells organized into tissues and tissues organized into organs.

THE TISSUES :

- A group of cells having common origin and perform one function.
- Plant tissues are classified into two types:-
 - **Meristematic tissue.**
 - **Permanent tissue**

Meristematic tissues :

- Growth in plants is restricted to specific regions with active cell division called meristems.
- Different types of meristems are:-
 - **Apical meristem:**
 - Occurs in the shoot and root tips.
 - Primary meristem
 - Increase the length of plant
 - **Intercalary meristem :**
 - Present in-between mature tissues.
 - Primary meristem
 - Occurs in grasses and regenerate parts removed by grazing.
 - **Lateral meristem:**
 - Occurs in the mature regions of roots and shoots.
 - Also known as secondary meristem.
 - Responsible for producing secondary tissues.
 - Fascicular vascular cambium, interfascicular cambium and cork cambium are example of lateral meristem.
- Axillary bud :
 - During formation of leaves and elongation of stem, some cells 'left behind' from shoot apical meristem, constitute the axillary bud.
 - Present in the axils of leaves and are capable for forming a branch or a flower.

Permanent tissues :

- Cells produced from primary or secondary meristem stop dividing and differentiated structurally and functionally, termed as **permanent cells**.
- A group of permanent cell constitutes the permanent tissues.
- Permanent tissues having similar in structure and function are called **simple tissues**.

- Permanent tissues having many different types of cells are called **complex tissues**.

Simple tissues :

- **Simple tissues made of only one type of cells.**

Parenchyma :

- Forms major component within organs.
- Cells are isodiametric.
- Thin cell wall made of cellulose.
- Cells may be spherical, oval, round, polygonal or elongated shape.
- Cells are closely packed or have small intercellular space.
- Perform various functions such as photosynthesis, storage, secretion.

Collenchyma :

- Found either in homogeneous layer or in patches.
- Cell wall thickened in the corner due to deposition of **cellulose, hemicelluloses and pectin**.
- Cells are oval, spherical or polygonal in shape
- Often contain **chloroplasts**.
- **No intercellular spaces**.
- Provide mechanical support to the growing part of the plant such as young stem and petiole of a leaf.

Sclerenchyma :

- Consists of long, narrow cells
- Cell wall is thick and lignified.
- Cell wall with few or numerous pits.
- Cells are usually dead and without protoplast.
- Provides mechanical support to the organs.
- Sclerenchymas are of two types on the basis of origin, form, structure.

Fibres :

- Thick walled
- Elongated and pointed cells
- Generally occurs in group in various parts of the plant.

Sclereids :

- Spherical, oval or cylindrical in shape.
- Highly thickened dead cells with very narrow cavities (lumen).
- Commonly found in fruit walls of nuts; pulp of guava, pear and sapota; seed coats of legumes and leaves of tea.

Complex tissues :

- Made of more than one type of cells and these work together as a unit.
- Xylem and phloem constitute the complex tissues in plants.

Xylem :

- Functions as conducting tissues for water and minerals from roots to stem and leaves.
- Provides mechanical support to the plant.
- It consists of four different kinds of elements:-
 - **Tracheids**
 - **Vessels**
 - **Xylem fibres and**
 - **Xylem parenchyma.**
- **Tracheids :**
 - Elongated or tube like cells.
 - Thick and lignified walls and tapering ends.
 - Cells are dead and without protoplasm.
 - Inner layers of cell walls have thickenings which vary in forms.
- **Vessels.**
 - Is a long cylindrical tube-like structure made up of many cells called vessel members.
 - Each with lignified walls and a large central cavity.
 - Cells are devoid of protoplasm.
 - Vessel members are interconnected through perforations in their common walls.
 - Presences of vessels are the characteristics of the angiosperm.
- **Xylem fibres :**
 - Have highly thickened walls and obliterated central lumen.
 - Either septate or aseptate.
- **Xylem Parenchyma :**
 - Cells are living and thin-walled.
 - Cell walls are made up of cellulose.
 - They stored food materials in the form of starch or fat.
 - Also store materials like tannins.
 - The radial conduction of water takes place by the ray parenchymatous cells.
- The primary xylem is of two types-
 - **Protoxylem**
 - **Metaxylem.**
- The first formed xylem elements are called **protoxylem**.

- The later formed primary xylem is called **metaxylem**.
- **Endarch**: the protoxylem lies towards pith and metaxylem towards the periphery of the organ (in stem)
- **Exarch**: in root the protoxylem lies towards periphery and metaxylem lies towards the centre.

Phloem :

- Transports food materials usually from leaves to other part of plant.
- It is composed of four elements:-
 - **Sieve tube elements.**
 - **Companion cells.**
 - **Phloem parenchyma.**
 - **Phloem fibres.**
- **Sieve tube elements :**
 - Long tube like structure arranged longitudinally
 - Associated with companion cells.
 - End walls are perforated to form sieve plates
 - A mature sieve element possesses peripheral cytoplasm and a large vacuole but lacks nucleus.
 - The function of sieve elements controlled by nucleus of companion cells.
- **Companion cells :**
 - Specialized parenchymatous cells.
 - Closely associated with sieve tube elements.
 - Connected with sieve tube element by pit field.
 - Helps in maintaining pressure gradient in the sieve tubes.
- **Phloem parenchyma :**
 - Made up of elongated tapering cylindrical cells
 - Have dense cytoplasm and nucleus.
 - Cell wall made of cellulose and has pits through plasmodesmatal connections exist between the cells.
 - Store food materials and other substances like resins and latex and mucilages.
 - It is absent in monocotyledons.
- **Phloem fibres :**
 - Also known as bast fibres.
 - Made of sclerenchymatous cells.
 - Absent in primary phloem but present in secondary phloem.
 - Much elongated, unbranched and have pointed, needle like apices.
 - Cell wall is quite thick.
 - On maturity loose their protoplasm and become dead.
 - Phloem fibres of jute, flax and hemp are used commercially.

- The first formed primary phloem consists of narrow sieve tubes and referred as **protophloem**.
- The later formed phloem has bigger sieve tubes and is referred to as **metaphloem**.

THE TISSUE SYSTEM :

- On the basis of their structure and location there are three types of tissue systems.
 - Epidermal tissue system.
 - Ground or fundamental tissue system.
 - Vascular or conducting tissue system.

Epidermal tissue system :

- Forms the outermost covering of the whole plant body and comprises:
 - Epidermal cells.
 - Stomata
 - Epidermal appendages like trichomes and hairs.
- Epidermis consists of single layer parenchymatous cells.
- Cells are elongated, compactly arranged, which form continuous layer.
- Epidermis is usually single layered.
- Outside the epidermis covered with waxy thick layer called **cuticle**.
- Cuticle absent in epidermis of root.
- **Stomata** are the structure present in the epidermis of leaf.
- Stomata regulate the process of transpiration and gaseous exchange.

Stomata :

- Each **stoma** composed of two bean shaped cell called **guard cells**.
- In grasses the guard cells are dumb-bell shaped.
- Outer wall of guard cell is thin and inner wall is thick.
- Guard cell possesses chloroplast and regulates the opening and closing of stomata.
- Epidermal cells in the vicinity of guard cell called **subsidiary cells**.
- Stomatal aperture, guard cells and subsidiary cells together called **stomatal apparatus**.
- The **root hairs** are unicellular elongations of the epidermal cells and help absorb water and mineral from the soil.

Trichomes :

- On stem the epidermal hairs are called **trichomes**.
- Trichomes are usually multicellular.
- May be branched or unbranched and soft or stiff.
- Sometimes secretory.
- **Trichomes** help in preventing water loss due to transpiration.

The ground tissue system :

- All the tissues except epidermis and vascular bundles constitute the **ground tissue**.
- It consists of simple tissues such as parenchyma, collenchyma, Sclerenchyma.
- Parenchymatous cells are present in cortex, pericycle, pith and medullary rays.
- In leaves, the ground tissue consists of thin-walled chloroplast containing cells called **mesophyll**.

The vascular tissue system :

- Vascular system consists of complex tissues - xylem and phloem.
- Xylem and phloem together constitute the vascular bundle.
- In dicot presence of cambium between xylem and phloem called **open vascular bundle**.
- Vascular bundle without cambium is said to be **closed vascular bundle**.
- **Radial vascular bundle**: xylem and phloem arranged alternate manner on the different radii.
- **Conjoint vascular bundle**: xylem and phloem are situated at the same radius of vascular bundle.

ANATOMY OF DICORYLEDONOUS AND MONOCOTYLEDONOUS PLANTS :-

Dicotyledonous Root :

- The outermost layer is epidermis.
- Presence of unicellular **root hairs** in epidermis.
- The **cortex** constitutes many layer thin-walled parenchyma cells with **intercellular spaces**.
- The innermost layer of cortex is **endodermis**.
- Endodermis consists of single layered barrel-shaped cells without intercellular spaces.
- Presence of **casparian strip** in the endodermis.
- Next to endodermis there is few layer parenchymatous cells form **pericycle**.
- Initiation of **lateral root** and **vascular cambium** during secondary growth takes place from the cells of pericycle.
- The parenchymatous cells present in-between xylem and phloem is called **conjunctive tissue**.
- The number of xylem and phloem bundle is three or four.
- All the tissues on the inner side of endodermis such as pericycle, vascular bundles and pith constitute the **stele**.

Monocotyledonous Root :

- **Monocot root have similar tissues as in dicot except :-**
 - It contains more than six xylem bundles called polyarch.
 - Pith is large and well developed.
 - Do not undergo any secondary growth.

Dicotyledonous Stem :

- Outermost layer is **epidermis**.
- Epidermis covered with thin layer of **cuticle** and has **trichomes** and few **stomata**.
- The cells arranged in multiple layers in-between epidermis and pericycle constitute the **cortex**.
- **Cortex has three sub-zones :**
 - **Hypodermis:** a few layers of collenchymatous cells below epidermis.
 - **Cortical layers:** consists of rounded thin walled parenchymatous cells with intercellular spaces.
 - **Endodermis:** it is the innermost layer of cortex. Cells are rich in starch grains and are referred to as **starch sheath**.
- **Pericycle** : present on the inner side of the endodermis and above the phloem in the form of semi-lunar patches of Sclerenchyma.
- **Medullary rays:** a few layers of radially placed parenchymatous cells present in between vascular bundles.
- A large number of **vascular bundles** arranged in a **ring**.
- Each vascular bundle is **conjoint**, **open** and **endarch** protoxylem.
- The central portion of stem constitutes the **pith**.

Monocotyledonous Stem :

- **It has similar tissues with the dicot stem except in following-**
 - Sclerenchymatous hypodermis.
 - Vascular bundles are **scattered** in the ground tissue.
 - Each vascular bundle is covered by **bundle sheath** cells.
 - Vascular bundles are **conjoint** and **closed**.
 - Peripheral vascular bundles are smaller than central one.
 - Phloem parenchyma is absent.
 - Water containing cavities are present within the vascular bundles.

Dorsiventral (Dicotyledonous) Leaf :

- Vertical section of a Dorsiventral leaf shows three main parts:
 - Epidermis.
 - Mesophyll cells.
 - Vascular systems.
- Epidermis covers both upper (**adaxial**) and lower (**abaxial**) surface of the leaf has a conspicuous cuticle.
- Abaxial surface has more stomata than the adaxial epidermis.
- Tissue between upper and lower epidermis called **mesophyll**.
- Mesophyll cells are two types:
 - **Palisade parenchyma**
 - **Spongy parenchyma**

- Adaxially placed **palisade parenchyma** is made up of elongated cells arranged vertically, parallel to each other.
- **Spongy parenchyma**: oval or round and loosely arranged cells below the palisade parenchyma.
- **Vascular bundles** are seen in the midrib and veins.
- The vascular bundles are surrounded by a layer of thick walled **bundle sheath cells**.

Isobilateral (Monocotyledonous) leaf :

- It is similar with Dorsiventral leaf in many respect except -
 - Stomata are equally distributed on upper and lower epidermis.
 - Mesophyll cells are not differentiated into palisade and spongy.
- In grasses, certain adaxial epidermal cells along the veins modified themselves into large, empty, colourless cells called **bulliform cells**.
- Causes rolling of leaves to reduce transpiration during water stress.

SECONDARY GROWTH :

- Apart from primary growth the dicot plant exhibit an increase in girth is called **secondary growth**.
- The tissues involved in secondary growth are two lateral meristem:
 - Vascular cambium.
 - Cork cambium.

Vascular cambium :

- Cells of cambium present between primary xylem and primary phloem is the **intrafascicular cambium**.
- The cells of medullary rays, adjoining these intrafascicular cambium become meristematic and form the **interfascicular cambium**.
- Intrafascicular cambium and interfascicular cambium joined to form complete **cambium ring**.
- The cambial ring becomes active and begins to cut off new cells both toward inner side and outer side.
- Cells produced toward pith mature into **secondary xylem**.
- Cells produced towards periphery mature into **secondary phloem**.
- Secondary xylem forms a compact mass, retaining primary xylem in the centre.
- At some places, the cambium forms a narrow band of parenchyma, which passes through secondary xylem and phloem is said to be **secondary medullary rays**.

Spring wood and autumn wood :

- In temperate region during spring season, cambium becomes more active and produces a large number of xylary elements having vessels with wider cavities. The wood formed in spring is called **spring wood** or **early wood**.
- In winter the cambium is less active and forms fewer xylary elements with narrow vessels thus called **autumn wood** or **late wood**.

- Spring wood is lighter in colour and lower density, where as the autumn wood is darker and has higher density.
- The two woods that appear as alternate concentric rings constitute an **annual ring**. Annual rings seen in a cut stem give an estimate of the age of the tree.

Heartwood and sapwood :

- In old trees the secondary xylem is dark brown due to deposition of organic compounds like tannins, resins, oils, gums, aromatic substances and essential oils in the central or innermost layers of the stem.
- These substances make it hard, durable and resistance to insect.
- These regions comprise dead elements with high lignified walls and are called **heartwood**.
- The heartwood never conducts water, provide mechanical support to plant.
- The peripheral region of secondary xylem is lighter in colour and is known as **sapwood**.
- It involve in transport of water and minerals from root to leaf.

Cork cambium :

- **Cork cambium** or **phellogen** developed usually in the cortex region.
- Phellogen is a couple of layers in thick.
- Made of narrow, thin walled and nearly rectangular cells.
- Phellogen cut new cells to both inner and outer side.
- The outer cells differentiated into **cork** or **phellem**.
- The inner cells differentiated into **secondary cortex** or **phelloderm**.
- The cork is impervious to water due to suberin deposition.
- Phellogen, phellem and phelloderm are collectively known as **periderm**.
- Bark is a non-technical term that refers to all tissues exterior to the vascular cambium, there fore including **secondary phloem** and **periderm**.
- At certain region the phellogen cuts off parenchymatous cells instead of cork.
- These parenchymatous cells ruptured the epidermis and forms lens-shaped opening called **lenticels**.
- Lenticels permit the **gaseous exchange** between the outer atmosphere and internal tissues of the stem.

Secondary growth in Roots :

- In dicot root the vascular cambium is completely secondary in origin.
- It originates from the tissue below the phloem, a portion of pericycle tissue, above the protoxylem forming a complete and continuous wavy ring.
- Later it becomes circular. Ruther all events are similar with dicot stem.