Plant anatomy

Plant anatomy Plant anatomy is also known as phytotomyis the study of plant tissues and cells in order to learn more about the way these organisms are constructed and how they work.

Why is learning plant anatomy important? Plant anatomy is Situated between the study of plant morphology and cell biology. Studying plant anatomy allows a student to conceptually integrate organismal structure and function, Further, it helps to reveal the relationships between structure, function, taxonomy, ecology, and developmental genetics.

Our course aims to help students understand

1) The arrangement of tissue and cells types within the dermal, ground, and vascular tissue systems in vascular plants.
2) The characteristics of specialized cells and their components.
3) The relationship between internal structure, physiology, and ecology.
4) Evolutionary history and taxonomic variation of vascular plant anatomy.
5) The genetics and process of vascular plant development.

The Importance of Studying anatomy

1. remains a powerful tool that can be used to help solve baffling problems, whether this is in the classroom, or at National botanical research facilities.
2. We also apply anatomy to help solve rather more academic questions of the probable relationships between families, genera and species.
3. The incorporation of anatomical data with the findings from studies on gross Morphology, pollen, cytology, physiology, chemistry or molecular biology and similar disciplines enables those making

revisions of the classification of plants to produce more natural systems.

4. Plant anatomy remains a central requirement for anyone experimenting with plants.

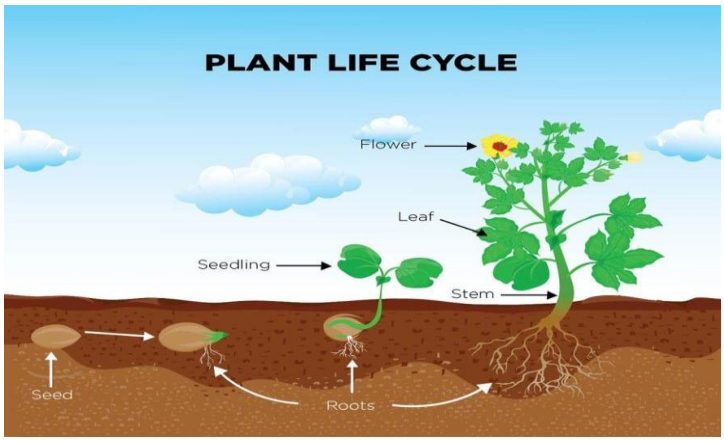
What is Plant Life Cycle?

Plants have a life cycle, just like humans and other animals. The life cycle of a plant describes the different stages of the plant from the beginning of its life until the end, which is from seed to mature plant.

not all plants produce seed. Some plants such as fern or mosses produce different kinds of cells called "**Spores**". These plant does not produce seeds.

Stages of Plant Life Cycle

1. **Seed**
2. **Germination**
3. **Seedling**
4. **Adult Plant**
5. **Flowering**
6. **Pollination**
7. **Seed Dispersal**



➢ 1. Seed –

The plant life cycle starts with a seed. From the outside seeds are protected by a tough layer, called Outer Coat. But inside every seed, there is a tiny plant, known as an embryo. The embryo has a root, shoot as well as the first true leaves. Seeds germination need to three factors:-

water, suitable temperature (warmth), and a good location (such as in soil).

➢ 2. Germination –

For germination, seeds need a suitable condition i.e. water, temperature and right location (such as in soil).

When the proper conditions are met for the seed, it will begin to sprout. The first root begins to grow downward. the roots which absorb water and minerals from the soil. The process of the sprouting of seed usually after a period of dormancy is called germination.

➢ 3. Seedling –

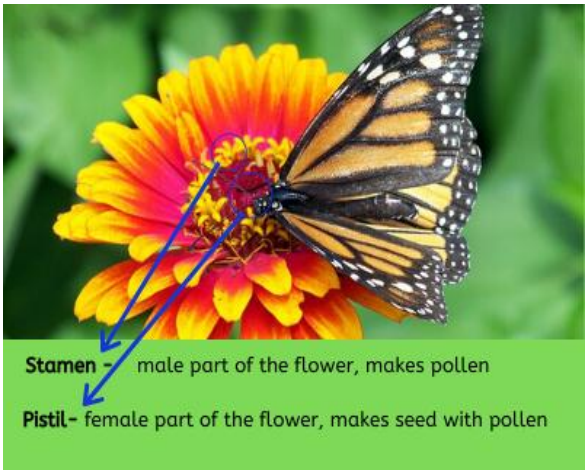
The next step is seedling. A very young plant that grow after germination. It starts growing towards the sunlight. Plants need sunlight, nutrients, water, and air to survive and grow. Photosynthesis helps the seedling grow into a mature plant.

➢ 4. Adult Plant –

When a plant becomes mature, it started to grow flower (in a flowering plant) and flowers produce seeds. A mature plant has leaves, roots, stem, flower and fruits.

➢ 5. Flowring –

Flowers are the reproductive part of a plant. It makes seeds which in turn make new plants. There are different parts of a flower such as petals, sepals, stamen, pistil etc



➢ 6. Pollination -

Pollination plays a very important role in the plant life cycle. Flowers use pollen to make seeds through a process called pollination. Pollen is transferred by different pollinators, such as birds, butterflies, insects, bees or even wind.

when pollen moved from the stamen to the pistil, called pollination. And Once pollination takes place, the seeds start to grow.

➢ 7. Seed Dispersal –

Finally, seeds get dispersed (scattered) away to new places and the plant life cycle starts again. Seeds can get spread by animals, wind, and water.

Seed		**The part of a plant that has a tiny new plant inside it.**
Germination		**The first root begins to grow downward. There are few tiny hairs on the roots which absorb water and minerals from the soil.**
Seedling		**It starts growing towards the sunlight.**
Mature Plant		**A mature plant has leaves, roots, stem, flower and fruits. Flower produce fruits & new plants**

The Cell

All plants are composed of cells, the cell is the smallest structural unit of plant body that is capable of independent functioning, consisting of one or more nuclei, cytoplasm and various organ.

Plant Cell Definition

"Plant cells are eukaryotic cells with a true nucleus along with specialized structures called organelles that carry out certain specific functions."

Plant cells are the basic unit of life in organisms of the kingdom Plantae. They are eukaryotic cells, which have a true nucleus along with specialized structures called organelles that carry out different functions. Plant cells have special organelles called chloroplasts, which create sugars via photosynthesis. They also have a cell wall that provides structural support.

Animals and fungi, are made of at least one eukaryotic cell. but, bacteria and archaea are made up of a single prokaryotic cell. Plant cells are differentiated from the cells of other organisms by their cell **walls, chloroplasts, and central vacuole.**

Chloroplasts are organelles that are central for plant cell function. These are the structures that carry out photosynthesis, using the energy from the sun to produce glucose. In doing so, the cells use carbon dioxide, and they release oxygen.

Other organisms, such as animals, rely on this oxygen and glucose to survive. Plants are considered autotrophic because they produce their own food.

Specifically, plant cells are photoautotrophic because they use light energy from the sun to produce glucose. Organisms that eat plants and other animals are considered heterotrophic.

The other components of a plant cell, the cell wall, and central vacuole, work together to give the cell rigidity. The plant cell will store water in the central vacuole, which expands the vacuole into the sides of the cell. The cell wall then pushes against the walls of other cells, creating a force known as **turgor pressure**. turgor pressure in plant cells allows plants to grow .

The Components of Plant Cell:

There are two components of plant cell:

A. Living Components of plant cell

B. Non -Living Components of plant cell

A. Living Components

1. **Cell Membrane:** This is a thin and a semi-permeable membrane that encloses the cell's contents. This thin lining will be present at the inner side of the plant cell wall.
2. **Cytoplasm:** This is a gel-like fluid that is found within the cell membrane. This will contain various elements like(Water, enzymes, Salts ,Organelles ,Organic molecules).
3. **Endoplasmic reticulum (ER):** This is a wide net of membranes. There are two types of regions in endoplasmic reticulum : rough endoplasmic reticulum (with ribosomes) and smooth endoplasmic (without ribosomes). The main function of this organ is protein and lipid synthesis.
4. **Microtubules:** These are the hollow rods whose primary function is to provide support, as well as shape to the cell. These have important roles to play in the chromosome movement during plant cell division.
5. **Mitochondria**: This is the "powerhouse" of the cell meaning that this generates energy for the cell through the process called respiration.
6. **Ribosomes:** These are the organelles that contain RNA and protein elements. As such, the ribosomes will be responsible for the protein assembly Within the plant cell, the ribosomes are either found in endoplasmic reticulum or floating in the cytoplasm.
7. **Golgi body:** This apparatus, which is found in all eukaryotic cells, is involved in distributing macromolecules to different parts of the cell.
8. **Lysosomes:** Are vesicles formed by Golgi bodies and they contain hydrolytic enzymes. The main enzyme present in lysosomes is acid phosphatase, other enzymes are acid DNAase, acid RNAase and β galactosidase etc.
9. **Peroxisomes:** These are small structures, which are enveloped by a single membrane that contains the enzyme. The peroxisomes will be involved in plant processes like photorespiration.

10.Nucleus

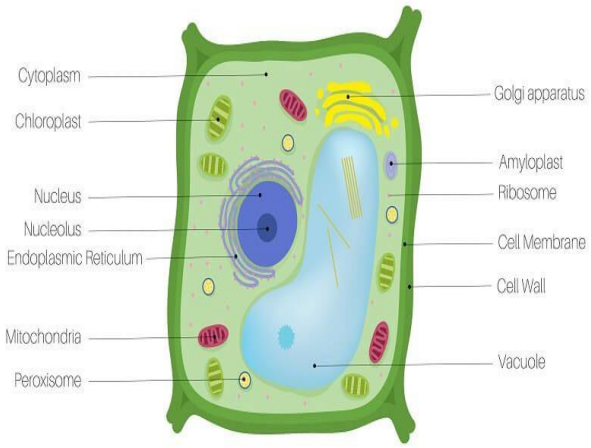
It is a denser protoplasmic body , circular or spherical surrounded by protoplasm. Its shape and size differs according to size of cell. It is composed of following organelles:

A. Nuclear Membrane: The membrane surrounded nucleus on the outside which is double walled and having numerous minute pores.

B. Nucleoplasm: It is viscous, granular, colorless fluid inside the nuclear membrane. It is also known as nuclear sap.

C. Chromatin network: The threads like bodies forming a reticulum are suspended in nucleoplasm, which are net of chromosomes.

D. Nucleolus: A spherical or circular body. It plays important role in protein synthesis.



Plastids

1.Chloroplasts

Chloroplasts are specialized organelles found only in plants and some types of algae. **These organelles carry out the process of photosynthesis, which turns water, carbon dioxide, and light energy into nutrients from which the plant can obtain energy.**

Chloroplasts are disk-shaped organelles that are surrounded by a double membrane. outer membrane and inner membrane.

The center of the chloroplast that is enclosed by the double membrane is a fluid matrix called the **stroma** .

Within the stroma, there are many structures called **thylakoids**, which look like flattened disks. Thylakoids are stacked on top of one another. Thylakoids have a high concentration of **chlorophyll** and **carotenoids**.

2. Chromoplasts

Chromoplasts are brightly colored plastids that act as the site of pigment accumulation. They are typically found in the fleshy fruits, flowers as well as various other pigmented parts of the plant such as leaves.

With such pigments as carotenoids accumulating in chromoplasts, the plastids play an important role in pollination given that they act as visual attractors for animals involved in pollination.

While chromoplasts can develop directly from chloroplasts during maturing of fleshy fruits.

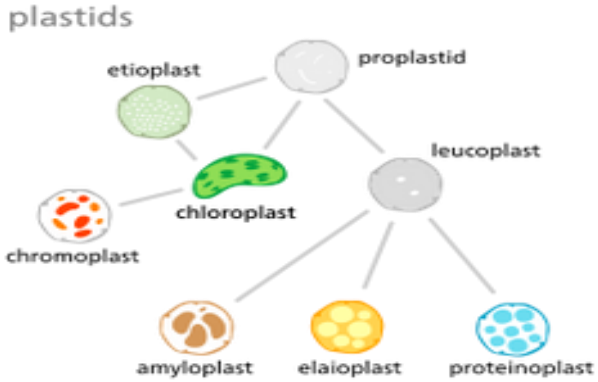
3.Leucoplasts

Generally, leucoplasts are colorless plastids that are commonly found in colorless leaves and rapidly growing tissues (tubers, stems, roots etc). Here, leucoplasts serve as the site of starch formation and storage.

Compared to plastids like chloroplast and chromoplasts, leucoplasts lack such pigments as chlorophyll. Moreover, they are located in deep tissue such as plant seeds and are therefore not directly exposed to light.

The following are the three major types of leucoplasts:

1. Amyloplasts are a type of plastid involved in long term storage of starch.
2. Elaioplasts are a type of leucoplast that contain oil.
3. Proteinoplasts contain higher levels of protein as compared to the other plastids.



B. Non -Living Components

1-Vacuoles: Most live cells in the plant are characterized by Vacuoles that contain a liquid called **cell sap**, separates cytoplasm by membrane that called **Vacuoles membrane or (tonoplast)** that is ditterentially permeable, it allows some materials to pass and not allowed for others. It contains water, salt, sugars, organic acid, protein compounds, fatty, tannins materials and anthocyanin pigments. It used in construction operations or its food transformation products or rubbish.

2- Crystals: Most of the crystals consist of **Calcium Oxalate** and **Calcium Carbonate.** There is many type of crystals:

a-Calcium Oxalate Crystals: Some type of Calcium Oxalate crustal

1. **Prismatic Crystals**: there is only individual.
2. **Rosette Crystals**: gather in Crystals masses.
3. **Raphides Crystals**: it be in needle Crystals.

B- Calcium Carbonate Crystals

Cystolith Crystal: the body of Crystal compound of Calcium Carbonate.
The neck is a compound of cellulose.
the cell container Cystolith Crystal Called **lithocyts**.

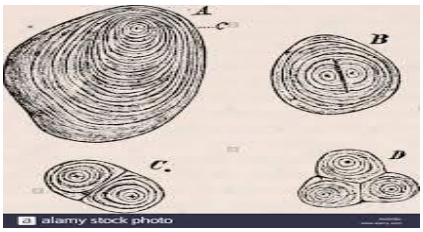
3- Starch Grains: Grains consists of Carbohydrate substance. The characteristics of granules are different This return to:

A. The site and shape of the grain that called hilum.
B. Presence or not presence layers.
C. Size and shape of the starch granules.

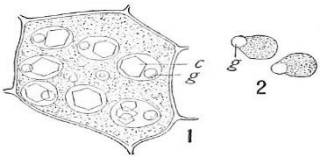
The nature of starch granules:

1. Simple Grain: All the layers are organized around one hilum.
2. Semi-compound Grain: if its two hilums or more and the layers are organized around each one and then organized around about all.

3. compound Grain: contains more hilum and there was barrier between every two hilum adjacent and the layers are organized around each one independently and it does not incorporate with them.



4- Aleurone grains: The aleurone grain (protein body), is a specialized dry vacuole where storage proteins accumulate in a stable form in seeds, usually in the endosperm. Cells containing aleurones form the aleurone layer.



Cell Wall

The wall in the plant cell is described as real dead wall. It is characterized by the presence of cellulose, which is free of non-living cells. The cell wall is formed as a result of cell protoplast activity, so it expands as a result of the increased size and growth of cell protoplast.

Formation The Cell Wall

At the time of its formation, the wall is very thin and there are several changes in both thickness and chemical composition.

Immediately after the cell division, the wall appears as a dark area formed at the equator of the spindle called phragmoplast. During phragmoplast, the wall appears as a thin plate called cell plate, which is initially in a central position and then gradually extends out until it reaches the mother cell wall and then called the Middle lamella, which is mainly composed of calcium and magnesium pectat.

The protoplast then precipitates two thin membranes on both sides of the middle lamella, when the cell arrives to full mature the primary wall merged with middle lamella and it is called compound middle lamella .

To distinguish between the middle lamella that originally formed and those that merged with the primary wall, used the name of the simple middle lamella to the first and compound middle lamella of the second, and the middle lamella in this case being 3- layered.

In many cases thickness occurs added to the wall after the cell arrives to the full matured, this thickness formation another wall over the primary wall is known secondary wall.

Cell Walls Layers

The cell wall features to the following layers:

A. Middle Lamella:

Features to the following**:**

1. It called intercellular substance which linked the two primary cell wall with it.
2. Composed of calcium and magnesium pectat and other materials for example lignin.

B. Primary Cell Wall:

Features to the following**:**

1. The first part of the wall added from the protoplast on the middle lamella in the stage when the cells are still in growth of the surface and size.

2. Consist of pectic substance, non-cellulosic polysaccharides and other substance.
3. There are in other plant cells and it is remained only wall in the cell for example in the meristematic cells, parenchyma cells, collenchyma cells and most of epidermis cells.
4. Relatively thin, surrounded live cells and primary pit fields.

C. Secondary Cell Wall:

Features to the following**:**

1. Adds the primary wall after the cell wall arrives to its final size.
2. Increases in the thickness of the wall without an increase in the surface of the wall.
3. Consists of cellulose which is the biggest part of the wall and non-cellulosic polysaccharides, in addition to lignin and suberin.
4. It is not contain true pectic substances.
5. It is associated with the cells die after mature.
6. It features layers that can be observed under the microscope.
7. It is found in specific tissues and cells:
    A. Tracheary elements such as a vessels and tracheids.
    B. Seclerenchyma tissues such as a fibers and stones cells.
    C. Some parenchyma cells such as in wood tissue.
    D. Cork tissue.
    E. In some epidermis layers.

Chemical Composition of Cell Wall:

Cellulose: Hyropholic carbohydrate substance, crystalline, having the general empirical formula $(C_6H_{10}O_5)n$, it consists of 3000-8000 molecule of β-glucose in one cellulose molecule.

1. Hemicellulose: Polysaccharides substance such as arabinose, xylose, mannose and galactose.

2. Pectin: Hyropholic carbohydrate substance, colloidal, its more preceding in the Middle Lamella and primary wall, it consists of Ester methyl Galaturonic acid.

3. Lignin: Non carbohydrate substance, its more present in the cells that contain secondary wall such as vessels, tracheids and sclereides cells that contains from phenyl propenoid.

4. Suberin: Fatty (wax) substance, presence in cork or phellen cells and it don't allow to passes water and gasses from it. the cells which are its walls contain this substance will died.

5. Cutin: Fatty substance not permeability water and gases, presence in epidermis.

6. Silica: Mineral substance, precipitate in cell wall for some plant tissues such as grasses , edges of leaves and in some algae for example Diatoms.

7. Chitin: Presence in the wall of fungi and some lower plants.

8. Gelatin: Protein substance, unknown interest, presence in secondary walls for the fibers of some plants.

9. Callose: Carbohydrate substance, when its analysis it give glucose, it is presence in phloem and pollen tubes**.**

10. Other compounds: Such as tannin, resins and gums, it presence in causing an increase in solidity and hardness of heart wood.

Pits

Pits are relatively thinner portions of the cell wall that adjacent cells can communicate or exchange fluid through. Pits are characteristic of cell walls with secondary layers. Generally each pit has a complementary pit opposite of it in the neighboring cell. These complementary pits are called "pit pairs".

Though pits are usually simple and complementary, a few more pit variations can be formed:

- Simple pits: A pit pair in which the diameter of the pit chamber and the diameter of the pit aperture are equal.
- Bordered pits: secondary wall arches over the cavity of the pits. Thus the pit opening become narrow than the pit diameter. Bordered pits of the opposite cells form bordered pit pair. The cavity in the thick secondary wall is called pit chamber. The bordered pit opens in the cell lumen by pit aperture.
- Half bordered pits: A pit pair in which a bordered pit has a complementary simple pit. Such a pit pair is called half bordered pit pair.
- Blind pits: A pit pair in which a simple pit has no complementary pit.
- Compound pits: A pit pair in which one cell wall has a large pit and the adjacent cell wall has numerous, small pits.
- **Plasmodesmata**

  The plasmodesmata are cytoplasmic strands that extend through the pores in adjacent cell walls. Plasmodesmata are transport of material and stimuli from cell to cell.

Internal Structure of plant

At first glance, plants consist of roots, stems, leaves and sometimes flowers. While these visible structures play a role in the plant's survival, within those roots, stems, leaves and flowers, you will find internal structures that also allow plants to carry out such basic functions as water transport and seed production. that structures different between type of plant (mono and dicot) as the following:-

Internal Structure of Dicot Stems

Internal structure of a typical dicot stem shows following features:

1. Epidermis:

- Epidermis is the outermost layer of the stem.
- It is single layerd and lack of chloroplast.
- Multicellular hairs (trichomes) and stomata are found on epidermis.
- Outer side of epidermis a layer is present which is made up of cutin is called cuticle.
- Epidermis plays a significant role in protection

2. Cortex:

In dicotyledon stem cortex divided into three parts:

(a) Hypodermis: It is present just below the epidermis. It provides additional support to epidermis. It is thick multicellular layer. This layer is composed of collenchyma and their cells contain chloroplast. So hypodermis is green and photosynthetic.

(b) General Cortex: This part is composed parenchyma. Storage of food is the main function of the cortex. Resin canal/ mucilage canal are present in it.

(c) Endodermis: It is single celled thick layer. The cells of endodermis are barrel shaped. These cells accumulate more starch in stem of dicot. Thus it is known as "Starch sheath".

3. Pericycle:

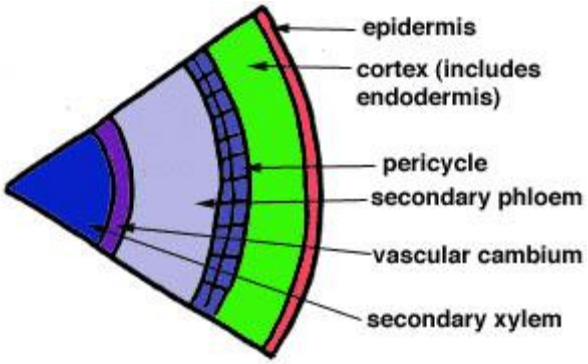
This layer is situated in between the endodermis and vascular bundles. The pericyclic of stem is multilayered and made up of sclerenchyma.

4. Vascular Bundle:

The vascular bundles are arranged in a ring. Each vascular bund is conjoint, collateral and open. Each vascular bundle is made of phloem, cambium and xylem. xylem containers are arranged in stem dicotyledonous in the form of rows .

5. Pith:

This is well developed region, spreading from ring of vascular bundle to the center. The cells of this region mainly made up of parenchyma. **Function of pith:** Storage of water and food.



Internal Structure of Monocotyledon Stem

1. Epidermis: Epidermis is the outer most single celled thick layer. It is covered with thick cuticle. Multicellular hairs are absent & stomata are also less.

2. Hypodermis: Hypodermis of monocotyledon' stem is made up of sclerenchyma. It is 2-3 layered monocot stem rigidity is more in hypodermis where as in dicot stem elasticity is more. It provides mechanical support to plant.

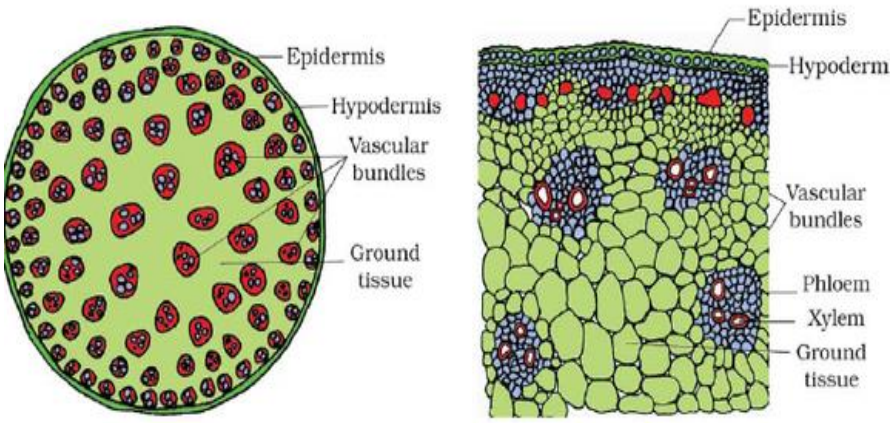
3. Ground tissue: The entire mass of parenchyma cells next to hypodermis and extending to the center is called ground tissue. There is no differentiation of ground tissue in monocotyledon stem. It means ground tissue is not differentiated into endodermis, cortex, Pericyclic etc.

Note: Sometimes in some grasses, wheat etc. the central portion of ground tissue becomes hollow and is called Pith cavity.

4. Vascular Bundle:

- Many vascular bundles are dispersed in the ground tissue and V.B. are generally oval shape.
- Vascular bundles lies towards the center are large in size and-less in number.
- Vascular bundles situated towards the periphery are small in size but more in number.
- Each vascular bundle are conjoint, collateral and closed.
- Vascular bundles surrounded by the layer of sclerenchymatous fiber are known as bundle sheath.
- So vascular bundles are called fibro vascular bundles.

(a) Xylem: In xylem number of vessels is less. In met xylem there occur two large vessels while in protoxylem there occur one or two small vessels. Vessels are arranged in V or Y shape. **Exception:** In Asparagus water cavity & bundle sheath are absent.
(b) Phloem: It consists of sieve tube elements and companion cells. Phloem parenchyma is absent.
5. Pith: Pith is undifferentiated in monocotyledon stems.



Internal Structure Of Typical Dicotyledon Root

structure of a dicotyledon Root shows following features:

1. Epidermis : It is outermost layer. It comprising tubular living components. Cuticle and stomata are absent. Unicellular root hairs are formed due to elongation of some cells of **Epidermal**. **Epiderm**al also known as Rhizodermis or Piliferous layer. Root hair are present in maturation zone of root.
2. Cortex: It is made up of parenchyma cells, Chloroplast is absent so they are no photosynthetic, The cells of outer part of cortex -are suberized in old root. It is called exodermises. exodermises is found in some dicotyledonous roots and most of the monocotyledon roots'.
3 Endodermis: This layer is situated between the pericyclic and cortex. Casparian strips are present on radial and tangential wall of endodermis. These strips are made up of lignin suberin (mainly suberin).

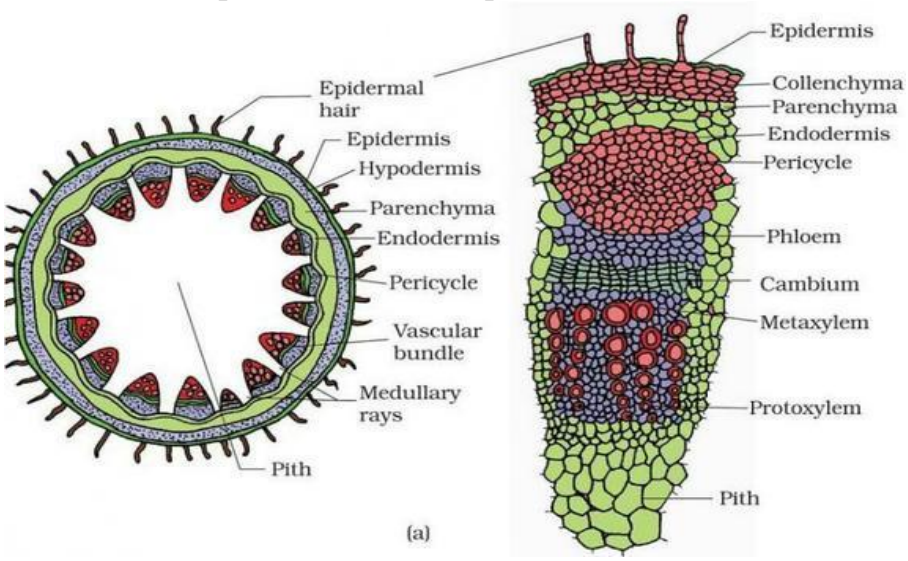
The cells of endodermis which are situated in front of protoxylem cells lack of casparian strips. These are called passage cells provide path to absorbed water from cortex to pericyclic.

4. **Pericyclic** : It is single layered. It is composed prosenchyma. Lateral roots are originated from the part of pericyclic which is lying opposite to

protoxylem. Thus lateral roots are endogenous in origin. A few mature cells of pericyclic usually opposite to protoxylem, become meristematic.

5. Vascular Bundles: Vascular bundles are radial and exarch(protoxylem found in outside but metaxylem in inner), xylem and phloems are separate and equal in number. The number of xylem bundles are two to six (diarch to hexarch). But exceptionally, Parenchyma which is found between xylem and phloem is called conjunctive tissue.

6. Pith: In dicot root pith is less developed or absent.

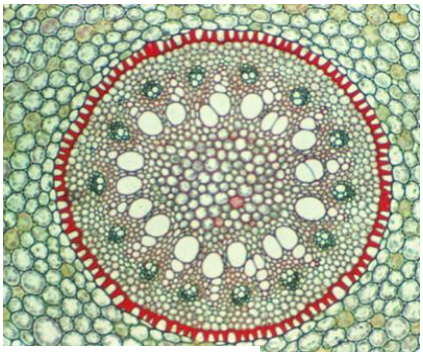


Internal Structure of Monocotyledon Root

The internal structure of a typical monocotyledon root is similar to dicotyledon root:

(1) Number of xylem bundles are more than six (Polyarch) in monocotyledon root (exceptionally the number of xylem bundles are two to six in onion).

(2) Pith is well developed in monocotyledon root



Internal Leaf Structure

a) **Cuticle**: Waxy layer water proofing upper leaves.

b) **Upper epidermis**: Upper layer of cells. No chloroplasts. Protection.

c) **Palisade Mesophyll**: Tightly packed upper layer of chloroplast containing cells.

d) **Spongy Mesophyll**: Lower layer of chloroplast containing cells. Air spaces around them.

e) **Lower Epidermis**: Lower external layer of cells in leaf.

f) **Vascular Bundle**: Bundle of many vessels (xylem and phloem) for transport.

g) Xylem: Living vascular system carrying water & minerals throughout plant.
h) Phloem: Living vascular system carrying dissolved sugars and organic compounds throughout plant.
i) Guard Cells: 2 cells surrounding stomata that control rate of gas & water exchange.
j) Stomata: Opening between guard cells for gas & water exchange.

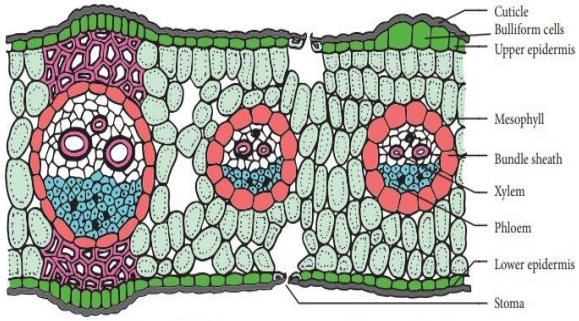
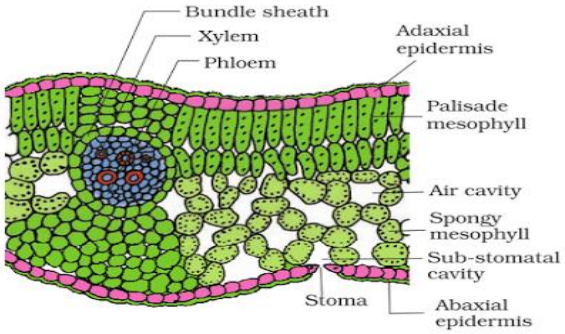


Figure 12.7 Transverse section of Monocot Leaf



Monocot leaf Dicot leaf

Differences between of Dicot and Monocot Leaf

S. No.	Dicot Leaf	Monocot Leaf
1	Dorsiventral leaf	Isobilateral leaf
2	Mesophyll is differentiated into palisade and spongy parenchyma	Mesophyll is not differentiated into palisade and spongy parenchyma

Vascular tissue

Vascular tissue transports water, minerals, and sugars to different parts of the plant. Vascular tissue is made of two specialized conducting tissues: **xylem** and **phloem**.

Xylem tissue transports water and nutrients from the roots to different parts of the plant, and also plays a role in structural support in the stem.

Phloem tissue transports organic compounds from the site of photosynthesis to other parts of the plant. The xylem and phloem always lie adjacent to each other in a **vascular bundle**

Plants are divided according to the presence or absence of vascular tissue into **vascular** and **non-vascular** plants

Types of Vascular Tissue

1.Xylem

2.Phloem

1.Xylem

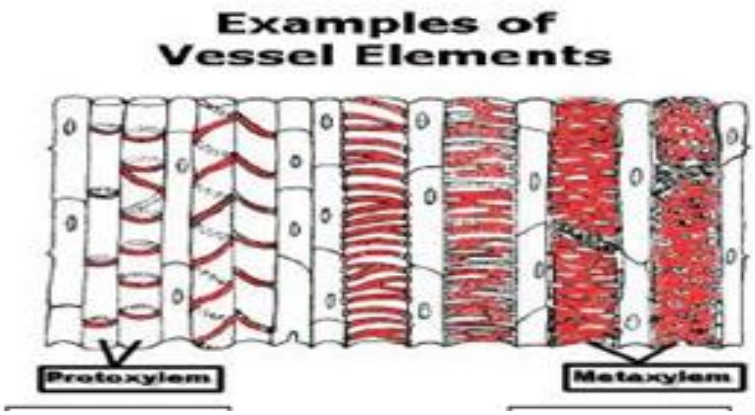
Xylem is a specialized type of vascular tissue created in vascular plants to transport water and nutrients from the roots of a plant to the tips of the leaves.. The xylem is created from hollow, dead cells. Water is absorbed into the roots, which creates a positive pressure on the water inside the column. As water evaporates out of the leaves, the process of transpiration pulls water into the leaves.

Xylem Development

The first xylem that develops in a growing plant is called **protoxylem**, and it contains narrow vessels. **Metaxylem** develops later on and has larger vessels and cells. There are four ways protoxylem and metaxylem can be arranged in a plant: **centrarch, exarch, endarch, and mesarch.**

Different between protoxylem, and Metaxylem

Protoxylem	Metaxylem
1. the first formed part of the xylem	forms later.
2. contains narrow vessels	contains larger vessels
3. tracheary elements thickenings in form: annular or spiral . ..	tracheary elements thickenings in spiral or helical ,sclariform ,reticulate and pitted
4.It develops before the plant organ has completed its growth	It differentiates when the plant .organ has completed its growth.



Types of Xylem

The two types of xylem, primary and secondary, perform the same function but are categorized by the type of growth that they are formed with.

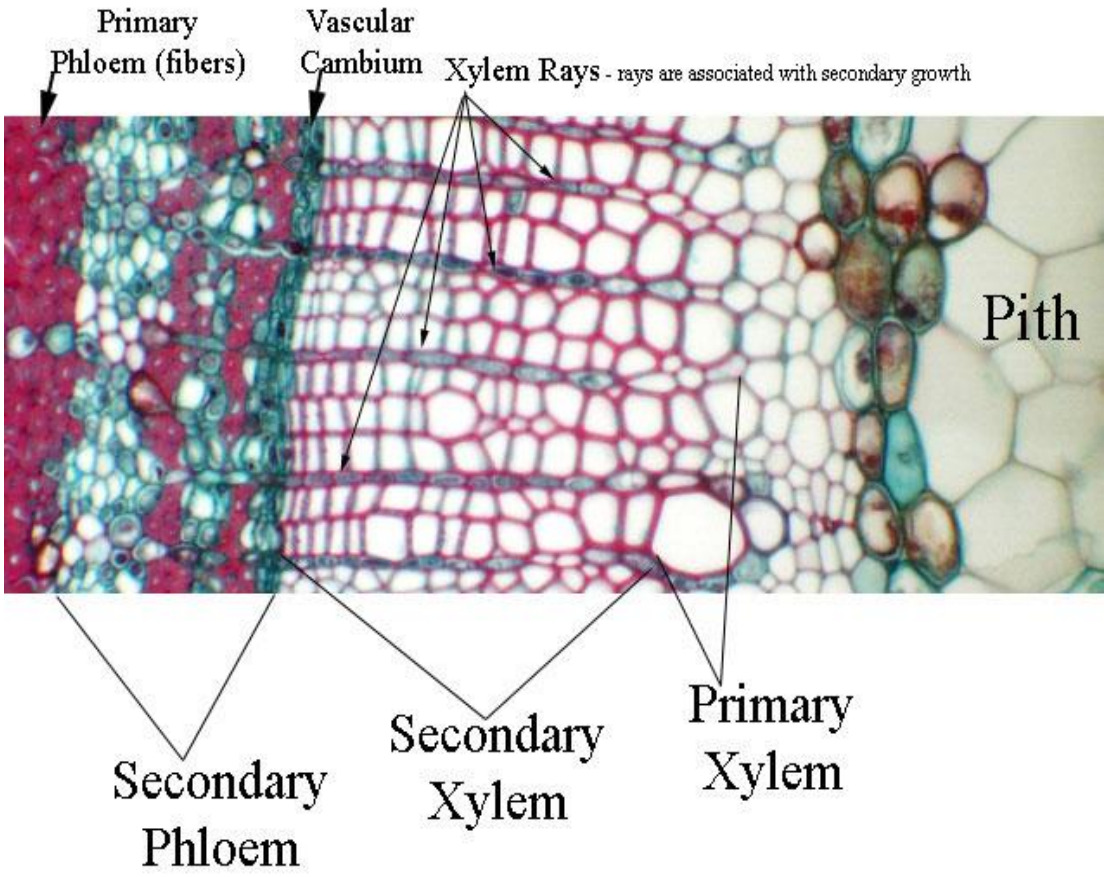
Primary Xylem:

1. Primary xylem forms with primary growth of a plant
2. arises from procambium.
3. This is the growth that occurs at the tips of stems, roots, and flower buds.
4. It allows the plant to grow taller and the roots to grow longer.

5. Primary xylem consists of tracheary elements (tracheids and vessel elements), which are dead at maturity (they have lost their protoplasts).
6. Absence xylem fibers
7. Parenchyma cells also are interspersed throughout the tissue. Both tracheids and vessel elements are long hollow cells with tapered end walls.
8. The primary xylem is differentiated into two main parts: protoxylem and metaxylem.

Secondary Xylem:

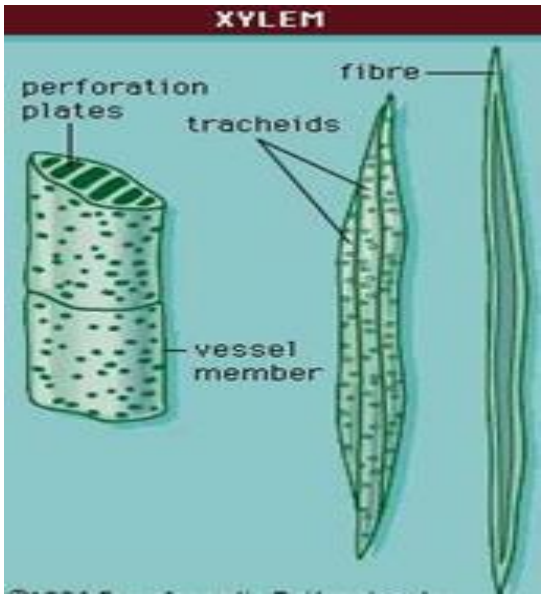
1. Secondary xylem is formed with a plant's secondary growth , arises from vascular cambium.
2. Secondary xylem is absent in non-woody plants but is present in trees and shrubs.
3. Its cell walls are thickened by deposition of lignin, thereby, rendering mechanical support to such plants.
4. Secondary xylem consists of tracheids and vessels that are shorter and wider than those of primary xylem.
5. It is also richer in xylem fibers than in primary xylem.
6. Secondary xylem may show growth rings (or annual rings). In large woody plants, the secondary xylem is differentiated into sapwood and heartwood.



Structure of Xylem

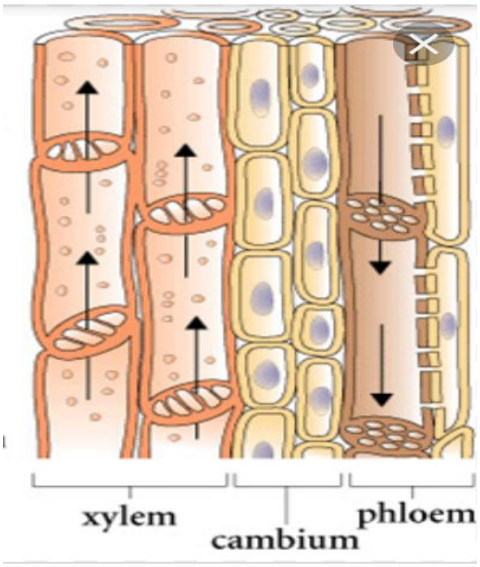
Xylem is made up of several types of cells:

1. **Tracheids** : are long cells that help transport xylem sap and also provide structural support, Tracheid, in botany, primitive element of xylem , consisting of a single elongated cell with pointed ends and a secondary, cellulosic wall thickened with lignin containing numerous pits. At functional maturity, the cell is dead and empty; Tracheids in all vascular plants and are the only such elements in conifers and ferns.
2. **Vessel elements** : are shorter than tracheids, but also help conduct water. They are found in flowering plants, but not in gymnosperms like pine trees. Vessel elements have perforation plates that connect each vessel element to form one continuous vessel.
3. **Xylem parenchyma**: a tissue that makes up most of the soft parts of plants.
4. **Xylem Fibers** that help support the plant. In a cross section of a plant, under a microscope, xylem appears star-shaped.


XYLEM
perforation plates
tracheids
fibre
vessel member

Phloem

Phloem: also called **bast**, tissues in plants that conduct foods made in the leaves to all other parts of the plant.



Phloem is composed of:

1. sieve tubes various specialized cells The sieve elements are elongated, narrow cells, which are connected together to form the sieve tube structure of the phloem. The sieve element cells are the most highly specialized cell type found in plants. They are unique in that they do not contain a nucleus at maturity and are also lacking in organelles such as ribosomes, cytosol and Golgi apparatus, which is found in angiosperms, and the more primitive 'sieve cells', which are associated with gymnosperms.

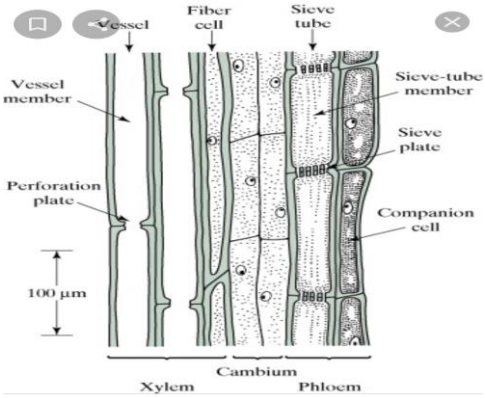
2. Sieve Plates

   At the connections between sieve member cells are *sieve plates*, which are similar *plasmodesmata*. Sieve plates are relatively large, thin areas of pores that facilitate the exchange of materials between the element cells,that two types of sieve plates:

A. simple sieve plates: pores display in plate

B. compound sieve plates: pores accumulated in separate zone name sieve area

3. **Companion Cells:** Each sieve element cell is usually closely associated with a 'companion cell' in angiosperms and an albuminous cell or 'Strasburger cell' in gymnosperm, absence in low plant and coniferales. Companion cells have a nucleus, are packed with dense cytoplasm contain many ribosomes and many mitochondria. This means that the companion cells are able to undertake the metabolic reactions and other cellular functions, which the sieve element cannot perform as it lacks. The sieve elements are therefore dependent upon the companion cells for their functioning and survival.
4. **Phloem Fibres**: The bast fibers, which support the tension strength while allowing flexibility of the phloem, are narrow, elongated cells with walls of thick cellulose, hemicellulose and lignin and a narrow lumen (inner cavity).
5. **phloem parenchyma cells**: The parenchyma is a collection of cells, which makes up the 'filler' of plant tissues. They have thin but flexible walls made of cellulose. Within the phloem, the parenchyma's main function is the storage of starch, fats and proteins as well tannins and resins in certain plants.



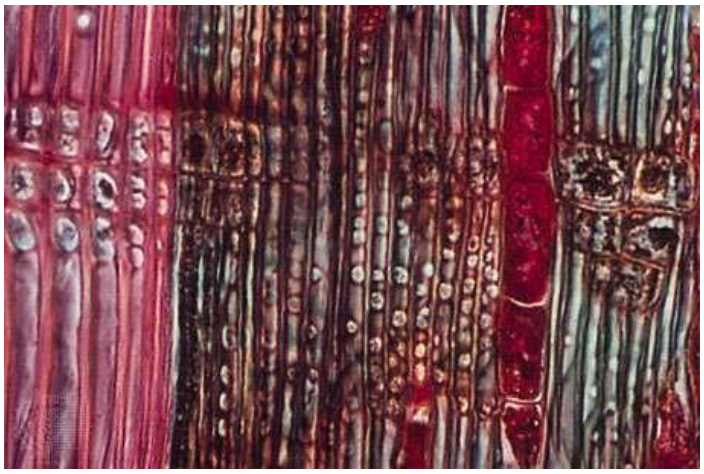
Types of phloem

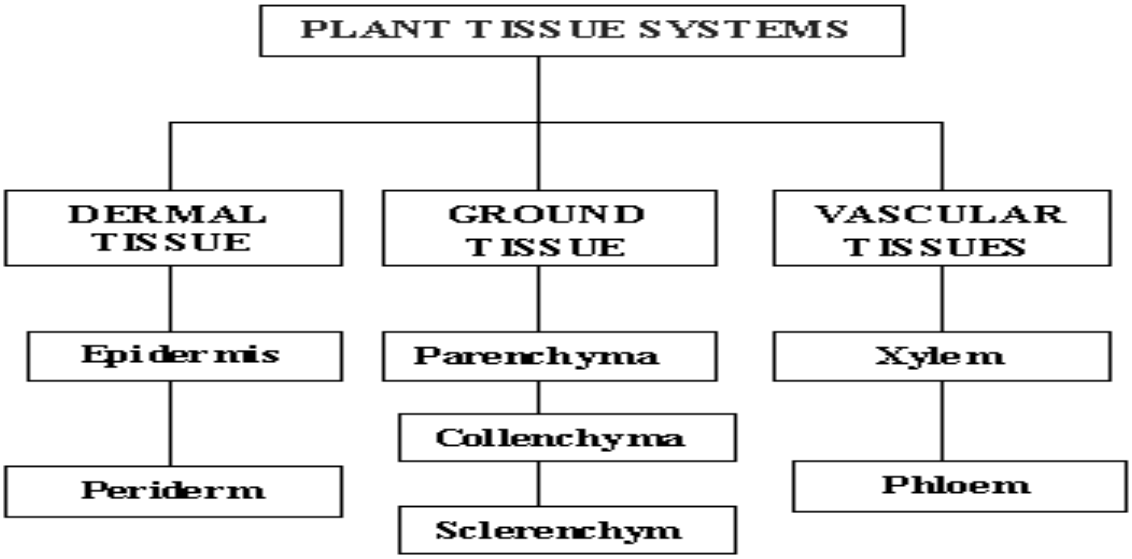
Primary phloem : formed by the apical meristems it may be classified into :

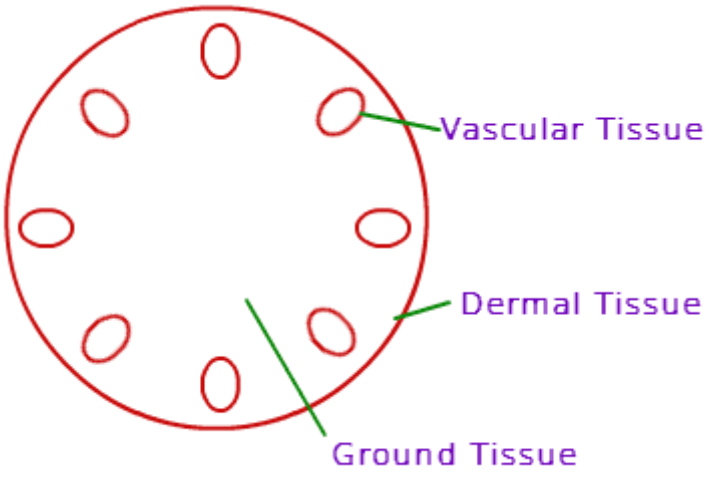
a. **Protophloem:** the cells of which are matured before elongation (during growth) of the area in which it lies.

b. **Metaphloem**: the cells of which mature after elongation. Sieve tubes of protophloem are unable to stretch with the elongating tissues and are torn and destroyed as the plant ages. The other cell types in the phloem may be converted to fibres. The later maturing metaphloem is not destroyed and may function during the rest of the plant's life in plants.

secondary phloem : formed by vascular cambium ,that arranged in axial or vertical system and they have vascular rays




PLANT TISSUE SYSTEMS
DERMAL TISSUE
GROUND TISSUE
VASCULAR TISSUES
Epidermis
Parenchyma
Xylem
Collenchyma
Periderm
Phloem
Sclerenchym


Vascular Tissue
Dermal Tissue
Ground Tissue

Plant Anatomy

Dr. Badia Abdul Razzak Malla Obaida

2021

Lec (1)

Plant Tissues

Tissue: is a group of cells that are adapted to perform a specific function or functions. It consists of two main types of tissues:

1. **Meristematic tissues:**

The term meristem (from the Greek meristos, meaning divisible), it is characteristic; small cells thin cell wall, nucleuses are large, dense cytoplasim, vacuoles absent or very small, contain proplastides, absent of intercellular spaces, have the ability of cell division, these tissues present in some places in the plant body.

Classification of meristematic tissues methods:

A- Depending on their position in plant body:

1. Apical meristems tissues

These tissues are present in stems and roots apices.

2. Intercalary meristems tissues.

It is found between persistent adult tissues away from the growing tops, such as those found in the leaf bases or above the nodes in the stems of monocotyledons. The rapid growth and increase in length in the stems of grasses and other monocots is due to the activity of this type of interstitial meristematic tissues in addition to the apical tissues.

3. Lateral meristems tissues.

It exist parallel to the epidermis.

Function: it divide to produce new cells that are added to the thickness of the stem or root. An example is the vascular cambium, which produces wood and secondary phloem, and the cork cambium or phellogen, which produces cork.

B- According to the origin:

1. Primary meristems

It arise directly from the promeristem .

Function: is forming primary parts of plant body exception of the vascular cambium or fascicular.

2. Secondary meristems

arise from meristematic cells that regain activity and the ability to divide. It builds the secondary parts of the plant body. Cork cambium gives a clear example of this type of meristematic tissue, as it arises from permanent parenchyma cells in the cortex or the surrounding circle of pericycle.

C- According to the function:

All plants contain meristematic tissue called Promeristem, which is found in the developing apices of roots and stems and arises from meristematic cells present in the embryo and from which the rest of the tissues in the plant are distinguished.

2. Permanent tissues

Tissues that have stopped active division and become distinct in a way that suits the functional specialization. Living cells contain the cytoplasm and the nucleus, and they retain their ability to divide, or some permanent tissues lose their nucleus, but the cytoplasm remains like the sieve tubes, and in some types of tissues cells die after maturation and become devoid of the nucleus and cytoplasm, and in such a case the cell becomes formed from a wall surrounding the lumen of the trait empty From protoplasts as in fibers, cork and tracheids.

Principles of Permanent Taxonomy:

1- Complexity:

a- Simple: like parenchyma tissue, collenchyma ,Sclerenchyma and cork (one kind of cells).

b- Complex: like xylem and phloem (more than one kind of cells).

2- Origin:

a- Primary: like protoderm and procambium.

b- Secondary: like secondary xylem and phloem.

3- Topographic continuity:

a- Dermal: It is represented by epidermis and periderm.

b- Vascular: It is represented by xylem and phloem.

c- Ground: It is represented by cortex and pith.

4- Physiologic similarity:

a- Protective (Dermal): epidermis and periderm.

b- Supporting (mechanical): sclerenchyma, tracheid, collenchyma.

c- Conductivity (vascular): xylem and phloem.

d- Photosynthetic: mesophyll in the leaves.

e- Secretor and excretory.

Dermal tissues

This term refers to the outer layer that envelops all plant body organs in primary and secondary growth, and connective tissue is a protective layer that separates the plant from its external surroundings and provides protection from mechanical damage it is exposed to, in addition to preserving tissues from excessive water loss They include:

1- **Epidermis**: During the period of primary growth.

2- **Periderm**: During the period of secondary growth.

Epidermis

It refers to the outer layer that envelops the primary plant body, including the root, stem, leaves, seeds and fruits. However, there are some structural, physiological and evolutionary differences between root epidermis and stem epidermis, so researchers used the term Rhizodermis

to denote root epidermis. The word is derived from two word of Greek origin (epi) = upon & (derma) = skin.

Epidermis cells characteristics:

1. Living cells, clear nuclei, with thin cytoplasm and vacuoles.
2. The cells are surrounded by a primary cell wall that contains primary pitts fields and plasmodesmata, and sometimes secondary cell walls such as *Pinus* sp.
3. without Intercellular Spaces, which hinders the passage of water vapor and gases through them except through the stomata.
4. In epidermis of air organs, the wall is saturated with a waxy substance cutin, which either penetrates the wall and is called cutinization on this process, or it is added in the form of a continuous outer layer, which is the cuticle, and this process is called an edema or cuticularization.
5. The dermis is found in the epidermis of the aerial organs, absent in the roots and the organs under the soil, and very thin or absent in hydrophytes.

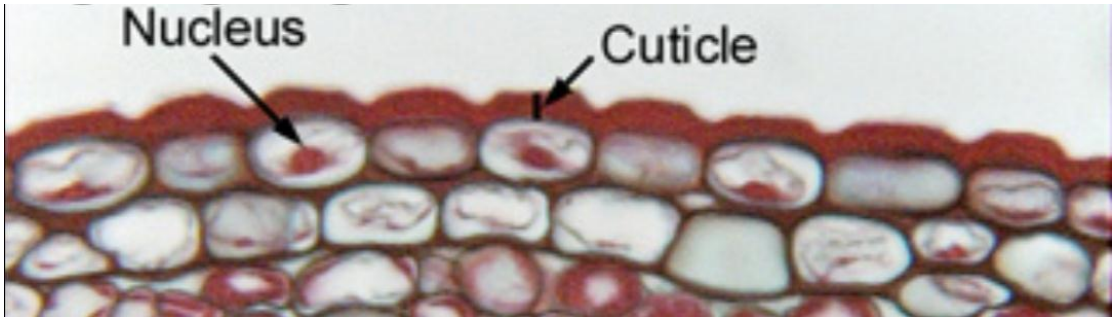


Figure showing epidermal cells and cuticle

Simple and Multiple Epidermis

-Simple epidermis (uniseriate)

-Double epidermis (double seriate)

-Multiple epidermis (multiseriate) the number of layers in this case ranges between (2 – 16) layer result from periclinal divisions.

Figure showing Simple epidermis

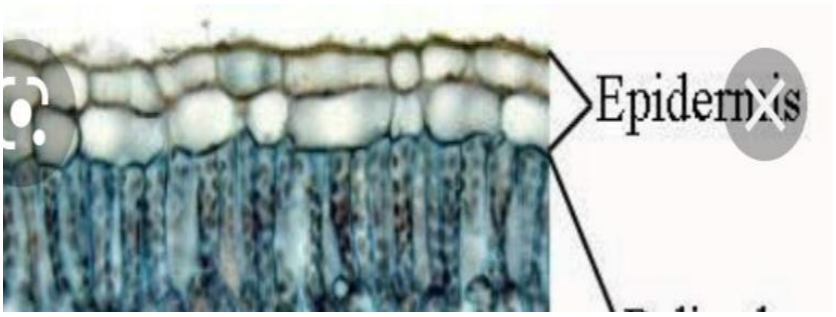


Figure showing Double epidermis

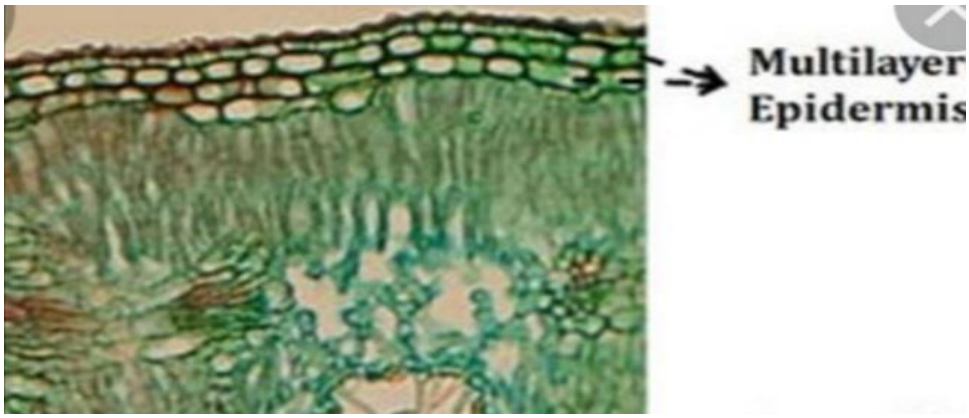


Figure showing Multiple epidermis

Epidermis functions

1- Protection.

2- Gases exchange regulation through stomata

3- Absorption through rhizosphere

4- Some kinds

of epidermis contain chloroplasts like hydrophytes & shadow plants epidermis.

5- Have the totipotenttiality to convert to secondary meristematic tissues like cork cambium.

6- Protection from:

a- mechanical damage.

b- insects and plant deseases.

c- Loosing water.

Epidermal cell types

1- ordinary epidermal cells.

2- guard cells.

3- epidermal hairs or trichomes.

Lec (2)

Types Epidermal Cell

1- Ordinary epidermal cells

The most common types of epidermal cells in most plants. Typical cell shapes and sizes vary among plants and organs. In general, they often tend to have an isodiameteric, elongated, or zig-zag shape.

2- Guard cells

It exist in pairs and each pair surrounds an opening, and the aperture and the two guard cells are called a stoma or stomatel apparatus. Kidney-shaped, it contains green plastids, living with a cytoplasm and nucleus, the side walls are thin. In sentinel cells to perform their primary function of opening and closing stomata.

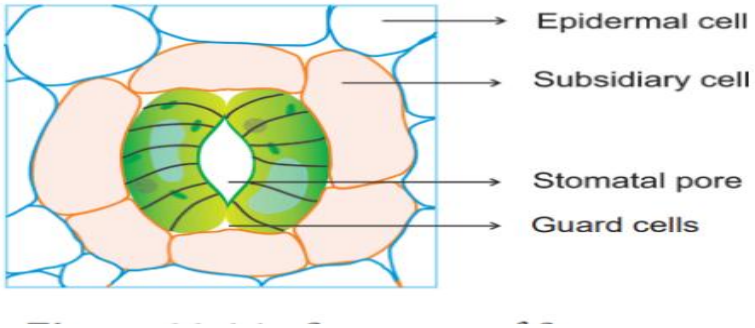


Figure showing Types Epidermal Cells

Stomata kinds

1- Monocot – Dicot type: The normal and most common type.

2- Graminae - cyeraceac type: It is found in Graminae and cyeraceac families, in this type guard cells are solitary or dumbbell shaped.

3- Coniferales type: it is called Gymnosperm type, it is found in coniferales plants such as *pinus* sp. The stomata are sunken and supplied with subsidiary cells.

Type of subsidiary cells

Stomata can be classified into :

1. **Anomocytic type:** In this type, the epidermis is not characterized by subsidiary cells.
2. **Anisocytic type:** It is characterized by the presence of three or more subsidiary, one is small and others are vary in size.
3. **Paracytic type**: In this type, the two subsidiary cells are parallel to guard cells and to the stomatal pore.
4. **Diacytic type:** In this type, the common walls of two subsidiary cells Perpendicular with guard cells on direction of stomatal pore.
5. **Actinocytic type:** In this type, the stoma is surrounded by a number of subsidiary cells that are arranged astral.

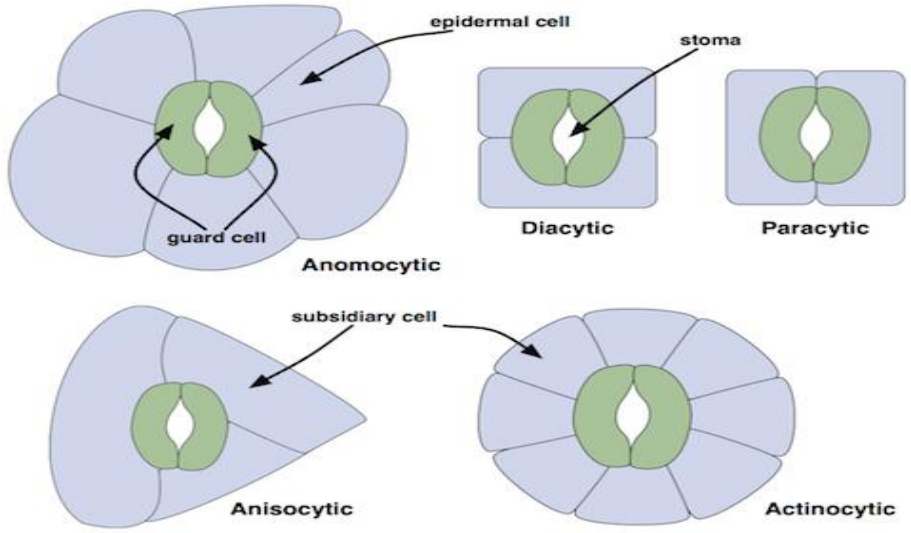


Figure showing Type of subsidiary cells

Stomata occurrence

Presence of stomata:

The stomata are found in the green aerial parts of the plant body, such as the stems and leaves, and are either on the upper and lower surfaces of leaf, or only on one of them, either upper or lower. It is absent in the parts that grow below the soil surface.

Formation of Stomata

Stomata formation Either by the oblique division of the primary epidermal cell in dicotyledons or monocytic division of the epidermal cell in monocotyledon.

3. Epidermal hairs / Trichomes

Superficial appendages or capillaries derived from skin cells differ greatly in terms of shape, composition, and function, the most important types. Trichomes can be classified into:

1- Unicellular:

a. unbranched in cotton seed

b. branched in Mathiola

2- Multicellular:

a. uniseriate in Cucurbita

b. multiseriate in Begonia

3- Dendroid (tree-like) in platanus

4- Stellate in Malva

5- Peltate in Olea

6- Glandular in Labiatae

8- Stinging hairs in Urtica

Periderm

Periderm is a protective tissue of secondary origin. It replaces the epidermis in plant organs that suffer from secondary thickening. The periderm is formed as a result of observed increase in thickness of plant organ in which secondary thickenings occur, which puts great pressure on epidermis and external parts of cortex. Which lead to torn and loses its function and replaced by dermal tissue called priderm.

The priderm has three layers from outside to inside:

1. Cork or phellem
2. Phellogen or cork cambium
3. The secondary cortex or phelloderm

The cork outer layer and the inner phelloderm are formed as a result of activity of cork cambium.

Cork or phellem

A permanent tissue composed of compact, spaced cells with sealed secondary walls usually click-free. Prismatic cells die at maturity after the completion of secondary walls. The cell becomes composed of a cell wall surrounding cell lumen devoid of protoplast.

Functions:

The function of cork layer is protective due to presence of suberin fatty substance in the walls of cells, which makes it impermeable to air and liquids.

cork cambium

Secondary meristem tissue, either side of the site, is made up of rectangular cells with largest number of indentations. It is a simple tissue that contains a single row of cells that divide to give cork to outside and phelloderm to inside.

The origin:

- In root from pericycle.
- In stem from hypodermis layer.

The secondary cortex or phelloderm

Parenchyma cells do not differ from cells of next cortex layer from inside except in regularity of their cells in continuous diagonal rows with cork cambium cells and cork cells located outside. It consists of one row of cells to a few layers, It may reach twenty layers.

The origin:

The first periderm from sub-epidermal layer.

Functions:

Phelloderm cells in some stems contain green plastids and thus contribute to photosynthesis. It also perform a storage function by retaining an amount of starch as a stored food.

Rhytidome: A term given to all the dead layers that accumulate as a result of formation periderm again and again in roots and stems of perennial tree plants and survival of those layers on plant organ. In shrubs, the dead layers of periderm often fall early and do not accumulate.

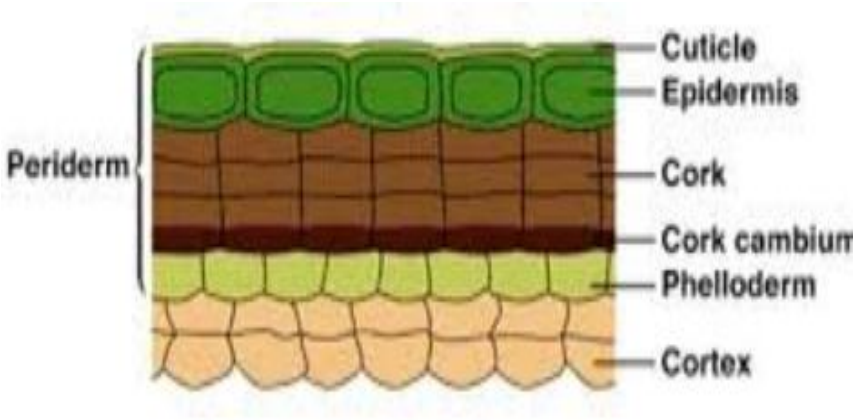


Figure showing Priderm layers

Lec (3)

Types of Tissue

Parenchyma tissue

It is found in all plant organs such as root, stem, fruits and seeds.

Characteristic:

1. It consists of live parenchyma cells, With thin primary walls, in a few cases, a secondary wall is added to the primary wall, and secondary walls are saturated with lignin.
2. Peppered with large intercellular spaces.
3. Parenchyma cells may be primary in origin, such as that consist of any primary meristems (ground meristem or procambium) during the period of primary growth, or secondary in origin when it origin from secondary meristems such as cork cambium and vascular cambium.
4. Cell shape usually globoid (spherical), isodiametric, different forces effect on cells shapes such as pressure and surface tension.
5. Parenchyma cells contain crystals, starch grains, plastids.

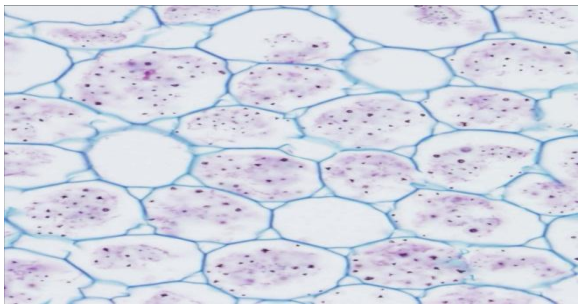


Figure showing parenchyma tissue

Functions:

1. Photosynthesis.
2. Respiration.
3. Secretory.
4. Storage.
5. Translation.

Parenchymatic tissues divided according to the shape of cells and function that it perform into:

1- Ordinary parenchyma tissues: It consists of cells that have not specialized for a particular function.

2- Chlorenchyma/ mesophyll tissues: Tissue for photosynthesis.

3- Storage parenchyma tissue: It stores fats, proteins, carbohydrates and water.

4- Aerenchyma tissue: The cells of this tissue are distinguished by their small size, paper walls, and the containment between them of large air spaces that connect these spaces to each other and form a system for ventilation, so this tissue spreads among aquatic plants.

Collenchyma tissues

Its presence is limited to the young aerial parts of plant.

Characteristic:

1. The thickness of primary cell walls is irregular.
2. There are no intercellulare spaces between cells, and if any, it is small.
3. It arises either from procambium or Ground meristem.
4. Longer and thinner compared to the parenchyma cells, as the cell length reaches 2 mm.
5. Collenchyma cells may contain chloroplasts.

Functions:

1. Provide support, especially for the young aerobic plant organs.
2. Photosynthesis.

According to the method of thickening in primary wall, the Collenchyma tissue divided into three types:

1. **Angular Collenchyma:** The cell walls are thickened in angles such as Cucurbita.

2. **Lamellar Collenchyma:** The thickenings are in the form of layers or lamina arranged on top of each other, as in the sunflower *Helianthus annus*.
3. **Lacunar or Tubular Collenchyma:** It is characterized by the presence of spaces between the cells, and the thickness is concentrated on the parts of the walls facing these spaces, as in the lettuce plant. This type is the least widespread species.

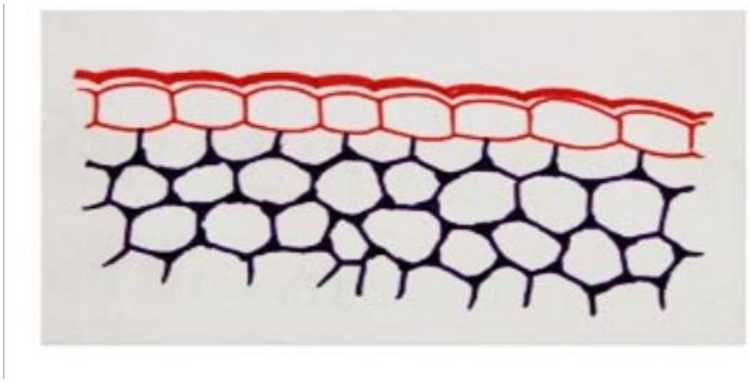


Figure showing Angular Collenchyma

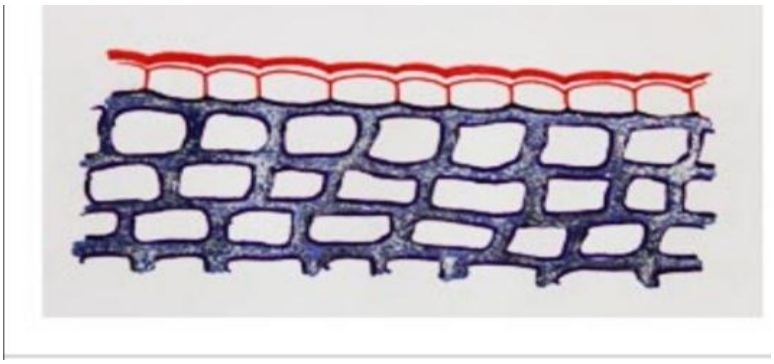


Figure showing Lamellar Collenchyma

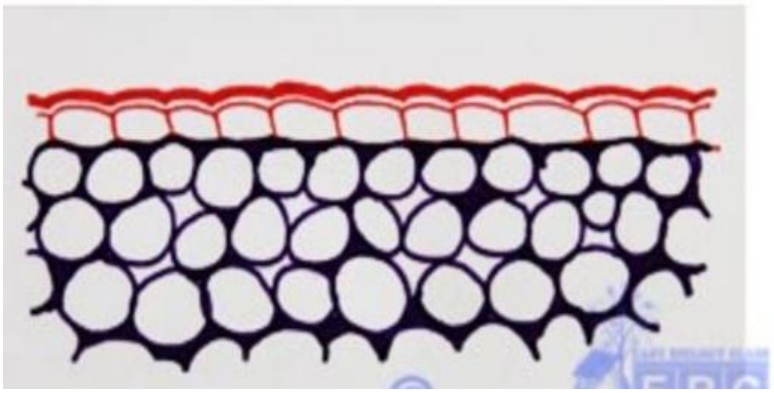


Figure showing Lacunar or Tubular Collenchyma

Sclerenchyma tissues

It is found in plant parts, whether subterranean or aerial, so it is found in roots, stems, leaves, fruits, seeds, etc.

Characteristic:

1. A simple permanent tissue whose cells die upon maturity and the cell becomes composed of a cell wall surrounding cell lumen devoid of protoplast.
2. The cells are characterized by the presence of a secondary wall saturated with lignin.

Function: support as it wins the parts where there is a mechanical support.

Sclerenchyma tissue differs from Collenchyma tissue by the following:

1. The mature Sclerenchyma cells are free of protoplasts and are surrounded by mechanized secondary walls. Distinguish it from Collenchyma tissue, whose cells are alive at maturity, and are surrounded by an elementary wall devoid of melanin and composed mainly of cellulose.
2. The presence of Sclerenchyma cells in aerial and terrestrial parts, while the presence of Collenchyma cells is limited to modern air parts only.

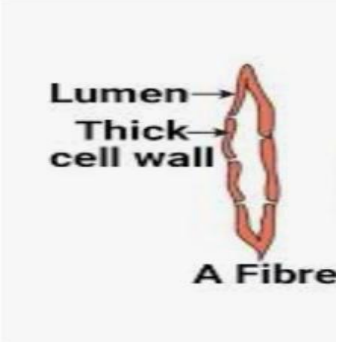
3.Sclerenchyma cells are characterized by thickening of their walls on a regular basis and in the form of elasticity, while the thickness of the walls of colinchyma cells is irregular and characterized by plasticity, which gives them flexibility.

Sclerenchyma cells are classified according to their shapes into two types:

1. Fiber Fibers
2. Sclereids

Fibers:

Long, slender selender cells with unbranched tapered ends. Its walls are characterized by elasticily, which makes cells able to regain their shape and length after stretching or stretching, making them suitable mechanical components for elderly members. The tapered ends of the fiber cells tightly overlap each other, gaining strength and durability in the parts.



Fibers are classified according to their location into:

1. xylem or wood fibers: These are found within the xylem or wood fibers.
2. Phloem fibers: These are located within the phloem tissue.
3. Pericycle fibers
4. Cortex fibers

Fibers in industry are classified into three types:

1. Surface fibers, also called short fibers.
2. Soft fibers.
3. Hard fibers.

Sclereids

It includes different types of cells that vary in their shapes and are divided into:

1. **Brachysclereids or stone cells:** it is characterized by mechanized fish secondary walls, as in the pear plant..
2. **Macrosclereids:** it is characterized by a cylindrical shape similar to gray cells, as in bean seed coat cells *Phaseolus vulgaris*.

3. **Osteosclereids or bone-shaped sclereids:** it is similar to bacillus, except that it is distinguished by their wide ends, which gives them a bone-like shape as in leaves of Hakea plant.
4. **Trichosclereids:** it is thin and may be branched, so they look like a letter Y or L, as in Olive.
5. **Astrosclereids or star-shaped sclereids:** The cells are characterized by a large number of branches, as in leaves of Nympheae water lily plant.

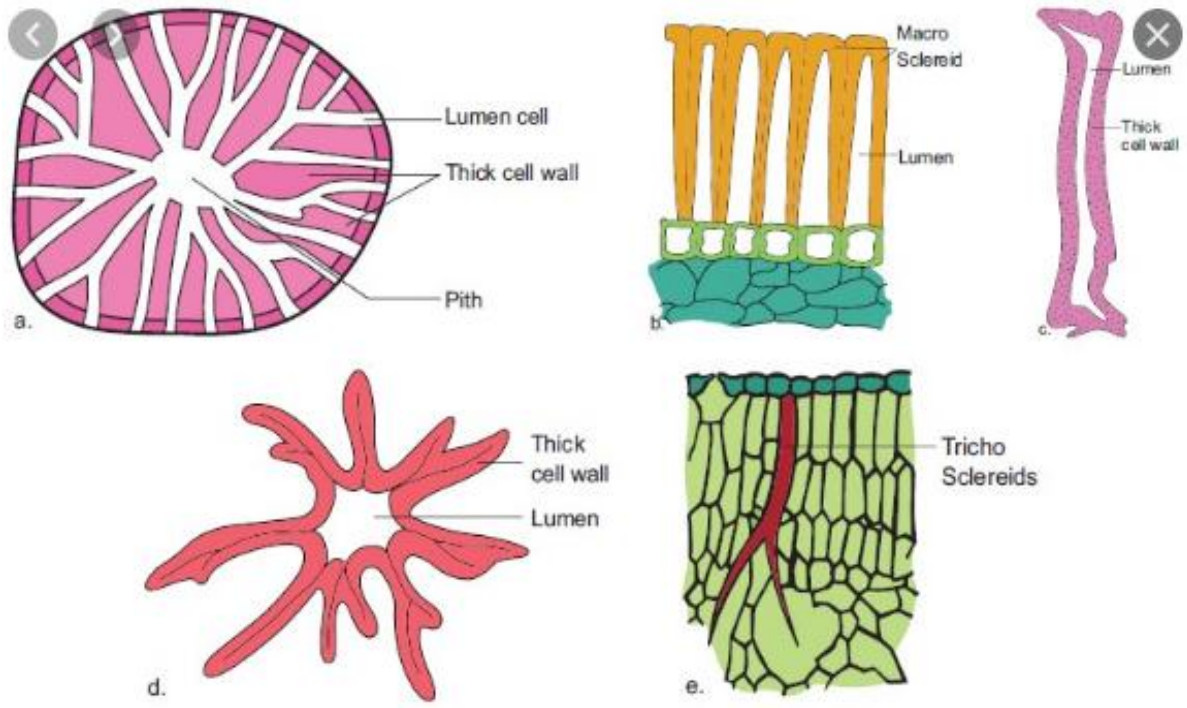


Figure showing Types of Sclereids

Lec (4)

Secondary thickening

It refers to the increase in plant thickness that occurs away from the growing vertices as a result of the formation of secondary tissues. This secondary thickening occurs in gymnosperms and in most dicotyledons. Secondary thickening is attributed to the activity of two types of meristematic tissues: the vascular cambium, which forms the secondary vascular tissue, and the cork cambium, which forms the periderm tissue.

Vascular cambium:

The lateral meristem that forms the secondary vascular tissues, it is located between the xylem & phloem in the stem & root, cylinder in shape, in most petioles & leaf veins it appears as strips. Vascular cambium cells characteristic are:

1- thin cell wall plasmodesmata, dense cytoplasm, dense endoplasmic reticulum, with many rhibosomes.
2- contain (1) nucleus its size in fusiform initials larger than in ray initials.
3- cambium cells appear in radial arrangement with the cell that produce it.
4- usually divide periclinal division and sometimes divide anticlinal division.

Vascular cambium consist of 2 kind of cells:

1- **Fusiform initials / cell:** elongated cells with tapering ends (spindle – shaped).
2- **Ray cell/ initials:** small, isodiametric cells.

Factors that effect on vascular cambium activity: (1)photoperiod, (2)temperature, and (3) water available.

Secondary Xylem Wood

When vascular cambium exerts its activity, especially in large woody plants with huge stems, large quantities of secondary wood are formed over the years, which plays a great role in delivering water and salts to all parts of the plant and providing mechanical support required by these plants.

Secondary wood structure

Secondary wood consists mainly of two systems

1. A vertical system that extends along main axis of plant organ, and it consists of tracheids, vessels, fibers and parenchymal cells.
2. A horizontal or radial system whose elements extend perpendicular to the elements of vertical system, and it consists of wood rays, which are mainly composed of paranchymic cells. In this system there may be vectors called ray tracheids as in some conifers.

Tyloses

bladder shape appear inside vessels and tracheids. It is formed as a result of swelling cell wall of parenchyma cell adjacent to a vessel or trachea through the pit into the space of that vessel or trachea, and then pit thin membrane also expands and extends into the space. This occurs when the wood becomes inactive or damaged, transfer to tyloses part of cytoplasm of the parenchyma cell, and sometimes the nucleus itself.

Annual Rings (Growth Rings)

Cambium activity in plants is seasonally because of the weather change therefore growth cycle appear and consist of:

Spring wood / Early wood: wide elements, thin cell wall, most of them are vessels.

Summer wood/ Late wood: narrow elements thickened cell wall most of them are fibers, few vessels.

Heart wood and Sap wood:

Heart wood: no active cells, cell walls thickened Low water ratio, colour dark, cells saturated with oils, gums resin, pigments. important, economical.

Sap wood: leaving cells, thin cell walls, high water ratio, light colour, function is transportation and mechanical.

Secondary Xylem in Gymnospermae

1) Simpler than Angiosperm xylem composed of tracheds, fibers, parenchyma. Vessels only occur in one order (Gnetales).
2) Some of gemnospermae contain (Grassulae) up and down border pit.
3) Xylem ray contain homocellular ray composed of parenchyma cells or parenchyma + tracheds.

Resin Ducts

Occur in gemnospermae xylem, derived in schizogenous intercellular space amon parenchyma cells which produce resin after that convert to epithelium cells. Sometimes resin duct may become closed by enlarging epithelial cells. These tylosis – like intrusions are called tylosoids they differ from tyloses in that they donol grow through pits.