

Practical plant anatomy

Plant anatomy (Second stage)/ Mustansiriyah University/ College of Science/
Dept. of Biology

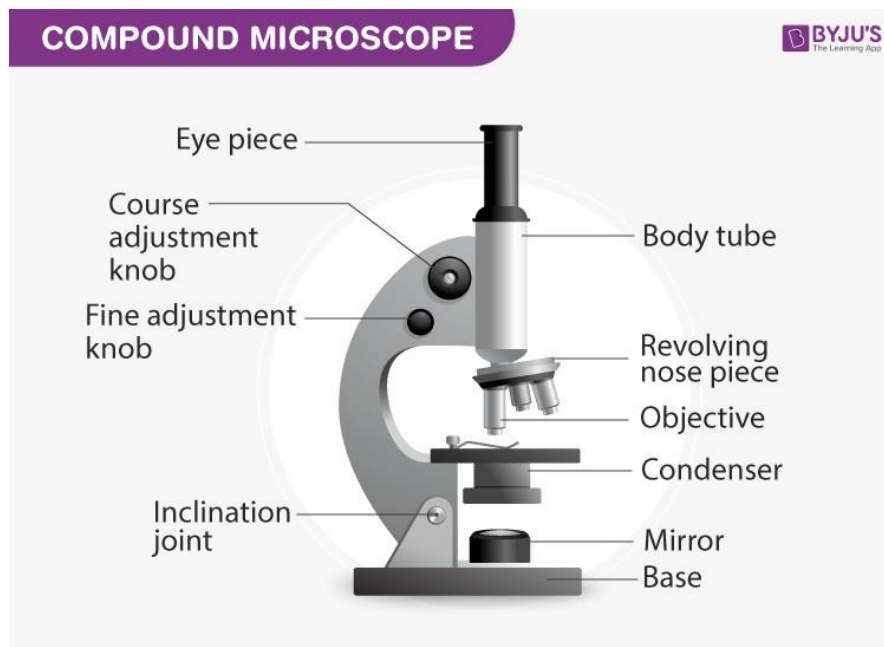
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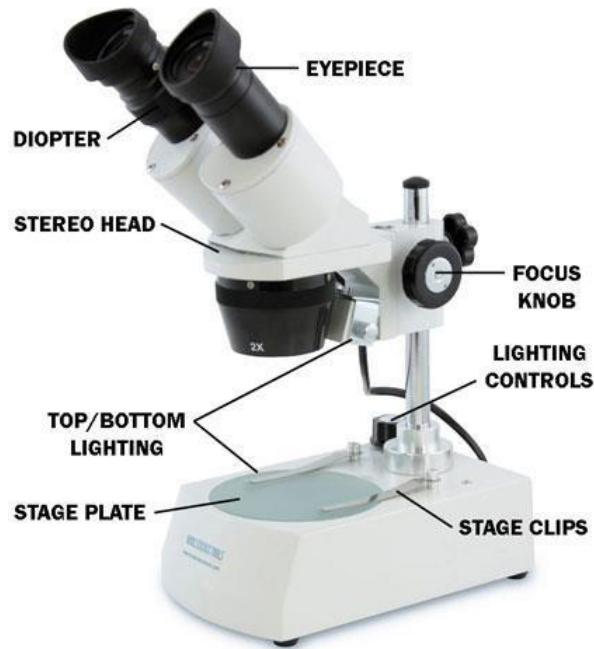
Lab 1:

Types of microscopes:-

1- Compound microscope: - It is a high resolution and uses two sets of lenses providing a 2-dimensional image of the sample. With this microscope, light is transmitted through a specimen that is mounted on a glass slide, and then focused through a series of lenses. Special lenses and optical refinements make magnifications of up to 2000 times. It is possible to observe Cell types, many of the larger cellular organelles (plastids, nuclei, vacuoles), and metabolic products such as calcium oxalate crystals and starch granules can be distinguished.



2- Stereo or dissecting microscope:- It allows the user to view the subject magnified up to 250 times its normal size; they are used primarily to study the morphology of a specimen. The magnification is relatively low.

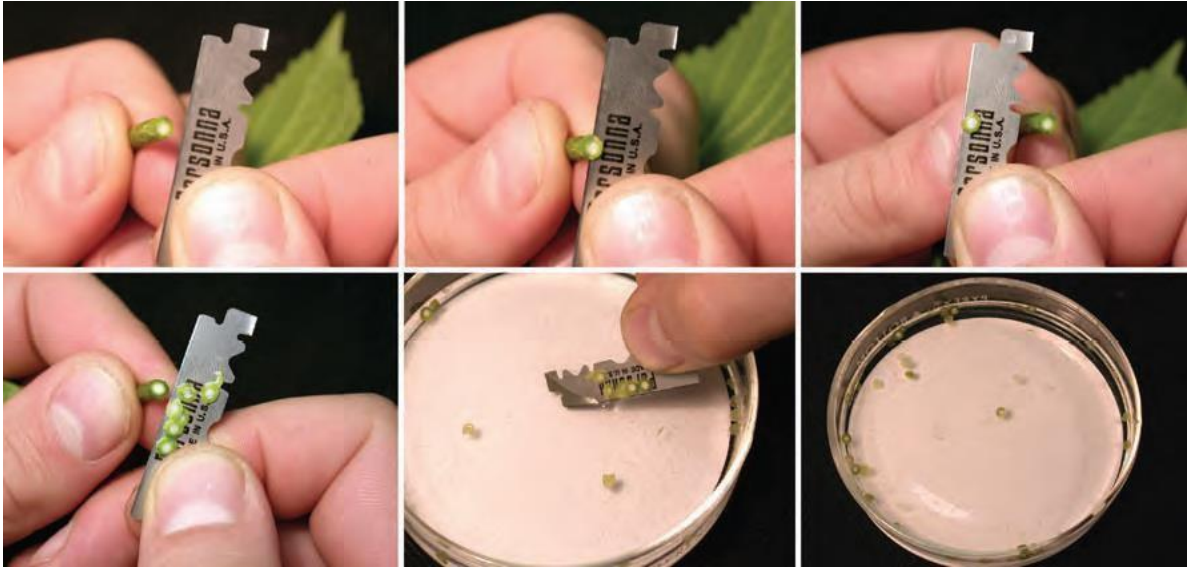


Sectioning: - There are two methods of sectioning

A- Microtome: - It is alternative methods to cut plant sections include the use of hand and electric and freezing microtomes.



B- Free-hand sectioning of living plant tissues: - It is usually done with a single edge razor blade often provides a good method for rapid and inexpensive microscopic observation of plants internal structure as illustrated in figure below.

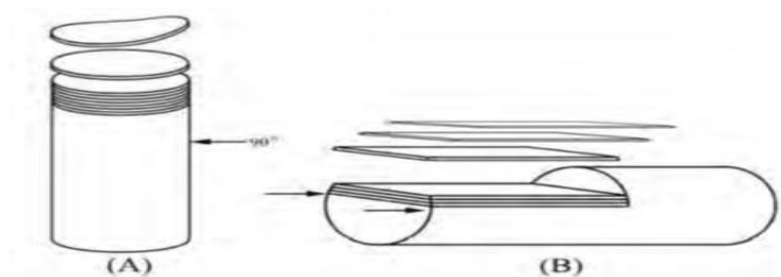


Section types:-

There are various types of sections can be prepared depending on the shape of the organ.

A- Cross sections: - When making cross (transverse) sections, it is important to cut at right angles to the longitudinal direction of the stem (or other organ) as illustrated below.

B- Longitudinal sections: - Those which are cut lengthwise along the line of the long axis of an organ or tissue.



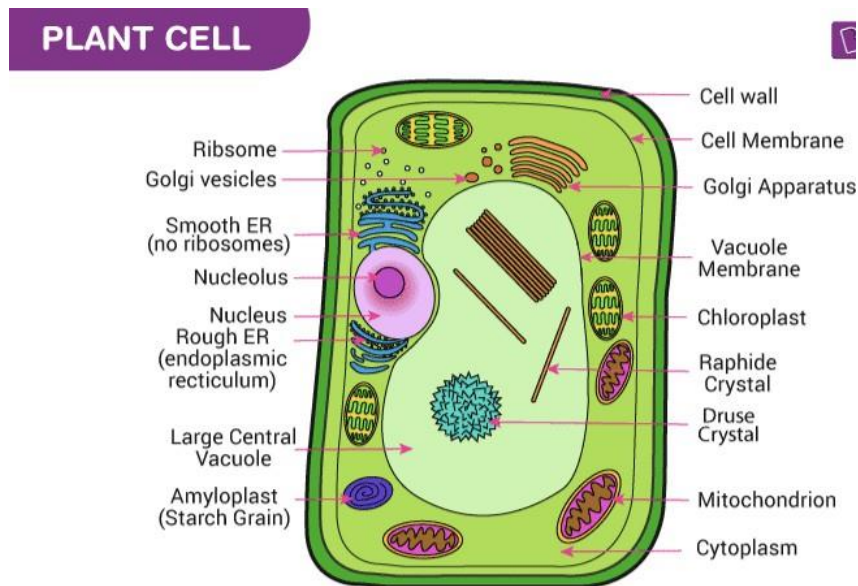
Practical work:-

Ask student to prepare sections to any available plants like carrots, stems of celery etc. to illustrate the types of sections.

Lec.2 Plant cell

Plant cell: - It is a eukaryotic cell enclosed by a cell wall, containing a membrane-bound nucleus and other cell organelles that perform different functions. The plant cell contents divided into **living** and **non-living** components.

***Non-Living components including: - Cell wall and ergastic compounds



Cell wall: - It is the outer layer of the cell, it surrounds a part of the protoplasm within it called protoplast. The presence of a non-living rigid wall containing cellulose is characteristic of plant cells. The primary cell wall in the plant is thin; in some time the primary cell wall becomes thick but it could be recognized by the presence

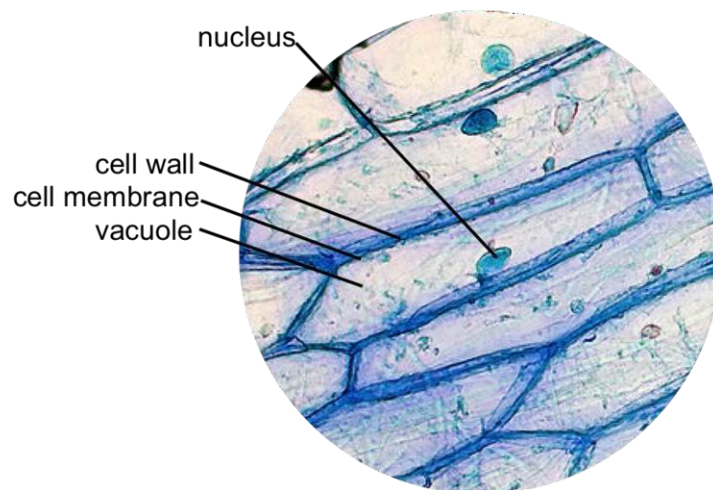
of plasmodesmata. The cell wall provides a rigid form to the cell and protects the parts inside.

Stages of forming plant cell wall:

1- Cell plate: - It is seen in the late anaphase or early telophase during plant during cell division. It is beginning in the center of dividing cell composed of pectin compounds.

2- Middle lamella: - It is a layer between the primary walls of adjacent cells.

3- Cell wall: - It usually consists of primary cell wall (cellulose, hemicelluloses, non-cellulosic polysaccharides, and pectin) and secondary walls (cellulose, non-cellulosic polysaccharides, lignin and suberin). However, the primary cell wall may be lignified to be a secondary cell wall that is thick and dead.



Primary cell wall in epidermis of onion bulb

*****Steps to prepare slide from epidermis of *Allium cepa* bulb**



Fig 1a Onion bulb sliced into sections.



Fig1b. Scale leaves of an onion bulb.



Figure 1c. Showing the removal of a portion of the epidermal layer forceps.

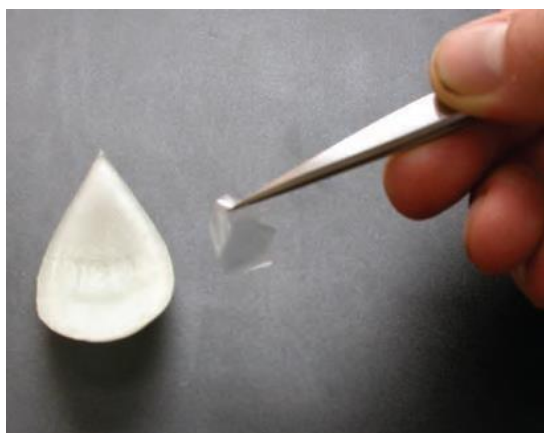


Fig 1d. A transparent epidermal peel



Figure 1e. Microscope slide of an onion

Practical work:-

- 1- Examine L.S. of onion (*Allium cepa*) root tip or *Zea mays* stem to study primary cell wall
- 2- Examine *Phoenix dactyliferae* seed to study plasmodesmata
- 3- Examine L.S. of Allium root tip (Telophase) to study cell plate and L.S. of Allium root tip (Cytokinesis) to study middle lamella.
- 4- Examine T.S of Draceana old stem to study secondary cell wall.

Lab.3

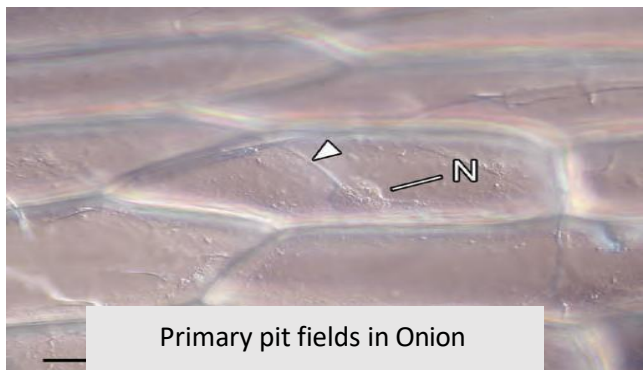
Pits

Pits: - They are thin areas or depressions on the secondary cell walls of plants. They help in the transport of minerals and water between the cells. Usually, a pit has a complementary depression in its neighboring cell. These are termed 'pit pairs'. The structure of a pit includes –

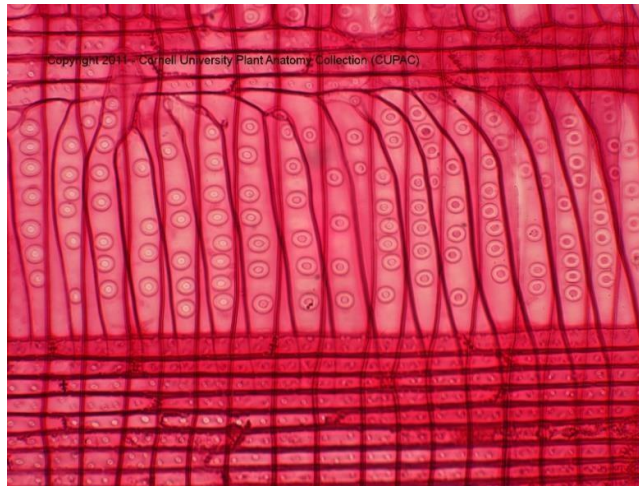
- 1- **Pit cavity** (located between pit membrane and pit aperture).
- 2- **Pit membrane** (consist of middle lamella and thin layer of primary cell wall).
- 3- **Pit aperture** (The opening that joins the pit with cell cavity).

Types of pits

- 1- **Primary pit fields:** - They are depressions on **primary cell wall** & usually associated with plasmodesmata.

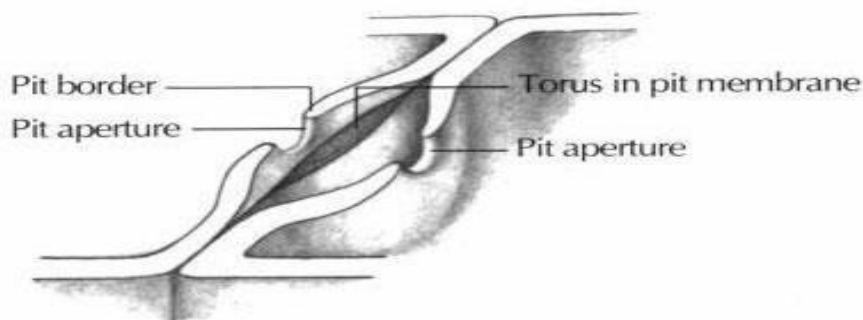


- 2- **Simple pits:** - They are thin, membrane-like structures comprising from the middle lamella and the primary cell walls which the diameter of the pit cavity and the diameter of the pit aperture are equal.
- 3- **Bordered pits:** - In this type, the secondary wall separates from the pit membrane extends into the cell forming a border, or In this case, secondary wall arches over the cavity of the pits. Thus the pit opening become narrow than the pit diameter it usually associates with xylem transport elements (tracheids and vessels) as in L.S. of Pinus Xylem appears as circular in shape.

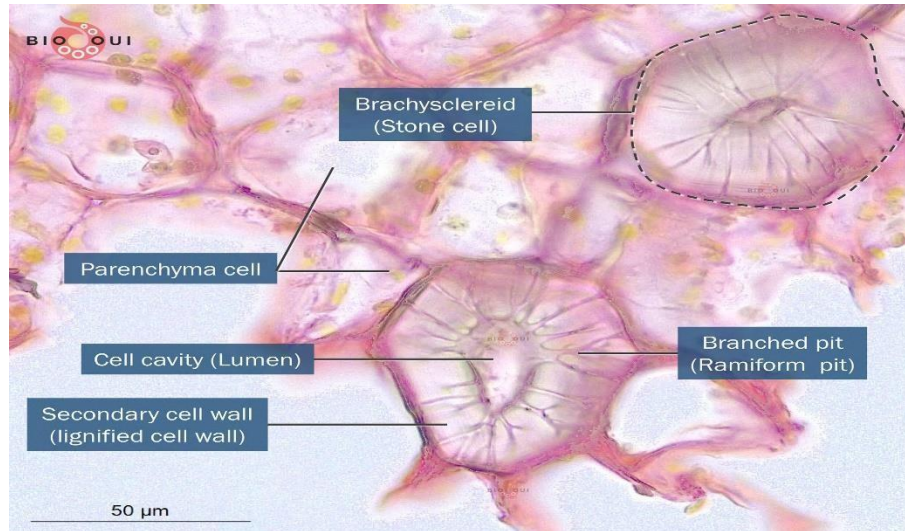


Bordered pits in L.S. of Pinus Xylem

- 4- **Aspirated pits:** In this type, the pit border is thickened to form torus to occupy the aperture, which effectively stops the flow of liquids through the pit. It found in gymnosperm tracheids as in Pinus Xylem T.L.S.



5-Ramiform or branched pits:- They occur when the secondary cell wall become more thick , so it's become like a canal connected between cell lumen and surface as in *Pyrus communis* (Pear fruit).



Branched pits in Pear fruit

Pit combination:

- 1- **Simple pit pair:** When two simple pits are combined
- 3- **Bordered pit pair:** When two bordered pits are combined as in xylem
- 4- **Half bordered pits pairs:** In this type, bordered pit has a complementary simple pit.

Practical work:-

- 1- Examine stripped of epidermis of *Allium cepa* bulb to study primary pit fields.
- 2- Examine L.S. of Pinus Xylem to study bordered pits.
- 3- Examine Pear fruit to study branched pits.

Lab.4

Ergastic or non-living substances: - Plant cells often synthesize and store substances. Some examples of these ergastic substances are starch grains, crystals, pigments, aleuron grains and phenolic compounds as following:

First-Starch grains: - They are the primary carbohydrate storage reserve, it is the most abundant carbohydrate in the plant world. Based on its biological functions, starch is often categorized into two types:

A- Transitory starch: - The starch which is synthesized in the leaves directly from photosynthates during the day is typically defined as transitory starch.

B- Storage starch: - The starch in non-photosynthetic tissues, such as seeds, stems, roots or tubers, is generally stored for longer periods and regarded as storage starch. It usually stored in amyloplasts.

The storage starch varied in shapes, types, sizes, position and shape of hilum and starch stratification. Regarding types of starch grains according to hilum, there are three:

A-Simple Grain: - It contain one Hilum accumulate around it starch layers.

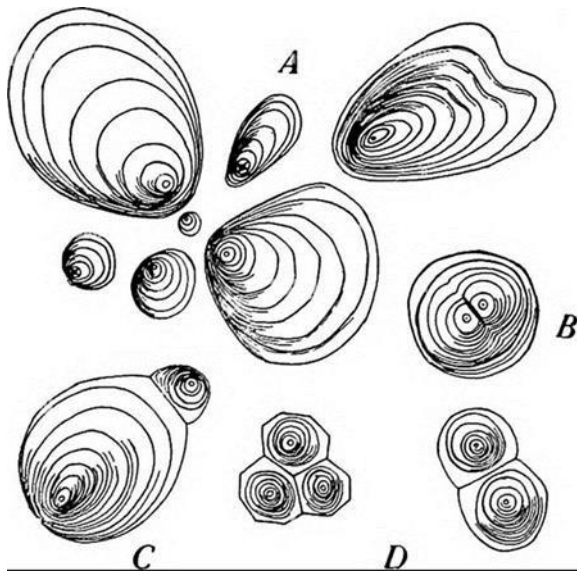
B-Semi-compound Grain: - It contain more than one Hilum and the starch layers accumulates around it and then a common layers accumulates around the Hilum.

C- Compound Grain: - It contain more than one hilum and the starch layers accumulates around it in separating shape from each other. Compound grains are commonly found in potato, sweet potato, rice and oats.

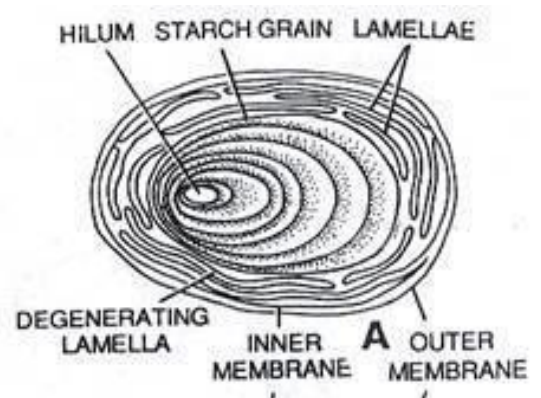
D- Cracked hilum starch grain:- The starch grain is cracked as in bean.



Cracked hilum in beans



A, simple grains; B, semi-compound grain; C and D compound grains in potato tuber



Structure of amyloplast containing starch grain

While starch stratification, most of the starch grains show this layering and are known as stratified starch grains. There are two types of starch grain according to stratification

A- Accentric grain: - If the concentric layers of the starch are formed on one side of the hilum of starch grain, the grain is said to be accentric (e.g., potato)

B- Concentric grain: When the layers are deposited concentrically around the hilum (e.g., wheat) the grain is known as concentric. This type of starch grains are quite common in most of the plants.

Two- Aleurone grains: - They are storage protein bodies, the grain composed from crystalline protein (crystal body) and amorphous protein part which is globoid body embedded in the matrix surrounding by membrane. These grains found in the endosperm of some seeds. These act as a source of amino acids for various synthetic activities during germination, but also represent important nutritional sources for humans.

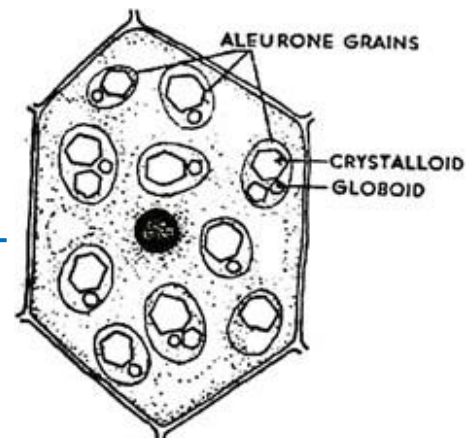
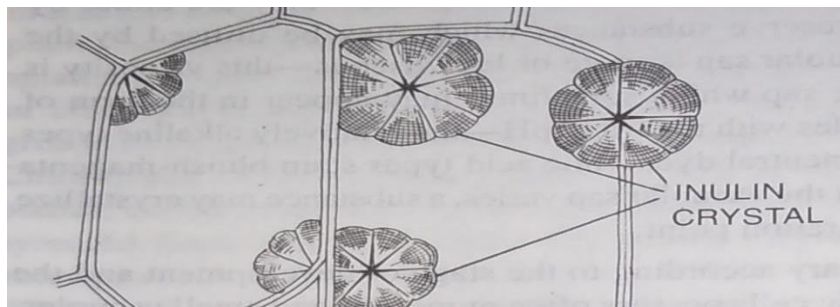


Fig. 126. Aleurone grains in a cell from endosperm of castor-oil seed.

Three -Crystals:- 1- Inuline crystals: - Inulin crystals are natural storage polysaccharides with a large variety of food and pharmaceutical applications. It is widely distributed in plants, especially in the tubers. The crystals of *Helianthus tuberosus* tubers are spherical in shape and it was shown to be a mixture of oligo- and/or polysaccharides composed of fructose units with β -configuration of the anomeric C2, which makes inulin-type fructans resistant to hydrolysis by human intestinal digestive enzymes that have specificity for α -glycosidic bonds. For this reason all these compounds have been classified as non-digestible oligosaccharides.



Practical work:-

- 1- Trim a piece of potato tuber and cut thin sections, including some of the peel (periderm), stain with a drop of I_2KI on a slide and mount in a drop of water under a cover glass. Large simple starch grains will stain purple.
- 2- Cut thin sections of a root of sweet potato, stain with I_2KI , and mount under a cover glass. Compound starch grains will stain purple.
- 3-Exam prepared slide of *Ricinus communis* seed to study Aleurone grains.

Lab.5 Non-living components

2- Calcium oxalate crystals: - They are distributed in many plant species. The crystal formation is generally intracellular and inside the vacuoles of specialized

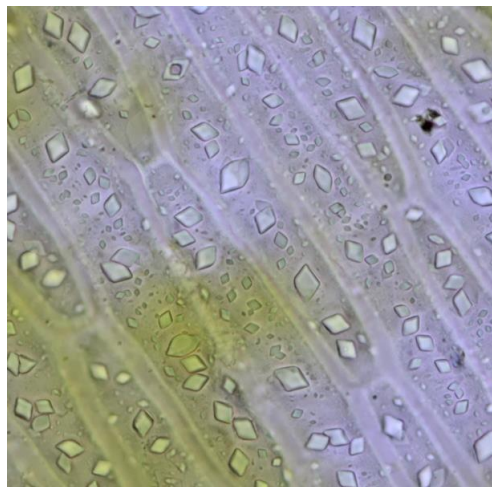
cells called idioblast. In many plants, oxalates might be metabolized very slowly. However, they might have a toxic effect when accumulating in excess quantities. They can be found in any organs of plant like root, stem, leaf, floral organs and fruits.

***Functions of calcium oxalate crystals

- A- Remove excess oxalate or calcium, other functions of CaOx crystal formation in plants include high-capacity calcium (Ca) regulation
- B- Protection against herbivores from eating plant parts.
- C- Participating in calcium homeostasis and storage of calcium.
- D- Participating in metal detoxification and tissue support.
- E- Tolerance to heavy metals

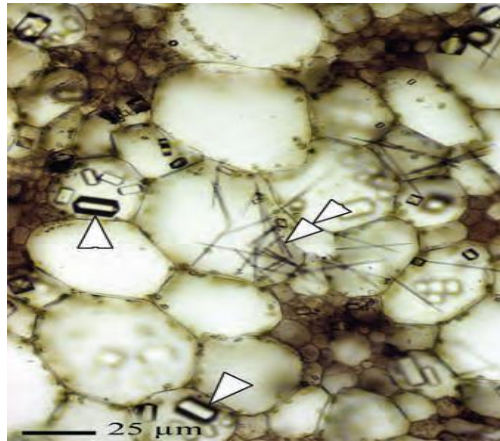
Furthermore, the presence or absence of crystals may represent useful taxonomic characters and also be used for understanding the evolutionary relationships of plant species. Calcium oxalate crystals have been classified into five main groups based on their morphology: as **prismatic**, **druses**, **styloids**, **raphides** and **crystal sand**.

A- Prismatic crystals:- They are colorless crystal with a shape resembling a prism.



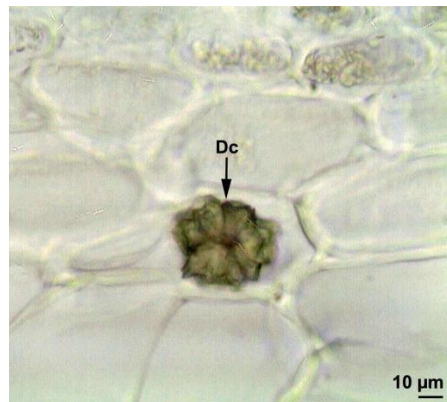
Prismatic crystals in the epidermis of *Dracaena marginata*

B- Raphides:- They are the most commonly form of crystals, they are distinguished by their pointed needle-like shape and range in length from around 16 up to 300 μm in some plants. Raaphides are typically observed in large numbers and closely packed and arranged in parallel in regular cylindrical bundles or thinner as in leaves and stems.



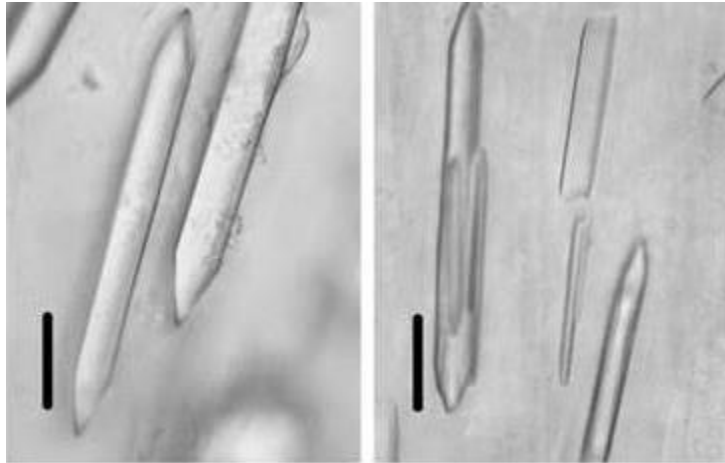
C.S of *Tradescantia* sp. stem showing prismatic crystals (arrowheads) and raphide crystals (double arrowhead)

C- Druses: - They are a common occurrence in many plants and are usually star-like in shape and are thought to be a defense against herbivory due to their toxicity



Druses crystal in the stem of *Tribulus terrestris*

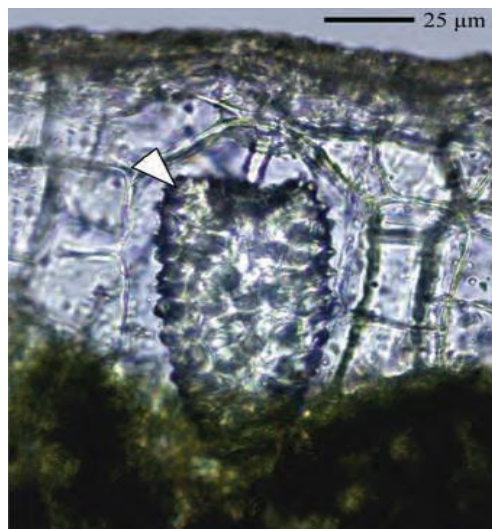
D- Styloids: - They are elongated crystals, with pointed ends, they are a diagnostic feature of certain families, including Agavaceae, Iridaceae and Asteraceae.



Styloids in Asteraceae

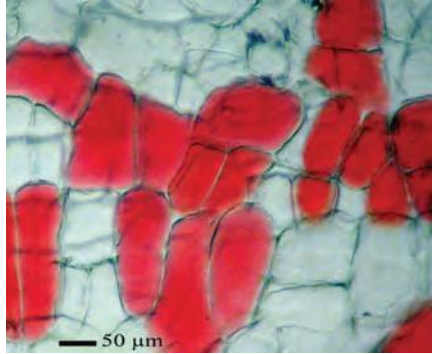
E- Sand crystals: - They are formed by accumulation of small individual crystals, it is found in the leaves of *Beta vulgaris*

3- Calcium carbonate crystal: - It is very unusual calcium carbonate crystals (cystoliths) in specialized large epidermal cells called lithocysts. The calcium carbonate is deposited around a cell wall extension found in the leaves of Rubber plant (*Ficus elastica*).



T.S. of a rubber plant leaf showing a large cystolith (arrowhead)

Four-Vacuolar pigments:-They are pigments found in the vacuoles like Anthocyanins which are red or blue water-soluble pigments that are found within vacuoles. Roots of garden beet (*Beta vulgaris*), some fruits, and many red and purple petals have cells with anthocyanin pigments in their vacuoles.



Unstained section of beet root showing cells with vacuoles filled with anthocyanin pigment

Practical work:-

- 1- Prepare thin sections of *Tradescantia zebrina* stems (at least 20 cm from the growing tip), place in a drop of water on a microscope slide and cover with a cover glass. Prismatic and raphide crystals will appear.
- 2- Prepare thin sections of sweet potato (*Ipomoea batatas*) roots or stem or leaves of *Tribulus terrestris* (distributed widely in Baghdad), mount them in water under a cover glass, and observe the druse crystals.
- 3- Prepare thin transverse sections of a portion of a rubber plant leaf and mount in water under a cover glass. Several lithocysts should be visible and these may have Cystoliths.
- 4- Prepare thin sections of a garden beet root, mount in water under a cover glass, and observe parenchyma cells containing anthocyanins.
- 5-

Lab 6:-

Plastids

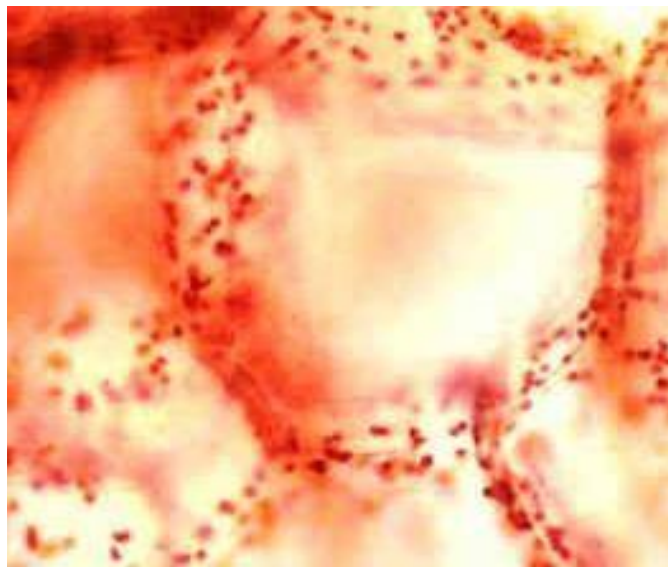
Plastids: - They are large cytoplasmic organelles, they synthesis and store carbohydrates that vary in structure and function and size. Most plant cells contain plastids, having their origin from proplastids. There are various types of categorized according to their structure, contents, and function.

- 1- Coloured plastids:-** chloroplasts (chlorophyll) and chromoplasts (carotenoids)
- 2- Colorless plastids (leucoplasts):** They include amyloplast (starch store), proteinoplast (protein store) and elaioplast (lipid store).

A- Chloroplast: - They are the primary type of plastids present in all green parts of plants which characterizing by their green pigment (chlorophyll). The chloroplasts can be found in leaves stems, petioles, pods, immature petals, sepals, tendrils and a variety of other green plant structures. Chloroplasts carry out the process of photosynthesis. Palisade and spongy mesophyll cells in leaves are the major sites for chloroplast development.



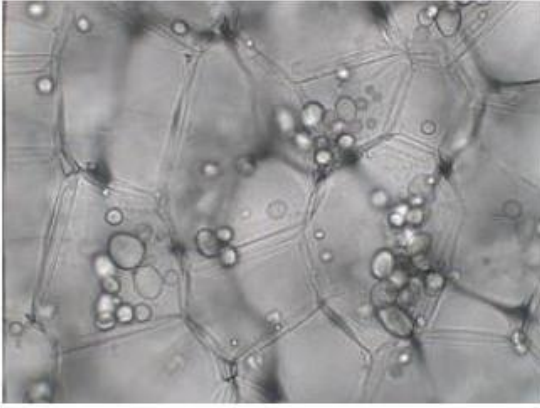
B- Chromoplasts: - They are colored types of plastids usually contain yellow and orange carotenoid pigments (carotenes and xanthophylls) which are the site of pigment accumulation in cells of flower petals, fleshy fruits and in a variety of other pigmented structures found in the diverse types of flowering plants. Chromoplasts that contain carotenoid pigments impart the red, orange, or yellow colors to various fruit (e.g., tomato fruits), roots (e.g., carrot roots), and petals. The main function of chromoplasts are assisting with pollination and seed dispersal.



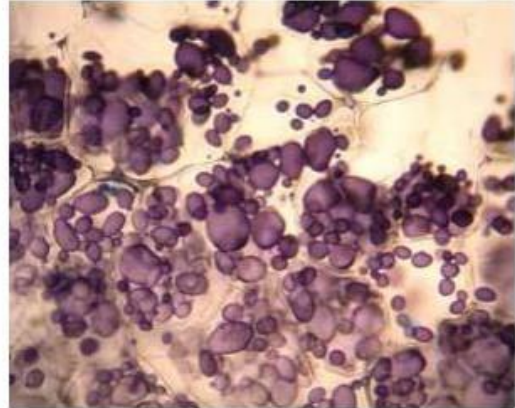
Chromoplasts in tomato fruits. Each red dot is a chromoplast that contains carotenoids

C- Leucoplasts: - They are colorless plastids. The main function is storing food materials. They do not involve in synthetic activities. There are three types of leucoplasts:-

1- Amyloplasts: - They are colorless plastid is found in some tubers and endosperms, they store starch such as tuber of potato.

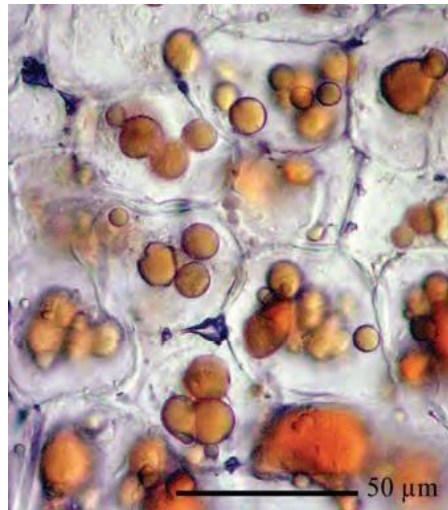


Potato cells with DI water



Potato cells with Iodine

- 2- **Elaioplasts:** - They are colorless plastid is found in the epidermal cells of Orchidaceae and Liliaceae. They store oils.



Section of an Avocado (*Persea americana*) fruit showing large lipid bodies

- 3- **Proteinoplasts:** - They are colorless plastid is found in some seeds and nuts. They store proteins such as tobacco root.

*****Practical work:**

- 1- An interesting exercise is to compare the plastids in a variety of sweet peppers (*Capsicum annuum*). Purchase green, yellow, orange, and red peppers from local market and prepare thin sections of each fruit type with a sharp razor blade. Mount these sections in water under a cover glass and observe the plastids.
- 2- Prepare a slide from potato tuber to observe amyloplasts.
- 3- Prepare a slide from Avocado fruit to observe lipid bodies.

Lab.7

Tissues

The plant body has four basic organs: roots, stems, leaves, and flowers/fruits which composed of tissues. Tissues are cell complexes, which are similar in origin and structure, and are carrying out specific functions.

Tissues are classified to

A- Meristematic tissues

B- Permenant tissues

A- Meristematic tissues: - They are groups of densely packed cells with thin cell walls. Meristematic tissue consists of meristematic cells that have the capacity to divide and form new cells. These tissues can be found in root tips, shoots, buds, and any place where new growth occurs.

The properties of meristem tissue are:

- 1- Small size
- 2- Cells are capable of active cell division

3-The cells surrounded by primary cell wall (thin wall)

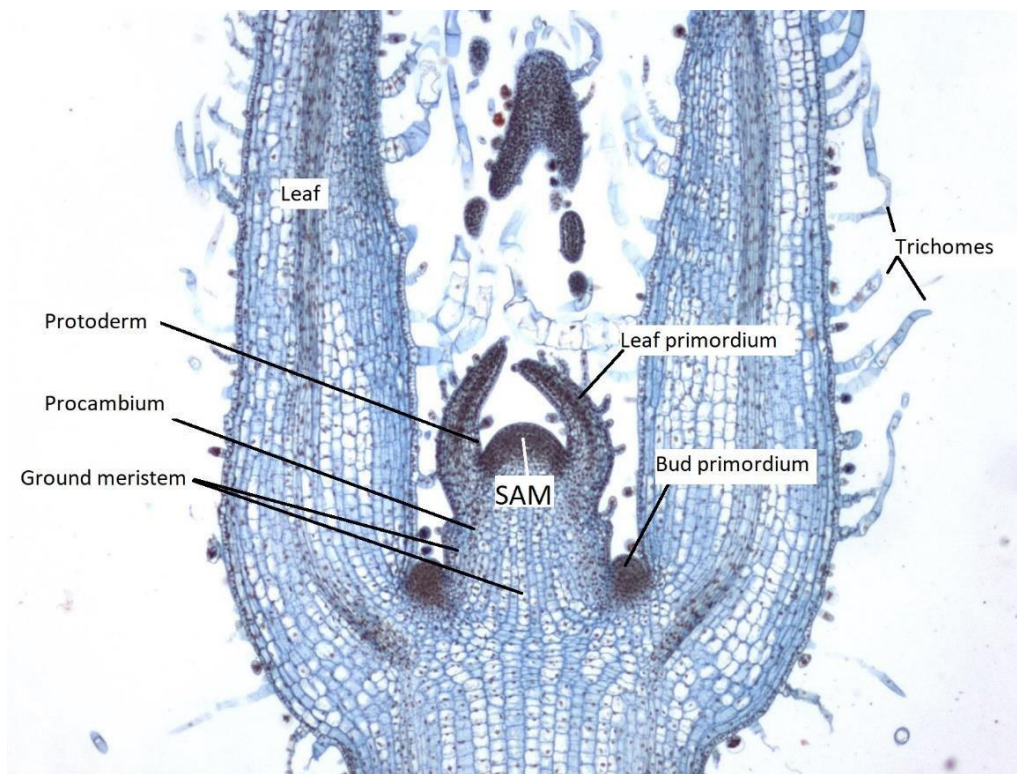
4-No intercellular spaces is found

5- The cells have less vacuoles or absent

6- They are rich in cytoplasm

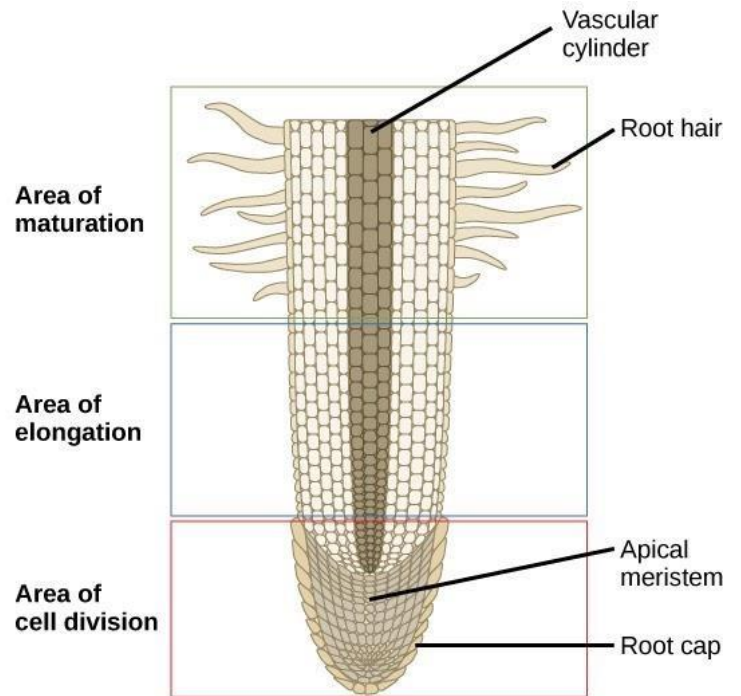
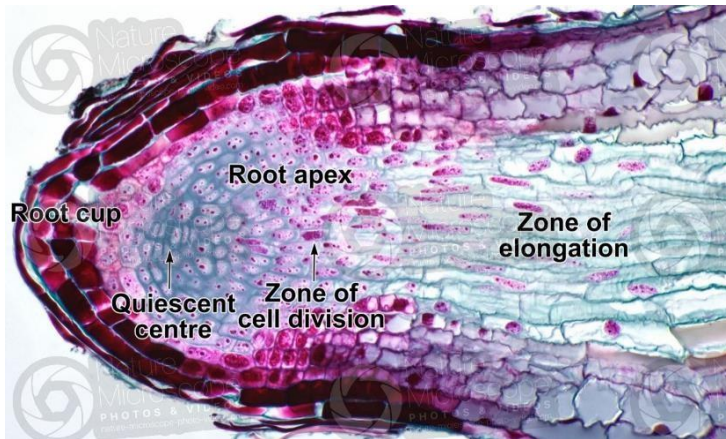
The meristematic tissues are divided according to position to **apical meristems**, **intercalary meristems** and lateral meristems

***** Apical meristems:** - They are specialized zones of growth found at the tips of plants. These are responsible for the extension of shoots and roots and are also responsible for the primary plant body.



Longitudinal section of Coleus stem tip showing the meristematic region

If L.S of a root tip is carried out, four root regions will be recognized: the **root cap**, the **region of cell division**, the **region of elongation** and the **region of maturation**



L.S. of pine root tip showing root regions

B- Permanent tissues are consisting of plant cells that are no longer actively dividing. This tissue is divided into

A- Simple (consisting of one cell type only), as in the case of parenchyma or collenchyma

B- Complex (consisting of two or more cell types) as in the case of xylem, phloem and epidermis. Thus, an organ such as a leaf is made of three different tissues (epidermis, mesophyll/Chlorenchyma and vasculature), with each tissue composed of up to three general cell types (parenchyma, sclerenchyma, or collenchyma).

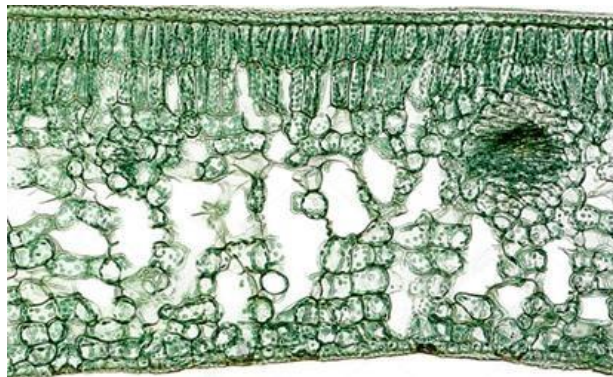
1- Parenchyma tissues: - They are type of simple tissues which its cells are alive, metabolically active, capable of dividing, bounded by thin primary cell wall, have nucleus, various amounts of cytoplasm, and one or more vacuoles. Usually intercellular spaces occur in the tissue. Altogether, parenchyma represents about 90% of the cells found in a typical herbaceous seed plant.

The main functions of parenchyma tissues are

- A- Photosynthesis
- B- Nutrient assimilation
- C- Respiration
- D- Storage and secretion

*** Parenchyma tissue can be divided according to its function to

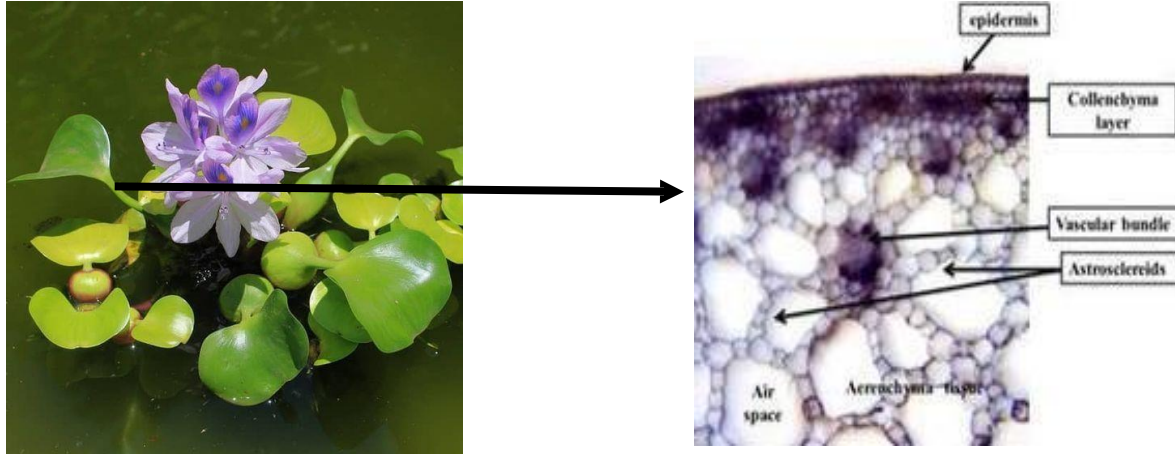
A- Chlorenchyma: - It is chloroplast-containing parenchyma of leaves that carry out photosynthetic activity because their thin primary cell walls allow more efficient diffusion of light, water, gases, and metabolites.



Cross section of a Camellia leaf (Tea plant) showing Chlorenchyma

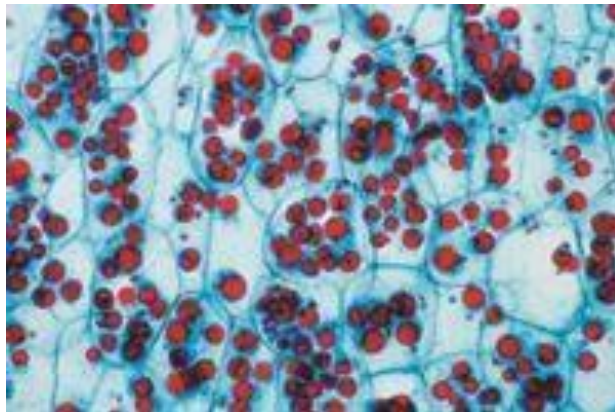
B- Aerenchyma (Air storage): - it is composed of parenchyma cells and common in the leaves, stems, and roots of aquatic plants. In these plants, the air in the spaces helps in aeration, floating leaves or stems and also to give the

plants floating and support. The buoyancy of many water plants further enables them to take light at the surface of the water for effective photosynthesis.



C.S. of petiole of Water Hyacinth (*Eichhornia crassipes*) showing aerenchyma

C- Food storage parenchyma: - Parenchyma cells store food material in the form of oil, fats, proteins, and starch, for example, parenchymatous tissues in roots and stem tubers.



Food storage parenchyma of C.S. of castor oil endosperm

D- Water storage parenchyma: - These store water as they act as a water reservoir in succulent plants such as Cactaceae, aloe, agave, etc. The cells are characterizing by thin-walled, chlorophyll free and water turgid cells.

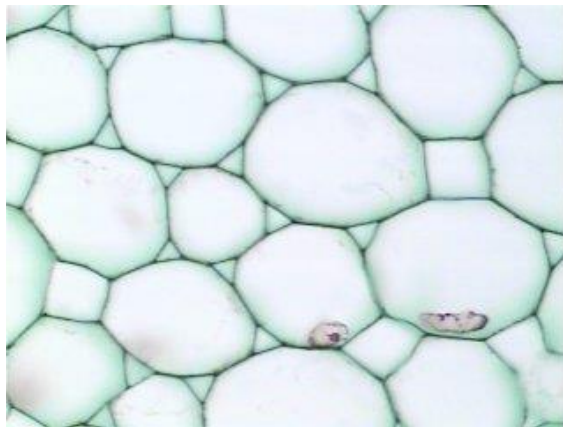


Water storage parenchyma

C.S of *Salsola oppositifolia* leaf showing storage parenchyma

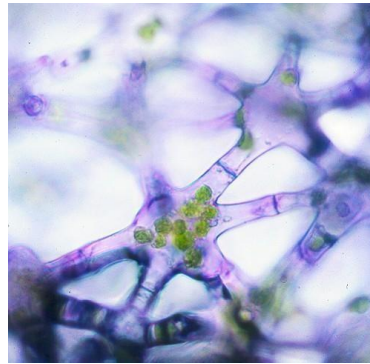
*****Parenchyma tissue can be divided according to its shape to**

A- Ordinary parenchyma cells: - They are the most dominant type of parenchyma in the plant, and it have large intercellular spaces, and also characterized by their large vacuoles. They distributed in the pith of stems.



Ordinary parenchyma cells in the pith of stem

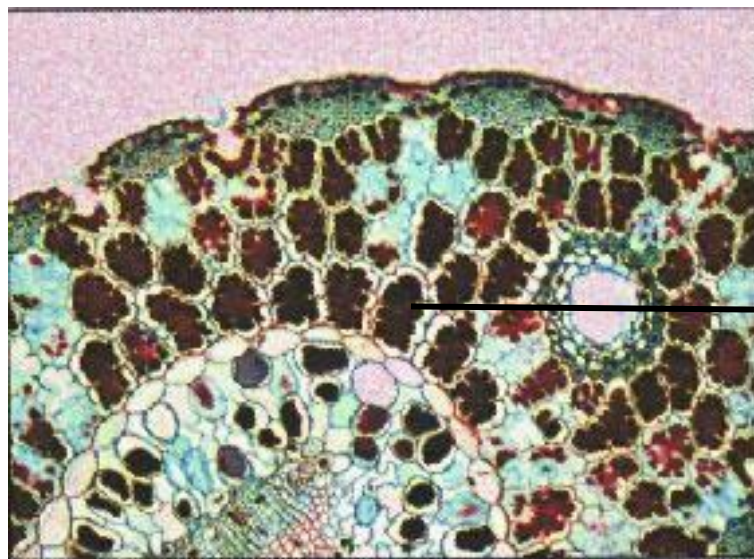
B- Stellate parenchyma: - They are present in the petioles and midribs of Canna and banana leaves. These are a type of aerenchymatous tissues that are made up of parenchyma cells and are found in aquatic plants.



C.S. of Canna petiole showing stellate parenchyma stained with Toluidine Blue

C- Columnar parenchyma: - it can be found in the palisade tissue of leaves.

D- Folded parenchyma: - It is s the parenchyma cells with folds around their edge, which usually a characteristics of some gymnosperm for example the pine leaf.



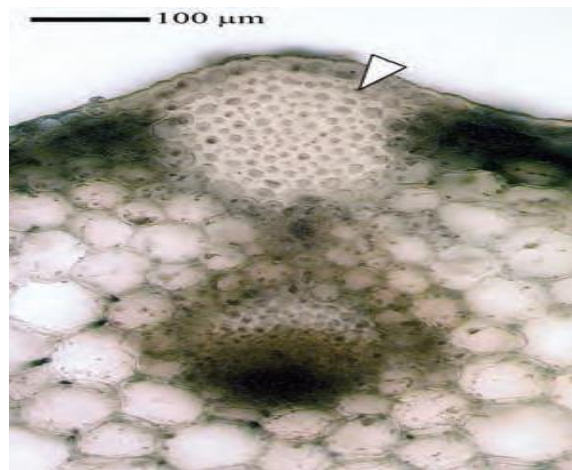
Folded parenchyma

C.S. of Pine leaf showing folded parenchyma

2- Collenchyma: - It is living supportive tissue that has elongated cells and an unevenly thickened primary cell wall. Its main function is the mechanical support of young stems and leaves; like parenchyma cell, collenchyma cells can restart meristematic activity. Collenchyma is not a widespread tissue in the body of the

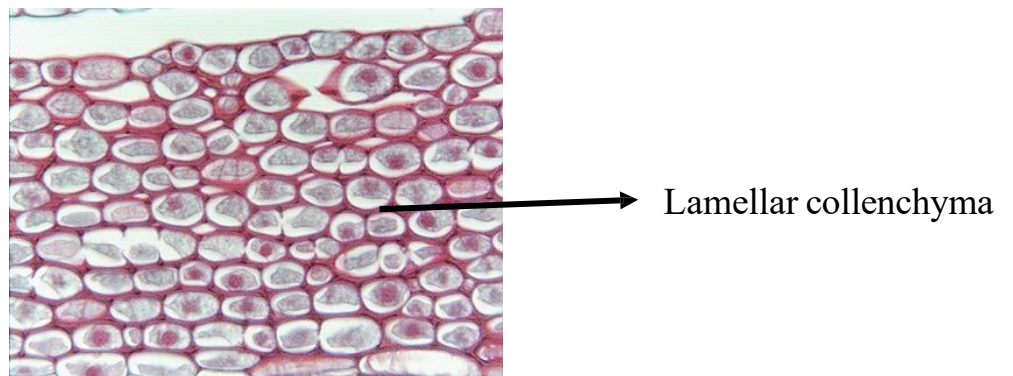
plants as it observed as supporting tissue in growing organs of numerous herbaceous and woody plants (stems, leaves and flowers). There are different types of collenchyma **depending on the thickenings** of their cell walls.

A- Angular collenchyma: The thickenings of the cell walls are located in the angles or corners of the cells and there are no intercellular spaces. This type of collenchyma cells can be seen in herbaceous stems and petiole



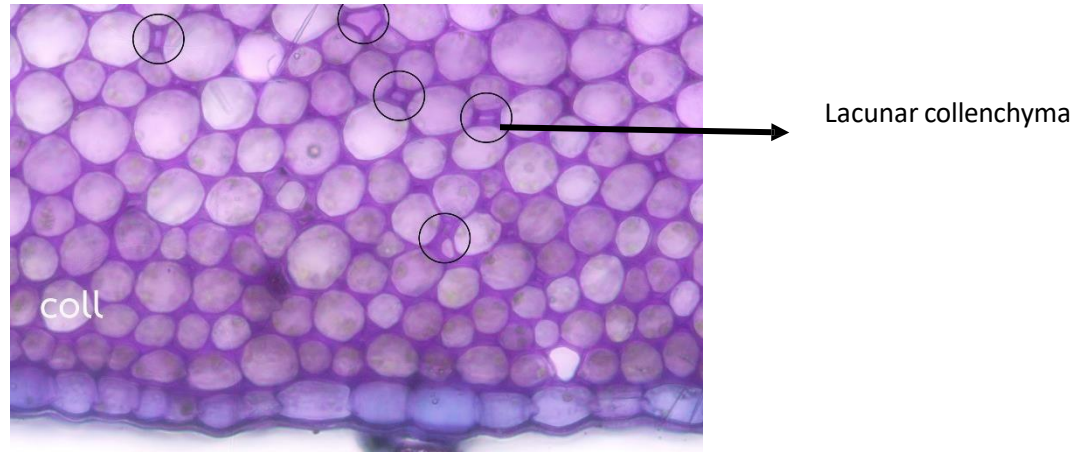
Unstained C.S. of celery petiole showing a bundle of angular collenchyma
(arrowhead)

B- Lamellar collenchyma: - It is very much alike to angular collenchyma but the cells are regularly arranged. Thickening occurs at the inner and outer tangential walls.



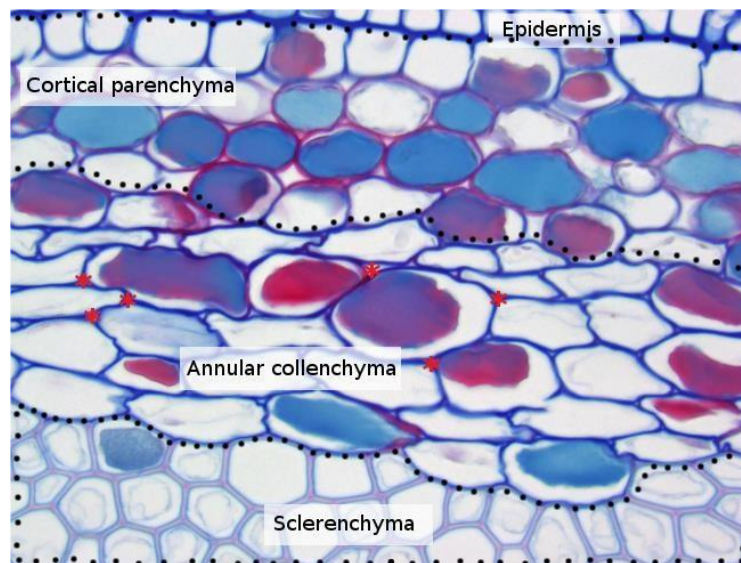
C.S of stem of elder (Sambucus) showing lamellar collenchyma

C- Lacunar collenchyma:-It is consisting of thickening around the cell walls facing the cavity lumen or intracellular spaces



Lacunar collenchyma in C.S. of stem

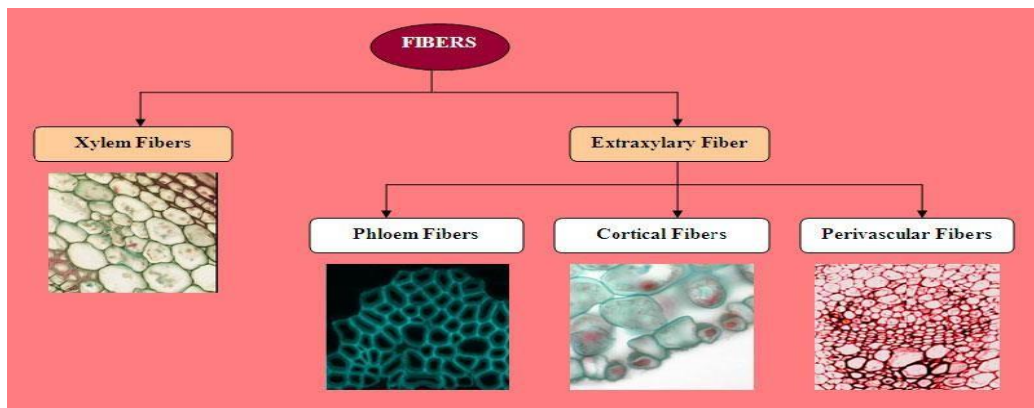
D- Annular collenchyma: - This is the only type of collenchyma where the thickenings of the cell walls are uniform around the cell. It contains empty intercellular spaces.



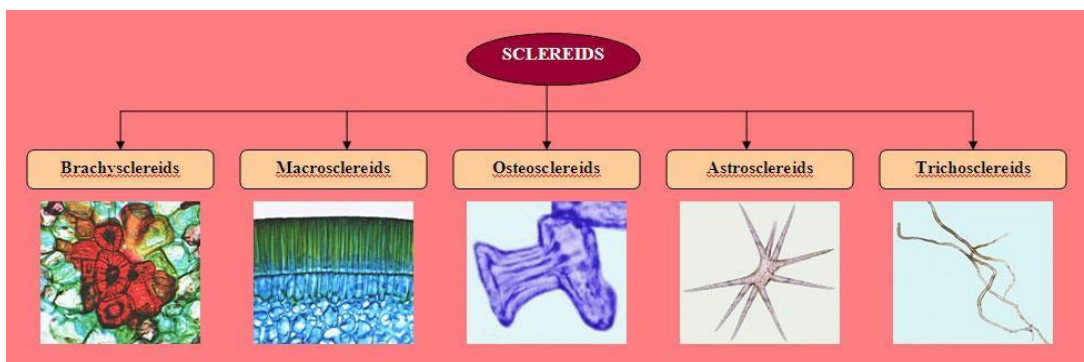
C.S. of mallow (*Malva sylvestris*) stem, the red star showing annular collenchyma

3- Sclerenchyma tissue:-It is type of simple tissue is composed of cells with rigid cell walls and the cells lack contents at maturity became dead. Sclerenchyma has a t function in the support of organs that do not grow anymore. This tissue is classified into three categories: **fibers**, **sclereids**, and **water-conducting sclerenchyma**.

***** Fibers:** - They are long, narrow, thick-walled cells that are dead at maturity. Fibers are found in various parts of plants, often in association with vascular tissues, particularly phloem in primary growth and secondary xylem (wood). Fibers are classified into four types as mentioned in diagram below.



*****Sclereids:** - They are smaller in size than fibers and more varied in shape with thick secondary walls that are heavily lignified. They occur singly or in clusters in various locations in the plant body such as stems, seed coats, fruit pulp, and leaves (especially in the mesophyll). They are classified into five types as illustrated in diagram below:



Practical work:-

- 1- Prepare C.S from stem of any available dicot plant to observe ordinary parenchyma.
- 2- Prepare a slide from petiole of Water Hyacinth (distributed widely in Al-Jaish channel in Baghdad) to observe aerenchyma
- 3- Prepare C.S sections of bean seed (*Phaseolus vulgaris*) or potato tuber to observe storage parenchyma.
- 4- Prepare C.S. from petioles and midribs of *Canna indica* to observe stellate parenchyma.
- 5- Cut thin transverse sections of leaves of *Nerium oleander* to observe columnar parenchyma
- 6- Cut thin transverse sections of leaves of pine to observe folded parenchyma
- 7- Cut thin transverse sections of petioles of celery (*Apium graveolens*) to observe patches of angular collenchyma.
- 8- Prepare C.S. from stem of Sambucus to observe lamellar collenchyma.
- 9- Prepare C.S. from leaves of *Nerium oleander* to observe lacunar collenchyma

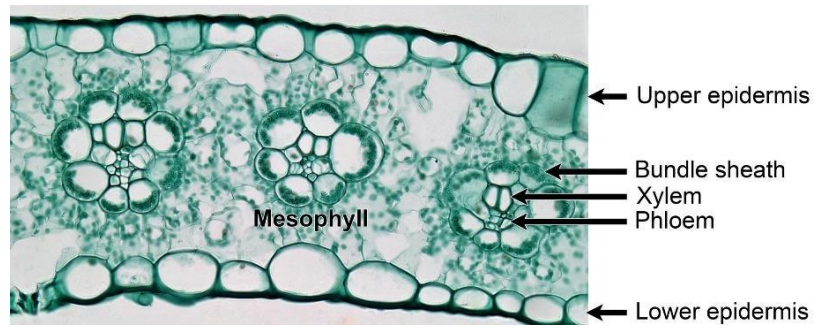
Lab 8:-

Epidermis

Epidermis: - It is the outermost cell layer of the primary plant body and compound tissue. The Cuticle is a complex waxy layer secreted by epidermal cells as it forms a barrier to water loss and the entrance of pathogens.

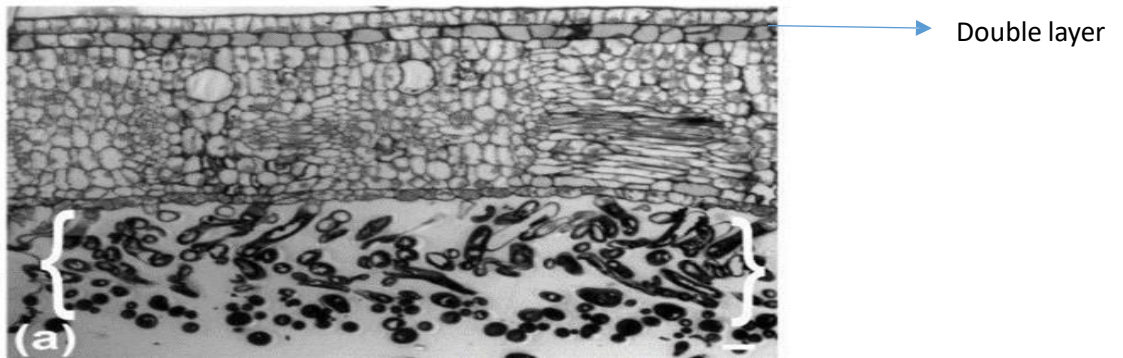
***The epidermis are classified into three types according to the number of epidermis

- 1- **Simple:** - It is consisting of one layer as in the leaf of *Zea mays*.

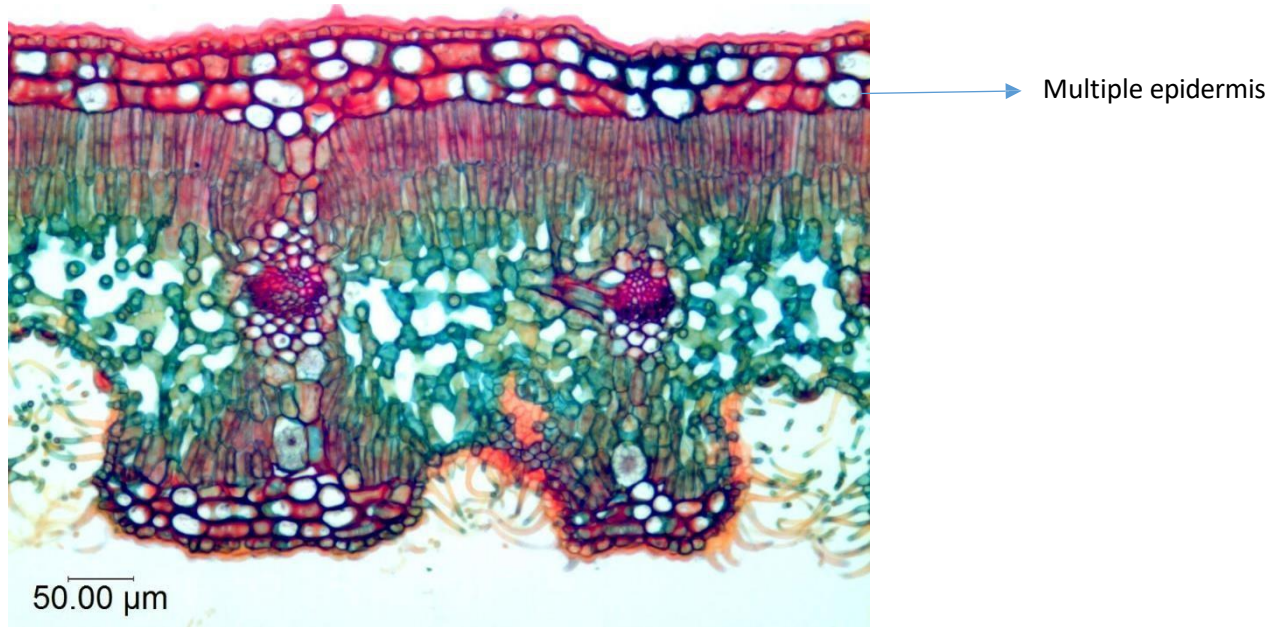


Simple epidermis in the C.S of *Zea mays* leaf

2- **Double:** - It consists of two layers as in leaf epidermis of *Magnolia grandiflora*.



3- **Multiple:** - It contains more than two layers as in leaf epidermis of *Ficus elastica* or *Nerium oleander*.



Multiple epidermis in leaf of *Nerium oleander*

*****Epidermal cell types:-**

- 1- **Ordinary or pavement cells:** - They are the most common and vary in shapes from longitudinal to curve.
- 2- **Guard cells:** - They are specialized plant cells in the epidermis of leaves, stems and other organs that are used to control gas exchange. They are produced in pairs with a gap between them that forms a stomatal pore.
- 3- **Subsidiary cells:** - They are located adjacent to the guard cell in the stoma of a leaf. The function is providing support in the movement of guard cells.
- 4- **Stomata:** - There are tiny openings in certain parts in all green plants which are essential in the gas control. They are kidney like shape in dicot and dumbbell shape in monocot.

*****Stomatal complexes.** The arrangement of subsidiary cells and guard cells.

There are several types of stomatal complex as listed below.

1. **Anomocytic (Irregular celled):** There is no differentiation of the epidermal cells around the guard cells. Ex. *Vicia faba* leaves.

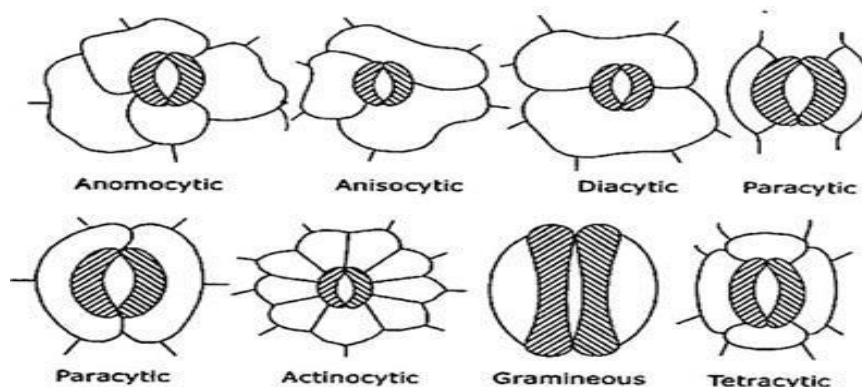
2. **Anisocytic (Unequal celled):** The guard cells are surrounded by three subsidiary cells, where one is distinctly smaller than the other two. This uneven size of surrounding cells is a defining feature. Ex. *Raphanus* leaves

3. **Paracytic (Parallel celled):** 1 or more subsidiary cells are parallel to guard cells. Ex. *Magnolia*, Graminae and Fabaceae (Bean)

4. **Diacytic (Cross celled):** 2 subsidiary cells with walls perpendicular to guard cells. Ex. *Dianthus* leaf peeling

5. **Actinocytic (radiate celled):** several subsidiary cells radiate from around the guard cells. Ex. *Zea mays* and *Rosa* leaf peeling

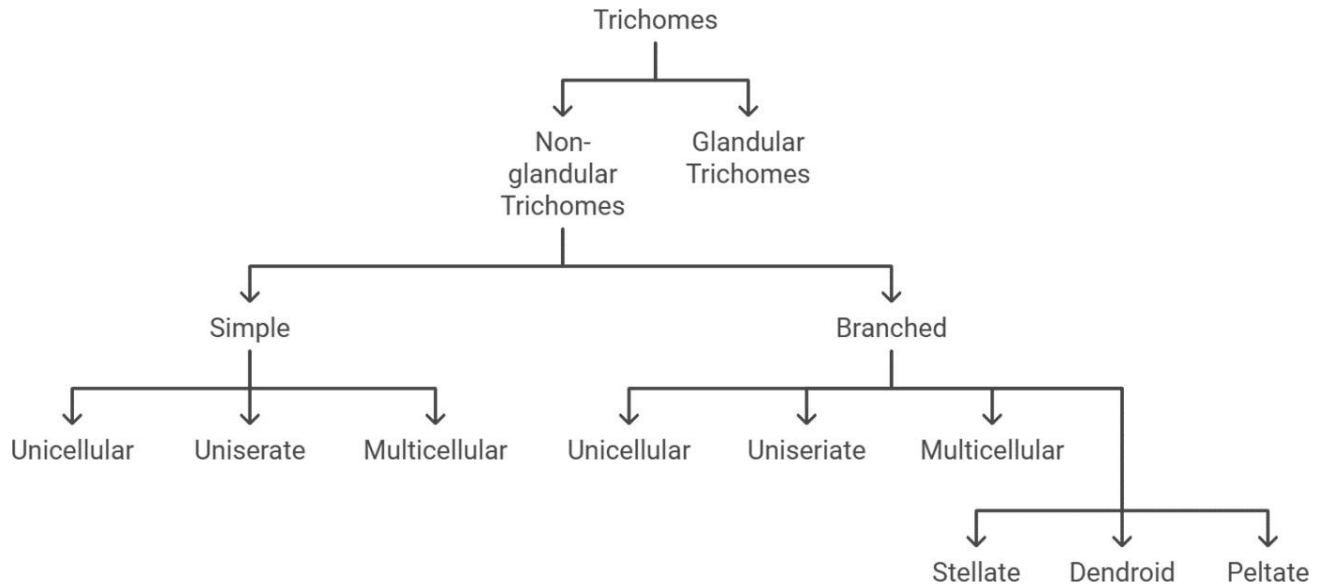
6. **Cyclocytic (cyclic celled):** subsidiary cells in 1-2 rings around guard cells.



Types of stomatal complex

The epidermis have several appendages like **trichomes, scales and papillae**

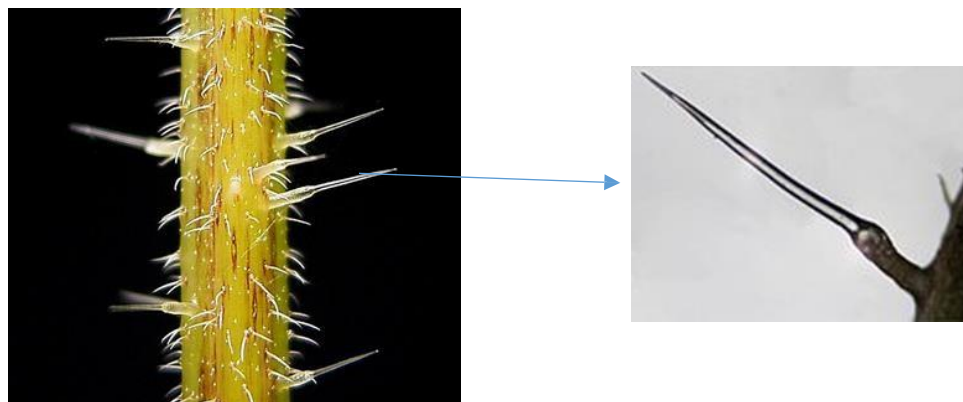
First:-Trichomes: - They are epidermal appendages which take different shapes and functions and can be found in all parts of plants. They are divided into:



****Non-glandular trichomes:** - They are pointed terminal cells, that do not secrete compounds (non-glandular) but serve other functions like preventing herbivory (insects and other animals) and reduce water loss by transpiration from the leaf. They can be divided into simple and branched as mentioned below.

1. Simple

a. Unicellular - e.g. root hair, an extension of the epidermal cells and stinging hair in *Urtica*.

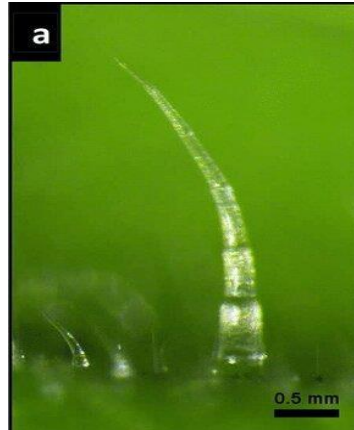


Stinging hair in *Urtica*

b. Uniserate - one cell layer thick ex. Malva leaf.

c. Multicellular - several cell layers thick and divided into

1- Uniserate: - It can be noticed in Cucurbita leaves.



2- Multiserate: - It can be noticed in *Portulaca oleracea* leaves or petioles.

2. Branched non-glandular trichomes

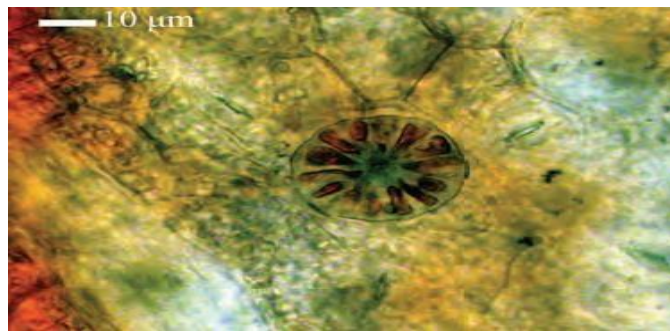
a. Unicellar. Such as the trichomes of Arabidopsis (usually has three branches).

b. Multicellular

- Stellate - star shaped. Some have stalks, such as this *Solanum quitoense*. Some don't have a stalk, like *Hibiscus rosa-sinensis*.

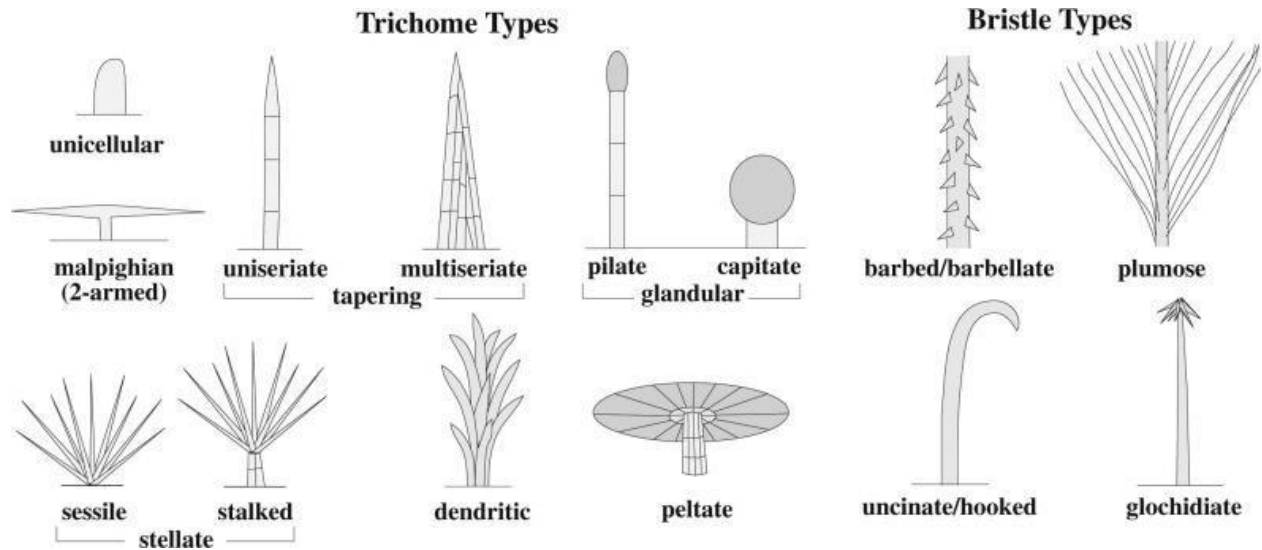
- Dendroid - tree-like, such as trichome of Verbascum.

- Peltate (umbrella shaped):- e.g. *Olea europaea* (olive).

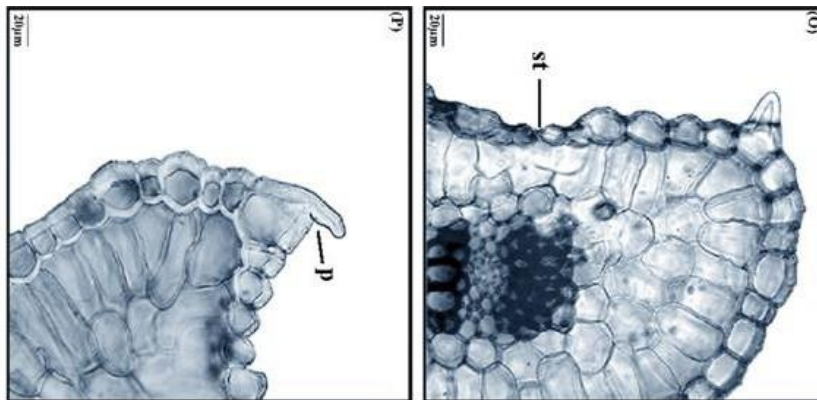


Peltate trichomes on leaf of the aluminum plant (*Pilea cadierei*)

*** **Glandular hairs:** - They are large stalk and multicellular secreting head and found on the surface of about 30% of all vascular plants and are responsible for secreting of some secondary metabolites like essential oils.



Second: - Papillae: - ex. *Rosa* spp. leaf petiole or stem c.s.



Cross sections of the leaf showing the stomata (st), papillae (p) in *Crocus* spp.

Third: - Lithocytes ex. C.S. of *Ficus elastica* leaf

Practical work:-

- 1- Prepare C.S of *Zea mays* leaf to observe simple epidermis.

- 2- Prepare C.S. of *Magnolia grandiflora* (Cultivated in Baghdad) leaf epidermis to observe double layers of epidermis
- 3- Prepare leaf peeling from different plants of monocot and dicot to observe different types of stomatal complex.
- 4- Prepare C.S. of leaf, stems and petioles from plants covered with trichomes to observe different types of epidermal appendages.

Lab 9:- Vascular tissues (Complex tissues)

Vascular tissues are complex conducting tissues in higher plants that are made up of different types of cells and elements. The two main components of vascular tissue in plants are – **Xylem** and **Phloem**. These tissues are responsible for the transport of water and nutrients in the plants.

- 1- **Xylem:** - It is one of the conducting tissues that is responsible for the transport of nutrients and water from roots to the aerial parts of the plant such as stem and leaves. In angiosperm xylem tissue consist of **tracheids**, **vessel elements**, **fibers** and **parenchyma cells** but in **gymnosperm** the conduct element is **tracheid** only.

*****Xylem components:-**

A- Tracheary elements: - They are called collectively the tracheid and the vessel element which represent the two chief types of water-conducting cells present in the xylem of vascular plants.

- 1- **Tracheids-** They are the basic cell in the xylem, all plants have tracheids. Tracheids are generally spindle shaped, elongated with tapered ends. Tracheids have a function of support and water conduction. The secondary wall of tracheids is developed in a wide variety of patterns, these include annular, spiral, scalariform, and reticulate thickenings.
- 2- **Vessel elements:-** They are Tubular structure, multicellular, each cell of

vessel called **element**, the end of wall of these elements called **perforation**

plates, when these plates have one pore it called **simple perforation plate**
 ex: *Vitis* stem when it have more than one pore it called **compound plate**,
 these plate may be **scalariform, reticulate, forminate or ephedral**
plates ex: *Ephedra*. The function of these elements in conduction only.

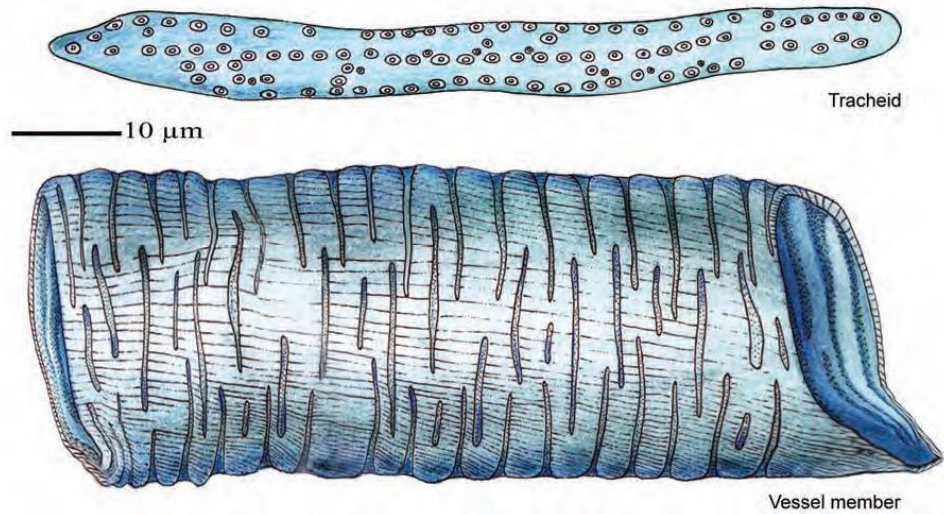
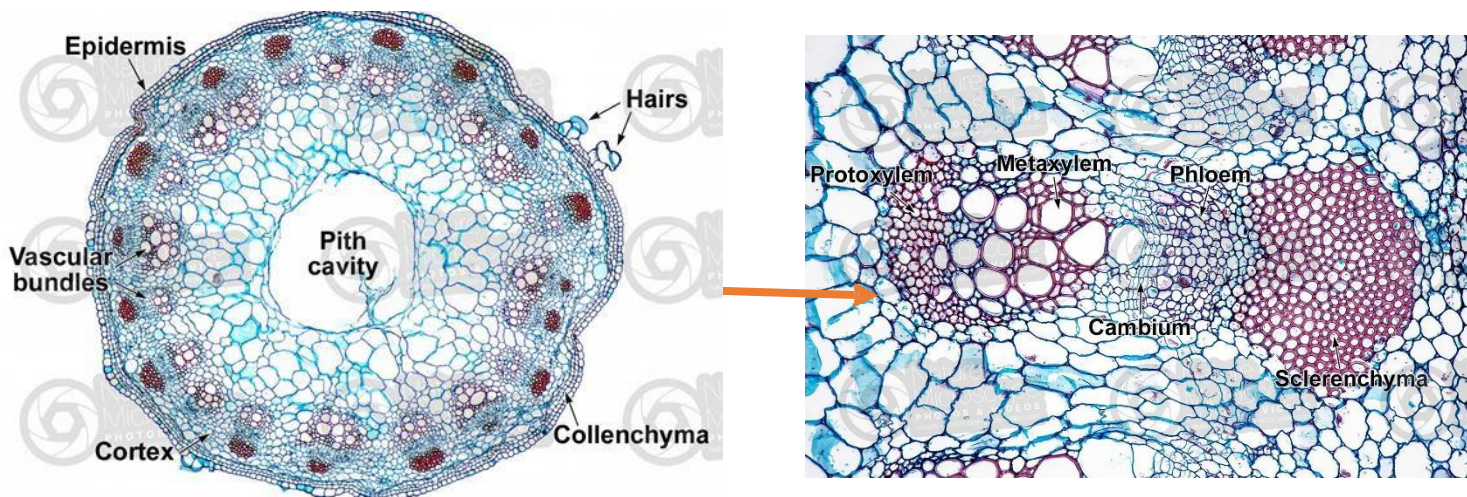
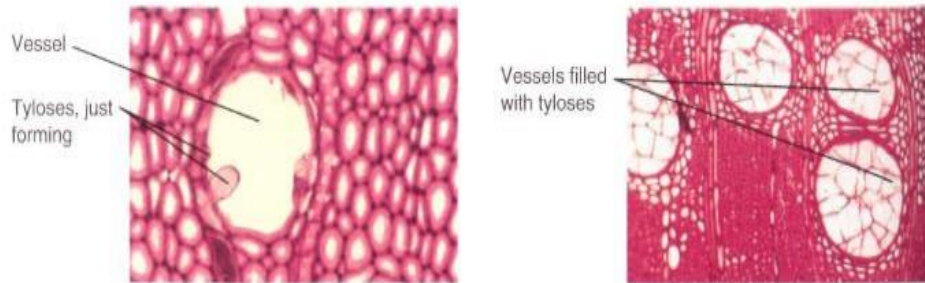


Diagram of tracheids and vessel elements

The xylem tissue undergoes primary and secondary growth. During primary growth, the xylem forms **protoxylem** and **metaxylem** from the **procambium** as illustrated in figure below C.S. of *Helianthus annuus* stem

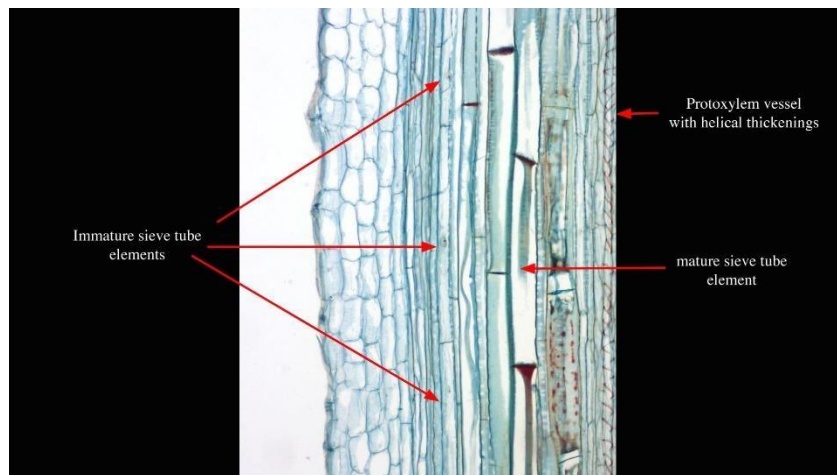


*****Tyloses:** - They are balloon-like swellings or projections that fill the vessels. When a tylosis is fully formed it plugs the vessel. The vessel can no longer conduct water. Tyloses form on some trees, such as white oak.



2. Phloem tissue: - A complex tissue, combine with xylem to form the vascular tissue system, the main function of it is food transportation. The phloem in Angiosperms plants consist of: Sieve tubes, companion cells, parenchyma cells and fibers

A- Sieve tubes: - They are specialized conducting cells. They have sieve plate at the terminal (transverse) walls, these sieve plates have numerous pores that cytoplasmic strands cross through its, these cytoplasmic strands covered with callose (carbohydrate substances).



L.S. of *Cucurbita* stem. The phloem here includes immature sieve tube elements with nuclei, mature sieve tube elements without nuclei, and a protoxylem vessel with helical secondary wall thickenings.

There are two kinds of sieve plate:

1- Simple sieve plate (pores diffuse irregularly) ex: C.S of Cucurbita stem.

2- Compound sieve plate (pores arrange in groups named sieve area) which probably found at lateral walls ex: L.S of *Vitis* stem.

B- Companion cell: - its parenchyma cell with big nucleus and dense cytoplasm, each one of these cells companies one element from sieve tube elements, and both of them derived from same mother cell.

The phloem in Gymnosperms plants consist of: Sieve cells, parenchyma cells (Albuminous cell) and fibers.

The Gymnosperm plants have sieve cells connect by cytoplasmic strands which cross through sieve area on transverse wall only. These plants have albuminous cells instead of companion cells ex: Pinus stem L.S.

There are two kinds of phloem tissue:

1- Primary phloem, derived from procambium, and consist of protophloem (non-functional phloem) and meta-phloem which is the functional phloem at all plant life (in plants don't have secondary growth ex: *Zea mays*).

2- Secondary phloem, derived from vascular cambium (in secondary growth plants) this phloem arrange in two systems:

1. Axial system: consist of (sieve tube elements, companion cells, some axial consist of parenchyma cells and fibers).

2. Radial system: consist of (phloem rays and parenchyma cells).

Practical work:-

- 1- Exam L.S of *Vitis* stem to observe Xylem.
- 2- Exam C.S of *Helianthus* stem to observe protoxylem and phloem.

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