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Plant anatomy
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المرحلة الثانية ـ الدراستين الصباحية والمسائية
الفصل الدراسي الاول

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Lab 1:

Cell wall

I-Wall layer

1- ***Allium***	root tip L.S. (Telophase)	Cell plate
2- ***Allium***	root tip L.S. (Cytokinesis)	Middle lamella
3- ***Diospyrus***	endosperm T.S.	primary cell wall
4- ***Draceana***	old stem T.S	Secondary cell wall

The plant cell is composed of a wall that surrounds a part of the protoplasm within it called protoplast so that the plant cell can be considered to be composed of two main parts, **the wall** ,and **the protoplast**. The presence of a non-living rigid wall containing cellulose is characteristic of plant cells as animal cells lack such a real wall as they are surrounded by plasma envelope. The primary cell wall in the plant is true, thin; in some time the primary cell wall becomes thick but it could be recognized by the presence of plasmodesmat.

Plasmodesmata: Protoplasmic strands that bind between a cell protoplast and a neighboring cell protoplast and play an important role in transporting water and other materials from a cell protoplast to another cell as a continuous and continuous unit.

The primary cell wall may be lignified to be **a secondary cell wall** that is thick and dead.

-The stages of cell wall formation and chemical composition for each it:

1- **Cell plate** (Ca & mg pectate)

2- **Middle lamella** (Ca & mg pectate)

3- **Primary cell wall** (cellulose, hemicelluloses, non-cellulosic polysaccharides, and pectin)

4- **Secondary cell wall** (cellulose, non-cellulosic polysaccharides, lignin & suberin)

II-Intercellular spaces

1- **Ordinary schizogeneous intercellular spaces in *Dracaena*** stem C.S

2- **Specialized schizogenous intercellular spaces** in ***Pinus*** leaf

3- **Lysigenous schizogenous intercellular spaces** in ***Eucalyptus*** leaf

4- **Schizolysigenous intercellular spaces** in ***Zea mays*** stem

The Intercellular spaces: blanks formed as a result of the separation of the cell walls, followed by the withdrawal of some separated parts or the movement of cells spatially

It's dividing into 4 kinds depending on **evolutionary aspects**. :-

1- **Ordinary Intercellular spaces**. (formed by division of middle lamella)
2- **Specialized Intercellular spaces**. (it have special function, and hear it specialized to transport resin substances)
3- **Lysigenous Intercellular spaces** (formed by lyses of cells)
4- **Schizolysigenous Intercellular spaces** (formed by division and lyses of cells)

Lab 2:

Pits

1- **Primary pit field** in ***Allium cepa*** stripped of epidermis
2- **Simple pits pair** in ***Sambucus*** (Elder) pith C.S,
3- **Bordered pit pair** in ***Pinus*** Xylem R.L.S
4- **Ramiform pits** in ***Pyrus communis*** (pear fruit) stone cell or brachysaclereids)
5- **Half bordered pit pair** or **Semibordered pit pair** in ***Pinus*** Xylem T.L.S.
6- **Aspirated pit pair** in ***Pinus*** Xylem T.L.S.

Pits define as depressions or cavities on cell walls . and it consist of :

1- **Pit membrane** (consist of middle lamella and thin layer of primary cell wall).

2- **Pit cavity** (located between pit membrane and pit aperture)

3- **Pit aperture** (The opening that joins the pit with cell cavity)

Types of pits

1- **Primary pit fields** (a depressions on primary cell wall & usually associated with plasmodesmata .) in ***Allium cepa*** stripped of epidermis
2- **Simple pits** (a cavity in secondary cell wall). in ***Sambucus*** (Elder) pith C.S
3- **Bordered pits** (Occurs when the secondary wall separates from the pit membrane extends into the cell forming a Border) associated with xylem transport elements [tracheids and vessels] in ***Pinus*** Xylem R.L.S

The bordered pit consist of :

1- Border 2- Torus 3- Pit chamber 4- Pit membrane 5- Pit aperture

4- **Ramiform or Branched pits** (occurs when the secondary cell wall become more thick , so it's become like a canal connected between cell lumen and surface) in ***Pyrus communis*** (pear fruit) stone cell or brachysaclereids

Pit combination

When the pit on one side of the cell wall is associated with one or more similar or different pits on the other side of the cell wall, the two associated pits are called **Pit pair**

1- **Simple pit pair** (Occurs if you meet two simple pits in two parenchyma cells)
2- **Bordered pit pair** (Occurs if you meet two bordered pits in xylem transport elements)
3- **Half bordered pit pair or Semi bordered pit pair** (Occurs if a simple pit in parenchyma cell is met with a bordered pit in xylem transport elements) in ***Pinus*** Xylem T.L.S.
4- **Aspirated pit** (happened when the torus closed the pit aperture of only one pit in Bordered pit pair to be un functional) in ***Pinus*** Xylem T.L.S.

Lab 3:

Plant cell content

I-Living contents

1-Cytoplasm & nucleus in **onion** (stripped of epidermis)

2-Plastids:

a-Chloroplast in **green pepper**

b- Chromoplast in **red pepper or tomato**

c- Leucoplast in **potato**

II- Non-living contents

1-starch grain in **potato** , **rice**, **bean**

2-Crystal :

a- Druses in ***Tilia*** stem T.S.

b- Prismatic in **onion** scaly leaf

c- Raphides in ***Mirabilis*** stem T.S.

d- Cystolith in ***Ficus*** leaf T.S.

3-Aleurone grain in ***Ricinus*** endosperm

I- Living contents:

Consist of cytoplasm , nucleus and other organelles like mitochondria , ribosomes , plastids , .. .

Plastids:

There are 3 kinds of plastids different according to their **position** , **function** and its **pigments** :-

Plastids	Position	Function	Pigments
1- Chloroplast	In green parts in plant	photosynthesis	1- Chlorophyll A, B and little amount of Xanthophyll and Carotene
2- Chromoplast	In any part in plant	Assisting in photosynthesis	Carotene and xanthophyll
3- Leucoplast	In plant parts which not contact with light	Starch production and storage	No pigment

II-Non-living contents

1-Starch grains

The starch grain different **according to** :

a-The differences in position and shape of hilum .

b-the presence or absence of starch stratification .

c- grain shape and size .

d-the structure of the grain (simple or compound)

Starch grain	grain shape	position of hilum	starch stratification
Starch grain in potato	**ovoid shape**	**terminal hilum**	**Starch stratification can be recognized a- Simple b- Compound c-Semi compound**
Starch grain in rice	**Prismatic shape**	**Hilum cannot be recognized**	**Starch stratification cannot be recognized**
Starch grain in bean	**Ovoid shape**	**Centric and Cracked hilum**	**Starch stratification can be recognized**

2- Crystals

The crystals different according to its **shape** and **chemical composition** :-

a- **Prismatic** (**Calcium oxalate**)
b- **Raphides** (**Calcium oxalate**)
c- **Druses or Rosette** (**Calcium oxalate**)
d- **Cystolith** Consist of **Body** [**calcium carbonate**] and **Stalk** [**cellulose**]

3-Aleurone grain

Its function **storage protein** composite of **Crystalloid** consist of (**protein Albumin**) and **Globoid** consist of (**protein Globulin with complex salt of calcium & magnesium phosphate) .**

Lab 4

Meristematic tissue

***Apical meristem**

A-Shoot apex

1-Single apical cell theory in ***Dictyota*** & ***Equisetum***

2-Tunica corpus theory in ***Ricinus*** , ***Salvia*** , ***Coleus***

B-Root apex

1-one apical initial zone in ***Allium cepa***

2-three apical initial layers in ***Zea mays***

Meristematic tissue are group of cells associated together to perform one or more function .

The properties of meristem tissue are:

1-Small size

2-Tissues consisting of cells capable of active cell division

3-Surrounded by primary cell wall (thin wall)

4-No intercellular spaces

5- Contain less vacuoles or absent

6- Rich in cytoplasm

7- Active nucleus

***Meristematic tissues** are divided according to:

1- According to **position** in plant body:

A- Apical meristems

B- Intercalary meristems

C- Lateral meristems

2- According to their **origin**

3- According to their **function**

Plant anatomy (Second stage)
اعداد: م.م. رشا خالد حسين

A- Apical meristems → **Shoot apex**

→ **Root apex**

Shoot apex : Meristematic cell in shoot apex are different in **number, arrangement, shape and division**

****Theories of shoot apex**

1- Single apical cell theory

In this theory there is **one cell**, either **lenticular shape** with **periclinal division** in ***Dictyota***, or **pyramidal shape** with **anticlinal division** in ***Equisetum***.

2- Tunica corpus theory

In this theory there are **two zones (tunica, corpus)** different in **position** ,**structure** and **cell division**

Tunica	**Corpus**
Terminal position	**Central position**
Cells are small in size and regular	**Cells are big in size and irregular**
Cells division is anticlinal only	**Cells division is anticlinal, periclinal and oblique**

Root apex:

****Theories of Root apex:**

1- One apical initial zone

All plant tissues are developed from one initial zone. Ex**:** ***Allium cepa***

2-Three apical initial layers

All plant tissues are developed from three initial zones. Ex**:** ***Zea mays***

B- Intercalary Meristematic tissues : It′s found between the permanent tissues.

C-Lateral Meristematic tissues: It′s found parallel to the epidermis and divide to give cells which increase the stem and root width in the secondary thickening.

a. Vascular cambium: function for **it produce the secondary xylem(inside) and secondary phloem (outside).** vascular cambium consists of **fascicular cambium** (inside the vascular bundle) which united with **interfascicular cambium** (outside the vascular bundle).**Ex**: ***Helianthus*** stem c.s.

Vascular cambium consists of **two types of cells**:

1. Fusiform initials.

2. Ray initials.

Ex: *Pinus* stem c.s.

b- Cork cambium: which produce **cork outside** and **phelloderm inside. Ex: *Sambucus* stem c.s.**

Lab 5

Epidermis

Epidermis tissue type

1- Simple (uniserrate) epidermis in ***Zea mays*** leaf

2- Multiple (multiserrate) epidermis in ***Ficus*** leaf

3- Sunken stomata in ***Pinus*** leaf

Epidermis

Epidermis is primary tissue system in the primary state of development ,it is represents the protective tissue which surrounds the plant organs (the young stem, young root, leaves, flower,……etc.)

Epidermis can be classified **according to the number of layers to:**

1.**Simple** when it contains one layer of cells

2.**Double** when it contains two layers of cells

3.**Multiple** when it contains many layers of cells

**** Epidermis cell types**

- **Ordinary epidermal cells**

Ordinary epidermal cells represents the most common types of epidermis cells which are living ,least differentiated& least specialized, lack chloroplast .

2.Gaurd cells

Highly specialized cells, exist in pair, kidney shaped, each pair in surrounding stomata ,have chloroplast, it found only in aerial parts ,**function** for it is regulation the exchange of gases, photosynthesis , respiration &transpiration.

3.Subsidiary cells

Somewhat specialized epidermal cells associated directly with guard cells and are absent in some plant such as ***Vicia faba*** .These cell that found in epidermal levels, and may also found

in a descending (sunken stomata),this case of adaptation occurs when the plant try to reduce the water loss in hot environment, such as ***Pinus***.

** The arrangement of subsidiary cells and guard cells is refer to **stomatal complex**

**** Stomatal complex**

1. Graminea type in ***Hordeum*** leaf stripped epidermis.

2. Paracytic type in ***Ricinus*** leaf stripped epidermis**.**

3.Diacytic type in ***Dianthus*** leaf stripped epidermis.

4.Anisocytic type in ***Raphanus*** leaf stripped epidermis.

5.Actinocytic type in ***Rosa*** leaf stripped epidermis.

6.Anomocytic type in ***Vicia faba*** leaf stripped epidermis.

4.Motor cells

These cells are living and big size ,plastid free, thin wall, storage a large amount of water and play important role in reduce it.

5.Lithocyte

Big cell contain cystolith crystal in side

The Trichomes

Is one of epidermal appendages , they have many types and functions.

The trichomes can be divided in two groups:

1.Non glandular trichomes : such as

- Peltate hair in ***Olea*** leaf, it's like tooth margin (disk with stalk)
- Pointed unicellular (uniserrate) hair in ***Malva*** leaf
- Pointed multicellula (multiserrate) hair in ***Helianthus*** petiole
- Stellate unicellular in ***Matthiola*** leaf

2.Glandular trichomes

It has **secretion function** such as:

- Colletors in ***Rosa*** petiole
- Stiging hair in ***Urtica*** leaf

Lab 6:

Parenchyma tissue

Characters of parenchymal tissue:

1.Living cells

2.Thin cytoplasm

3.Primary cell wall

4.Found in aerial and subterranean parts of plants

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

1.Chlorenchyma tissue : Photosynthesis Ex*:* ***Crysanthemum*** stem

2.Thin walled storage parenchyma Ex : ***Ricinus*** endosperm

3.Thick walled storage parenchyma Ex: ***Diospyrus***

4.Aerenchyma (Air storage) Ex: ***Eclipta alba*** stem T.s.

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

1.Columnar and lobed parenchyma cells Ex: ***Ligustrum*** leaf

2.Stellate parenchyma Ex: ***Canna indica***

3.Folded parenchyma Ex: ***Pinus*** leaf

***** Collenchyma tissue**

Characters of Collenchymal tissue:

1.Living cells with primary cell wall

2.cells thickening with pectin

3.Found in aerial parts

Collenchyma tissue can be **divided according to thickness into:**

1.Angular collenchyma: **thickness in angles** .Ex:***Cucurbita*** stem

2.Lamellar collenchyma :**thickness in the outer and inner tangential walls.**

Ex**:** ***Sambucus*** stem

3.Lacunar collenchyma: **thickness in cell wall opposite to intercellular spaces** .Ex:

Lactuca stem

Lab7:

Sclerenchyma tissue

Characters of Sclerenchyma tissue:

1.Permanent simple tissue, usually it cells dead at maturity.

2.Thick secondary cell wall with lignin

3.Found in aerial and subterranean parts of plants

4.Its function is support

** The sclerenchyma cells can be divided according to it **shapes to :**

A. Sclereids

B. Fibers

A. Sclereids can be divided according to its **shapes to:**

1.Stone cells or brachysclereids: like parenchyma cells with secondary cell wall and ramiform pit ex**:** ***Pyrus*** fruit.

2.Macrosclereids : like cylinder or like **columnar .ex** ***:Allium sativum***

3.Osteosclereids or bone shaped sclereids : like macrosclereids but different in wide ends like bone. ex: ***Hakea*** leaf T.S.

4.Trichosclereids or Filiform sclereids :thin cells may be branched like Y or L letters . ex: ***Olea*** leaf

5.Astrosclereids or Star –shaped sclereids : have many branches .ex**:** ***Nympheae*** leaf

B. Fibers:

Characters of fibers

1.Tall,thin with pointed ends

2.have no branched elasticity wall with narrow lumen

Fibers can be divided according to its **position** to:

1.Xylem or wood fibers in *Vitis* macerated stem

2.Extraxylery fibers

** Extraxylery fibers including**:**

a. Hypodermal fibers .ex***: Zea mays*** stem.

b. Bundle sheath fibers. ex***: Zea mays*** stem

c. Perivascular fibers .ex**: *Aristolochia*** stem

d. Bundle cap fibers .ex**: *Helianthus*** stem

e. Phloem fibers. ex**: *Tilia*** stem

Lab 8:

Complex tissue

Vascular connecting system

Conduction or vascular tissue system : specialized in conducting ,consist of xylem and phloem tissue .

1. Xylem tissue

Xylem is a complex tissue ,the main function is **transport** , in angiosperm xylem tissue consist of **tracheids** , **vessel** , **fibers** and **parenchyma cells** but in gymnosperm the conduct element is **tracheid** only.

Xylem elements:

1. **Tracheid**: Long cells died at maturity its function **transport and support.** The wall of tracheids are thickness in different type like **annular , spiral** , **reticular** , **scalariform** and **pitted.**
2. **Vessels:** 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
3. when it have more than one pore it called **compound plate,** these plate may be **scalariform, reticulate, forminate or ephedronal plates** ex**:** ***Ephedra***

****Annual ring:** (**Growth ring**) arranged in serial manner ,the xylem element in spring are widely , thin walls and the most element are vessels and it called **spring wood** or **early wood** ,while the most xylem elements in summer wood are fiber , vessels are narrow and thick walls and it called **summer wood** or **late wood** ex: ***Pinus*** stem T.S

***** Diffused porous wood :**
The vessels are in same diameters and have regular arrangement in annual ring ex**:** ***Pyrus***
*****Ring porous wood**
The vessels are in different diameters and have irregular arrangement in annual ring ex**:** ***Quercus***
Tyloses : Bladder like structure ,appears in side vessels and tracheids so they closed and been un function.

Lab 9:

Vascular connecting system

2. Phloem tissue

A complex tissue, combine with xylem to form the vascular tissue system, the main function of it is food transportation ex: ***Zea mays*** stem C.S.

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The phloem in **Angiosperms** plants **consist of:**

1. Sieve tubes.

2. Companion cells.

3. Parenchyma cells

4. Fibers

***The sieve tubes**

it's a chain of cells named sieve tube elements, each one of these elements has 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) ex: ***Cucurbita*** stem C.S.

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There are **two kinds of sieve plate**

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

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

****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:**

1- Sieve cells.

2- Parenchyma cells (Albuminous cell).

3- 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 **pro-cambium**, and consist of proto- phloem (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) ex: ***Cucurbita*** stem.

2.Radial system: consist of (phloem rays and parenchyma cells) ex: ***Cucurbita*** stem

Lab:10

Anatomy of stem

A. anatomy of Dicot stem

In the transverse section of young stem of sunflower **(*Helianthus*)** , the stem appears circular or slightly wavy in outline, the tissue are arranged as follow:

1.Epidermis:

It is the outer most uniseriate layer composed of parenchymatous cells , in young stem chloroplasts may be observed, and covered by cuticle material, stomata are present.

2- Cortex

It lies below the epidermis and is differentiated in to following zones:

a- Hypodermis

this layer is immediately below the epidermis and is composed of 3 to 4 layers of thick collenchymatous cells, this layers forms a continuous band of external cortex which provides mechanical support to the peripheral portion of the stem.

b- General cortex

it consist of thin walled, living parenchymatous cells, having conspicuous intercellular spaces. The cells may contain some chloroplasts

C- endodermis

It is the inner most layer of the cortex and separates the cortex from stele, compactly arranged having no intercellular spaces and are parenchymatous. They contain numerous starch grains, the layer is therefore referred to as a starch sheath.

3- Stele

It is consist of the following:

a- pericycle

it lies below the endodermis and is composed partly of parenchyma cells and partly of sclerenchymatous tissues**.**

b- Vascular bundles

these are conjoint collateral open, wedge shaped and arranged in a ring around the central pith. (The size of the bundles varies in different species).

c- Pith

the center of the stem is known as pith or medulla, it is composed of parenchyma cells.

d- Pith rays

B. Anatomy of monocot stem

In monocot stems there is no secondary growth. The stems bear only primary permanent structures which are formed due to the activity of the apical meristem only. We are discussing here the anatomy of ***Zea mays*** stem .It can be distinguished in the following region**.**

1- Epidermis :

It is single outermost layer composed of small thin walled parenchymatous cells without intercellular spaces .A thick-cuticle is present on the outer surface.

2- Cortex :

The cortex is not well differentiated into disinct regions it is composed of the following regions **:**

a- Hypodermis

It lies just below the epidermis comprising few layers of thick walled lignified sclerenchymatous cells without intercellular spaces.

b-Ground tissue :

It is a continuous mass of thin-walled, parenchymatous tissues**.**

******There is no differentiation of general cortex, endodermis, pericycle, pith and pith-rays ,vascular bundles are irregularly embedded in this region.

c- Vascular bundles

the vascular bundles are conjoint, collateral, and closed without cambium, irregularly scattered in the ground tissue**.**

3- Stele

Absent, the vascular bundles are irregularly arranged in the cortex.