# Botany 2

# Plant Anatomy

## 2nd year Physical and Chemical sciences - Botany

## Prepared by: Dr. Azza Misk

1. Biological sciences are known since Paleothetic times. Biology started by illustrations of different plant and animal species where human survival mainly relied on the gathering knowledge of them.
2. **Morphology**; came first which describes the **external** structure of plants. Then with the invention of the light microscope, **Anatomy** came next with the extensive studies of the plant **internal** structure.
3. The electron microscopy was a revolutionary step for the start of many sciences such as **Microbiology** and **Genetics** where other branches were derived from as **Genetic Engineering**, **Molecular Biology** and **Biotechnology** .
4. **Molecular Biology** is concerned with the study of:

   1. Genetic structure 2. Micro-cellular structure

   3. Cellular differentiation..

- 5. Molecular analysis; comparing between different types of proteins, enzymes, hormones as well as amino acids' sequences in both DNA and RNA. Biology or life sciences are concerned with the study of a group of characters that characterizes only the living organism such as:

   1. Growth 2. Motility 3.Metabolism

   4. Reproduction 5.Adaptation

- **Anatomy** deals with the study of internal structure, function and evolution of the living being.
- **Cytology** deals with the structure and function of different cells.
- **<u>Scientific Information Resources</u>**:
   1. Where do we obtain them from?
   2. How to verify their credibility ?

# Scientific Information Resources

It starts by observation and description

Information are gathered through experiments

Deduction of general relationships and discussions to come up with a hypothesis

If proven, the hypothesis becomes a theory and when generalized, it becomes a law. The verification of the studies done is the main core of science.

A new discovery can change previous laws, which is known as Scientific Criticism where it mainly relies on critical curiosity.

In conclusion, facts are only investigated through accuracy and honesty.

Research works are discussed through conferences and periodical meetings.

Researchers publish their research work as a research paper in specialized journals.

**Scientific Nomenclature:** is a formal system of naming species of living beings, structures, functions, even chemical components where Latin or Greek forms are used.

**Measuring Units**:

1. **Length Units:** micrometre ($10^{-3}$ mm), nanometer ($10^{-6}$ mm), Angstrom ($10^{-9}$ mm).
2. **Weighing Units:** mg ($10^{-3}$ g), micro gram (ηg) ($10^{-6}$ g), Nanogram ($10^{-9}$g), Pico gram or Dalton ($10^{-12}$ g).

<u>**Dalton**</u>: it is equivalent to the molecular weight of hydrogen atom. (the molecular weight of water molecule is 18 Daltons, while the molecular weight of hemoglobin is 64500 Daltons).

# Cellular structures and vital functions

Any living being is called “Organism”

Organism: an organized system

With a specific identifiable shape

Each organ within this system has a specific function *i.e.* growth, reproduction, sensitivity, metabolism, etc…

So, it is easy to identify plants and animals as living organisms as well as rocks and stones as nonliving. On the other hand, it is not an easy task to define Viruses as living beings. Why?

The living material is called the Cytosol (portion of the cytoplasm) is a translucent semifluid substance of the cell, colorless to slightly yellowish viscous liquid resembles egg white.

The Cytosol is examined by the light or electron microscopy or by using diffractive analysis of X-ray.

## Characters of living cell

1. Cellular organization: each organism has a specific form, shape and size by which it is identified. As each one consists of different parts that ends up with the cell.

   Body Systems Organs Tissues Cells

   **The Cell**: is the body building unit both in structure and function.

2. **Metabolism**: is essentially a collection of chemical reactions occurring within the body cell, where food is transformed into substances similar to that of the body. It consists of two processes:

   1. **Anabolism**: A process where energy is consumed for building up complex substances such as proteins, lipids or carbohydrates from simple ones

   2. **Catabolism**: A process where energy is released such as respiration or breaking up reserve food materials to simple substances to obtain energy during growth, mobility, reproduction, etc…

3. **Locomotion**: the ability of an organism to change place. This character differ from one organism to another. In plants, mobility is slightly noticed compared to animals, however plants mobility can be observed in blossoming of flowers and buds, opening and closure of stomata, streaming of the cytoplasm (cyclosis).

**4. Response to Stimuli (Sensitivity):** a reaction to an internal or external force i.e. phototropism or Geotropism.

**5. Growth:** Increase in size or weight till reaching a certain size. Growth is either limited (animals) or unlimited (plants).

**6. Reproduction**: it is the ability of the living organism to produce new individuals (offspring) when it reaches a certain age (maturation). As viruses have this character they were considered living beings, inspite of their inability to perform other characters such as growth, respiration, etc…

**7. Respiration:** a vital process which characterizes living organisms only.

$$C_6H_{12}O_6 + 6\,O_2 \qquad 6\,CO_2 + 12H_2O\ +Energy$$

**8. Adaptation:** the ability of the living organism to change slightly over time to be able to continue to exist in a particular environment. Adaptation can be quick or momentarily according to the response of enzymes, inhibitors or activators or it can be very slow in case of mutation or natural selection.

**9. <u>Excretion</u>:** a process by which metabolic wastes are eliminated from a living organism. It could be two contractile vacuoles as in *Chlamydomonas* or a complicated excretory system as in higher organisms.

- **<u>There are some common characters between living and non living which are</u>**:

1. **Increase in size**: like in crystals
2. **Movement**:

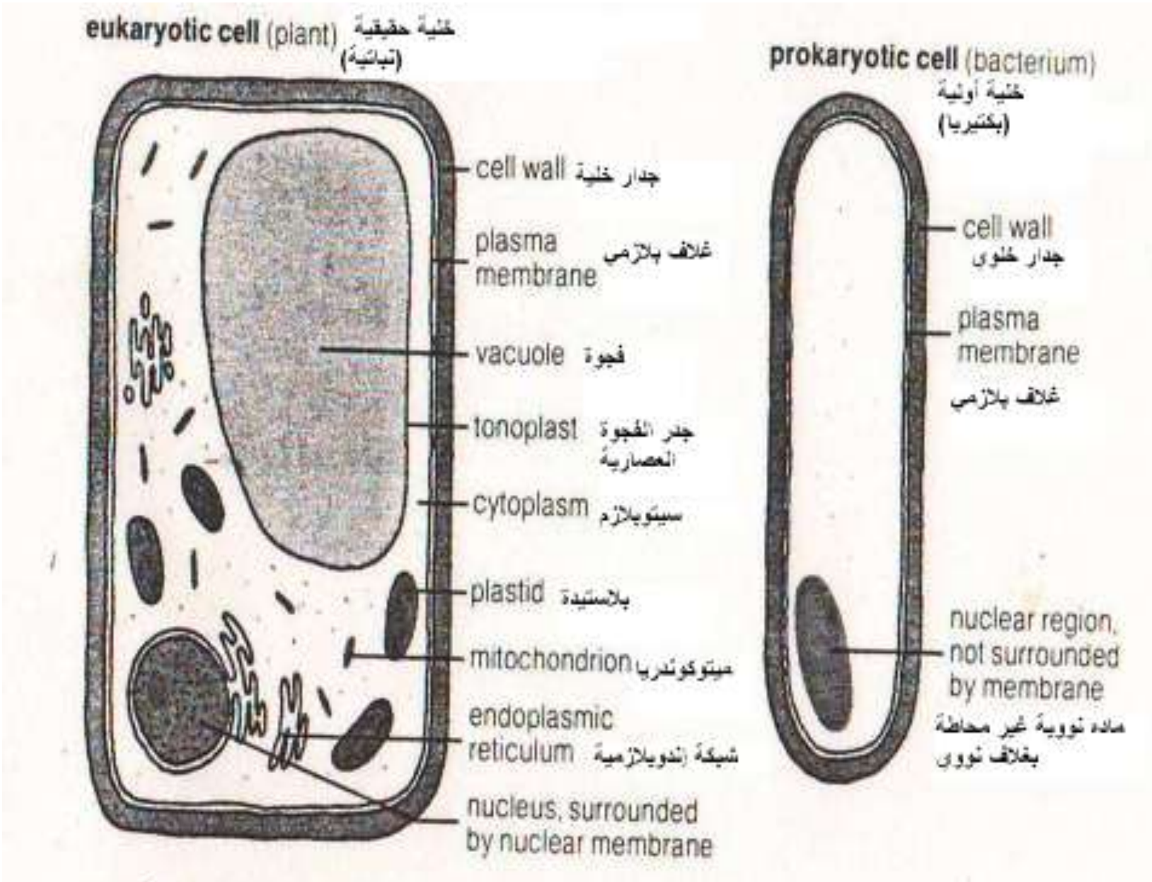
- a piece of metallic Sodium can move over water surface due to a chemical reaction.
- A drop of oil can move over water surface and form something like pseudopodia (false feet) in *Amoeba.*

# Cellular Structures and Functions

- **The Cell**: is the body building unit both in structure and function.
- **Protoplasm**: It is called on the cell constituents.
- **Cellular Theory**: Plant and animal bodies consist of cells. New cells are only produced through the division of former existing cells (Schwan & Shleiden).
- Each cell consists of a nucleus surrounded by a nuclear membrane, with some exceptions as the Red Blood Cells (RBCs), losing its nuclei during maturation) or skeletal muscles (multinucleated).
- 
- **<u>Organisms are either</u>**:

1. Cellular: either unicellular or multicellular
2. Acellular: Bodies whose cells never divide *i.e. Viruses*.

- Harrison-an American scientist-was able to cultivate *Salamander* cells in artificial media outside the body. Since then many plant and animal tissues were cultivated *in vitro* (in lab) by the help of Tissue Culture techniques.




# Exchanges of materials between cell and Environment

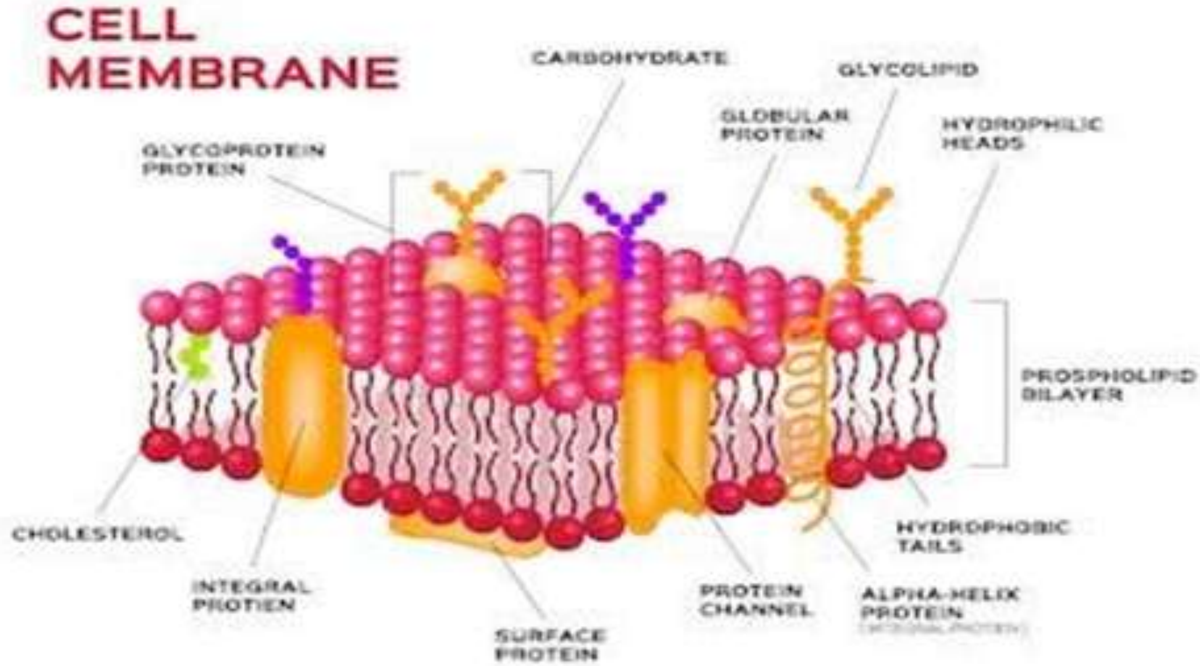
- **Plasma Membrane**: A membrane that regulates the possibility of substances or nutrients to pass in or out of the cell. They are living membranes that are selectively permeable. (they can allow the passage of substance even against concentration gradient).
- **Factors controlling the passage of a particle through cell membrane:**

1. Particle Size. 2. Solubility in lipids.

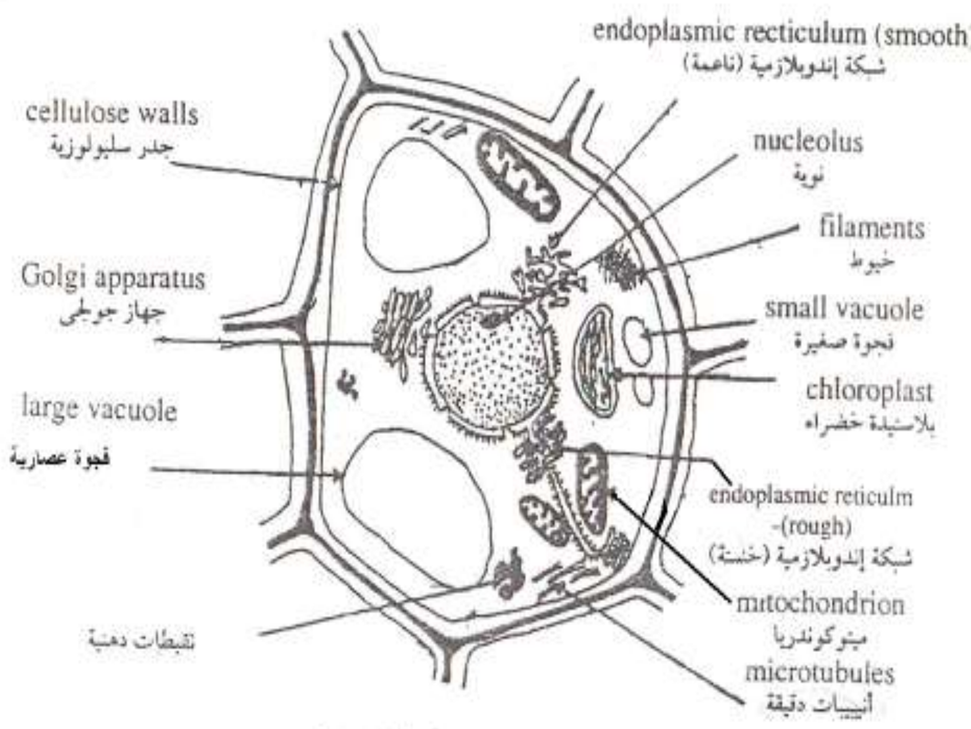
3. Number of water molecules adhered to the particle.

4. Electric charge carried on the particle.

5. Thickness of the *Endoplasmic reticulum* folds.






(شكل ٢): التركيب الدقيق لخلية نباتية

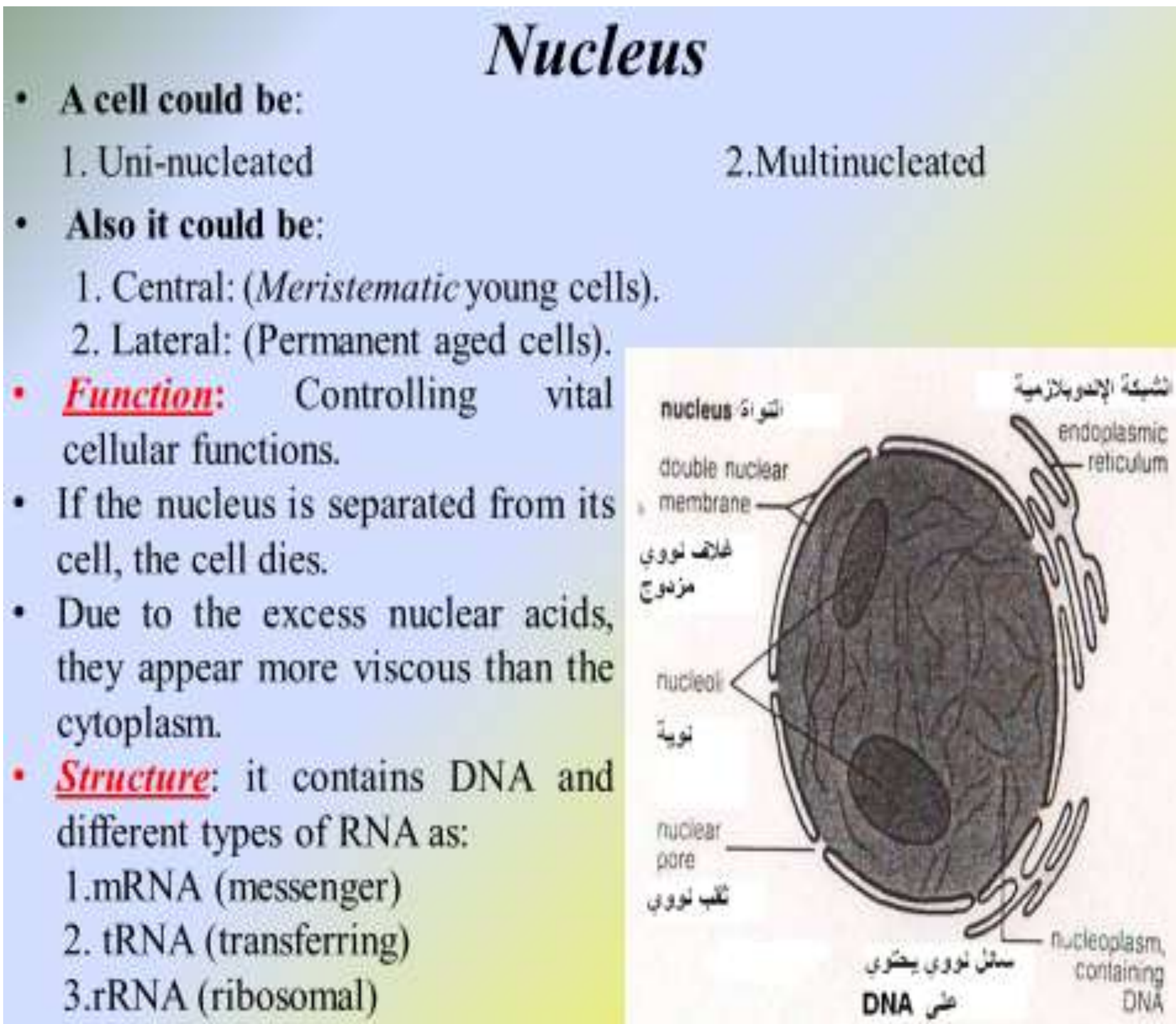
*(Fig. 2) ultramicroscopic structure of plant cel*

# Endoplasmic Reticulum

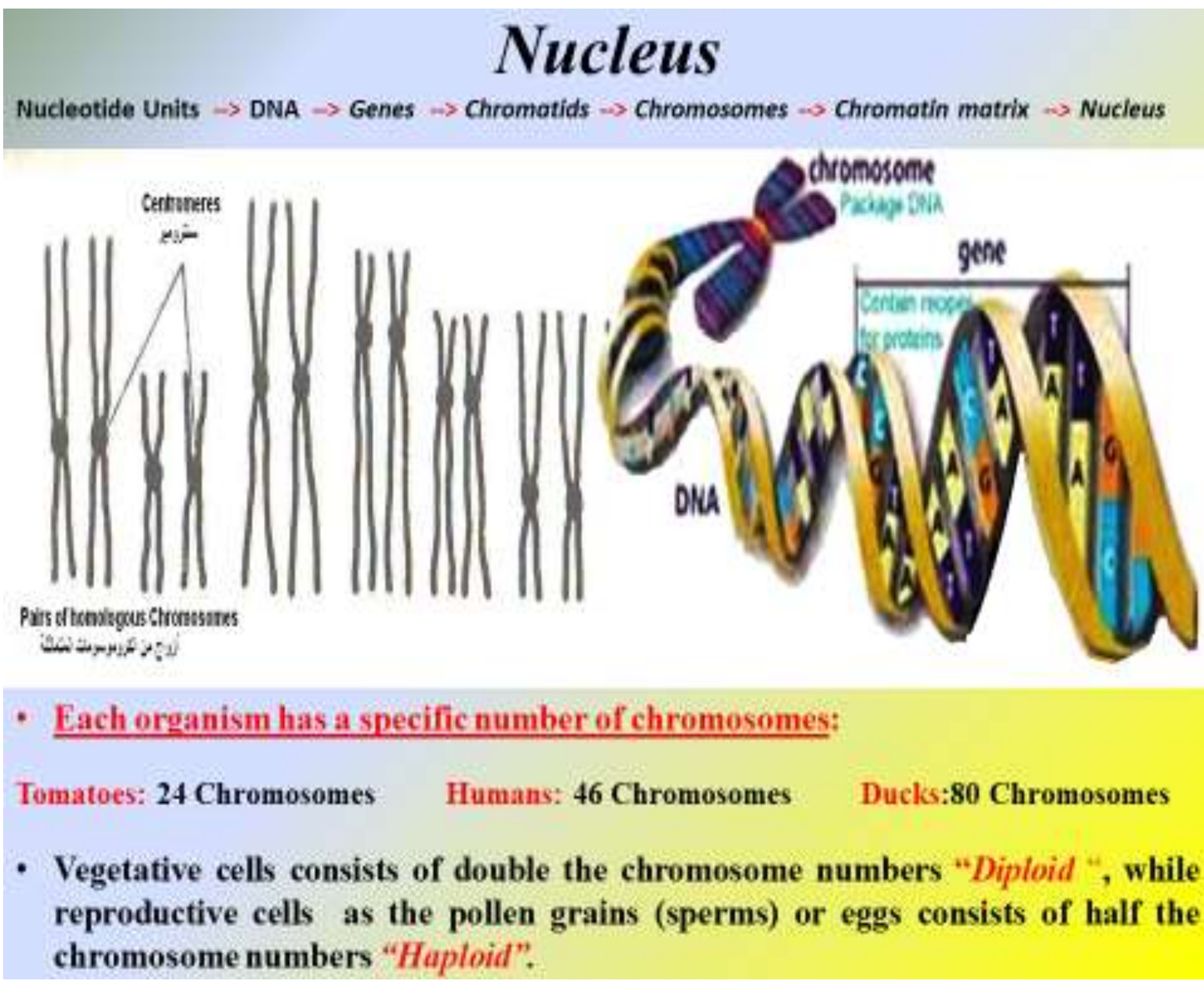
- ***Shape*:** Fine tubes and vesicles of two types:

1. Smooth
2. Rough: due to the presence of *Ribosomes*.

- ***Function*:** Passing and storing substances and nutrients inside the cell ( specially the proteins)
- ***Ribosomes*:** Small protoplasmic bodies that maybe found free or attached to the rough *Endoplasmic reticulum*, *plastids*, *nuclei* and *mitochondria.*
- ***Function***: They attach to mRNA to synthesis protein in the cell.

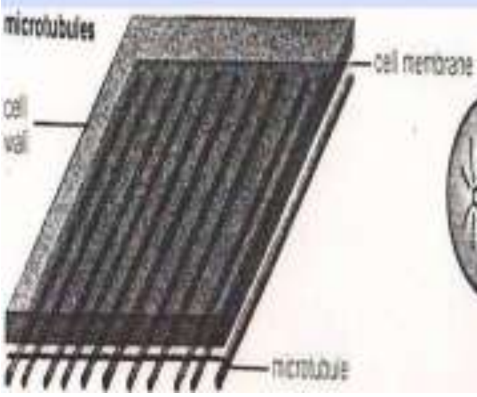


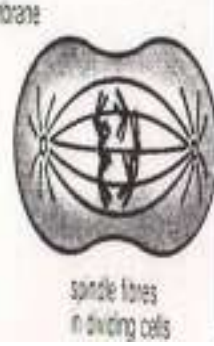
- It consists of a gelatinous substance rich in protein, fats and nucleic acids known as Nuclear Sap.
- It is enveloped by a nuclear membrane which is a bilayer membrane carries *Ribosomes* on its surface.
- One or more *Nuclei* is found in the nuclear sap.
- ***Nuclei***: A spherical body devoid of a membrane, more viscous than the nuclear sap as it is very rich with RNA and proteins with little DNA.
- ***Function***: Center of formation of RNA, proteins and *Ribosomes.*
- It is composed of a chromatin matrix from units called *Chromosomes.* Each *Chromosome* consists of two *Chromatids* connected by a *Centromere.*
- Each *Chromatid* consists of proteins and nucleic acids.
- Each *Chromatid* consists of *genes* that compose DNA.

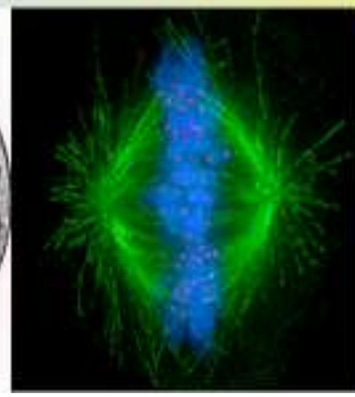


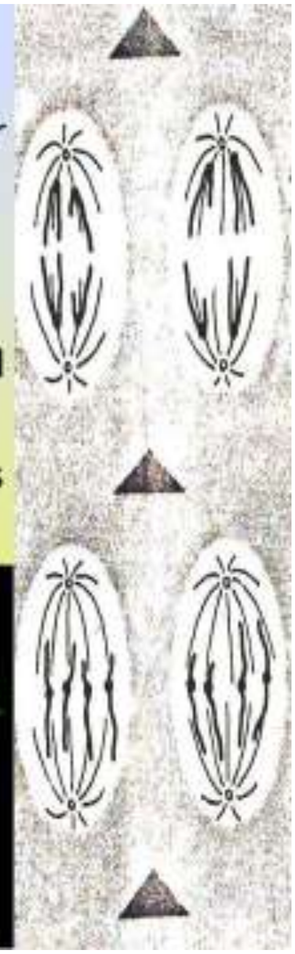
# Centrioles

- Two small dark colored cylindrical bodies found near the nucleus.
- Found in animal cells and primitive plant cells.
- It plays a basic role in cell division.
- Form what is known as Spindle Fibers (Chromosomal & Continuous).
- **Spindle Fibers**: Microtubules radiating filaments, lies between the Chromosomes and on the cell poles.



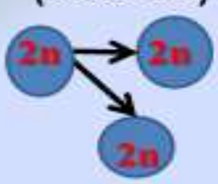



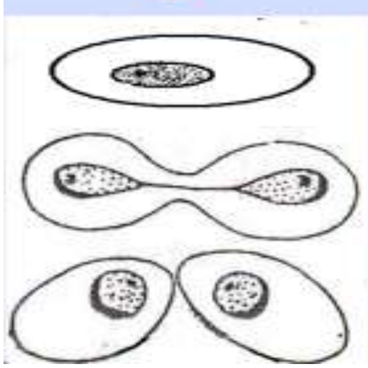





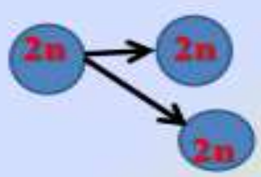
## Cell Division

1. *Amitosis* (fission)

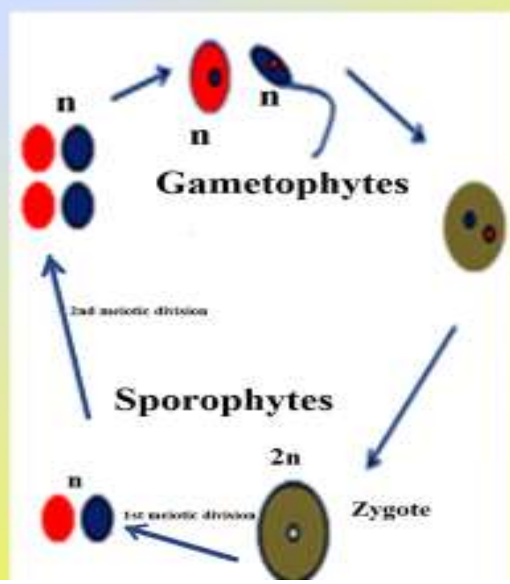


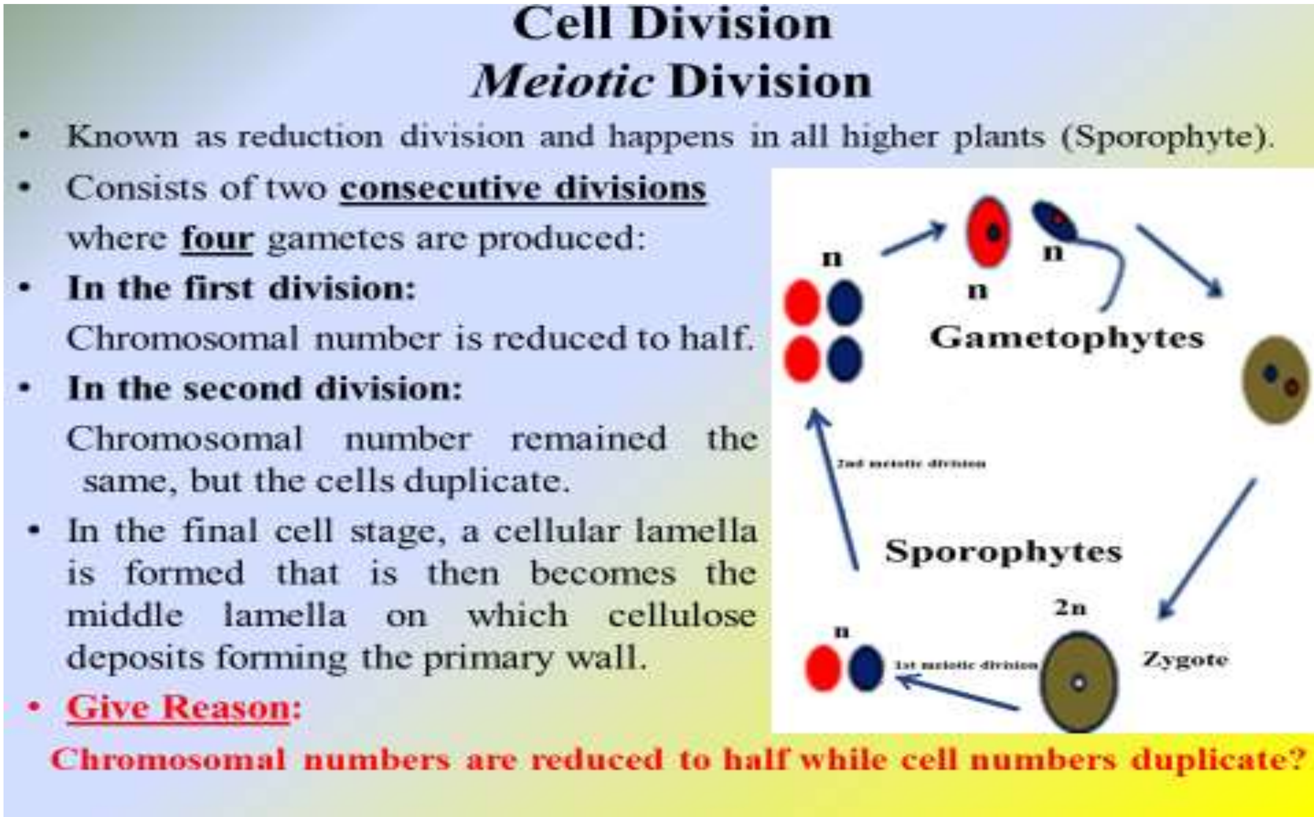



2. *Mitosis*



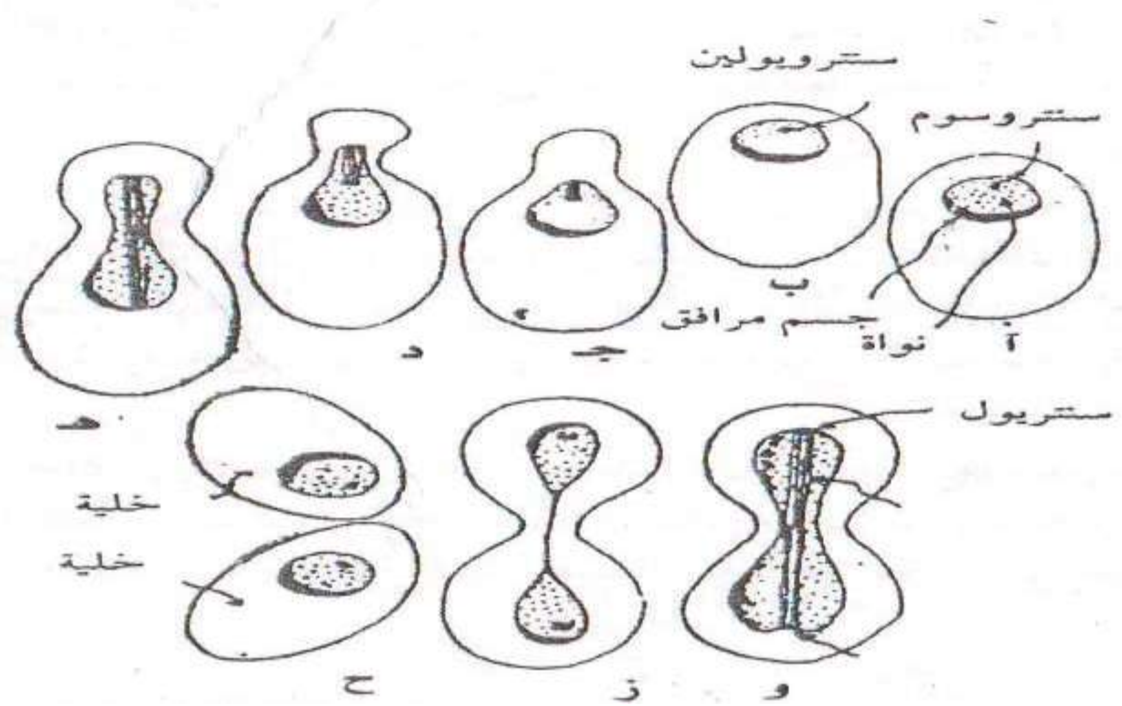

3. *Meiosis*






# Cell division
## 1. *Amitosis* (Fission)

- It is also called Binary fission, it happens in lower organisms like *Bacteria* and some *Fungi*.



# Cell division

## 2. *Mitosis*

- **<u>It occurs in five stages</u>**:

### 1. Interphase stage:

➢ DNA duplicates.

➢ Nucleus enlarges and cytoplasm becomes granular.

### 2. Prophase stage:

➢ Chromosomes get short, thicker and is coated by the matrix.

➢ Nucleus and nuclear membrane disappear.

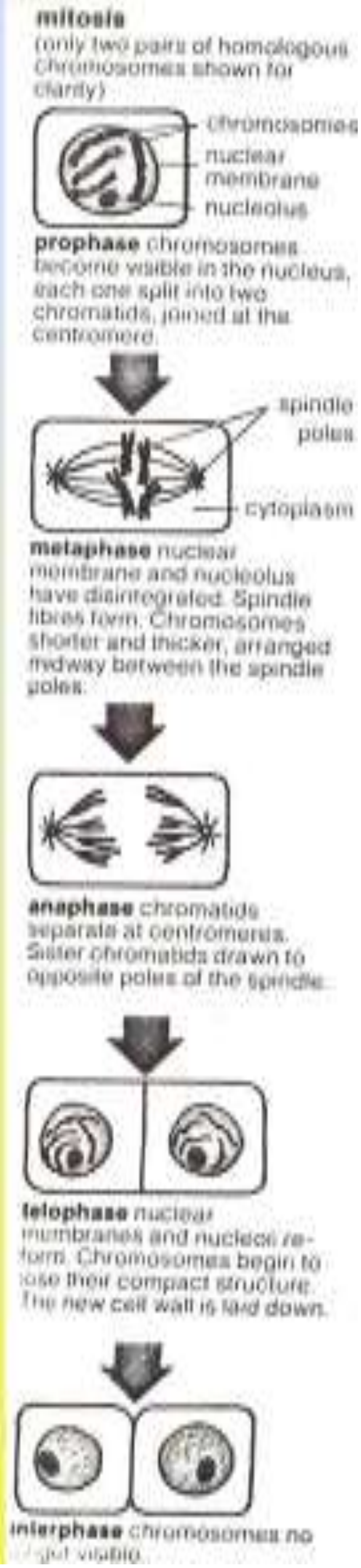
### 3. Metaphase stage:

➢ Each centriole migrates to one pole of the cell.

➢ Spindle fibers form, those attached to the centromere are called "Chromosomal fibers" while the others are called "Continuous fibers".

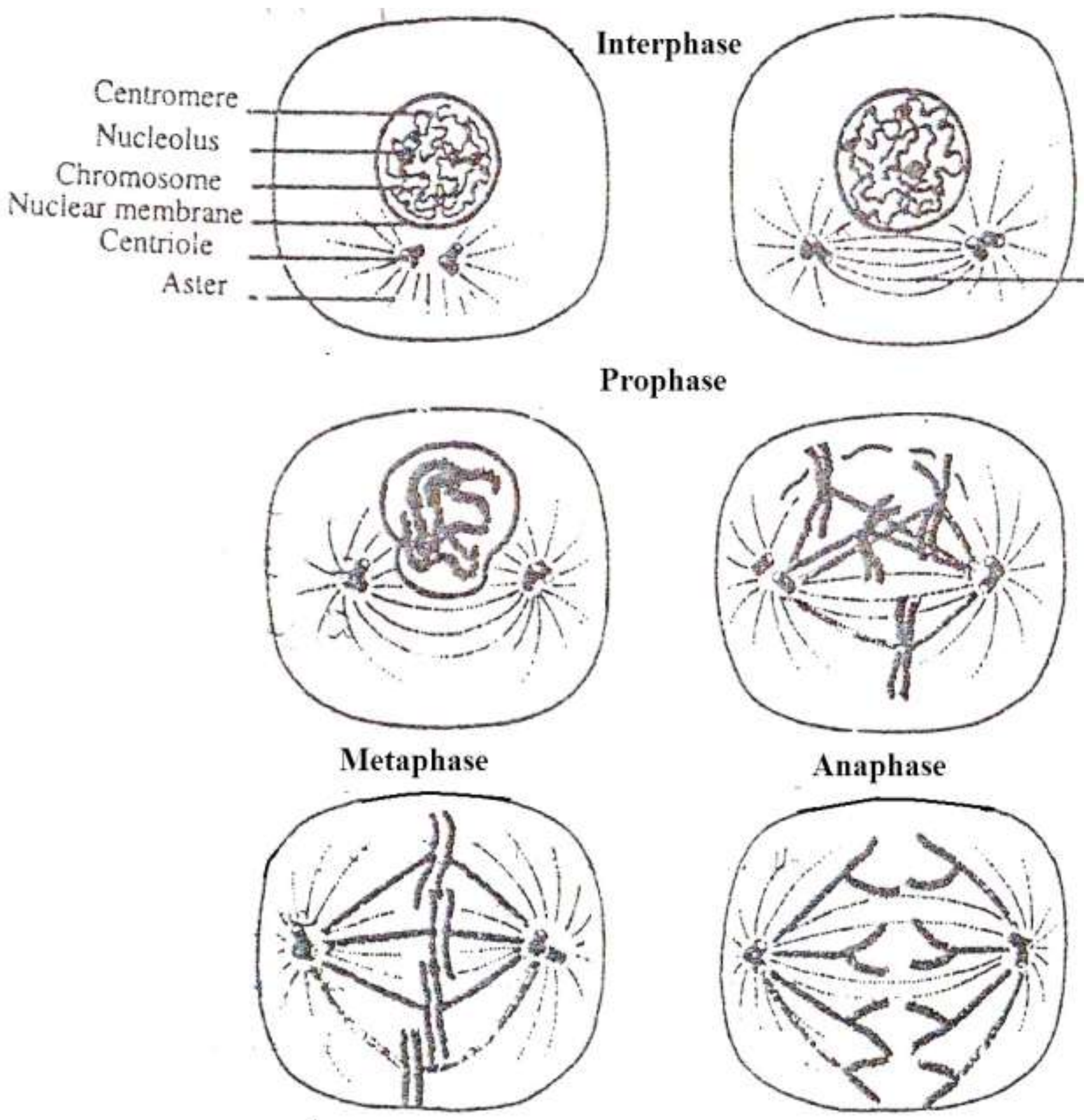
➢ Chromosomes are arranged in midway.

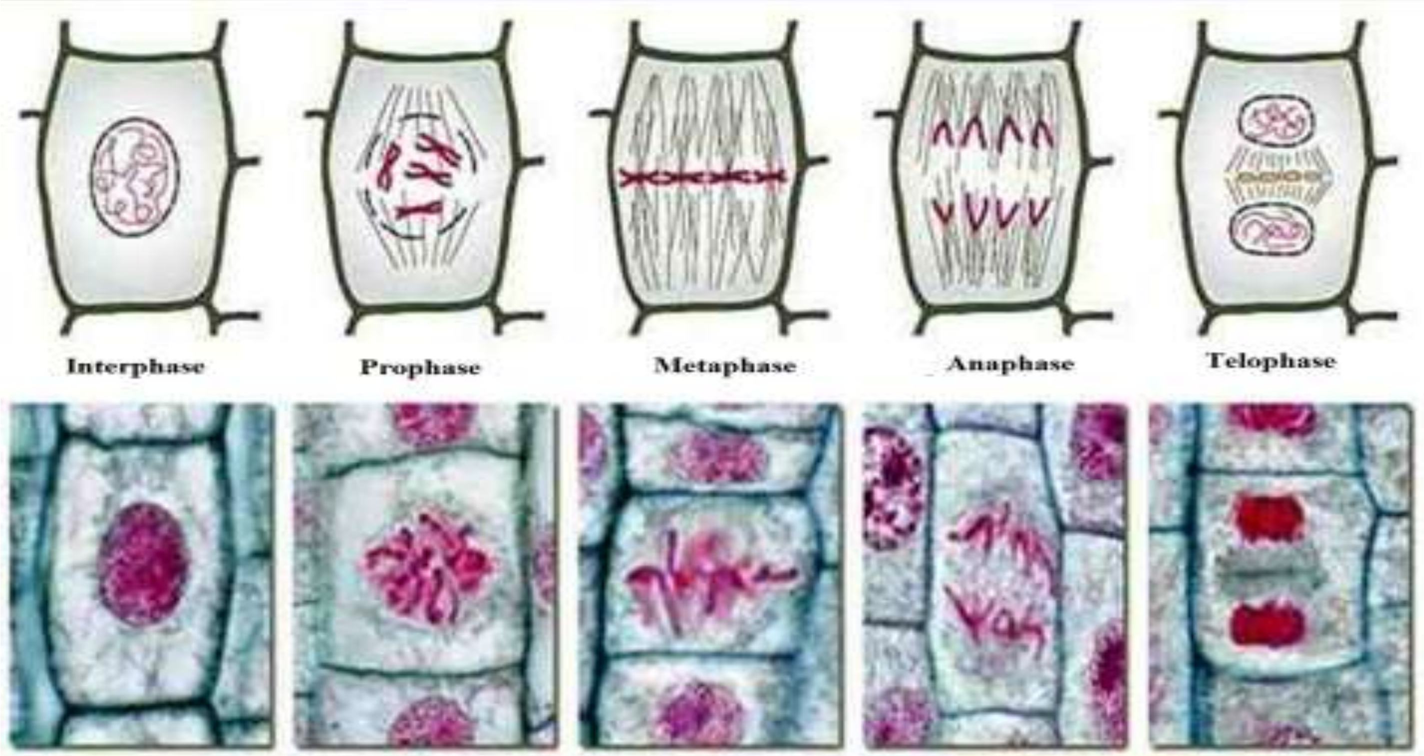
**4. Anaphase stage:** Chromosomes at the centromeres, sister chromatids drawn to opposite poles of the spindle.



5. Telophase stage: the steps are opposite to that of prophase, where:

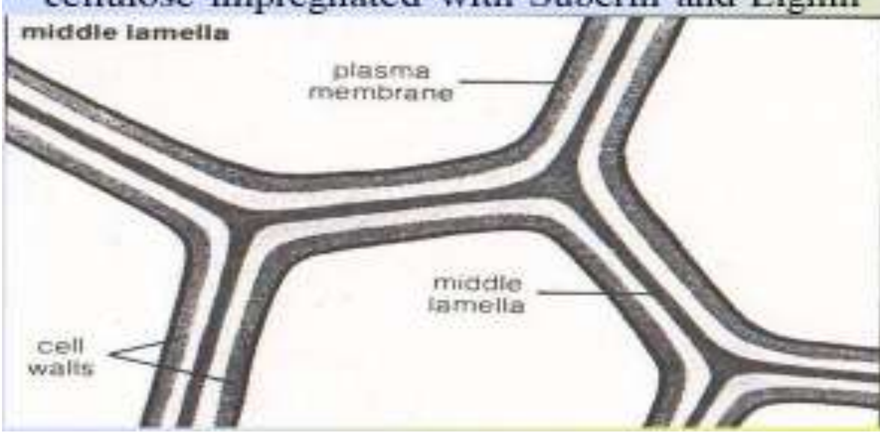
- The matrix disappears, the chromosomes become thinner and longer.
- Nuclear membrane and nucleoli reform.
- Vesicles are formed in the cell midway by Golgi apparatus forming the cell lamella which with two plasma membranes form the middle lamella on which cellulose is deposited to form the primary cell wall.

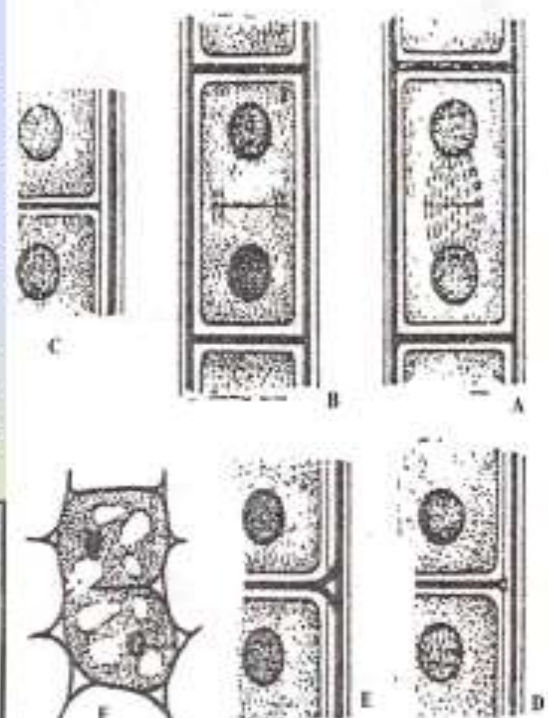





# Cell Wall

1. **Cellular Lamella** is formed in between the two cells resulting from division.
2. Ca and Mg pectates are deposited to form the **Middle lamella**.
3. **Primary cell wall** is formed when cellulose is deposited.
4. **Secondary cell wall** is then formed of three layers, the middle is thick and the other two surrounding it are thin where they all are of cellulose impregnated with Suberin and Lignin



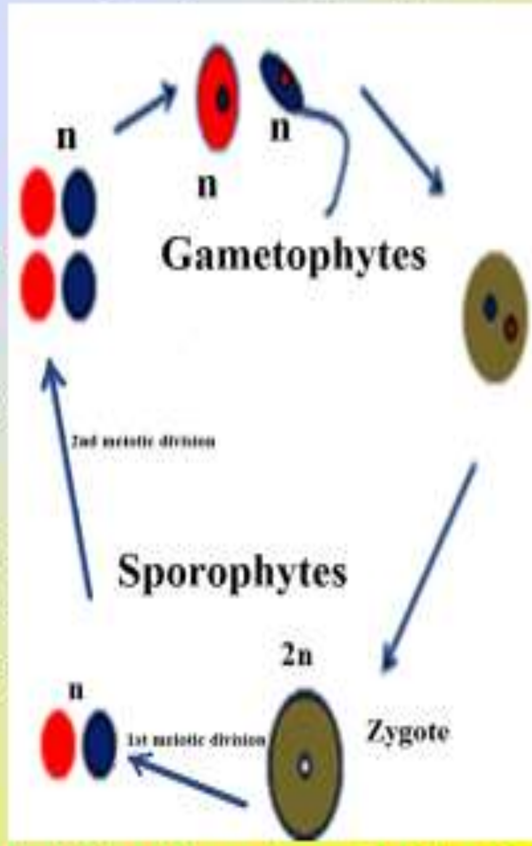

(شكل ٧) : خطوات تكوين الجدار الخلوي

*(Fig. 7) steps of cell wall formation*

(A),(B) Cellular Lamella Formation (C) Middle Lamella Formation
(D),(E) Intercellular Spaces (F) Formation of Divided Cells

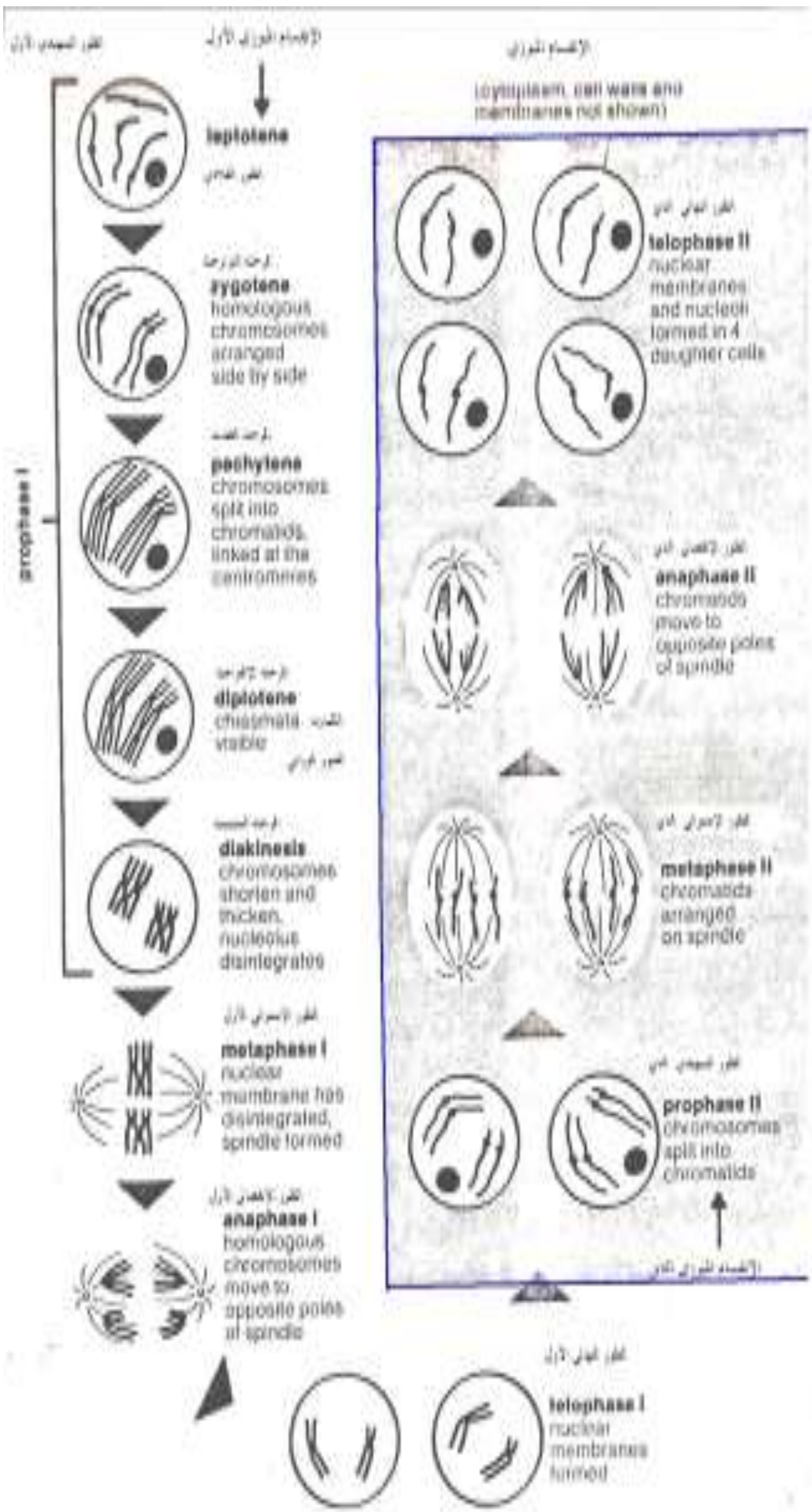
# Cell Division
## *Meiotic* Division

- Known as reduction division and happens in all higher plants (Sporophyte).
- Consists of two **consecutive divisions** where **four** gametes are produced:
- **In the first division:**
  Chromosomal number is reduced to half.
- **In the second division:**
  Chromosomal number remained the same, but the cells duplicate.
- In the final cell stage, a cellular lamella is formed that is then becomes the middle lamella on which cellulose deposits forming the primary wall.




- **Give Reason:**

**Chromosomal numbers are reduced to half while cell numbers duplicate?**

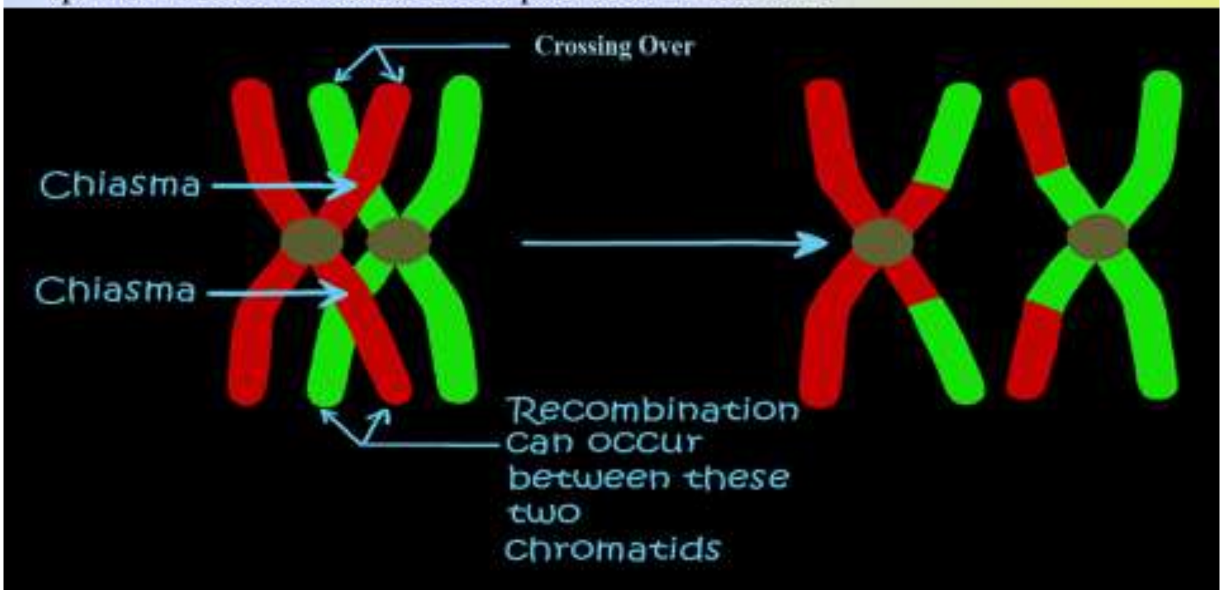


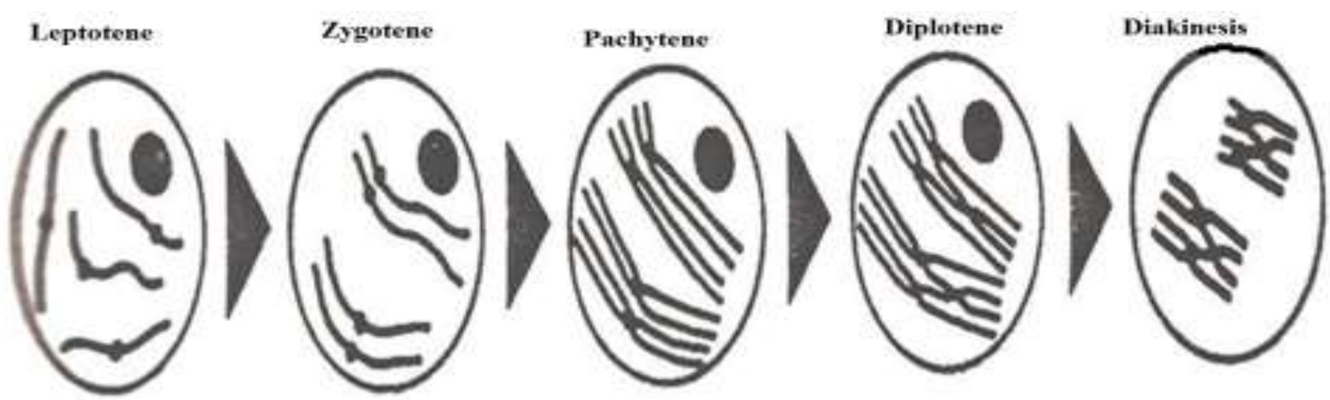
leptotene
zygotene
homologous chromosomes arranged side by side
pachytene
chromosomes split into chromatids, linked at the centromeres
diplotene
chiasmata visible
diakinesis
chromosomes shorten and thicken, nucleolus disintegrates
prophase I
metaphase I
nuclear membrane has disintegrated, spindle formed
anaphase I
homologous chromosomes move to opposite poles of spindle
telophase I
nuclear membranes formed
(cytoplasm, cell walls and membranes not shown)
telophase II
nuclear membranes and nucleoli formed in 4 daughter cells
anaphase II
chromatids move to opposite poles of spindle
metaphase II
chromatids arranged on spindle
prophase II
chromosomes split into chromatids

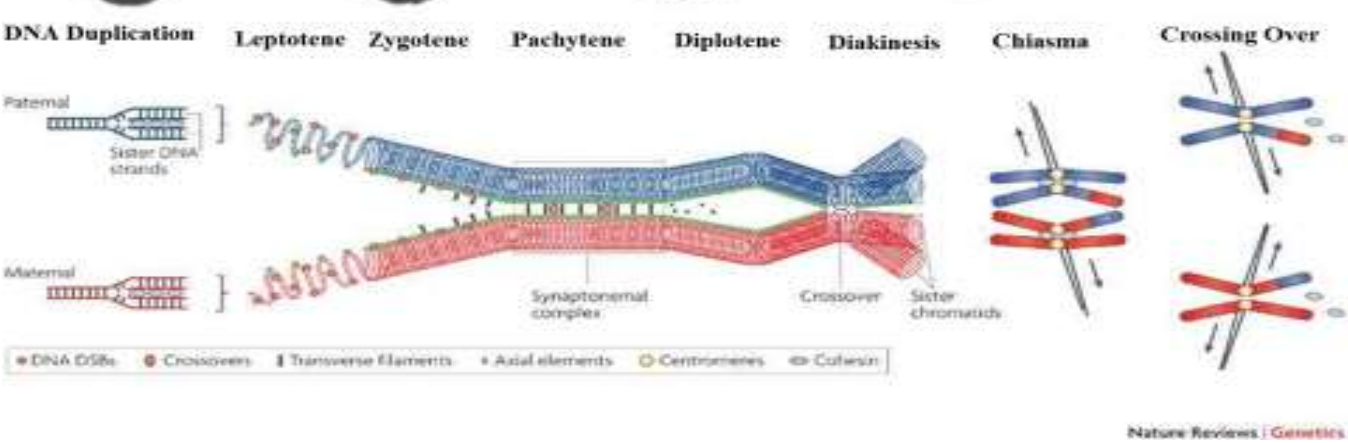
crossing-over
during first meiotic division
2 homologous chromosomes
chiasma
chiasmata formed
bivalent or tetrad
genetic material exchanged, chromosomes separate

# *Meiotic* Division

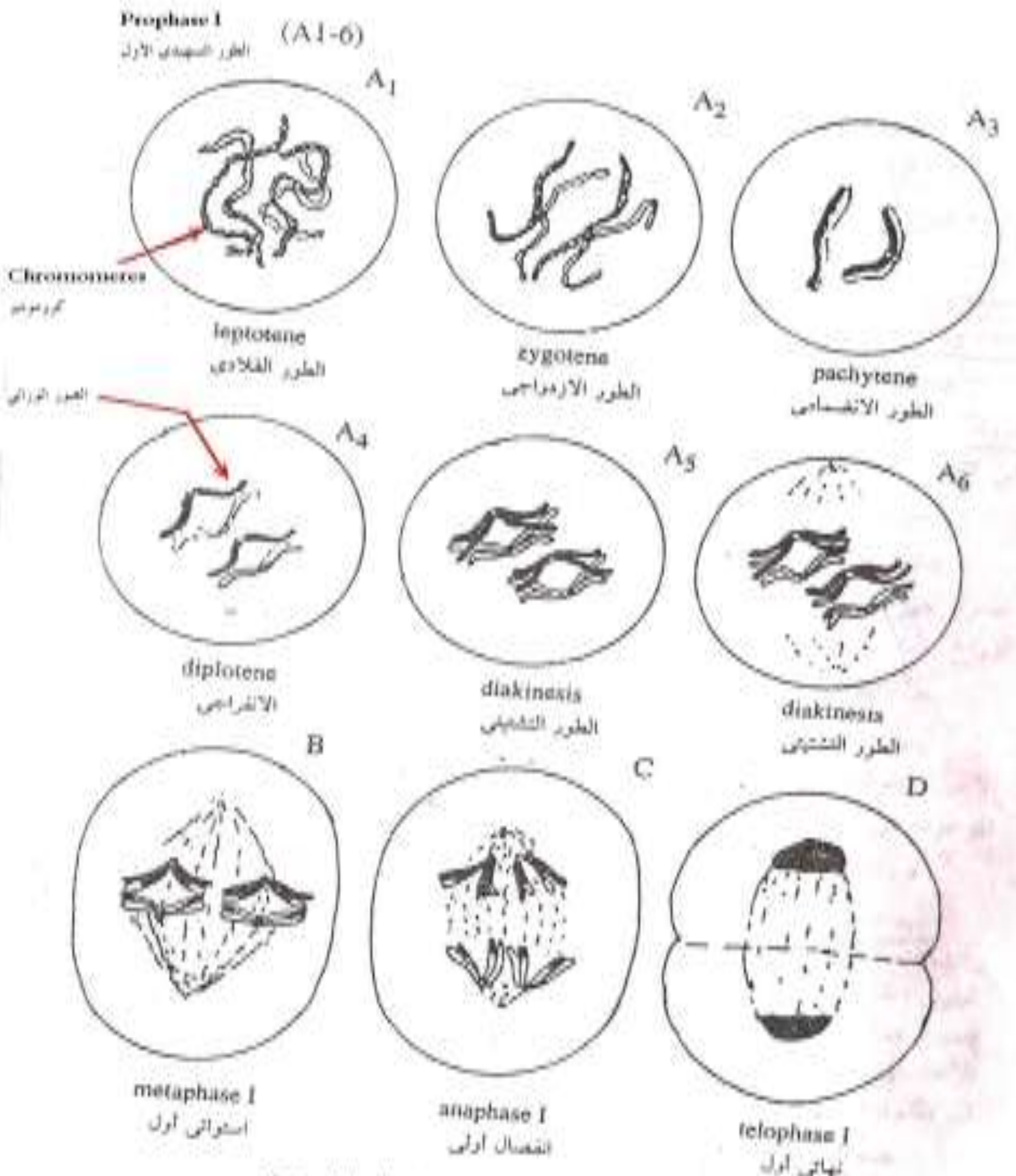
- **Chiasma:** The recombination of the internal chromatids of the two sister chromosomes during the diplotene phase in the 1st meiotic division.
- **Crossing Over:** The exchange of parental genetic material during the split of the chromatids at the points of chiasmata.



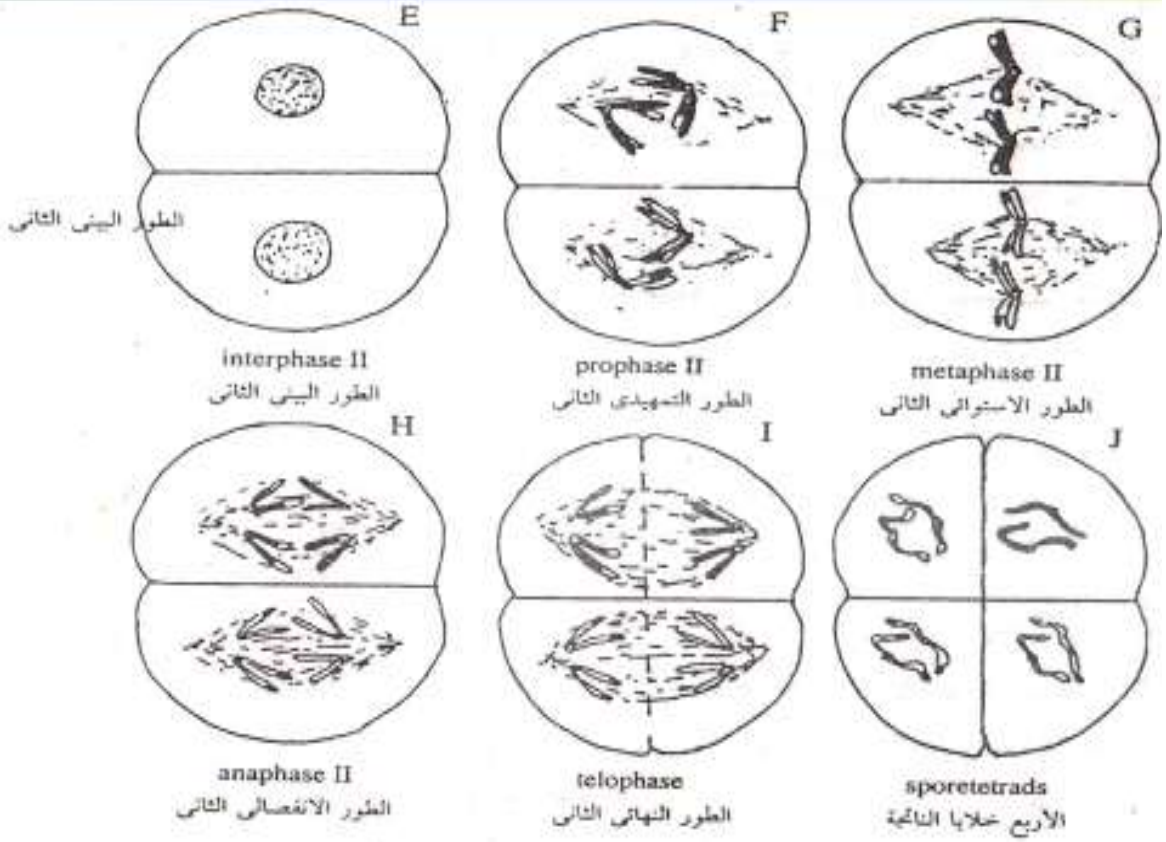



# 1st *Meiotic* Division

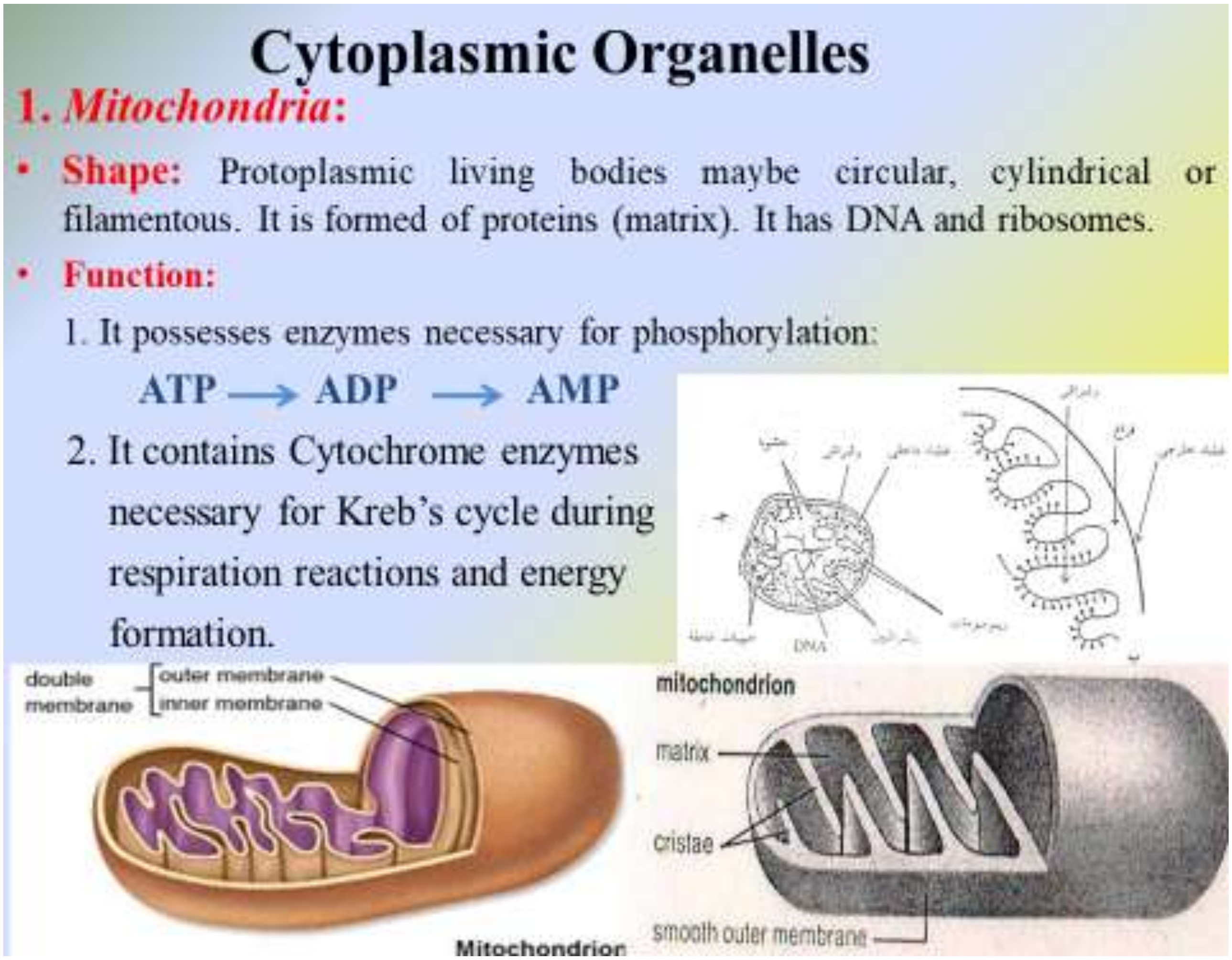



(شكل ٦): خطوات الانقسام الاختزالي (الميوزي)
(Fig. 6) stages of meiosis

# $2^{nd}$ *Meiotic* Division




تابع (شكل ٦): خطوات الانقسام الاختزالى (الميوزى)
*(Cont. Fig. 6) stages of meiosis*




## 2. <u>Plastids:</u>

### Structure:

Protoplasmic living organelles that are able to grow and divide.

It is formed from small bodies called Proplastids.

It is not found in lower organisms like Bacteria and Fungi. The cell may possess one large plastid (as in Algae i.e. Chlamydomonas) or many plastids (as in higher plants).

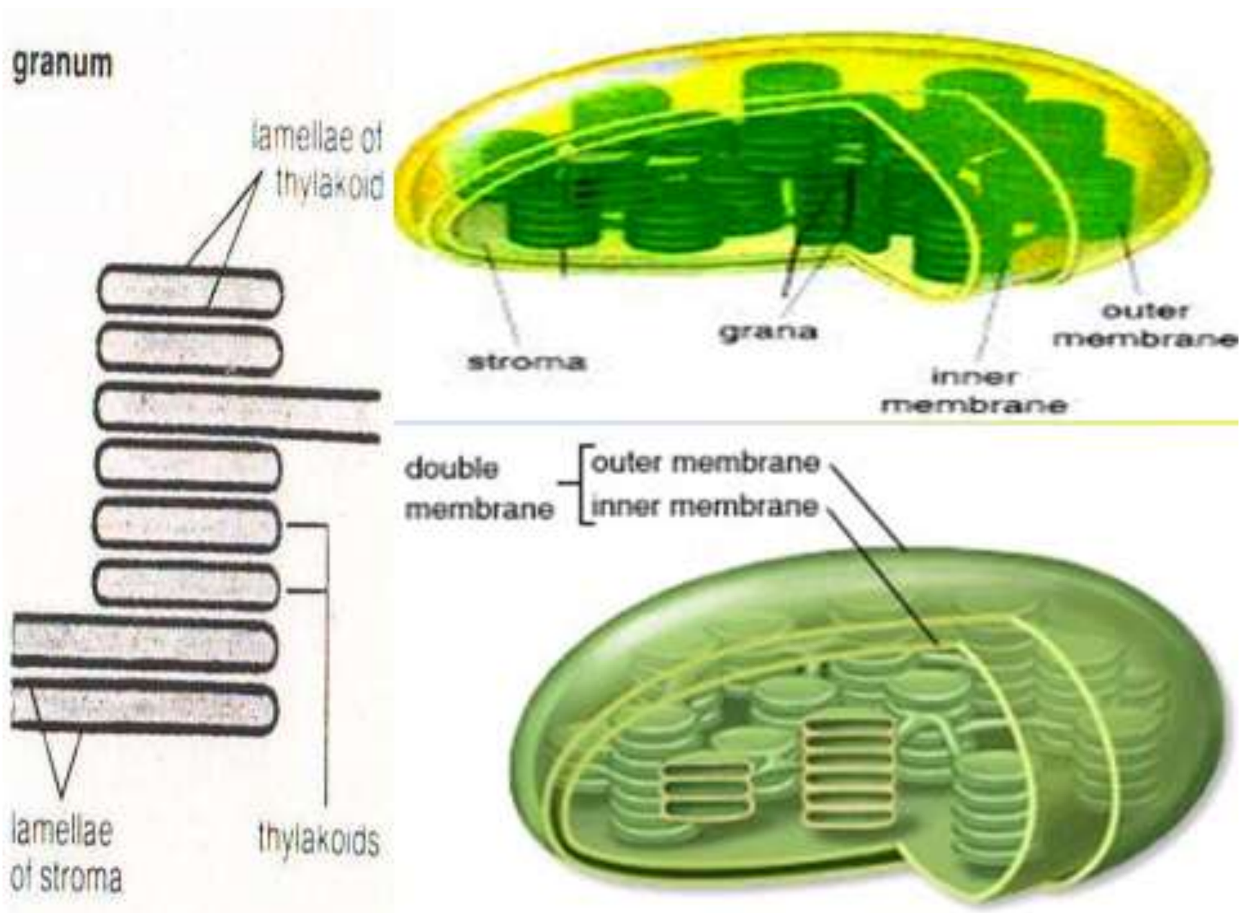
The plastids may be green, colored (pepper) or colorless (onion) and it can change from form to another when exposed to light.

It contains Chlorophyll A, B, Carotene and Xanthophyll.

**Function:**

It undergoes photosynthesis through transforming light energy into chemical energy.

Colorless plastids are centers of storing starch or any other substance.



chromoplasts in a root cell of ***Daucus*** carota

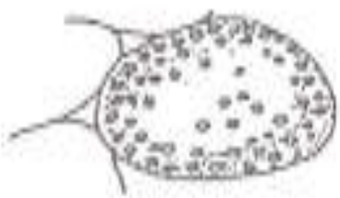
بلاستيدات ملونة في خلية لجذر نبات الجزر

leucoplasts in a young endosperm cell of ***Zea mays.***

بلاستيدات عديمة اللون في خلية صغيرة لاندوسبيرم نبات الذرة الشامية

chromoplasts in an epidernal cell from calyx of ***Tropaeolum majus***

بلاستيدات ملونة في خلية بشرة الكأس لنبات أبو خنجر



chromoplasts in a fruit cell of ***Capsicum***

بلاستيدات ملونة في خلية ثمرة نبات الفلفل

***Spirogyra*** showing spiral - shape chloroplast

طحلب اسبيروجيرا لمشاهدة البلاستيدات الخضراء الحلزونية الشكل

***Elodea*** leaf showing disc shape chloroplast

ورقة نبات الالوديا لمشاهدة البلاستيدات الخضراء القرصية الشكل

***Zygnema*** showing star-shap chloroplast

طحلب الزيجنما لمشاهدة البلاستيدة الخضراء النجمية الشكل

(شكل ٩) : أنواع البلاستيدات

(Fig. 9) types of plastids

# Cytoplasmic Organelles

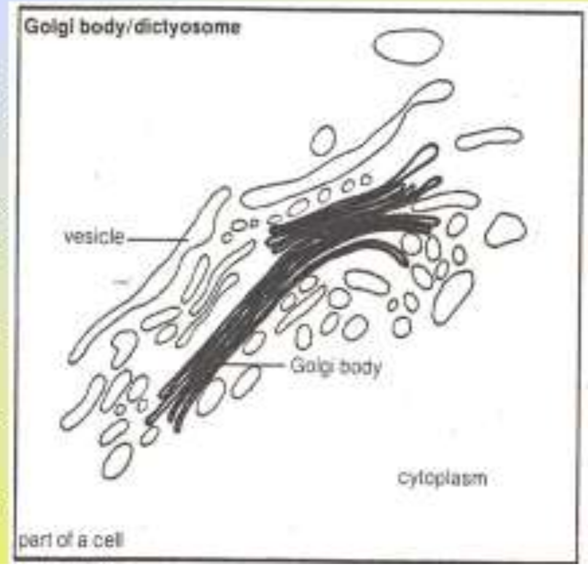
**3. Golgi Apparatus:** Found in all animal cells except sperms and RBCs.

- Shape:

1. It consists of group of bodies called ***Dictysomes***, which are hollow discs contains carbohydrates and proteins.
2. *Dictysome* wall is formed of a membrane made up of lipids and proteins.

- Function:

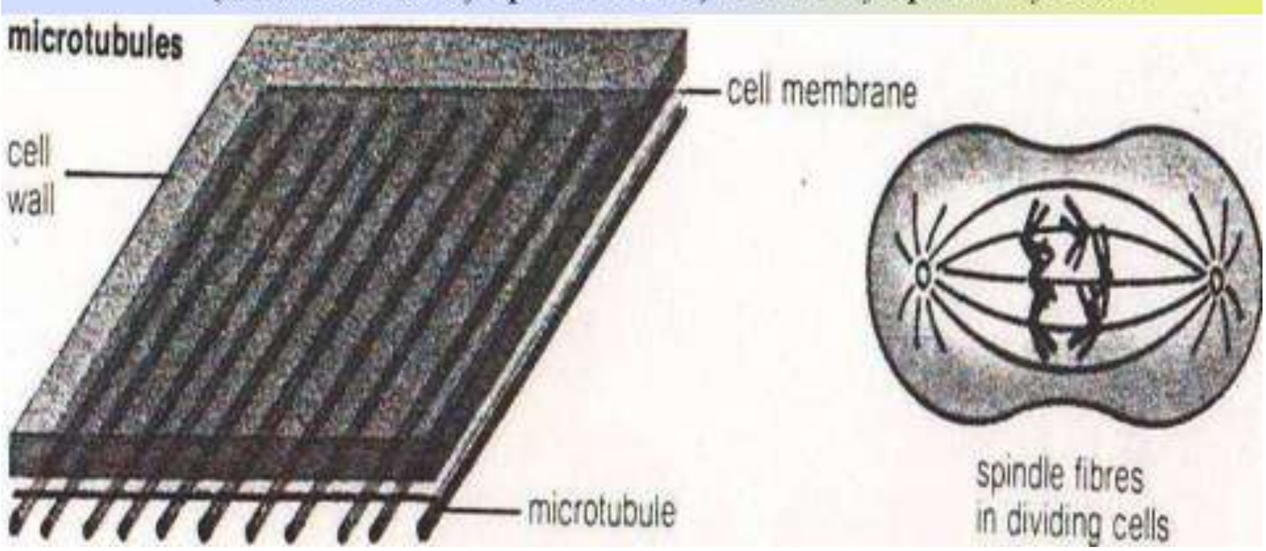
1. It secretes pectin substances necessary for the middle lamella formation.
2. It secretes mucilaginous substances to easy the penetration of root tips into the soil.
3. It secretes cellulose for cell wall formation.
4. Storage of proteins, carbohydrates and fats.
5. Transferring stored substances in and out of the cell




# Cytoplasmic Organelles

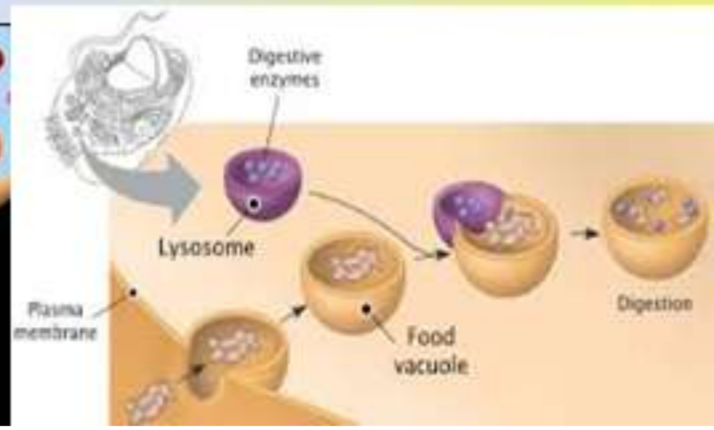
**4. *Microtubules*:**

- **Shape**: Rod-like hollow proteinous membranes. It is formed of ß and ∝ tubulin (types of proteins).
- **Function**: 1. It controls cell shape
  2. It plays an important role in the movement inside the cell (chromosomes by spindle fibers) and the cytoplasm cyclosis.



## 5. *Lysosome*:

- Shape:
  1. It is found in most animal cells and if found in plant cells they are in small spherical bodies.
  2. It appears as a vesicle surrounded by a membrane. It contains digestive active enzymes. When its walls ruptures it helps in destroying the cell.
- Function:
  1. Secreting enzymes as lipases (digesting fats), proteases (digesting proteins) and nucleases (digesting nucleic acids and nuclear membranes).


# Non-protoplasmic Components

## *Peroxisomes*

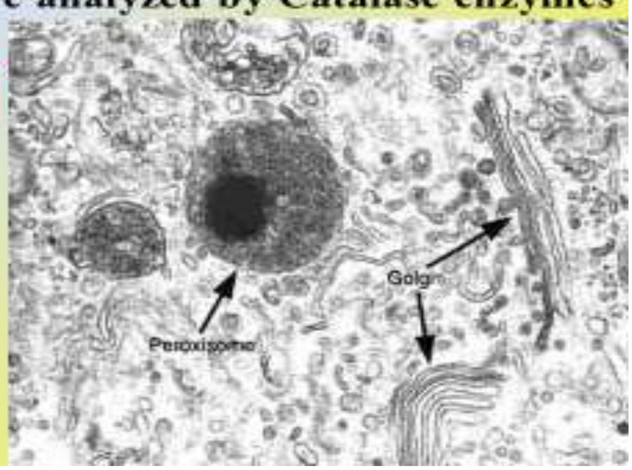
**Structure:**

- **They are vesicles the size of which reaches 1** mμ.
- **They are filled with enzymes and proteins.**

**Function:**

- **They produce peroxides which are analyzed by Catalase enzymes during photosynthesis.**

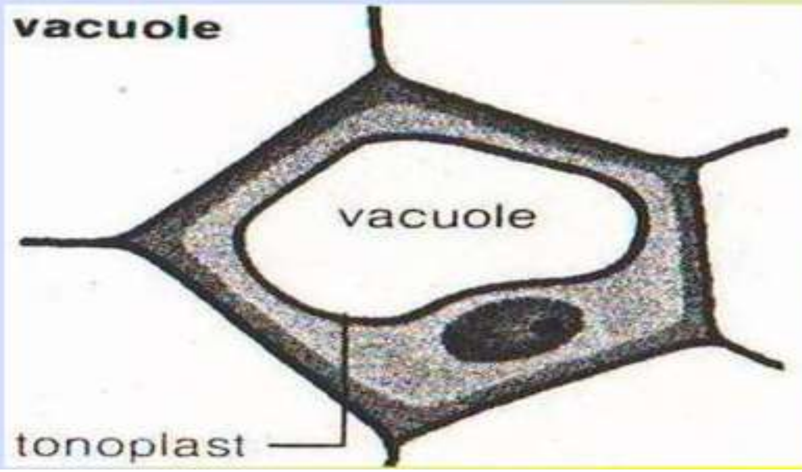
$$2\,H_2O_2 \xrightarrow{Catalase} 2\,H_2O + O_2\uparrow$$



## Non-protoplasmic Components

### *Vacuole*

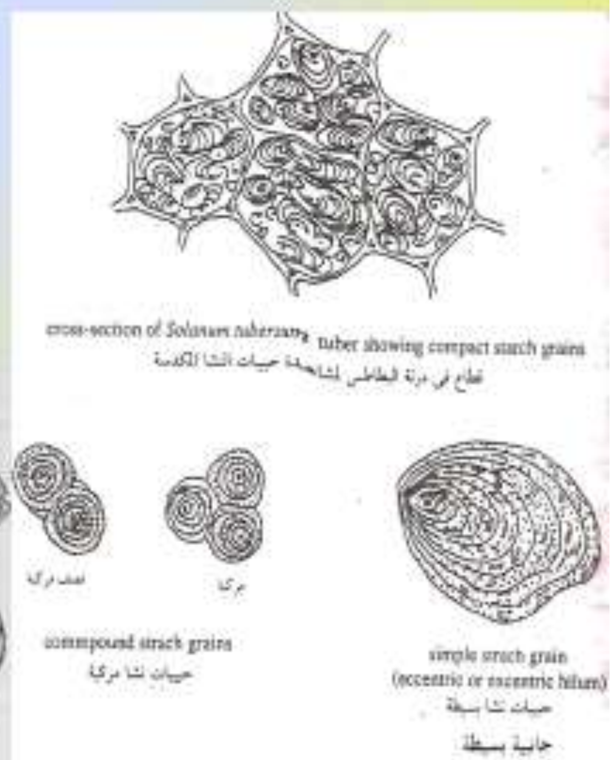
- It contains a colloidal solution, which consists of sugars, salts, proteins in addition to other metabolic wastes

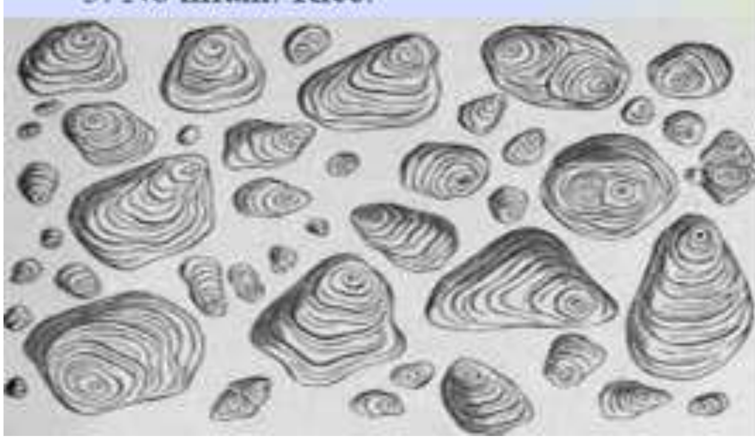


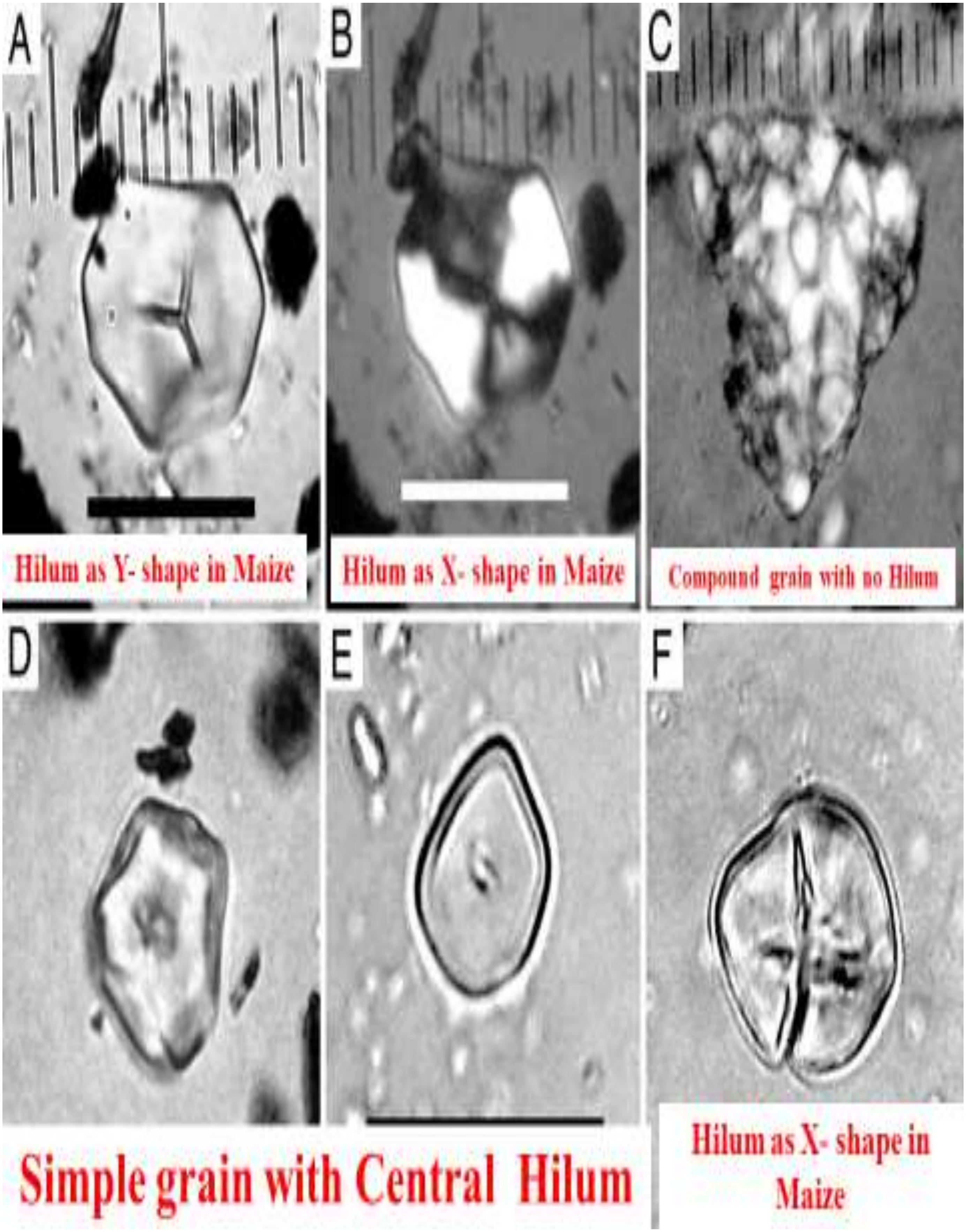

## Non-Protoplasmic components

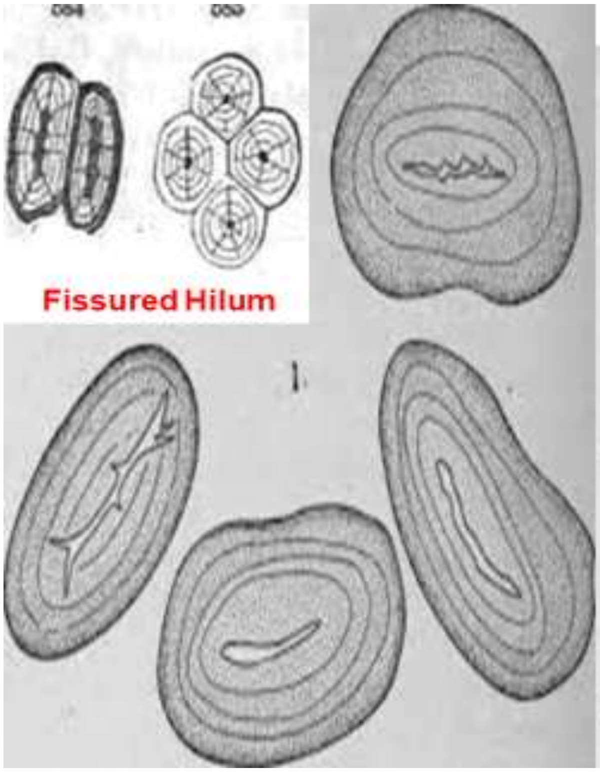
### Starch grains

- Striations of starch formation around a central point called the "**Hilum**", where the starch grains are:
  - Either: **Simple** or **Compound**.
  - According to the position of the Hilum they are either **Central** or **Lateral**.
  - In some plants the Hilum appears as:
    1. X or Y- shaped: Maize.
    2. Fissure: Kidney beans or Peas.
    3. No hilum: Rice.

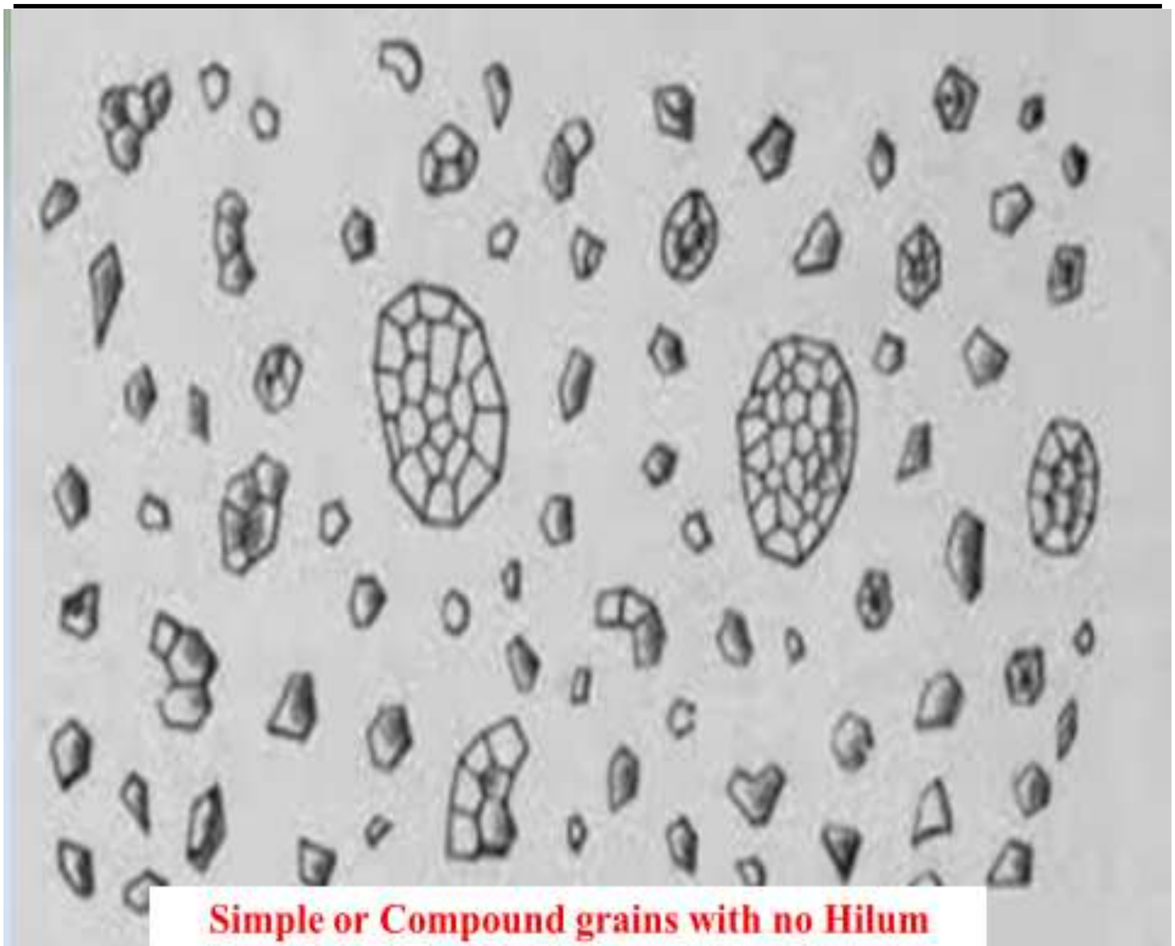



A
B
C
Hilum as Y- shape in Maize
Hilum as X- shape in Maize
Compound grain with no Hilum
D
E
F
Simple grain with Central Hilum
Hilum as X- shape in Maize


Fissured Hilum


X or Y-shaped Hilum

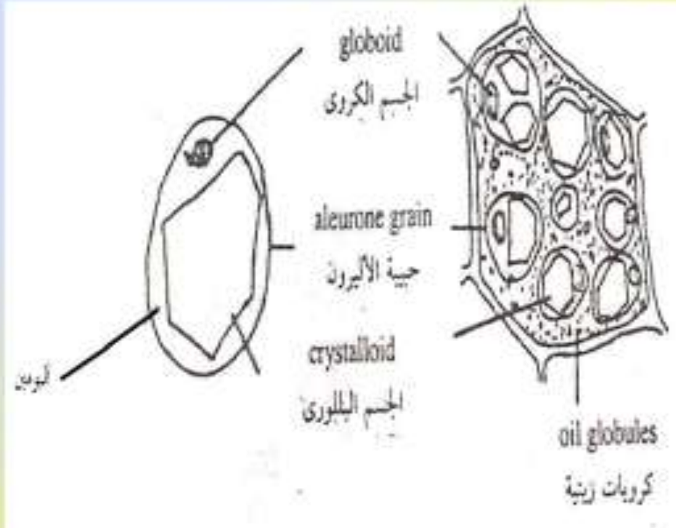

Simple or Compound grains with no Hilum

# Non-Protoplasmic components

- **Proteins:**
- It consists of *Aleurone* grains which is composed of:
  - Globoid Body of proteins.
  - Crystalloid Body
- **Function:** it is responsible for seed germination by the production of enzymes.

- **Fats and Oils:**

It is stored in fruits, seeds as well as rhizomes and tubers.




(شكل ١٢): حبيات الإليرون فى خلية اندوسبيرم نبات الخروع

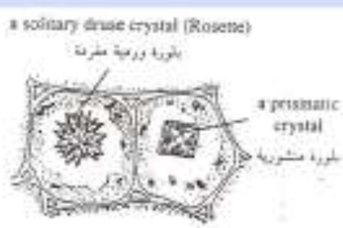
# Non-Protoplasmic components

## Crystals

- **Types**:
  1. **Proteinous**; in the form of small cubes.
  2. **Sugary**; like Inulin spherical crystals.
  3. **Salts**; Calcium crystals are one of the most widespread ones. It's divided into:
     - ✓**Ca-oxalate**:Solitary-Raphides-Druses.
     - ✓**Ca-carbonate**

(شكل ١٣): بللورات الإنيولين فى خلايا درنة نبات الداليا

*(Fig. 13) sphaerocrystals of inulin in cells of a Dahlia tuber*

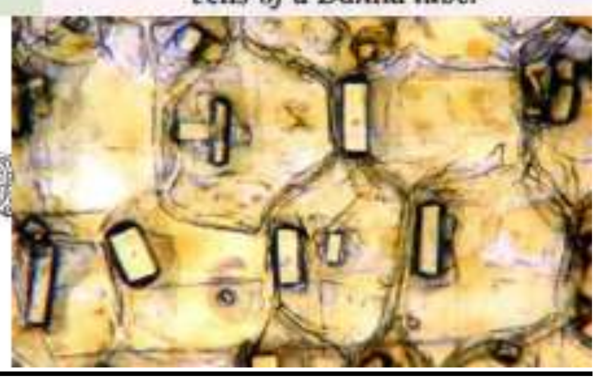


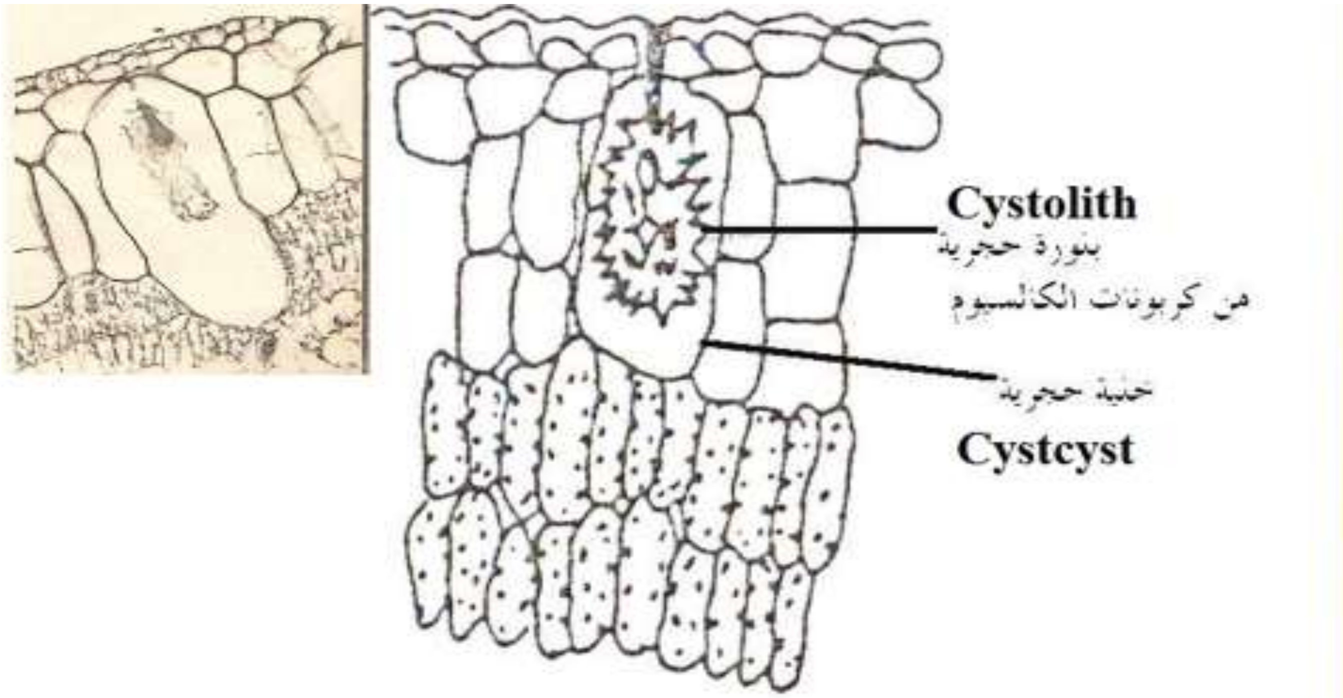

(شكل ١٤): خليتان من عنق نبات البيجونيا

*(Fig. 14) two parenchyma cells from the petiole of Begonia.*

(شكل ١٤): حزمة من بللورات إبرية

*(Fig. 14) a bundle of raphides.*






**T.S. in *Ficus elastica* leaf showing stone cell**

(شكل ١٤): بلورة حجرية فى نصل ورقة نبات الفيكس المطاط

# Non-Protoplasmic components

- **<u>Tanins</u>**: Phenolic compounds that is characterized by:

  Being colloidal in nature.

  It is found in dead tissues.

  It appears like thin or thick masses.

  It appears in red, yellow or brown colors.

  **Function**: 1. They protect the plants against drought.

  2. They are antioxidant in nature.

  3. They are antimicrobial agents.

- **Alkaloids**: Nitrogenous compounds, examples of which are:
- **Caffeine**:(In tea leaves or coffee beans) a nervous system stimulant
- **Opium**: the dried latex of Opium plants. Used as analgesic.

- **Quinine**: Isolated from the bark of Cinchona tree . Used to treat Malaria, but can cause deafness, irregular heart beat and sweating.
- **Pigments**: They are divided into two groups of pigments:

1. Insoluble in water: They dissolve in alcohol. Examples of which are those pigments found in plastids as Chlorophyll and Carotene.
2. Soluble in water: It includes Flavones and Anthocyanins

$$\text{Flavones} \xrightarrow{(O)} \text{Anthocyanins}$$

**<u>Anthocyanin changes its color according to the pH</u>**:

a. It is Red in Acidic, and
b. Blue in Alkaline

## Comparison between Plant and Animal Cells

| Point of Comparisons | Plant Cell | Animal Cell |
|---|---|---|
| **Centrioles** | Do not exist | Exist |
| **Plastids** | Exist | Do not exist |
| **Cellulosic Cell Wall** | Exist | Do not exist |
| **Plasma Membrane** | They Both have plasma membranes | |
| **Size** | They range from 1μm to less than 1cm | |

# Methods Of Studying Cells

## The Possibility Of Cell Cultivation In Laboratory:

1. It can be cultivated on nutrient media of:

   - Blood Plasma - Embryonic tissues -Salts &vitamins

2. The nutrient media is either liquid or solid (by adding agar)
3. The media is then sterilized to be used later.

## Cell Microscopic Examination:

Chemical fixation of the tissue to stabilize the specimen's mobile macromolecular structure.

The tissue is sectioned into thin slices using a microtome.

A slice is then placed in a glass slide and covered by a thin cover; to be examined later under the microscope.

Parts of the cell can be stained (i.e. nucleus or mitochondria).

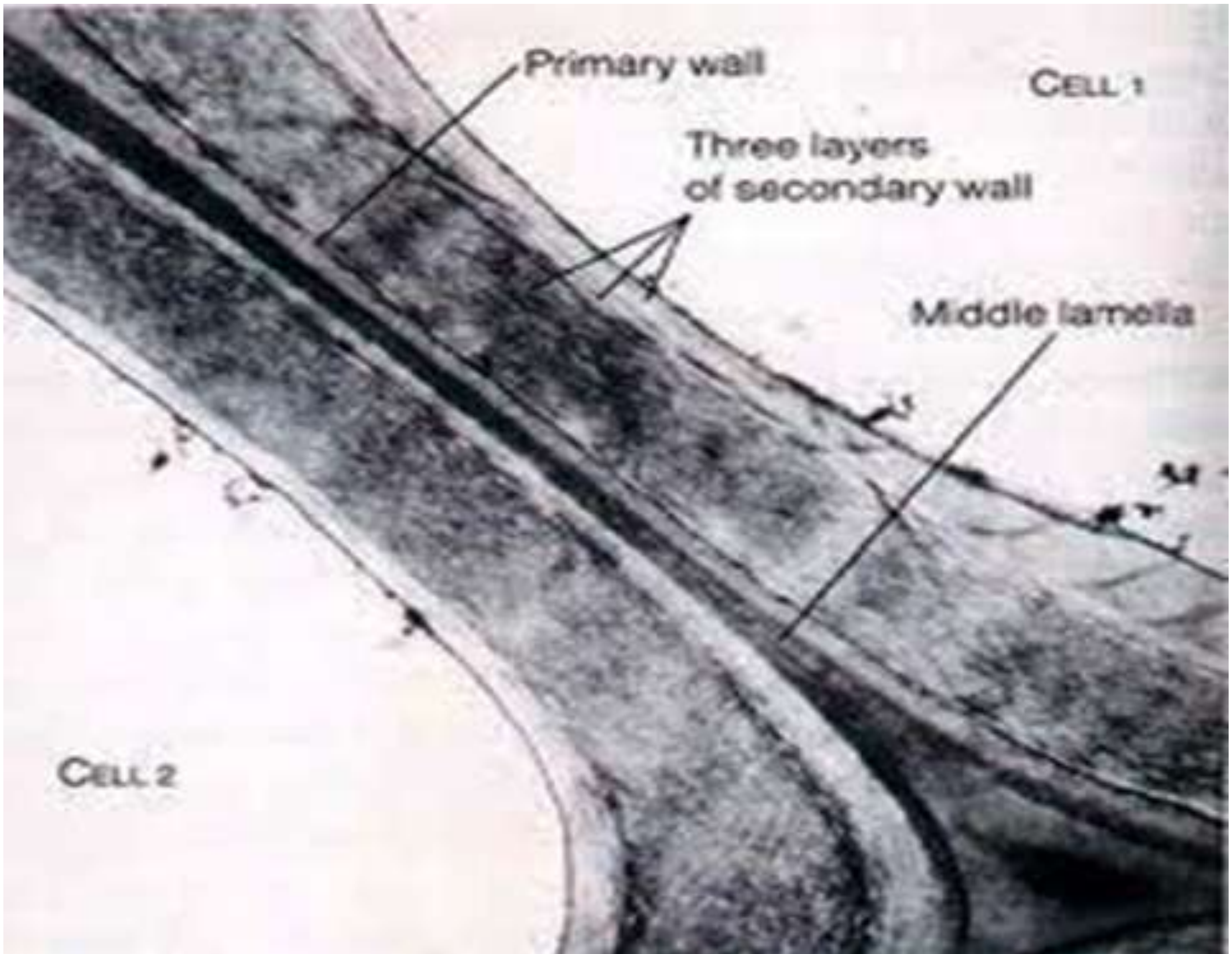
Using the electron microscope, the tissue is fixed by Osmic acid and embedded in acrylic plastic or resin to be sectioned by an ultra-microtome with glass or diamond.

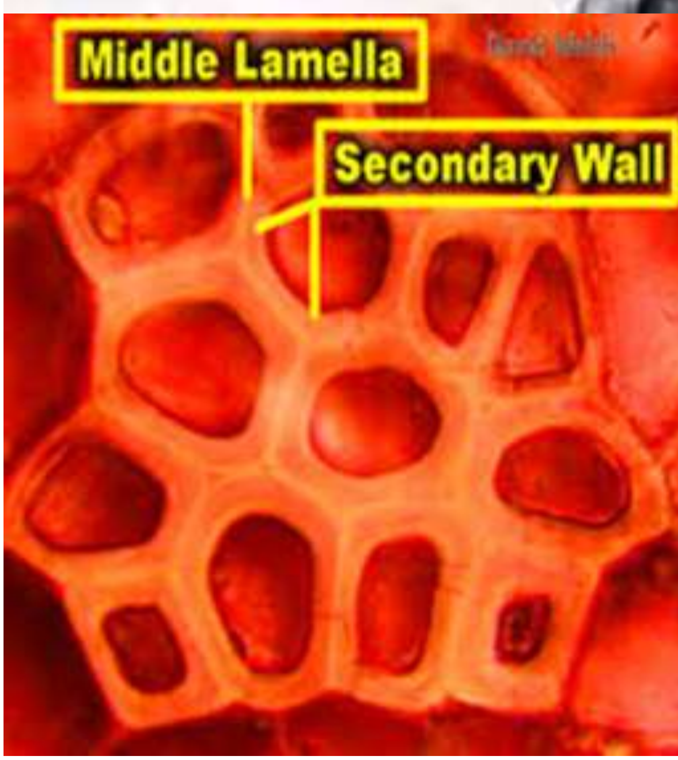
## Electron Microscopy revealed the following:

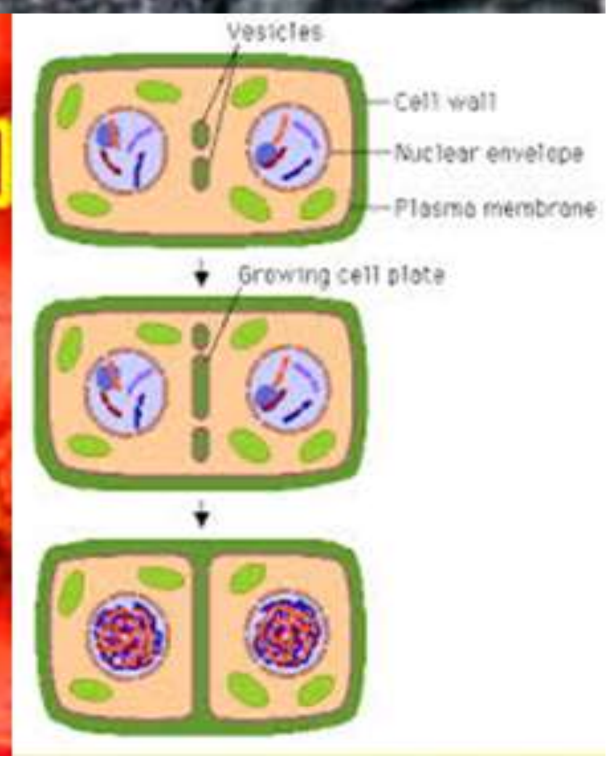
A skeletal network of cellulose in the form of bundles -with spaces in between- Cell wall: they are first collected as **microfibrils** then are gathered to form **macrofibrils** in the secondary cell walls. In these spaces different materials are deposited according to the type of wall as well as cell type and age.

## Examples of which are:

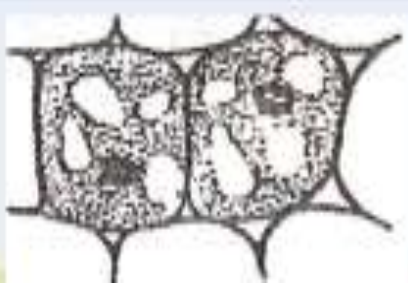
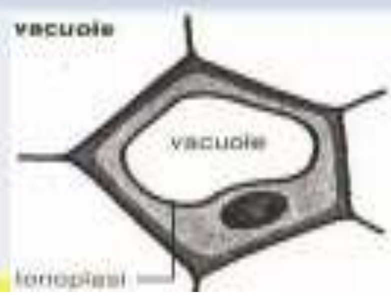
1. Primary cell walls are filled with Ca- and Mg- pectates.
2. Xylem Vessels are filled with lignin.
3. Epidermal Cell wall is filled with Cutin (impermeable to water)
4. Phellem is filled with Suberin (impermeable to water).
5. While Root Cell Wall -in secondary cell wall- is filled with water, like those in cotton plant.


Primary wall
Cell 1
Three layers
of secondary wall
Middle lamella
Cell 2


Middle Lamella
Secondary Wall

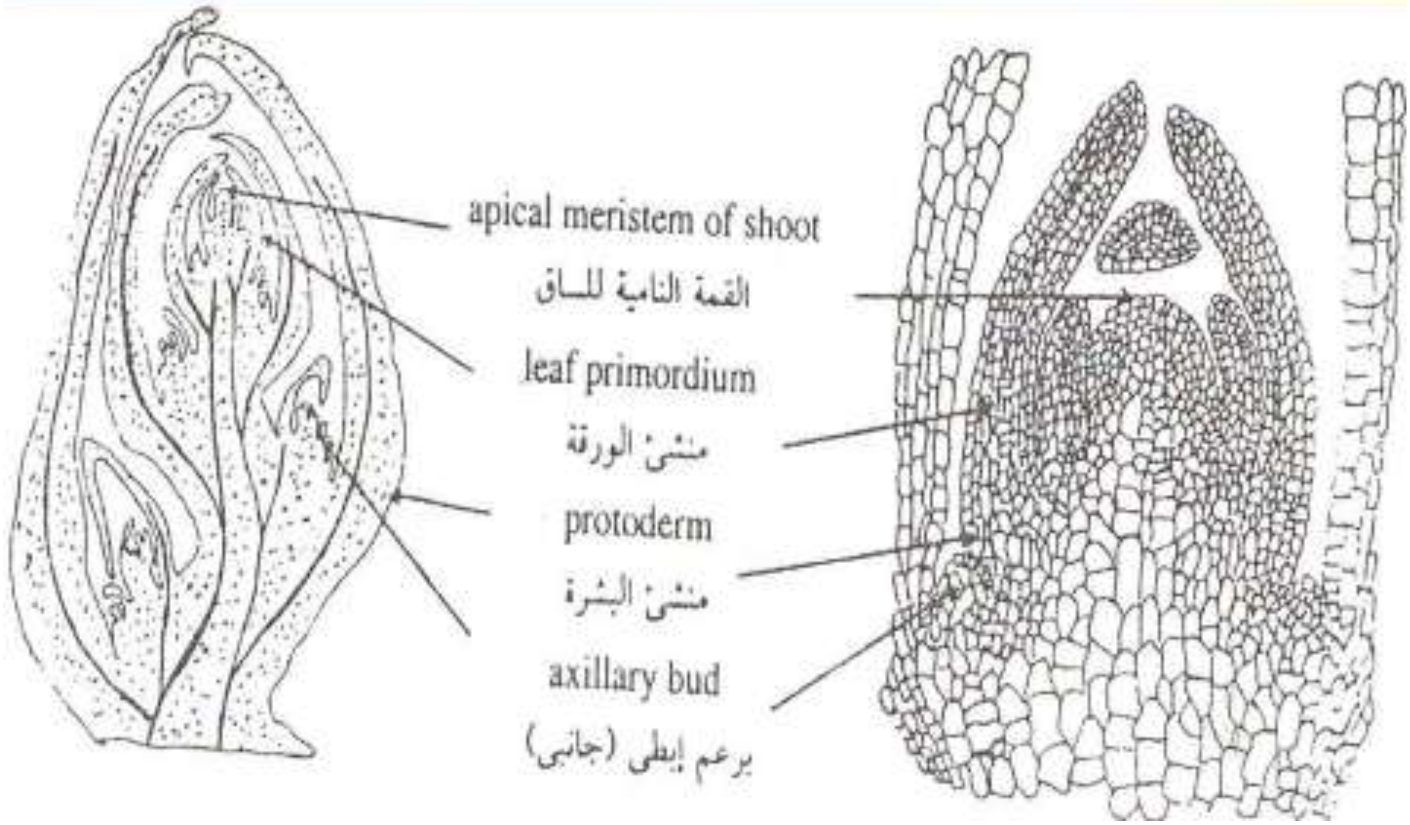

Vesicles
Cell wall
Nuclear envelope
Plasma membrane
Growing cell plate

# Comparison Between *Meristematic* and Permanent Tissues

| Points of Comparison | *Meristematic* Tissue | Permanent Tissue |
|---|---|---|
| **Size** | Small | large |
| **Cell Wall** | Thin | Thick |
| **Vacuole** | Does not exist and if found are small and scattered | Large |
| **Intercellular Spaces** | Exist | Does not exist |
| **Cell Division** | Divisible | Lost its ability to divide |
| **Nucleus** | Small & lateral | Large & Central |
| **Nature** | Subdivided into primary and secondary | ------- |
| **Shape** |  |   |

# 1. Primary *Meristematic* Tissue

1. It includes the whole "**Embryo**": the root and stem Apices, leaf primordia as well as bases of the internodes.




The term "meristem" was coined in 1858 by Karl Wilhelm von Nägeli. The term is adapted from the Greek word "merizein," meaning "to divide," a reference to the function of the cells in the meristematic tissue. Characteristics of Meristematic Plant Tissue

**The Cells Within the Meristem Have Some Unique Characteristics**:

Cells within the meristematic tissues are self-renewing, so that each time they divide, one cell remains identical to the parent while the other can specialize and become part of another plant structure. The meristematic tissue is therefore self-sustaining.

While other plant tissues can be made of both living and dead cells, the meristematic cells are all living and contain a large ratio of dense liquid.

When a plant is injured, it is the undifferentiated meristematic cells that are responsible for healing the wounds through the process of becoming specialized.

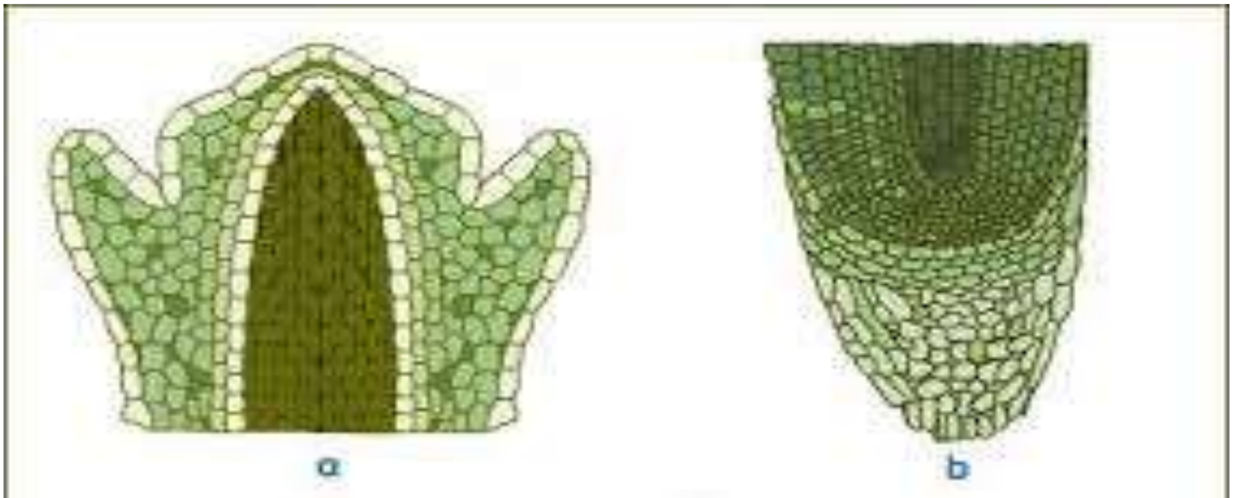
**Types of Meristematic Tissue**

There are three types of meristematic tissues, categorized according to where they appear in the plant: "apical" (at the tips), "intercalary" (at the middle), and "lateral" (at the sides).

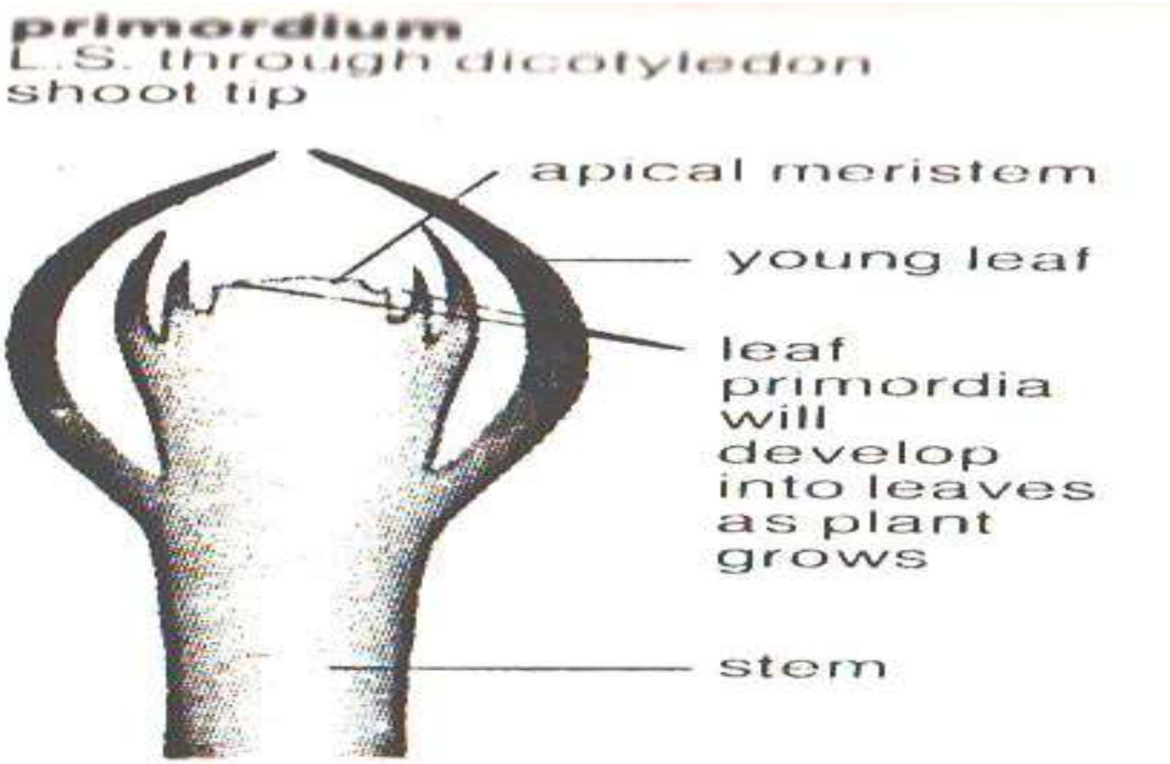
**The apical meristematic tissues**: are also known as "**Primary Meristematic Tissues**," because these are what form the main body of the plant, allowing for vertical growth of stems, shoots, and roots. The primary meristem is what sends a plant's shoots reaching for the sky and the roots burrowing into the soil.

**Lateral meristems** are known as "**Secondary Meristematic Tissues**" because they are what is responsible for an increase in girth. The secondary meristematic tissue is what increases the diameter of tree trunks and branches, as well as the tissue that forms bark.

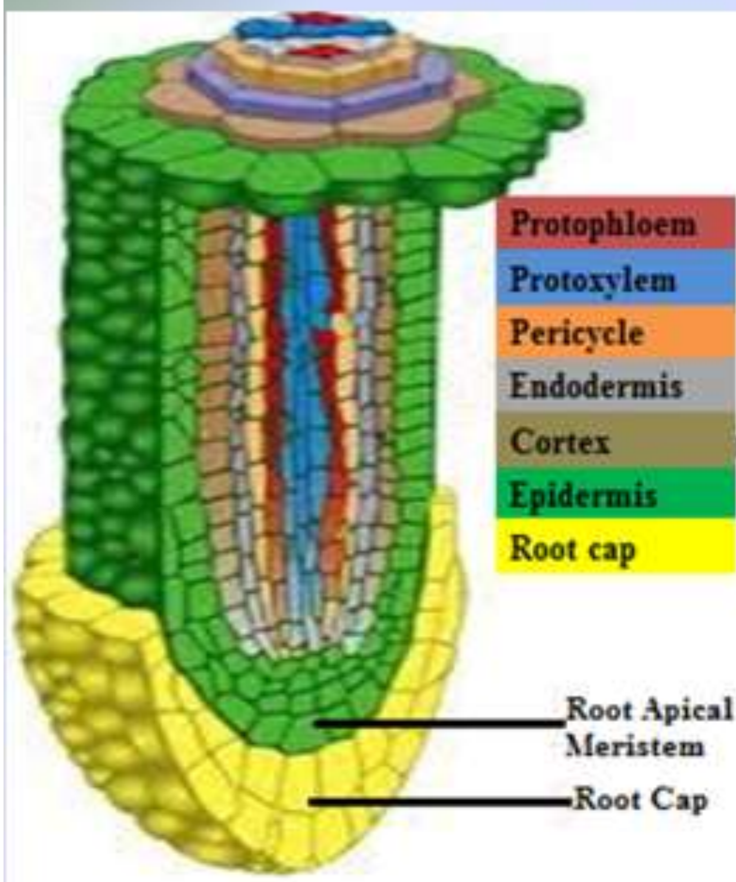
**Intercalary meristems** occur only in plants that are monocots, a group that includes the grasses and bamboos. Intercalary tissues located at the nodes of these plants allow the stems to regrow. It is intercalary tissue that causes grass leaves to grow back so quickly after being mowed or grazed.

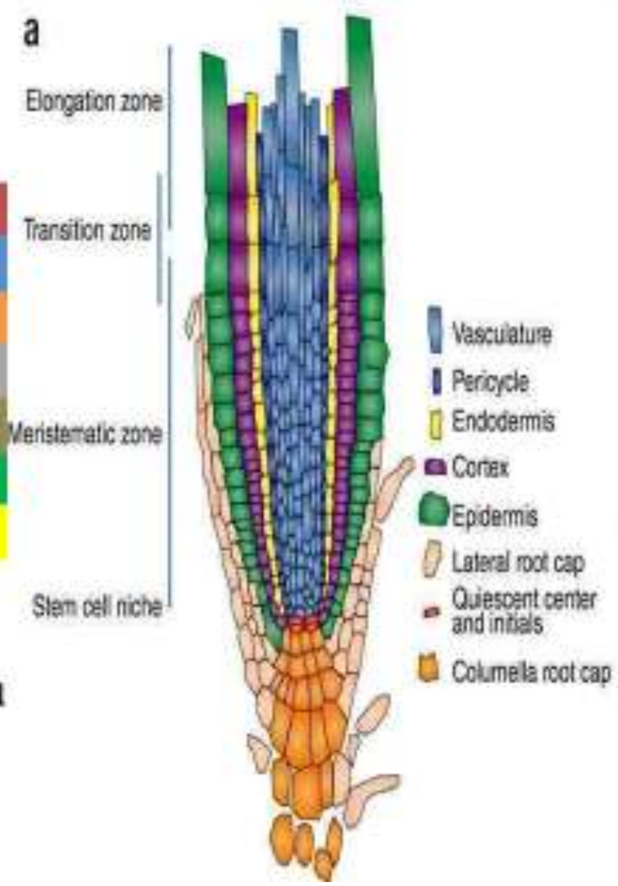



Sections Through (a) Stem Apex and (b) Root tip Showing Meristematic Tissue




# 1. Primary *Meristematic* Tissue: Root Apex

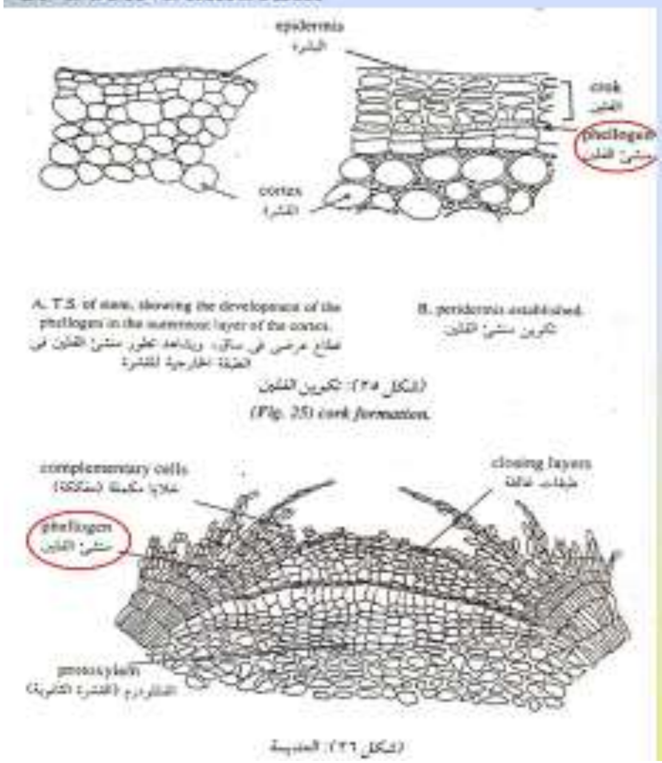


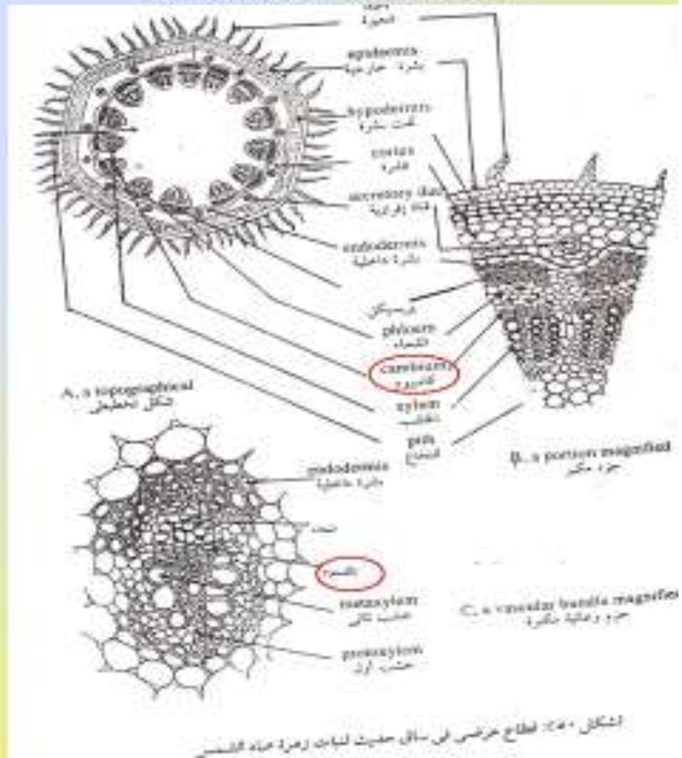
# 2. Secondary *Meristematic* Tissues

It is formed from primary meristems that lost its ability to divide for sometime and gained it back. **Examples:**

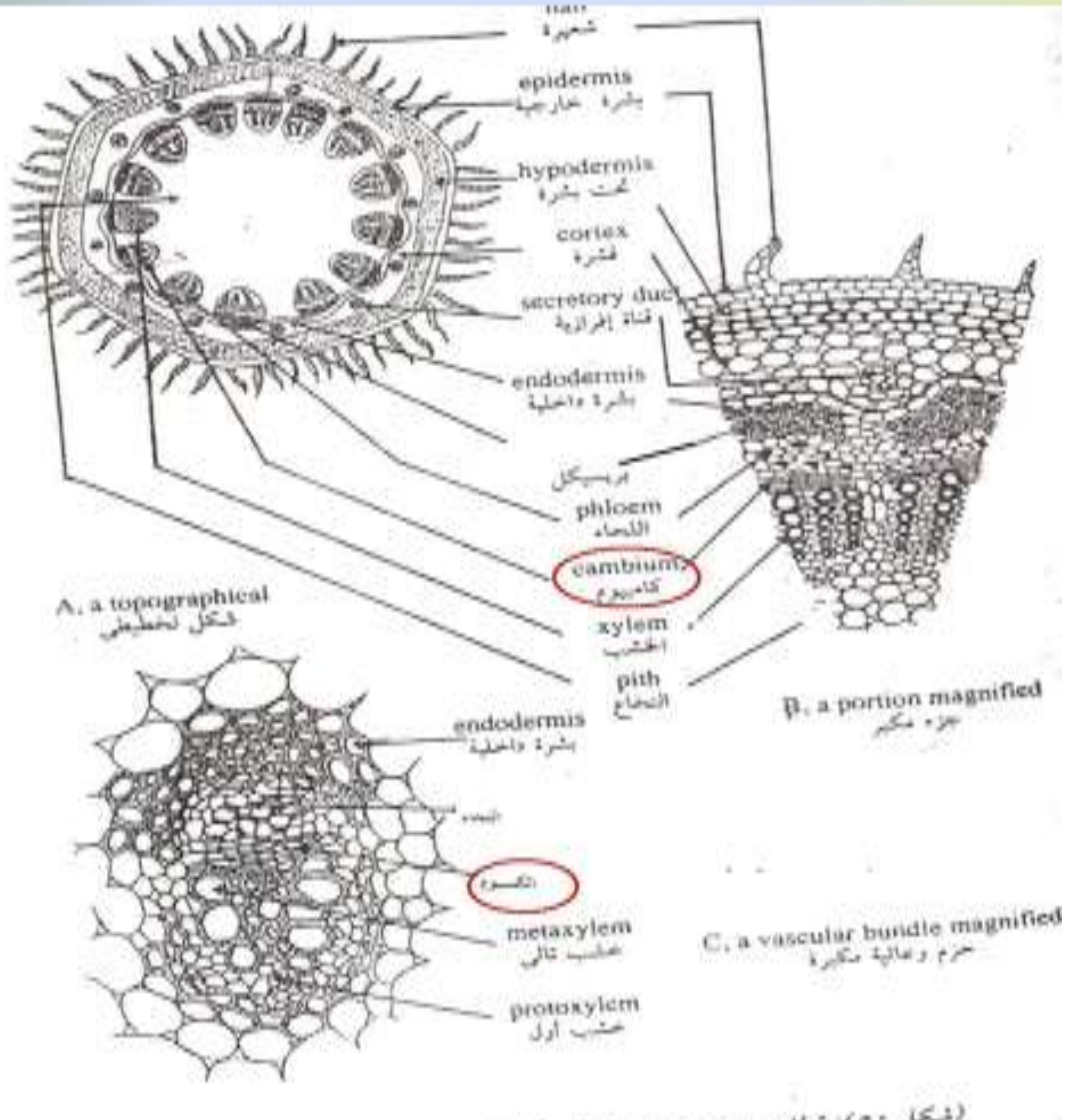
### 1. Cork Cambium



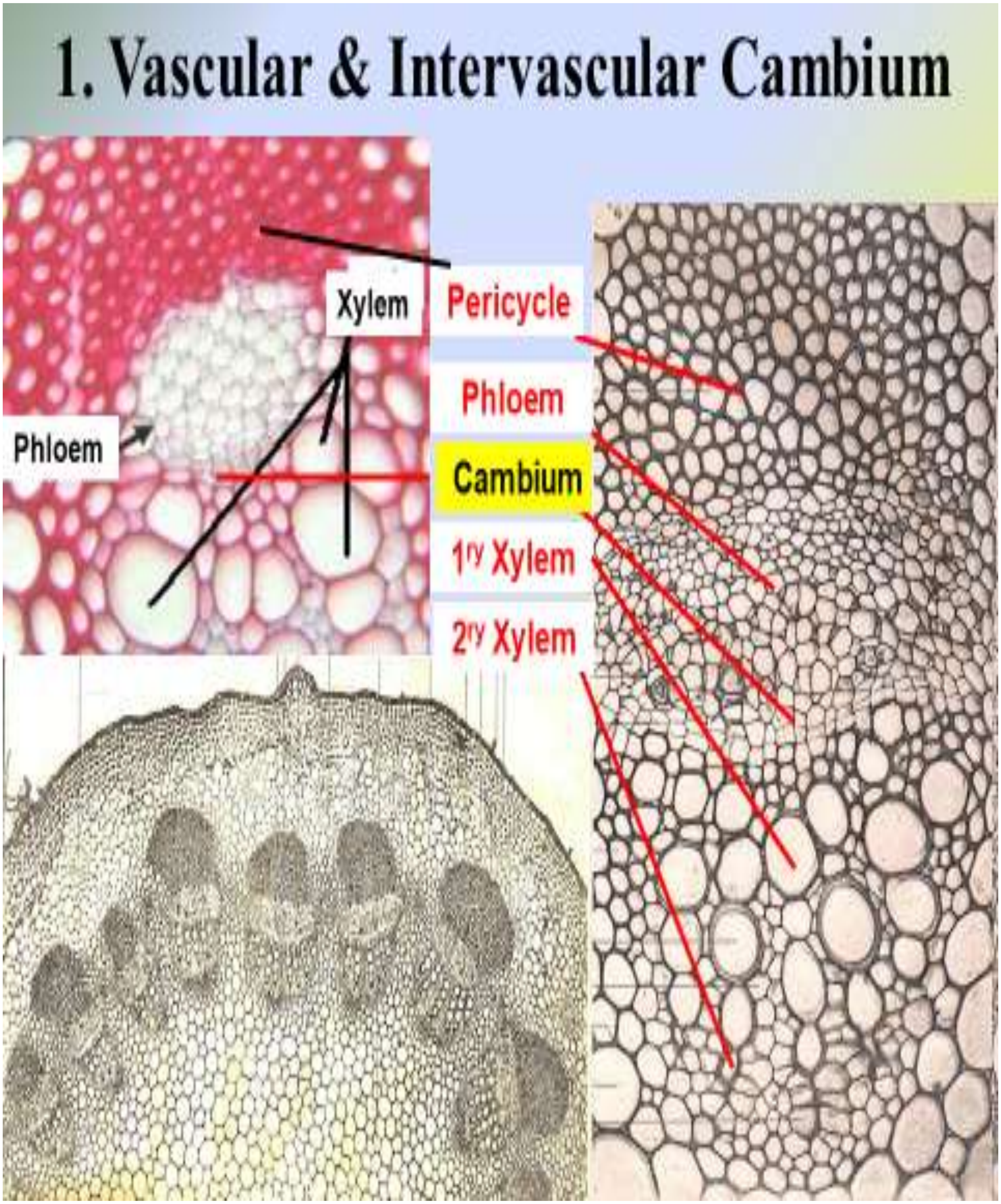

### 2. Vascular Cambium



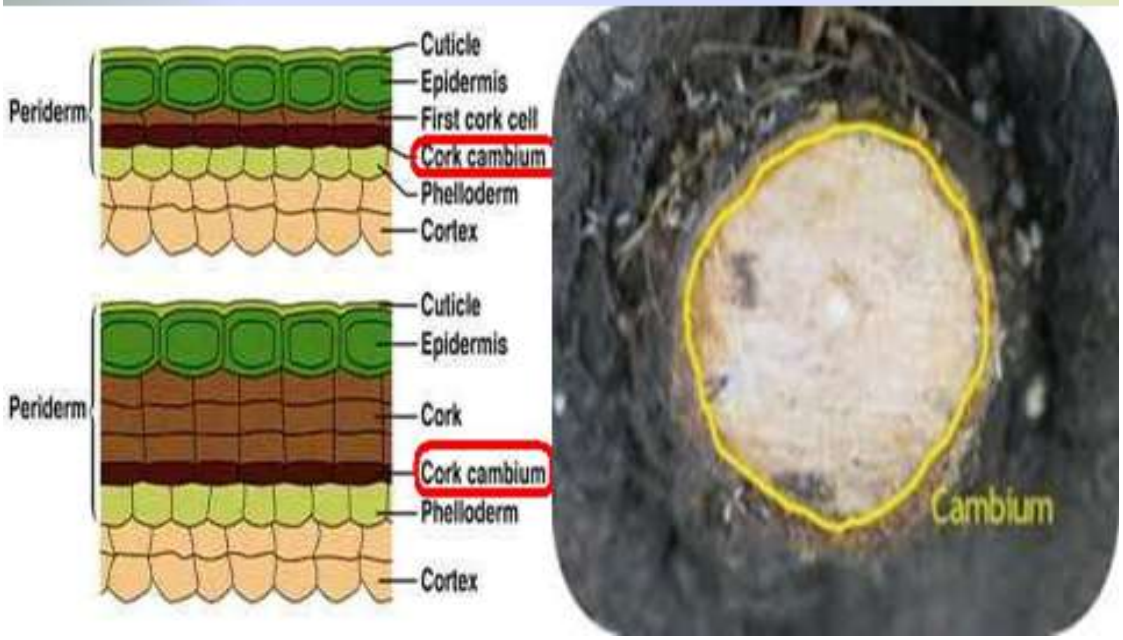
# 1. Vascular & Intervascular Cambium




(شكل ٥٠): قطاع عرضي في ساق حديث لنبات زهرة عباد الشمس


1. Vascular & Intervascular Cambium
Xylem
Pericycle
Phloem
Phloem
Cambium
1ry Xylem
2ry Xylem

# 2. Cork Cambium




# Tissue Systems

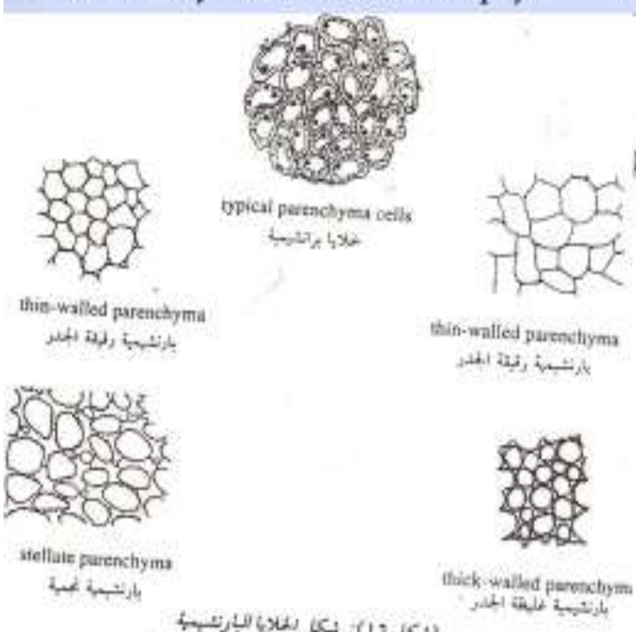
**It is divided into three groups**:

1. **Ground Tissue** 2. **Epidermal Tissue** 3. **Vascular Tissue**

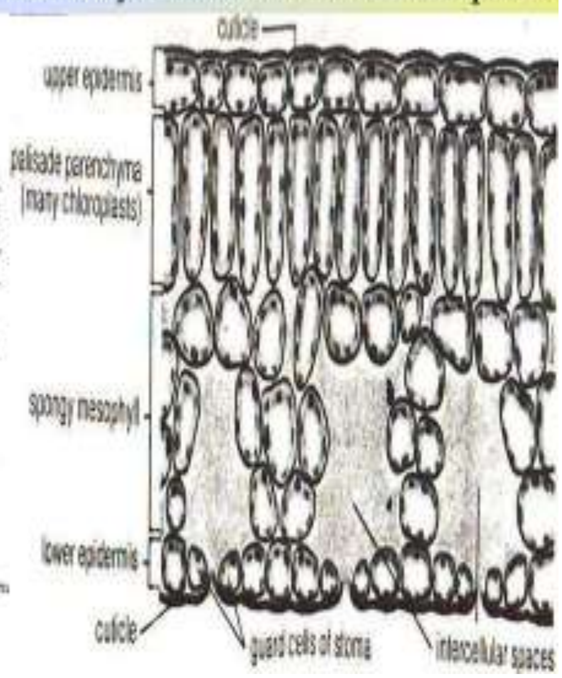
**1. Ground Tissue:** *Parenchyma, Collenchyma, Sclerenchyma* and Secretory tissues.

**A) *Parenchyma*:** Thin cellulosic cell wall, types of which are:

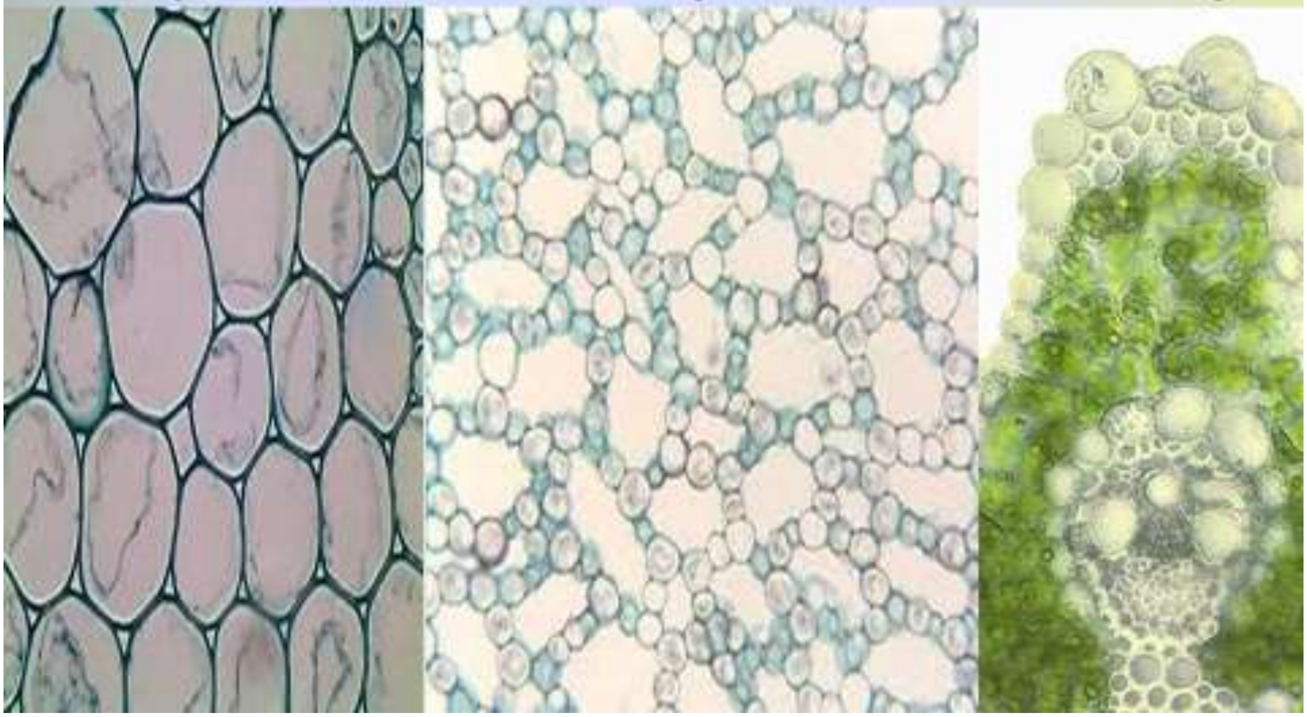
- *Chlorenchyma*: contains Chlorophyll -*Aerenchyma*: contain intercellular spaces




(الشكل ١٦): شكل الخلايا البارنشيمية
*Fig. 16, the shape of parenchyma cells.*



# A. *Parenchyma*

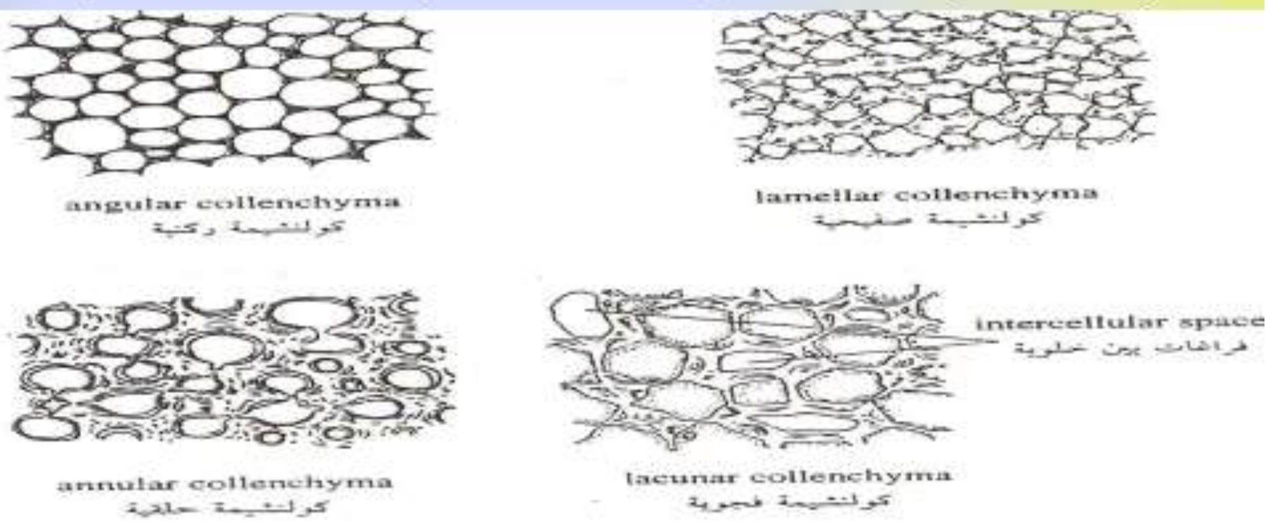



## Tissue System: 1. Ground Tissue

***B. Collenchyma***: According to the quantity and position of cellulosic thickening, *Collenchyma* are of various types:

1. Angular 2. Lamellar 3. Lacunar 4. Annular

- It provides the tissue (stems and leaves) with elasticity and strength.

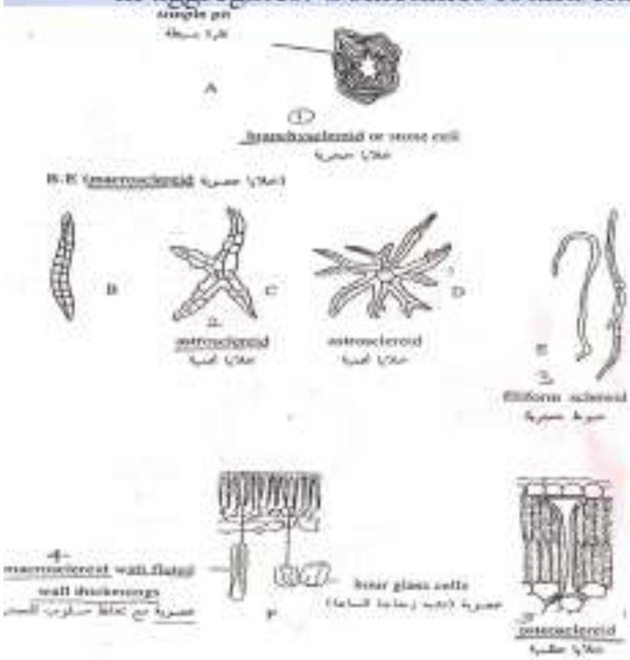



(شكل ١٧): الأنواع المختلفة من النسيج الكللونشيمى
*(Fig. 17 ) different types of collenchyma.*

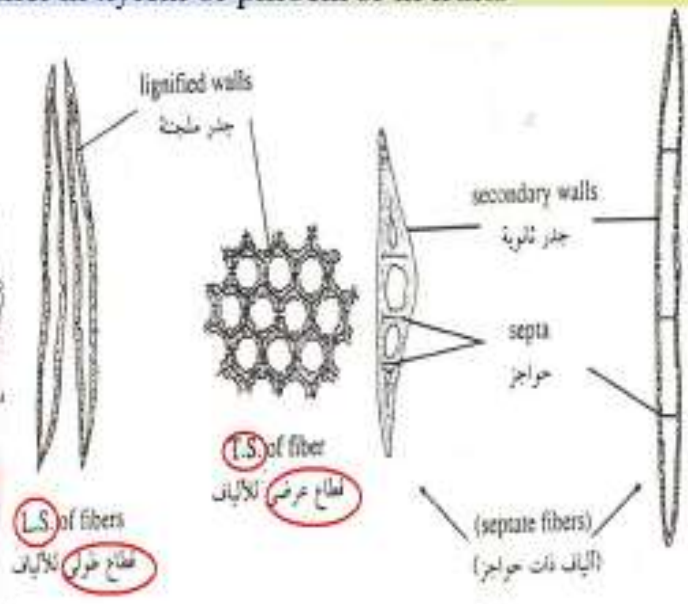
# Tissue System: 1. Ground Tissue

**C. *Sclerenchyma* fibers:** They provide strength to the plant body. They are mostly dead tissues, thickened with lignin. They are of two types:

1. **Fibers:** Their walls are lignified in an **early** stage in the form of: Ring or Bundle
2. **Sclereides:** Their walls are lignified in a **later** stage. They are found in solitary or in aggregates. Sometimes found either in xylem or phloem or in fruits

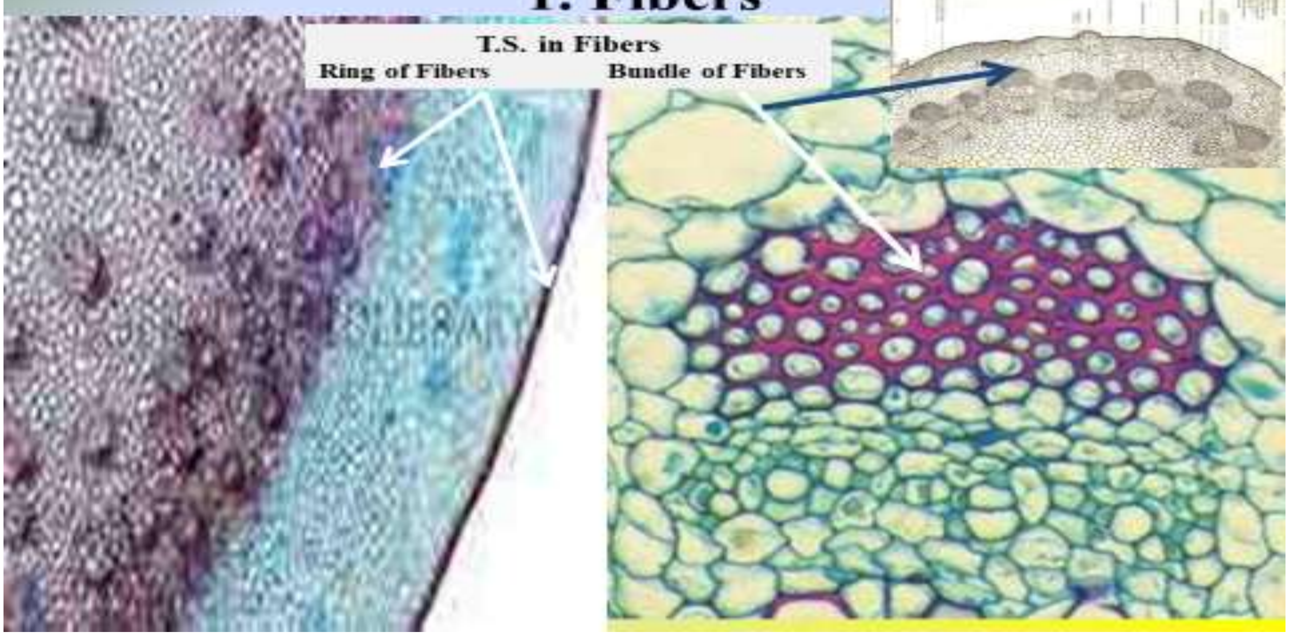


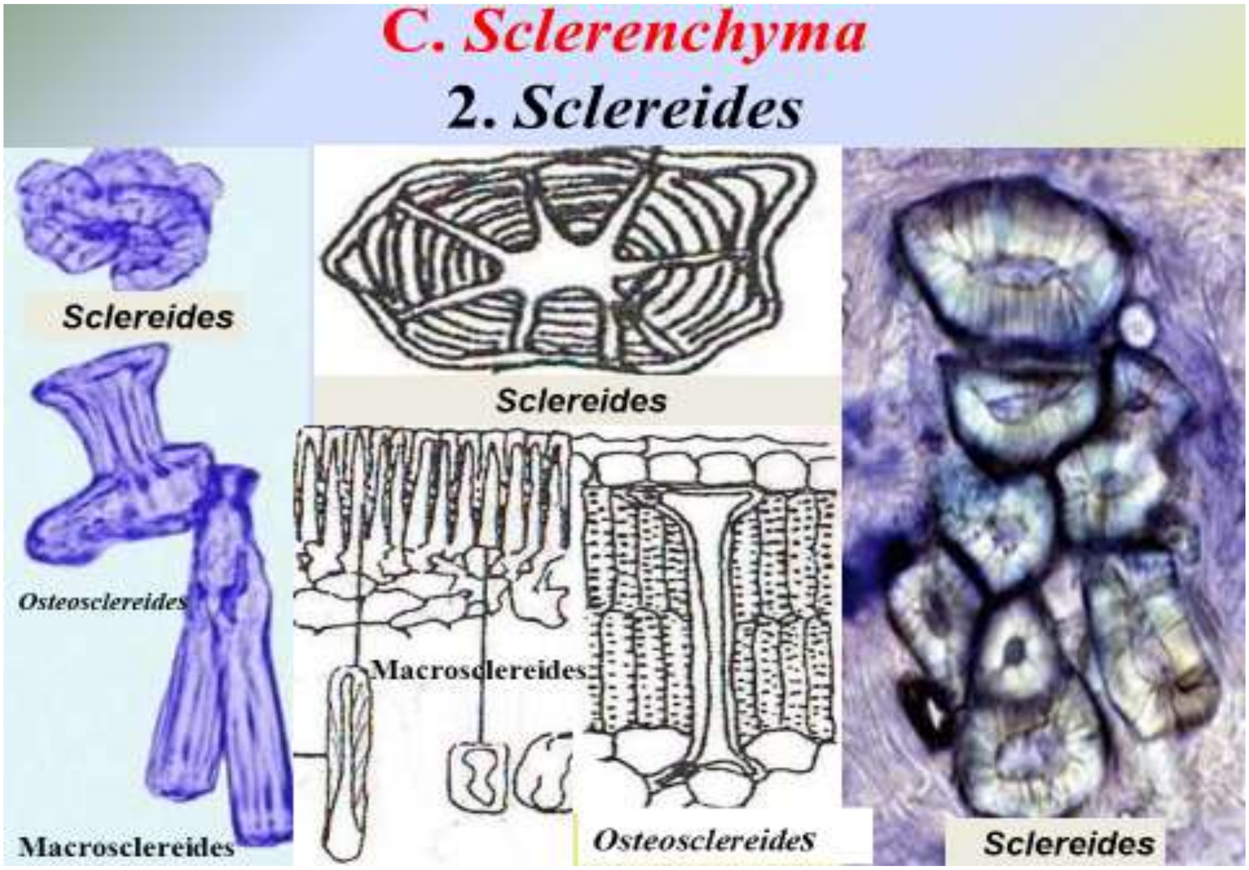

(شكل ١٩): بعض الأنواع المختلفة من الاسكلريدات
(Fig. 19) some different types of sclereids.

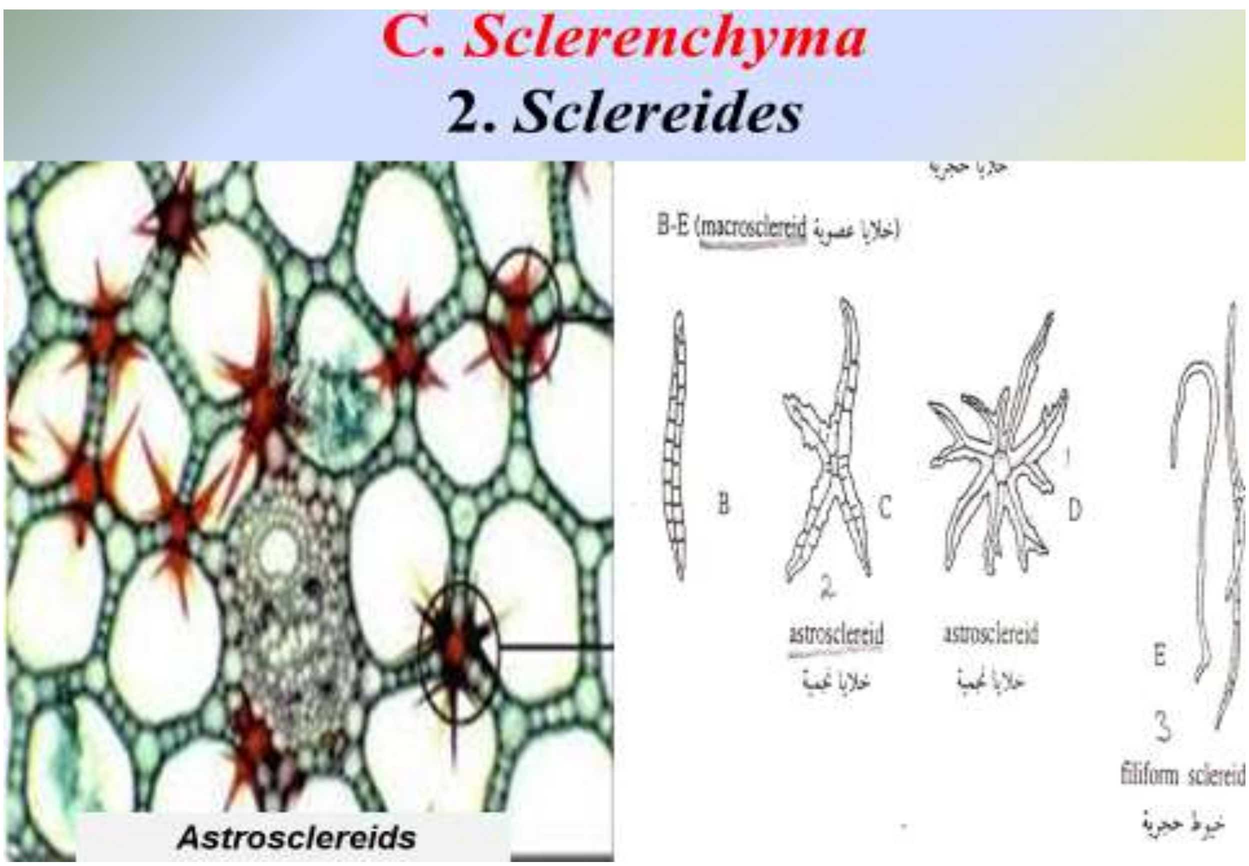



(شكل ١٨): بعض الأنواع المختلفة للألياف
(Fig. 18 ) some different types of fibers.

## C. *Sclerenchyma*
### 1. Fibers



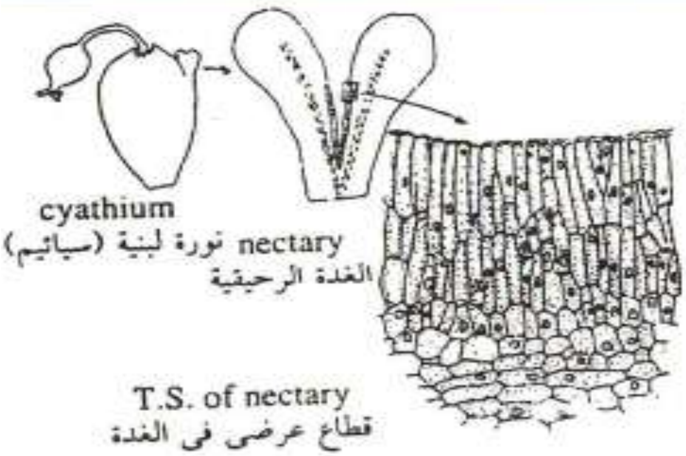

C. Sclerenchyma
2. Sclereides
Sclereides
Sclereides
Osteosclereides
Macrosclereides
Osteosclereides
Sclereides
Macrosclereides


C. Sclerenchyma
2. Sclereides
Astrosclereids
B-E (macrosclereid خلايا عصوية)
B
C
D
astrosclereid
خلايا نجمية
astrosclereid
خلايا نجمية
E
filiform sclereid
خيوط حجرية

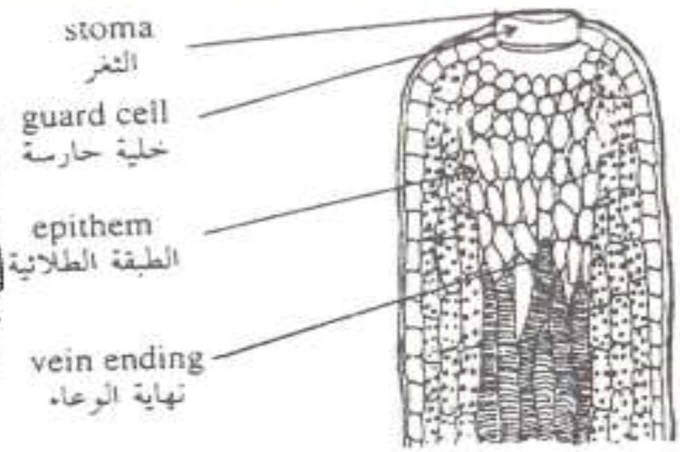
# Tissue System: 1. Ground Tissue

**4. Secretory Tissues:** They are of two types: 1. External 2. Internal

**1. External Secretory Tissues:** Examples of which are; **nectar glands** (flowers), **Hydathodes** on leaf margins, (**Guttation**) and **glandular hairs** (Tentacles in insectivorous plants).

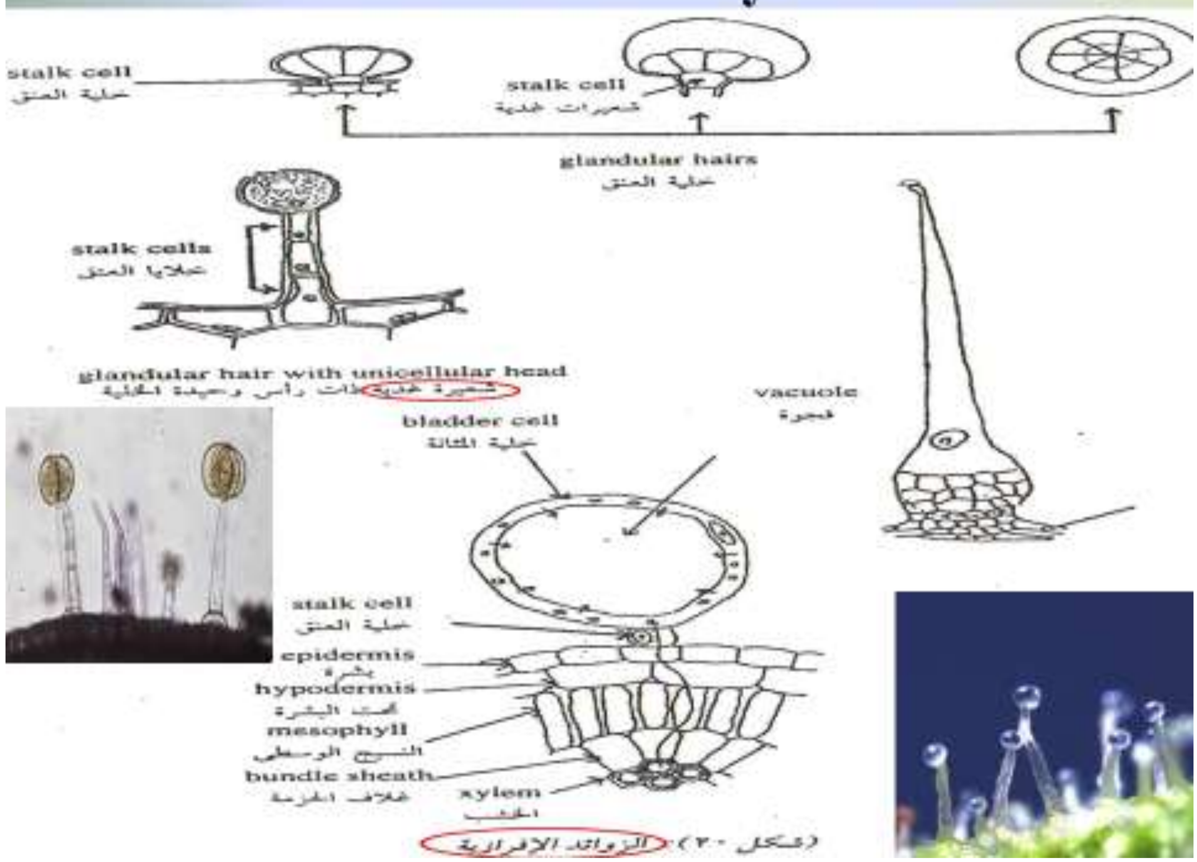



تابع (شكل ٢٠ب): غدة زهرية
*(Fig. 20 b) floral nectary.*




تابع (شكل ٢٠ أ) : الثغر المائى

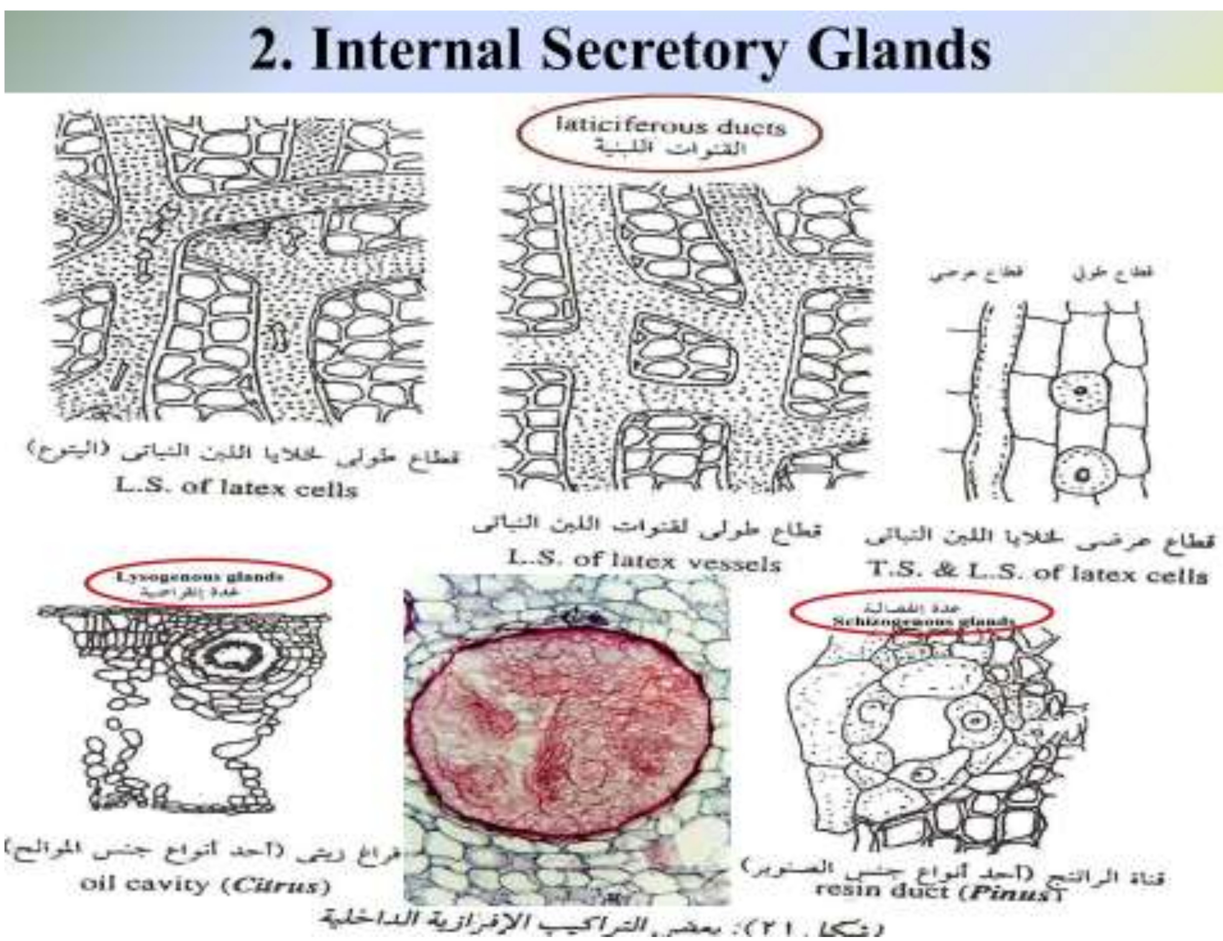
## 1. External Secretory Glands




(شكل ٢٠): الزوائد الإفرازية

2. **<u>Internal Secretory Glands:</u>** Vacuoles inside the tissues; they are of three types according to their origin:

- **Lysogenous glands:** They are originated by the disintegration and dissolution (autolysis) of the glandular cells. *i.e.* Citrus fruits
- **Schizogenous glands:** They are commonly produced by the separation of cells of vascular tissues or ground tissues, resulting in an intercellular space lined with secretory epithelial cells, <u>thus the vacuoles appear more regular than the Lysogenic glands</u> *i.e. resin ducts*
- **Laticiferous glands:** They refer to individual cells or groups of connected cells containing a liquid called **Latex**. When formed of several cells, they can produce complex tube-like structures. They are classified into two types:
    1. **Articulated:** Longitudinal chains of connected cells**.**
    2. **Non-articulated**: A long tube like single cells

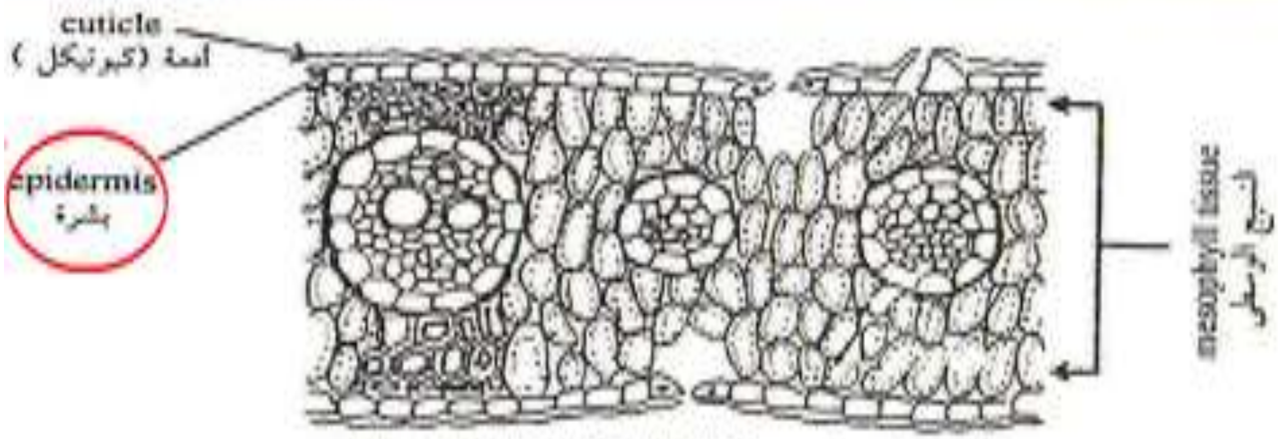


# Tissue System: 2. Epidermal Tissue

- One or more layers surround plant body to protect it against external factors.

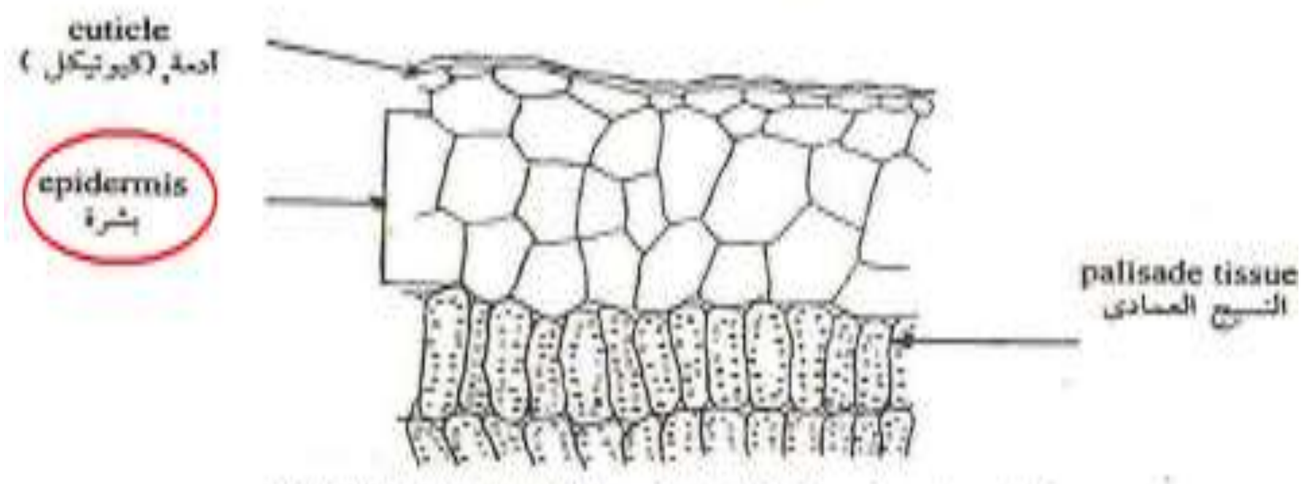
**1. Epidermis:** 1ry permanent tissue of **uni** or multilayered cells covered by cuticle.

**2. Periderm:** 2ry tissue found in **older** roots and stems replacing the epidermis when it is torn away.




قطاع عرضي في ورقة نبات الذرة لبيان البشرة البسيطة

T.S. of *Zea mays* leaf, showing uniseriate



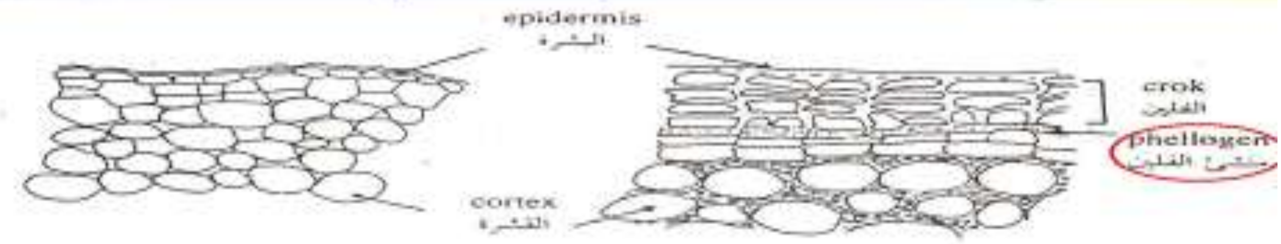

قطاع عرضي في ورقة نبات الفيكس المطاط لبيان البشرة المتضاعفة

T.S. of *Ficus elastica* leaf showing multiseriate epidermis

(شكل ٢٢): البشرة البسيطة والمتضاعفة

# Tissue System: 2. Epidermal Tissue
## B. *Periderm*

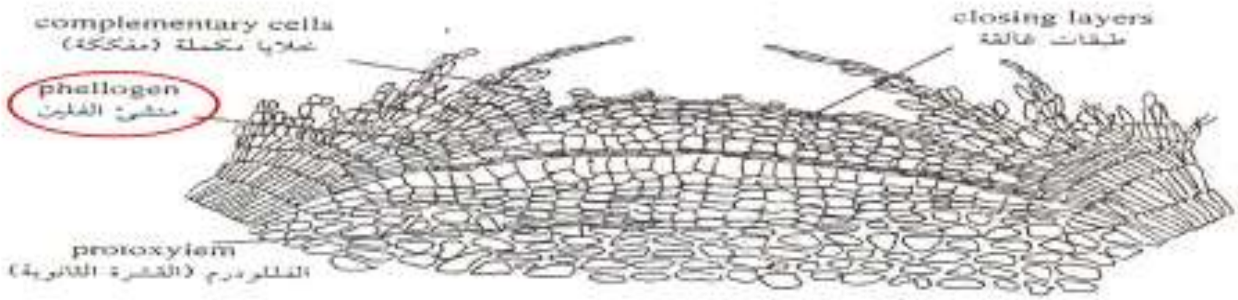
- **Lenticels:** Intercellular spaces within periderm for aeration, similar to stomata.



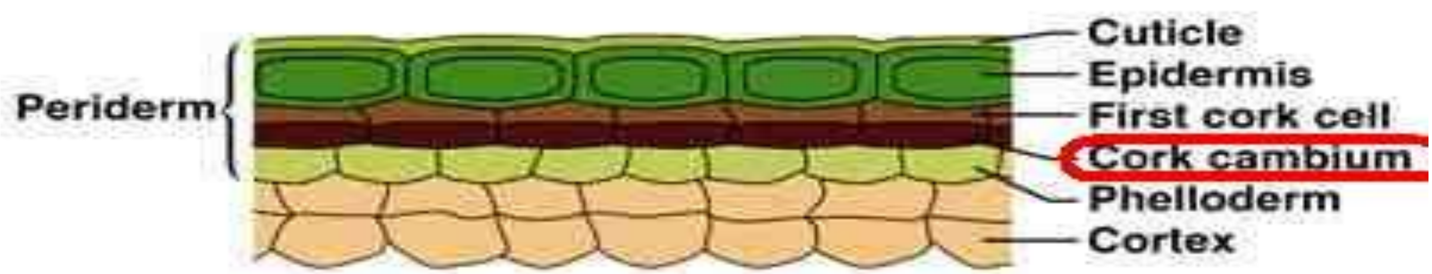

A. T.S. of stem, showing the development of the phellogen in the outermost layer of the cortex.
قطاع عرضي في ساق، ويشاهد تطور منشئ الفلين في الطبقة الخارجية للقشرة

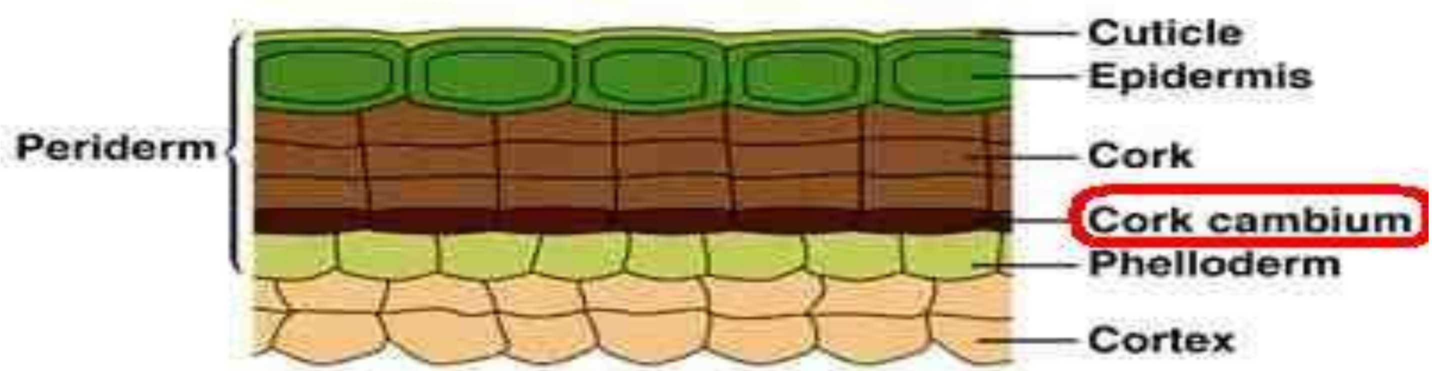
B. periderms established.
تكوين منشئ الفلين

(شكل ٢٥): تكوين الفلين
*(Fig. 25) cork formation.*



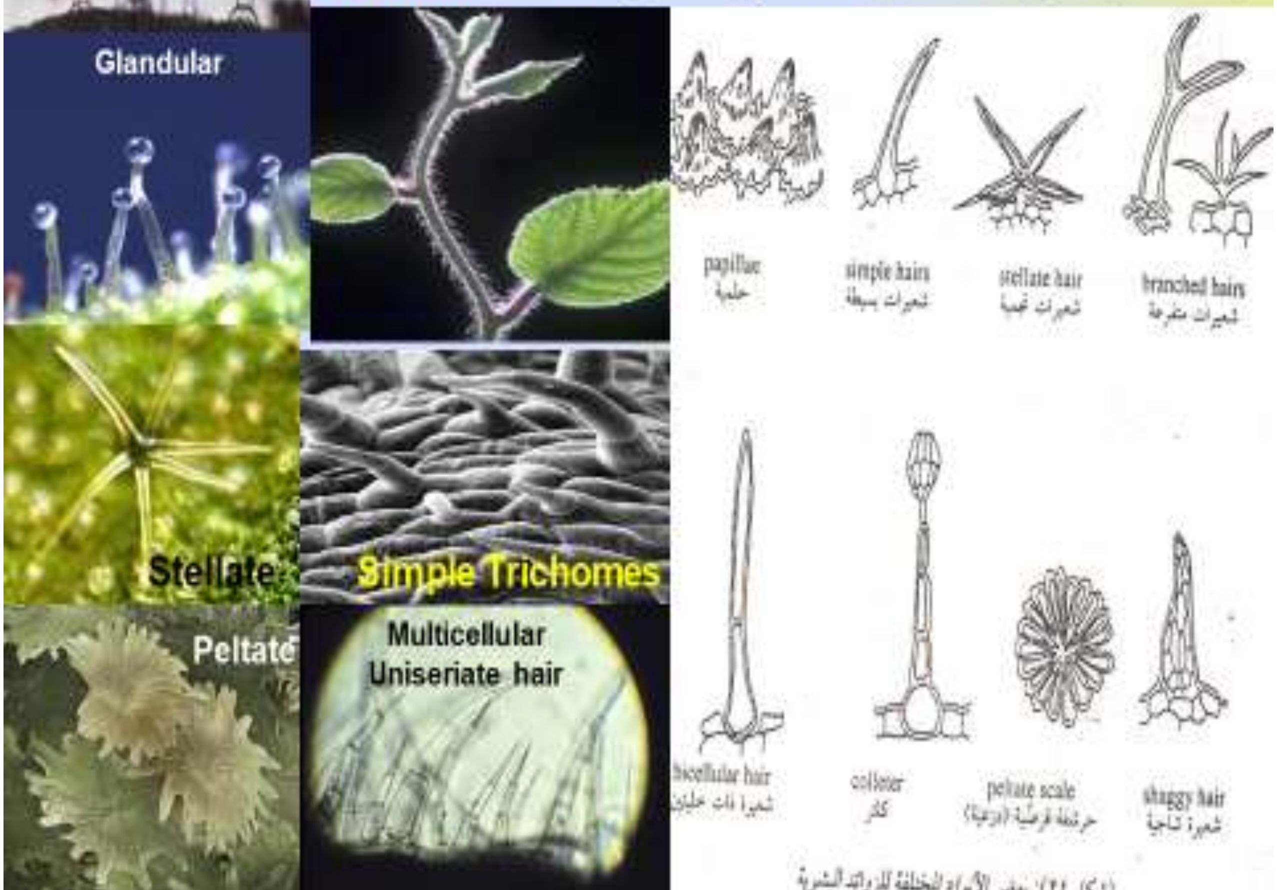

(شكل ٢٦): العديسة



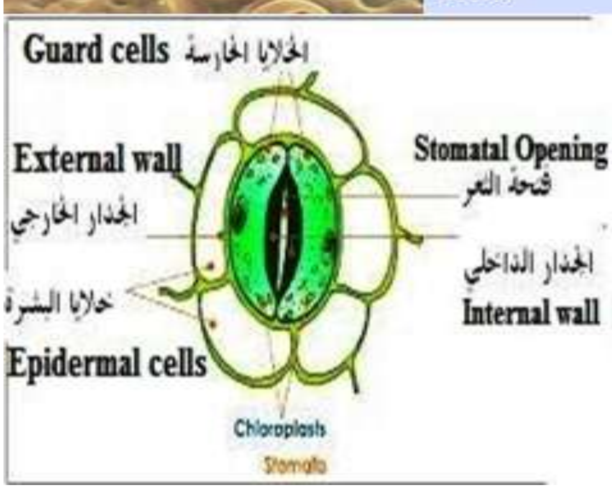

# 2. Epidermal Tissue: C. *Trichomes*

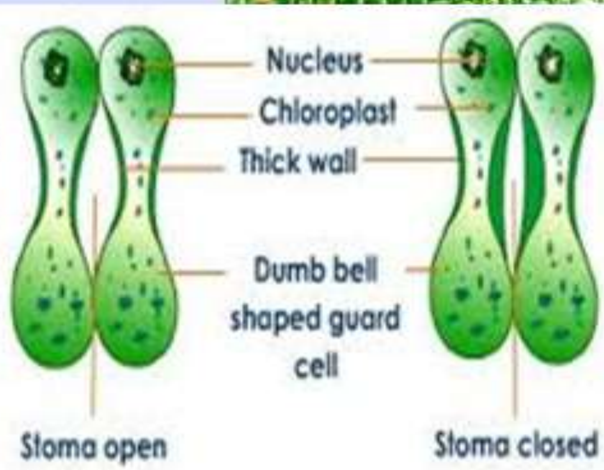
- **Divided into:** **1. Unicellular:** Branched or unbranched (Simple) hairs.
  **2. Multicellular:** Uni- or multi-seriate hairs.
- **Function:** Lower transpiration, protection, water absorption (root hairs)




## 2. Epidermal Tissue
## D. Stomata

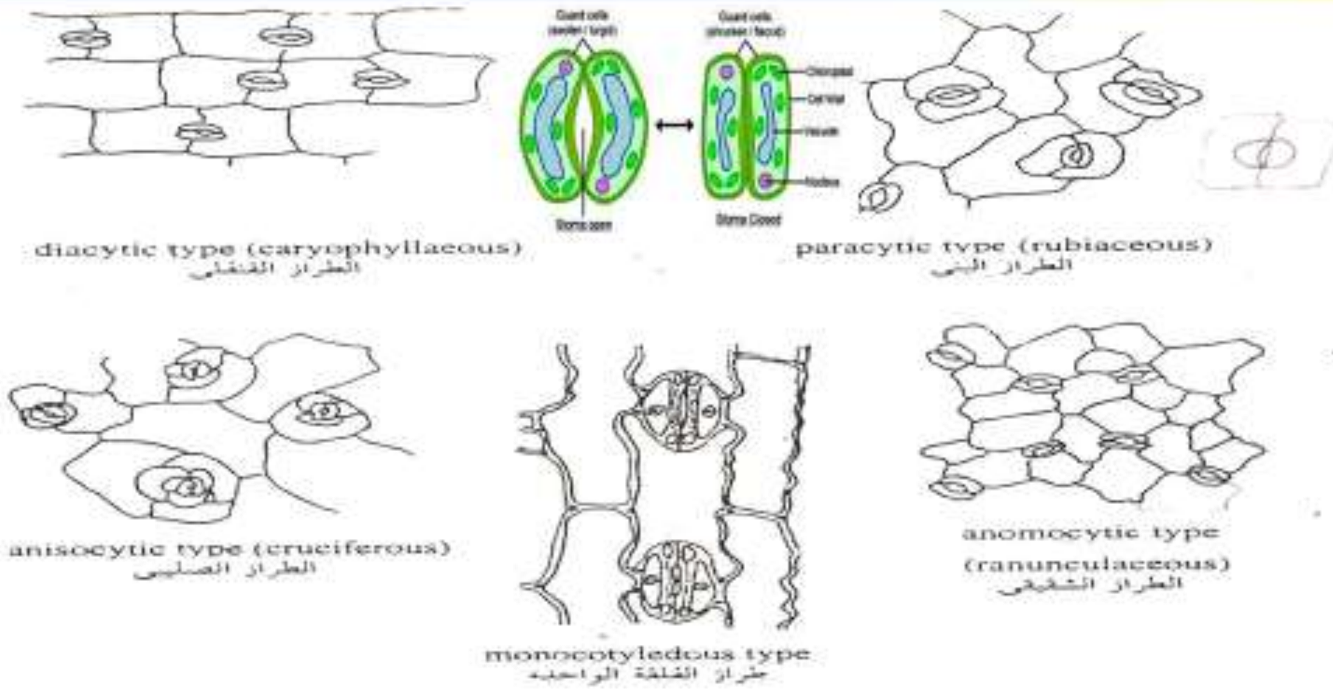
*Dicot* *Monocot*



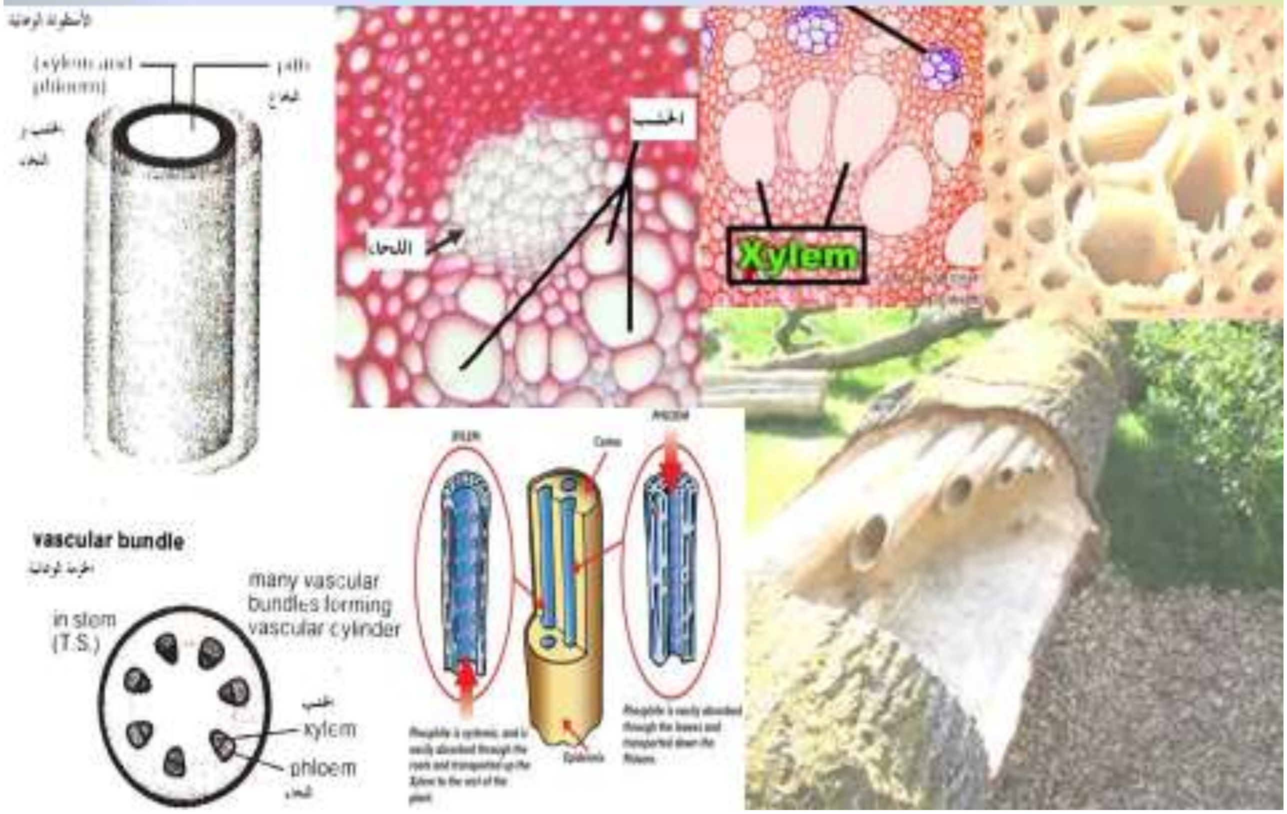
# Tissue System: 2. Epidermal Tissue
## D. Stomata

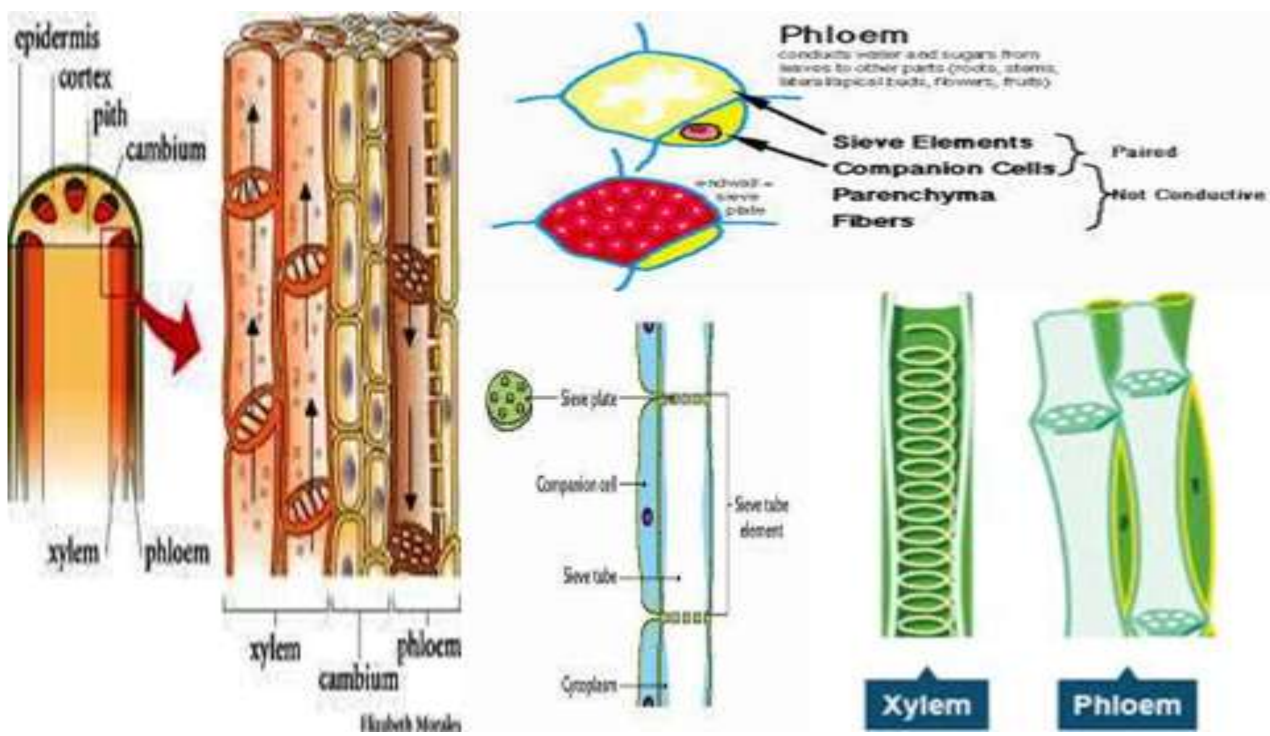
- **Function:** 1.Gaseous exchange (photosynthesis& respiration).
  2. Getting rid of excess water by transpiration.
- **Opening & Closure of Stomata:** By changing cellular osmotic pressure.




# Tissue System: 3. Vascular Tissue

- **Vascular Tissue:** Conducting nutrients, water and minerals. Xylem & Phloem sap
- **Consists of:** 1. Xylem 2. Phloem



# 1. Xylem

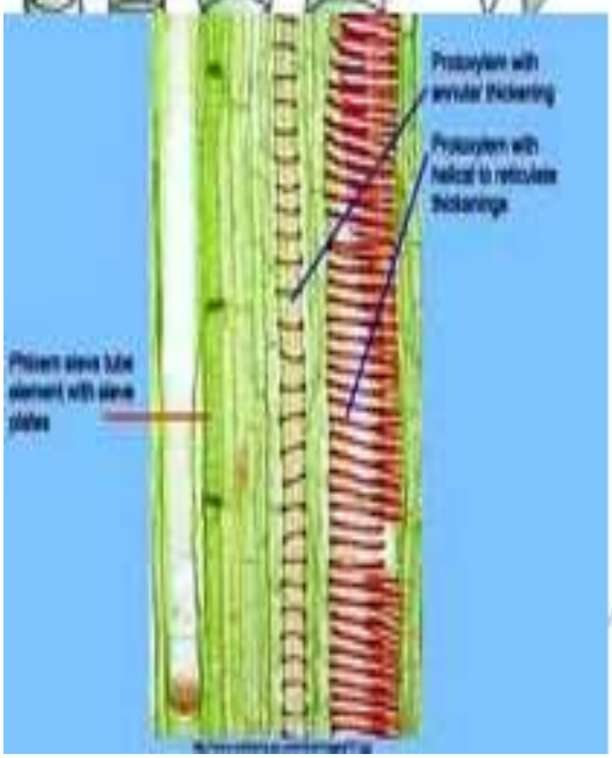
- **Consists of:** 1. Vessels 2. Tracheids 3. Fibers 4. Xylem parenchyma

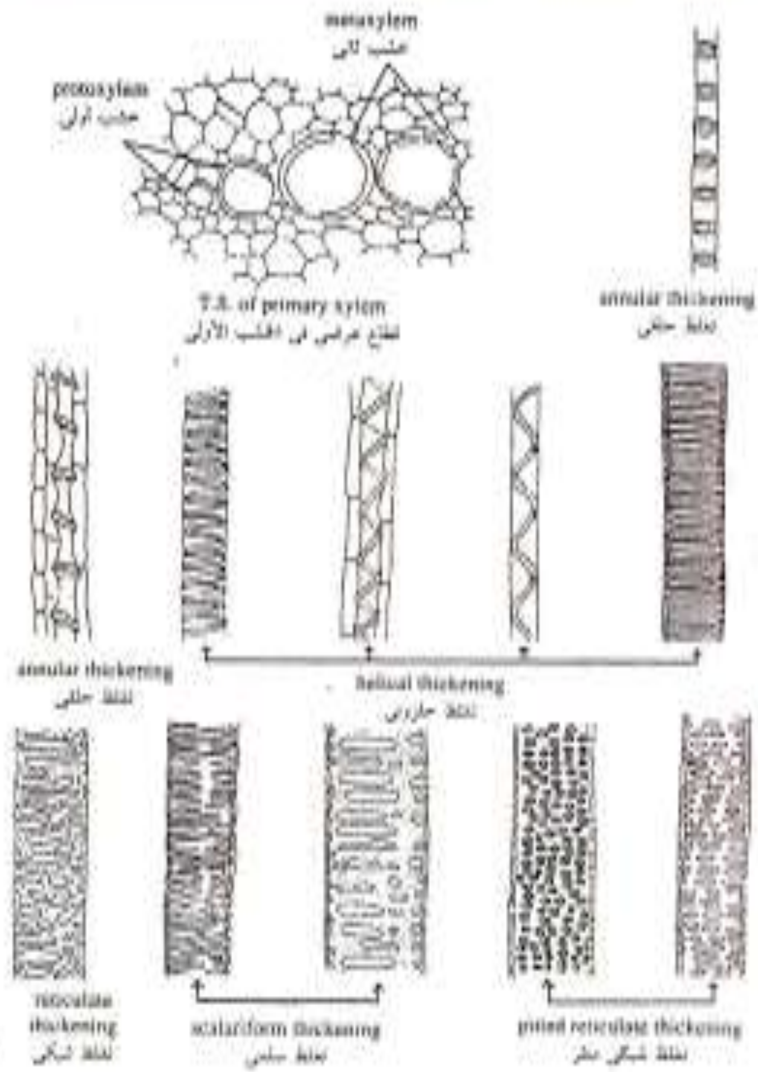
**1. Vessels:** Lignified walls: **1ry** (annular, spiral) **or 2ry** (pitted, scalariform, reticulate).

**2. Tracheids:** A dead lignified cell **3. Xylem parenchyma:** found with 1ry&2ry xylem

**4. Fibers: Lignified pointed pitted** cells, resemble sclerenchyma, found in old xylem.

Xylem vessels with tracheids have **lesser** fiber elements as fibers do the same function

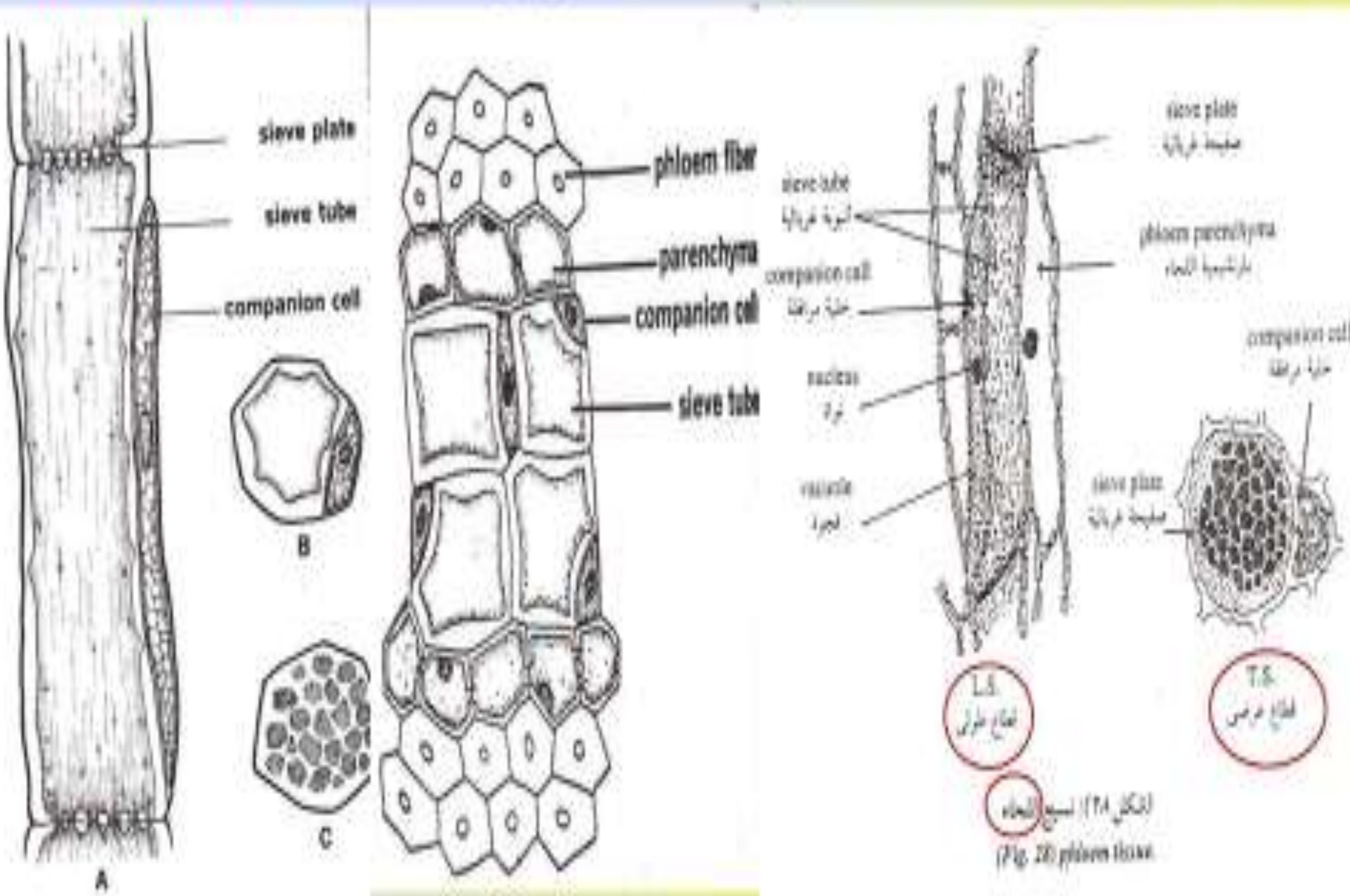




(شكل ٣٧): تركيب الخشب الأولي
الأنواع المختلفة لتغلظ الجدار في العناصر الخشبية

# 2. Phloem

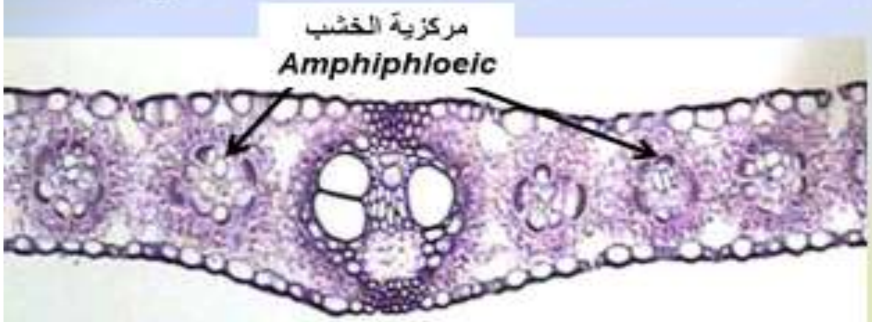
- **Function:** Conducting nutrients from leaves to the rest of the plant body.
- **Consists of:**
  1. **Sieve tube:** Rectangular cellulosic thin walled perforated cells. Lost their nucleus during growth.
  2. **Companion cell:** the cell divides into two unequal cells, the larger becomes the sieve tube and the smaller is the companion cell.
  3. **Phloem parenchyma:** Store starch formed by photosynthesis.
  4. **Phloem fibers:** found in aging cells to strengthen the tissue



# Vascular Tissues

- **It divides into:** **1.** Concentric **2.** Radial **3.** Collateral

**1. Concentric Vascular Bundle:** Either the xylem or the phloem occupies the center of the bundle while the other one surrounds it.

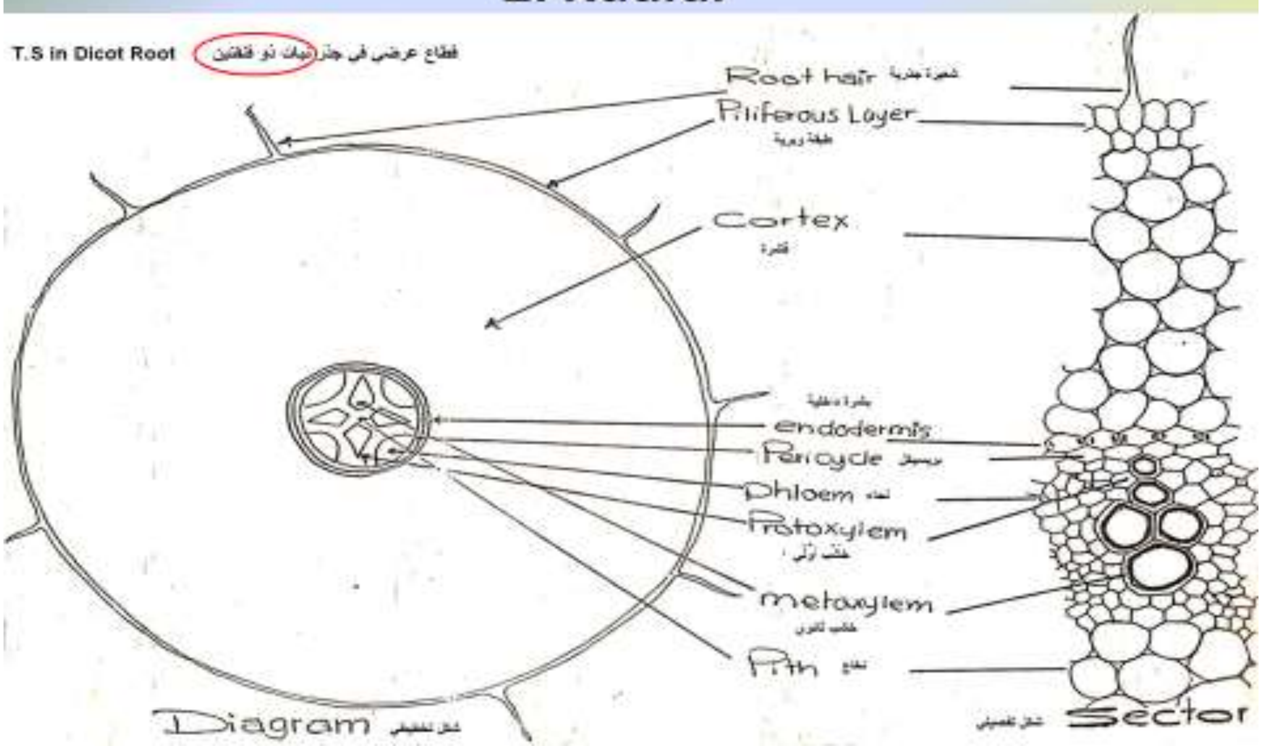




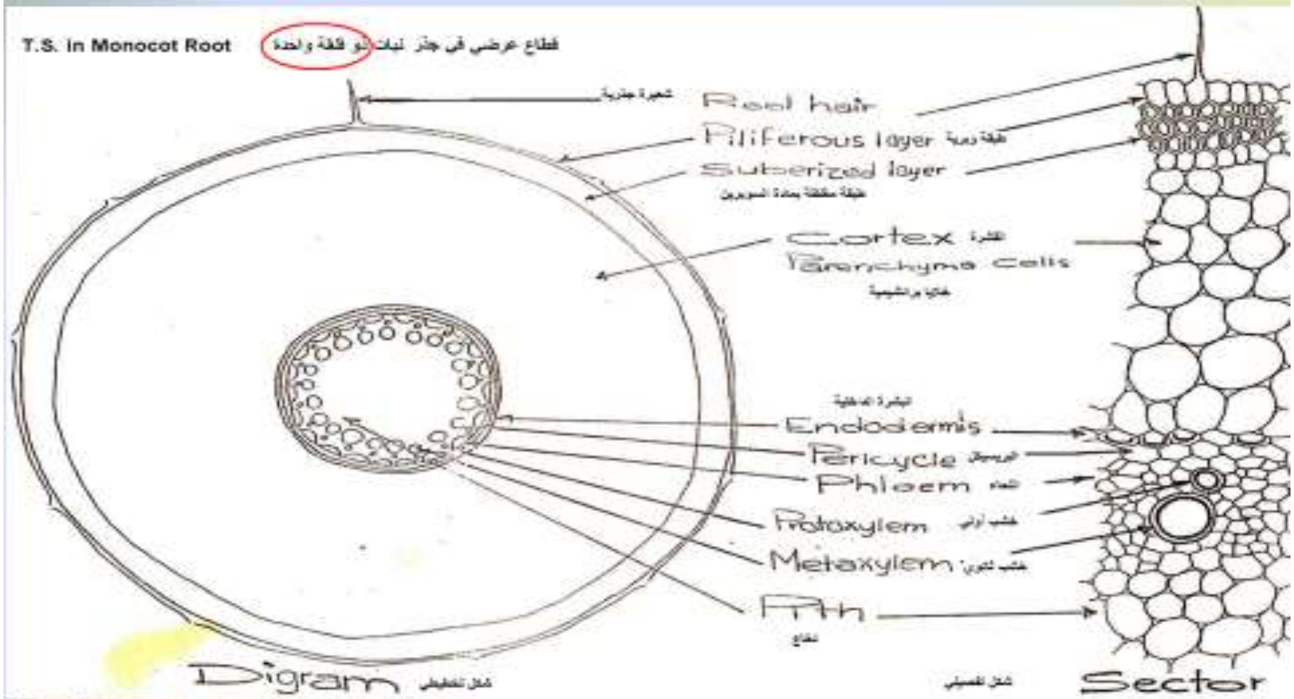
**2. Radial V.B. :** Both the xylem and the phloem are arranged on different radii, the vascular bundle is surrounded by a one layered cells called "**Pericycle**" *i.e.* roots.

**3. Collateral V.B. :** Both the xylem and the phloem are arranged on the same radius (*i.e.* stems). There is another type called "**Bicollateral Vascular Bundle**" where inner and outer phloem are present.

# Vascular Tissues
## 2. *Radial*



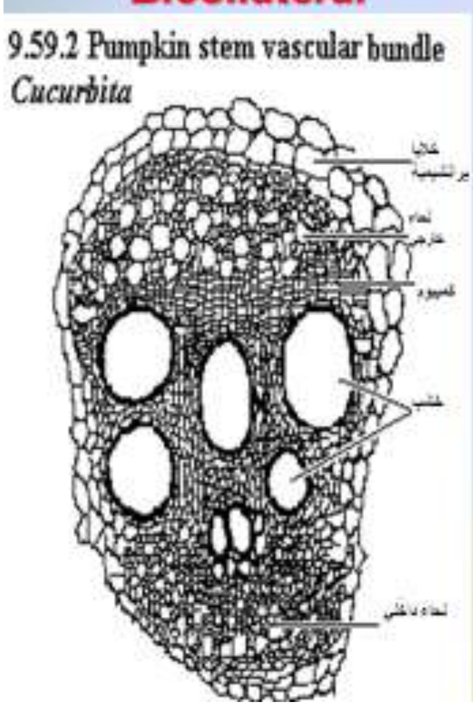
# Vascular Tissues
## 2. *Radial*

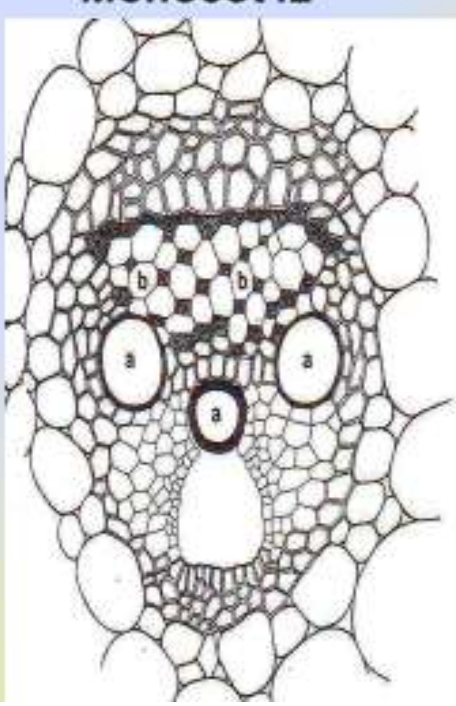


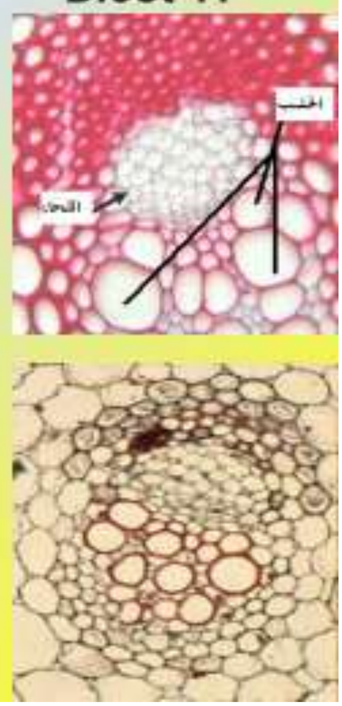

# Vascular Bundles
## 3. Collateral and Bicollateral

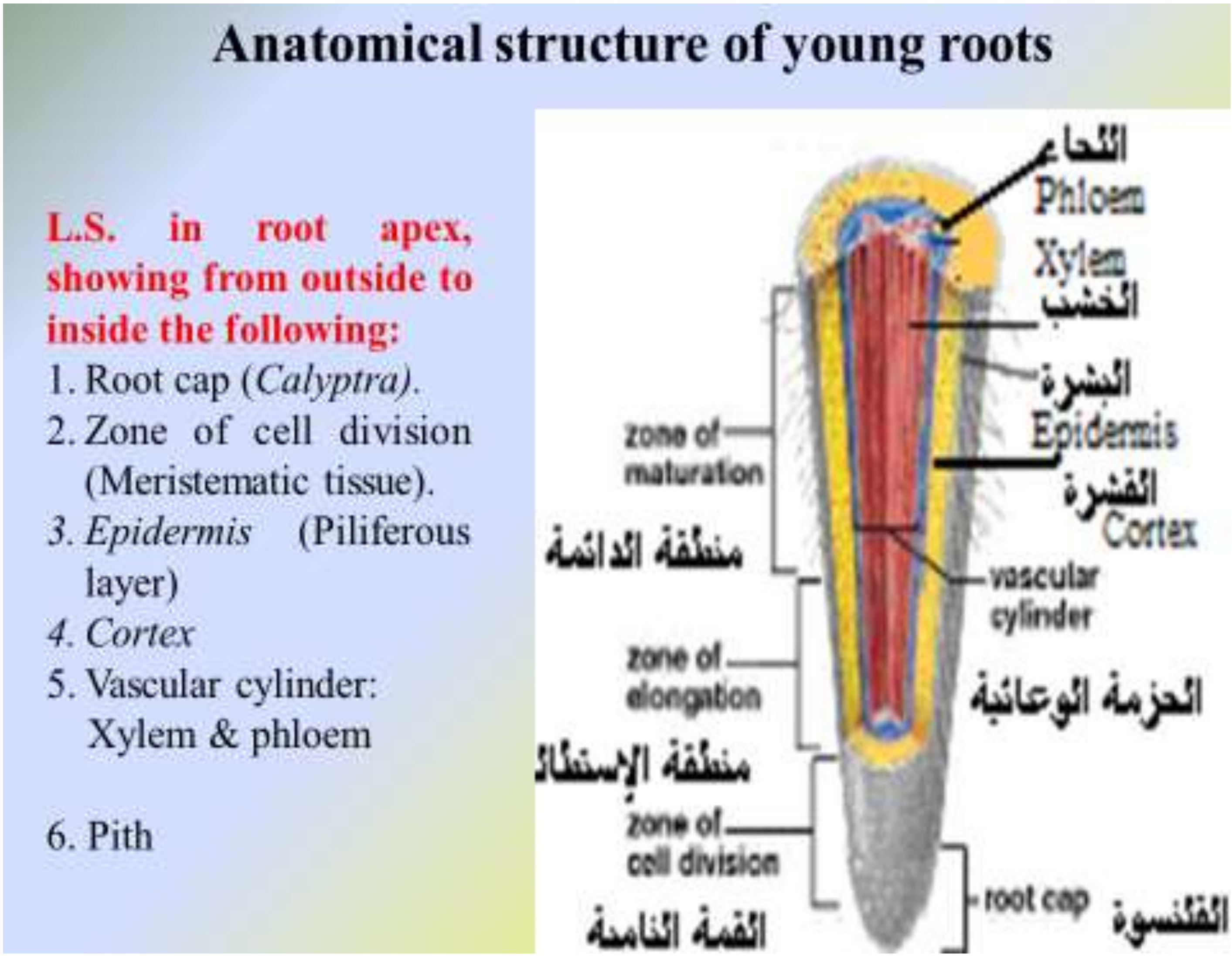
**Collateral**

**Bicollateral** — *Monocot .2* — *Dicot .1*






<u>**Different Regions of Dicot Root:**</u>

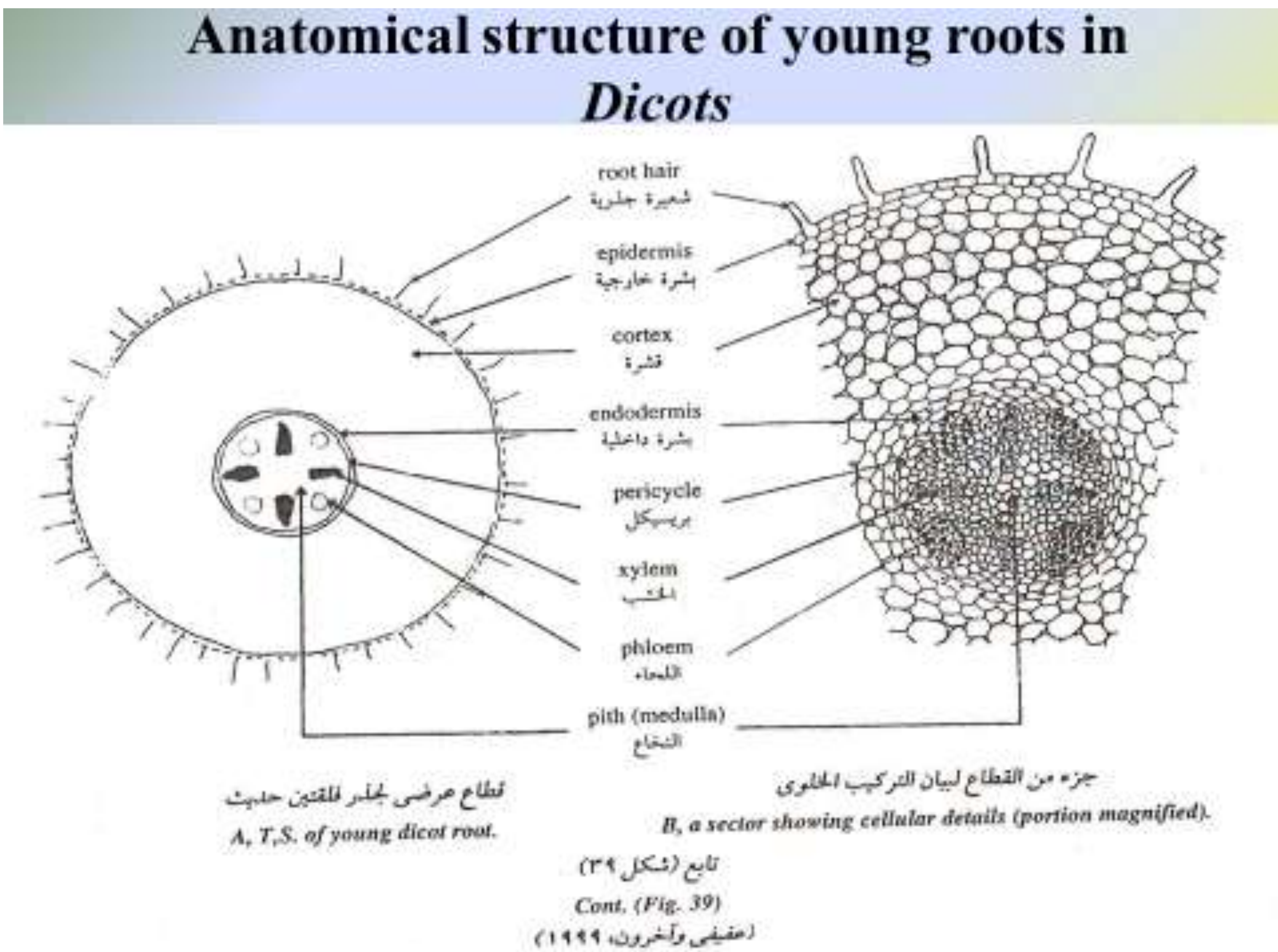
1. **Epiblema or Epidermis**: It is the outermost unlayered with several unicellular root hairs. It consists of thin-walled, compactly arranged living parenchymatous cells. Usually, epiblema is characterized by the absence of stomata and cuticles. Sometimes the epiblema may be less cuticularised. It provides protection to the roots due to the presence of unicellular root hairs it also helps in the absorption of water and minerals from the soil.

2. **Cortex:** It is a thin-walled, multilayered region made from circular or polygonal parenchymatous cells. they usually have intercellular spaces. The cortical cells have no chloroplast but may contain leucoplast for storage of starch grains. The cortex is responsible for the transportation of water and salts from the root hairs to the center of the root.

**3. Endodermis –** It is the innermost layer of the cortex and covers the stele. It consists of compactly arranged barrel-shaped parenchyma without intercellular spaces. Most of the cells are characterized by the presence of special thickening of suberin and lignin on their radial and tangential walls called casparian strips. Some endodermal cell near the protoxylem has no casparian strips and are called passage cells or transfusion cells. These cells allow the radial diffusion of water and minerals through the endodermis.

**4. Pericycle –** It is the outermost layer of the stele and is composed of a uniseriate layer of parenchymatous cells without intercellular spaces. Some dicots and hydrophytes do not bear pericycle. Several lateral roots and lateral meristem arise from the pericycle region (hence lateral roots are endogenous in origin). At the time of secondary growth, it produces secondary cambium or phellogens.

**5. Vascular bundles –** They are 2-8 in number, radial, and arranged in a ring. Xylem and phloem bundles are separated from each other by parenchymatous cells called conjuctive or **complementary tissue**.



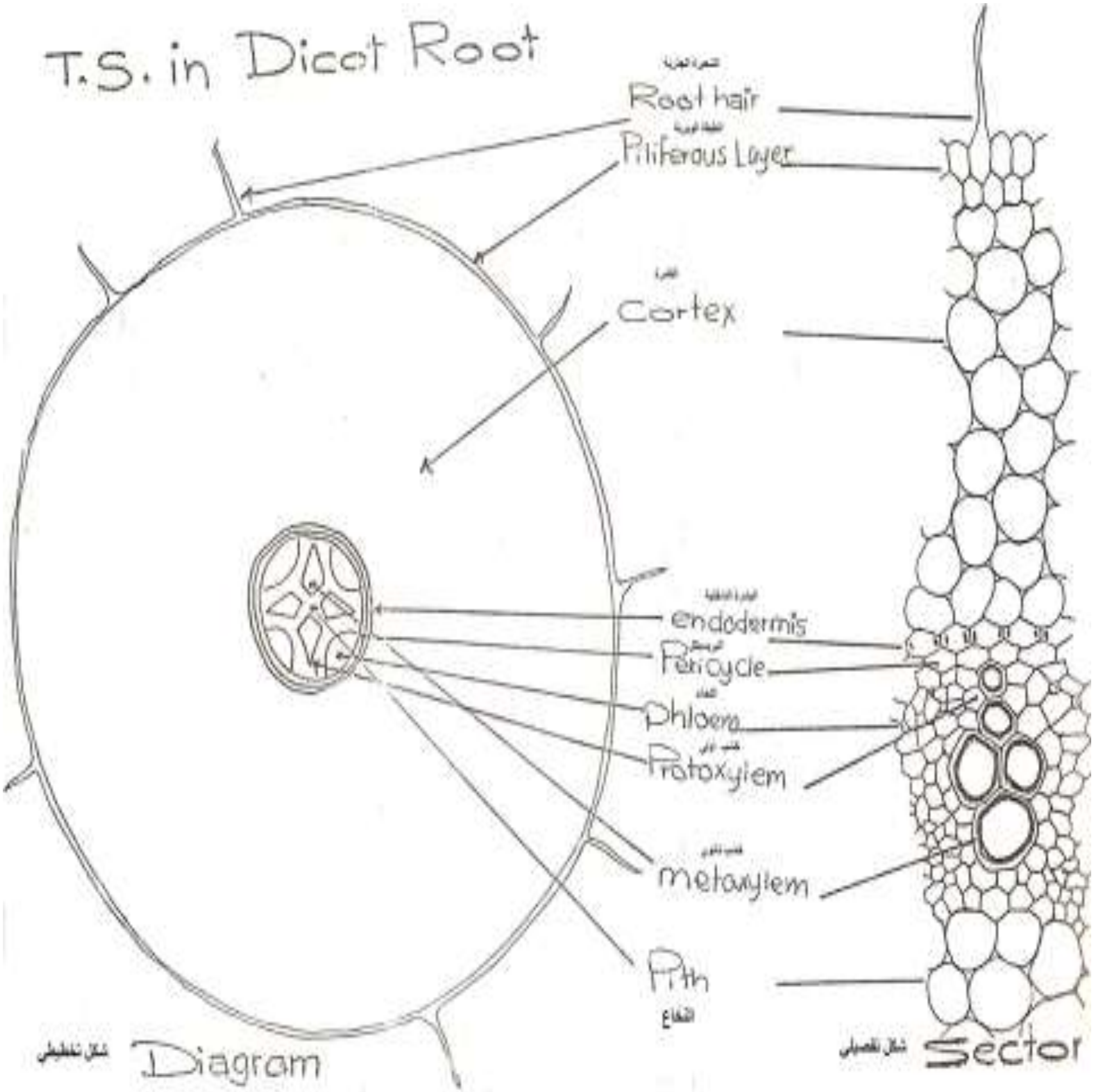
- Xylem is exarch (i.e. protoxylem towards the periphery and metaxylem towards the centre) and consists of tracheids, vessels, xylem parenchyma and xylem fibres.
- The pholem forms oval masses beneath the pericycle, alternating with xylem bundles. Pholem consists of sieve tubes, companion cells and pholem parenchyma. Usually pholem fibres are absent or reduced.

6. **Pith:** It is feebly developed and centrally located. It consists of thin-walled, polygonal parenchyma cells with intercellular spaces. In dicots roots, it may be reduced or absent. It helps in the storage of food materials.

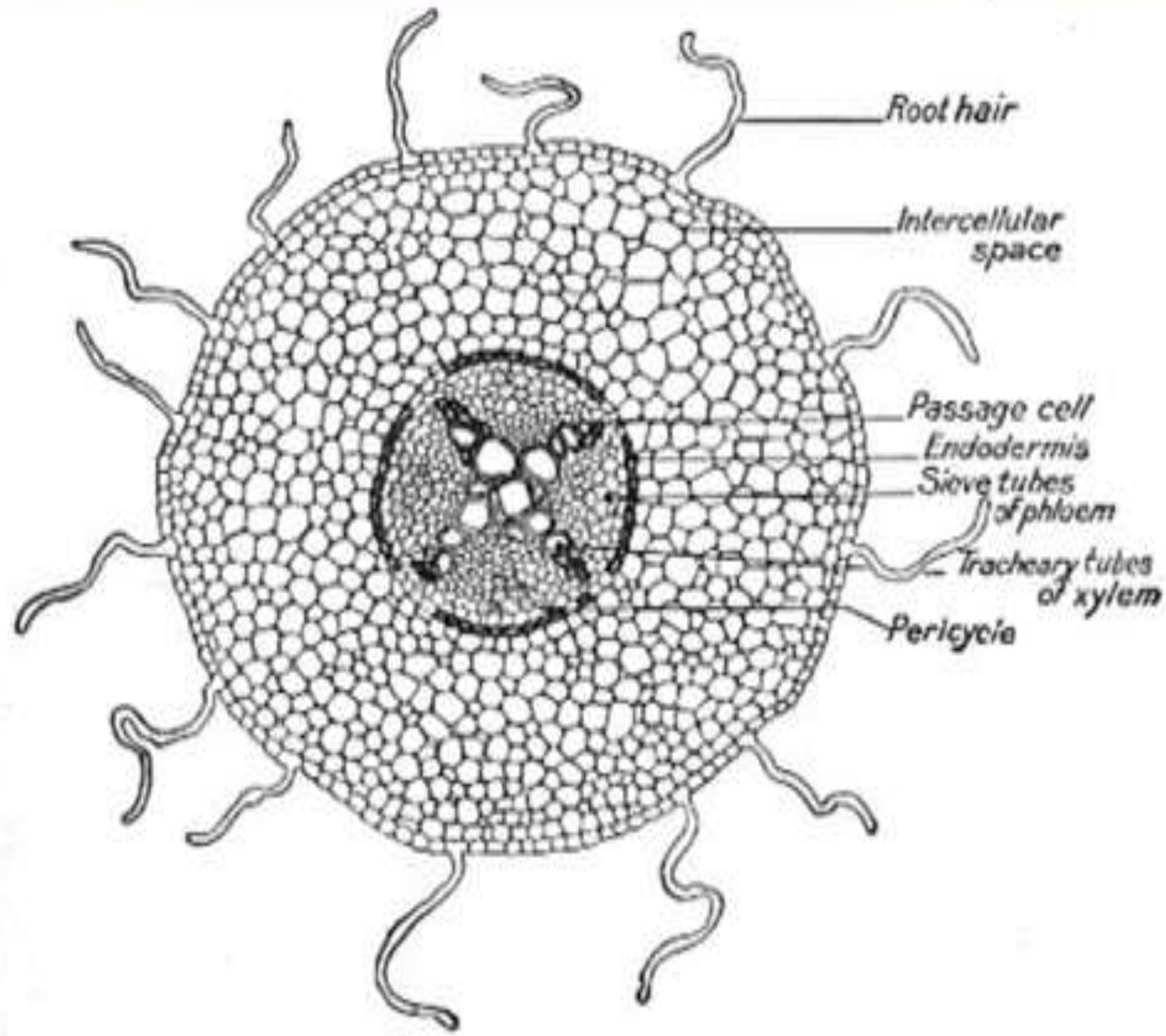
**Distinguishing Features of Dicot Root:**

The typical dicot roots show the following features.

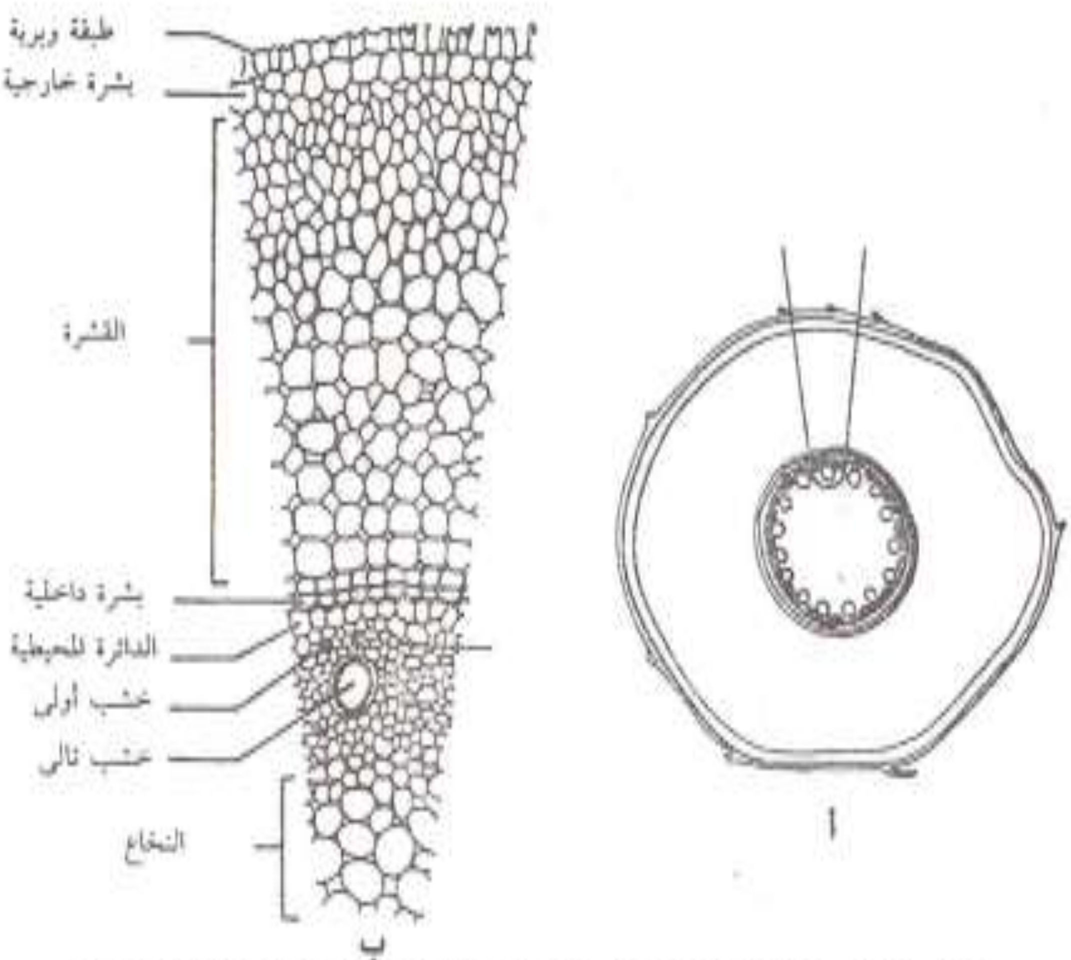
- Epiblema is uniseriate, thin walled, colourless without intercellular spaces and produce unicellular root hairs, hence also called as piliferous layer or rhidodermis.
- Cortex is homogenous (without differentiation).
- Endodermis consists of barrel shaped compact parenchymatous cells. It contains both casparian stripes and passage cells.
- Pericycle uniseriate and become meristematic to give secondary roots and secondary tissues.
- Vascular bundles are radial; Xylem is exarch; number of xylem bundles varies from 2 to 4 rarely more (up to 6-8). Metaxylems are angular arranged in linear.
- Usually conjunctive tissues are well developed.
- Pith is very small or completed obliterated.


T.S. in Dicot Root
Root hair
Piliferous Layer
Cortex
endodermis
Pericycle
Phloem
Protoxylem
metaxylem
Pith
Diagram
Sector

# Anatomical structure of young roots in *Dicots*



# Anatomical structure of young roots in *Monocots*




(شكل ٣٩): رسومات لقطاع عرضي في جذر حديث نبات من ذوات الفلقة الواحدة.

أ- رسم تخطيطي للقطاع.    ب- رسم لجزء تفصيلي للقطاع.

(Fig. 39) T.S. in monocot young root A- diagram B- sector

(المصدر : دين ١٩٨٢م، Dean, 1982)

**The typical monocot roots show the following features:**

- **Epiblema** is single layered, thin walled, colorless, polygonal without intercellular spaces, with presence of unicellular root hairs, hence also called as piliferous layer or rhizodermis.
- **Cortex** may be heterogeneous with outer dead exodermis.
- **Endodermis** consists of barrel shaped parenchyma without intercellular spaces. Casparian stripes are little present but passage cells are absent.
- **Pericycle** gives lateral roots only, secondary growth is absent.
- **Vascular bundles** are radial; Xylem is exarch, bundles more than six. Metaxylem elements are oval or circular.
- **Conjunctive tissues** are limited or even absent.
- **Pith** is large or rarely reduced.

**2. Features of Different Regions of Monocot Root**

1. **Epiblema** is the outermost single layer made from compactly arranged parenchymatous cells without intercellular space. Usually Epiblema has no stomata but bears unicellular epidermal root hairs and less amount of cutin. It contains more cuticle than dicot roots. The root hairs and thin walled epidermal cells take part in the absorption of water and minerals from the soil. The epiphytes have several layered hygroscopic epidermis, called **velamen tissues**. It is made from spongy dead cells which helps in absorption of water from atmosphere. It also checks excessive loss of water from cortex. Usually the wall of velamen has spiral or reticulate secondary thickening of cellulose, pectin and lignin.
1. **Cortex** is a multi-layered well developed and made from oval parenchymatous cells with intercellular spaces. The intercellular spaces usually help in gaseous exchanges, storage of starch, etc. In monocots and several old roots, few layers of cortex just below epiblema give rise to a single or multilayered cuticularised sclerenchymatous region called **exodermis**. Cortex helps in mechanical support to the roots (like hypodermis to stem).
2. **Endodermis** is innermost layer of cortex made from barrel shaped parenchyma. It forms a definite ring around the stele. These cells are characterized by the presence of casparian stripes. It is deposition of suberin and lignin, and their radial and tangential walls. Usually passage cells are absent in monocot roots. Due to presence of **casparian stripes**, endodermis forms water tight jacket around the vascular tissues, hence it is also

called biological barrier. It regulates the inward and outward flow of water and minerals and prevents diffusion of air into xylem elements.

3. **Pericycle** is uniseriate (multiseriate in Smilax) and made from thin walled parenchymatous cells. It is outermost layer of stellar system. Usually it is made from parenchymatous cells but it may become sclerenchymatous in older roots. Several lateral roots arise from this layer. Hence, lateral roots are endogenous in origin.
4. **Vascular bundle** is radial, arranged in a ring (except mangrove, which also contains lenticels), **polyarch** (presence of many alternating xylem and phloem bundles). Xylem and phloem are found at different radii alternating with each other (radial). The number of xylem and phloem vary from, 8 to 46 (100 in *pandanus*). The xylem is exarch, i.e. the protoxylem lies towards periphery and metaxylem toward center. The protoxylem has smaller vessels with spiral or annular thickening, whereas the walls of metaxylem contains pitted thickening. Phleom consists of seive tubes, companion cells and phloem parenchyma. Usually phleom sclerenchyma or fibers are absent. The phloem is also exarch (protophloem towards the periphery and metaphloem towards the center). Secondary growth is absent in monocot roots due to lack of vascular and cork cambium. **Conjunctive tissue** is parenchymatous tissues which separates xylem and phloem bundles. It may become sclerenchymatous in older roots.
5. **Pith** is large, well developed portion of monocot root. It occupies the central portion and made from thin walled parenchymatou tissue with intercellular spaces. It contains abundant amount of starch grains.

Monocot roots of maize have bands of vascular bundles. Bundles are not separate and vessels are not found in linear rows but arranged in V-shaped structure.

**General Characters of Roots:**

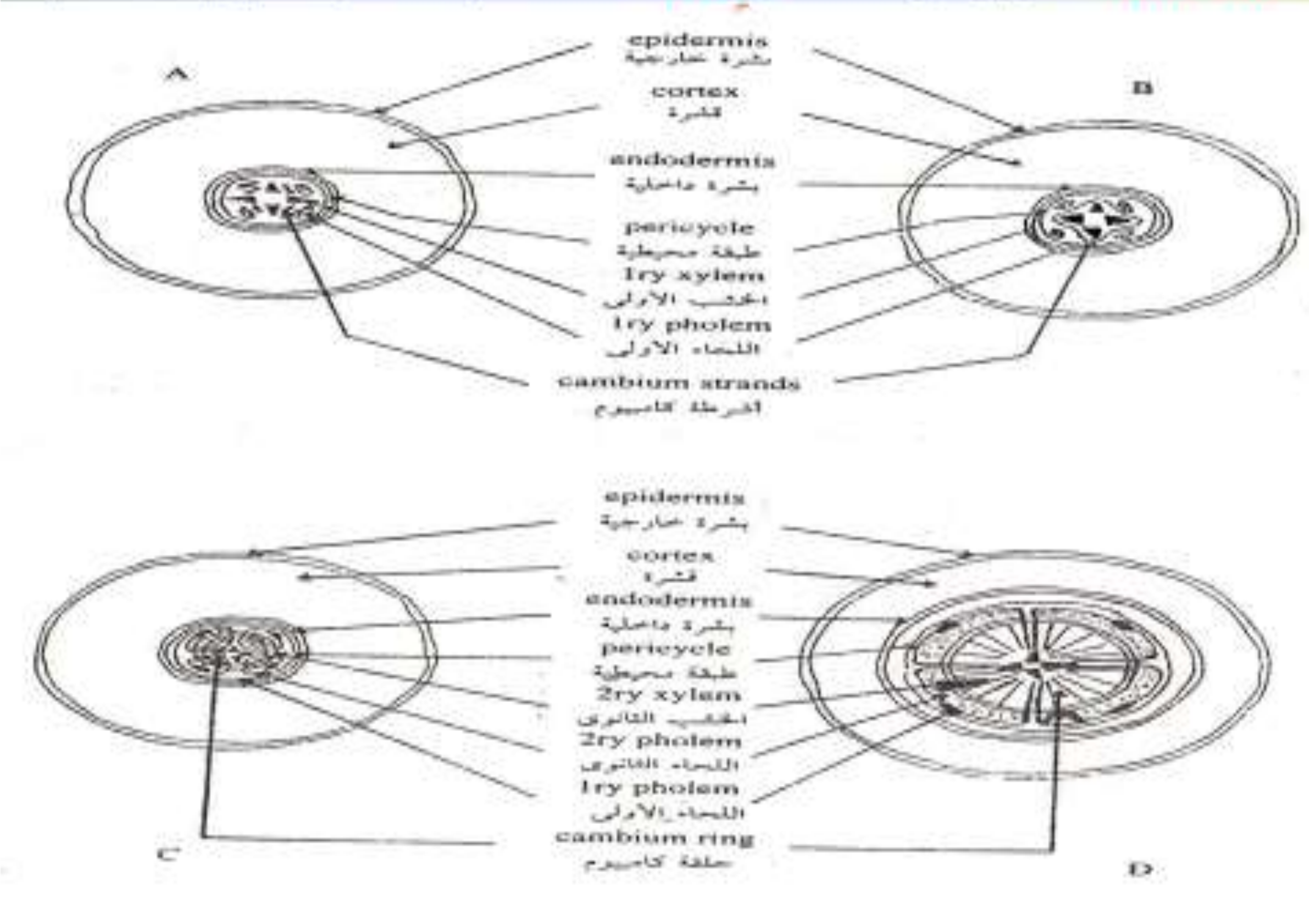
1. A piliferous layer is found in young roots which is replaced by an Exodermis known as the periderm during secondary growth.
2. The ground tissue is characterized into cortex and pith.
3. The cortex is wider than the pith.
4. Presence of a single layer of Endodermis.
5. Suberin (impermeable to water) is deposited on the walls of Endodermis forming The Casparian Strip which is in the form of an O or U –shaped (Monocots), or in the form of lateral strips on their radial and tangential walls (Dicots). Walls that are not impregnated with Suberin are called passage cells.
6. Radial arrangement of the vascular cylinder (Xylem and Phloem are arranged on alternating radii).
7. The Xylem is Exarch.

**Comparison between *Dicot* and *Monocot* roots**

| Points of Comparisons | *Dicot* Root | *Monocot* Root |
|---|---|---|
| ***Xylem* archs** | Limited in number (2-8) | Unlimited in number (30) |
| ***Phloem*** | Irregular (presence of *Phloem Parenchyma*) | Regular (absence of *Phloem Parenchyma*) |
| ***Pith*** | Narrow | Wide |
| ***Xylem* Vessels** | Angular | Circular |
| **Casparian Strips** | Lateral Strips | U or O - shaped |
| **Secondary Growth** | Always happens | Rarely happens |

# Secondary Growth in Old Roots

- **<u>Secondary growth</u>: It always occurs in *Dicots*, but rarely happens in *Monocots*.**




(شكل ٤٠): قطاعات عرضية تخطيطية في جذر لذات الفلقتين لمشاهدة النمو الثانوي في السمك
Fig. 40. diagrams of T.S. of a dicotyledonous root, showing secondary growth
(عفيفي وآخرون، ١٩٩٩)

The secondary growth in root also takes place by the activity of the cambium and cork cambium. It is a usual feature of dicotyledonous and gymnospermous roots, where it generally starts at a very early stage, so much so that it is difficult to get the roots without secondary growth in most of the cases.

***1. Activity of Cambium:***

Certain of the cells of conjunctive tissue just beneath the phloem become meristematic and form strips of cambium. The number of strips produced depends upon thus number of phloem bundles present. In a diarch root two, in triarch root three and in tetrarch root four such strips are formed. These strips exertend both ways in between phloem and xylem and ultimately unite with the pericyclic cells lying just outside the protoxylem.

The pericyclic cells divide tangentially and produce two layers of which the cells of inner layer also become meristematic and unite with the strips of cambia and thus, a continuous wavy band of cambium is produced extending down the phloem and over the xylem. It becomes active and forms new cells.

It divides by periclinal divisions and then by anticlinal divisions for increase in circumference. The strip of cambium below the phloem becomes active earlier and the activity is much faster on the inner side. Because of this, phloem and cambium strip below it are pushed outward and the wavy band of cambium now becomes circular to form a cambium ring. Now the entire of the cambium becomes active.

The cells formed on the inner side get differentiated into secondary xylem. It consists of comparatively large vessels, tracheids, a little wood fibres and well evolved xylem parenchyma. The activity of cambium is so fast on the inner side that after secondary growth xylem forms the main bulk of the root and is present in the form of solid core.

The primary xylem bundles can remain intact up to the last or the crushed. The annual rings like the stem are not visible in roots. The pith is entirely crushed, or if some part is left the cells become thick walled.

The secondary vascular tissues produced by the activity of cambium do not form a continuous ring but are interrupted by the bands of radially-elongated, parenchymatous cells, known as primary medullary rays. These are formed above each primary xylem patch and extend up to the phloem. Sometimes, other smaller medullar rays can also develop from other parts of cambium and may be known as secondary medullary rays. The number of rays goes on increasing with the increase in the size of the vascular cylinder.

The secondary xylem cells vary in quantity if different roots, they have only tracheids in gymnosperms, only vessels in willow and both tracheids and vessels in most of the plants. In some storage roots storage parenchyma develops in the secondary xylem. The cells of secondary xylem are arranged in definite rows when first produced become irregularly disposed due to differential enlargement of various tracheid elements.

Like the stem, in roots of perennial trees, shrubs and woody climbers also, the xylem elements produced in the bringing of each season are larger and thin walled, while those formed during late are smaller in size and are thick walled. Thus, annual rings are produced.

## 2. Activity of Cork Cambium:

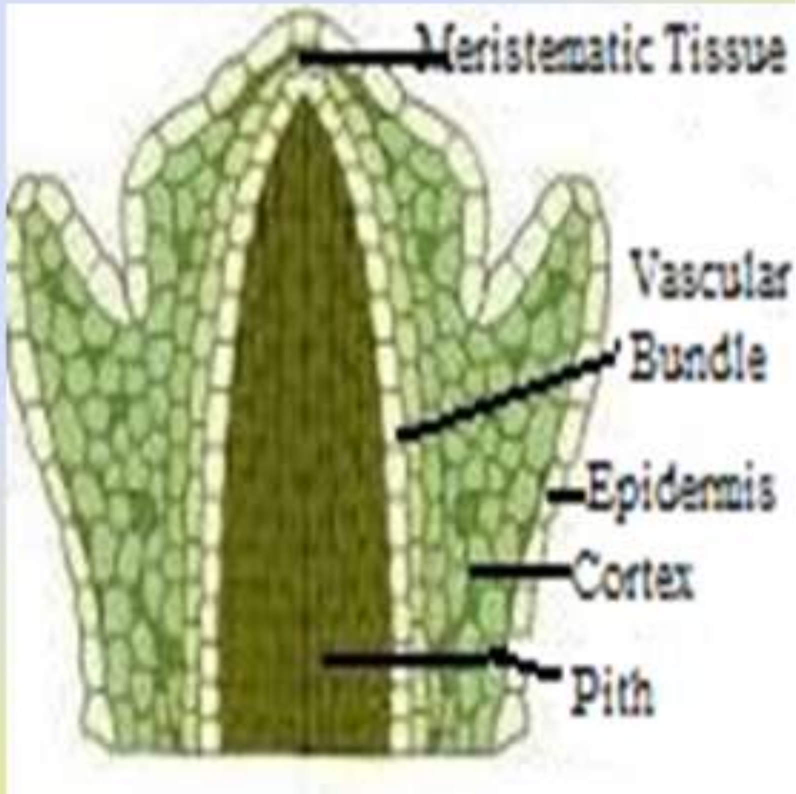
The secondary tissues produced by the activity of cambium exert a pressure on the outer tissue. To withstand this pressure, the cells of pericycle become meristematic and function as the phellogen or cork cambium. The cells of pericycle divide tangentially. Similar to stem, here also it produces layers of cork or phellem on the outside and secondary cortex or phelloderm on the inner side.

The bark in the case of roots includes cork, endodermis, cortex and epiblema. In certain cases, the cork cambium may be formed from the phloem cells. In this case, the pericycle also produces the part of bark. Subsequent barks have only cork. Lenticels can also be formed here and there. When the bark is removed, the new cork cambium layer is formed from the parenchyma produced by the previous cork cambium.

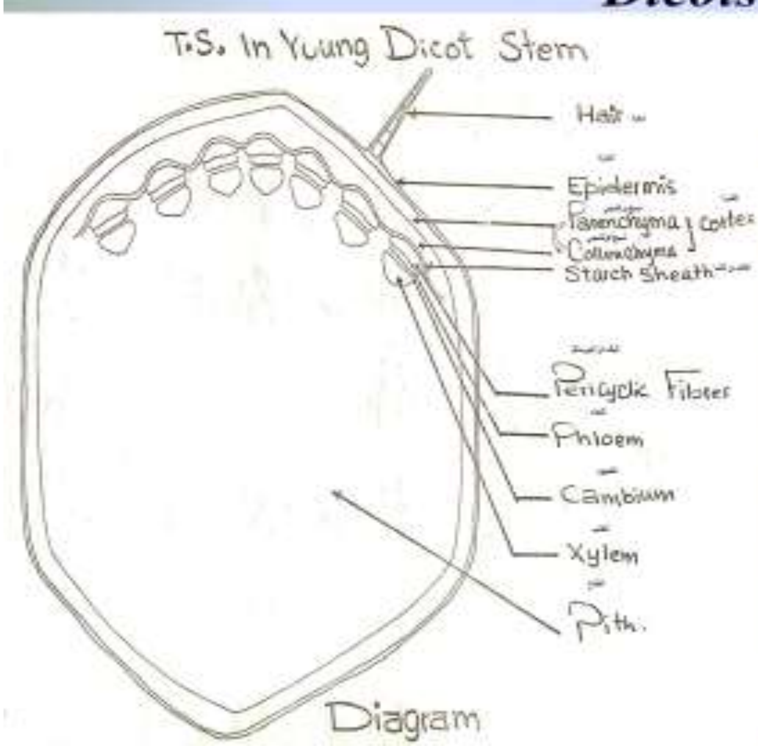
# Anatomical structure of young stems

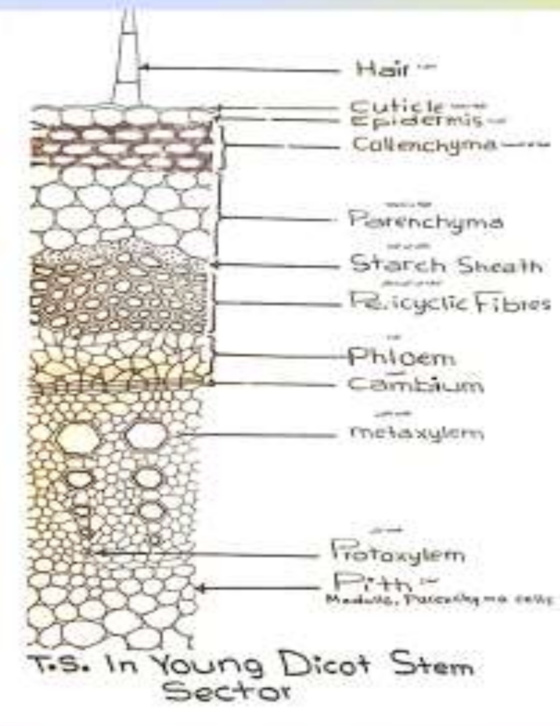
**L.S. in stem apex, showing from outside to inside the following:**

1. Growing Apex (Meristematic tissue).
2. *Protoderm* (*Epidermis*)
3. *Cortex*
4. Vascular bundle: *Xylem*, *phloem* & *Cambium*.
5. Pith




# Anatomical structure of young stems in *Dicots*



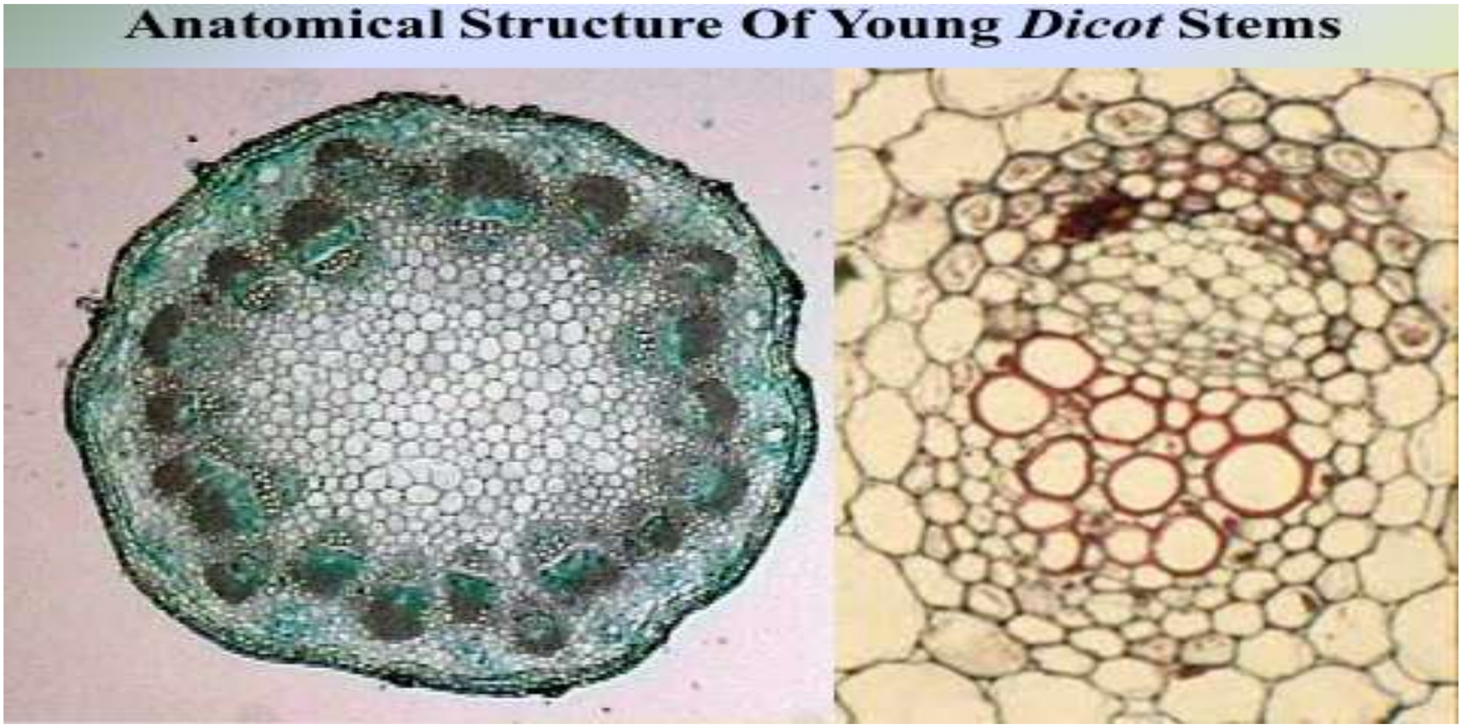



# Dicotyledonous and Monocotyledonous Stem

## Dicot Stem

The dicotyledonous stem is usually solid. The transverse section of a typical young dicotyledonous stem consists of the following parts:

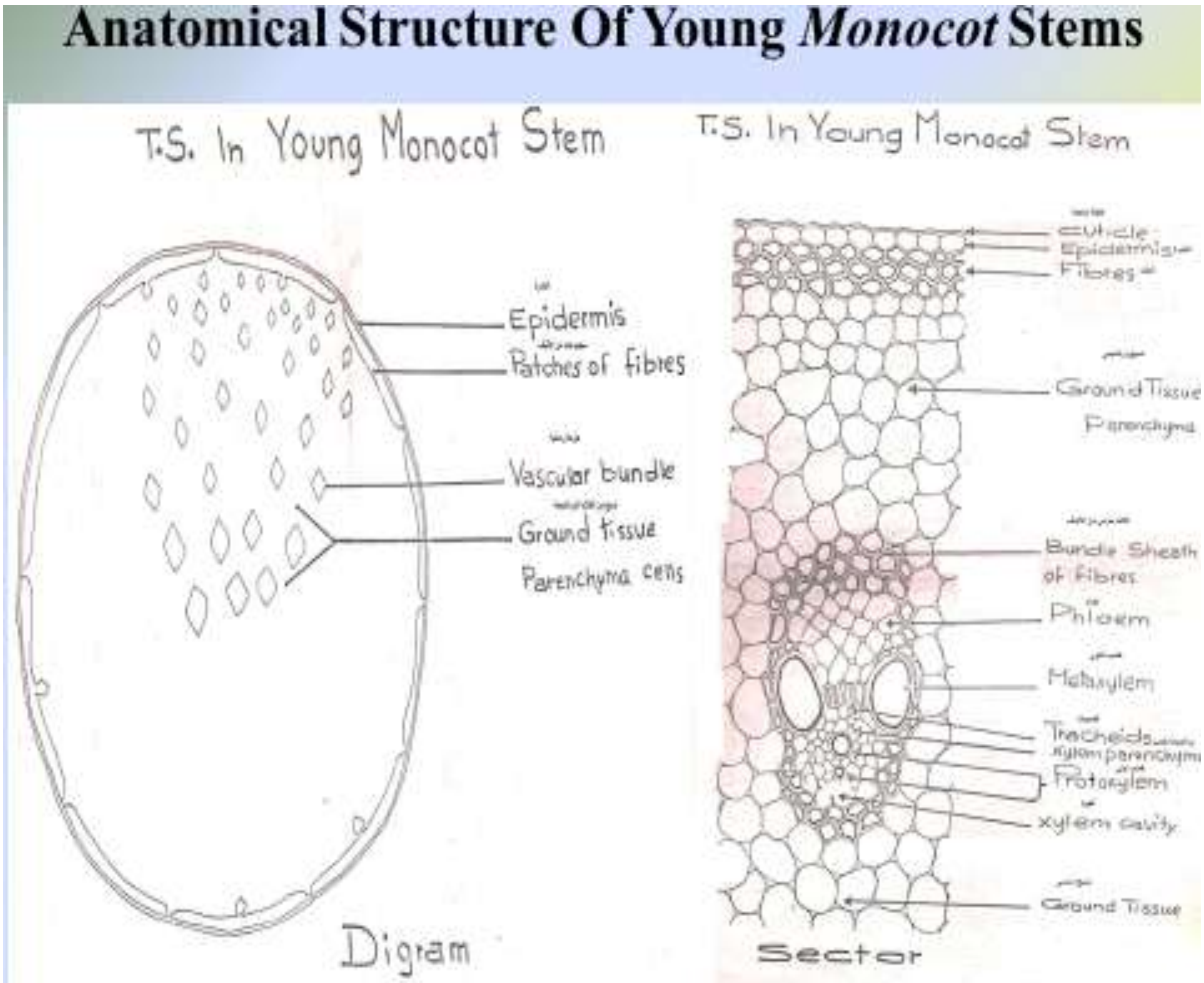
- The epidermis is the outermost protective layer, which is covered with a thin layer of cuticle.
- Epidermis possesses trichomes and a few stomata.
- Cortex is multi-layered cells sandwiched between epidermis and pericycle.
- The outer layer, hypodermis (collenchymatous cells), the cortical layers (parenchymatous cells) and the inner layer, endodermis together make up the three subzones of the cortex.
- Next to endodermis is the pericycle, which is constituted of semi-lunar patches of sclerenchyma.
- ‘Circled’/ ‘ring’ arrangement of vascular bundles is present only in dicot stem.
- The Vascular bundle is conjoint, open and with endarch protoxylem.
- Pith is evident and is made of parenchymatous cells.


Anatomical Structure Of Young *Dicot* Stems

## Monocot Stem

Monocot stem is usually hollow with no secondary growth. The anatomy of monocot and dicot stem are similar, however, some notable differences are as follows:

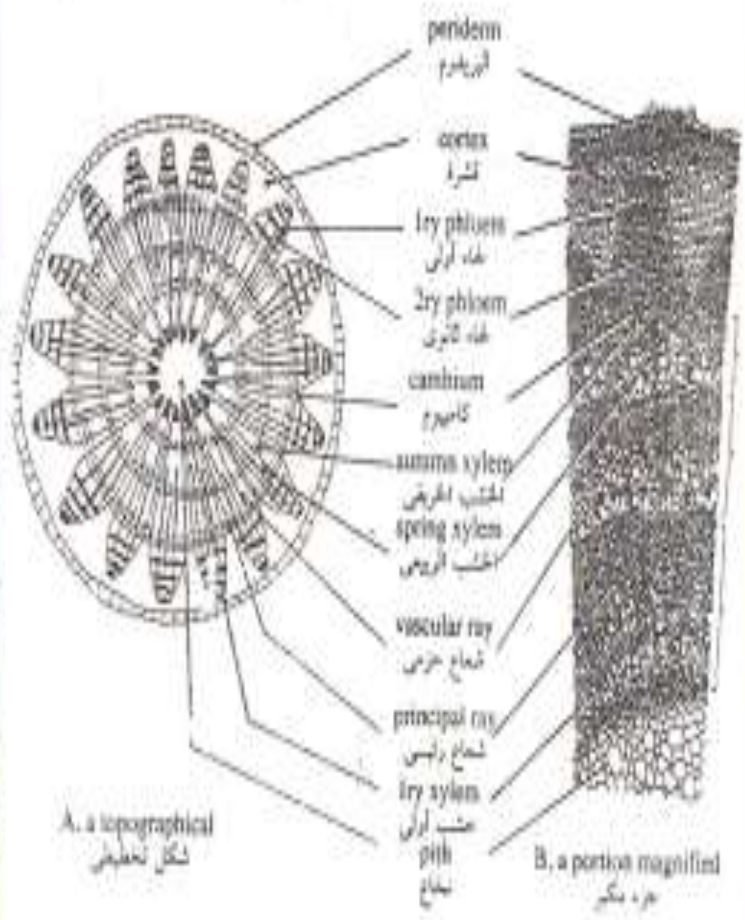
- The hypodermis of the cortex in monocots is made of sclerenchymatous cells.
- Vascular bundles are numerous, but scattered, conjoint and closed, surrounded by the ground tissue.
- Phloem parenchyma is absent.



# Anatomical Structure in Old *Dicot* Stems

During the continuous growth of *Dicot* plant and the increase of its size, the plant needs to increase its mechanical support tissues, vascular elements, storage tissues and sometimes the *Periderm* which replaces the *Epidermis*. Thus the plant needs to undergo "**Secondary Growth**" by the activation of Cambium to form:

1. Secondary *Xylem* and *Phloem*.
2. Formation of a *Cambial* Ring: which is differentiated into Fascicular and Interfascicular Cambium.
3. Vascular Rays: formed by the division of Fascicular Cambium (narrow and unlimited) subdivided into *Xylem* and *Phloem* rays (horizontal and vertical).
4. Pith Rays: formed by the division of Interfascicular Cambium (wide and limited)

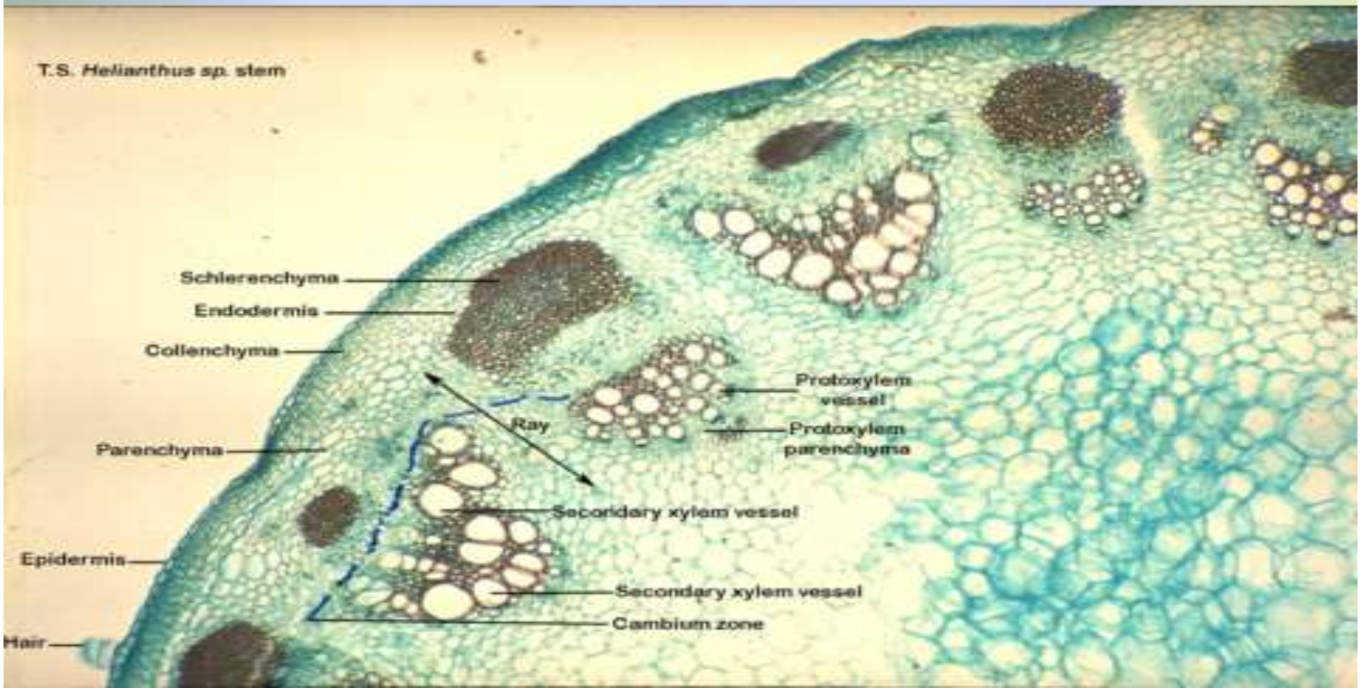


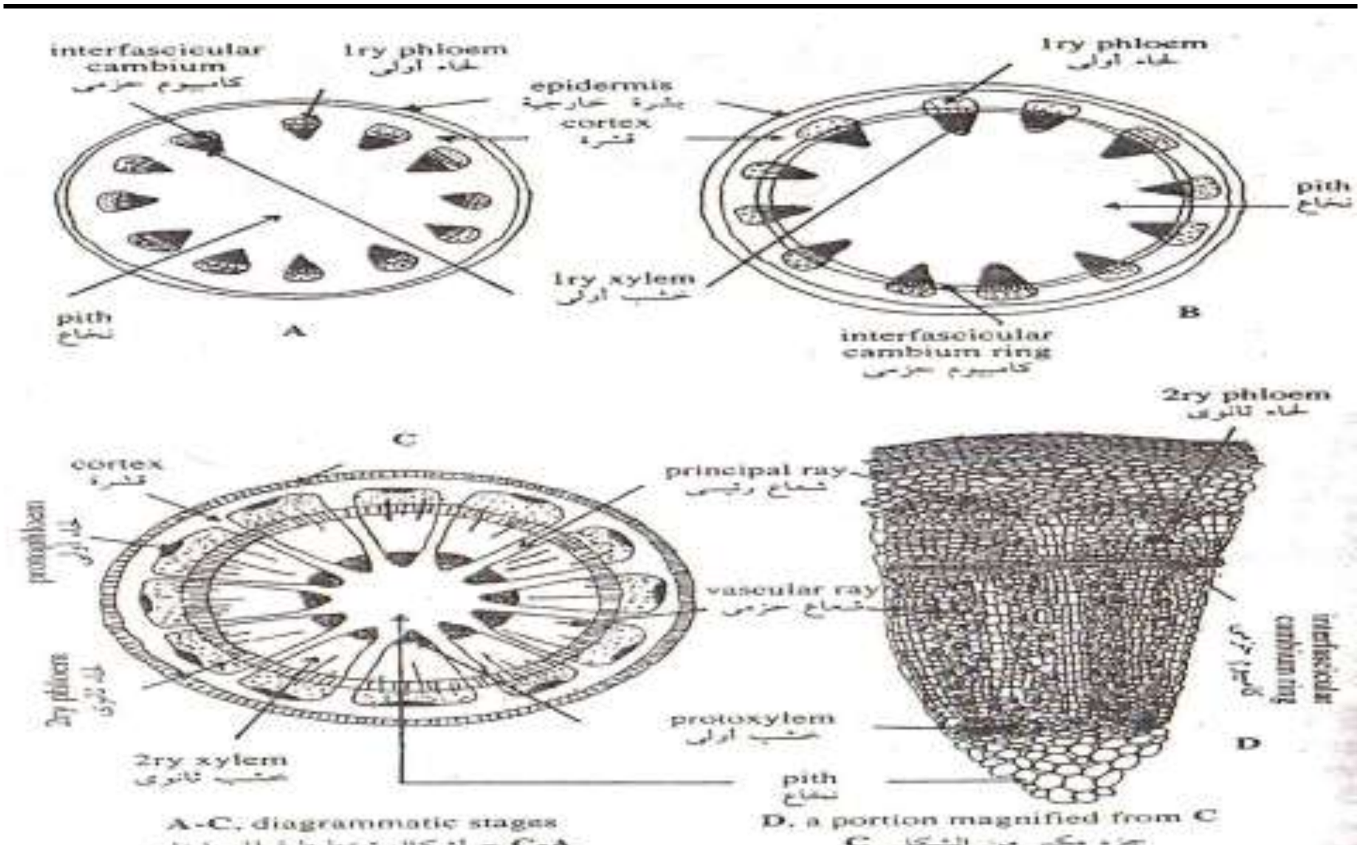

(شكل ٥٣): قطاع عرضي في ساق نبات التليا المسن

(Fig. 53) T.S. of old stems of Tilia.

(حنفي وآخرون، ١٩٩٩)

# Anatomical Structure in Old *Dicot* Stems

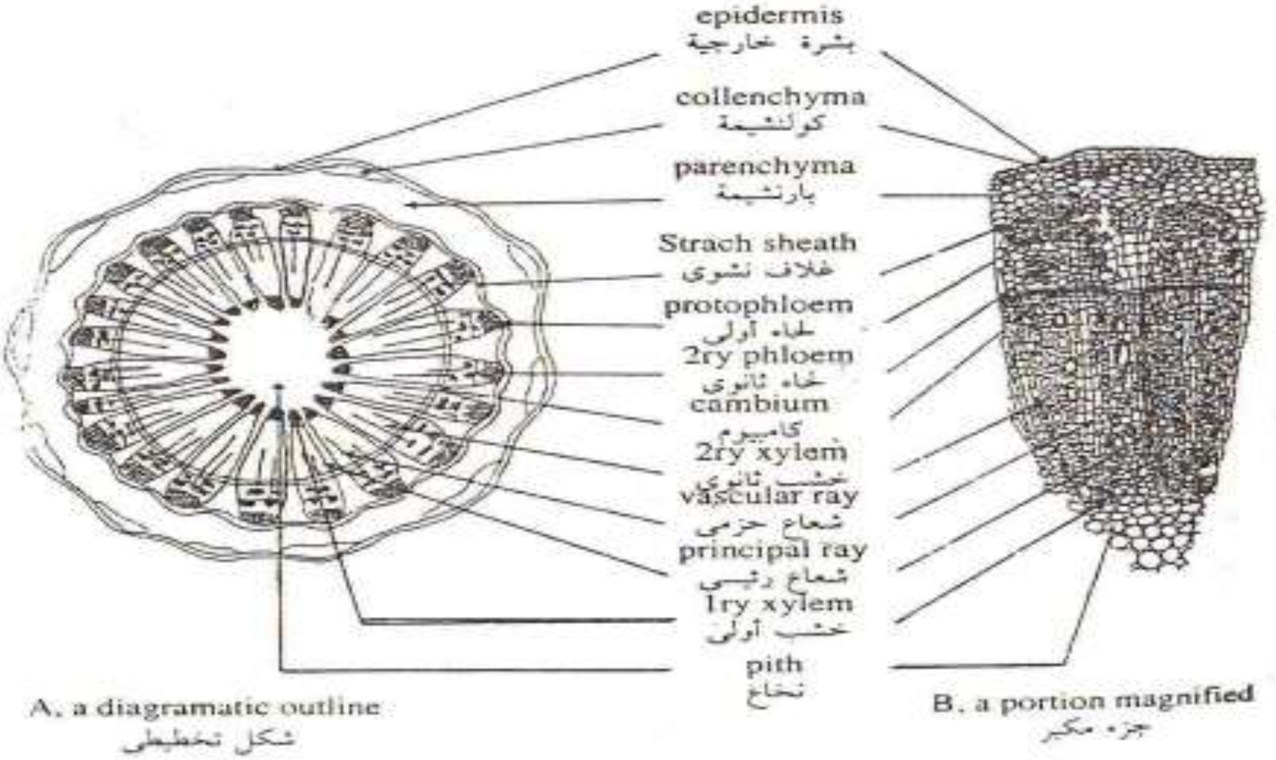



(شكل ٥٣): أشكال تخطيطية لقطاعات عرضية لساق فلقتين لشاهدة النمو الثانوي في السمك

*(Fig. 53) Diagrams of T.S. of a dicotyledonous stems, showing secondary growth.*

(عفيفي وآخرون، ١٩٤٩)




(شكل ٥٢): قطاع عرضى فى ساق نبات العنب المسن

*(Fig. 52) T.S. of old stems of Vitis.*

(عفيفى وآخرون، ١٩٩٩)

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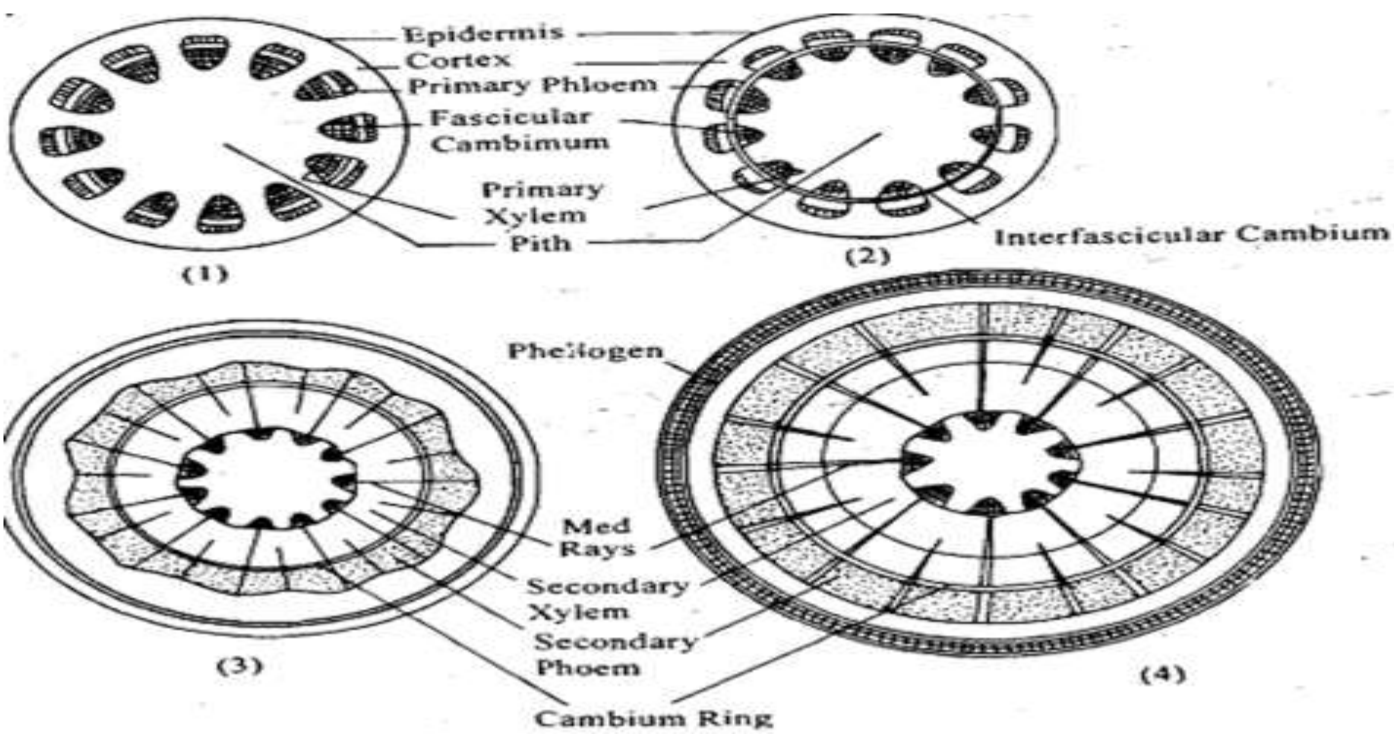


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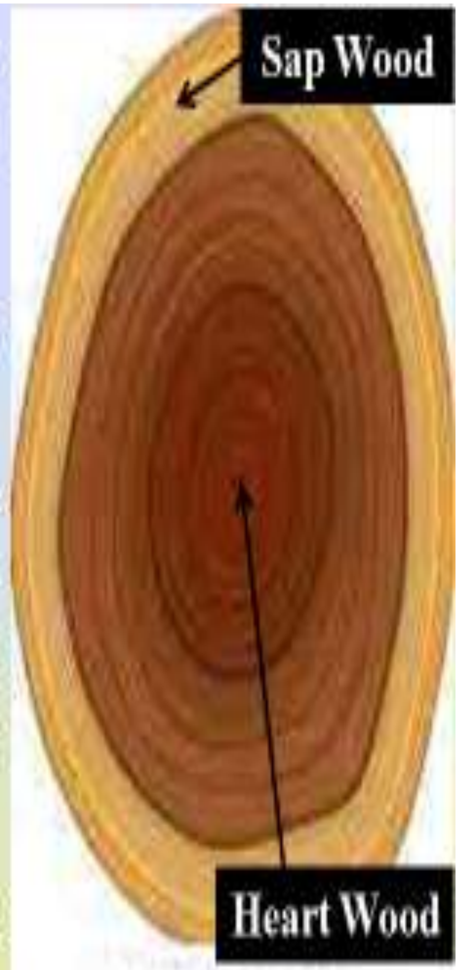
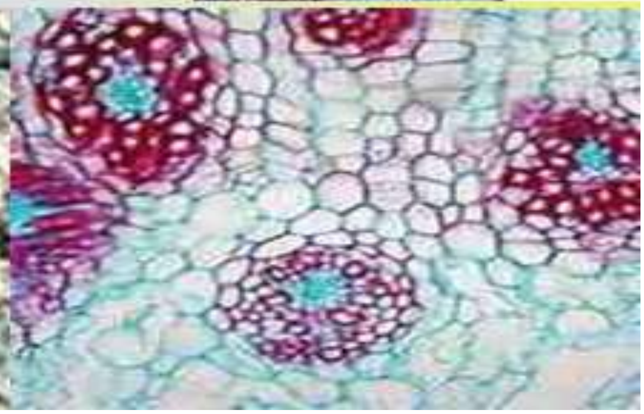
- **Annual Rings:** The activity of cambium varies from one season to another where each year is represented by a ring which consists of two layers:
  1. **Spring Wood:** The vessels are usually large, circular thin walled and numerous.
  2. **Summer (or Autumn) Wood:** Vessels are smaller, thick-walled and fewer in number. Such variation is due to the environmental conditions or the shedding of leaves. Defoliation may result in the deactivation of cambium.



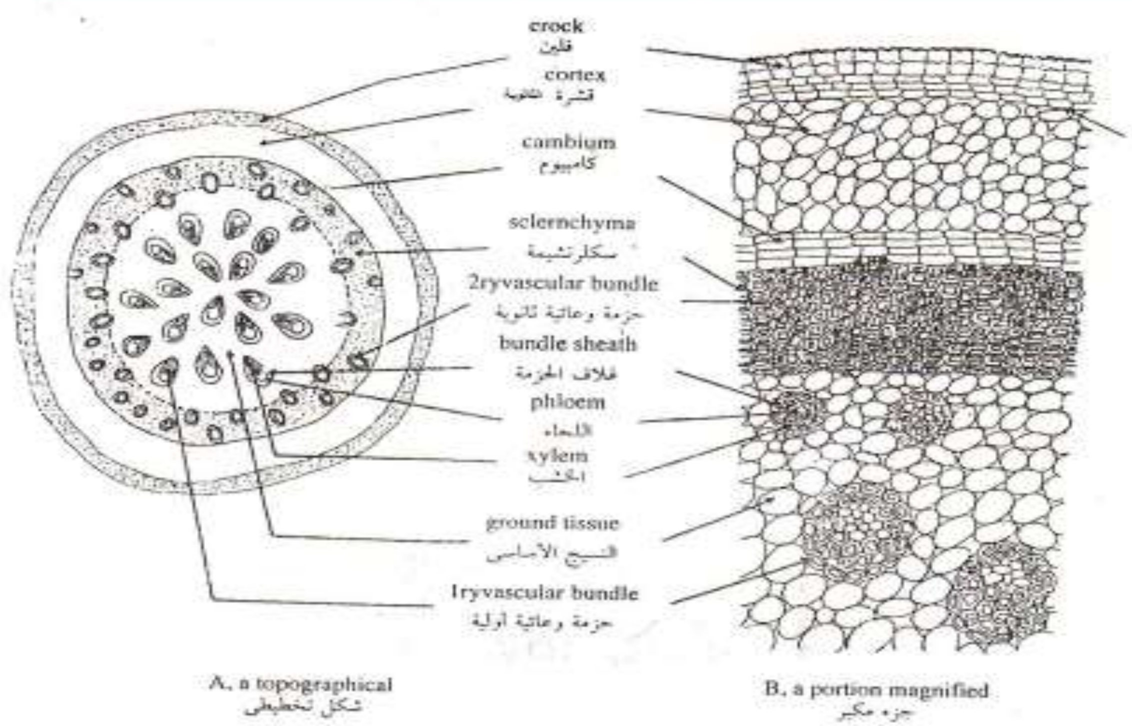

- **In a cross section of an old woody stem , one observes:**
  1. **Heart Wood:** A darker-colored inner zone (of *Pith* and *Protoxylem)* due to the deposition of resins, gums, tannin, pigments and certain substances. All of them increase the weight, hardness and durability of the heart wood which increase its economic value. (i.e. Mahogany)
  2. **Sap Wood:** Light-colored outer zone.

# Anatomical Structure in Old *Monocot* Stems

- **Secondary growth is restricted to the:**
  1. Increase of the stem diameter by the increase in the number of *Parenchyma* cells.
  2. Increase in the area of fibrous tissue.
- **Sometimes secondary growth occurs by** the formation of a ring of 2 ry cambium that divides to give 2ry cortex and 2ry VB (**concentric**) which are found crowded in radial arrangement.

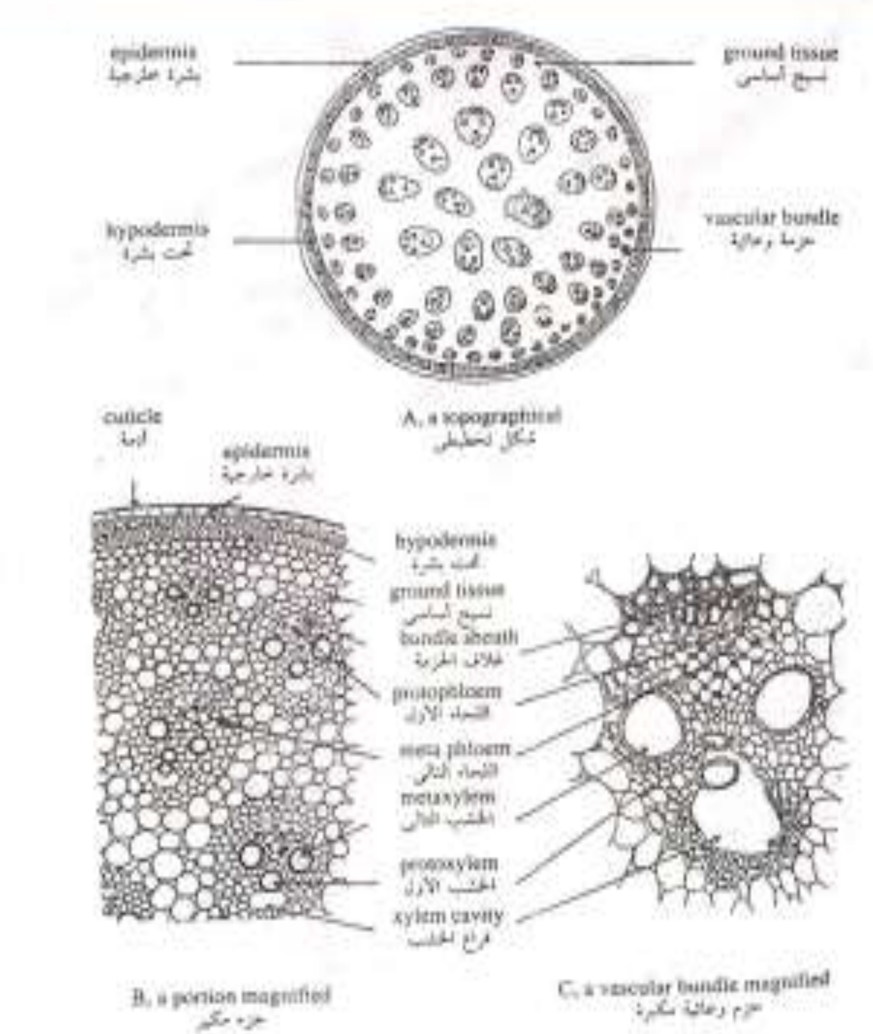


# Anatomical Structure in Old *Monocot* Stems




(شكل ٥٤): قطاع عرضي في ساق نبات الدراسينا المسن
(Fig. 54) T.S. of old stems of *Dracaena*.
(حلمي وآخرون، ١٩٩٩)

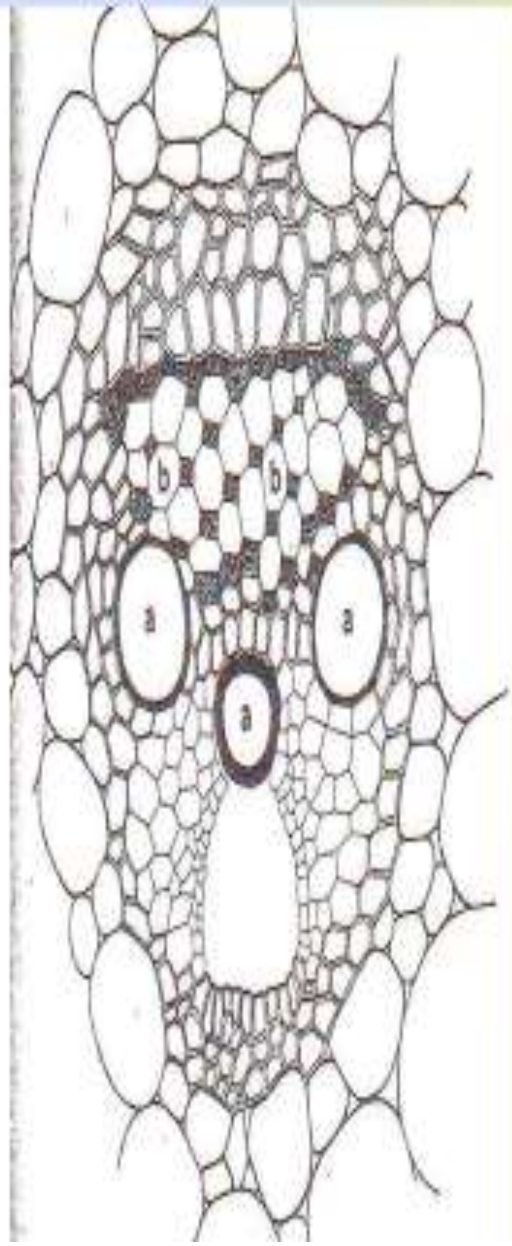
# Anatomical Structure Of Young *Monocot* Stems




(شكل ٥١). قطاع عرضي في ساق الذرة الشامية

*(Fig. 51) T.S. of Zea mays stem*

(عطيفي وآخرون، ١٩٩٩)



# Plant Leaf

Leaf tissues are composed of layers of plant cells. Different plant cell types form three main tissues found in leaves. These tissues include a mesophyll tissue layer that is sandwiched between two layers of epidermis. Leaf vascular tissue is located within the mesophyll layer.

## Epidermis

The outer leaf layer is known as the epidermis. The epidermis secretes a waxy coating called the **cuticle** that helps the plant retain water. The epidermis in plant leaves also contains special cells called **guard cells** that regulate gas exchange between the plant and the environment. Guard cells control the size of pores called **stomata** (singular stoma) in the epidermis. Opening and closing the stomata allows plants to release or retain gases including water vapor, oxygen, and carbon dioxide as needed.

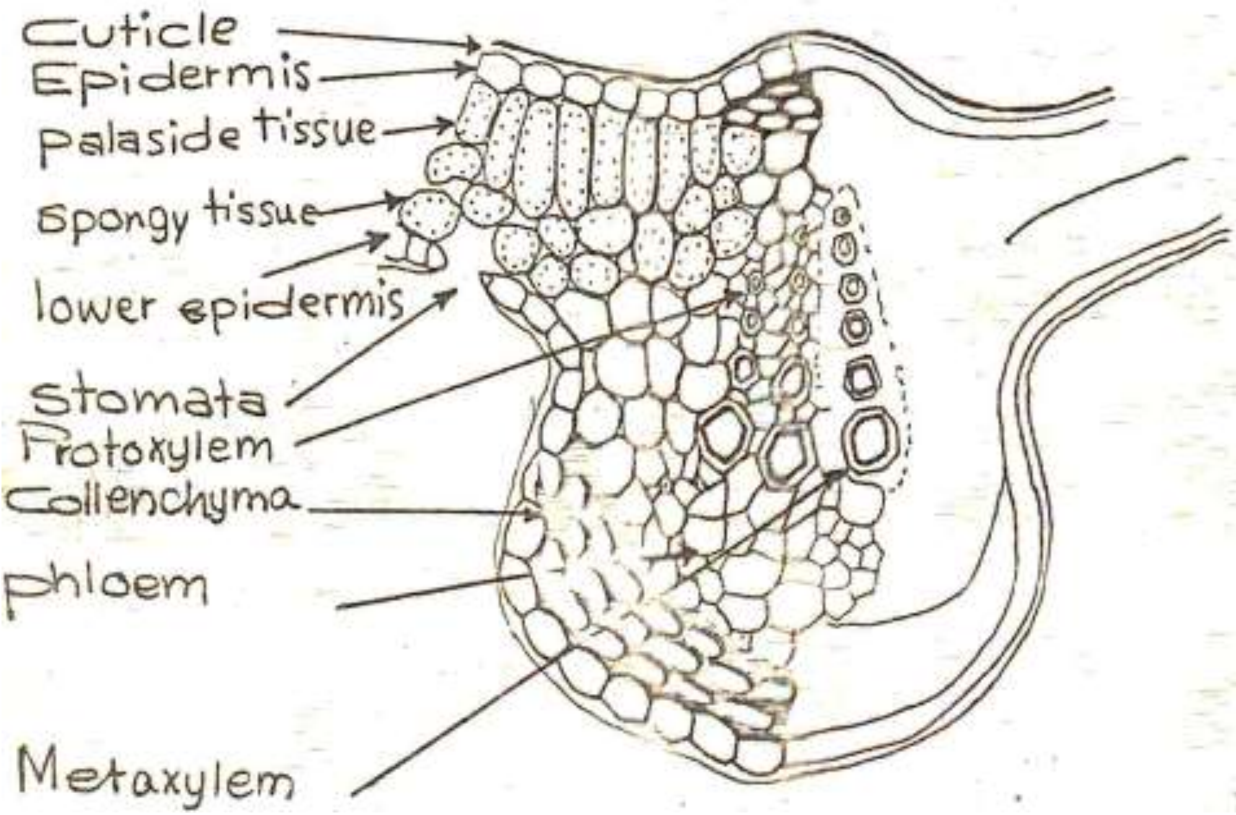
## Mesophyll

The middle mesophyll leaf layer is composed of a palisade mesophyll region and a spongy mesophyll region. **Palisade mesophyll** contains columnar cells with spaces between the cells. Most plant chloroplasts are found in palisade mesophyll. Chloroplasts are organelles that contain chlorophyll, a green pigment that absorbs energy from sunlight for photosynthesis. **Spongy mesophyll** is located below palisade mesophyll and is composed of irregularly shaped cells. Leaf vascular tissue is found in the spongy mesophyll.

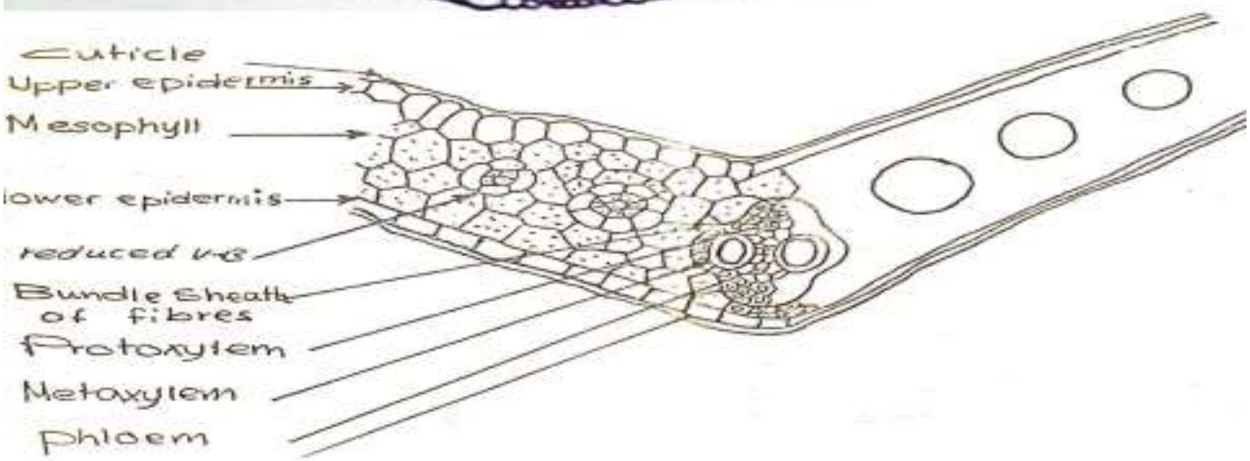
## Vascular Tissue

Leaf veins are composed of vascular tissue. Vascular tissue consists of tube-shaped structures called **xylem and phloem** that provide pathways for water and nutrients to flow throughout the leaves and plant.

## T.S. in *Dicot* leaf




## T.S. in *Monocot* leaf



# REFERENCES


1. **Khalil *et al.* (1975). General botany. Cairo Univ. Press.**
2. **Sinnott andWilson (1983). Botany Principles and Problems Mc Graw-Hill Company 6th edition.**
3. **Eskarous *et al.*(1987). Practical Botany. Cairo Univ. Press.**
4. **Megahed *et al.*(1996). General Botany. Anglo Press. 7th edition.**
5. **Afiffy *et al.* (2004). General Botany. Dar El Fikr El Araby Pub.**
6. **Kamel *et al.* (2005). Basics of Plant Sciences. Dar El Fikr El Araby Pub. 2nd edition.**
7. **Plant Atlas (2010).**


# GRADING

1. **Student activities & attendance (5 marks): 2 lab notebook+2quiz+1attendance**
2. **Practical exam: 10 marks**
3. **Final written exam: 60 marks**

# TEACHING HOURS

1. **Lectures: 2 hours**
2. **Lab: 2 hours**