Subject: General Plant Biology

UE: Fundamental Unit ,TP: 3 hours, Lecture: 1.5 hours / per week

Practical / Tutorials (Lab & TD): 15 h

Credits: 7

Coefficient: 03

Semester: 2

Evaluation Methods:

- (TP*0,4 + EXAM *0,6)/2

INTRODUCTION TO PLANT BIOLOGY (S2)

1. DIFFERENT TYPES OF TISSUES

1.1. Primary meristems (root and shoot)

1.1. 1. Primary tissues

- 1.1.1. Protective tissues (epidermis)
- 1.1.2. Ground tissues (parenchyma)
- 1.1.3. Supporting tissues (collenchyma and sclerenchyma)
- 1.1.4. Conducting tissues (primary xylem, primary phloem)
- 1.1.5. Secretory tissues

1.2. Secondary (lateral) meristems (cambium and phellogen)

1.2.1. Secondary tissues

- **1.2.2. Conducting tissues (secondary xylem and secondary phloem)**
- **1.2.3. Protective tissues (suber or cork, phelloderm)**

2. ANATOMY OF HIGHER PLANTS

- 2.1. Study of the root
- 2.2. Study of the stem
- 2.3. Study of the leaf
- 2.4. Comparative anatomy between monocotyledons and dicotyledons

3. MORPHOLOGY OF HIGHER PLANTS AND ADAPTATION

- 3.1. Roots
- 3.2. Leaves
- 3.3. Stems
- 3.4. Flowers
- 3.5. Seeds
- 3.6. Fruits

4. GAMETOGENESIS

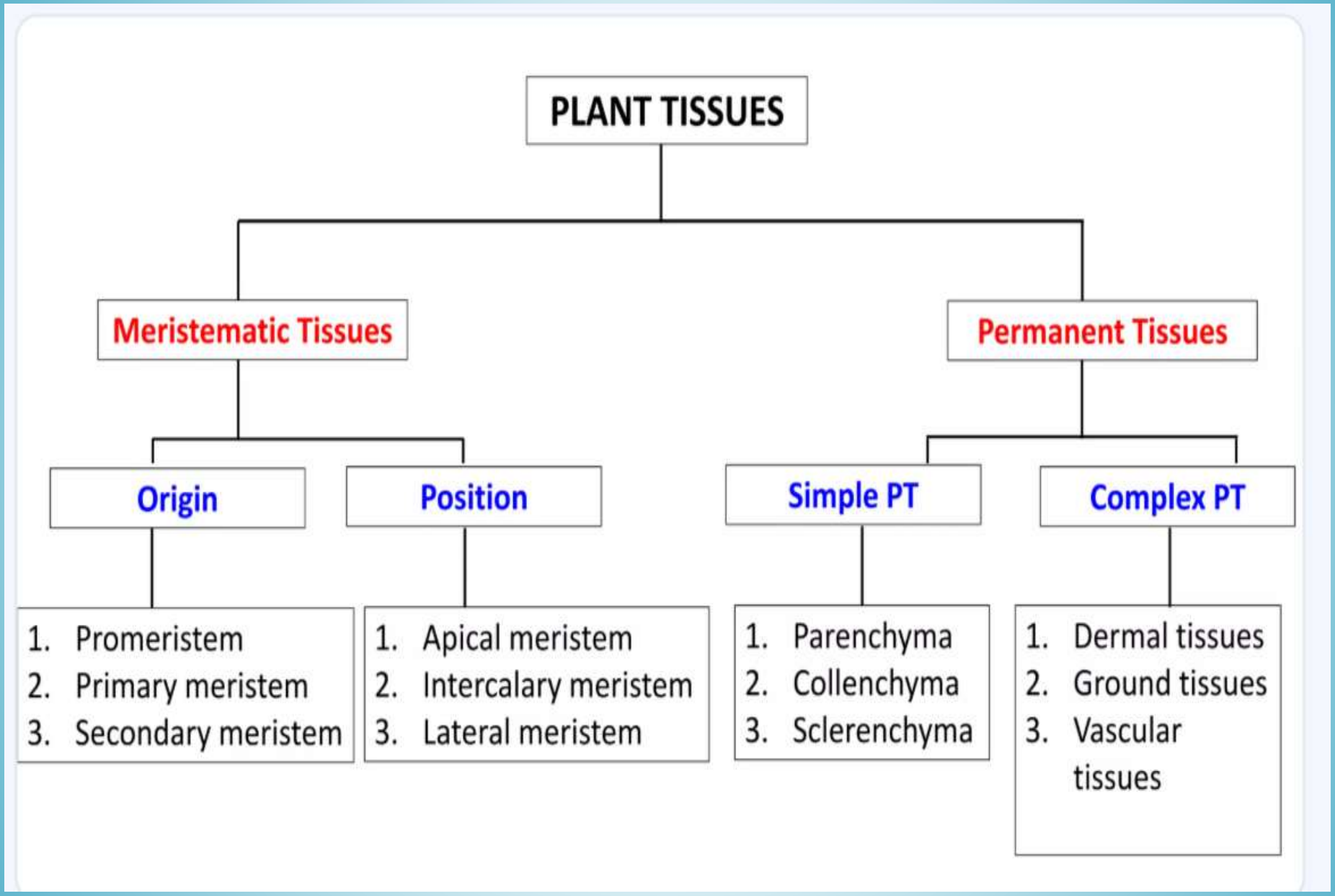
- 4.1. Pollen grain
- 4.2. Ovule and embryo sac

5. FERTILIZATION

- 5.1. Egg cell and embryo
- 5.2. Concept of the life cycle

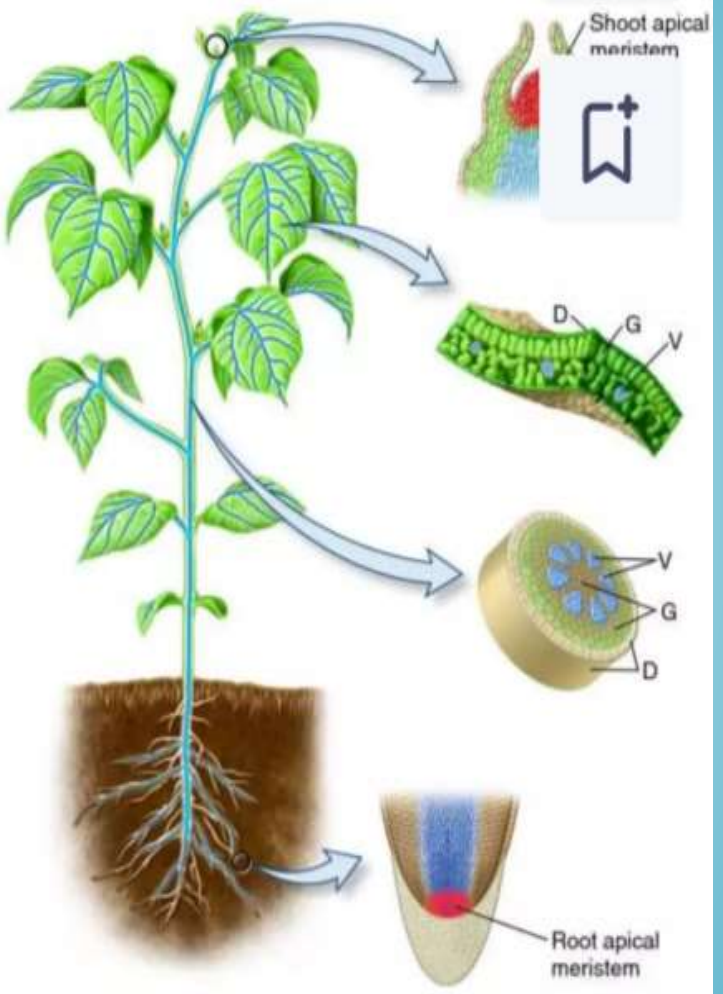
OBJECTIVE

- Identify the various types of plant tissue
- Give structural, locational and functional differences of these tissues
- Present at least one significance of plant tissue


PLANT TISSUES
Meristematic Tissues
Permanent Tissues
Origin
Position
Simple PT
Complex PT
1. Promeristem
2. Primary meristem
3. Secondary meristem
1. Apical meristem
2. Intercalary meristem
3. Lateral meristem
1. Parenchyma
2. Collenchyma
3. Sclerenchyma
1. Dermal tissues
2. Ground tissues
3. Vascular tissues

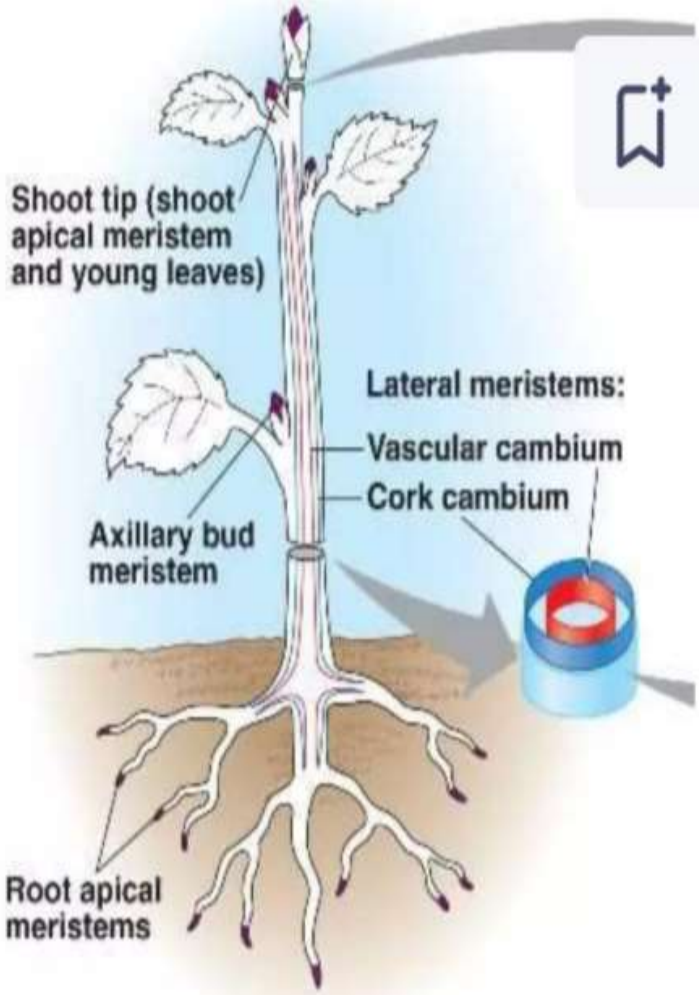
MERISTEMATIC TISSUES

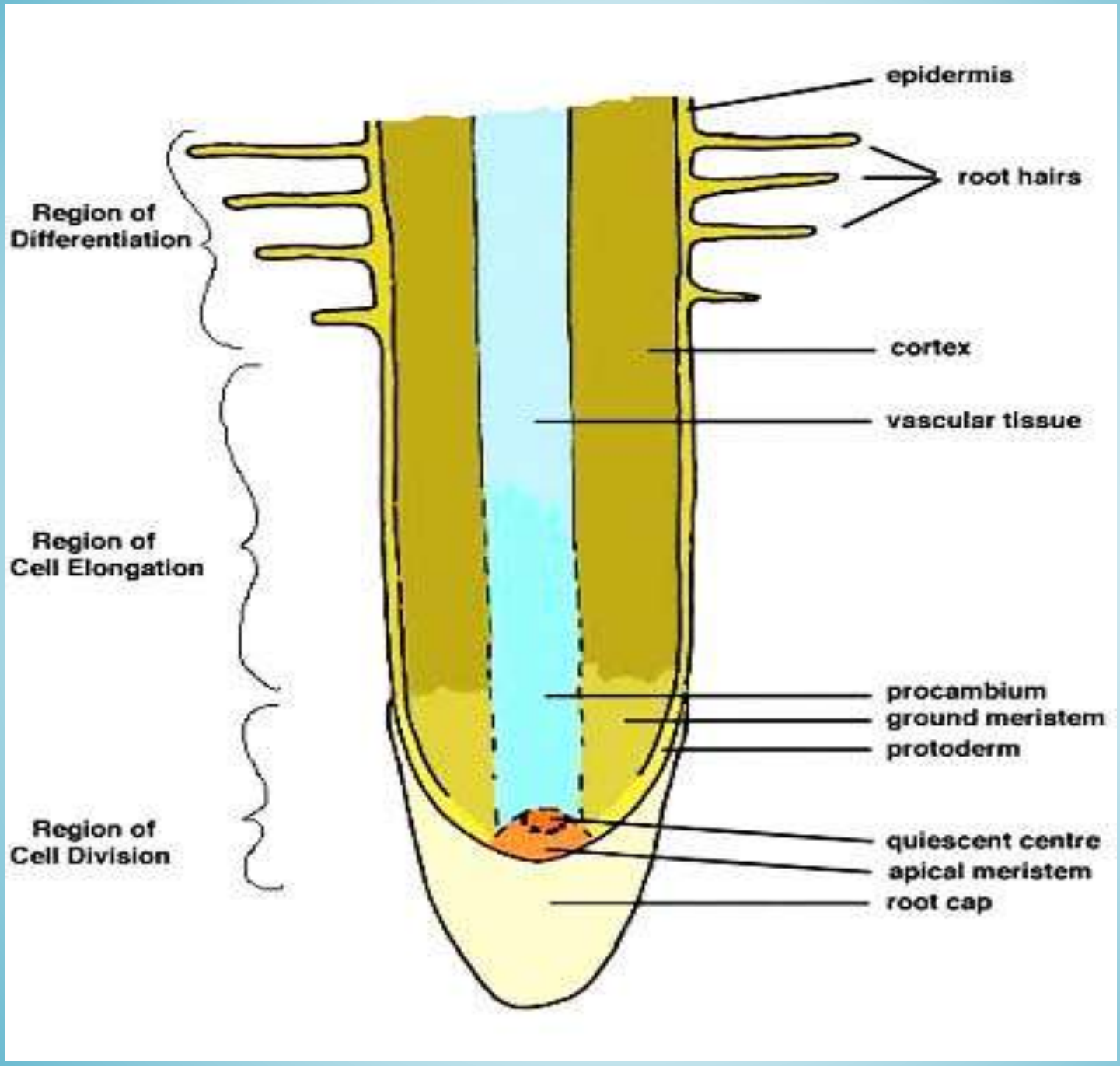
- Derived from Greek *meristos* – *"**Divided**"*
- Unspecialized cells that can divided indefinitely to produce new cells
- **Meristems** is the region where meristematic cells dwell
- Meristematic tissues are usually found at the apex of root and shoot

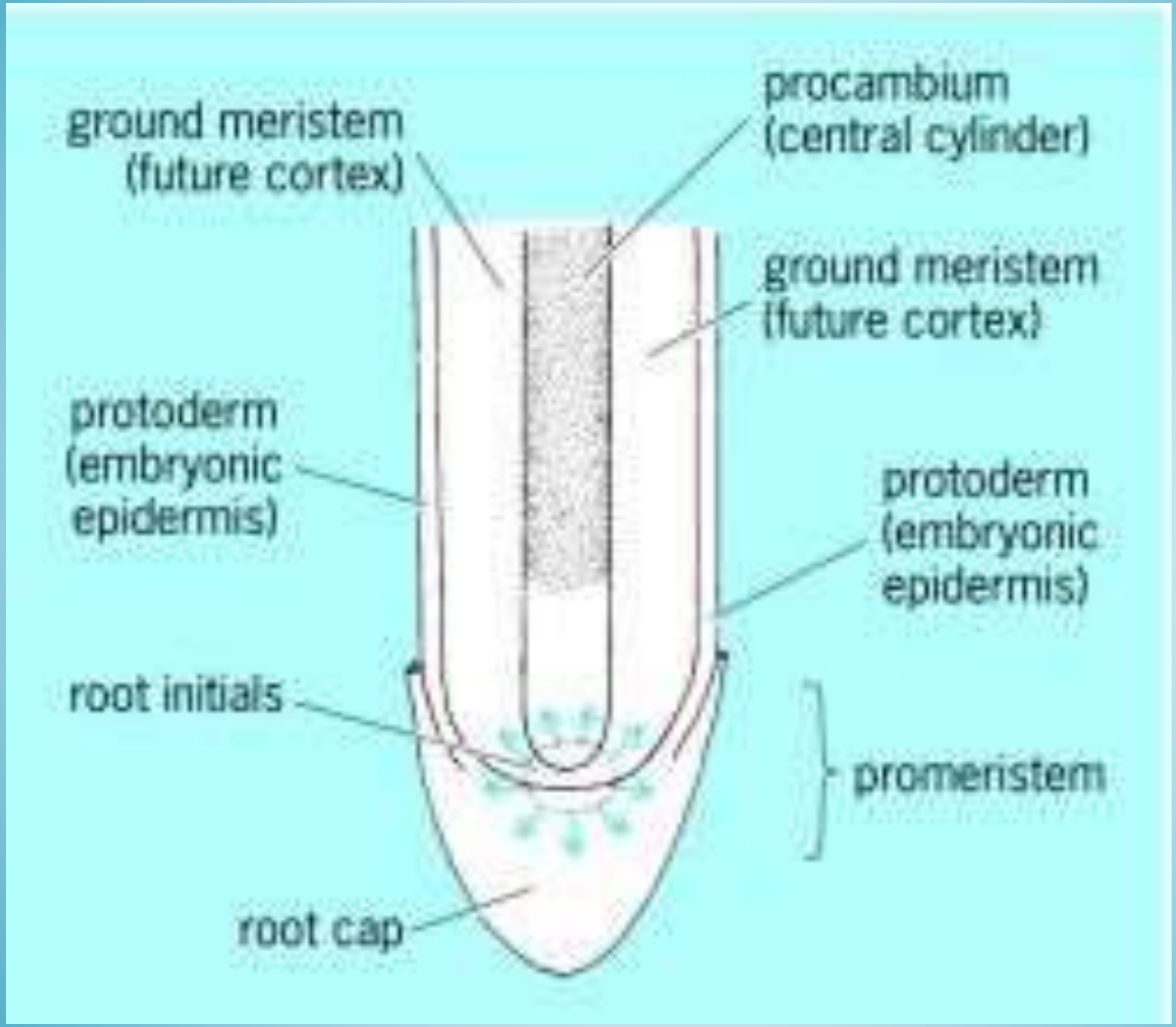


APICAL MERISTEM

- Located at the tips of root and shoots of plants
- **Primary growth**
- Increase plant length

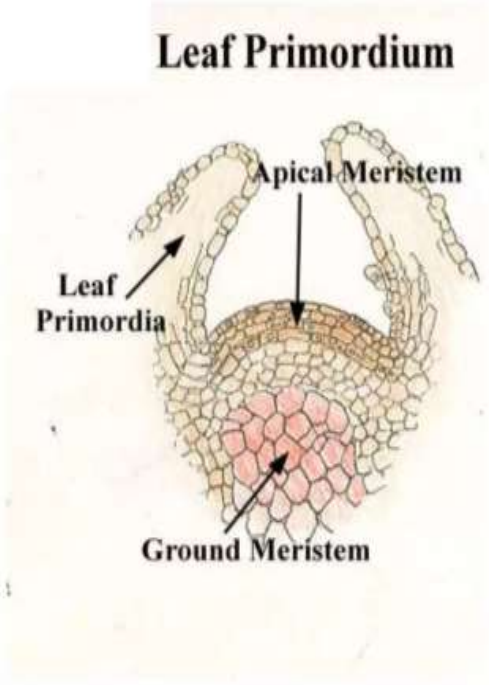


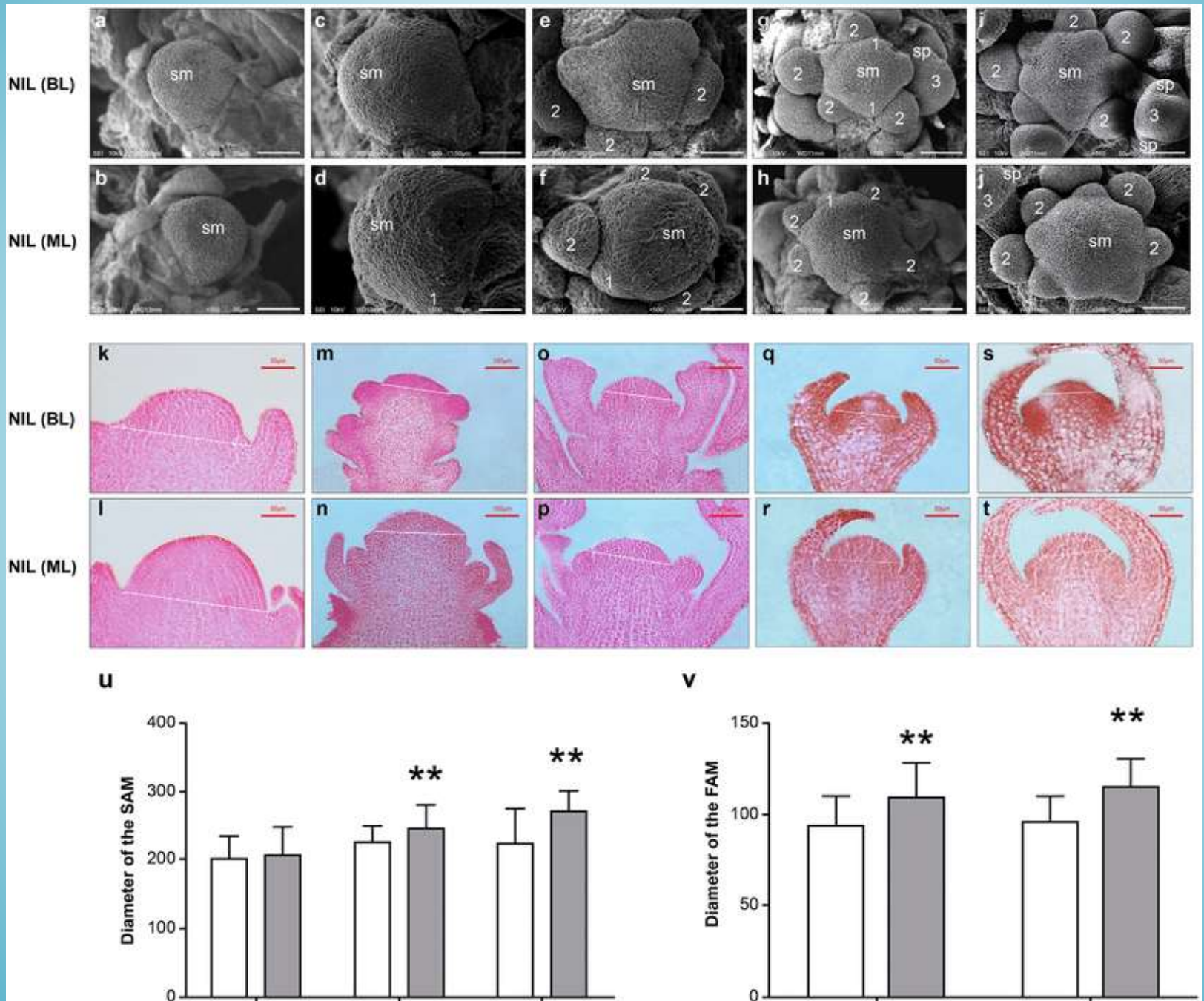

epidermis
root hairs
Region of Differentiation
cortex
vascular tissue
Region of Cell Elongation
procambium
ground meristem
protoderm
Region of Cell Division
quiescent centre
apical meristem
root cap


ground meristem
(future cortex)
procambium
(central cylinder)
ground meristem
(future cortex)
protoderm
(embryonic
epidermis)
protoderm
(embryonic
epidermis)
root initials
promeristem
root cap

PROMERISTEM

- Early embryonic meristem from which other advanced meristems are derived
- Their function is to produce the cells of the **primary meristems**
- In Plants, it occupies a small area at the tip of stem and root
- It is composed of **Initials**
- Continuous division is the characteristic of initials
- It divide further to form primary meristem




NIL (BL)
NIL (ML)
a
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NIL (BL)
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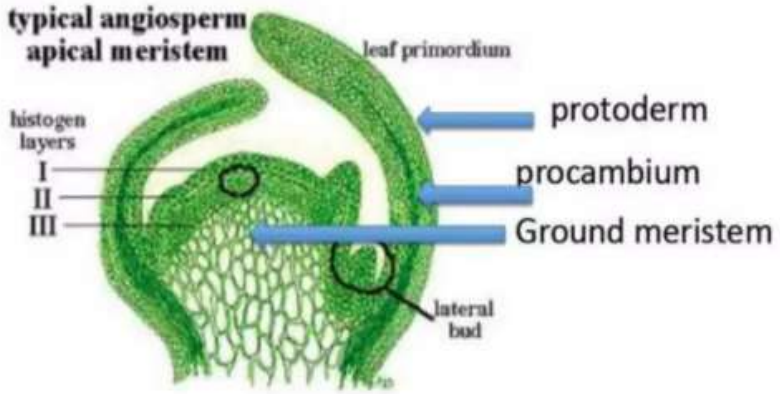
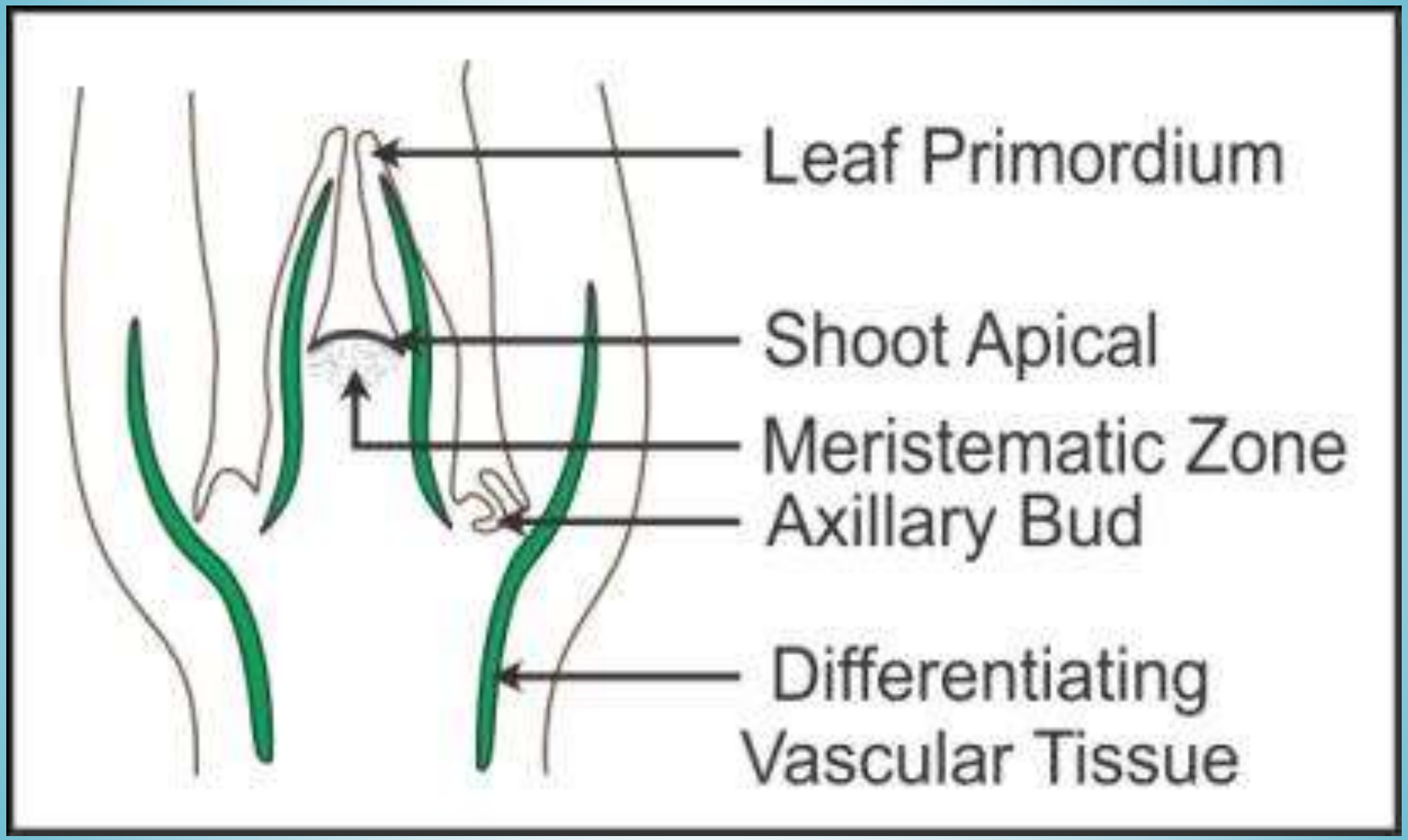
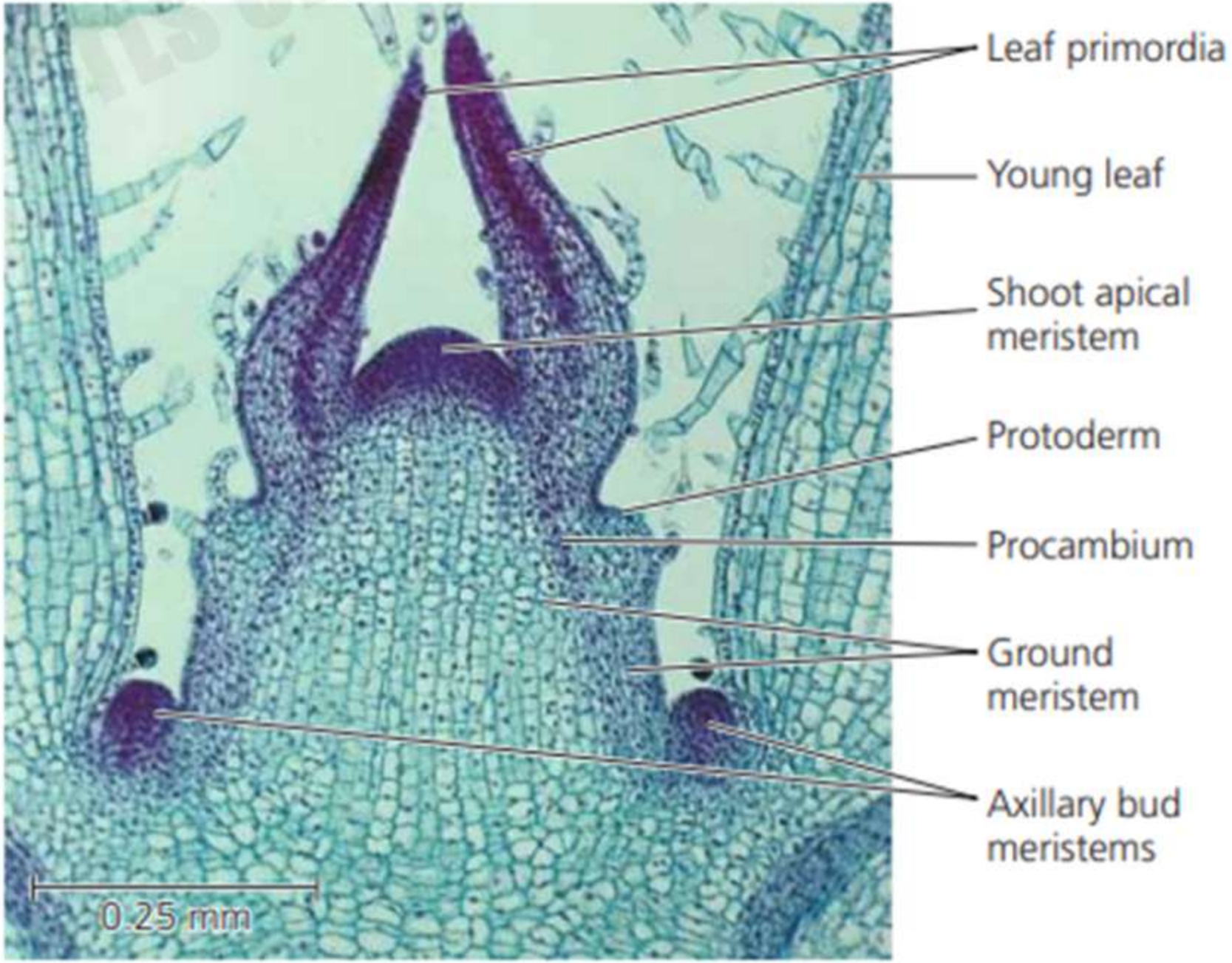
Diameter of the SAM
400
300
200
100
0
**
**
v
Diameter of the FAM
150
100
50
0
**
**

PRIMARY MERISTEMS

- Derived from promeristem
- Give rise to the primary tissue systems
- They are present below the promeristem at shoot and root apex
- These cells divide and form **permanent tissues**




Leaf Primordium
Shoot Apical
Meristematic Zone
Axillary Bud
Differentiating
Vascular Tissue


Leaf primordia
Young leaf
Shoot apical meristem
Protoderm
Procambium
Ground meristem
Axillary bud meristems
0.25 mm

II. Classified based on their position in the plant body

1. Apical meristem
2. Intercalary meristem
3. Lateral meristem

CHARACTERISTICS

- They are living and have thin walled
- Vacuoles are few and small in size
- Cells contain dense protoplasm and conspicuous nuclei
- Cells are spherical, oval or polygonal in shape
- Do not store reserve food materials and are in an active state of metabolism

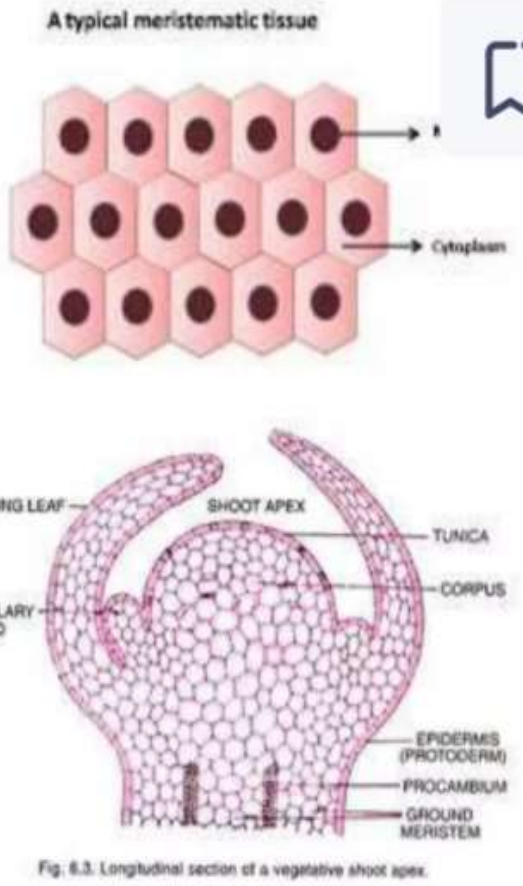
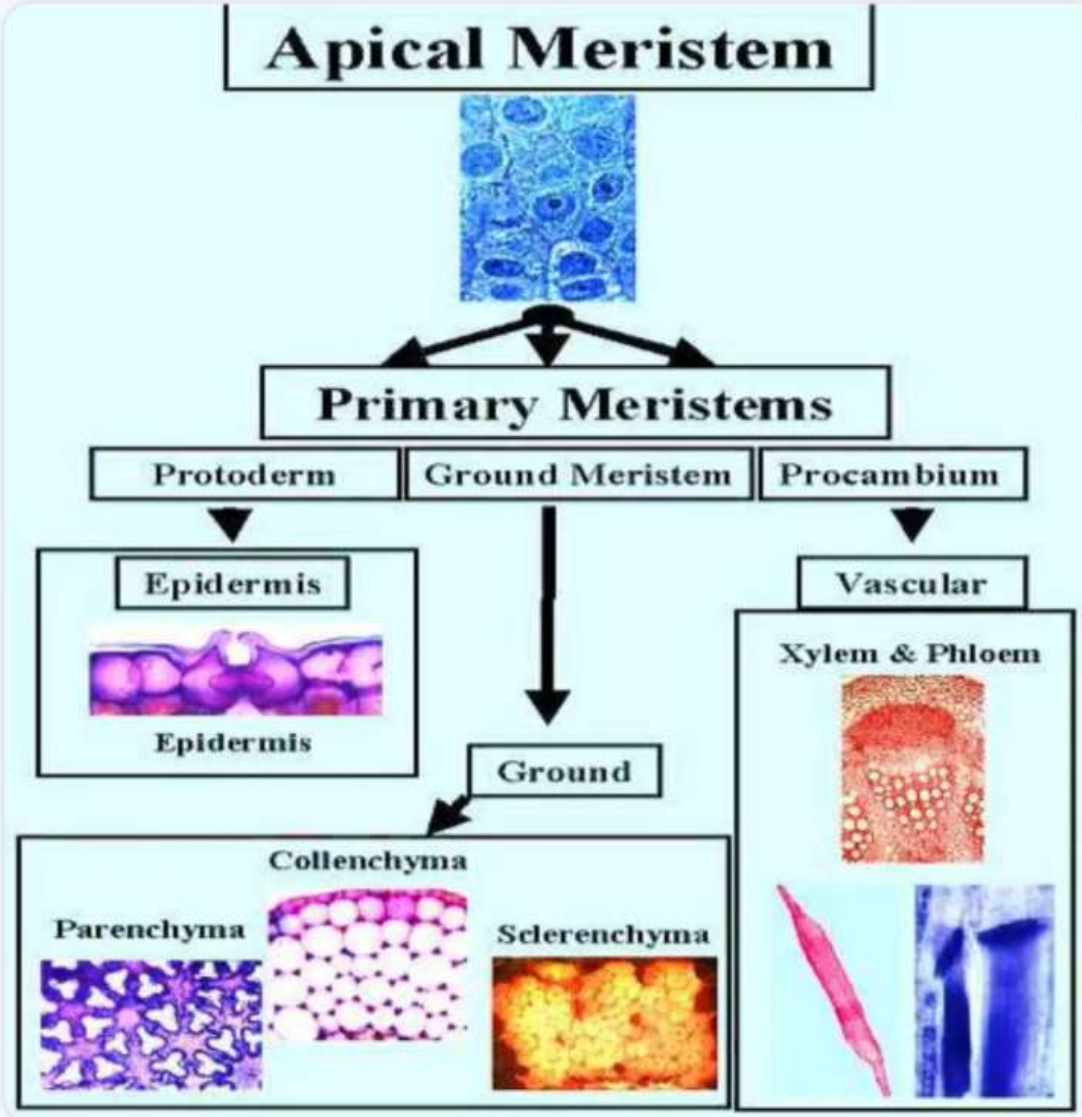


Fig. 6.3. Longitudinal section of a vegetative shoot apex.



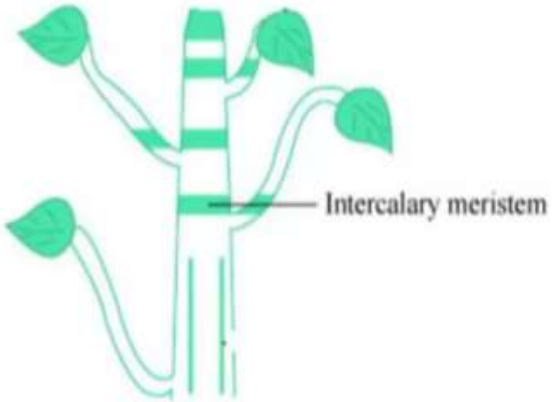
Apical meristem produce primary meristems:

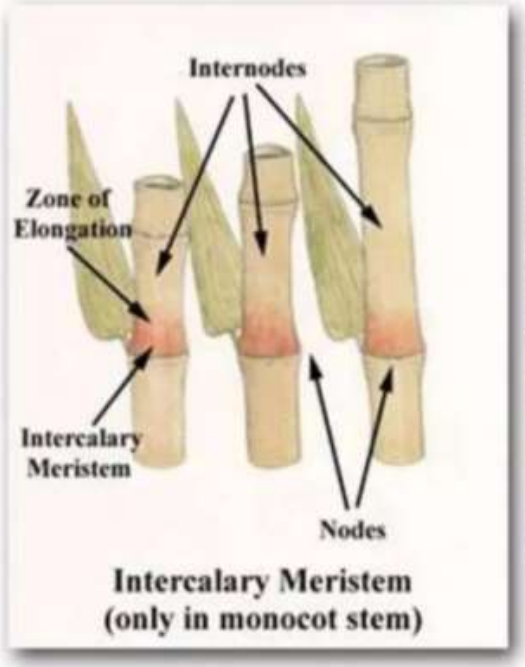
- Protoderm
- Ground meristem
- Procambium

The tissues they produce are called primary tissues

INTERCALARY MERISTEM

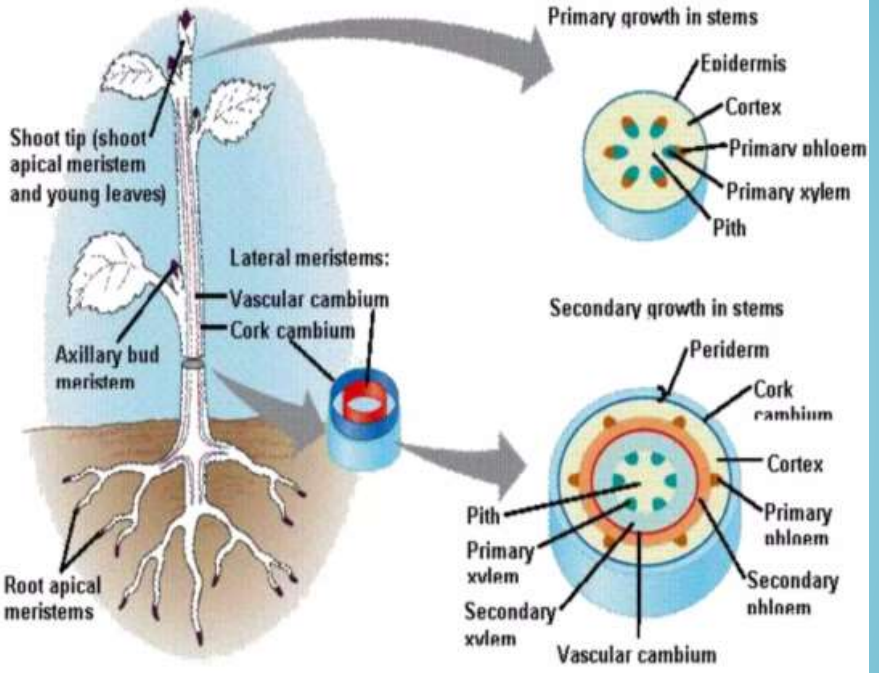
- Present at the **base of leaves, nodes** and **internodes**
- Help in longitudinal growth of plants





LATERAL MERISTEMS

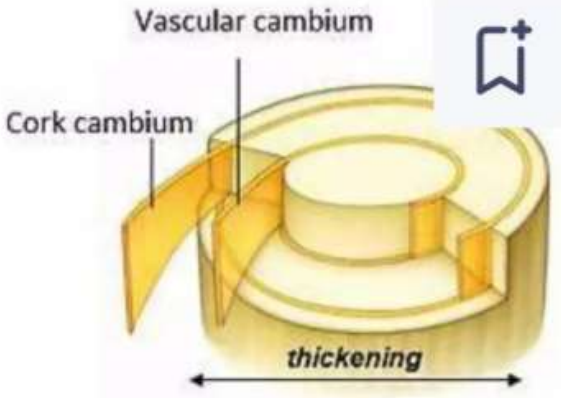
- This tissue lies on the side of the plant's body.
- Gives the plant it's width or girth (**Secondary growth**)
- The *vascular cambium* and *cork cambium,* are **lateral meristems**
- produces *secondary tissues* that function primarily in support and conduction.



SECONDARY MERISTEM

- Derived from primary meristem permanent tissues that have the capacity of division

- Form meristematic tissues (cambium)
  - **vascular cambium**, responsible for the secondary thickening of plant organs
  - **Cork cambium**, which produce the periderm, secondary dermal tissues



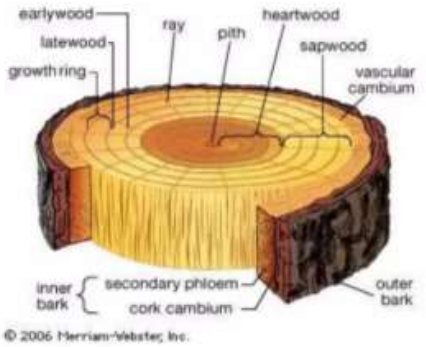


TABLE 31-2 *Types of Meristems*

Type	Location	Function
Apical meristem	tips of stems and roots	growth; increase length at tips
Intercalary meristem	between the tip and base of stems and leaves	growth; increase length between nodes
Lateral meristem	sides of stems and roots	growth; increase diameter

TISSUES PRODUCED BY MERISTEM

- After cells are produced by meristems, the cells assume various shapes and sizes related to their functions as they develop and mature.

- Some tissues consist of only one kind of cell, therefore they are called **Simple tissues** whereas others may have two to several kinds of cells known as **Complex tissues**

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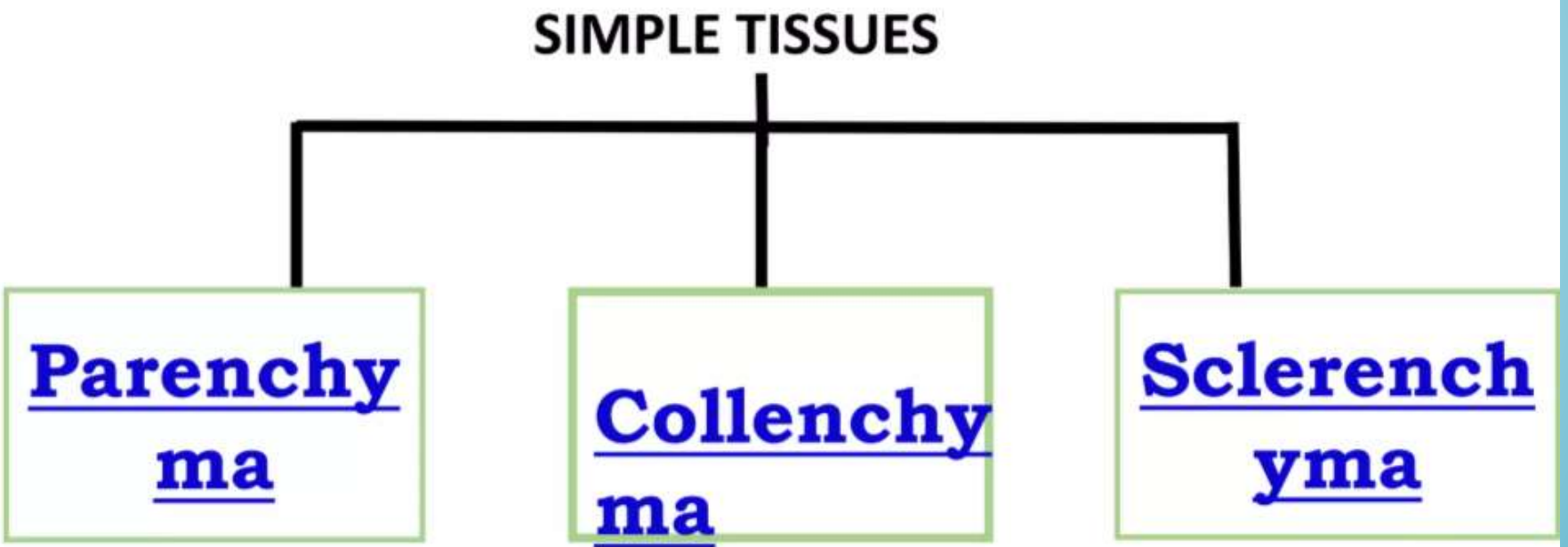
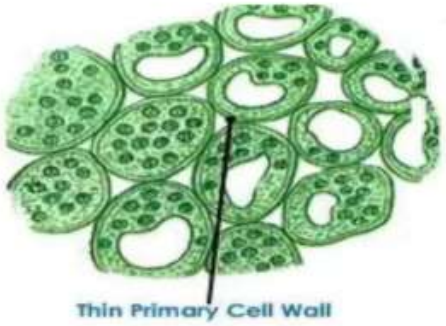
SIMPLE TISSUES

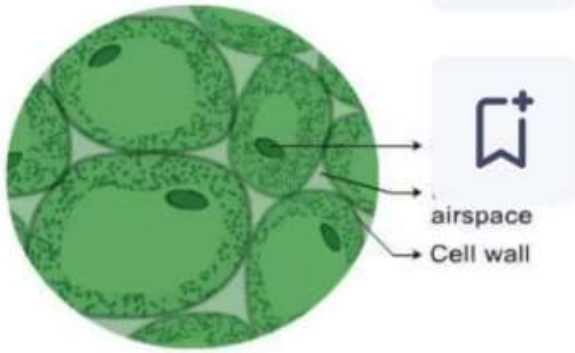
- Made up of only one type of cell

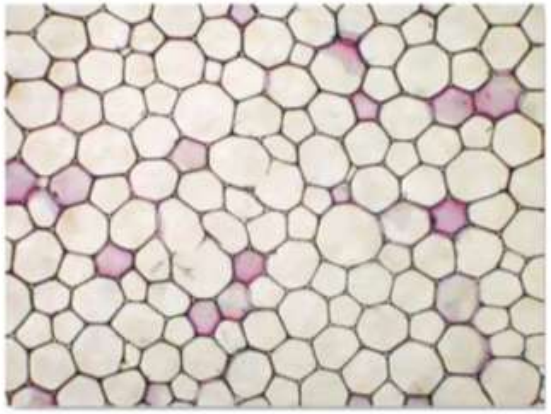


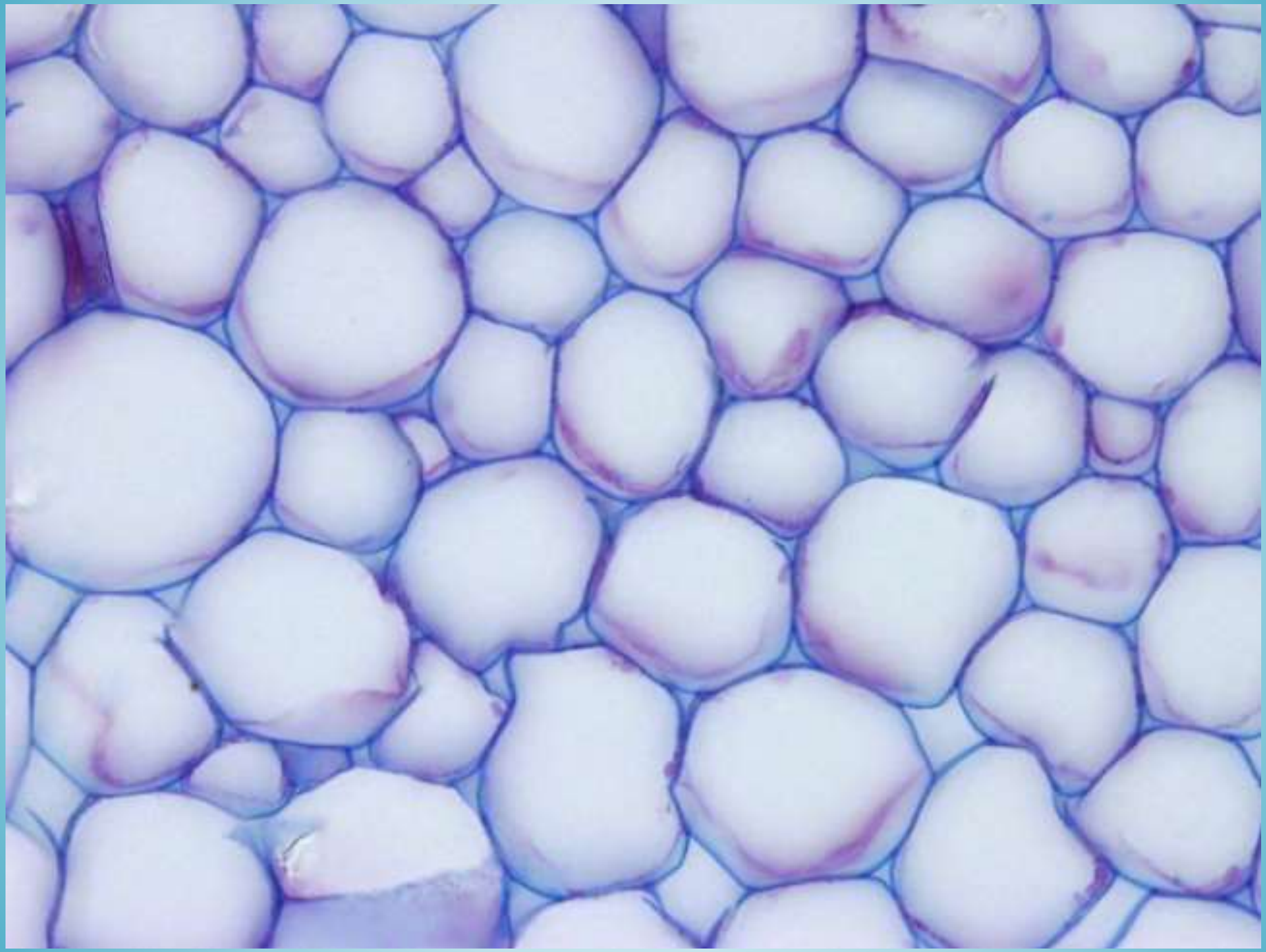
Parenchyma cells

- They are the most abundant of the cell types in plants
- They are less spherical, cubical, or elongated in shape
- Have very large vacuoles and are frequently found in all **roots**, **stems**, **leaves** and **fruits**
- Have thin primary cell wall
- Serve as space-fillers and structural components



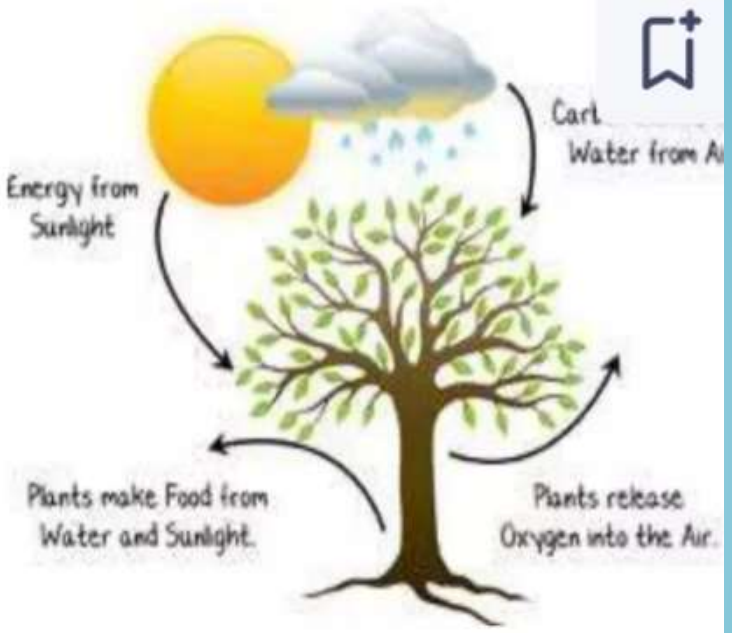






Parenchyma cells

- Aid in photosynthesis
- Store foods and water in leaves, stems, seeds and fruits
- Controls plant's metabolism like photosynthesis, respiration, protein synthesis
- **They also paly a vital role in wound healing and regeneration of plants**



2 types:

- 1. Chlorenchyma - provides support to plants and also **stores food**. In some situations, it contains chlorophyll and performs photosynthesis.

- 2. Aerenchyma - give **buoyancy** to the plants to help them float.

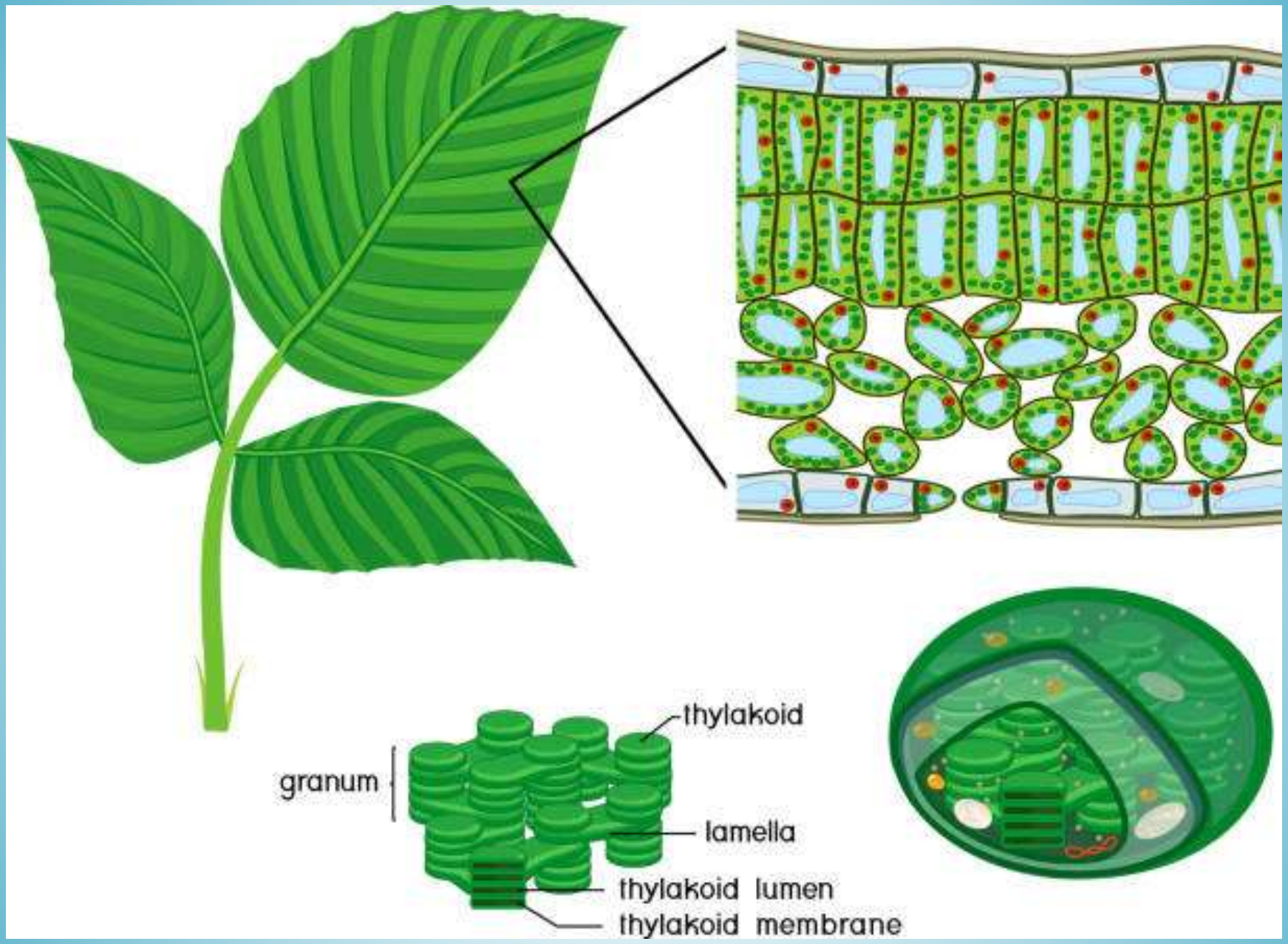
CLASSIFICATION OF PARENCHYMA TISSUE

Based on Function

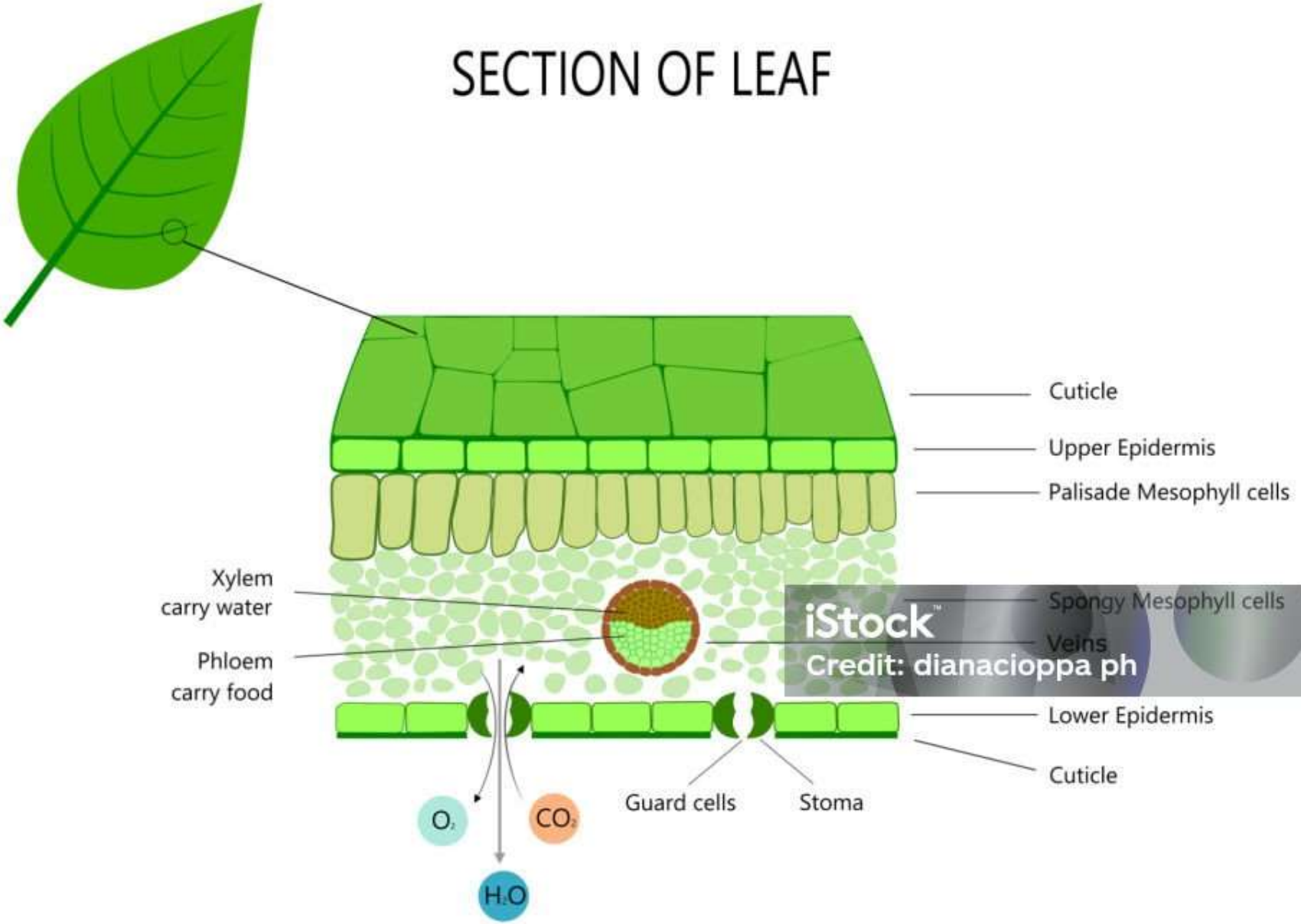
- CHLORENCHYMA
- AERENCHYMA
- PROSENCHYMA
- STORAGE PARENCHYMA

1.Chlorenchyma: It refers to the parenchymatous cell that possesses chloroplast. In leaves, it differentiates into mesophyll cell that has two distinct parenchymatous cells (palisade and spongy). It is present in the mesophyll zone of the leaves, sepals and phyllodes.

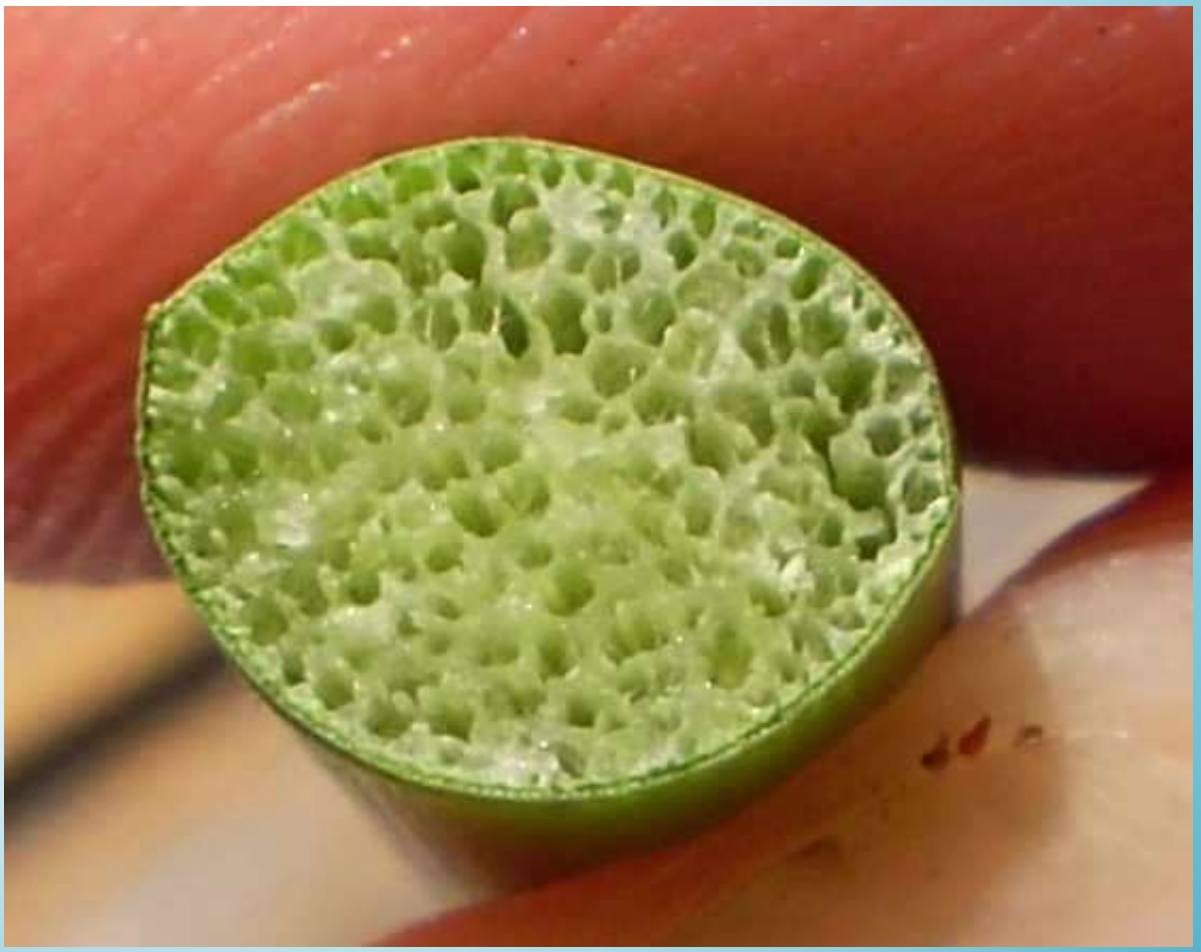
Function: Participates in photosynthesis.


thylakoid
granum
lamella
thylakoid lumen
thylakoid membrane

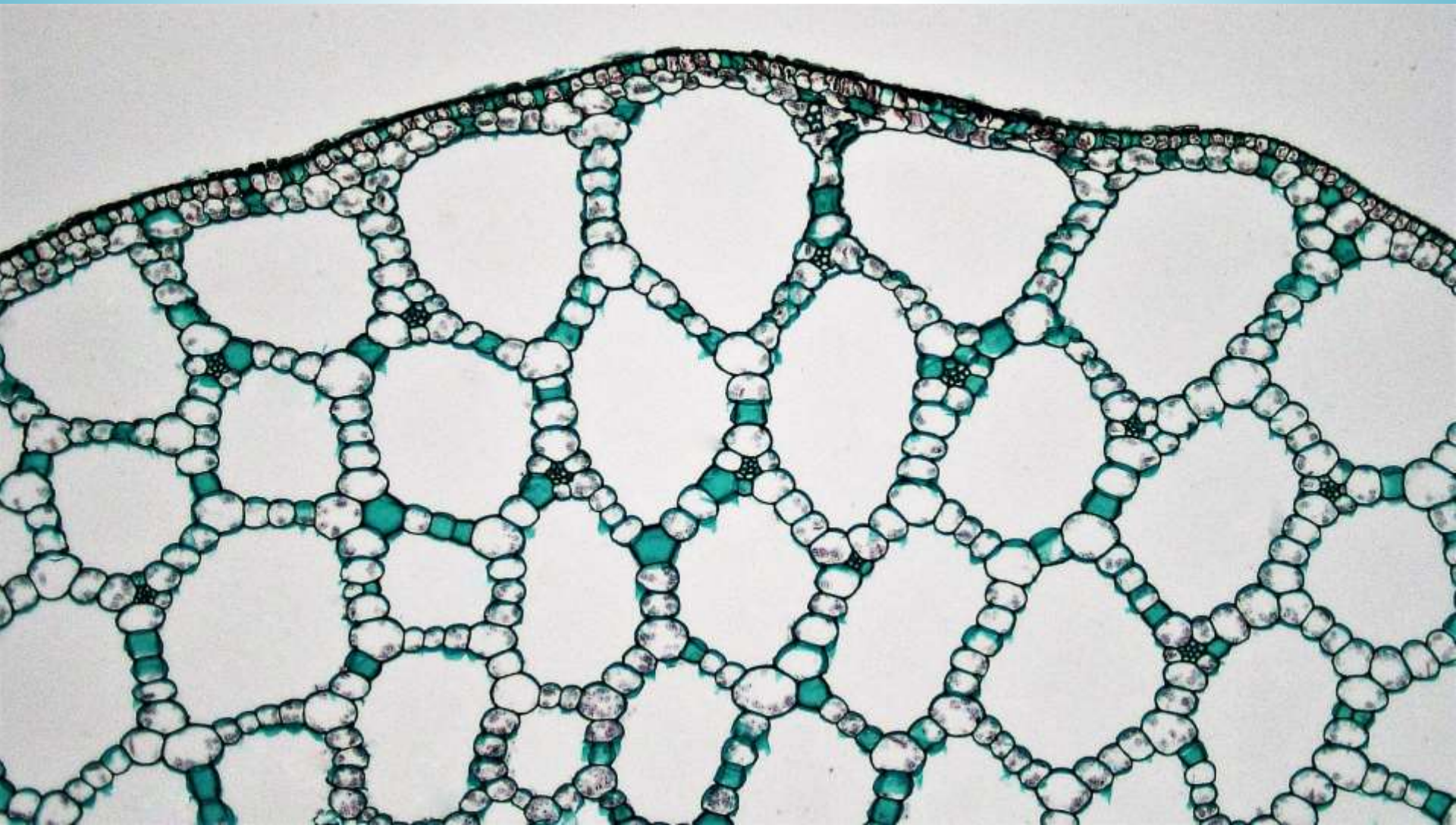
SECTION OF LEAF



2. Aerenchyma: It refers to the parenchymatous cell that comprises large air-filled intercellular spaces and is termed “Air storing parenchyma”. Aerenchyma cells are prevalently present in the roots, stems and leaves of hydrophytes. It comprises a few large-sized air cavities between the parenchymatous cells to perform various functions.



Function: Participates in gaseous exchange and maintains the buoyancy of hydrophytes.



3. Prosenchyma: It refers to the parenchymatous tissue that possesses elongated cells with a thickened wall. The prosenchyma appears spindle-shaped with tapering ends.
Function: Promotes rigidity to a plant.

4. Storage parenchyma: It refers to the parenchymatous tissue that contains large-sized vacuolated cells. It stores water, minerals, sugar, protein granules, oil droplets etc. The cell wall of storage parenchyma is generally thick because of hemicellulose deposition.
   Function: Helps in the storage of food.

AQUIFEROUS

parenchyma cells containing mostly water are observed in a section of the plant stem. They have thin primary cell walls and mucilage in the cytoplasm, stained with safranin. Intercellular spaces are also observed.

xerophyte

is a species of plant that has adaptations to survive in an environment with little liquid water like Cacatus : fig tree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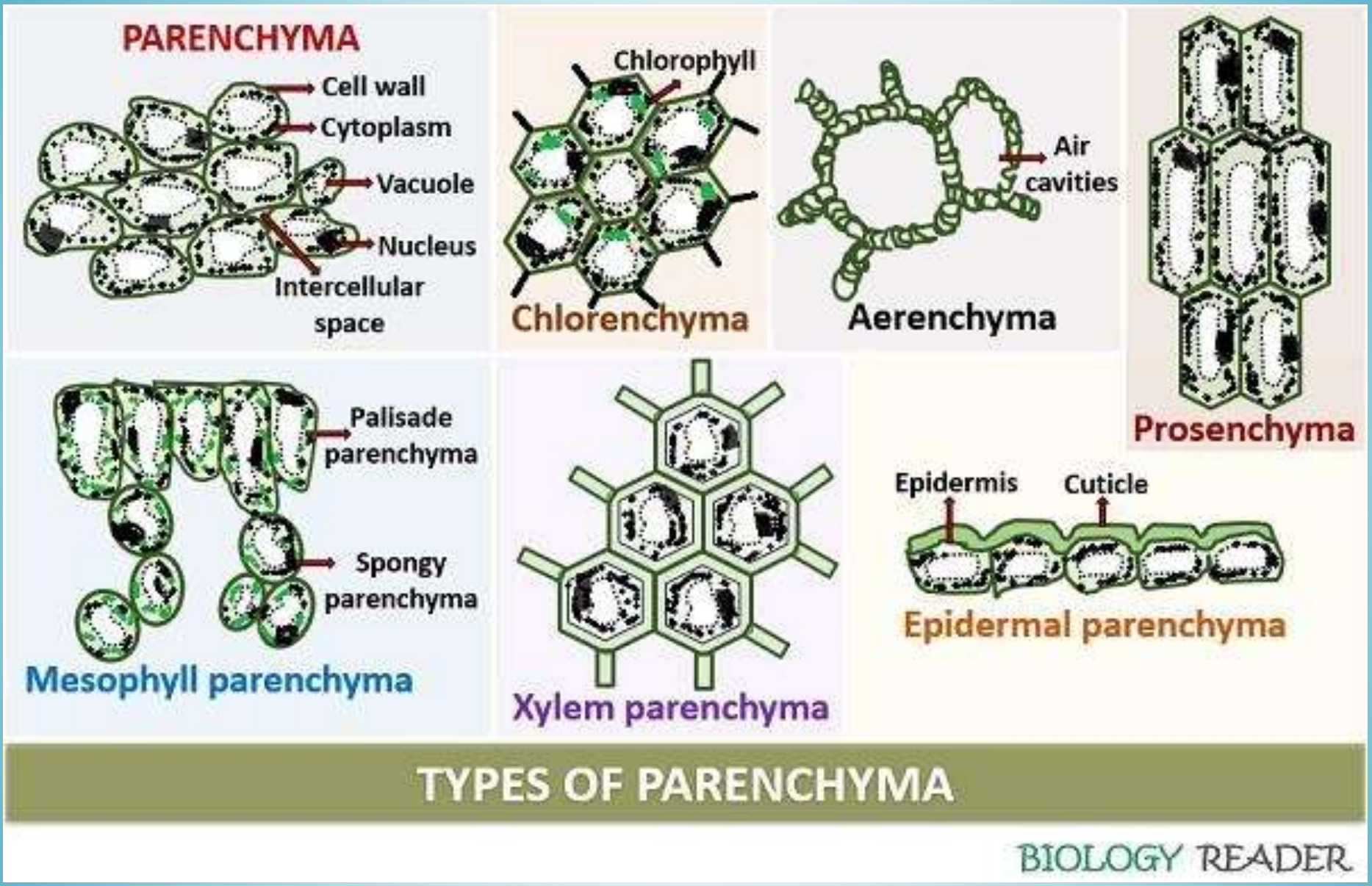
5. Xylem parenchyma: This kind of parenchymatous cells possess a small size and a thick cell wall.
Function: Facilitates water and mineral conduction.

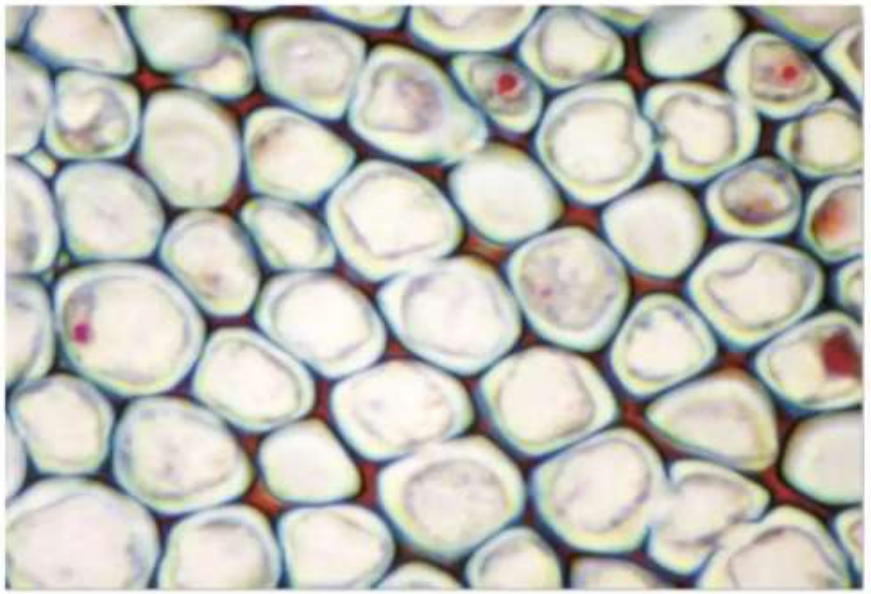
6.Phloem parenchyma: This kind of parenchymatous cells have elongated cells and a thin cell wall.
Function: Facilitates conduction of food prepared by the leaves.

7. Epidermis parenchyma: This kind of parenchymatous cells are elongated with zero intercellular space. Epidermis parenchyma possesses a cutinized cell wall or cuticle enclosing a single-layered epidermis.
Function: Protects the plant in counter to environmental stress.


PARENCHYMA
Cell wall
Cytoplasm
Vacuole
Nucleus
Intercellular space
Chlorophyll
Chlorenchyma
Air cavities
Aerenchyma
Prosenchyma
Palisade parenchyma
Spongy parenchyma
Mesophyll parenchyma
Xylem parenchyma
Epidermis
Cuticle
Epidermal parenchyma
TYPES OF PARENCHYMA
BIOLOGY READER

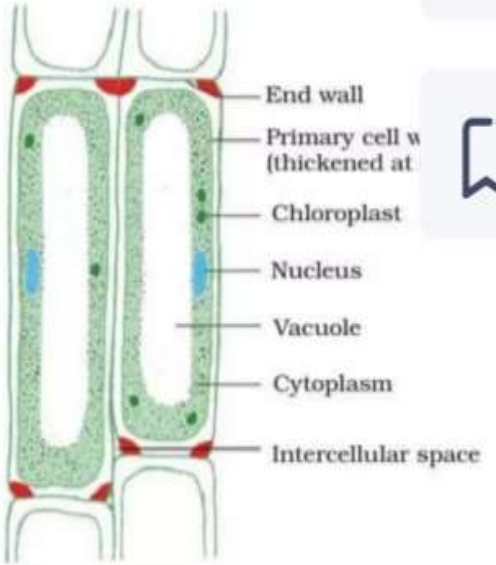
Collenchyma cells

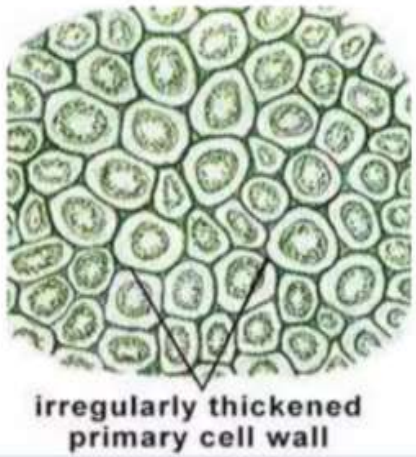
- The main function of collenchyma cells is to provide ***flexibility***

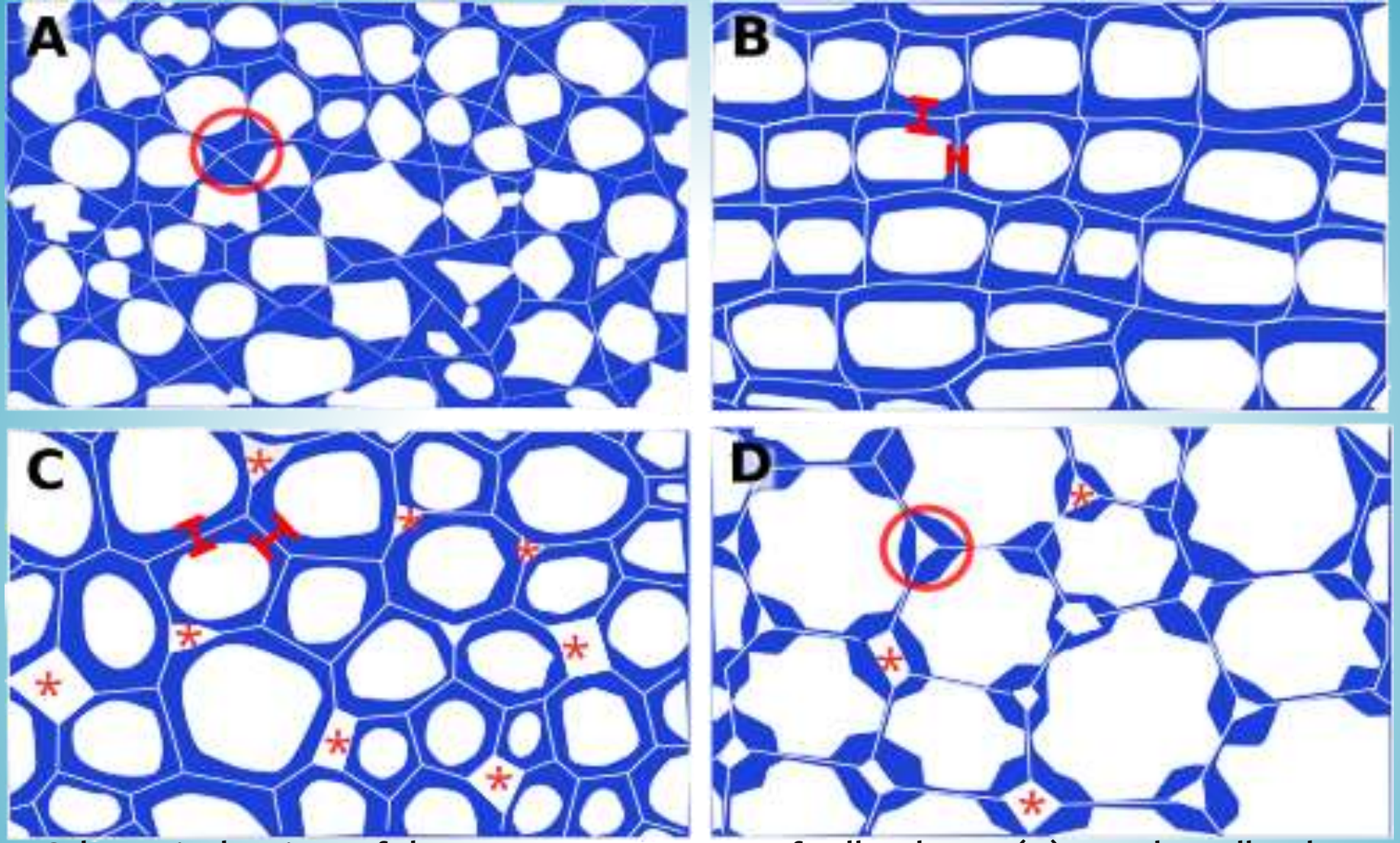


Collenchyma cells

- From Greek *Kolla* – ***" Glue"***
- They are alive during the cell maturity
- They are elongated
- They have a thicker and more uneven wall than parenchyma cells
- Found in **leaf blades** and **below the stalks** below epidermis
- In other to provide support both parenchyma and collenchyma cells must be ***turgid***

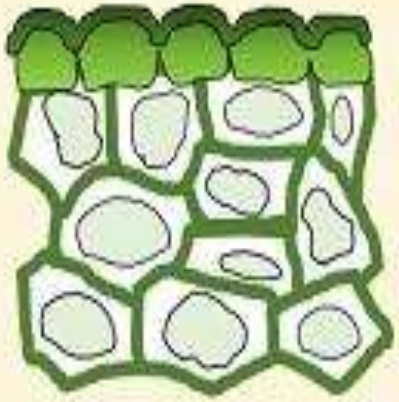






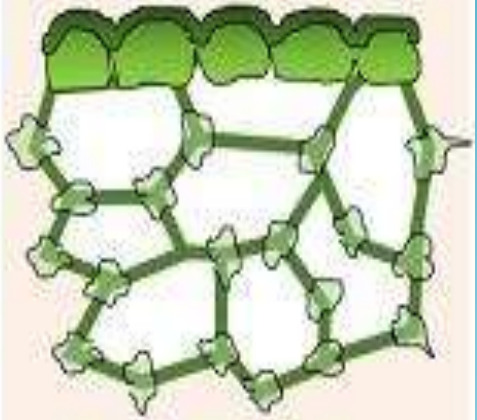
Schematic drawings of the most common types of collenchyma. (A) Angular collenchyma. (B) B. Lamellar collenchyma orTangential collenchyma. (C) Annular collenchyma. (D) Lacunar collenchyma. This type often occurs as an intermediate type with angular and lamellar collenchyma, in which the size of the intercellular spaces can vary from minute spaces (1) to large cavities surrounded by collenchymatous walls (2).

Angular collenchyma



Annular collenchyma

Lamellar collenchyma

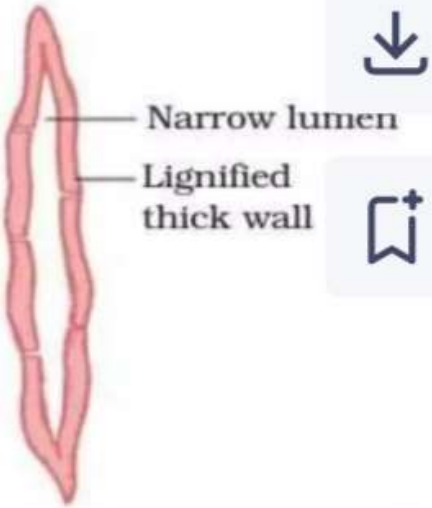


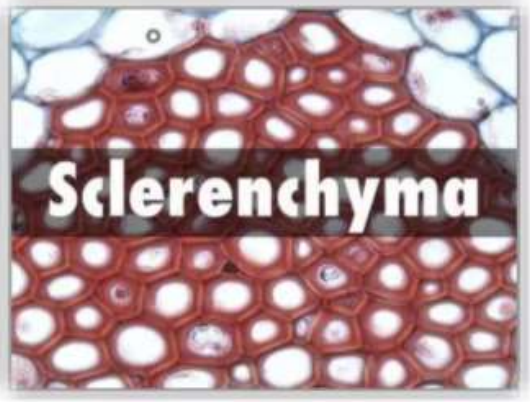
Lacunar collenchyma

TYPES OF COLLENCHYMA TISSUE BASED ON CELL THICKENING AND ARRANGEMENT

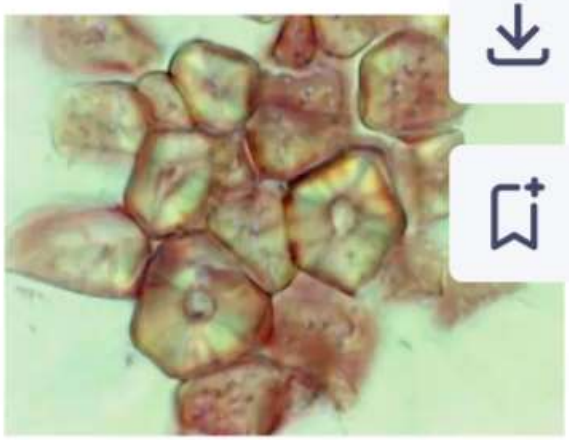
Sclerenchyma cells

- From a Greek word – *skleros meaning* ***"hard"***
- Sclerenchyma tissues have cells with thick, tough, secondary wall normally impregnated with **lignin**
- **Lignin makes them flexible as well as strong**
- Most are dead at maturity
- They vary in shape and but are often cubical
- Provide rigid structure and protection



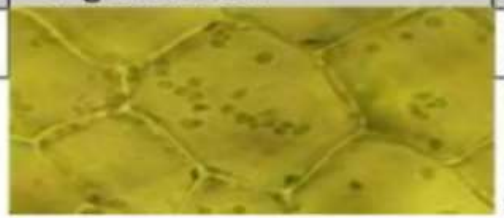
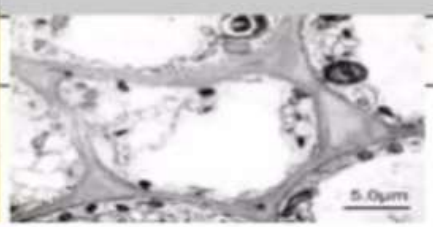
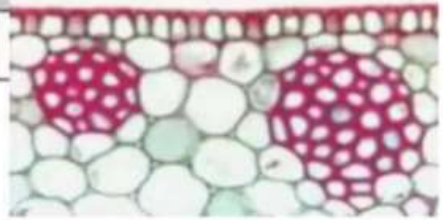


- **They provide structural strength in regions that have stopped growing in length and no longer need to be flexible**



- **2** main kinds:
- **fibers and sclereids**
  - ✓Fibers are elongated with secondary walls and impregnated with lignin
  - ✓**They are usually in group and this enable stems to move in wind without snapping.**
- Sclereids vary in shape but are often cubical or spherical
  - ✓They make structures rock-hard and inflexible

Ground Tissue

	PARENCHYMA	COLLENCHYMA	SCLERENCHYMA
Characteristics	• spherical • thin-walled • living, metabolizing tissue	• elongated cells with unevenly thickened cell walls • alive at maturity	• with primary and secondary cell walls • dead at functional maturity
Location	• throughout the plant	• beneath the epidermis in young stems and in leaf veins	• fibers in wood, bark, leaves, stems • sclereids in fruits and seeds
Functions	• photosynthesis and respiration • storage • regeneration	• flexible support system	• structural support
Appearance			

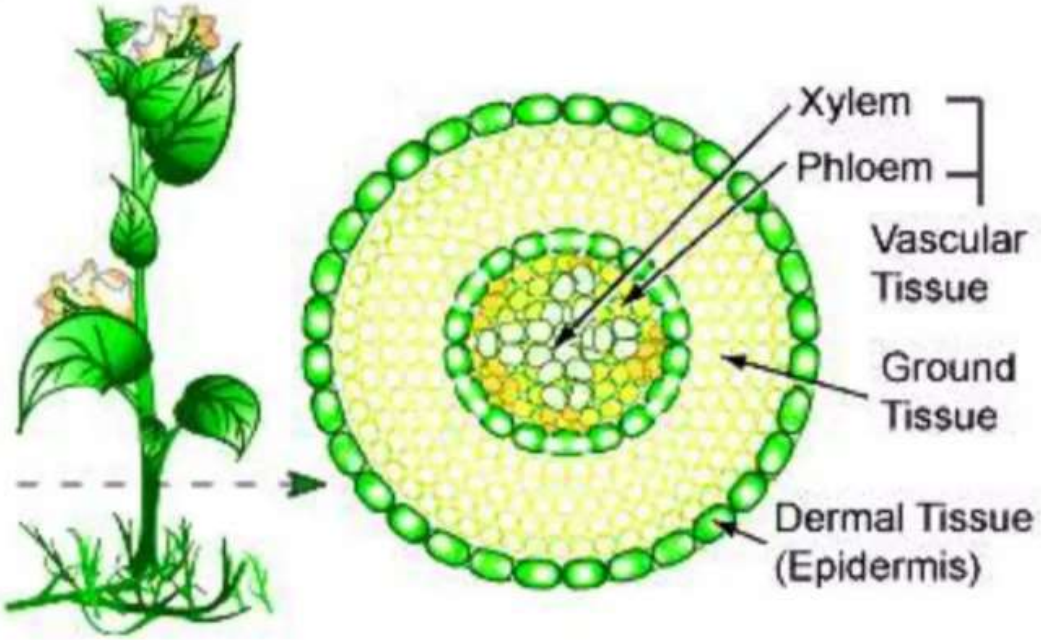
COMPLEX TISSUE

- A tissue that is made of several cell types, such as a mixture of parenchyma, sclerenchyma, and water conducting cells.

- These simple tissues can modify into more specialized cells for transport , support, and protection.

- Complex tissues are organized into three functional unit known as **Tissue System**, and they are continuous throughout the plant

- The three tissue systems in vascular plants are the **Dermal tissue system**, the **Vascular tissue system** and the **Ground tissue system**, all of which originates from meristematic cells



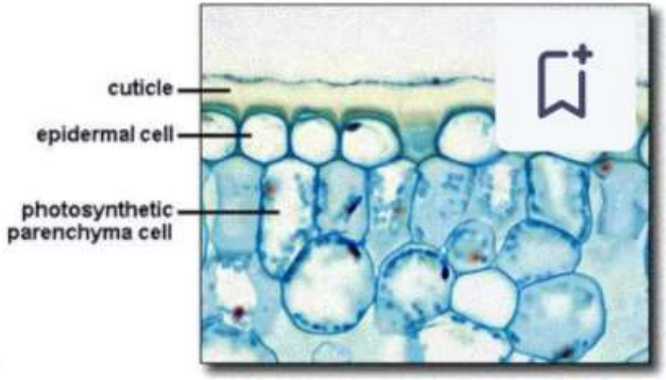
A. The Dermal Tissue System

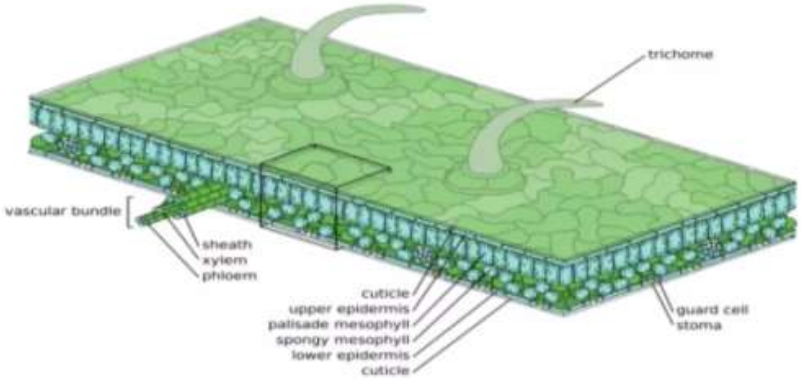
- Dermal from Greek *derma* – **"Skin"**
- The dermal tissue system is the outer protective covering of the plant.
- The dermal tissue begin as parenchyma cells, which are then modified to form various types of cells that protect the plant from physical damage and desiccation
- In a typical plant the dermal tissue is made of one layer with their cells closely packed together to produce a secure boundary known as **Epidermis.**

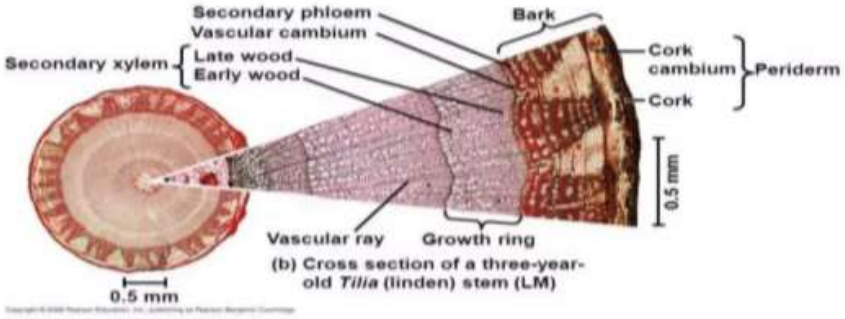
The Dermal System

- In plants that have more then one growing season, the epidermis of the stem and root is replaced by a protective tissue known as **Periderm**.

- The periderm consists mainly of nonliving cork cells that protect the plants from predators and water loss.

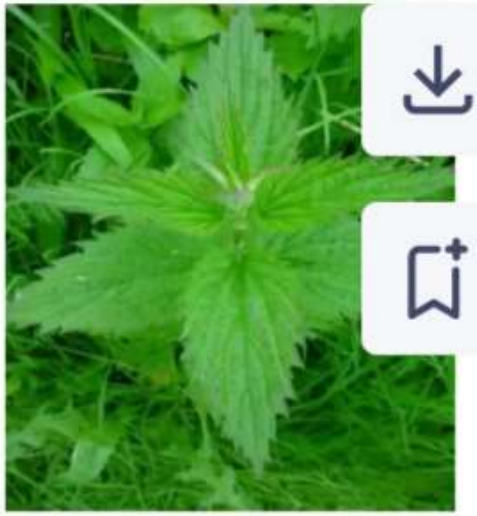






Features of The Epidermis

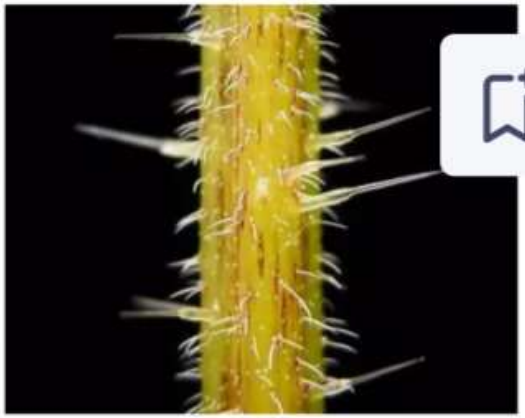
- The dermal tissue can become more modified through the production of hair like extensions called **Trichomes.**

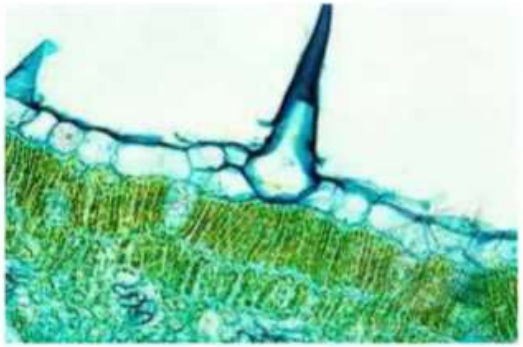


- Plants may use trichomes in order to inhibit herbivore attack via physical and/or chemical means.
- e.g. in specialized, **stinging hairs** of **Urtica** (Nettle) species they deliver inflammatory chemicals such as **histamine**

Trichromes

Capsicum pubescens

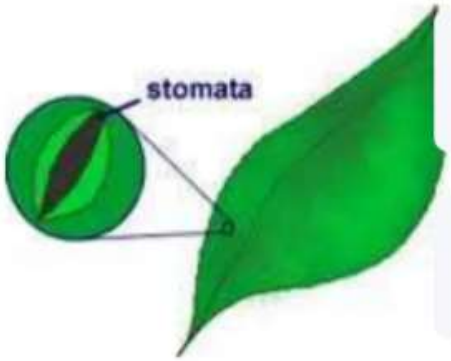


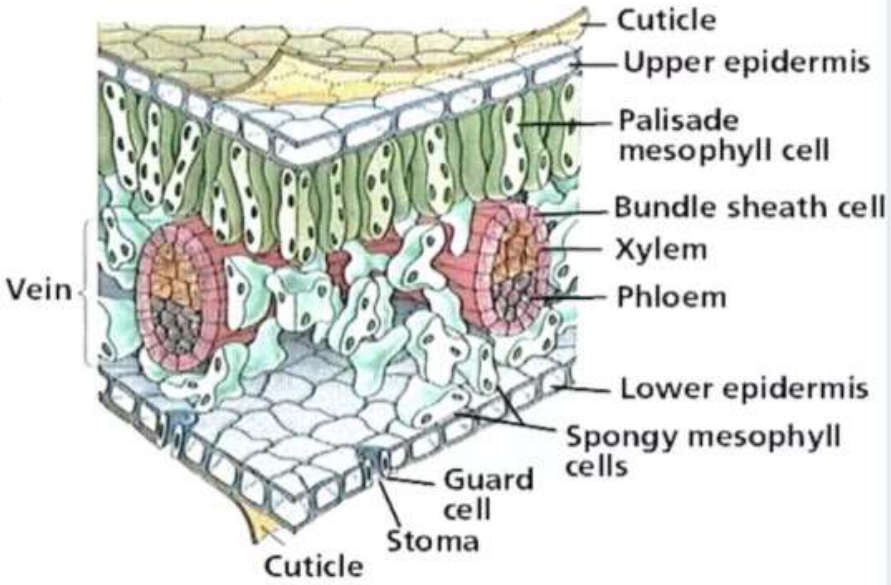


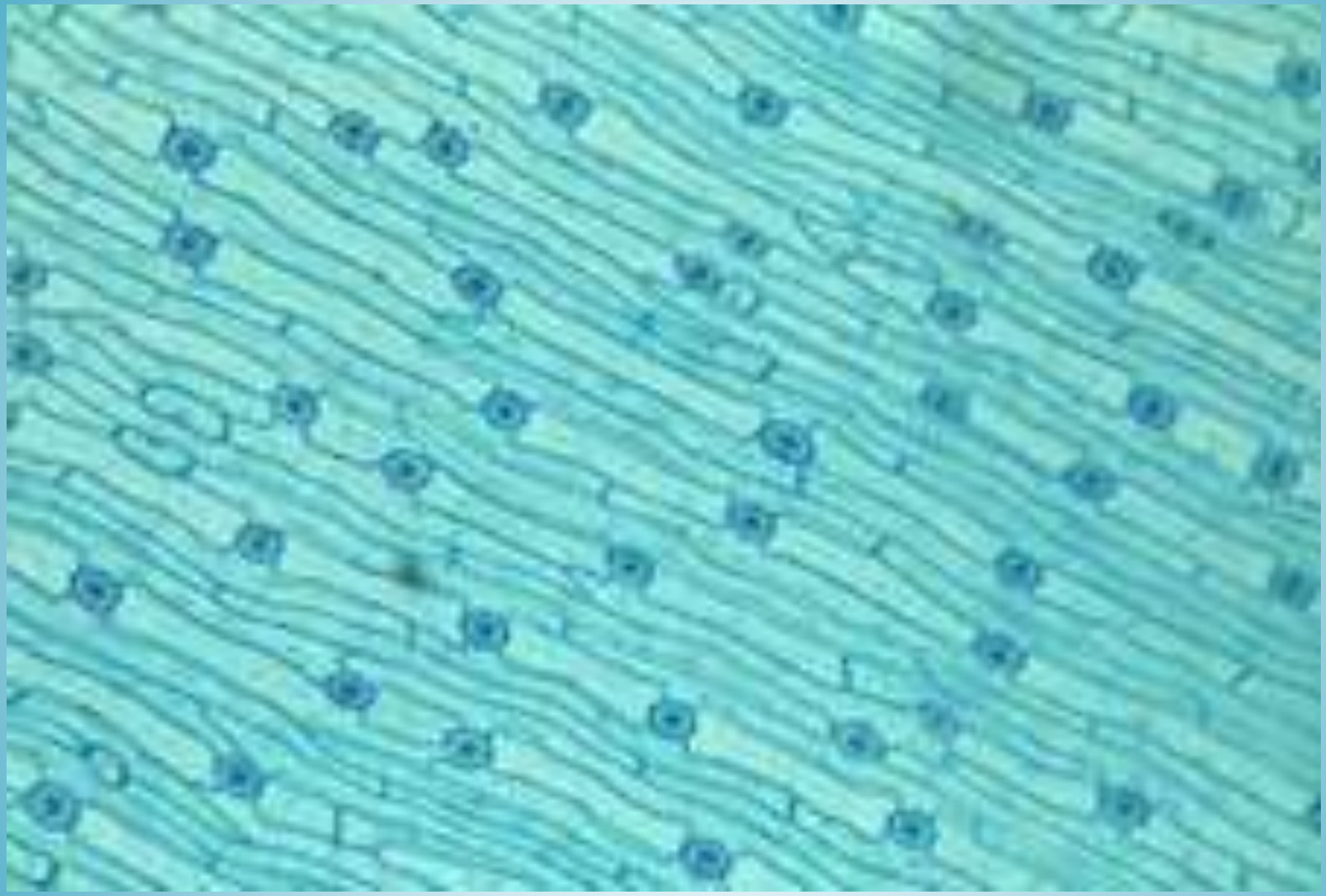
- On top of the epidermis is a thin layer of **waxy cuticle** made of fatty substance called **cutin**

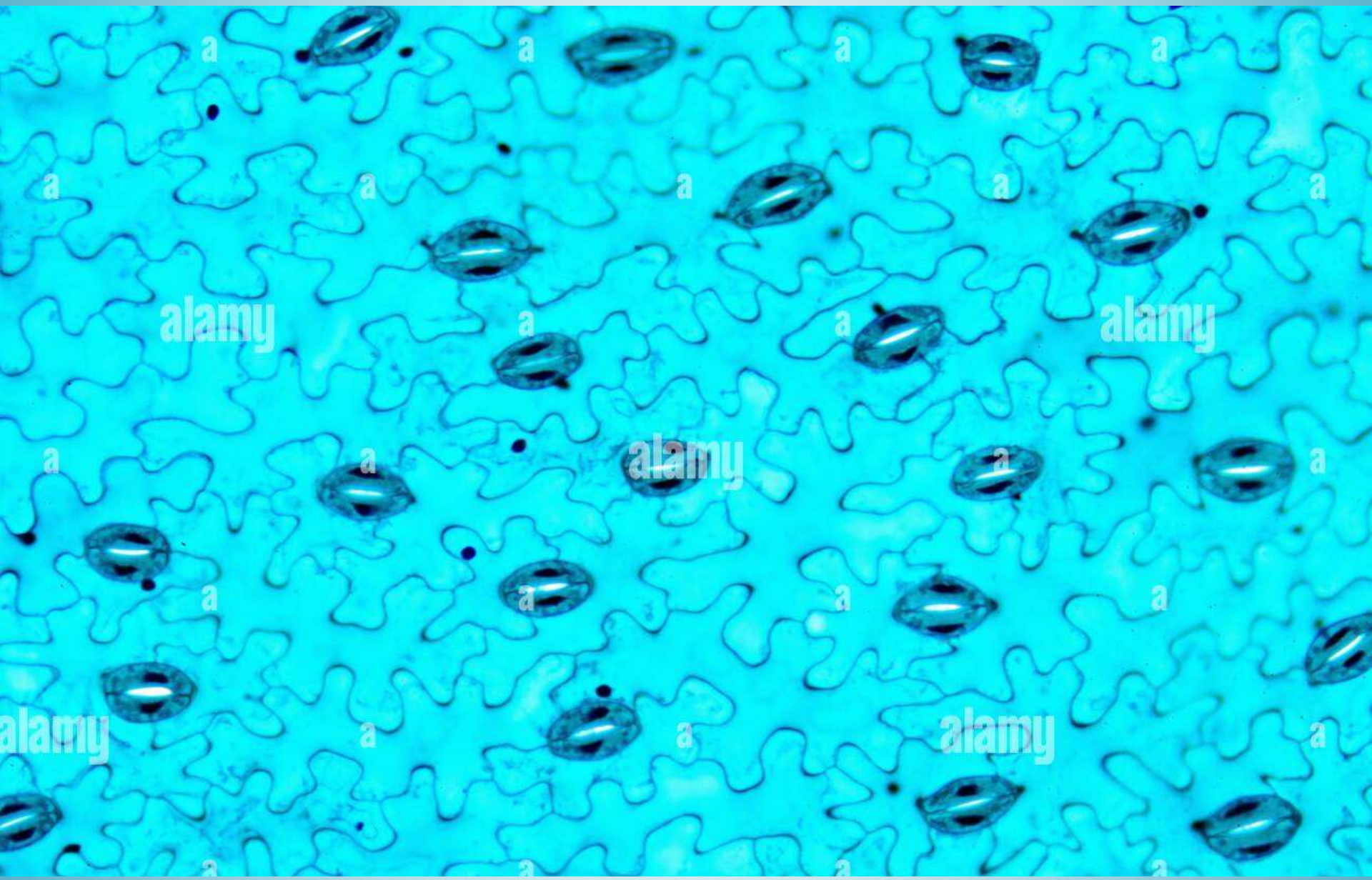
- The function of this layer is to prevent **water loss**
- The epidermis also has two highly specialized cells that contains chloroplast known as **Guard cells**
- The guard cell formed tiny hole on the leaves known as **stoma** (stomata).

- The stoma allow gases to diffuse in and out of the leaves (gaseous exchange).

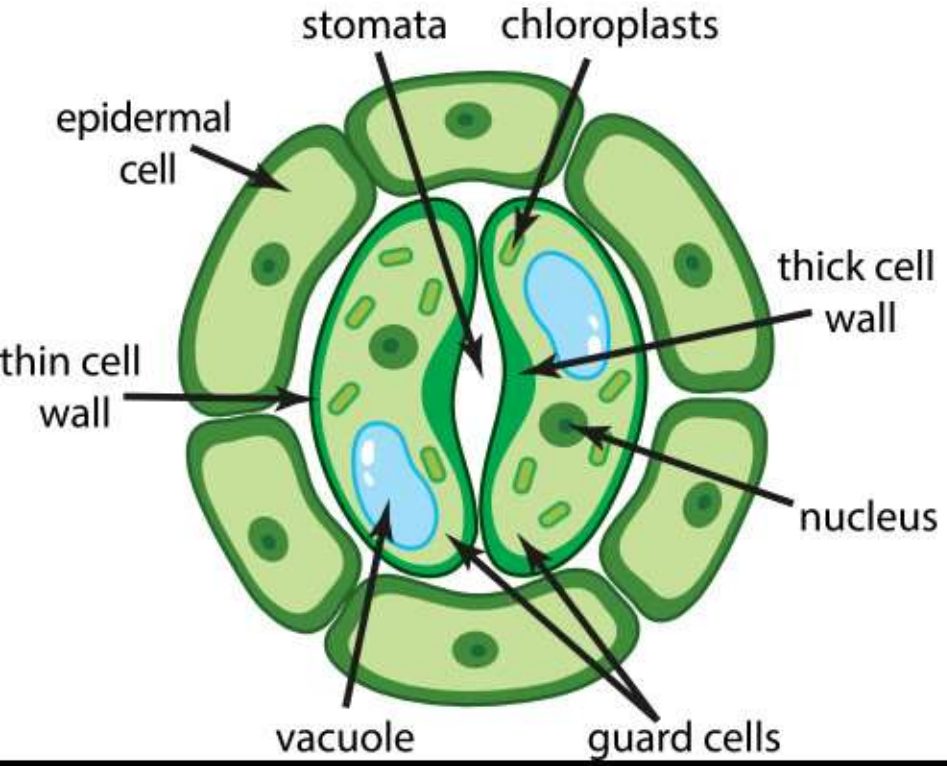




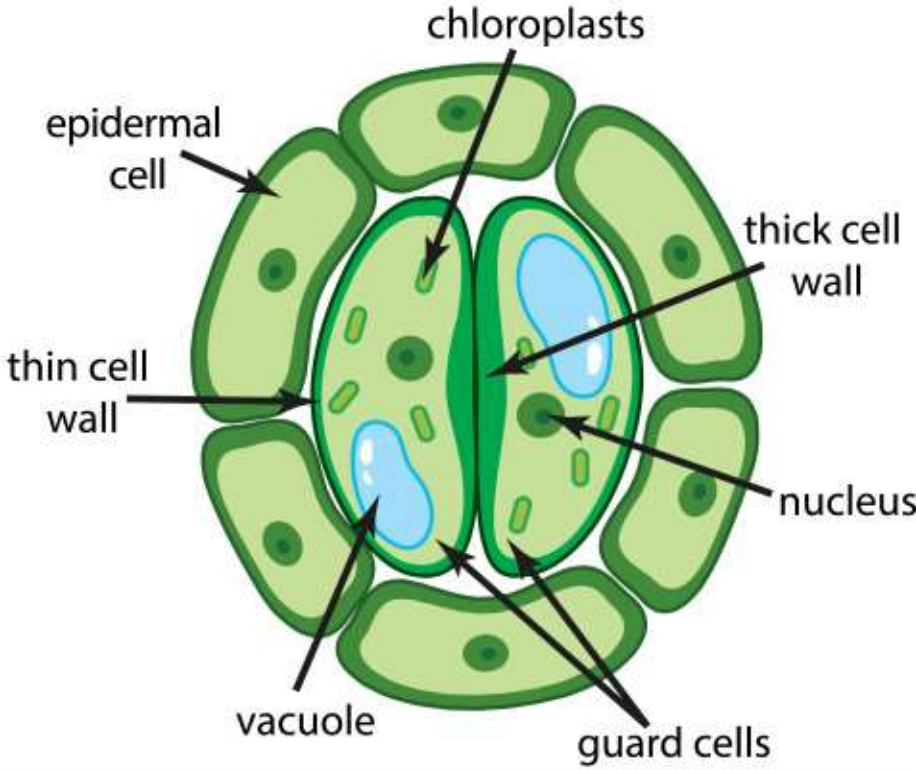


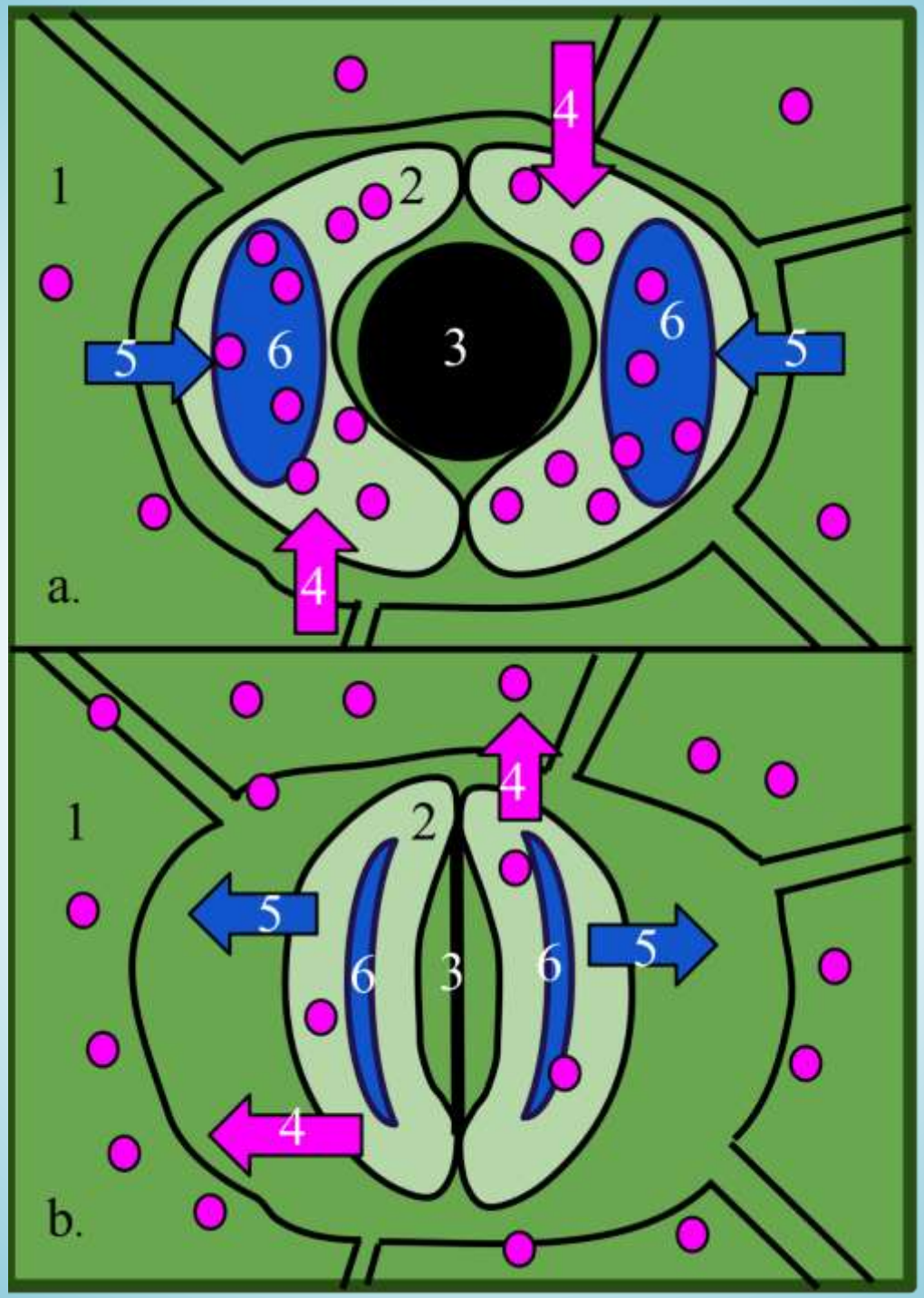


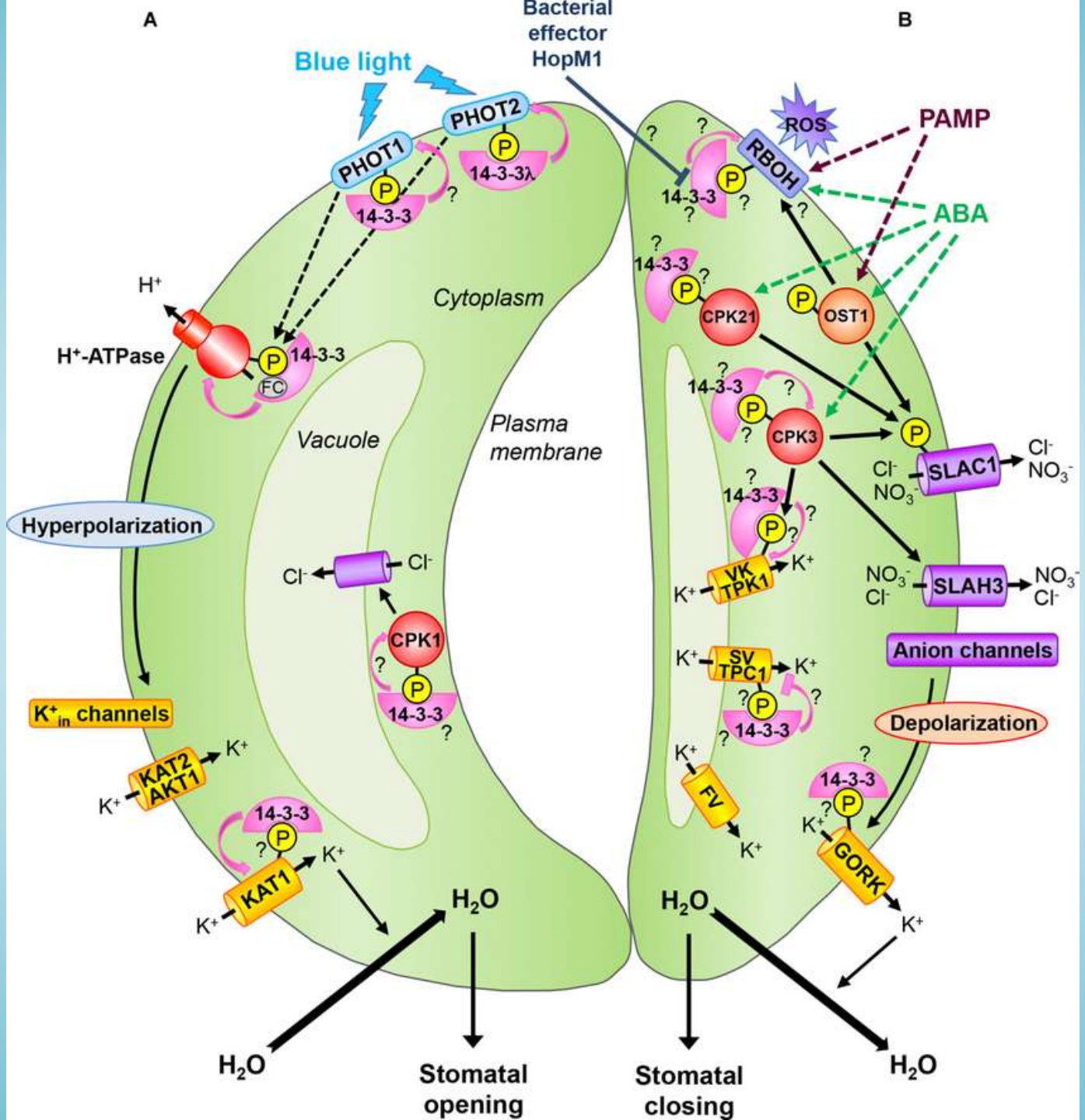
Open Stomata

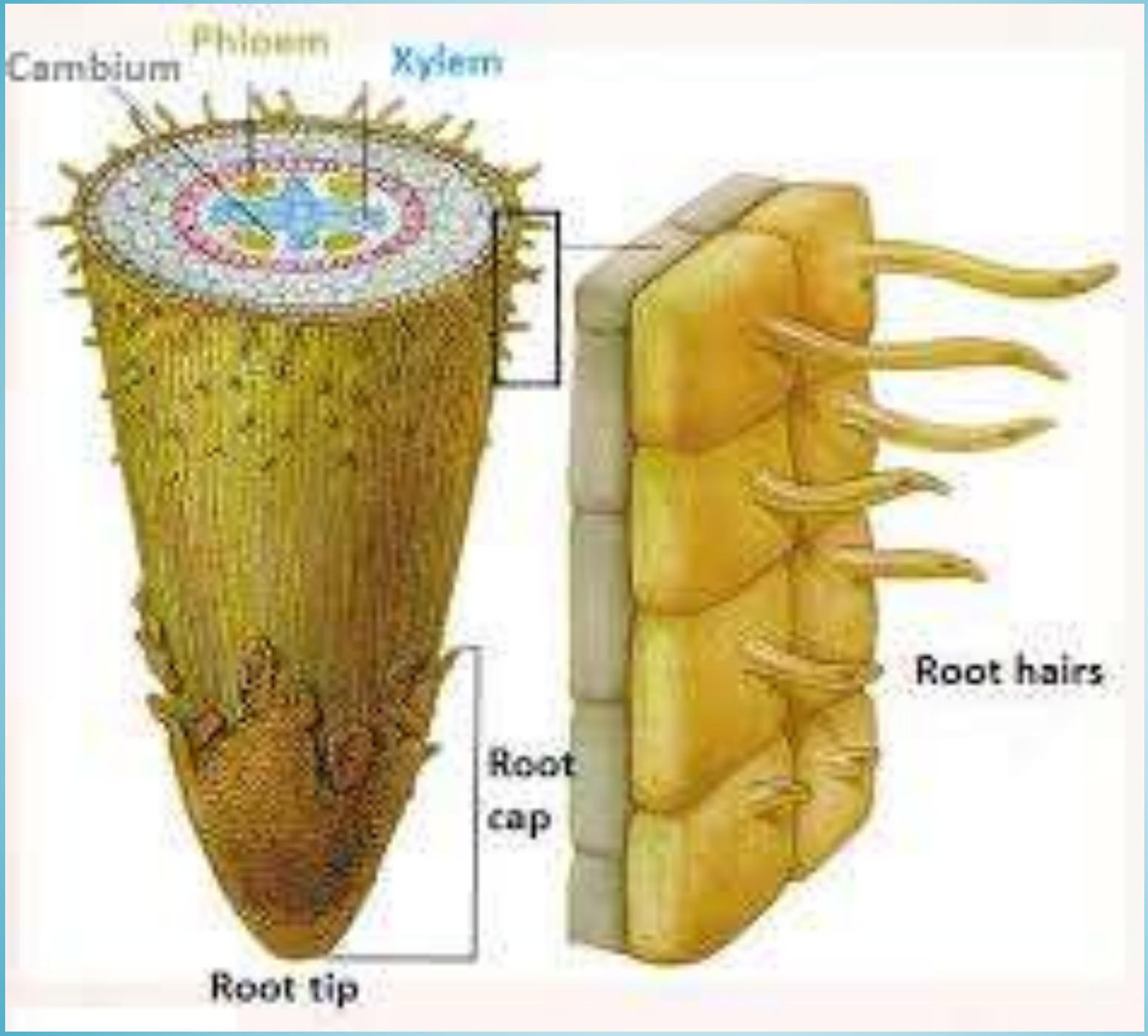


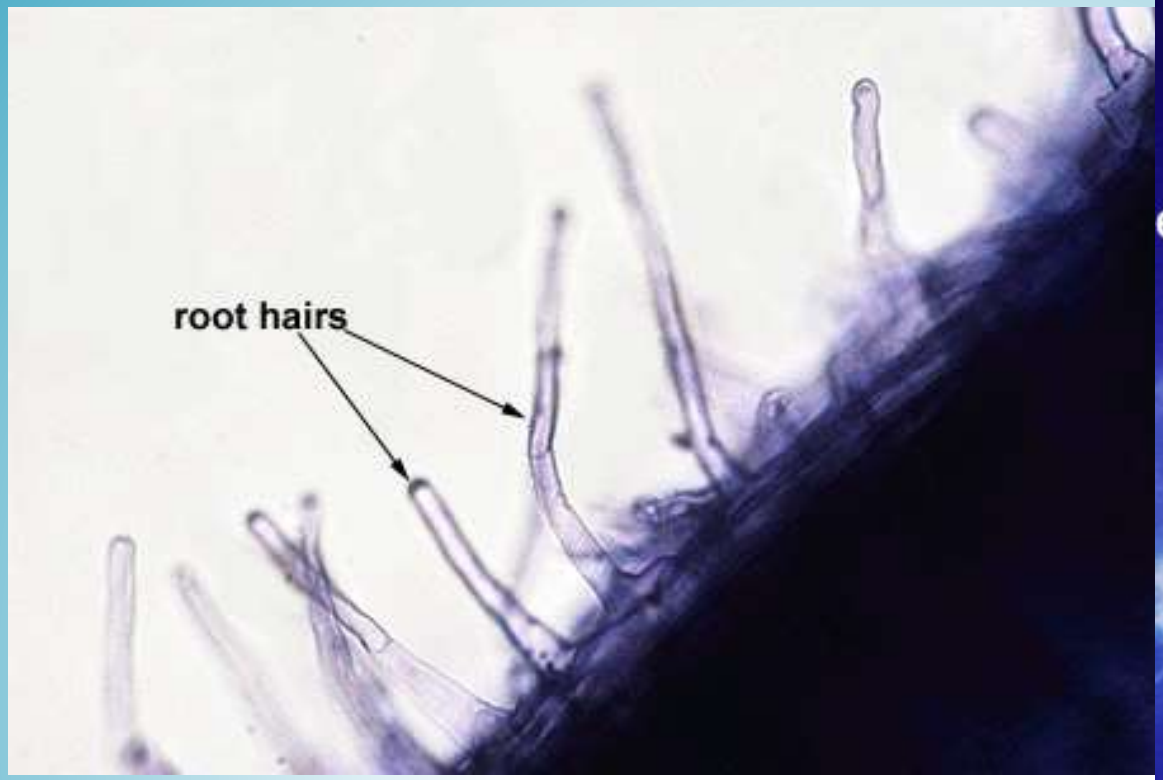
Closed Stomata

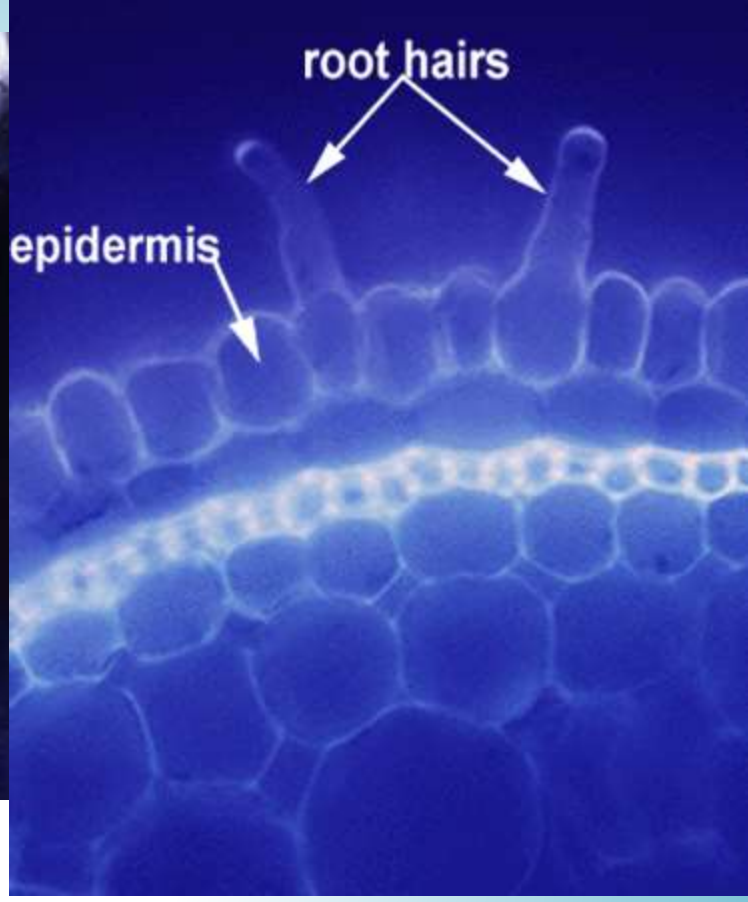



1
2
3
4
5
6
a.
1
2
3
4
5
6
b.


A
B
Blue light
Bacterial effector HopM1
PHOT1
PHOT2
14-3-3λ
14-3-3
Cytoplasm
Vacuole
Plasma membrane
H+
H+-ATPase
FC
Hyperpolarization
Cl-
CPK1
K+in channels
KAT2
AKT1
KAT1
K+
H2O
Stomatal opening
ROS
PAMP
ABA
RBOH
CPK21
OST1
CPK3
SLAC1
NO3-
SLAH3
VK
TPK1
SV
TPC1
FV
Anion channels
Depolarization
GORK
Stomatal closing

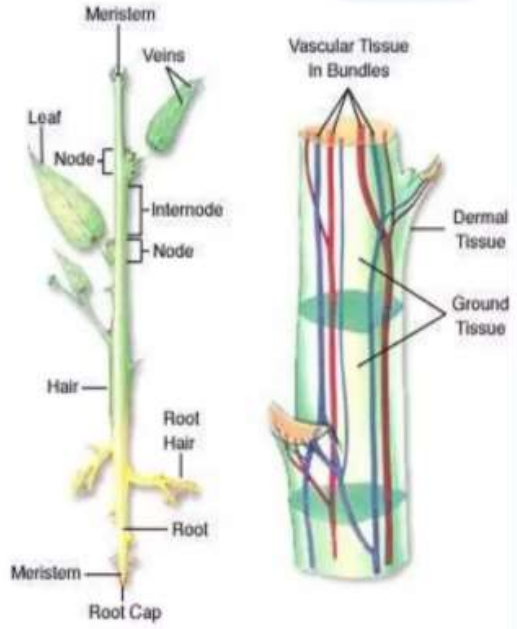

Cambium
Phloem
Xylem
Root hairs
Root cap
Root tip

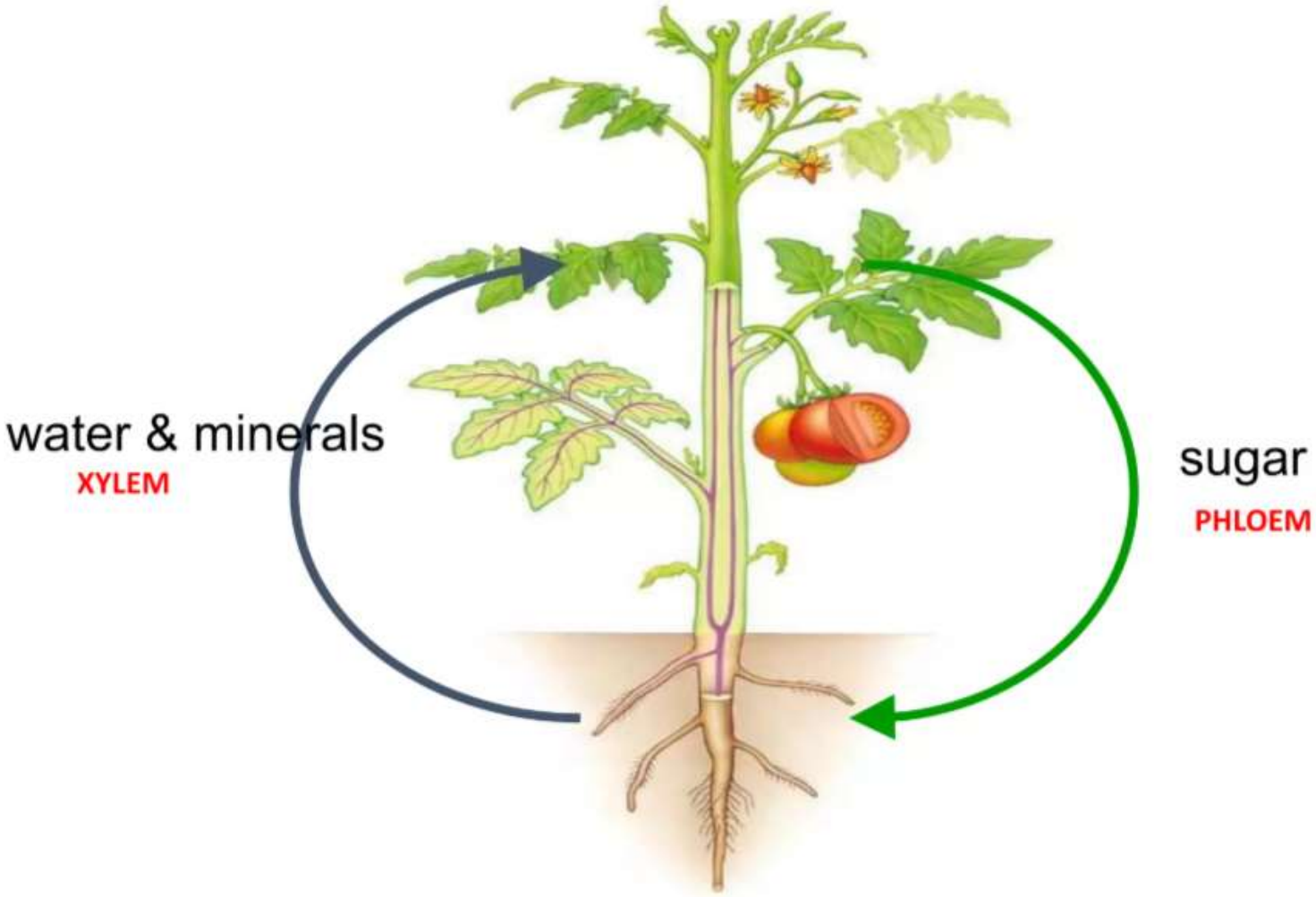

root hairs


root hairs
epidermis

B. VASCULAR TISSUE SYSTEM

- It is a continuous system of tissue that conduct water, minerals, and food.
- **Vascular plants:** plants with well developed conductive system
- Vascular plants are also called **Tracheophyta**
- Main function of vascular tissues: **CONDUCTION**
- Conduct **Water, Minerals and Food** materials
- Additional function: provide **Mechanical support**
- Vascular tissue is composed of two types of tissues:
  - **Xylem**
  - **Phloem**
- **Sap:** It is the name giving to the contents transported by the xylem and phloem



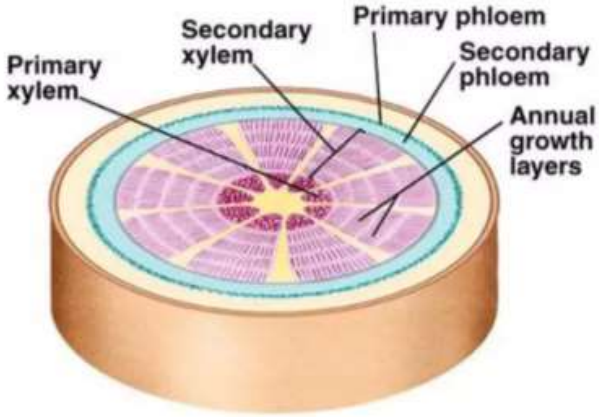

water & minerals
XYLEM
sugar
PHLOEM

VASCULAR TISSUE SYSTEM : XYLEM

- Xylem is one of the two types of transport tissue in vascular plants.

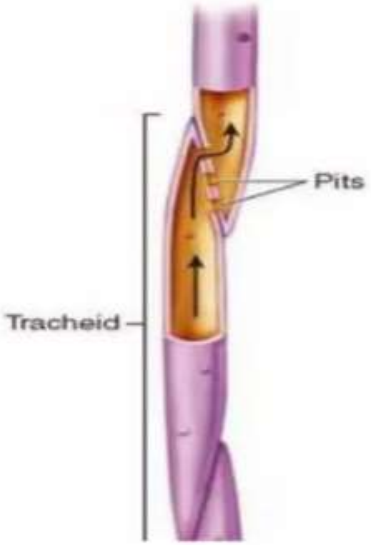
- **Main function**: conduction of water and minerals from root to the rest of the plant's body

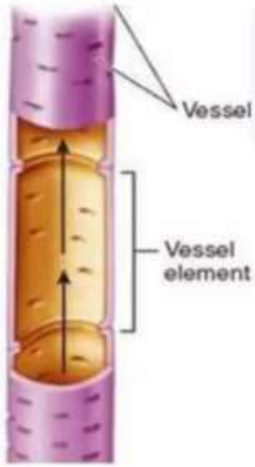
- **Additional function**: provide mechanical support
- The four xylary elements are:
  1. **Tracheids**
  2. **Vessels**
  3. **Xylem fibres**
  4. **Xylem parenchyma**

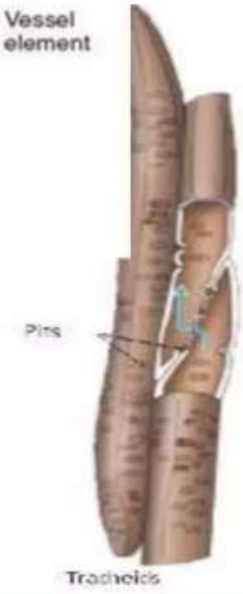


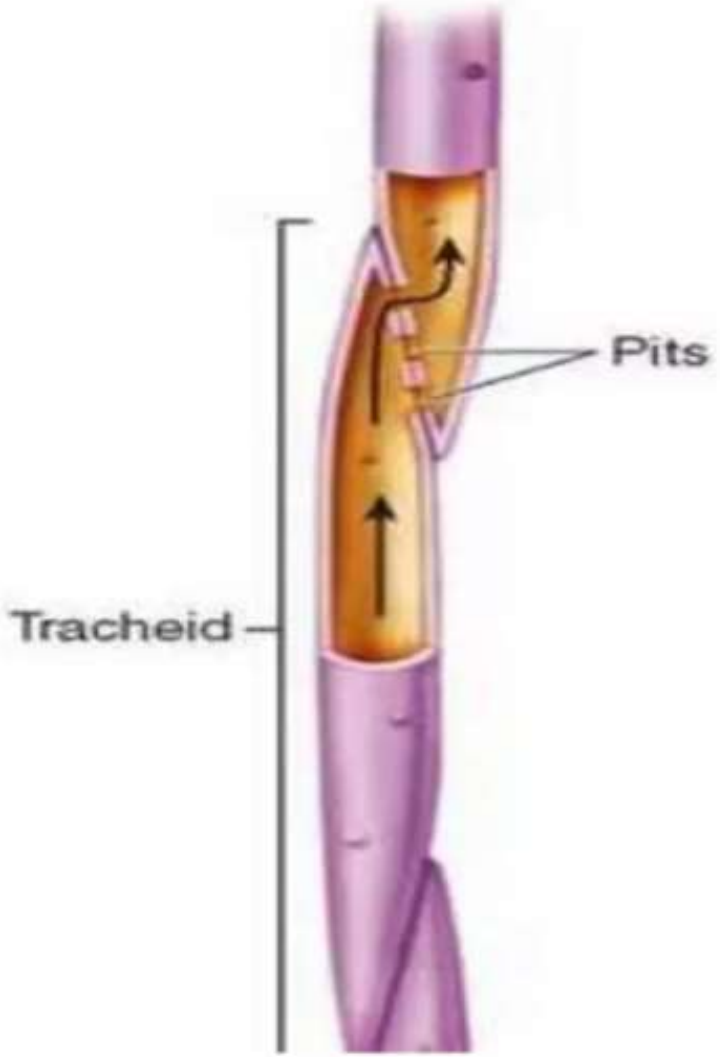
VASCULAR TISSUE SYSTEM : XYLEM

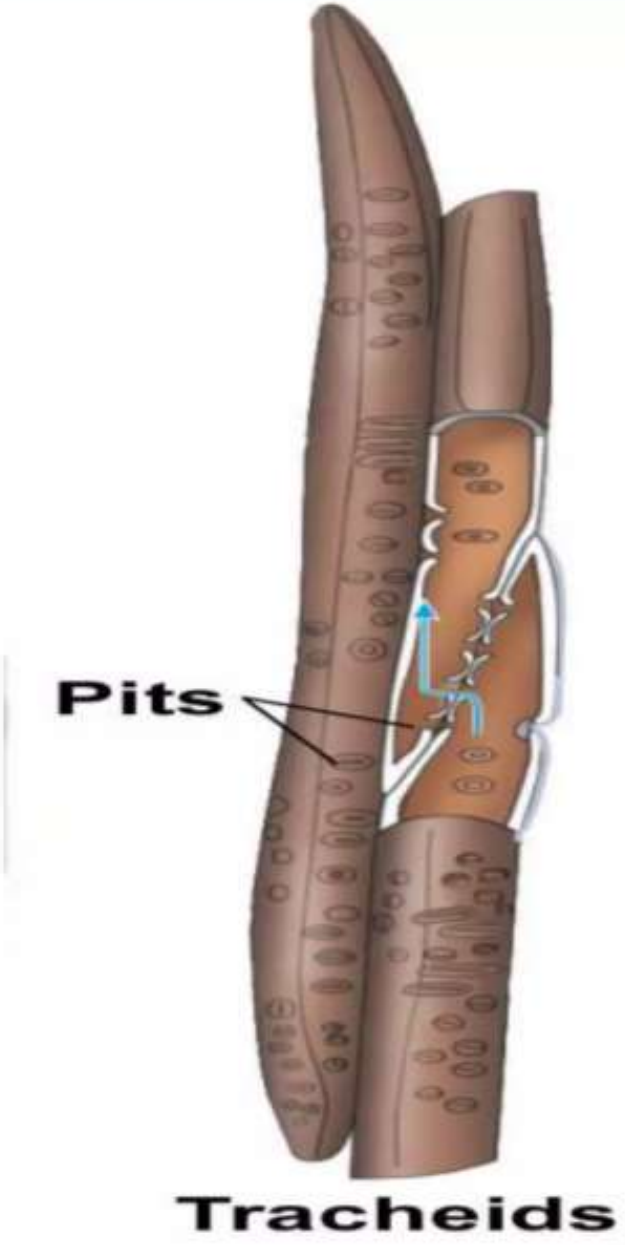
- **TRACHEIDS**
  - Tracheids are long cells with tapered ends
  - Average length 5 – 6 mm
  - They are the fundamental cell type in xylem
  - They are non-living at maturity
  - Mature cells are empty without protoplast
  - Contain secondary cell wall
  - Secondary cell wall highly **lignified**
  - Major portions of the cell wall of tracheids are perforated(**PIT)**
  - **Torus** of pit act as valves







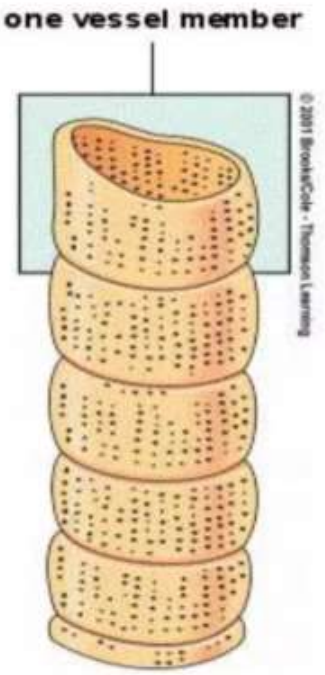

Pits
Tracheid


Pits
Tracheids

VASCULAR TISSUE SYSTEM : XYLEM

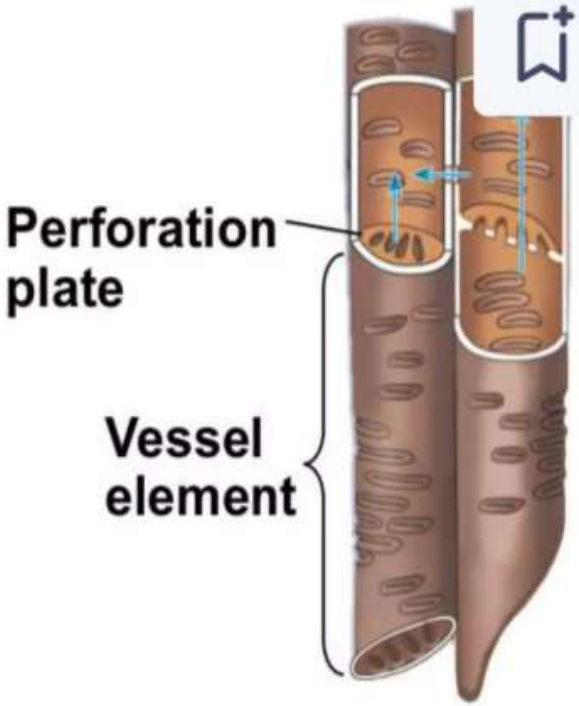
•VESSELS

- Also called **trachea**
- Diameter up to 100 µm
- Components of vessel are called **vessel elements**
- Vessel elements are wider, shorter and less tapered than tracheids
- Vessel elements are tube-like cells
- Cells are non-living at maturity
- Cells are devoid of protoplast at maturity



VASCULAR TISSUE SYSTEM : XYLEM

- Cells are arranged as series in an end-to-end fashion
- Cells are arranged parallel to the long axis of organ
- Vessel has numerous pits present in the lateral walls for communication
- Has opening in each vessel end wall called **Perforation plates**



VASCULAR TISSUE SYSTEM : XYLEM

•XYLEM FIBRES

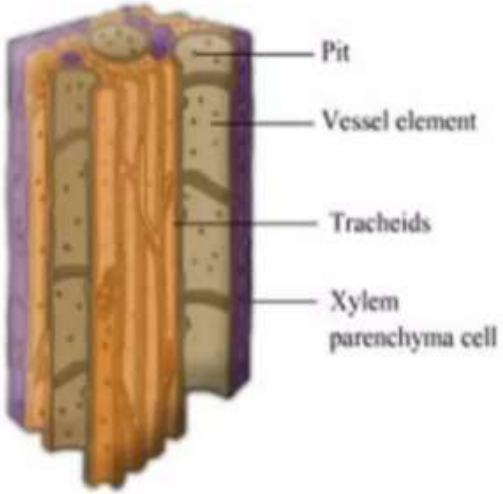
- Also called **xylary fibres**
- Xylem fibers are tread like cells that provide support to the tissues as well as the plants
- Cell contain lignified secondary cell wall
- Dead cells, no protoplast at maturity
- **Main function:** provide mechanical support

phloem fiber

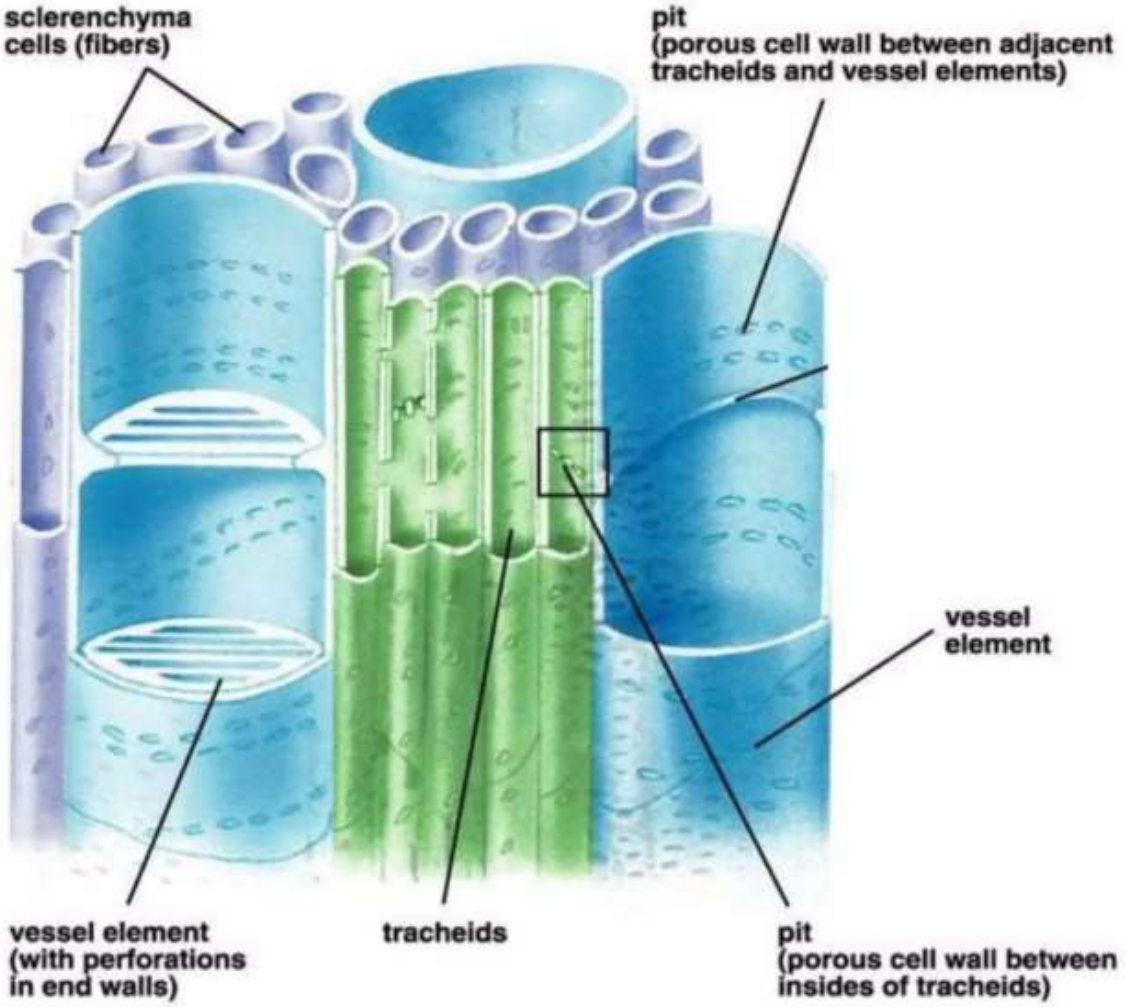
VASCULAR TISSUE SYSTEM : XYLEM

•XYLEM PARENCHYMA

- Only living cells of xylem
- Cells has cytoplasm and prominent nucleus
- Thin cell wall impregnated with cellulose
- **Parenchyma stores:** starch, oil and other ergastic substances



XYLEM STRUCTURE



VASCULAR TISSUE SYSTEM : PHLOEM

- Phloem is one of the two types of transport tissue in vascular plants.
- **Main function**: conduction of food and organic nutrients from leaves the rest of the plant's body
- Composed of several types of cells
- Based on development, there are two types of phloem:
  1. **Primary phloem**
  2. **Secondary phloem**
- Primary phloem is derived from **procambium** during primary growth
- Secondary phloem is derived from the **vascular cambium** during secondary growth

VASCULAR TISSUE SYSTEM : PHLOEM

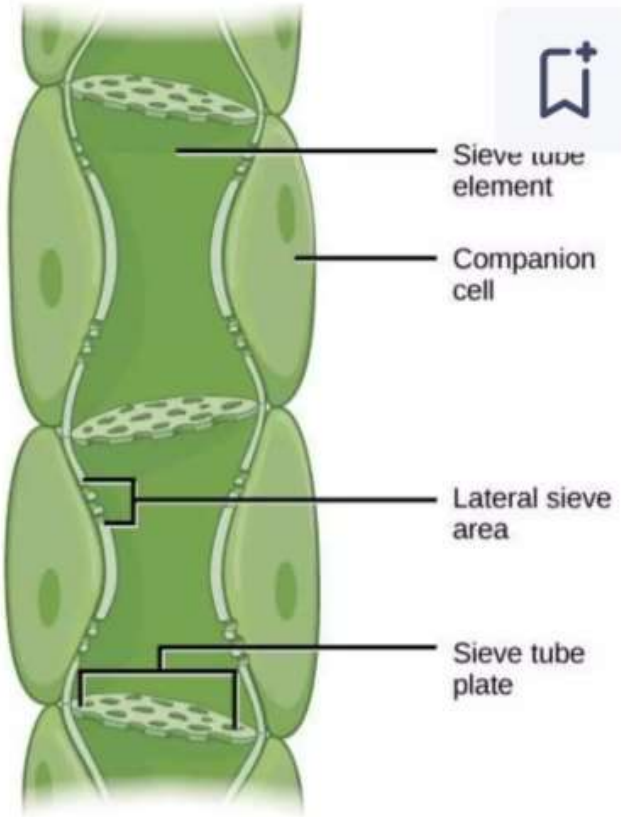
- Phloem is composed of several elements, these are:
  1. **Sieve-tube elements**
  2. **Companion cells**
  3. **Phloem parenchyma**
  4. **Phloem fibres**

VASCULAR TISSUE SYSTEM : PHLOEM

•SIEVE-TUBE ELEMENTS

- living cells in the phloem
- Consist of protoplasm
- They have no lignified secondary cell wall
- At maturity, it lacks nucleus
- Sieve elements are of two types:

1. **Sieve tubes**
2. **Sieve plates**



VASCULAR TISSUE SYSTEM : PHLOEM

✓**SIEVE TUBES**

- These are longitudinal series of cells with each cell referred to as a sieve tube element
- Conduct organic nutrients from leaves to other parts of the plant

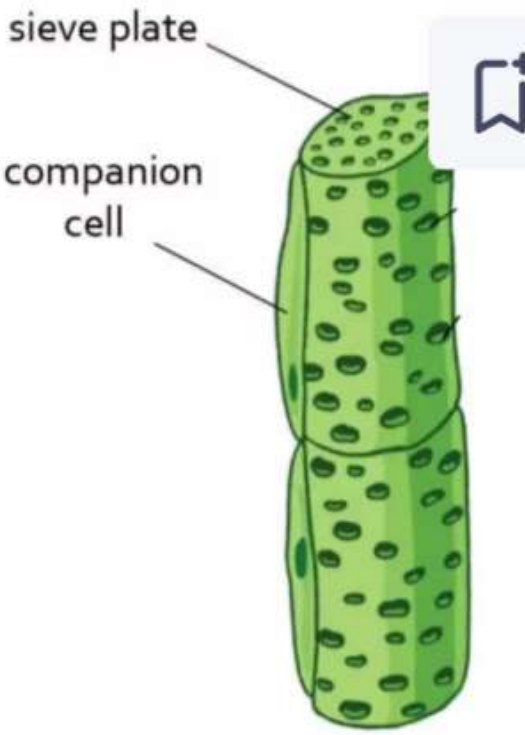
✓**SIEVE PLATES**

- Pores that allow materials to pass from cell to cell without crossing the plasma membranes and cell walls.

VASCULAR TISSUE SYSTEM : PHLOEM

•COMPANION CELLS

- These are specialized parenchyma cells that aids in the transport of food and nutrients in a plant's body
- At maturity it contains **nucleus**, therefore it can supply proteins for the sieve-tube members
- Companion cells are narrow than sieve-tube elements
- They are connected to sieve-tubes by **plasmodesmata**



sieve tube and companion cell

VASCULAR TISSUE SYSTEM : PHLOEM

- **PHLOEM PARENCHYMA**
  - These are thin walled cells
  - Living cells
  - Primarily help to store starch

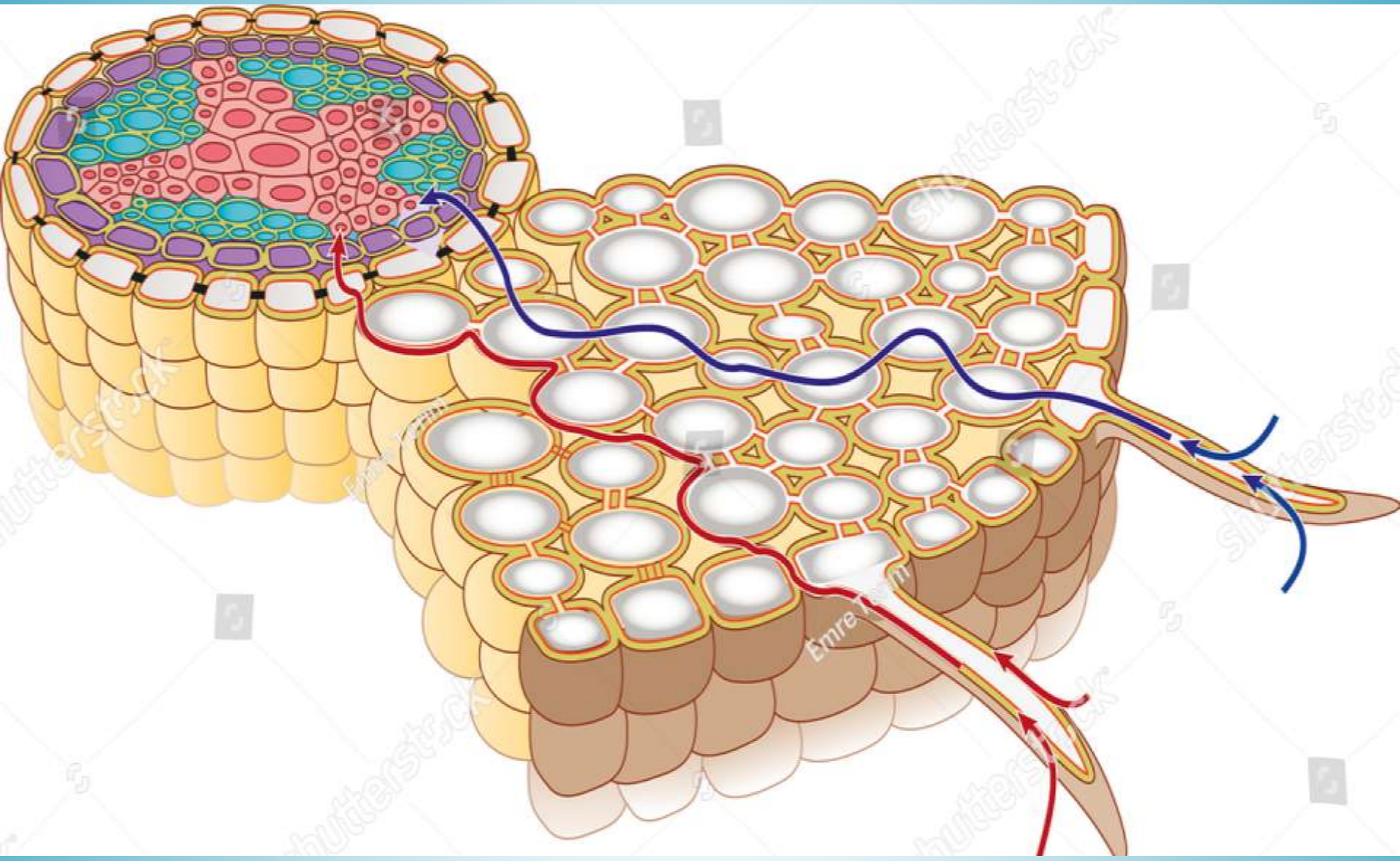
- **PHLOEM FIBRES**
  - Phloem fibres are flexible long cells that provides support for the plant

C. GROUND TISSUE SYSTEM

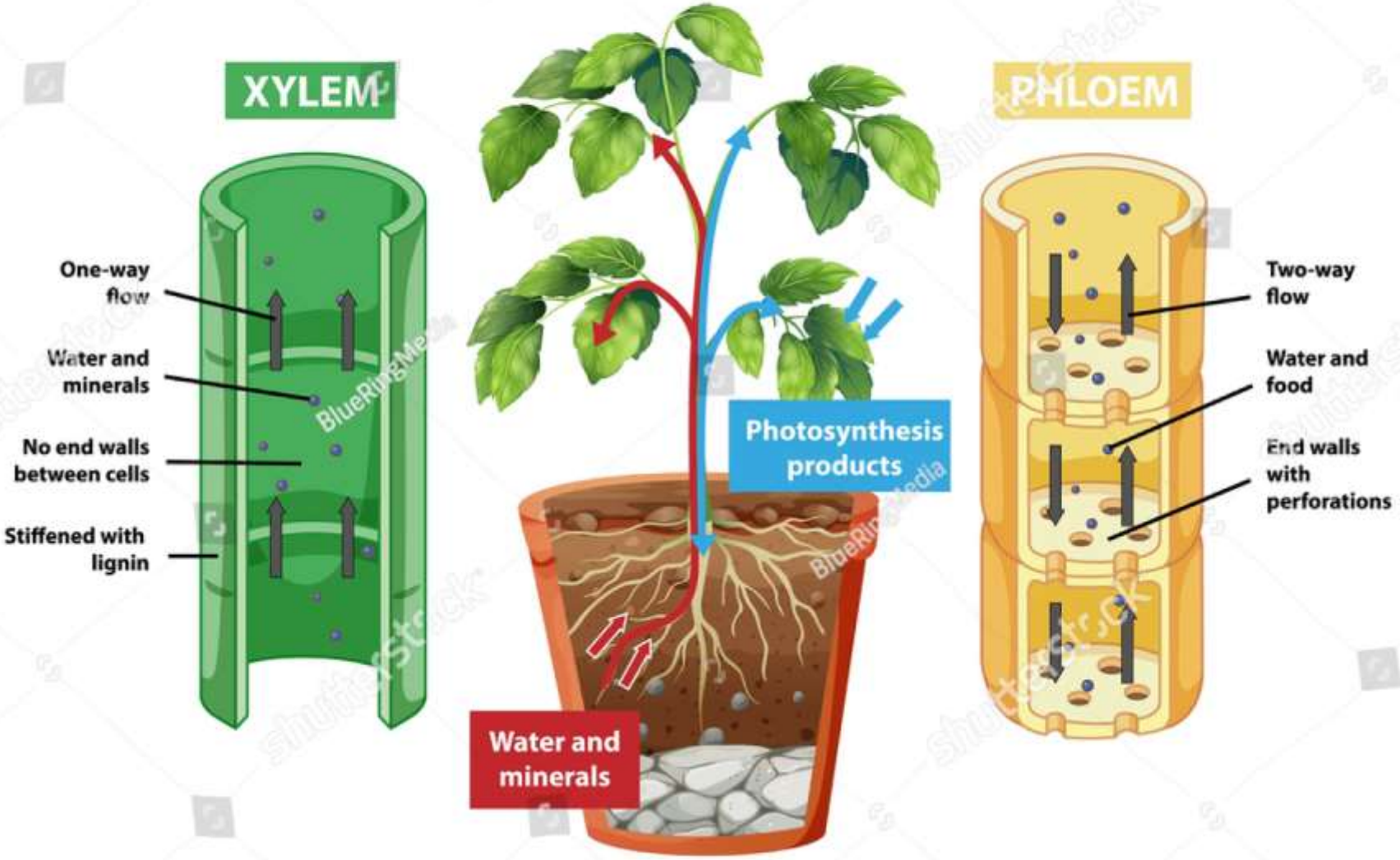
- Also called the **fundamental tissue system**
- Consist of all the tissues other than the vascular and dermal tissue system
- The are usually formed between the dermal and vascular tissue were they are known as the **cortex**.
- The ground tissues can appear on the inside of vascular tissues sometimes and here they are called **pith**

Differences between Xylem and Phloem

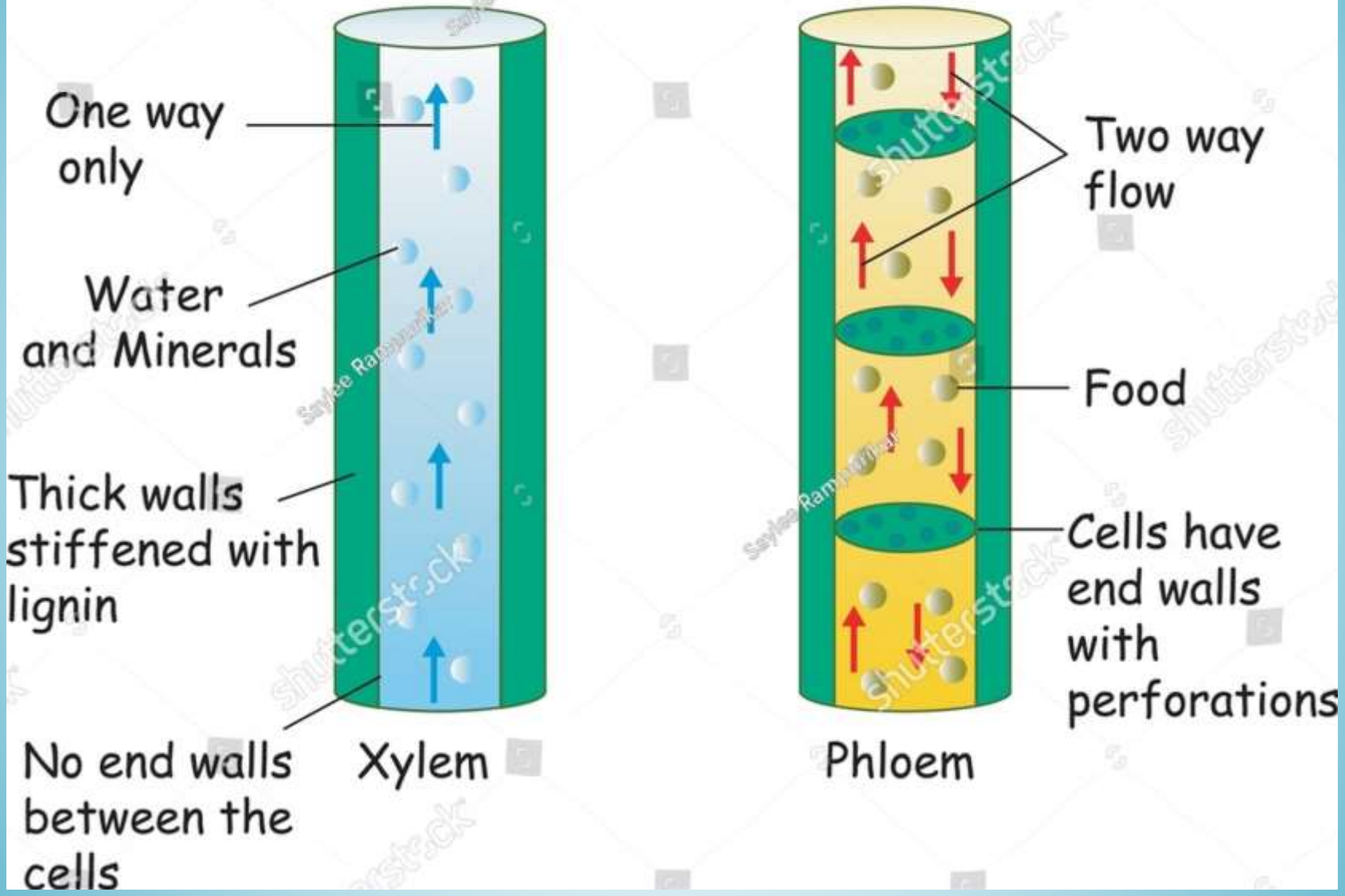
Xylem	Phloem
Consists of dead cells	Consists of living cells
-Transports water and mineral salts -Provide mechanical support to the plant	Transports sugar and amino acids
Transport is unidirectional	Transport – directional, upwards and downwards
Substances are transported by passive transport - osmosis, root pressure, capillary action, transpiration pull	Substances are transported by active transport, diffusion



XYLEM AND PHLOEM



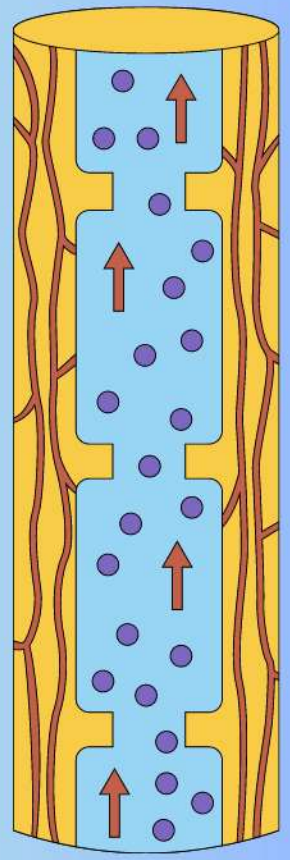
XYLEM AND PHLOEM



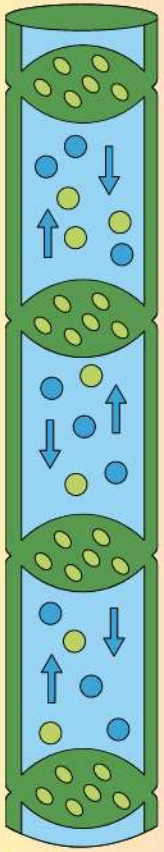
Xylem and Phloem

Plant Vascular System

- Transports water and minerals
- One-way (upward) flow
- Transport is bulk flow due to negative pressure
- Hollow dead cells
- No end walls
- Form center of the vascular bundle
- Rich in lignin, which supports the plant

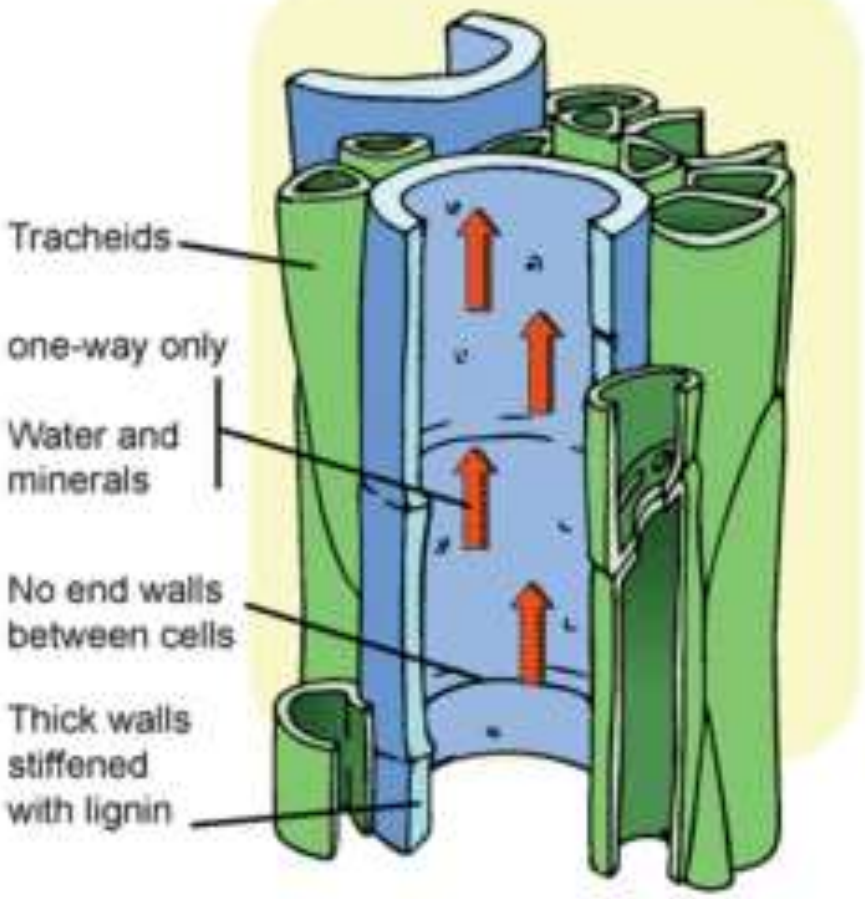


Xylem

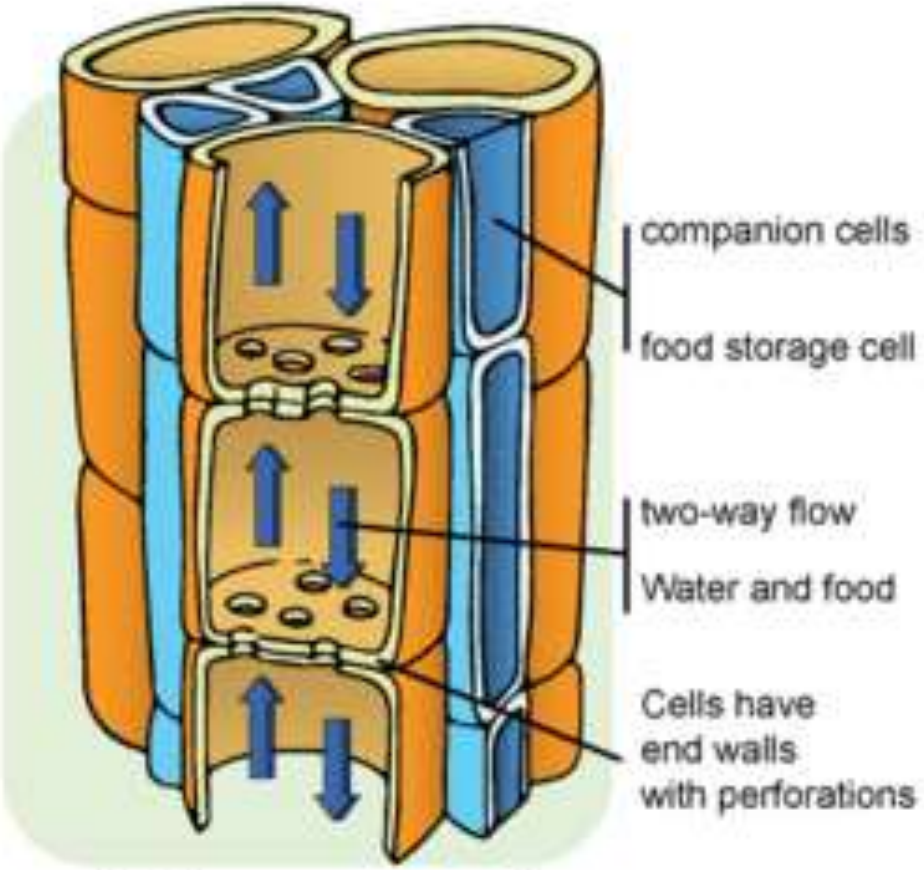


Phloem

- Transports food in the form of sugars
- Two-way flow
- Transport is by osmosis/turgor pressure
- Live cells with no nucleus
- Perforated end walls
- Outside edge of vascular bundle
- Also transports amino acids, mRNA, and hormones



Xylem vessel



Phloem vessel

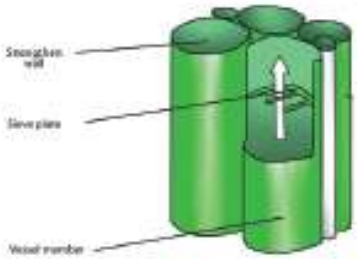
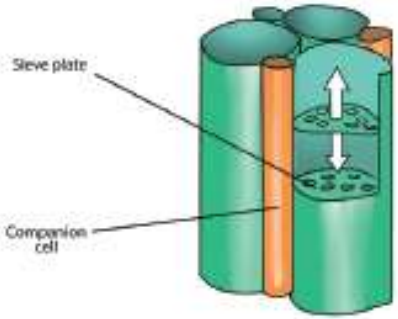
	Xylem	Phloem
Diagrams		
Transport	Water and mineral from the roots to the shoots and leaves	Sugar and amino acids produced in leaves during photosynthesis to every part of the plant.
Process	Transpiration	Translocation
Structure	Cylindrical cells arranged end to end, in which the cytoplasm dies and the cell walls between adjoining cells breaks down leaving a dead empty tube with strengthened cell walls.	Phloem tubes are made up of columns of living cylindrical cells. The cell walls between adjoining cells develop holes like a sieve allowing transport through the tube.
Components	Dead cells and Fibers	Living cells and companion cells
Direction of flow	Upwards	Up and downwards
Permeability	Impermeable	Permeable
Cytoplasm	None	Cytoplasm lining

TABLE 31-1 *Characteristics of Plant Tissue Systems*

Tissue system	Type of cells	Location	Function in roots	Function in stems	Function i leaves
Dermal tissue system	flat, living parenchyma (epidermal cells) in nonwoody parts; flat, dead parenchyma (cork cells) in woody parts	outermost layer(s) of cells	absorption, protection	gas exchange, protection	gas exchange protection
Ground tissue system	mostly parenchyma, usually with some collenchyma and fewer sclerenchyma	between dermal and vascular in nonwoody plant parts	support, storage	support, storage	photosynthesis
Vascular tissue system	elongated cells—dead xylem and living phloem, also parenchyma and sclerenchyma (fibers)	tubes throughout plant	transport, support	transport, support	transport, support