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Plant anatomy or phytotomy

Dr. sami kareem alchalabi

T0PICS REQUIRED (reports)

- 1- Plant cell (components, kinds, functions …etc. , differences between plant vs. animal cell.)
- 2- Lateral Meristem tissues (vascular & cork cambium)
- 3- Simple Permanent tissues. (parenchyma, collenchyma, sclerenchyma & cork tissue).
- 4- Complex per. tis. (epidermis).
- 5- Complex tissue (phloem)
- 6- Complex tissue (xylem)
- 7- Anatomy of flowers.
- 8- Plastids (all kinds)

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What are we going to study

- Plant anatomy……. Definition, Plant parts.
- Plant cell…… Introduction, kinds, differences (plant vs. animals), (Eucaryotic vs. procaryotic).
- Plant cell parts… (protoplasmic and non-protoplasmic components).
- Plant tissues…. (meristematic & permanent)
- Plant organs (leaf, stem, root, flower). Anatomy, primary growth(for all organs).
- Primary & secondary growth of stems & roots.
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Plant anatomy

- The study of the internal structure of plants
- It is investigated at the cellular level, and often involves the sectioning of tissues and microscopy.

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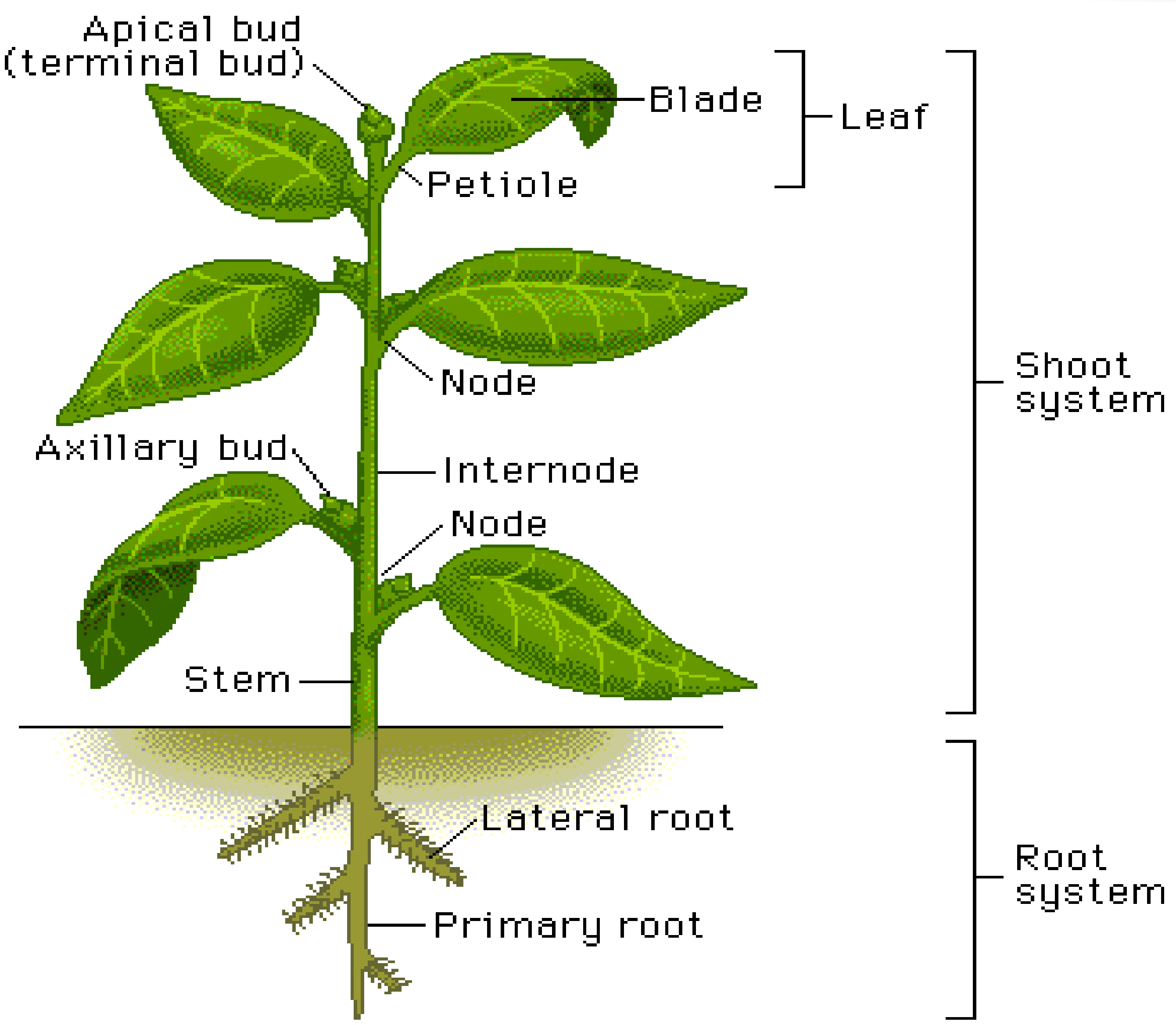
Plant Parts



Apical bud
(terminal bud)
Blade
Leaf
Petiole
Node
Shoot
system
Axillary bud
Internode
Node
Stem
Lateral root
Root
system
Primary root

The plant body consists of two basic parts: the **shoot system** and the **root system**.

- **Shoot System:** includes organs such as leaves, buds, stems, flowers, and fruits and usually it develops above ground.
  - The functions of the shoot system includes:
    - Photosynthesis
    - Reproduction
    - Storage
    - Transport
    - Hormone production

- **Root System:** includes roots as well as modified stem structures such as tubers and rhizomes and usually it develops underground.
  - The functions of the root system includes:
    - Anchorage
    - Absorption
    - Storage
    - Transport
    - Production of certain hormones

PLANT CELL

WHAT IS A CELL?

- A cell is the basic unit of structure and function in organisms.
- Cells differ in size, shape and in function.
- A cell consist of smaller structures called organelles.

Plant cell

- It has been defined as unit of live; that is the smallest unit which can carry on the activities which we associate with life such as growth, synthesis of new living material, and reproduction of other cells.
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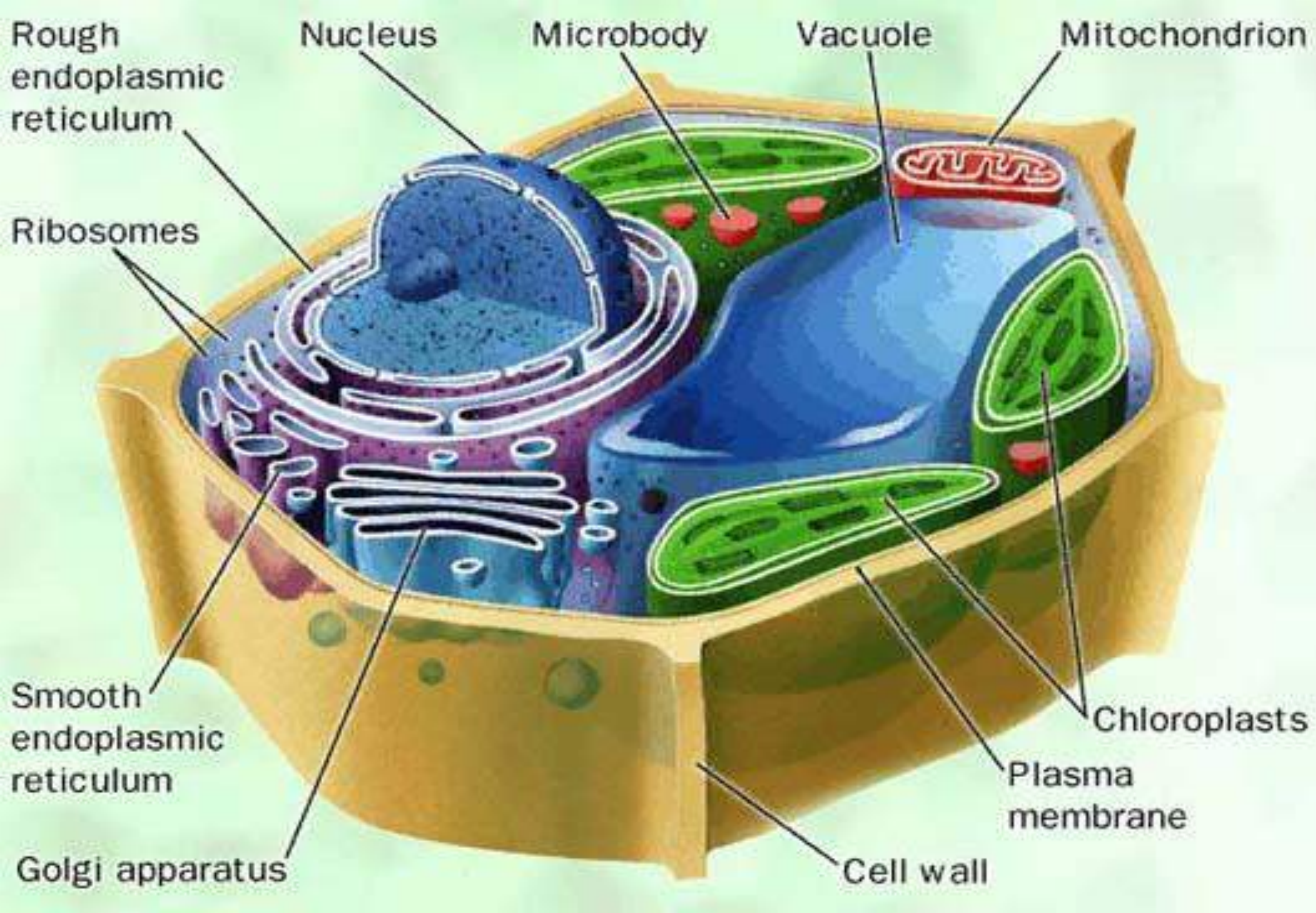
Rough endoplasmic reticulum
Nucleus
Microbody
Vacuole
Mitochondrion
Ribosomes
Smooth endoplasmic reticulum
Golgi apparatus
Chloroplasts
Plasma membrane
Cell wall

- Cells are modified according to the functions they perform.
- Some live for a few days others live for many years.
- The discovery of cells is associated with the development of the microscope.

History of cell discovery

- Robert Hooke coined cells for boxlike compartments he saw in cork in 1665.
- In 1833, Brown discovered that all cells contain a nucleus, and shortly thereafter Schleiden saw a nucleous within a nucleus.
-

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- In 1858, Virchow contended that every cell comes from preexisting cell and that there is no spontaneous generation of cells from dust.
- In 1862, Pasteur proved that fermentation involves activity of yeast cells.

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- In 1897, Buchner found that yeast cells do not need to be alive for fermentation to occur.
- During the first half of the 20^{th} century, great advances were made in the refinement of microscopes and in tissue preparation techniques. Many structures and bodies were observed in cells, and the relationship between structure and function were understood.
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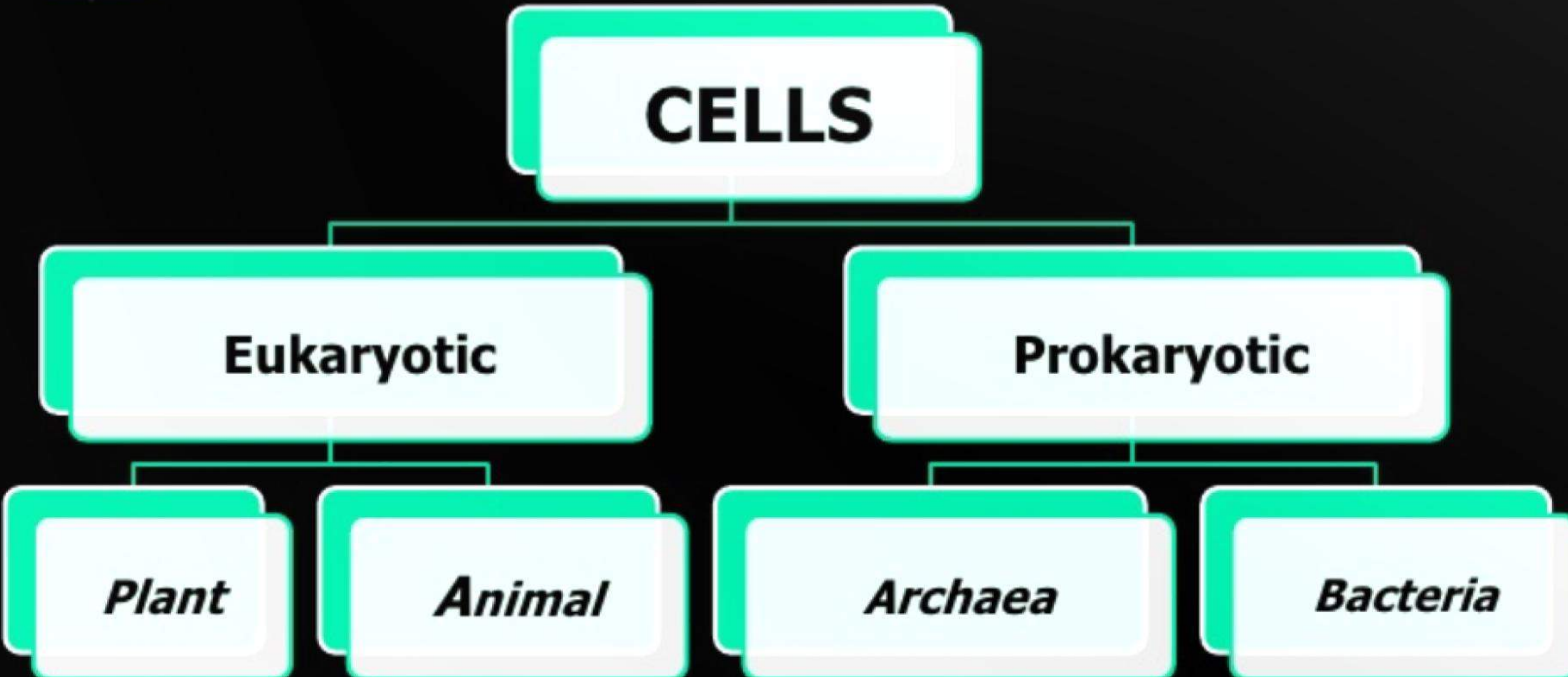
Prokaryotic and Eukaryotic Cells



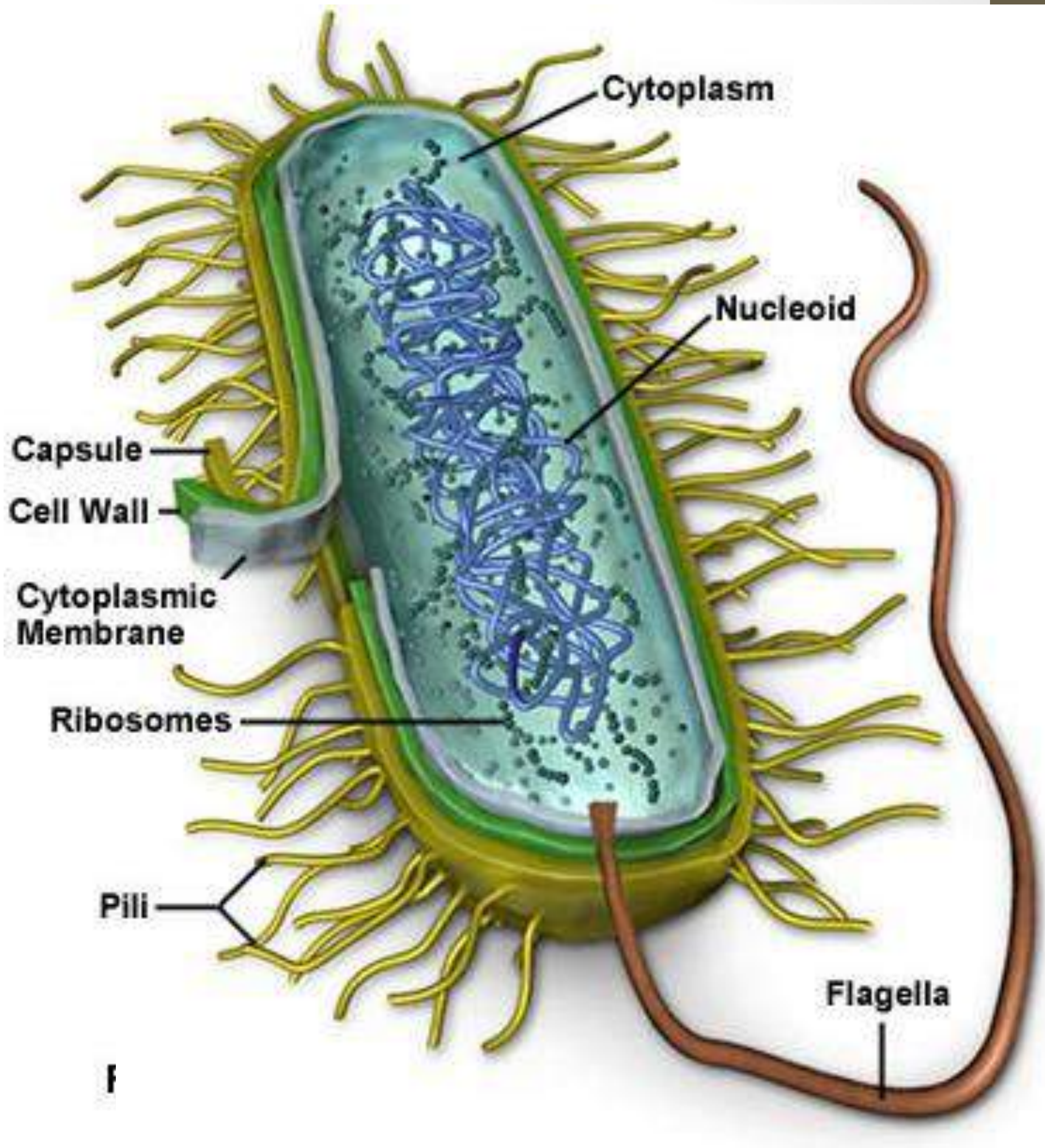
Two types of cells

- **Prokaryotic** or **Eukaryotic cells.**
- Only organisms of the domains Bacteria and Archaea consist of prokaryotic cells – cells without a membrane bound nucleus.
- **Protists, fungi, animals and plants** all consist of **eukaryotic cells** – cell with a membrane bound nucleus.

Prokaryotes

1. **Oldest of cell types, first appeared 3.5 billion years ago.**
2. **Cells that do not contain a nucleus.**
3. **DNA is not contained in an internal structure.**
4. **Have a cell membrane.**
5. **Do not have membrane-bound organelles.**
6. **Generally smaller and simpler than eukaryotic cells.**
7. **Can live in hostile environments. Halophiles and thermophiles that are archeabacteria.**
8. **Very diverse in their metabolic process: obligate aerobes (require O_2), obligate anaerobes (killed by O_2), and facultative anaerobes (can survive with or without O_2).**
9. **Example: Bacteria**

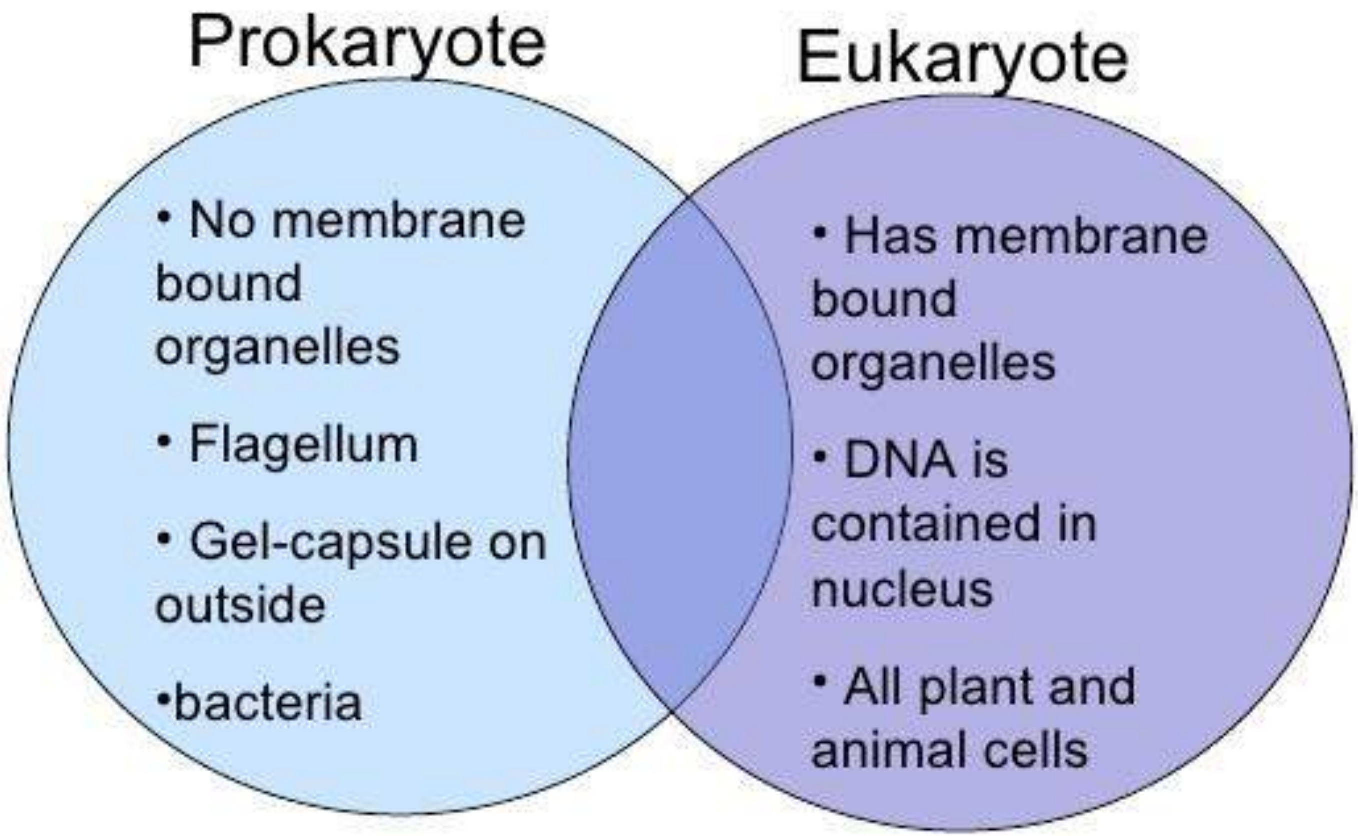
Prokaryotic Cell Structure



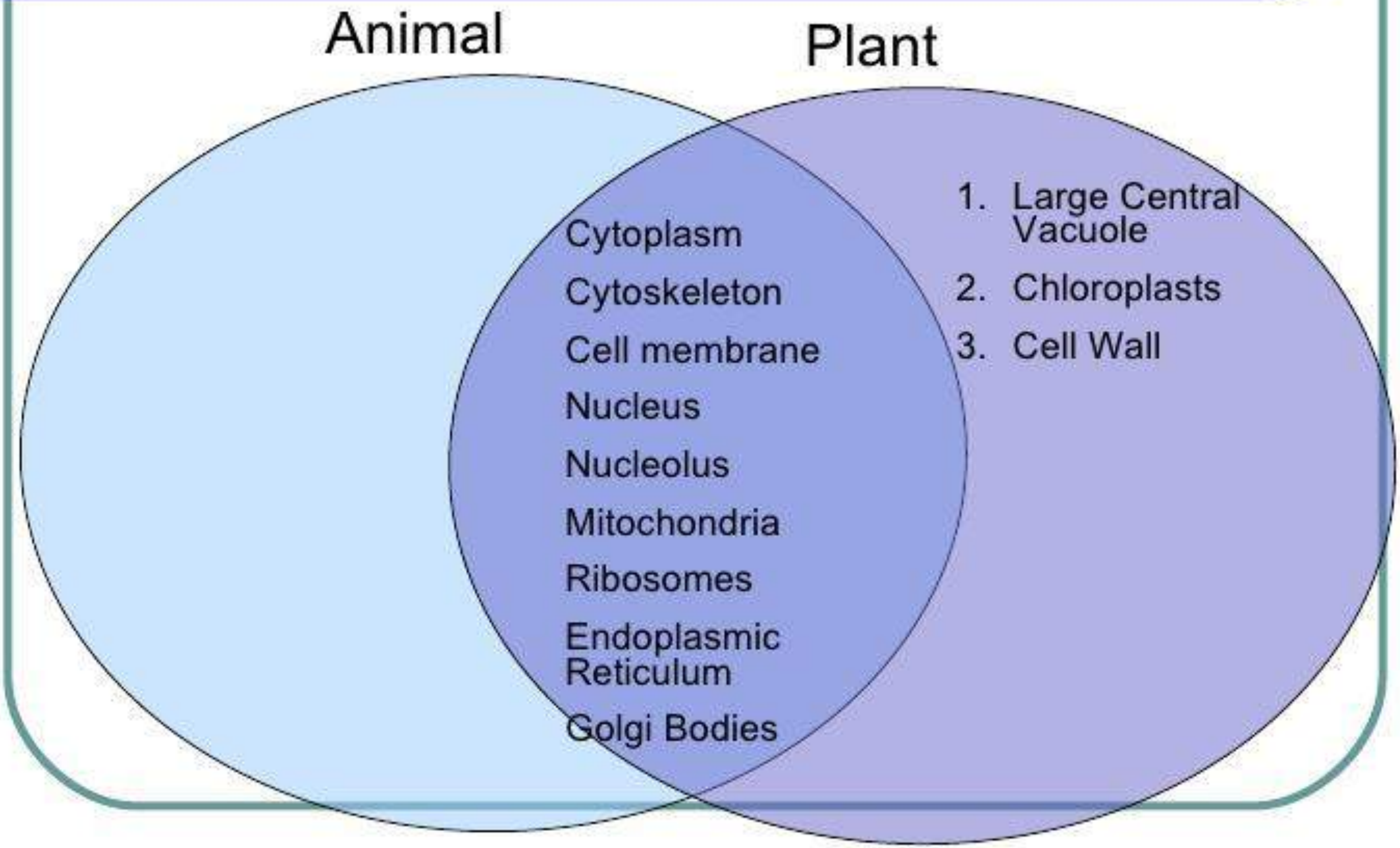
Eukaryotes

1. First appeared in the fossil record 1.5 billion years ago.
2. Eukaryotes are organisms that have a nucleus in each cell.
3. The nucleus contains that cell's DNA.
4. Have a cell membrane.
5. Generally larger and more complex than prokaryotic cells.
6. Have complex membrane bound organelles (mitochondrion, chloroplast, Golgi apparatus, etc.)
7. Many eukaryotic cells are highly specialized.
8. Examples: Plants, animals, fungi, and protists.

Two Types of Cell

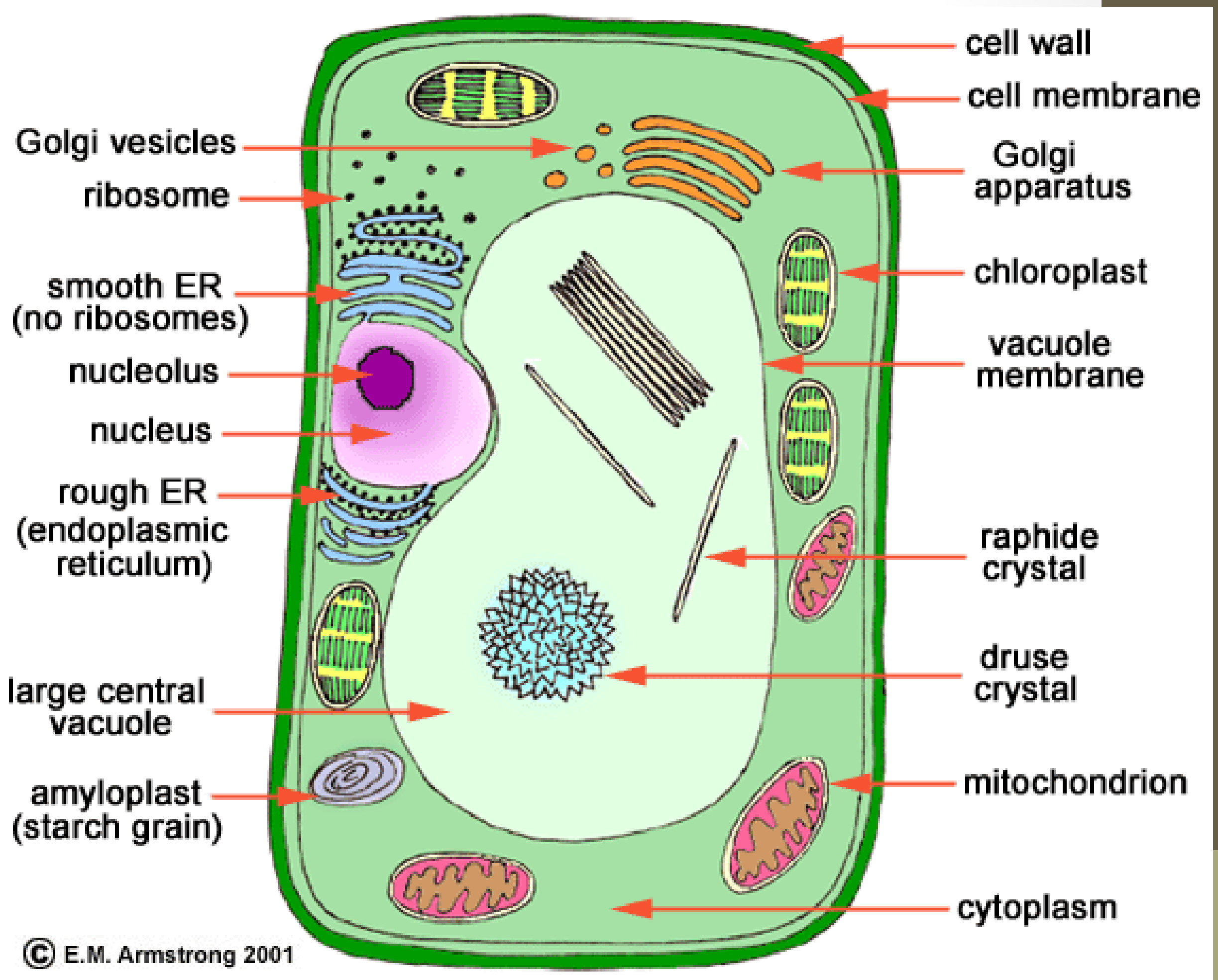


Two types of Eukaryotic Cell

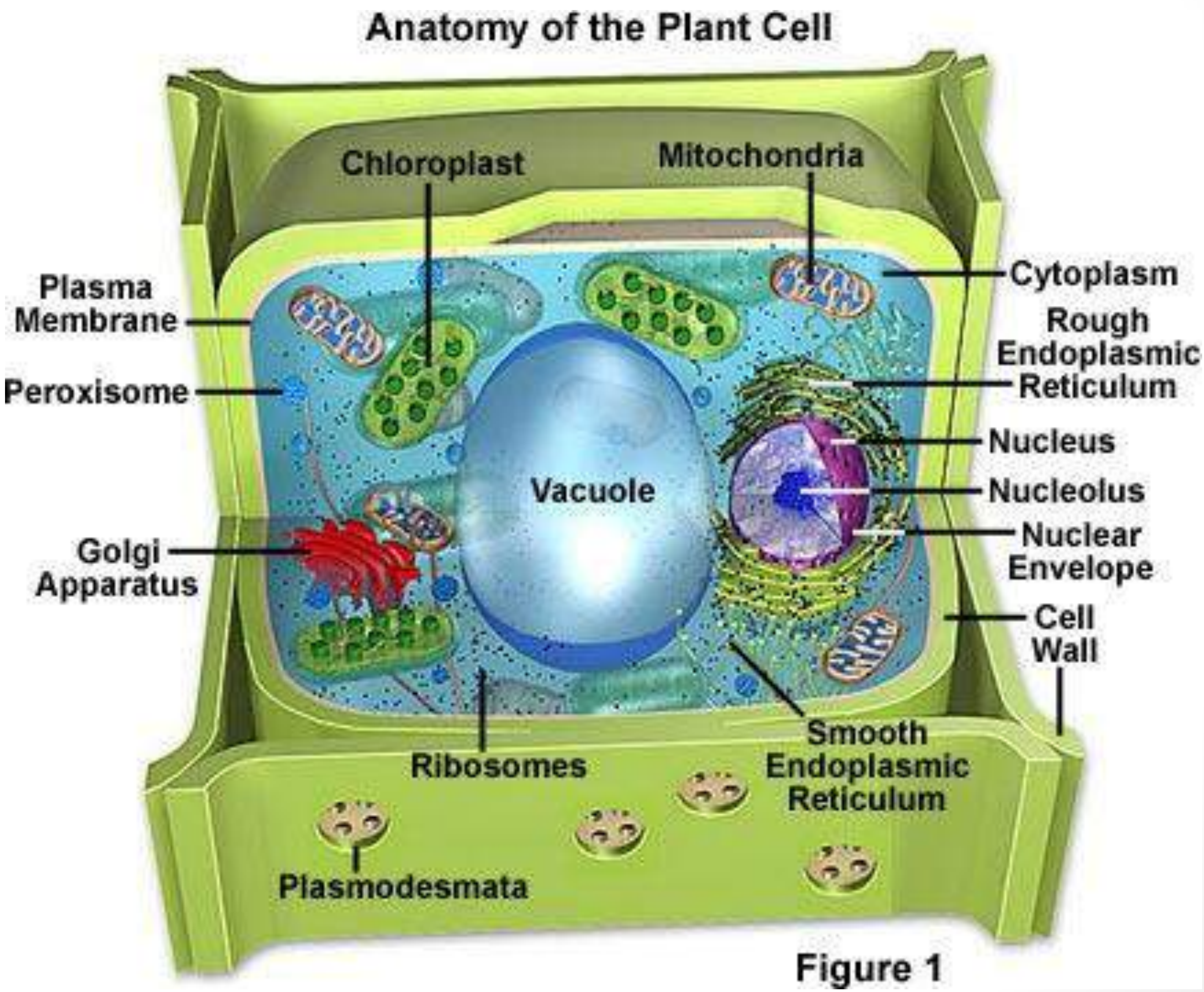


Eukaryotic Cell Structure and Function

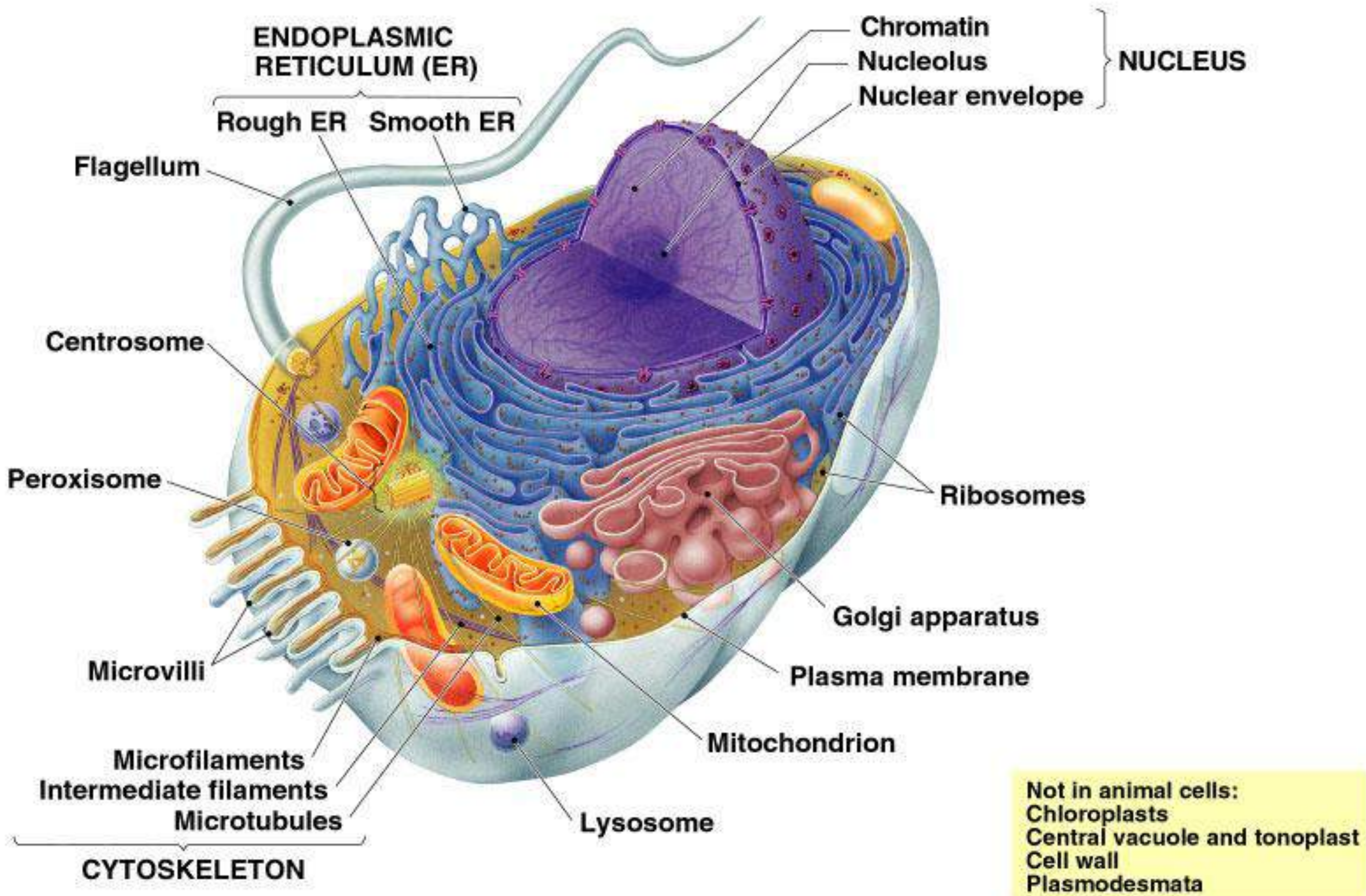
- Plasma Membrane
- Nucleus
- Ribosomes
- Nucleolus
- Endoplasmic Reticulum
- Golgi Bodies
- Lysosomes
- Plastids
- Chloroplasts
- Mitochondria
- Vacuoles
- Microtubules
- Cytoplasm



Plant cells are eukaryotic



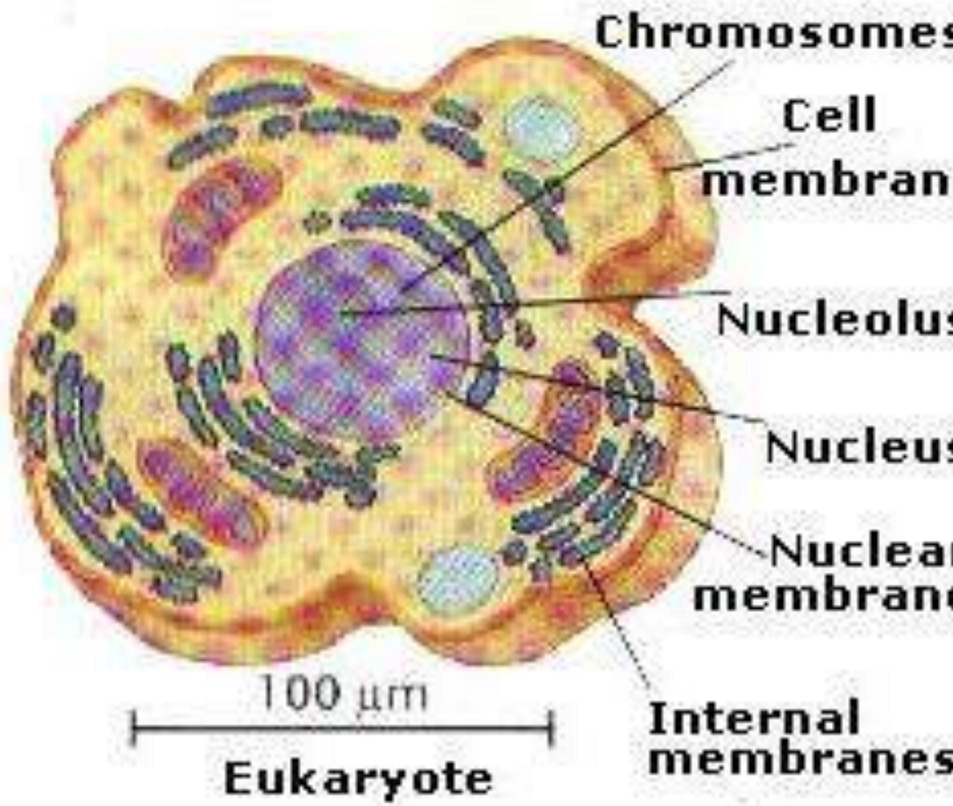
Animal Cells are Eukaryotic



Prokaryotic cells are much *smaller* and *simpler* than eukaryotic cells are

Prokaryote

- No nucleus or other organelles



Prokaryotic Cells

- Came from the Greek word ***pro*** : before and ***karyon*** : kernel or nucleus
- Prokaryotes lack a membrane-bounded nucleus.

Eukaryotic Cells

- Came from the Greek words meaning **true nucleus.**
- Thus, eukaryotic cells have nucleus and membrane bound organelles.

Differences between plant cells and animal cells

Animal cells	Plant cells
Relatively smaller in size	Relatively larger in size
Irregular shape	Regular shape
No cell wall	Cell wall present

Differences between Plant Cells and Animal Cells

Animal cells	Plant cells
Vacuole small or absent	Large central vacuole
Glycogen as food storage	Starch as food storage
Nucleus at the center	Nucleus near cell wall

- Lack plasmodesmata since they have no walls.
- Cell plates do not form. Cells divide by pinching in two.

- Higher plant cells have plasmodesmata connecting the protoplasts with each other through microscopic holes in the wall.
- A cell plate is formed during the telophase of mitosis.

PLANT BODY ORGANS

- Plants have organs that compose of different tissue,
- which in turn are composed of cells of different types.
- A tissue is a group of cells with a common function, structure or both.
- An organ consist of several types of tissues that together carry out particular functions.

- Because cells are so minute, full- grown organisms have astronomical numbers of them. For example a single mature leaf of a pear tree contains 50 million cells. The total number of cells in the roots, stem, branches, leaves, and fruit of a full-grown pear tree exceeds 15 trillion.

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Plant cell parts

- It consists of two main portions

- **Cell wall** and **Protoplast**

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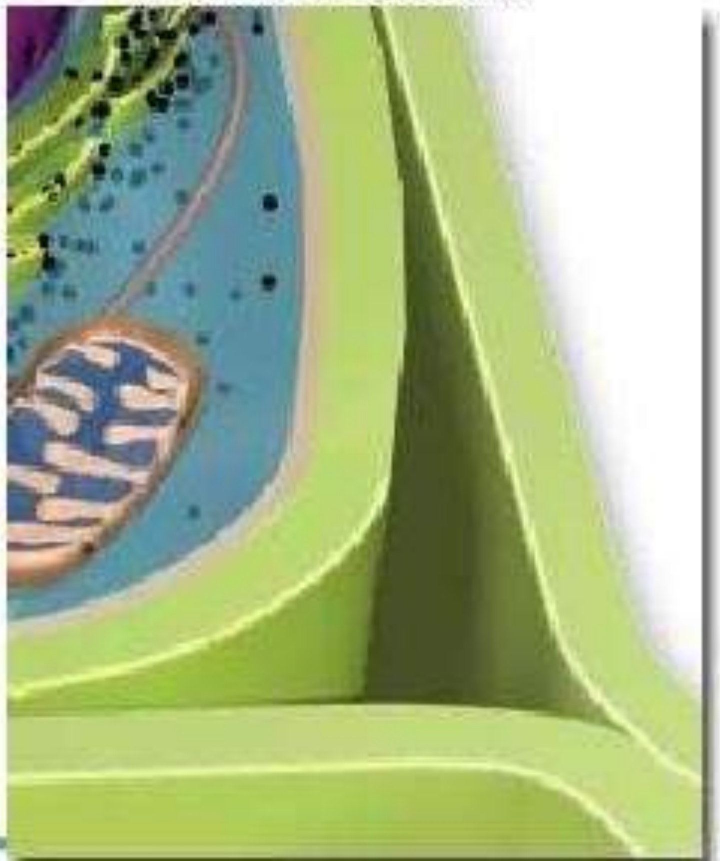
Cell wall

- Rigid outer covering of a plant cell that protects the cell and gives it shape

Plant Cell Wall



Cell Wall

- Function: provides support and protection to the cell membrane
- Found outside the cell membrane in plant cells

Cell Wall

- Only found in plant and bacteria(prokaryotic) cells
- Cell wall in plants is made of cellulose
- Provides strength and support to the cell membrane
- The strength of billions of cell walls in plants enables a tree to stand tall and its limbs to defy gravity

Cell wall layers

- It is composed of two to three layers:
- 1- Primary wall.   All cells
- 2- Middle lamella. All cells
- 3- secondary wall. Some cells.

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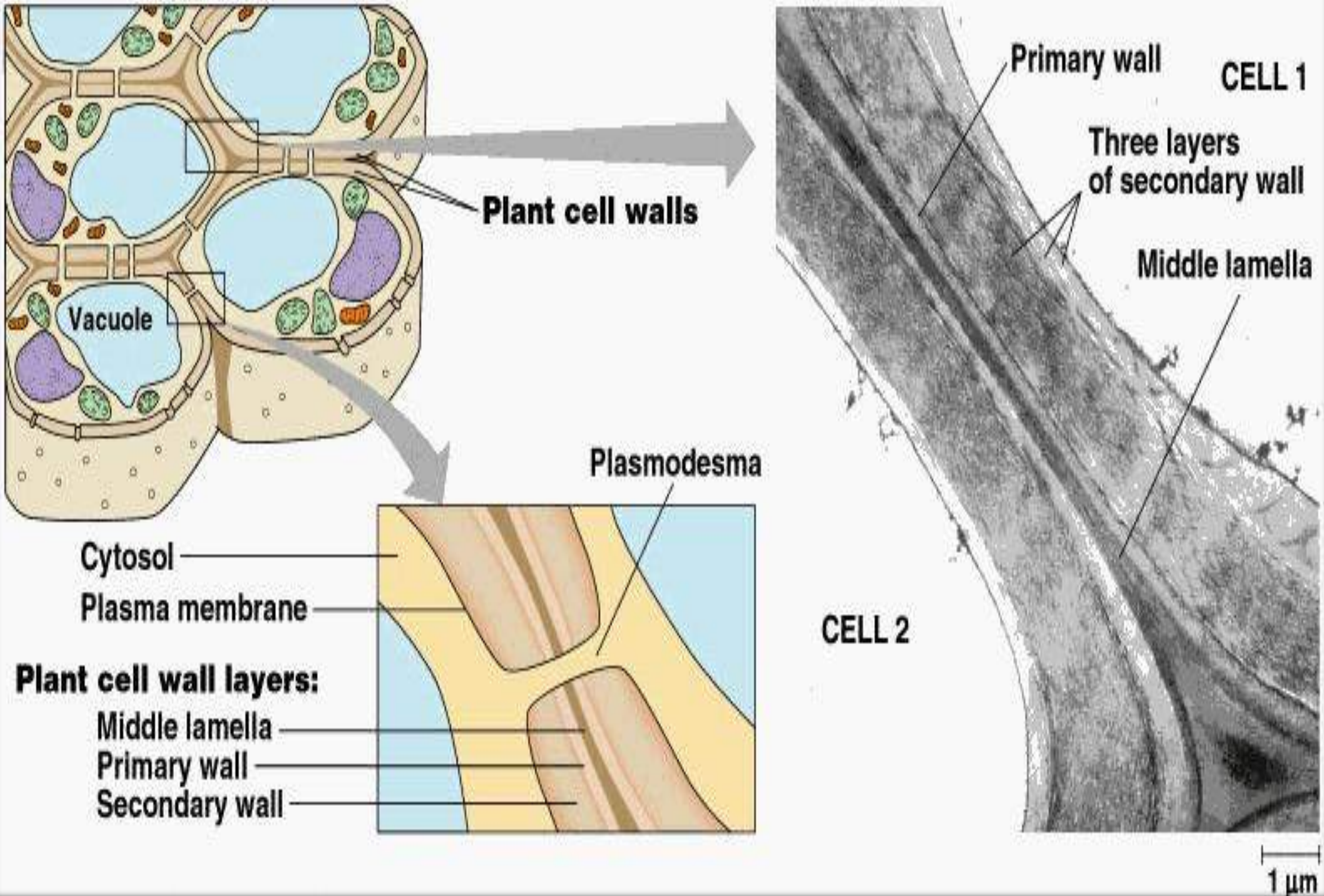
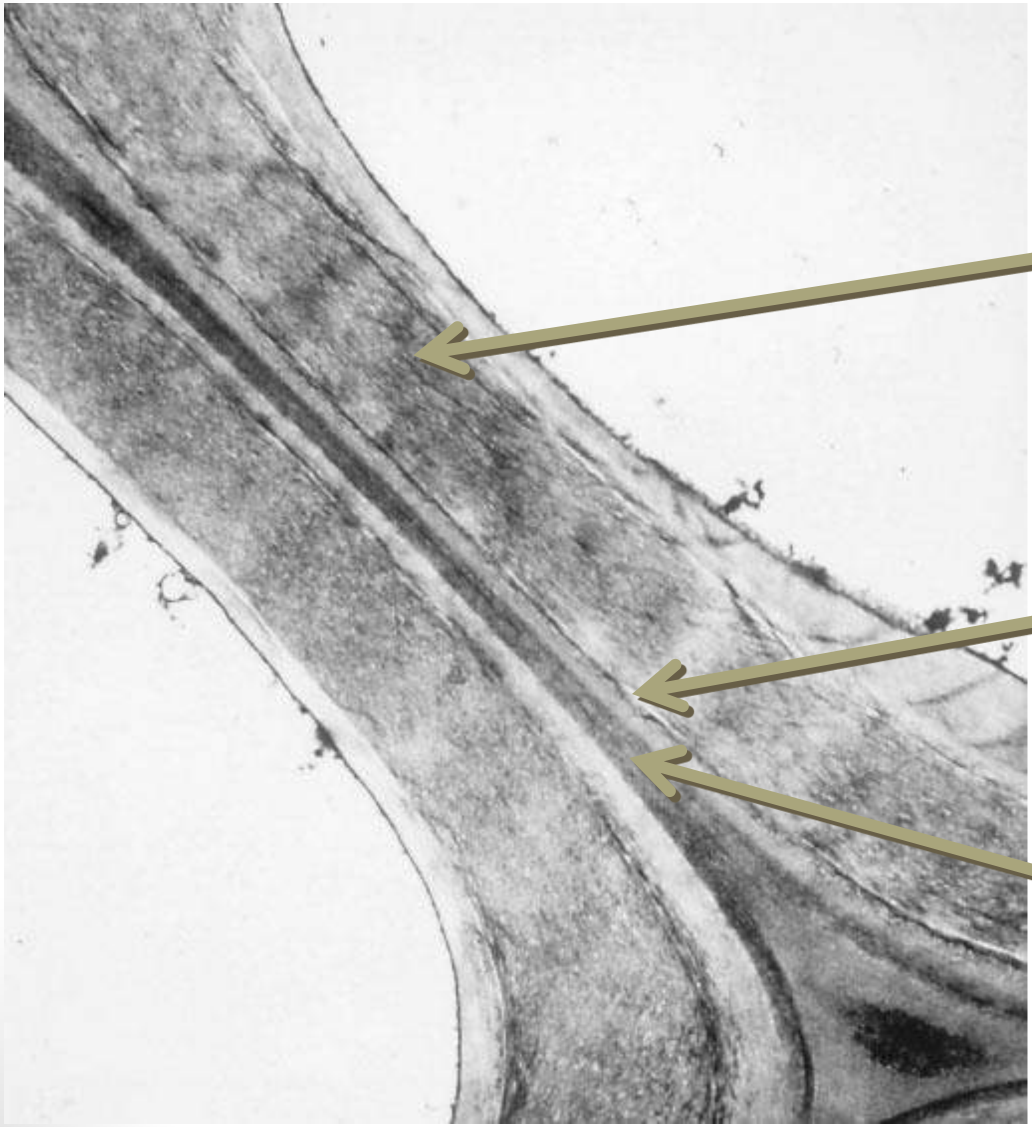
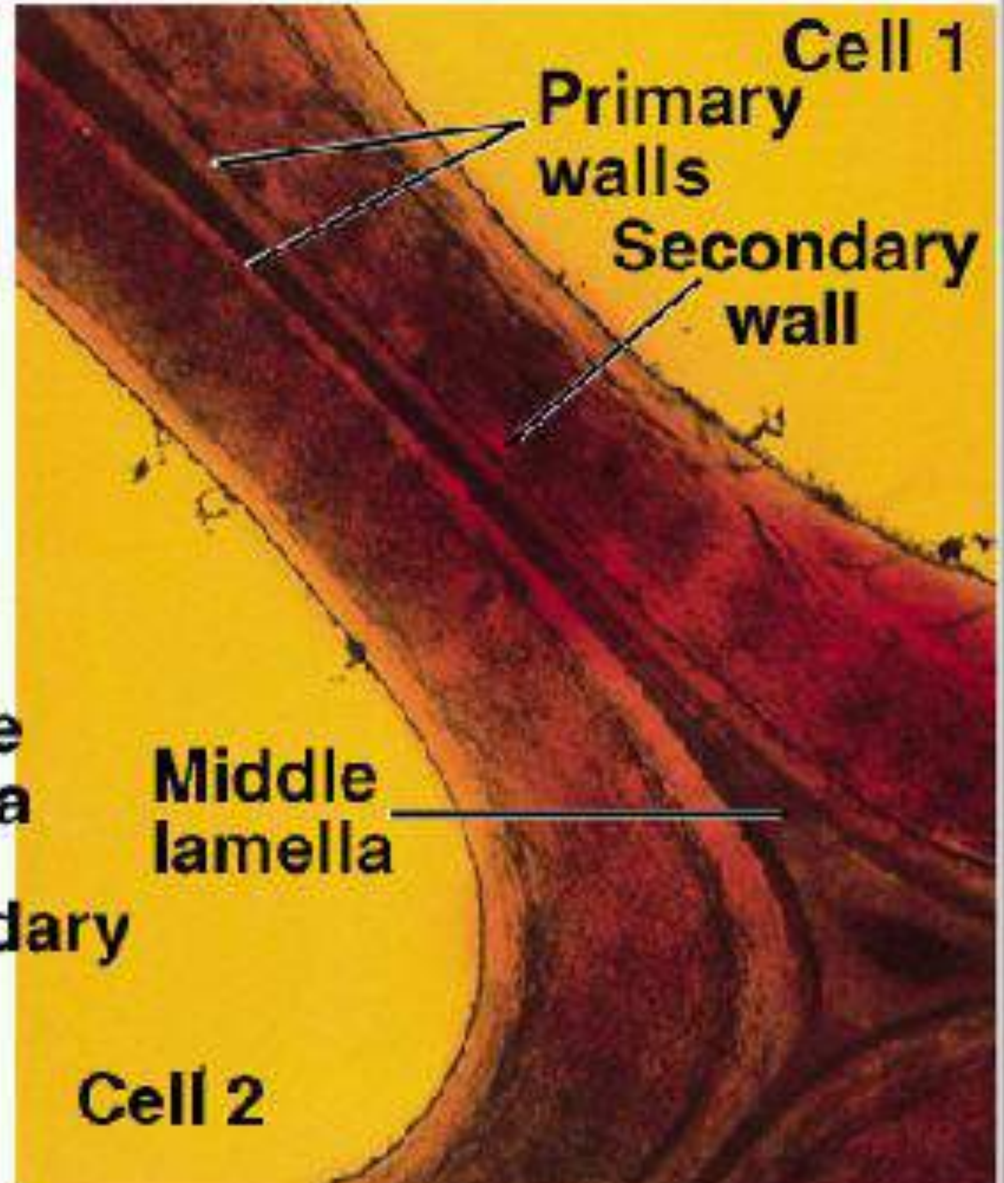

Primary wall
CELL 1
Three layers
of secondary wall
Middle lamella
Plant cell walls
Vacuole
Plasmodesma
Cytosol
Plasma membrane
Plant cell wall layers:
Middle lamella
Primary wall
Secondary wall
CELL 2
1 µm

Cell Wall Structure

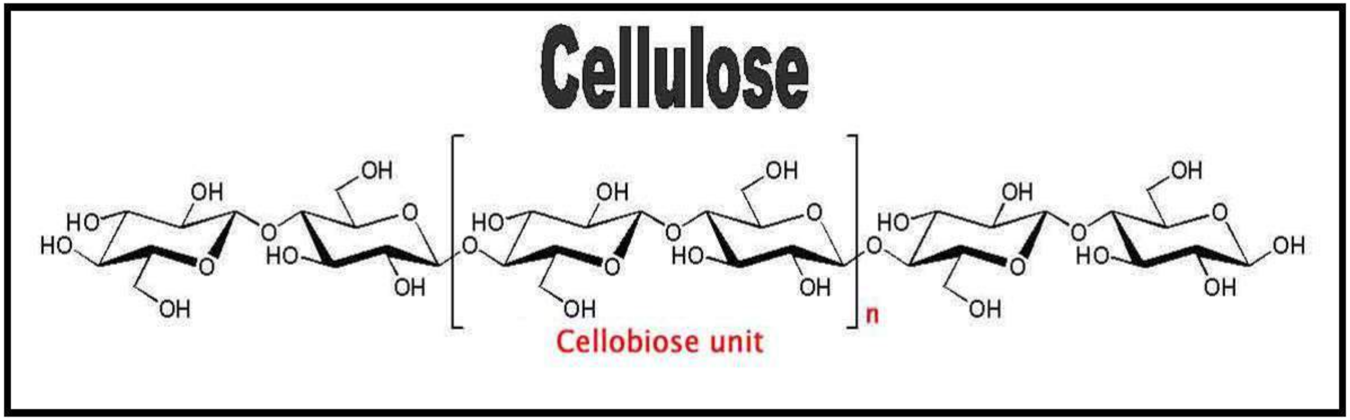


Plant Cell Walls

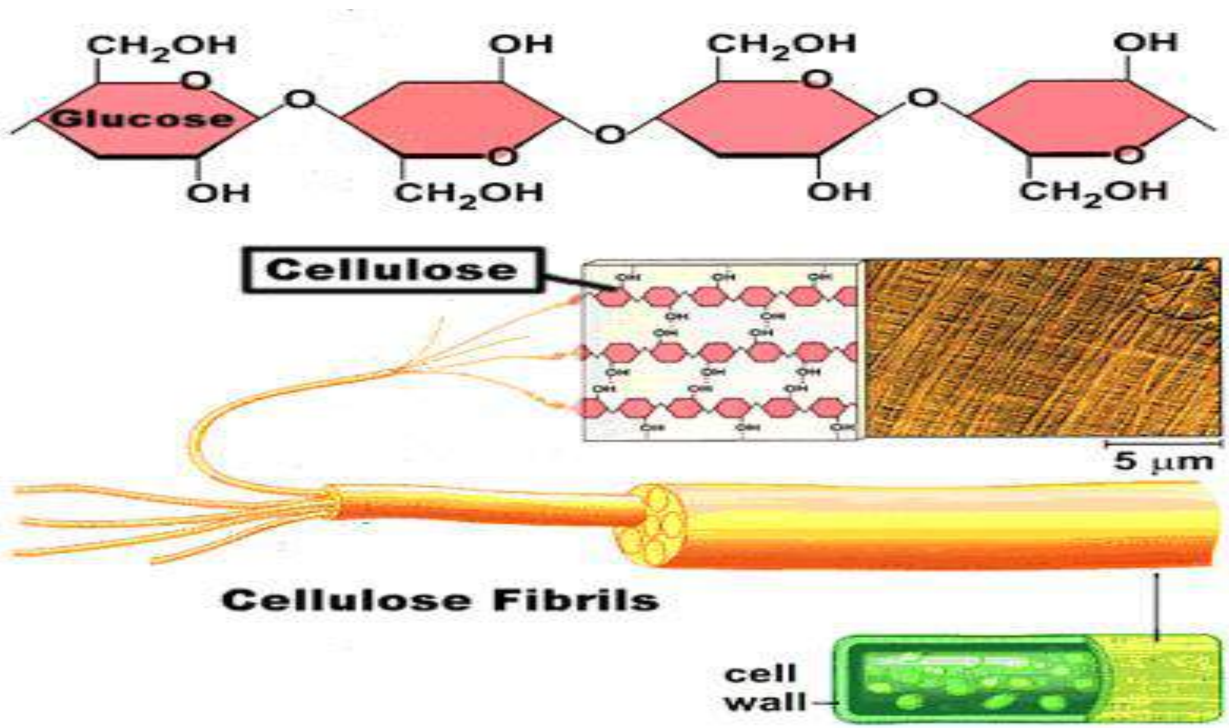


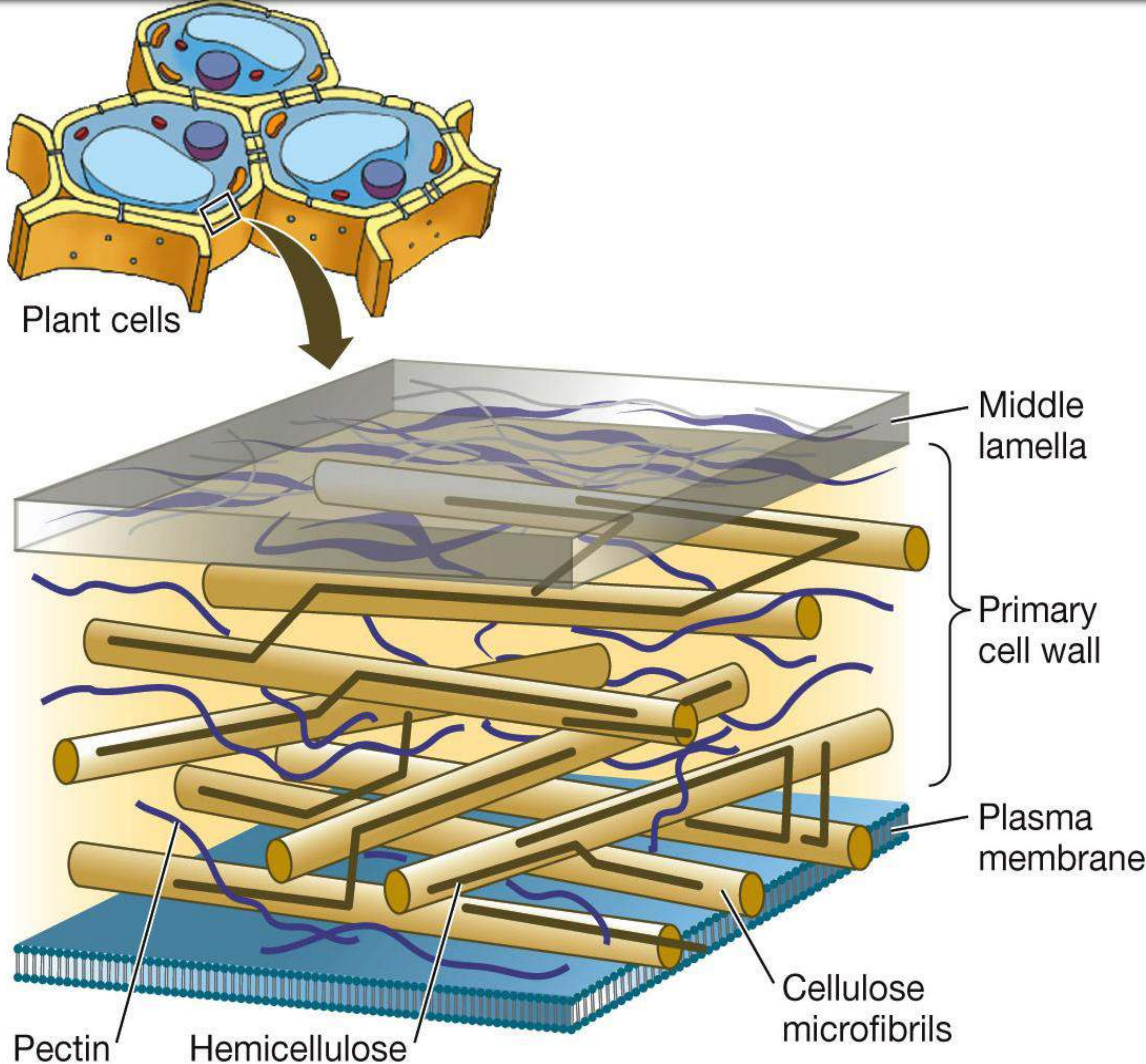
1- Primary wall

- It is the first wall formed by the protoplast and it is composed mainly of cellulose, beside pectin, glycoprotiens and hemicellulose.

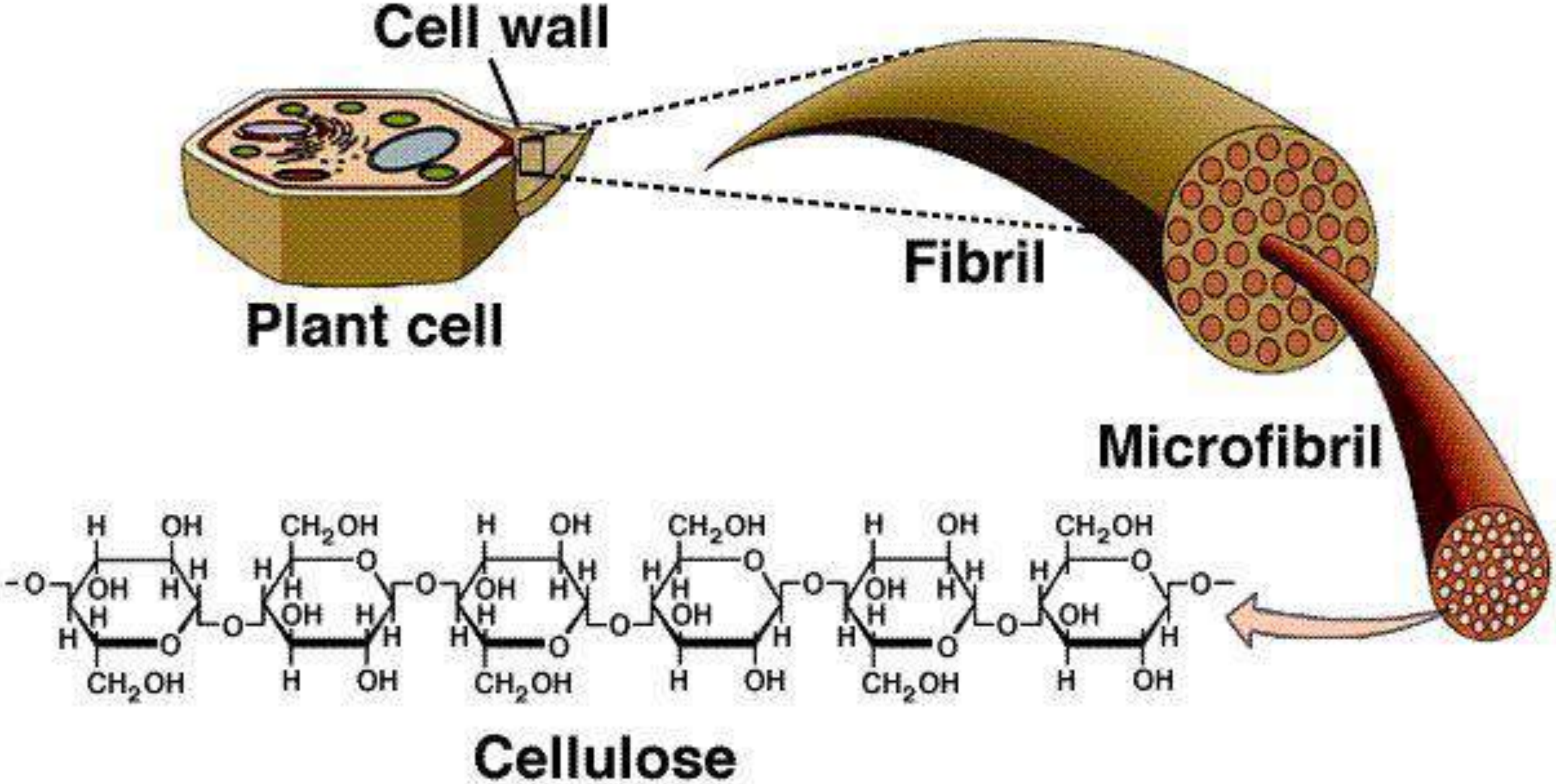


- Cellulose in primary wall is arranged of fibrils. There are two kinds of fibrils, macro (the largest) and micro fibrils




Plant cells
Middle lamella
Primary cell wall
Plasma membrane
Cellulose microfibrils
Pectin
Hemicellulose

Arrangement of Fibrils, Microfibrils, and Cellulose in Cell Walls



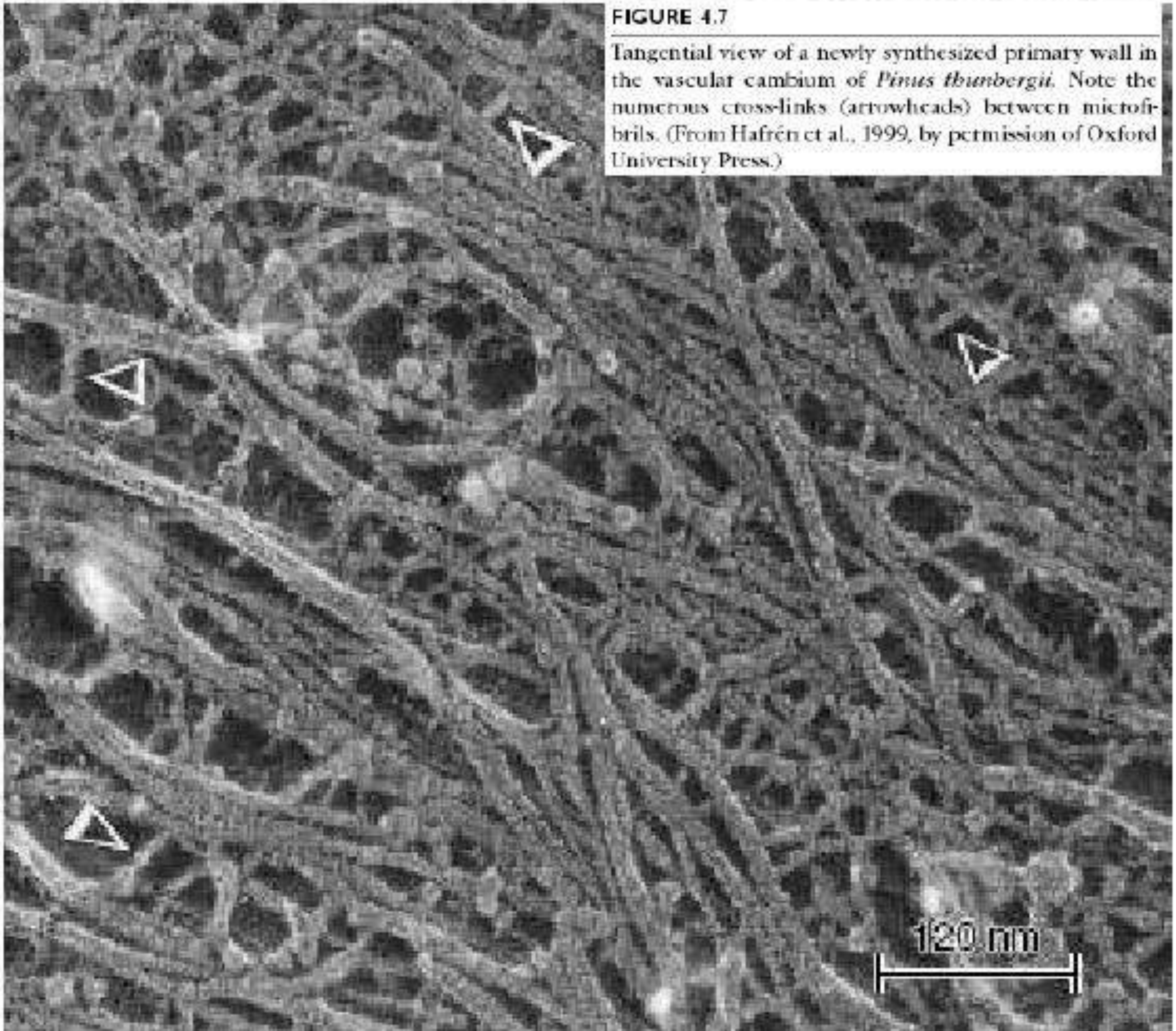
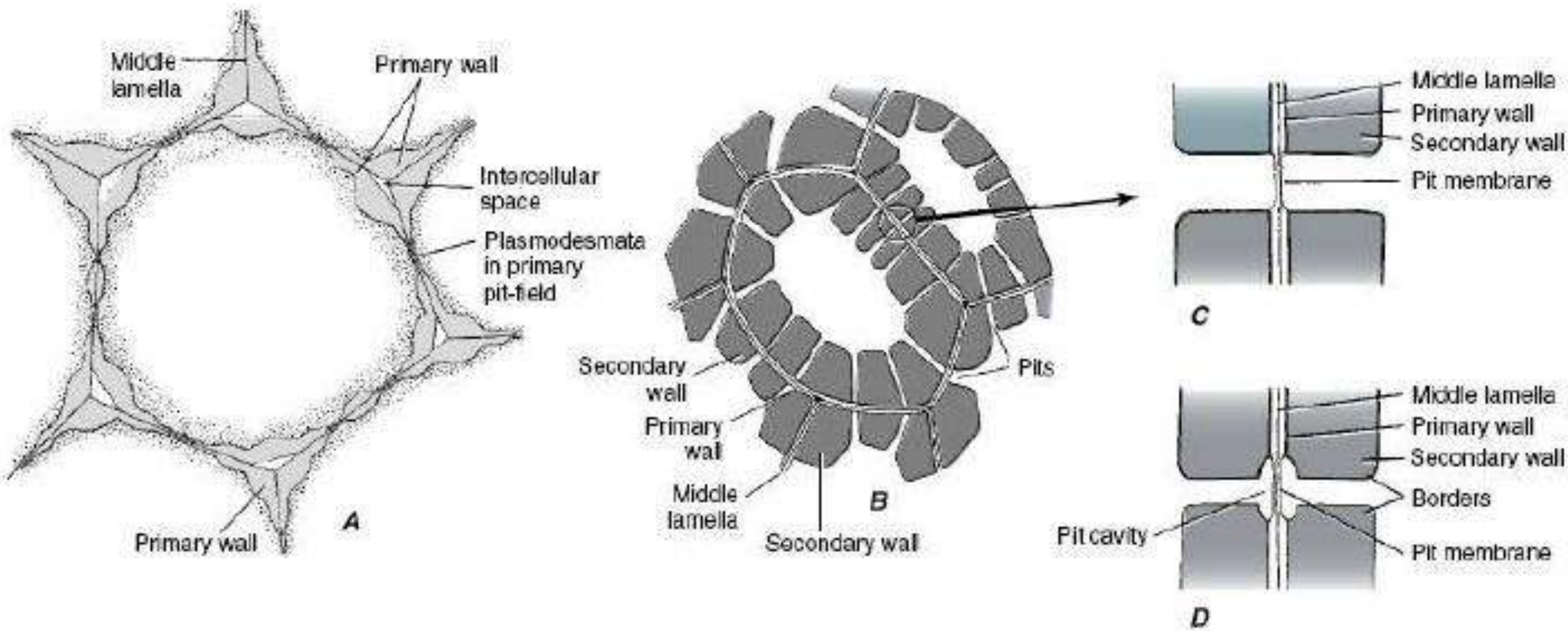
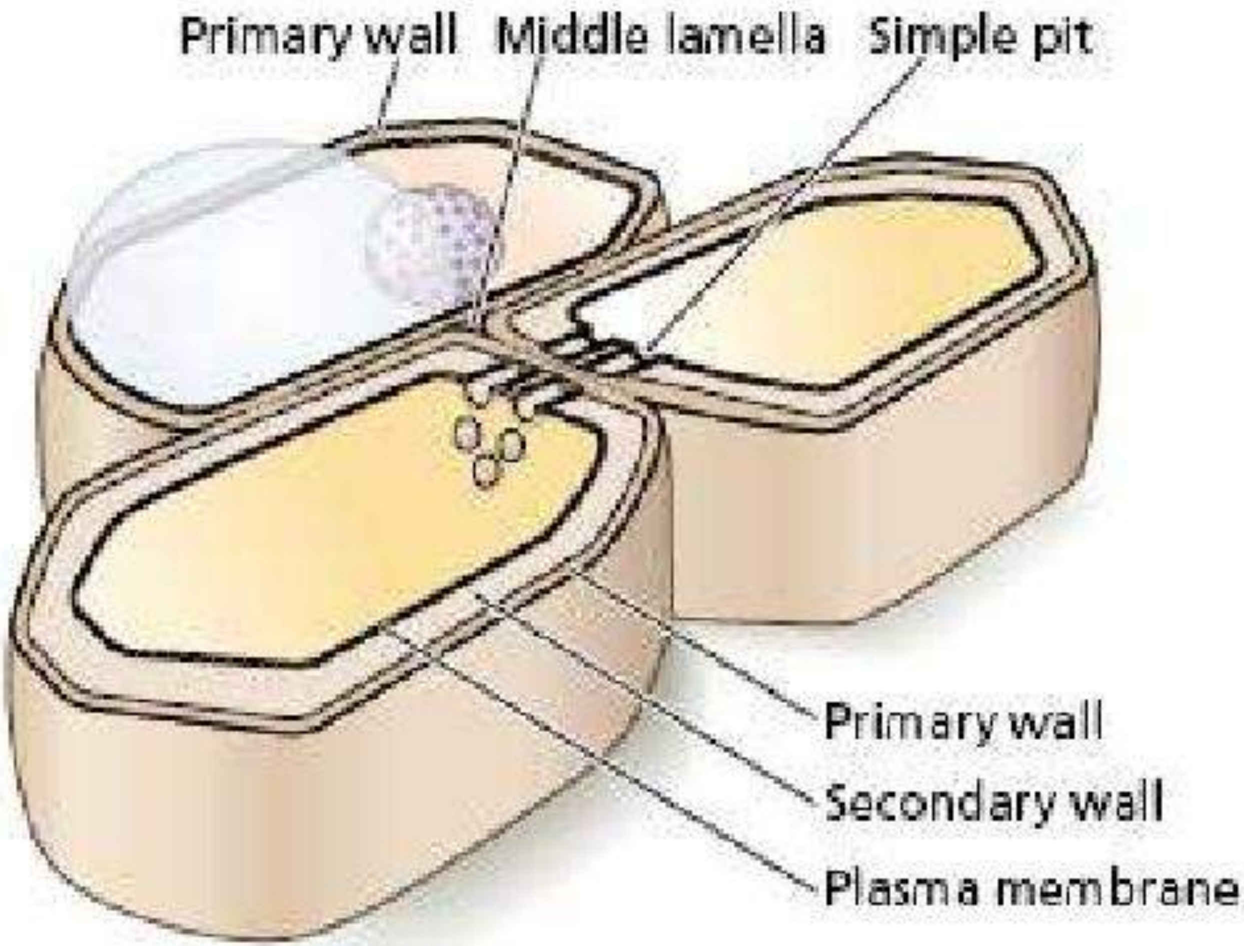


FIGURE 4.7

Tangential view of a newly synthesized primary wall in the vascular cambium of *Pinus thunbergii.* Note the numerous cross-links (arrowheads) between microfibrils. (From Hafrén et al., 1999, by permission of Oxford University Press.)



Middle lamella
Primary wall
Intercellular space
Plasmodesmata in primary pit-field
Primary wall
A
Secondary wall
Primary wall
Middle lamella
Secondary wall
B
Pits
Middle lamella
Primary wall
Secondary wall
Pit membrane
C
Middle lamella
Primary wall
Secondary wall
Borders
Pit cavity
Pit membrane
D



Primary wall
Middle lamella
Simple pit
Primary wall
Secondary wall
Plasma membrane

2- Middle lamella

- It is the region of union of the primary walls of two contiguous cells. The middle lamella is largely pectin (Mg + K) in nature but often becomes lignified in older cells.

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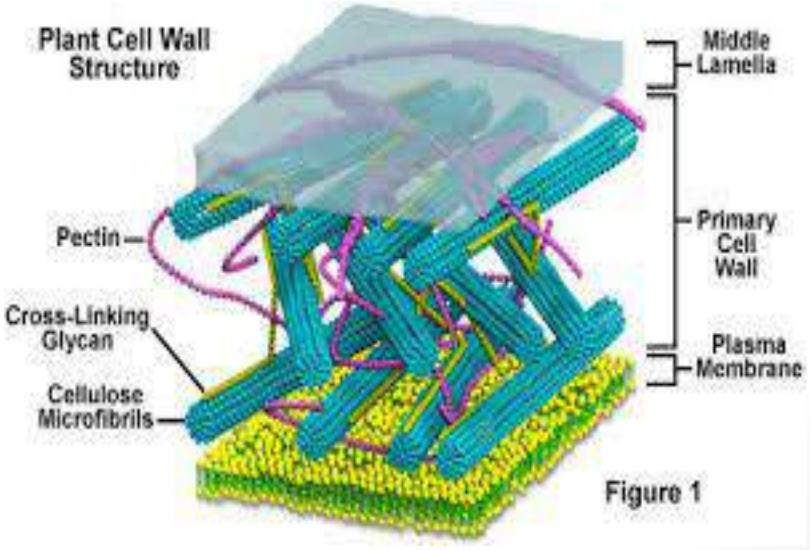
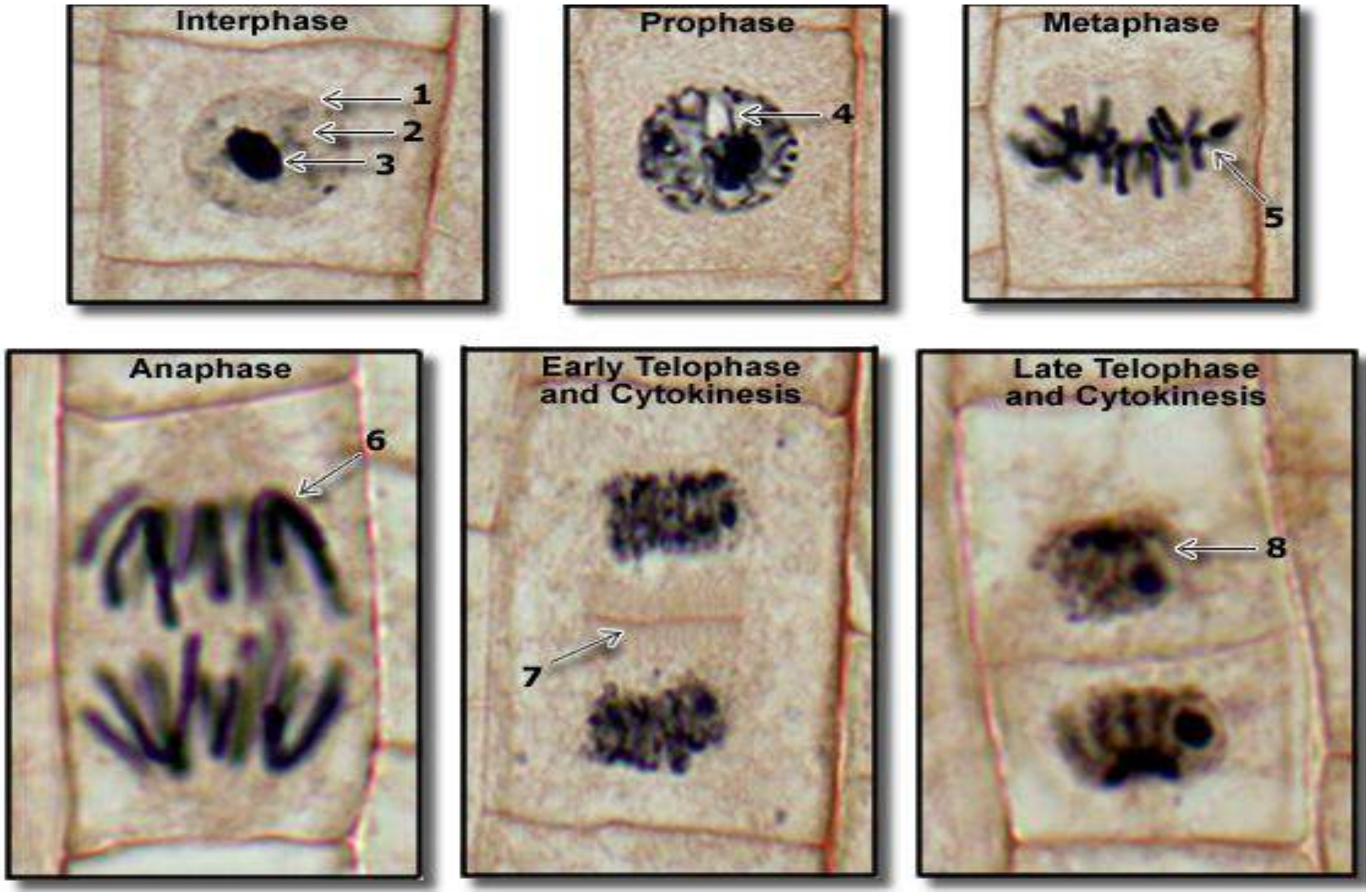


- Cell plate becomes the middle lamella



3- Secondary wall

- Three layers can be recognized in the mature secondary cell. These layers are designated S1, S2, and S3. The S2 layer is the thickest . The S3 may be very thin or lacking entirely.
- The separation of the secondary wall into the three layers results mainly from different orientations of microfibrils in the three layers.

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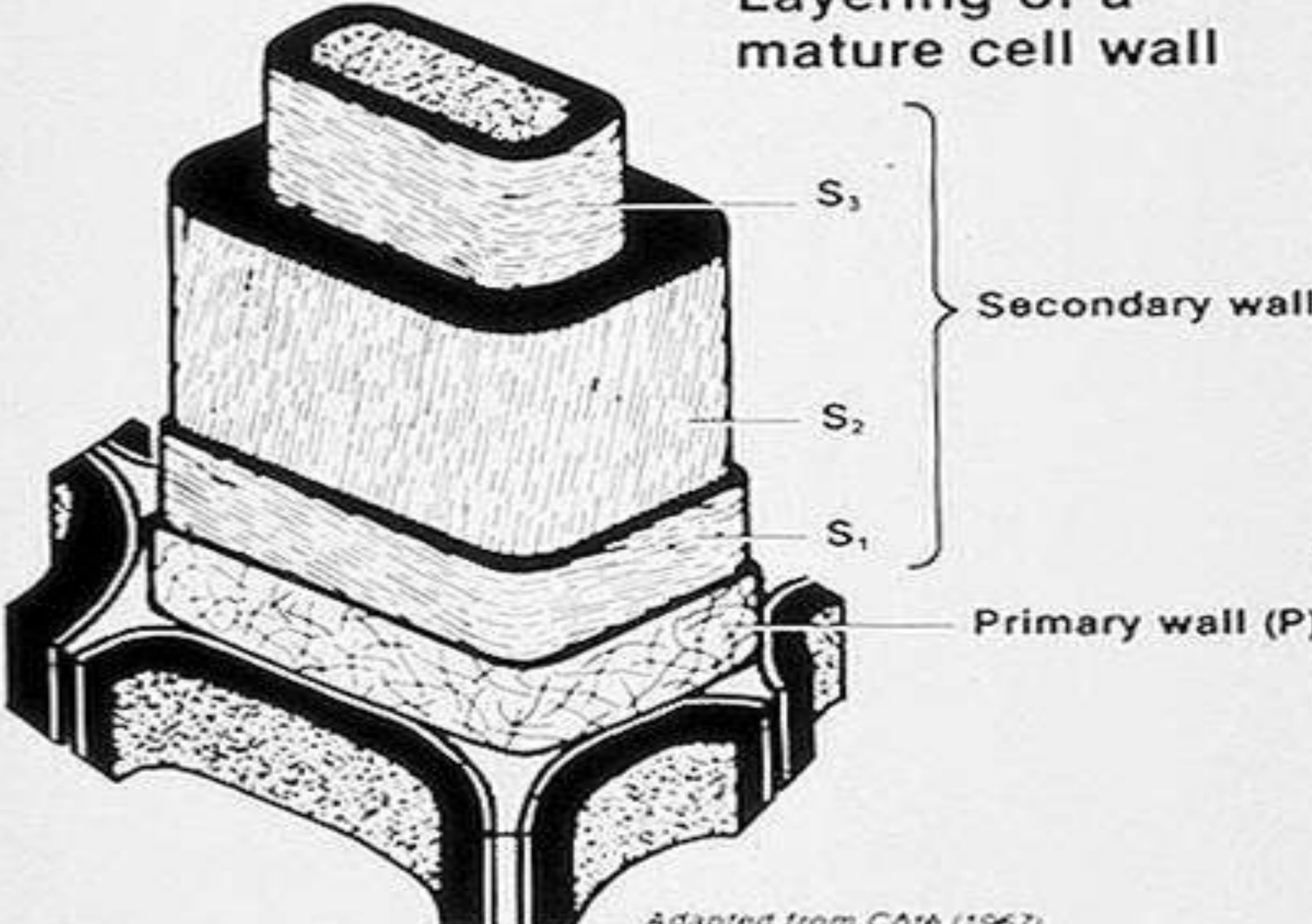
Layering of a mature cell wall



Adapted from Côté (1967)

- The secondary wall components are deposited by the protoplast. Cellulose, lignin, suberin are the main compound of the secondary wall.
- Some cells have this wall,
- It is rigid , when it is deposited no more increasing in the cell size.
- Cells have the secondary wall die after secondary wall formation.

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Cells having S.W.

Vessels

- Trachieds
- Cork cells
- Secleranchyma cells
- Xylems parenchyma cells
- Some epidermal layers tissue in conifers

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Protoplast

- Protoplast consists of two main parts:
- 1- Protoplasmic (living) components.
- 2- Ergastic (non-living) substances.

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Protoplasmic components

- 1- Cytoplasm: It is the protoplamic matrix surrounding the nucleus.
- Cytoplasm contains proteins, lipids, nucleic acids, and other substances soluble in water.
- The cytoplasm is viscous and capable of forming gel.
- Cytoplasmic movement is frequently observed in living cell.
- The cytoplasm is delimited from the cell wall by the plasmalemma, and from the vacuole by the tonoplast.

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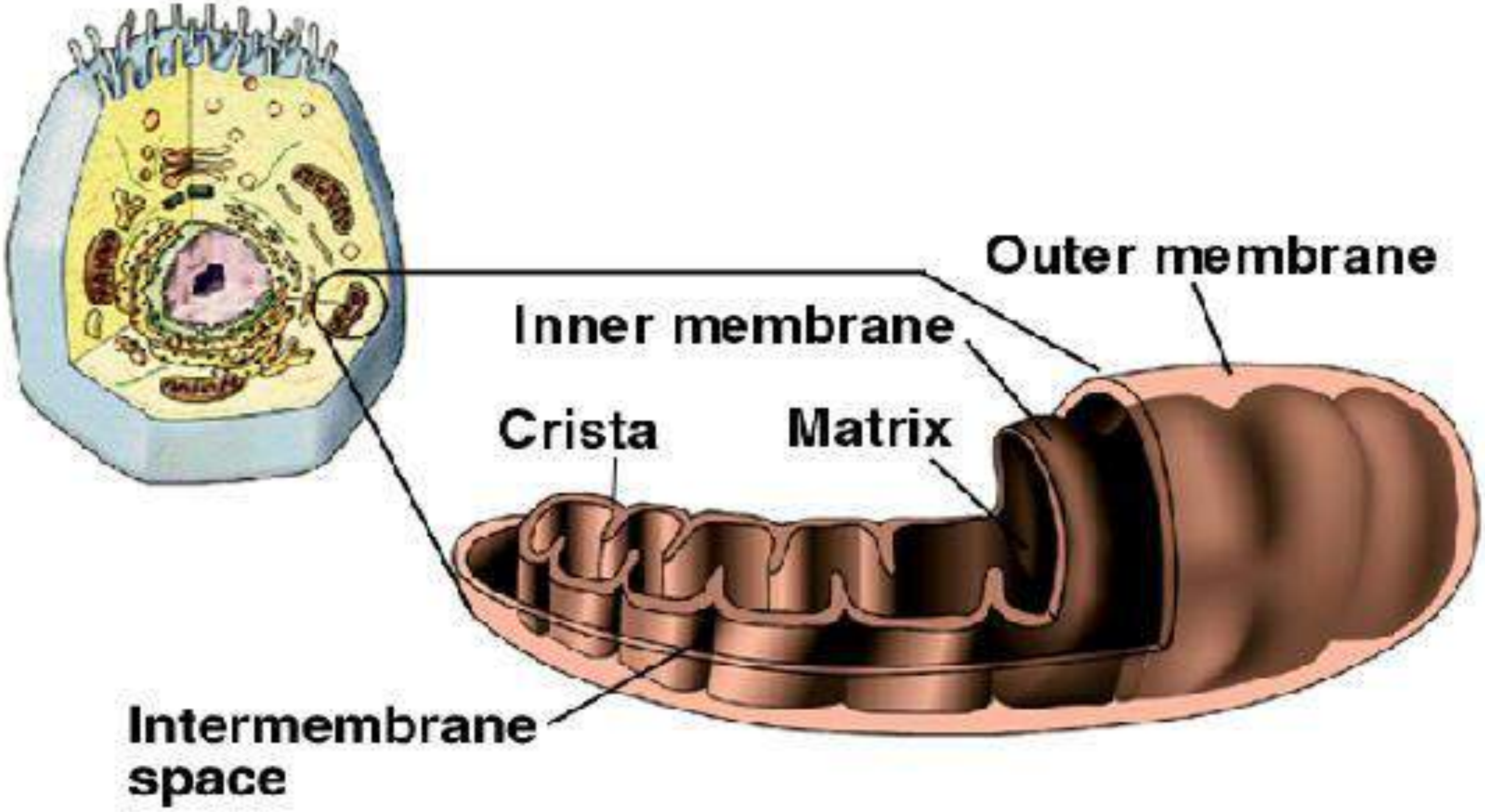
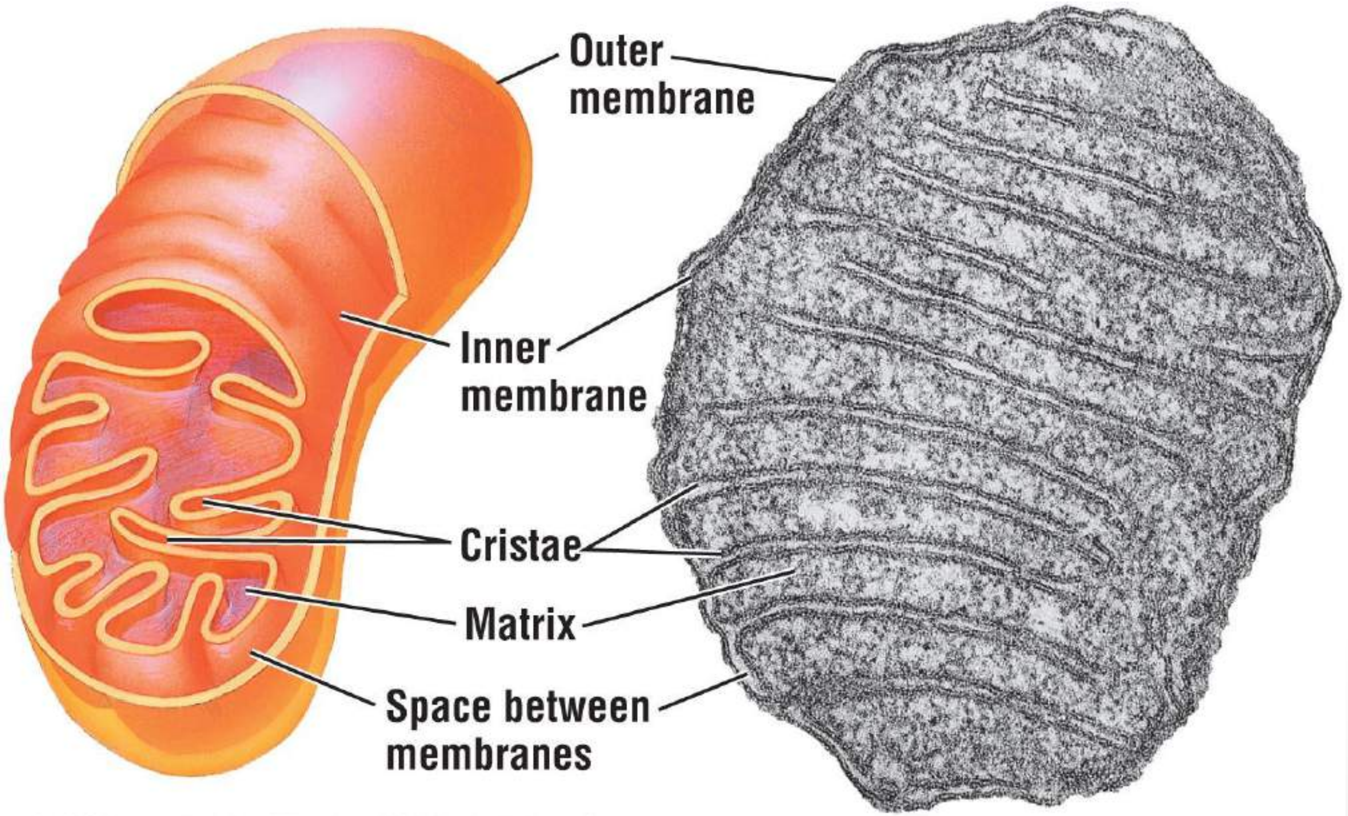
- 2- Mitochondria
  - Is the main power source of a cell.
  - It is the organelle in which sugar is broken down to produce energy.
  - Mitochondria is covered by two membranes (outer membrane, inner membrane).

Mitochondria



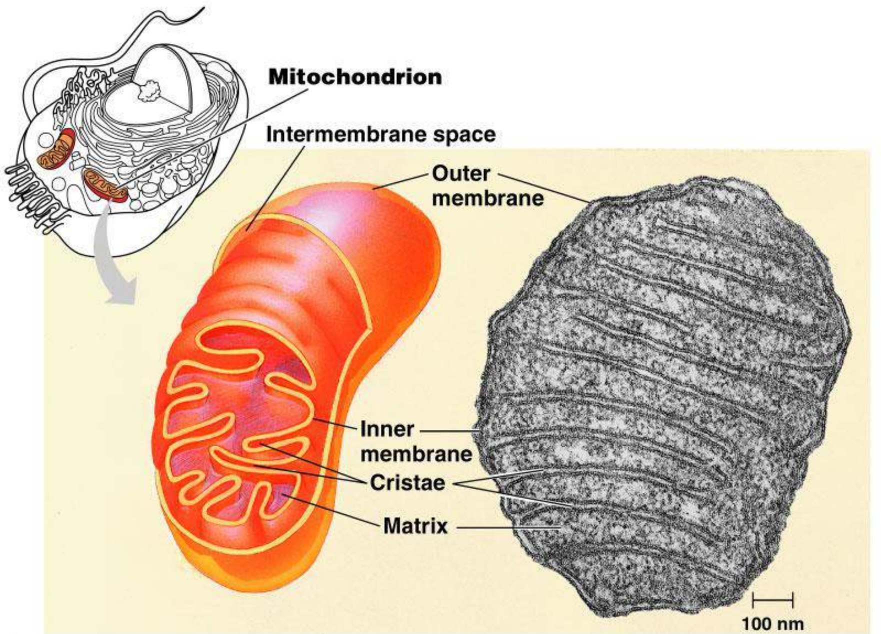
Mitochondria

- Mitochondria are the sites of cellular respiration, which involves the production of ATP from food molecules.



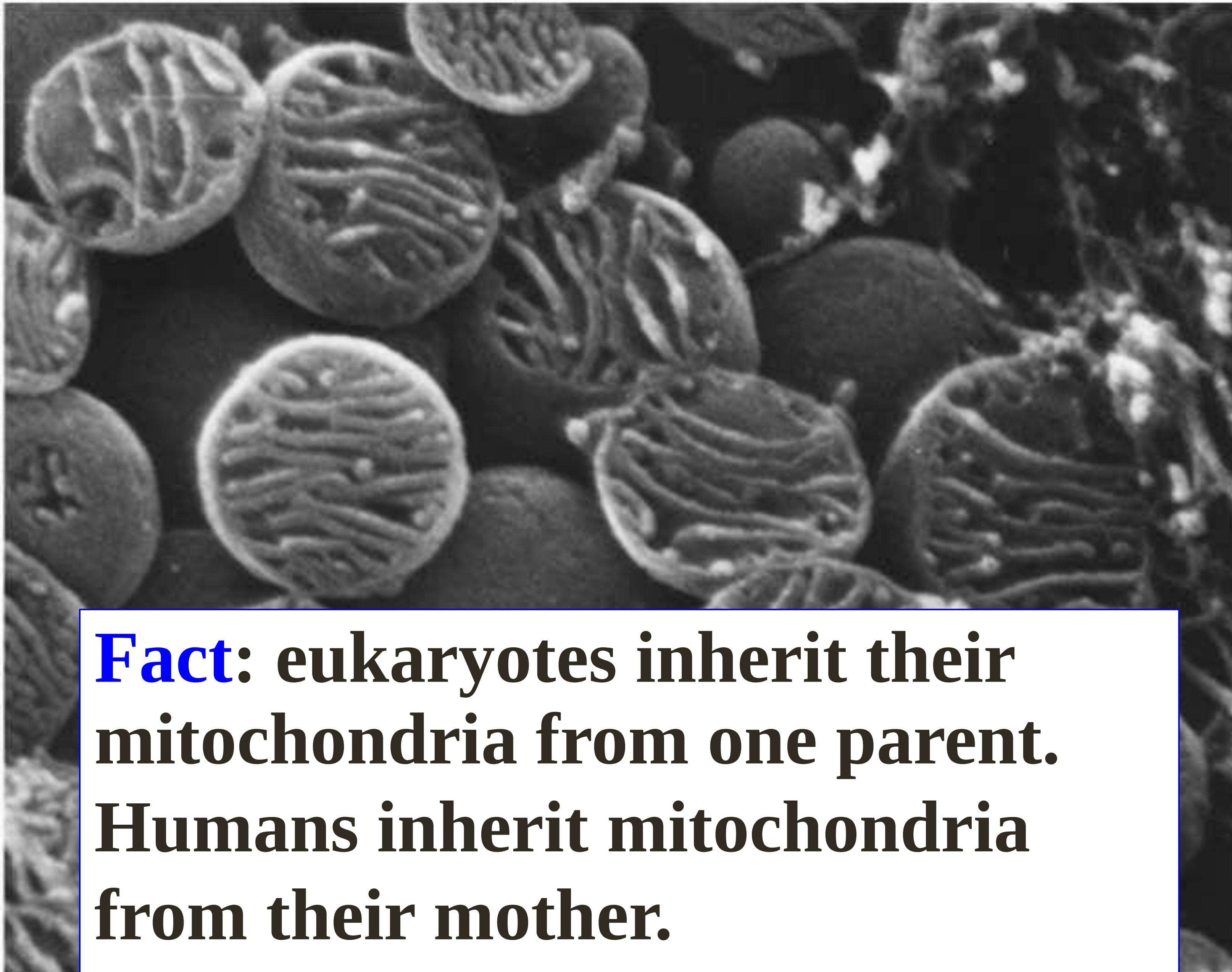
Mitochondria

The mitochondria is a double membrane structure with an outer membrane which surrounds a highly folded inner membrane. It is the site of aerobic cellular respiration in which ATP is produced. The inner membrane has finger like projection called cristae which increase the surface area. The inner space within the mitochondrion is called the matrix and contains cytoplasm, ribosomes, and DNA. Mitochondrion are self replicating. All animal's mitochodria originate from the mitochondria present in their mother's egg! They are found in both plant and animal cells and are sometimes called "the powerhouse of the cell".



Mitochondria

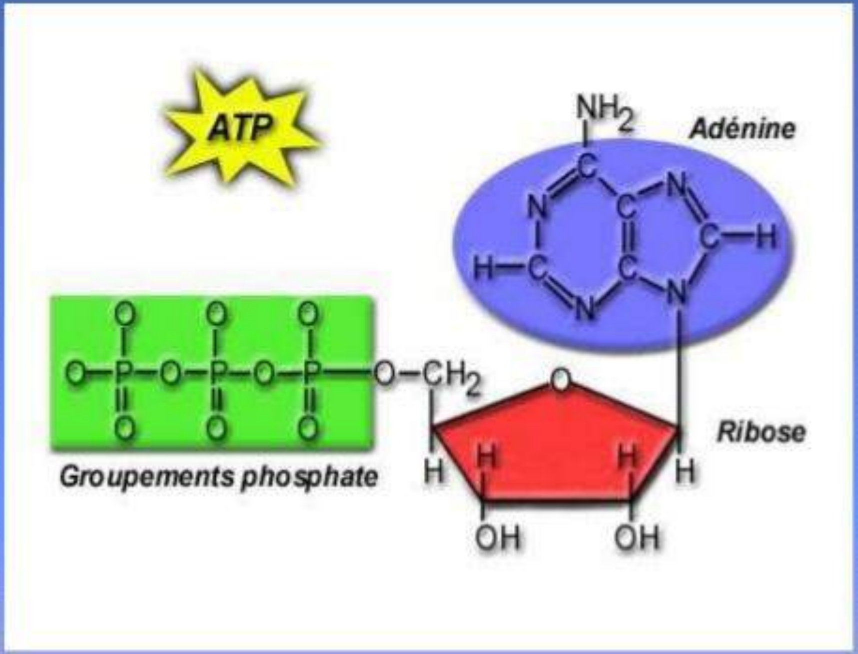
- Energy released by mitochondria is stored in a substance called ATP (adenosine triphosphate).
- Most eukaryotic cells have mitochondria.
- Mitochondria are the size of some bacteria.
- Mitochondria have their own DNA, and can divide within a cell.



Fact: **eukaryotes inherit their mitochondria from one parent. Humans inherit mitochondria from their mother.**

5 micrometers

ATP

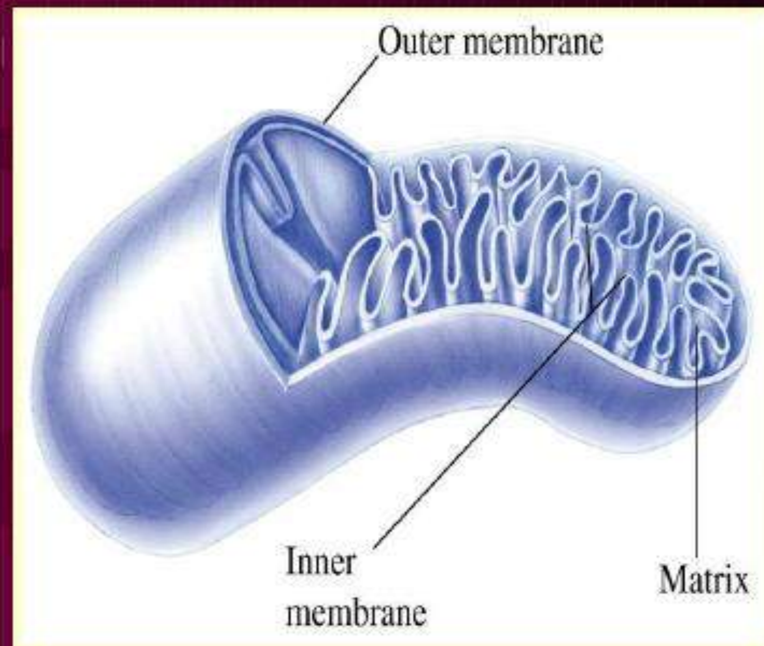


- Adenine (blue part)
- Ribose (red part)
- 3 phosphates (green part)

The Mitochondria structure has three main parts:

OUTER MEMBRANE:
covers the mitochondria

INNER MEMBRANE:
folds many times to increase the surface area because chemical reactions (glycolysis) occur here
So…the more space it has the more energy it can create



- They break down food molecules so the cell has the energy to live

- If a cell needs a lot of energy…it will have more mitochondria

3- Plastids

- Plastids are characteristic organells of eucaryotic cells.
- This term was coined by Schimper in 1885.
- Plastids are large cytoplasmic organelles.
- They are the site of manufacture and storage of important chemical compounds used by the cell.

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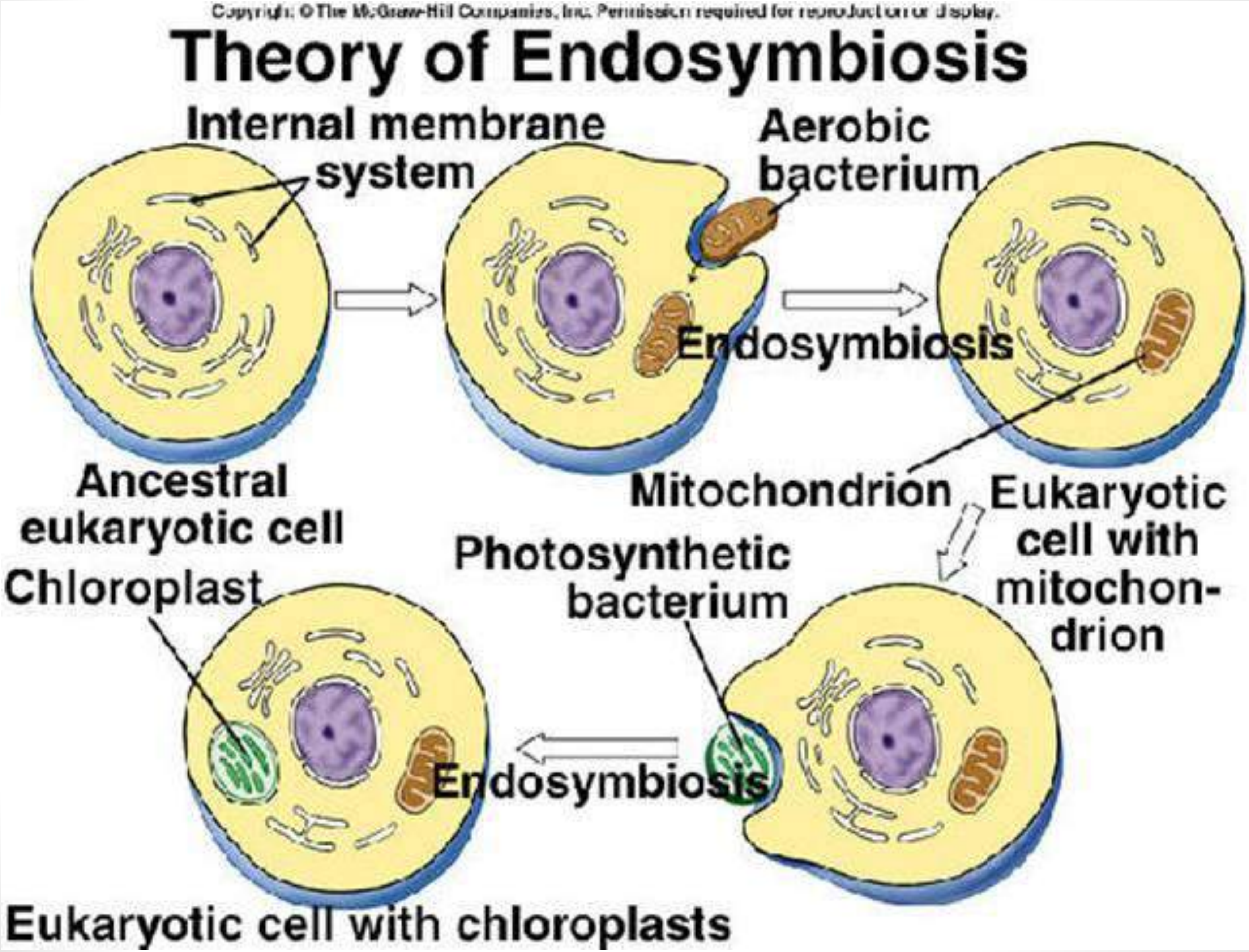
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Theory of Endosymbiosis
Internal membrane system
Aerobic bacterium
Endosymbiosis
Ancestral eukaryotic cell
Mitochondrion
Eukaryotic cell with mitochon-drion
Photosynthetic bacterium
Chloroplast
Endosymbiosis
Eukaryotic cell with chloroplasts

- Plastids often contain pigment used in photosynthesis, and the types of pigments present can change or determine the cell,s color.
- They appear in many forms and sizes .
- They are categorized chiefly on the basis of presence or absence and type of pigmentation.

- Plastids are originated from the proplastids.
- Proplastids are colorless and lack an inner membrane system.
- One type of plastid may change into another.

- Proplastids : The plastids present in meristematic cells.
- They are simpler in internal structure than plastids and have fewer thylakoids, they are not arranged in grana stacks.
- Proplastids frequently divide and become distributed throughout the cell; after a cell divides.
- Plastids also arise through the division of mature plastids.

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- Plastids contain DNA and ribosomes and thus could be genetically autonomous.
- This led to the concept that plastids originated as free-living procaryotes.

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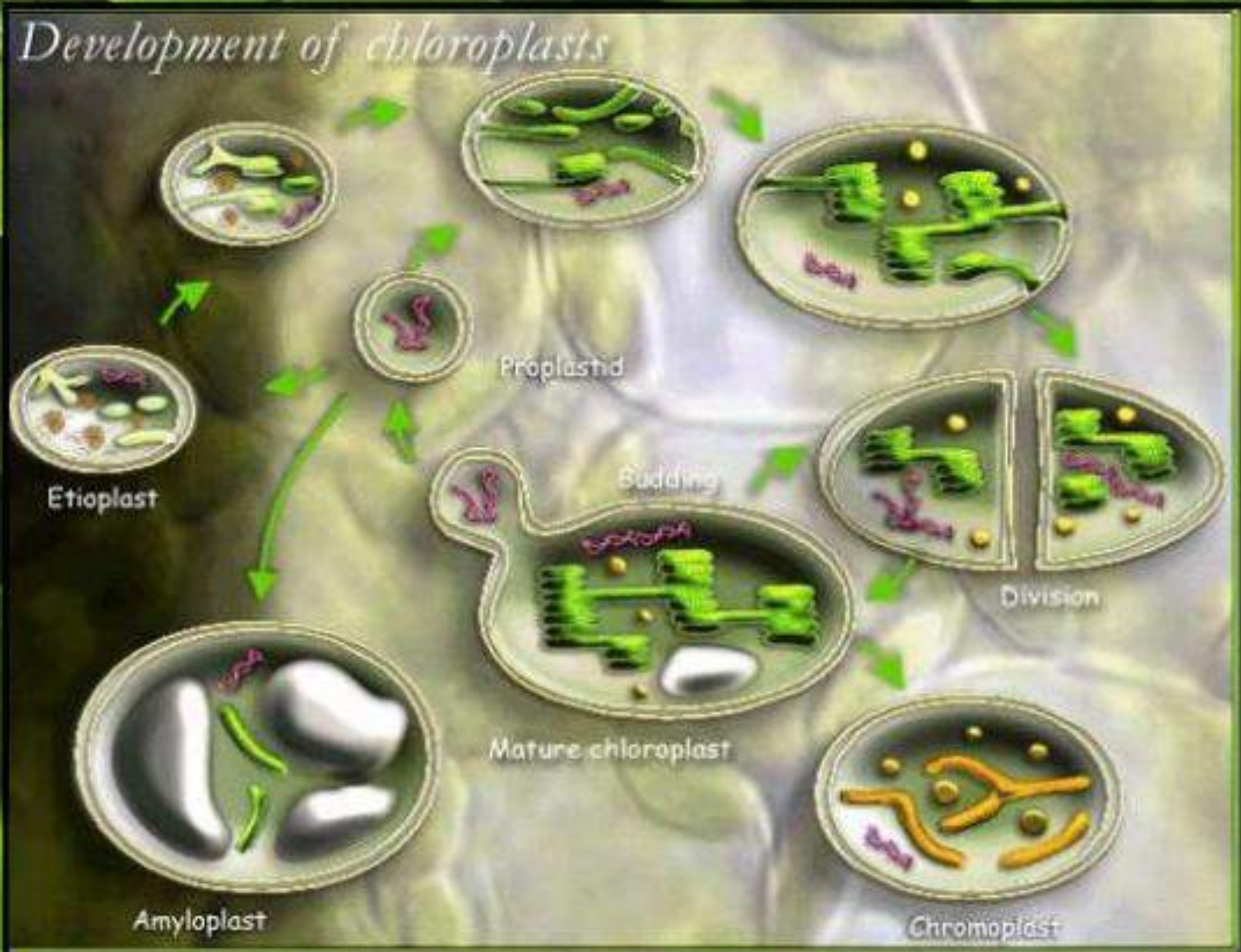
Inheritance of plastids

- Most plants inherit the plastids from only one parent. In general, angiosperms inherit plastids from the female gamete, whereas many gymnosperms inherit plastids from the male pollen. Algae also inherit plastids from only one parent.

- The plastid DNA of the other parent is, thus, completely lost. Approximately 20% of angiosperms, including alfalfa (*Medicago sativa*), normally show biparental inheritance of plastids.

BIOGENESIS OF CHLOROPLAST



Categories of plastids

- There are seven types of plastids:
- a- Chloroplasts
- b- Chromoplasts
- c- Tannosomes
- d- Leucoplasts
- e- Amyloplasts
- f- Elaioplasts
- g- Protienoplasts
- h- Etioplast

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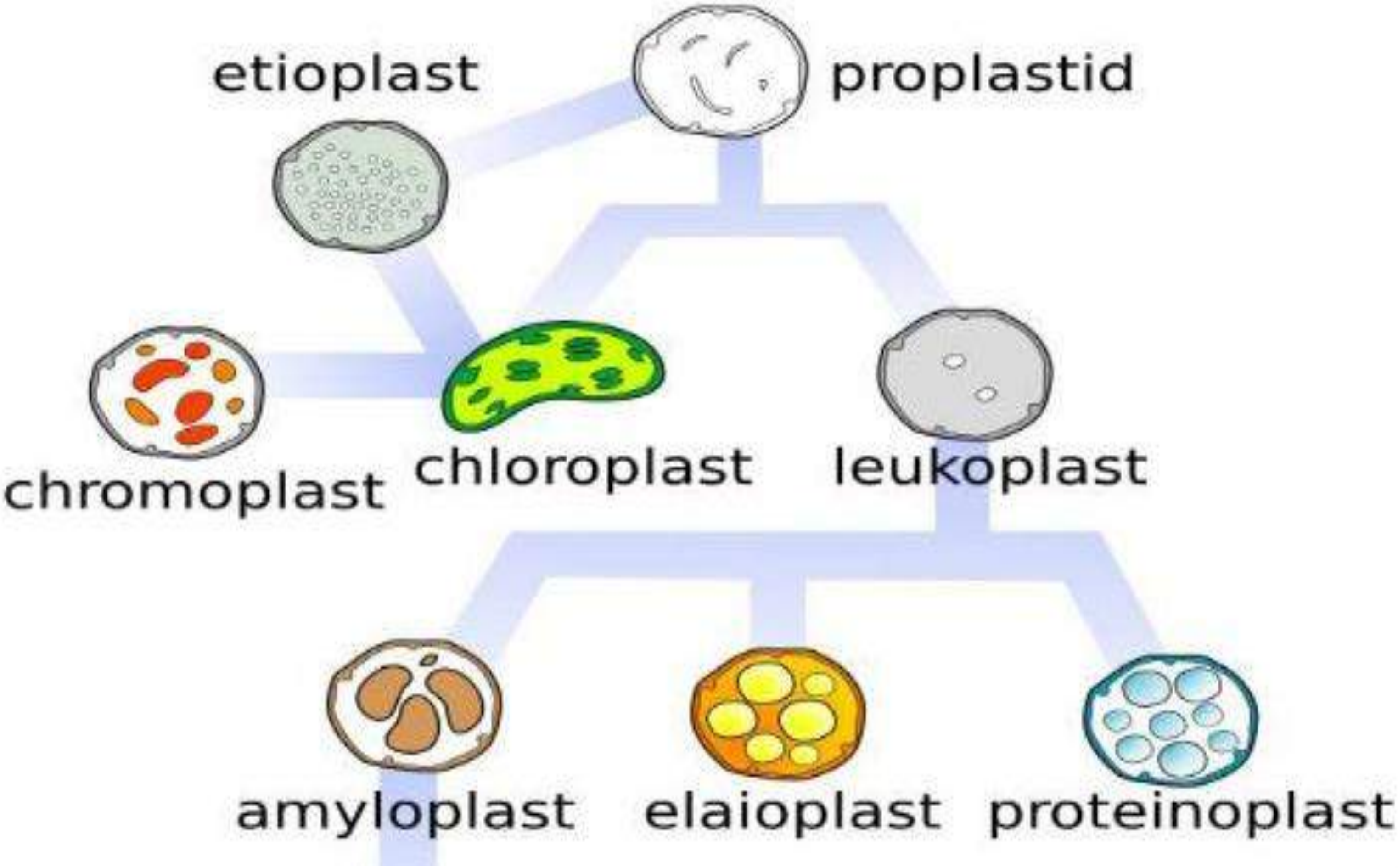

etioplast
proplastid
chromoplast
chloroplast
leukoplast
amyloplast
elaioplast
proteinoplast

Chloroplasts

- Number of chloroplast in a green cell of higher plants is 75 – 125 , with the green cells of a few plants having several hundred .
- Chloroplasts may be from 2-10 micrometers in diameter.

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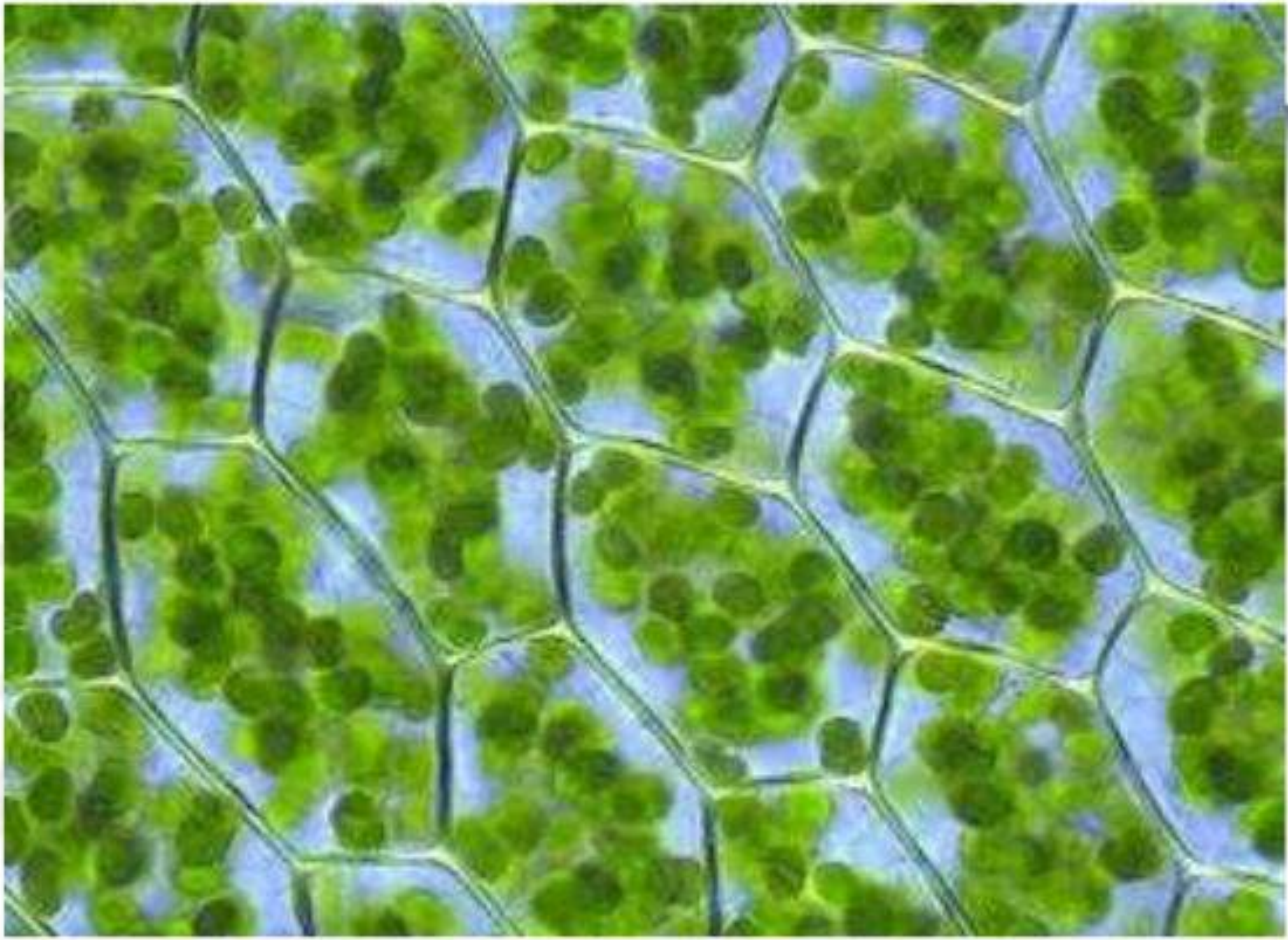
- **Chemical Composition:**
- Chloroplast limiting membranes contain normal lipid protein composition. But the granal membranes including both thylakoid and intergranal membranes, posses 20-30% of the lipids and the rest of it is all proteins. The most common lipids found in these membranes are ethanolamine, sulfolipids, phytosterols and glycolipids and pigments

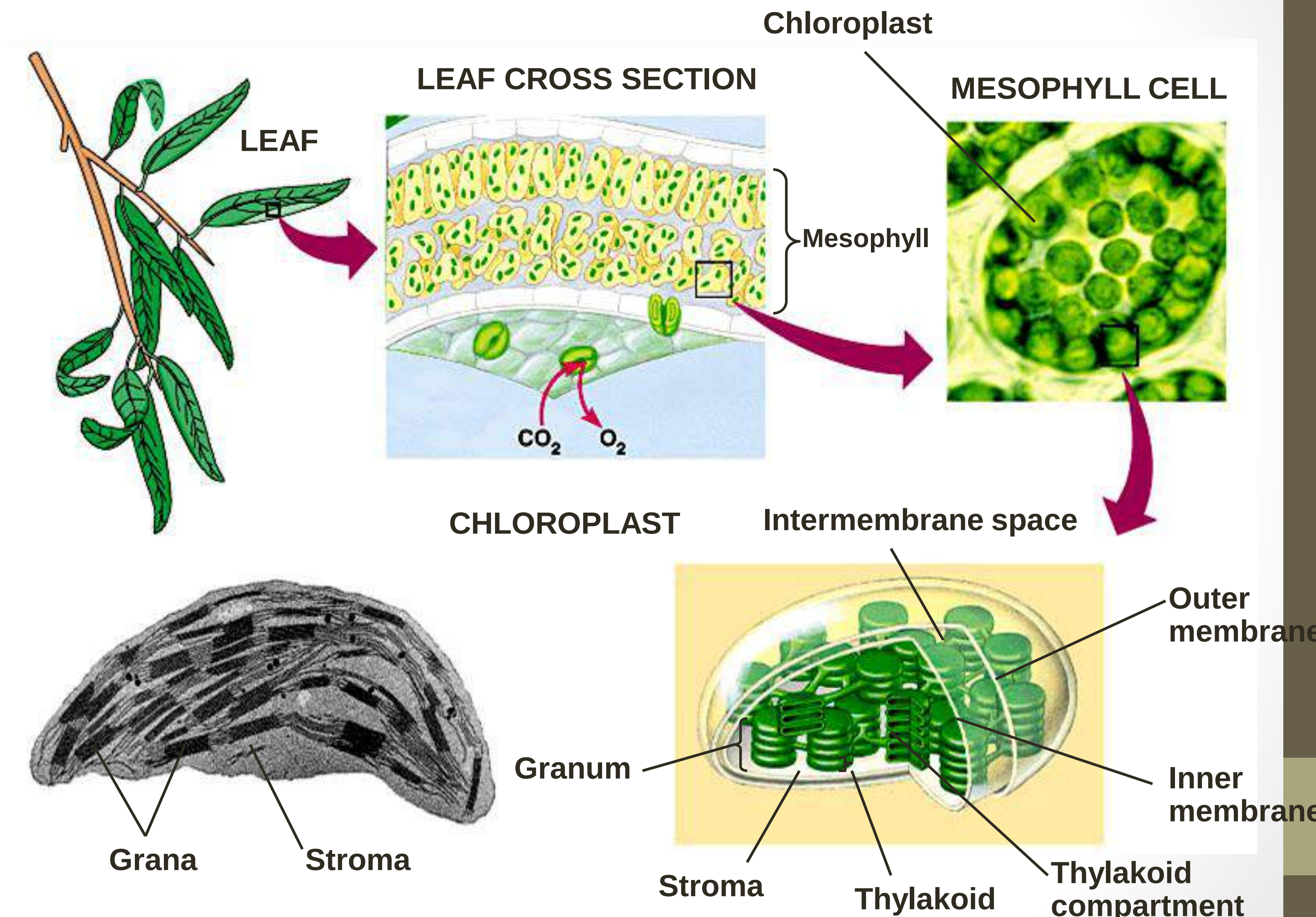
Chemical Constituents	Percent dry weight	Components (Percent)
1.Protein	35-55	Insoluble 80%
2.Lipids	20-30	Fats 50% Sterols 20% Wax 16%Phosphatides 2-7%
3.Carbohydrates	Variable	Starch, Sugar , Phosphates 3-7%
4. Chlorophyll	9.0	Chlorophyll a 75% Chlorophyll b 25%
5.Carotenoids	4.5	Xanthophyll 75% , Carotene 25%
6. Nucleic acid RNA , DNA	3-4 < 0.02-0.1	

- Each chloroplast is bounded by an envelope consisting of two delicate membranes.
- The outer membrane is derived from endoplasmic reticulum, while the inner membrane is believed to have originated from the cell membrane.

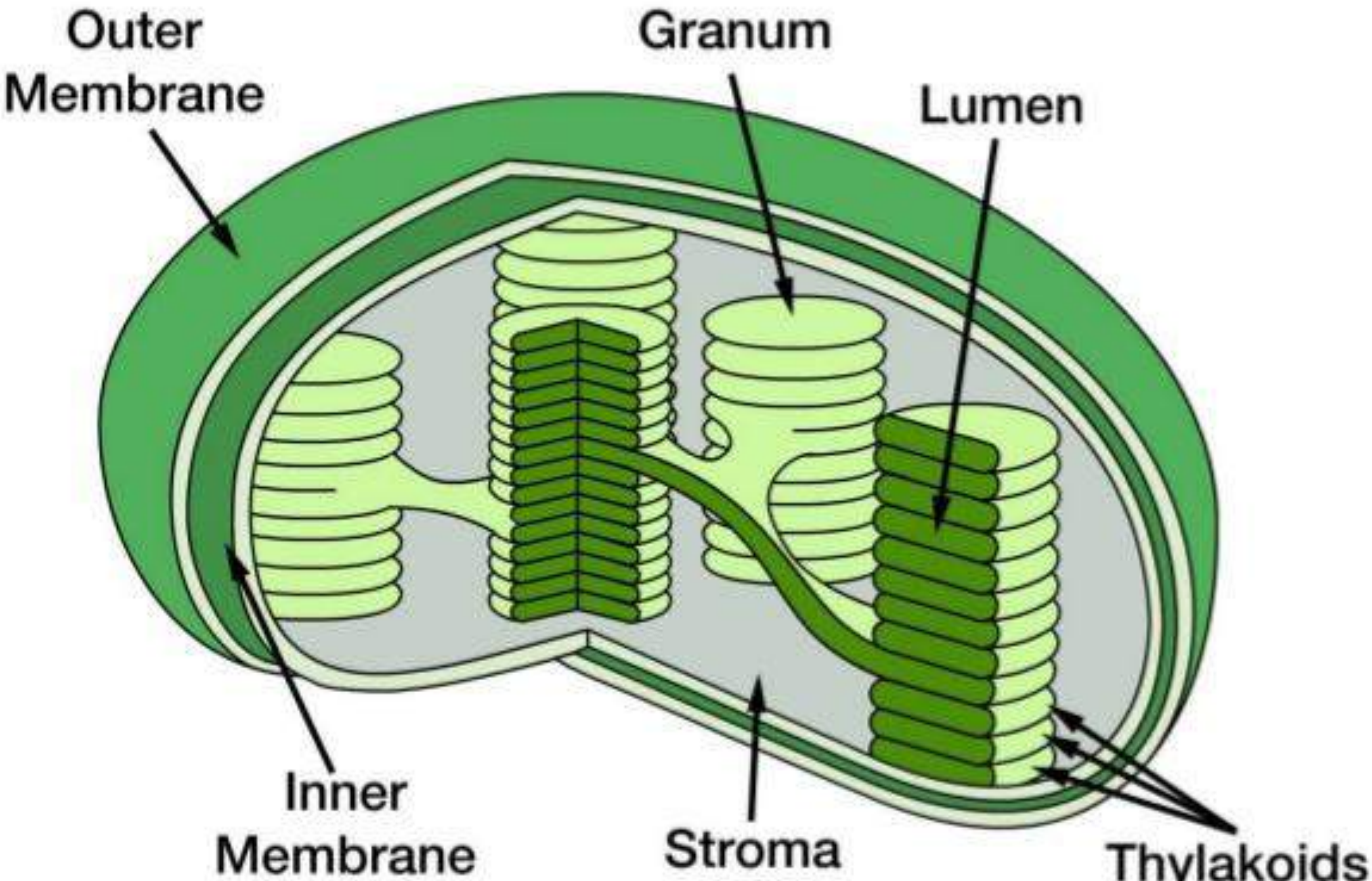
- Chloroplast also contains some metallic ions like Fe, Cu, Mn and Zn



- The location and structure of chloroplasts



Chloroplast

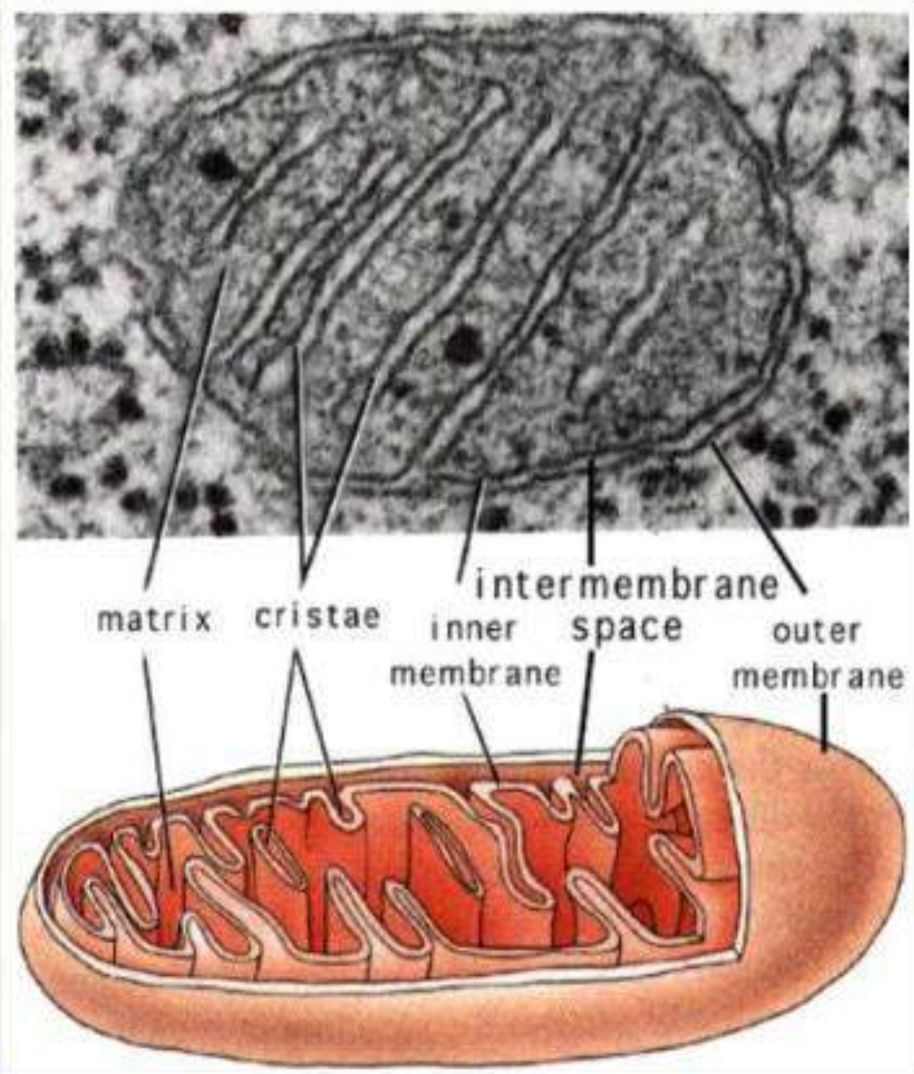


Chloroplast

- Kloros means green.
- Green colored bodies containing chlorophyll.

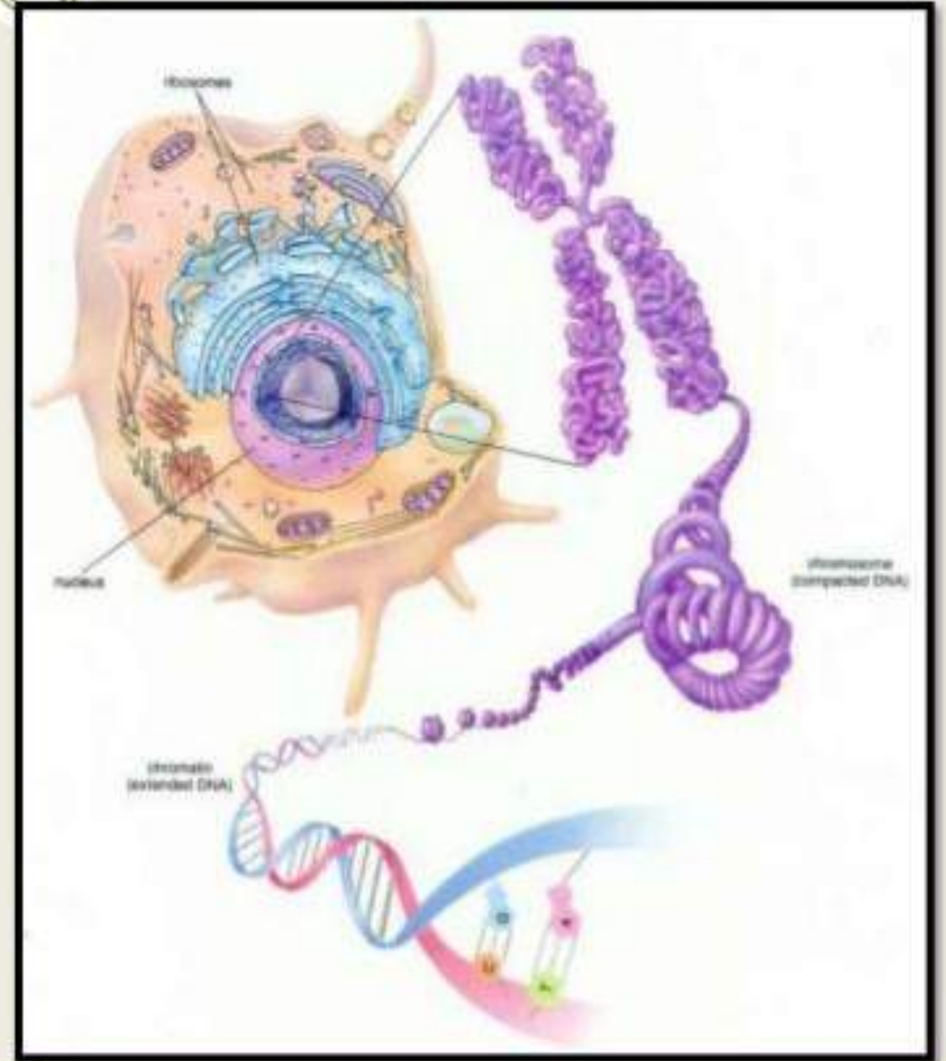
Chloroplast

- Larger and more complex than Mitochondria.



Chloroplast

- Also contain DNA
- Membranous organelle.

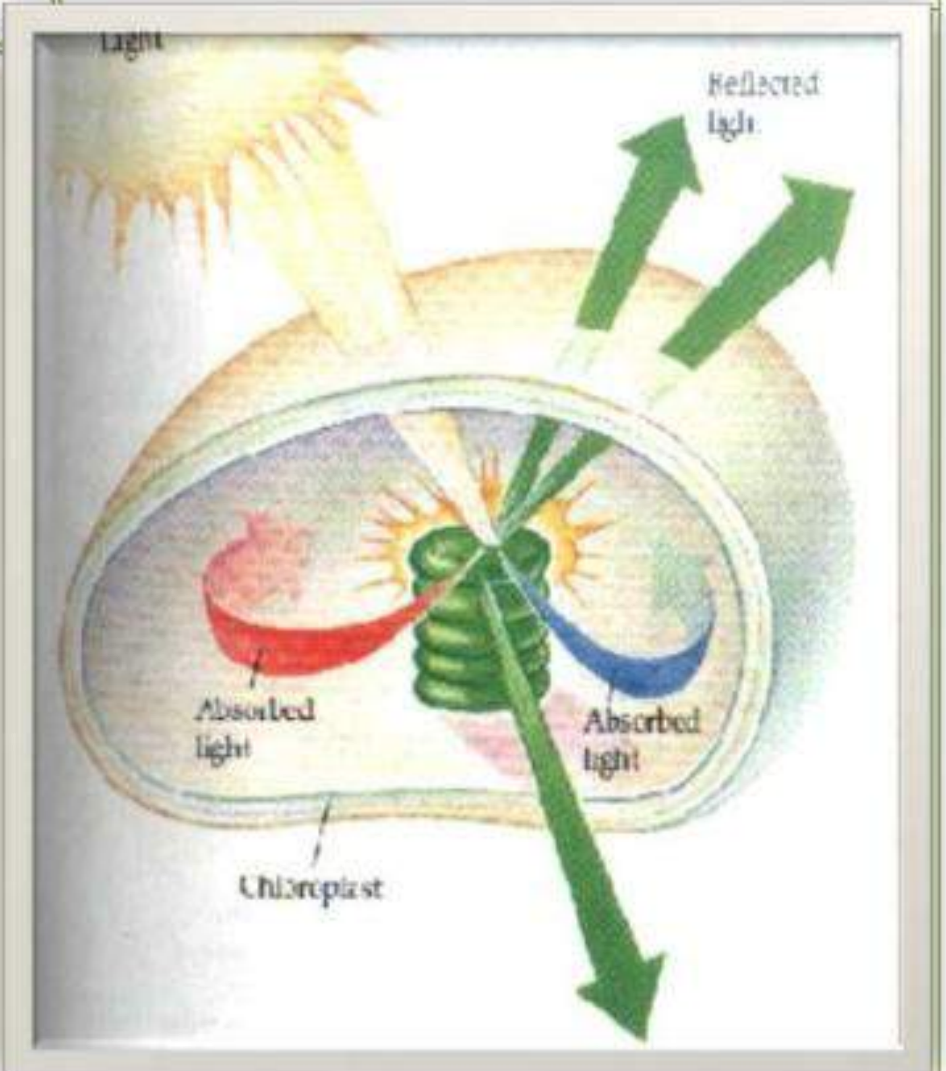


Chloroplast

- Chlorophyll

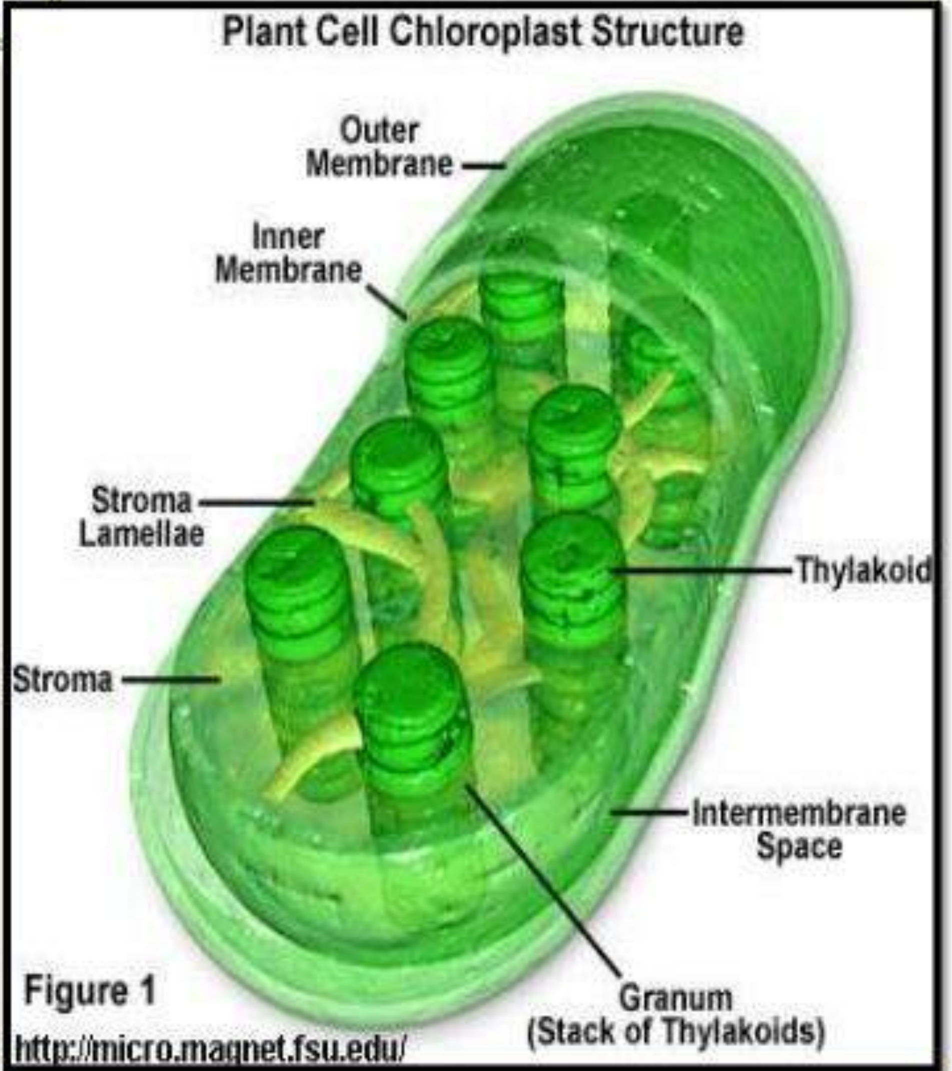
  - green coloring pigment.

  -responsible for trapping light energy into chemical energy in photosynthesis.



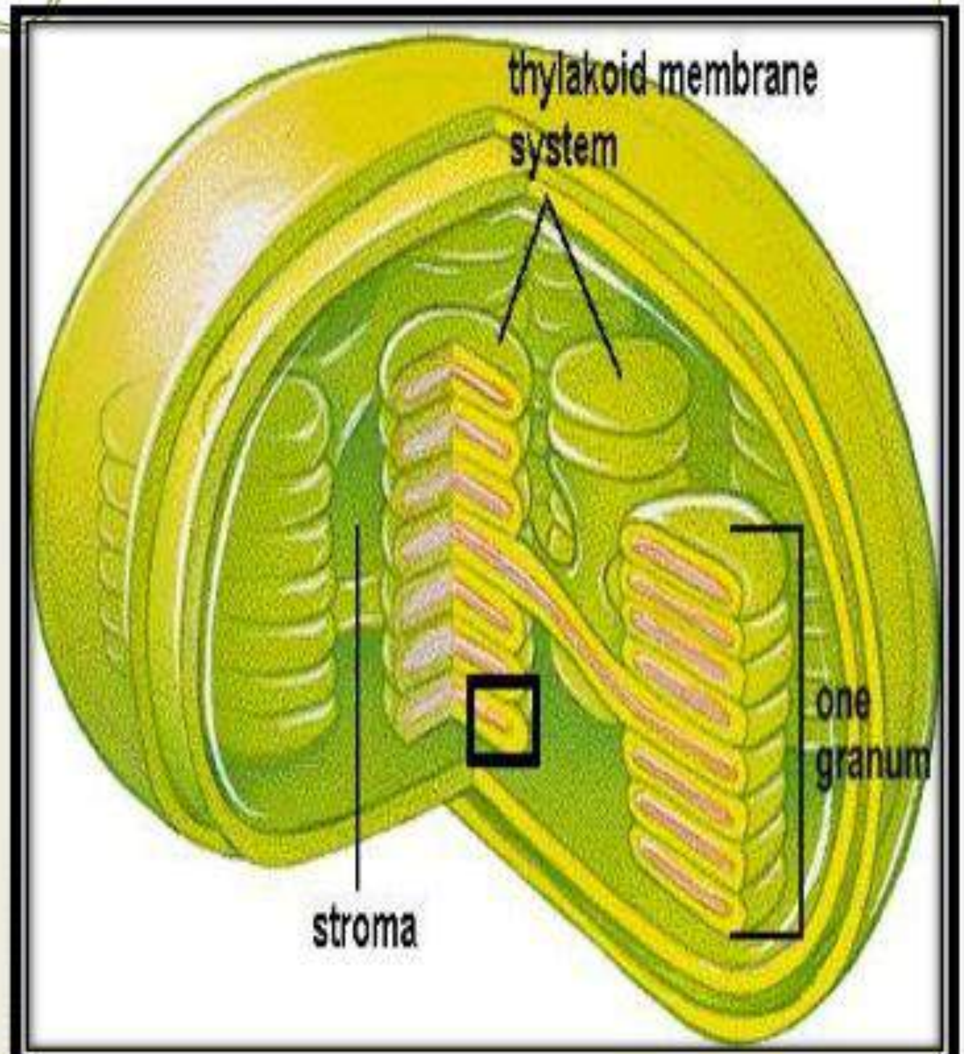
Structures:

1. Grana
2. Thylakoids
3. Stroma
4. Inner Membrane
5. Outer Membrane



Grana

- Stacks of thylakoids membrane within the chloroplast.



- Grana are highly specialized membrane clusters. Each chloroplast may contain 10-30 such granal clusters, a single granum can be compared to a flat circular membranous discs called thylakoids stacked one above the other. Such 20-60 thylakoids together constitute a granum.

- Moreover the grana are interconnected by another membrane structure called intergranal lamellae or stromal lamellae, which is located in between the stacks of thylakoid membrane, but it extends laterally, so as to form a kind of network of interconnecting membranes.

- Though the above described structure hold good for most of the chloroplasts, but certain plants belonging to tropical grass members like sugarcane, zea mays, sorghum, crab grass and even some dicots like amaranthus contain chloroplasts of two types.

- Chloroplasts found in mesophyll cells have the same granal organization as described above, but lack in thylakoids. In its place only stromal lamellae are found. Such dimorphic chloroplasts though found in the same leaf and exhibit different functions.

Thylakoids

- Flattened sac-like membrane within a chloroplast.

Thylakoids

- Contain the enzymes necessary for light-dependent reactions.

Pigments in chloroplasts

- Chlorophyll a and b are the main pigments. In addition, there are other pigments (carotenes and xanthophylls).
- Generally, chlorophylls comprise about 65%, carotenes 6% and xanthophyll 29% of total pigments in chloroplasts.
- The thylakoid membranes contain these pigments.

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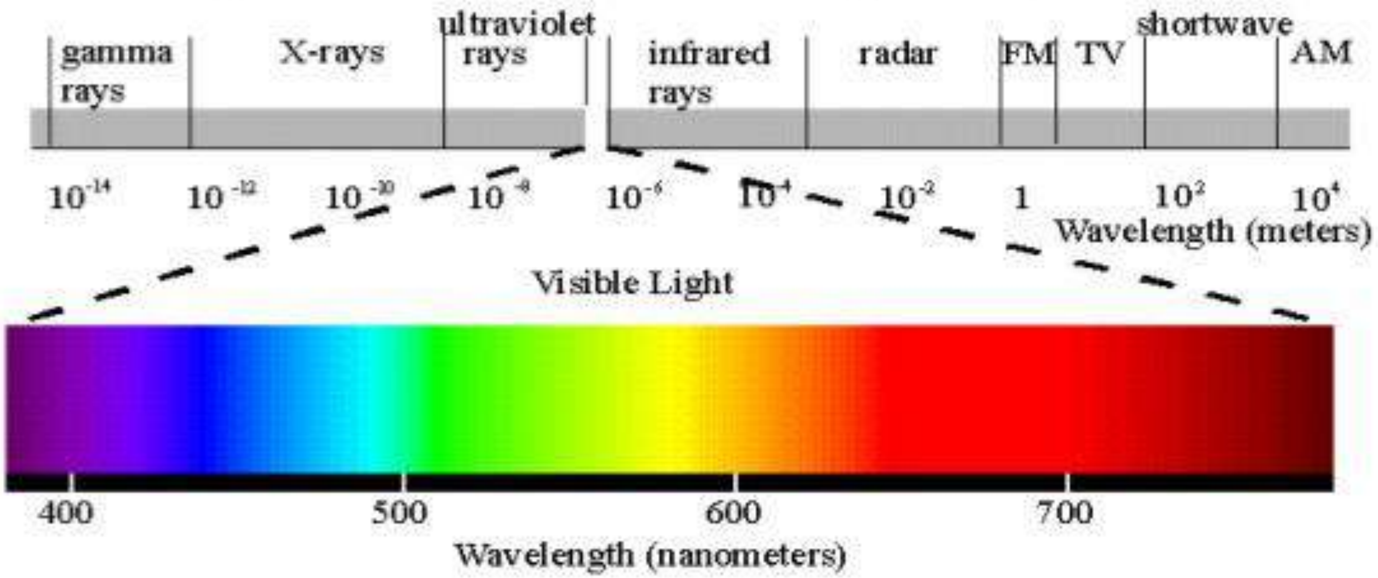
PIGMENTS

- Chlorophyll A is the most important photosynthetic pigment.
- Other pigments called antenna or accessory pigments are also present in the leaf.
  - Chlorophyll B
  - Carotenoids (orange / red)
  - Xanthophylls (yellow / brown)
- These pigments are embedded in the membranes of the chloroplast in groups called photosystems.

IT ALL STARTS WITH SUNLIGHT

- This shows the visible light spectrum
- Notice that different colors have different light wavelengths.
- Pigments found in chlorophyll absorb various portions of visible light as seen in this absorption spectrum.



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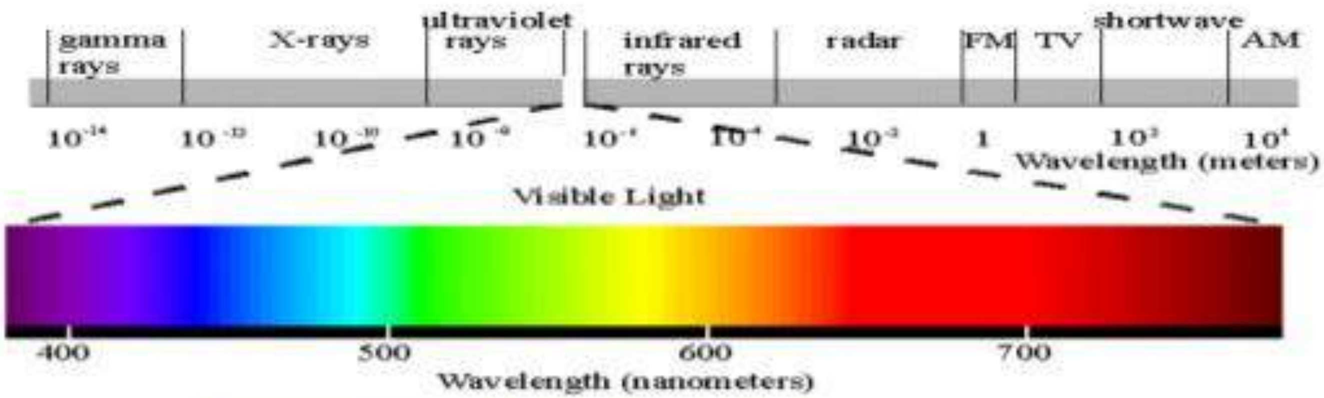
Visual Stimulus

IT ALL STARTS WITH SUNLIGHT

- Two major photosynthetic pigments are
  - chlorophyll a
  - chlorophyll b.
- Both chlorophylls absorb violet, blue, and red wavelengths best.
- Very little green light is absorbed; most is reflected back; this is why leaves appear green.



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Visual Stimulus

AUTUMN COLORS

- Carotenoids are yellow-orange pigments which absorb light in violet, blue, and green regions.
- When chlorophyll breaks down in fall, the yellow-orange pigments in leaves show through.

2. Carotenoids

Carotins

Xanthophylls

- $C_{40}H_{56}$

Carotenoids

- **Carotenoids** expand the range of wavelengths absorbed

b. Carotenoid structure

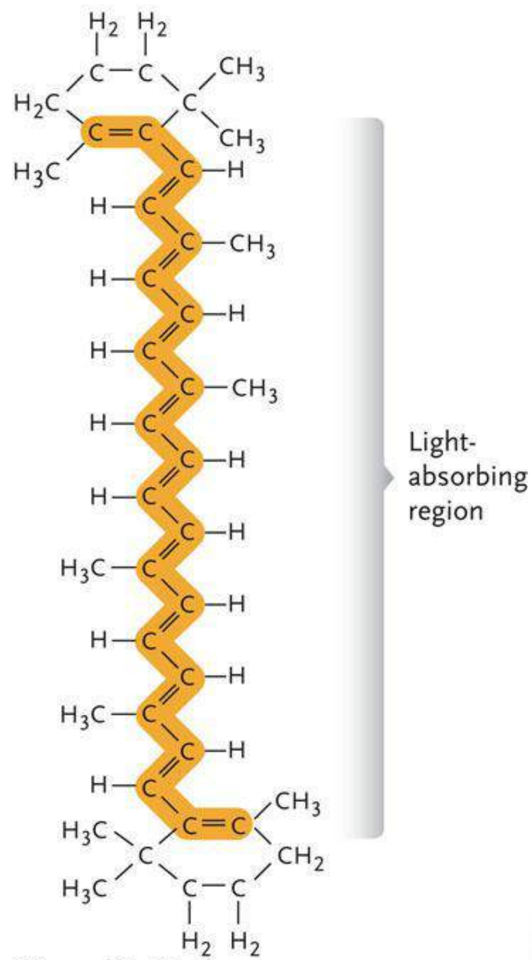
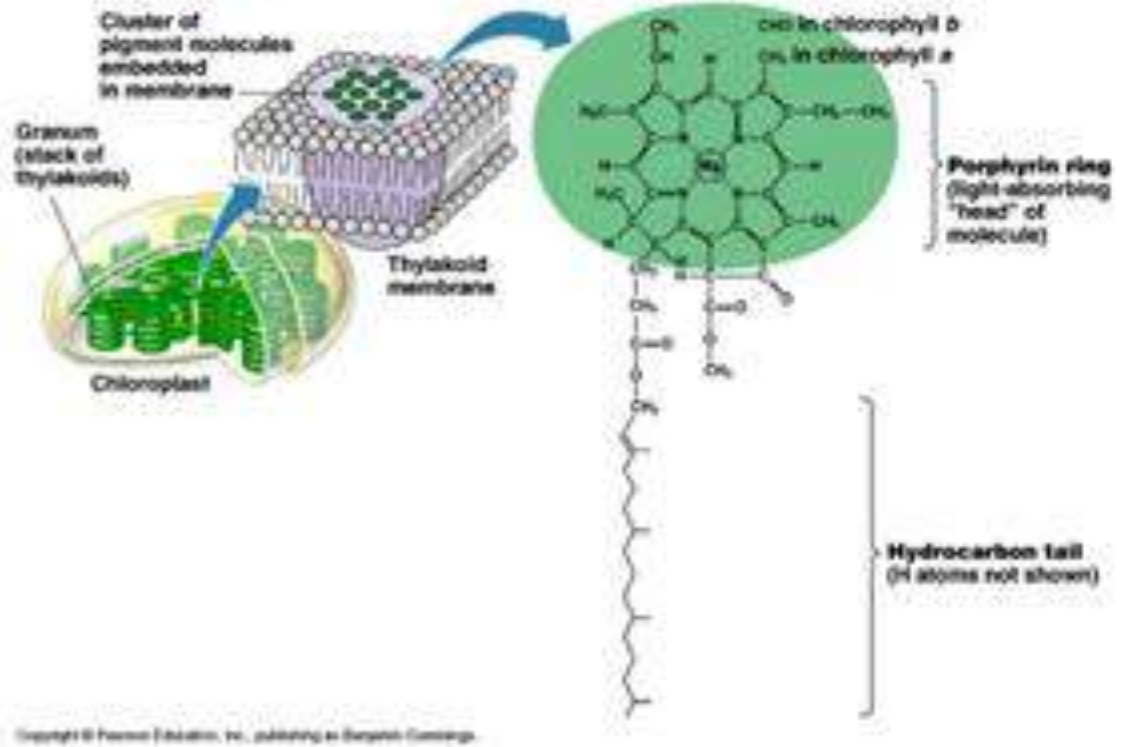
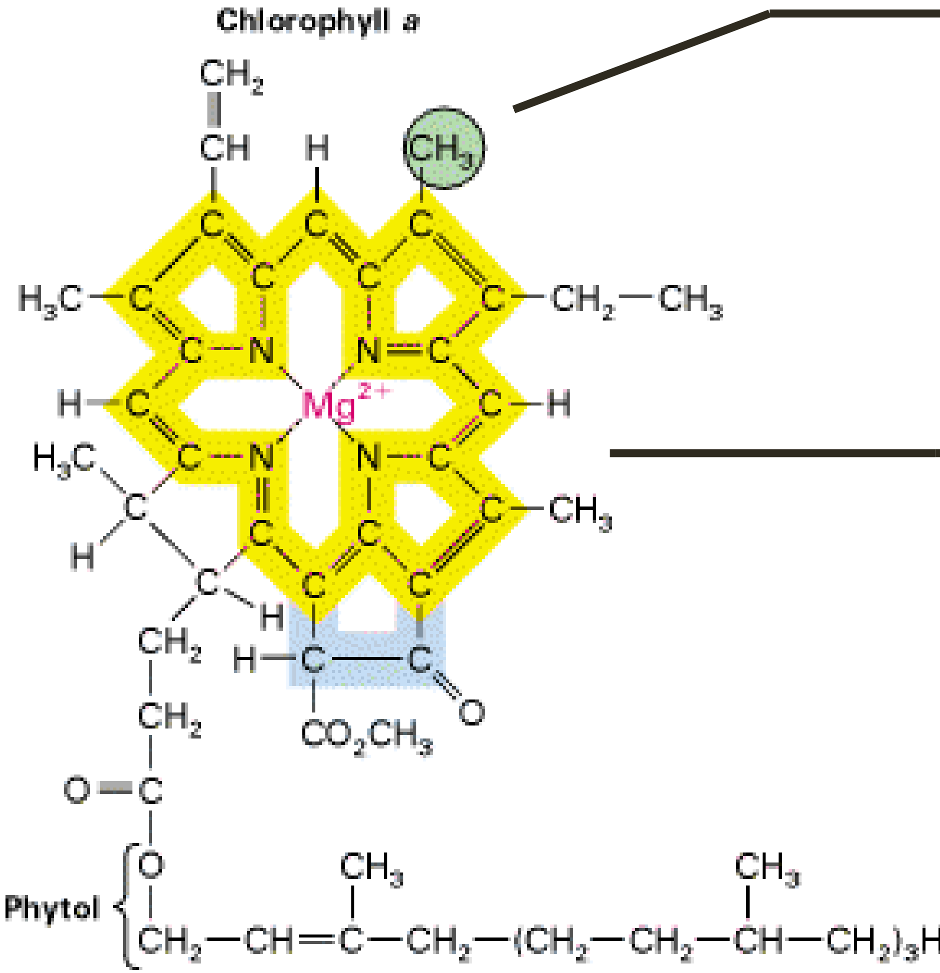


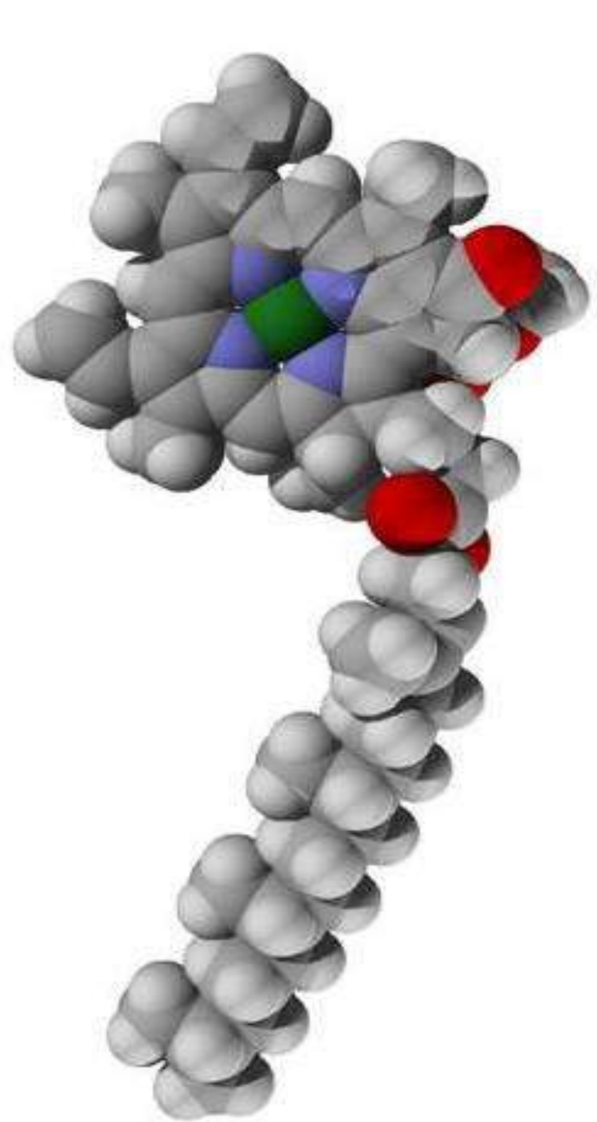
Fig. 9-6b, p. 183

Chlorophyll Structure and Function



Chlorophyll a & b





Phytol tail

Chlorophyll looks green because it absorbs red and blue light, making these colors unavailable to be seen by our eyes.

The green light which is NOT absorbed reaches our eyes, making chlorophyll appear green.

It is the energy from the red and blue light that are absorbed allowing the plant to do photosynthesis.

The green light we can see is not / cannot be absorbed by the plant, and cannot be used for photosynthesis.

TWO SETS OF REACTIONS

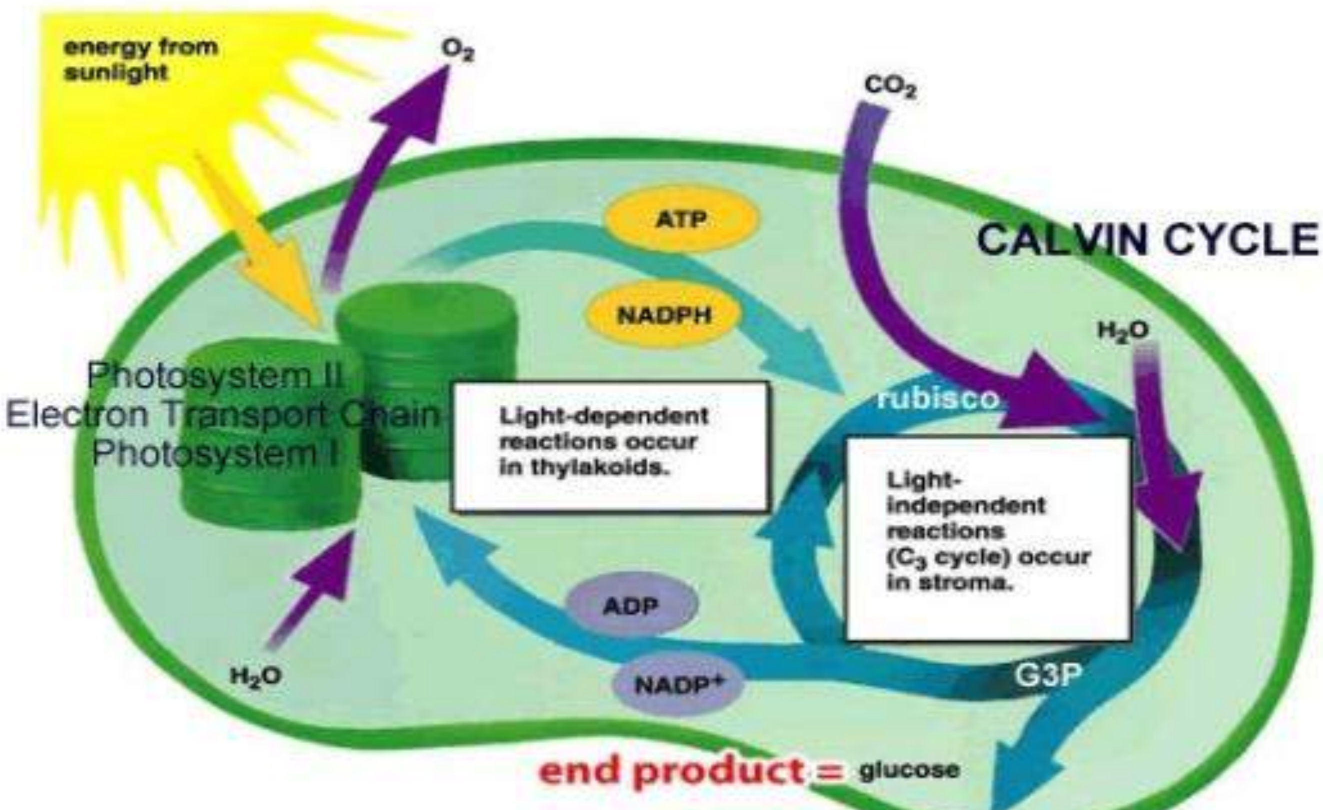
- Occurs in two main phases.
  - Light reactions
  - Dark reactions (aka – the Calvin Cycle)

- Light reactions are the "photo" part of photosynthesis. Light is absorbed by pigments.

- Dark reactions are the "synthesis" part of photosynthesis. Trapped energy from the sun is converted to the chemical energy of sugars.

TWO SETS OF REACTIONS

- Light reactions cannot take place unless light is present. They are the energy-capturing reactions.



CHLOROPLASTS

Chloroplasts are highly structured, membrane-rich organelles.

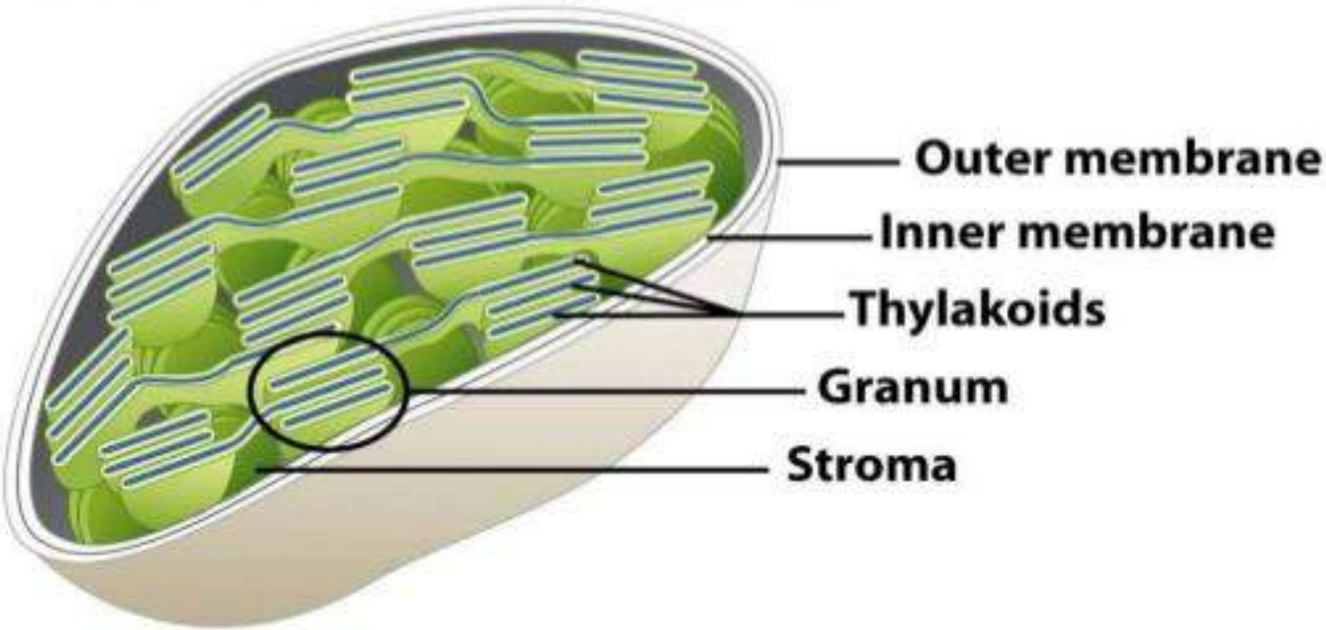
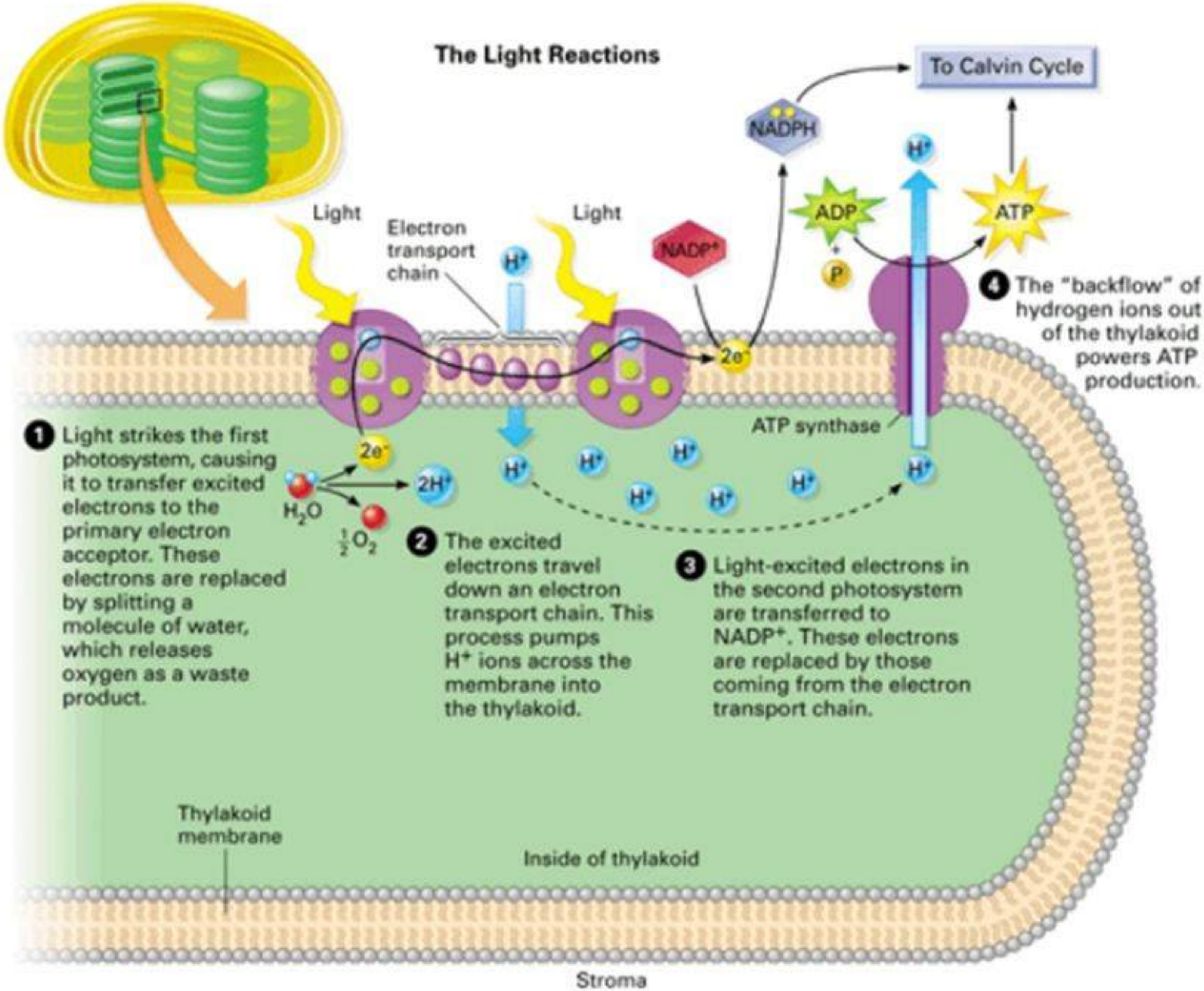


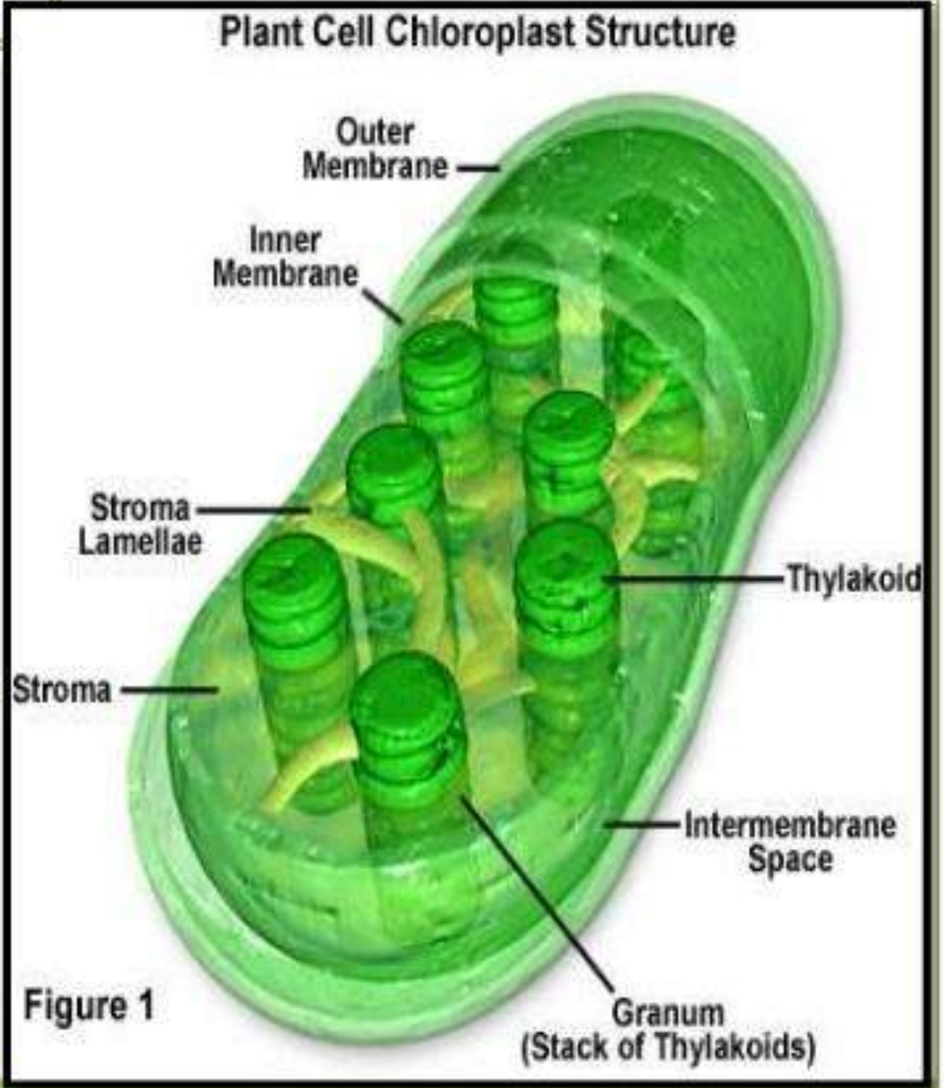
Figure 10-2b part 2 Biological Science, 2/e



Click image to see a membrane view of the light reactions

Stroma

- Contain the enzymes of the light-independent reactions.
- Ground matrix of chloroplast.



- **Stroma:**
- Amorphous, often semi viscous fluid present within the chloroplast membrane is called Stroma. A large number of enzymes responsible for carbon fixation, amino acid synthesis, protein synthesis, nucleic acid metabolism, pigment synthesis, N2 metabolism and fatty acid synthesis are present in stromatic fluid.

- It has also enzymes for the synthesis of Gibberellic acid and Abscisic acid. Some of the biosynthetic pathways in the stroma are under the control of various factors like light, phytochromes, temperature and photoperiods.

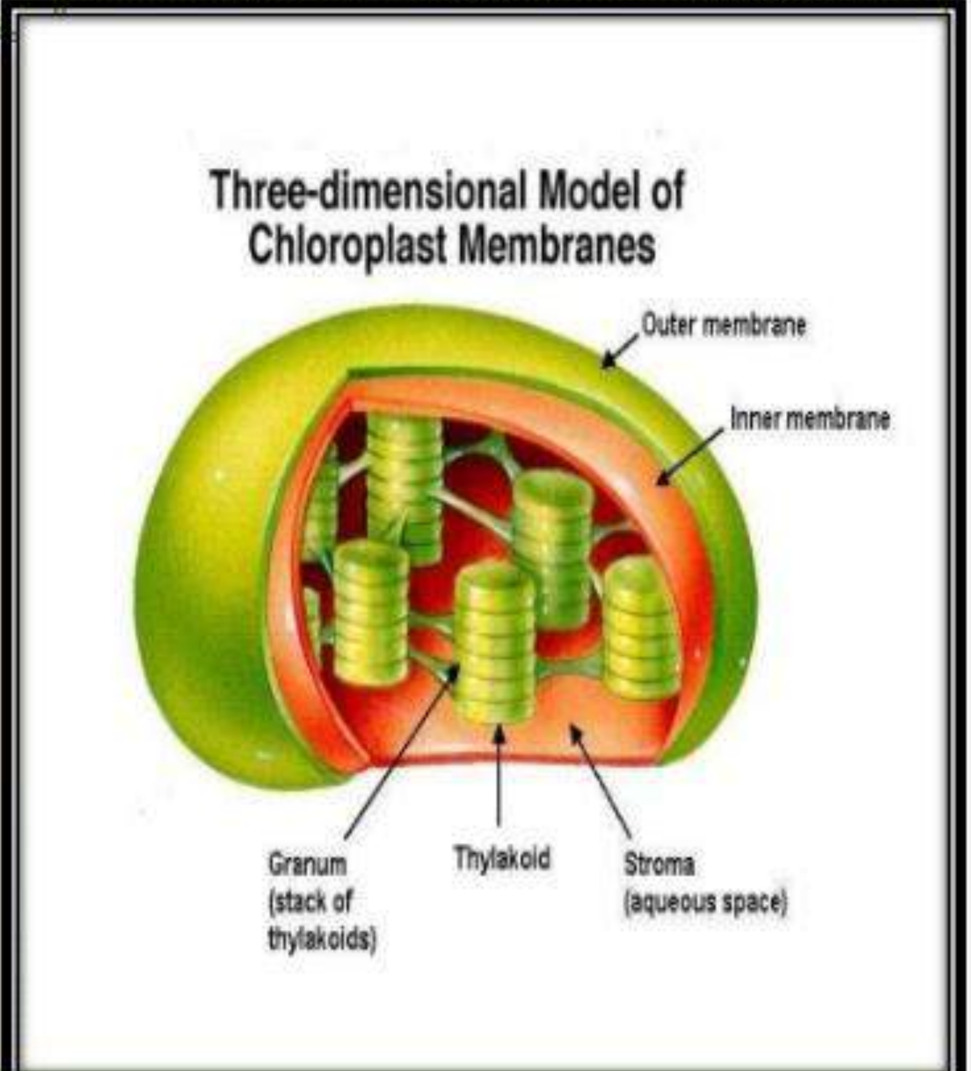
- Though chloroplasts have their own genetic material, the synthesis of various components required for chloroplast is under the dual control of nuclear genome and plastogenome.

- In the case of C4 plants, the stromatic fluid of chloroplasts found in mesophyll cells contain enzymes for Hatch and Slack pathway. Such enzymes are totally absent in the stroma of C3 chloroplasts.

- On the other hand, C4 chloroplasts found in bundle sheath cells possess enzymes for C3 pathway and also contain malate dehydrogenase. Thus C4 and C3 chloroplasts show dimorphism both in their structure and in function.

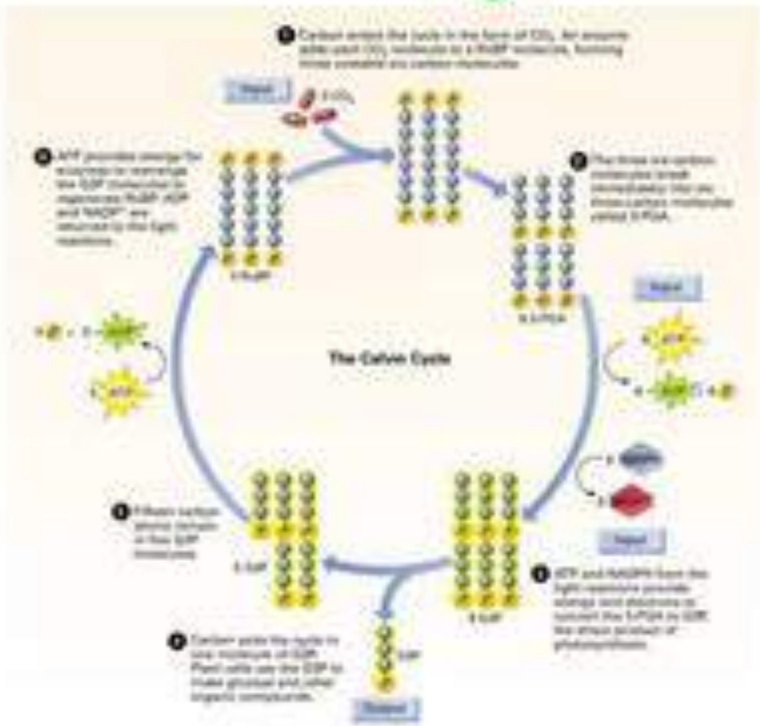
Outer Membrane

- Controls what enters and leaves the organelle.



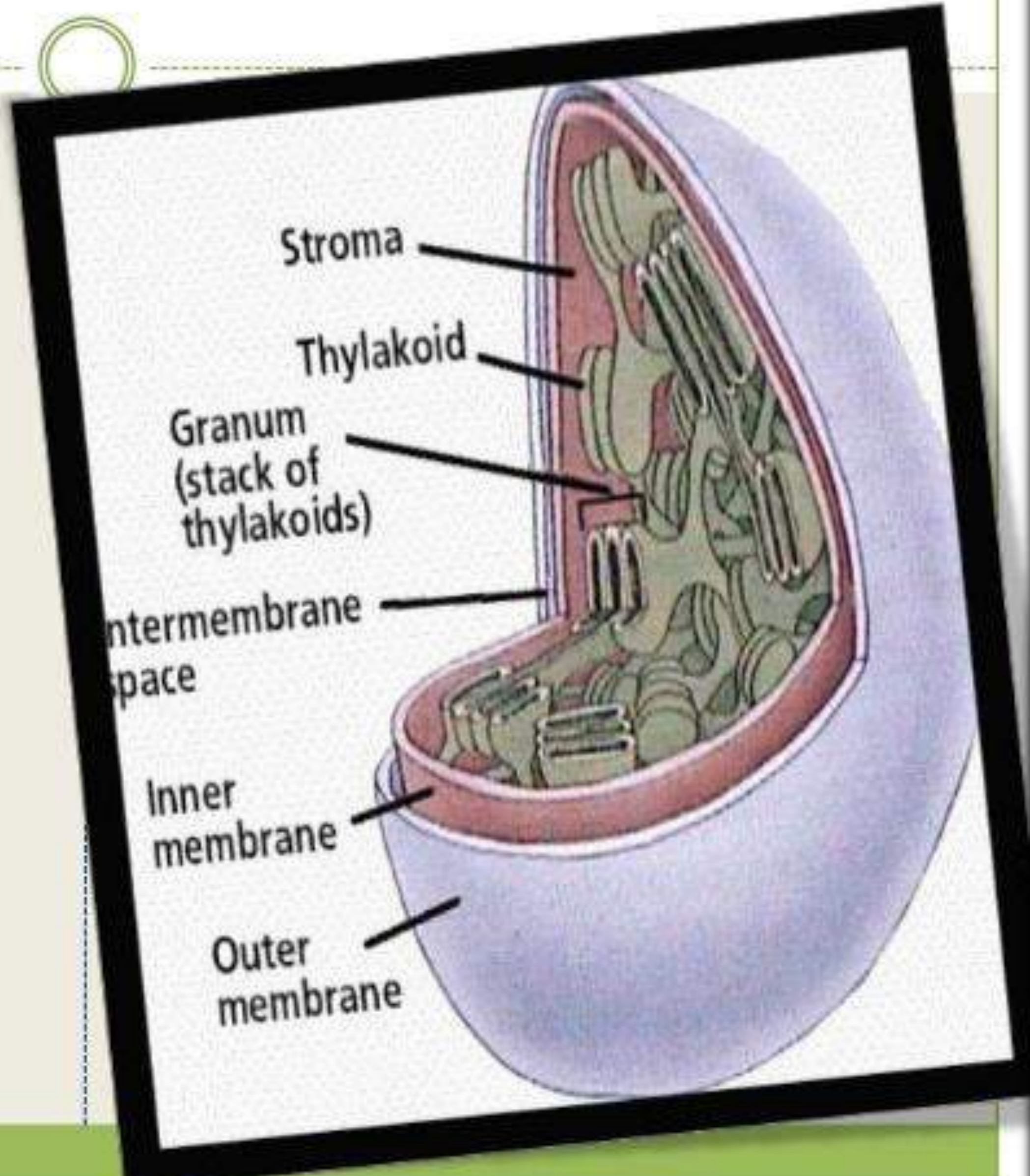
The Calvin Cycle

- Occurs in the Stroma
- Uses ATP and NADPH from Light Rxns
- CO_2 is Raw Material



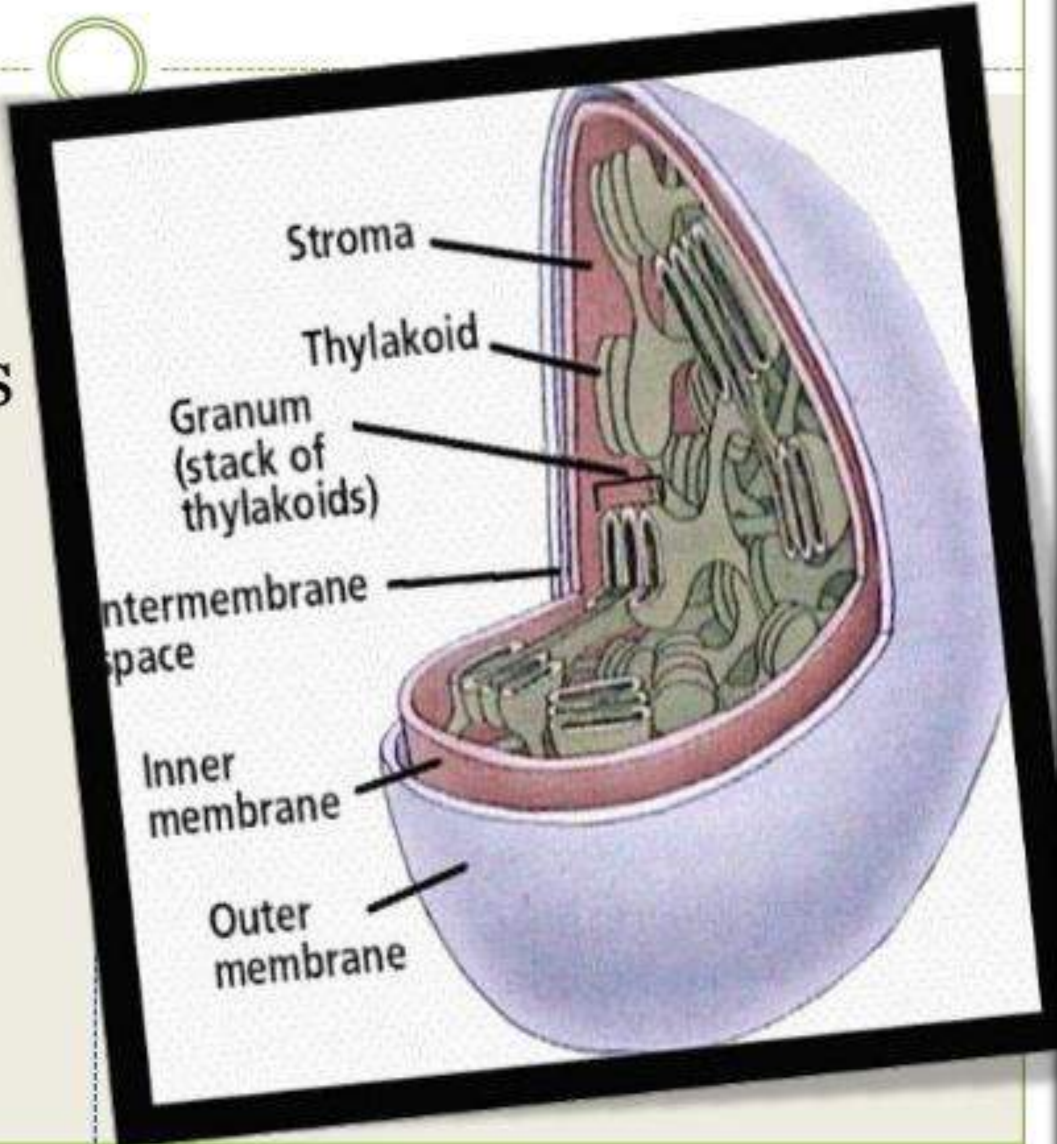
Inner Membrane

- Some spans the entire organelles.
- Others restricted to narrow stacks.



Inner Membrane

- Holds the pigments as well as many of the enzymes of photosynthesis.



- **Functions of chloroplast**:
- Chloroplast has the following functions:
- **1. Protein Synthesis:** As chloroplast contains its own DNA and ribososmes, it synthesizes certain amount of proteins for its metabolism.
- **2. Starch Storage:** Chloroplasts temporarily store starch during the day time in the pyrenoid which is a starch forming organelle. At night the starch is transferred to regions of growth and storage.

- **3. Oxygen Supply:** Chloroplasts utilize carbon dioxide for photosynthesis and release oxygen. This oxygen is used by all animals and plants for respiration. Oxygen release occurs during photophosphorylation process of light reactions. During light reaction, water lytic center or oxygen evolving center, release oxygen by breaking water molecules in the presence of light by photosystem-II.

- **4. Photosynthesis:** Photosynthesis is a process that converts carbon dioxide into organic compounds, especially sugars, using the energy from sunlight. Photosynthesis occurs in plants, algae, and many species of Bacteria. Photosynthetic organisms are called *photoautotrophs*, since it allows them to create their own food. In plants, algae and cyanobacteria photosynthesis uses carbon dioxide and water, releasing oxygen as a waste product. Photosynthesis is vital for life on Earth.

- **5. Photorespiration:**
- Photorespiration is a process when Ribulose bisphosphate carboxylase / oxygenase (RUBisco) fix oxygen instead of carbon dioxide. Photorespiration can occur when carbon dioxide levels are low. Photorespiration produces no ATP (energy for cells) and leads to a net loss of carbon and nitrogen (as ammonia) which slows the growth of plants.

Chromoplasts

- Chromoplasts are similar to chloroplasts in size, they vary considerably in shape, often being somewhat angular.
- They sometimes develop from chloroplast through internal changes including the disappearance of chlorophyll.

- They are responsible for the red, yellow, orange color of many fruits and vegetables and the petals of many flowers.
- These colors are due to pigments called carotenoids.
- Pigments in chromoplasts include:
- Carotene (carrot), lycopene (tomato) or red pepper.

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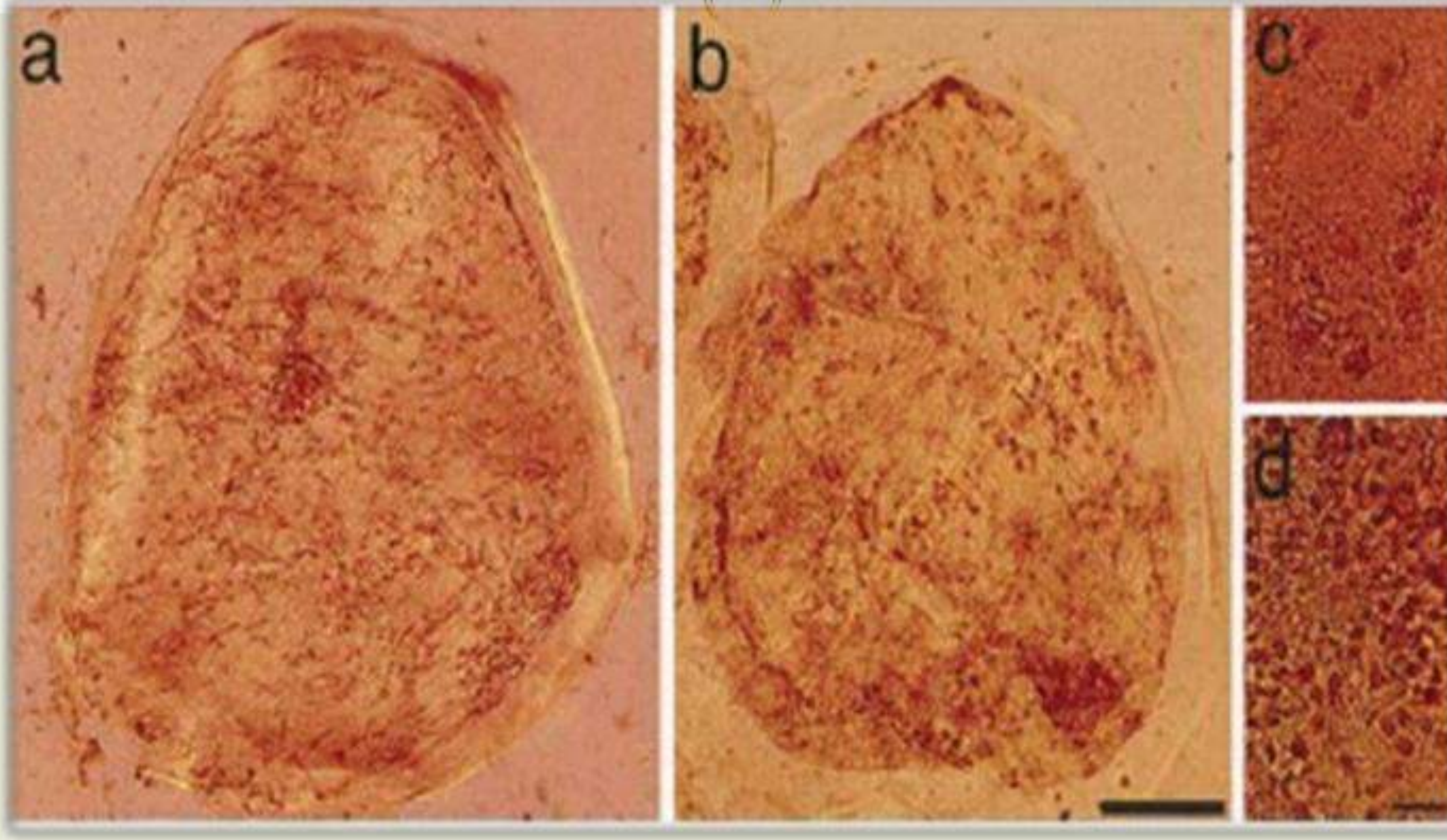
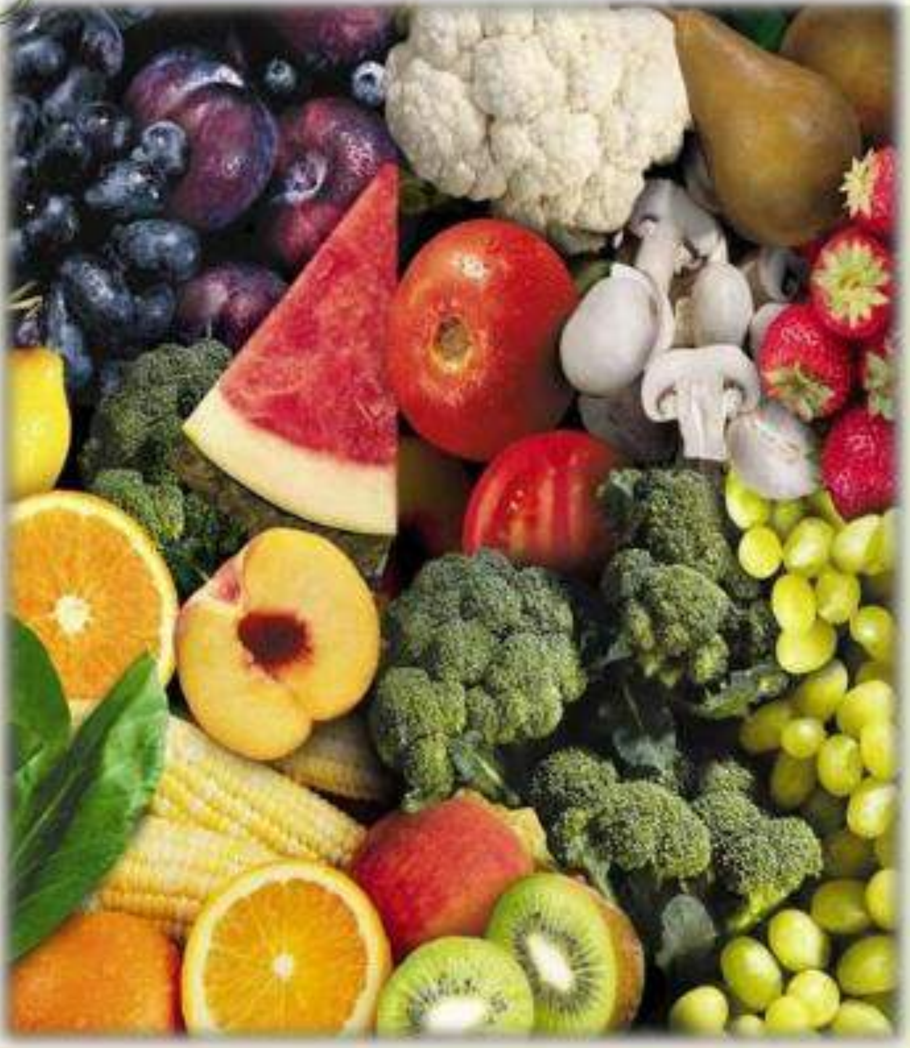
Chromoplast



Carotenoids

- Yellow and Orange pigments.



- **Tannosome**
- Tannosomes were discovered in September 2013 by French and Hungarian researchers

- The discovery of tannosomes showed how to get enough tannins to change the flavour of wine, tea, chocolate, and other food or snacks

- Tannosomes are formed when the chloroplast membrane forms pockets filled with tannin. Slowly, the pockets break off as tiny vacuoles that carry tannin and to the large vacuole filled with acidic fluid.[32] Tannins are then released into the vacuole and stored inside as tannin accretions

- They are responsible for synthesizing and producing condensed tannins and polyphenols. Tannosomes condense tannins in chlorophyllous organs, providing defenses against herbivores and pathogens, and protection against UV radiation

Leucoplasts

- They are colorless plastids whose function is storage food.
- They occur in plant cells not exposed to light (roots). The leucoplasts are subdivided into three types:

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1- Proteinoplasts store protein and found in seeds and nuts.

2- Elaioplasts it store oil and found in the epidermal cells of the monocot families Liliaceae and Orchidaceae.

3- Amyloplasts … store starch, found in tubers, cotyledons and endosperm.

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- Etioplast chloroplasts grown in the dark.
- If some of leucoplasts exposed to light , they will develop into chloroplasts.

usually found in flowering plants (Angiosperms) grown in the dark. If a plant is kept out of light for several days, its normal chloroplasts will actually convert into etioplasts. Etioplasts lack active pigment and can technically be considered leucoplasts. High concentrations of etioplasts will cause leaves to appear yellow rather than green.

These plant organelles contain

- They are converted to chloroplasts via the stimulation of chlorophyll synthesis by the plant hormone cytokine soon after exposure to light.

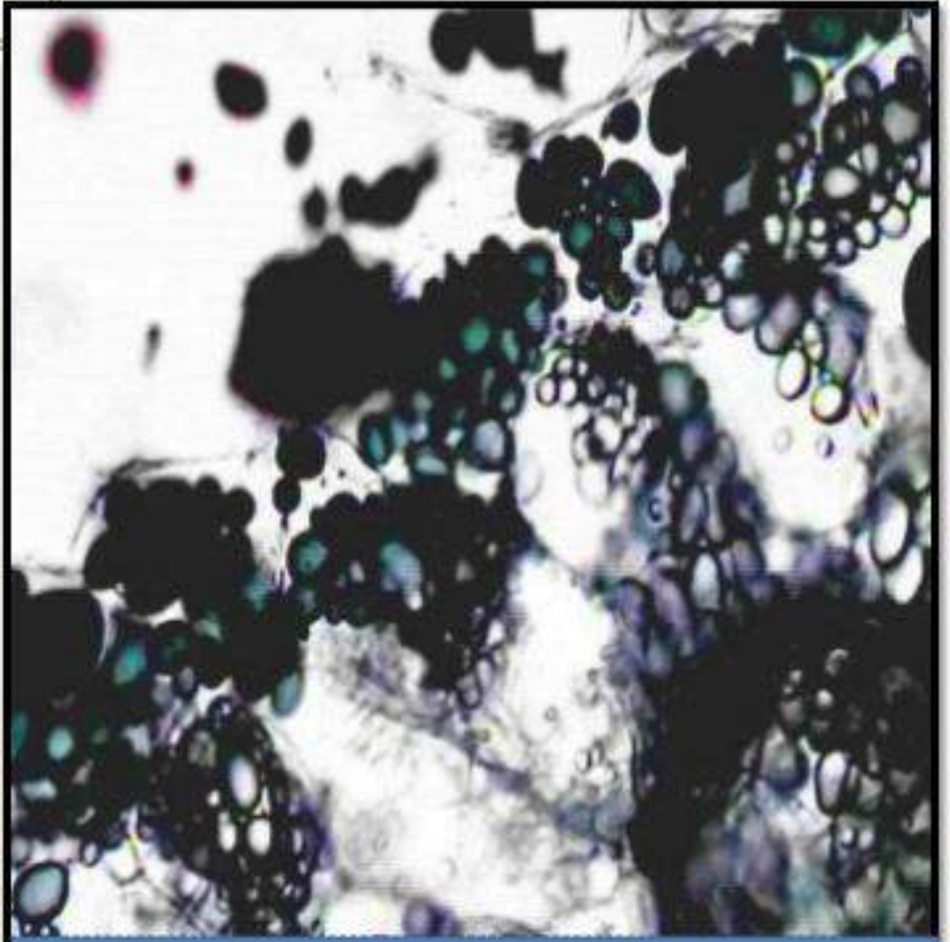
Leucoplasts

- Leuko means white.
- Where starch, oils, protein s and lipids are stored.

Leucoplast
[EM = Electron Micrograph]

Leucoplasts

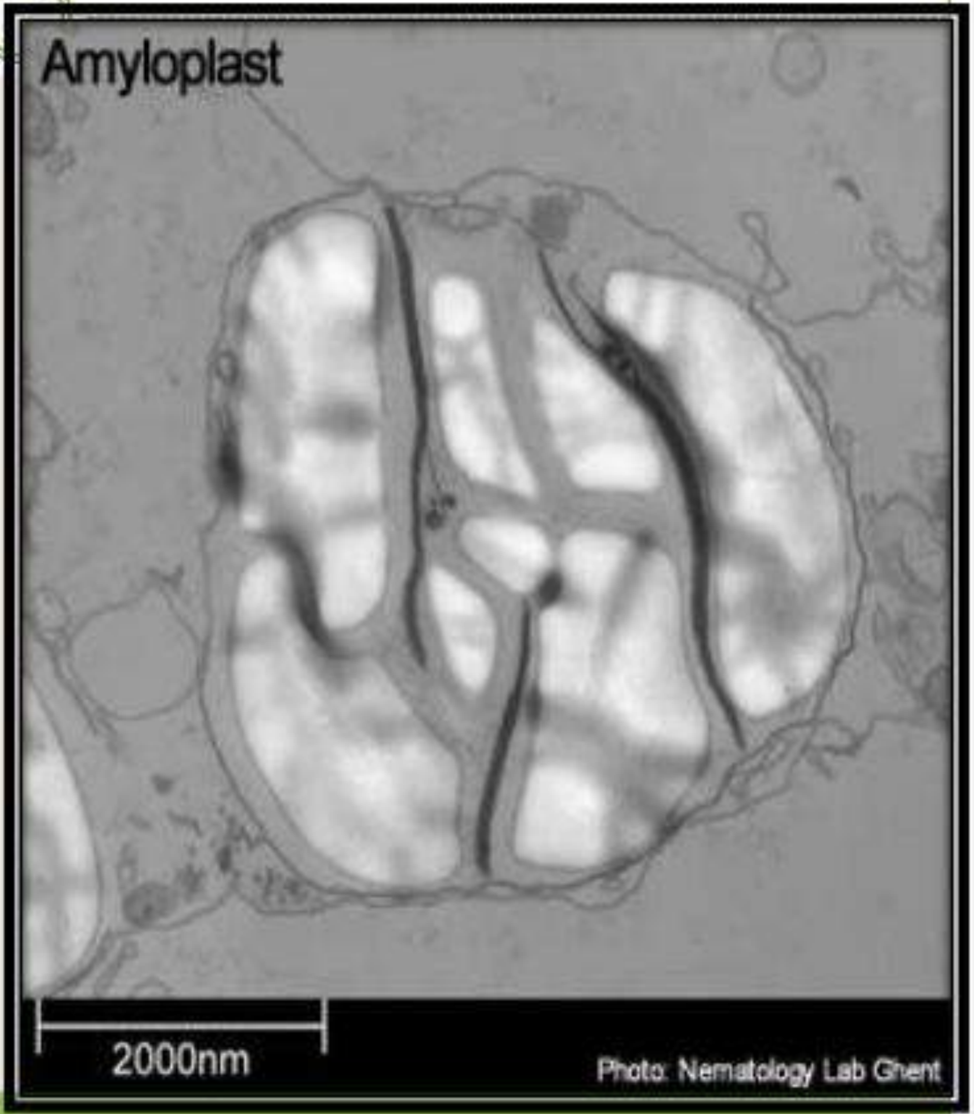
- Colorless plastids present in non-photosynthesizing plant tissue.



Potato cells with stained starch grains in leucoplasts.

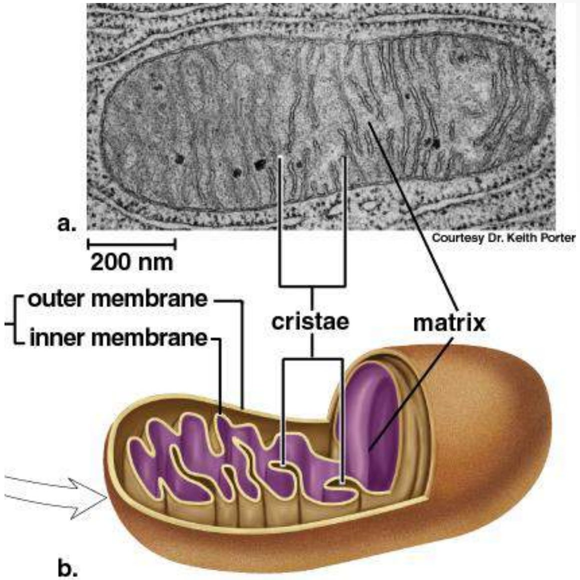
Leucoplasts

- A leucoplast that stored starch (amylose) is sometimes termed as amyloplast.

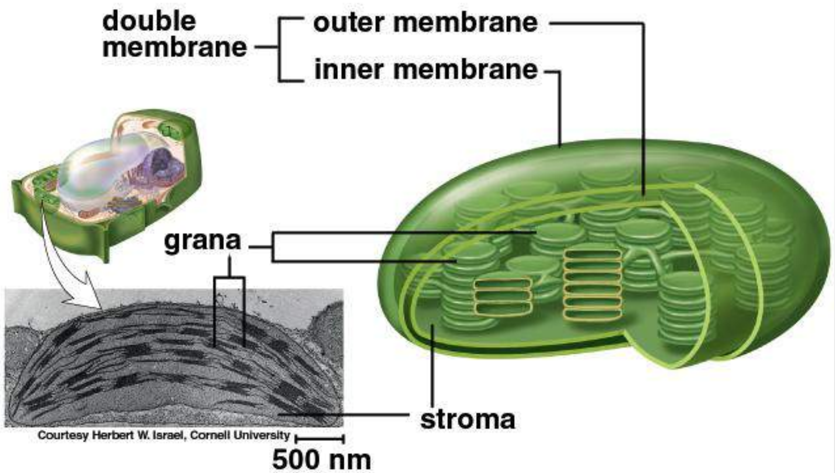


Self-Replicating Organelles

- **Mitochondria**
  - Involved in energy release



- **Plastids**
  - Involved in energy capture and storage.
  - –Chloroplasts
  - –Amyloplasts
  - –Chromoplasts



4- Endoplasmic reticulum

- The outer membrane of the nucleus is connected to and continuous with the endoplasmic reticulum, which also connected to the plasma membrane.

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- Many important activities, such as the synthesis of 16 membranes for other organelles and the synthesis of proteins from components assembled from elsewhere within the cell, occur either on the surface of the ER or within the compartments.

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- ER is enclosed space consisting of a network of flattened sacs and tubes that form channels throughout the cytoplasm
- In section, it looks like a series of parallel membranes that resemble long, narrow tubes or sacs, creating subcompartments within the cell.

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- The ENDOPLASMIC RETICULUM, or ER, is a system of folded membranes in which proteins, lipids, and other materials are made.

- Its folded membrane contains many tubes and passageways.

- The outer surfaces of the ER may be lined with the Ribosomes, such ER is said to be ROUGH ER and is primarily associated with the synthesis, or secretion, or storage of proteins.
- This contrasts with ER which has few, if any , ribosomes lining the surface of ER and is associated with lipid secretion.

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- Both types of ER can occur in the same cell, and can be inter converted depending on the demands of the cell.
- Many enzymes involved in the process of respiration are synthesized on the surface of ER.
- ER also appears to be the primary site of membrane synthesis within the cell.

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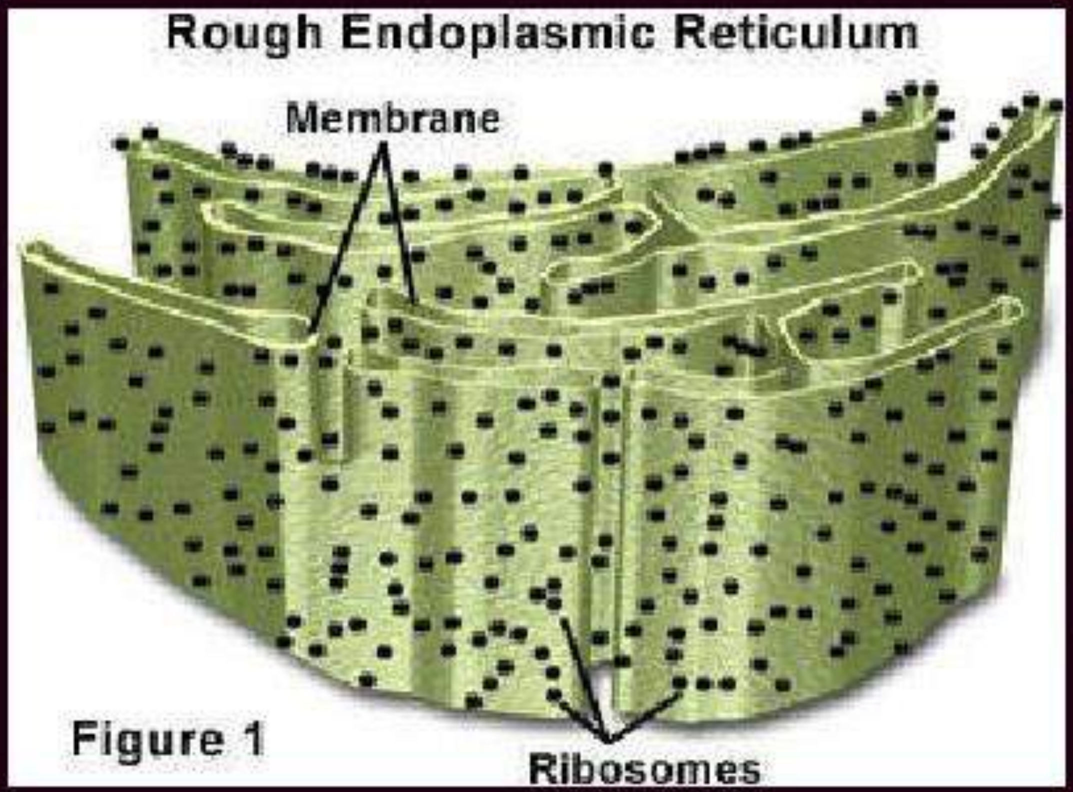
Smooth ER vs. Rough ER

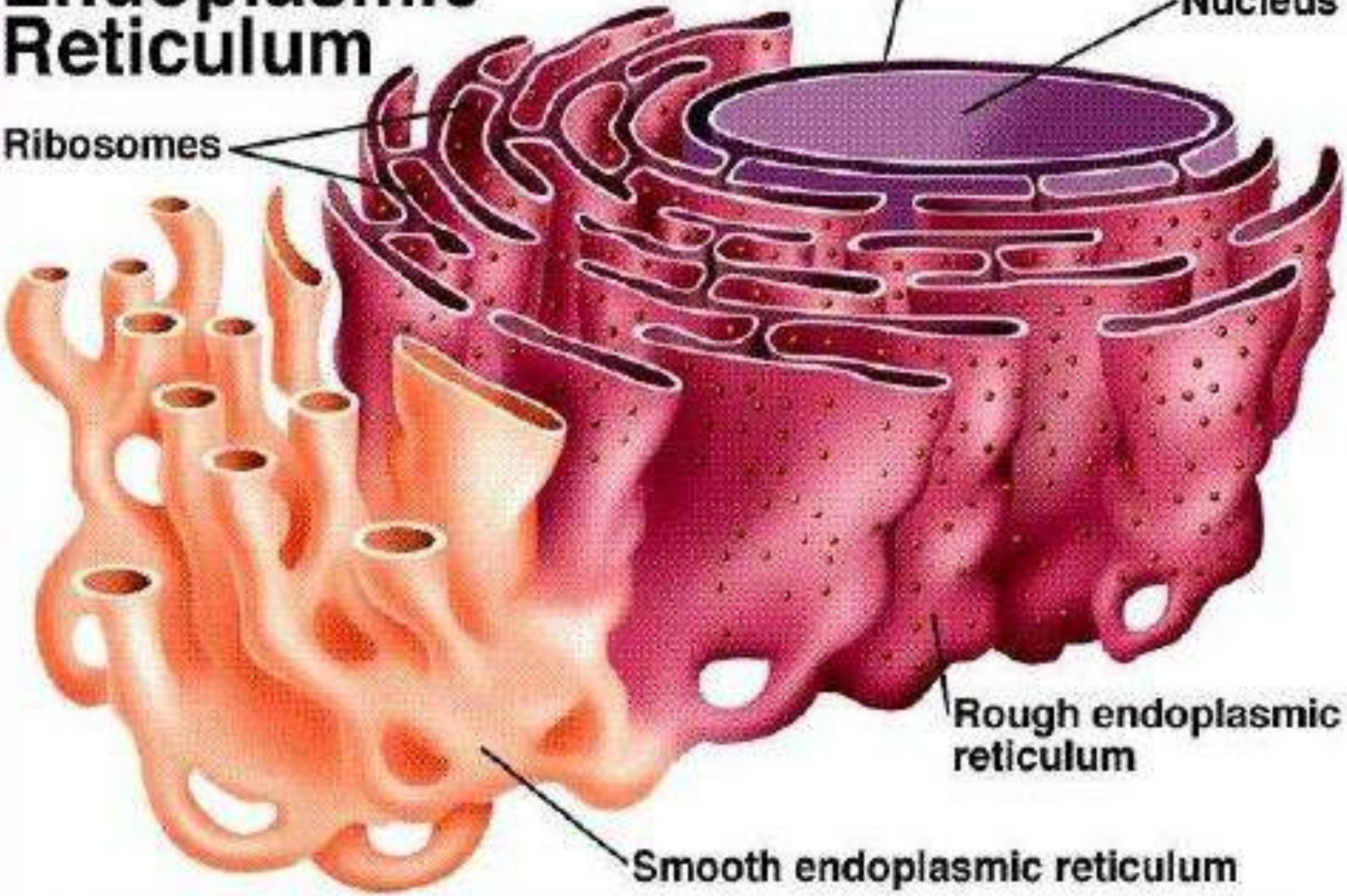


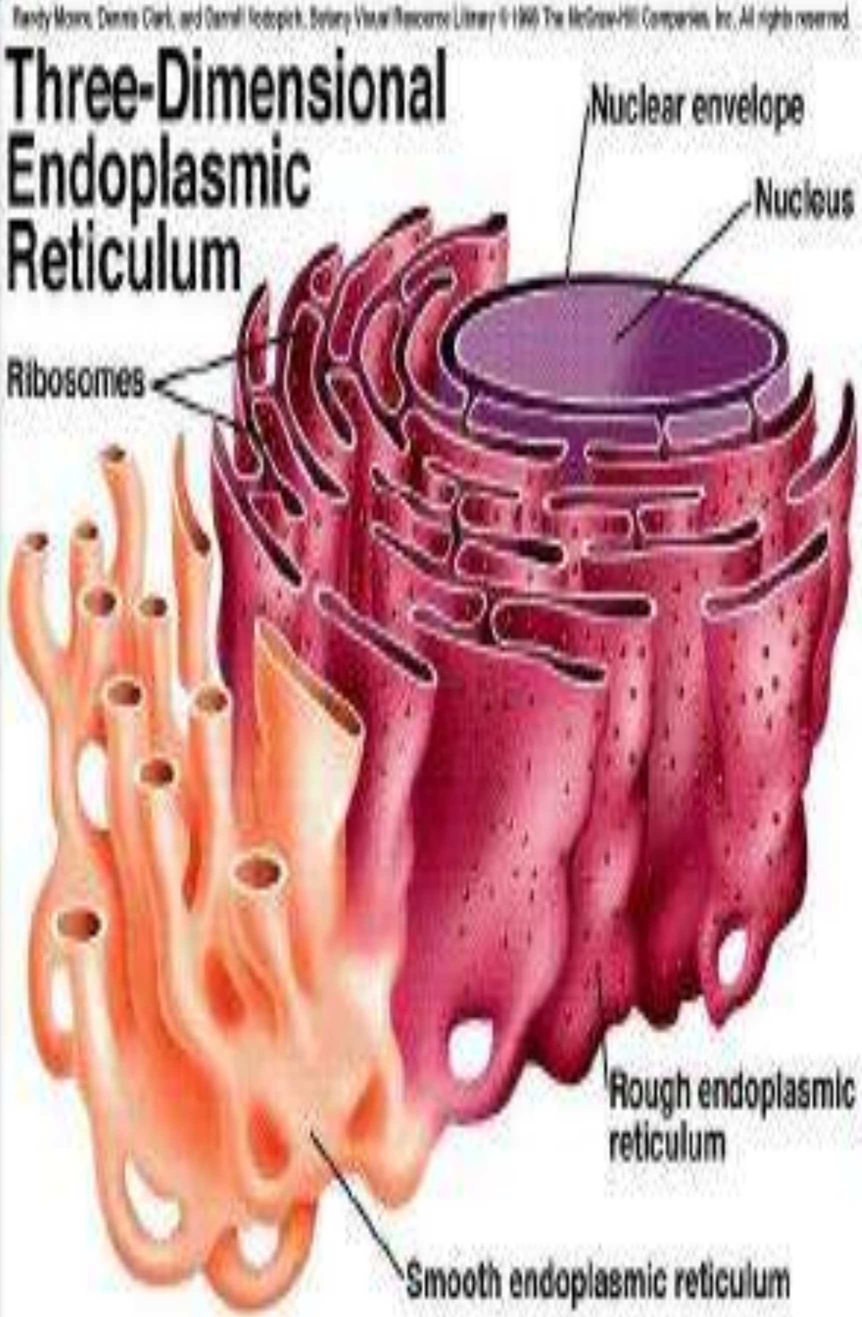
- Endoplasmic Reticulum is either rough ER or smooth ER.
- The part of the ER covered in ribosomes is rough ER, it is usually found near the nucleus.
- Ribosomes on rough ER make many of the cell's proteins. The ER delivers these proteins throughout the cell.

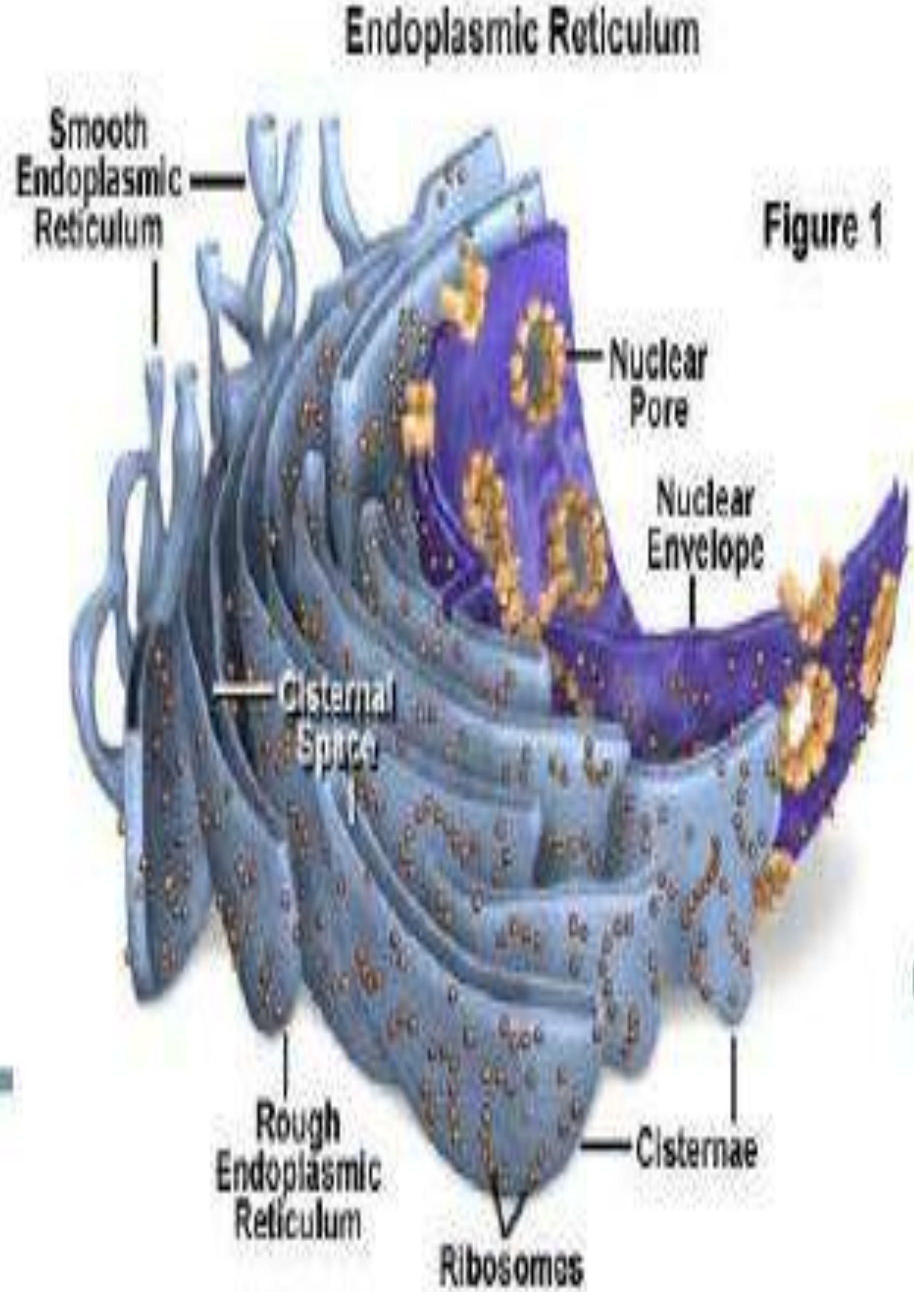
- ER that lacks ribosomes is smooth ER.

- The functions of smooth ER include making lipids and breaking down toxic materials that could damage the cell.

Three-Dimensional Endoplasmic Reticulum

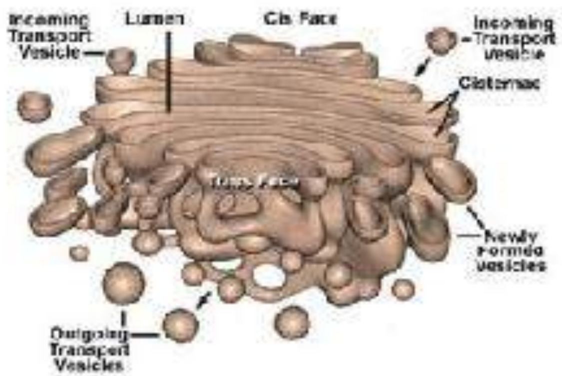



Three-Dimensional Endoplasmic Reticulum
Nuclear envelope
Nucleus
Ribosomes
Rough endoplasmic reticulum
Smooth endoplasmic reticulum


Endoplasmic Reticulum
Smooth Endoplasmic Reticulum
Figure 1
Nuclear Pore
Nuclear Envelope
Cisternal Space
Rough Endoplasmic Reticulum
Cisternae
Ribosomes

5- Dictyosomes (Golgi apparatus)

The Golgi bodies are the post office they send and receive messages.



Golgi Apparatus

- Looks like ER but is located closer to the cell membrane
- Receives and modifies lipids and proteins sent from the ER
- Final products are then enclosed in a piece of the Golgi's membrane that pinches off to form small compartment
- Compartment transports contents to other parts of cell or outside the cell

- Sort and package proteins and other substances to deliver to the rest of the cell or outside the cell
- The "packages" that move the materials are called vesicles

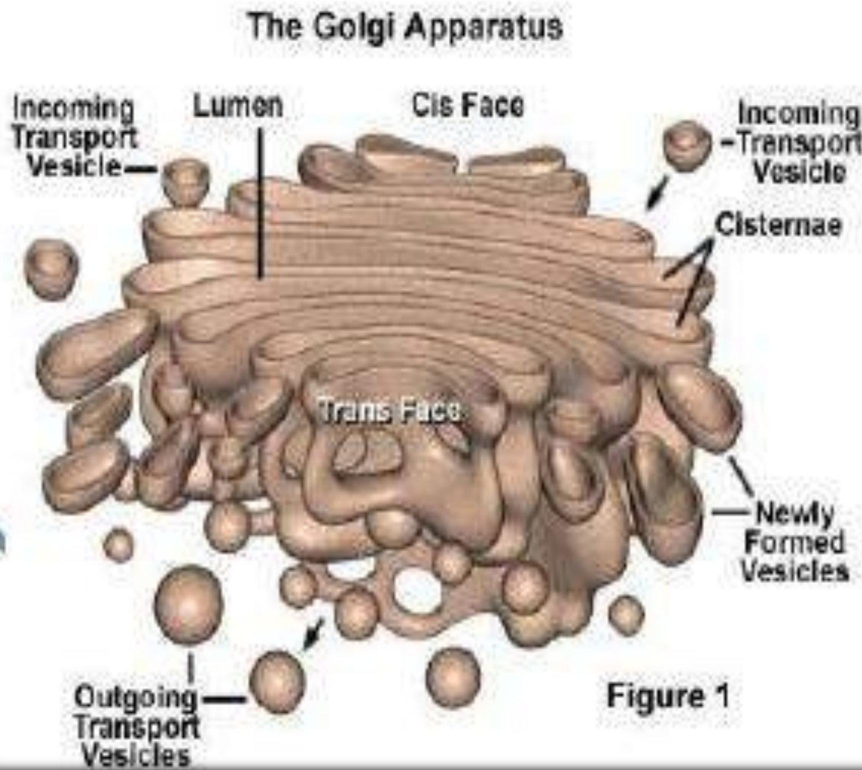
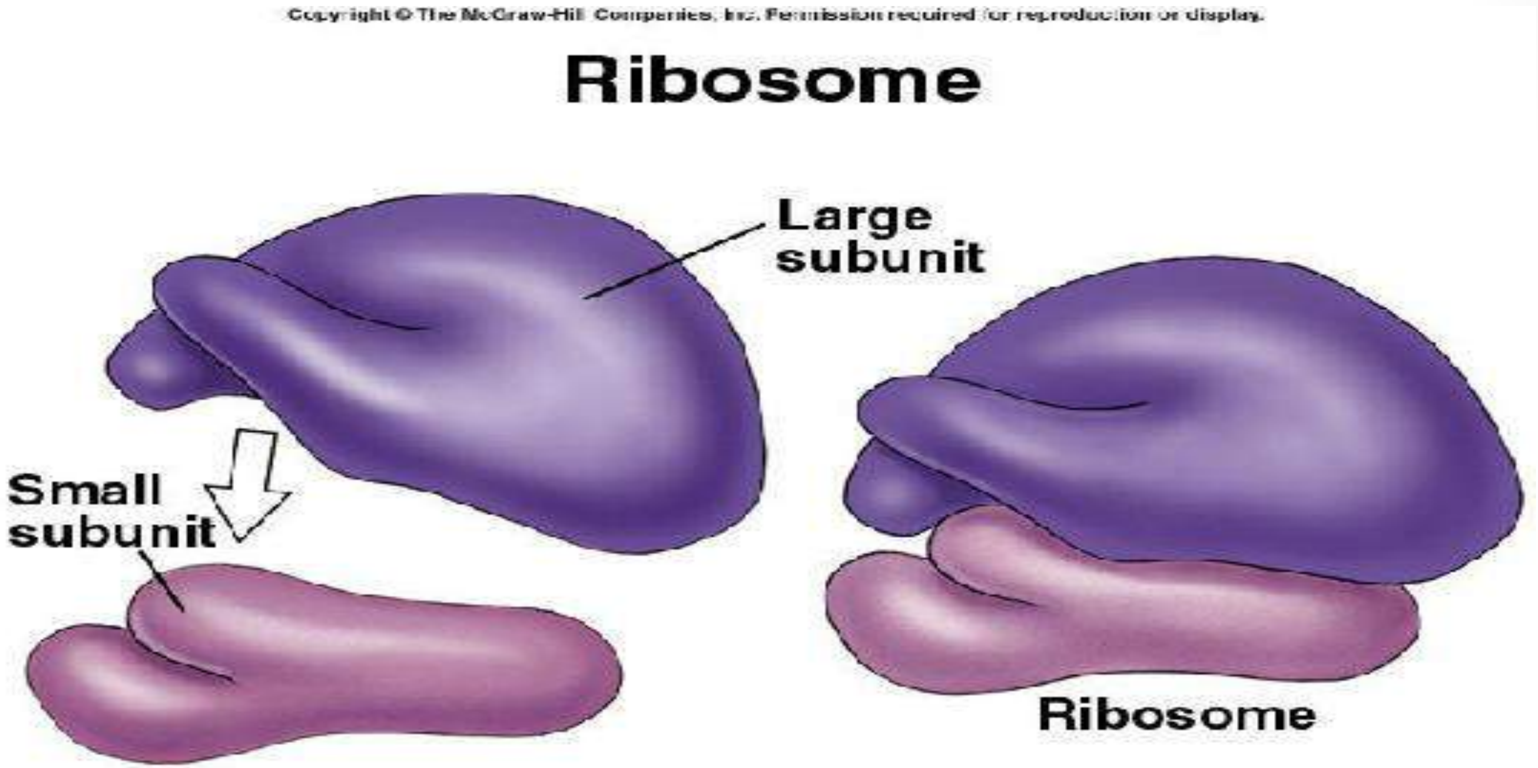


Figure 1

6- Ribosomes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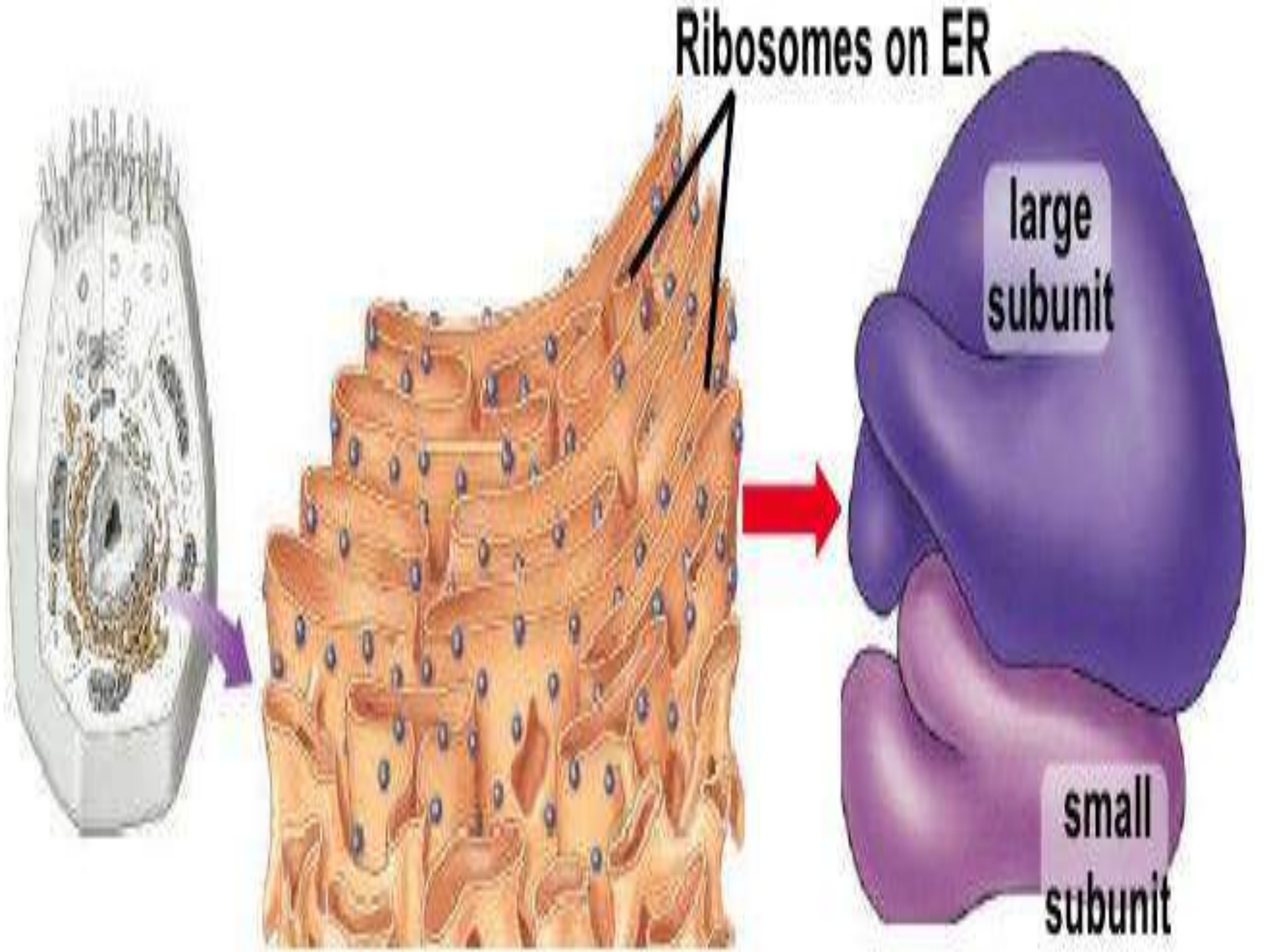
Ribosome
Large subunit
Small subunit
Ribosome

- Proteins are made of AMINO ACIDS.
- An AMINO ACID is any one of about 20 different organic molecules that are used to make proteins.
- All cells need proteins to live.
- All cells have RIBOSOMEs.

- Organelles that make proteins are ribosomes.
- Ribosomes are the smallest of all organelles.
- Some ribosomes float freely in the cytoplasm.
- Ribosomes are not covered by a membrane.


Ribosomes on ER
large
subunit
small
subunit

7- Cell membranes

- Live and flexible.
- Selective permeability.
- a- Plasmalemma (Ectoplast).
- The external membrane bounds the protoplast.
- It is involved in the production of cellulose for cell wall.

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- b- Vacuolar membrane (Tonoplast).
- A membrane that surrounds the vacuole.

- Evidence obtained since the early 1970s indicates that the plasma membrane and other cell membranes are mosaics composed of lipids arranged in two layers, with protein interspersed throughout.

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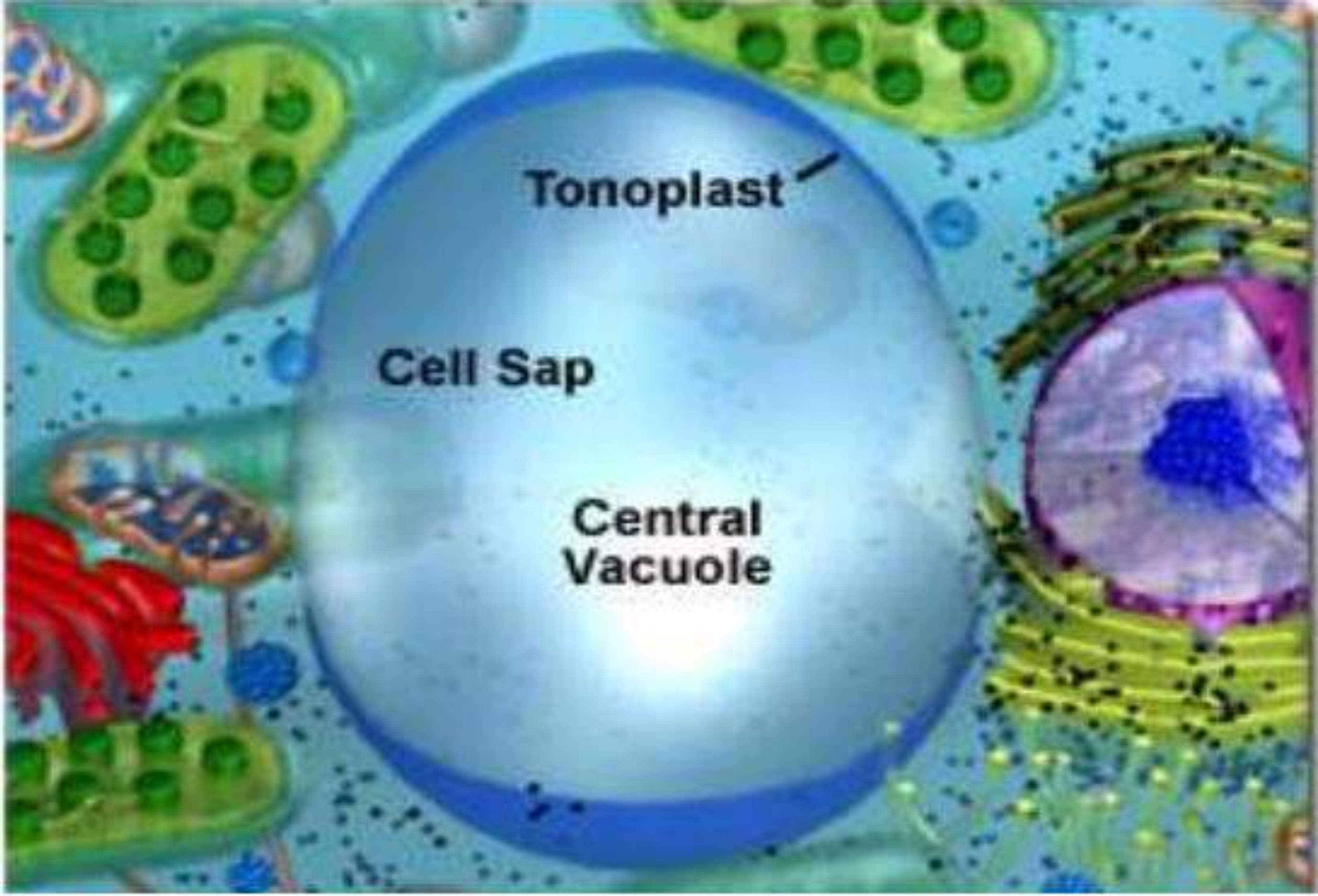
Tonoplast
Cell Sap
Central
Vacuole

- Covalent bonds link carbohydrates to both the lipids and the proteins on the outer surfaces of the membranes.
- Some proteins extend across the entire width of the membrane, while others are embedded or loosely bound to the outer surface.

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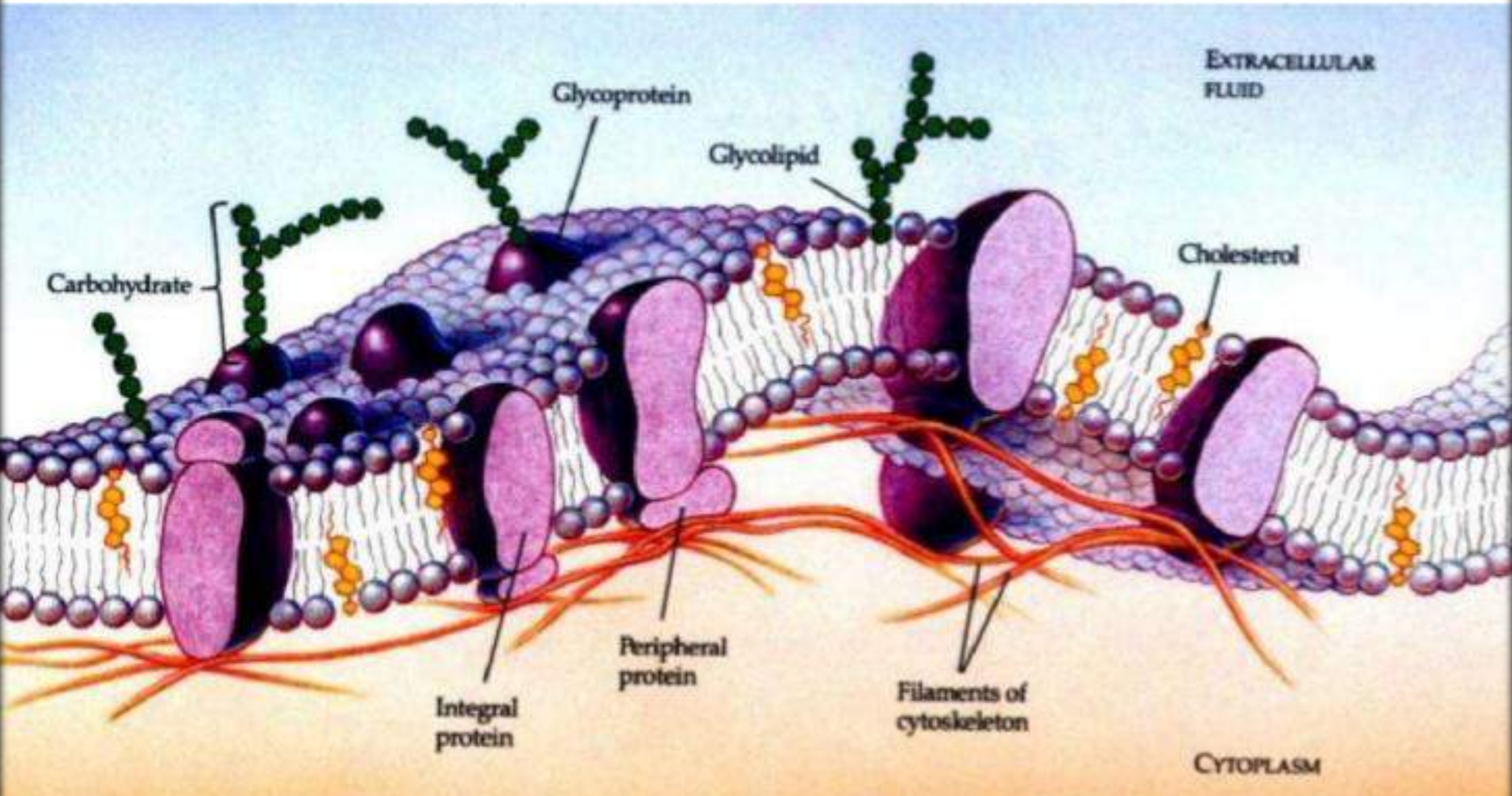
Cell Membrane

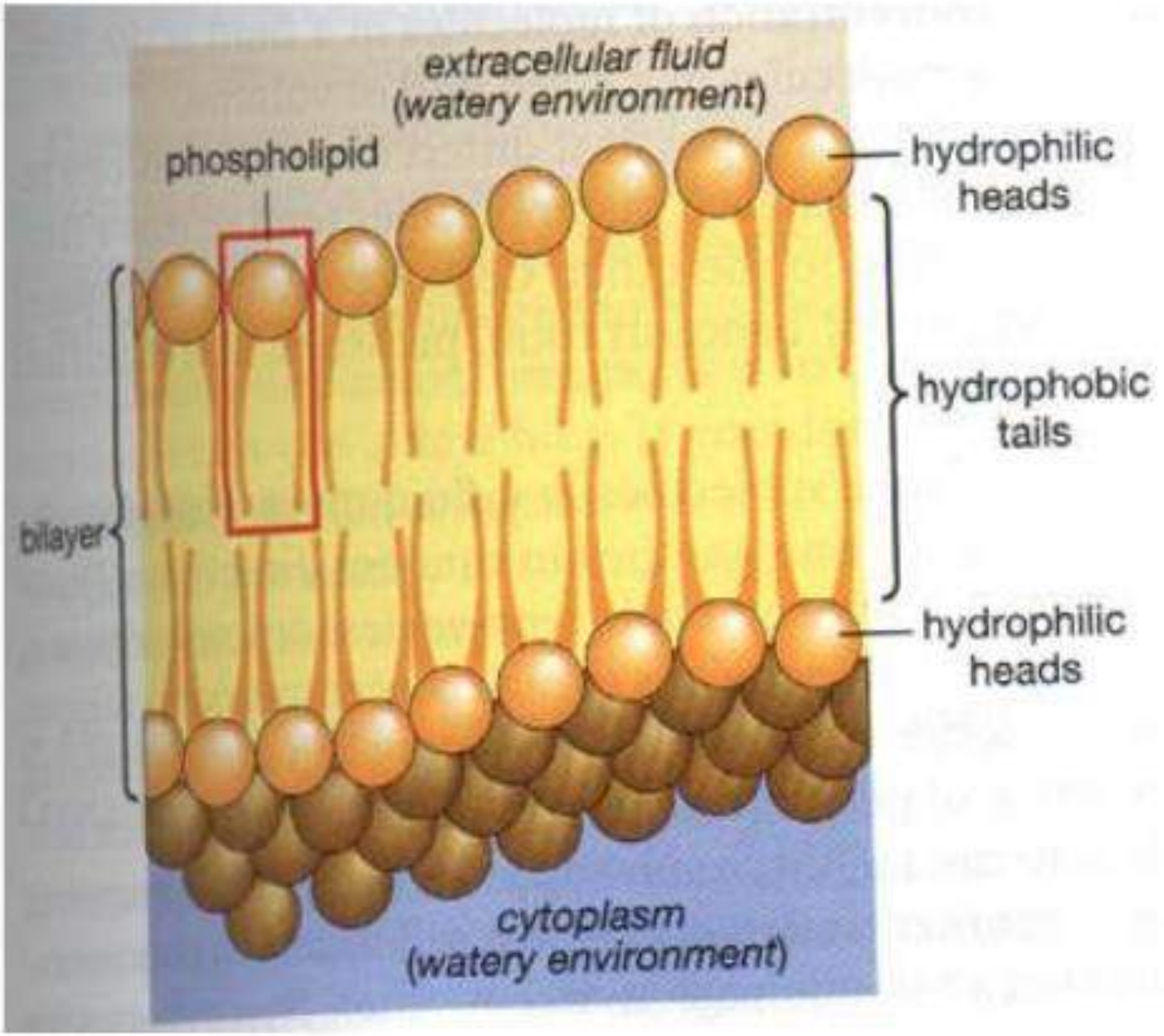
- All cells have cell membrane. The cell membrane is a protective barrier that encloses a cell.
- The cell membrane contains proteins, lipids and phospholipids.
- Lipids (fats and cholesterol), do not dissolve in water.

Cell Membrane

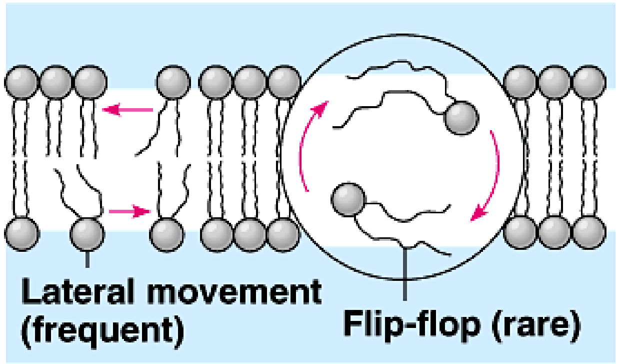
- The cell membrane has two layers of phospholipids.
- Phospholipid is a lipid that contains phosphorus.
- Some of the proteins and lipids control the movement of materials into and out of the cell.
- Nutrients and water move into the cell, and wastes move out of the cell, through these protein passageways.


EXTRACELLULAR FLUID
Glycoprotein
Glycolipid
Carbohydrate
Cholesterol
Peripheral protein
Integral protein
Filaments of cytoskeleton
CYTOPLASM

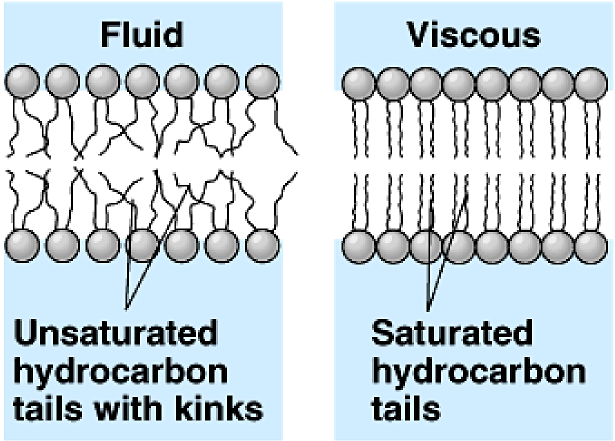
Phospholipids



Cell or Plasma Membrane Structure
Fluid Mosaic Model

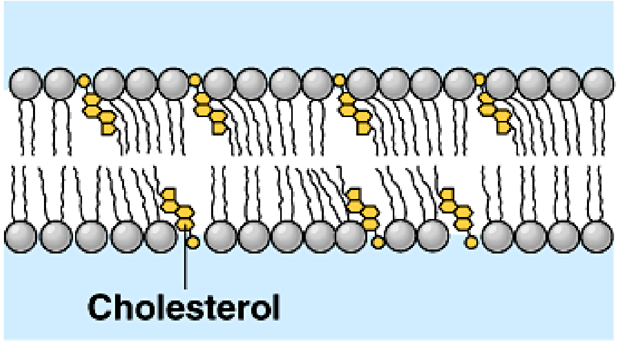


(a) Movement of phospholipids



(b) Membrane fluidity

Phospholipid bilayer & protein molecules



(c) Cholesterol within the membrane

Cell Membrane structure

- yellow structure - hydrophillic or water loving section of the phospholipid.
- blue tails - hydrophobic or water fearing end of the Phospholipid.

8- Microbodies

- It is also called Cytosomes.
- Microbodies have a single bounding membrane and their matrix is granular or fibriliar.
- Microbodies contain enzymes, they are Peroxisomes if they function in the glycolate metabolism and Glyoxysomes if they contain enzymes of the glycolate cycle involved in lipid degradation.

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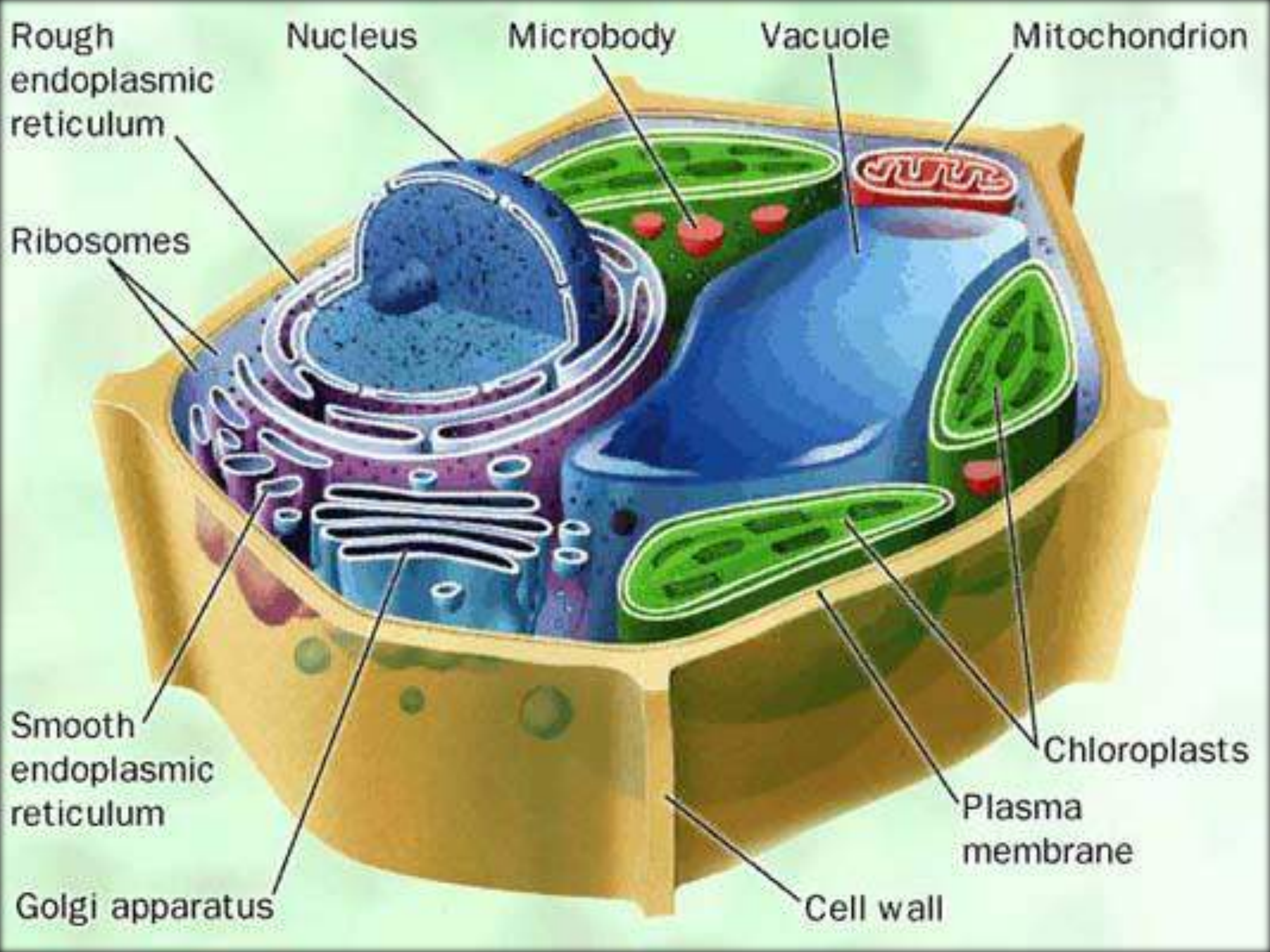

Rough endoplasmic reticulum
Nucleus
Microbody
Vacuole
Mitochondrion
Ribosomes
Smooth endoplasmic reticulum
Golgi apparatus
Chloroplasts
Plasma membrane
Cell wall

9- Microtubules

- Surrounded by a single membrane.
- It is a hollow, straight tube.
- Microtubules are components of mitotic and meiotic spindles and of phragmoplast.

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- Microtubules control the addition of cellulose to the cell wall.
- They are composed of protein called tubulins and of varying lengths.
- They are most commonly found just inside the plasma membrane.

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10- Plasmodesmata

- Singular: plasmodesma
- Microscopic channels which traverse the cell wall.
- Plasmodesmata allow molecules to travel between cells through minute holes in the walls.

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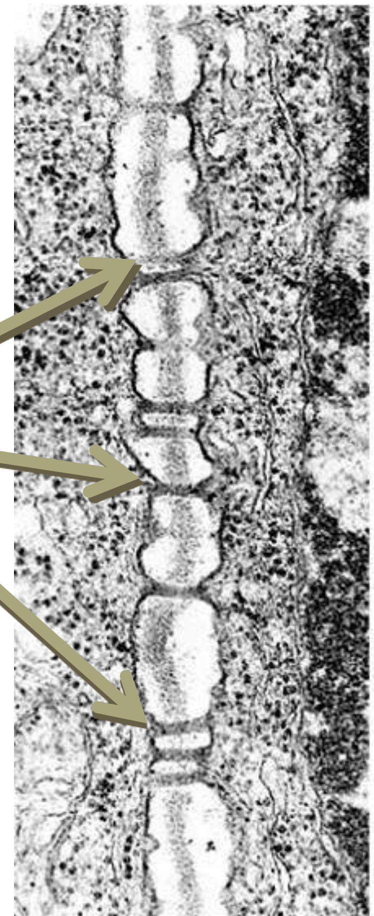
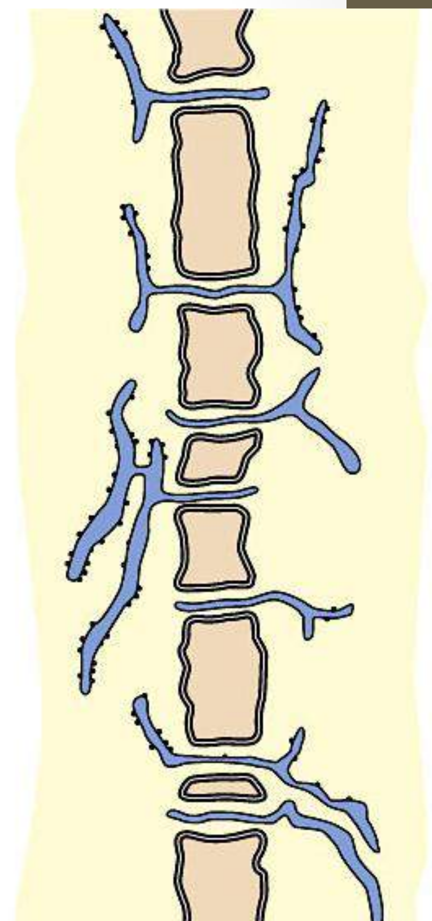
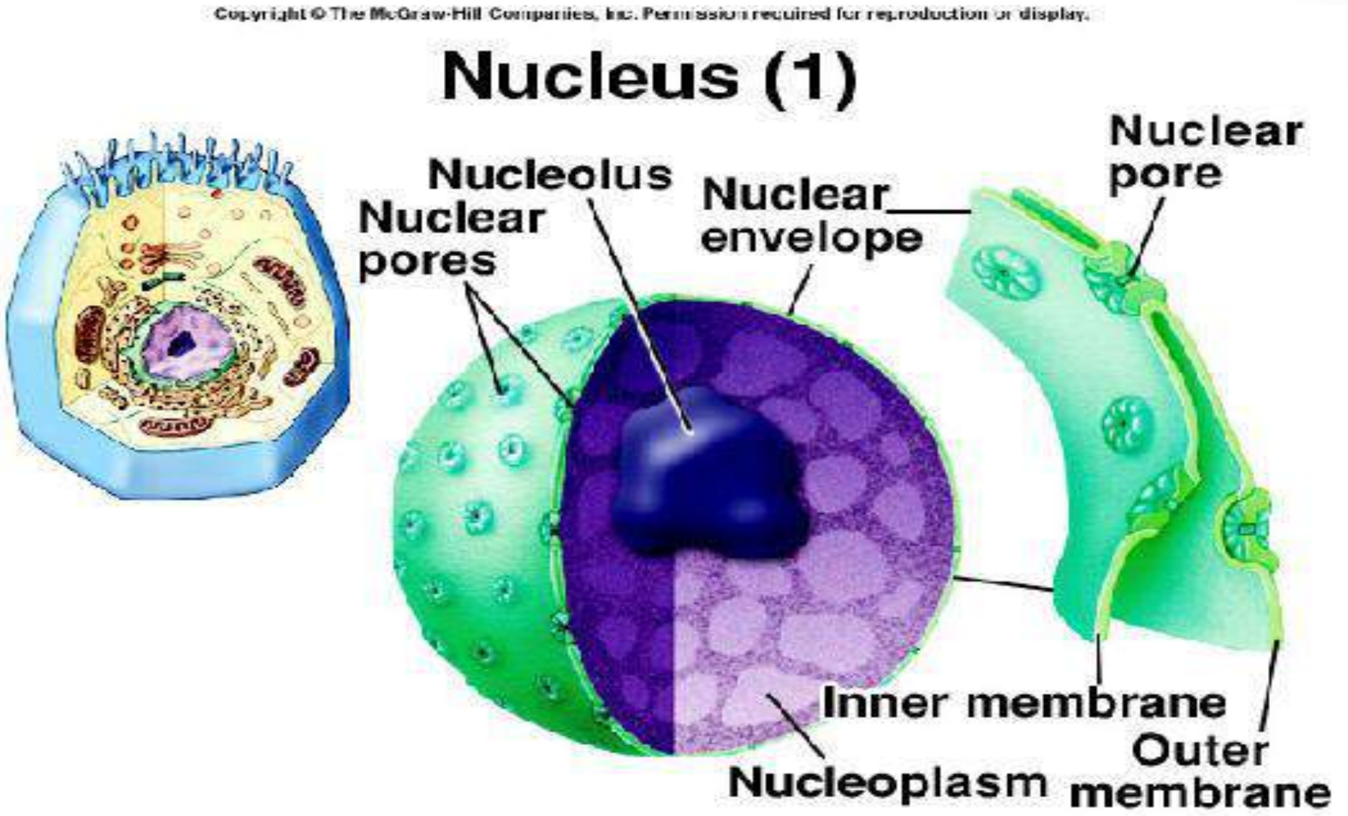
plasmodesmata





11- Nucleus



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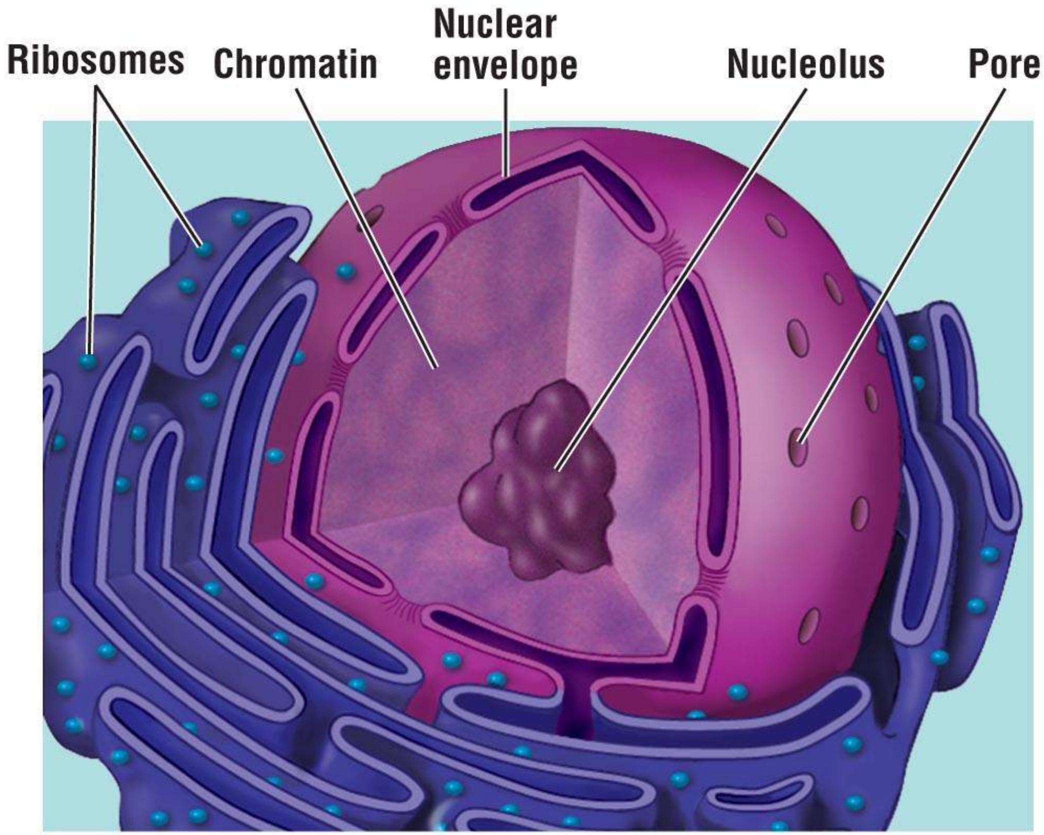
Nucleus (1)
Nucleolus
Nuclear pores
Nuclear envelope
Nuclear pore
Inner membrane
Outer membrane
Nucleoplasm

Structure and Function of the Nucleus

- The nucleus is bordered by a double membrane called the nuclear envelope.
  - It contains chromatin and a nucleolus.

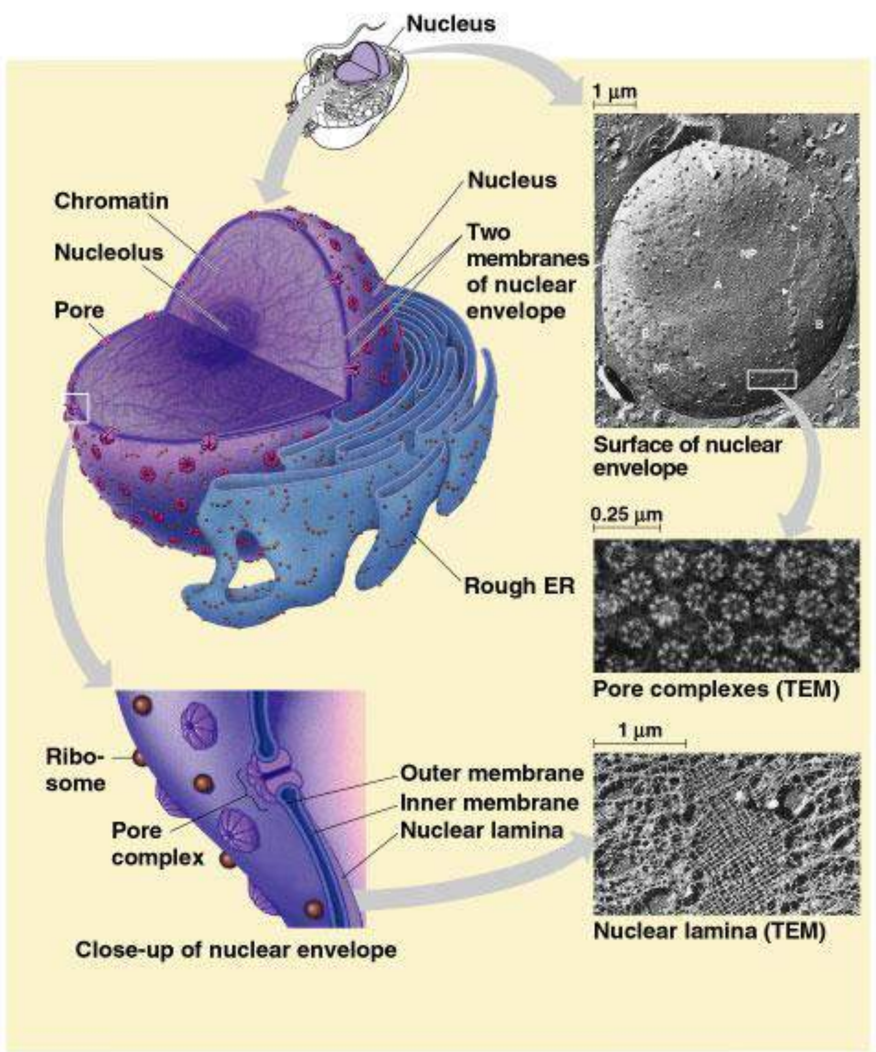
Chromatin: long strands of DNA and associated proteins. The DNA stores the genetic information (genes).



Nucleolus: assembles ribosomes

Nucleus

The Nucleus is enclosed in an envelope which is a double membrane structure. It has pore complexes in the membranes which allow the movement of materials in and out of the structure. It contains DNA and proteins in the form of loose threads called chromatin. During mitosis or meiosis the chromatin super coils to form chromosomes. Self duplicating structure -divides when the cell divides. The nucleolus is a structure composed of RNA located in the nucleoplasm. There maybe be more than one present and it functions in the production of ribosomes. The overall function of the nucleus is the regulation of cellular activities.



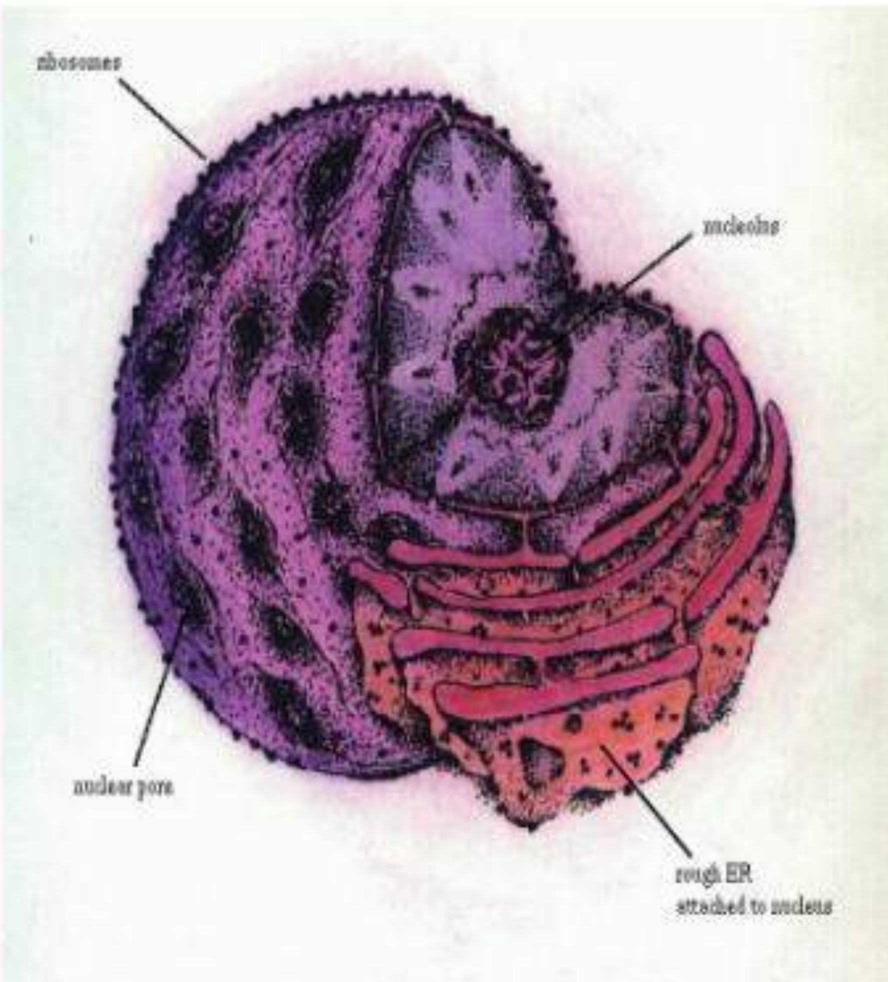
Nucleus

- The nucleus is a large organelle in a eukaryotic cell.
- It contains cell´s DNA, or genetic material.
- DNA contains the information how to make a cell's proteins. Proteins control the chemical reactions in a cell, also support for cells and tissues.

Nucleus

- The nucleus is covered by two membranes .
- The nucleus of many cells has a dark area called the nucleolus.
- The nucleolus is where a cell begins to make its ribosomes.

The nucleus is made up of three important structures



1. *Nuclear Envelope*
2. *Nucleolus*
3. *Chromosomes*

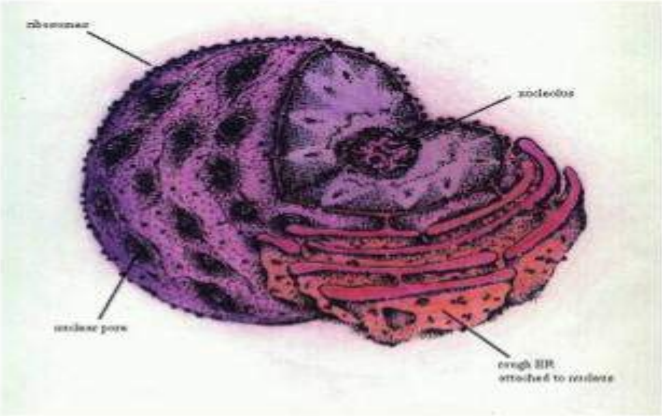
Nuclear Envelope

- double-layered membrane that encloses the contents of the nucleus during most of the cell's lifecycle
- appears to connect with the rough endoplasmic reticulum
- perforated with tiny holes called nuclear pores
- these pores regulate the passage of molecules between the nucleus and cytoplasm, permitting some to pass through the membrane, but not others.
- during mitosis, or cell division, the nuclear envelope disintegrates, but reforms as the two cells complete their formation and the chromatin begins to unravel and disperse

Nuclear Envelope

Surrounds the nucleus and separates its contents from the rest of the cell

Contains pores, or small openings, that allow certain molecules to move in and out of the nucleus



- Nucleoli (singular : nucleolus) are the noticeable of the larger nuclear bodies.
- One to several nucleoli may be present in each nucleus.
- Nucleoli composed primarily of protein and are not bounded by membranes.

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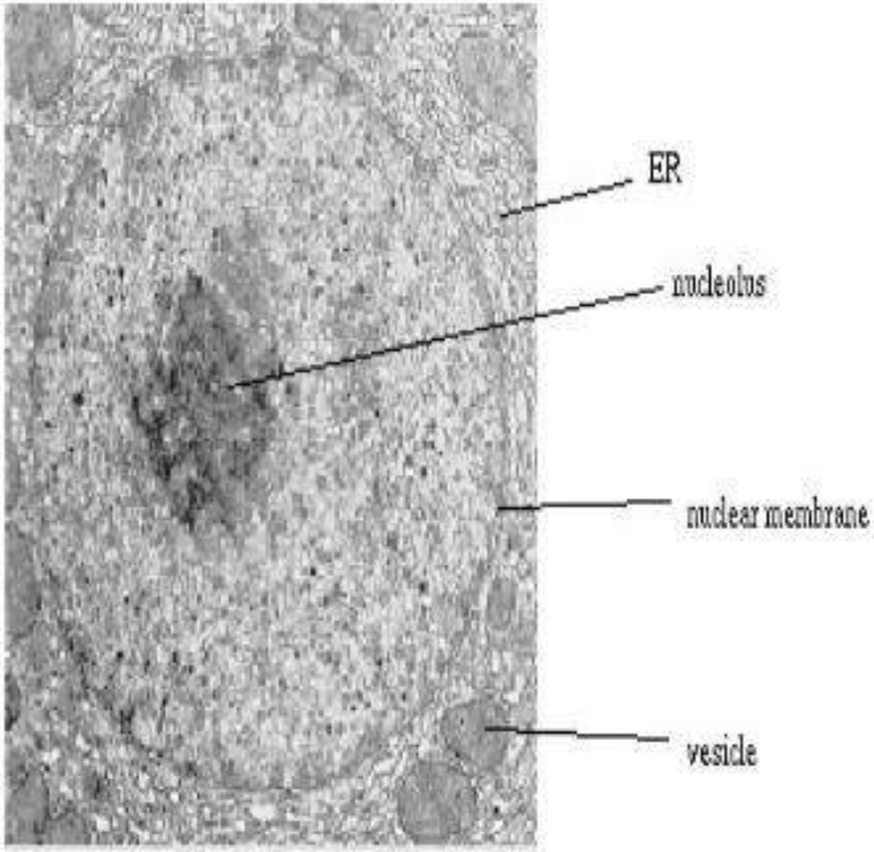
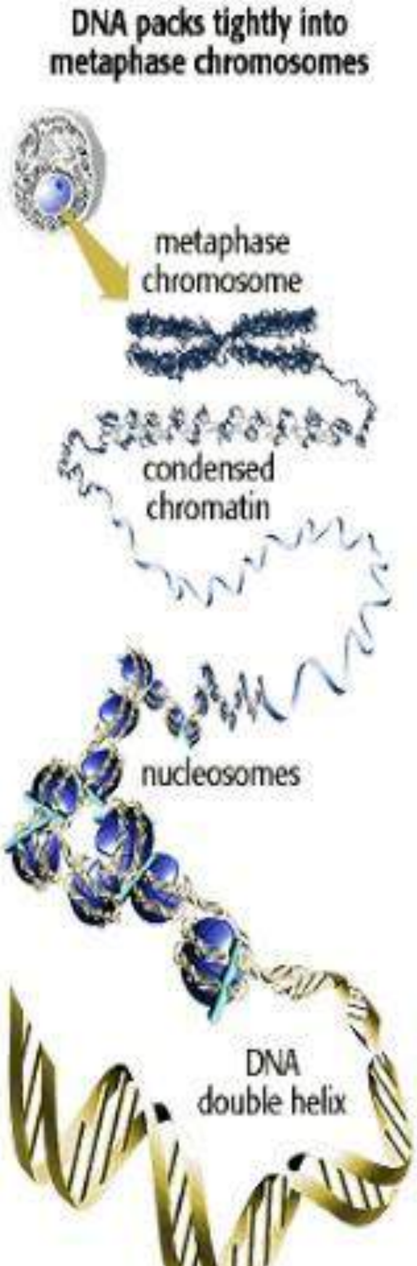
The nucleolus is a dark, dense region made up of the genetic material RNA



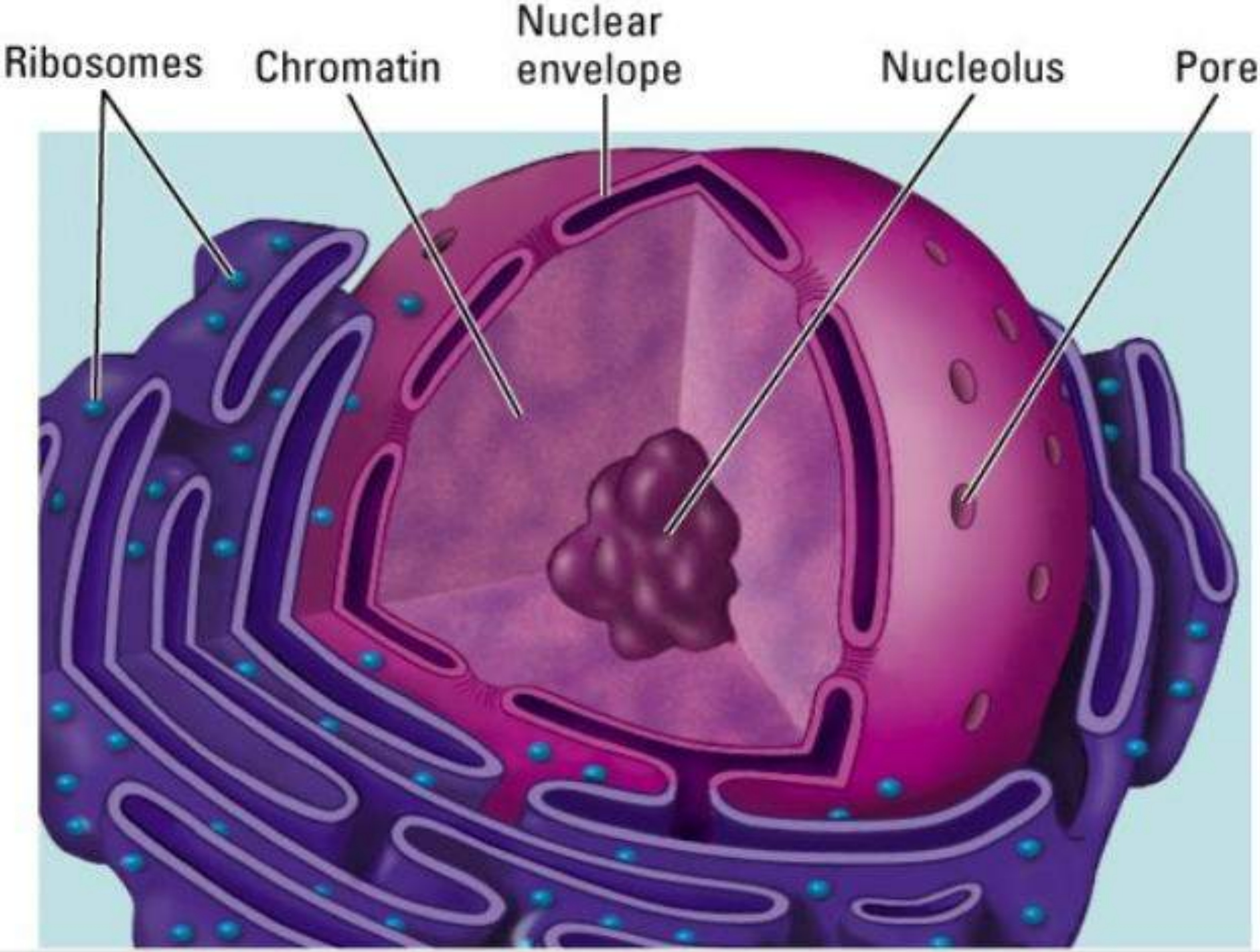
The nucleolus where <u>ribosomes</u> are made



Chromosomes

Small, threadlike structures made up of proteins and DNA molecules

Contain the hereditary information that is passed from one generation to the next


Ribosomes
Chromatin
Nuclear
envelope
Nucleolus
Pore

Non- protoplasmic components

It is not part of the protoplast.

Soluble or not in the cytoplasm or in the cell sap (vacuolar sap).

They are a by-product of certain activities of the protoplast.

Cell sap contains, mainly water; carbohydrates; proteins; organic and non-organic acids; pigments (anthocyanin); crystals….

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Vacuole

Vacuole

The vacuole stores food and wastes.

Plant Vacuole

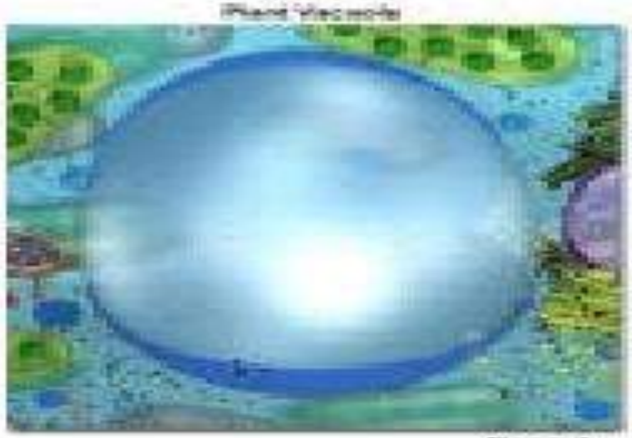
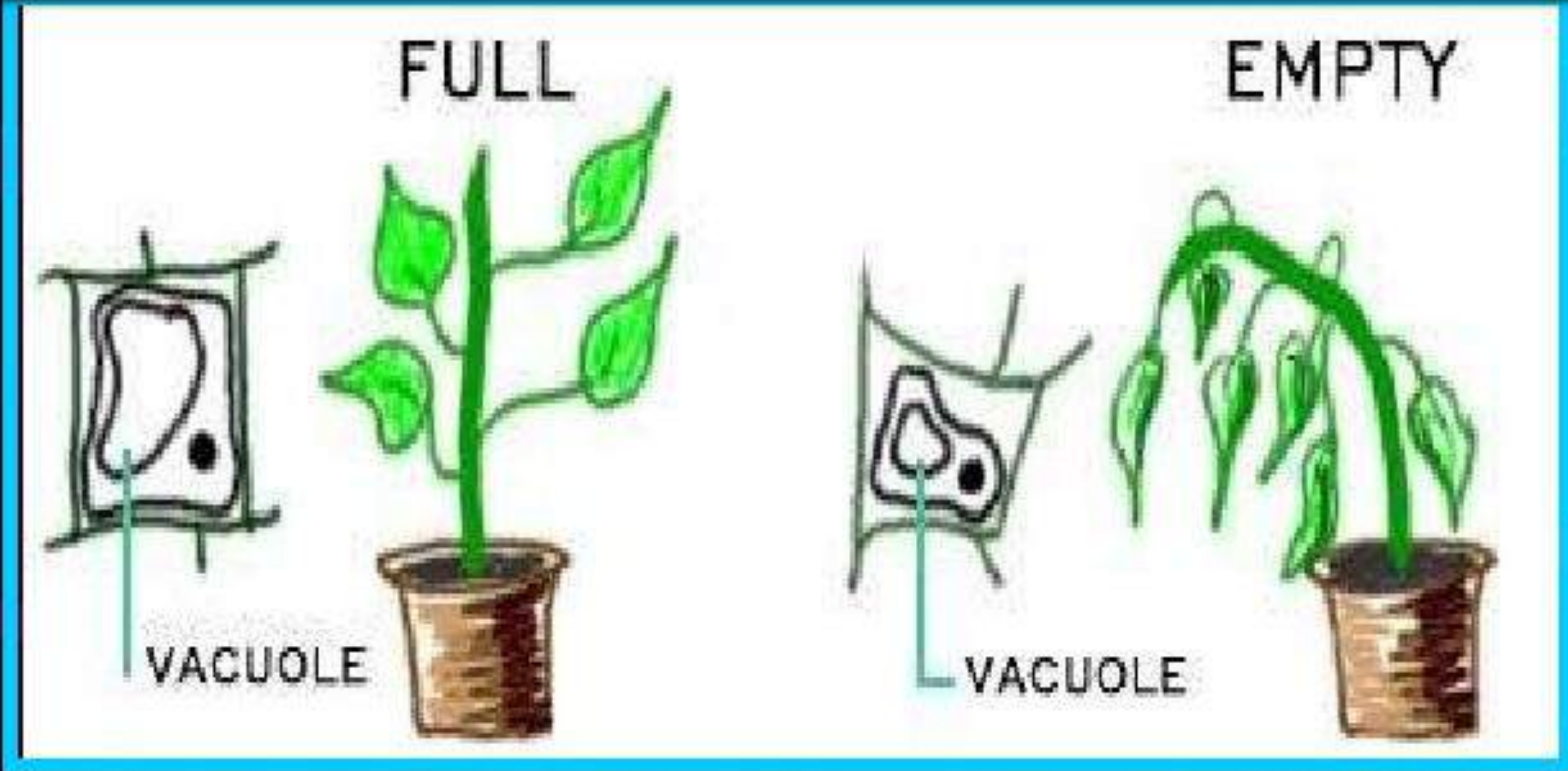


Figure 1

- **Vacuoles**
  - Very large in plant cells, much smaller in animal cells
  - Store water and other liquids
  - If full of water they help support the cell
- Store the liquids that make roses red and violets blue
- Contain the juices you associate with oranges and other fruits



Turgor Pressure- force exerted by the water entering (osmosis) the vacuole, which then swells exerting internal force on the cell wall

- Causes "rigidity" so the plant my increase by stacking cells

Crystals

- Two kinds of crystals:
- 1- Majority of crystals composed of Calcium oxalate that are not soluble; so oxalic acid poisinous effect will be prevented.
- 2- Crystals composed of Carbonic acid.

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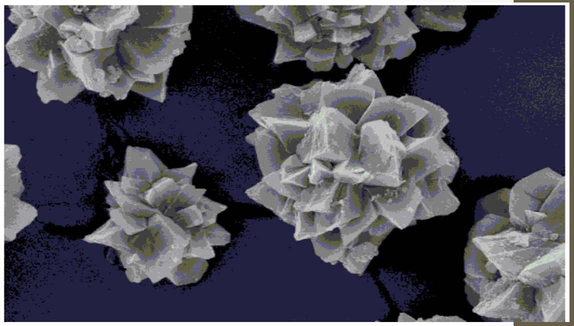
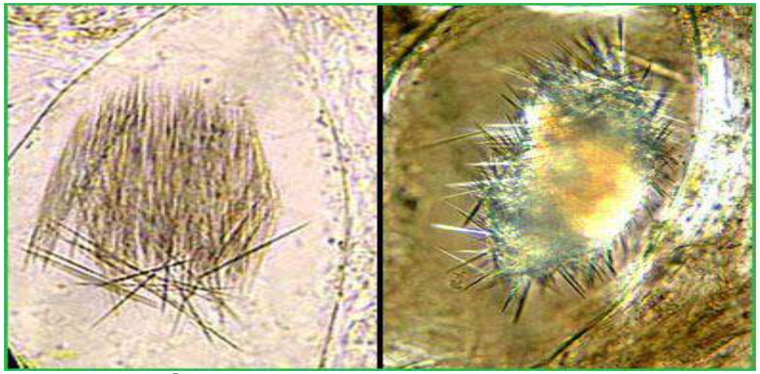
Morphologies of crystals

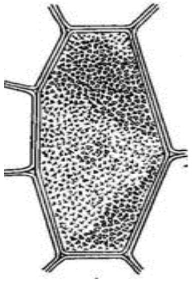
- 1- Druse crystals



- 2- Needle-shaped crystals



- 3- Crystal sand.



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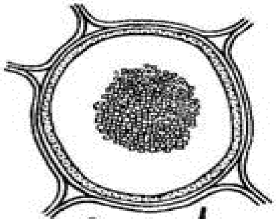
- 4- Spherical crystals

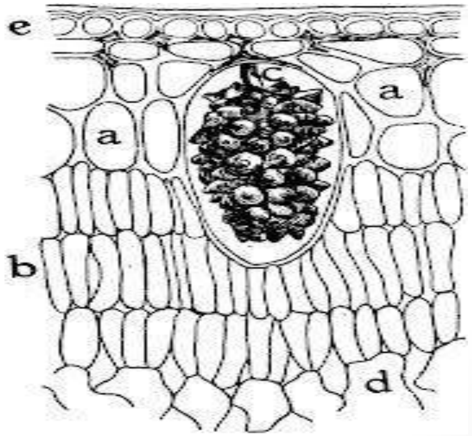


- Cytolith crystals

  Composed of

  The body consists of C.C.

  the neck is cellulose.



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Plant tissues

- Groups of cells that are similar in appearance and function.

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- There are two kinds of tissues.
- 1- Meritematic tissues.
- 2- Permanent tissues.

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Tissues in Plants

- **Plant Tissues**
  - **Meristimatic Tissues**
    (These cells continuously divide throughout the life of the plant)
    - Apical Meristem
    - Lateral Meristem
    - Intercalary Meristem
  - **Permanent Tissues**
    (Cells with speciallised structure and function that have lost their ability to divide further)
    - Simple Permanent Tissue
      - Parenchyma
      - Collenchyma
      - Sclerenchyma
    - Complex Permanent Tissue
      - Xylem
      - Phloem

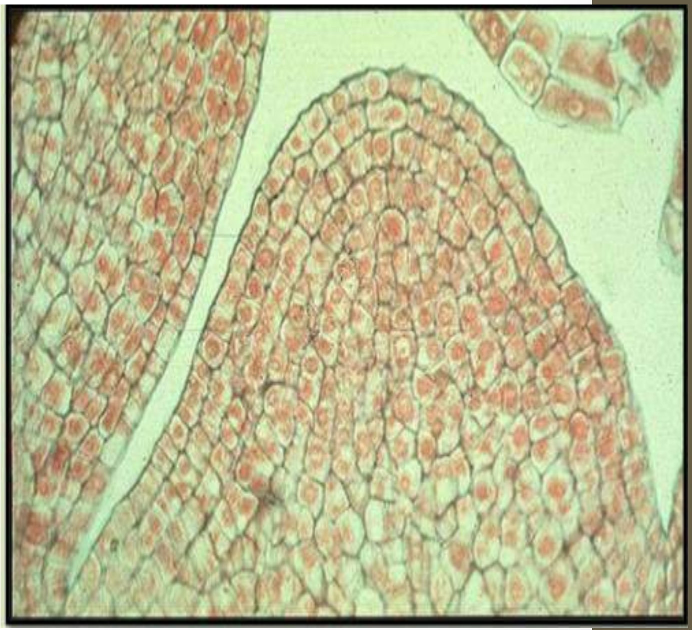
Meristematic tissue

MERISTEMATIC TISSUE

- The main characteristic of this tissue is that it is responsible for the growth of plants.
- The cells of this tissue continuously divide and later differentiate (i.e. get converted) into permanent tissue.

Meristematic cells characters

- 1- Smaller in size compared to mature cells.
- 2-They are either rectangular or diametric in shape.
- 3- The cells are always compactly arranged without intercellular spaces
- 4- The cells have a thin cell wall which is composed of only cellulose.



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- 5- With large nucleus
- 6- Dense cytoplasm
- 7- Small or without vacuoles
- 8- Ergastic substances are absent.
- 9- The cells are capable of under going regular, continuous mitotic divisions.

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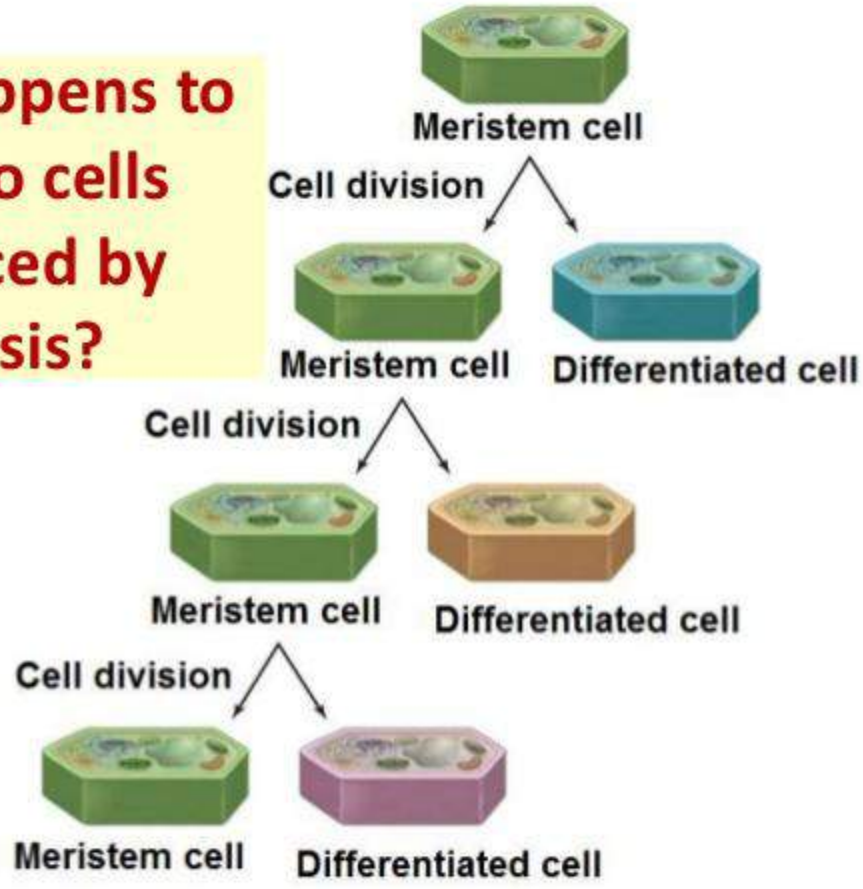
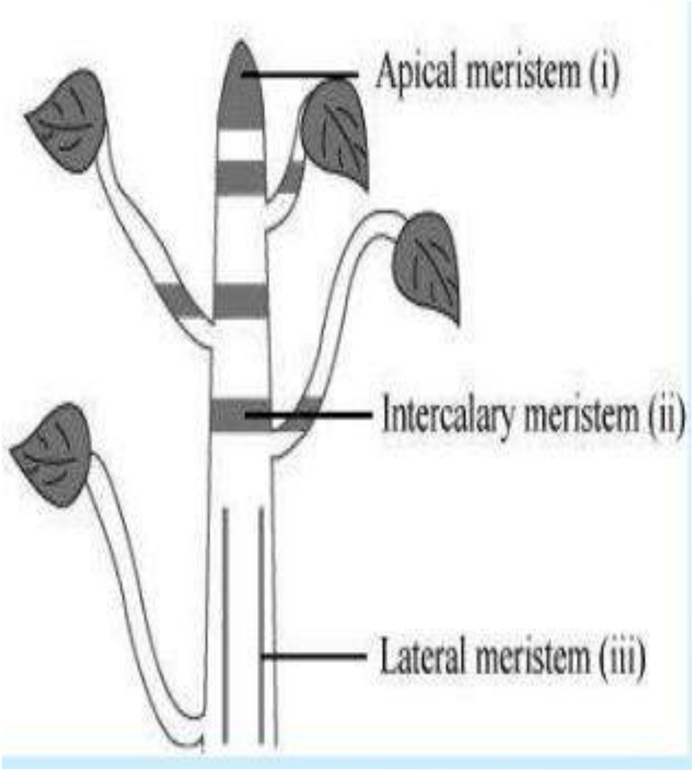
What happens to the two cells produced by mitosis?



Types of meristems

- Meristematic tissues divided into three kinds, based on location, origin in plant body and differentiation :
- A- Based on location:
- 1- Apical meristem
- 2- Lateral meristem
- 3- Intercalary meristem.



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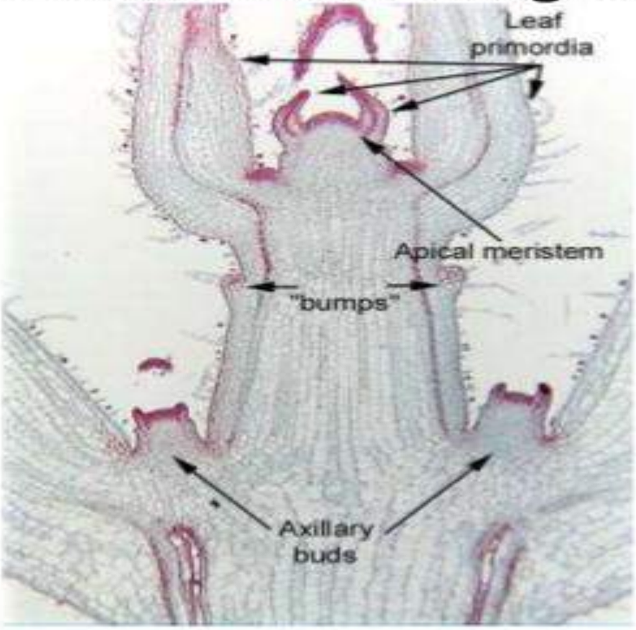
Name of the tissue	Location	Function
Apical Meristem	Present at the growing tip of stem and root	Increase in length of stem and root
Lateral Meristem (also called cambium)	Found on the lateral sides of roots and stem	Increase in girth of stem and root
Intercalary Meristem	Present at the base of leaves or internodes	Growth of leaves and branches

Apical meristem

- Apical meristem of shoot

The group of undifferentiated cells that divide to produce increased length of stems and roots



Apical Meristems

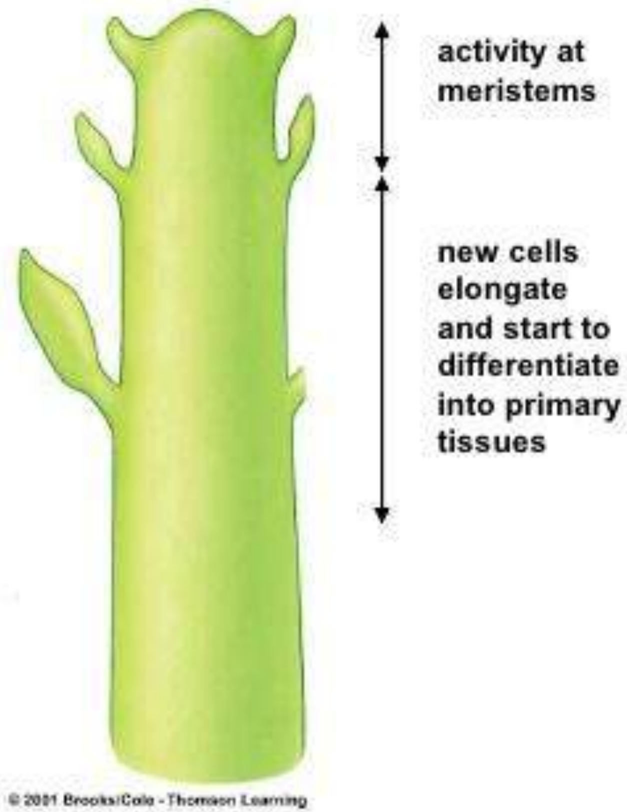
Lengthen shoots and roots: SAM and RAM

Cells that form at apical meristems:

protoderm → epidermis

ground meristem → ground tissues

procambium → primary vascular tissues



B. Classification of meristems :

- Based on position in plant body
- (i) Apical meristems
- ➡ Occur at apices
- ➡ Differentiate into primary tissues
- ➡ Cause increase in length
- ➡ Axillary buds are present in axils of leaves

Primary Growth of the Shoot

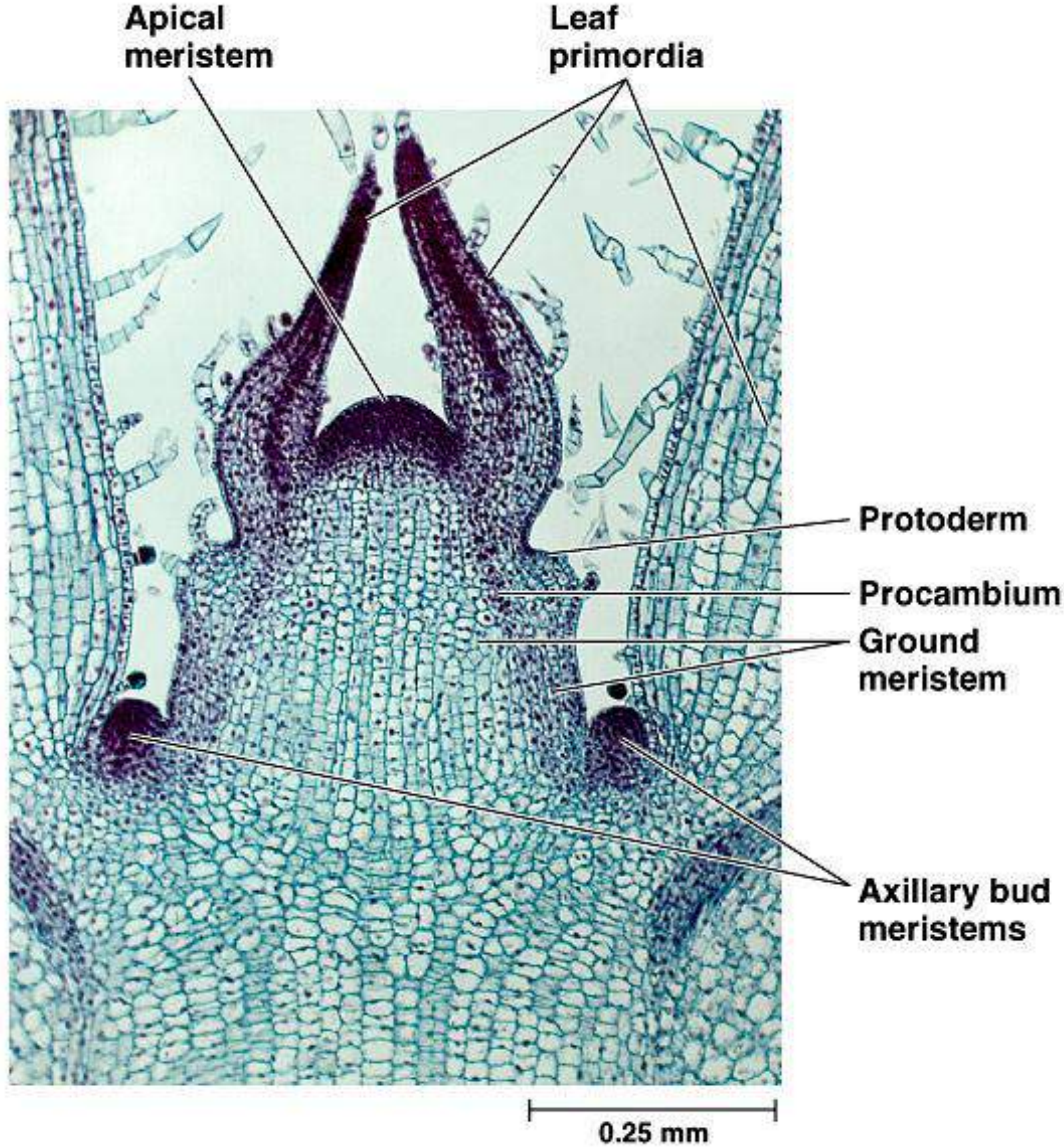
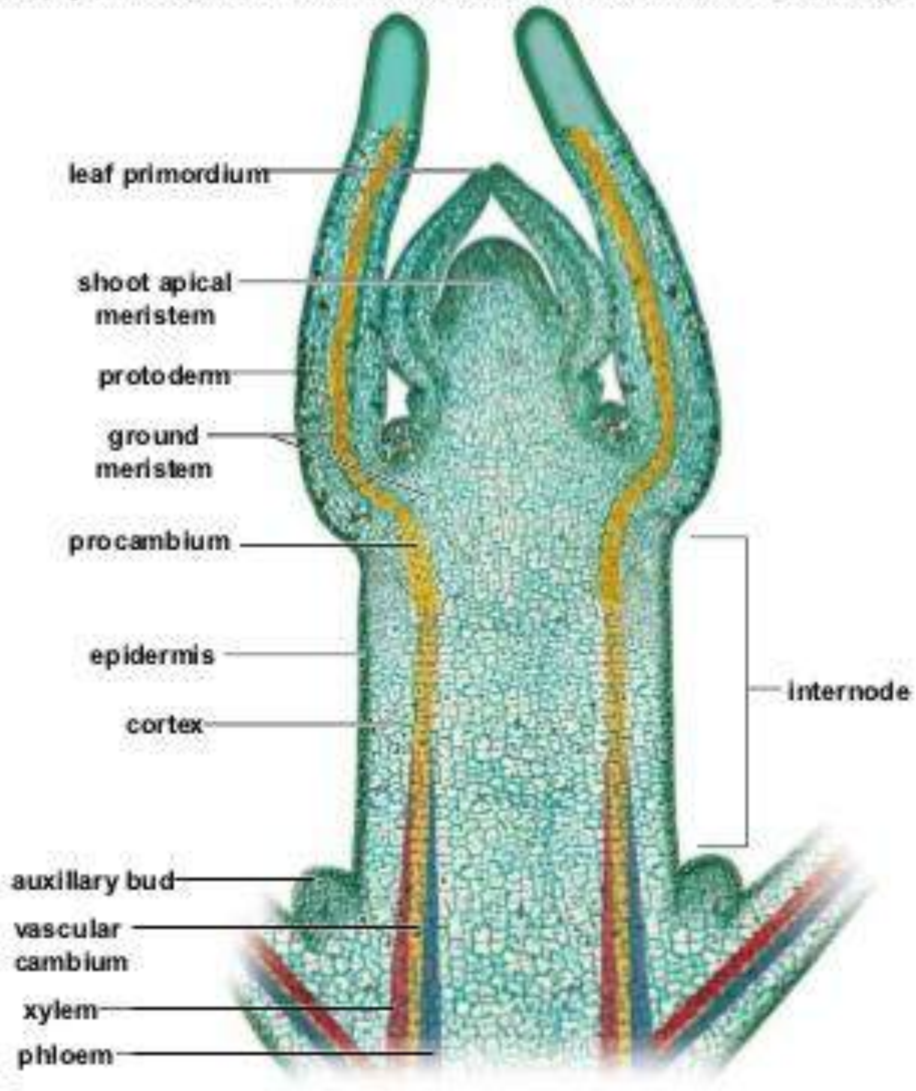
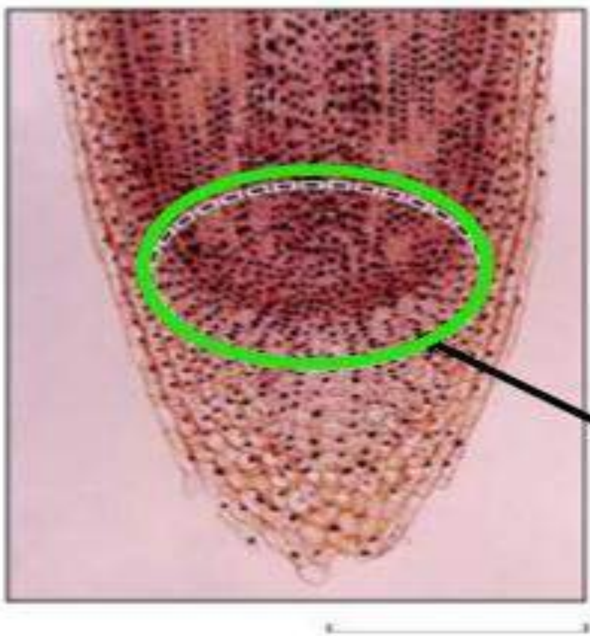
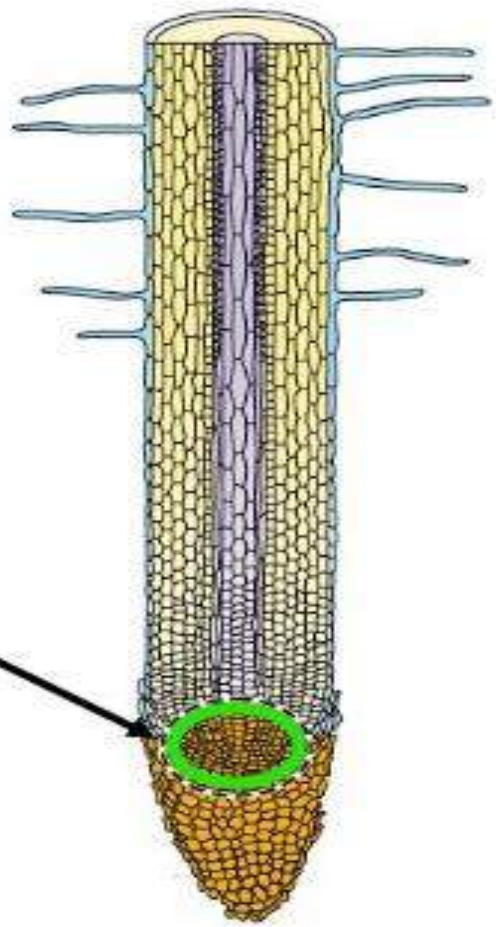


Figure 21.5B, pg. 441 Shoot apical meristem



- Apical meristem of root





Lateral meristem

- Two kinds of lateral meristem responsible for secondary growth:
- 1- Vascular cambium
- 2- Cork cambium
- They lie on the sides of the plant body.
- Give the plant width or girth.

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(ii) Lateral meristems :

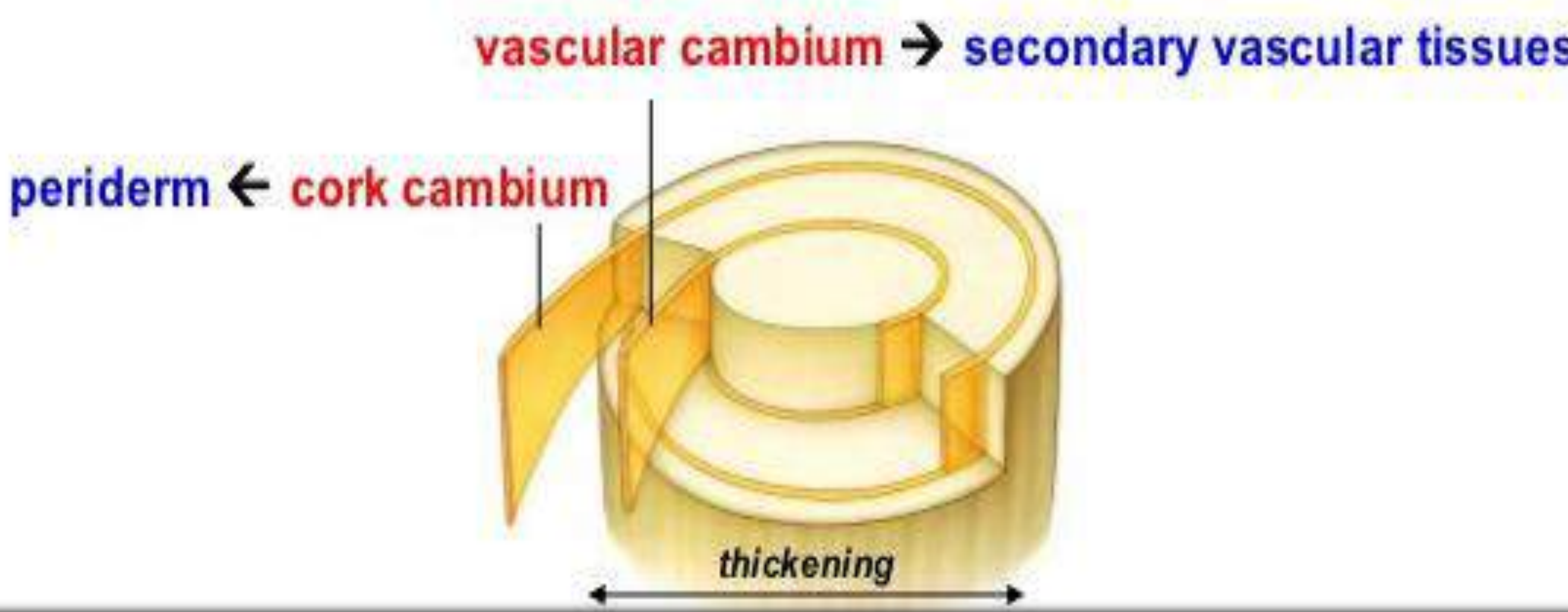
- Arranged parallel to the sides of organs of plant
- Cells produced by them differentiate into secondary tissues
- Cause increase in width of plant organ

e.g., Fascicular cambium & cork cambium

Lateral Meristems

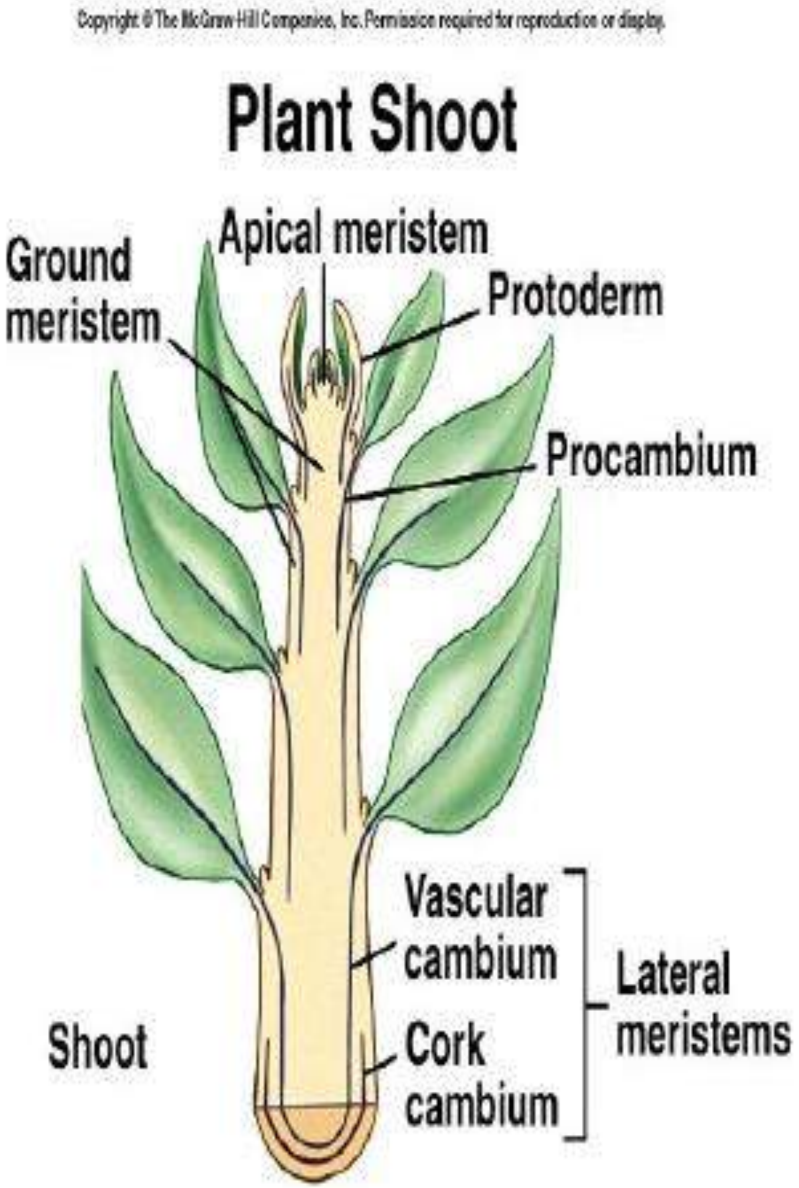
Increases girth of older roots and stems

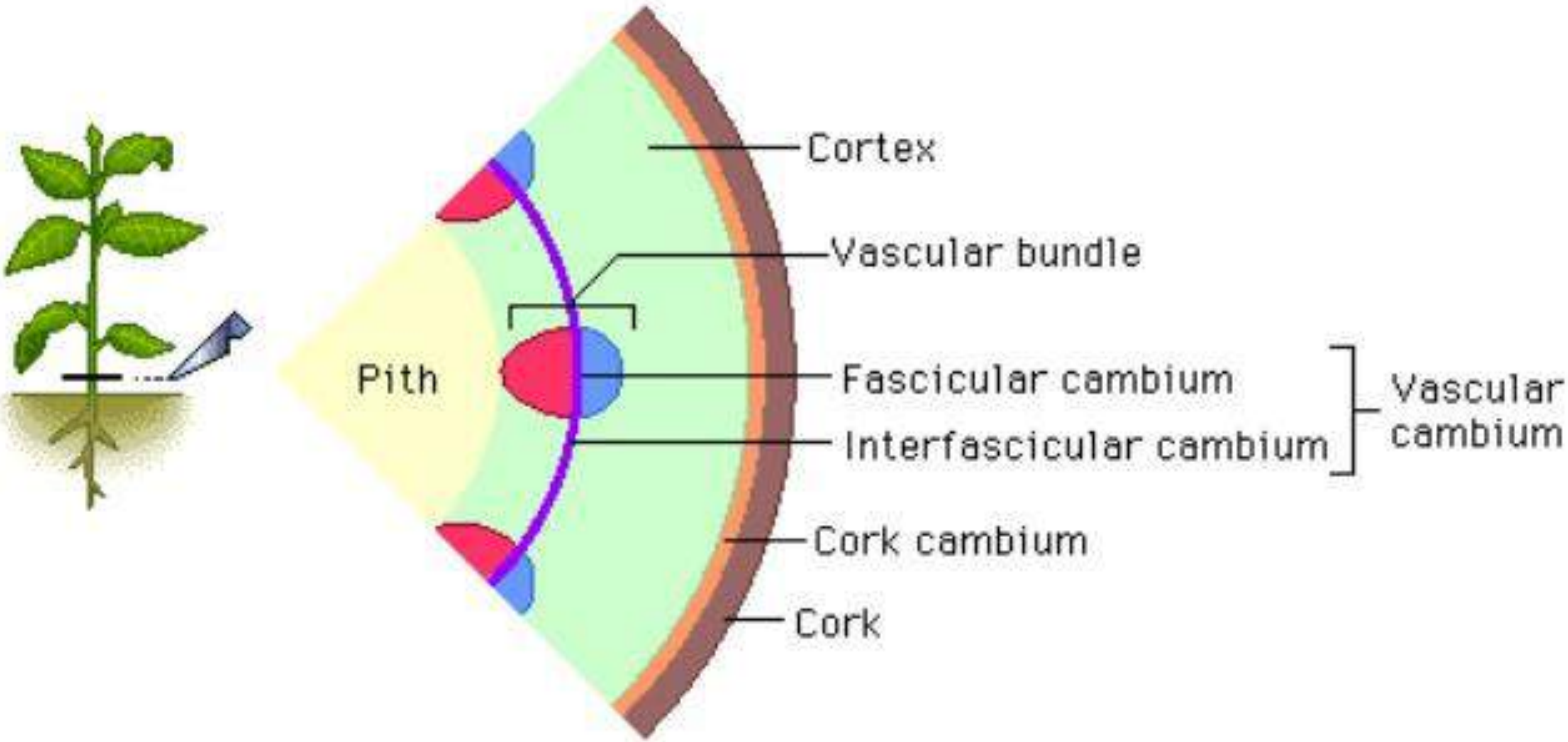
Cylindrical arrays of cells



- Secondary growth (increased girth) is the thickening of roots and shoots, which occurs in woody plants due to development of lateral meristems.

- Tissues formed from lateral meristems, comprise most of the trunk, branches, and older roots of trees and shrubs.

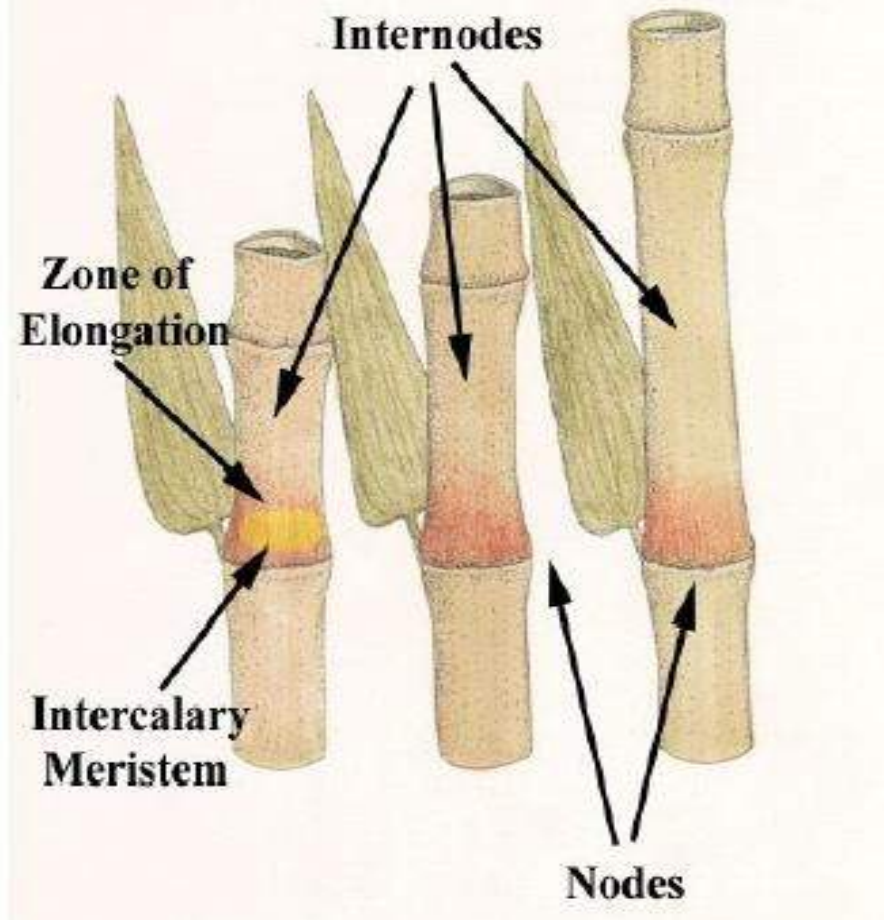




Cortex
Vascular bundle
Pith
Fascicular cambium
Interfascicular cambium
Vascular cambium
Cork cambium
Cork

Intercalary meristem

- Common in grasses (occur at bases of nodes).
- Helps regenerate parts removed (by herbivores, etc.)
- Stem elongation in very short time.



Intercalary Meristem
(only in monocot stem)

(iii) Intercalary meristems :

- Meristems occur in between mature/permanenet tissues
- Produce cells that form primary tissues
- Cause increase in length
- Occur at bases of internodes & leaf sheaths of grasses & other monocots;
  They regenerate parts removed by grazing animals

- B- Based on origin:
- 1- Primary meristem: It presents from the emberyonic stage and continuous to be active throughout the life of plant. It is responsible for primary growth in the plant body.

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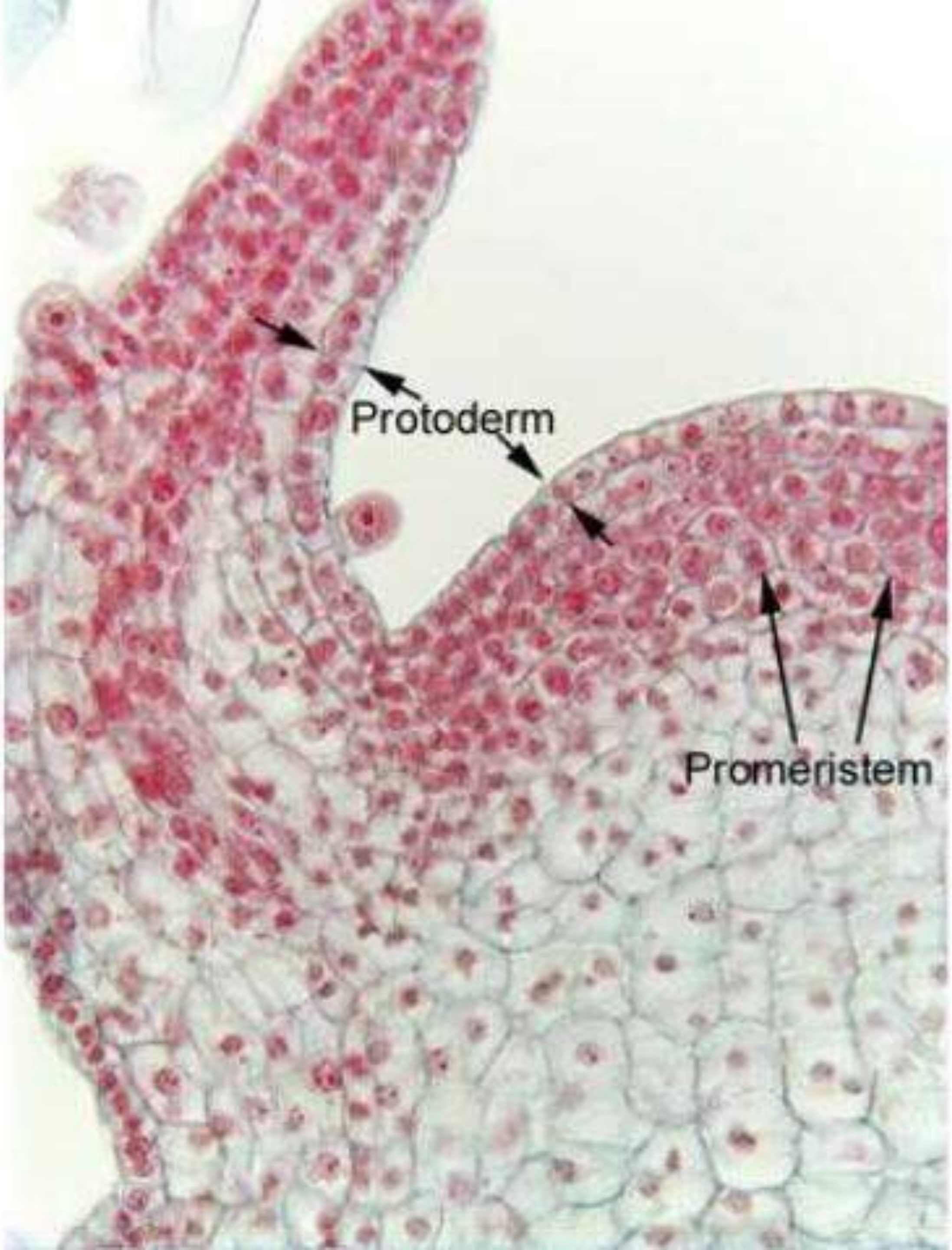
Based on origin

(i) Promeristems :

- Group of meristematic cells in embryo / seedlings
- Give rise to primary meristems


Protoderm
Promeristem

- 2- Secondary meristem: It appears later in the life cycle of plant. It develops by a process called in the permanent tissues. It is responsible for secondary growth.

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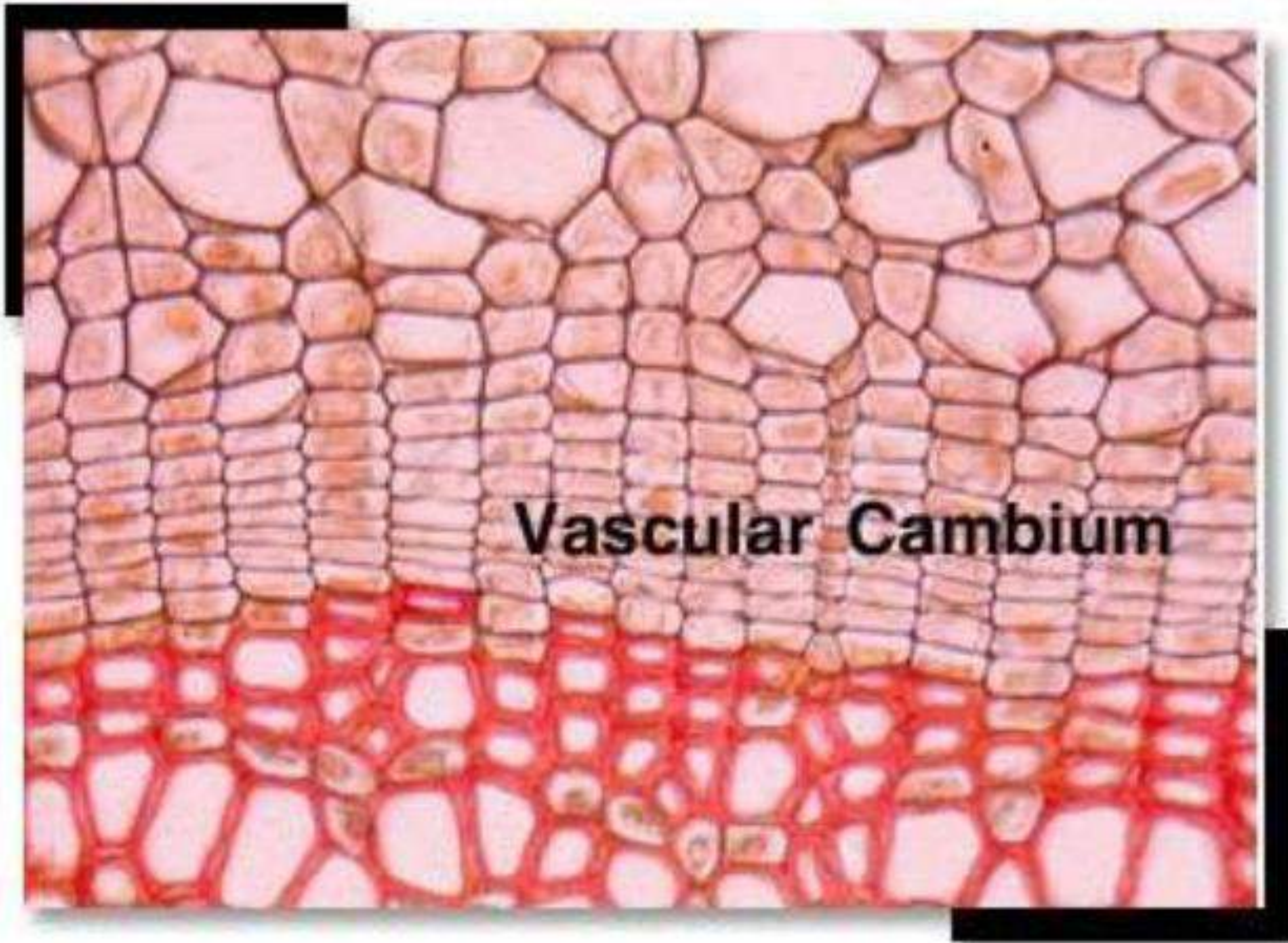
(iii) Secondary meristems :

- Formed at a later stage in the life of plant from permanent tissues by process of dedifferentiation, e.g., Cork cambium & inter-fascicular cambium


Vascular Cambium

- C- based on differentiation: Depends on type of permanent tissue differentiates from meristem, three types of meristem can be recognized:
- 1- Protoderm, gives rise to epidermis.
- 2- Ground meristem, gives rise to ground tissue.
- 3- Provascular tissue (procambium), gives rise to 1 vascular tissue.

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PERMANENT TISSUE

- The permanent tissue are derived from the meristems tissues
- but their cells have lost the power of division and have attained their definite form.

(which growth have stopped either completely or for the time being)

Permanent tissues

- 1- Simple tissues
  - a- Parenchyma
  - b- Collenchyma
  - c- Sclerenchyma
  - d- Cork
- 2- Complex tissues
  - a- Xylem
  - b- Phloem
  - c- Epidermis

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Simple tissues

SIMPLE PERMANENT TISSUE

This tissue comprises of same type of cells which perform the same function and all arise from the same origin. There are three categories of simple permanent tissues: Parenchyma, Collenchyma, & Sclerenchyma.

Parenchyma tissue

PARENCHYMA

- Characteristics:

a) The cells are living.

b) The cells are thin walled.

c) There may or may not be intercellular spaces.

d) They are the most unspecialized cells.

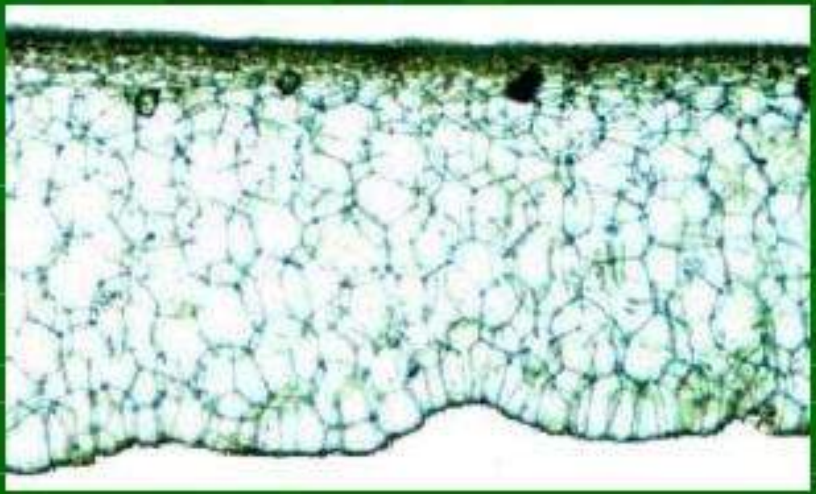
e) No depositions are seen, the cell wall consists only of cellulose.

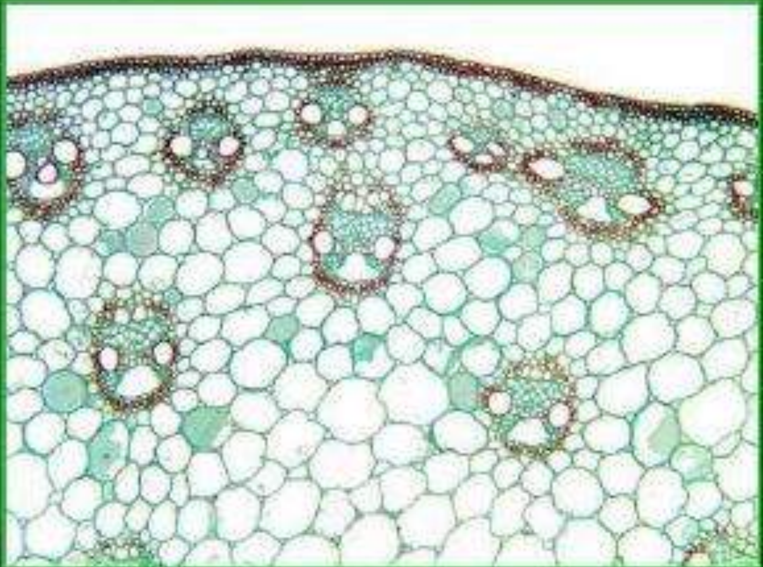
f) There is a prominent nucleus, cytoplasm & vacuoles.

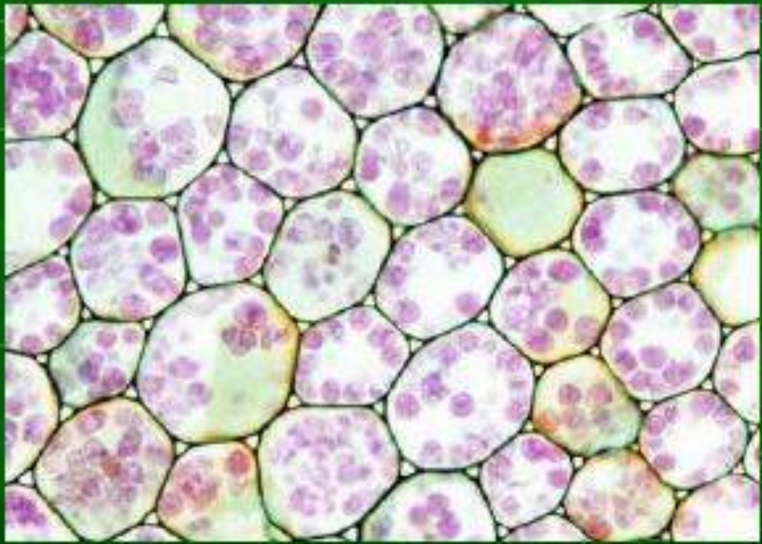
- There are some special types of parenchyma tissues :
- Storage parenchyma : The cells enlarge to store nutrients & water.
- Aerenchyma : Air cavities are present in the parenchyma tissue to provide buoyancy to the aquatic plants.
- Chlorenchyma : These parenchyma cells have presence of chlorophyll & hence can perform the function of photosynthesis.

Parenchyma tissue is found generally in all parts of the plant body. It forms the Ground tissue in leaves, stem, roots & fruits etc.

Parenchyma



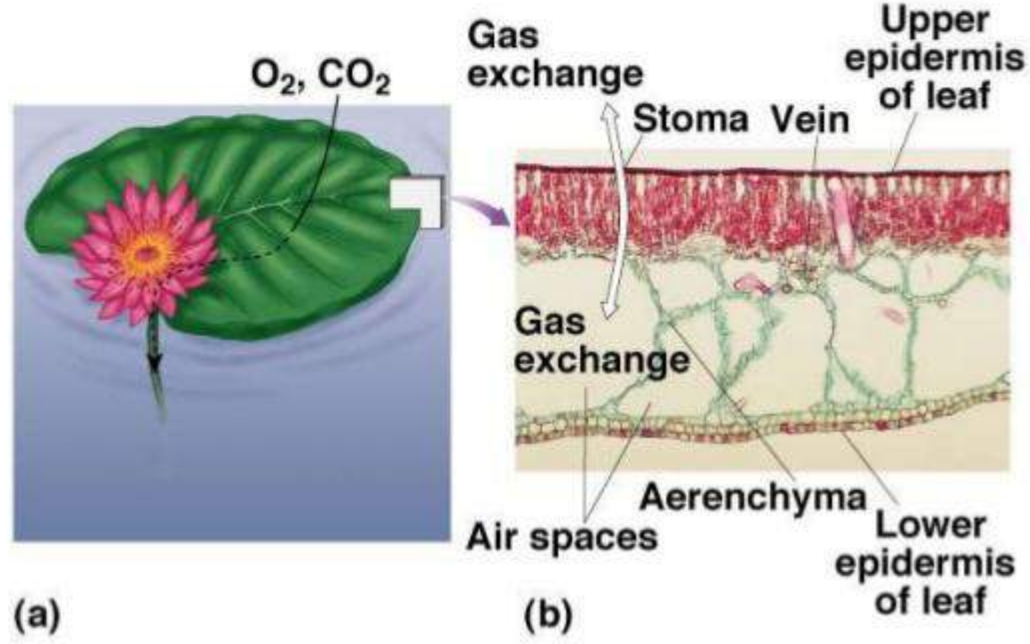




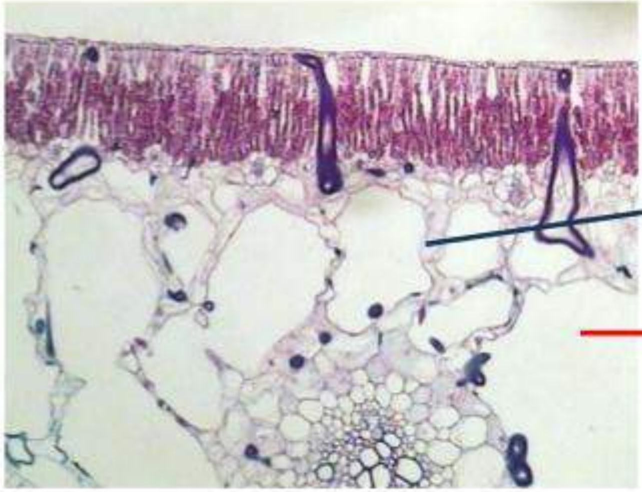
Functions of parenchyma :

a) To store materials such as starch, proteins, hormones etc and waste products such as gum, tannin, resin etc.
b) Parenchyma cells perform the metabolic activities of the plant.
c) Forms the packaging tissue between the specialized tissue.
d) By providing turgidity , they provide mechanical strength.
e) Chlorenchyma helps in performing photosynthesis.

Aerenchyma in Aquatic Plants



LS leaf of *Nymphaea alba* (water lilly)



Aerenchyma

Large air spaces form throughout the entire plant and help to:

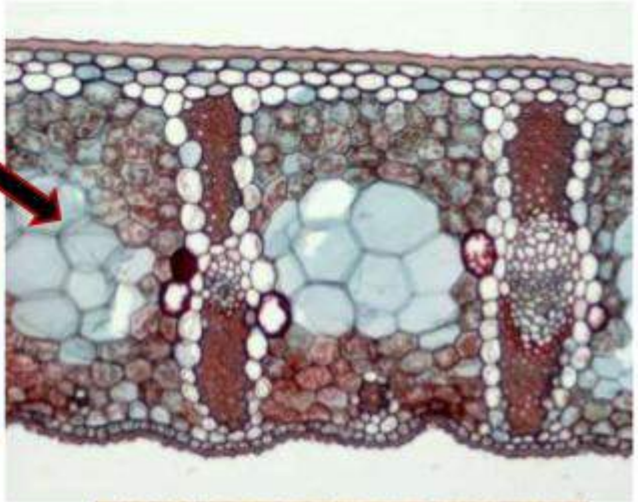
1. allow O_2 to diffuse to the submerged leaves
2. provide buoyancy

Aqueous parenchyma

- stores water in **succulent** plants

Aqueous parenchyma

- ✓ Cells are large
- ✓ Walls are thin
- ✓ Cells store water in a large vacuole

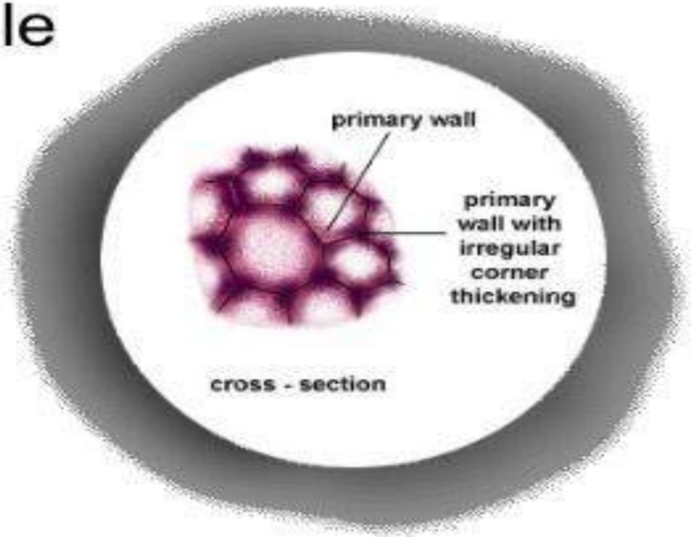


- when cells use up water, the cells shrink by enfolding the wall

Collenchyma tissue

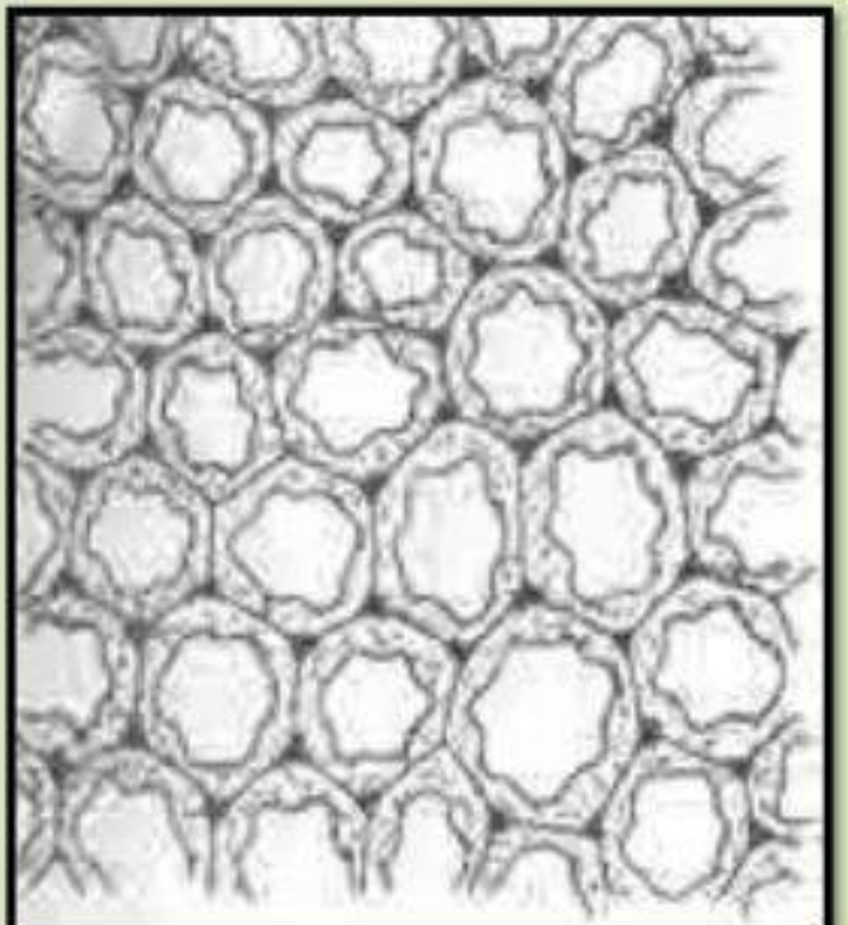
Collenchyma: A Simple Tissue

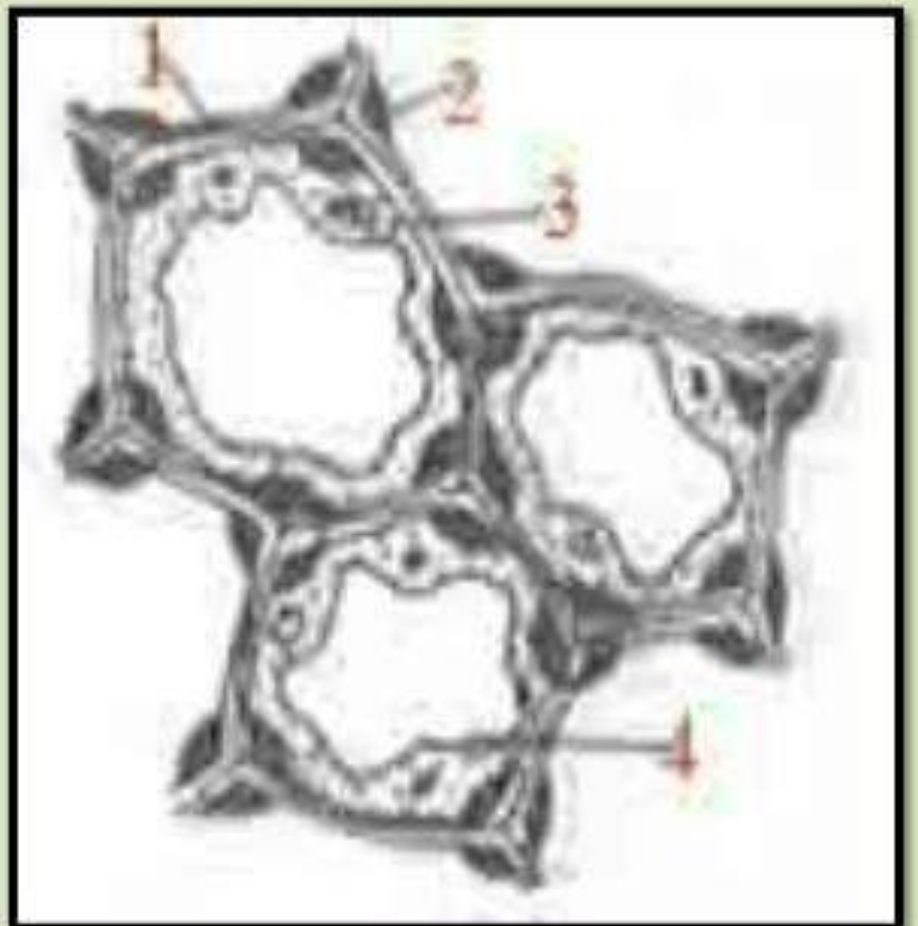
- Specialized for support for primary tissues
- Cells are elongated, with walls (especially corners) thickened with pectin
- Makes stems strong but pliable
- Cells are alive at maturity



Collenchyma in Transverse Section Showing Wall Thickenings

1. Cell Wall
2. Wall Thickenings
3. Protoplasm
4. Vacuole

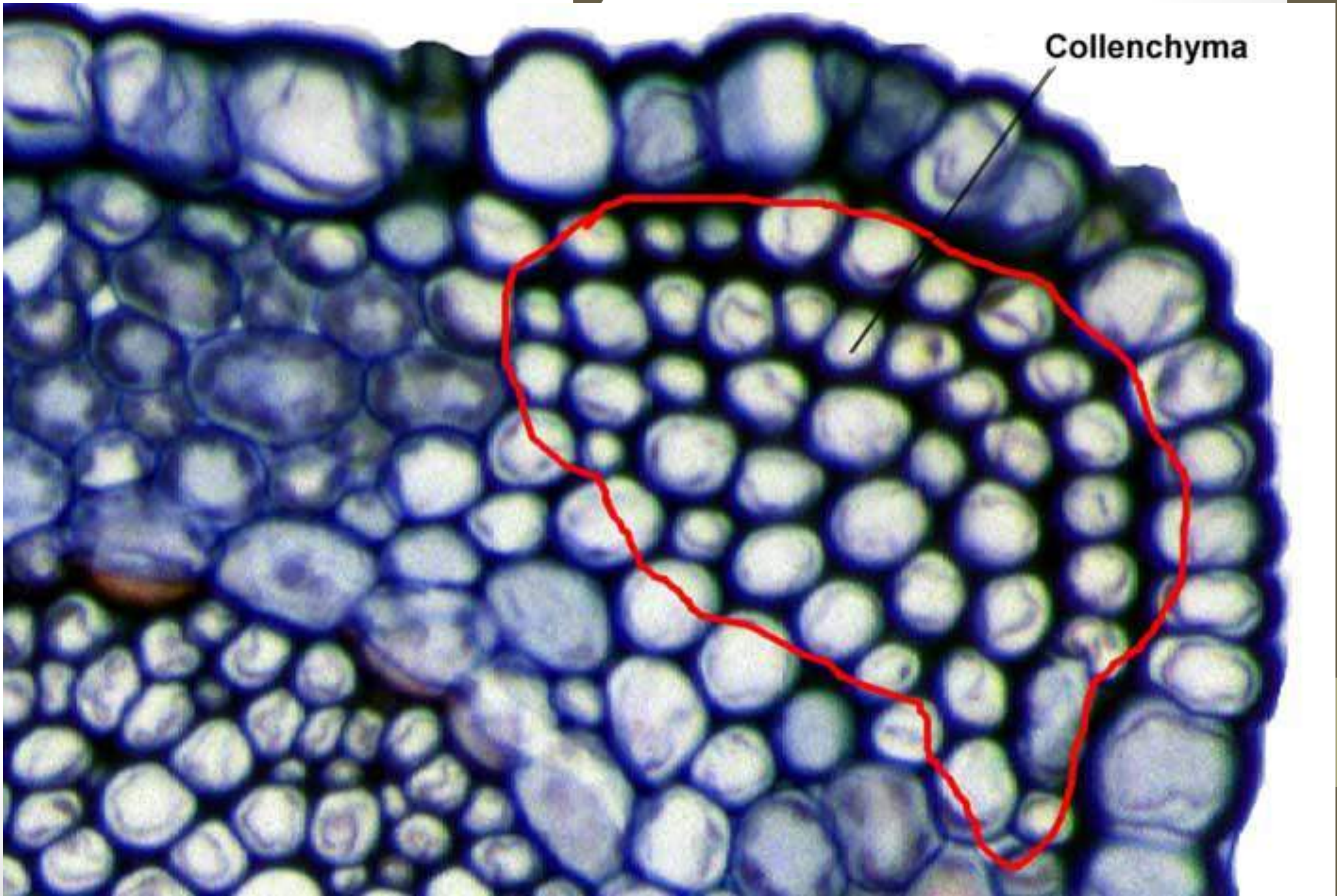


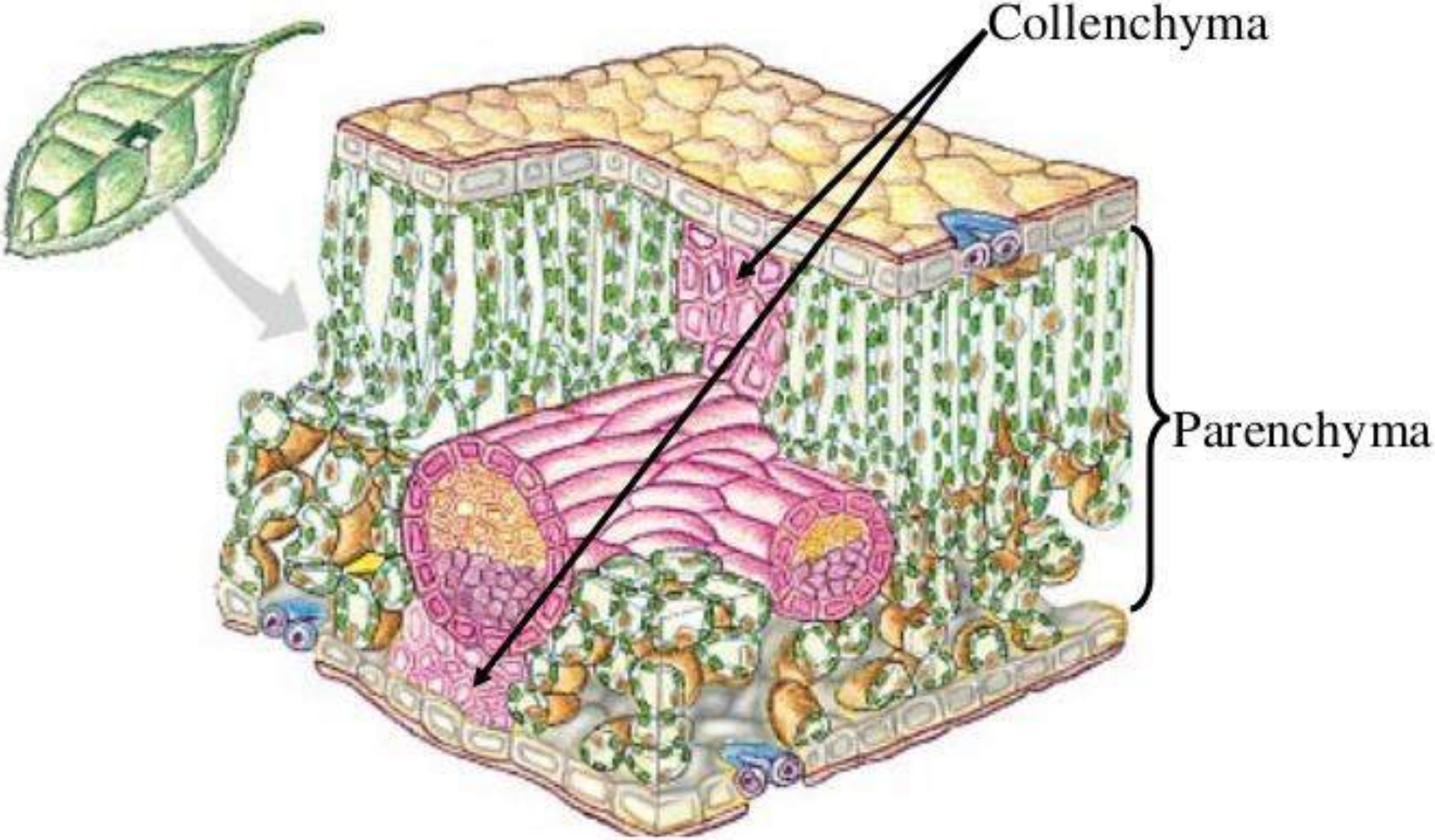


(ii) Collenchyma

- Cells living at maturity
- Cells are variously shaped
- Cell wall is unevenly thickened
- Occurs below epidermis of dicot stem
- Cells may possess chloroplast
- Provides strength & flexibility to growing organs

Collenchyma



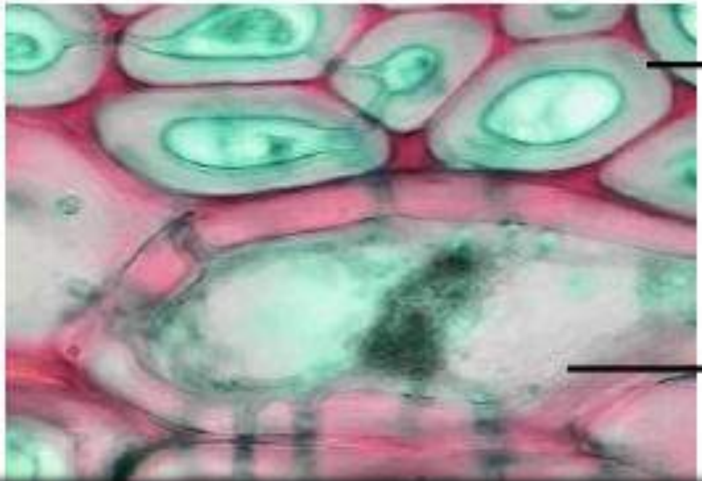

Collenchyma
Parenchyma

Sclerenchyma tissue

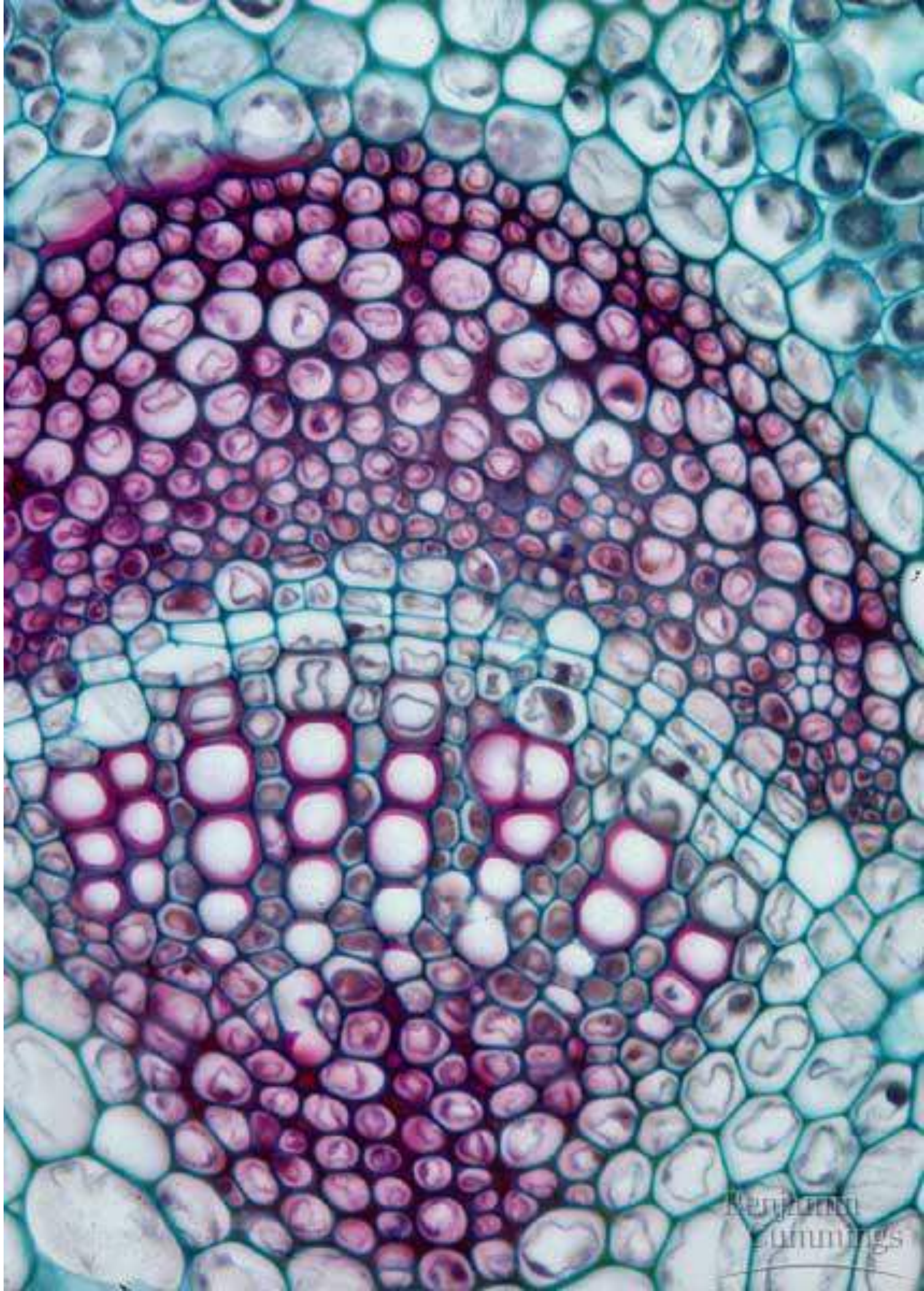
- **Sclerenchyma cells** are rigid because of thick secondary walls strengthened with lignin
- They are dead at functional maturity
- There are two types:
  - **Sclereids** are short and irregular in shape and have thick lignified secondary walls
  - **Fibers** are long and slender and arranged in threads

- Fiber (long, slender, tapered cells occurring in bundles) usually association with xylem & phloem, also found in the leaves of monocotyledons
  - main supporting tissue in many mature stems e.g Linen

- Sclereids (shorter, irregularly-shaped cells, roughly spherical)
  - stone cells are simple sclereid found protecting seeds & in hard-skinned fruits e.g The gritty structure of pear



Fiber Cells



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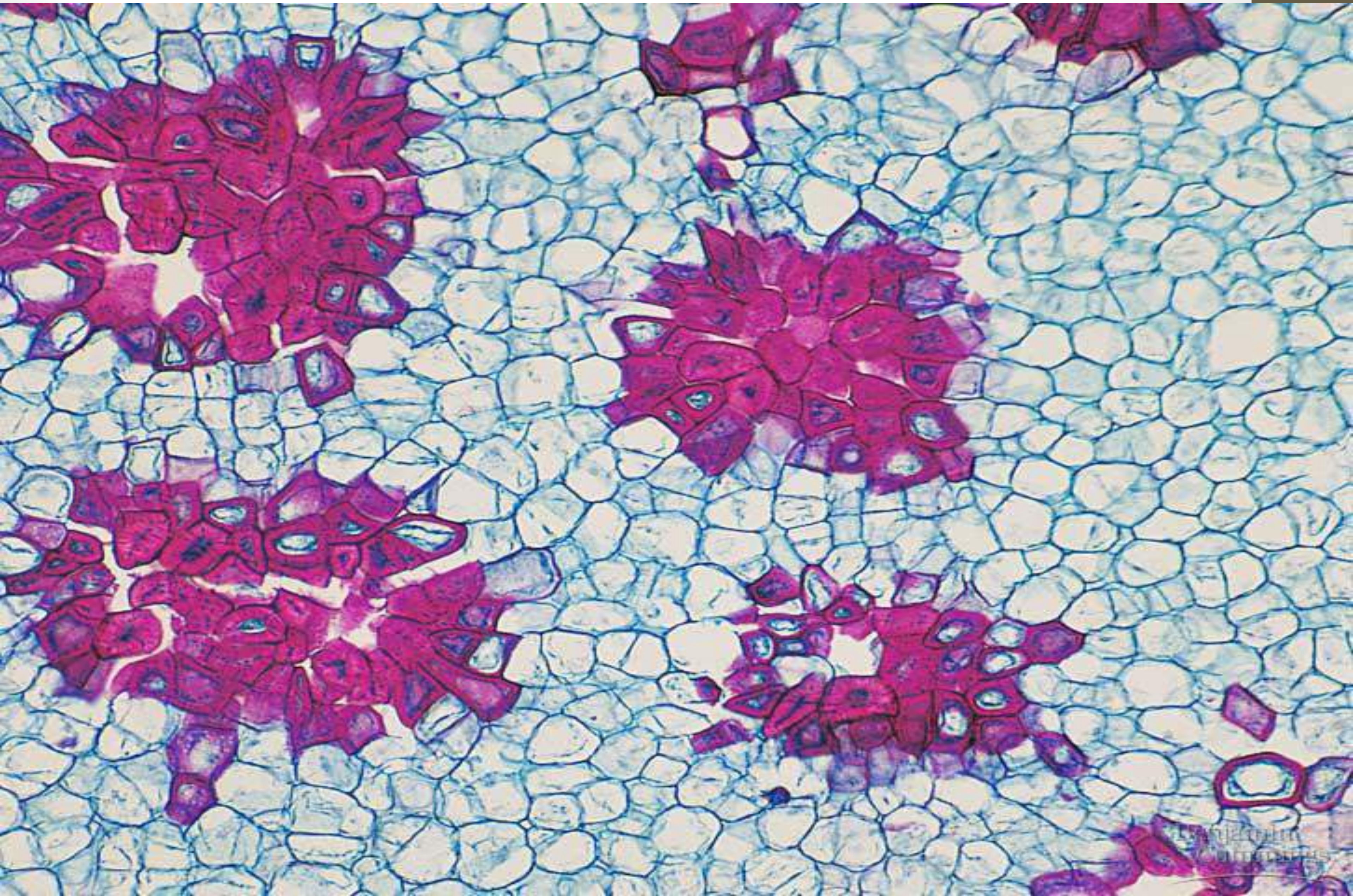

Complex tissue

Composed of a mix of cell types

Xylem

Phloem

Epidermis

- The xylem is responsible for the transport of water and soluble mineral nutrients from the roots throughout the plant.
- It is also used to replace water lost during transpiration and photosynthesis Xylem sap consists mainly of water and inorganic ions, although it can contain a number of organic chemicals as well.

Xylem

- Xylem + Phloem = Vascular (conducting) tissues

Vascular tissue forms a transport system that moves water and nutrients throughout the plant.

Vascular tissue is made up of xylem, a water-conducting tissue, and phloem, a food-conducting tissue.

Xylem

The water conducting elements of xylem are the **tracheids** and **vessel elements.**

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Xylem

- dual function (support & transport)
- Made up of four different types of cells
  - parenchyma cells – standard plant cells, no chloroplast
  - fibers – elongated cells with dead lignifies walls
  - vessel elements
  - tracheids

Xylem - vessel elements

- make up the xylem vessels
- began as normal cell, but lignin in cells
- walls impermeable to water
- \- as it builds up, cells die, empty lumen left
- \- no lignin at plasmodesmata – kept open = pits

Xylem

- Vessel Elements
  - Characteristics
    - shorter and wider than tracheids
    - possess thinner cell walls than tracheids
    - Aligned end-to-end to form long micropipes
    - dead at functional maturity
  - Functions
    - transport of water plus dissolved minerals
    - Support.

Xylem - tracheids

- - non living lignified walls
- - not open ended, not tubes
- - H_2O moves through pits
- - primitive plants, ferns & conifers

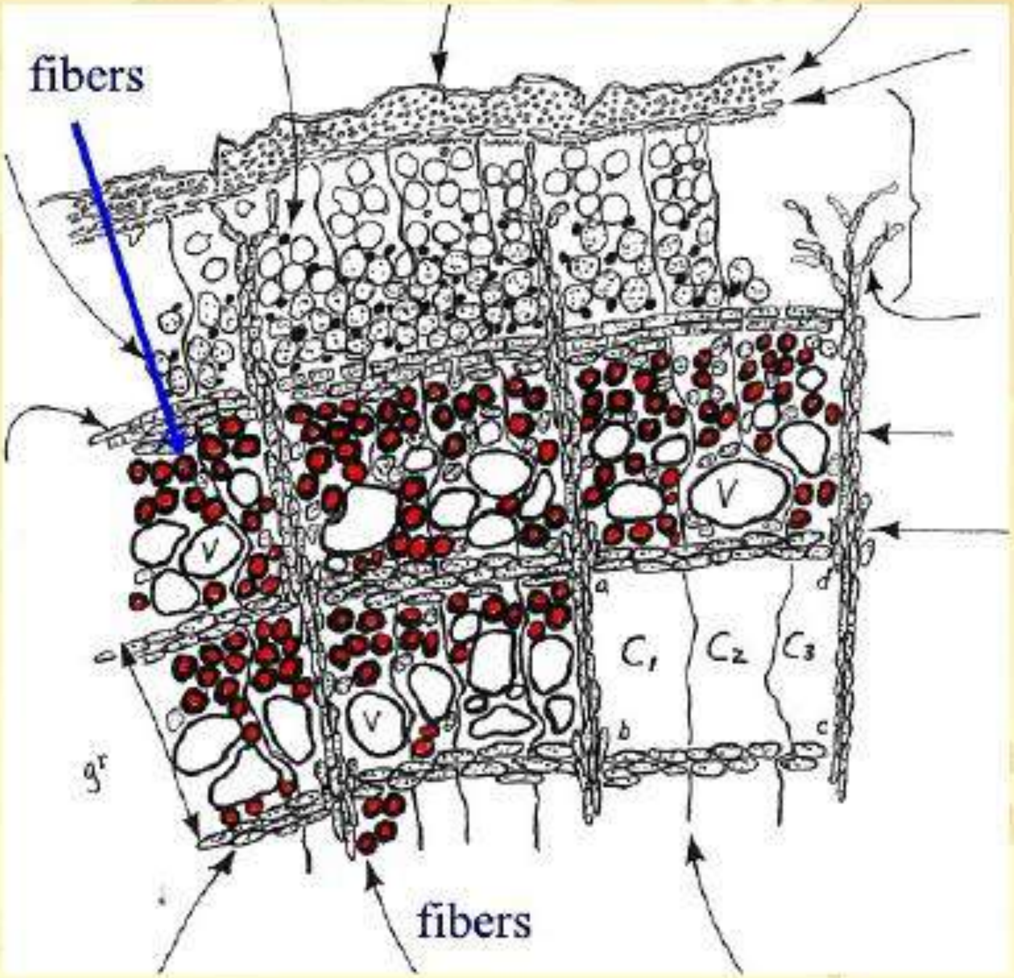
Xylem

- Tracheids
  - Characteristics
    - tapered elongated cells
    - connect to each other through pits
    - secondary cell walls strengthened with lignin
    - dead at functional maturity
  - Functions
    - transport of water plus dissolved minerals
    - Support.

The Xylem: fibers:

Fibers are cells with heavily lignified walls making them stiff.

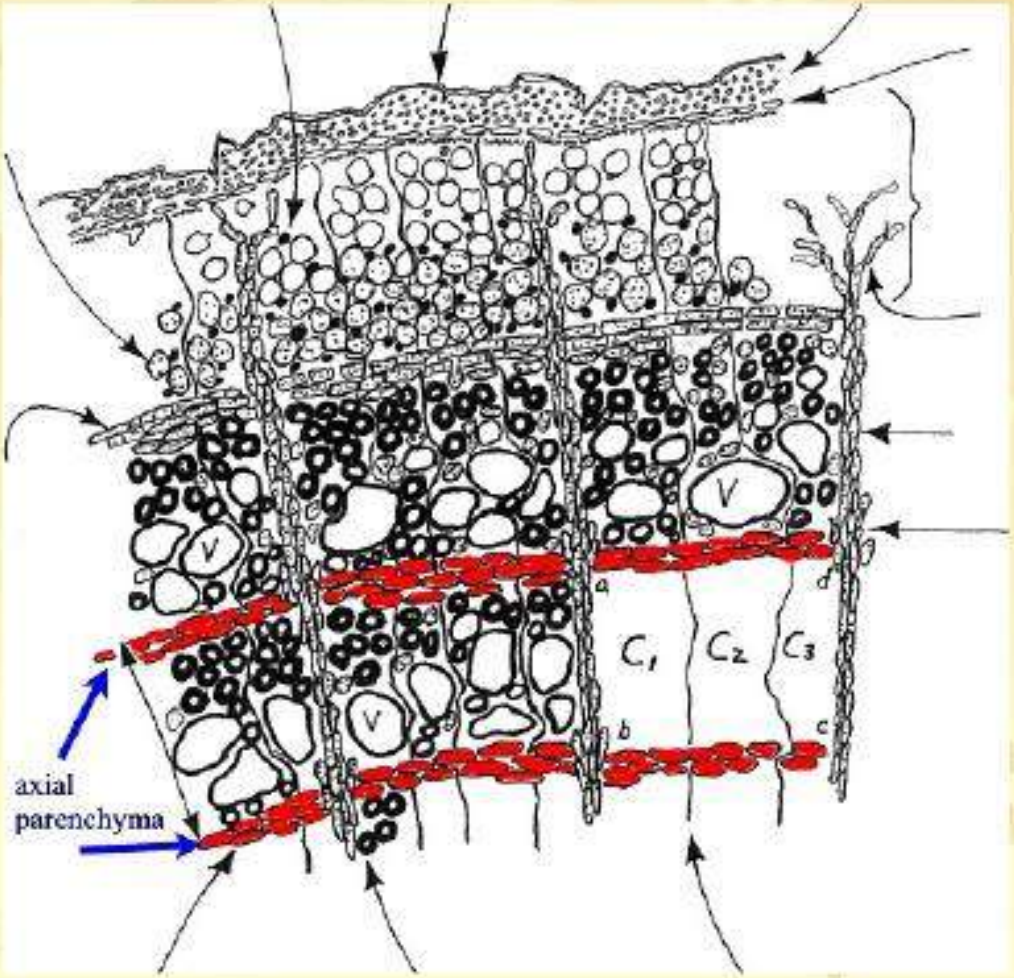
Many fibers in sapwood are alive at maturity and can be used for storage.



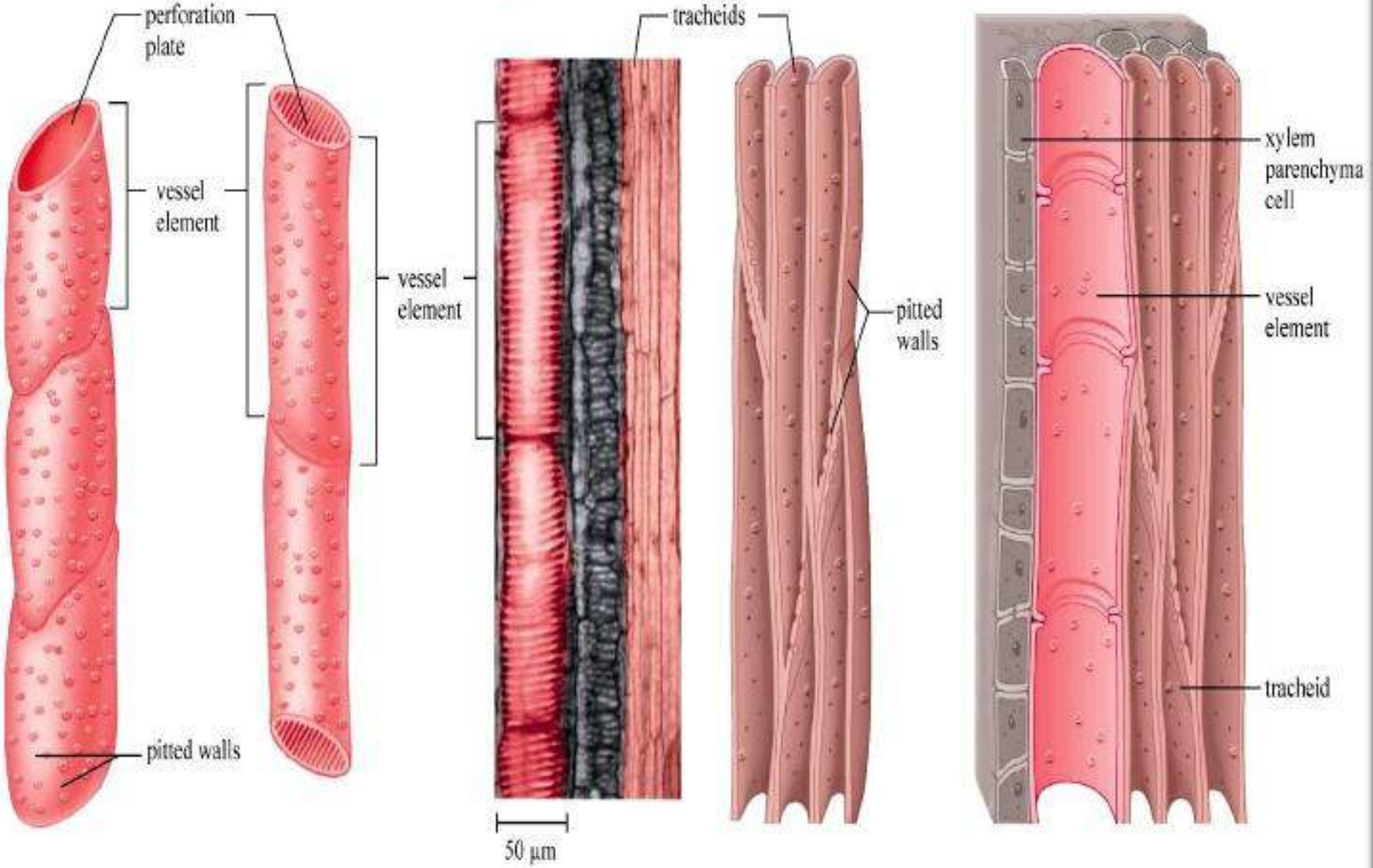
The Xylem: axial parenchyma:

Axial parenchyma is living tissue!

Remember that parenchyma cells can be used for storage and cell division.



Xylem Structure



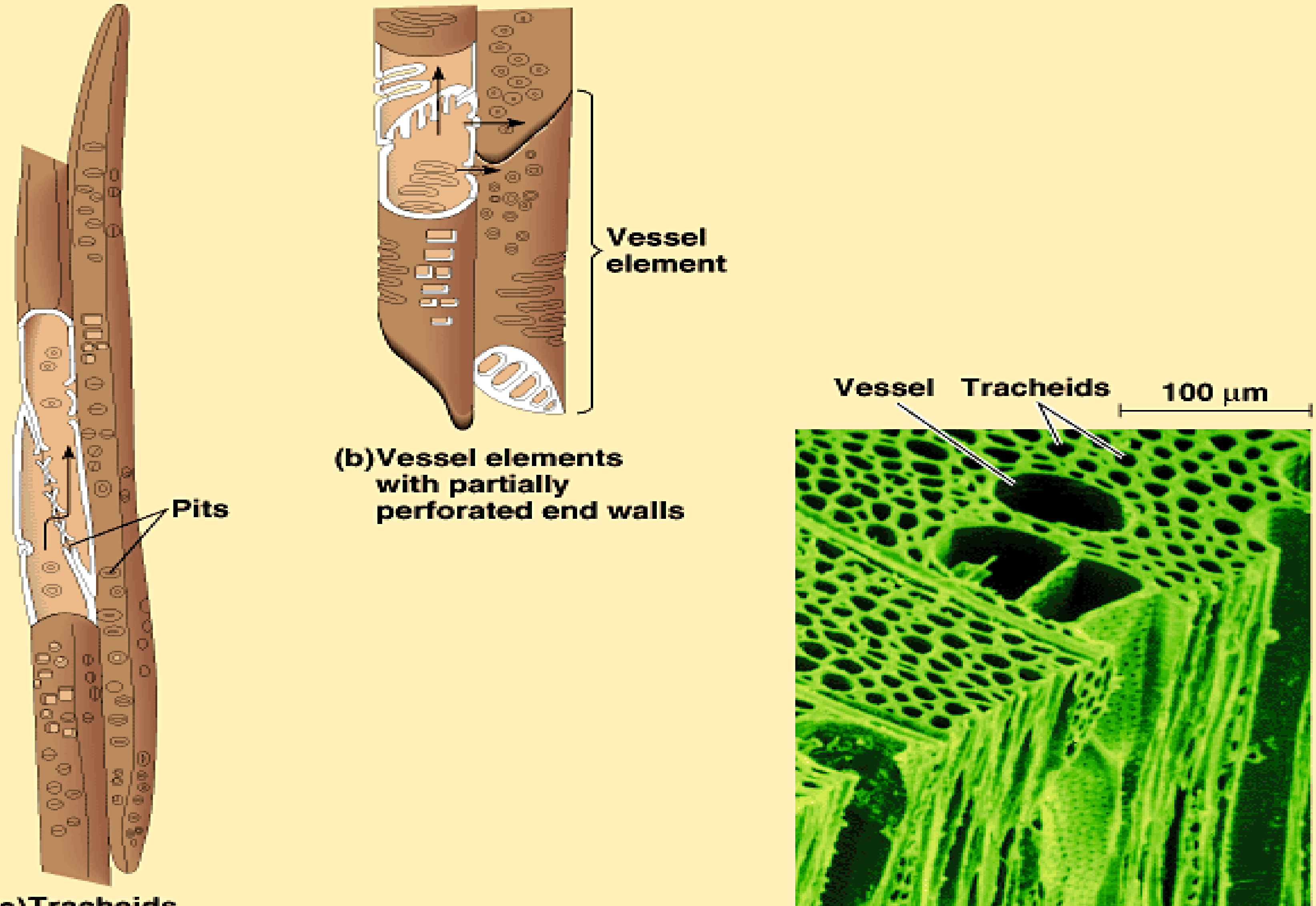
a. Two types of vessels (drawings)

Xylem (micrograph)

Tracheids (drawing)

b. Xylem (drawing)

Water conducting cells of the xylem

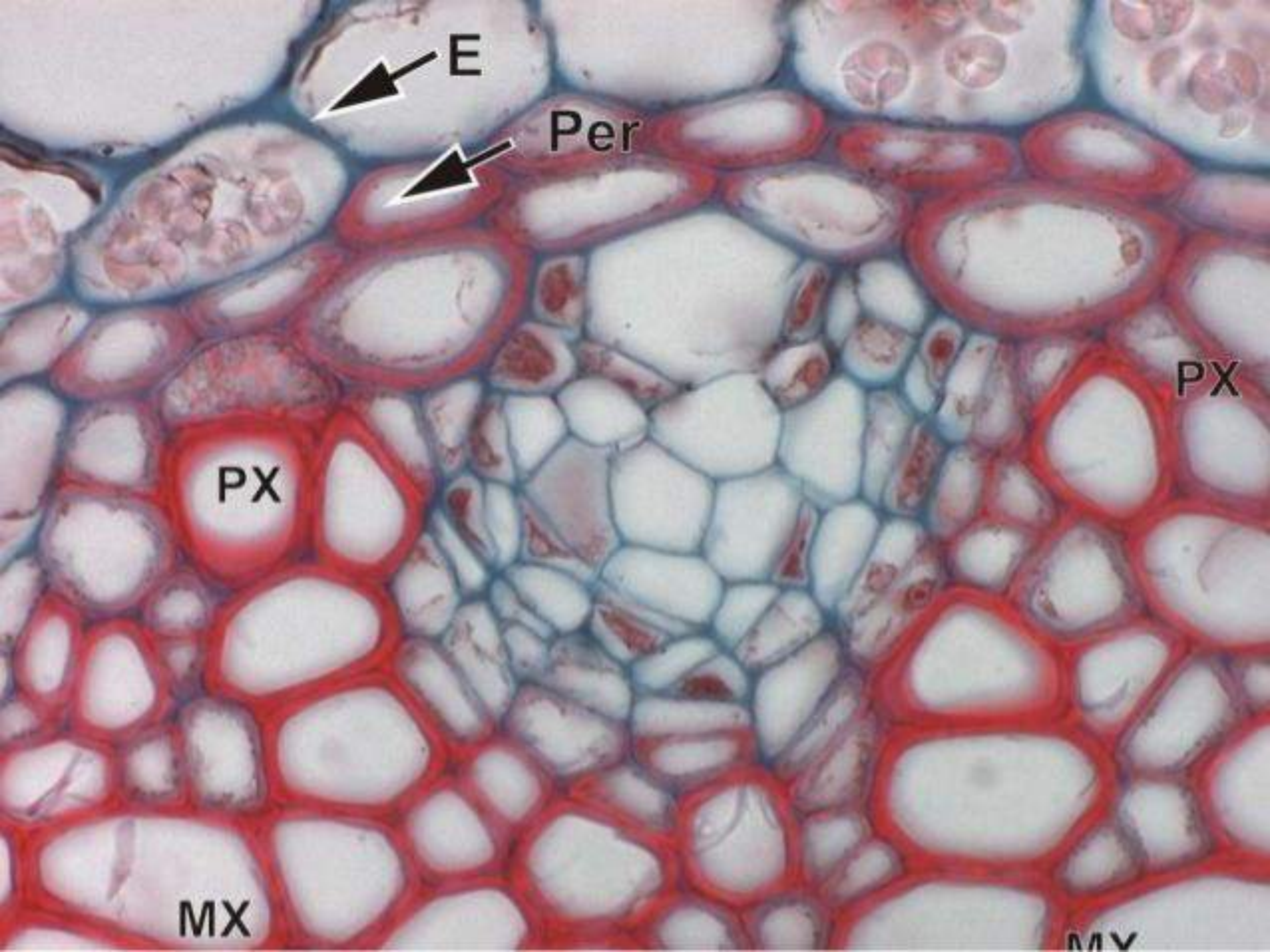


(a) Tracheids

(b) Vessel elements with partially perforated end walls

(c) Tracheids and vessels (colorized SEM)

- Xylem formed in primary plant body by procambium is called primary xylem
- 1st formed primary xylem is called protoxylem
- Later formed is called metaxylem
- In stems, protoxylem lies towards pith & metaxylem towards periphery ; such an arrangement is called endarch
- In roots, protoxylem lies towards periphery & metaxylem towards pith ; such an arrangement is called exarch



E
Per
PX
PX
MX

Phloem


types of cells
➢ sieve (tube) elements
➢ companion cells
➢ parenchyma
➢ fibers

PHLOEM

- The sieve tubes, the companion cells and the phloem parenchyma represent the living components of the tissue while phloem fibres represent the only nonliving component of the tissue.
- Phloem is commonly described as a living, complex permanent tissue.

Phloem

A. Primary function= <u>translocation</u>

B. <u>Translocation</u>-movement of substances from one part of a plant to another in the phloem

C. Sugars, amino acids and other organic compounds produced by photosynthesis are transported away from the leaf

-materials sprayed on the plant can also be transported from the leaves via the phloem

Phloem

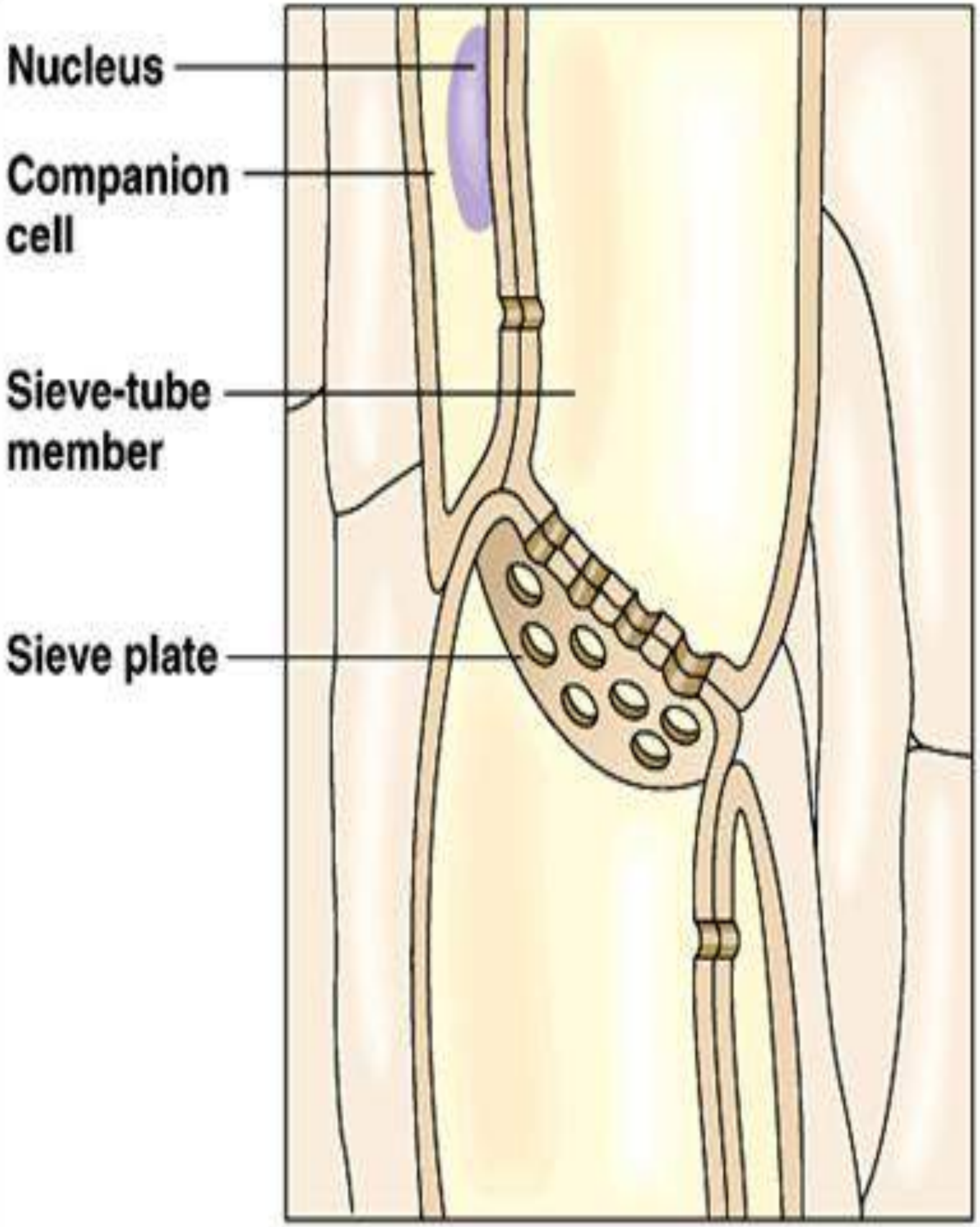
D. Found in all leaf veins

E. Materials can be transported in both directions

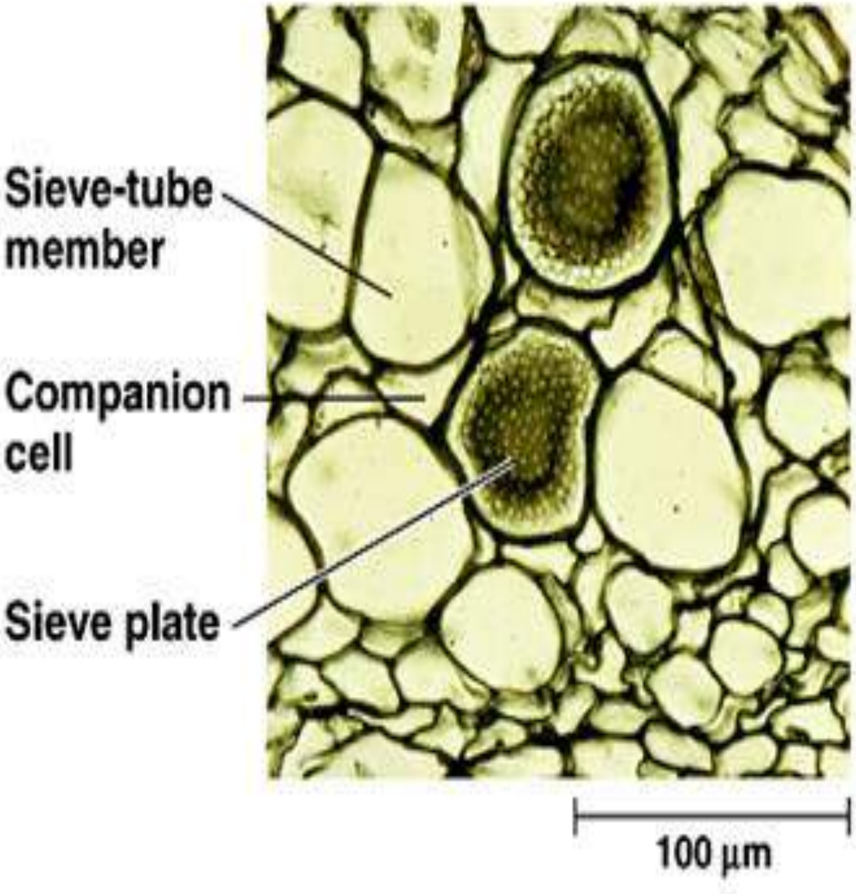
**Remember xylem only transports one way (up)

Ex: In summer trees transport sugars from leaves to roots

-In spring transport sugar from roots (where it is stored) to the new branches



(a) Longitudinal view



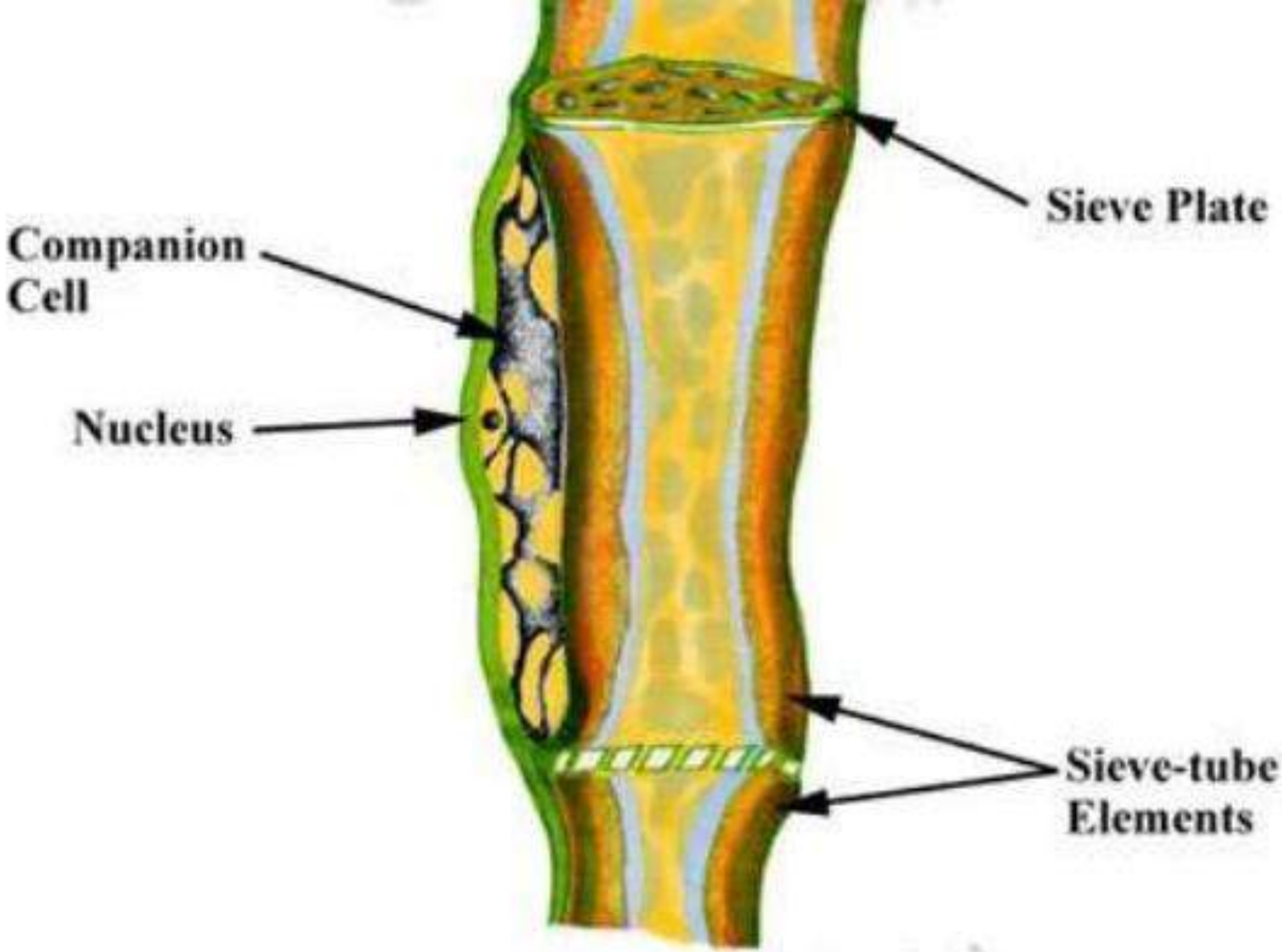
(b) Transverse section (LM)

Sieve Tube Element

Phloem cell that is joined end-to-end to similar cells to form sieve tube

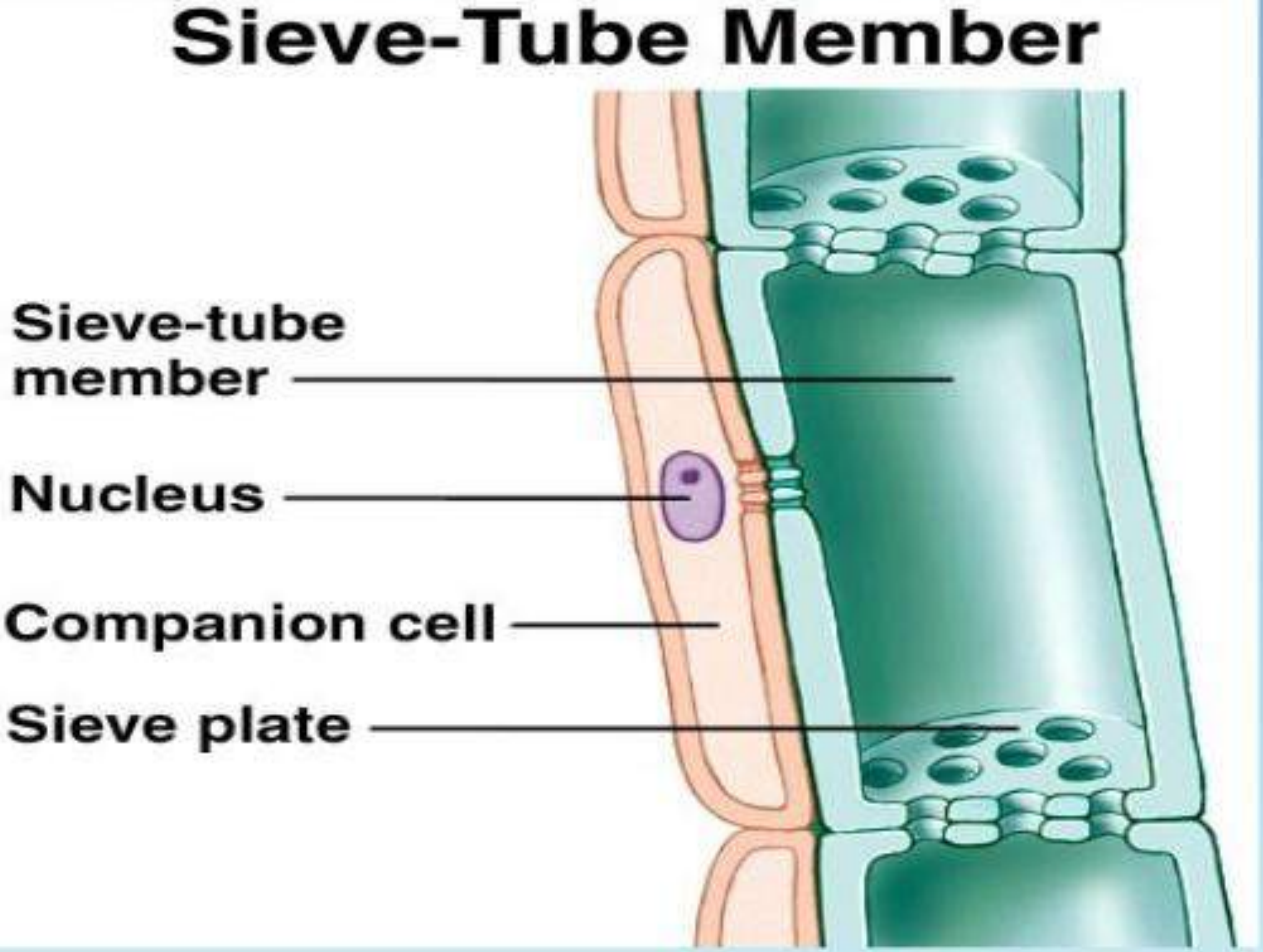
(a) SIEVE TUBES:

- Formed by elongated sieve tube members
- Cross walls have number of perforations
- Mature sieve tube has peripheral cytoplasm
- Functions are controlled by nucleus of companion cells
- Members are characteristically present in angiosperms



Sieve-Tube

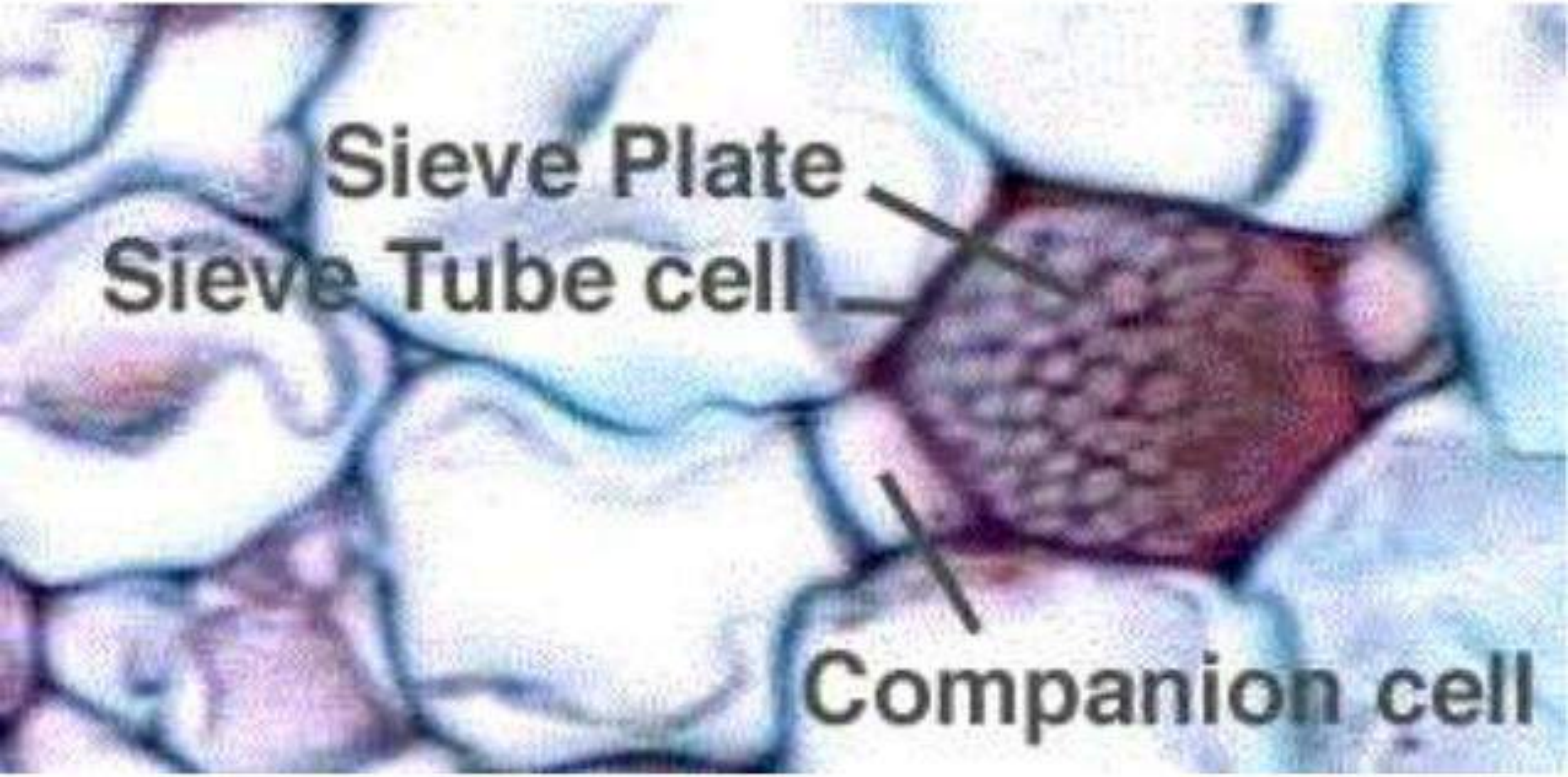
Phloem



Sieve-Tube Member
Sieve-tube member
Nucleus
Companion cell
Sieve plate

(a) SIEVE CELLS :

- Sieve areas are found to occur throughout the end walls & lateral walls
- Cells are living, but lack nucleus
- Found in lower vascular plants

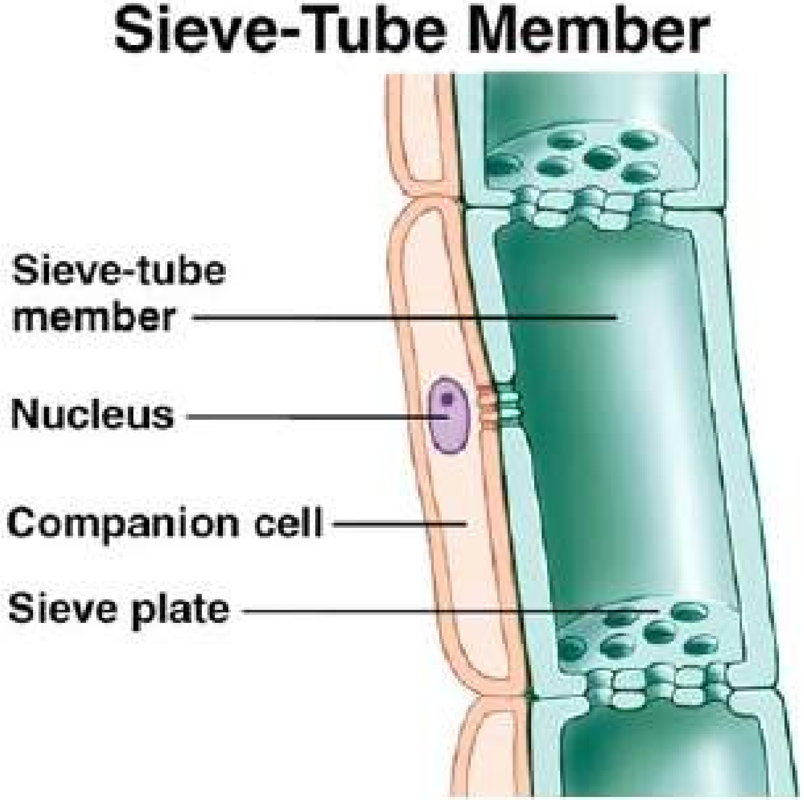


Sieve Plate
Sieve Tube cell
Companion cell

ii) Companion cells

- Companion cells are found only in angiosperms

- They are adjacent and closely associated with the sieve tube elements



(d) PHLOEM PARENCHYMA :

- Cells are elongated & cylindrical
- Have dense cytoplasm & prominent nucleus
- Stores food materials & other substances
- Absent in monocot plants

(e) PHLOEM FIBRES (BAST FIBRES) :

- Found along with other elements of phloem
- Elongated & thick walled cells
- Dead at maturity
- Absent in primary phloem
- 1st formed primary phloem is known as protophloem
- Later formed is known as metaphloem
- Elements formed by fascicular cambium constitute secondary phloem

PHLOEM

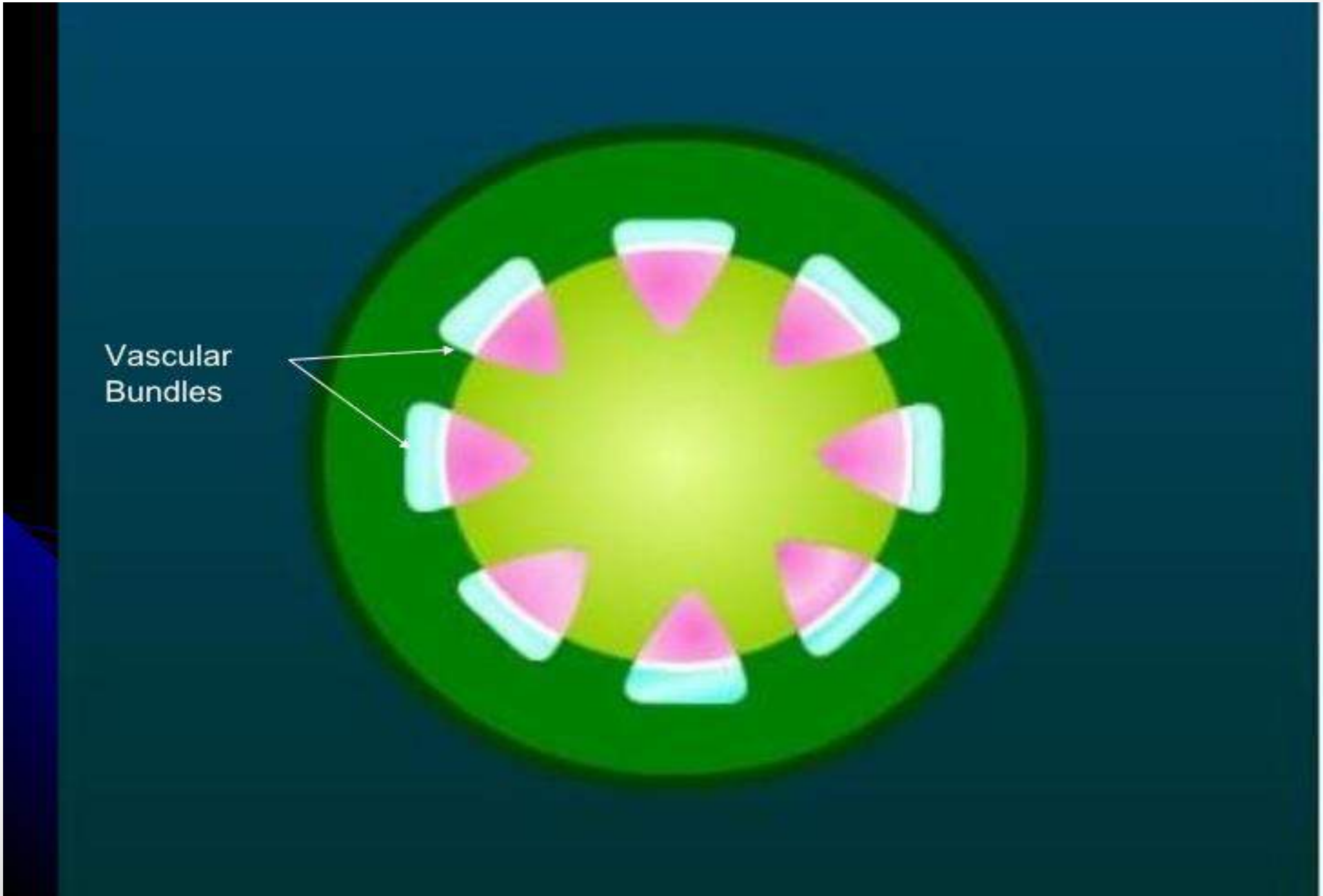
- **Phloem Parenchyma**
  - Phloem parenchyma is represented by a group of living parenchyma cells that are found in-between the sieve tubes.
  - They are meant only for storage of organic food.
- **Phloem Fibres**
  - Phloem fibres are represented by the dead sclerenchyma fibres that are found in between the sieve tubes.
  - They are meant only for providing mechanical support.

Differences between xylem and phloem transport

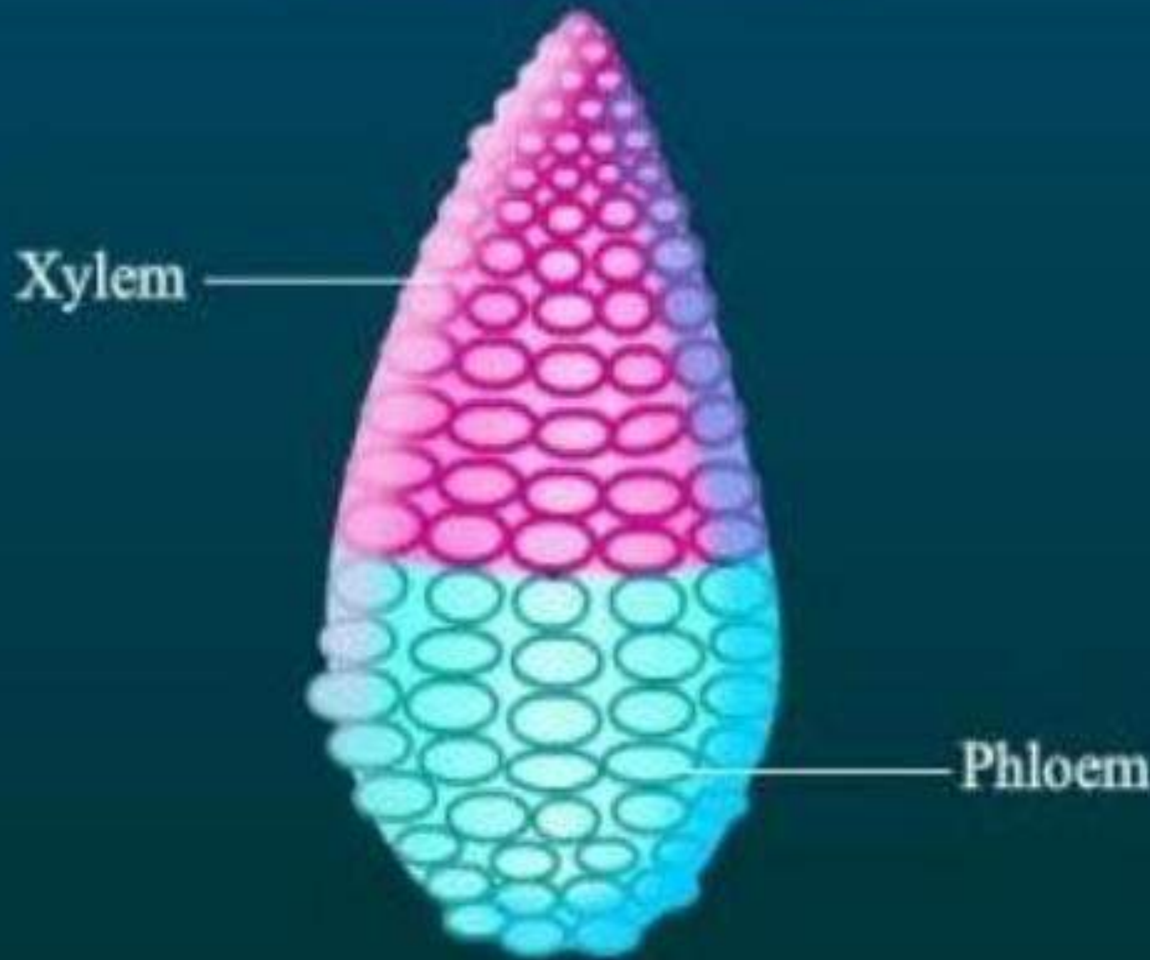
PHLOEM	XYLEM
1. Conduits are living cells called sieve tube elements in angiosperms	1. Conduits are dead cells • Tracheids • Vessel elements
2. Organic transport	2. Water + mineral ions
3. Bidirectional movement (up or down, can change seasonally)	3. Unidirectional movement (up)

PHLOEM	XYLEM
4. Slow - maximum flow rate of 1 m/hr	4. Fast - maximum flow rate of 15 m/hr
5. Sap driven by a positive pressure potential (push from source)	5. Sap driven by a negative pressure potential (pull from top)
6. Pressure-flow model	6. Cohesion-tension model
7. Process requires ATP to load and unload sugars	7. No ATP; energy provided by the sun as water evaporates

Vascular Bundle



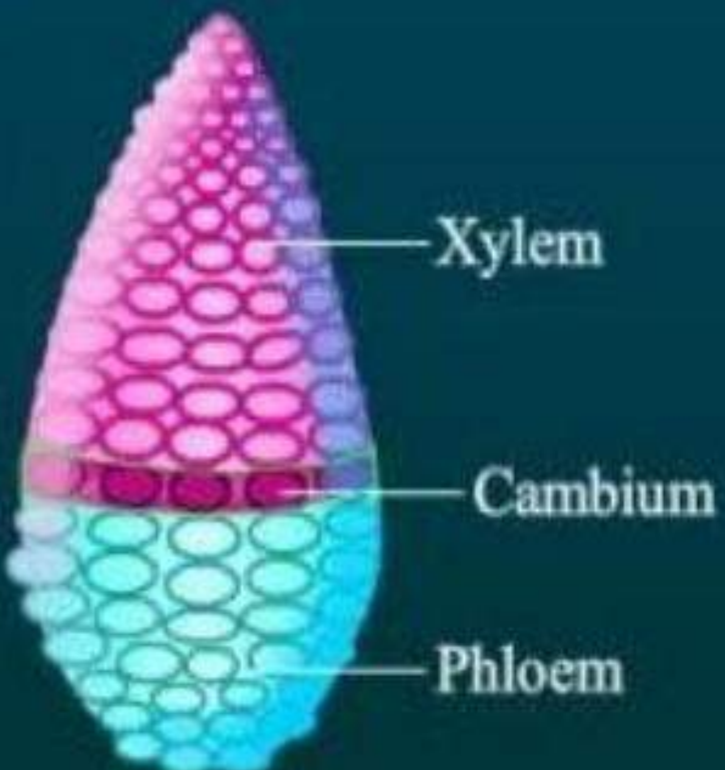
Vascular Bundles



Vascular Bundles

In dicot plants

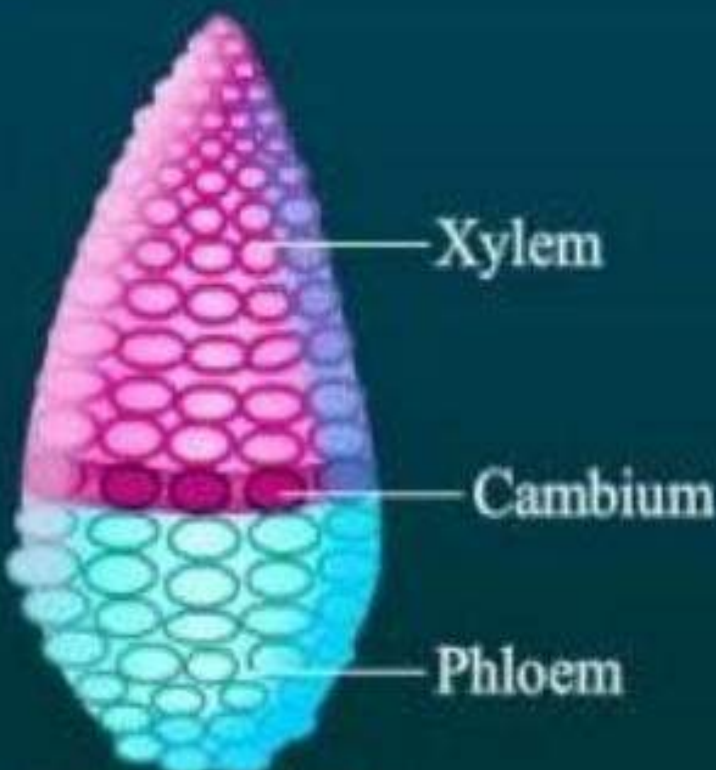
In monocot plants



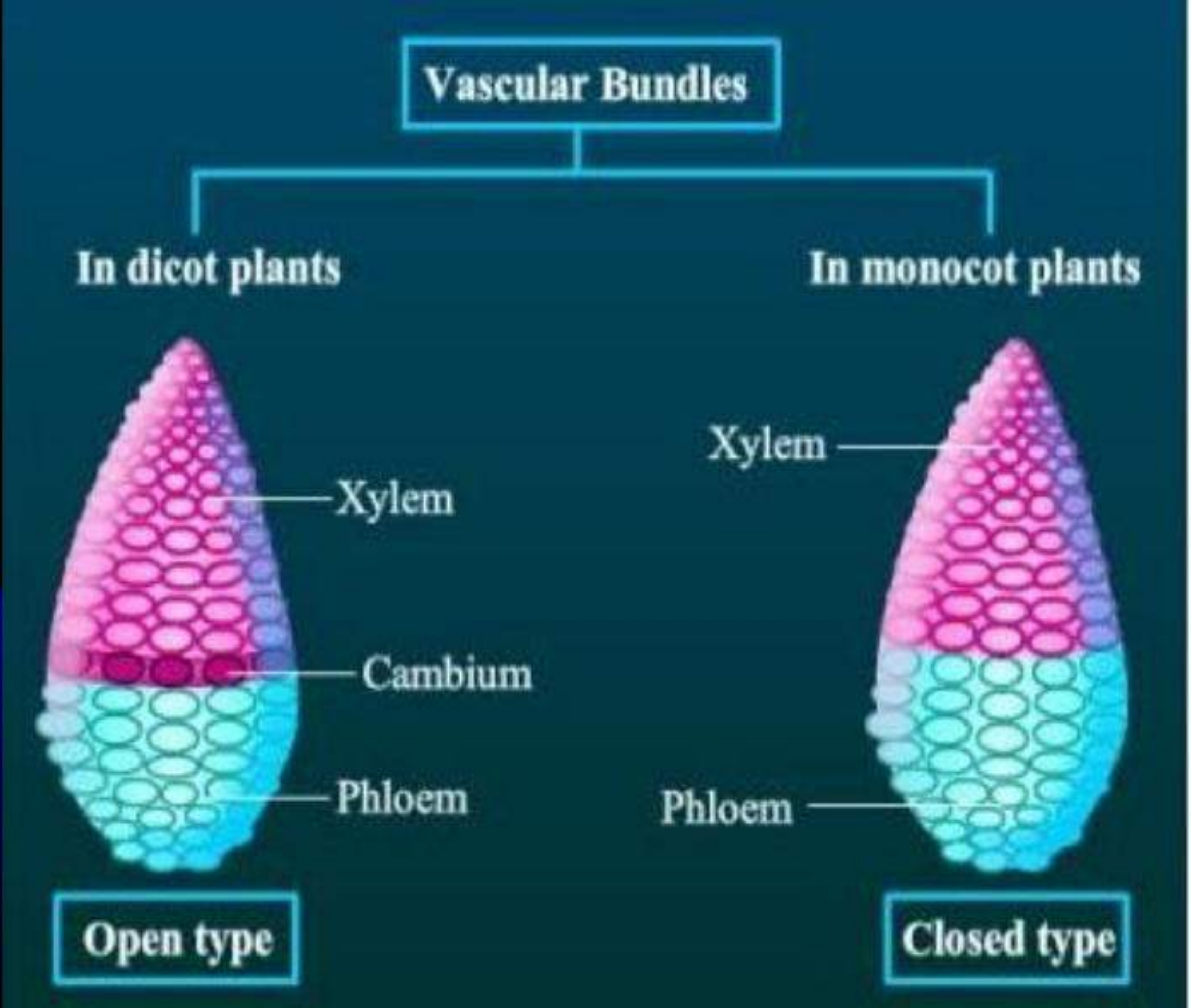
Vascular Bundles

In dicot plants

In monocot plants



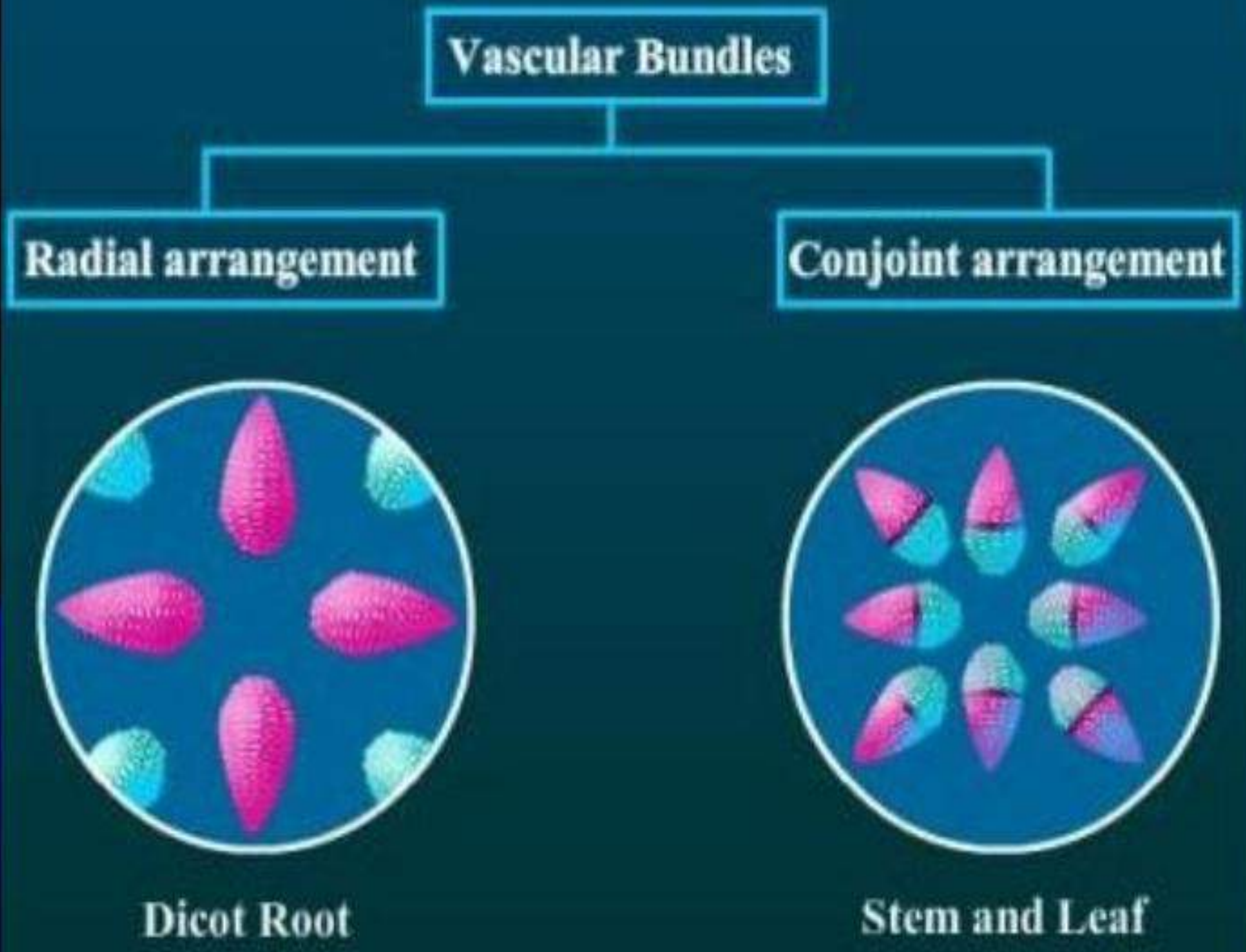
Open type


Vascular Bundles
In dicot plants
In monocot plants
Xylem
Cambium
Phloem
Xylem
Phloem
Open type
Closed type

Vascular Bundles

Radial arrangement

Dicot Root

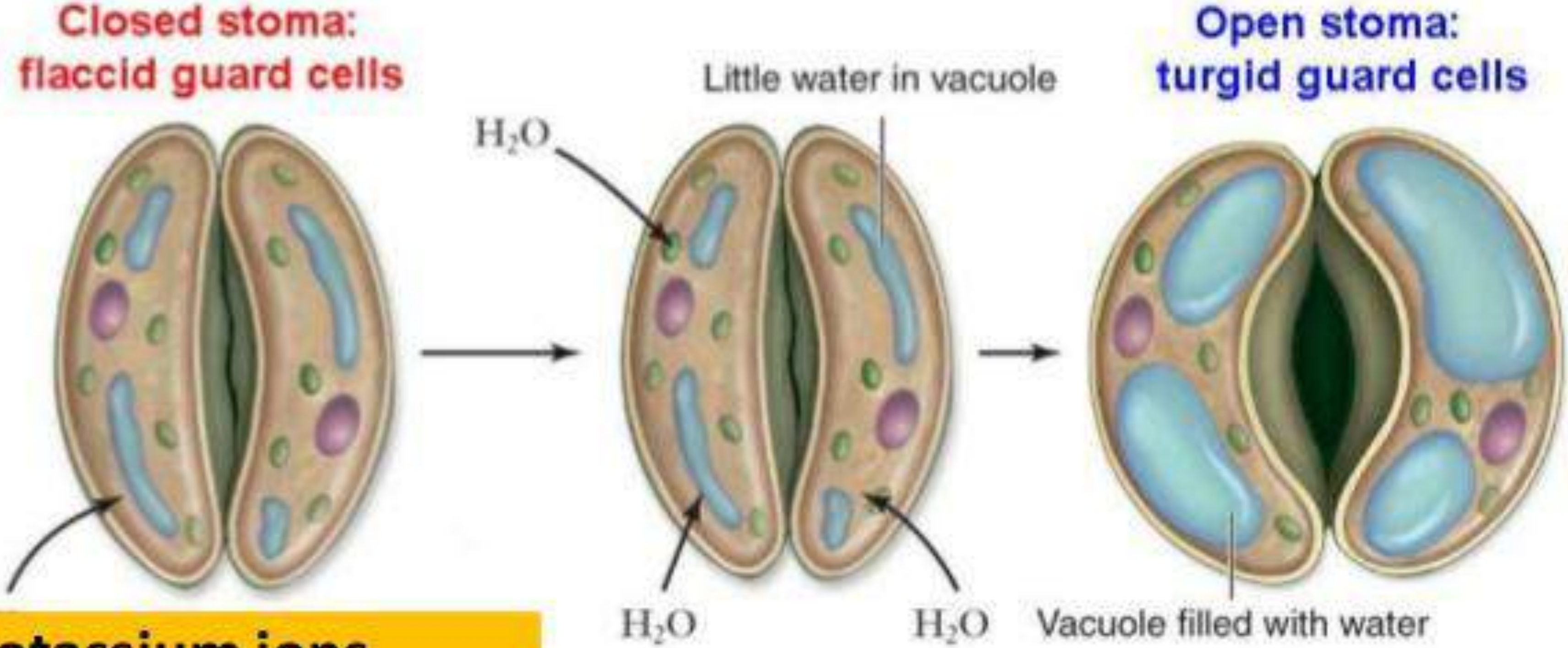

Vascular Bundles
Radial arrangement
Conjoint arrangement
Dicot Root
Stem and Leaf

Epidermis

- Outermost layer, covering stems, leaves and roots of young plants
- Flat, with large vacuoles
- Walls that are exposed to air covered with waxy waterproof cuticle
- Cuticle reduces water loss, mechanical injury and infection
- Root cells have root hairs to increase water absorption
- Guard cells, containing chloroplasts, open and close stomata

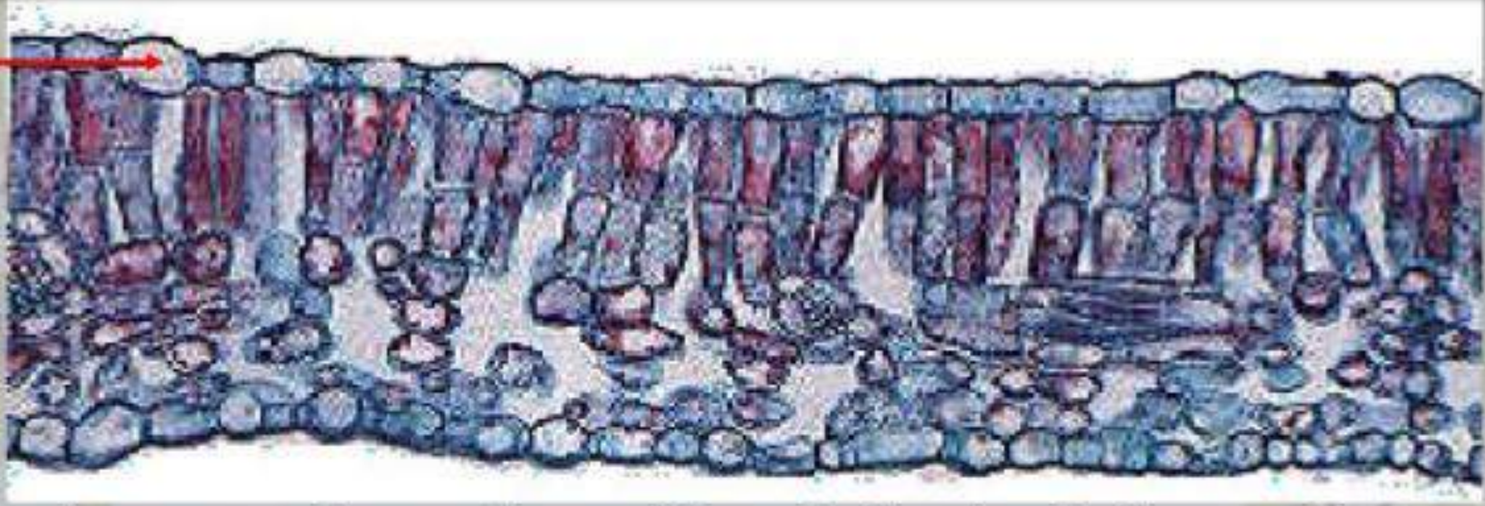
- Guard cells are bean-shaped in dicot plants & dumb bell in monocots
- Outer wall is thin & inner wall is thick
- They possess chloroplasts & carry out photosynthesis
- Epidermal cells in their vicinity become specialised in their size & shape
- Stomatal apparatus – stomatal aperture, guard cells & surrounding epidermal cells
- Epidermis also bears appendages
- Root hairs are unicellular elongation of epidermal cells of the root
- Appendages on stem epidermis are called trichomes
- Help in preventing water loss by transpiration
- Glandular/ secretory in many plants

How do stomata open during the day?



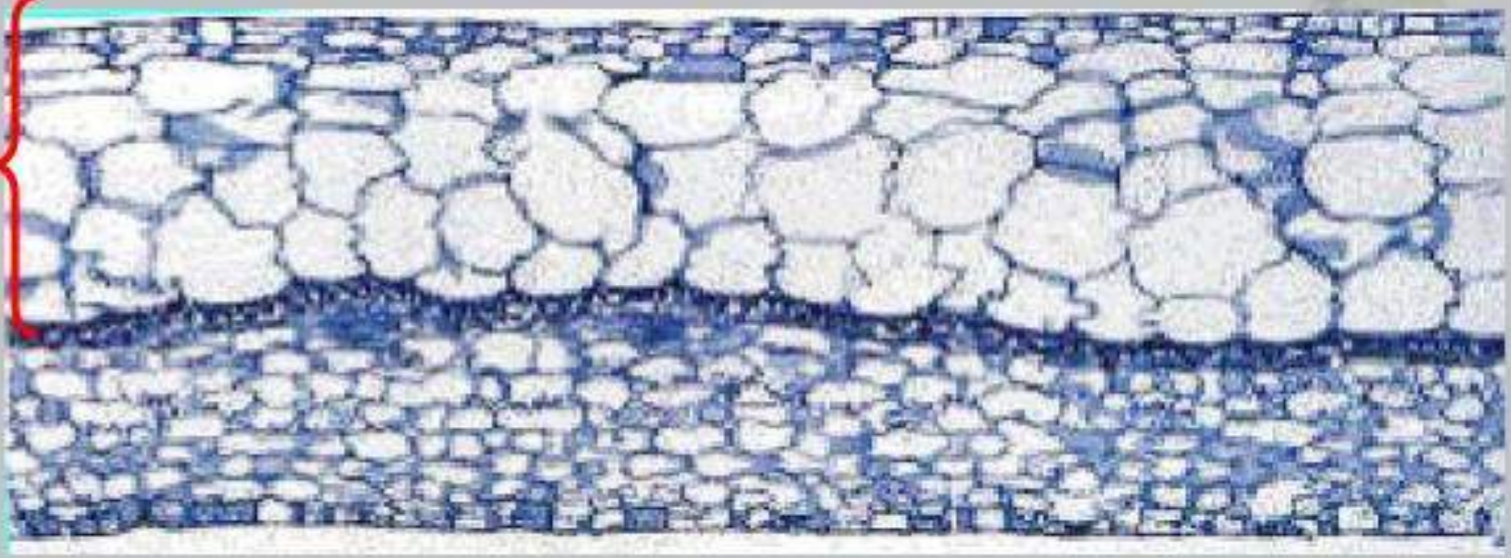
potassium ions enter the guard cells & water follows.

epidermis



In most plants the epidermis is single layered.

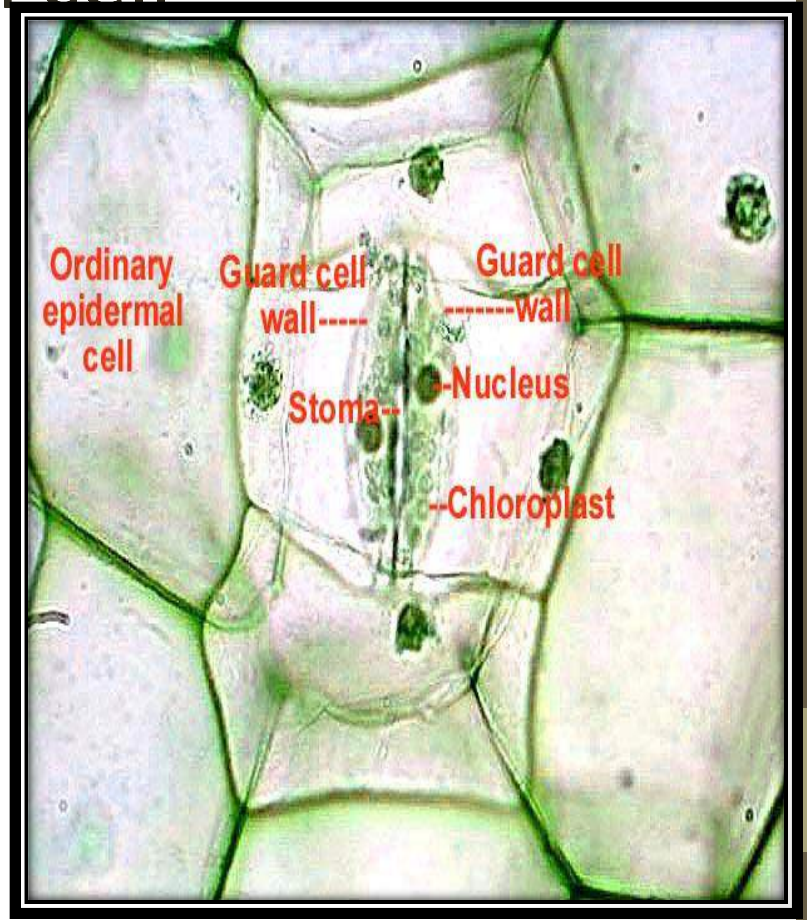
epidermis



Others, as in rubber tree plant, have multiple layers allowing them to occupy varied selective habitats

Types of epidermal cells

- 1- Ordinary epidermal cell
- 2- Guard cell
- 3- Trichomes



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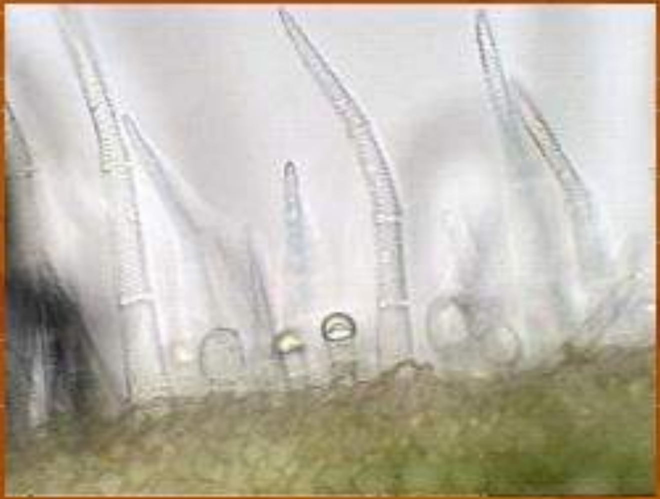
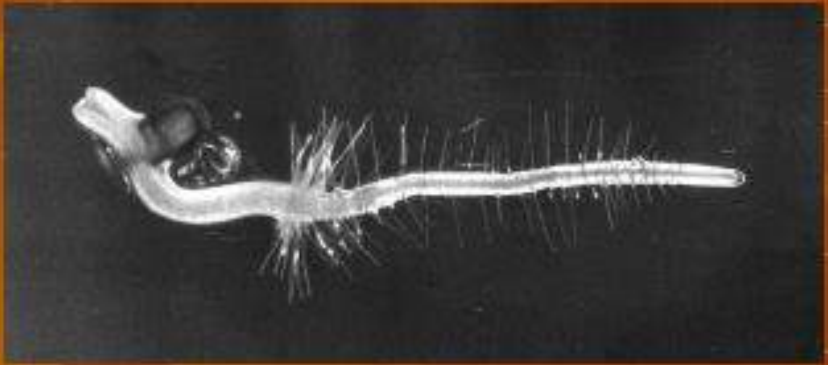
Trichomes

- protection against water loss

Epidermis – stoma, trichomes, & root hairs

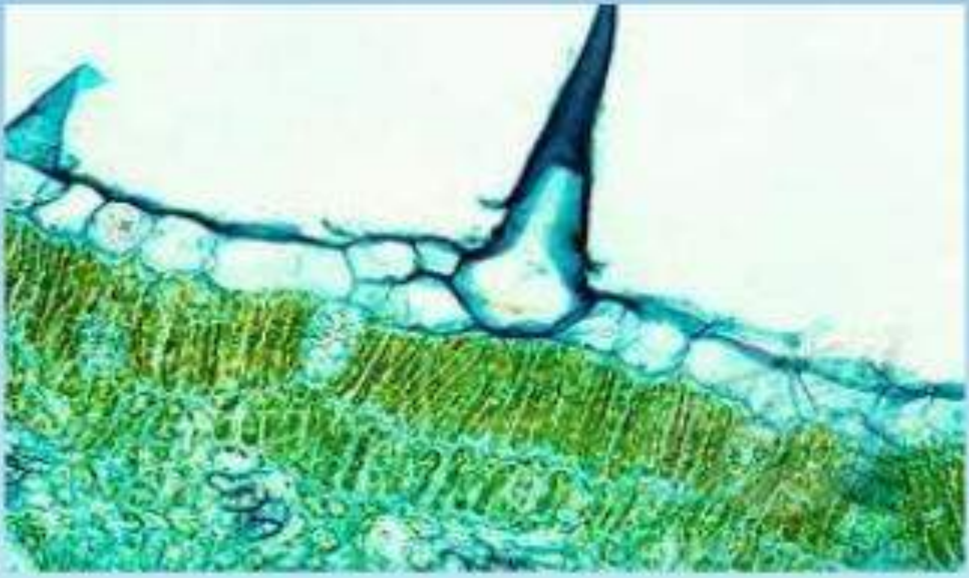




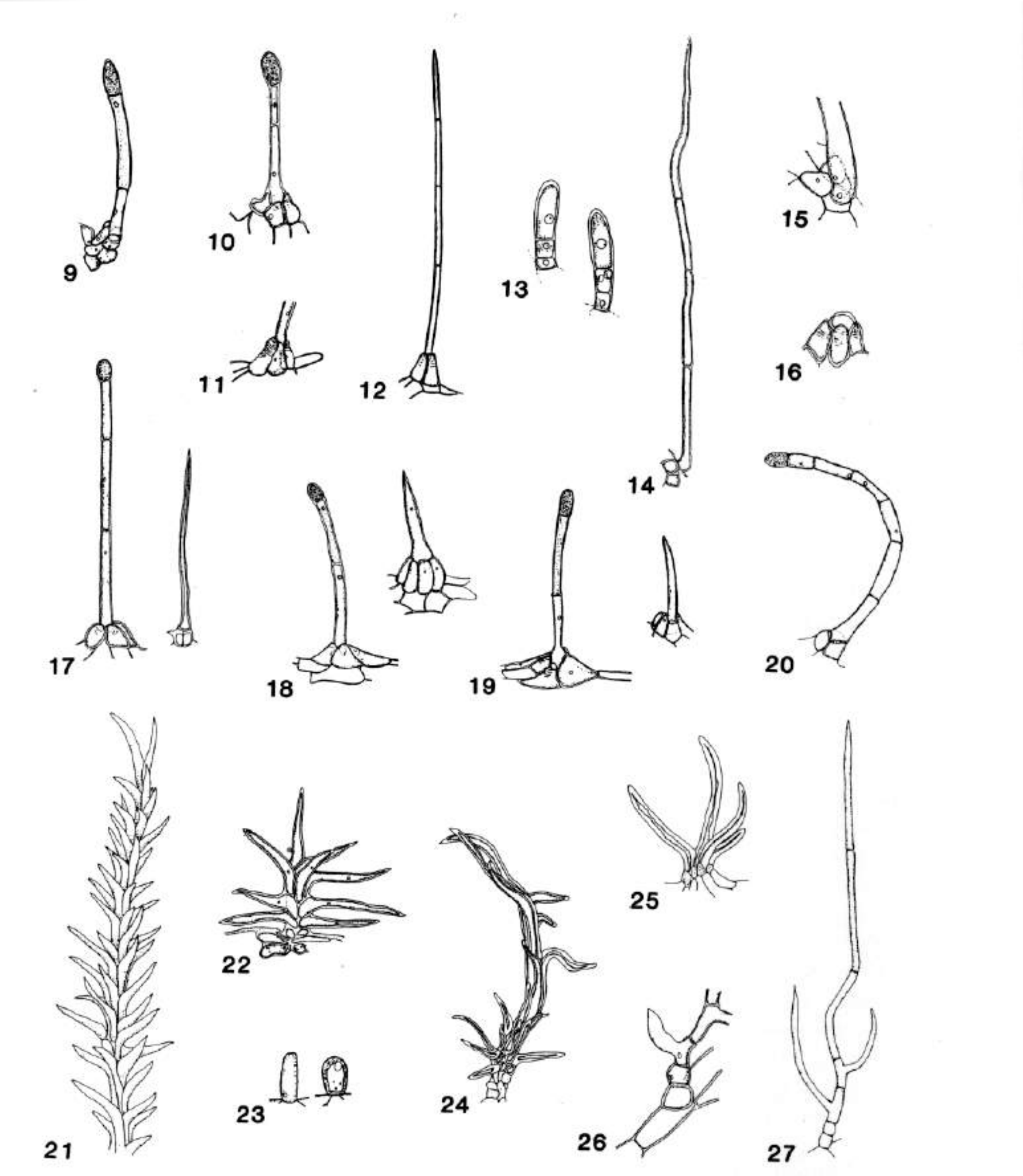
http://www.ucd.ie/botany/Steer/hair/roothairs.html

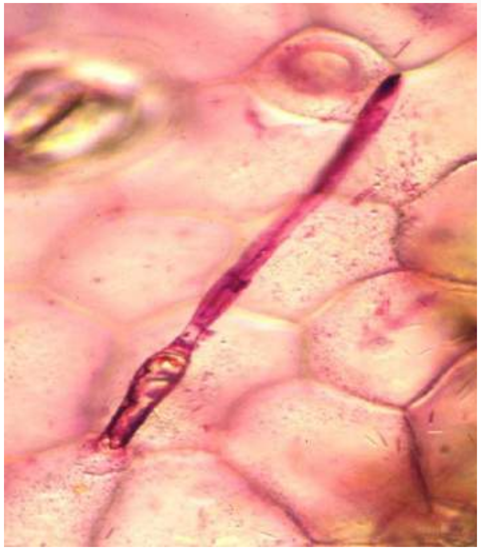
Trichomes

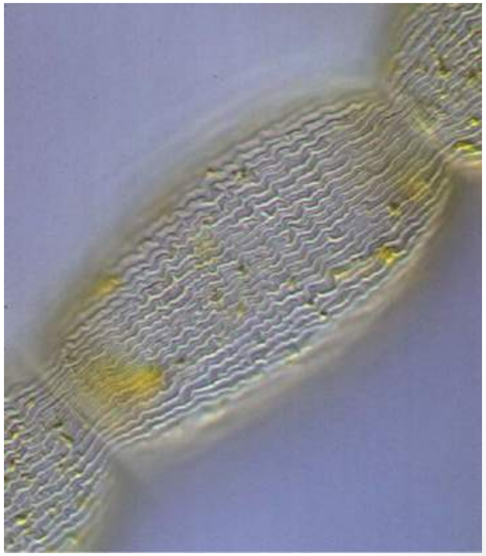
Trichomes – outgrowths of epidermal cells



Trichome anatomy







GUARD CELLS & STOMATA

Stomata:

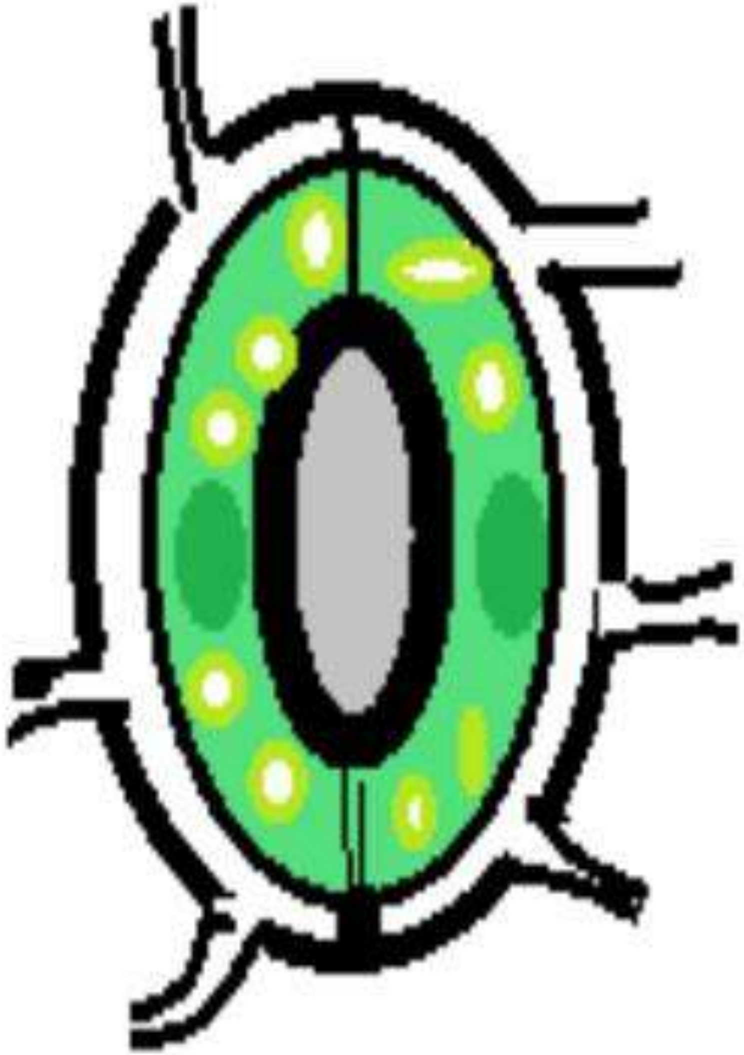
- A stoma is a minute epidermal opening with following characteristics:
  - ✓ A central
  - ✓ Two kidney shaped similar cells containing chloroplasts known as Guard cells and varying number of subsidiary (epidermal) cells covering the guard cells.
- A stoma is made up of a pair of identical guard cells, forming a pore in centre through which gaseous exchange takes place.

Stomata :-

Stomata Denoted To Small Pore Present On Leaf , Which Are For Mean Of Gasseous Exchange & Transpiration

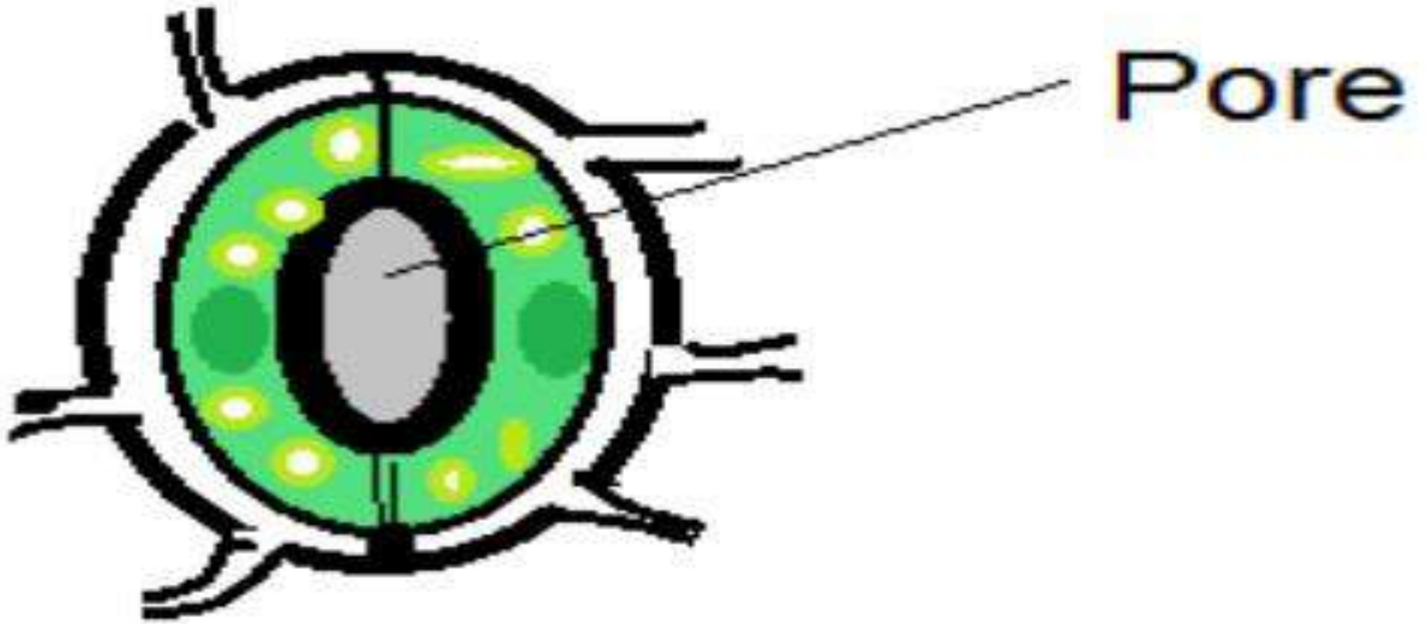
They Constituent Three Part

- Cell Pore
- Guard Cell
- Subsidiary Cell



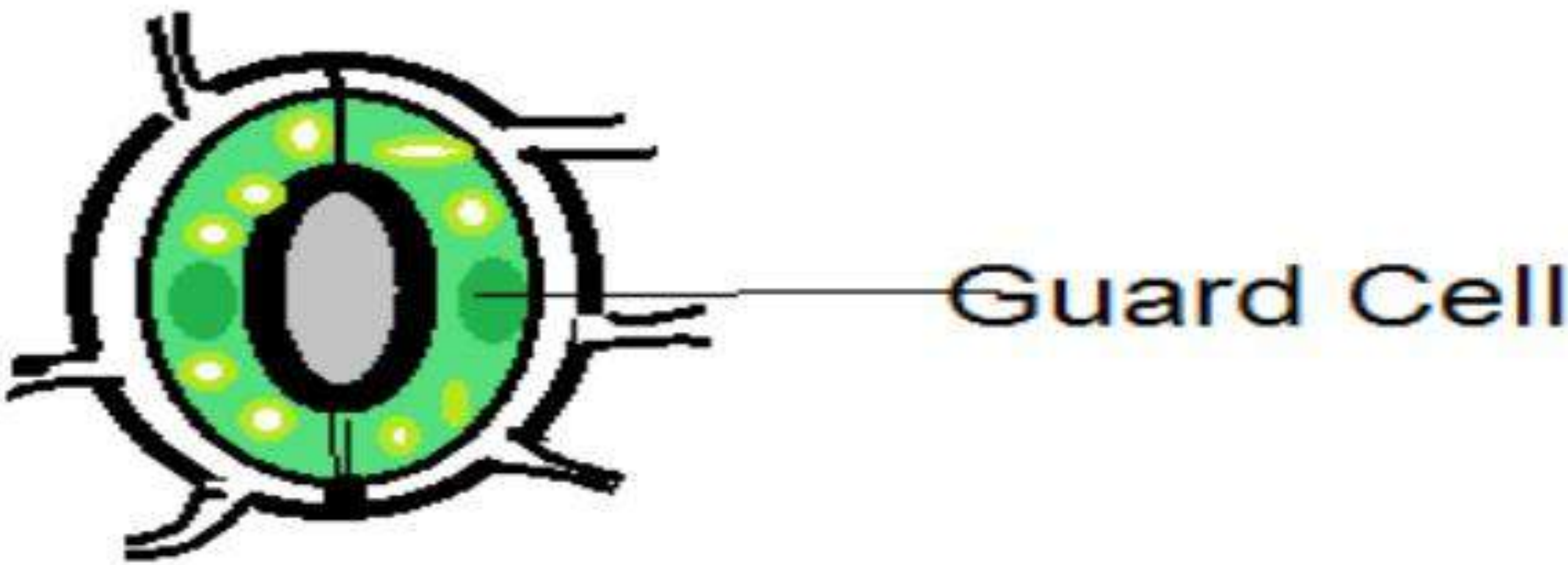
Cell Pore :-

- Pore Present On Leaf
- Help In Gasseous Exchange
- Transpiration Occur By This



Guard Cell

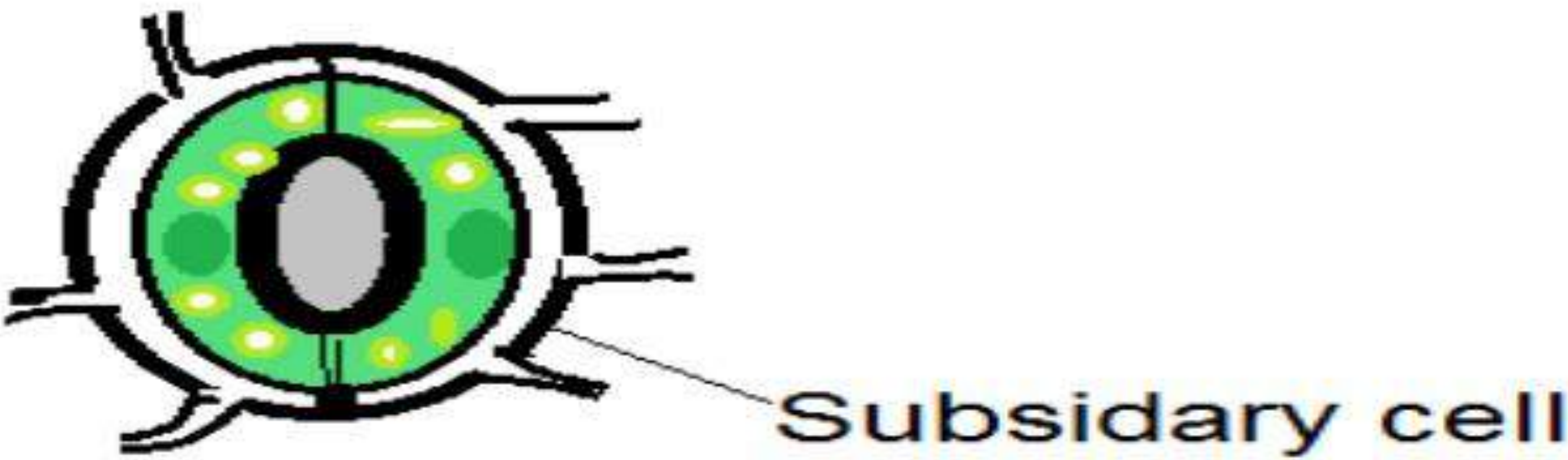
- Specialized Cell surrounds Stromatal Pore
- Always Present In Pair
- Helping Stomata In Opening & Closing



Subsidiary Cell

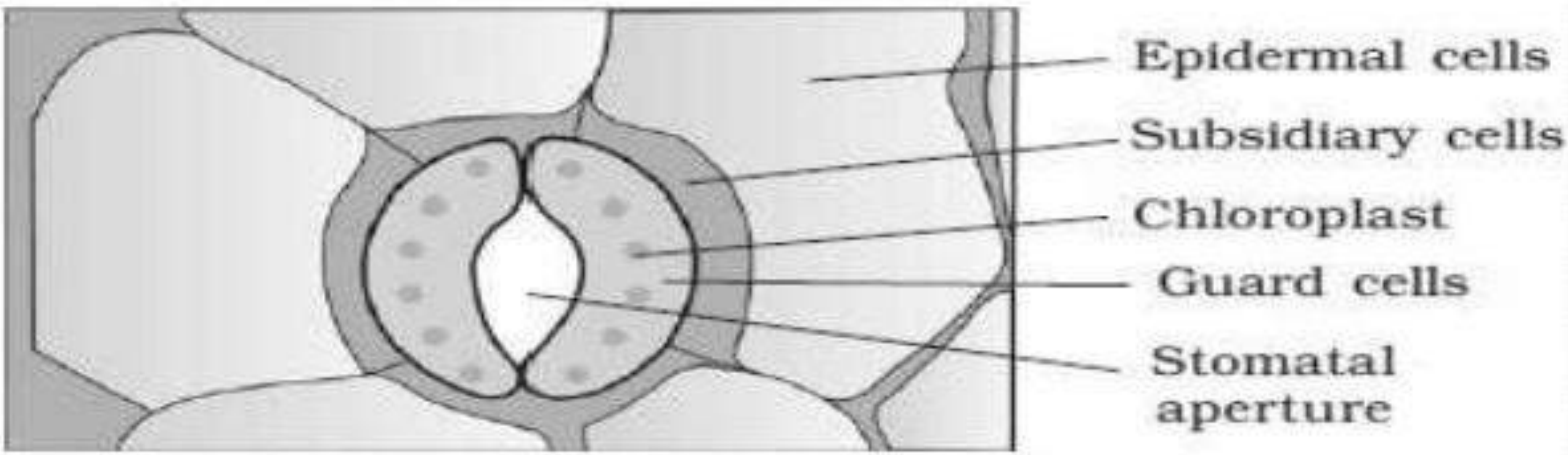
These Are Type Of Epidermal Cell Which Are Associated With Guard Cell

They Are Morphologically Different From Guard Cell also Called Accessory Cell



Stomatal Apparatus

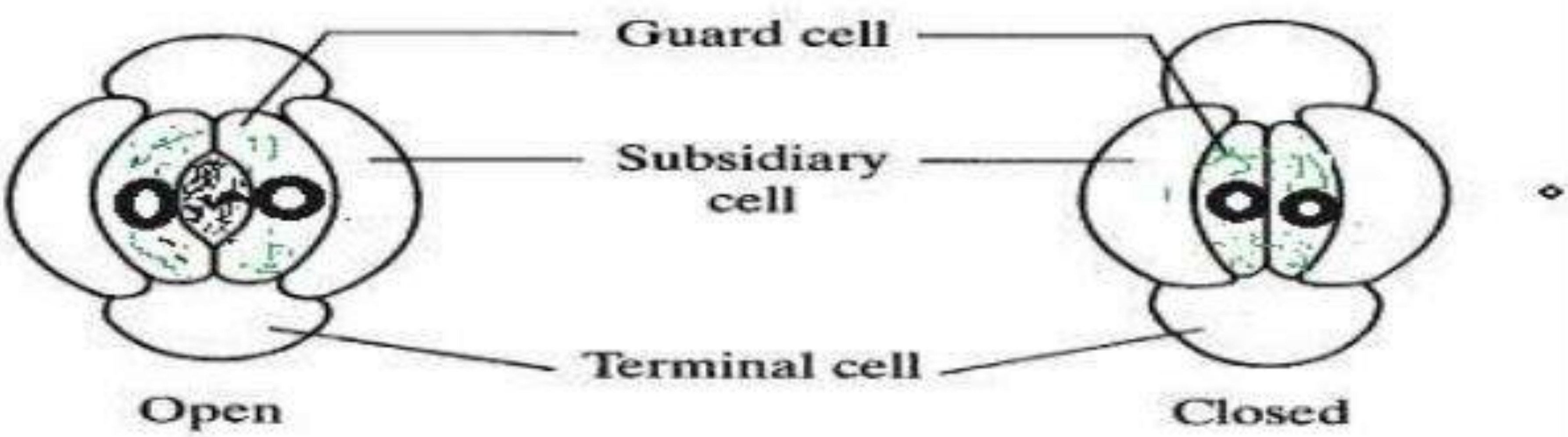
Stomatal Pore , Guard Cell & Subsidiary Cell Together Called Stomatal Apparatus



Open & Closed Stomata

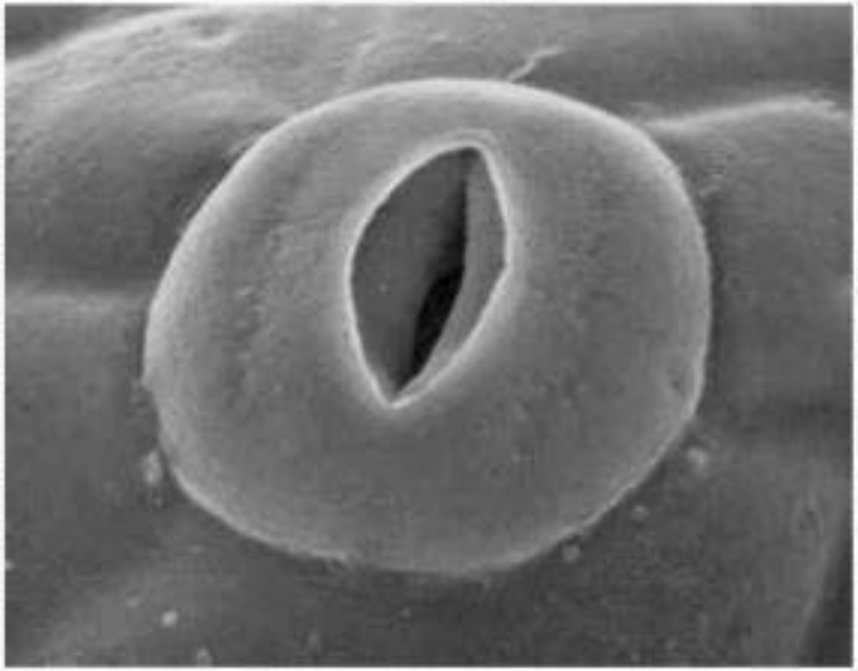
>> Open Stomata Happen At Day Time
Closed Stomata Happen At Night Timing

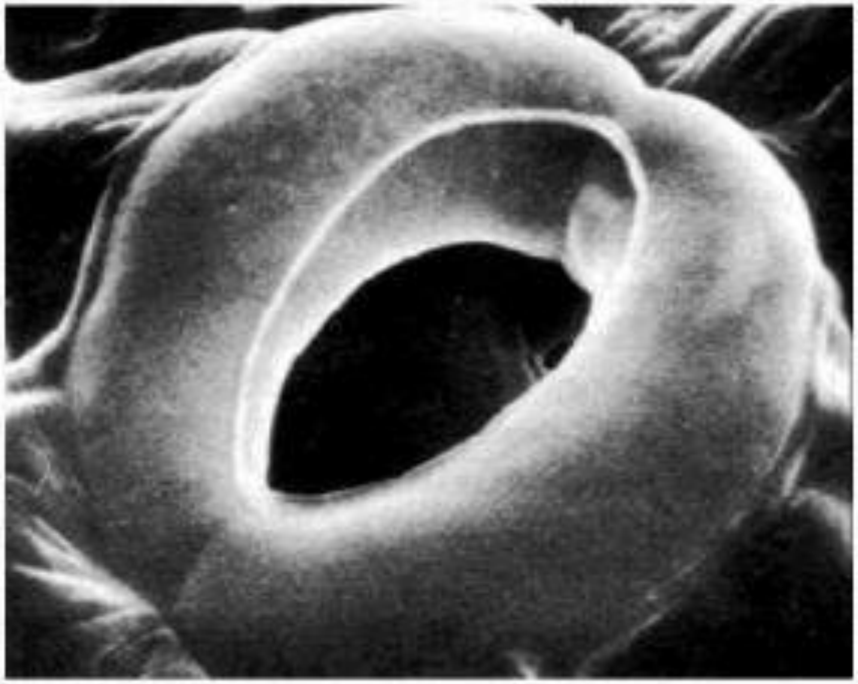
>>At Open Time Transpiration Occur
At Closed Timing No Transpiration Occur



Types Of Guard Cell

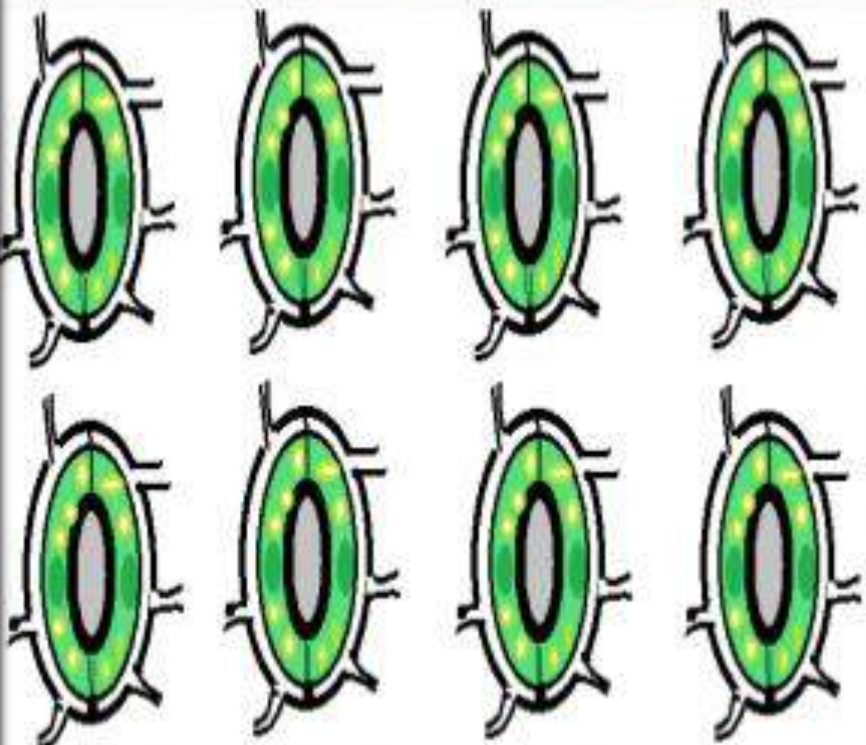
In Dicot Leaf= Kidney Shape **In Monocot Leaf= Dum bell Shape**



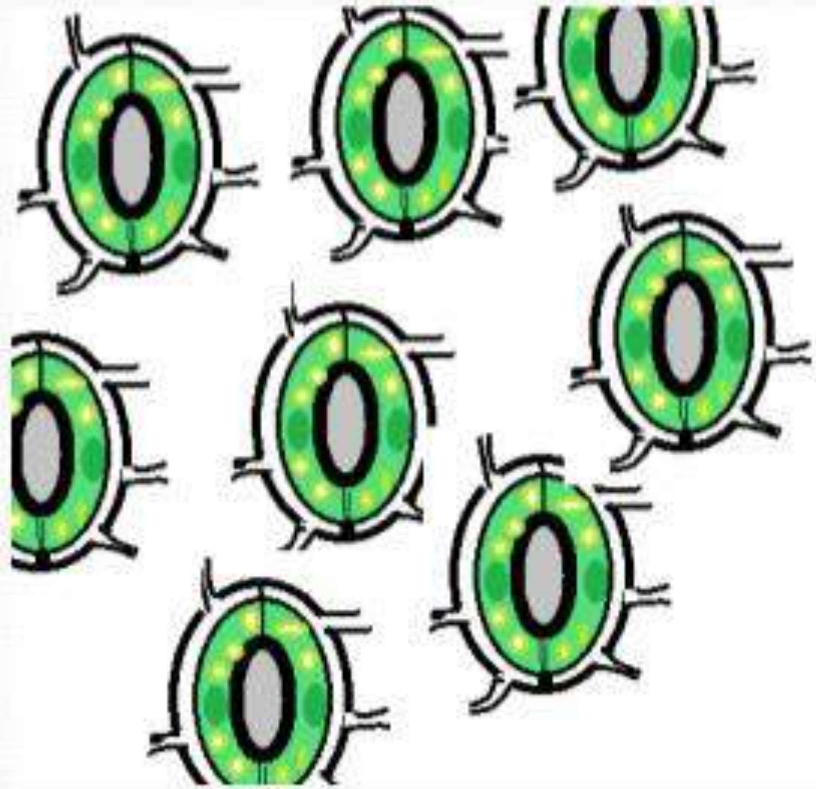


Arrangement Of Stomata

In Monocot = Parellel



In Dicot = Irregular



Types of stomata

- There are 4 basic types of stomata among the dicotyledons, these types are distinguished on the basis of the subsidiary cells surrounding the stomata & their arrangements,
- <u>The four types are as the following</u>

A) Anomocytic type, Ranunculaceae

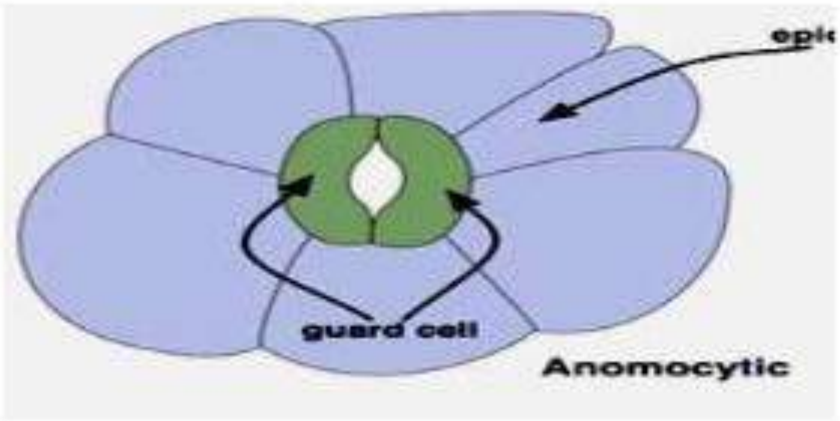
B) Anisocytic type, Curciferae

C) Paracytic type, Rubiceae

D) Diacytic type, Caryophyllaceae

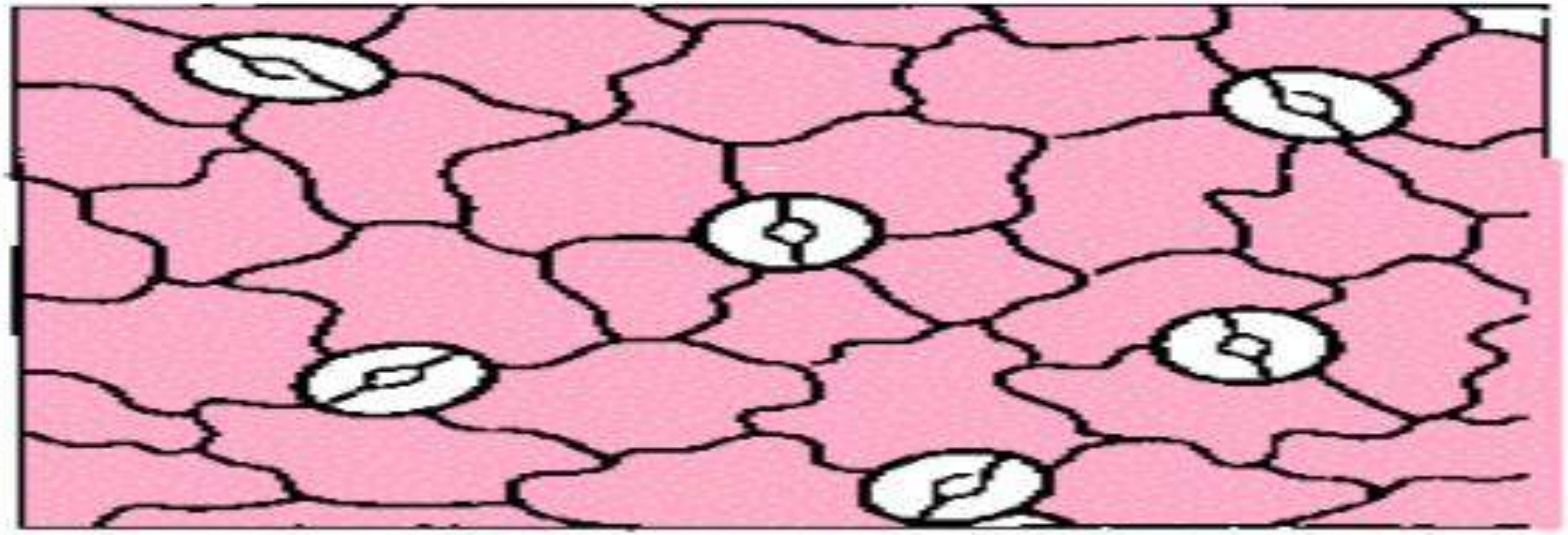
A) Anomocytic or Ranunuculaceae

- The surrounding epidermal cells have no special arrangement, they are all similar & there are no subsidiary cells, so all the cells are normal epidermal cells without any modification, like to stomata of digitalis, see the following example pictures.



Anomocytic Type :-

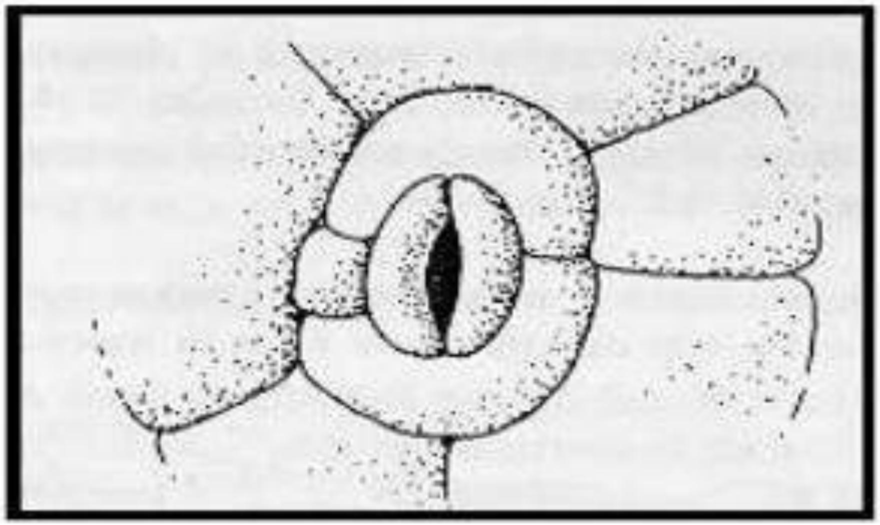
Here , Stomata Surround With Limited Number Of Cell , Which Cannot be Differentiated From Other Cell



Anomocytic Type

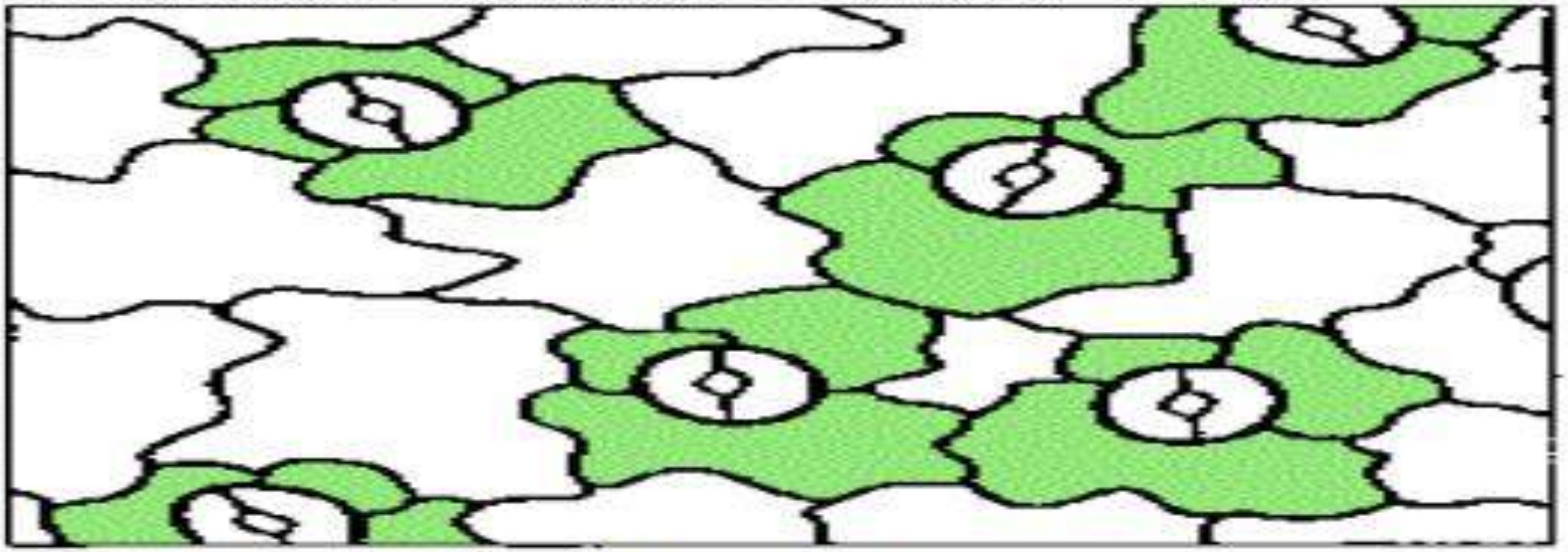
B) Anisocytic type or Cruciferae

- **The stomata is surrounded by 3 or more subsidiary cells, one of them is distinctly smaller that the others like in Hyoscymus niger, check the following picture.**



Anisocytic Type :-

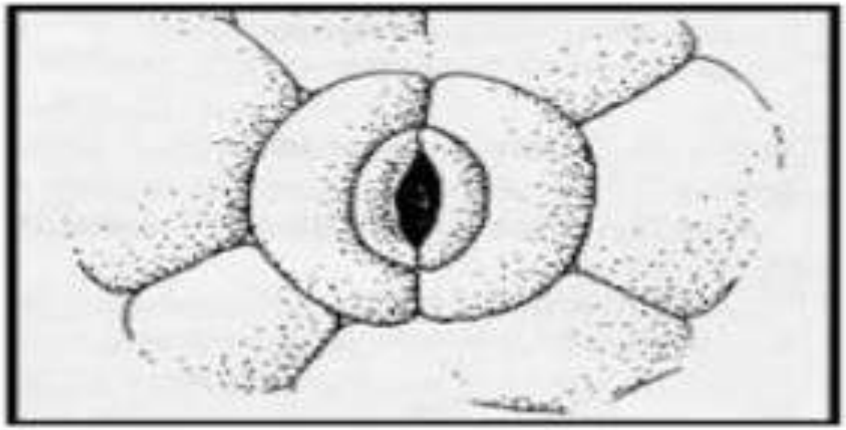
Here, Stoma Surrounds by 3 Subsdiary Cell , In Which One cell is Smaller Than Other Two



Anisocytic Type

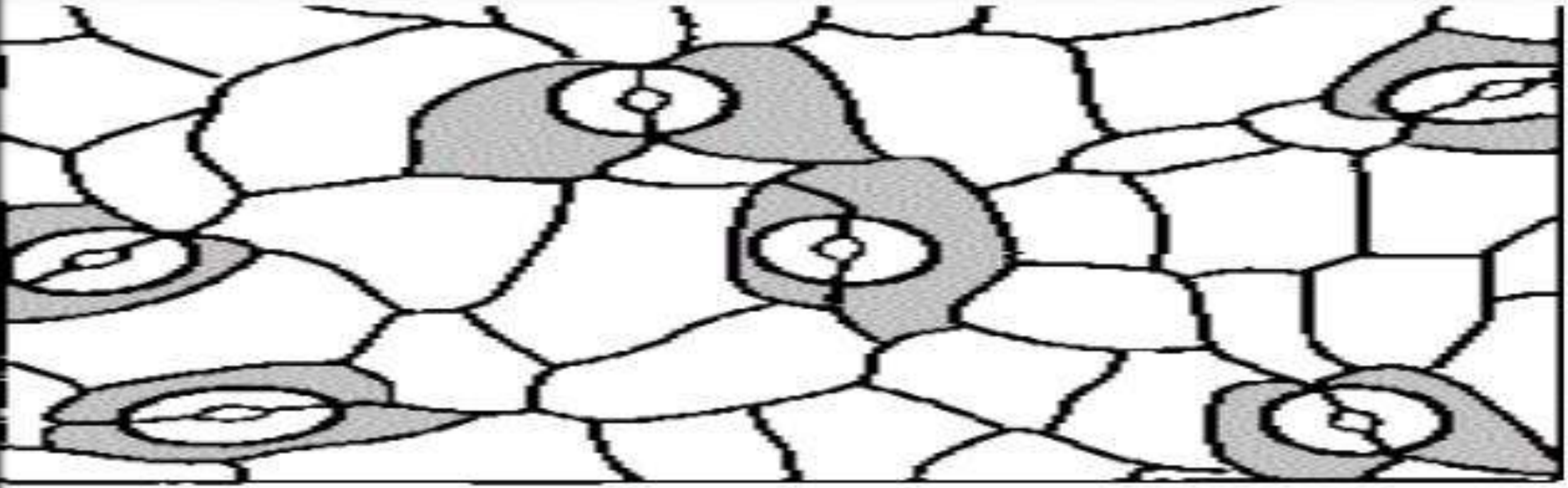
C) Paracytic type or Rubiaceae

- Each stoma is surrounded by 2 or more subsidiary cells, 2 of them have their long axes parallel to the pore, which means that the axes of the subsidiary cells are parallel to the axes of the pore like the one in senna leaves, check the following picture.



Paracytic Type :-

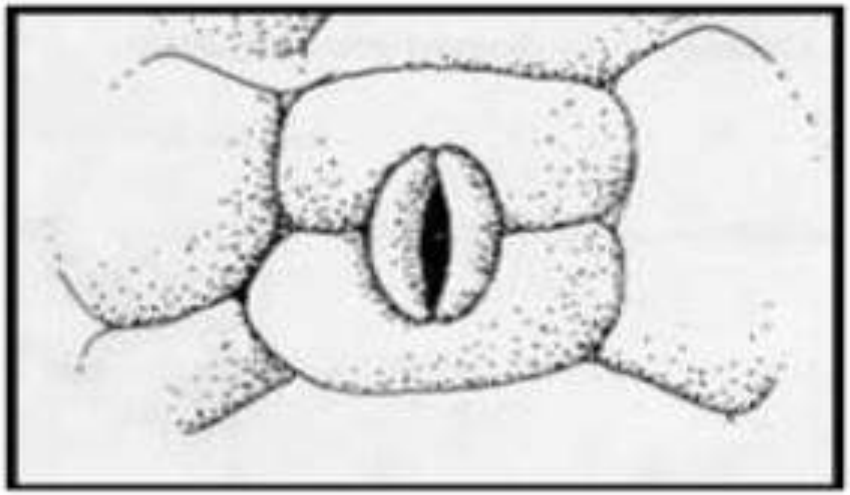
Here Subsidairy Cell Arranged In That Manner They Having Same Arrangement As Guard Cell



Paracytic Type

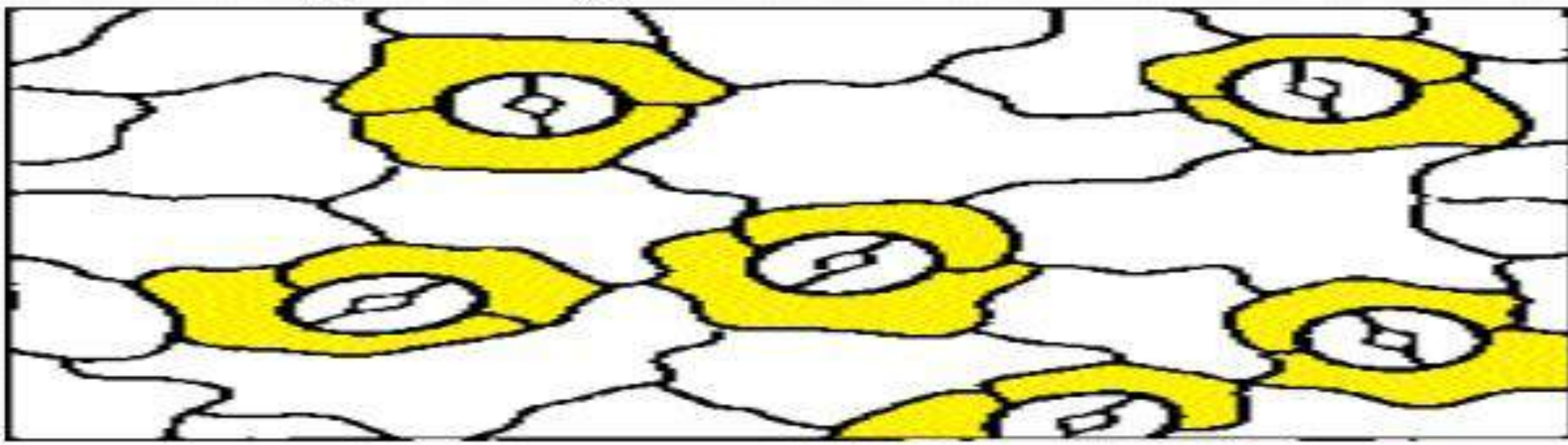
D) Diacytic type, Caryophyllaceae

- Each stomata is surrounded by 2 subsidiary cells having their long axes perpendicular to the pore like in peppermint, Mentha piper, check the following picture



Diacytic Type :-

Here, Stomal Encloses In Pair Of Subsidiary Cell In Which They Are in At Right angle To Guard Cell



Dicytic Type

Where are stomata located in:

1. Dicot
2. Monocot
3. Aquatic plant

Stomata are located:

Dicot

- mostly on the lower leaf surface

Monocot

- each leaf surface has an equal number of stomata

Aquatic plant

- NO stomata in submerged leaves
- Stomata only on upper leaf surface in floating leaves

Why are stomata located like this?

Dicot

Lower leaf surface is more protected from the sun

Monocot

Each leaf surface is equally exposed to the sun

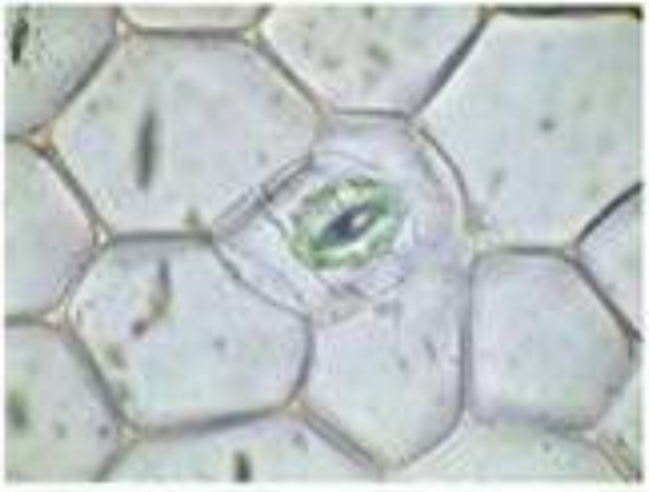
Aquatic plant

- Stomata are useless: they are not in contact with air

- Stomata allow gas exchange with the air

Differences between guard cells and the surrounding epidermal cells.

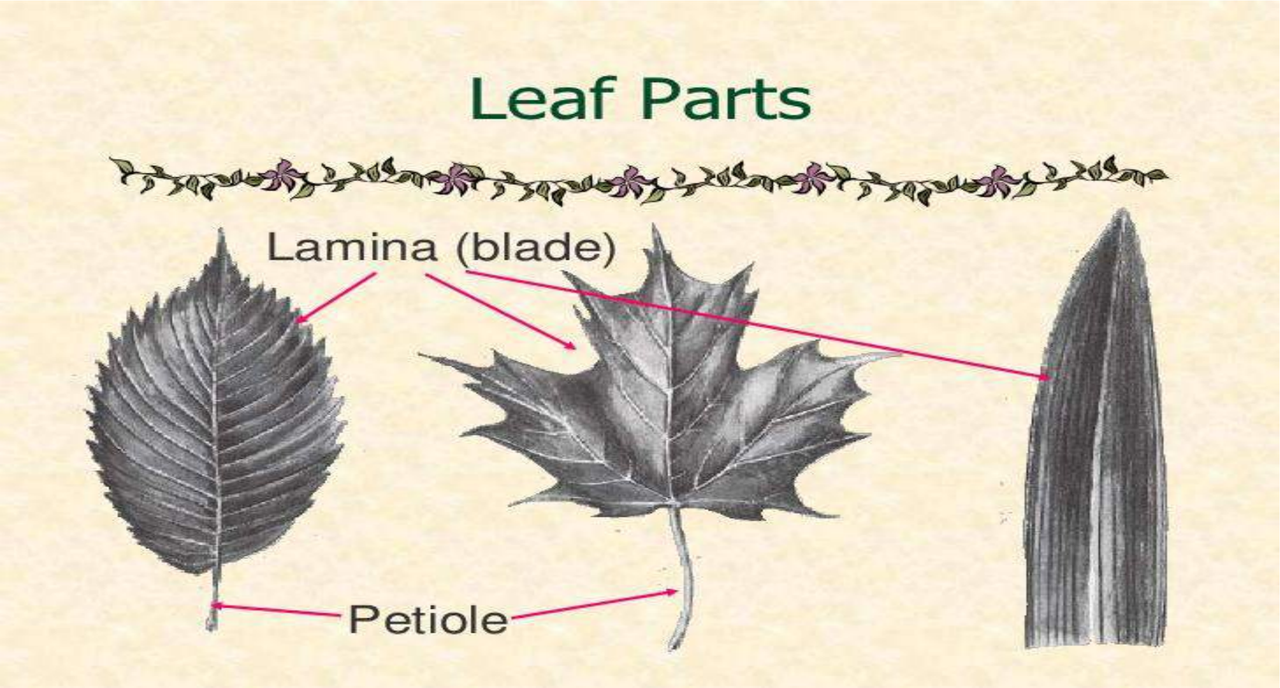
Guard cells	Epidermal cells
1) have chloroplasts	Chloroplasts absent
2) are bean-shaped	Cuboidal in shape
3) cell walls are not evenly thick	Cell walls evenly thick



Meristematic tissues	Permanent tissues
Continuously dividing cells.	Do not divide continuously
Cells are small and isodiametric.	Variable in shape and size
Cell wall is thin.	Cell wall is thick
Nuclei are large.	Nuclei are small
Vacuoles are absent	Vacuoles are present
Intercellular spaces absent	Intercellular spaces present
Metabolic activities are at high rate.	Low rate
Inorganic inclusion absent	Present
Cells are undifferentiated.	Cells are differentiated
Simple tissue	Simple or complex

Plant organs

- 1- The leaf



- A leaf is a thin, flattened organ borne above ground and specialized for photosynthesis.

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The origin of the leaf

- The leaf originates as a leaf primordium at the shoot apical meristem.
- This origin is exogenous.
- The leaf primordium is attached to zones of little elongation growth known as nodes.

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- The leaf primordia tend to arch over the zone of cell division in the stem to protect the meristematic tissue.

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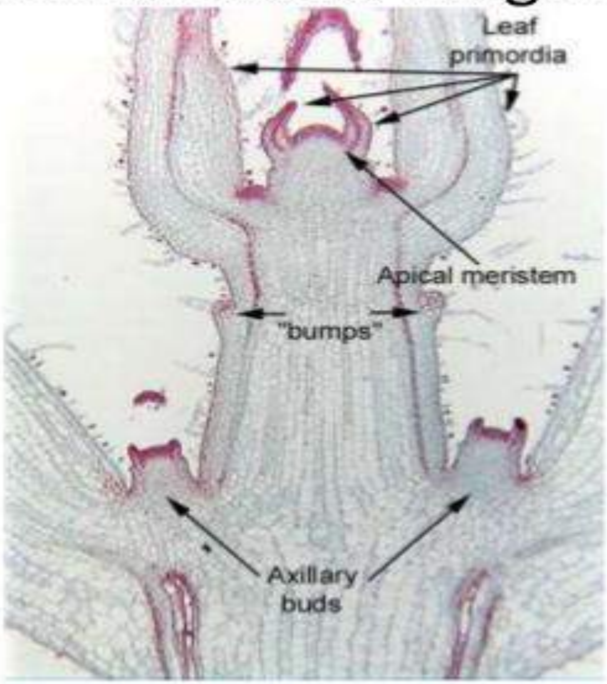
- Apical meristem of shoot

The group of undifferentiated cells that divide to produce increased length of stems and roots



Leaves

- Leaf Parts
  - Leaf Blade: Large, broad, flat surface whose job is to collect sunlight
  - Petiole: supports the leaf and holds it away from the stem.
  - Midrib: Main vein running down the center of the leaf. It helps hold the leaf so it is facing the sun.

Leaves

- Leaf kinds
  - Simple leaf: Has only one leaf on the petiole.
  - Compound leaf: A leaf with multiple blades.

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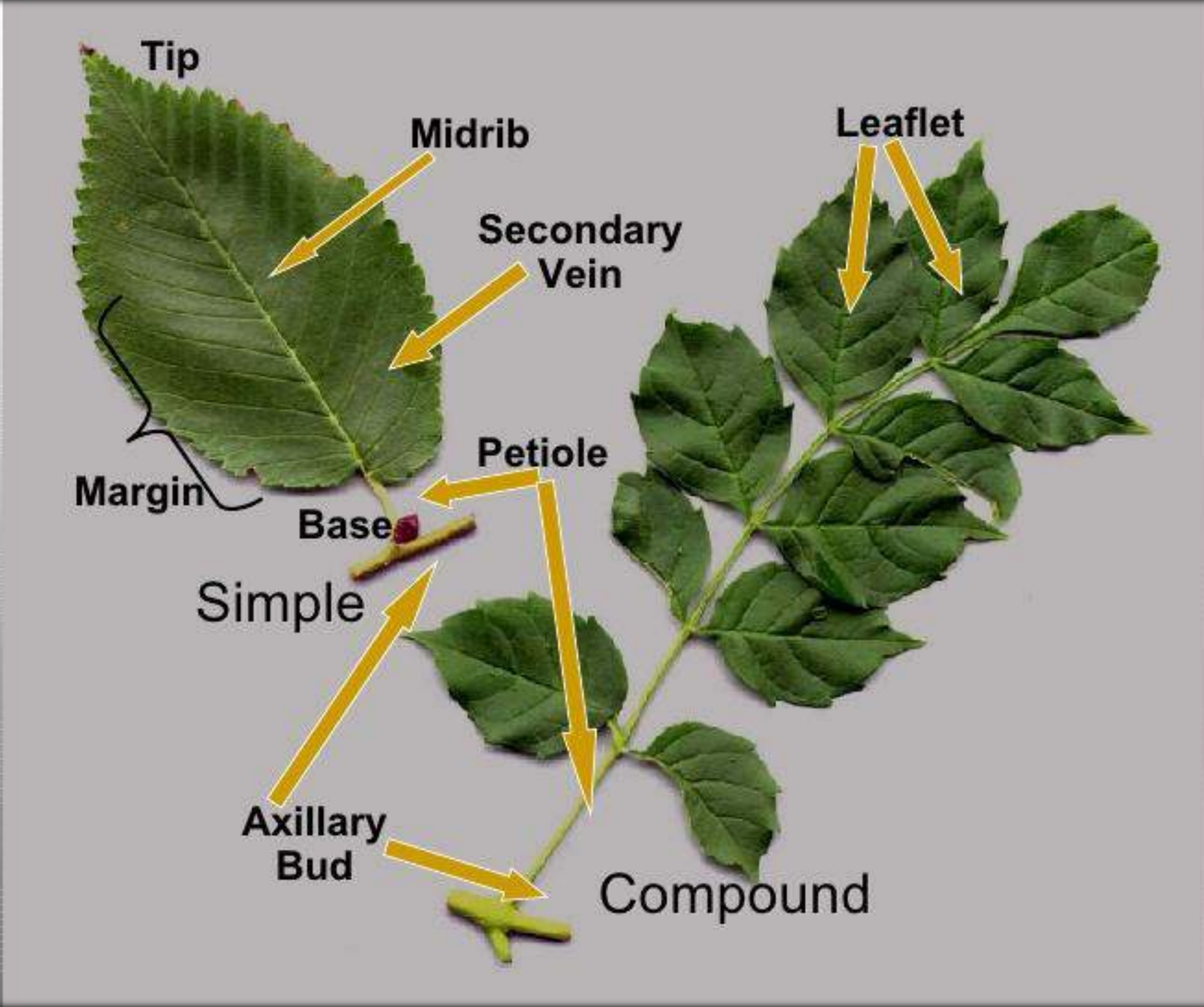
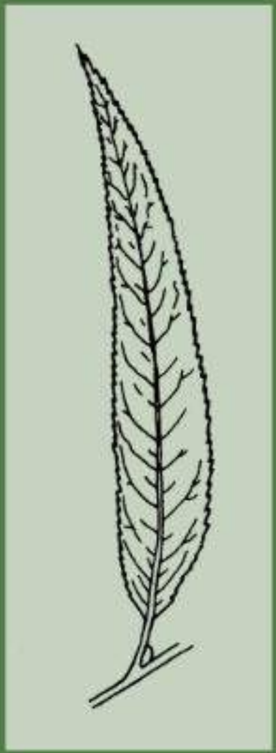
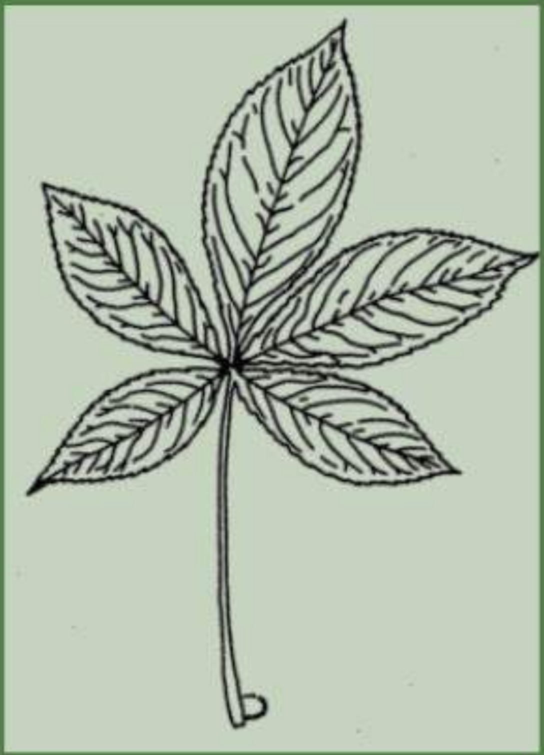

Tip
Midrib
Leaflet
Secondary
Vein
Margin
Petiole
Base
Simple
Axillary
Bud
Compound

Leaf Structure Comparison



Simple leaf

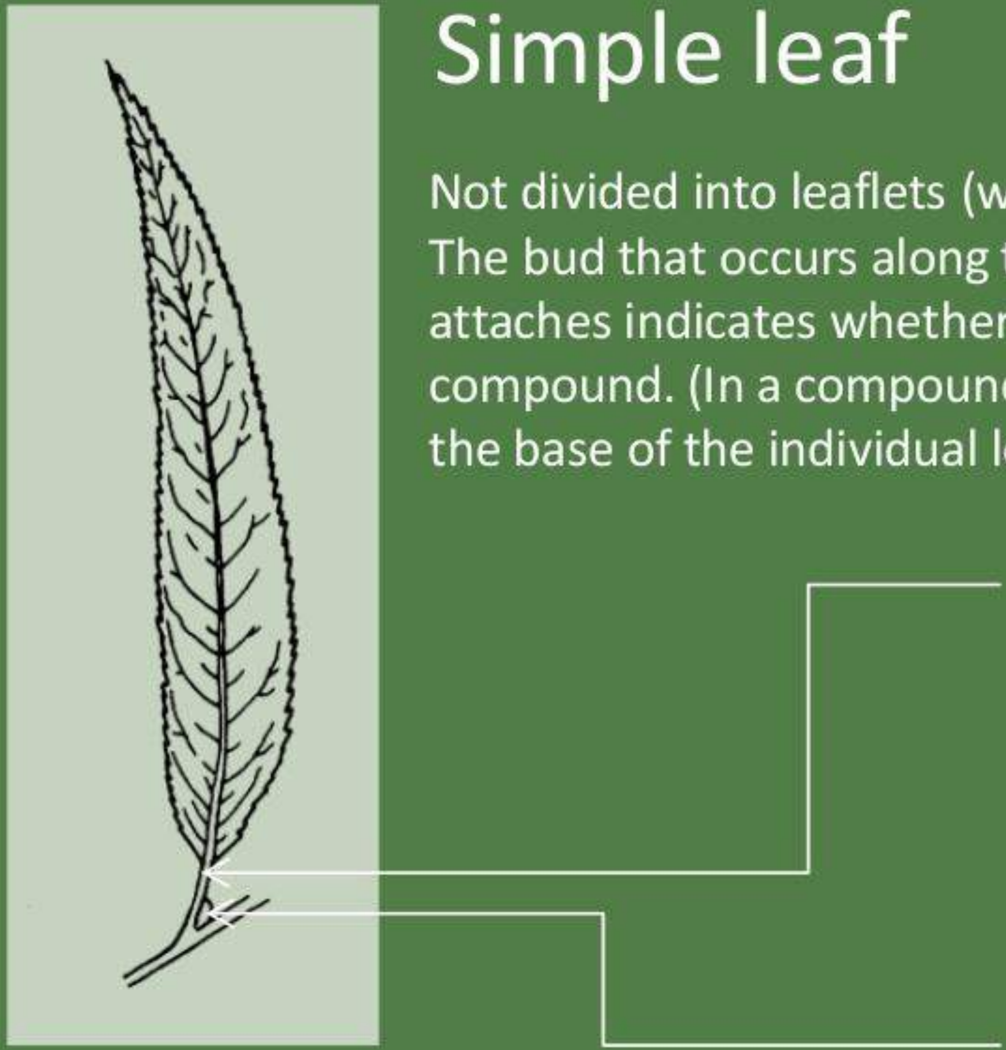
Pinnately compound leaf



Palmately compound leaf

Simple leaf

Not divided into leaflets (which we'll see shortly). The bud that occurs along the stem where the leaf attaches indicates whether the leaf is simple or compound. (In a compound leaf, there is no bud at the base of the individual leaflets.)

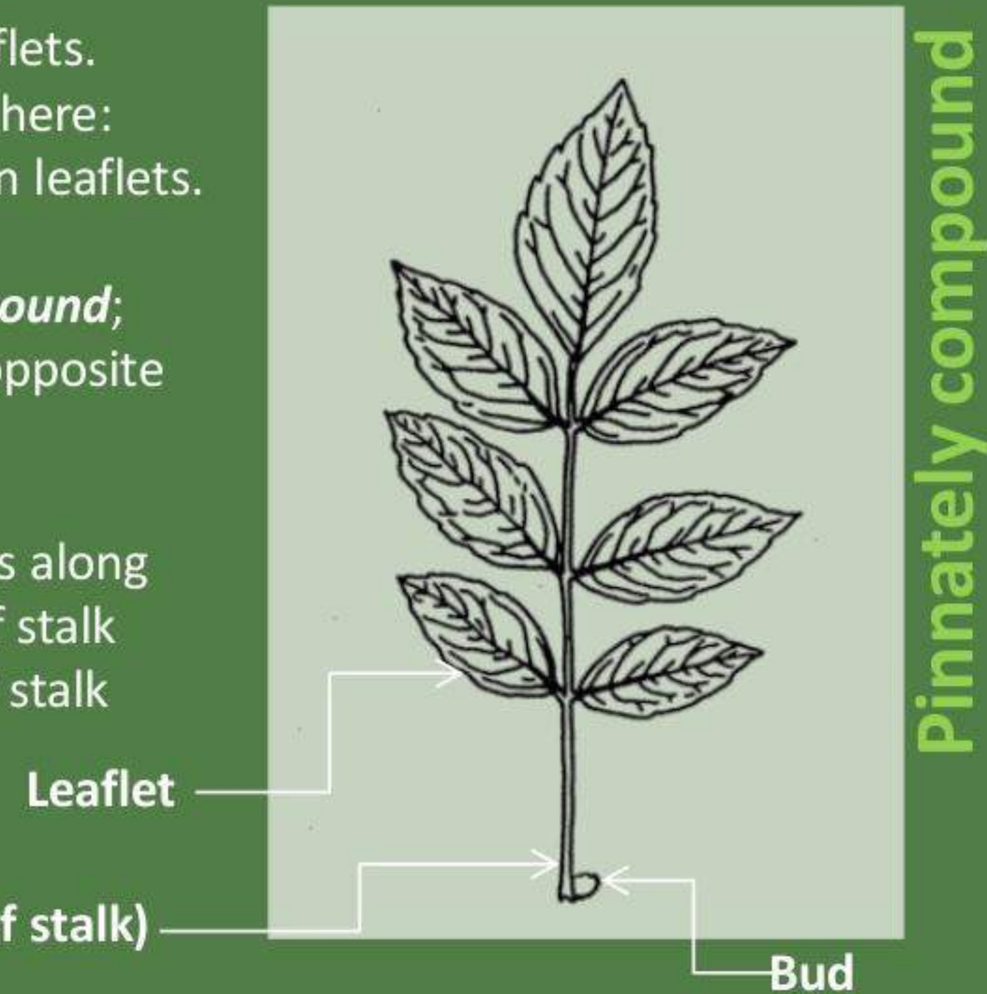


Compound Leaf

A leaf that is divided into leaflets. Notice there is only one bud here: thus, only one leaf with seven leaflets.

This figure is ***pinnately compound***; having leaflets arranged on opposite sides of an elongated axis.

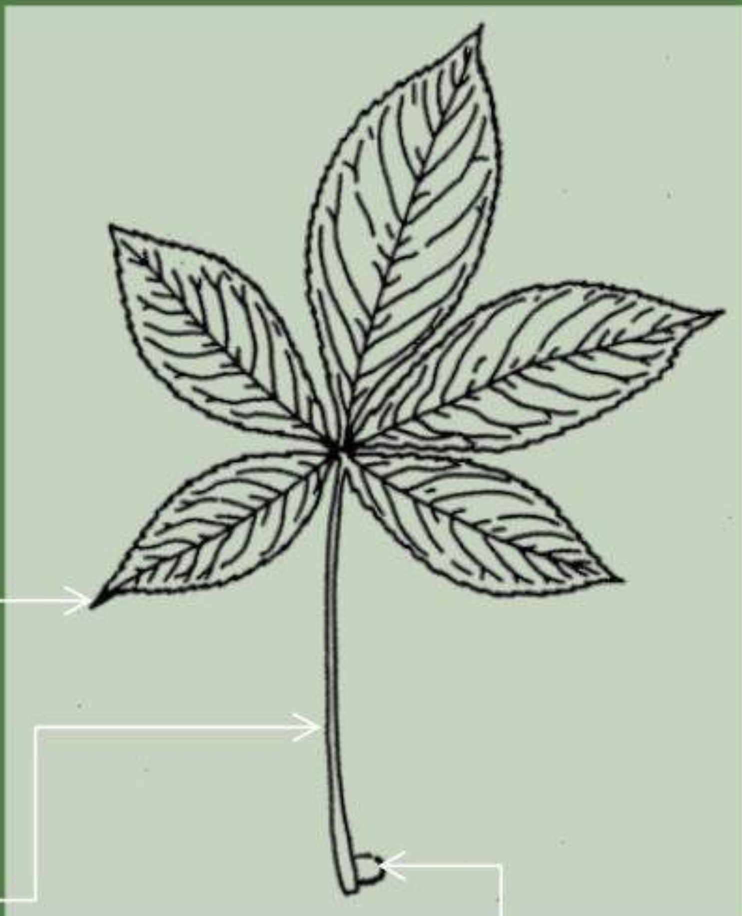
Note: The bud actually occurs along the twig, near where the leaf stalk attaches, and not on the leaf stalk itself.



Compound Leaf

This is an example of a ***palmately compound*** leaf; leaflets all attach near a common point, resembling the fingers of a hand.

Note: There is only one bud here; thus, there are five leaflets that make up one leaf.



Types of Leaves

- Scale leaves (cataphylls) - enclose and protect rhizomes and buds
- Seed leaves (cotyledons) - store food for seedlings
- Spines & Tendrils - protect or help support
- Storage leaves - found on bulbous plants & succulents, store food
- Bracts - modified, often brightly-colored leaves around flowers

Courtesy of:
National Gardening Association

Parts of the Tulip

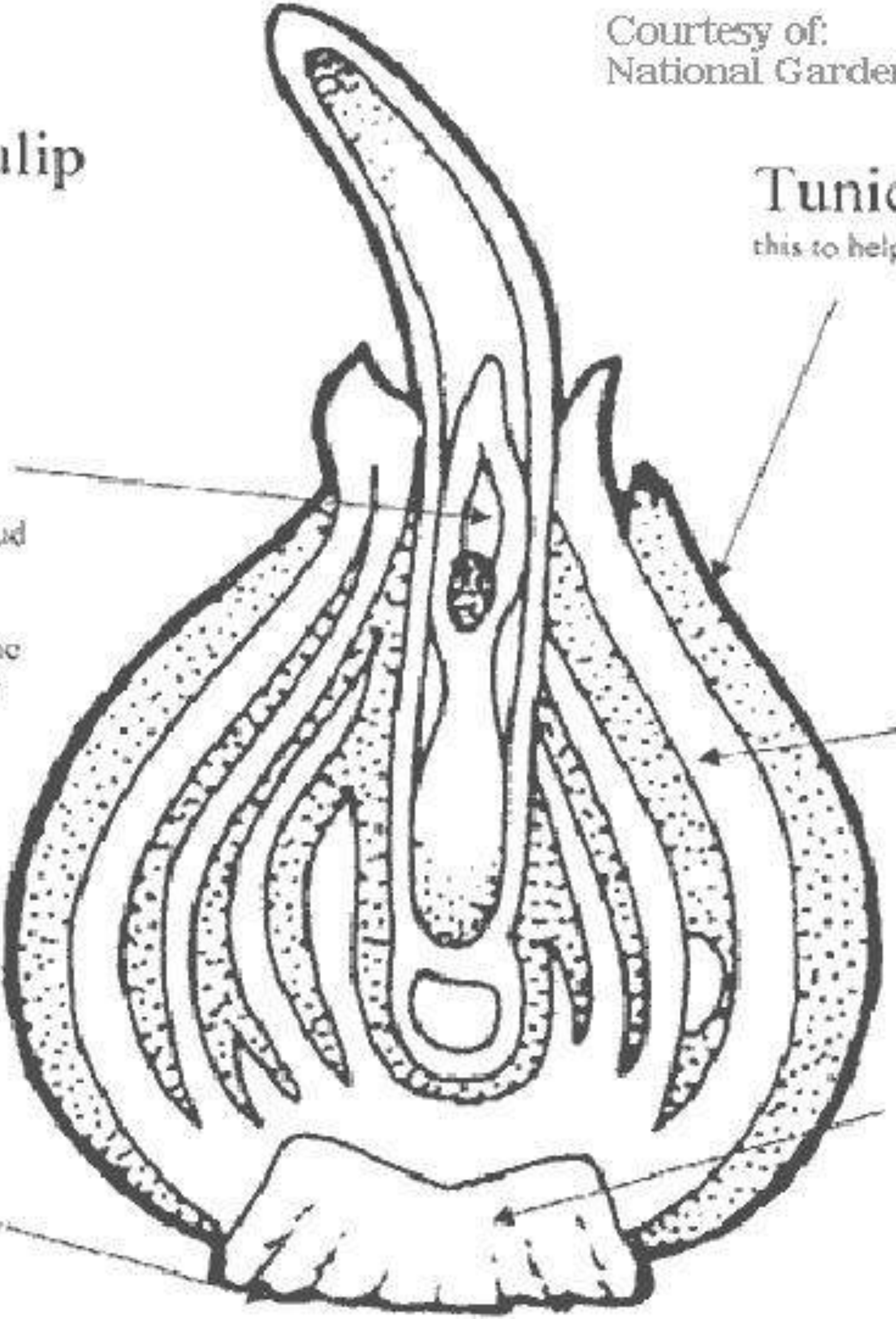
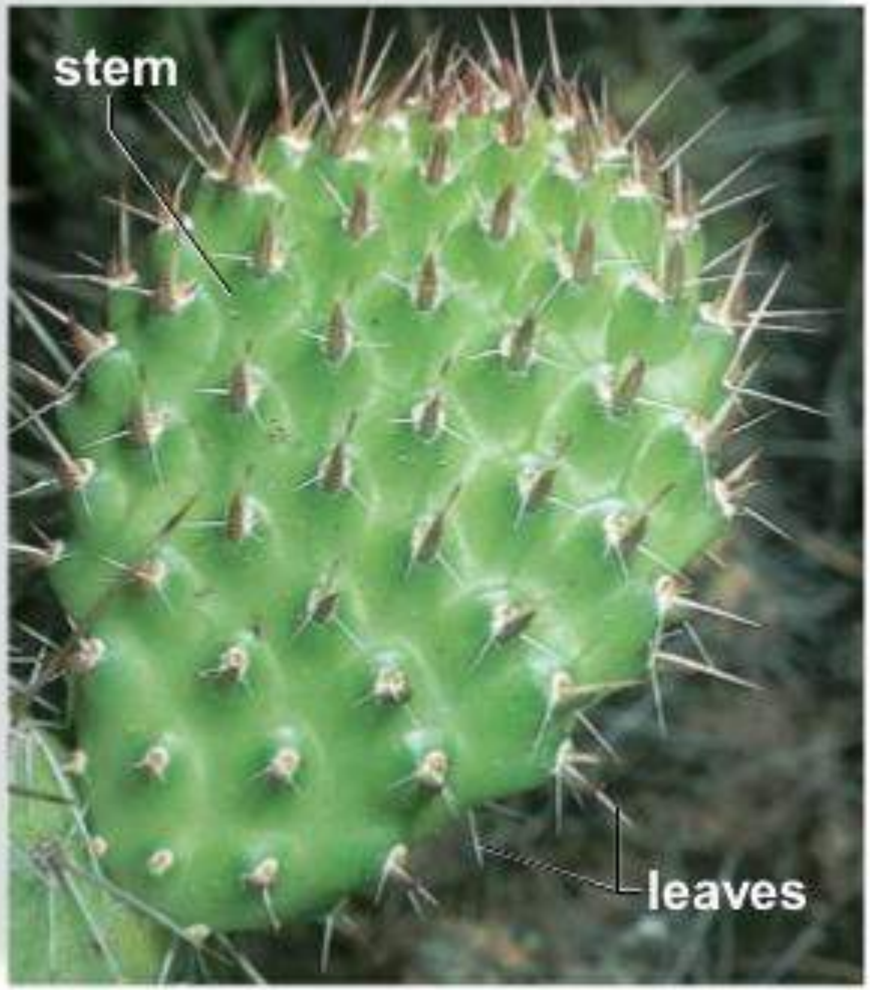


Figure 21.1B, pg. 433: Modified leaves adapt to a plant's environment



Spines are the leaves of a cactus

Figure 21.1B Modified leaves adapt to a plant's environment (Cont.)

Tendrils are modified leaves of a cucumber

Figure 21.1B Modified leaves adapt to a plant's environment (Cont.)

Leaves of a Venus flytrap capture insects

Fleshy and succulent leaves

- for storage

ex. Sabila

Leaves

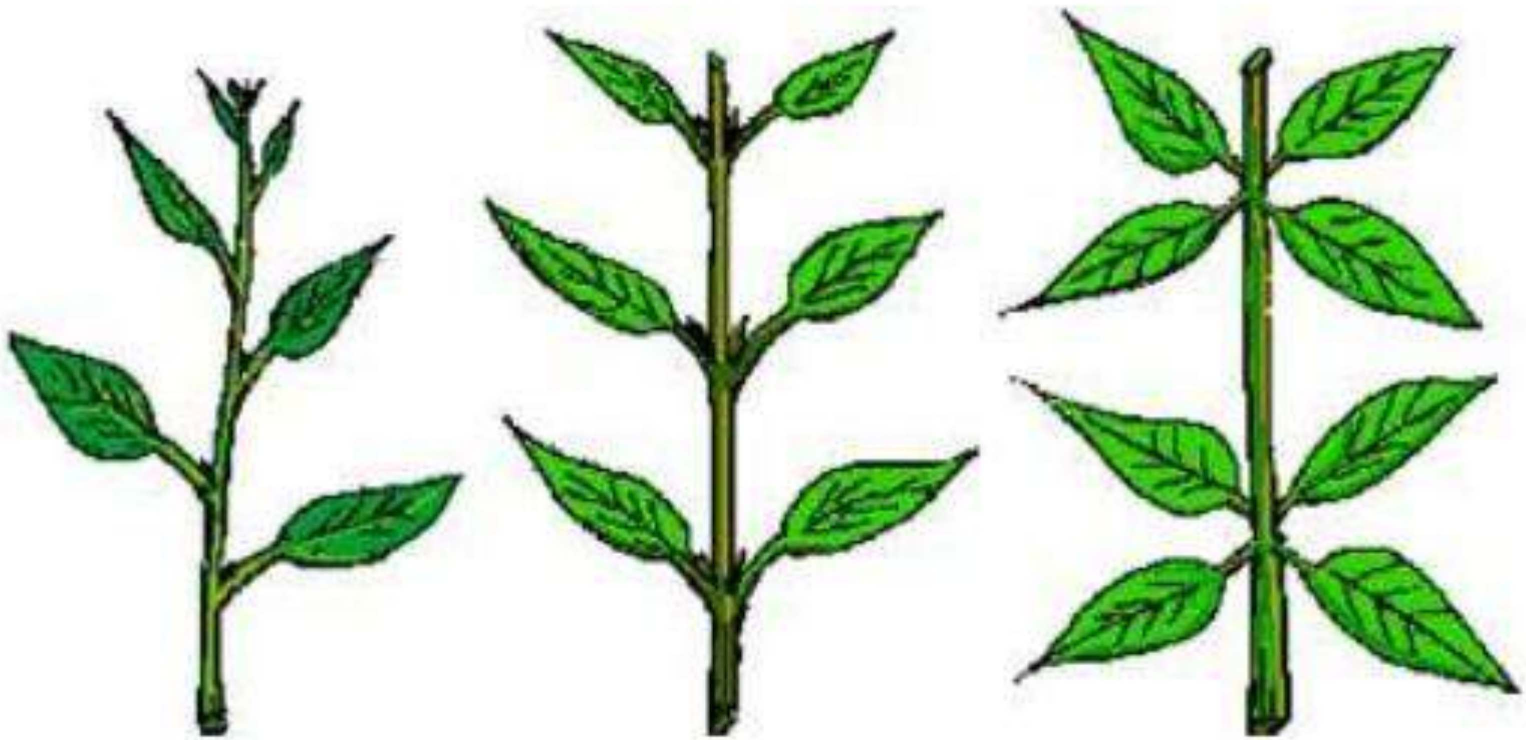
- Function in food production (photosynthesis)
- **Epidermal cells** – outer layer of cells, covered with a waxy cuticle
  - **Stomata** surrounded by guard cells
- **Mesophyll** – cell layers containing chloroplasts
  - **Palisade Layer** – tall, closely packed, sit of most photosynthesis
  - **Spongy Layer** – loosely packed, air spaces allow gases to enter and exit the leaf

Role of leaves:

- Trap light for photosynthesis
- Exchange gases

Leaves do not shade each other

- To trap as much light as possible



Leaf functions

1-

The leaf in typical plants is the site of photosynthesis for the plant.

2-

The flow of water in the xylem continues from root to the leaves via the stem.

The water leaves the xylem in the leaf and evaporates from the internal cells into the atmosphere.

This evaporation accomplished three functions:

a. It cools the leaf.

b. It draws more water up through the xylem in the stem.

c. It concentrates the mineral nutrients supplied by the root.

3-

Sugars and amino acids from photosynthesis in the leaf are loaded into its phloem and exported to the rest of the plant.

4-

In the of succulent plants water can be stored.

5-

Leaves have evolved into spines in cacti and other plants.

Leaves of some plants produce chemical compounds (secondary products) to deter or kill herbivores.

6-

In peas leaves sometimes produce tendrila at their tips, these assist plants climb.

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Anatomy of a leaf

A leaf is a plant organ and is a collection of tissues in a regular organization.

The major tissue systems present are:

1- The epidermis, which covers the upper and lower surfaces.

2- The mesophyll tissue inside the leaf, which is rich in chloroplasts.

3- The arrangement of veins (the vascular tissue).

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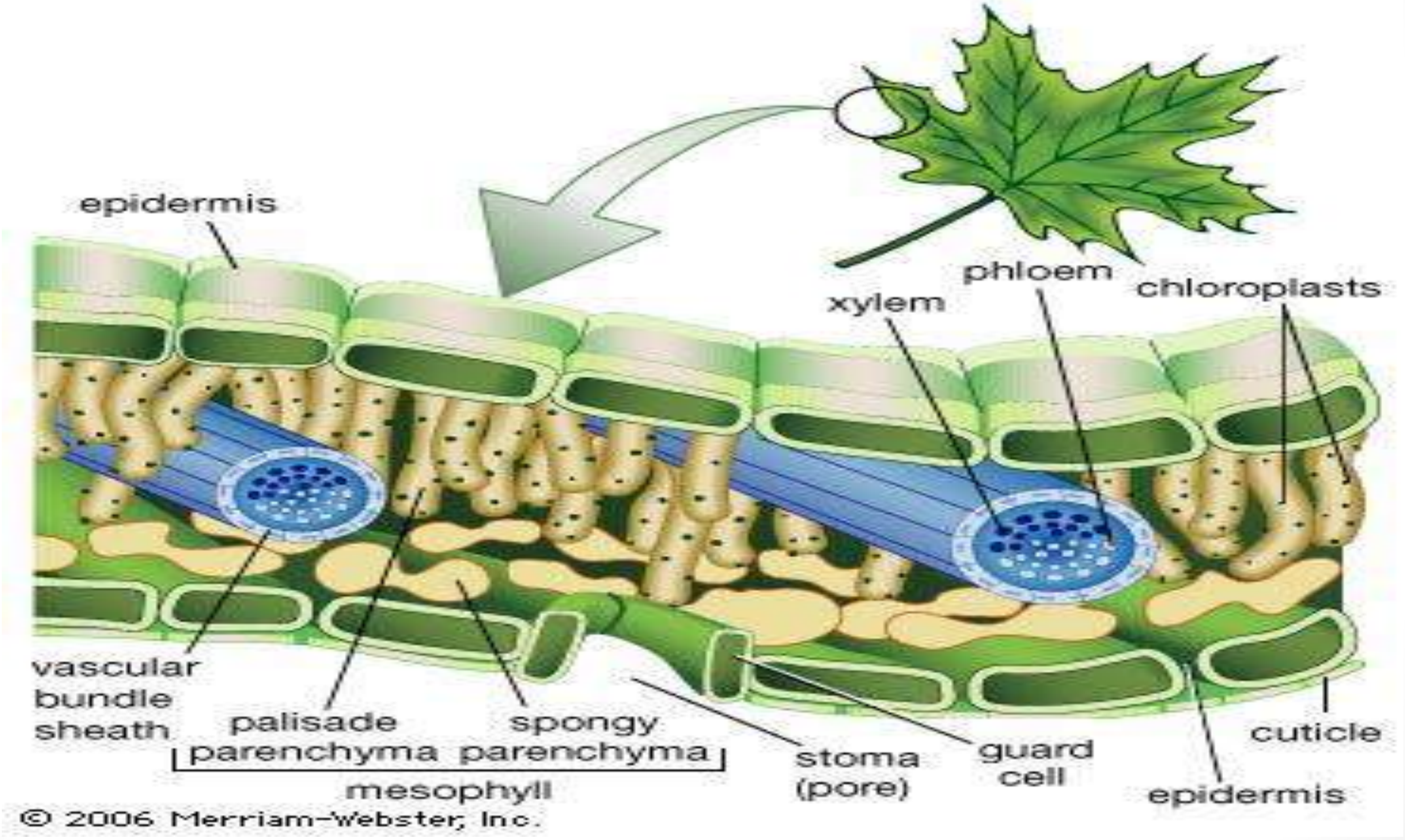
Leaf structure



Epidermis

The epidermal of leaves is composed of the various type of epidermal cells:

a. Ordinary epidermal cells.

b. Guard cell of the stomata, commonly accompanied by subsidiary cells.

c. Trichomes.

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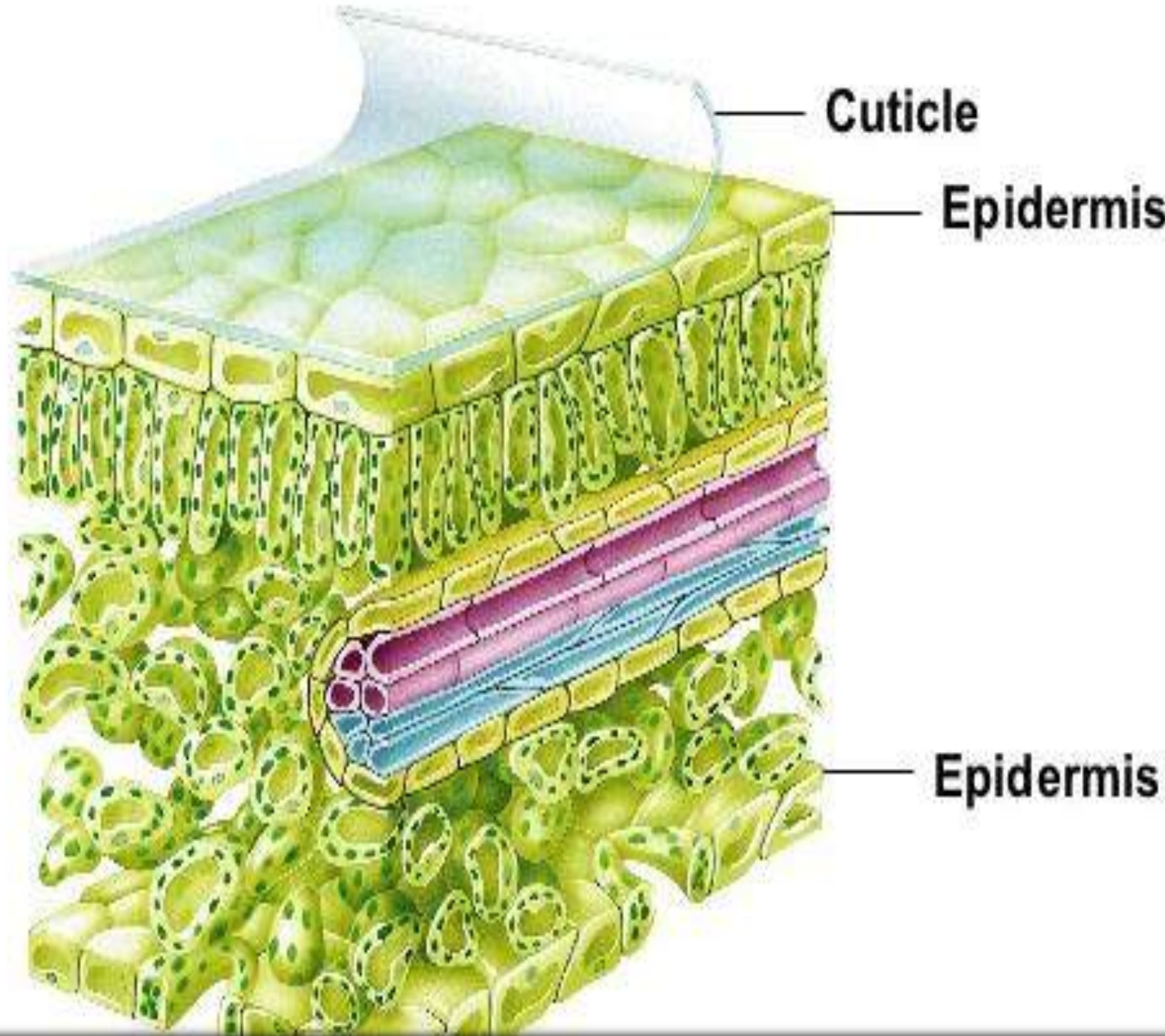
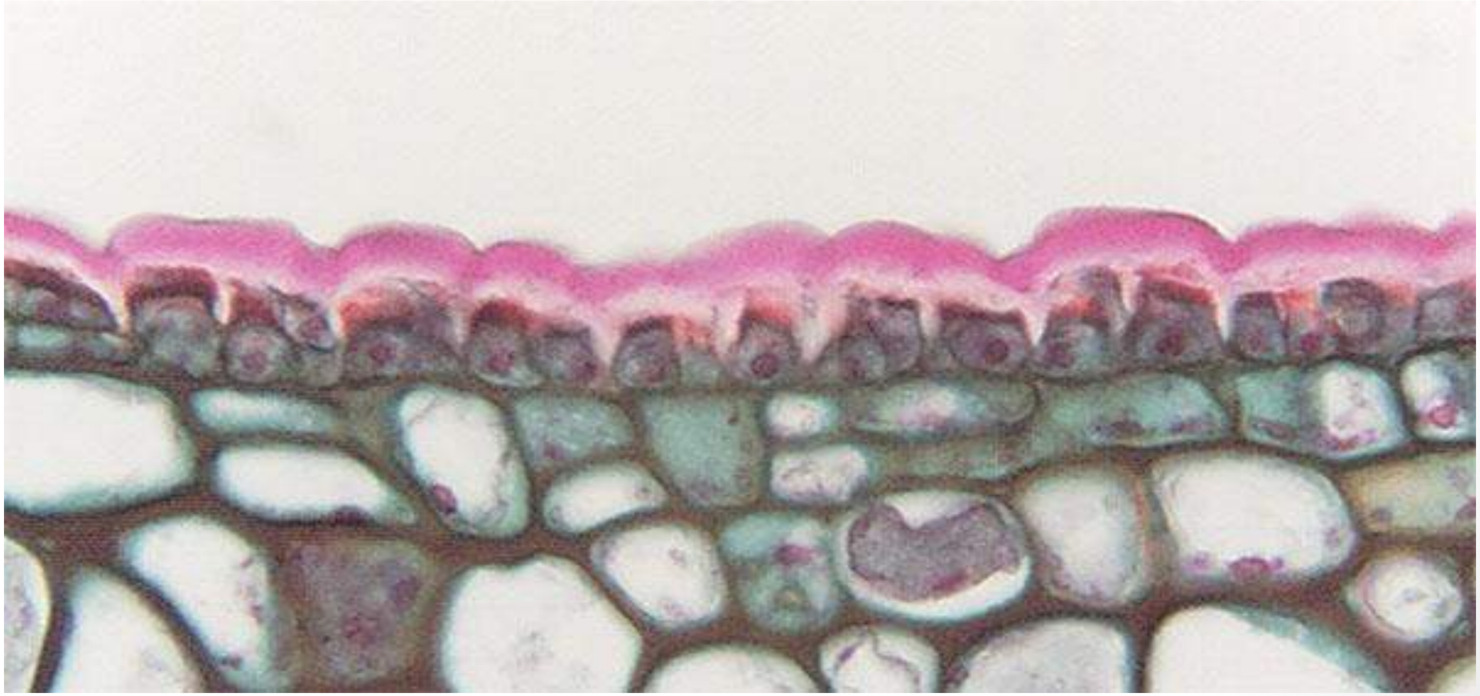
The epidermis of many leaves is covered by the cuticle.

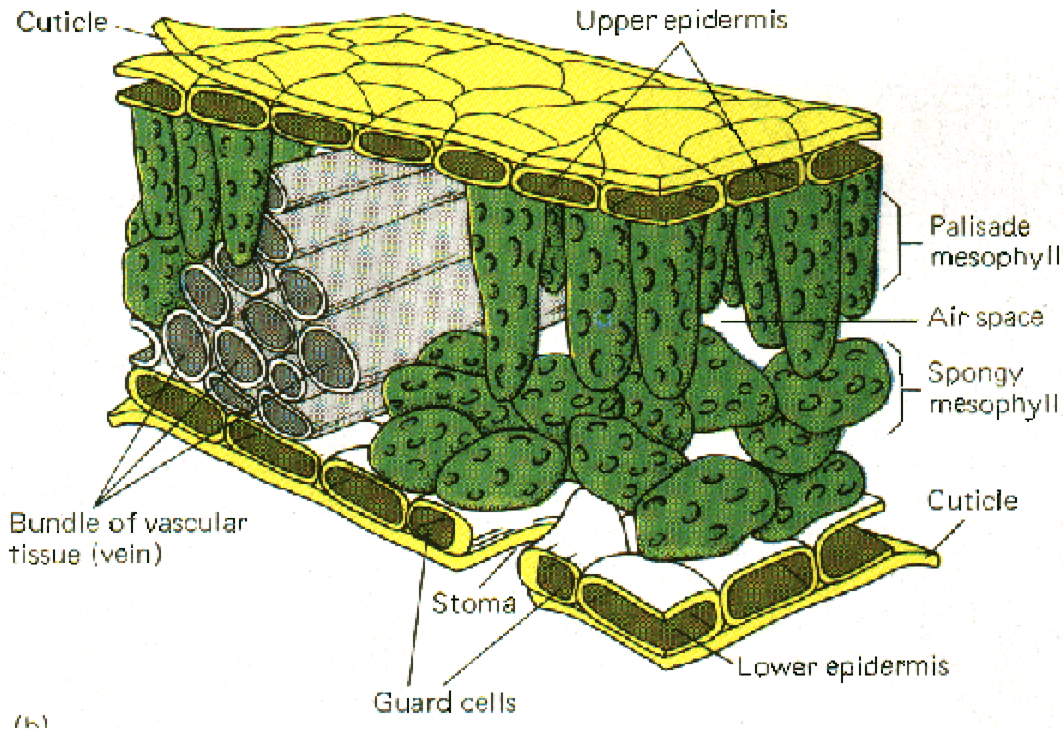


Cuticle

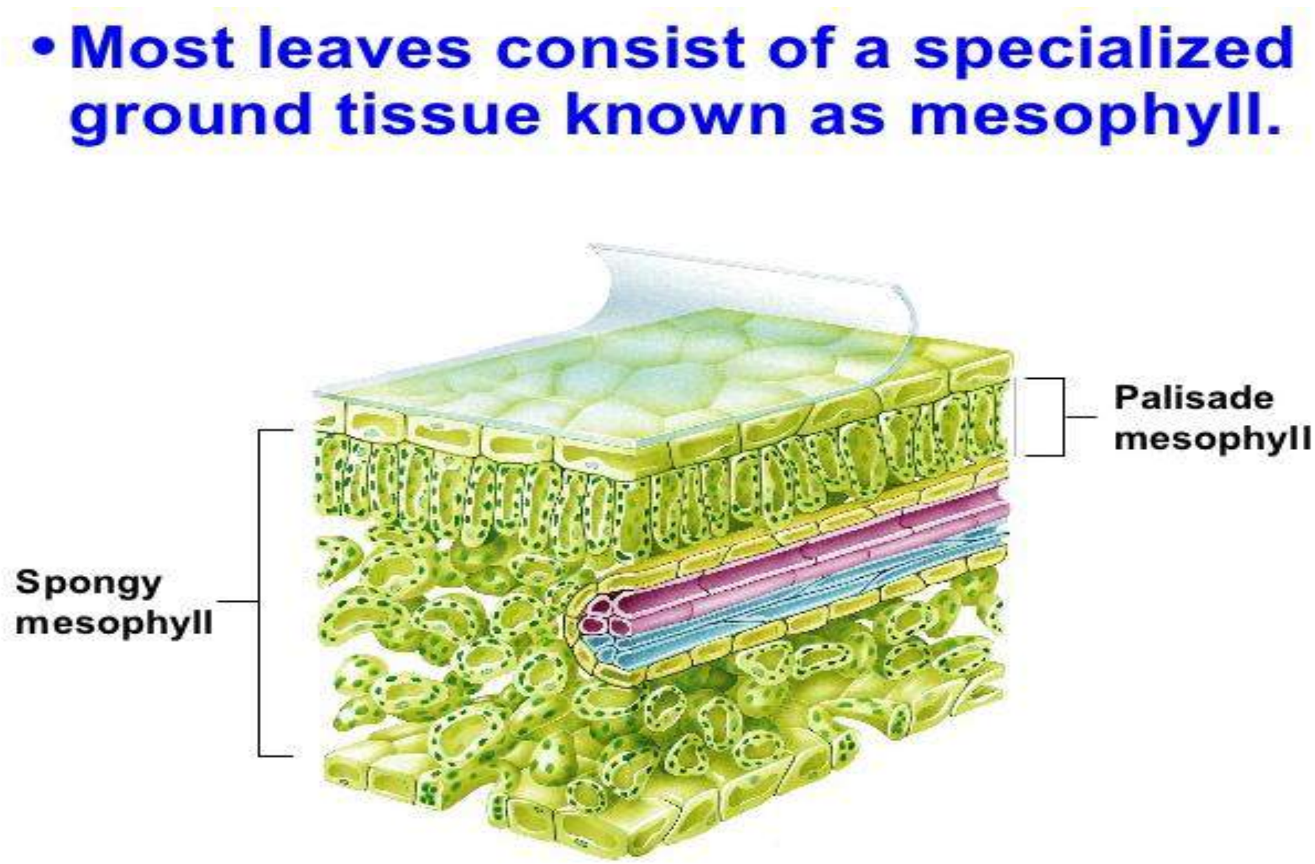
- This is a thin non-living waxy substance that covers leaves.
- The cuticle helps reduce water loss and protection from most bacteria, fungi, and insects.



Upper epidermis



- Mesophyll layer
- Palisade layer + Spongy layer



Mesophyll

- The green leaf cells between the upper and lower epidermis of a leaf which is loaded with chloroplasts.
- The mesophyll consists of 2 layers:
  - Palisade layer (parenchyma cells)
  - Spongy Layer

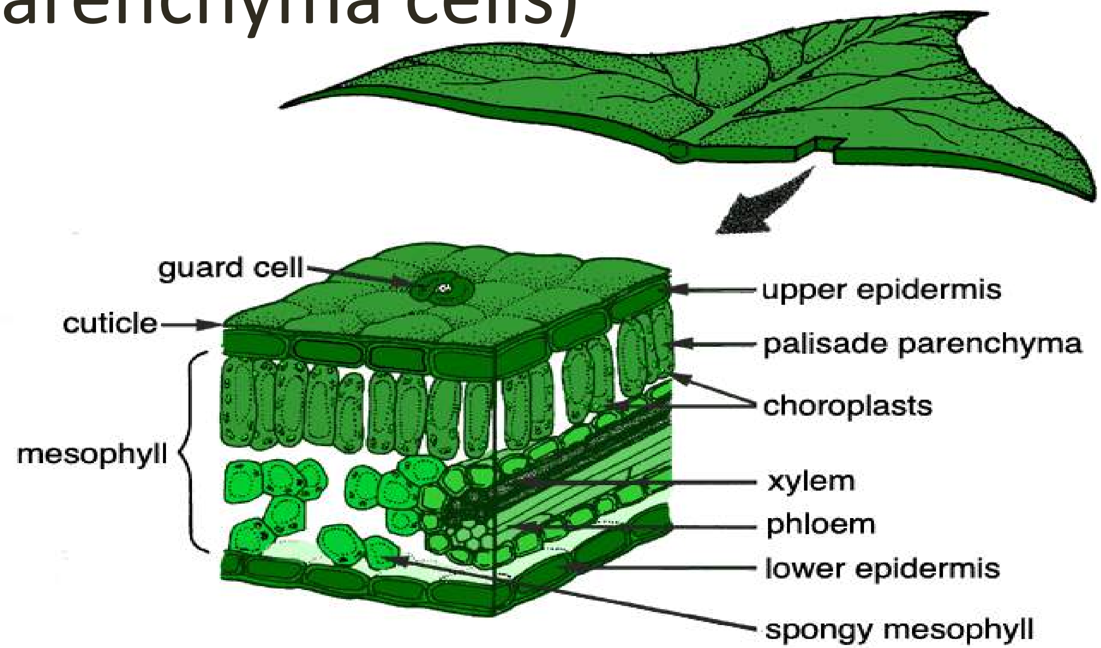
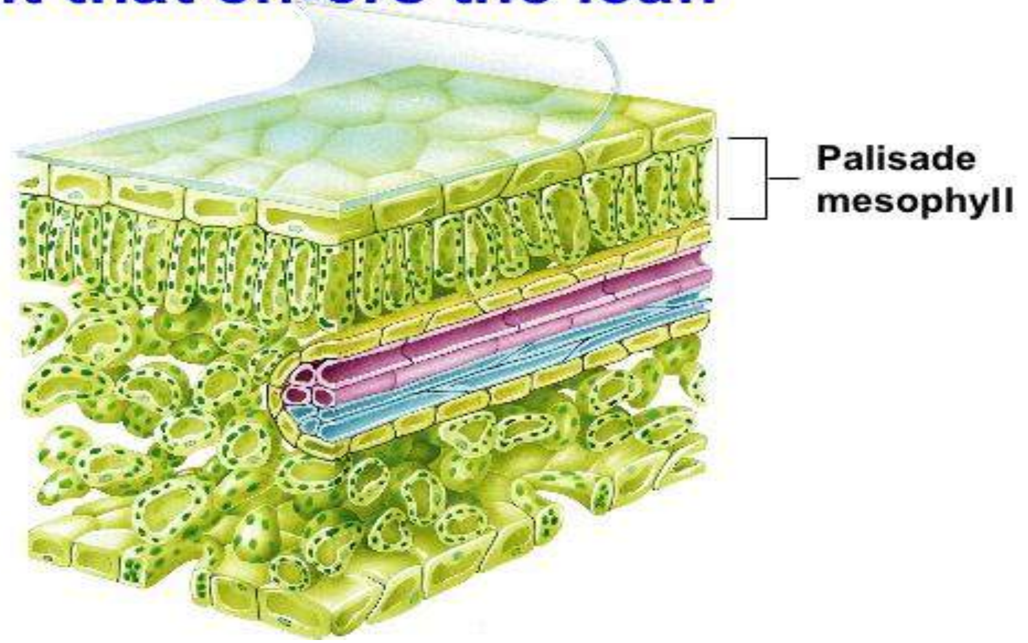


Figure 12a. Leaf cross section

Palisade layer

The layer of mesophyll cells found directly under the epidermis is called the palisade mesophyll. These closely-packed cells absorb light that enters the leaf.



- Palisade cells occur beneath the upper epidermis.
- There may be more than one layer of palisade cells.
- In xerophyte plants, the palisade tissue occur on both side of the leaf.

- In many hydrophyte plant, mesophyll is undifferentiated, have no palisade tissue.
- Palisade tissue is more differentiated in leaves exposed to light (sun leaves). As contrasted with (shade leaves).
- Most of the chloroplasts occur in this layer.

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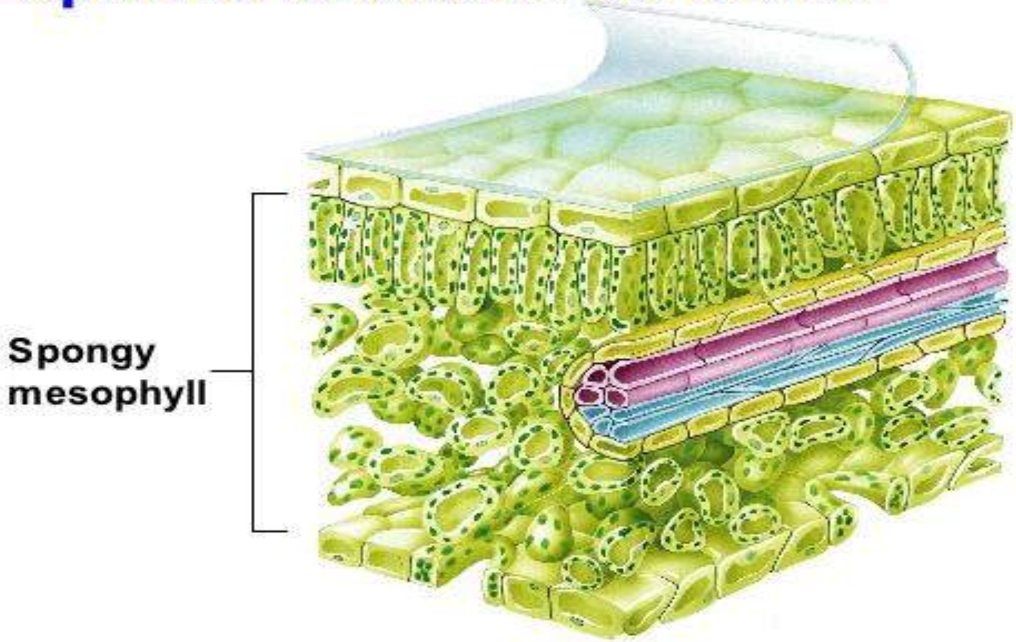
Spongy layer

Beneath the palisade mesophyll is the spongy mesophyll, a loose tissue with many air spaces between its cells.



- The spongy parenchyma shows many forms of cells. Either nearly isodiametric, or elongated in the same direction as the palisade cells and connected with each other by lateral extensions of various lengths, or most commonly elongated parallel with the surface of the leaf.

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- In most grasses of the temperate regions, the mesophyll is not differentiated into palisade and spongy, appears homogeneous.
- In many tropical grasses the mesophyll cells surrounding the vascular bundles and oriented with them.

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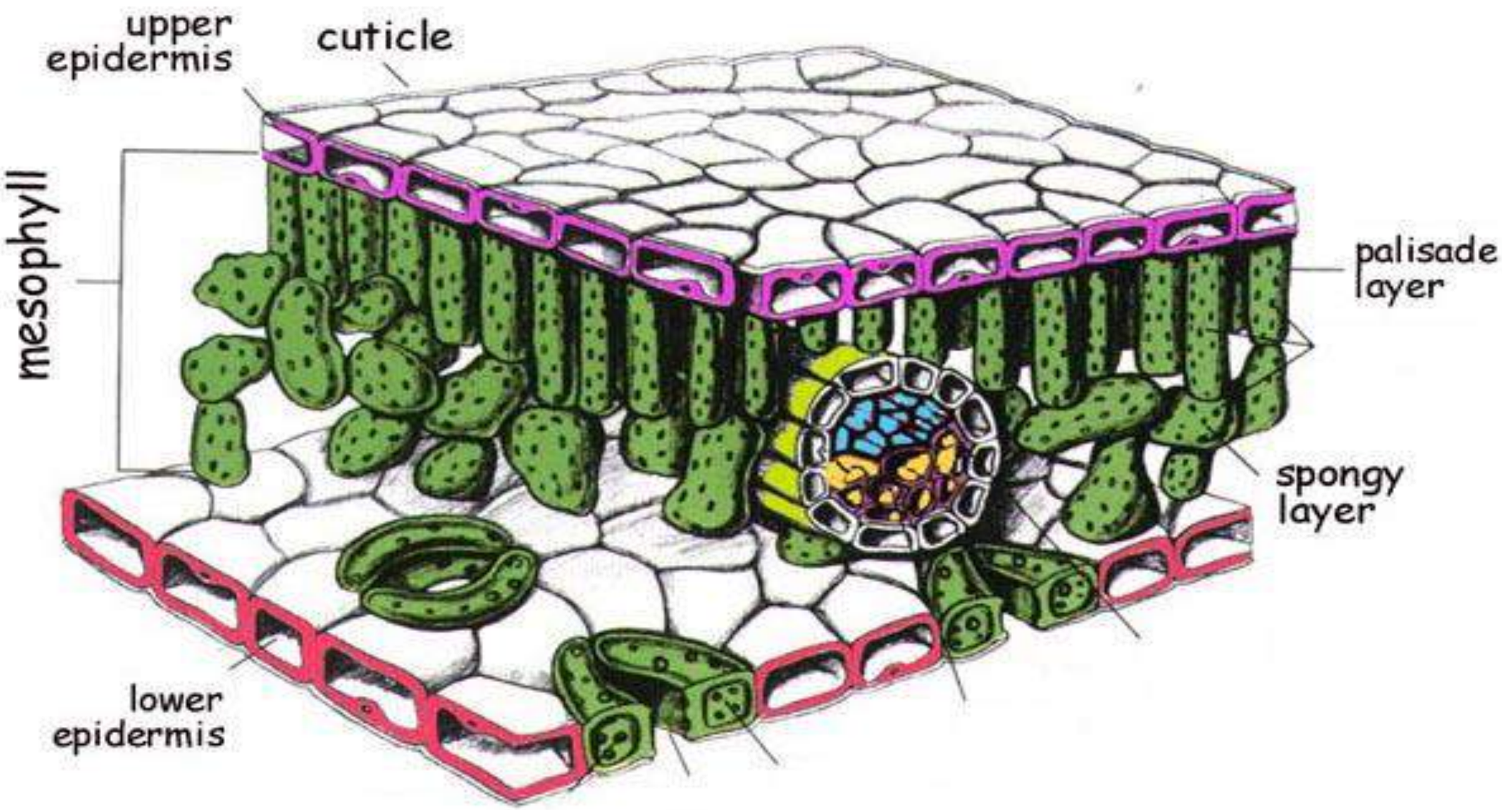
Lower epidermis



Vascular tissue (veins)

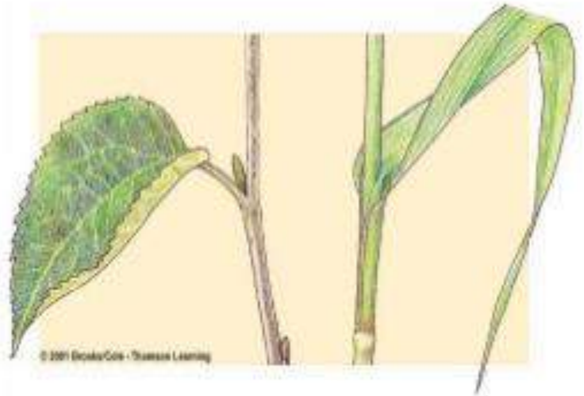
Leaf Veins: Vascular Bundles

- Xylem and phloem –

  often strengthened with fibers

- In dicots, veins are netlike

- In monocots, they are parallel



Leaf Classification

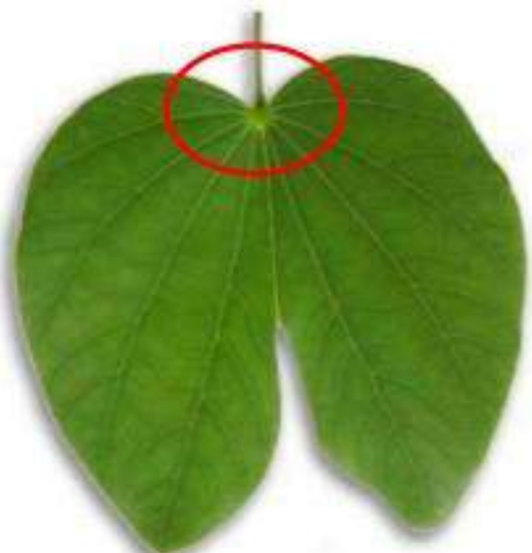
- Based on basic pattern of the veins.
- Botanists have developed a systems that uses three patterns.
  - Palmate
  - Pinnate
  - Parallel

Palmate

- Several large veins extending from the place where the leaf stem attaches to the leaf.
- Think of the palm of your hand and your fingers as the main veins.

b. Palmately netted

- principal veins arise at one point at the base of the leaf



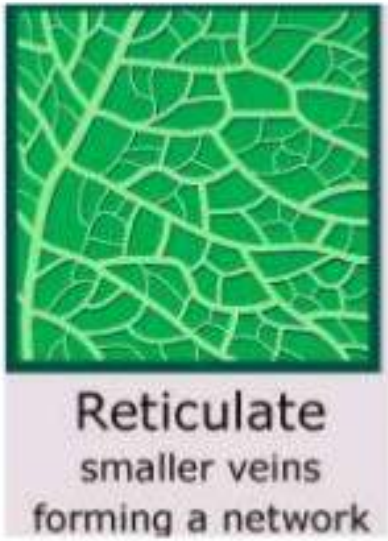
Pinnate

- One large vein extending the length of the leaf with smaller veins branching off.
- Pinna means feather, so a pinnate leaf resembles a feather

2 Systems of Venation:

1. Reticulated/Netted

- main vein branches
- forms network

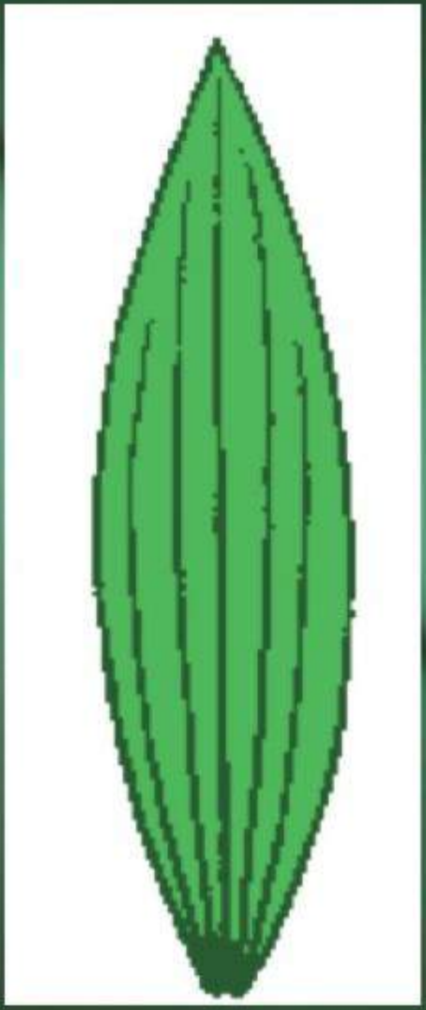


a. Pinnately netted

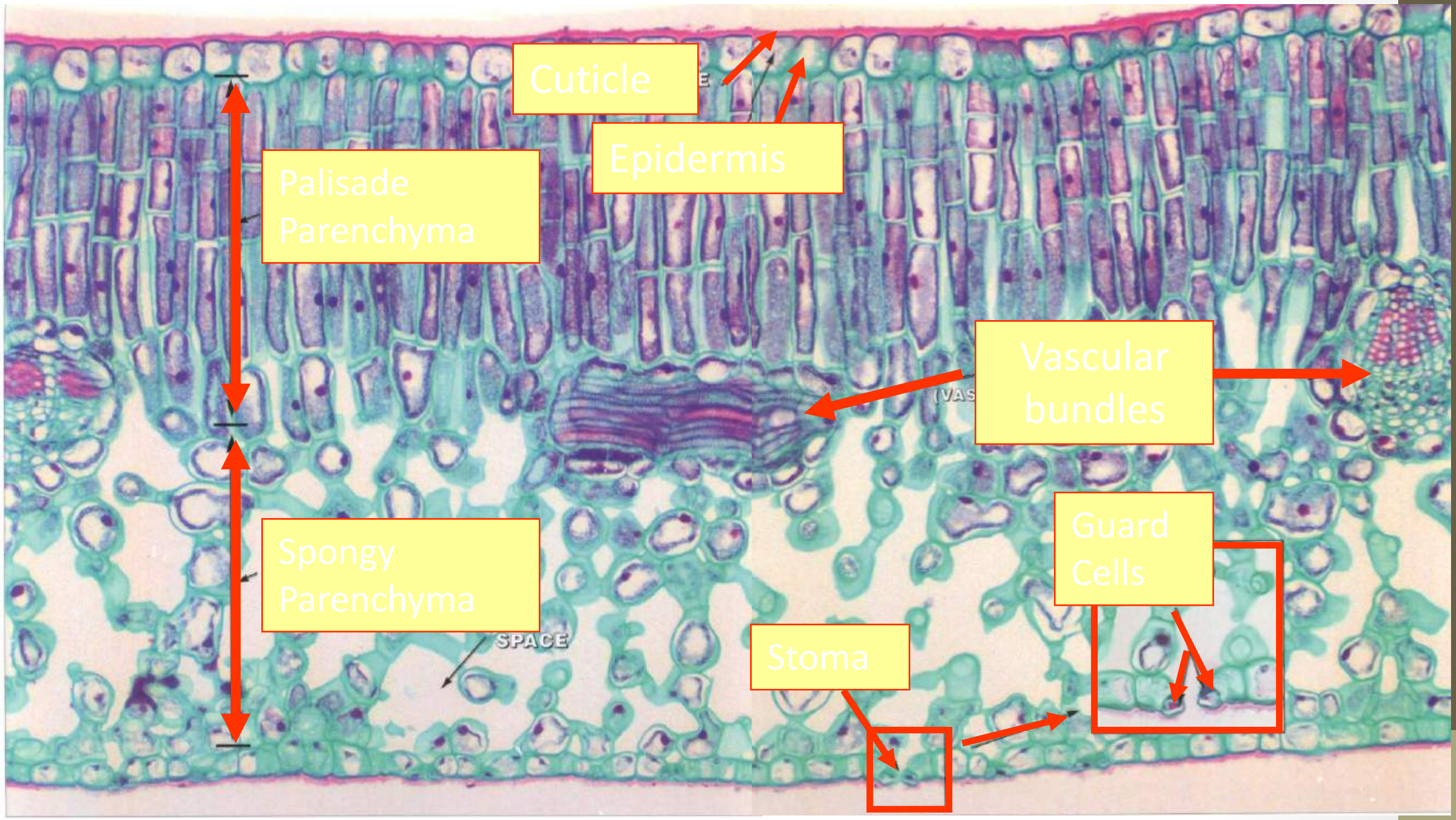
- main vein
- veins and veinlets arise from the midrib and ramify throughout the lamina

Parallel

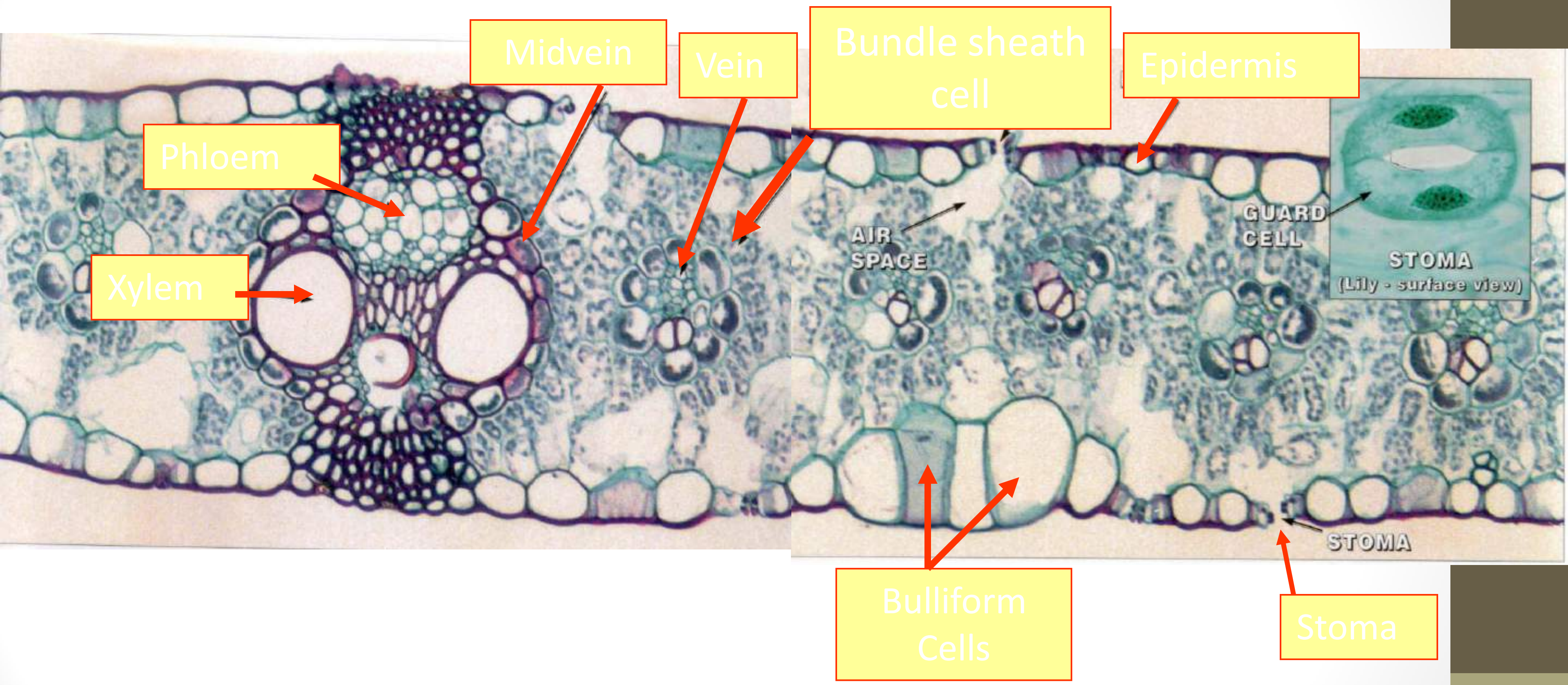
- Many small veins running the length of the leaf.
- Long, narrow leaves, like blades of grass, tend to have parallel veins.



Typical Dicot Leaf X-Section



Typical Monocot Leaf X-Section



Monocot leaf cross section

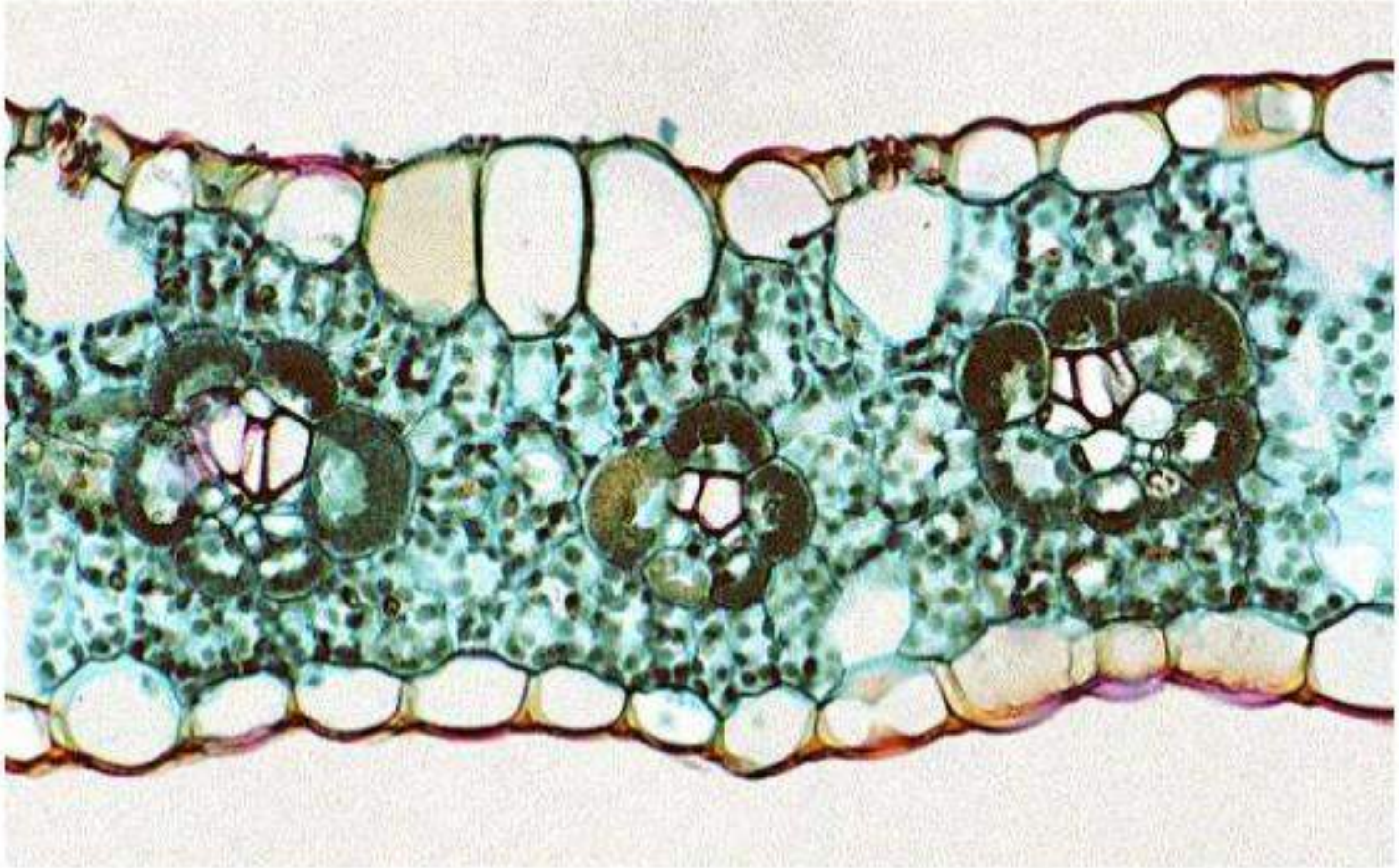
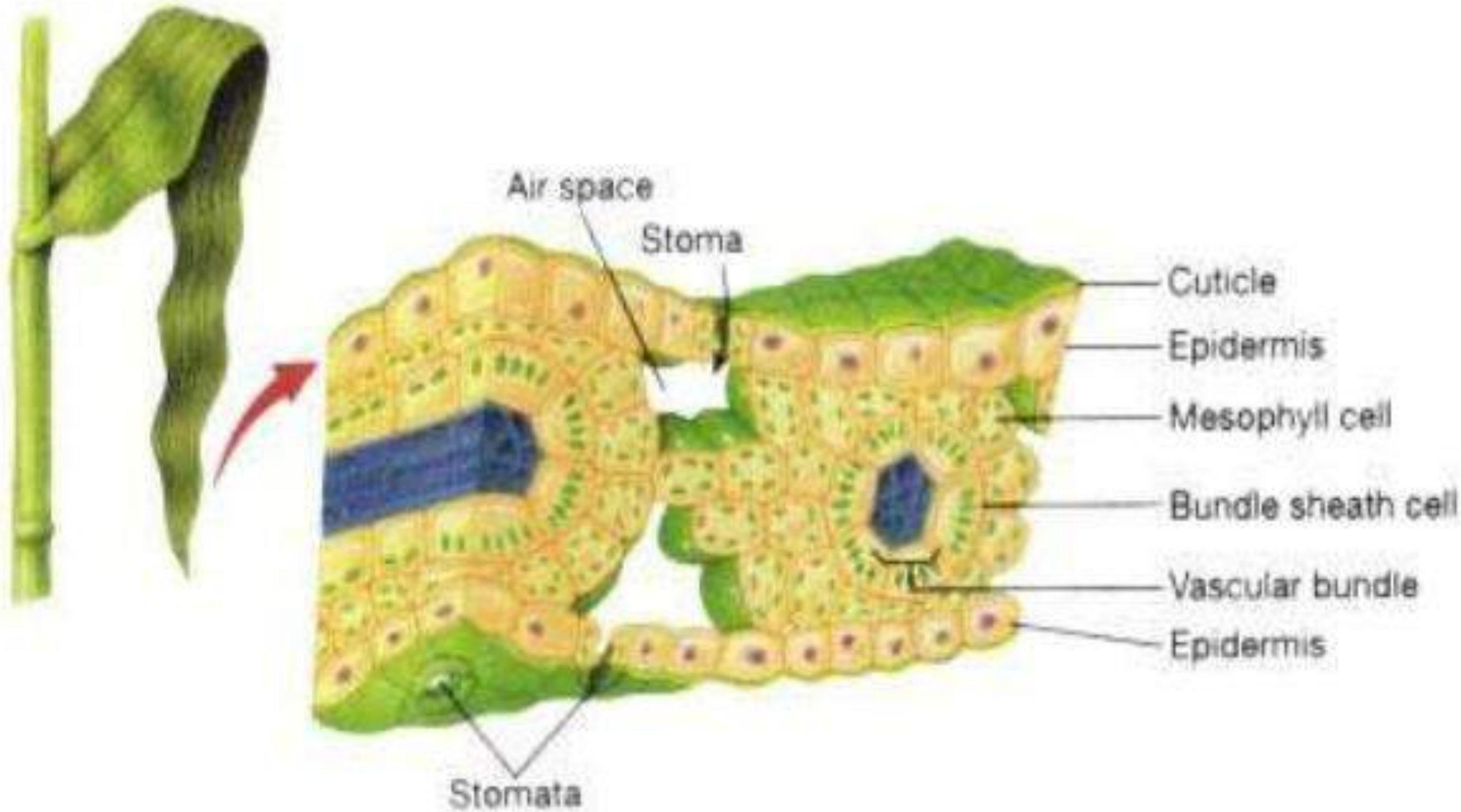


Diagram of Monocot Leaf



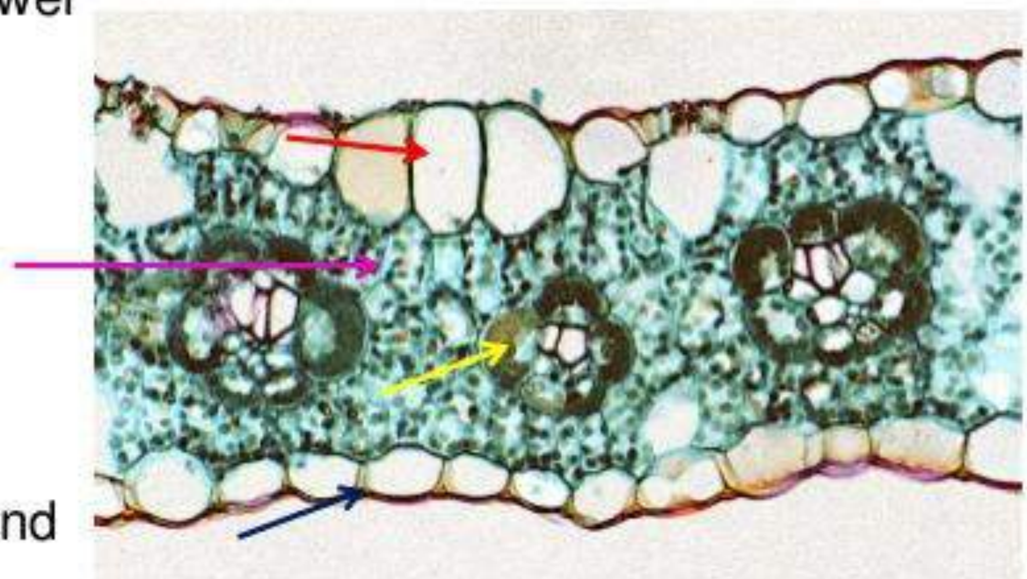
Internal Anatomy of Monocot Leaf

1. Upper epidermis
   - covered with cuticle
   - bulliform cells
   - stomata present in upper and lower epidermis

Guard cells monocot
- dumbbell in shape

Guard cells dicot
- kidney shaped

2. Mesophyll
   - not differentiated into palisade and spongy mesophyll



Leaves

- Vein Patterns
  - Parallel: Veins never cross. Found in monocots.
  - Netted: Veins form a network. Found in Dicots.

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- A leaf may have a single or two or more of vascular bundles.
- The largest vein often occur in amedian position and forms midvein, and the smaller veins diverge from it laterally.
- In other leaves there may be several large veins, spreading out from the base of the blade toward the margins.

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Stoma (plural stomata)

- Stoma is a pore found in the epidermis of leaves, stems and other organs that is used to control gas exchange.
- The pore is bordered by pair of specialized parenchyma cells known as guard cells that are responsible for regulating the size of the opening.

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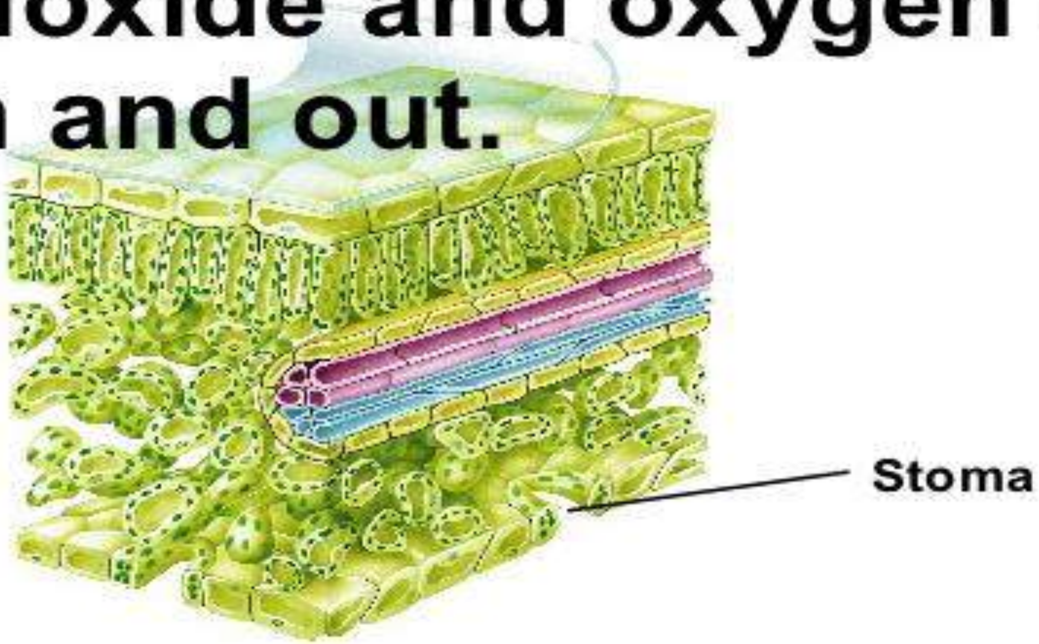
- Dicotyledons usually have more stomata on the lower epidermis than the upper epidermis. Monocotyledons usually have the same number of stomata on the two epidermis.
- In plants with floating leaves, stomata may be found only on the upper epidermis, submerged leaves may lack stomata entirely.

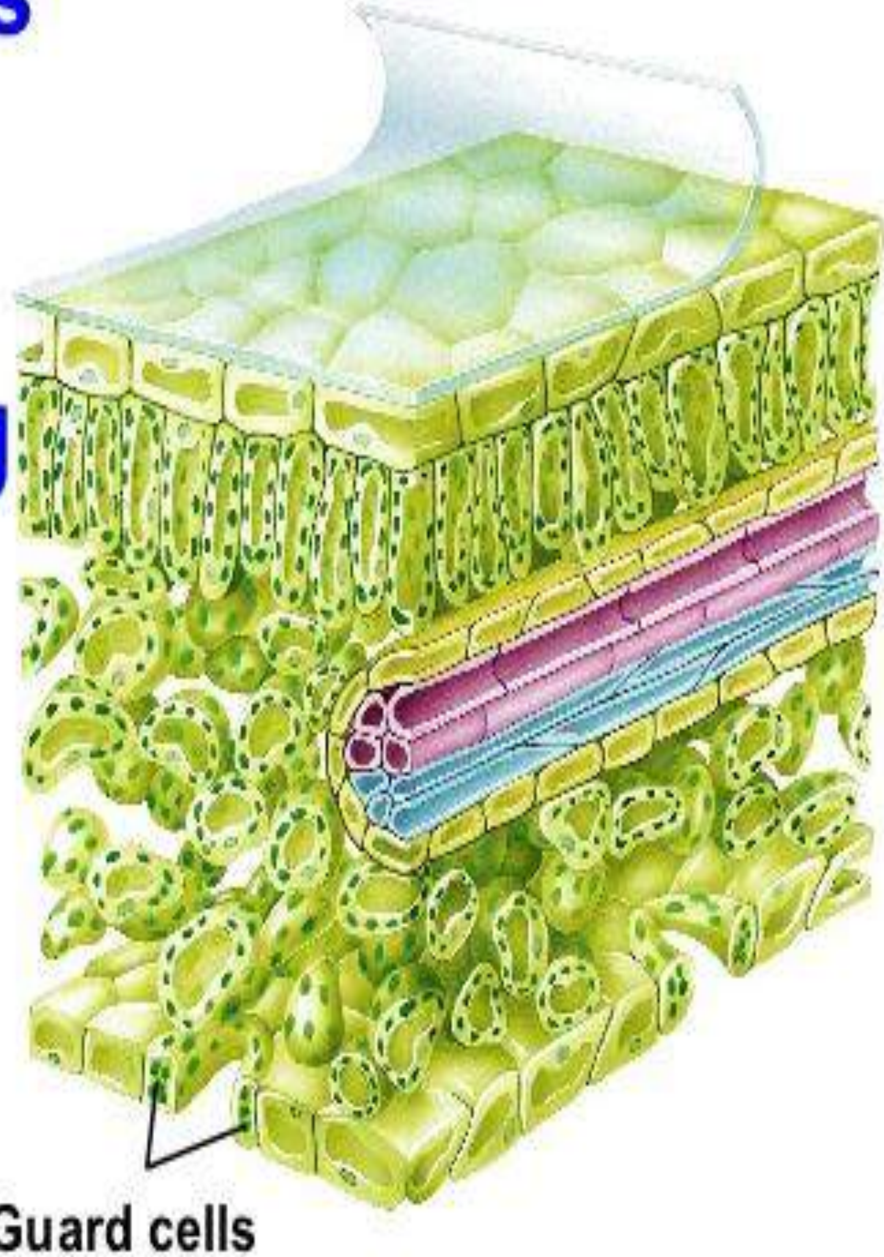
Stomata

The air spaces connect with the exterior through stomata.

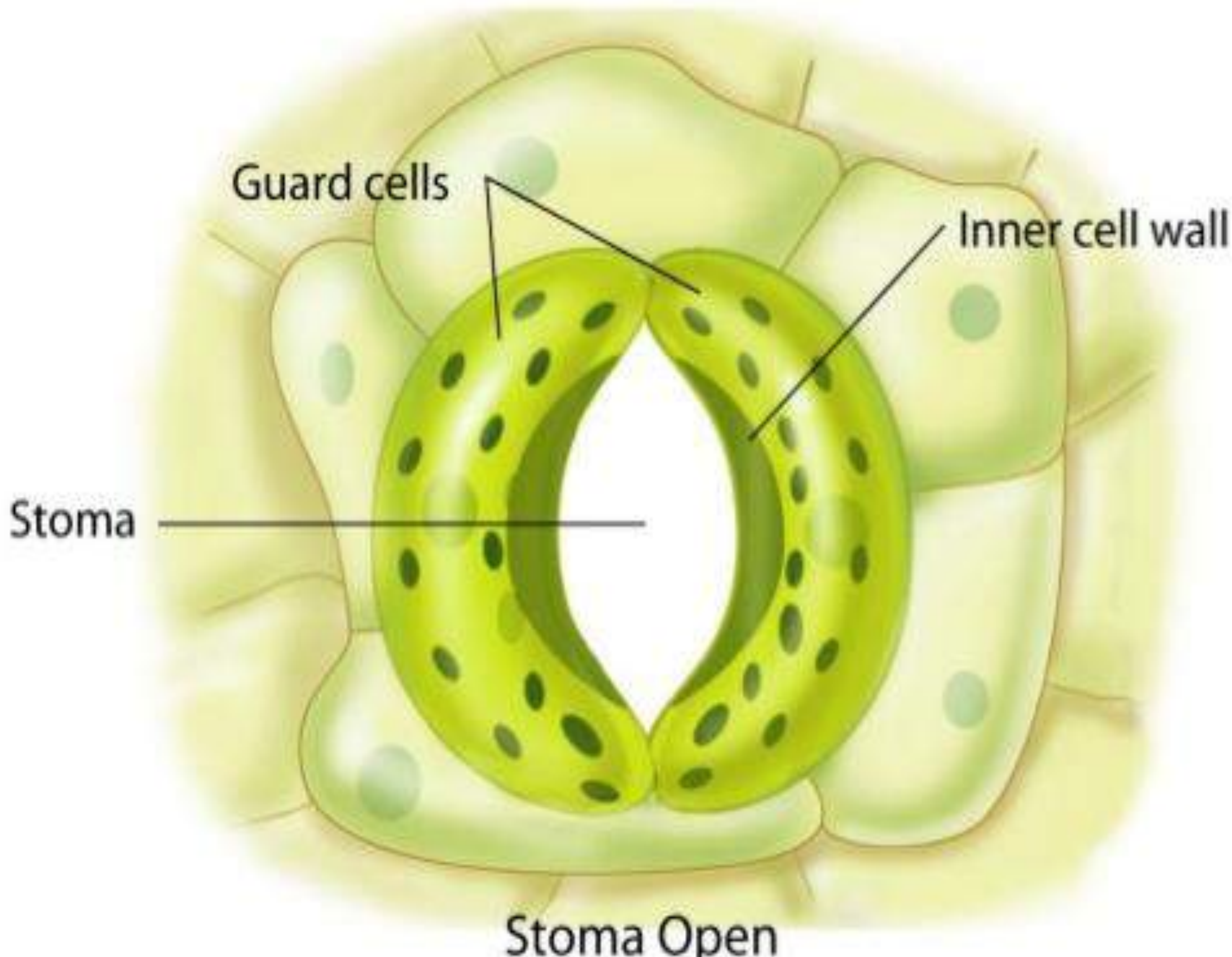
Stomata are openings in the underside of the leaf that allow carbon dioxide and oxygen to diffuse in and out.



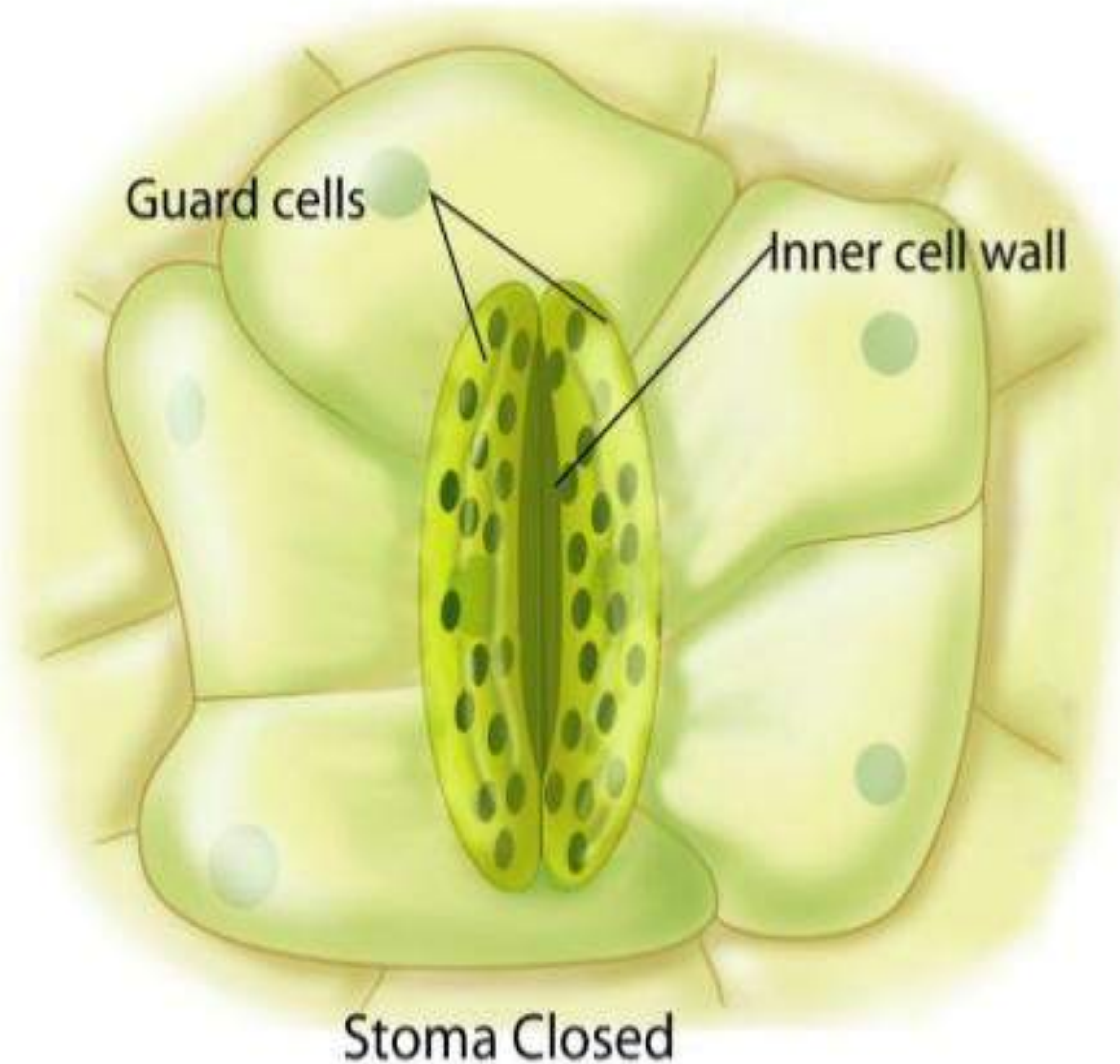
Each stoma consists of two guard cells that control the opening and closing of stomata by responding to changes in water pressure.



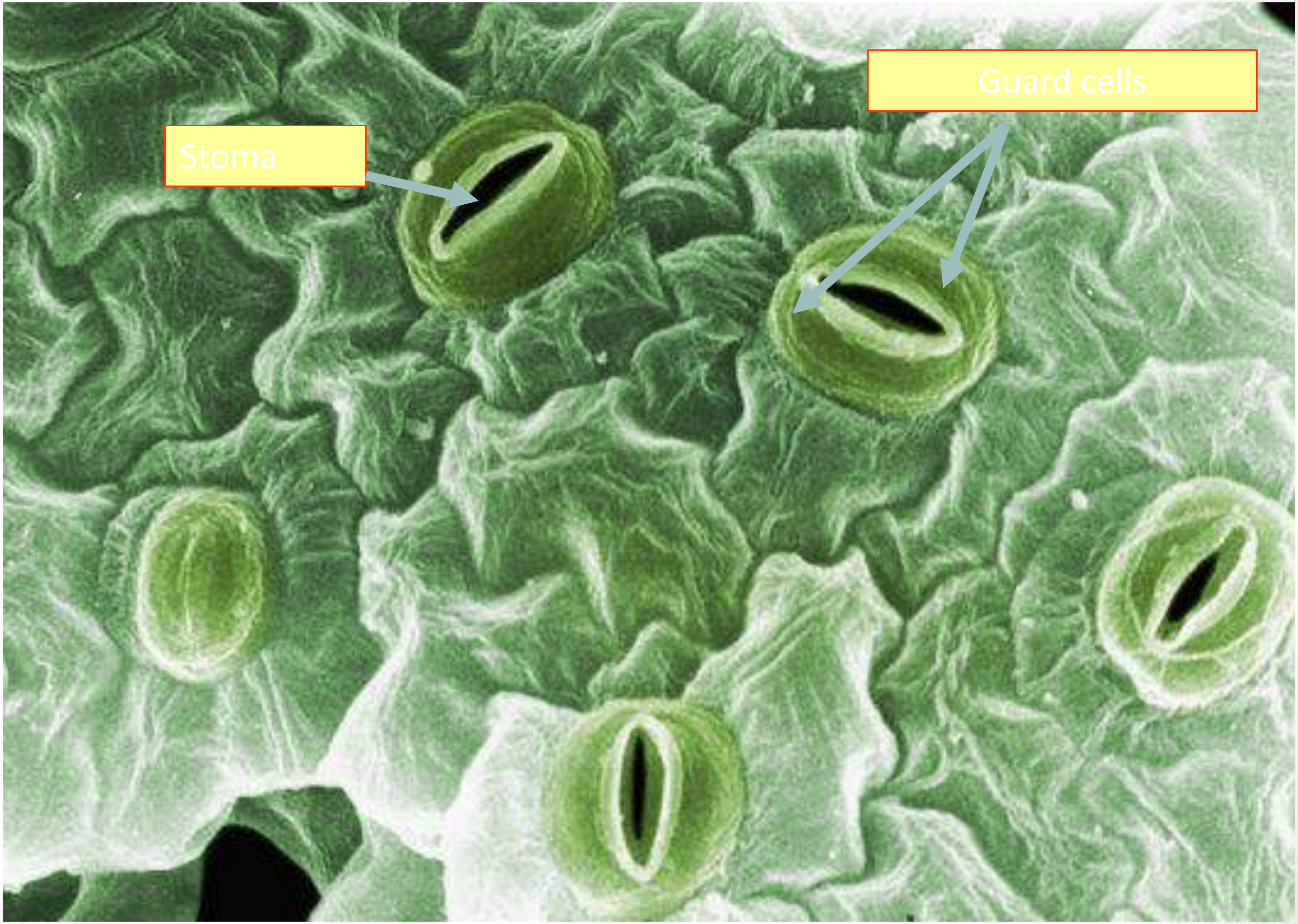
When water pressure within guard cells is high, the stoma open.



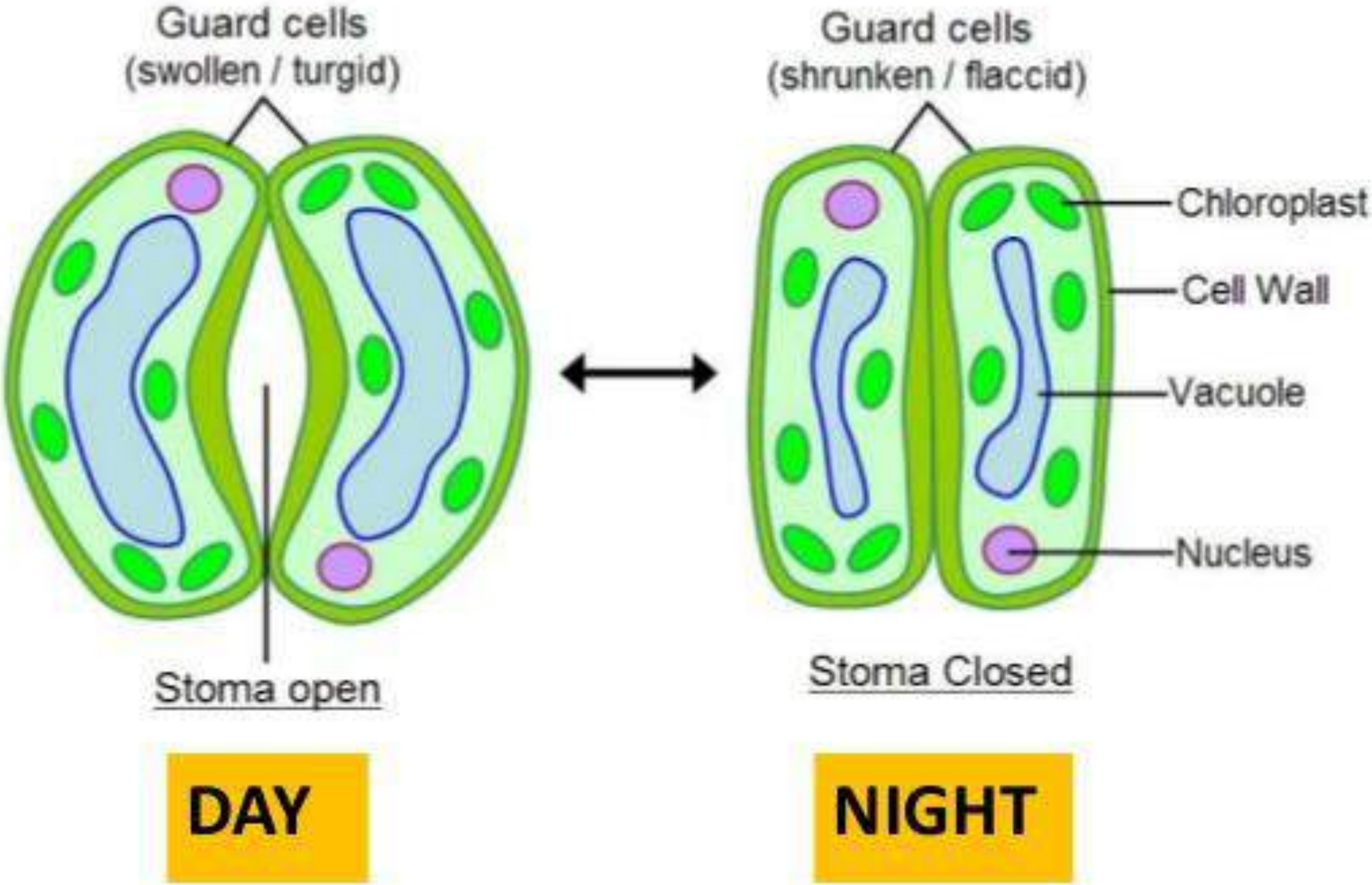
When water pressure within guard cells decreases, the stoma closes.



Leaf Stomata: Allow Gas Exchange

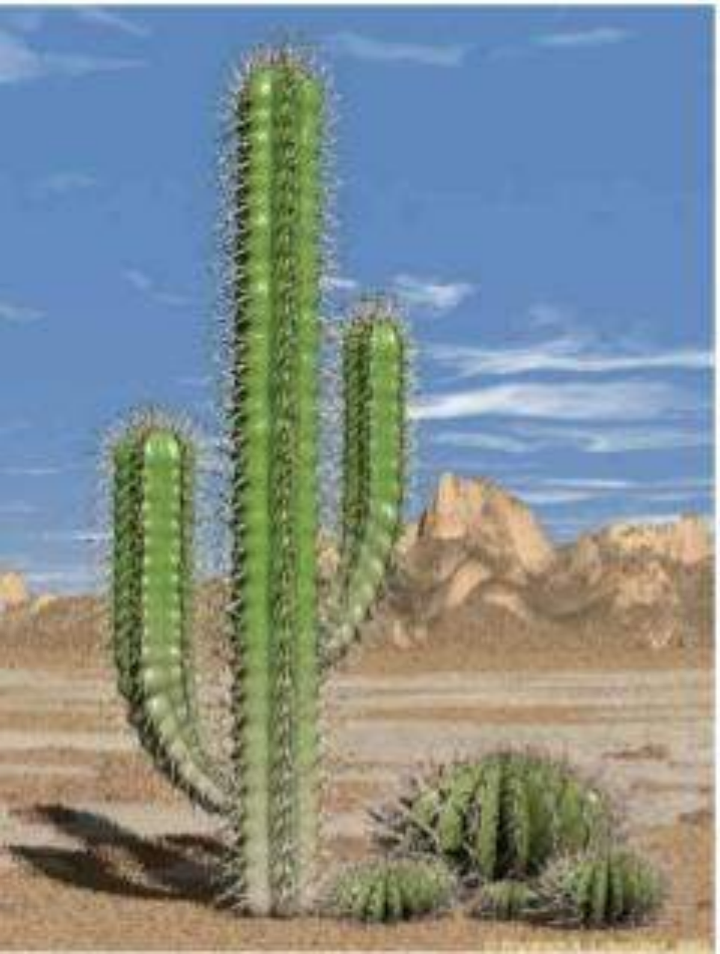


When are stomata open and when are they closed?



EXCEPTION

Desert plants



open their stomata during the NIGHT

Dicot leaf	Monocot leaf
1. More stomata towards lower epidermis.	1. Stomata are equally distributed on both the sides of leaf.
2. Bulliform cells are absent	2. Bulliform cells are present in the upper epidermis.
3. Mesophyll is differentiated into palisade and spongy tissues.	3. Mesophyll is undifferentiated.
4. Bundle sheath extensions are parenchymatous	4. Bundle sheath extensions are sclerenchymatous.

COMPARISON

Why is the upper leaf surface darker green than the lower surface?

More chloroplasts in palisade layer than in spongy layer.

2- The stem

- All growth of shoot begins in the terminal bud.
- The region is called apical meristem.
- As more cells are produced by the apical meristem, the shoot elongates and the cells behind the apical meristem begin to differentiate into special cells that give rise to fundamental plant tissue.

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- **REMEMBER**
- There are three fundamental tissues in plants:
- 1- Protoderm… forms tissue which becomes the epidermis of the plant.
- 2- Provascular tissue, forms primary xylem , primary phloem and .

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- **Cambium** is another meristematic tissue that continues to produce xylem tissues toward inside and phloem tissues toward outside. It is a single- celled layer. Cells division of the cambium tissues adds width to the stem.
- Cambium can lead to secondary growth in plants.
- 3- Ground meristem.. Gives rise to two tissues.

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A- Pith

which is found in the center of the dico. Stems. In some plants the pith breaks down forming a hallow stem. It is primarily storage tissue, Amylose and amylopectin are often stored in the pith.

- B- Cortex
- like pith serves as a storage tissue. It is externally bounded by the epidermis and internally by the phloem.

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- The apical meristem is also responsible for the generation of bud and leaf primordia.
- Bud primordial give rise to axillary buds and leaf primordia.

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Stem functions

- 1- Support: stems support the plant,s leaves, flowers and fruits.
- 2- Conduction: like roots, stems contain vascular tissue (xylem and phloem), xylem conducts water and minerals, while phloem conducts the sugar created during photosynthesis.

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- 3- Storage: stems are sometimes modified to store food and (or) water, as in tubers, rhizomes, corms and bulbs.
- 4- Stems produce leaves, branches and flowers.
- 5- Stems can do photosynthesis.
- 6- They hold leaves to the sunlight.

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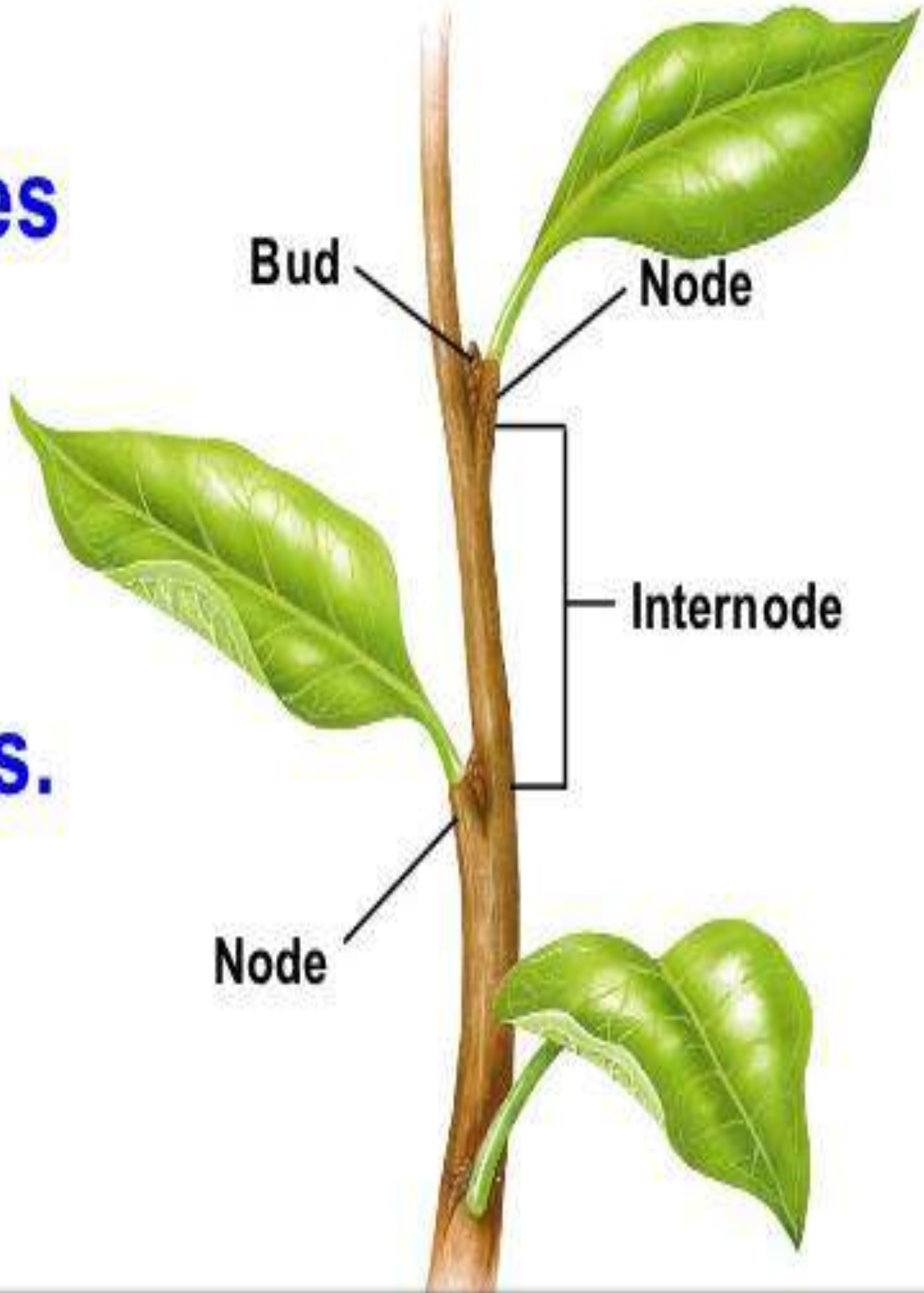
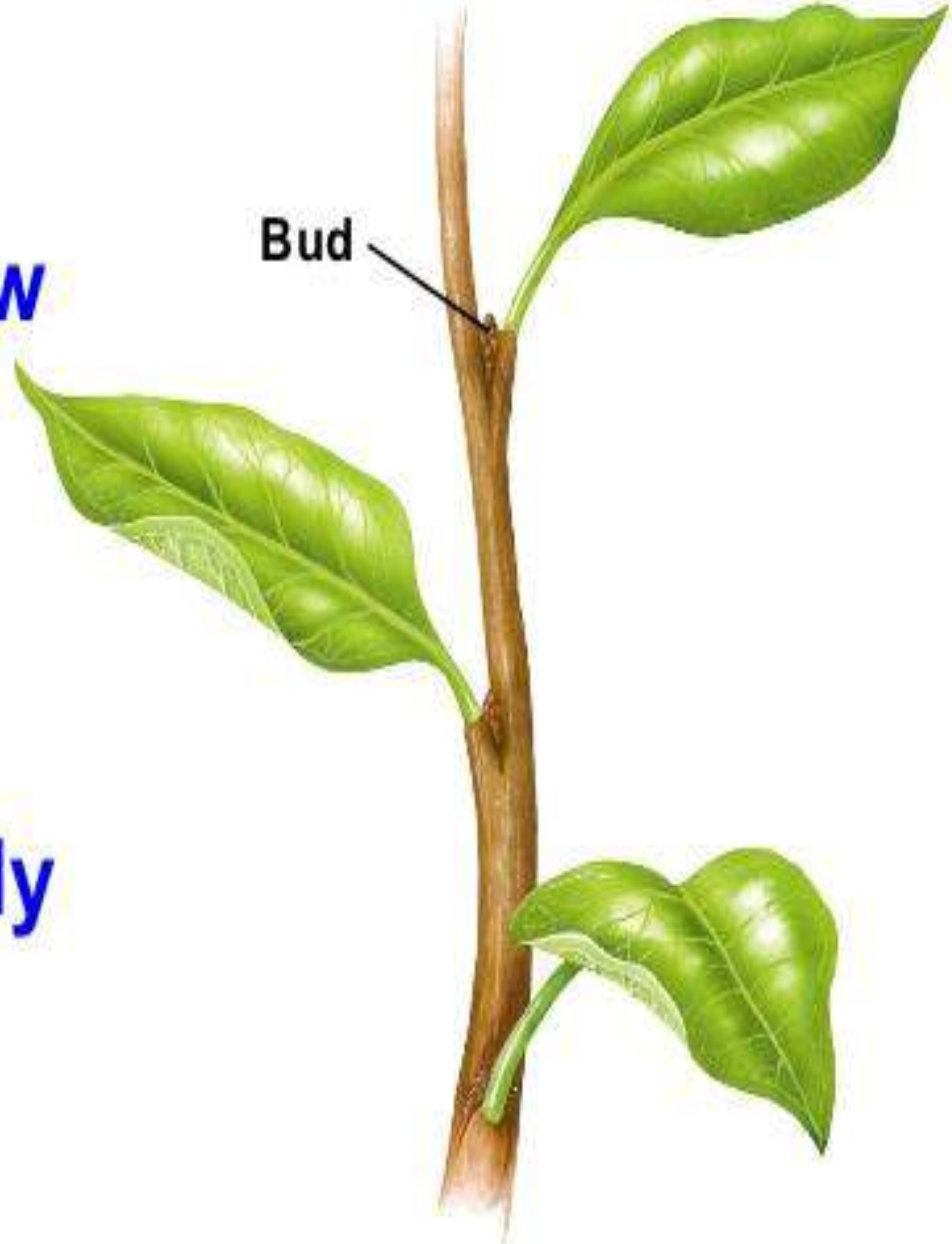
Leaves attach to the stem at structures called nodes.

The regions of stem between the nodes are internodes.

Small buds are found where leaves attach to nodes.



Buds contain undeveloped tissue that can produce new stems and leaves.

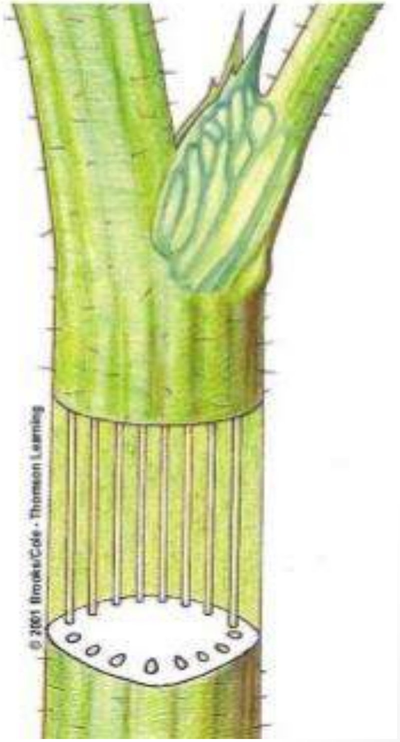


In larger plants, stems develop woody tissue that helps support leaves and flowers.

Primary structure of a Dicot. stem

- Sunflower stem

- Outermost layer is epidermis
- Cortex lies beneath epidermis
- Ring of vascular bundles separates the cortex from the pith
- The pith lies in the center of the stem



- Epidermis:

- ❖ It is protective in function.
- ❖ Forms the outermost layer of the stem.
- ❖ It is a single layer of parenchymatous rectangular cells.
- ❖ The cell are compactly arranged without intercellular spaces.

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- The outer walls of the epidermal cells have a layer called cuticle.
- The cuticle is made of a waxy substance known as cutin.
- Stomata may be present.
- Epidermal cells are living.
- Chloroplast are usually absent (except in the guard cells).
- A large number of multicellular hairs occur on the epidermis.

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- Cortex:

- It lies below the epidermis.
- Cortex is differentiated into three zones:

1- Hypodermis.. It is a few layers of collenchyma cells which gives mechanical strength to the stem. These cells are living and thickened at the corner.

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- 2- Chlorenchyma… it lies below the hypodermis, consist of a few layers of cells, this region performs photosynthesis. Some resin ducts occur here.
- 3- Parenchyma cells… they are stored food materials. They are arranged compactly without intercellular spaces. Starch grain are abundant in these cells, this layer is also known as starch sheath.

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- Stele: it consists of :
- . a- Pericycle.. It is layers of cells, in sunflower, a few layers of sclerencyhma cells occur.
- b- Vascular bundles.. Consists of xylem, phloem and cambium. Xylem and phloem in the stem form the vascular bundles. They are arranged in form of ring.
- c- Pith.. It is the large central portion of the stem. It is composed of parenchyma cells. Function of the pith is storage of food

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Stem Tissues

- Xylem - conduct water & minerals
- Phloem - carry sugars & starches
- Epidermis - Outermost layer of plant tissue, protective layer
- Cortex - primary tissue surrounding vascular bundles
- Pith - thin-walled cells at center of stem

Stems

- Internal Structures
  - Xylem: Tissue responsible for carrying water and nutrients from the roots to the leaves. It is located near the center of the stem.
  - <u>Xylem Up</u>!!

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Stems

- Internal Structure:
  - Phloem: Tissue responsible for carrying food produced in the leaf to the rest of the plant. The phloem is usually located near the outside of the stem.
  - Phloem Down!!

Stems

- Internal Structure
  - Cambium: Tissue responsible for the production of new xylem and phloem. It is found between the xylem and phloem.

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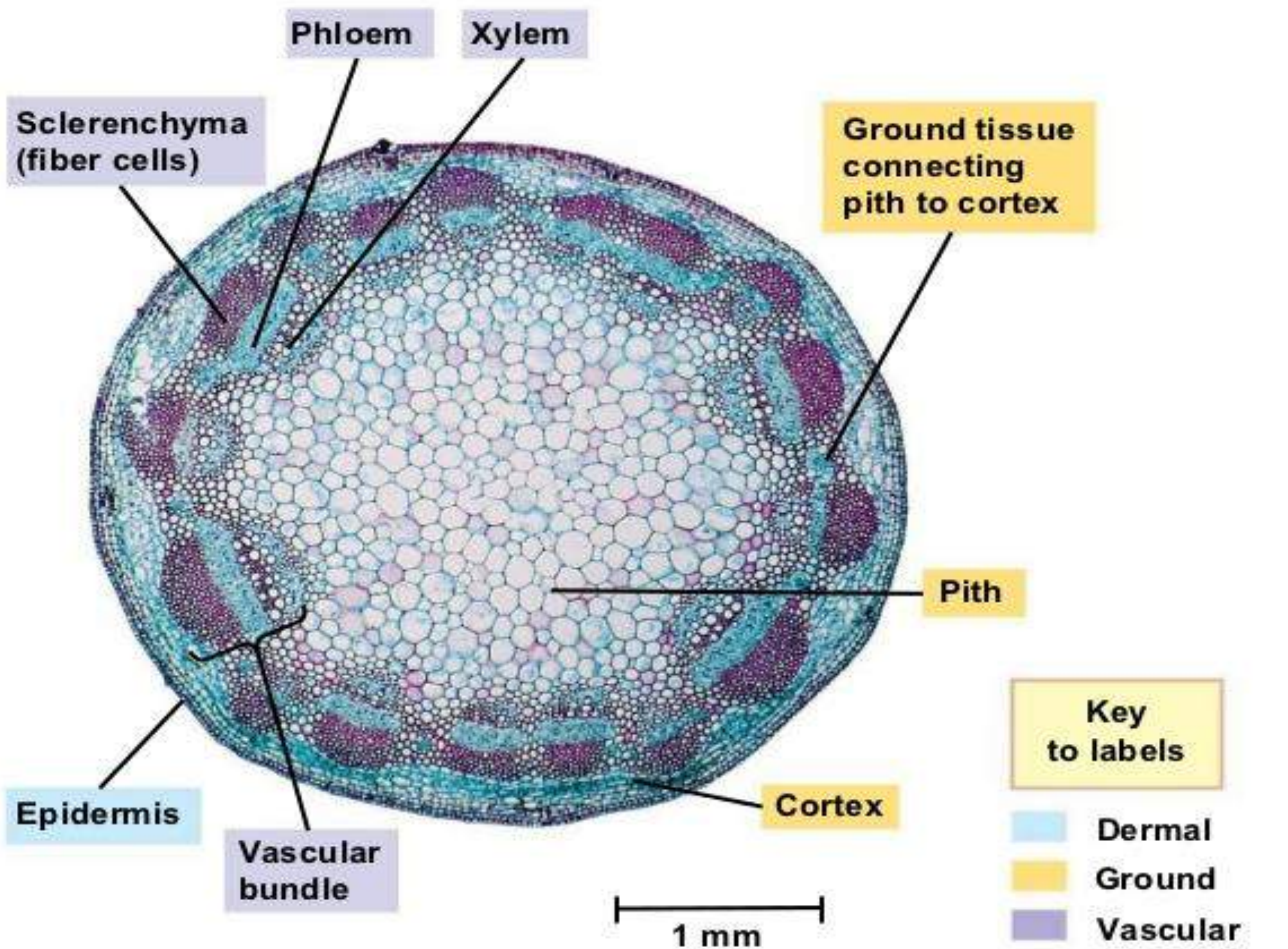
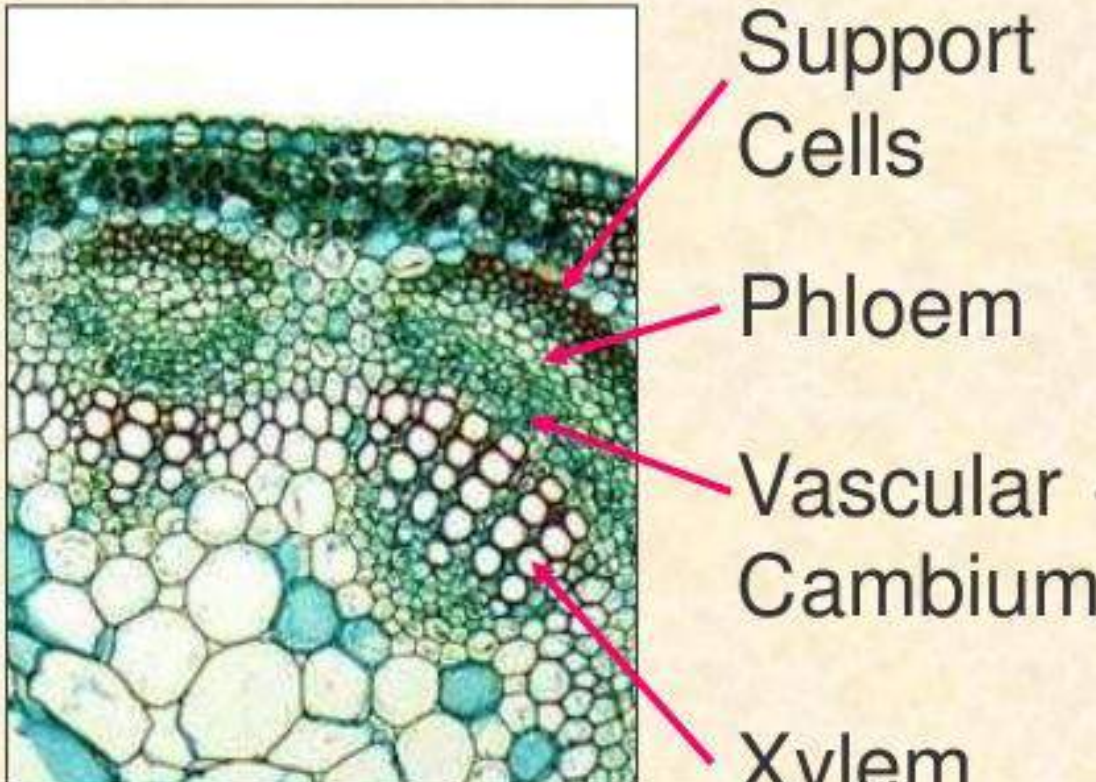
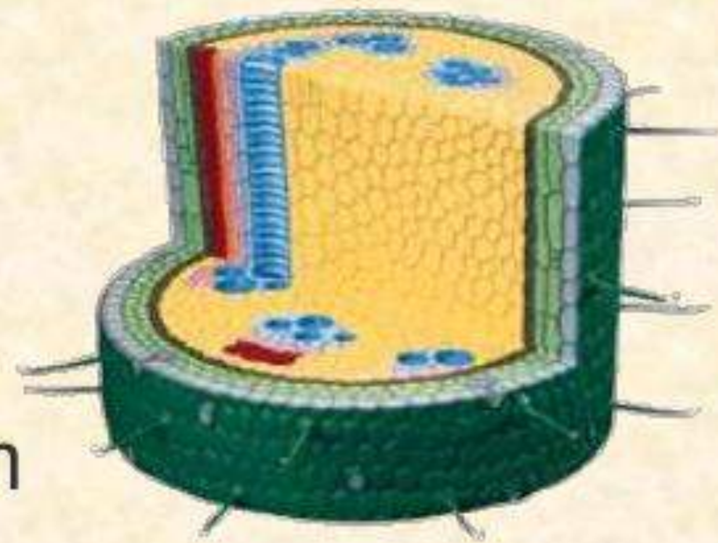
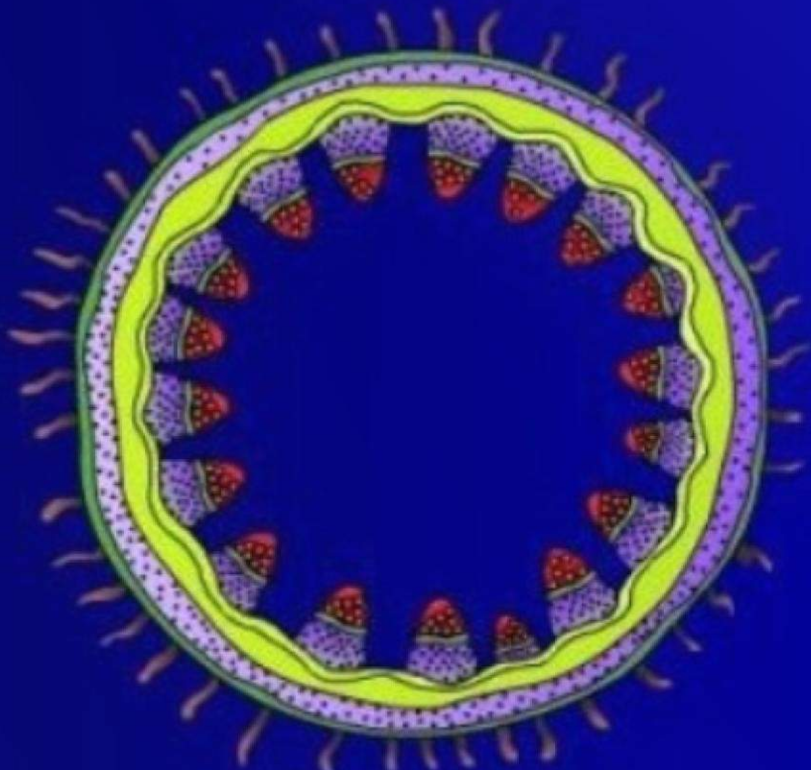

Phloem
Xylem
Sclerenchyma (fiber cells)
Ground tissue connecting pith to cortex
Pith
Epidermis
Vascular bundle
Cortex
1 mm
Key to labels
Dermal
Ground
Vascular

Dicot Vascular Arrangement

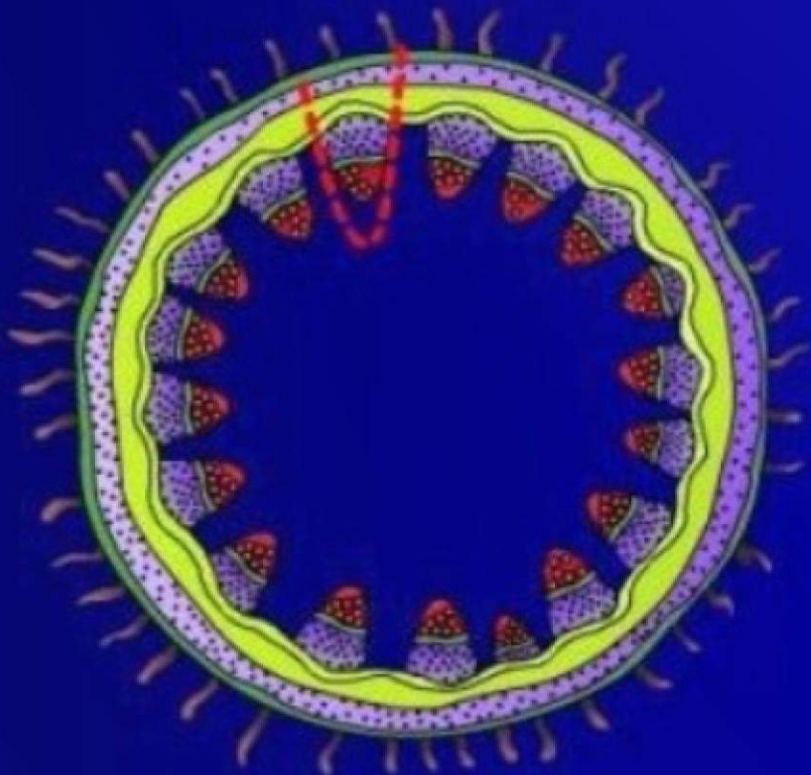




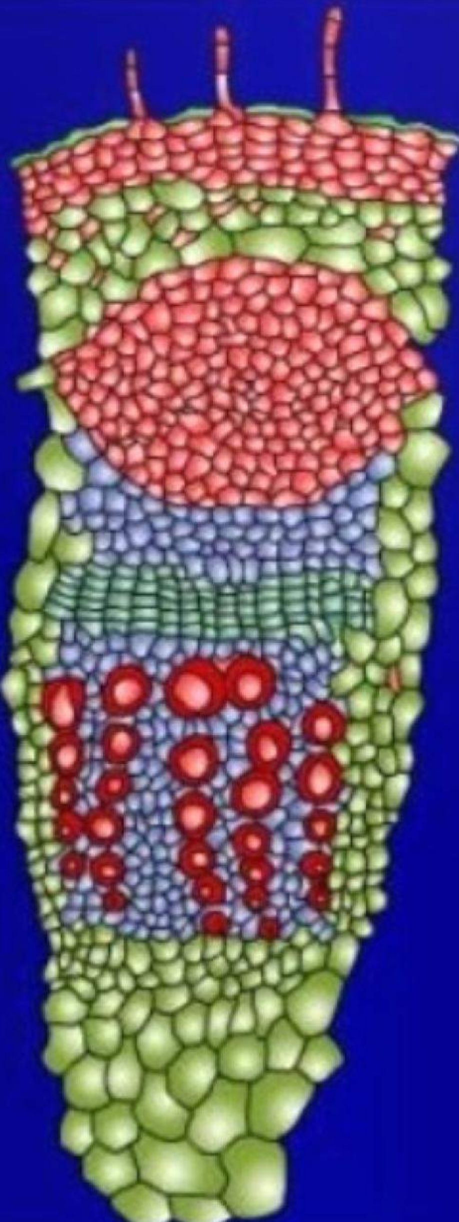
T.S of dicot stem



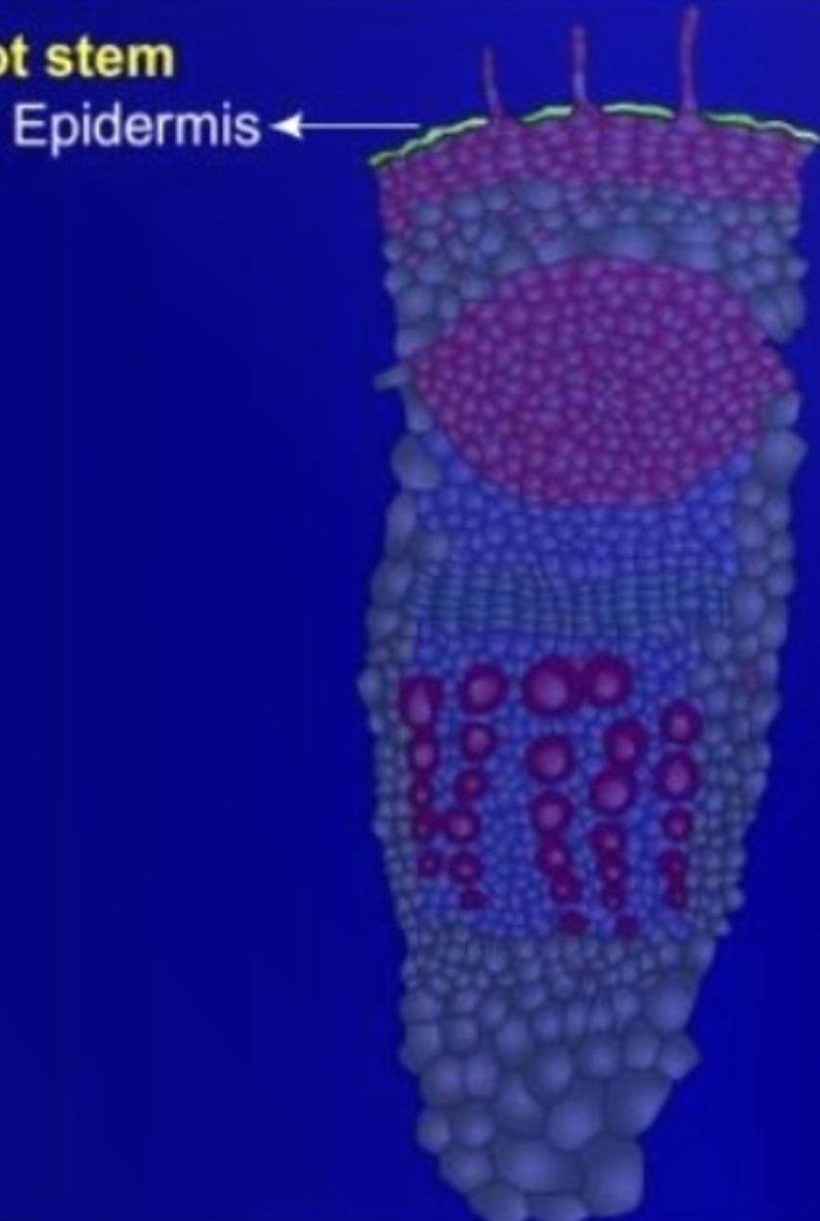
T.S of dicot stem



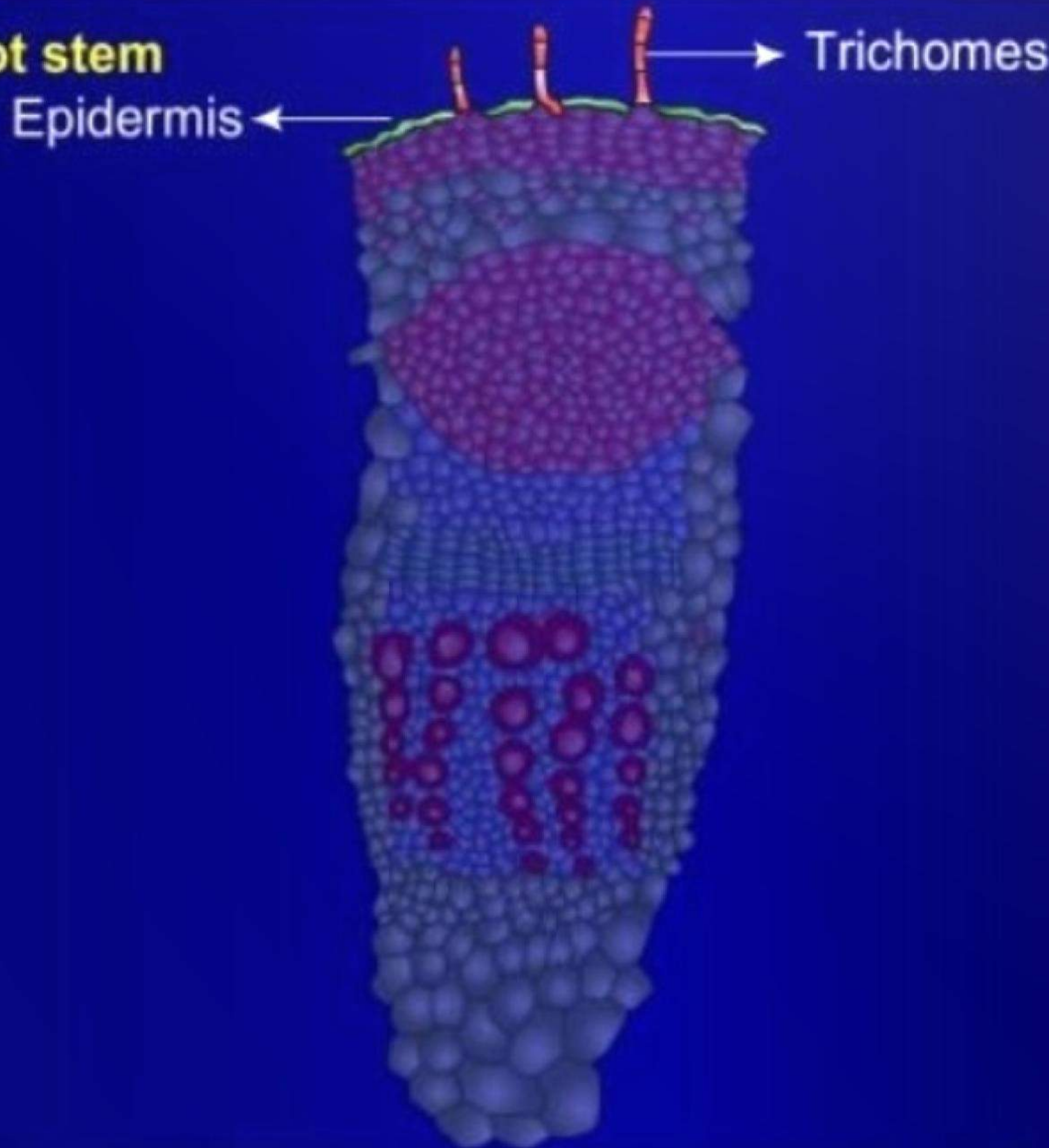
T.S of dicot stem

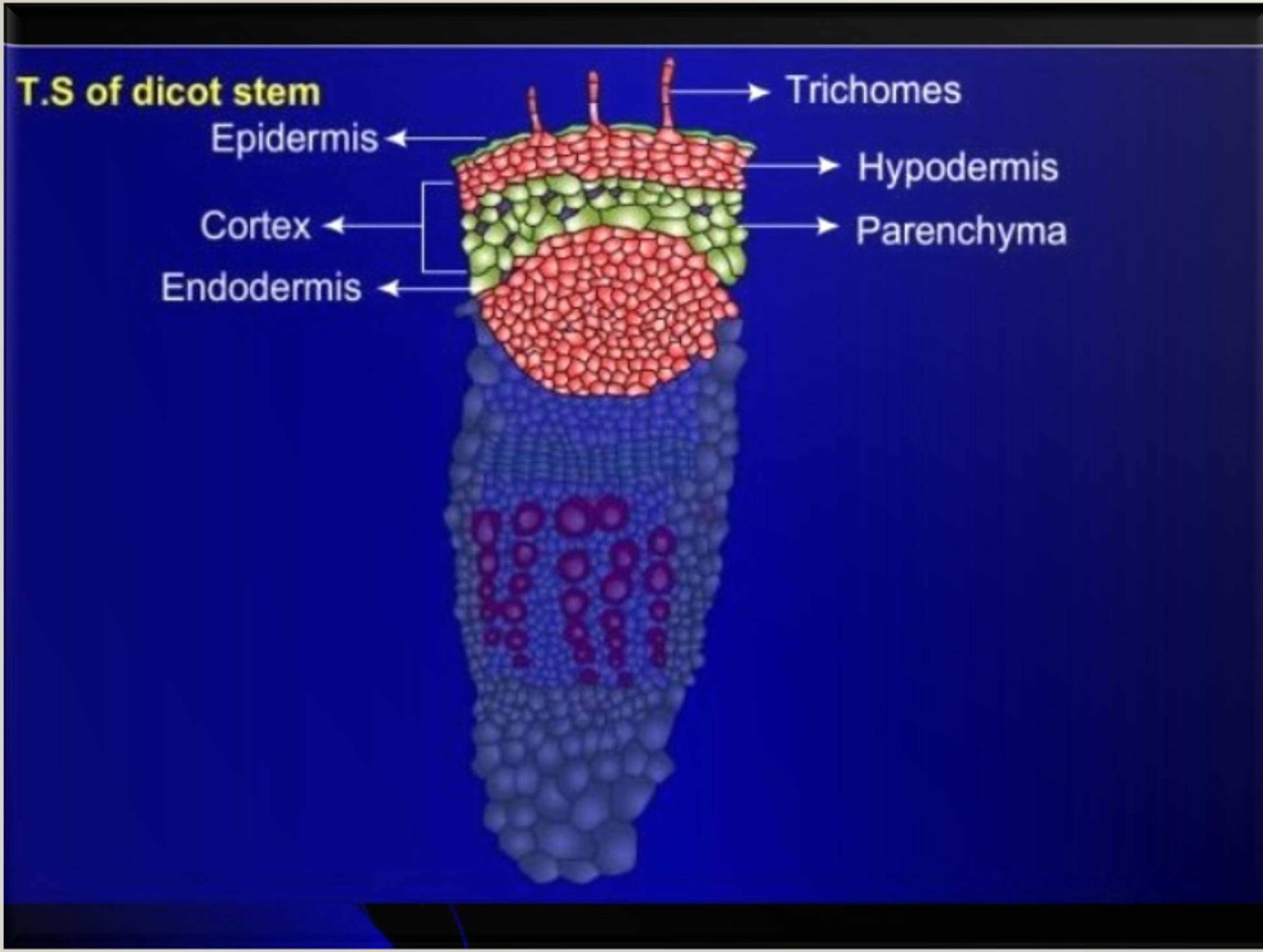


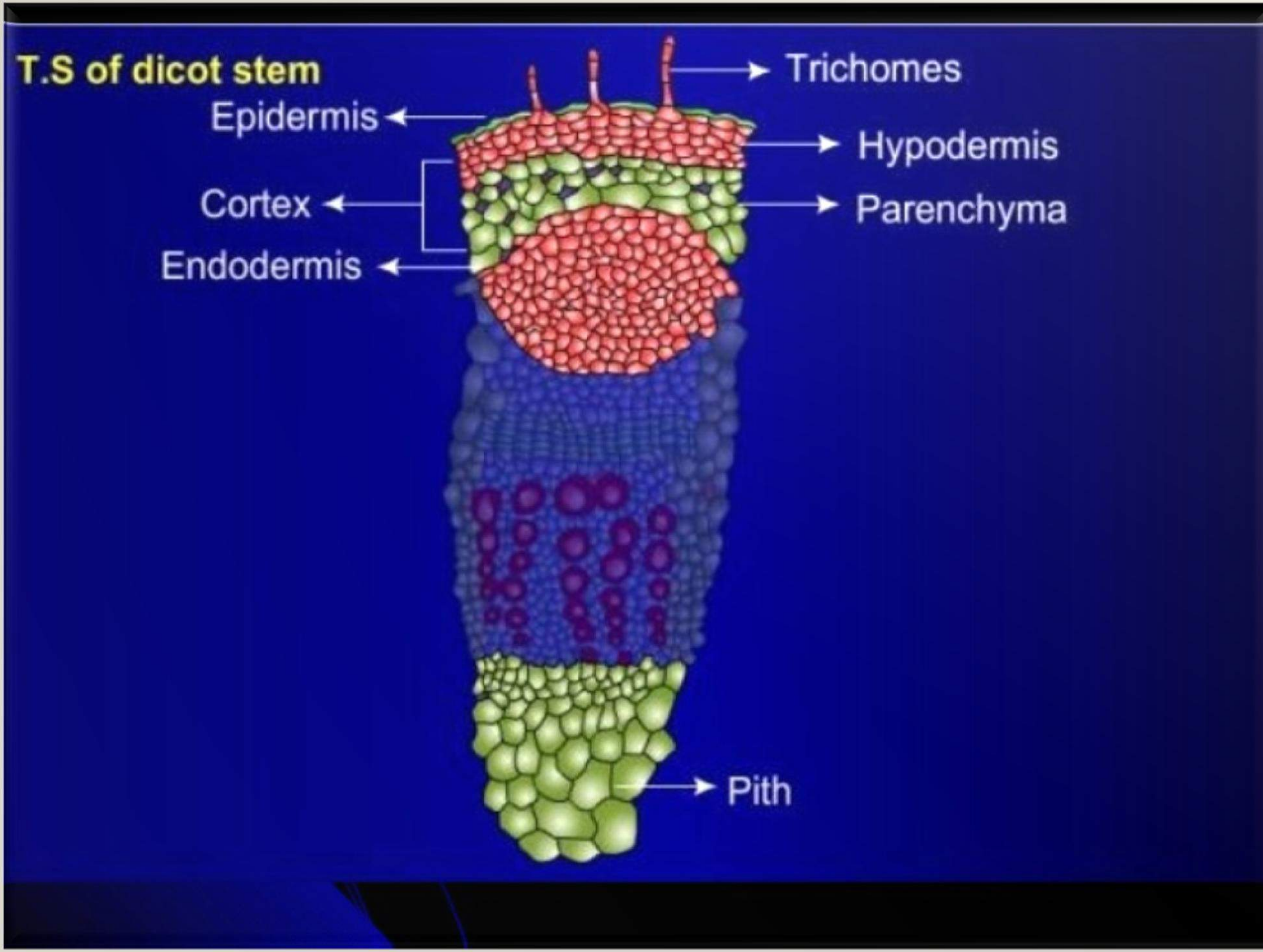
T.S of dicot stem



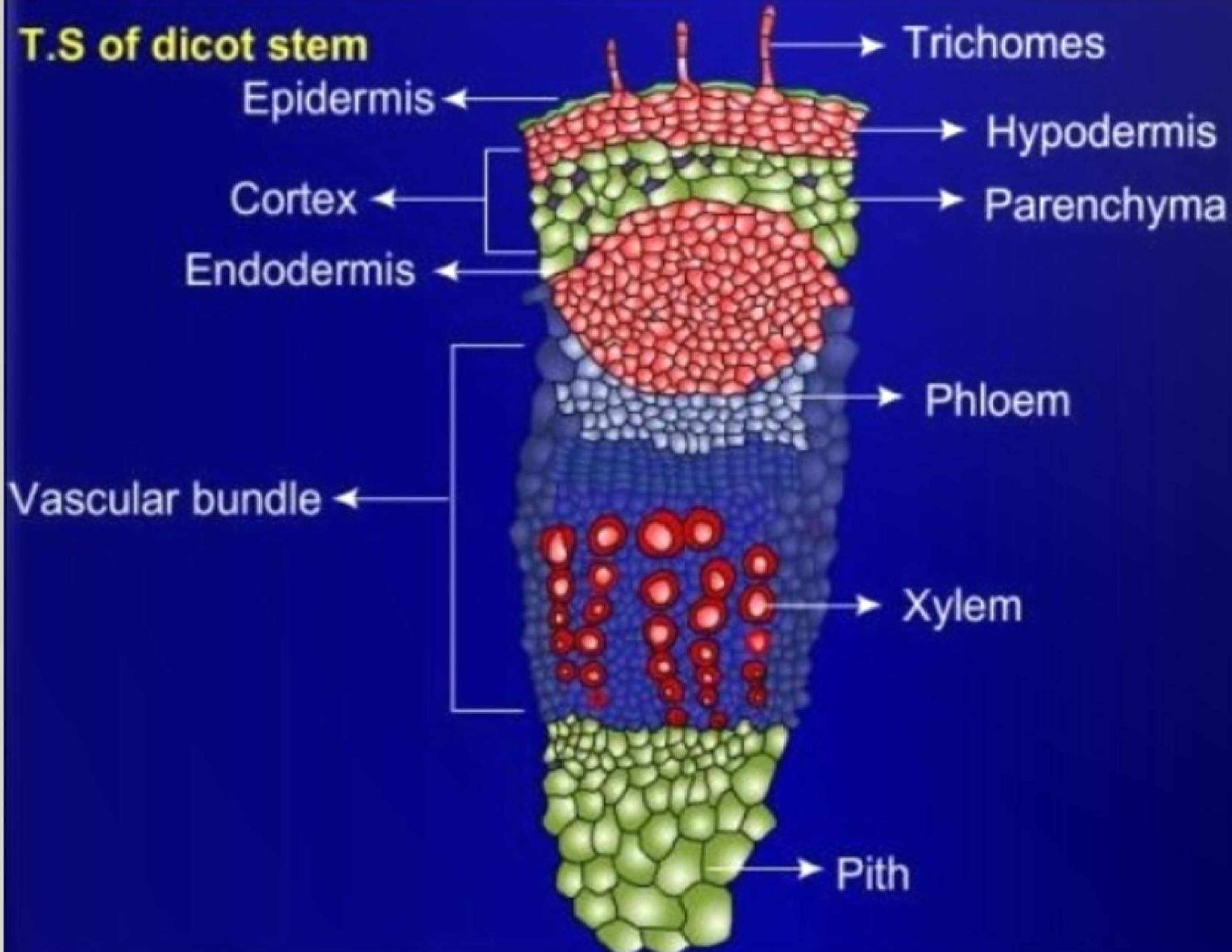
T.S of dicot stem



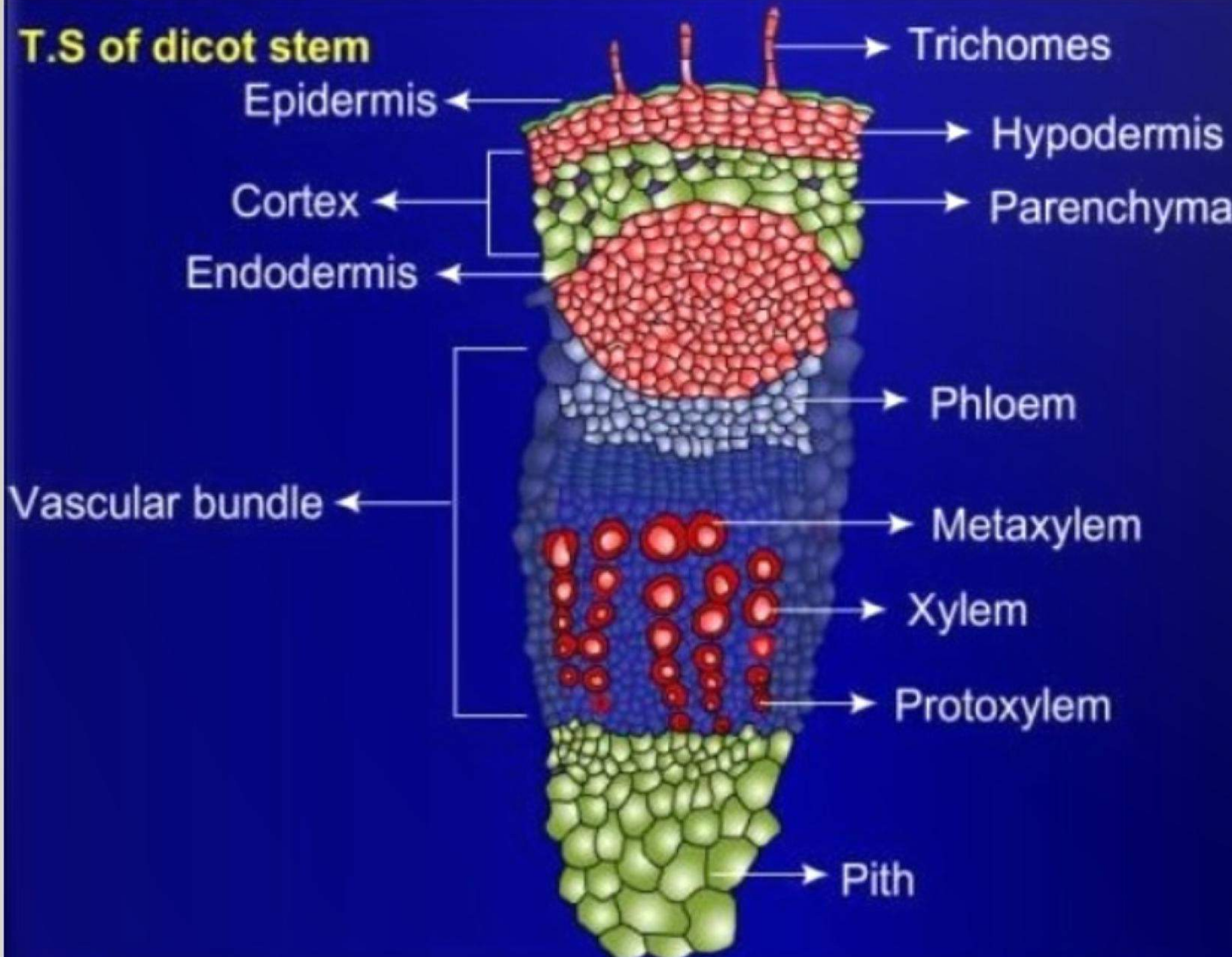

T.S of dicot stem
Trichomes
Epidermis
Hypodermis
Cortex
Parenchyma
Endodermis


T.S of dicot stem
Trichomes
Epidermis
Hypodermis
Cortex
Parenchyma
Endodermis
Pith

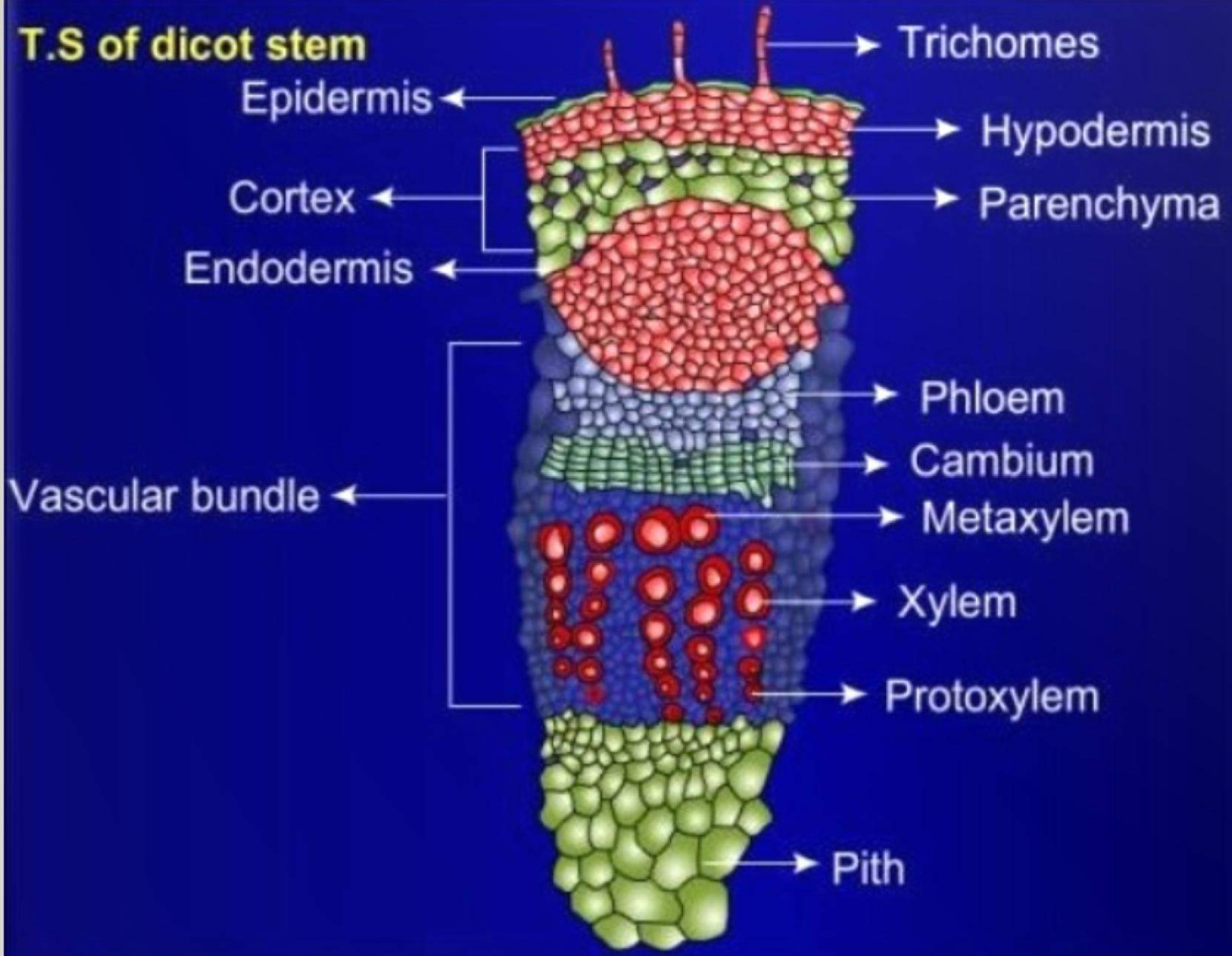
T.S of dicot stem



T.S of dicot stem

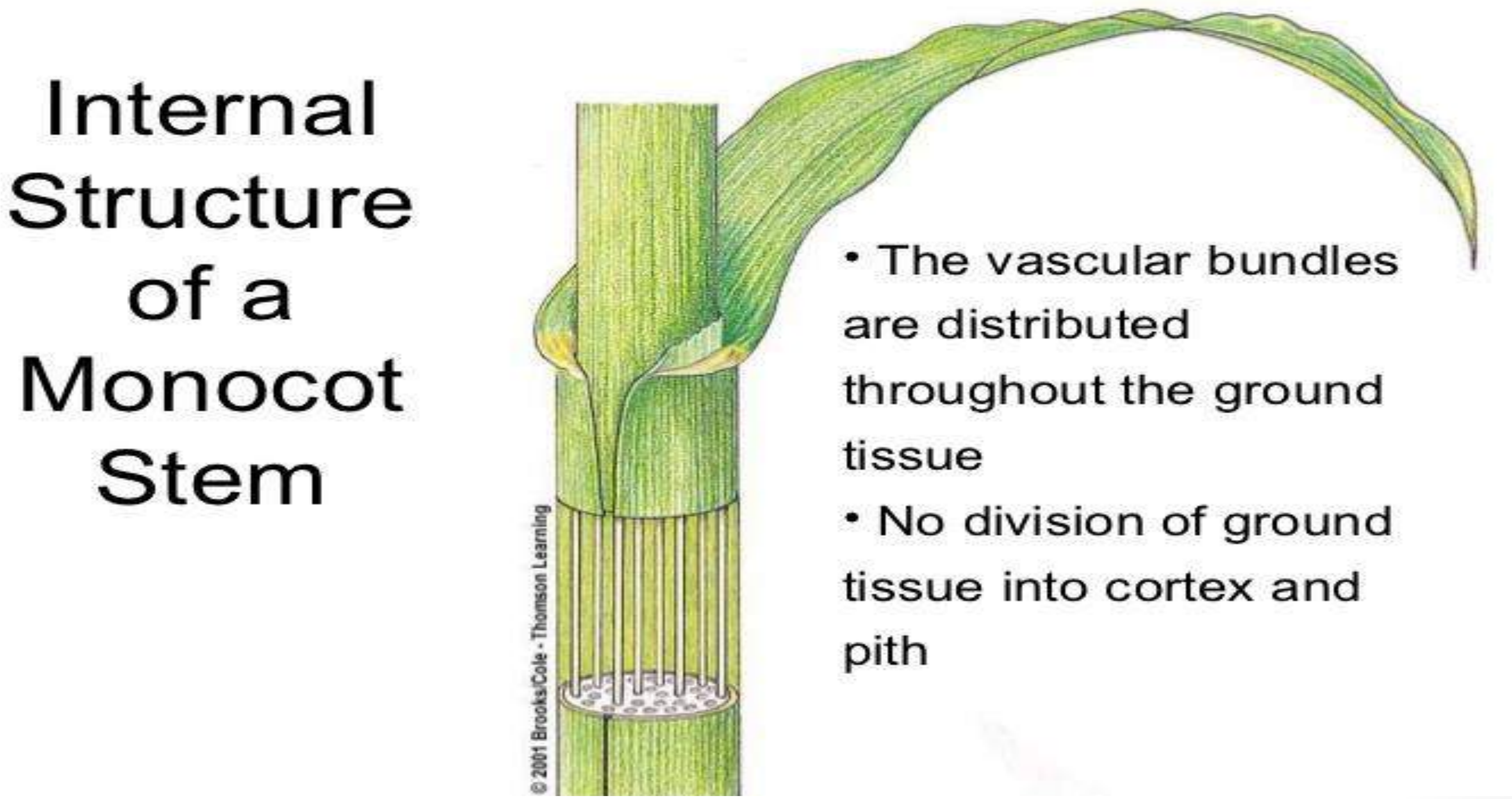


T.S of dicot stem



Internal structure of a Mono. stem

- Maize stem:



- Internal structure of mono. Stem reveals:
- 1- Epidermis:
- - The outermost layer of the stem.
- - It is made up of single of tightly packed parenchymatous cells. Their outer walls are covered with thick cuticle.
- - There are no epidermal outgrowths.

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- 2- Hypodermis:
- - A few layers of sclerenchymatous cells laying below the epidermis.
- - It gives mechanical strength to the plant.
- - It is interrupted here and there by chlorenchyma cells .

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- 3- Ground tissue:
- - There is no distinction into cortex, endodermis, pericycle and pith.
- - The entire mass of parenchymatous cells lying inner to the hypodermis forms the ground tissue.
- - Vascular bundles lie embedded in this tissue.
- - The ground tissue stores food .

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- 4- Vascular bundles:
- - They are scattered in the parenchymatous ground tissue.
- - Each vascular bundle is surrounded by a sheath of sclerenchymatous fibers called **bundle sheath .**

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- - The vascular bundles are closed (without cambium between xylem and phloem).
- - They are numerous, small and closely arranged. Towarde the center, the bundles are large in size and loosely arranged.

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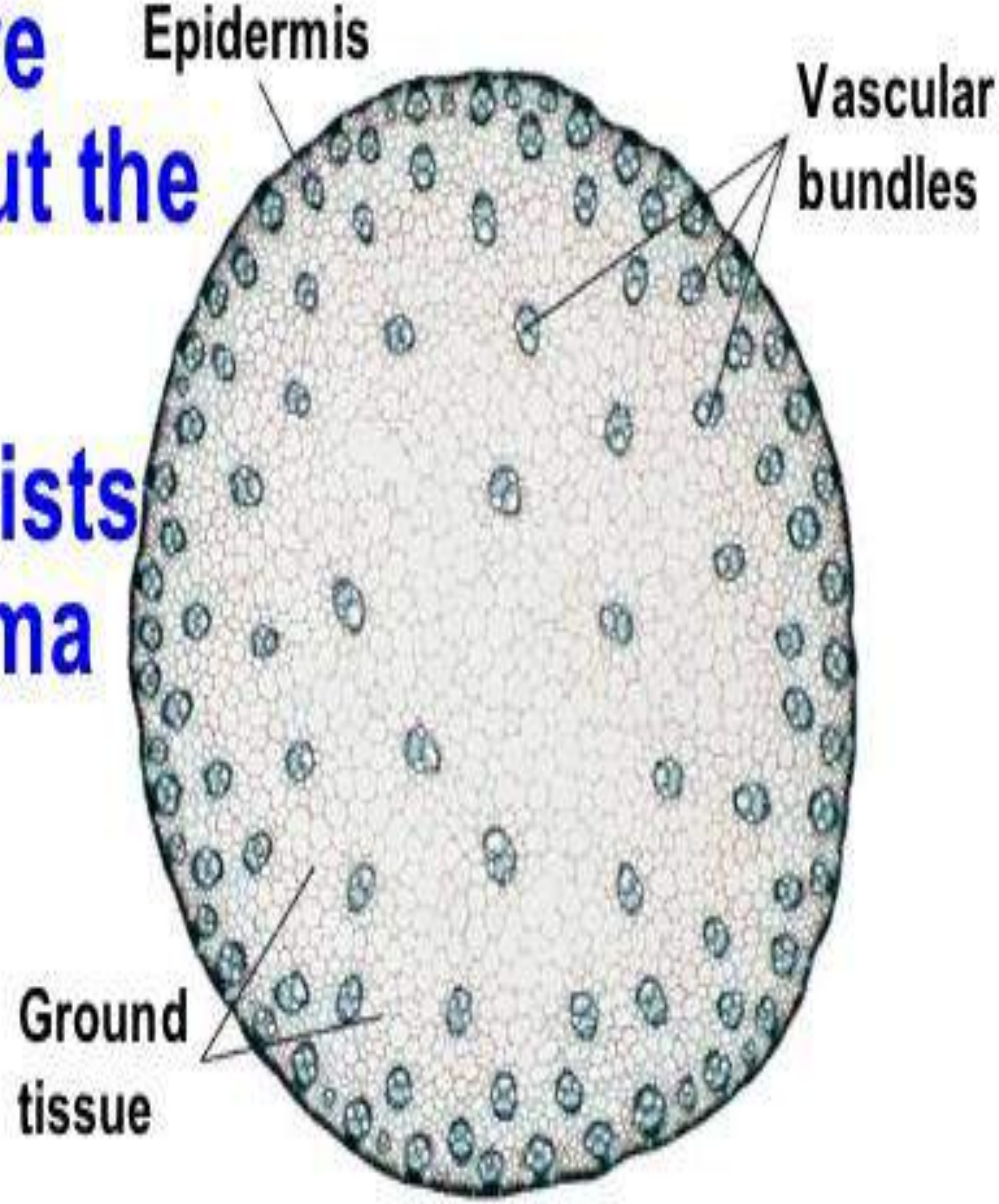
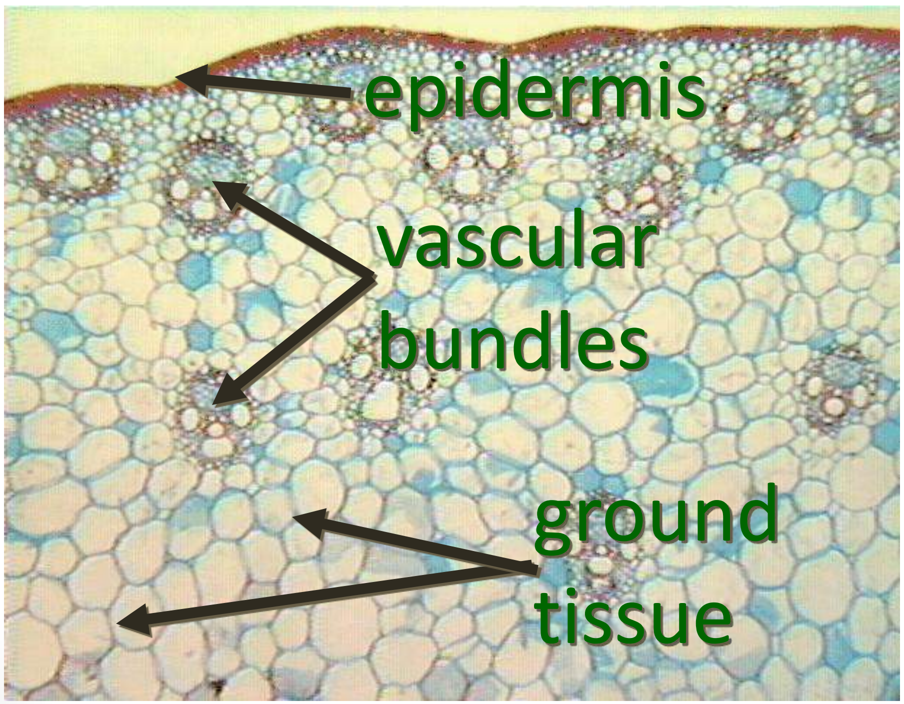
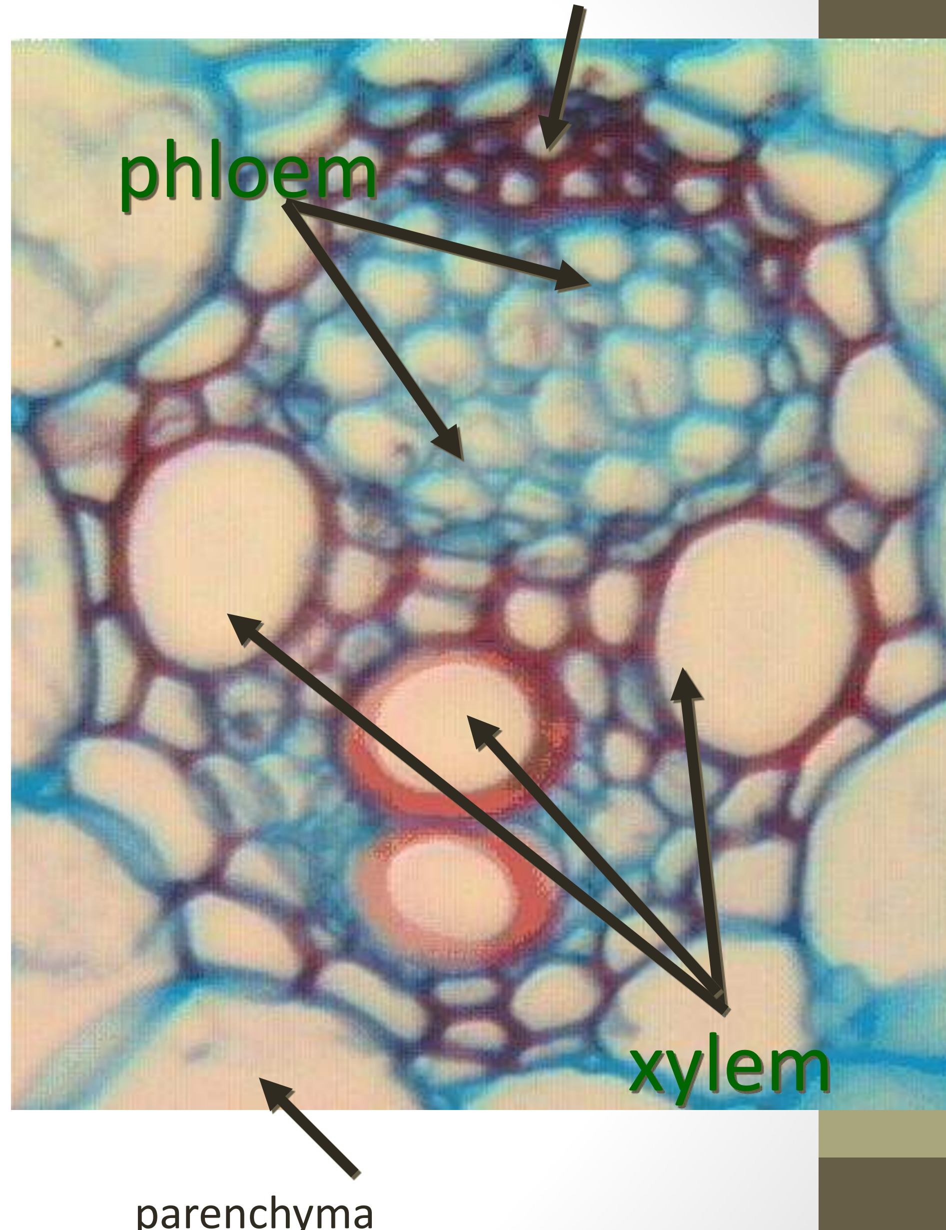
- Vascular bundles are scattered throughout the ground tissue.
- Ground tissue consists mainly of parenchyma cells.



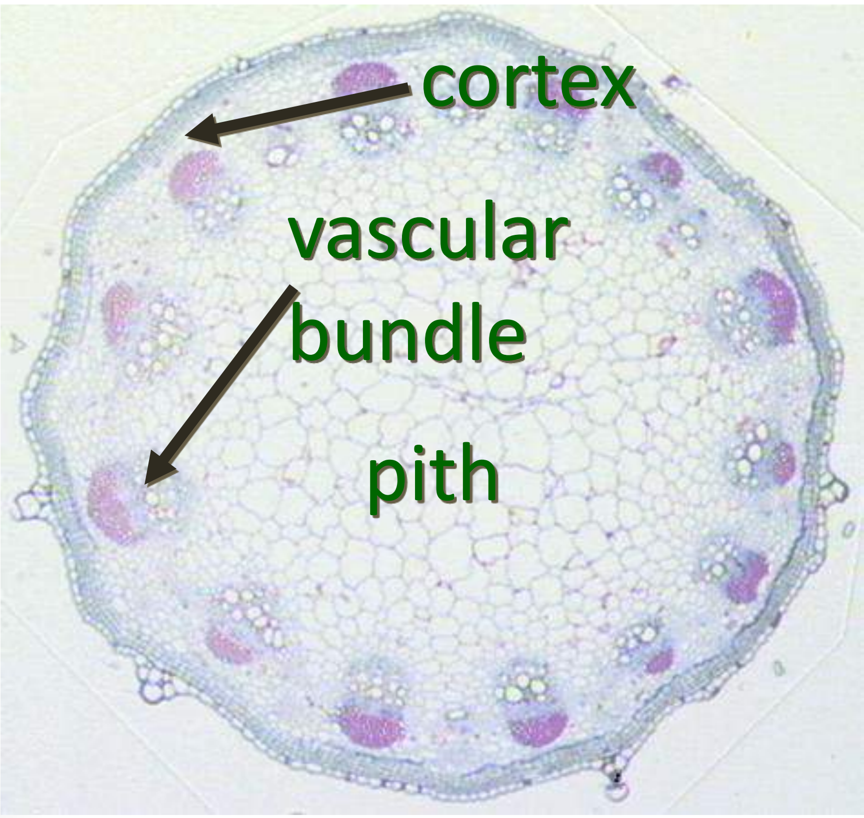
Monocot

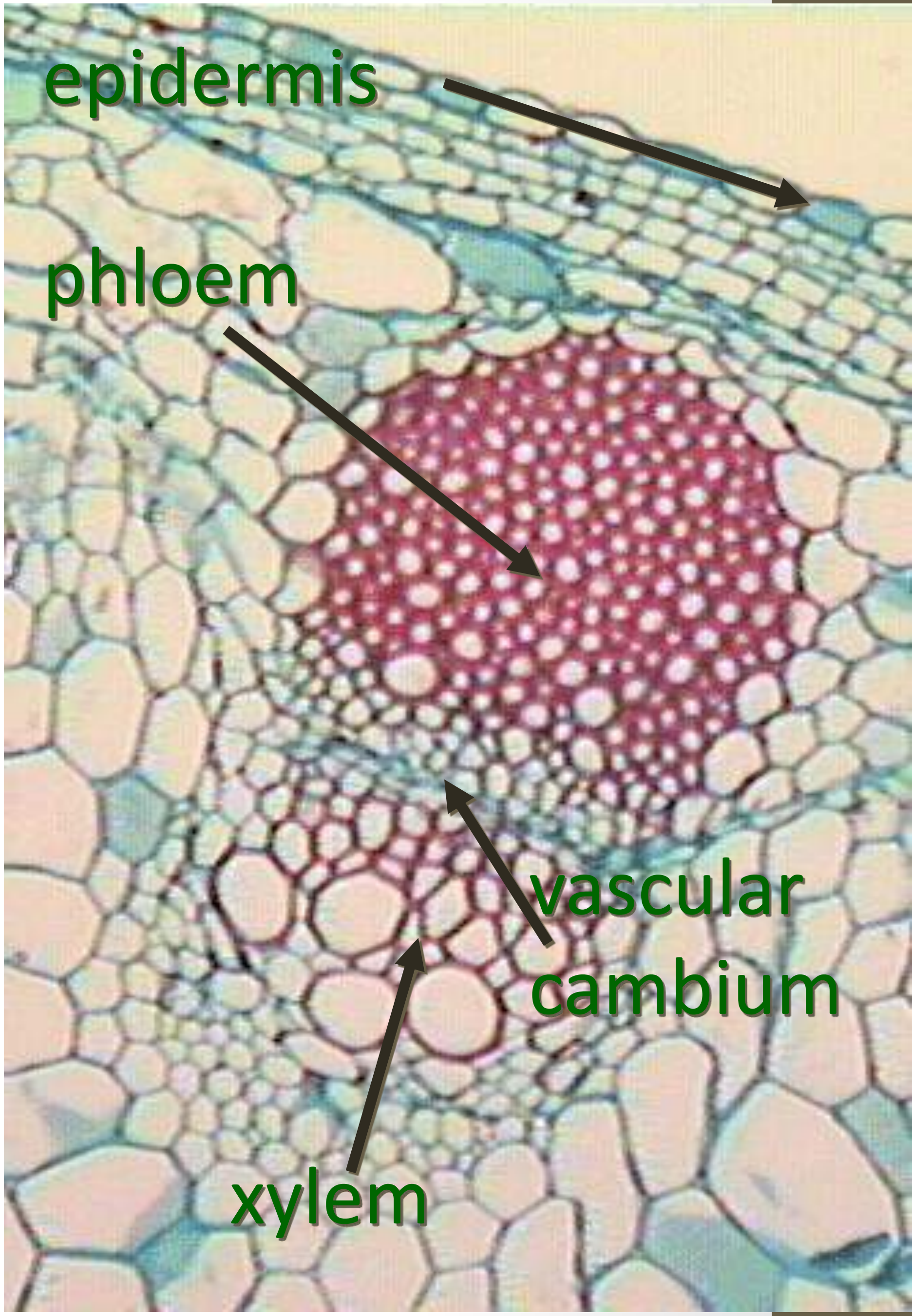
Monocot Stem Anatomy





Dicot Stem Anatomy





Anatomical differences between Dico. and Mono. stem

- Dicot. Stem
- 1- Hypodermis is made up of collenchymatous cells
- 2- Ground tissue is differentiated into cortex, endodermis, pericycle and pith

- Monocot stem
- 1- Hypodermis is made up of sclerenchyatous cells.
- 2- Ground tissue is not differentiated, but it is a continuous mass of parenchyma.

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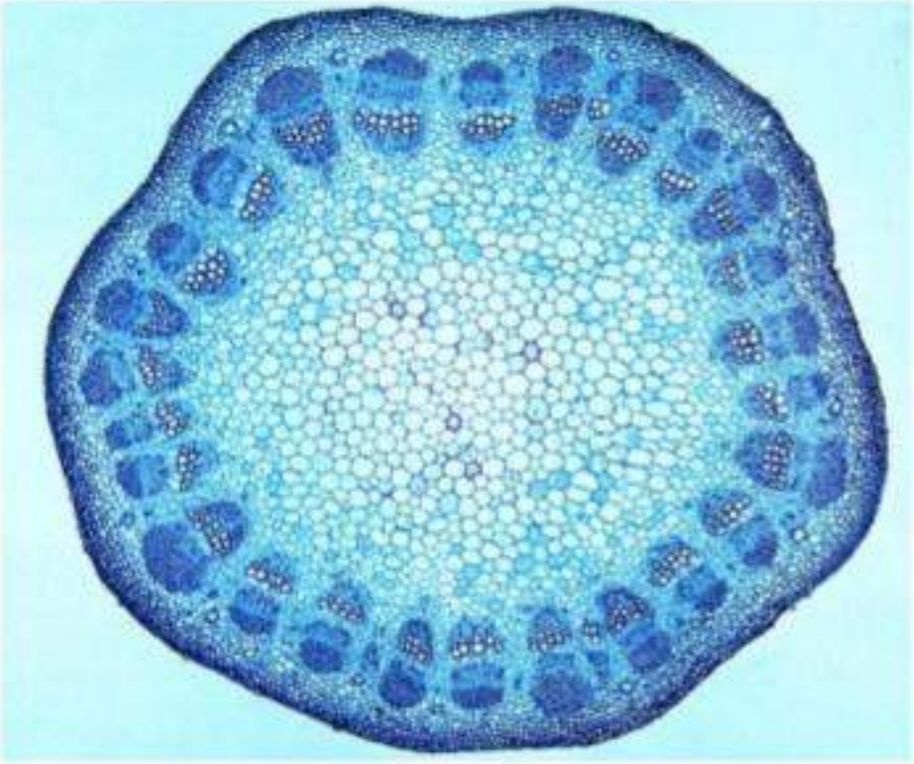
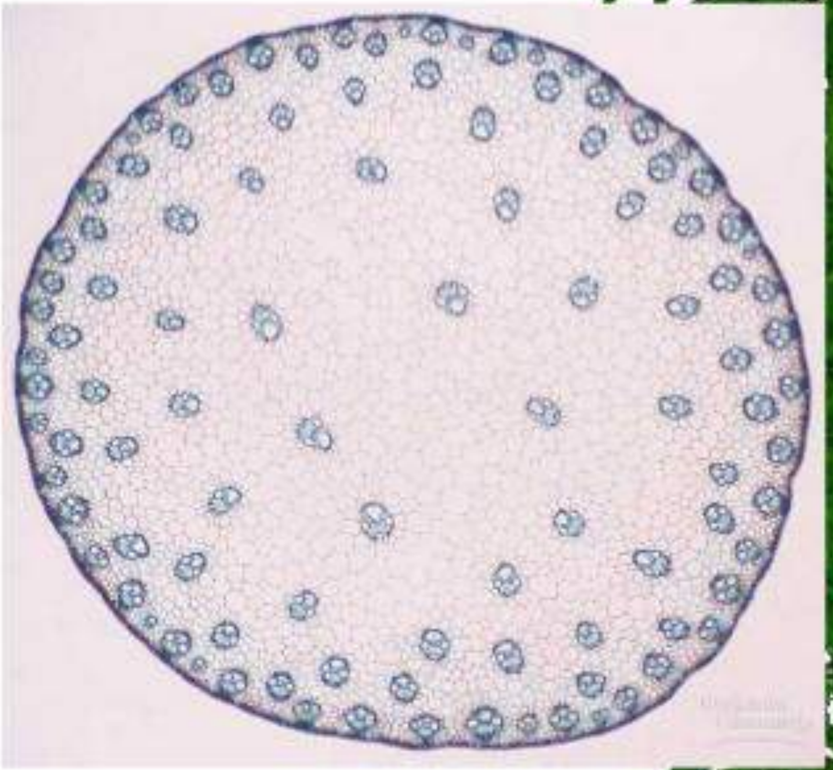
- 3- Pith is present.
- 4- Pericycle is present.
- 5- Vascular bundles are open.
- 6- Vascular bundles are arranged in a ring.

- 3- Pith is absent.
- 4- Pericycle is absent.
- 5- Vascular bundles are closed.
- 6- Vascular bundles are scattered in the ground tissue.

Stems

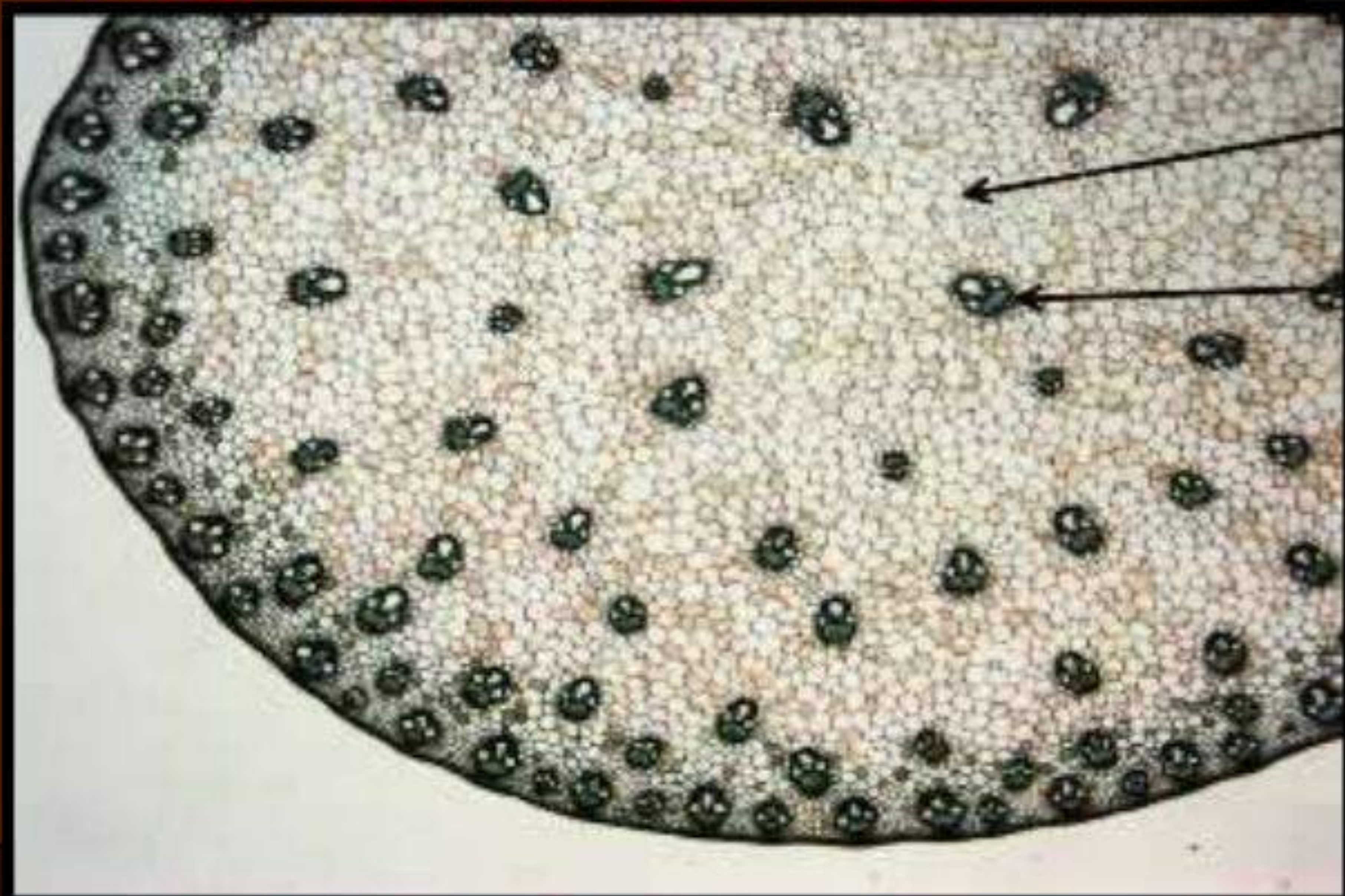


Dicot Stem

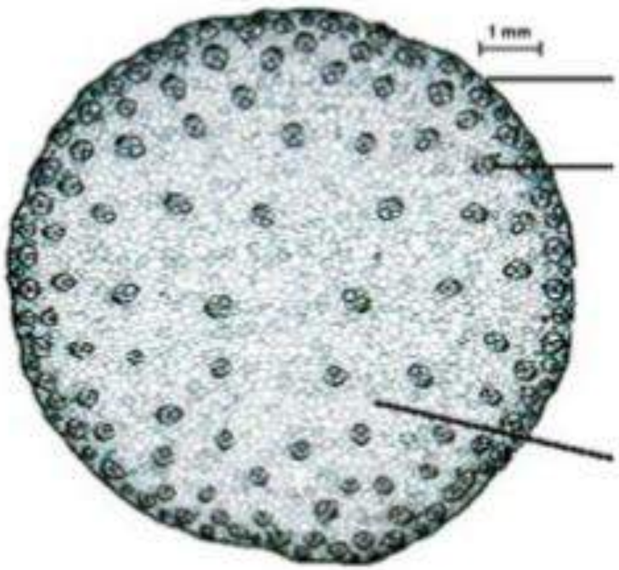


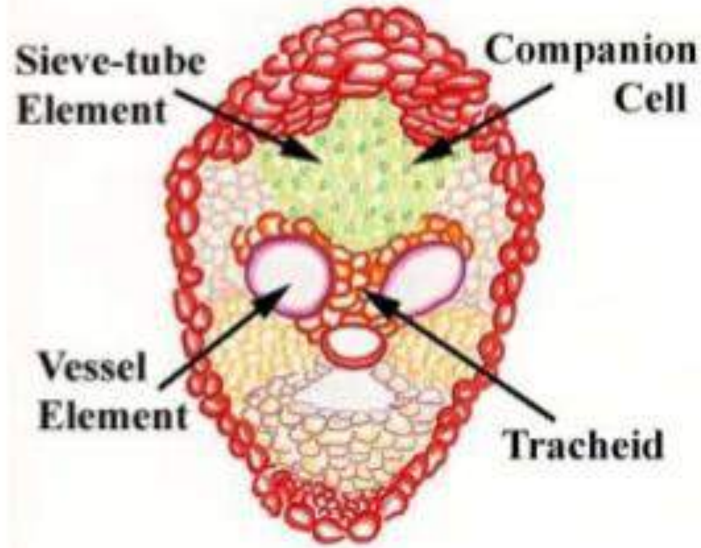
Monocot Stem

- Vascular bundles are scattered.



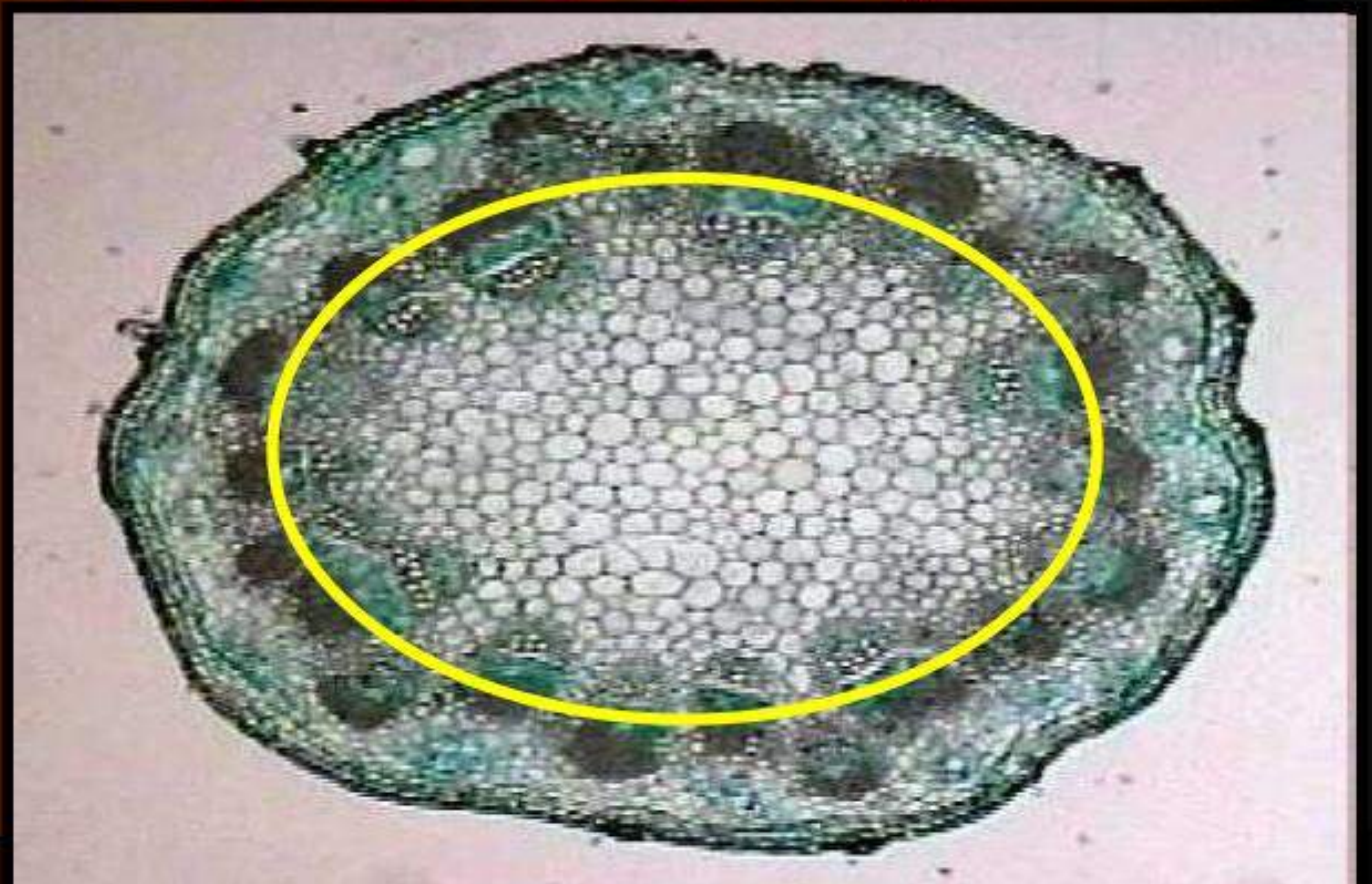
Monocot Stem – cross section





Monocot Vascular Bundle

- Vascular bundles are in a ring.



The differences between Mono. Vs Dicot. (in general)

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Monocots

- Leaves have parallel Veins
- Fibrous Roots
- Flower parts in 3’s
- Seed has one part (cotyledon)
- Vascular bundles are scattered.

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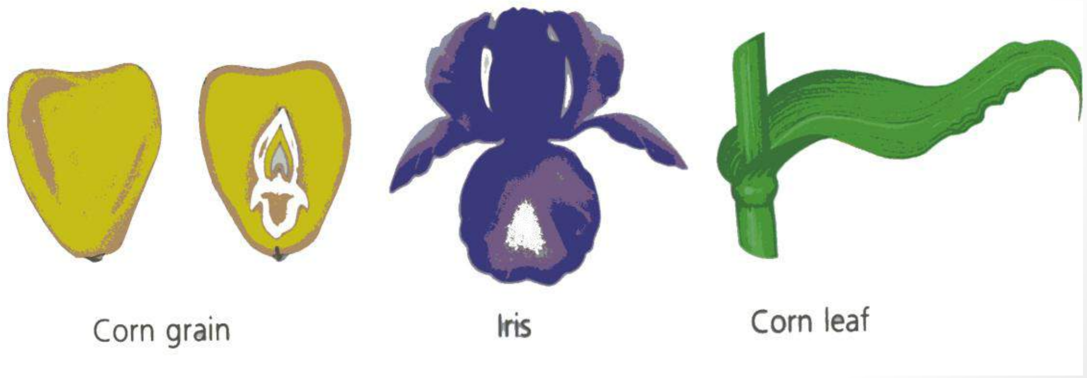
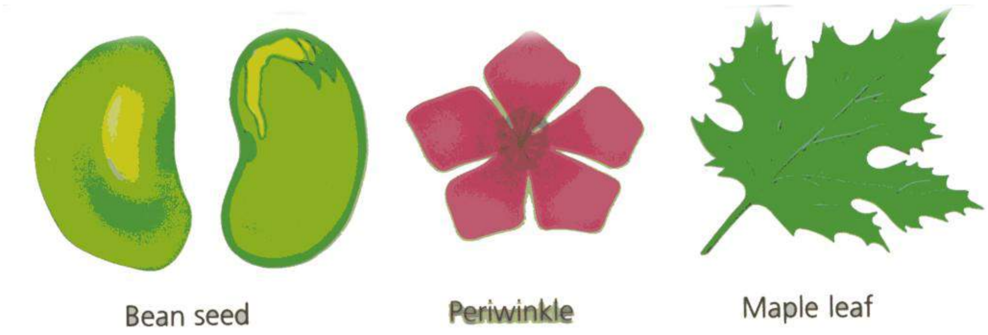


Dicots

- Leaves have branched Veins
- Tap Roots
- Flower parts in 4's & 5's
- Seed has two parts (cotyledons)
- Vascular bundles are in a ring.



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- Flower petals are in 3's.

- Flower petals are in 3's.

- Flower petals are in 3's.

- Lillies and the Iris are tricky. Note the 3 and then 3 in the Lilly.

- Flower parts are groups of 4 to 5.

- Lillies and the Iris are tricky. Note the 3 and then 3 in the Lilly.

Warm-up 03/16

- Monocot or Dicot?

Primary growth of stem

- The primary structure of the plant is caused by the activity of apical meristem
- The primary permanent tissues produced by the apical meristems cause growth in length.
- This is called primary growth.

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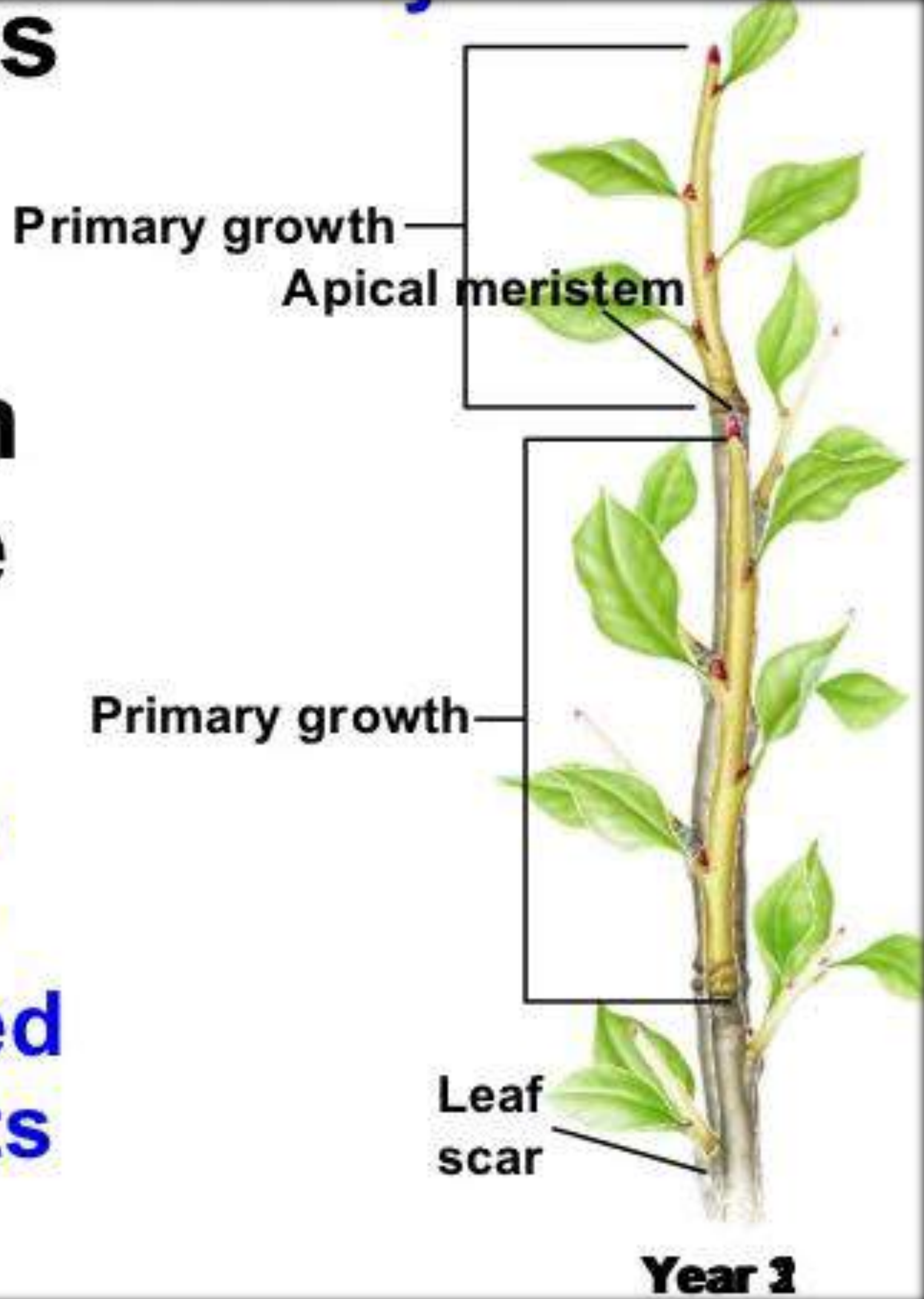
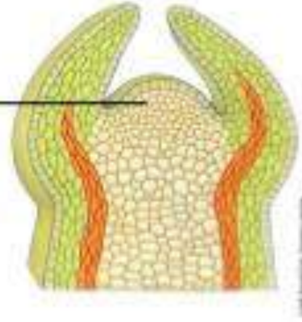
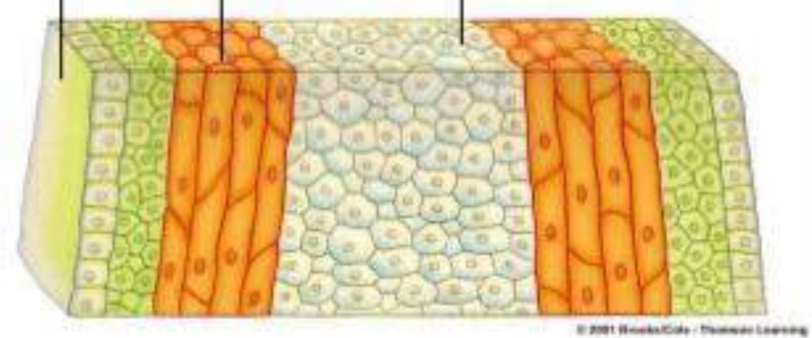
- All seed plants undergo __primary growth__, which is an increase in length.
- For the entire life of the plant, new cells are produced at the tips of roots and shoots.

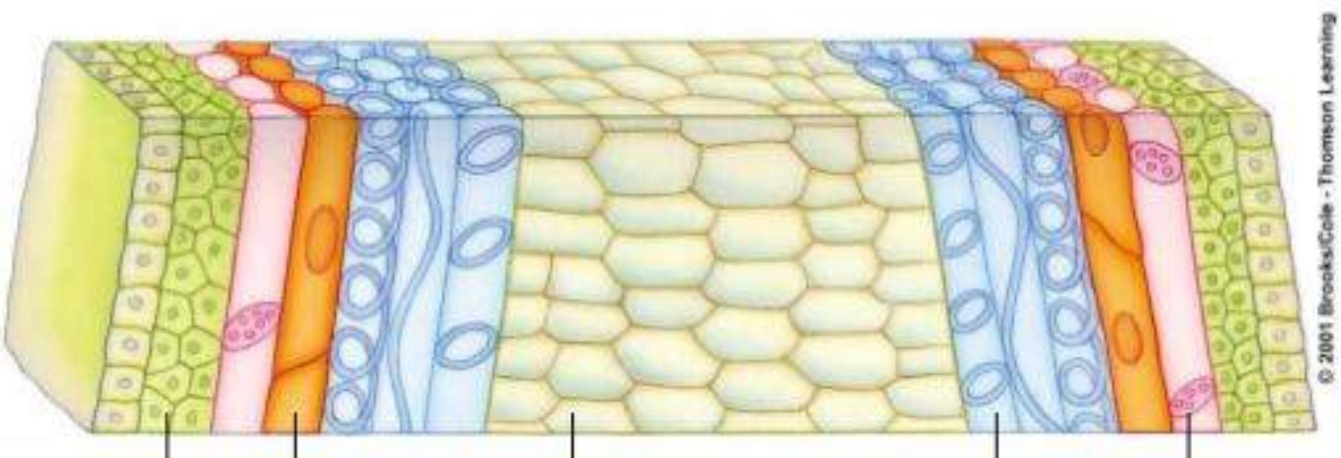


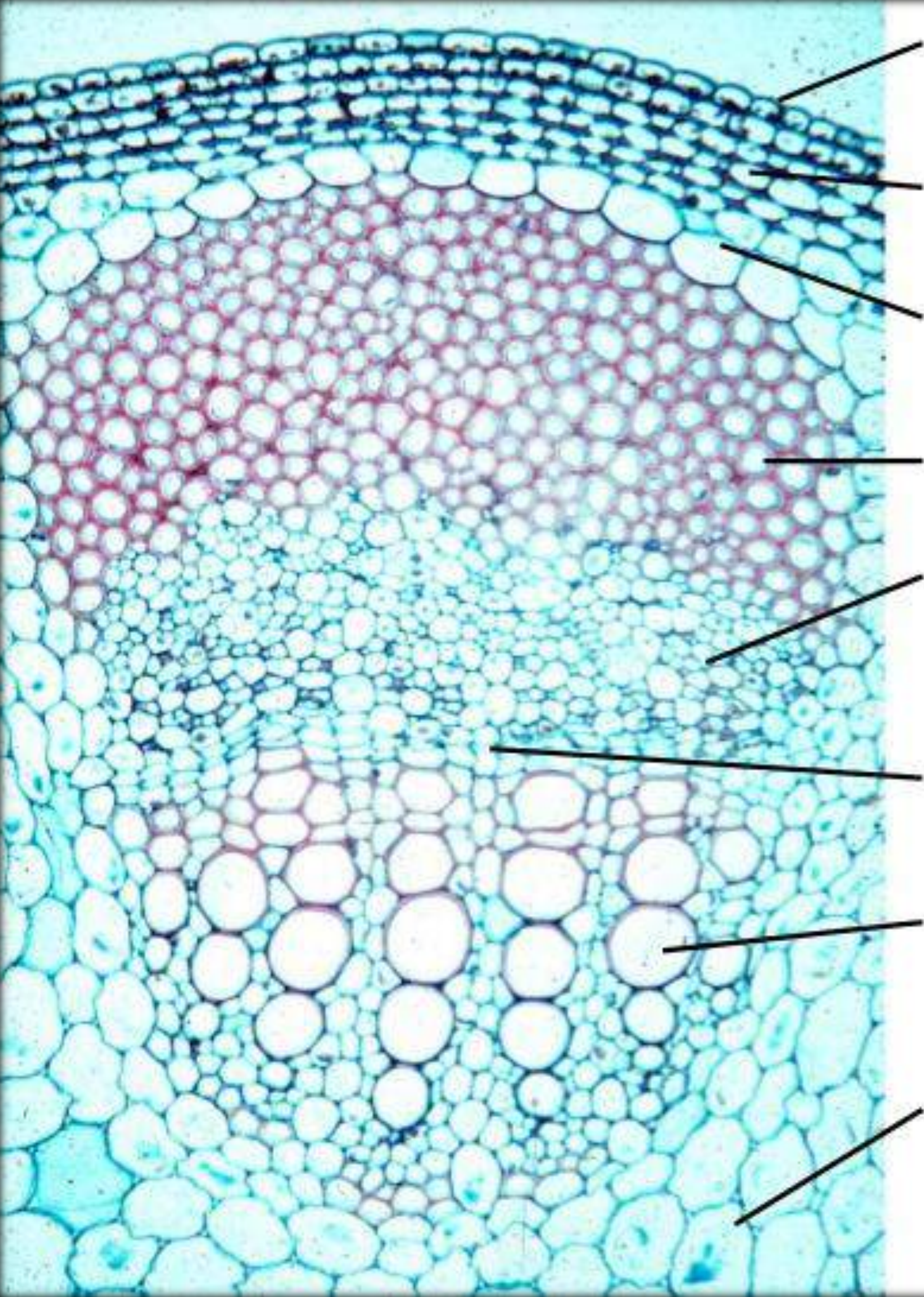
Primary growth of stems is produced by cell divisions in the apical meristem. It takes place in all seed plants.

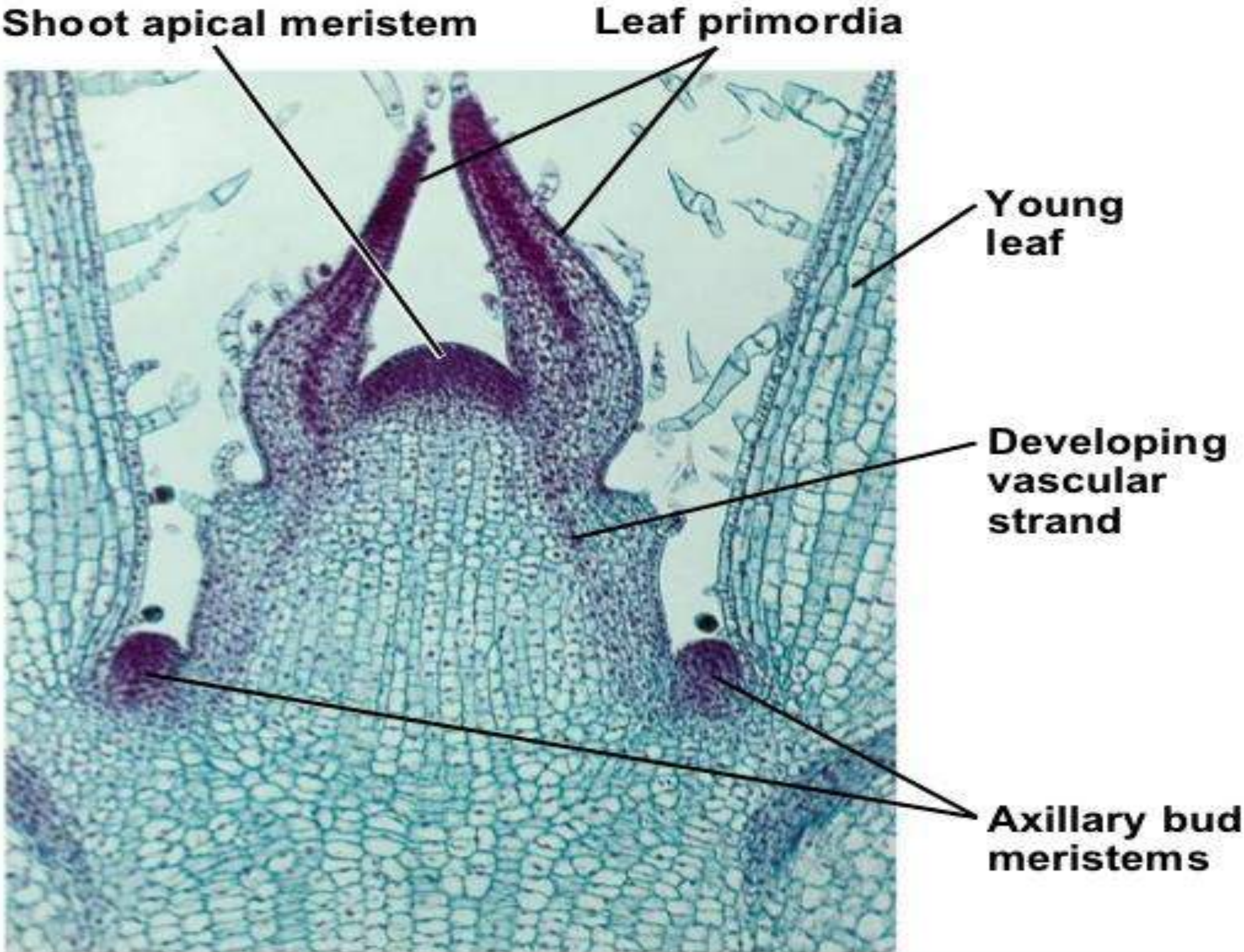
Shoot Development








Epidermis
- window, reduce water loss
Cortex Collenchyma
- extensible support
Cortex Parenchyma
- photosynthesis, etc.
Fibers- rigid support
Functional Phloem
- conduct sugars etc. away
from leaf to rest of plant
Vascular Cambium
- adds 2° xylem and 2° phloem
Xylem
-conduct water and minerals
up from soil
Pith
-water storage, defense?



Shoot apical meristem
Leaf primordia
Young
leaf
Developing
vascular
strand
Axillary bud
meristems

Secondary growth of dicot. stem

- Thickness in stem (observed mostly in dicot. Plants.
- This thickness is caused by the addition of new tissues by the activity of the lateral meristems like vascular cambium and cork cambium.

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- The new tissues, which are formed by the lateral meristems, are called secondary tissues.
- The increase in thickness is called secondary growth.

Secondary growth

- Secondary growth occurs in stems and roots of woody plants but rarely in leaves
- The **secondary plant body** consists of the tissues produced by the vascular cambium and cork cambium
- Secondary growth is characteristic of gymnosperms and many eudicots, but not monocots

Secondary Growth

- Occurs in perennials
- A ring of vascular cambium produces secondary xylem and phloem
- Wood is the accumulation of these secondary tissues, especially xylem

Formation of vascular cambial ring

- The cambium occurring between the xylem and the phloem in the vascular bundles, is called fascicular cambium.
- In between the vascular bundles, a few parenchymatous cells of the medullary rays that are in line with the fascicular cambium become meristematic and form a strip of cambium.

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- It is called interfascicular cambium.
- This cambium joins up with fascicular cambium on both sides and forms a continuous ring.
- This ring is called a vascular cambial ring.

- The vascular cambial ring becomes active and begins to cut off new cells both towards the inner and outer sides.
- The cells, which cut off new towards the outer side, get differentiated into the secondary phloem, whereas those cut off the inner side are differentiated into secondary xylem.

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Formation of the Vascular Cambium

- Once secondary growth begins, the vascular cambium appears as a thin layer between the xylem and phloem of each vascular bundle.

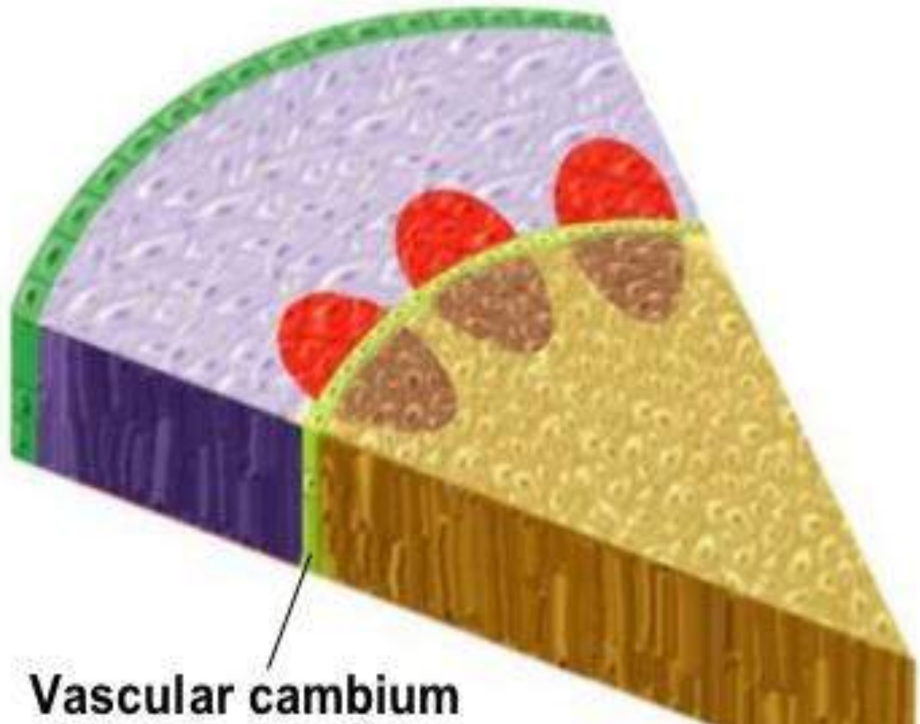
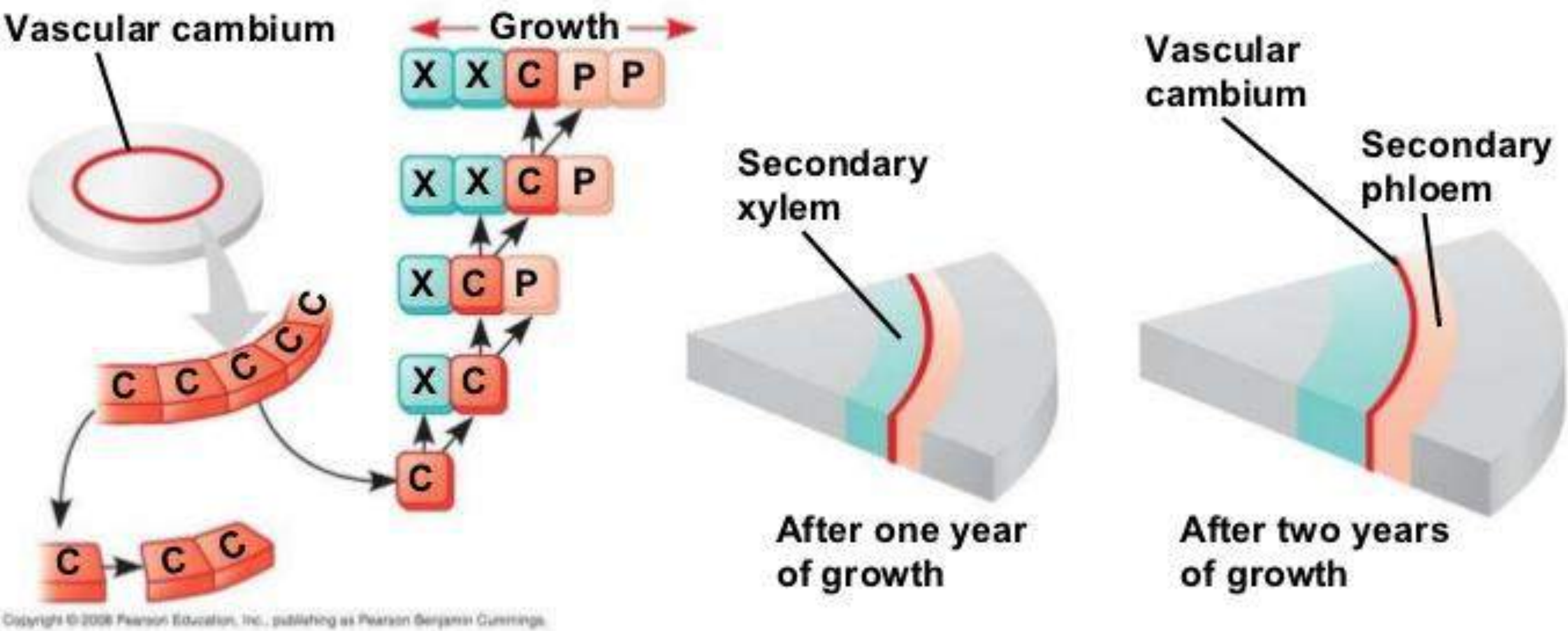


Fig. 35-20


Vascular cambium
Growth
X X C P P
X X C P
X C P
X C
C
C C C C C
C C C
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Secondary xylem
After one year of growth
Vascular cambium
Secondary phloem
After two years of growth

- Secondary phloem consists of

  sieve tubes

  companion cells

  phloem parenchyma

  phloem fibers

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- Secondary xylem consists of

  vessels

  tracheids

  xylem fibers

  xylem parenchyma

Secondary xylem occupies the major part of the woody stem.

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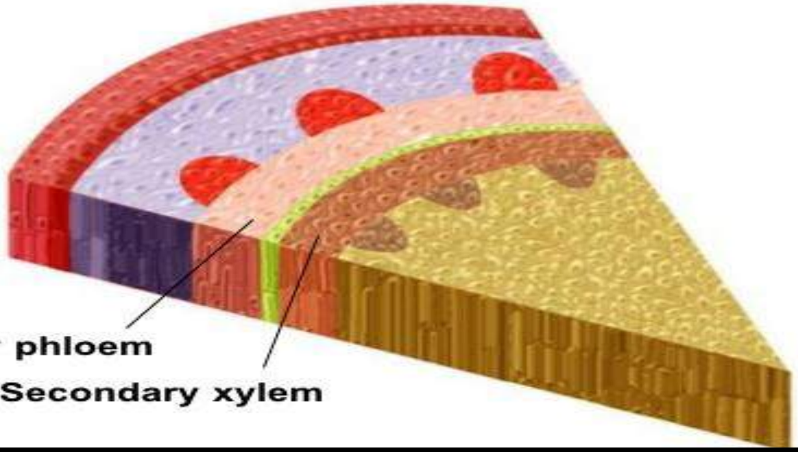
Secondary growth of a stem

Vascular cambium produces vascular tissues and increases the thickness of stems over time.

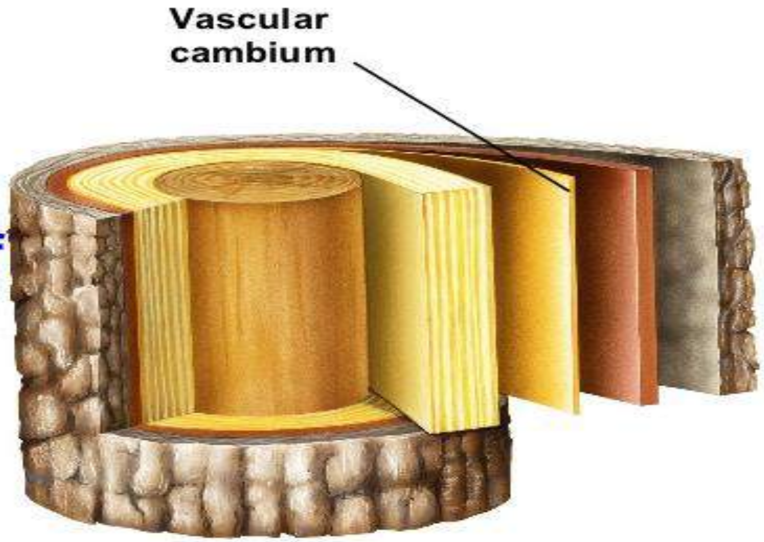
Cork cambium produces the outer covering of stems.

The addition of new tissue in these cambium layers increases the thickness of the stem.

The vascular cambium divides to produce xylem cells toward the center of the stem and phloem cells toward the outside.



The vascular cambium produces new xylem and phloem, which increase the width of the stem.



Formation of periderm

- As secondary vascular tissues are continuously added in the stelar region, pressure is exerted on the cortex and epidermis.
- The epidermis gets ruptured and the cortex stretched.
- Then the secondary protective layer is developed.
- It is called periderm.

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- During the formation of this periderm, a few layers of meristematic tissue are formed in the cortex.
- This is called cork cambium or phellogen.

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- The cells of the cork cambium cut off on both sides.
- Those formed on the outerside become suberised. This region is called cork or phellem
- The cork cells are uniform in size and arranged in radial rows without intercellular spaces.

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- These cells are dead at maturity.
- The cells that are cut off on the inner side of the cork cambium are parenchymatous, called phelloderm or secondary cortex.
- The cells of the phelloderm are living, isodiametric and radially arranged with intercellular spaces.
- As these cells have chloroplasts, they carry out photosynthesis.

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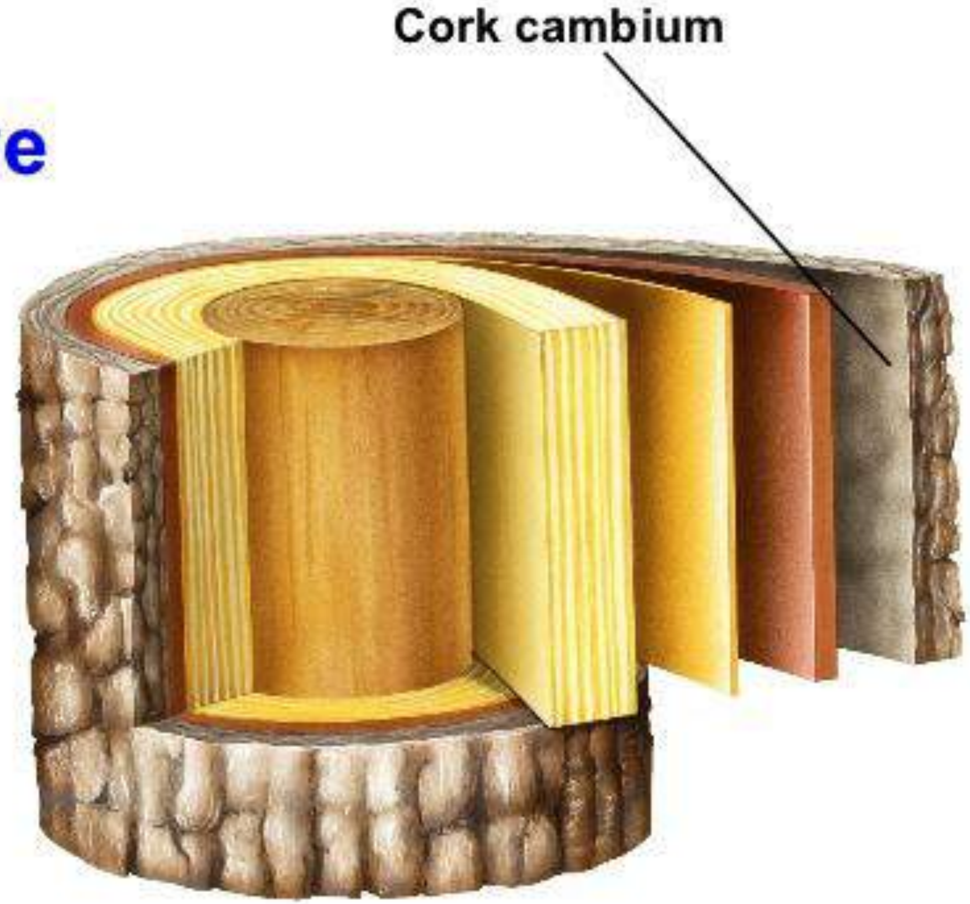
- The cork (phellem), cork cambium (phellogen) and the secondary cortex together called
- All the tissues outside the vascular combium i.e. secondary phloem, cortex and the periderm are together called BARK
-

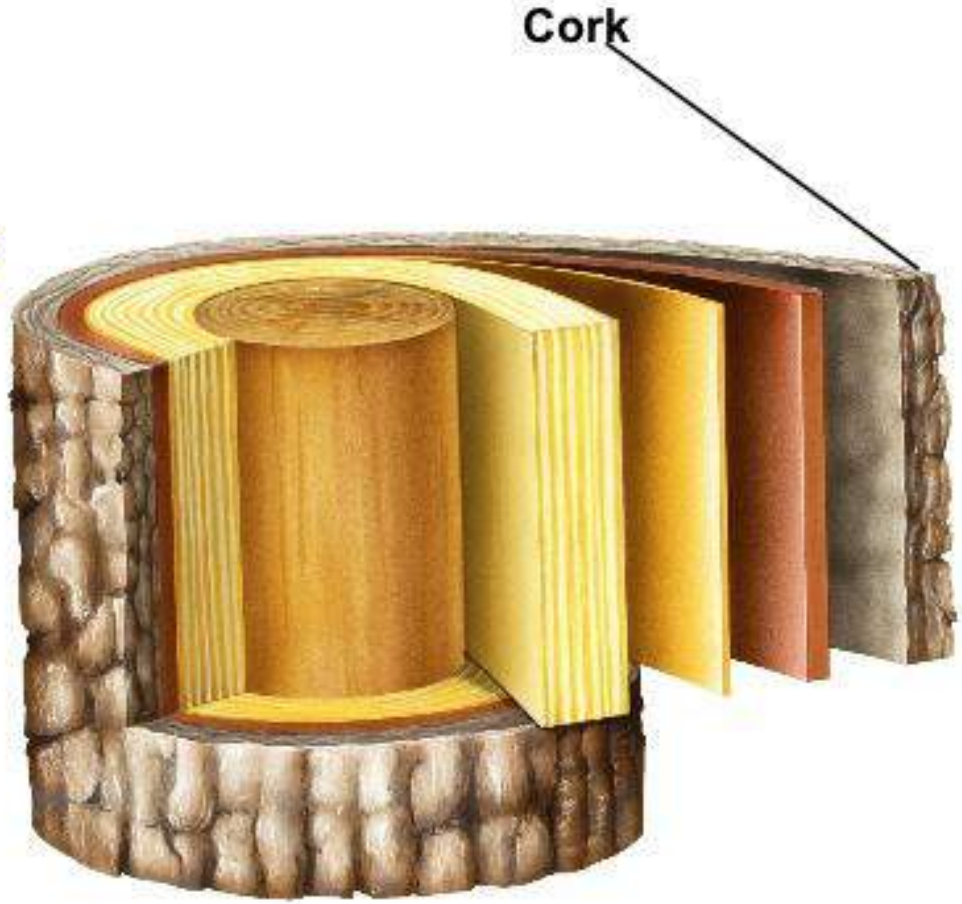
Secondary Growth of Stems

The cork cambium produces a protective layer of cork.



Secondary Growth of Stems

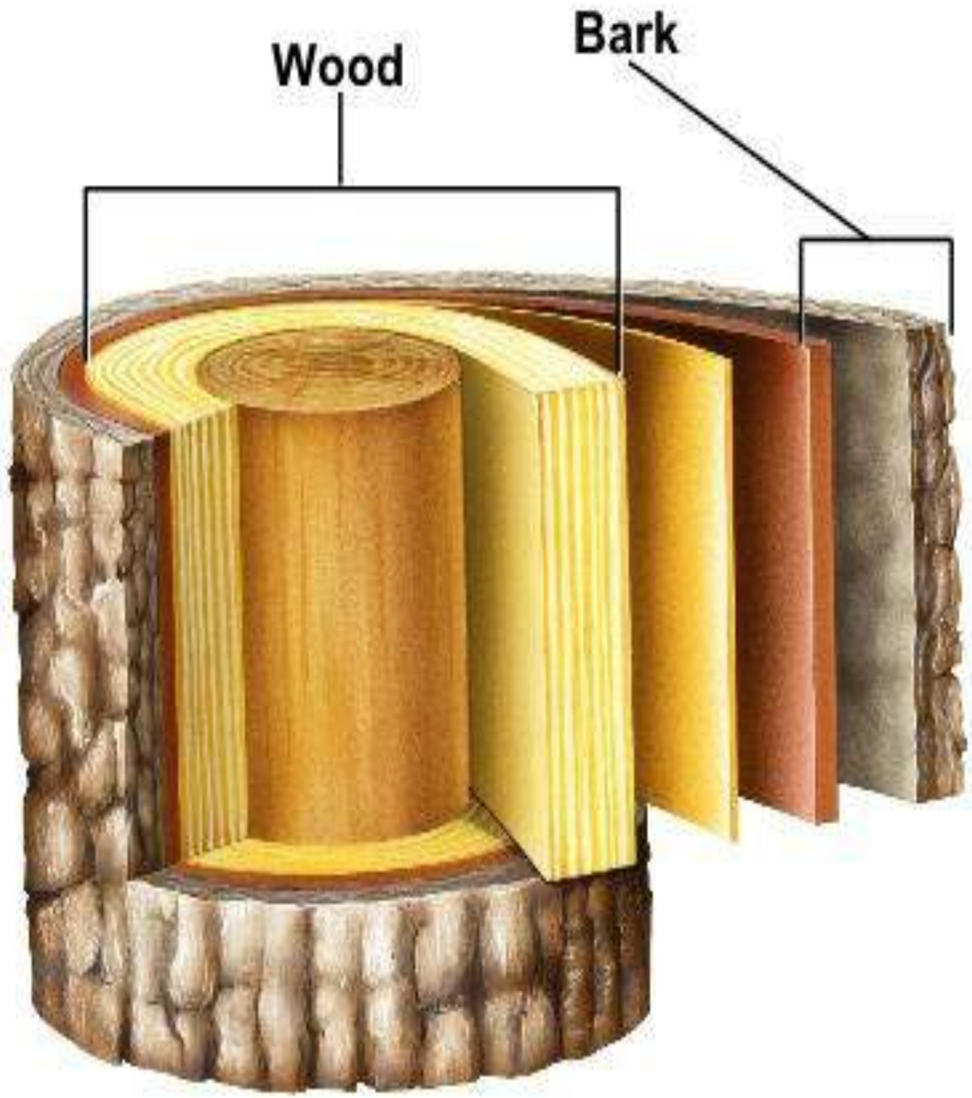
The cork contains old, nonfunctioning phloem that protects the tree.



Formation of wood

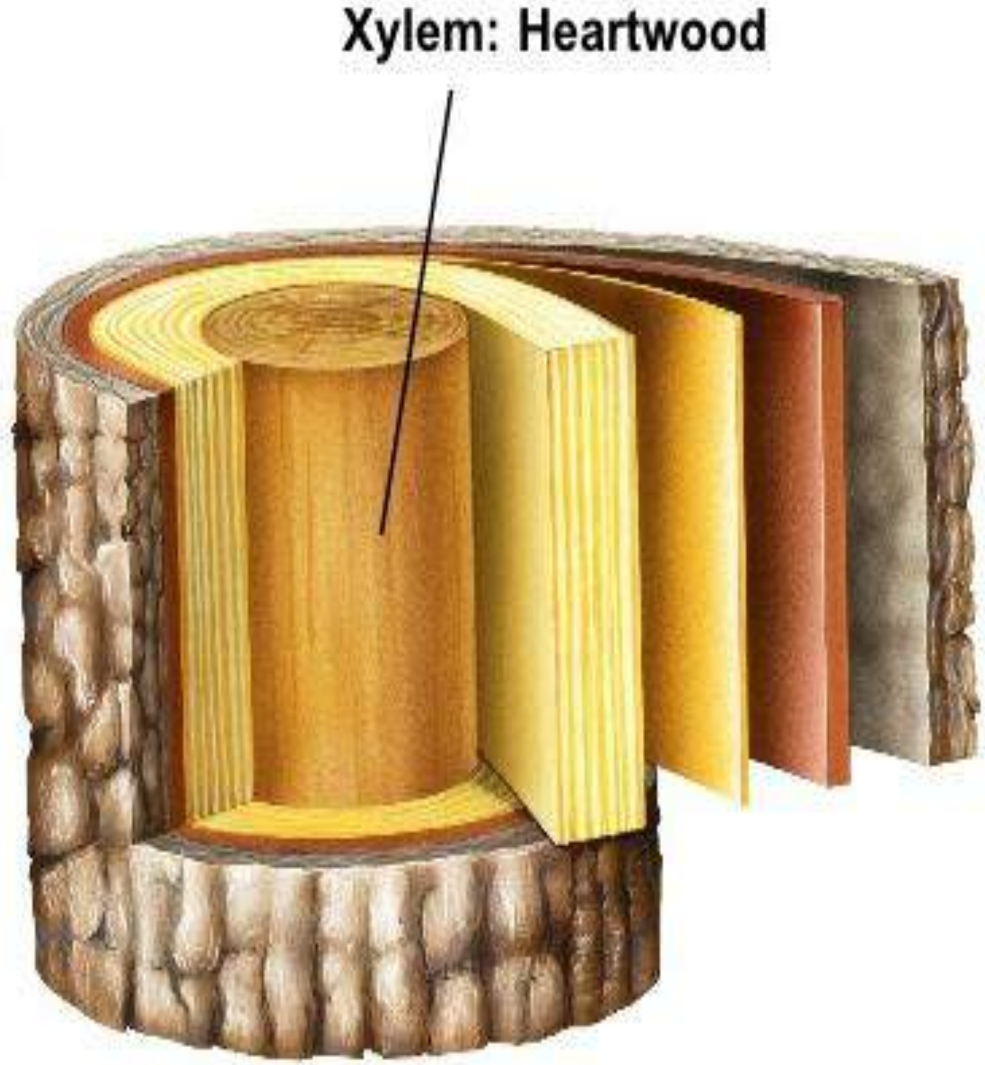
Formation of Wood

- Wood is actually layers of xylem. These cells build up year after year.

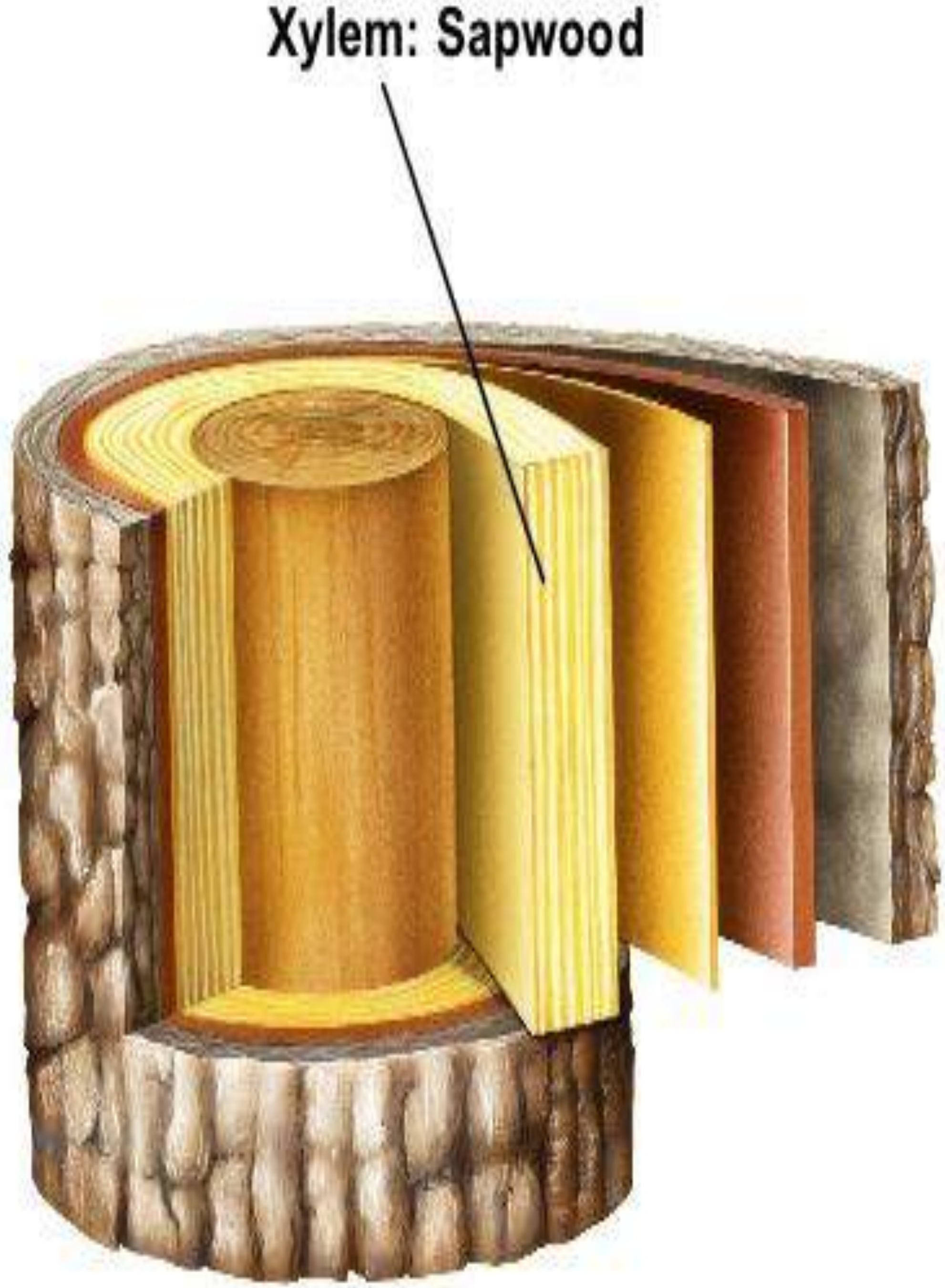


As woody stems grow thicker, older xylem cells near the center of the stem no longer conduct water.

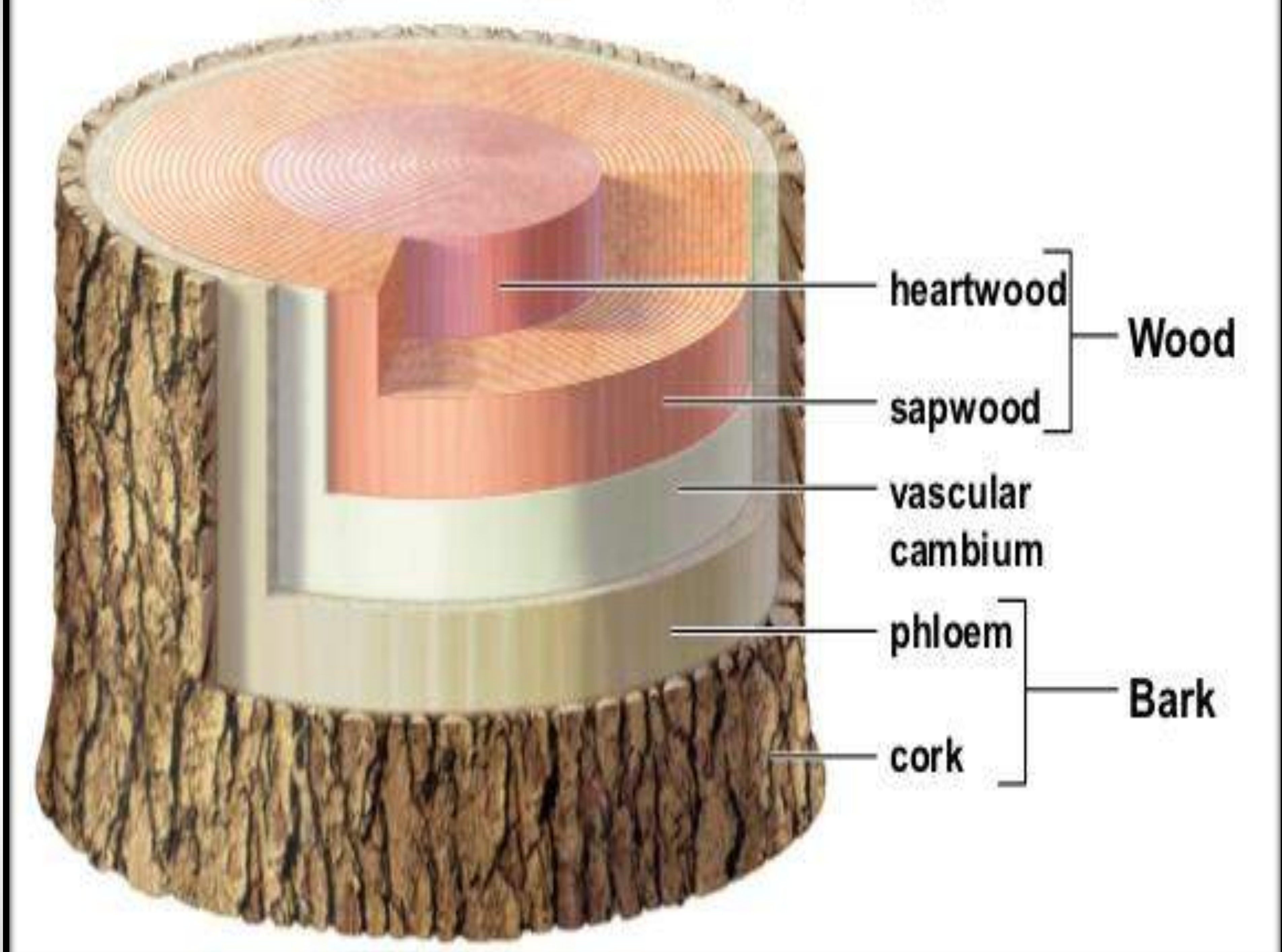
This is called heartwood. Heartwood supports the tree.

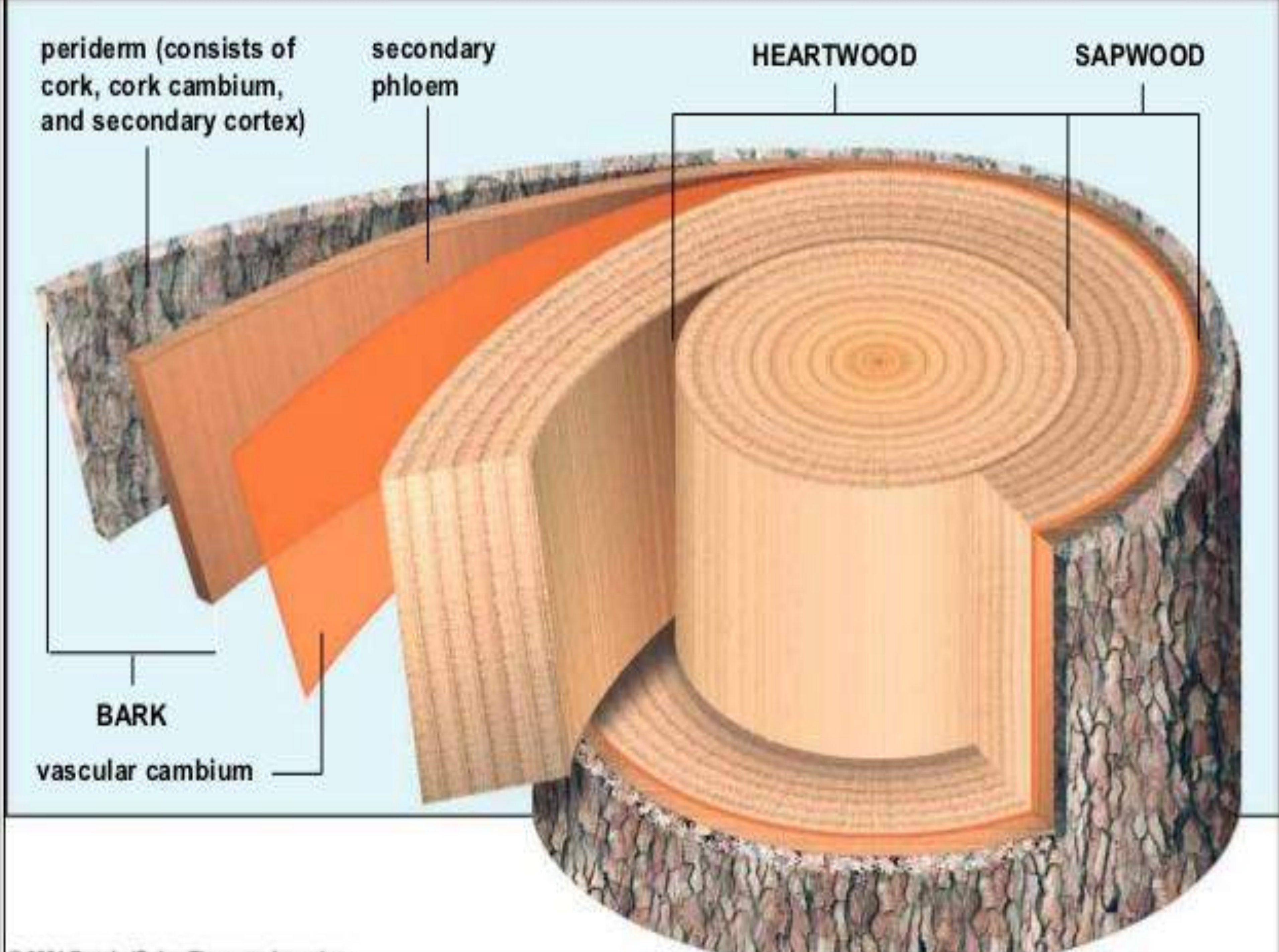


Heartwood is surrounded by sapwood.



Sapwood is active in water and mineral transport.


heartwood
sapwood
Wood
vascular
cambium
phloem
cork
Bark


periderm (consists of cork, cork cambium, and secondary cortex)
secondary phloem
HEARTWOOD
SAPWOOD
BARK
vascular cambium

Annual rings

- During Spring and Summer seasons vegetative growth of a tree is induced and more leaves are produced.
- So there is a dire need of efficient transport of water and mineral salts.
- The vessels produced during these season are larger and wider than those produced in the Winter and Fall.

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- Xylem elements of spring wood are larger, thin walled and lighter in color.
- In winter and Fall seasons less amount of xylem elements is produced.
- These xylem elements are smaller, thick walled and darker in color.

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- The xylem (wood) formed during the spring and the Summer is called Early wood or spring wood
- The xylem formed during the winter and fall is called Late wood or Fall wood

These two kinds of wood appear together called Annual ring or growth ring .

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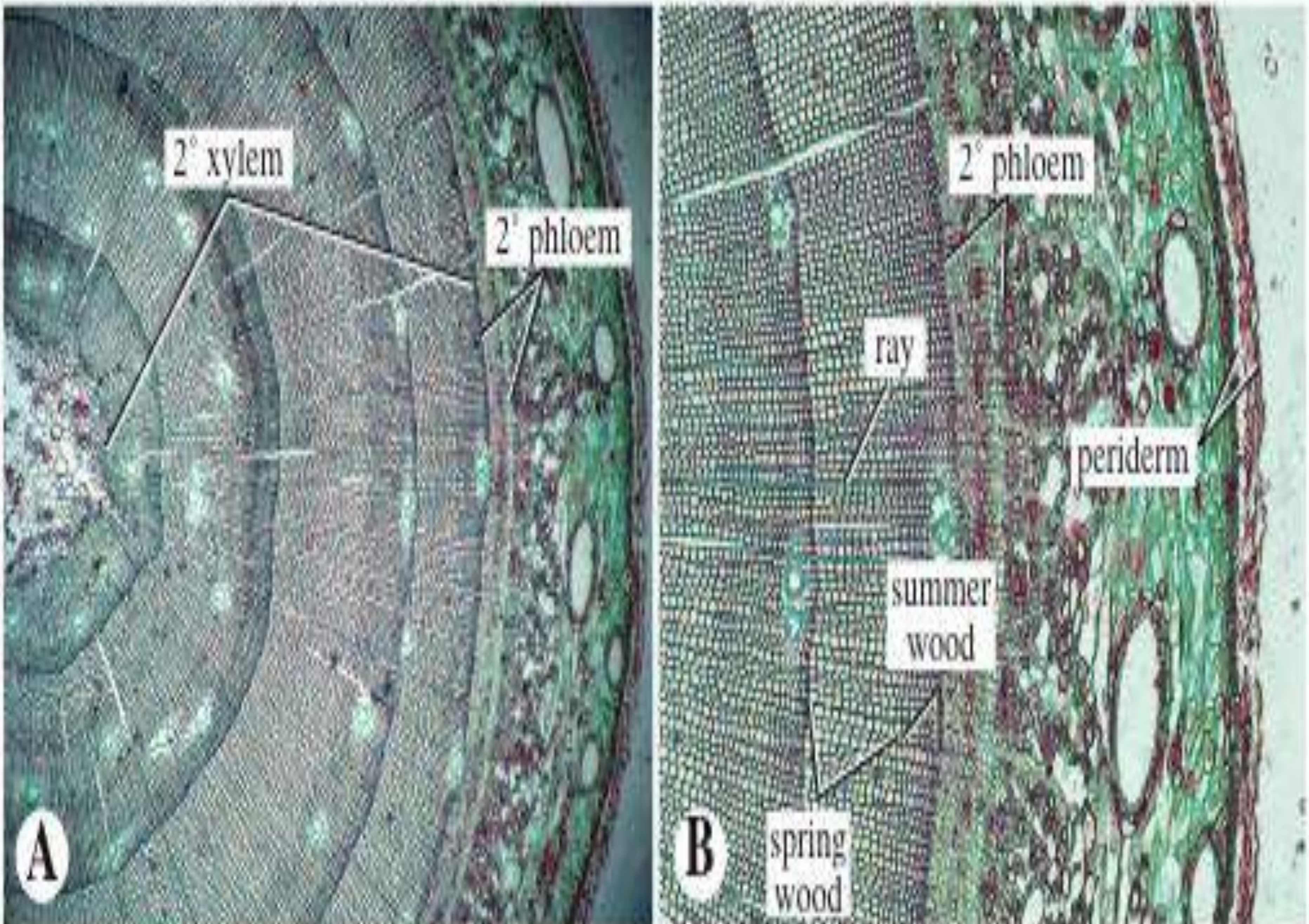
- Each annual ring refers to one year growth.
- The age of the plant can be calculated.
- The determination of the age of a tree by counting the annual ring is called Dendrocronology

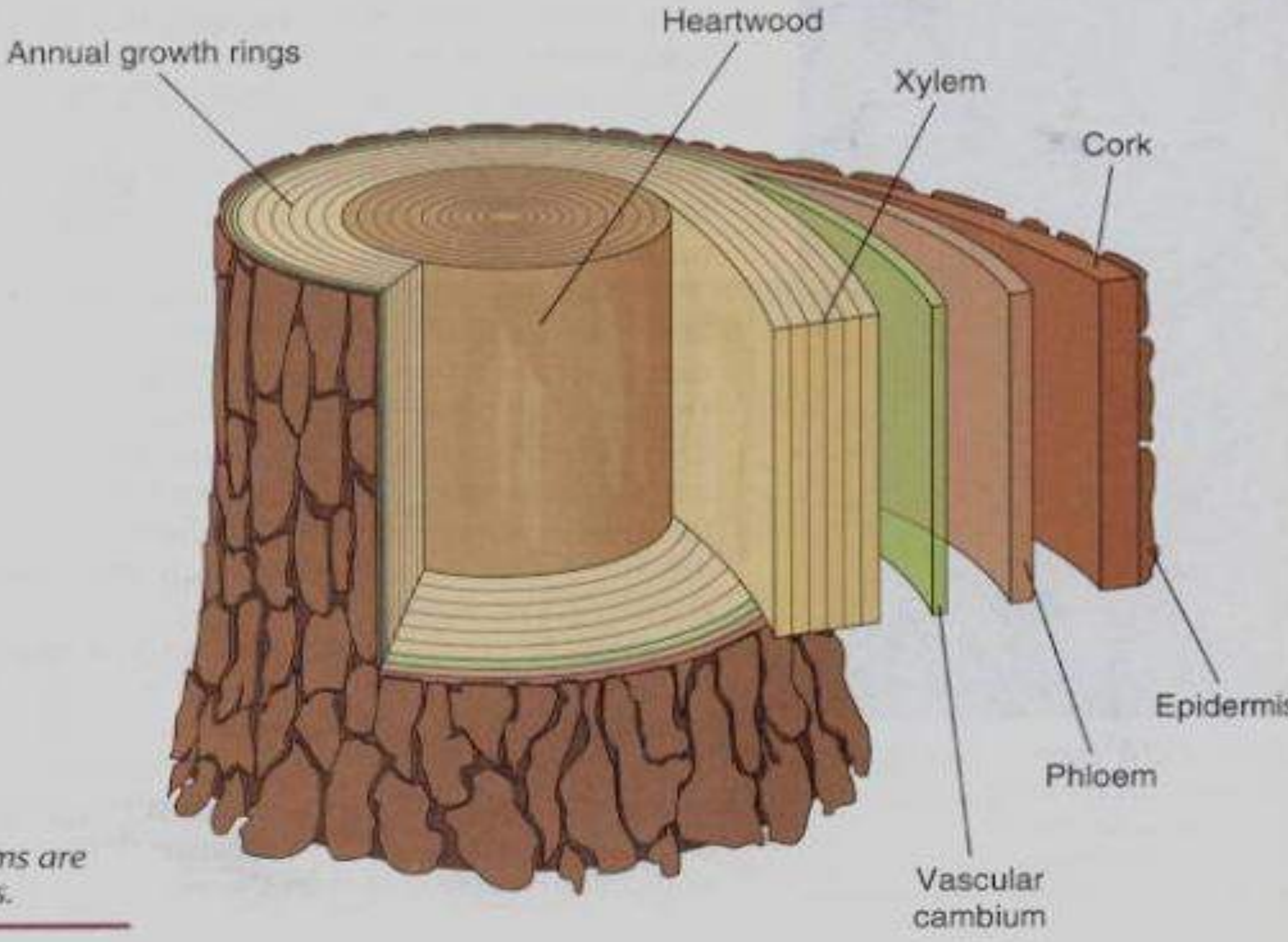
.

Annual Rings

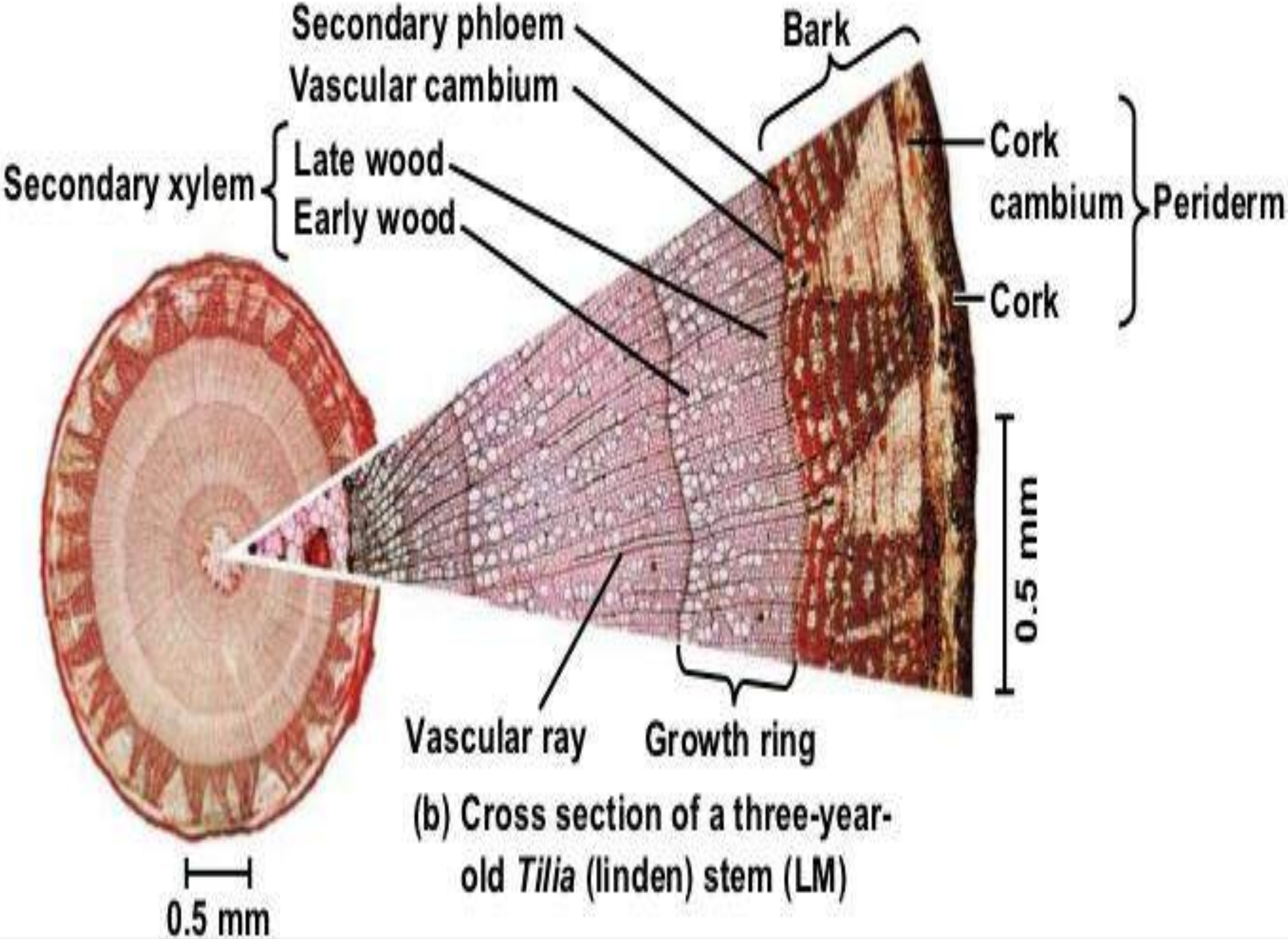
- Concentric rings of secondary xylem
- Alternating bands of early and late wood
- Early wood
  - Xylem cells with large diameter, thin walls
- Late wood
  - Xylem cells with smaller diameter, thicker walls



2° xylem
2° phloem
A
2° phloem
ray
periderm
summer wood
spring wood
B



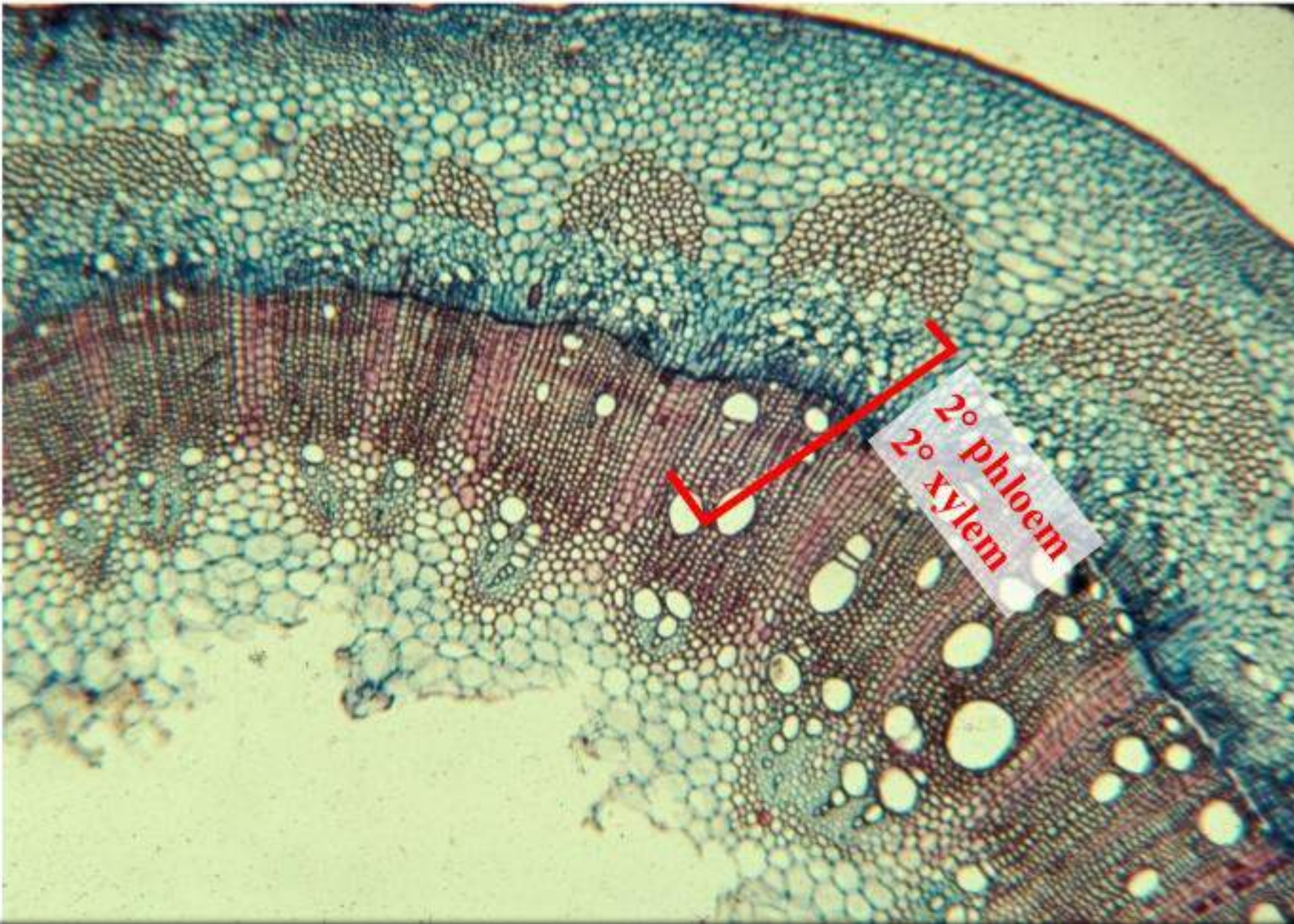
stems are
yers.



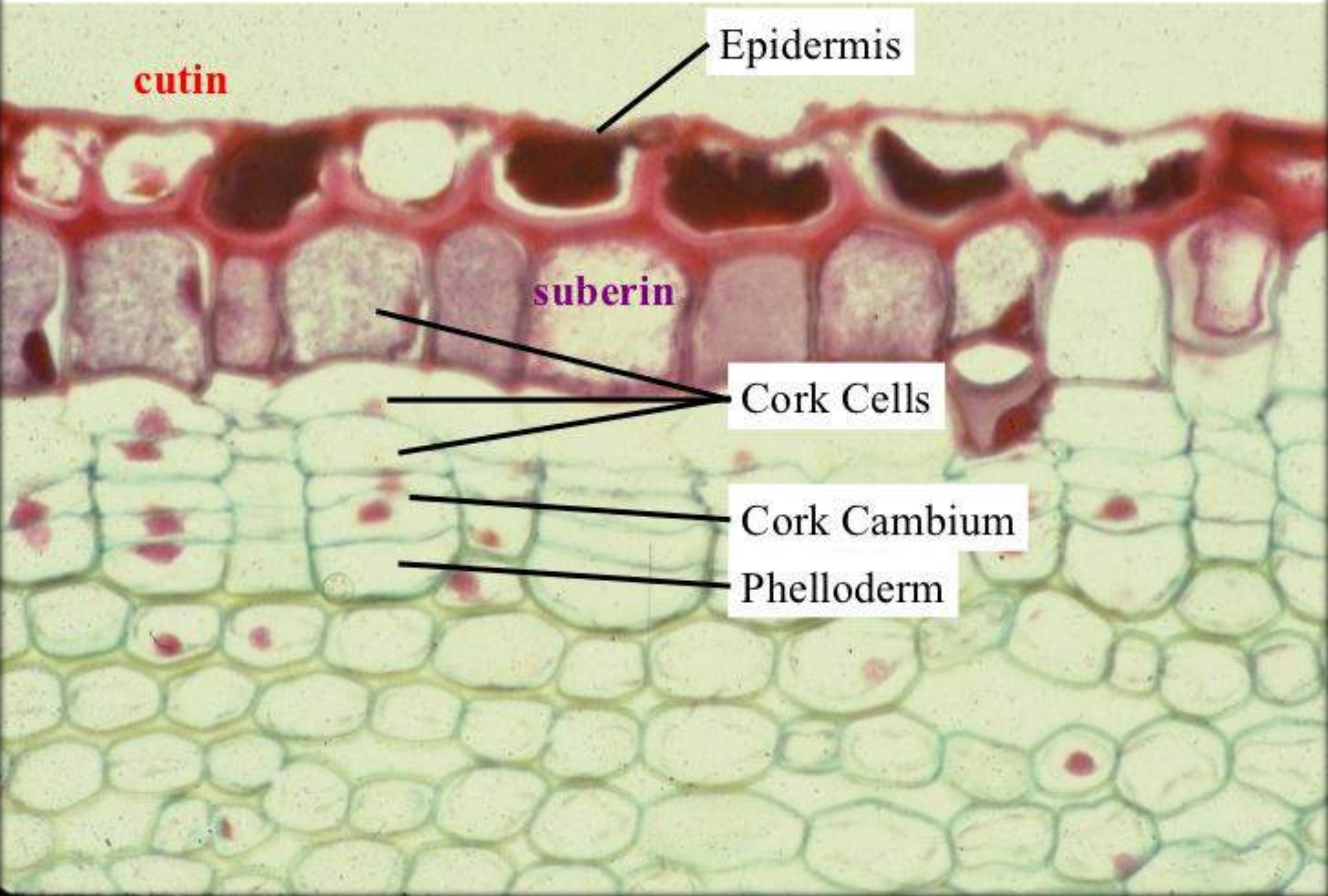
(b) Cross section of a three-year-old *Tilia* (linden) stem (LM)

The vascular cambium makes 2° tissues:

Vitis vinifera - grape



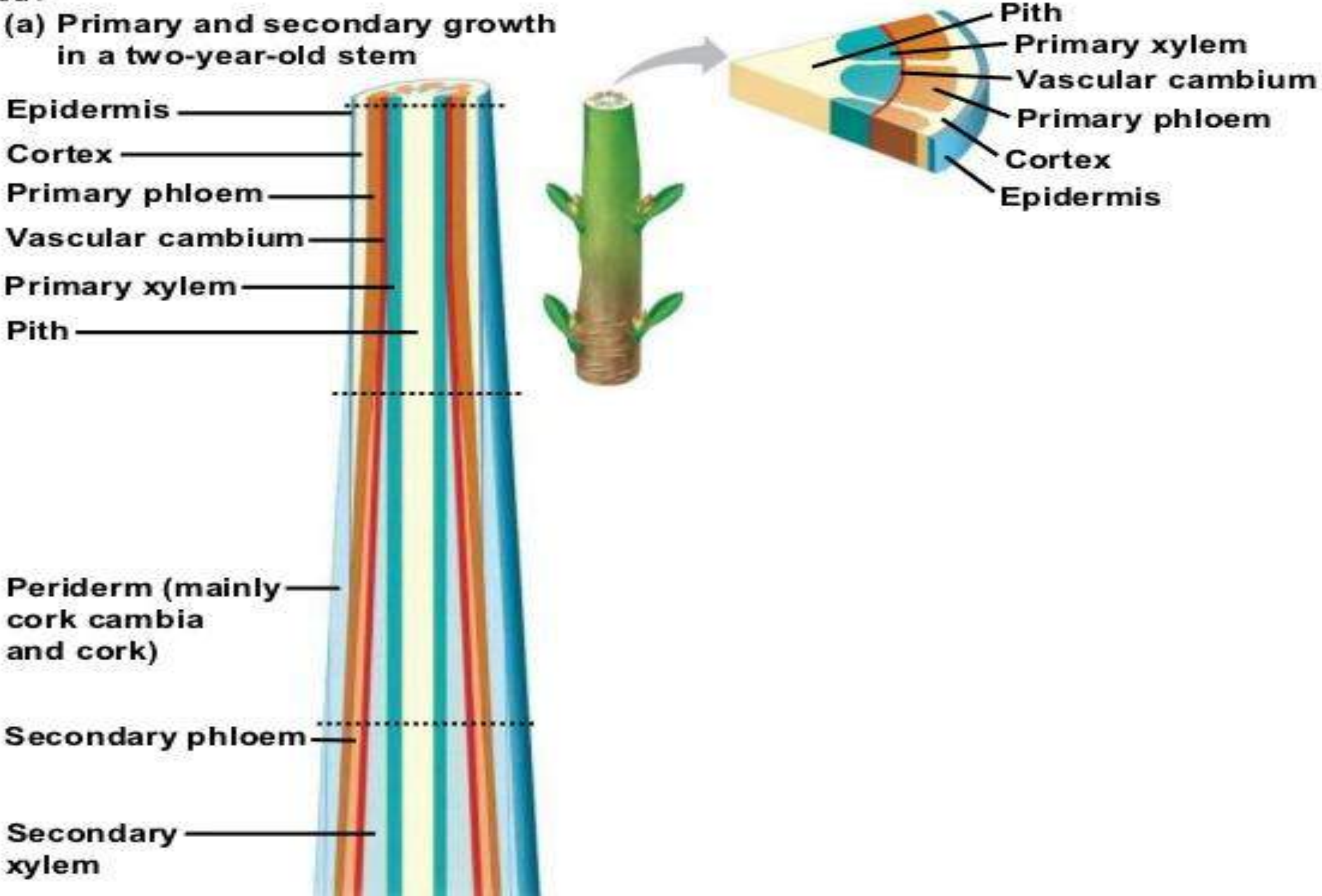
A cork cambium differentiates and produces a periderm.



Primary and secondary growth

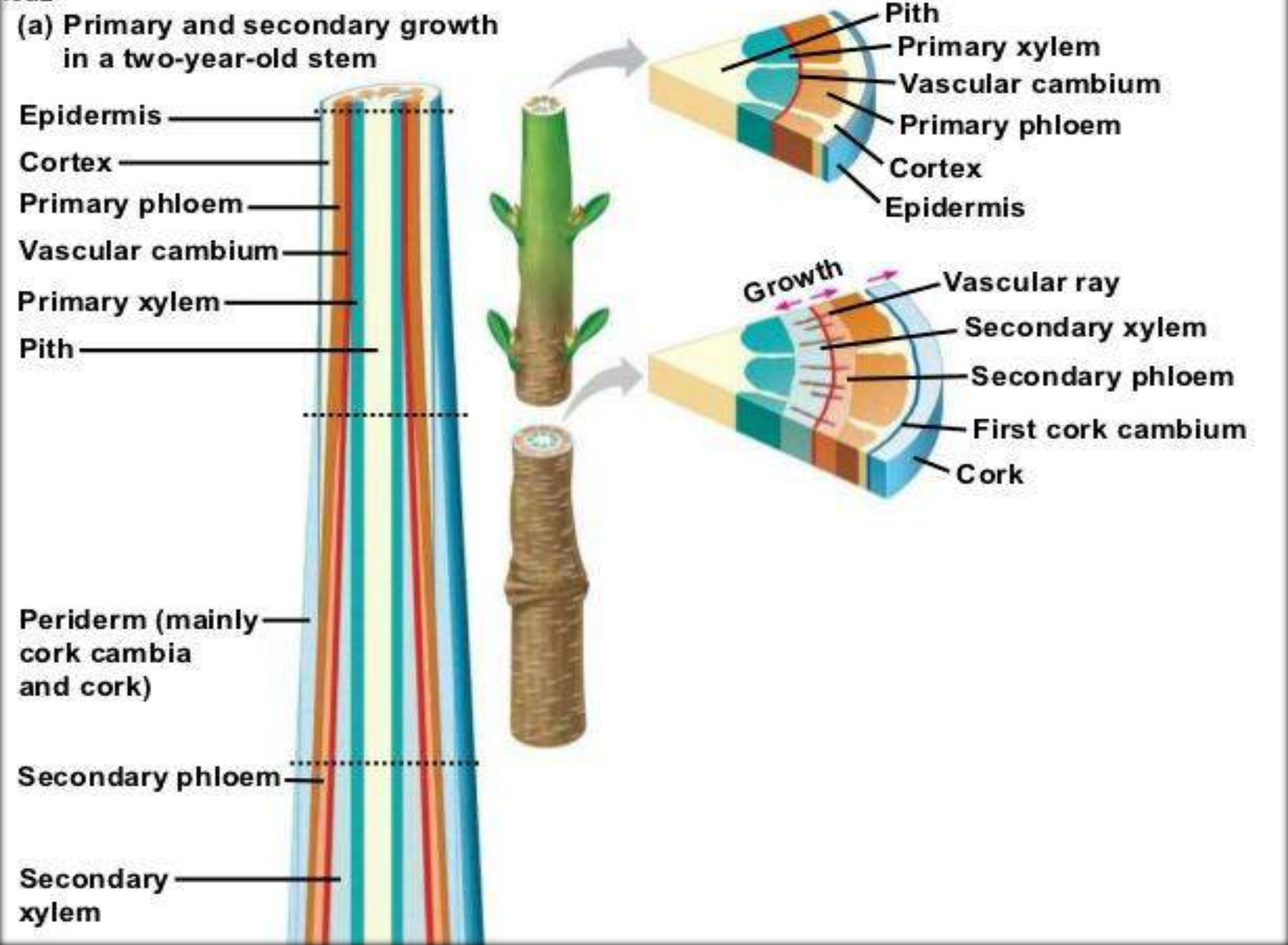
Fig. 35-19a1

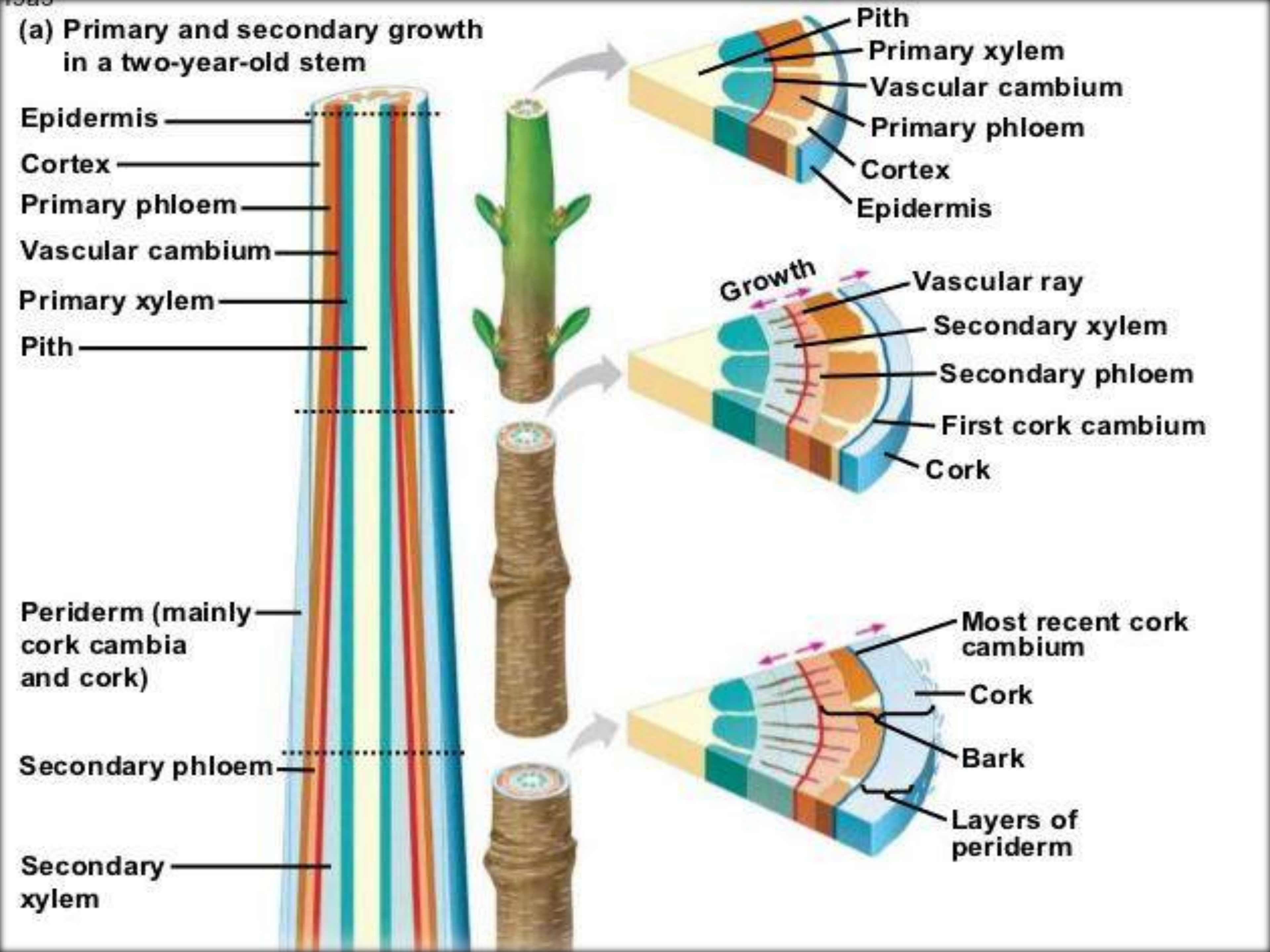
(a) Primary and secondary growth in a two-year-old stem



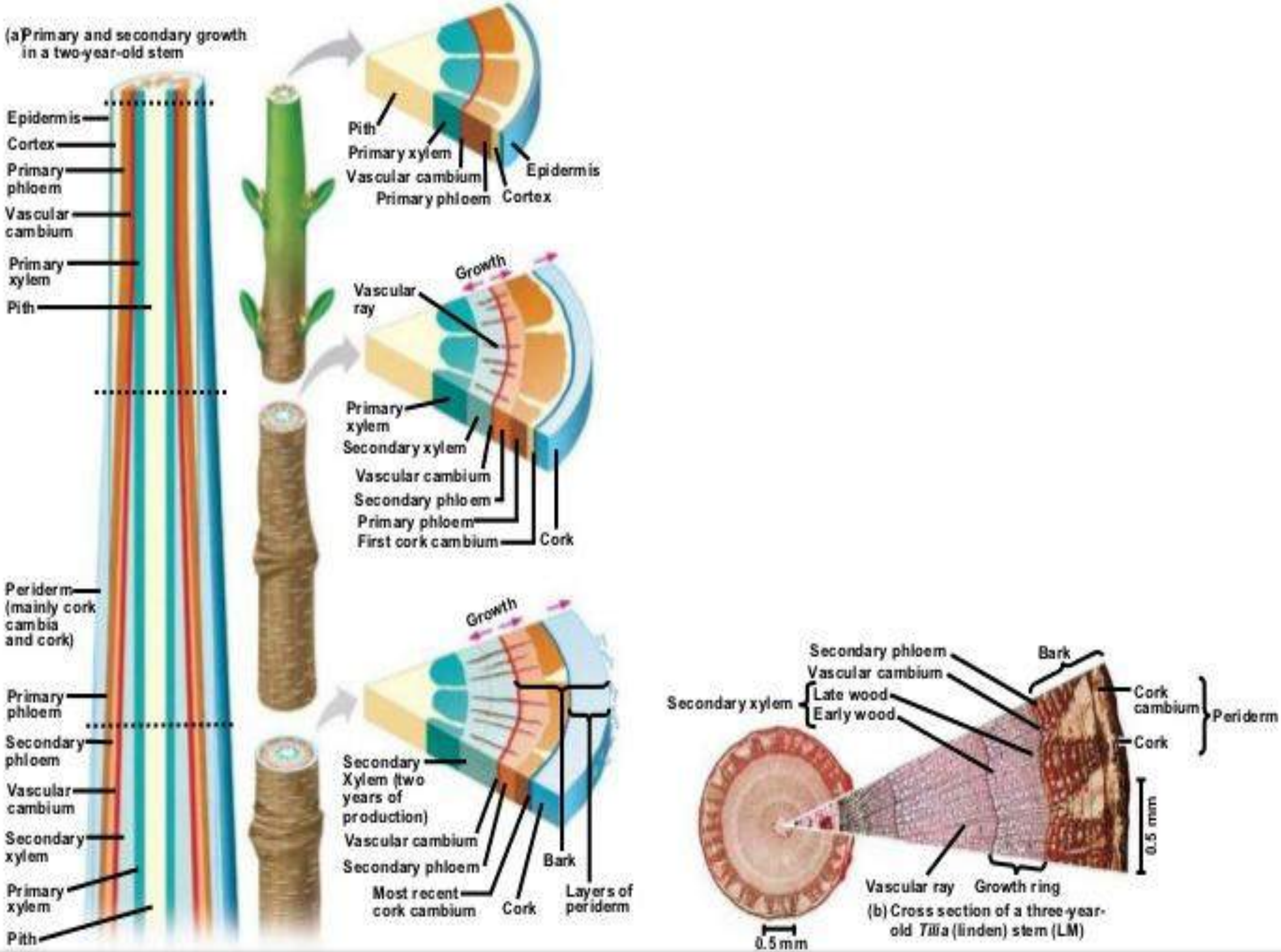
19a2

(a) Primary and secondary growth in a two-year-old stem





(a) Primary and secondary growth in a two-year-old stem
Epidermis
Cortex
Primary phloem
Vascular cambium
Primary xylem
Pith
Periderm (mainly cork cambia and cork)
Secondary phloem
Secondary xylem
Pith
Primary xylem
Vascular cambium
Primary phloem
Cortex
Epidermis
Growth
Vascular ray
Secondary xylem
Secondary phloem
First cork cambium
Cork
Most recent cork cambium
Cork
Bark
Layers of periderm



(a) Primary and secondary growth in a two-year-old stem

(b) Cross section of a three-year-old *Tilia* (linden) stem (LM)

Bark =

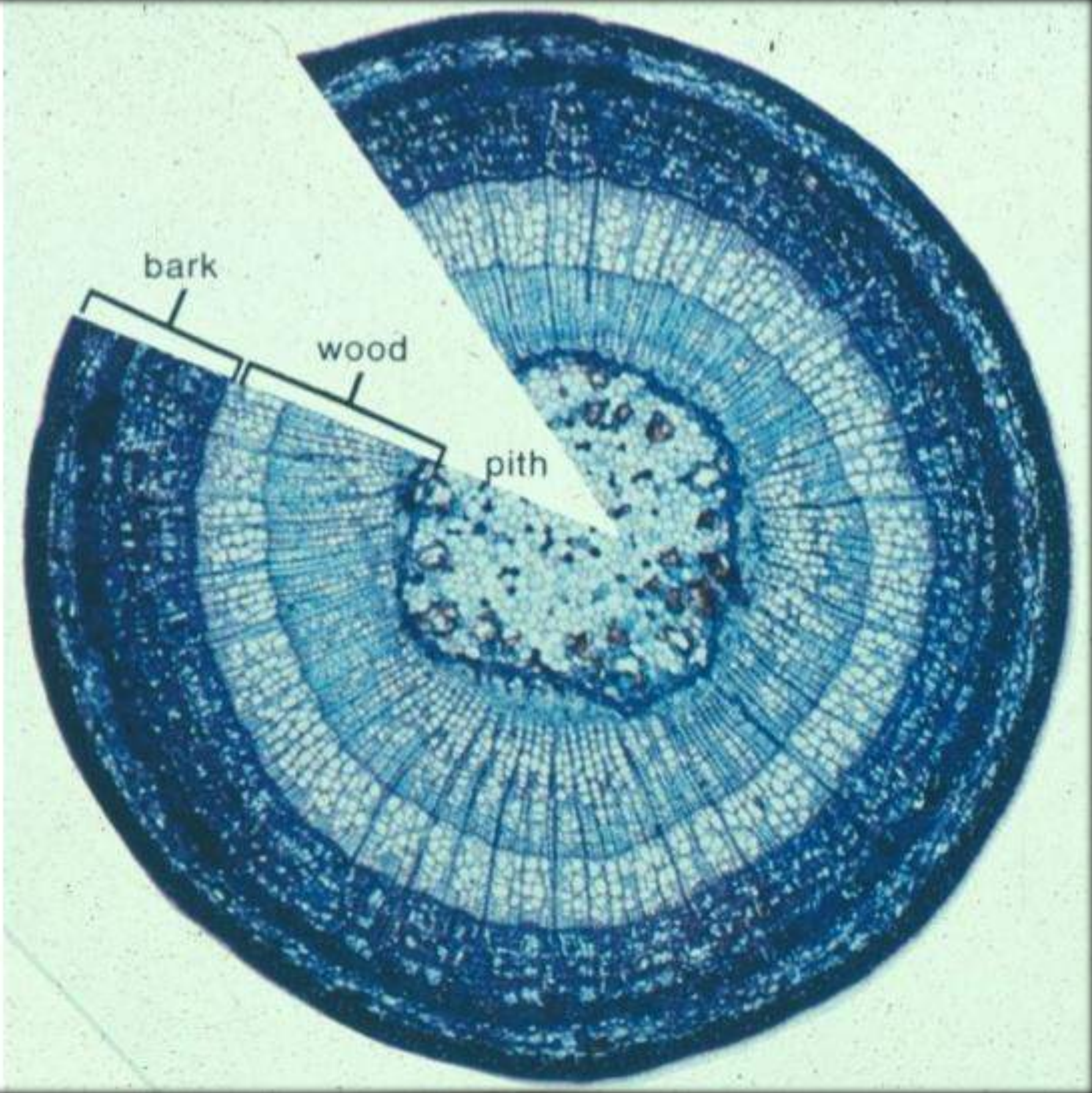
epidermis +
periderm +
cortex +
phloem +
vascular
cambium

Wood =

secondary
xylem only!

Pith =

a small
percentage of
tree diameter
at maturity



Lenticels

- are the lense shaped openings or breaks in the cork tissue.
- They are formed due to the rupture in the epidermal layers during
- The secondary growth.
- Lenticels are useful in
- Exchange of gases.

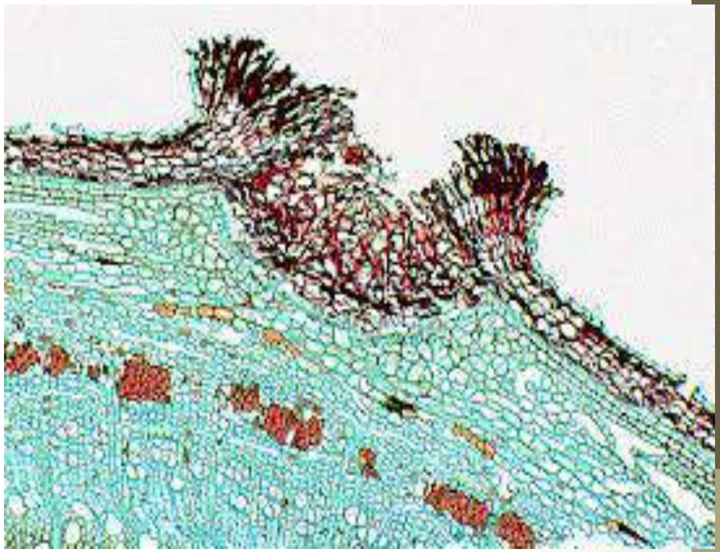


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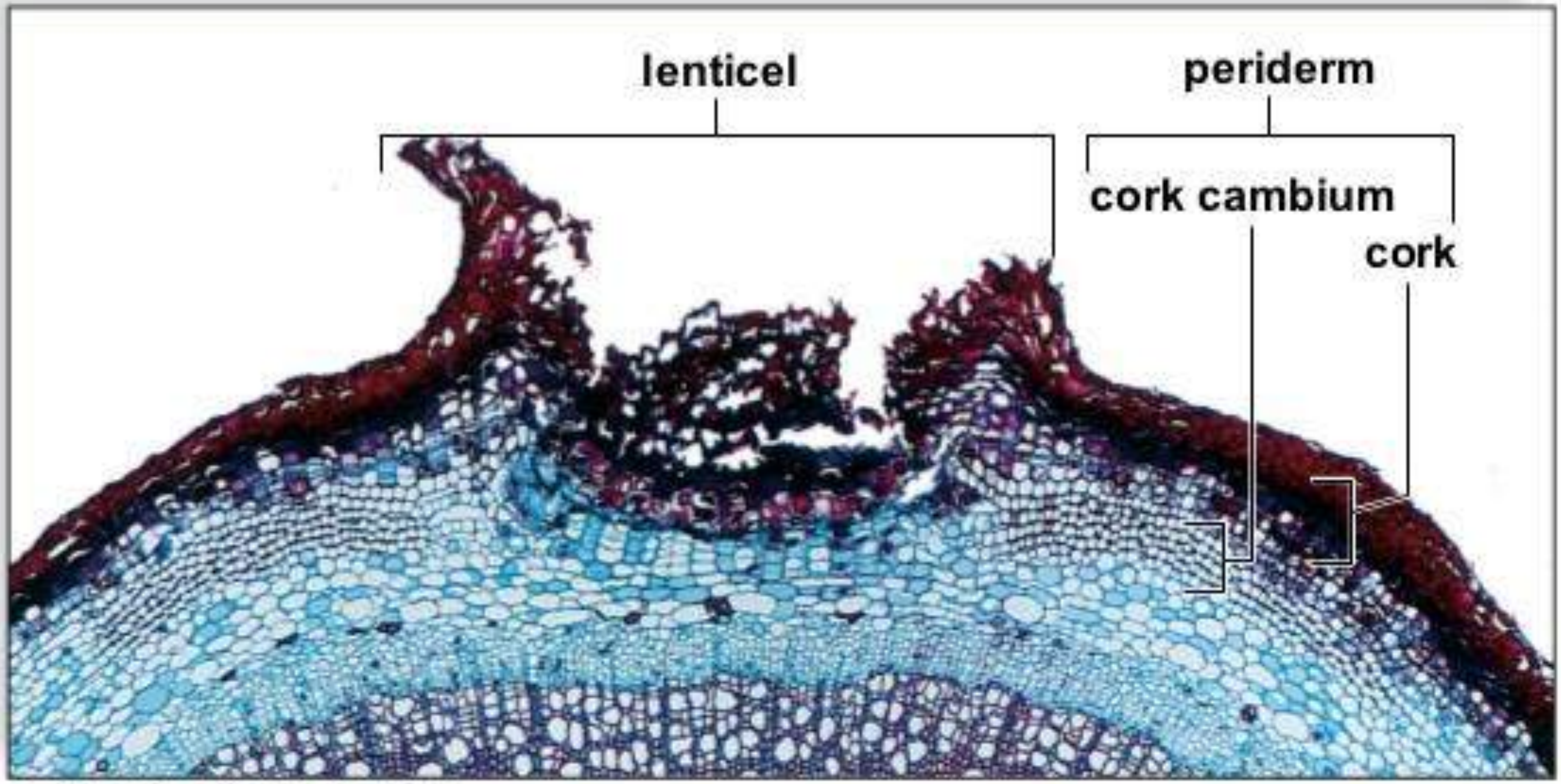
Figure 21.3A Modifications of epidermal tissue (Cont.)



c. Cork of older stem

3- The root

- The root is the organ of a plant that typically lies below the surface of the soil.
- The root is best defined as the non- leaf, non- nodes bearing parts of the plant body.
- The first root that comes from the plant is called Radical.

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Functions of the root

- 1- Absorption of water and inorganic nutrients.
- 2- Anchoring of the plant body to the ground, and supporting it.
- 3- Storage of food and nutrient.
- 4- Vegetative reproduction.

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Root morphology is highly variable

- most dicotyledonous plants (those with 2 seed leaves) have a prominent primary root
- monocots (with one cotyledon or seed leaf) typically have a more diffuse fibrous root system

Roots

- Root Systems:
  - Fibrous: A system that has no dominant primary root.
  - Tap: A system composed of one primary root and many secondary roots that branch off.

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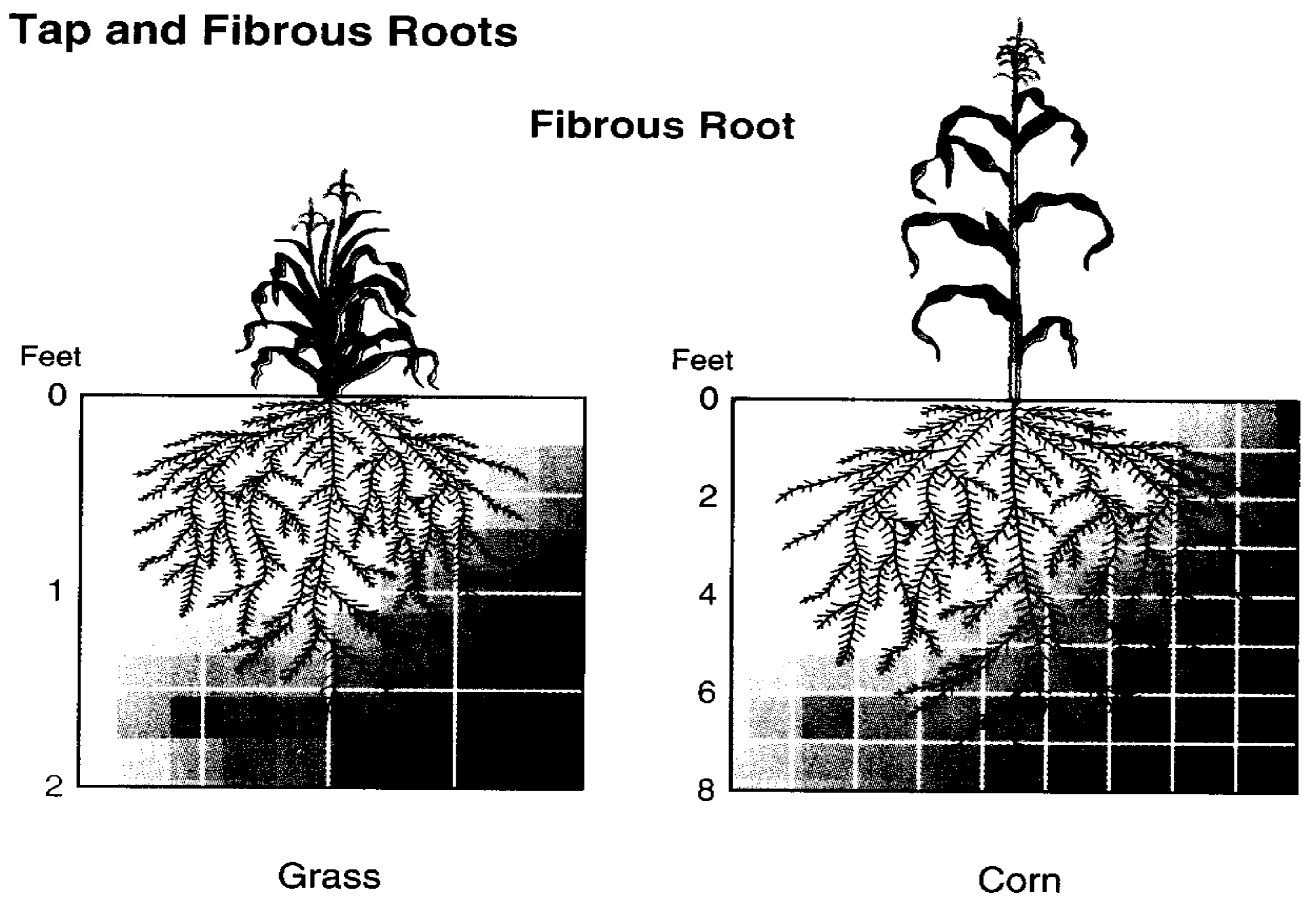
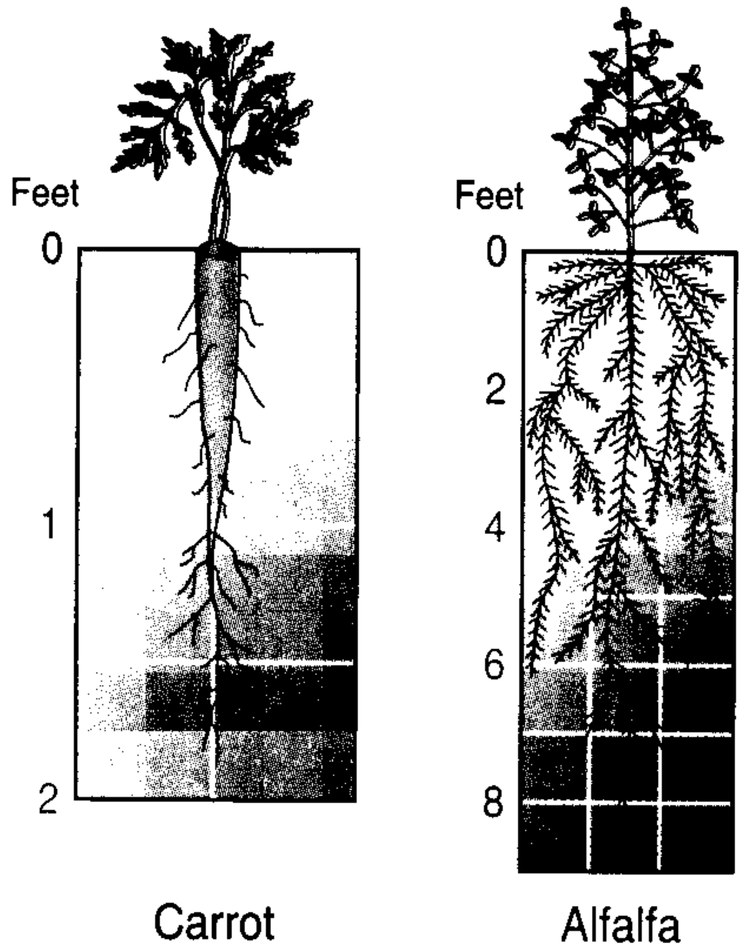
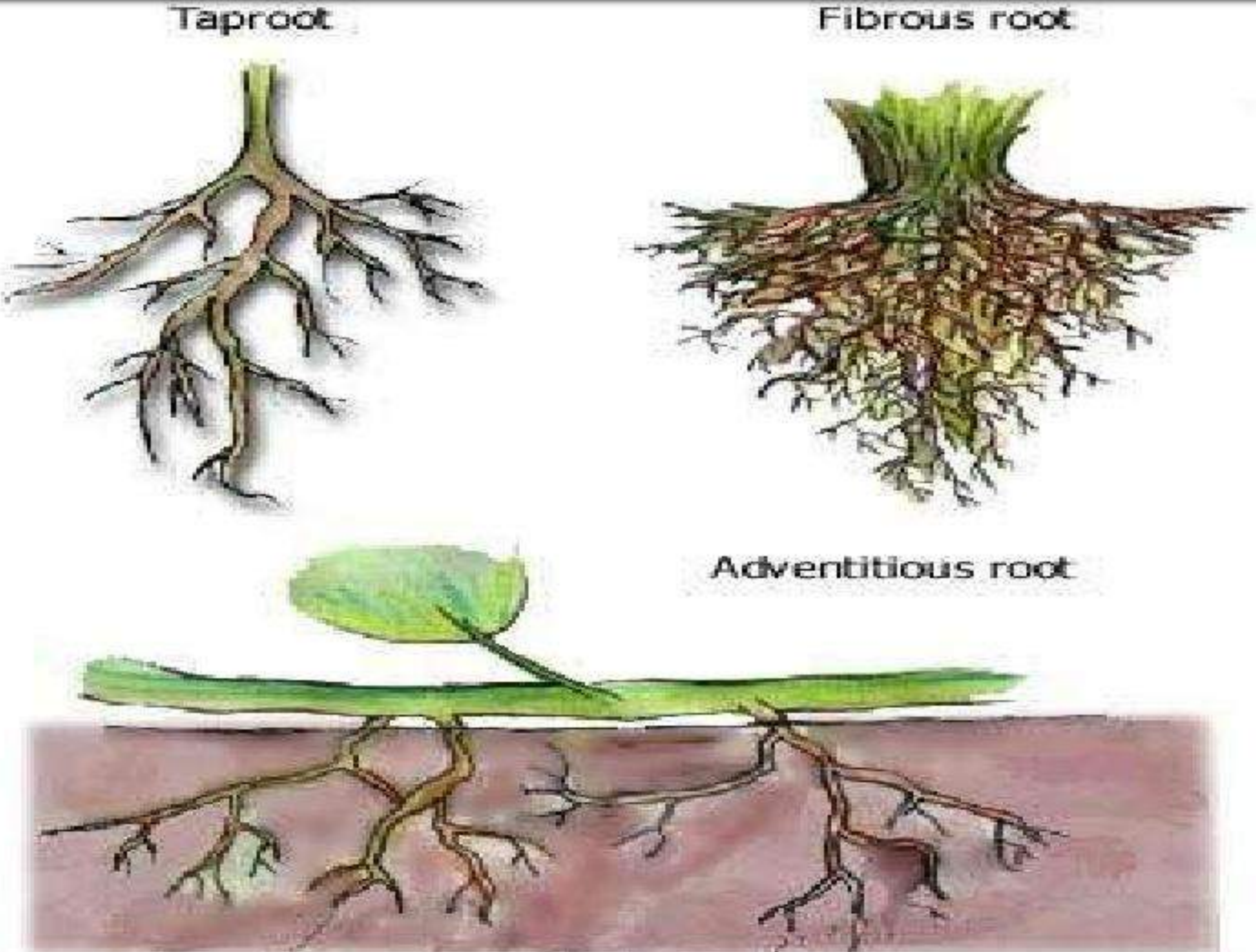
Fibrous



Tap and Fibrous Roots
Fibrous Root
Feet
0
1
2
Grass
Feet
0
2
4
6
8
Corn

Tap Roots




Taproot
Fibrous root
Adventitious root

Regions of a root

- 1- Root cap.
- 2- Root tip.
- 3- Region of elongation.
- 4- Region of differentiation (Root hair region.

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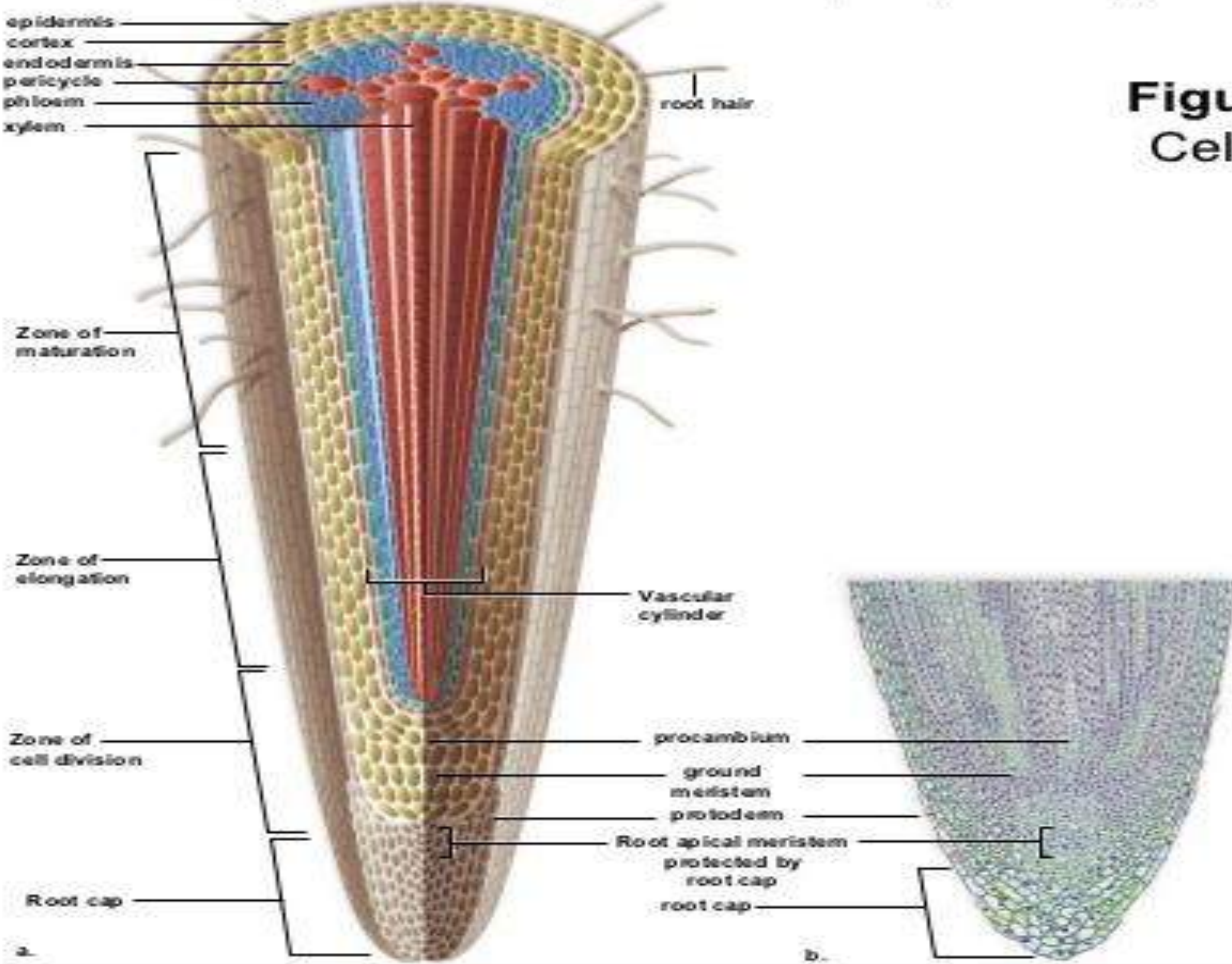
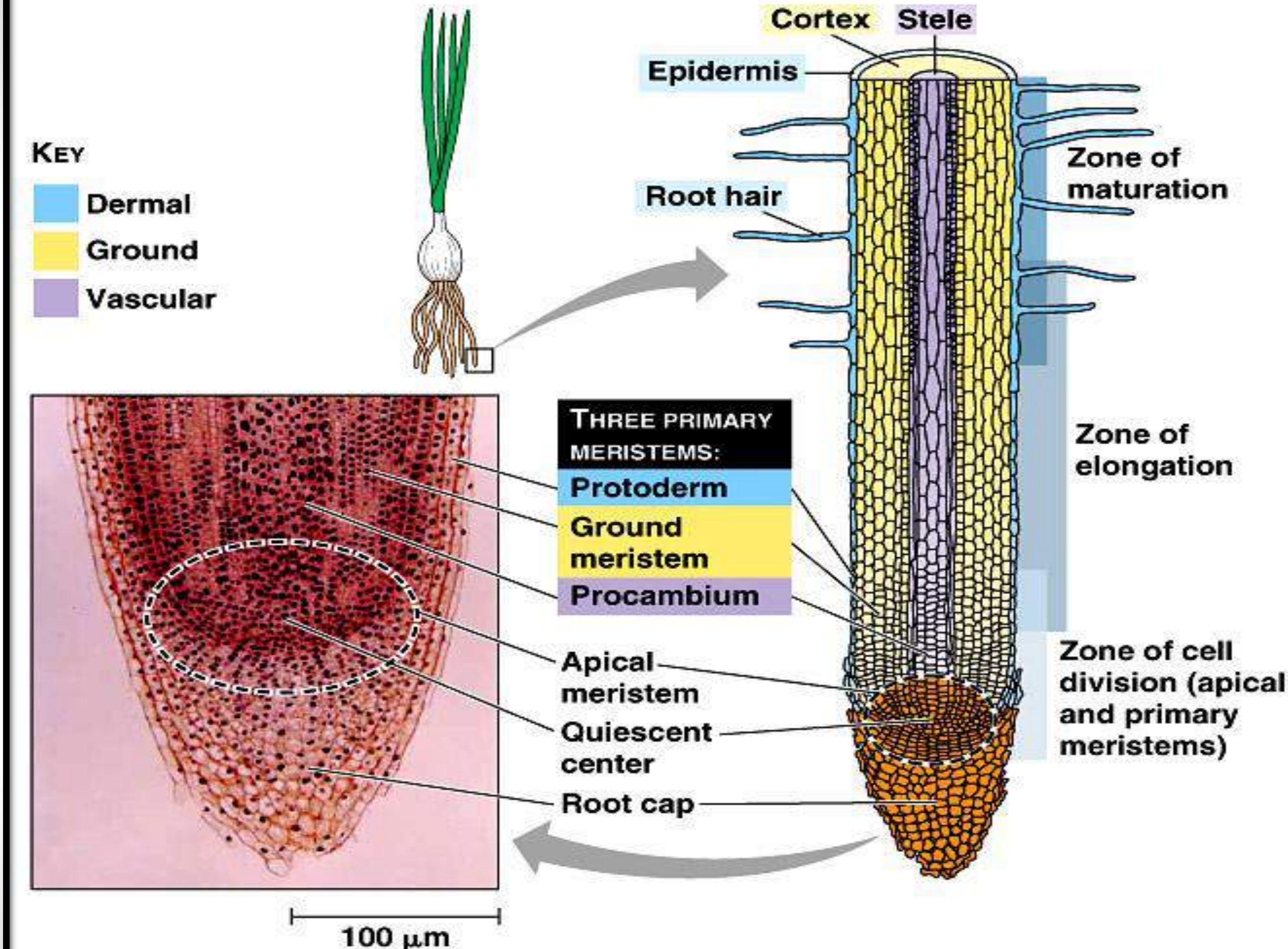
Figur

Cells



epidermis
cortex
endodermis
pericycle
phloem
xylem
root hair
Zone of maturation
Zone of elongation
Vascular cylinder
Zone of cell division
procambium
ground meristem
protoderm
Root apical meristem protected by root cap
Root cap
root cap
a.
b.



Key
Dermal
Ground
Vascular
Cortex
Stele
Epidermis
Root hair
Zone of maturation
Zone of elongation
Zone of cell division (apical and primary meristems)
Three primary meristems:
Protoderm
Ground meristem
Procambium
Apical meristem
Quiescent center
Root cap
100 μm

1- Root cap

- Thimble- shaped mass of parenchyma cells at the tip of each root.
- Protects the root from mechanical injury.
- Possibly important in perception of gravity.
- Amyloplasts appear to accumulate at the bottom of cells.

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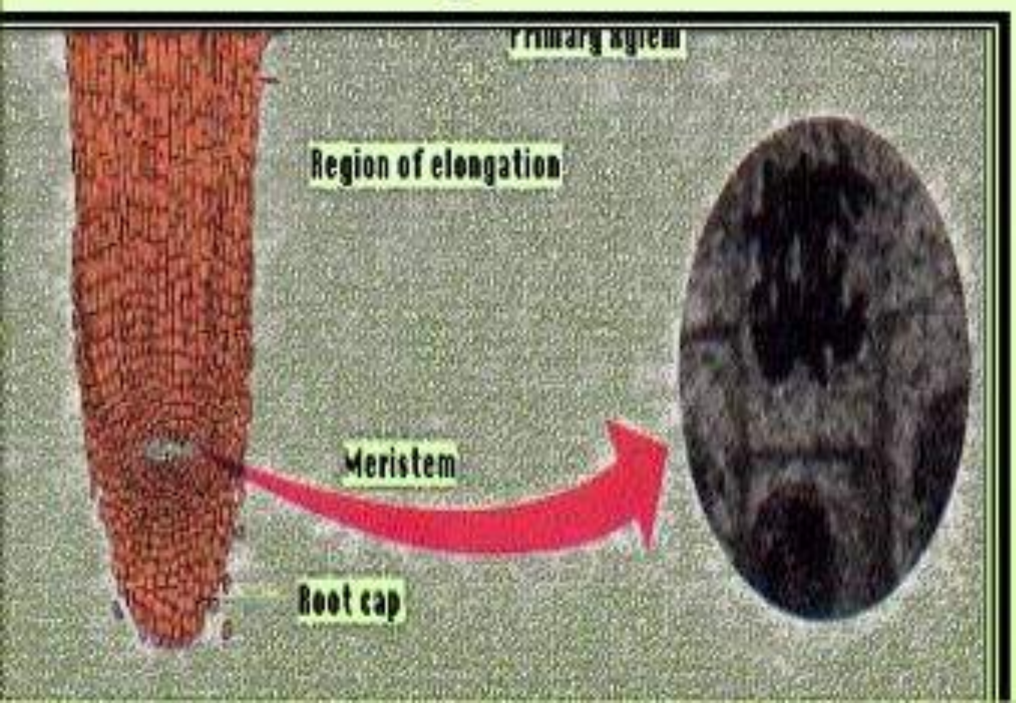
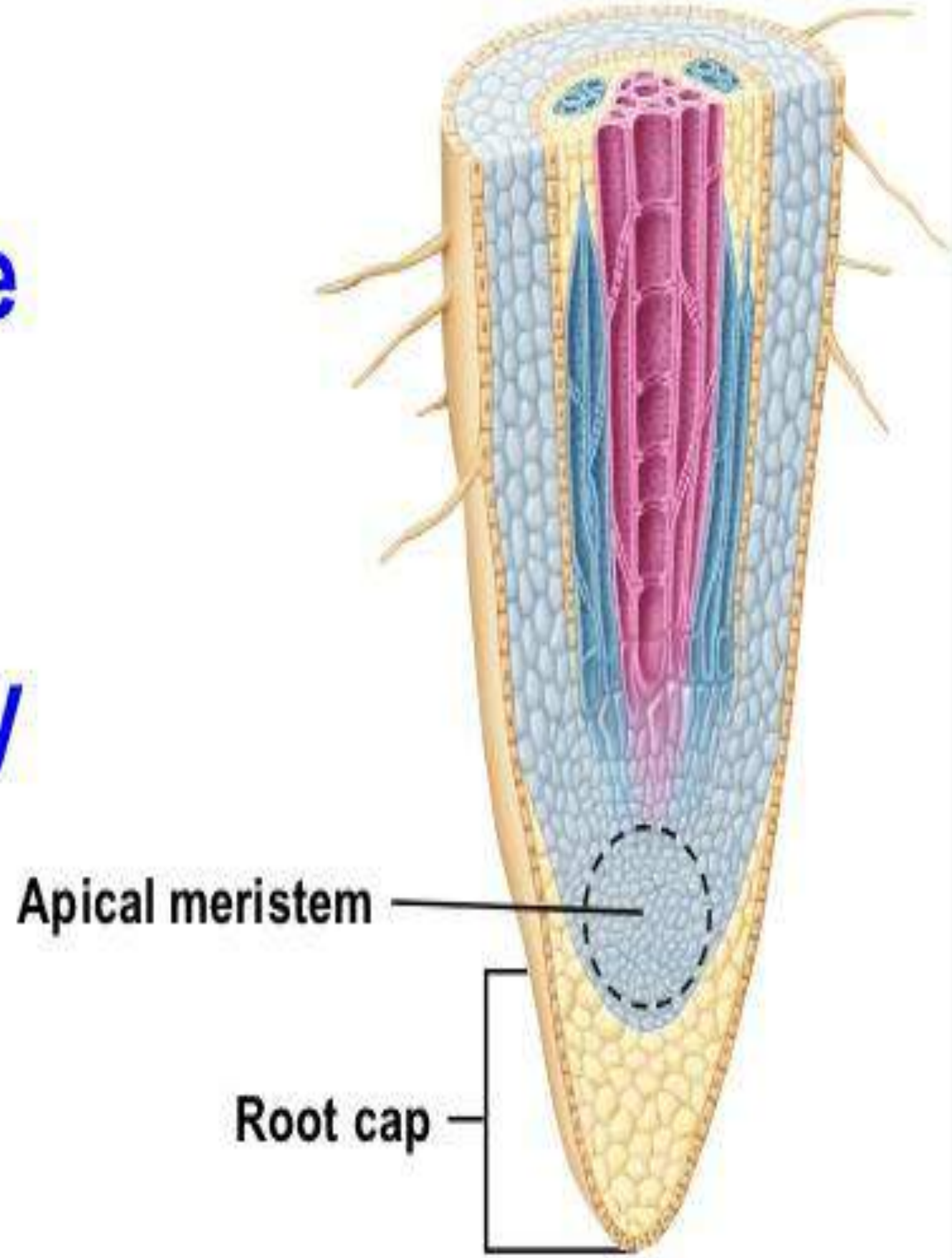
PARTS OF A ROOT

- Root Cap
  - a sheath of cells that protects the meristem from abrasion and damage as the root tip grows through the soil.



These new cells are covered by the root cap that protects the root as it forces its way through the soil.



2- Region of cell division (Root tip)

- Apical meristem – cells divide once or twice a day.
- The meristem include

The protoderm (which forms the epidermis).

The ground meristem (which forms the ground tissue).

The procambium (forms the primary phloem and xylem.

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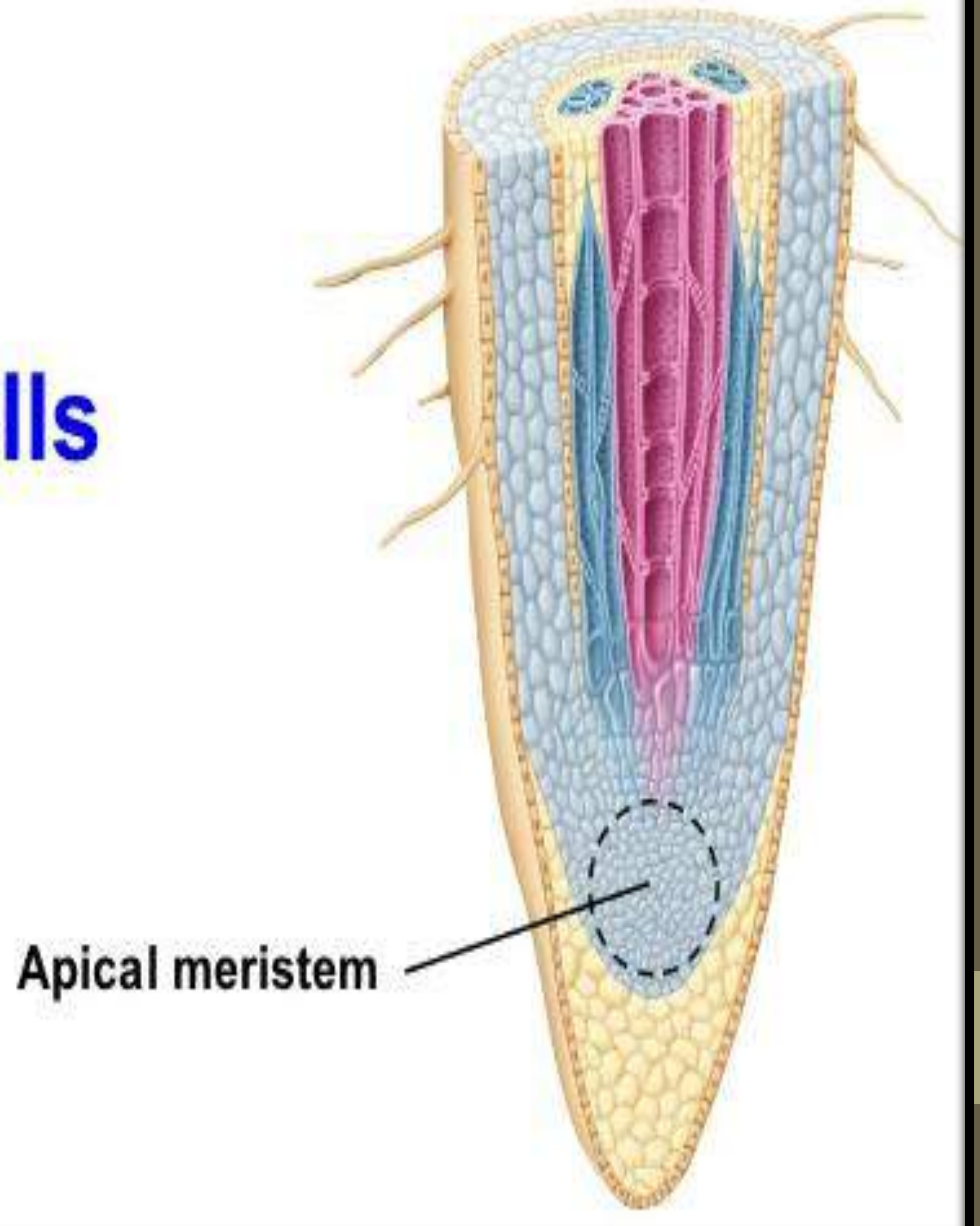
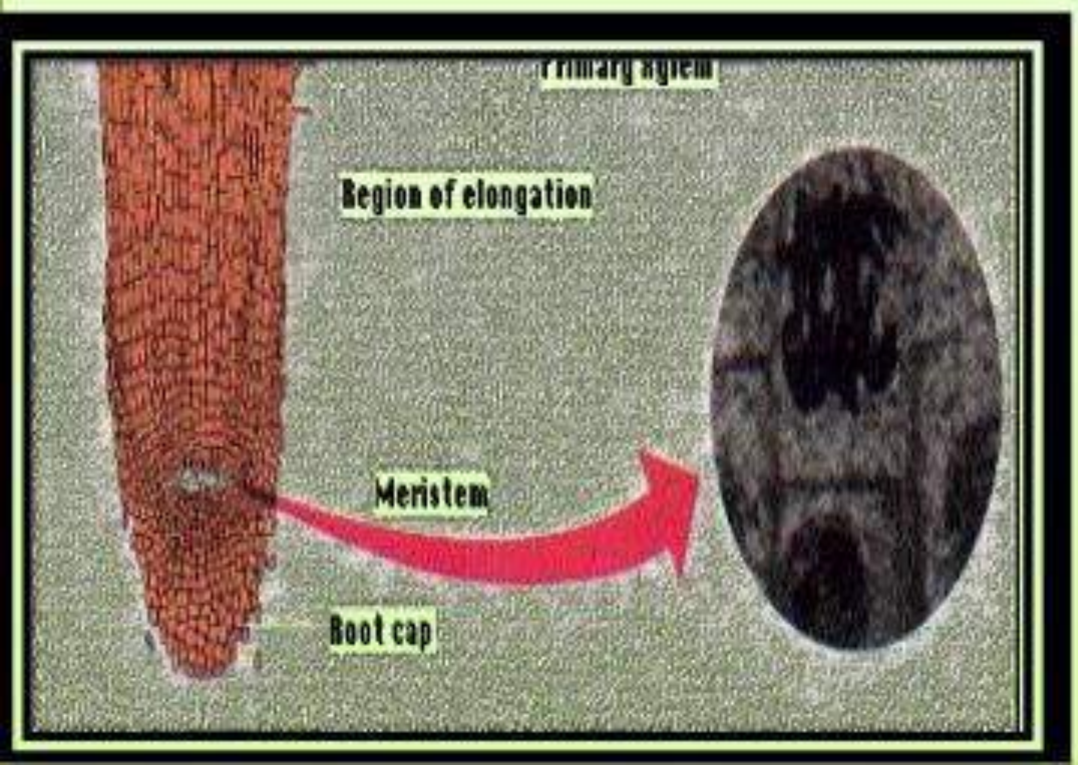
Roots grow in length as their apical meristem produces new cells near the root tip.

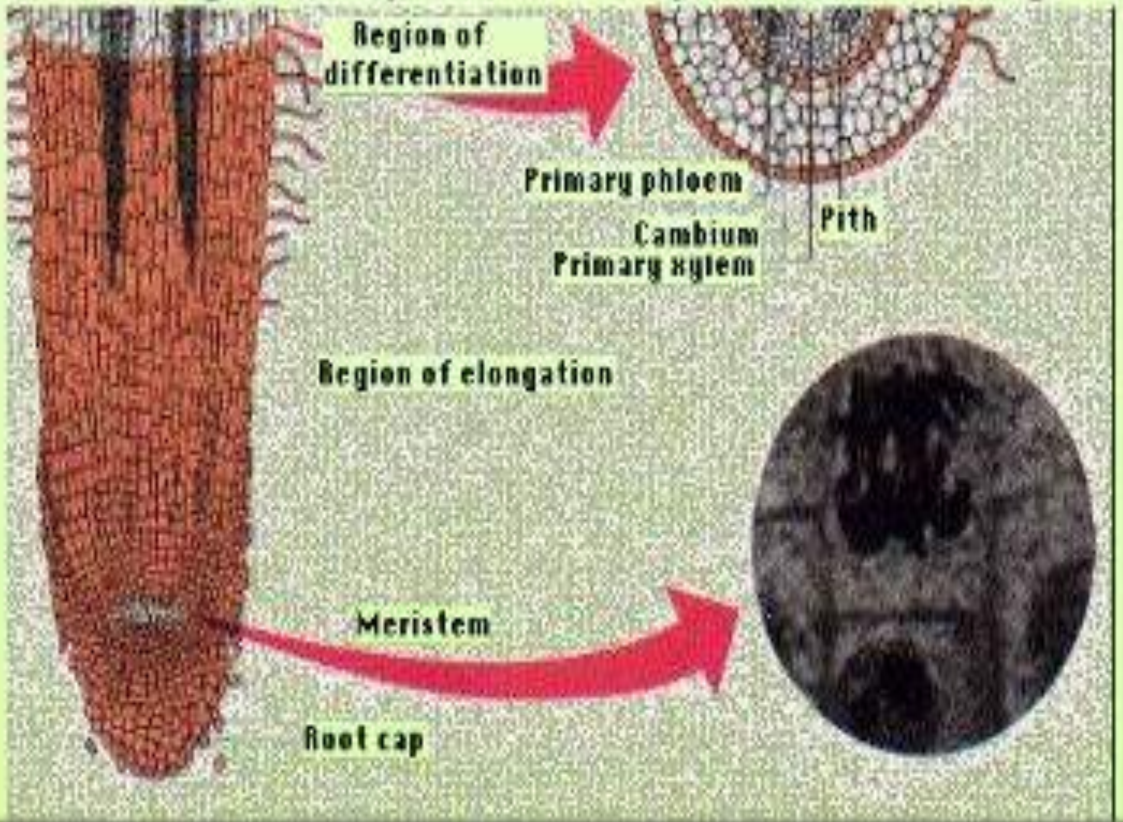


PARTS OF A ROOT

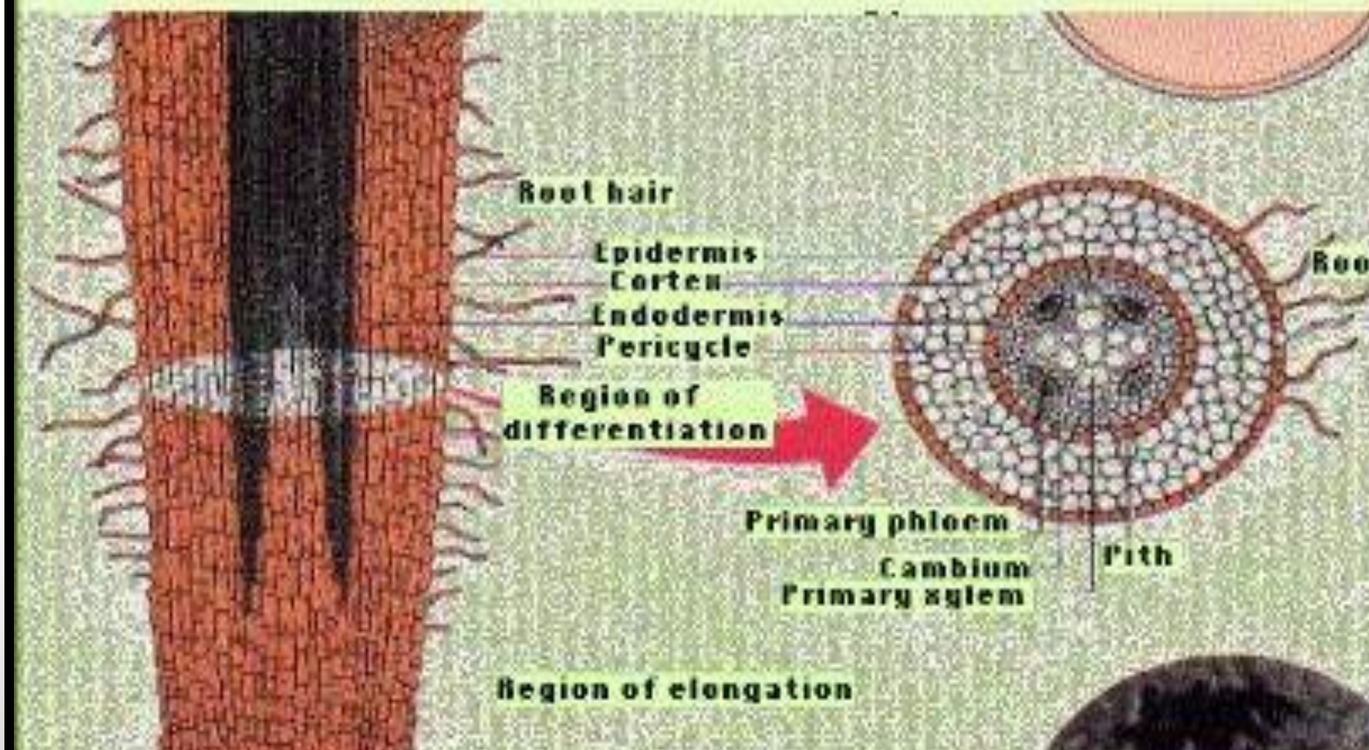
- Root Tip
  - Meristem- a region of rapid mitosis, which produces the new cells for root growth.



- The Region of Elongation
  - Here the cells produced by mitosis undergo a period of elongation in the direction of the axis of the root. It is at this time that they are sensitive to gravity and respond with **gravitropism**.



- **The Region of Differentiation**
  - Here develop the differentiated tissues of the root.



Internal structure of a root

- 1- Epidermis
- 2- Cortex
- 3- Endodermis
- 4- Pericycle
- 5- Vascular tissue

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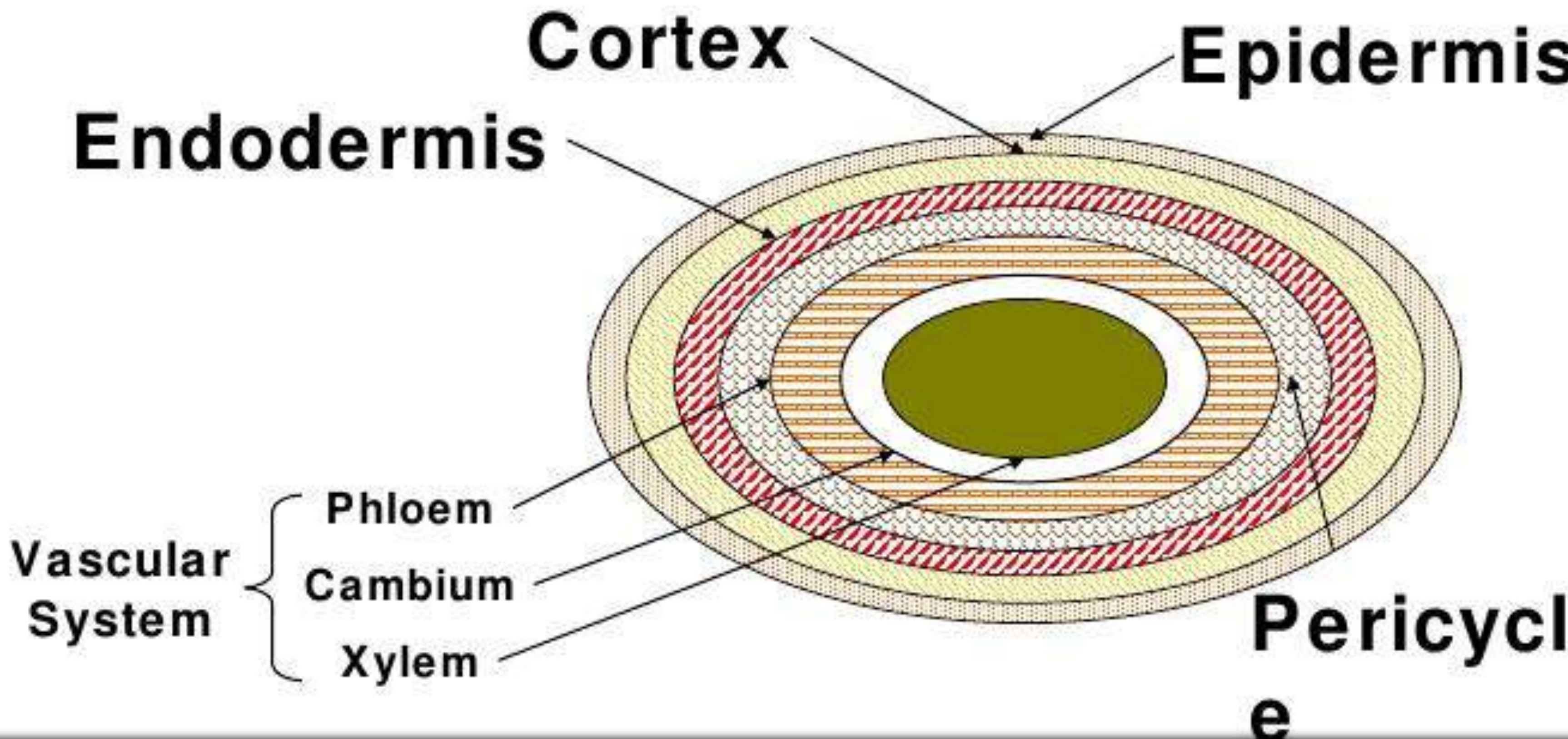
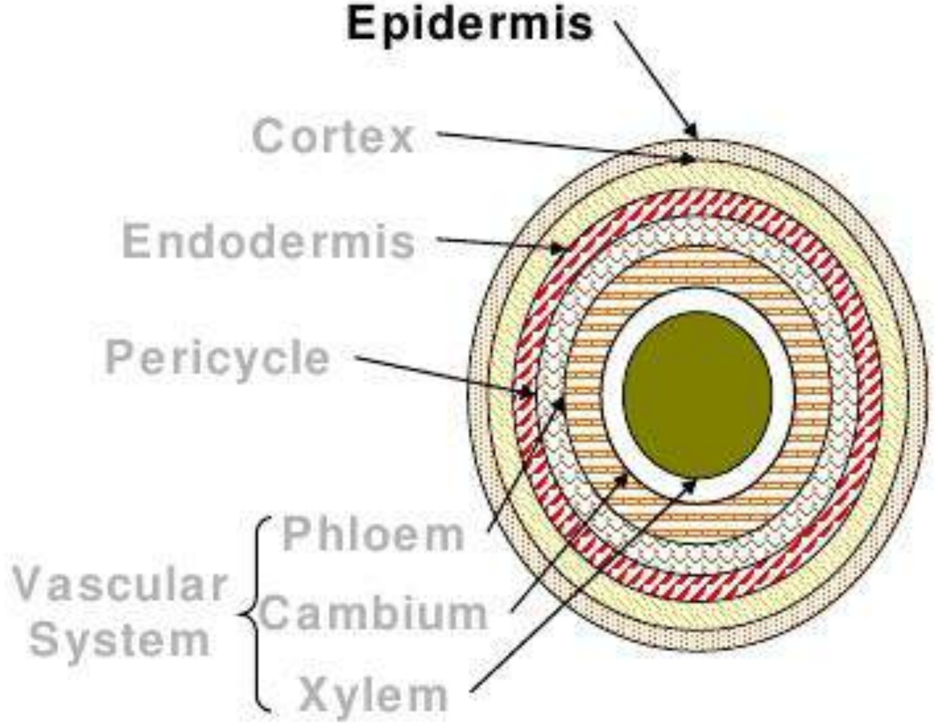
Tissues of the root

Root tissues can be regarded as a series of concentric rings of different tissues



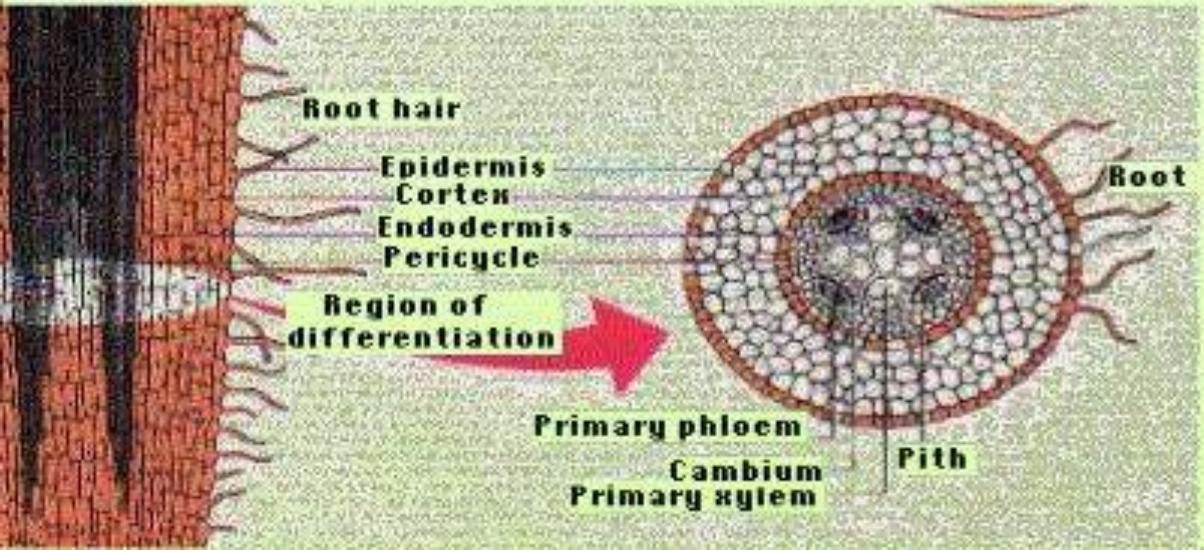
Epidermis

- Single layer of cells on the exterior of the root
- **NOT covered with a cuticle**
  - root is designed for water uptake
  - cuticle is a barrier to water

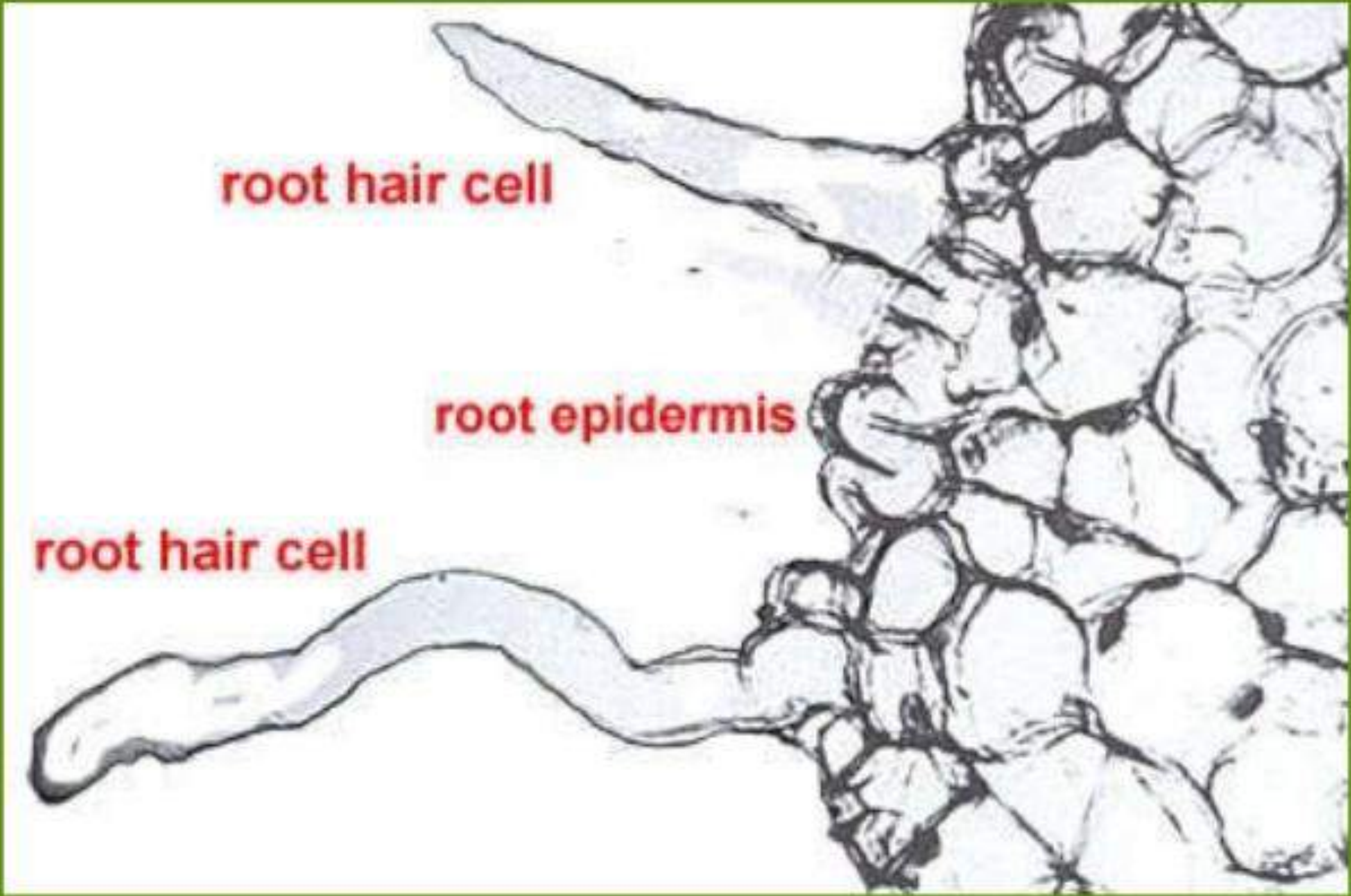


PARTS OF A ROOT

- Epidermis
  - A single layer of flattened cells at the surface. When first formed, epidermal cells have extensions - the **root hairs** - which greatly increase the surface area available for the **uptake of water** from the soil. The photo below shows the root hairs in the region of differentiation of a germinating radish seed.

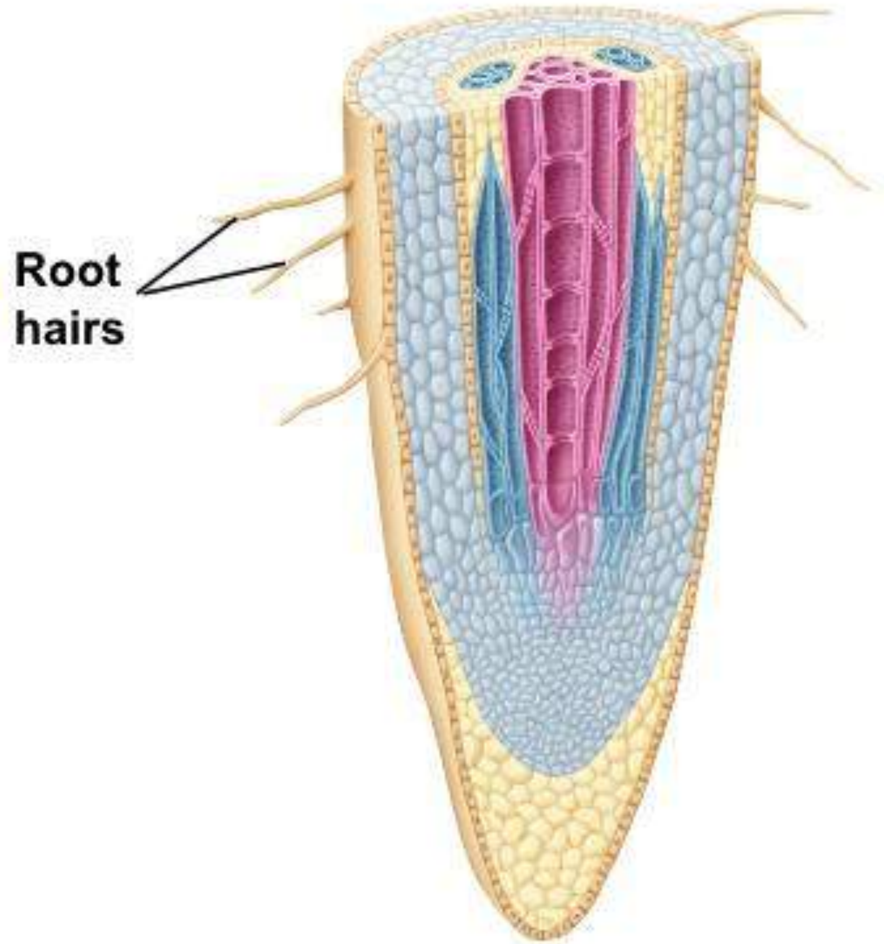


Root hairs:



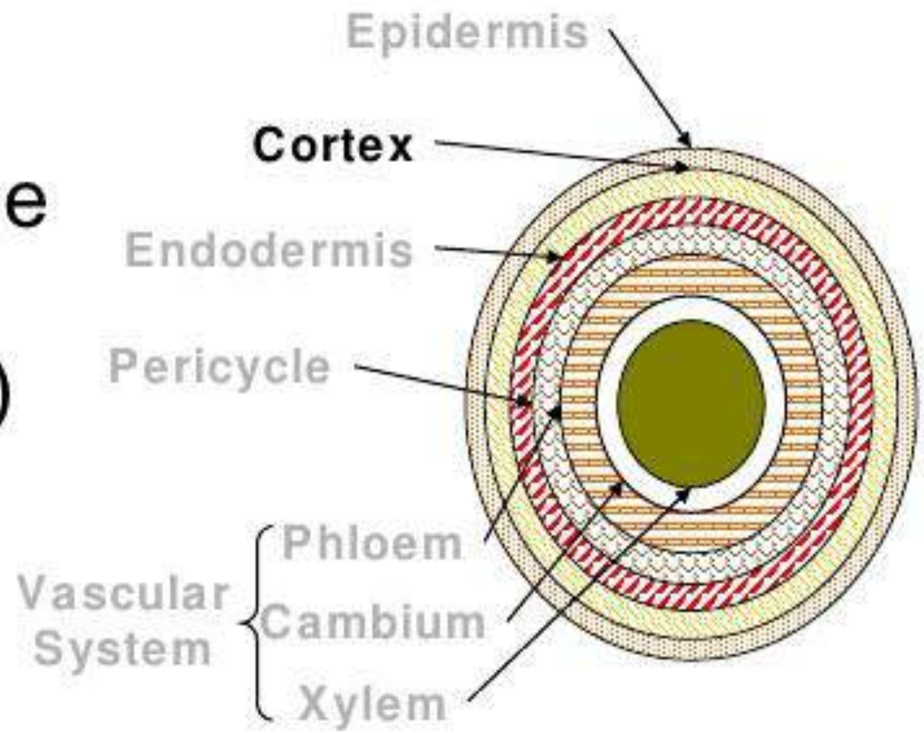
Root Structure and Growth

The root's surface is covered with cellular projections called root hairs. Root hairs provide a large surface area through which water can enter the plant.



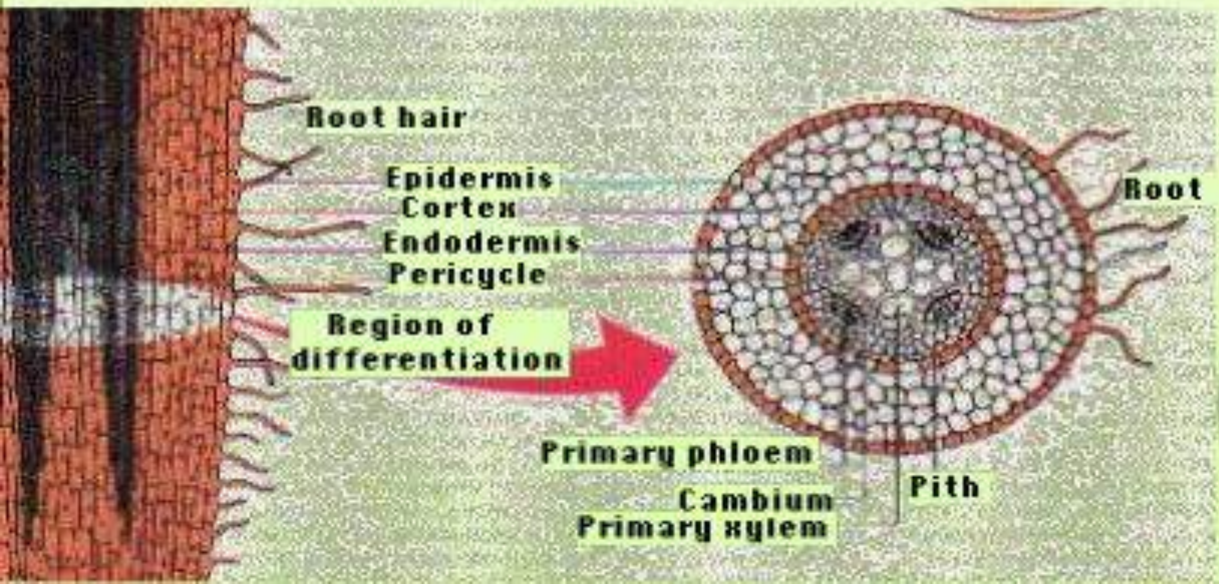
Cortex

- Comprised of large undifferentiated cells
- Functions in the storage of food reserves (proteins and starches) in root tissues



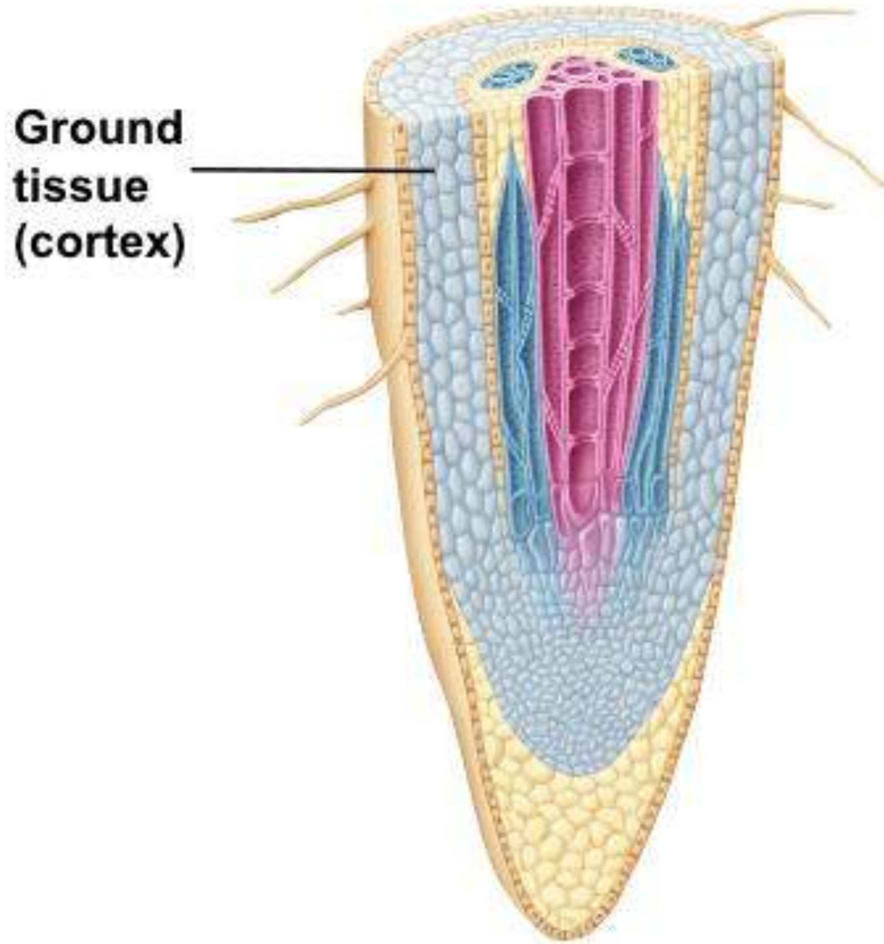
PARTS OF A ROOT

- Cortex
  - A band of parenchyma cells that develops beneath the epidermis. It stores food. Its inner surface is bounded by a single layer of cells, the
- Endodermis.



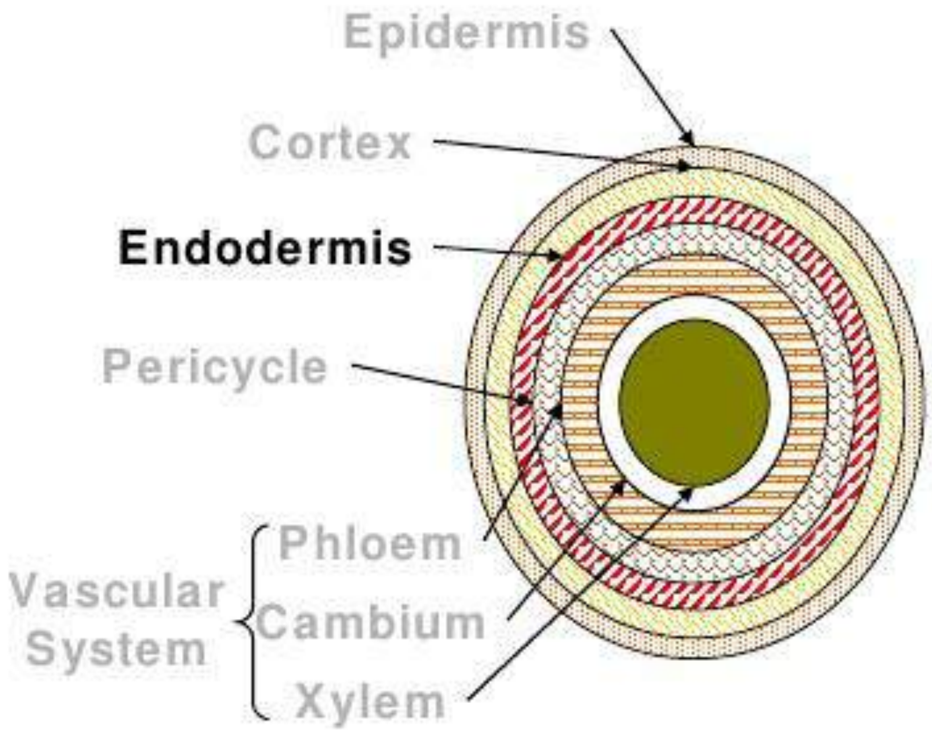
Root Structure and Growth

Inside the epidermis is a layer of ground tissue called the cortex.



Endodermis

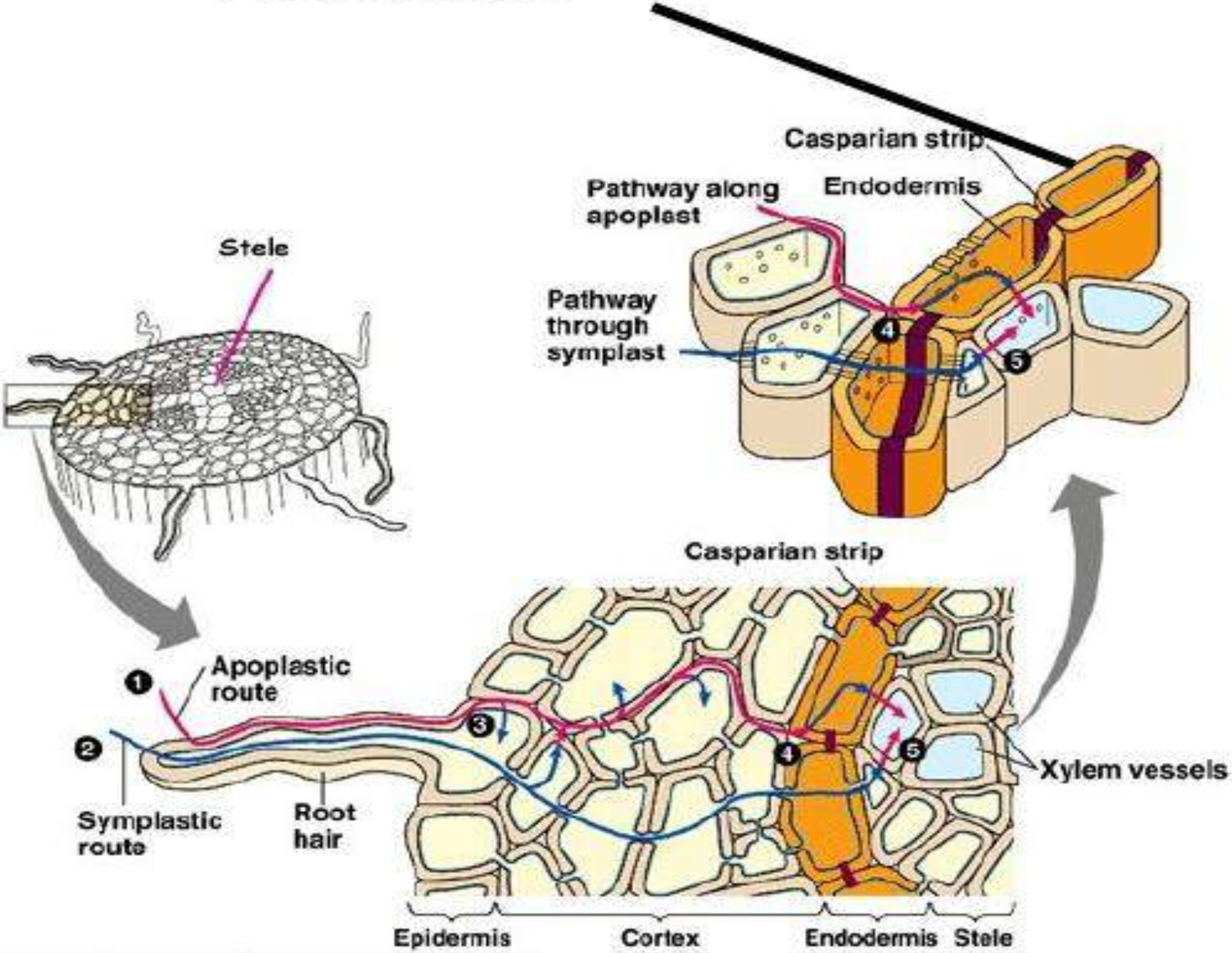
- Single layer of cells outside vascular system
- Spaces between the cells are covered with a waxy layer, called **suberin**
  - Similar to grout between ceramic tiles, and serves a similar function



Endodermis

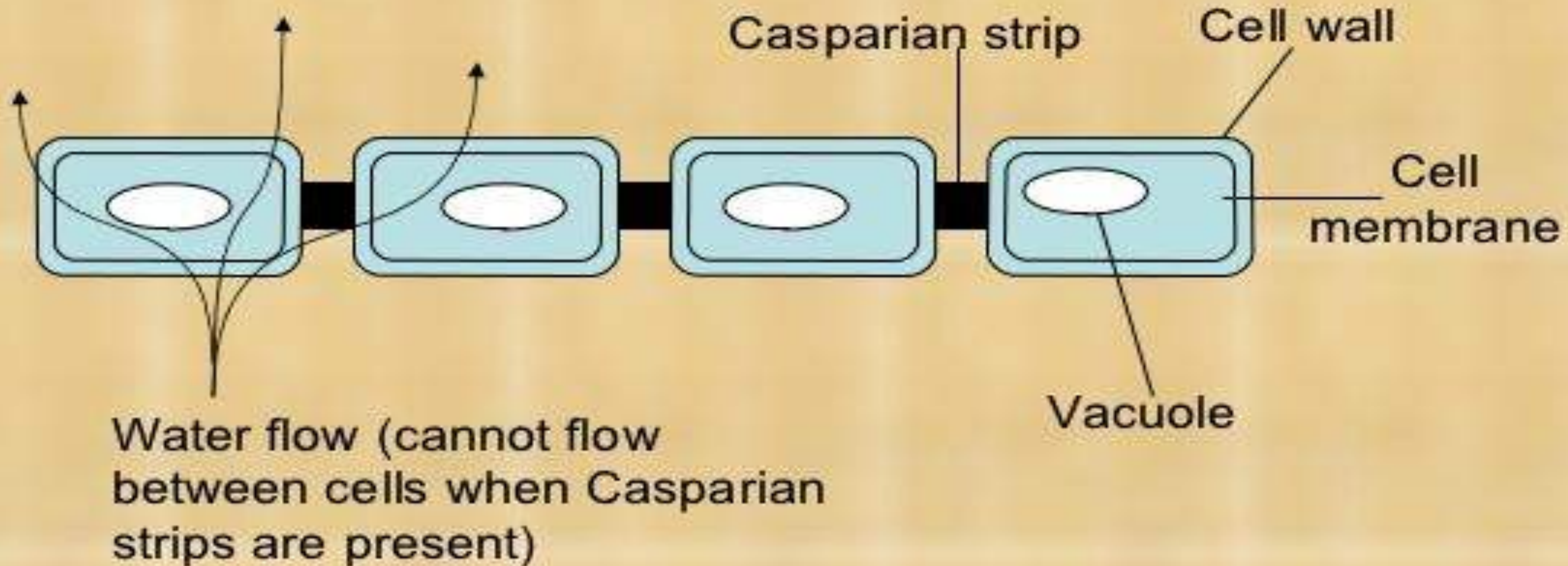
- Blocks passage of water and dissolved nutrients into the vascular system
- Water, nutrients and other solutes must enter a cell, cannot go round the endodermis
- Endodermis functions to **regulate the uptake of water and nutrients into the plant**

Endodermis

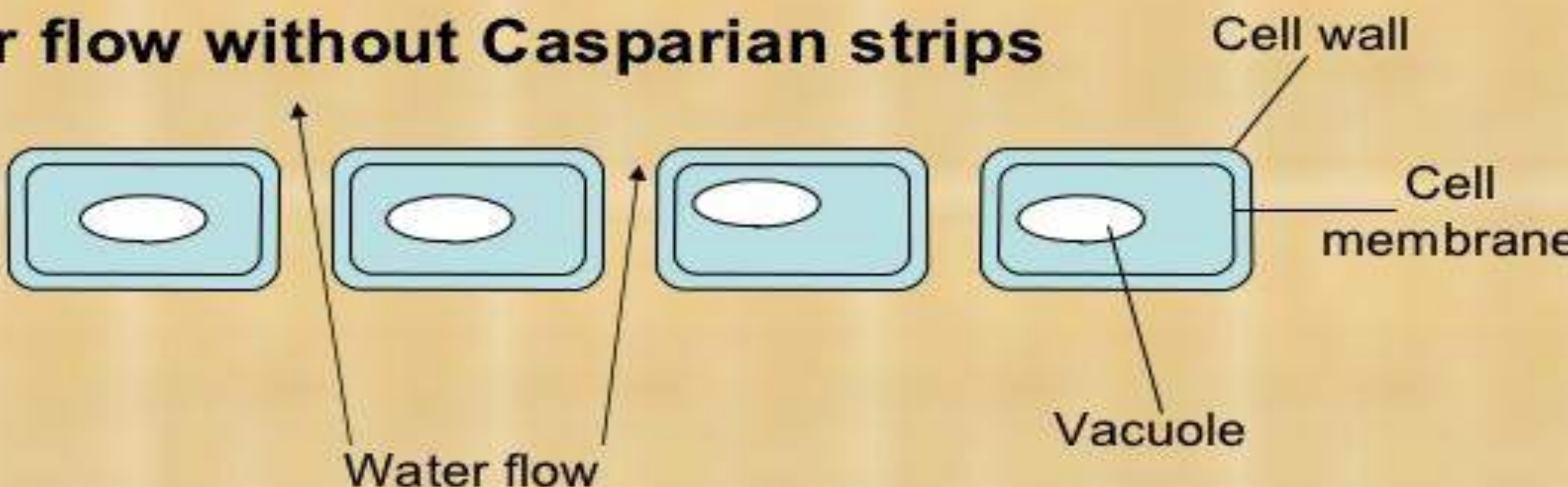


Casparian strip
Pathway along apoplast
Endodermis
Stele
Pathway through symplast
4
5
Casparian strip
1
Apoplastic route
2
Symplastic route
Root hair
3
4
5
Xylem vessels
Epidermis
Cortex
Endodermis
Stele

Water flow with Casparian strips

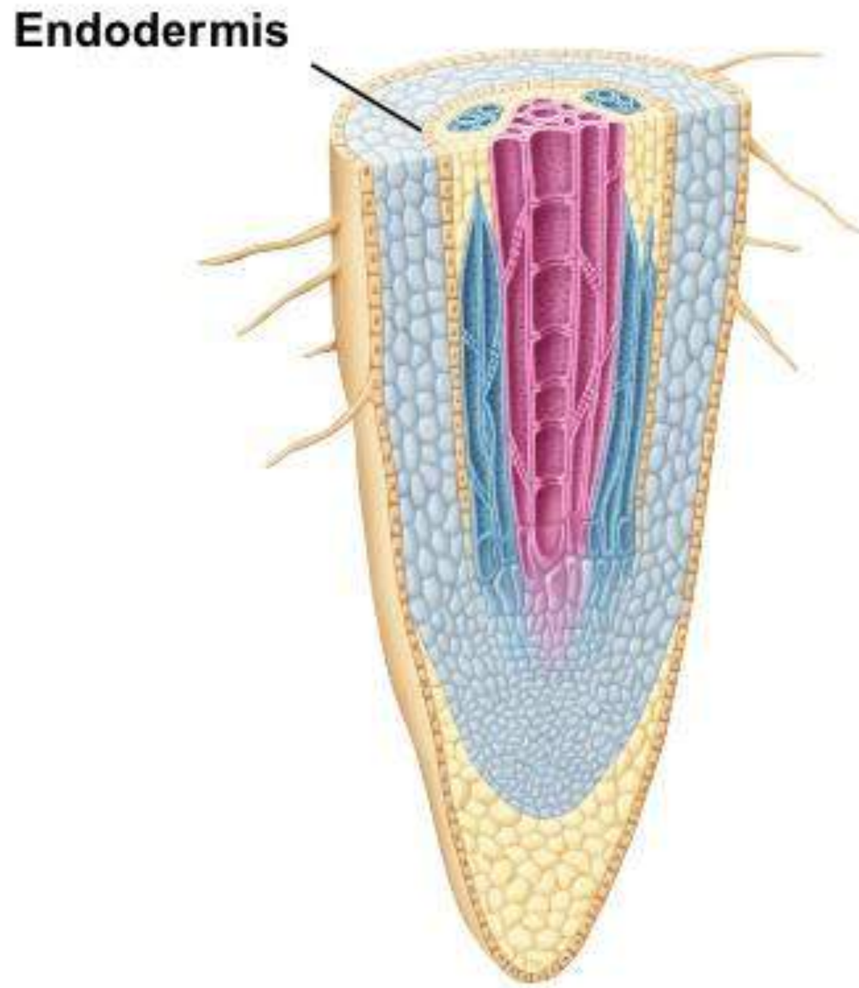


Water flow without Casparian strips



Root Structure and Growth

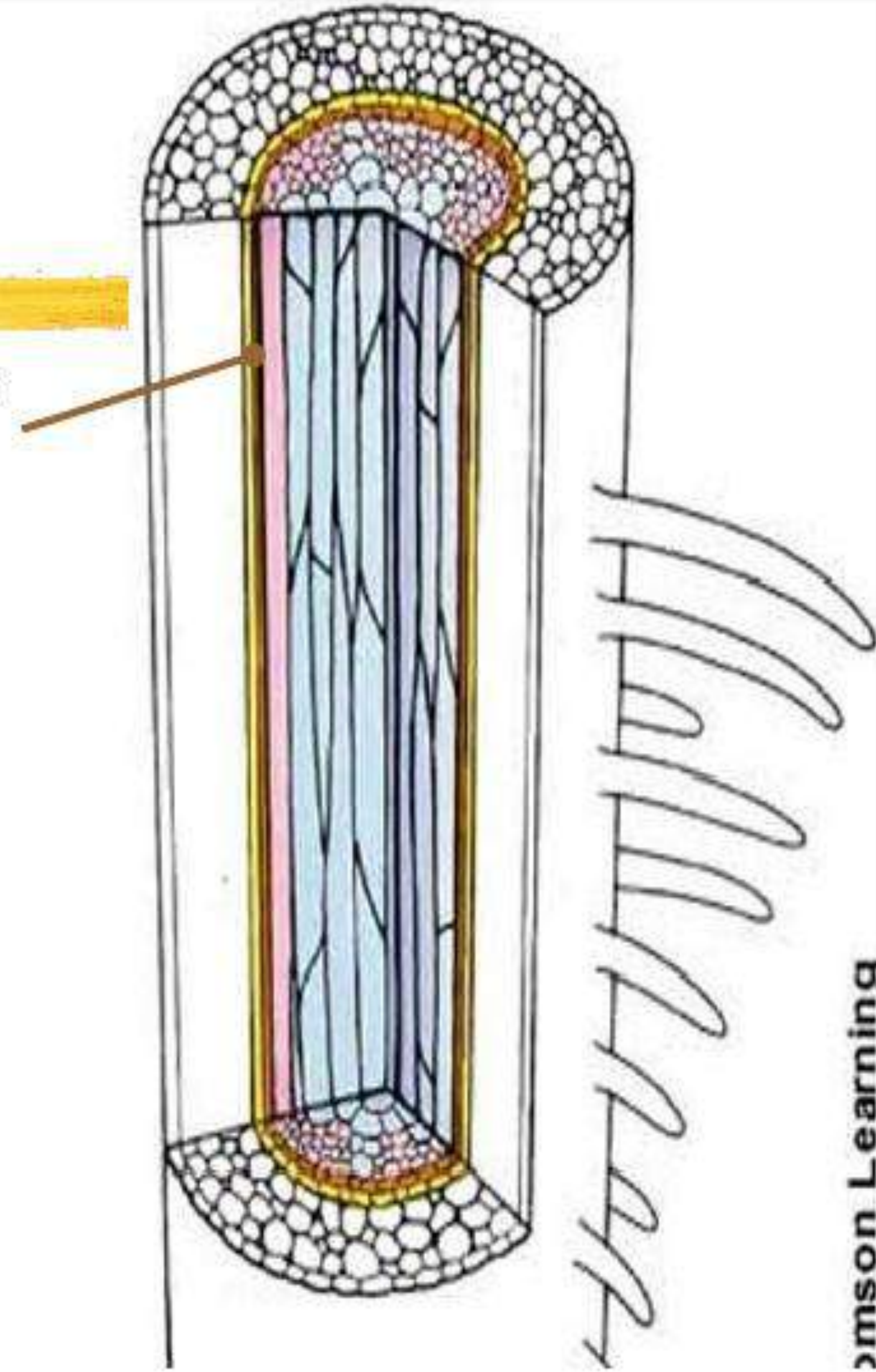
The cortex extends to another layer of cells, the endodermis.



The endodermis completely encloses the vascular cylinder.

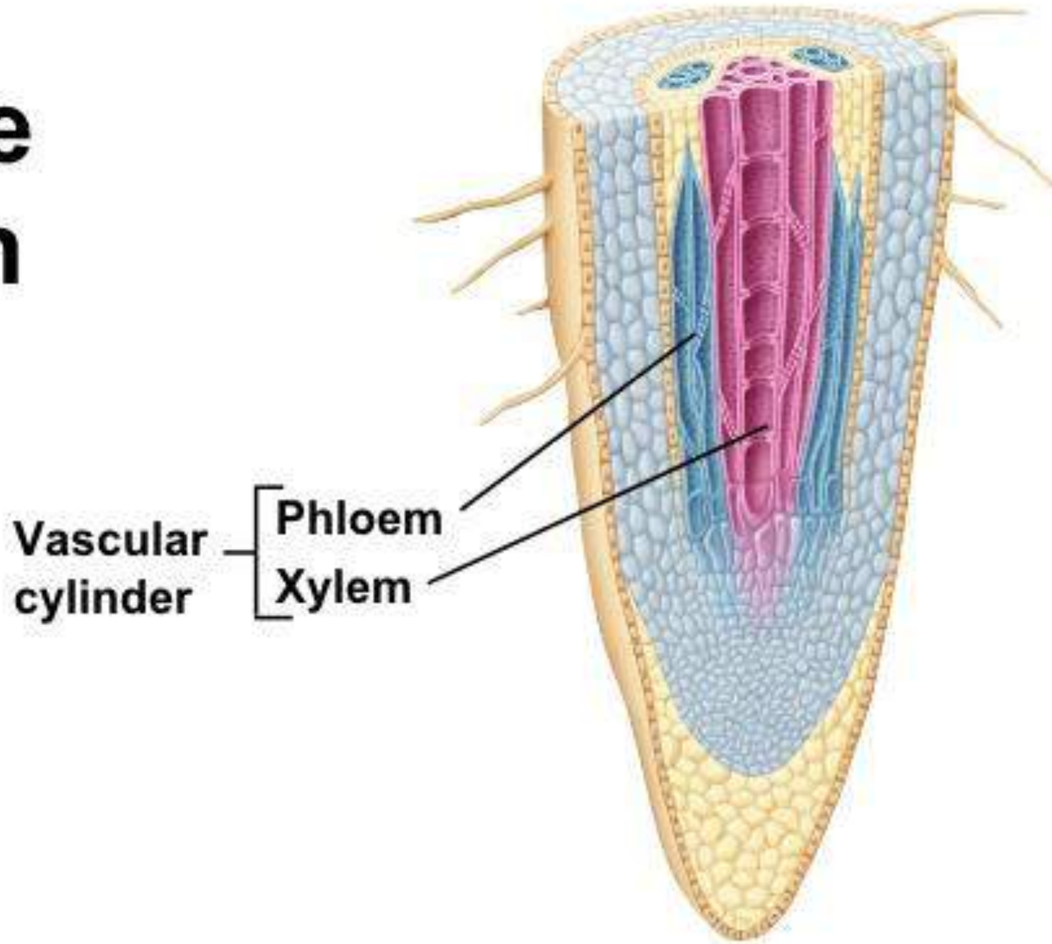
Pericycle

- A thin layer of undifferentiated cells
- A **meristem** tissue
- The source of new lateral, or secondary, roots
- Surrounds the vascular bundles

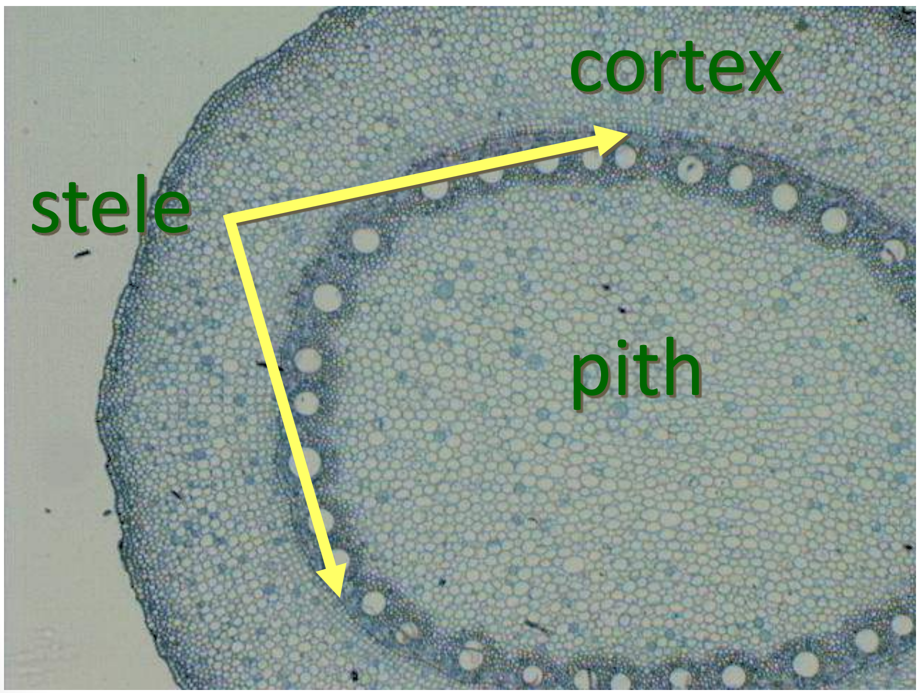


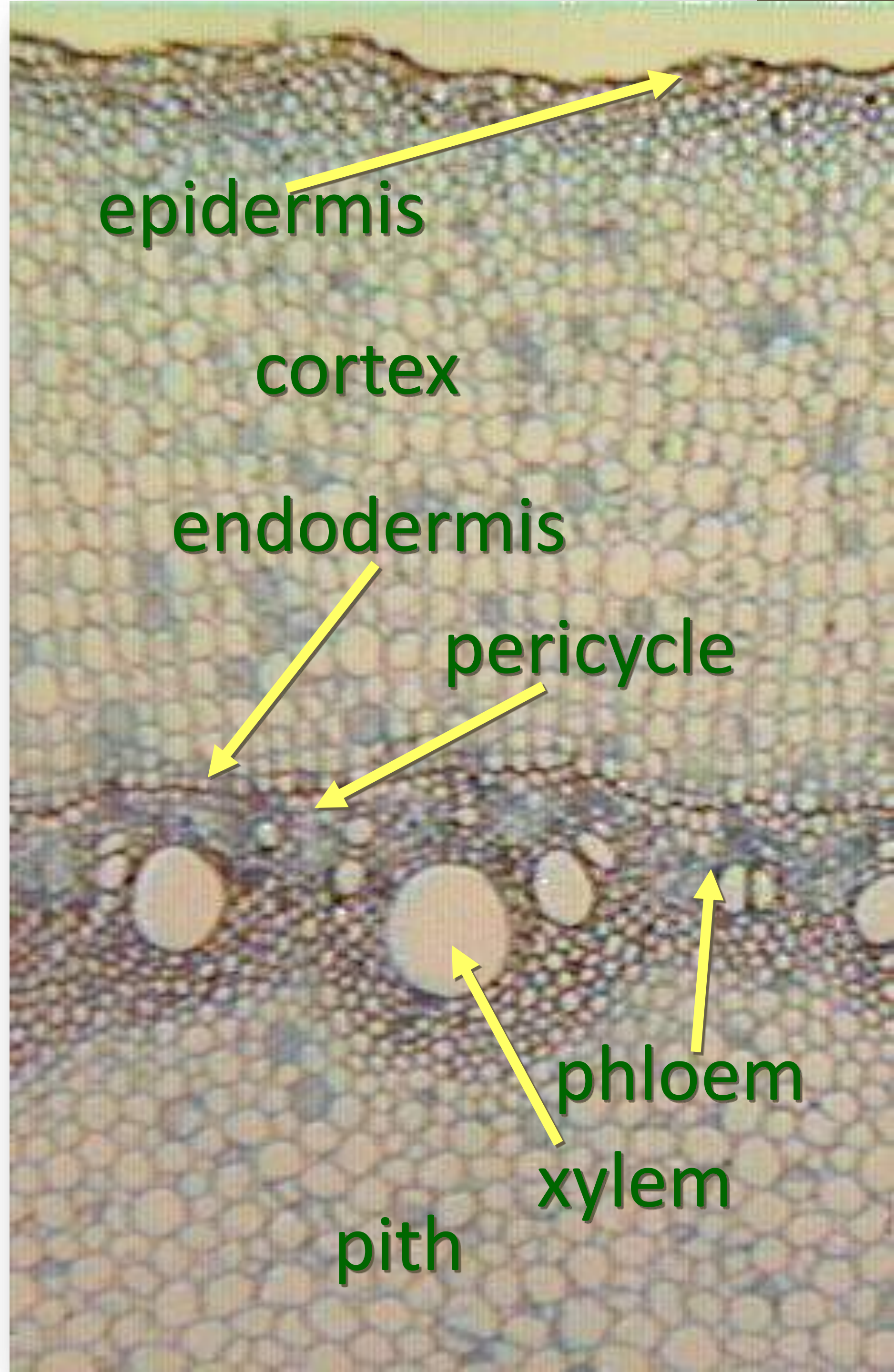
Root Structure and Growth

The vascular cylinder is the central region of a root that includes the xylem and phloem.

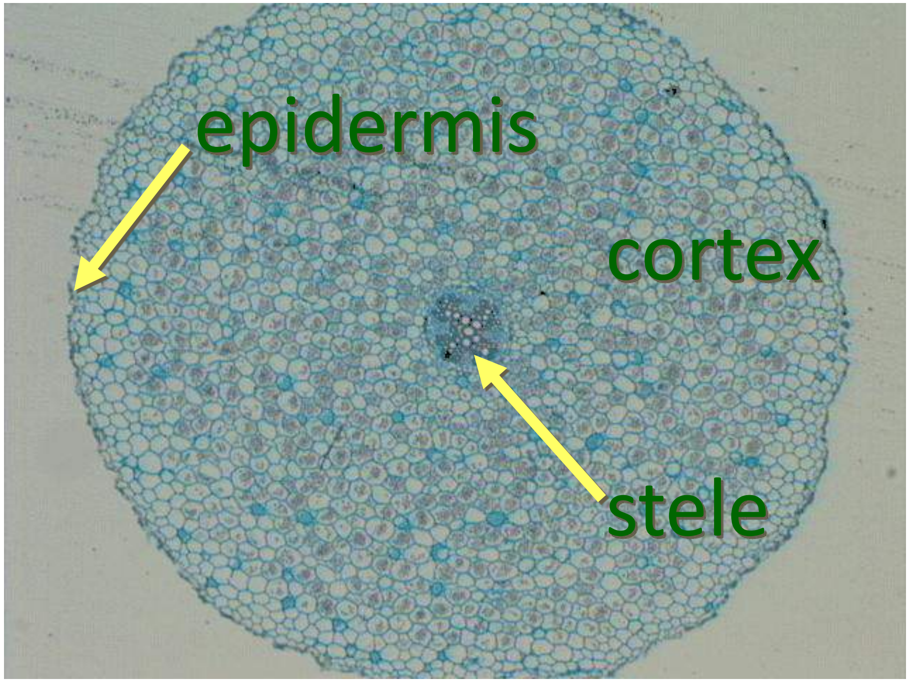


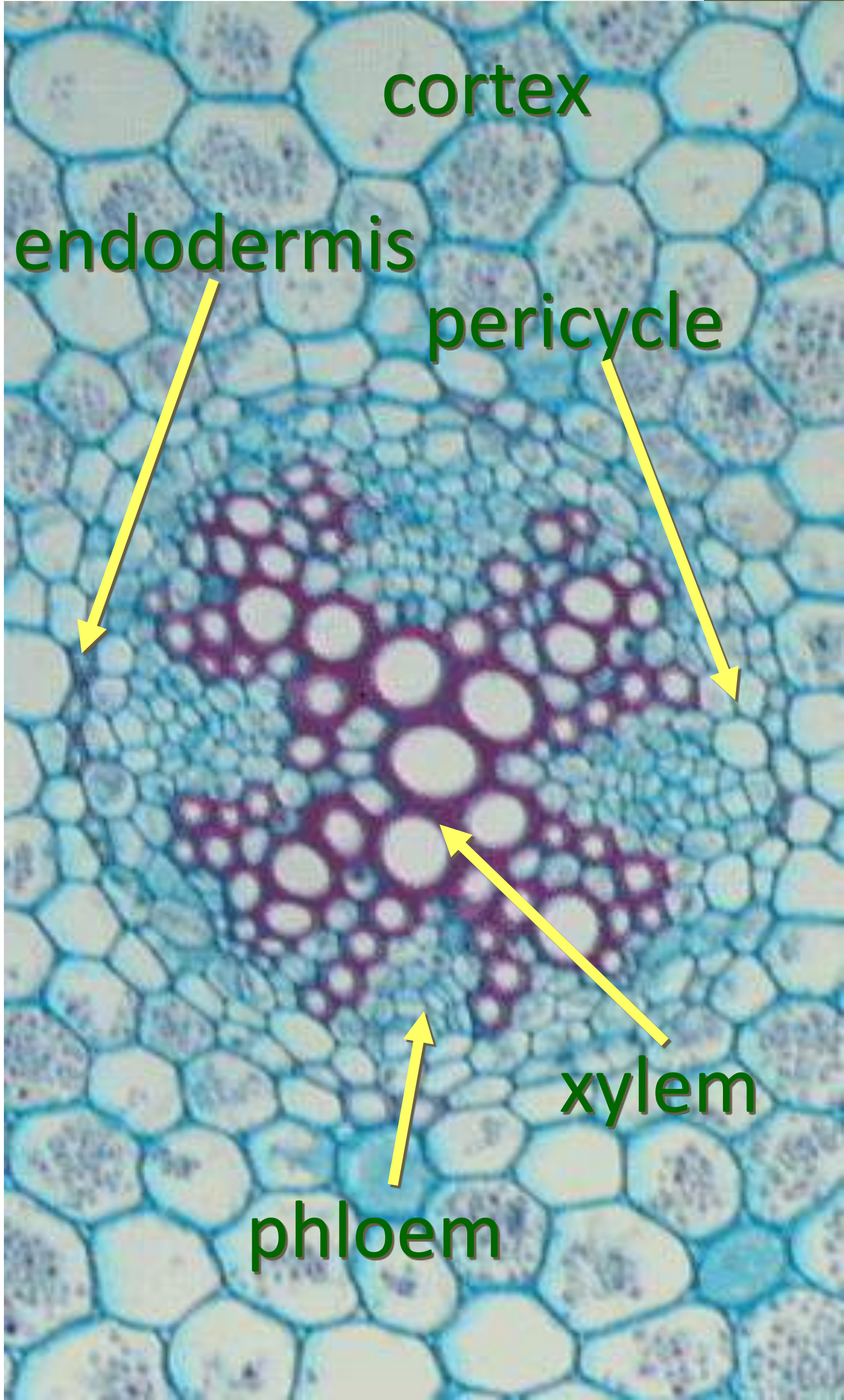
Monocot Root Anatomy



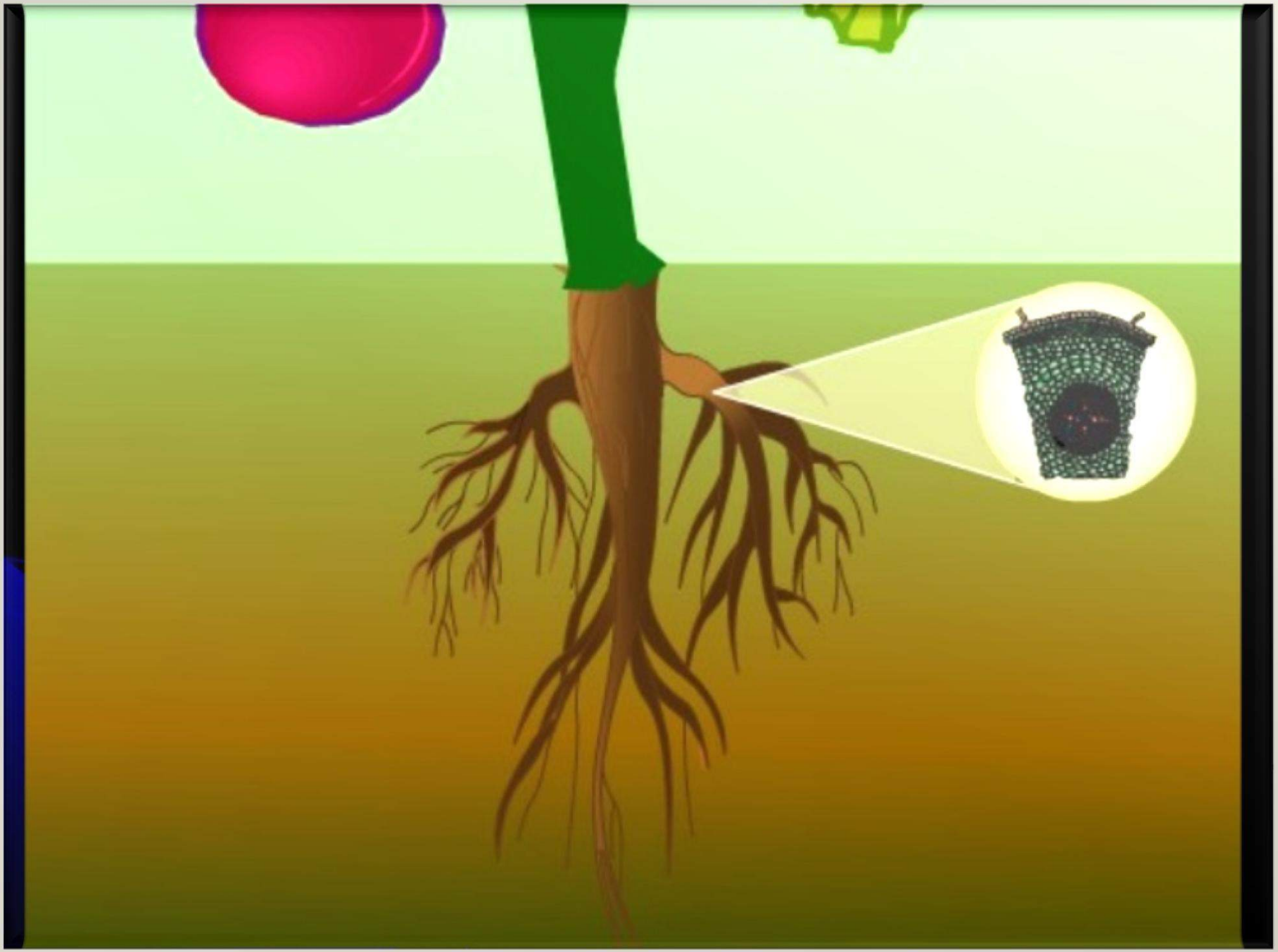


Dicot Root Anatomy

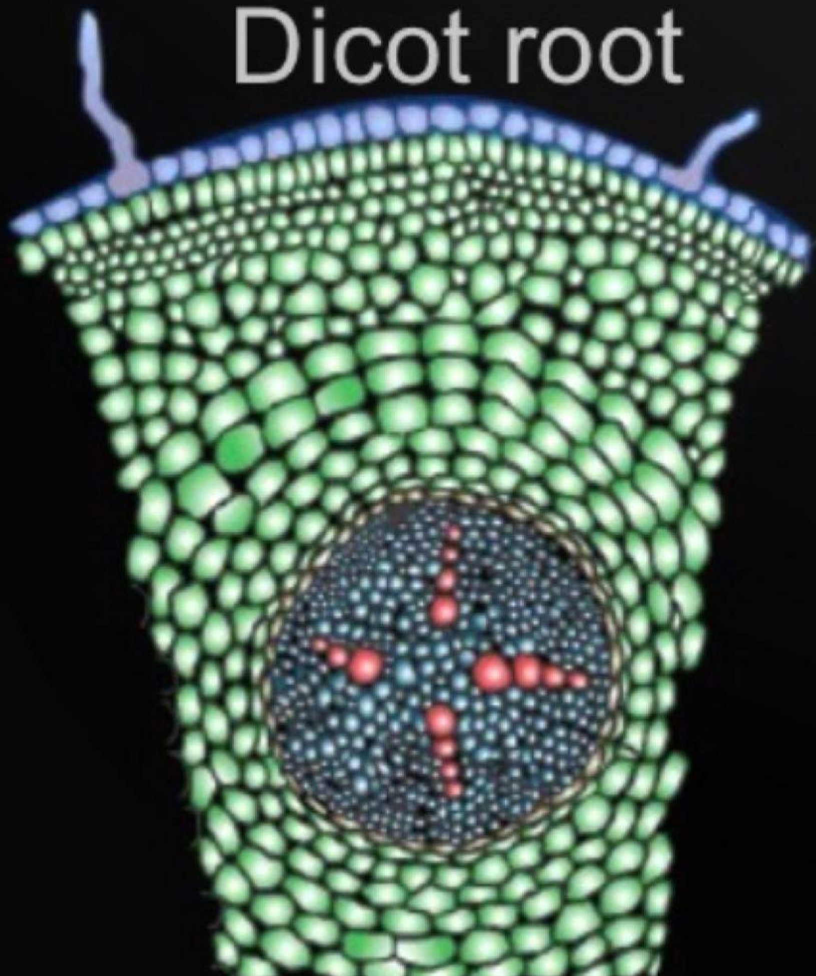


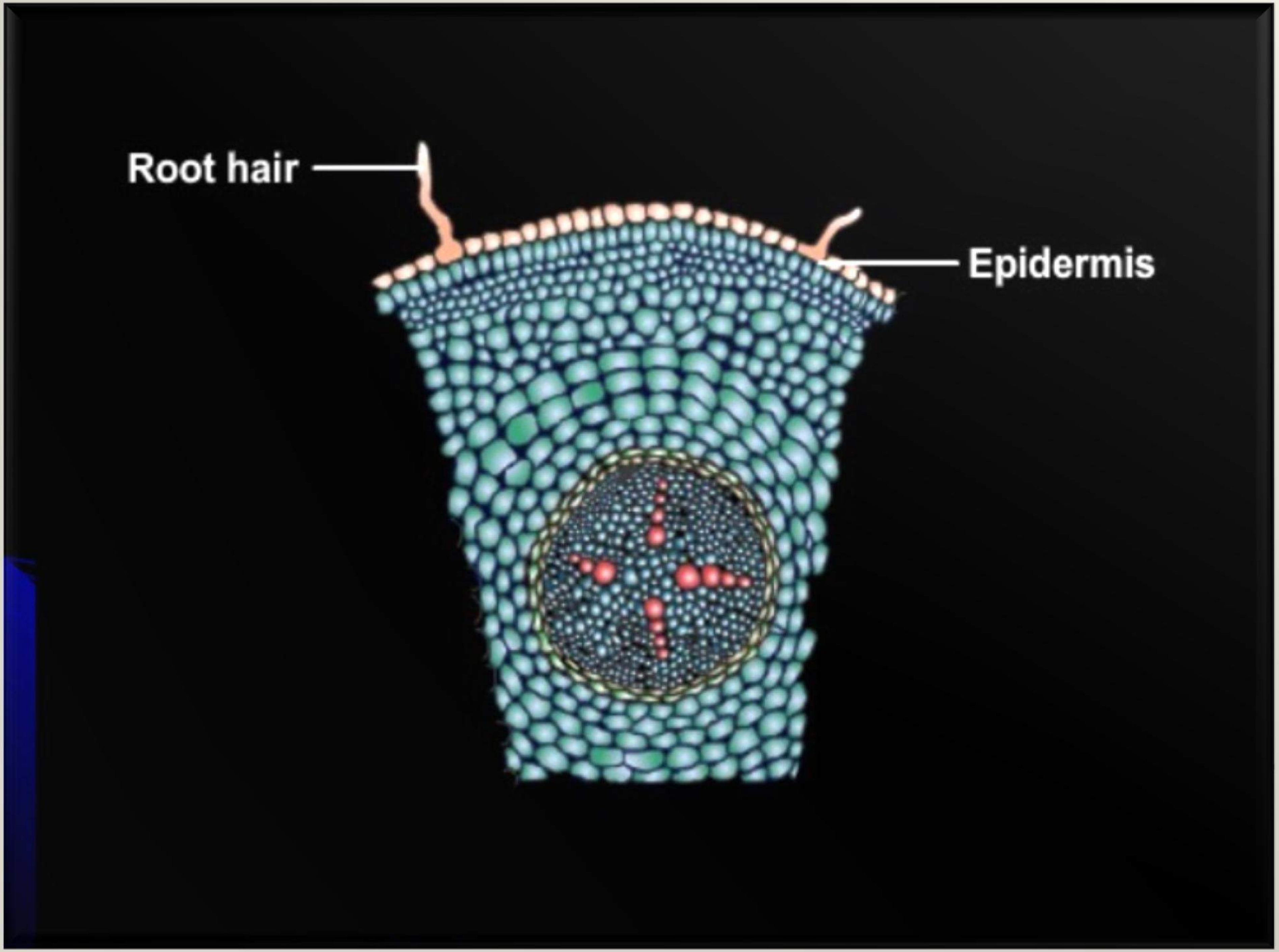


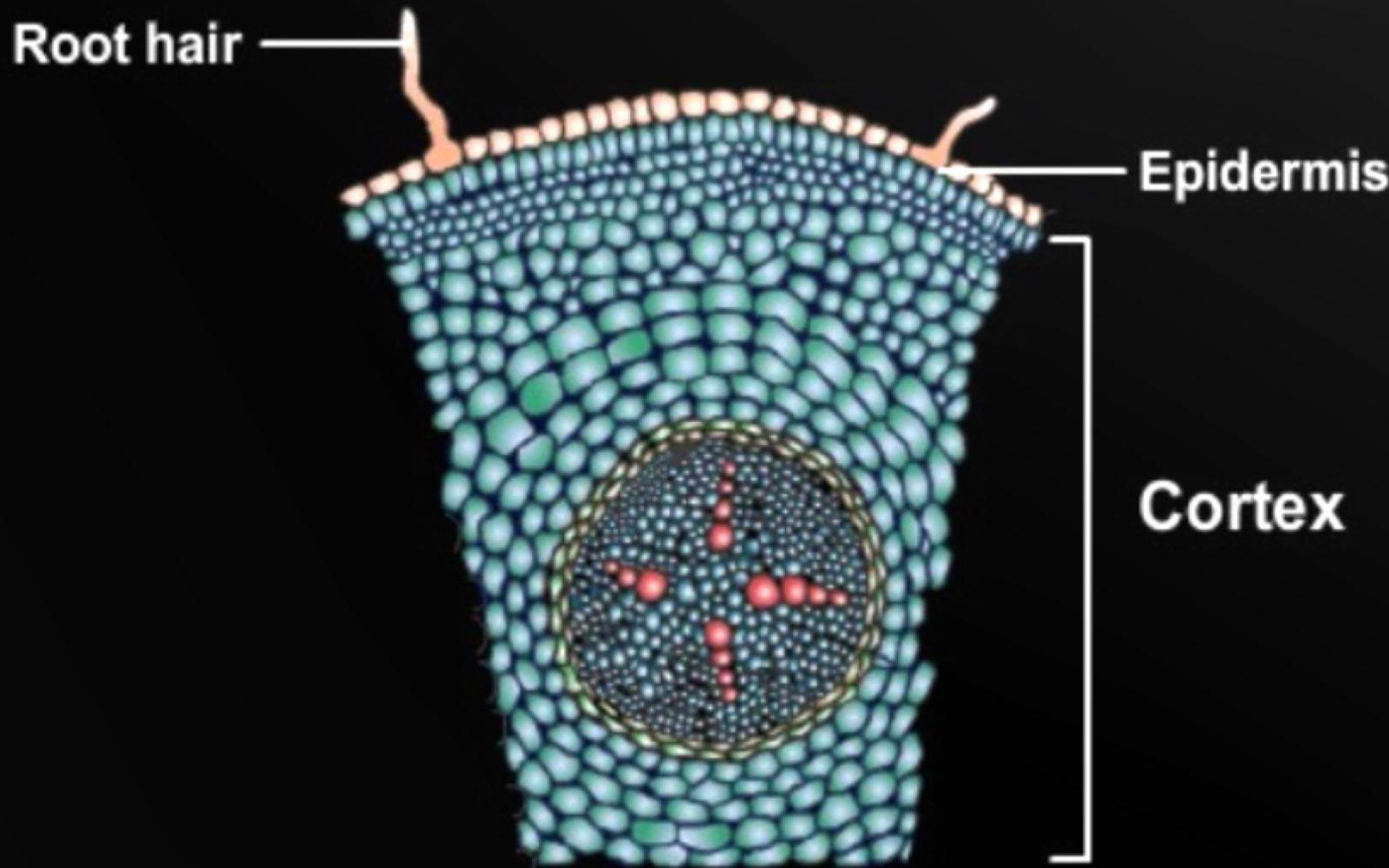
Anatomy of Dicot Roots

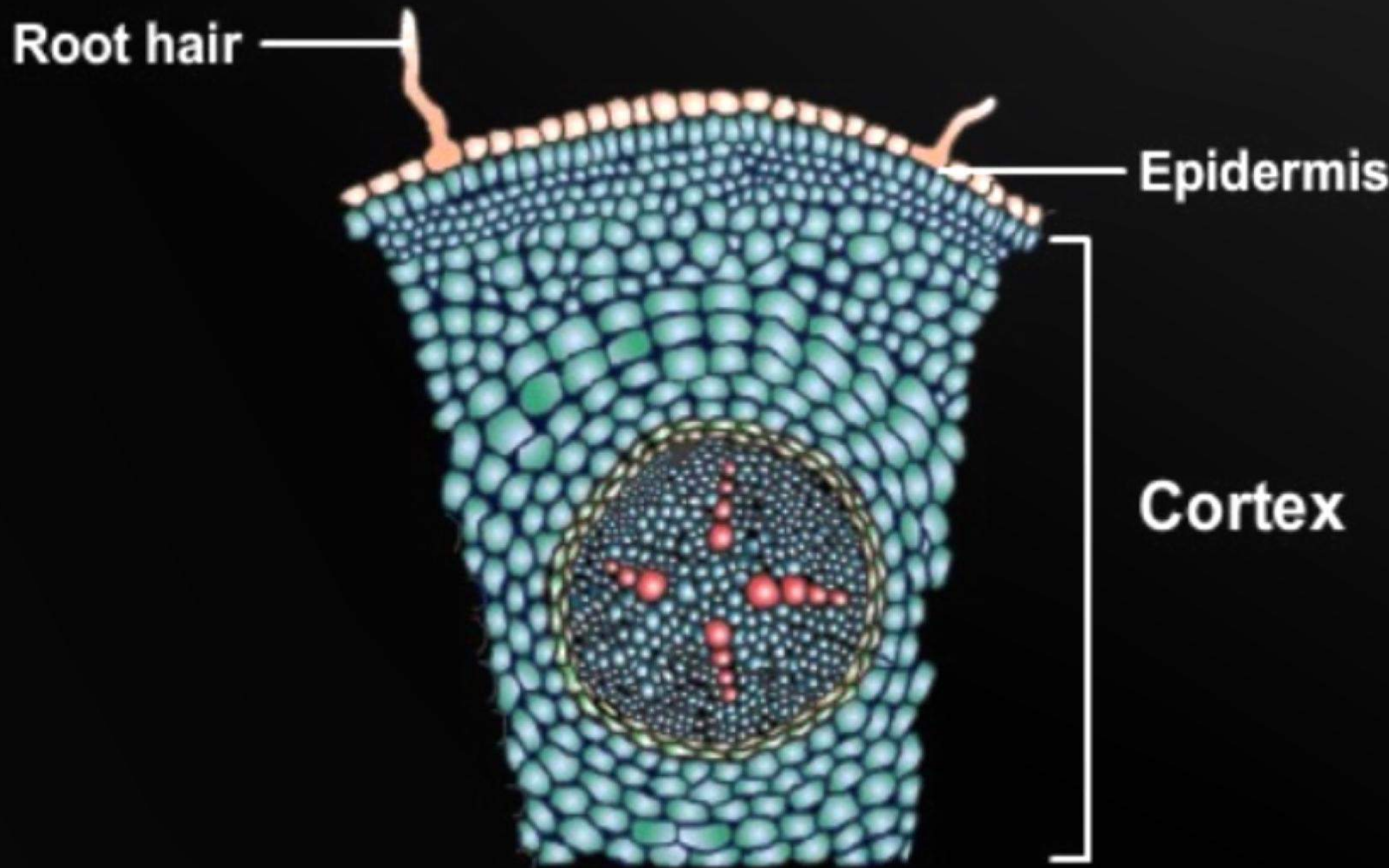


Enlarged view of cross section of Dicot root

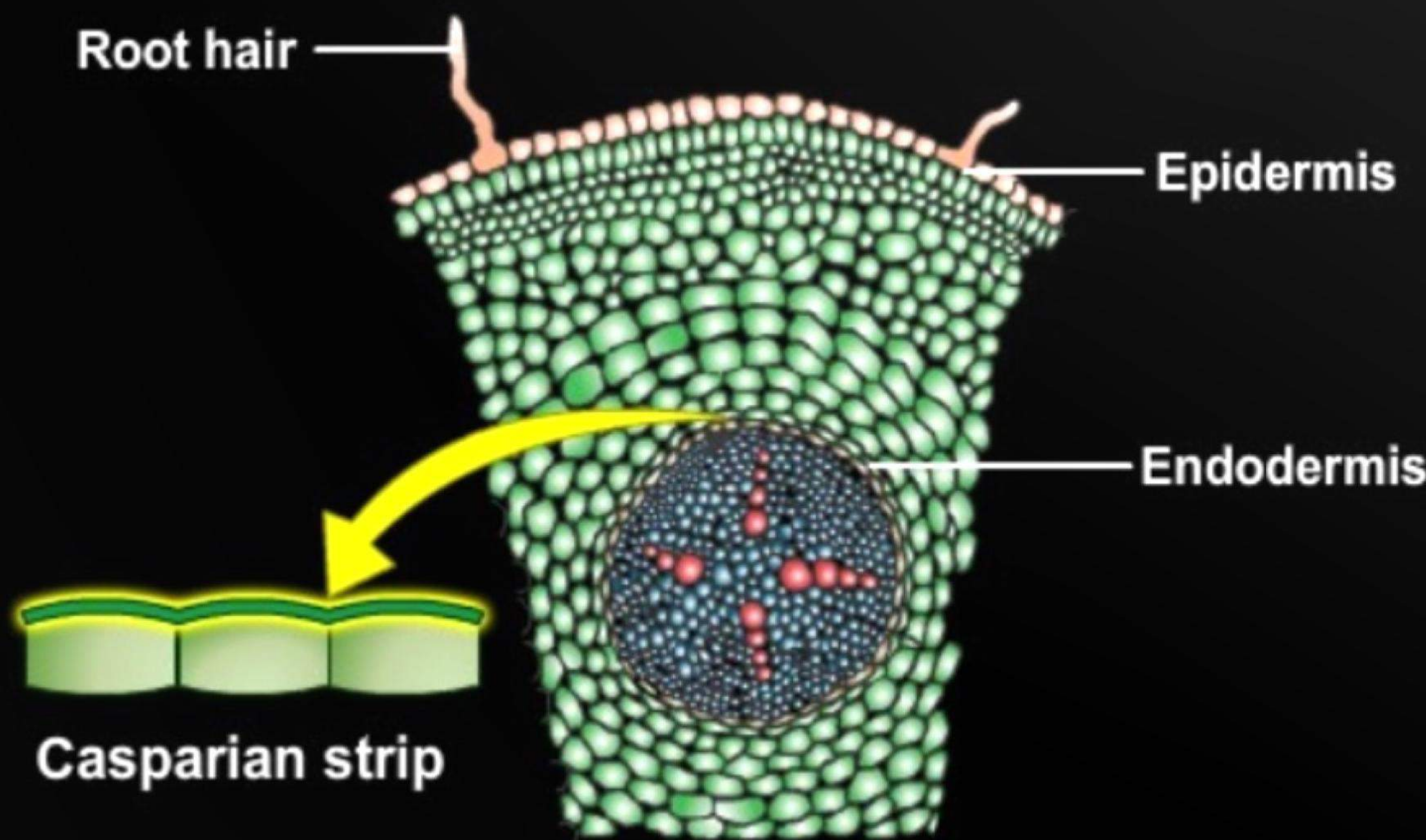


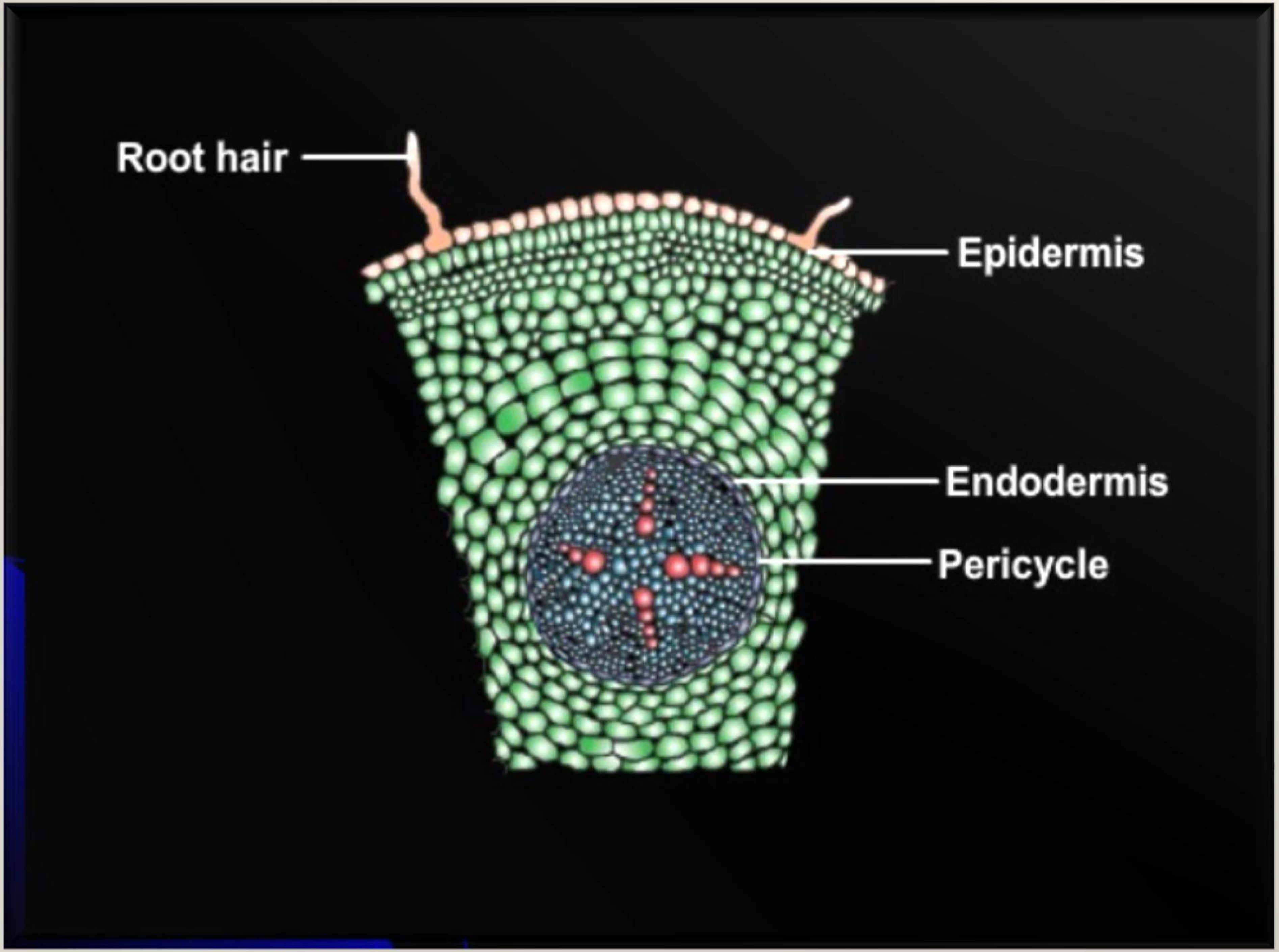

Root hair
Epidermis


Root hair
Epidermis
Cortex

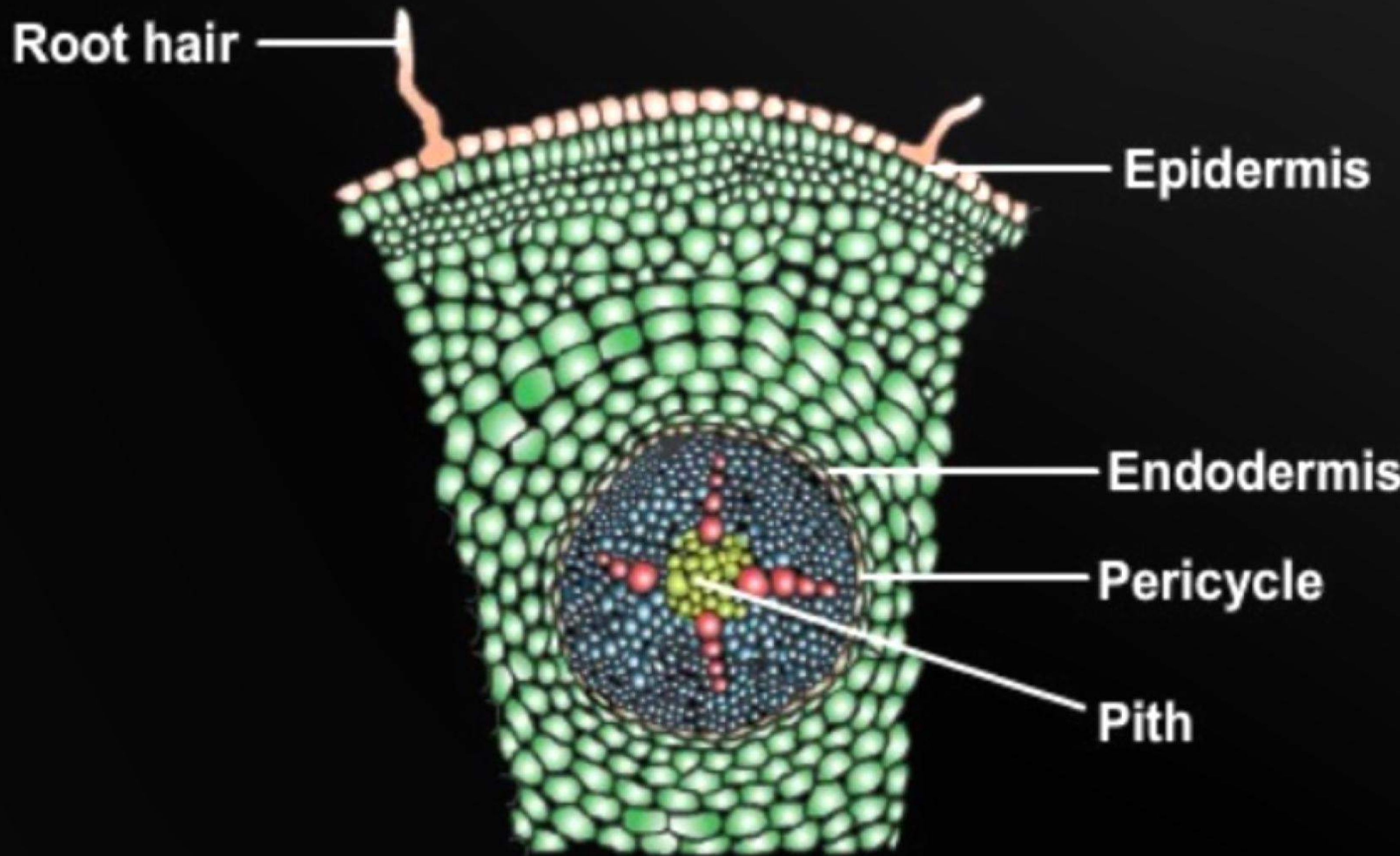

Root hair
Epidermis
Cortex

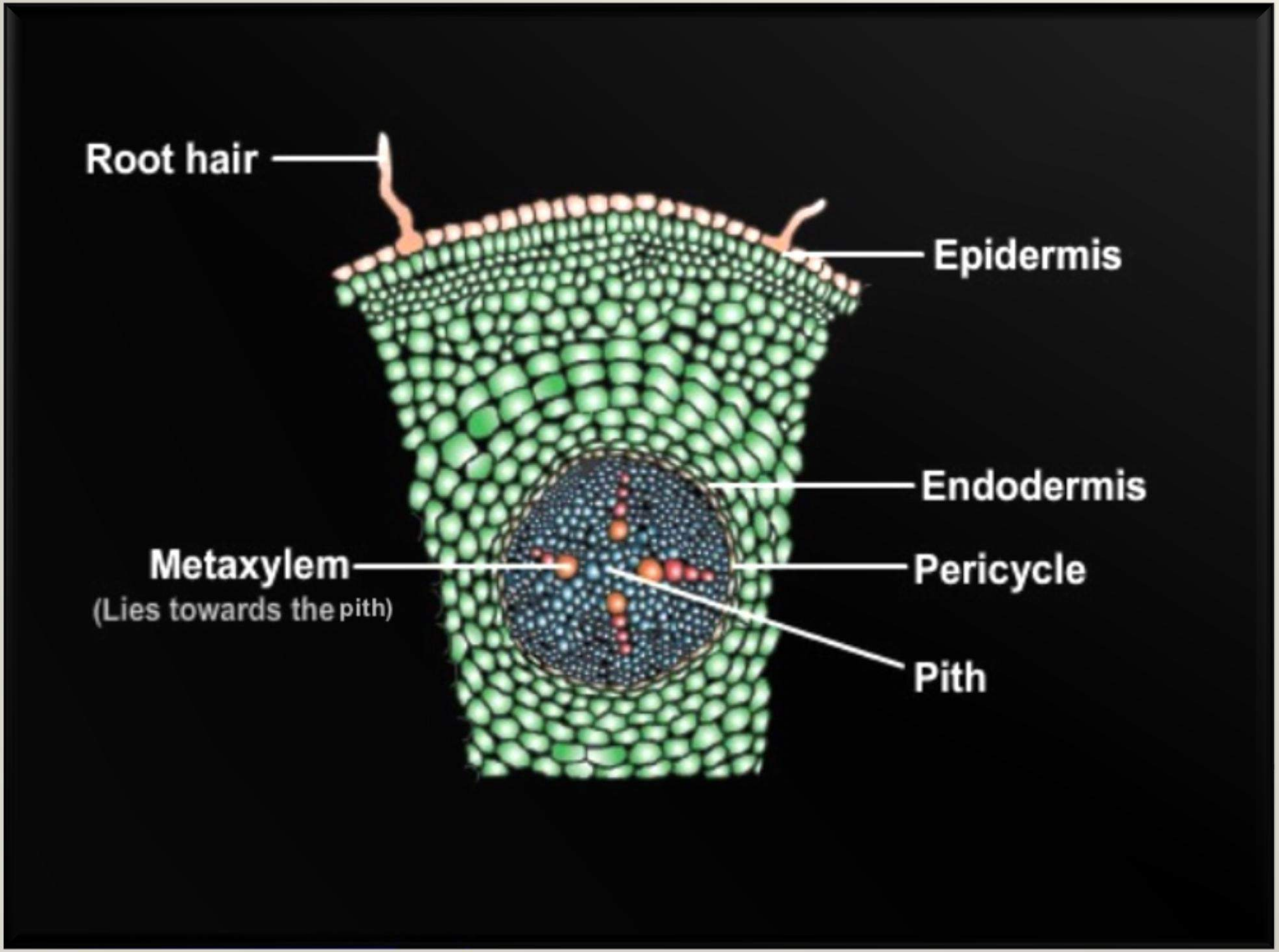
The walls of the endoermal cells consist of a waxy , water impermeable suberin layer called the casparian strip.

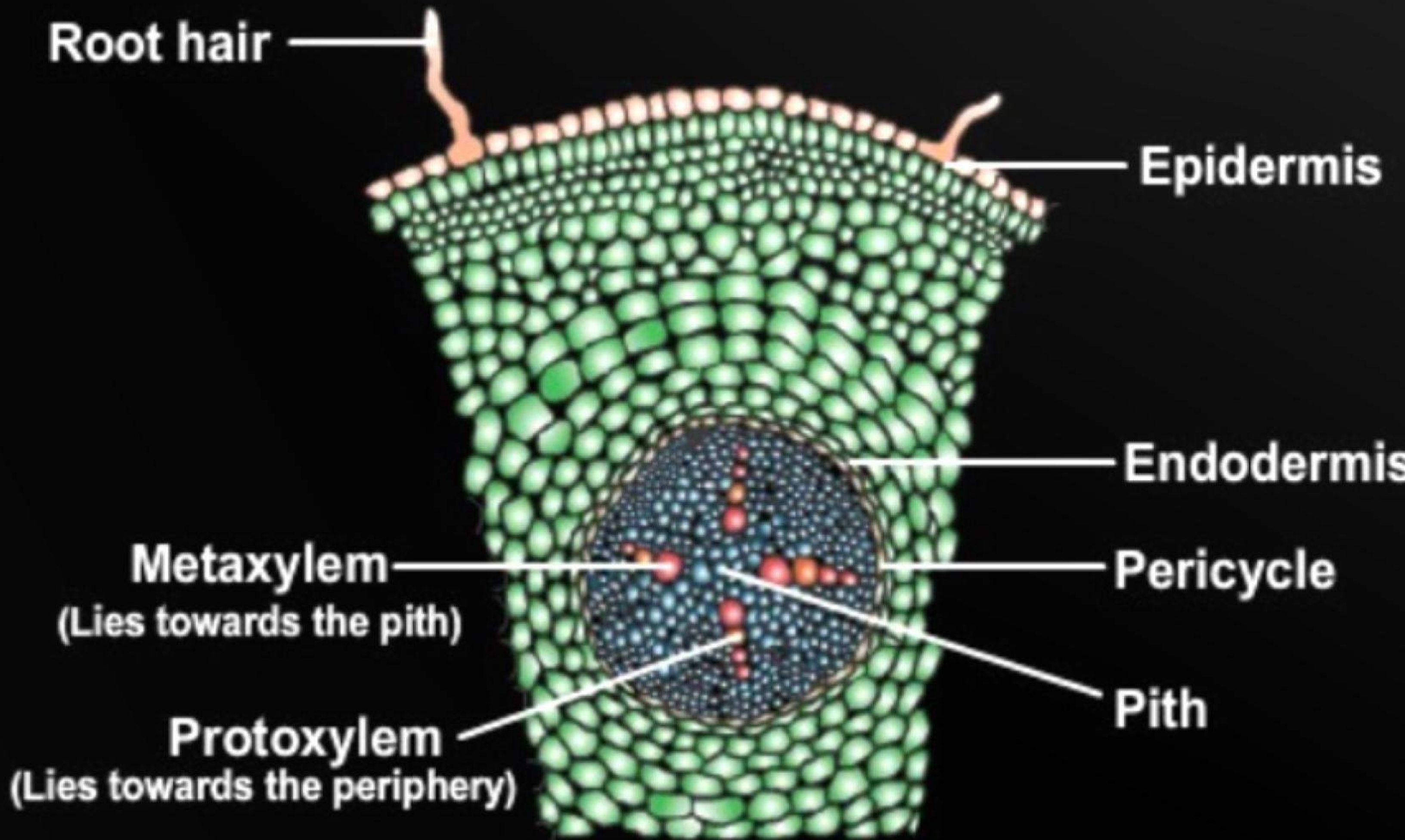


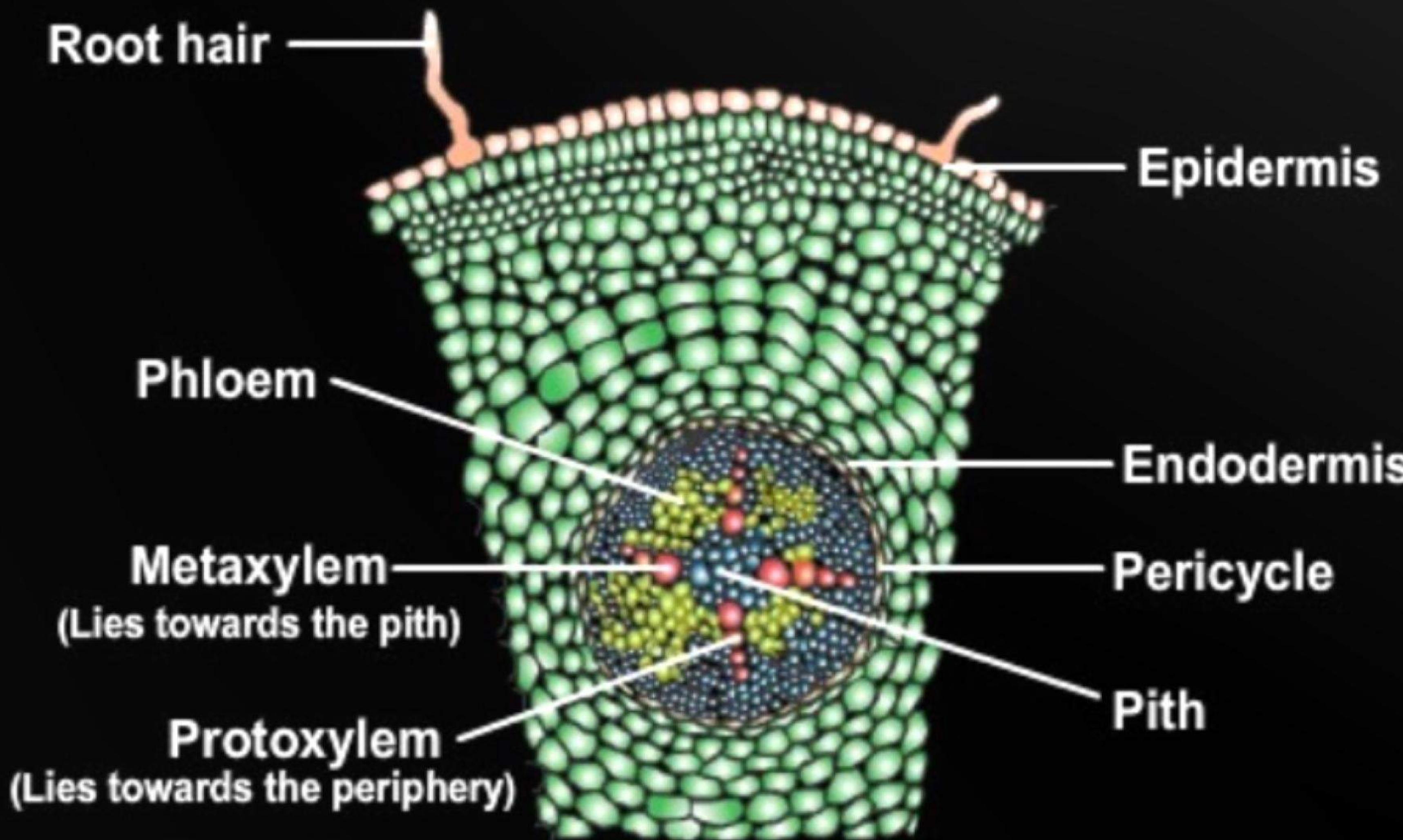


Root hair
Epidermis
Endodermis
Pericycle


Root hair
Epidermis
Endodermis
Pericycle
Pith

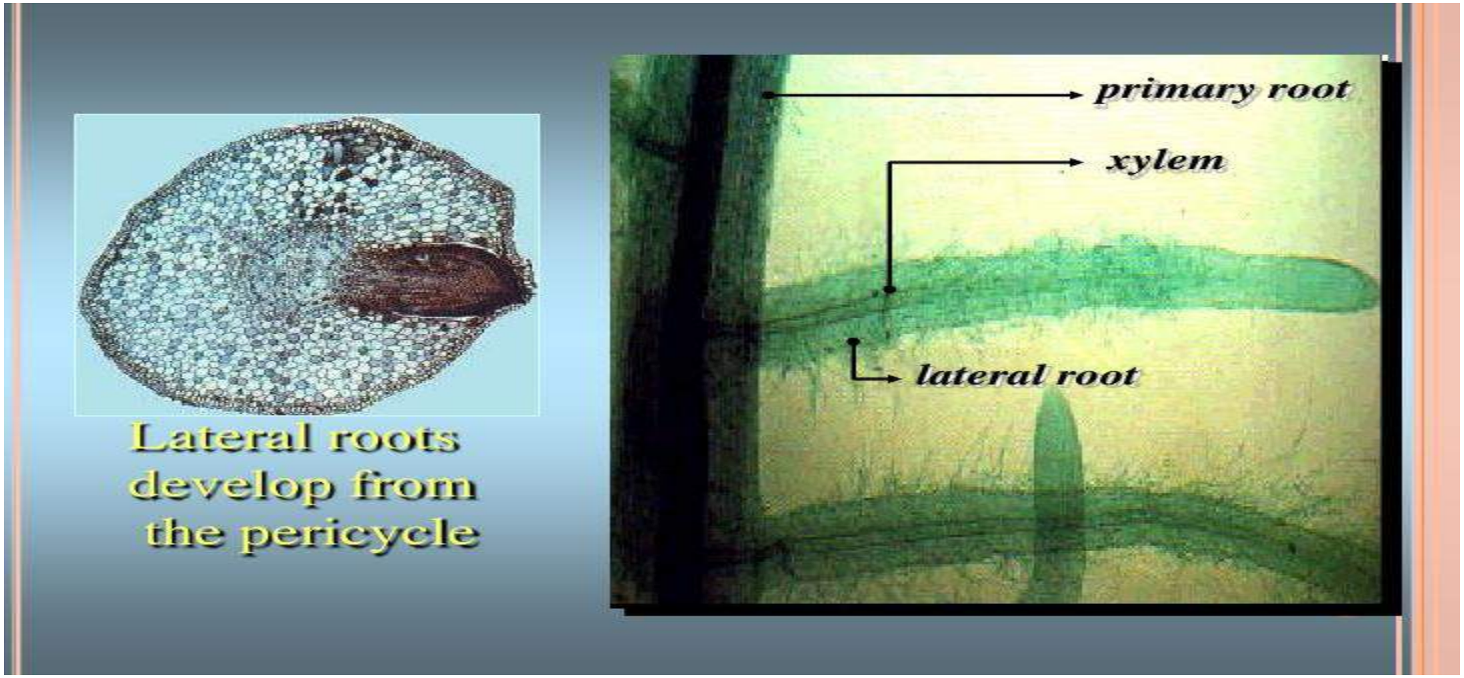

Root hair
Epidermis
Endodermis
Metaxylem
(Lies towards the pith)
Pericycle
Pith

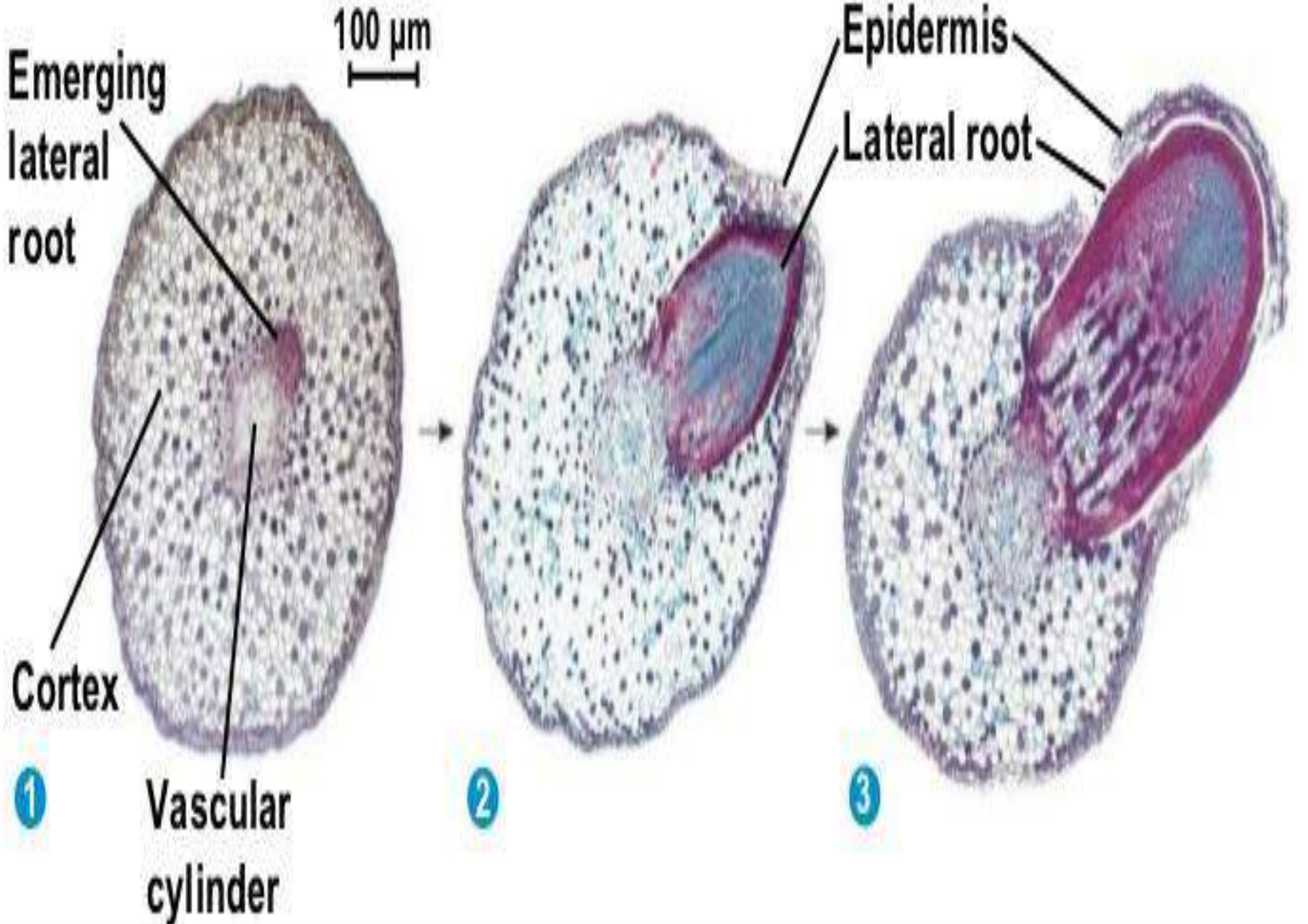

Root hair
Epidermis
Endodermis
Metaxylem
(Lies towards the pith)
Pericycle
Pith
Protoxylem
(Lies towards the periphery)


Root hair
Epidermis
Phloem
Endodermis
Metaxylem
(Lies towards the pith)
Pericycle
Pith
Protoxylem
(Lies towards the periphery)

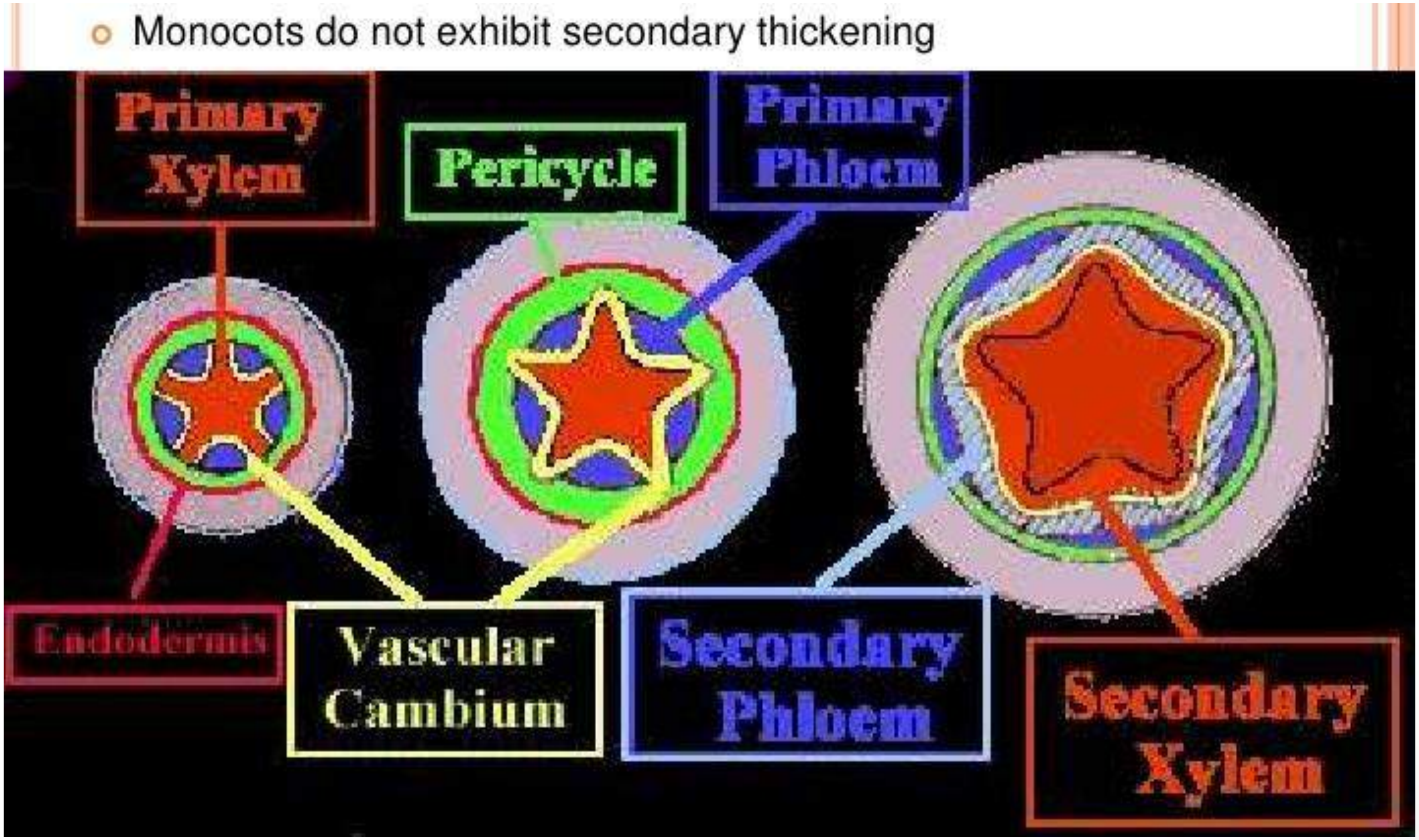
Lateral root

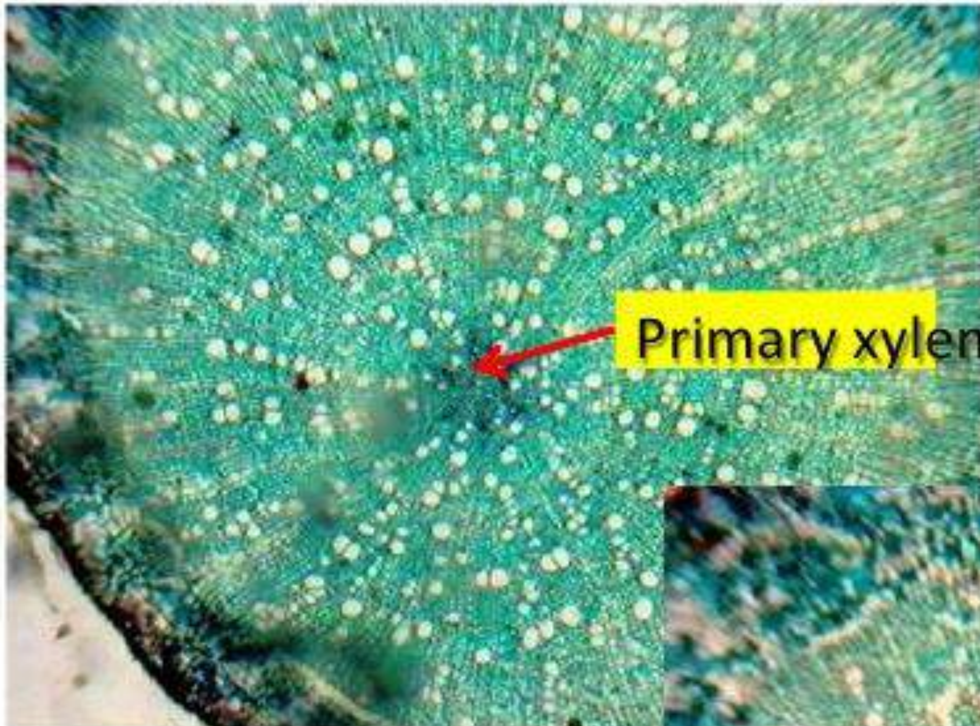
- It is originated from the pericycle layer.



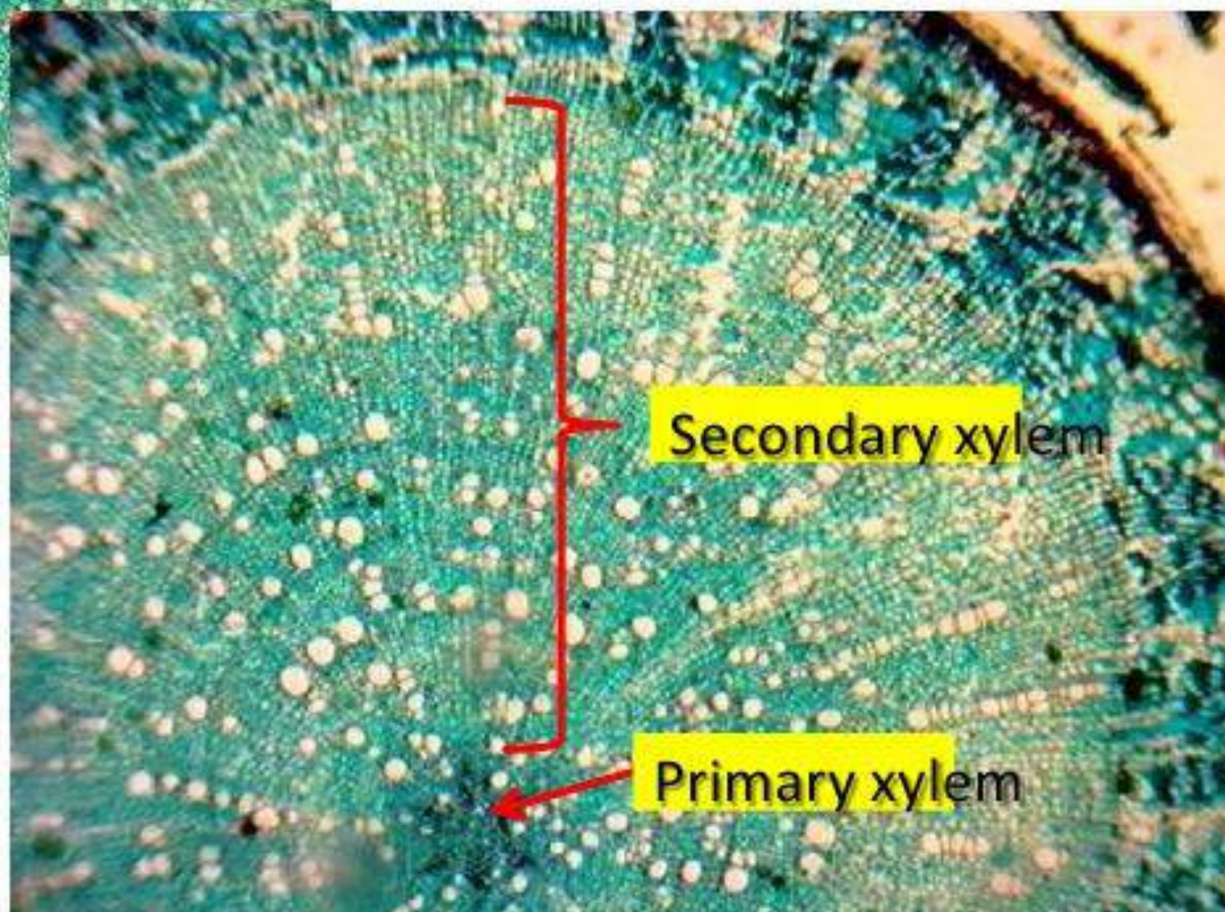

100 µm
Emerging lateral root
Cortex
Vascular cylinder
Epidermis
Lateral root
1
2
3

Secondary growth of a root



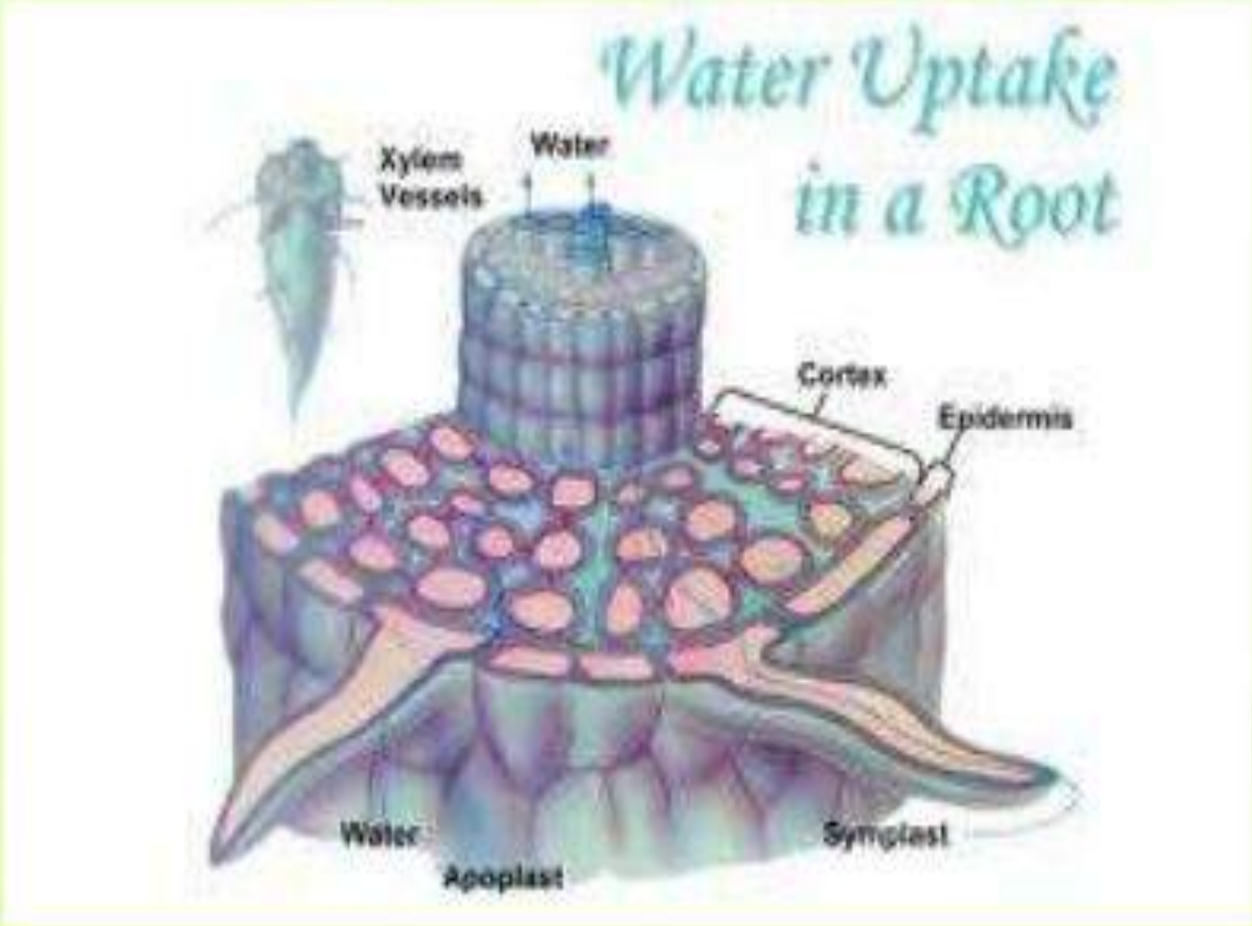


Roots which have undergone
Secondary growth are shown



The structure of the root in
Secondary growth is similar
With the structure of stem in
secondary except for the absence of

- **Water Uptake**
  - Water enters the root through the root hairs. These extensions of epidermal cells have sickly walls and adhere tightly to soil particles with their film of moisture.



- **Mineral Uptake**
  - One might have expected that minerals would enter the root dissolved in water. But, in fact, minerals enter separately:Even when no water is being absorbed, minerals enter freely.
  - Minerals can enter against their concentration gradient; that is, by active transport.
  - Anything that interferes with the metabolism of root cells interferes with mineral absorption.

- **Gas Exchange**
  - The older parts of roots are sheathed in layers of dead cork cells impregnated with a waxy, waterproof (and airproof) substance called **suberin**. This sheath reduces water loss but is as impervious to oxygen and carbon dioxide as it is to water.
  - However, the cork is perforated by nonsuberized pores called **lenticels**. These permit the exchange of oxygen and carbon dioxide between the air and the living cells beneath.

4- The flower

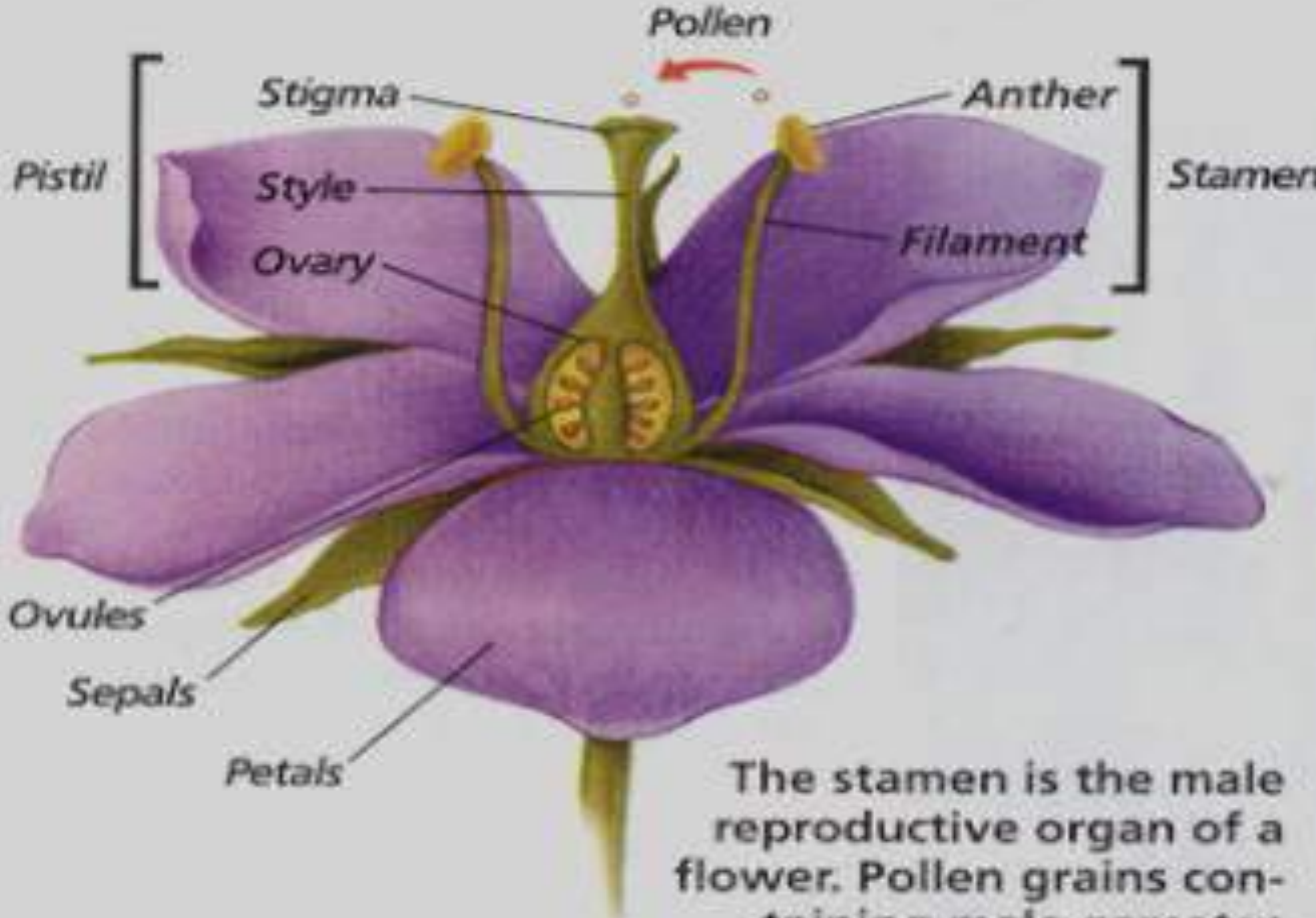
- A flower is regarded as a modified stem with shortened internodes and bearing, at its nodes, structures that may be highly modified leaves.[1] In essence, a flower structure forms on a modified shoot or *axis* with an apical meristem that does not grow continuously (growth is *determinate*).

FLOWER

- “Bloom” or “Blossom”
- It is the part of the plant from which the fruit or seed is developed.

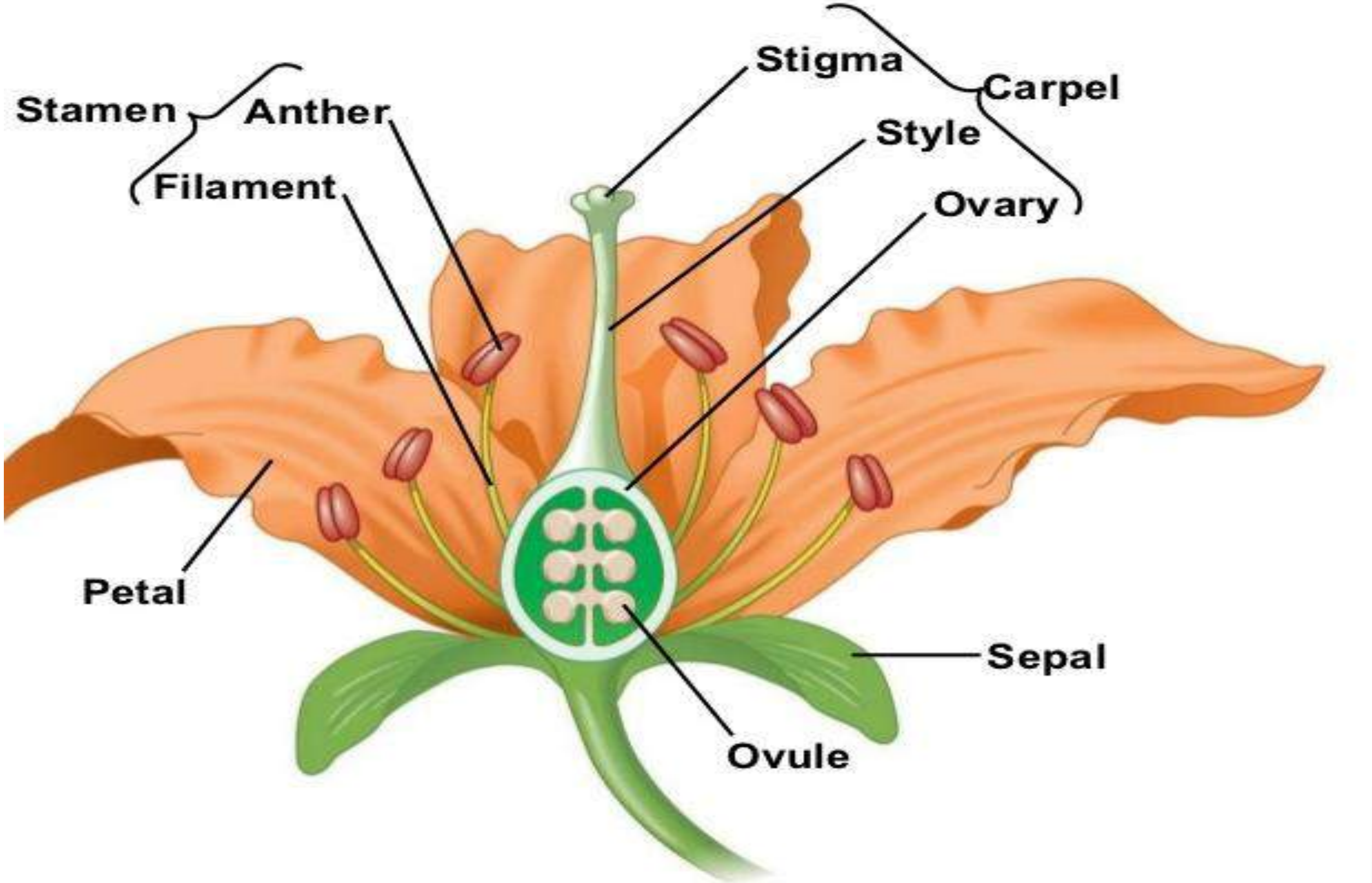
Flower Functions

- Exchange pollen
- Achieve fertilization
- Produce seed



The stamen is the male reproductive organ of a flower. Pollen grains containing male gametes form inside the anther.

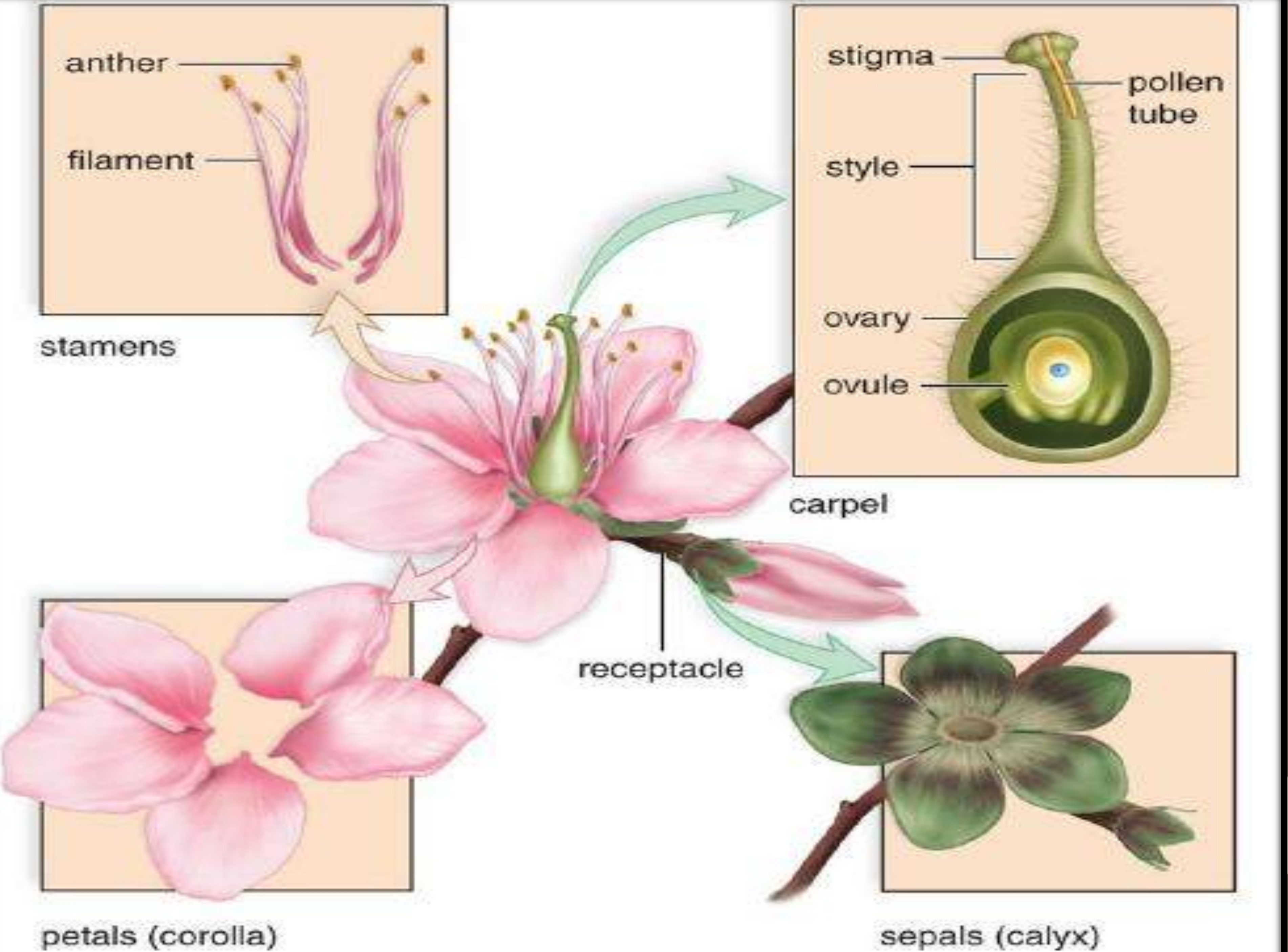
Structure of flowers



- Flower Parts – Neither male or female
  - Petals: colorful leaf-like structures which attract animals and insects.
  - Corolla: When all of the petals are fused together.
  - Sepals: Green leaves that protect the flower before it opens.
  - Dr. Sami Alchalabi

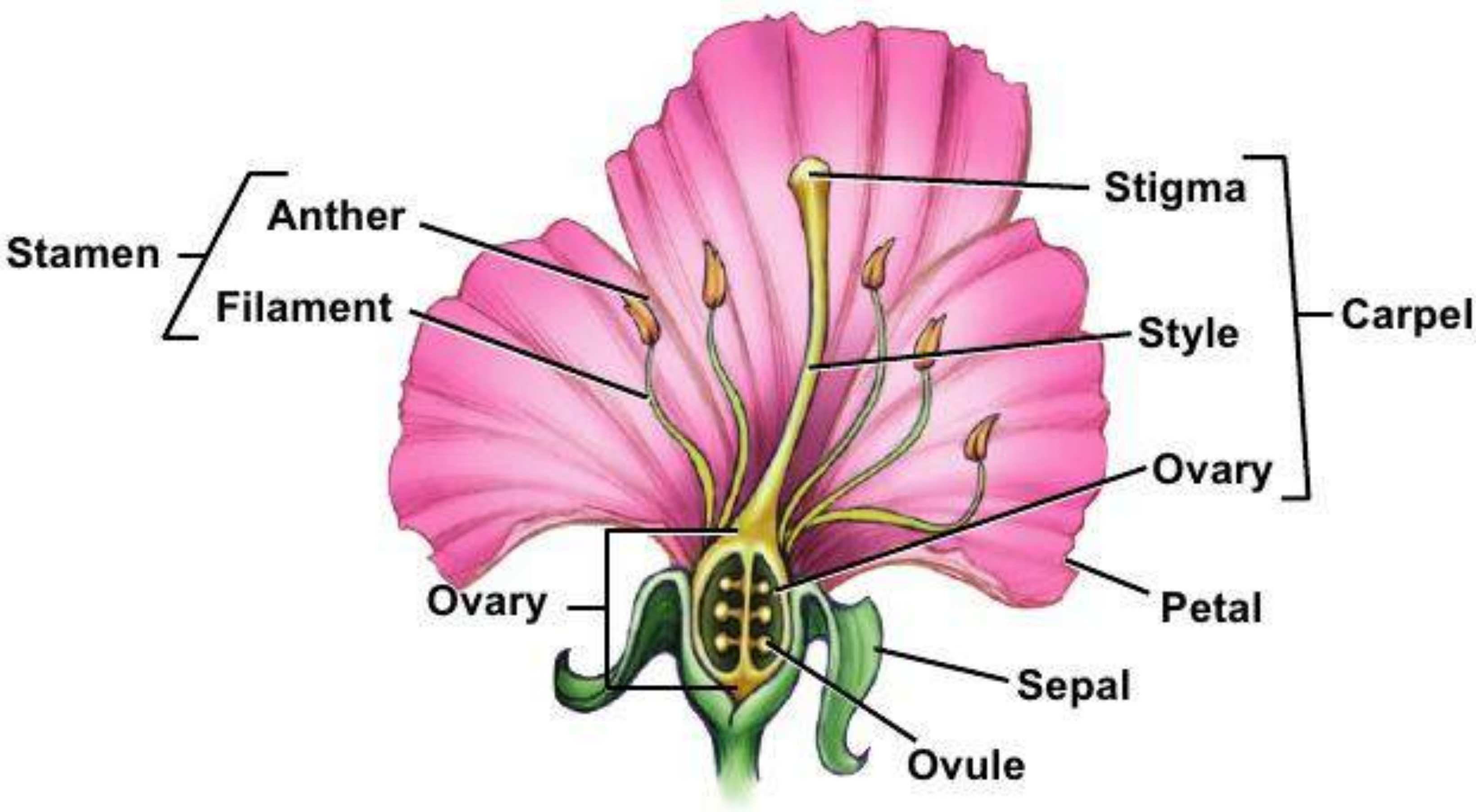
- Flower Parts – Niether male or female
  - Calyx: When all of the sepals are fused together.

Dr. Sami Alchalabi


anther
filament
stamens
stigma
pollen tube
style
ovary
ovule
carpel
receptacle
petals (corolla)
sepals (calyx)

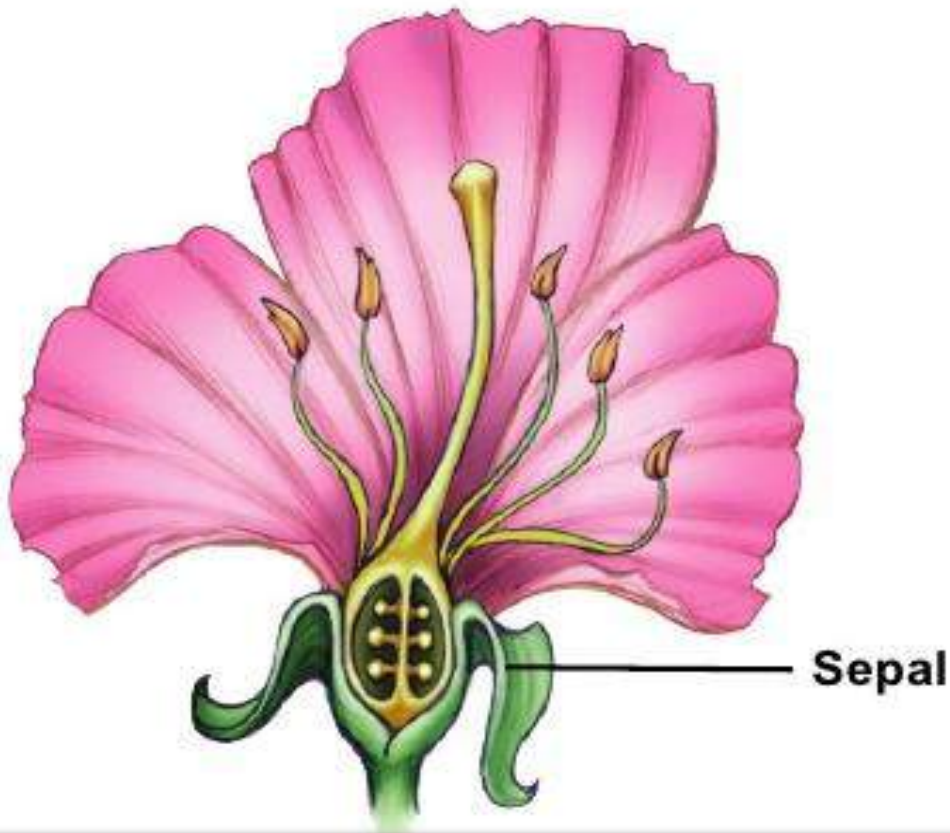
Structure of Flowers

Parts of a Typical Flower



Structure of Flowers

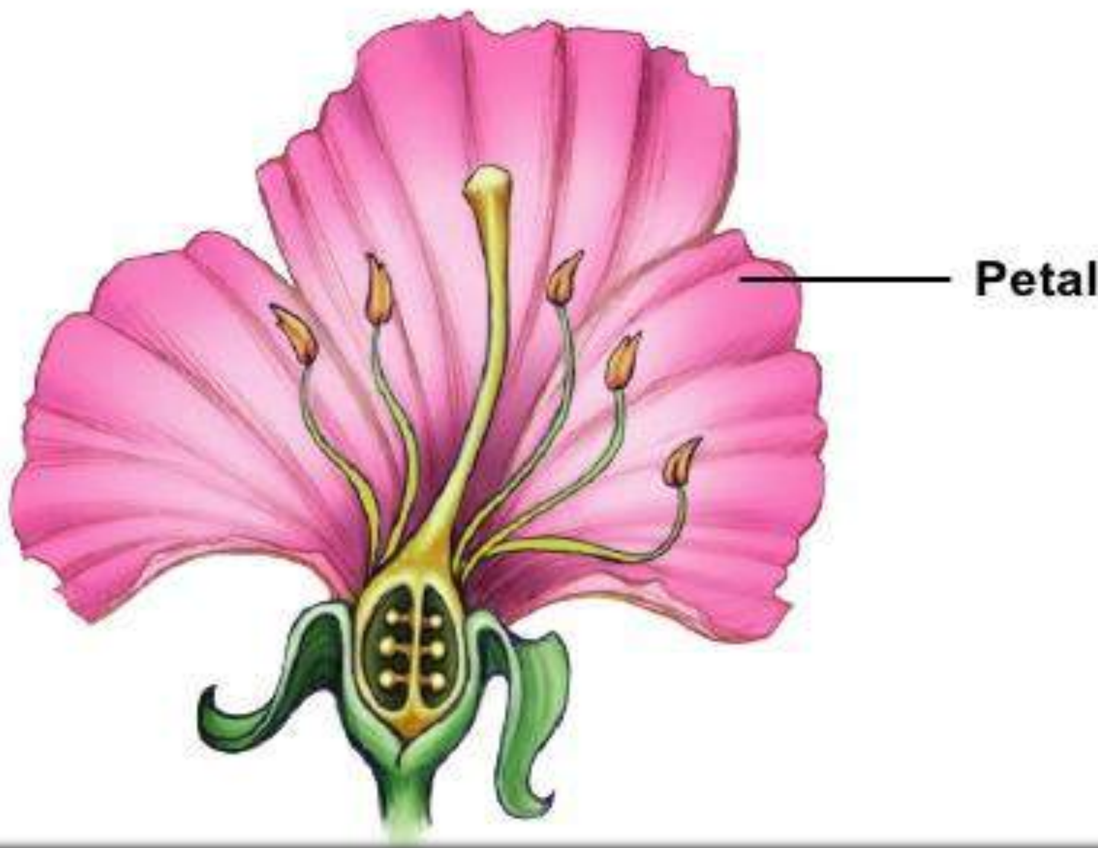
Sepals enclose the bud before it opens and protect the flower while it is developing.



Structure of Flowers

Petals are often brightly colored and are found just inside the sepals.

Petals attract insects and other pollinators to the flower.



- Flower Parts -- Male
  - Stamen: Male part of the flower.
  - Filament: Stalk like in the stamen that holds up the anther
  - Anther: Sack-like structure that contains pollen.

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- Flower Parts -- Male
  - Pollen grains are released from the anther that contains sperm.
  - Staminate: Flowers that have only male parts.

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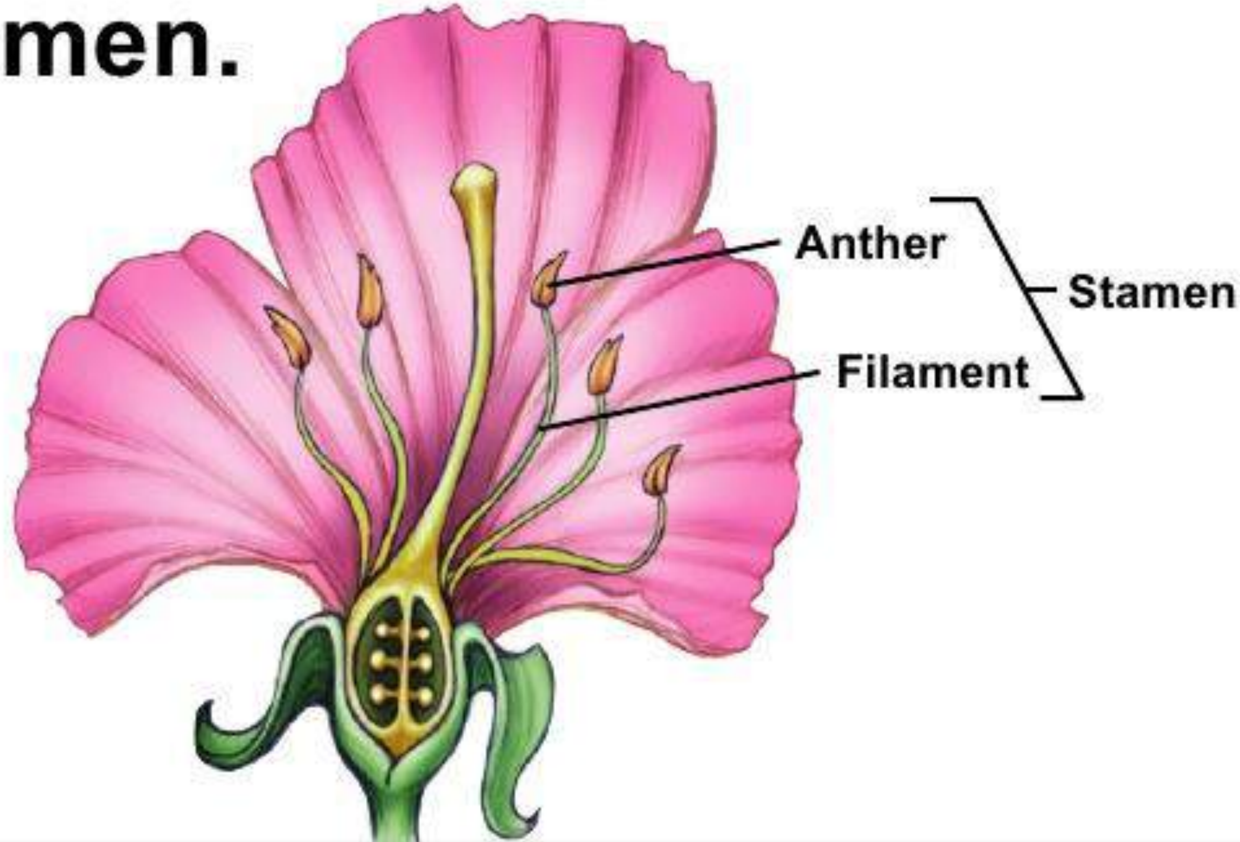
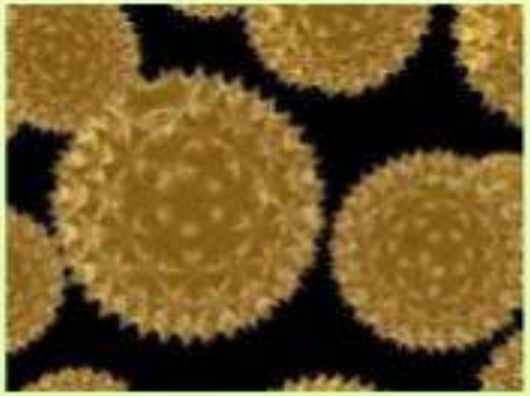
Structure of Flowers

The male parts of a flower consist of an anther and a filament, which together make up the stamen.



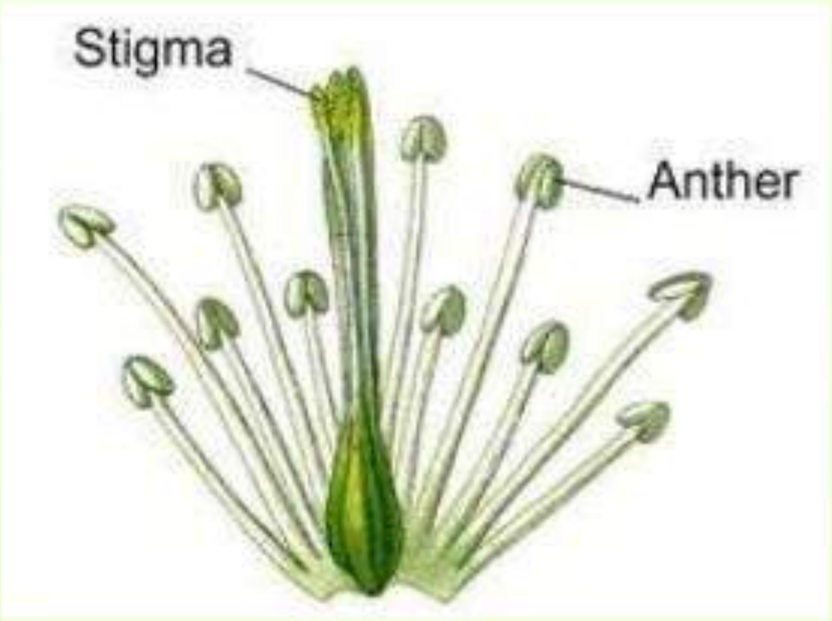
Parts of Flower

- Pollen
  - sperm of the plant.
  - is a fine to coarse powder containing the micro gametophytes of seed plants, which produce the male gametes (sperm cells).



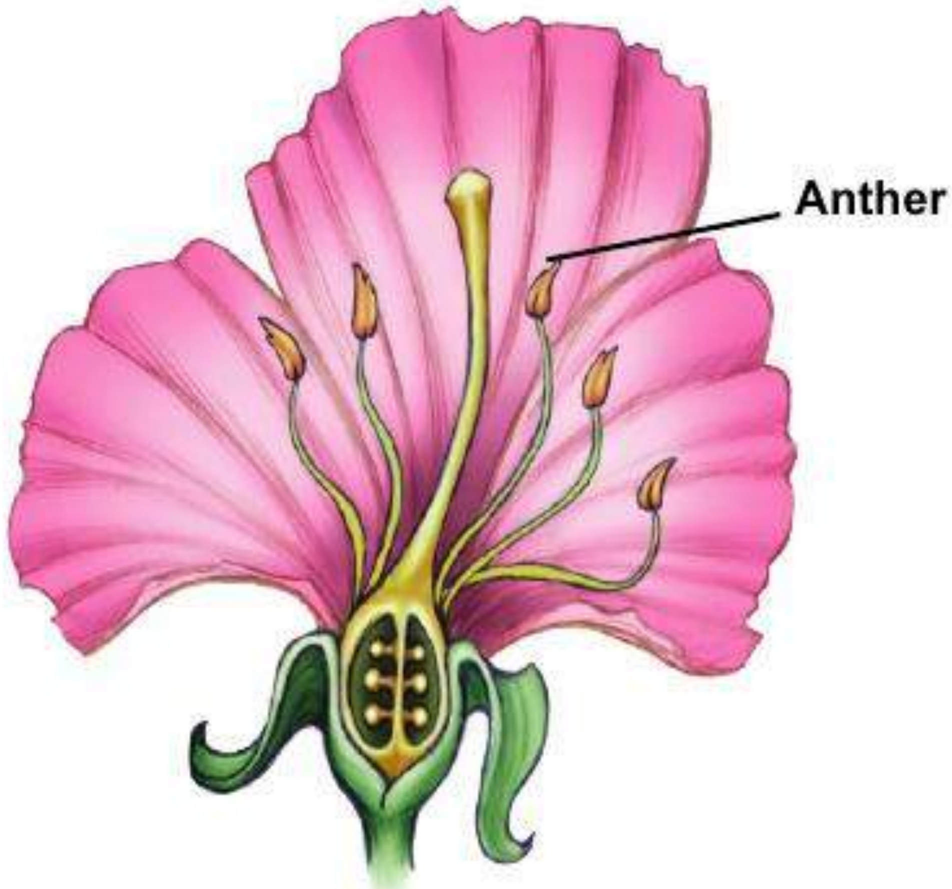
Parts of Flower

- Anther
  - contains the pollen.



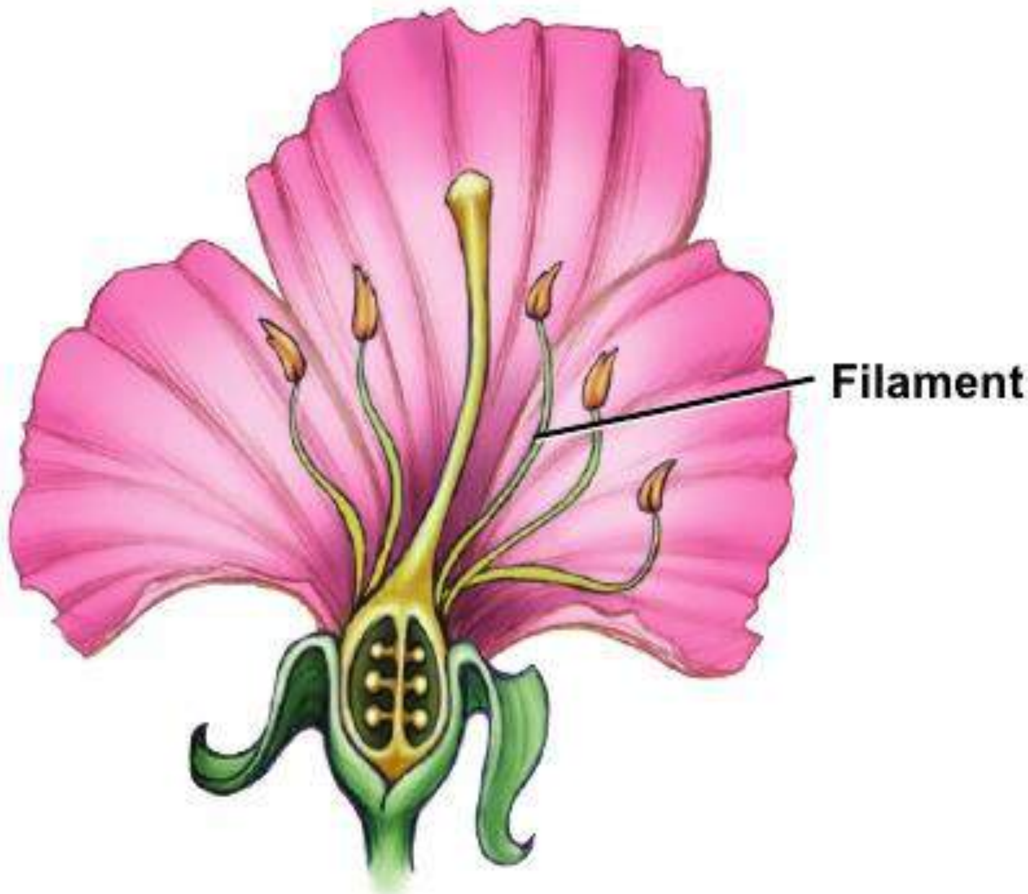
Structure of Flowers

An anther is an oval sac where meiosis takes place, producing pollen grains.



Structure of Flowers

The filament is a long, thin stalk that supports an anther.

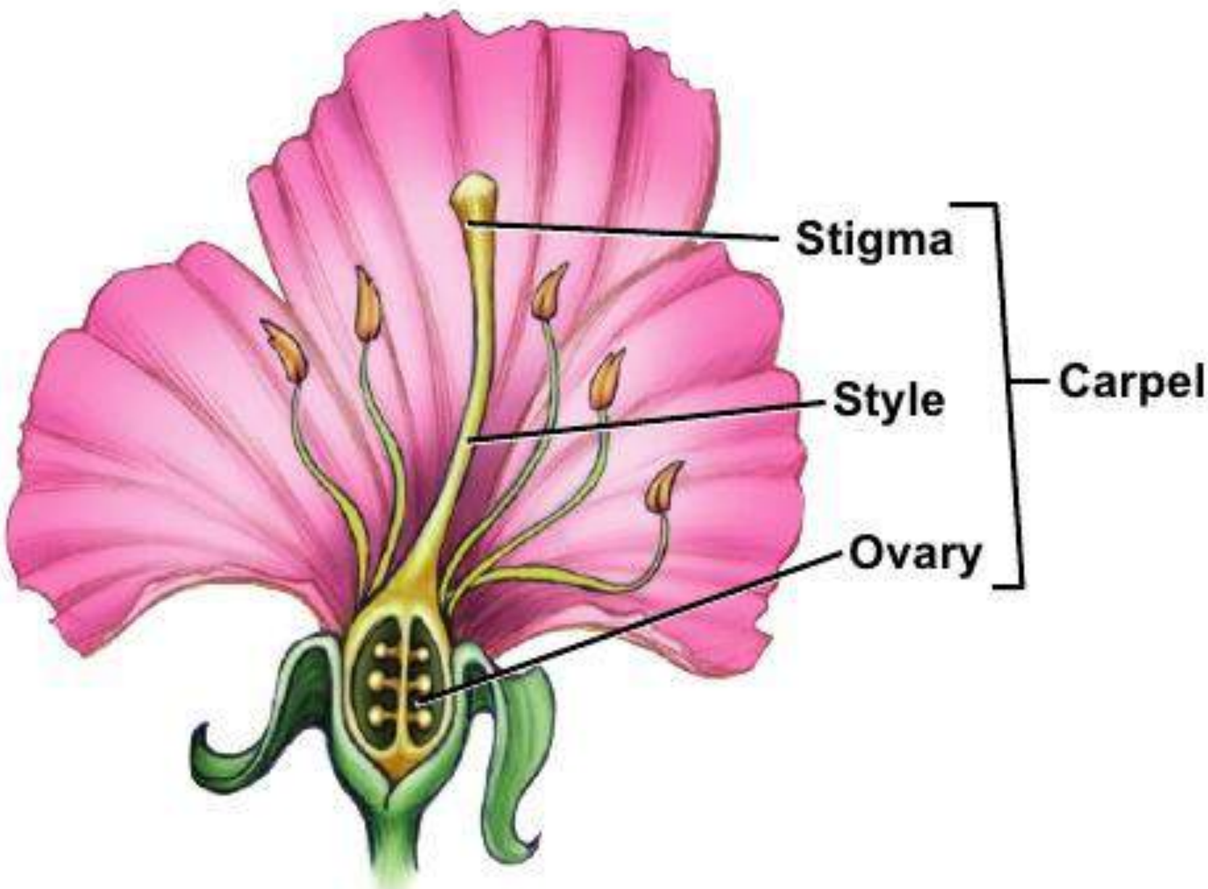


Parts of Flower

- Filament
  - are a series of chain like cells.
  - stalk on which anther is attached, longer in wind pollinated plants.

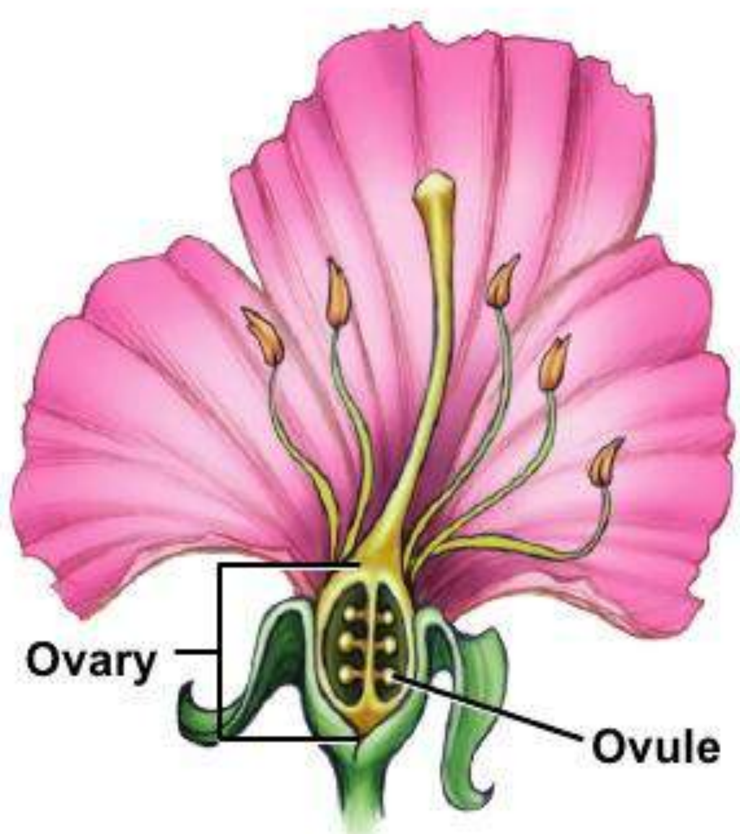
Structure of Flowers

The innermost parts are carpels(pistils).



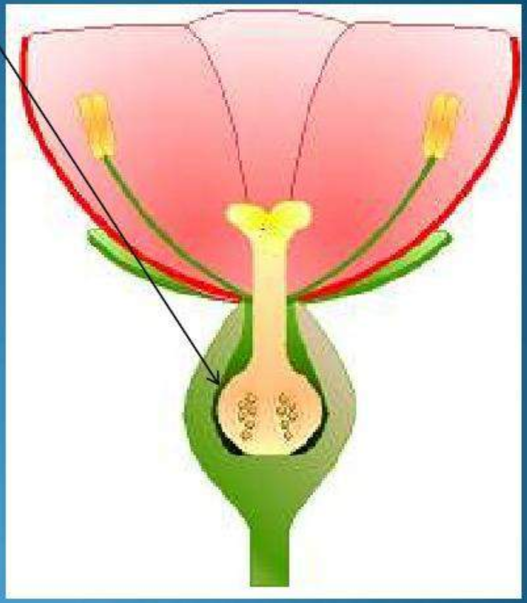
Structure of Flowers

Each carpel has a broad base forming an ovary where female gametophytes are produced.



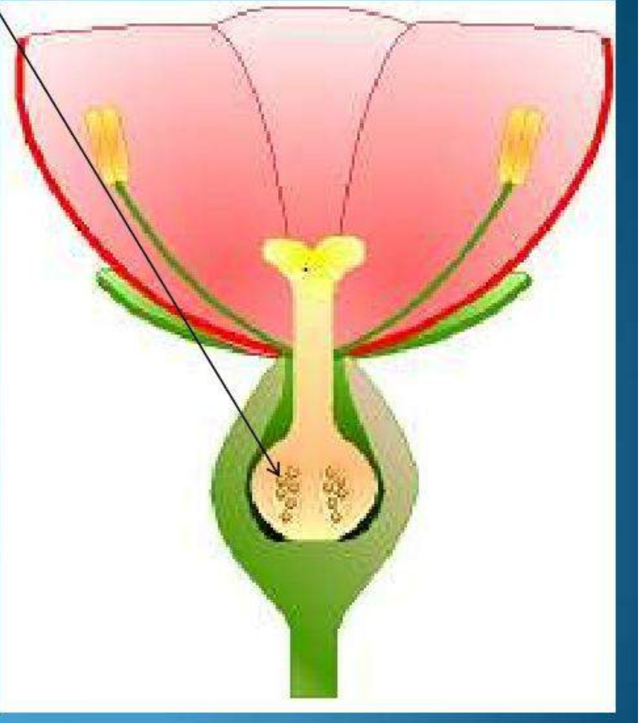
Ovary

The ovary are a structure that houses the ovules of the flower. Once these ovules become fertilized, they then develop into seeds.



Ovule

The ovule is similar to the egg in animals. It is the female reproductive cells and when fertilized by pollen, will develop into a seed.



- Flower Parts – Female
  - Pistil: Female part of the flower
  - Stigma: Sticky part of the pistil that is receptive to pollen.
  - Style: Rod shaped middle part that has a swollen base (ovary) containing eggs.

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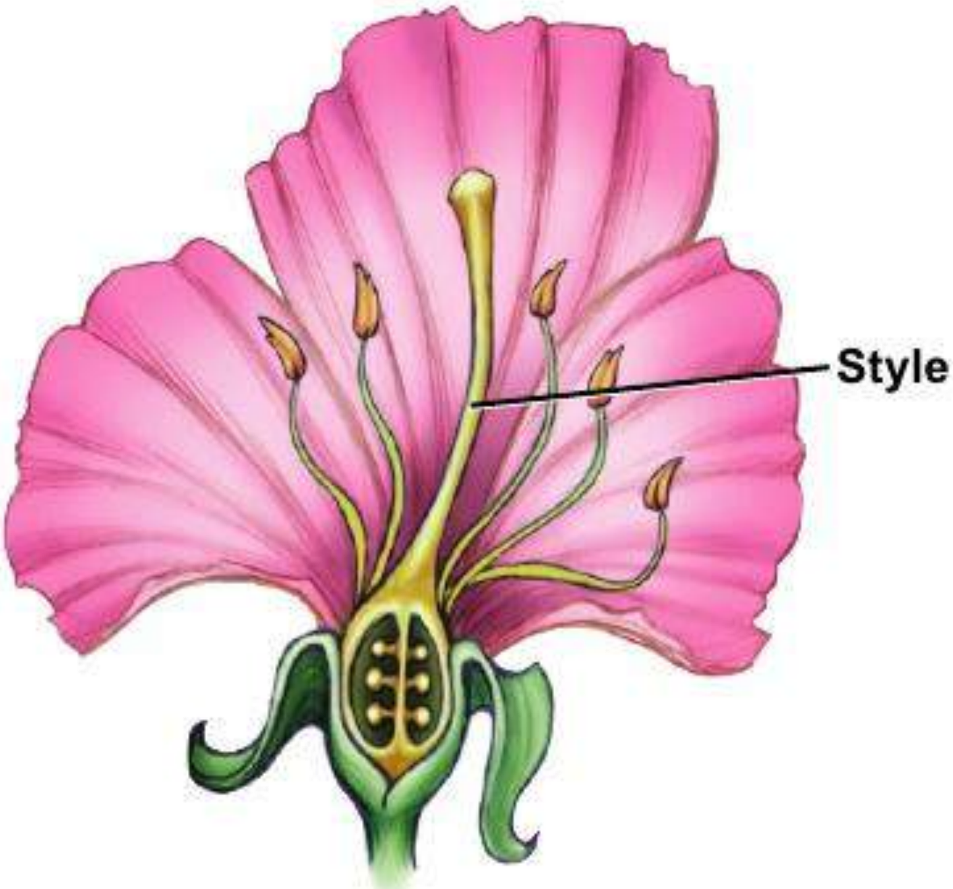
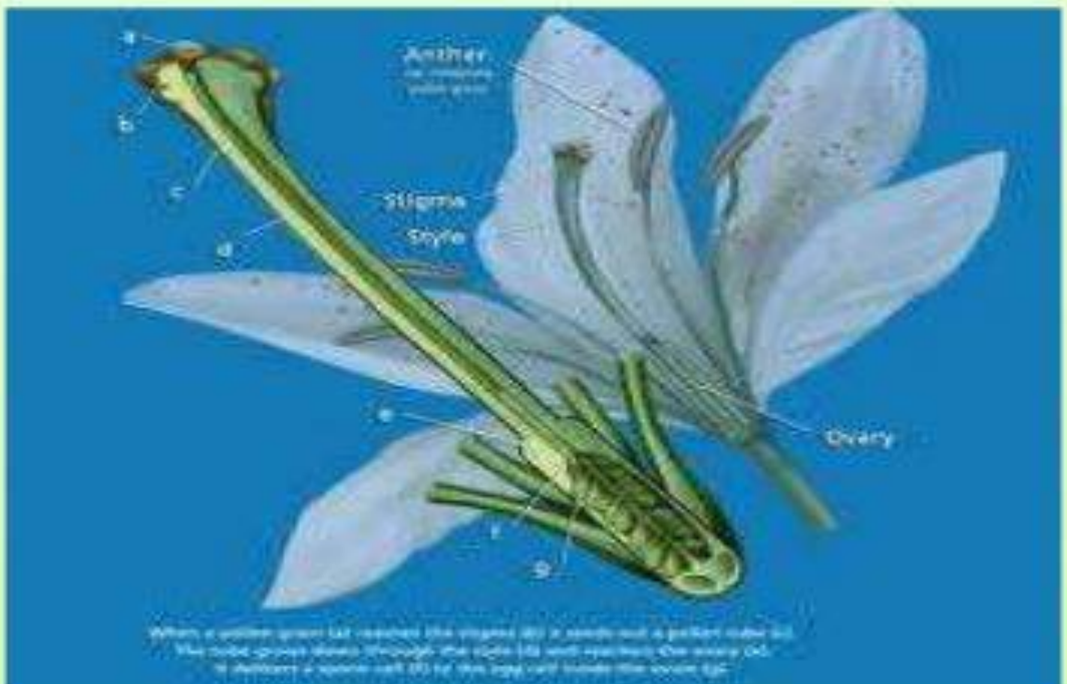
Structure of Flowers

The narrow stalk of the carpel is the style.



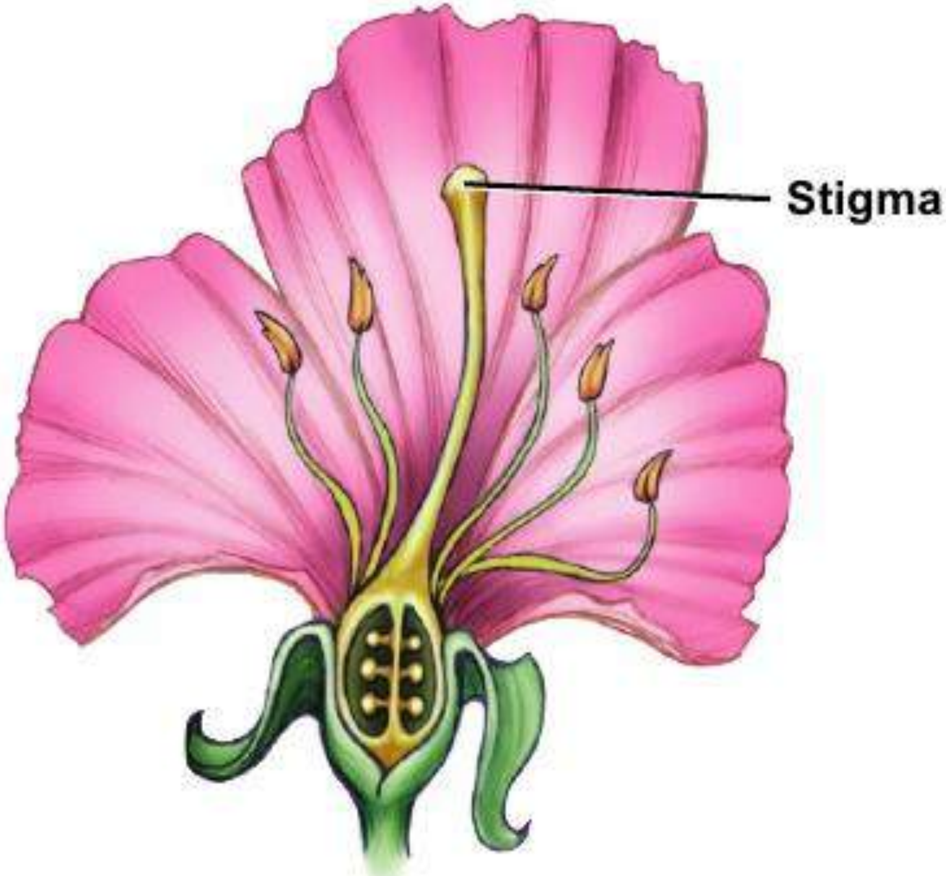
Parts of Flower

- Style
  - simply, a tube through which sperm travel to seeds.



Structure of Flowers

At the top of the style is the stigma—a sticky portion where pollen grains frequently land.



Flowers

- Flower Types:
  - Perfect Flower: Has both male and female parts.
  - Imperfect Flower: A flower that is missing either male or female parts.
  - Complete Flower: Flowers that have sepals, petals, pistils, and stamens.

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- Flower Types:
  - Incomplete Flowers: When a flower is missing sepals, petals, pistils, or stamen.
  - Imperfect Flowers are always incomplete. Incomplete flowers may or may not be imperfect.

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- Pistillate flower: Flowers having only female reproductive organ. (Gynoecium)

Cucurbita Female flower

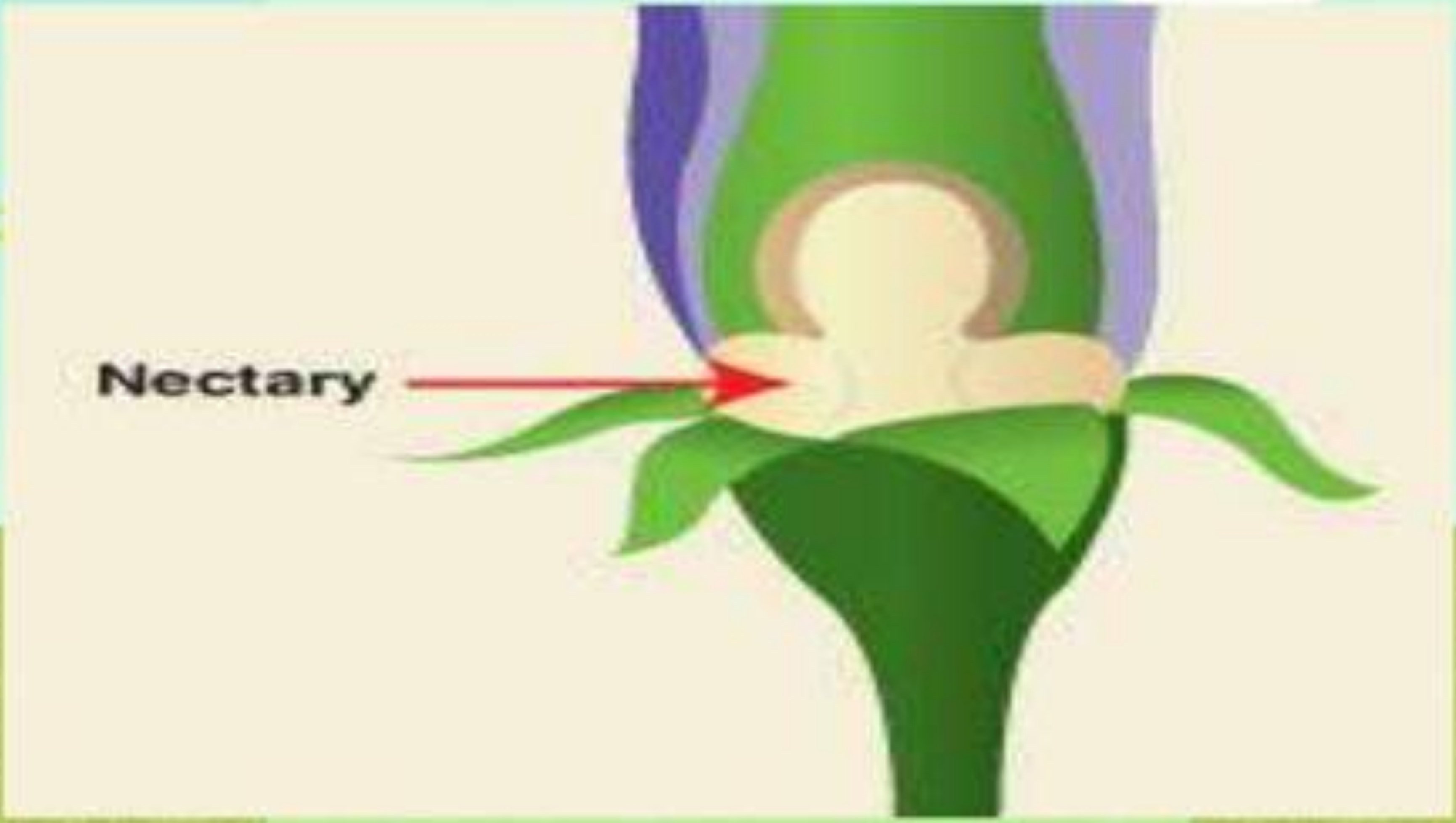
- Staminate flower: Flowers having only male reproductive organ. (Andro

Cucurbita Male flower

NECTARIES

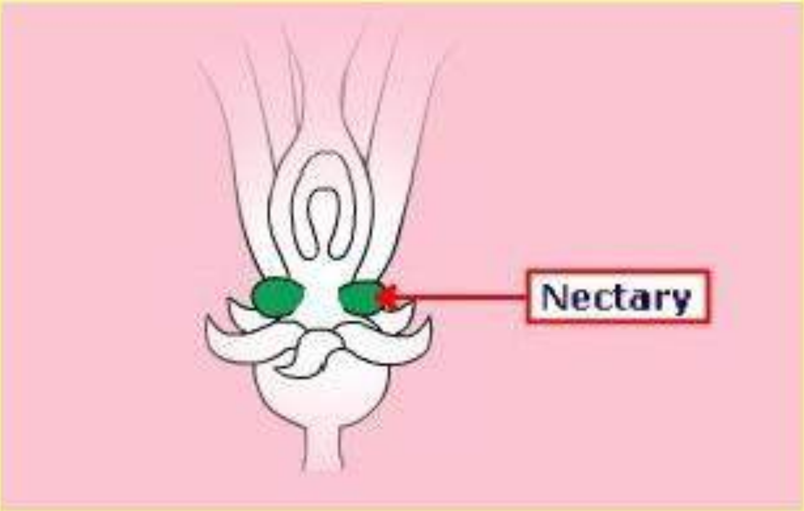
- The **nectaries** are the parts of a flower that make **nectar**. Nectar is a sweet substance. Insects drink it to get energy! Bees also use nectar to make honey.
- The **nectaries** are usually right **in the centre of the flower**. This means the insects have to go deep into the flower to find the nectar. As they do so, their bodies pick up pollen from the anthers, and they carry it to the next flower they visit.

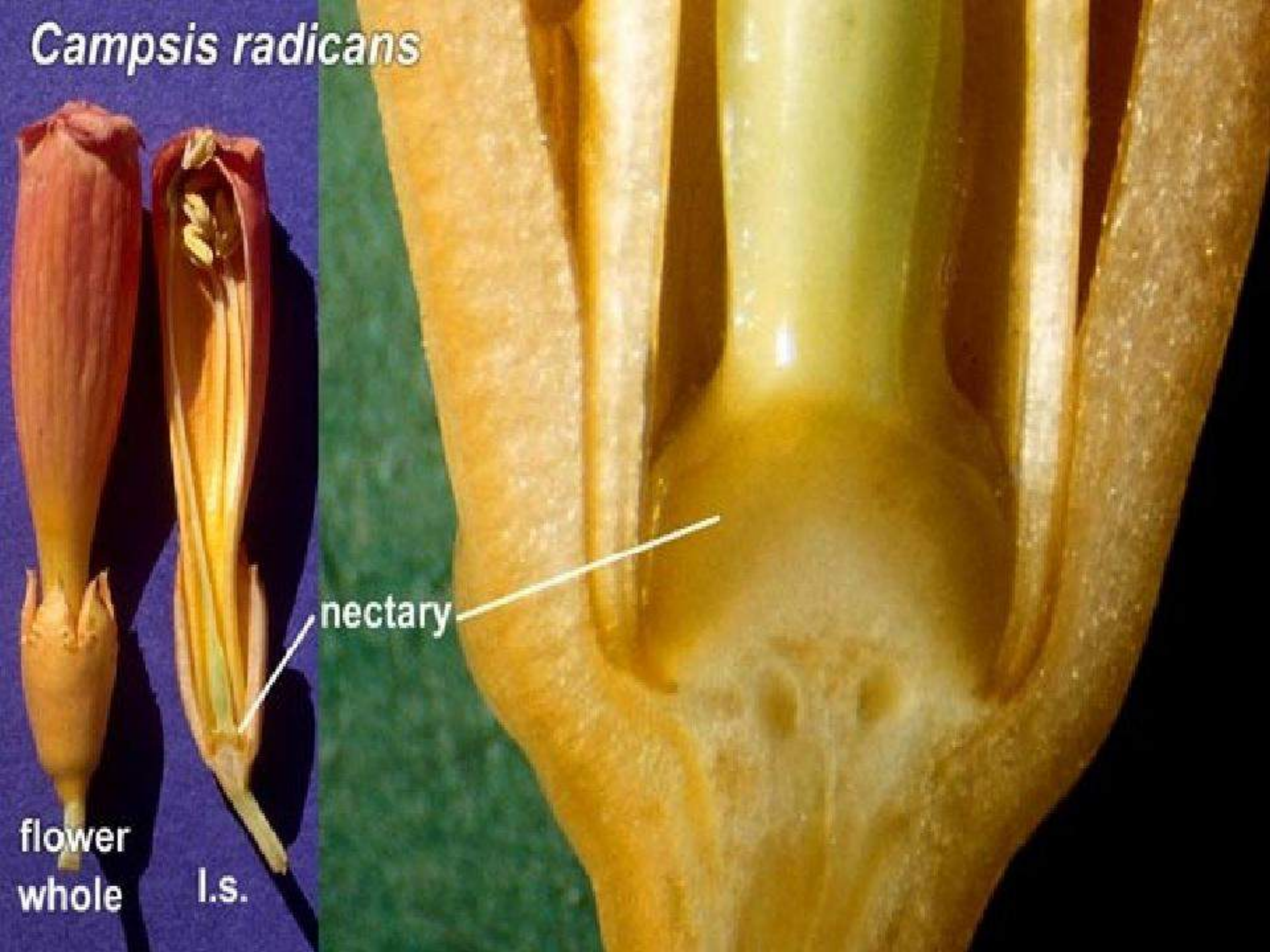
NECTARIES



Nectary

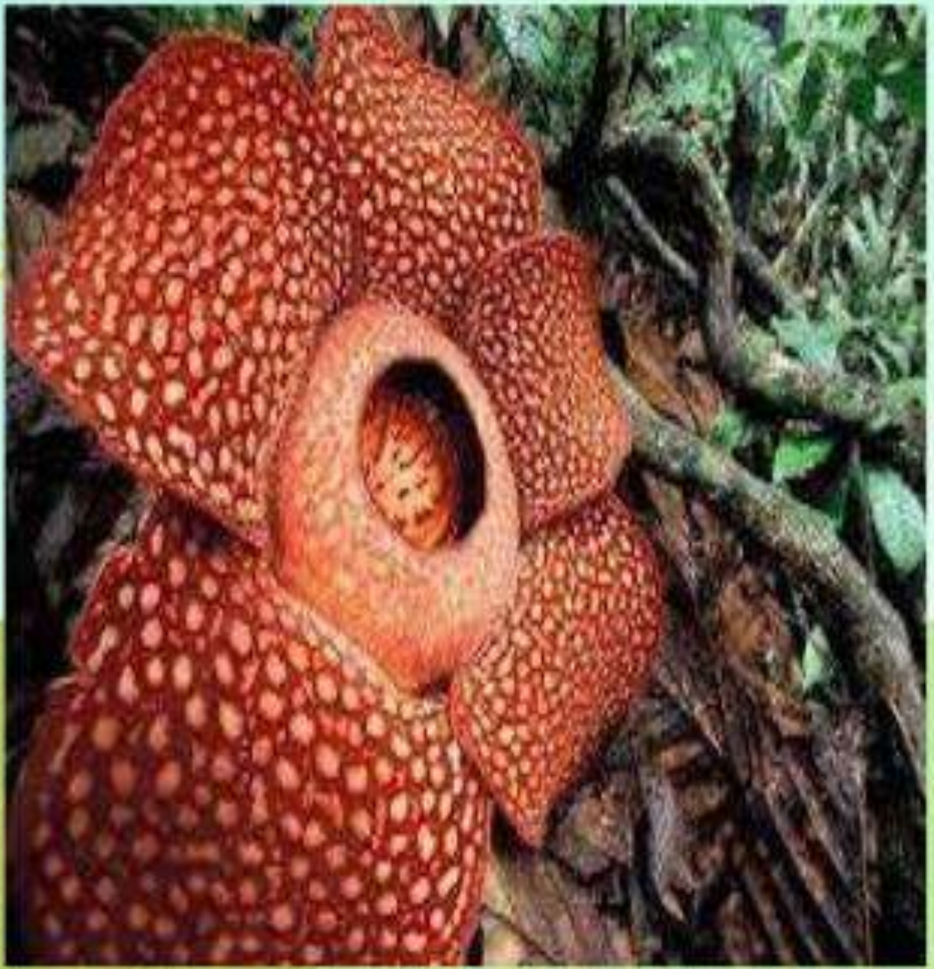
- The **nectaries** make nectar.
- They are in the centre of the flower.
- Nectar is a sweet substance, which insects drink to give them energy.





Campsis radicans
nectary
flower
whole
l.s.

THE LARGEST FLOWER IN THE WORLD...



Rafflesia arnoldii: This is a strange flower! It is the largest flower in the world, with a diameter of metres and weighs 11 kg! It grows in the forests and jungles of Southeast Asia, especially in Indonesia and the Philippines.

...AND THE SMALLEST!

Wolffia is officially the world's smallest flower, with each bloom weighing about as much as two grains of sand.

Wolffia sometimes grow in colonies The only way to identify the exact species of a Wolffia flower is to view it under a microscope.

SEED

Seed Structures

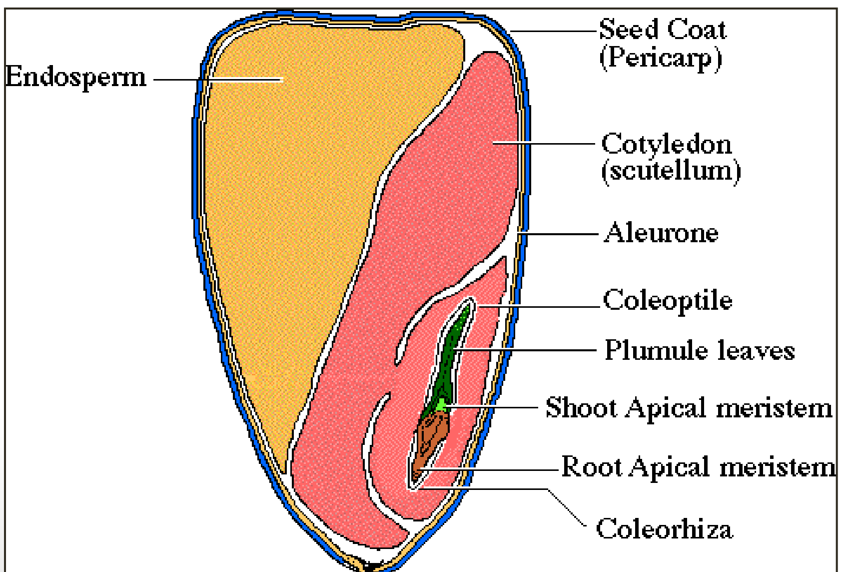
- Seed
- Seed coat
- Cotyledon
- Embryo
- Endosperm
- Hypocotyl
- Radicle
- Epicotyl (plumule)

Germination

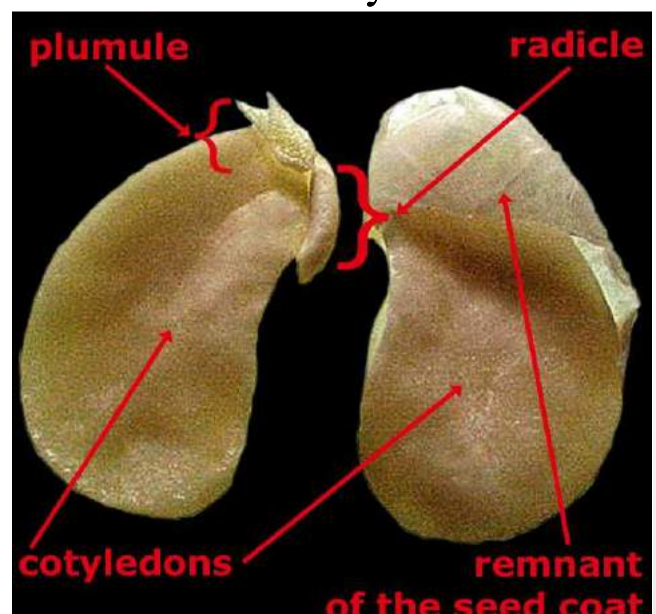
- Hypogeous
- Epigeous

Seeds

Monocots: single cotyledon; endosperm and cotyledon are separate.

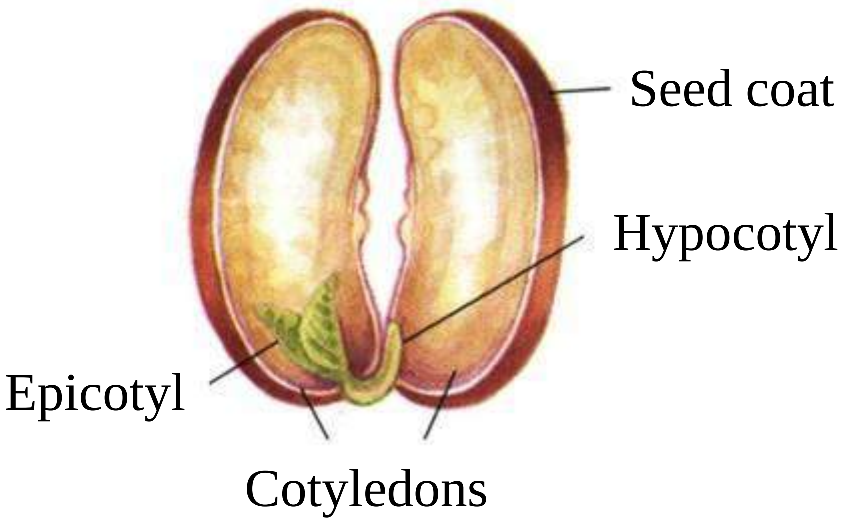


Dicots: two cotyledons; endosperm is contained in the cotyledon.

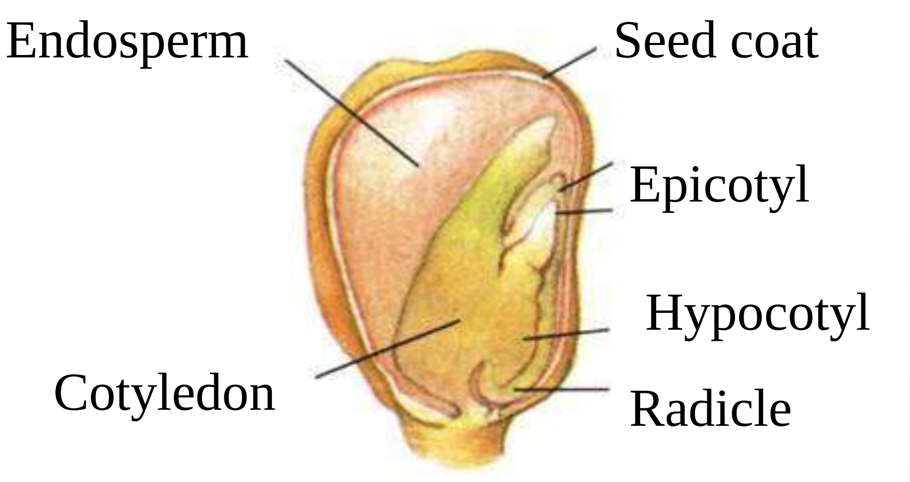


Parts of a seed

- Dicot



- Monocot



Seed Germination