Lec. One
Parts of the Optical Microscope and Their Function

Dr. Anaam F. Hussain

A microscope is a high precision optical instrument that uses a lens or a combination of lenses to produce highly magnified images of small specimens or objects.

Microscopy is the use of a microscope or investigation by a microscope.

Specific categories for using microscopes

- **Hobbyists** :gems, coins, stamps, collectibles, learning and discovery, etc.

- **Education :** chemistry, biology, botany, zoology, geology etc…..

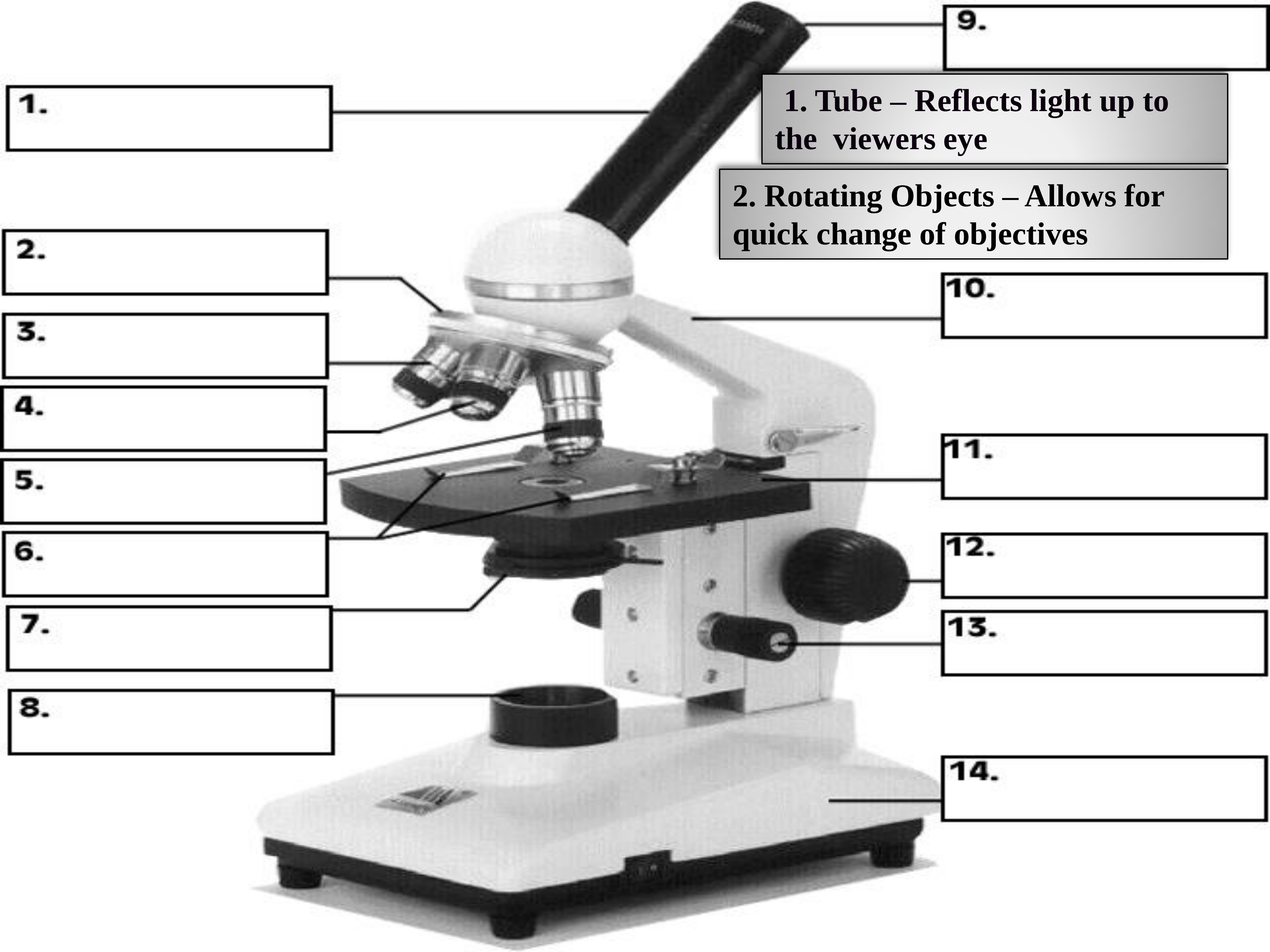
- **Industry:** inspection of electronic assembly components and many different materials such as metals, textiles, plastics, etc. Used in agriculture, wineries, breweries, and for fine engravings and mining inspection. Used by jewelers and geologists.

- **Medical:** microbiology, hematology, pathology, entomology, dermatology, dental usage, veterinary use, everyday analysis to advanced research. From medical schools to labs to hospitals

Optical microscope

Is the simplest form of microscope uses visible light and a system of lenses to magnify images of small samples.

- It has tools that are used to observe the small organisms or object and even macromolecules. It has wide variety of microscopic tools for studying the biomolecules and biological processes. It includes all forms of microscopic methods that use electromagnetic radiation to achieve magnification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1. Tube – Reflects light up to the viewers eye
2. Rotating Objects – Allows for quick change of objectives
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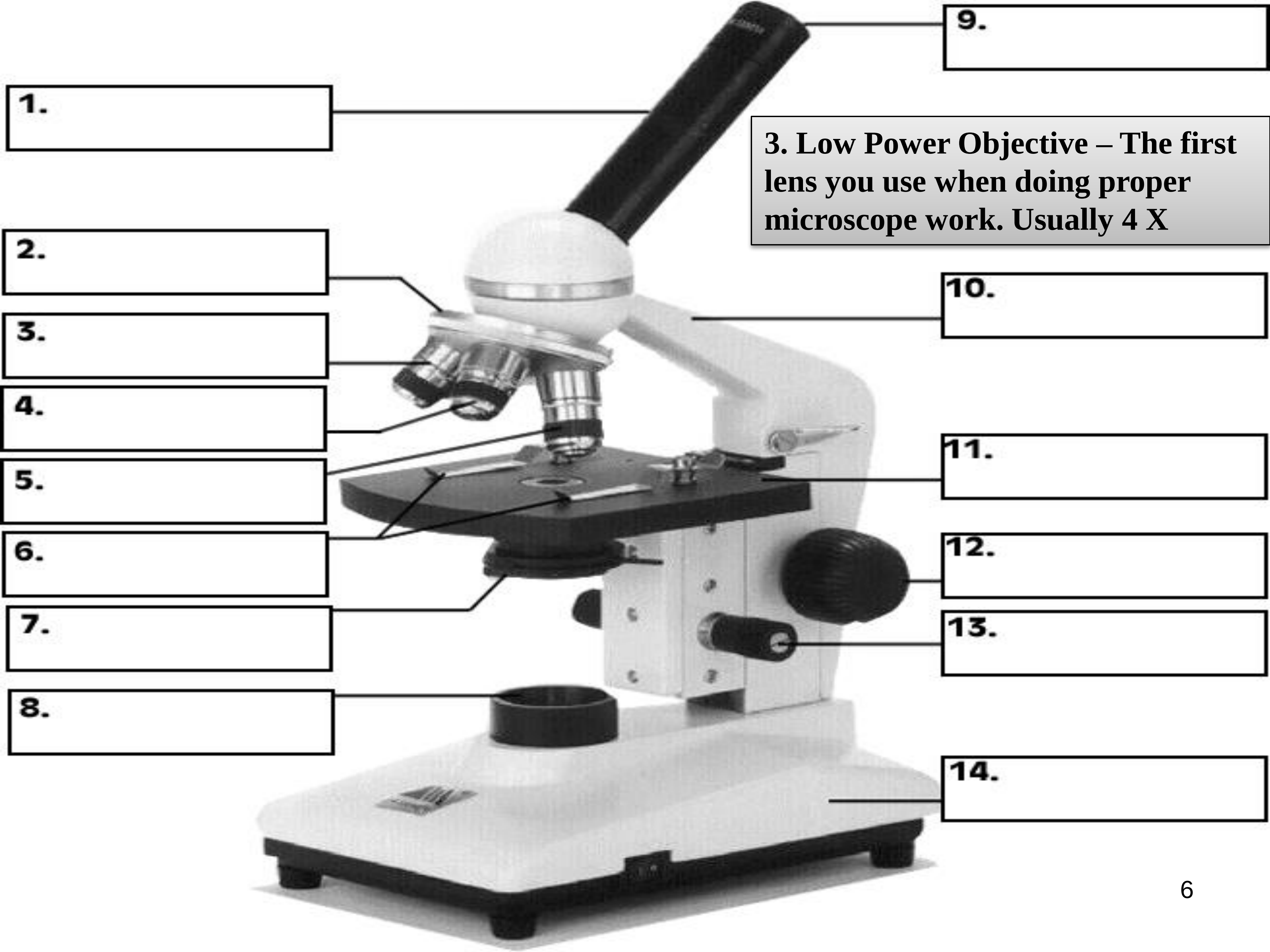
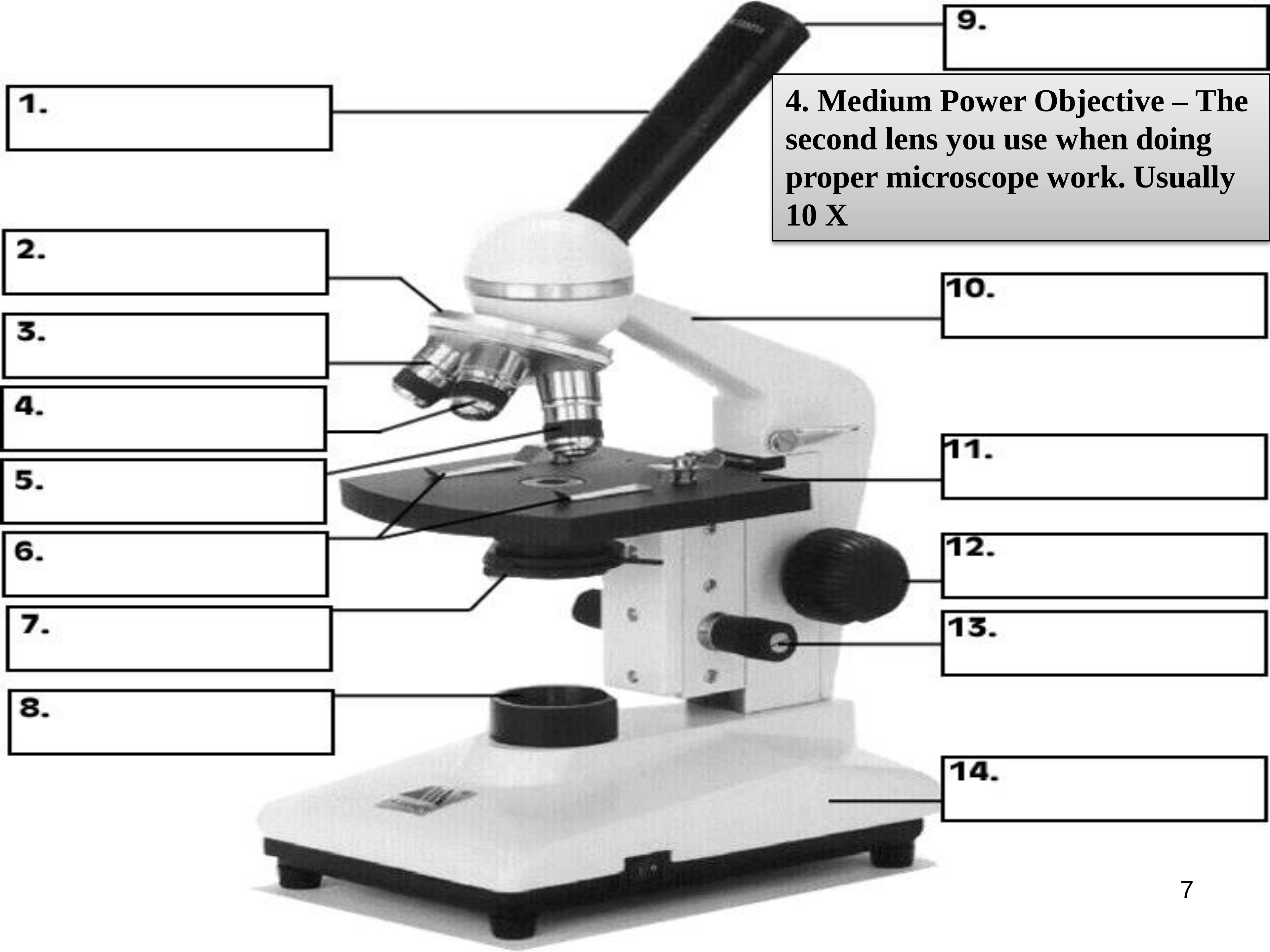
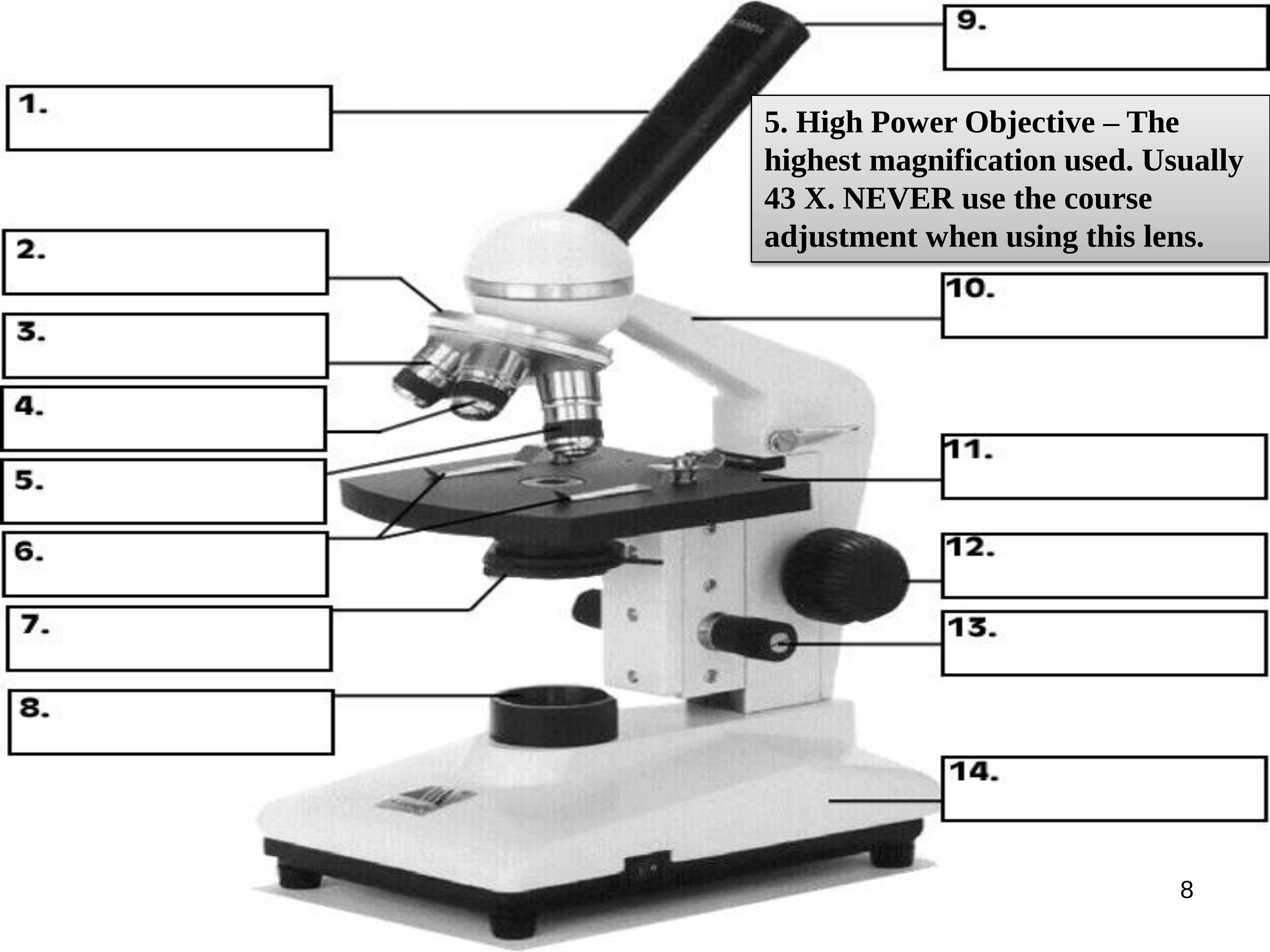


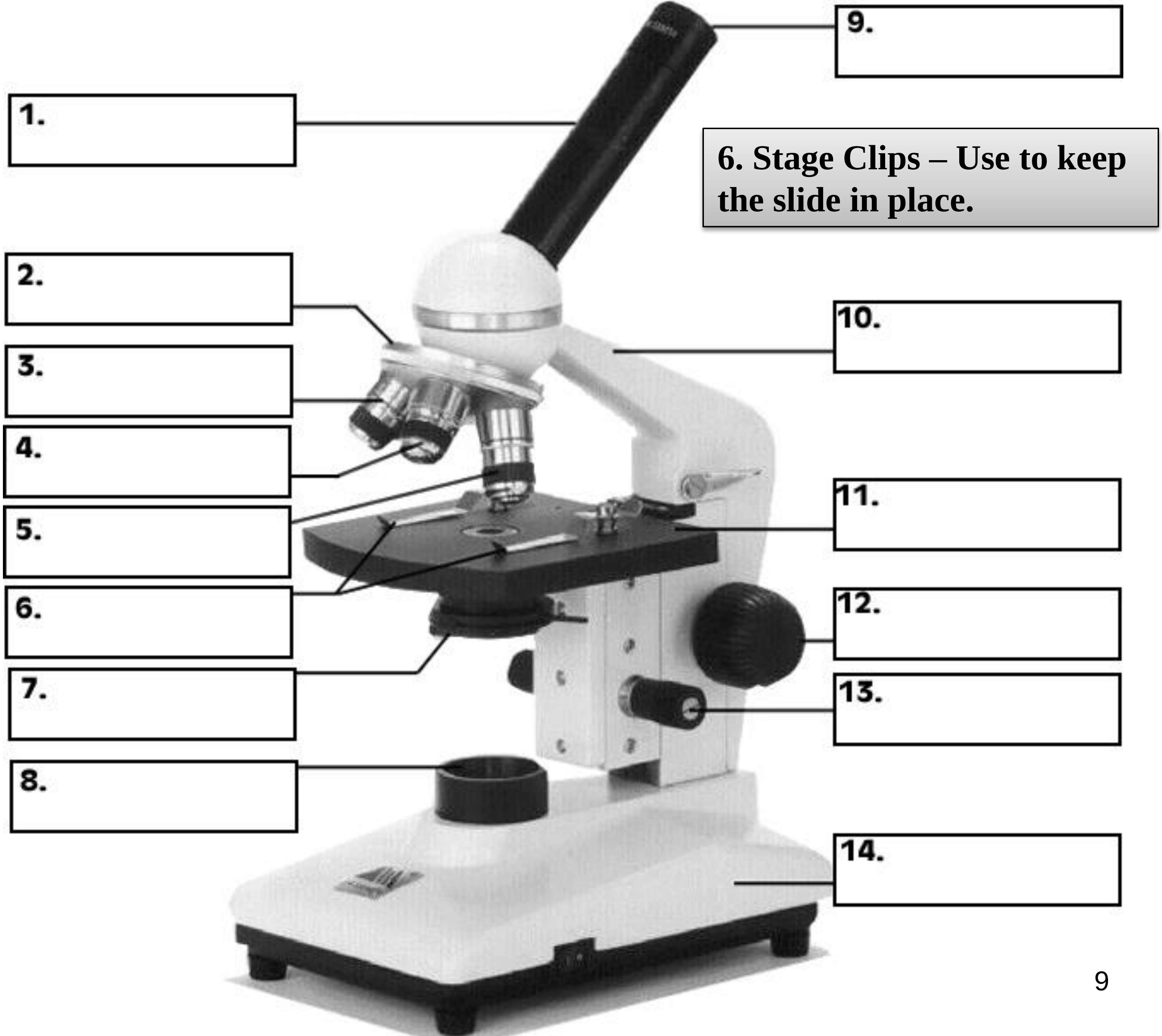
3. Low Power Objective – The first lens you use when doing proper microscope work. Usually 4 X



4. Medium Power Objective – The second lens you use when doing proper microscope work. Usually 10 X



5. High Power Objective – The highest magnification used. Usually 43 X. NEVER use the course adjustment when using this lens.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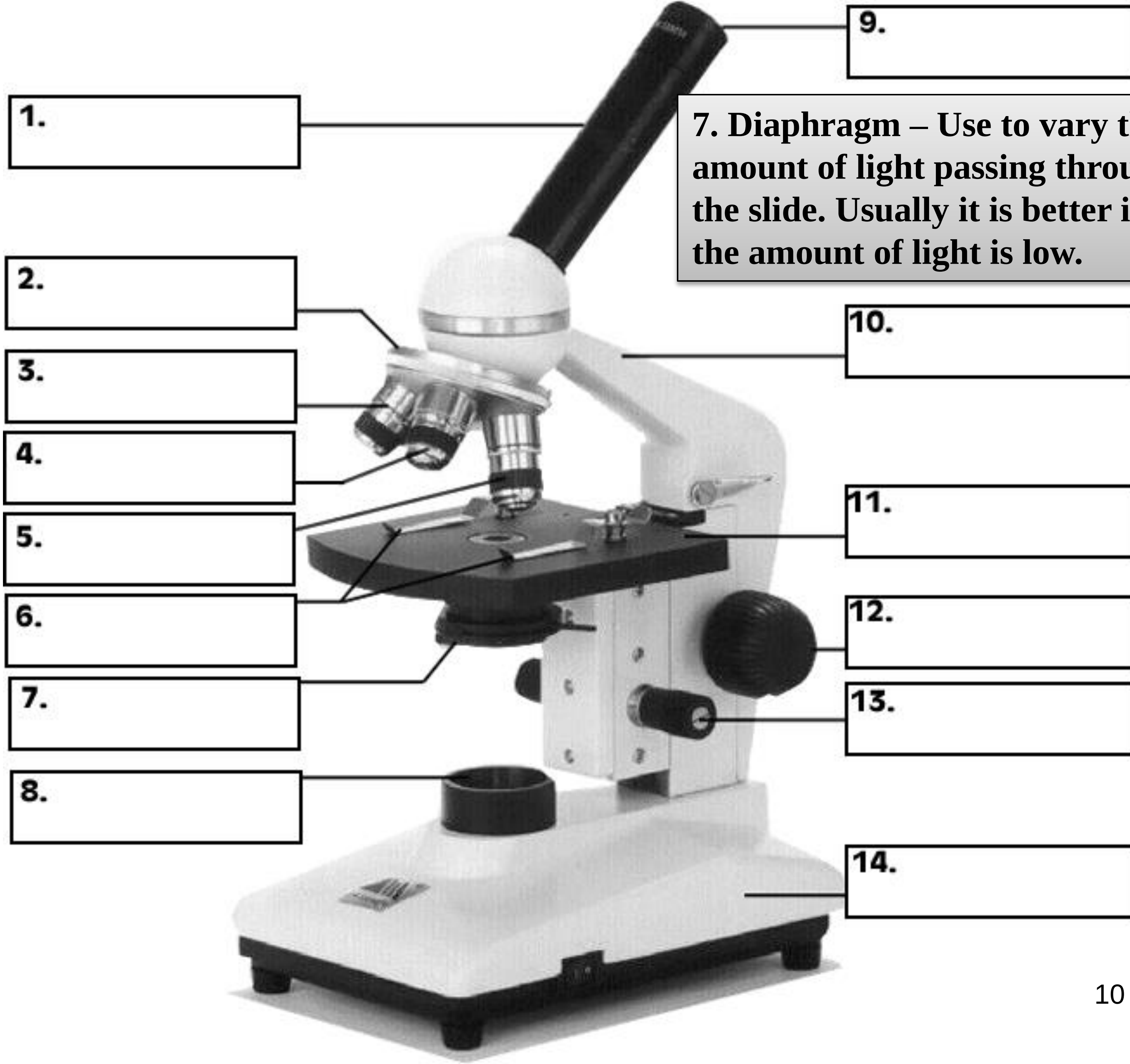
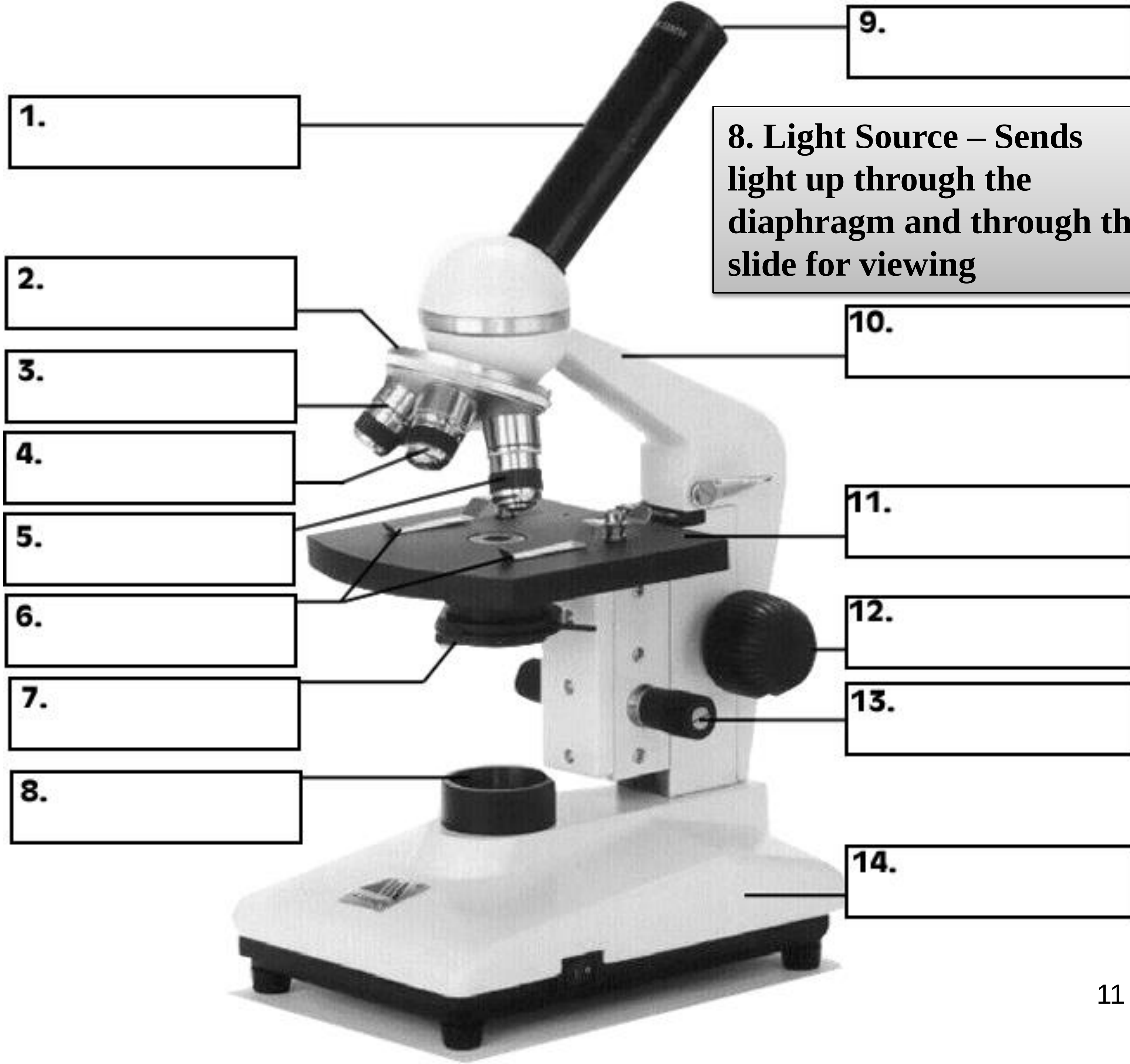
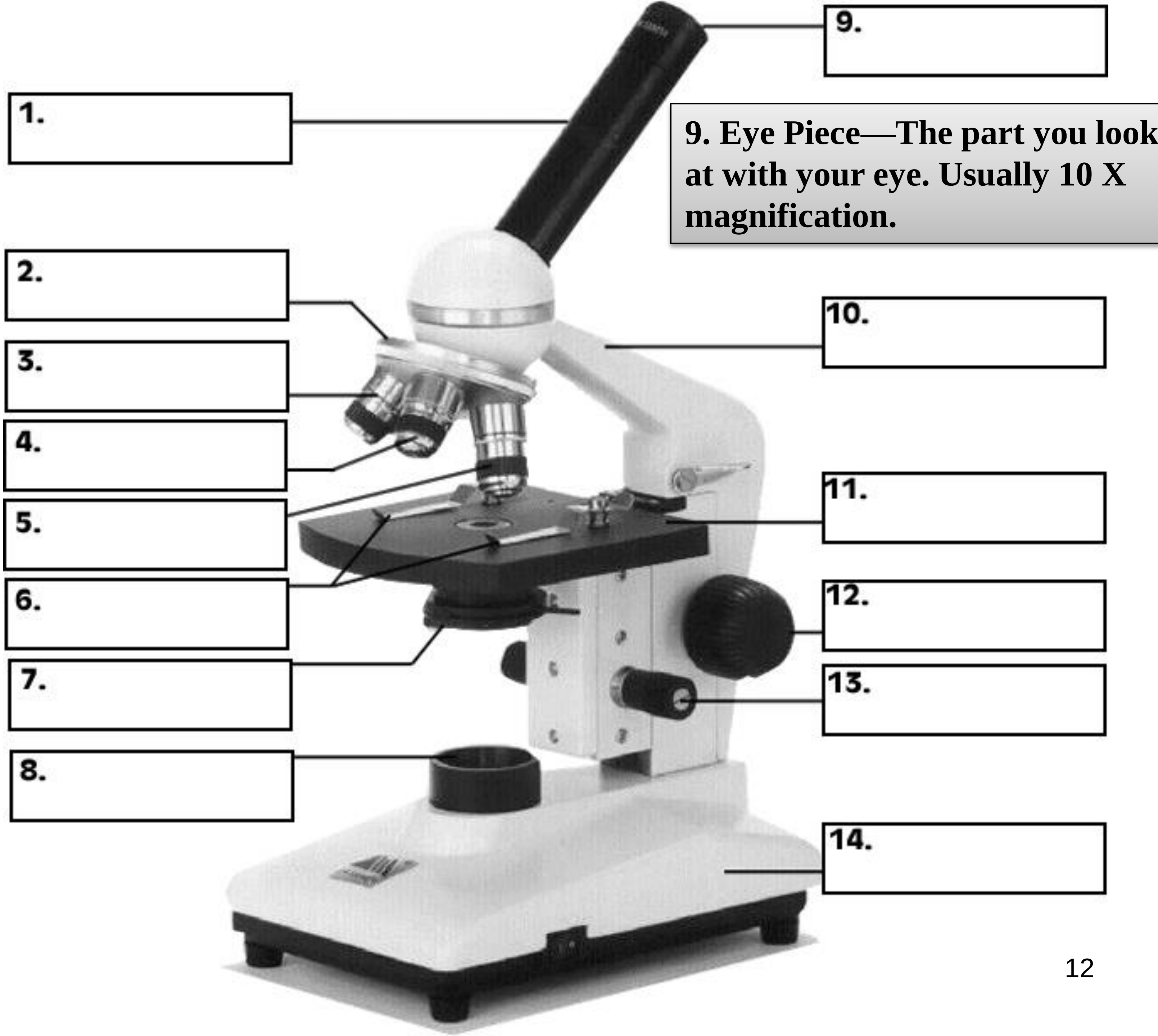
6. Stage Clips – Use to keep the slide in place.



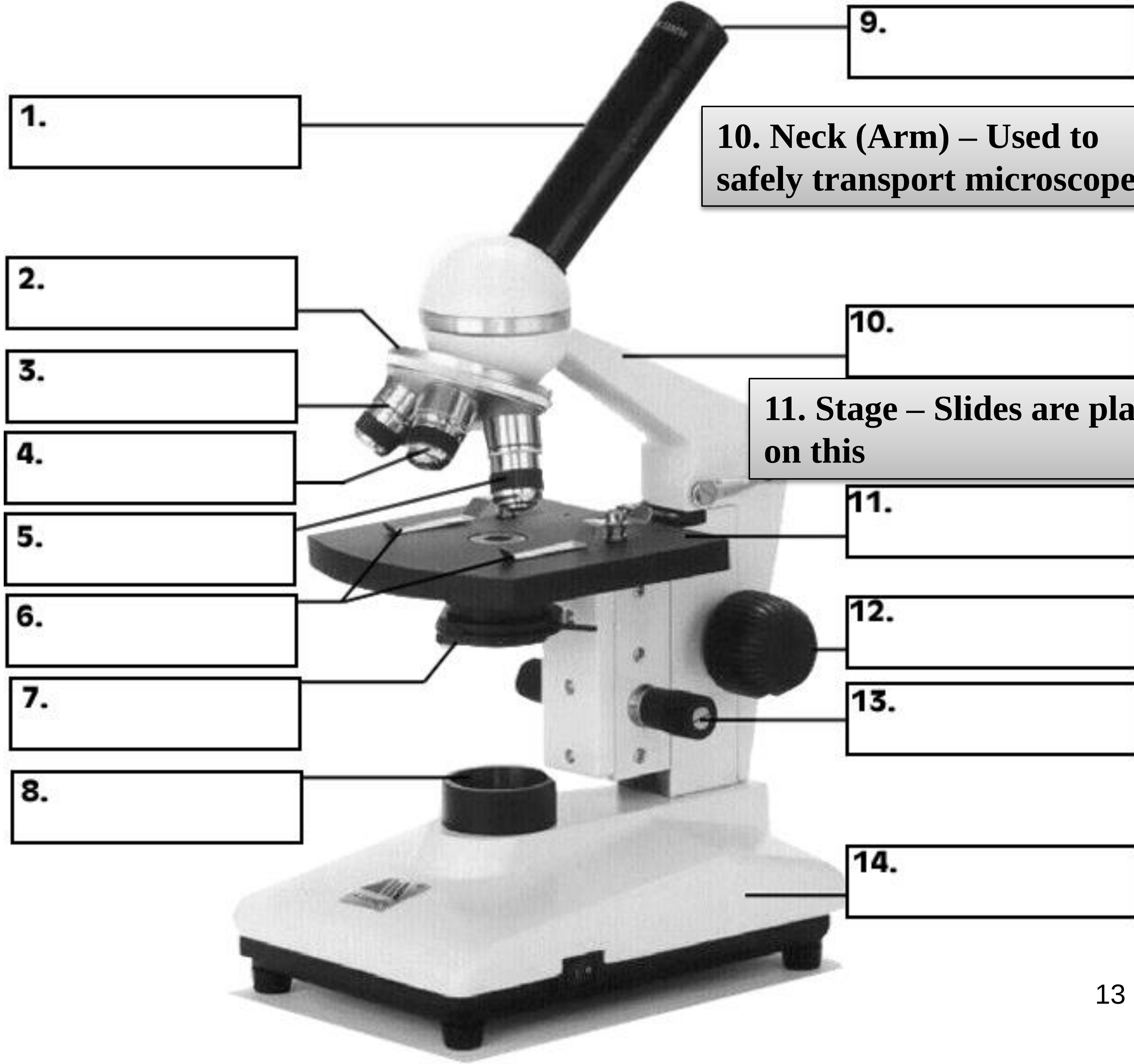
7. Diaphragm – Use to vary the amount of light passing through the slide. Usually it is better if the amount of light is low.



8. Light Source – Sends light up through the diaphragm and through the slide for viewing

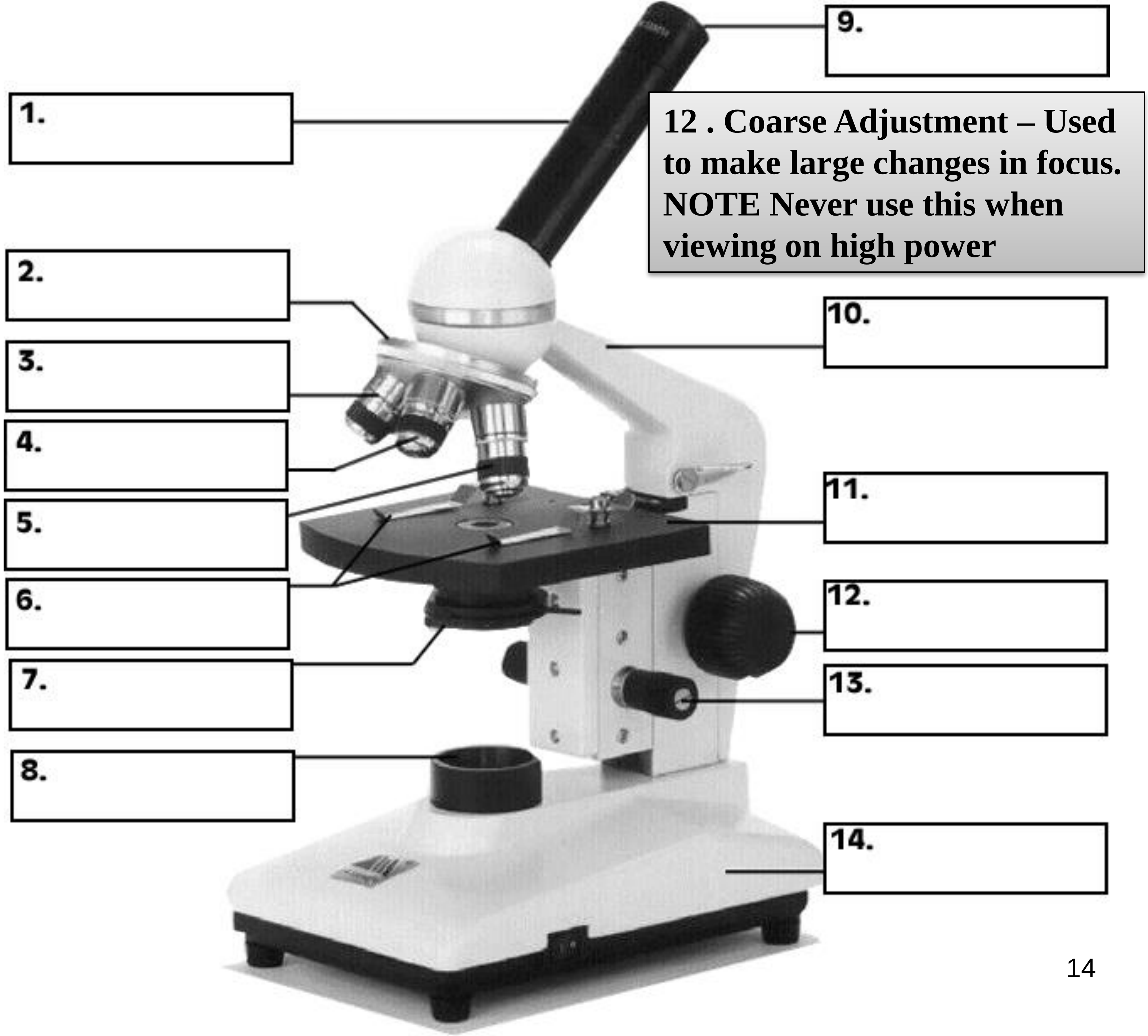


9. Eye Piece—The part you look at with your eye. Usually 10 X magnification.



10. Neck (Arm) – Used to safely transport microscope

11. Stage – Slides are placed on this



9.
1.
12 . Coarse Adjustment – Used to make large changes in focus. NOTE Never use this when viewing on high power
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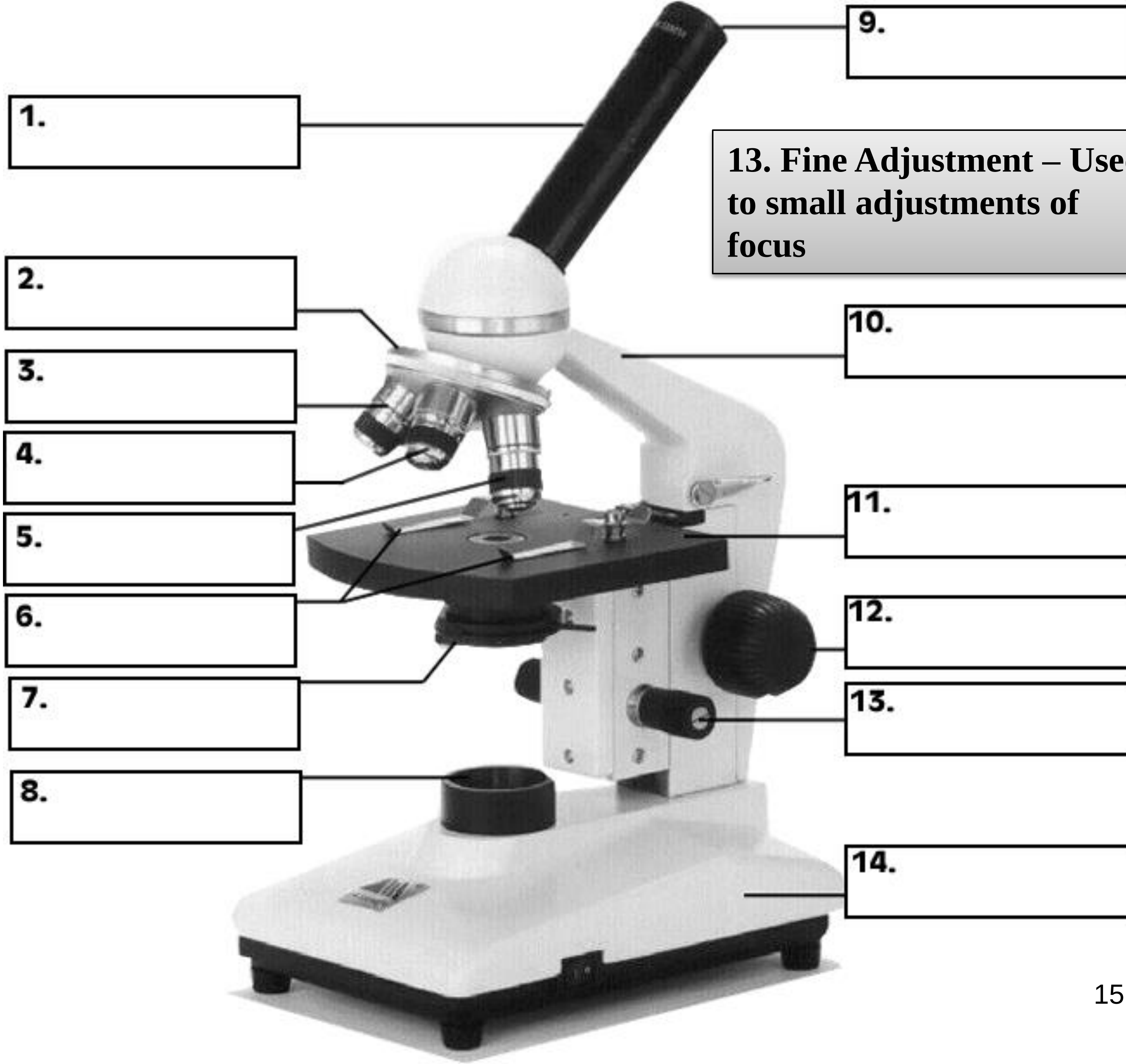
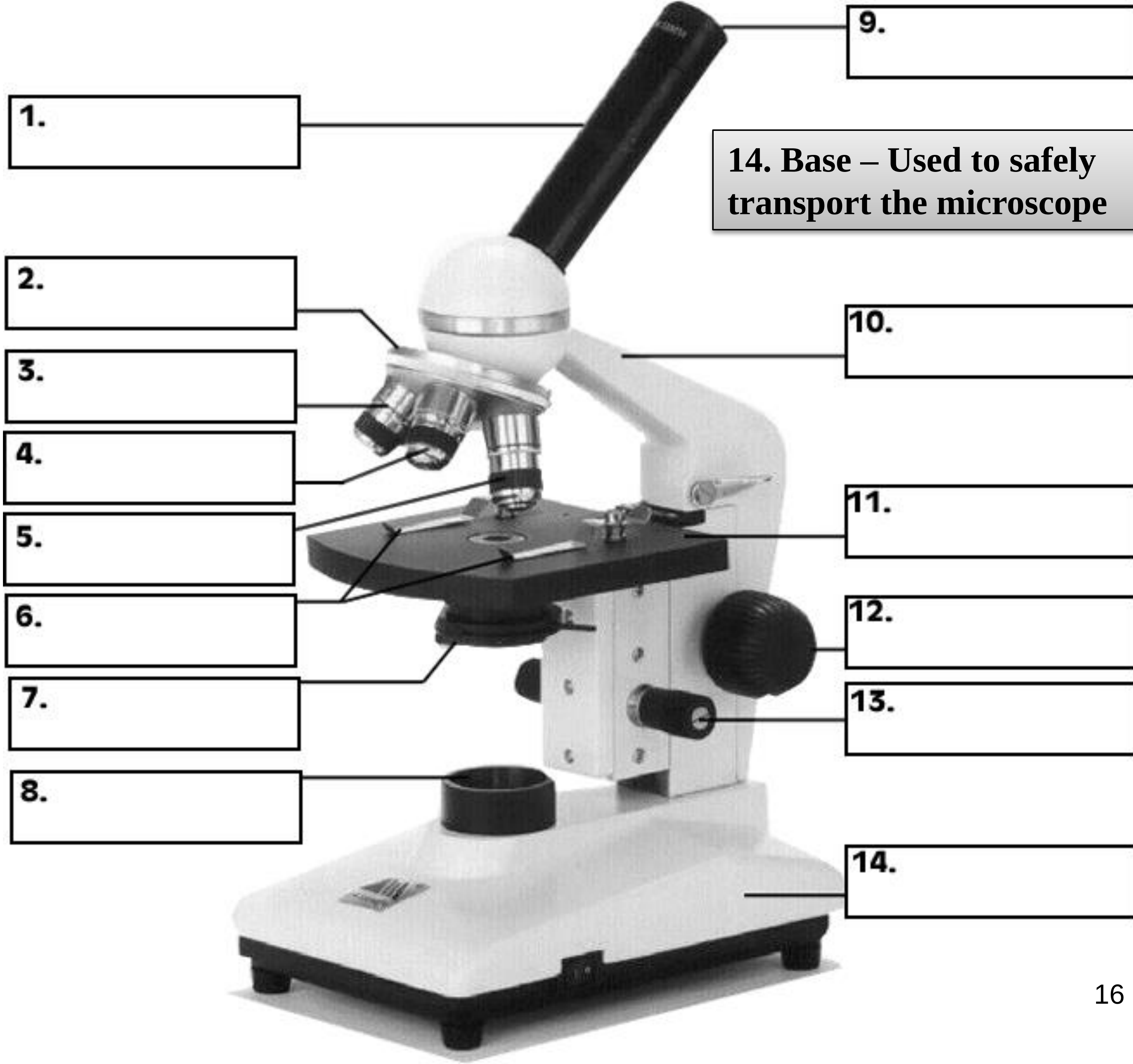


13. Fine Adjustment – Used to small adjustments of focus

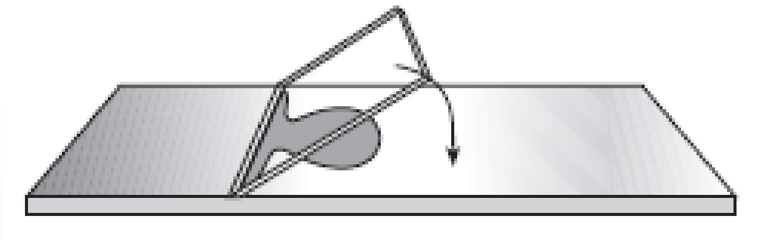


14. Base – Used to safely transport the microscope

How a Light Microscope Works

1. Use lenses to make small objects appear larger
2. Compound light microscope: Two lenses separated by a tube
3. Lenses magnify an object by bending the light that passes through the lens
4. Magnification: ability to make things appear larger than they are (Multiply the eyepiece magnification (10X) by the objective magnification (4X, 10X, 40X) Example: 4 x 10 = 40X total)
5. Resolution: fineness of detail that can be seen in an image

How to Prepare a Slide



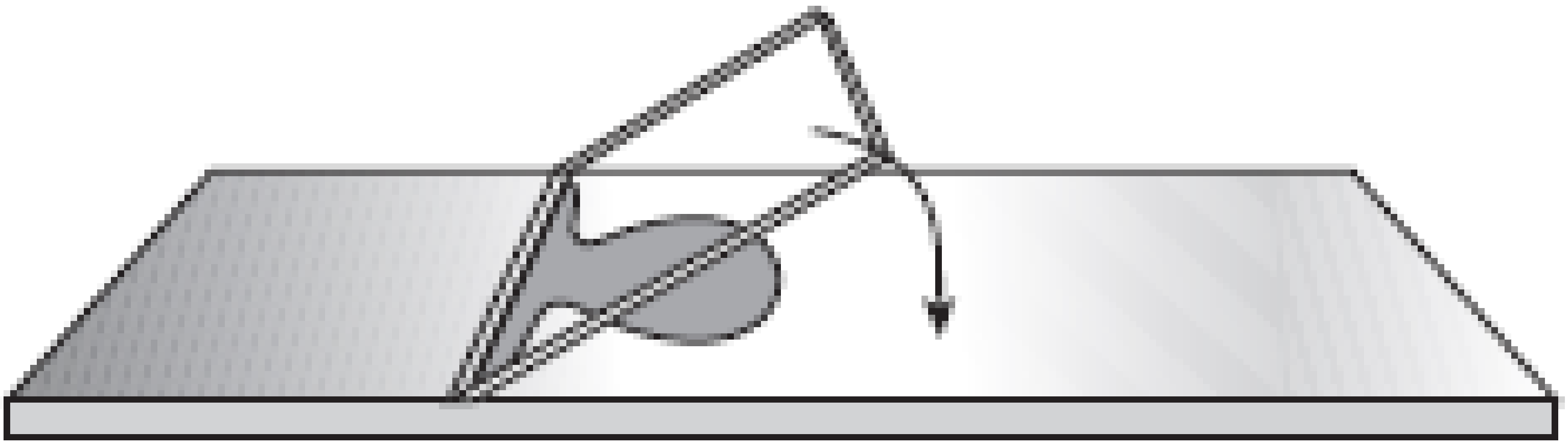
1. Place slide on a flat surface.

2. Place a drop of water on the slide. Add the specimen to the drop of water (at times, you may want to have the specimen already on the slide before adding the water).

3. Hold the coverslip by its sides and lay its bottom edge on the slide close to the specimen. Holding the coverslip at a 45° angle helps.

4. **Slowly lower the coverslip so that it spreads the water out. If you get air bubbles (looking like little black doughnuts), gently press on the coverslip to move hem to the edge. If there are dry areas under the coverslip, add a little more water at the edge of the coverslip. Too much water can be dabbed off with a piece of paper towel**

The diagram below shows how a cover-slip should be lowered onto some single-celled organisms during the preparation of a wet mount.



Why is this a preferred procedure?

A. The cover-slip will prevent the slide from breaking.

B. The organisms will be more evenly distributed.

C. The possibility of breaking the cover-slip is reduced.

D. The possibility of trapping air bubbles is reduced.

Rules of using a microscope

- Always carry with 2 hands
- Only use lens paper for cleaning
- Do not force knobs
- Always store covered
- Be careful of the cords

Inverted microscope

- An **inverted microscope** is a microscope with its light source and condenser on the top, above the stage pointing down, while the objectives and turret are below the stage pointing up. It was invented in 1850 by J. Lawrence Smith, a faculty member of Tulane University (then named the Medical College of Louisiana)

Inverted Microscope

The stage of an inverted microscope is usually fixed, and focus is adjusted by moving the objective lens along a vertical axis to bring it closer to or further from the specimen.

The focus mechanism typically has a dual concentric knob for coarse and fine adjustment. Inverted microscopes are useful for observing living cells or organisms at the bottom of a large container (e.g., a tissue culture flask) under more natural conditions than on a glass slide, as is the case with a conventional microscope

Lec. Two
Prokaryotic and Eukaryotic Cell

Dr. Anaam F. Hussain

Introduction

The term **cell** is derived from the Latin 'cella' means store room or chamber.

The cell was first seen by **Robert Hooke in 1665** using a primitive, compound microscope. He observed very thin slices of cork and saw a multitude of tiny structures that he resembled to walled compartments of a monk. Hence, named them cells. Hooke's description of these cells was published in Micrographia.

The cell is the smallest unit of a living system and fall in the microscopic range of 1 to 100 µm. They attain various shapes and sizes to attain variety of functions.

Cell Theory

Pioneering work by Theodor Schwann, Matthias Jakob Schleiden on cells, gave birth to the cell theory. Their theory states:

1. All living things are made of cells.

2. Cells are the basic building units of life.

3. New cells are created by old cells dividing into two.

*****Viruses are exception to the cell theory

The Essential component of Living Cell

1.Nucleic acids deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

2. Ribosomes

3.Cell membrane

4. Mitochondria or Mesosomes (Chonderiods in prokaryotes)

Classification of cells

Any living organism may contain only one type of cell either **A. Prokaryotic cells; B. Eukaryotic cells**.

Prokaryotic cells:

Prokaryote: an organism whose cell lack a membrane enclosed nucleus .

Mycoplasma, virus, bacteria and cyanbacteria(blue-green algae) are prokaryotes.

Most prokaryotes are unicellular, exceptions being myxobacteria which have multicellular stages in their life cycles.

They are membrane bound mostly unicellular organisms lacking any internal membrane bound organelles. Though prokaryotes lack cell organelles they harbor few internal structures, such as the cytoskeletons, ribosomes. Membranous organelles are known in some groups of prokaryotes, such as vacuoles or membrane systems devoted to special metabolic properties, e.g., photosynthesis or chemolithotrophy. In addition, some species also contain protein-enclosed microcompartments, which have distinct physiological roles (carboxysomes or gas vacuoles).

The Characteristics of Prokaryotes

1.The absence of a membrane around the nuclear material.

2.The absence of clearly defined membrane limited organelles like mitochondria, chloroplast, Golgi complex and lysosomes.

3.The genetic material is located on a single chromosome which consists of a circular double strand of DNA.

4.The basic protein-histones, which are one of the most important constituents of chromosomes of eukaryotic cells, are absent in prokaryotic chromosomes.

5. The absence of nucleolus and mitotic apparatus.

6. The cell wall is non-cellulosic, being formed of carbohydrates and amino acids.

7. The plasma membrane which lies below the cell wall is produced into the cytoplasm and acts as the mitochondrial membrane carrying respiratory enzymes.

8. The cytoplasm neither exhibits streaming nor the amoeboid movement.

Morphology of prokaryotic cells

Prokaryotic cells have various shapes; the four basic shapes are:

Cocci - spherical

Bacilli - rod-shaped

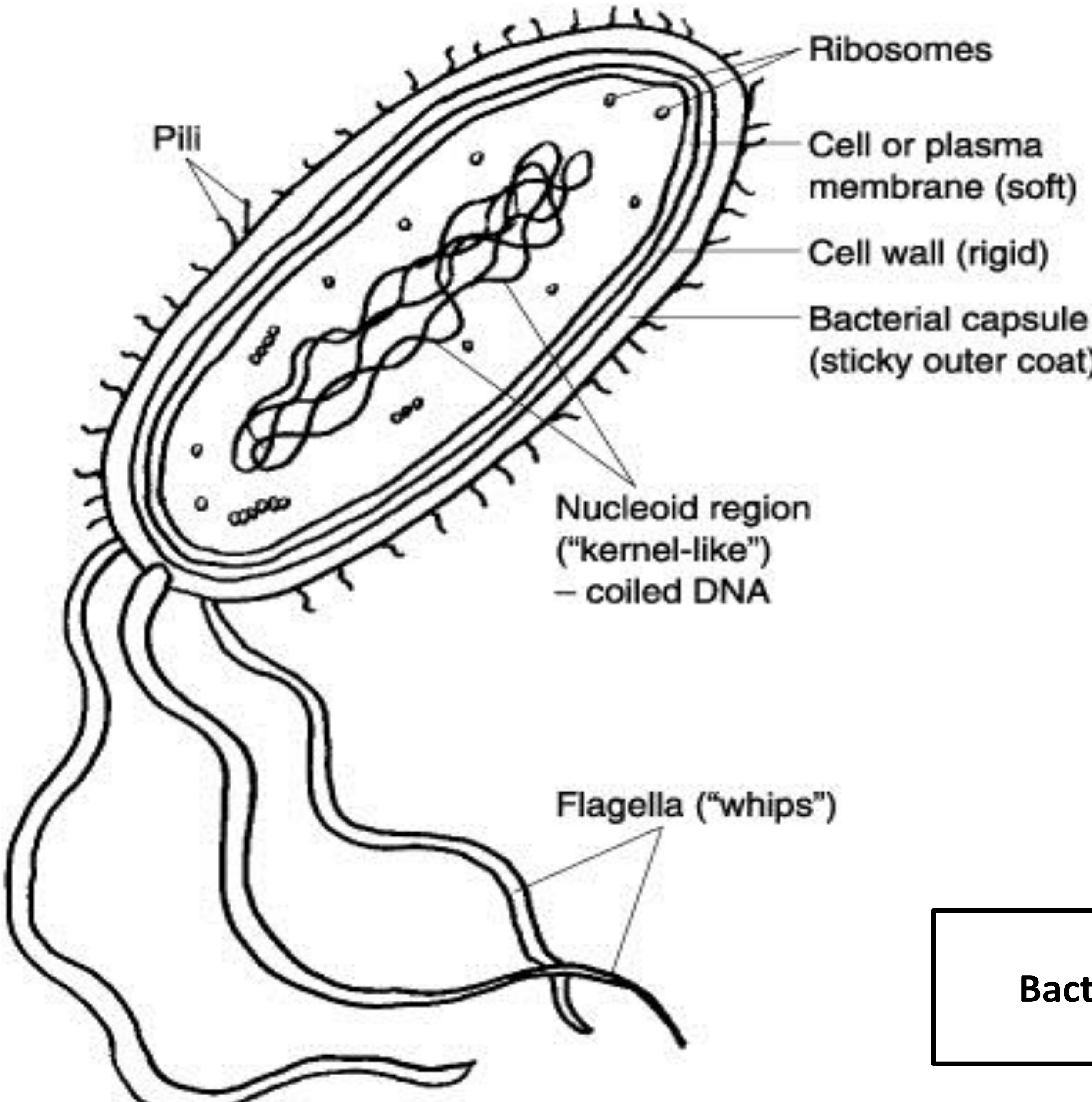
Spirochaete - spiral-shaped

Vibrio - comma-shaped

Cell organization of prokaryotes

From inner to outer :

1. Cytoplasm which contains a variety of components
2. Plasma membrane
3. Periplasmic space with periplasm
4. Cell wall
5. Slime layer or capsule
6. Flagella and pili



Bacterial cell

Eukaryotes

Eukaryote is an organism with complex cells, or a single cell with a complex structure.

Characteristics

1.cytoskeleton composed of microtubules , microfilaments , and intermediate filaments , which play an important role in defining the cell's organization and shape.

2. Eukaryotic DNA is divided into several linear bundles called chromosomes , which are separated by a microtubular spindle during nuclear division. In these cells the genetic material is organized into chromosomes in the cell nucleus .

3.They belong to the taxa Eukaryota.

4.All species of large complex organisms are , including animals, plants and fungi and most species of protista microorganisms.

5.Eukaryotes appear to be monophyletic (organisms that form a clade) and make up one of the three domains of life.

6.Eukaryotic cells are much larger than prokaryotic cells. Range between 10 to 100 micrometers.

Classification of Eukaryotes

The eukaryotes are composed of four kingdoms:

- Kingdom Protista
- Kingdom Mycetae (Fungi)
- Kingdom Plantae
- Kingdom Animalia

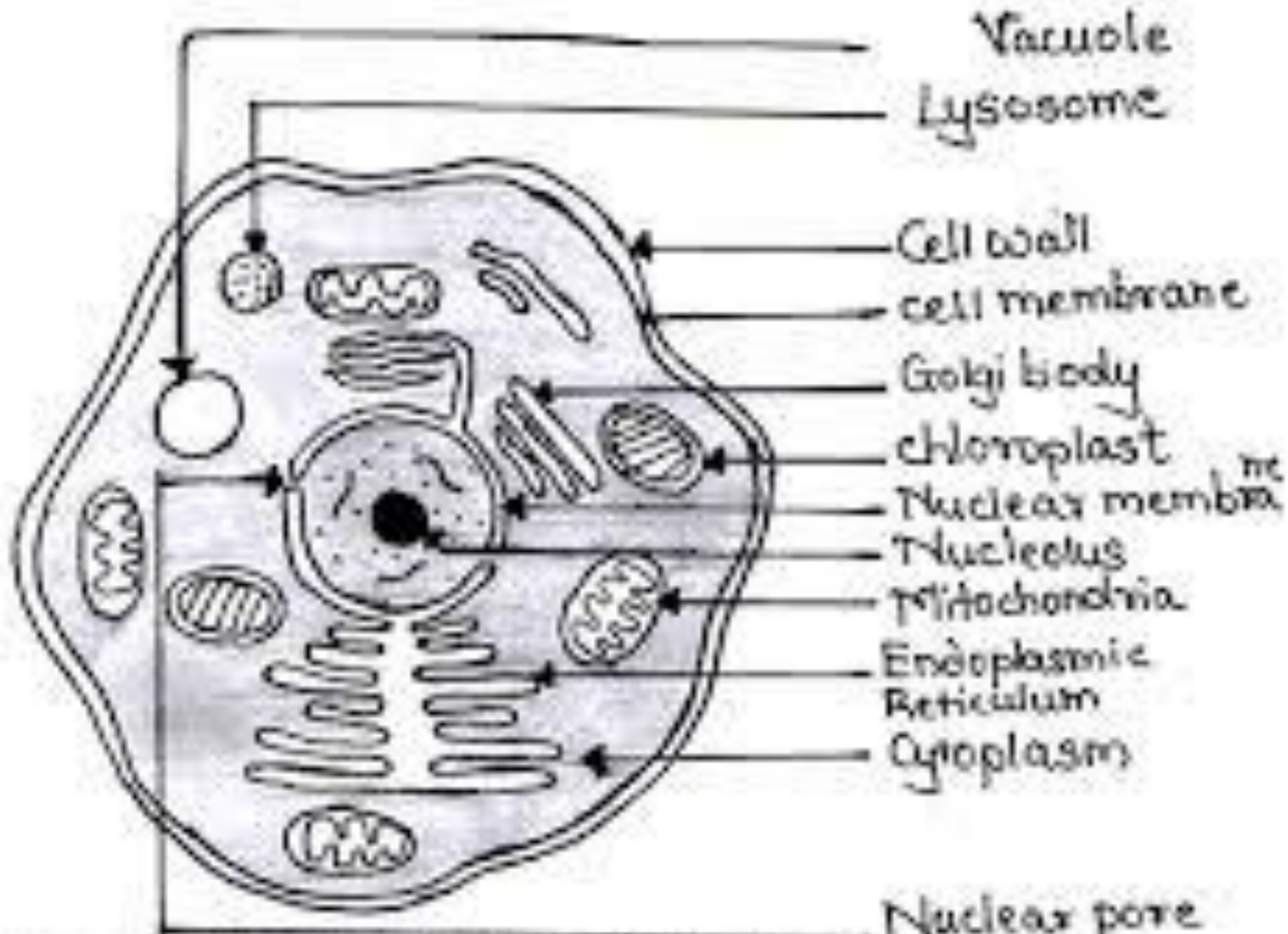
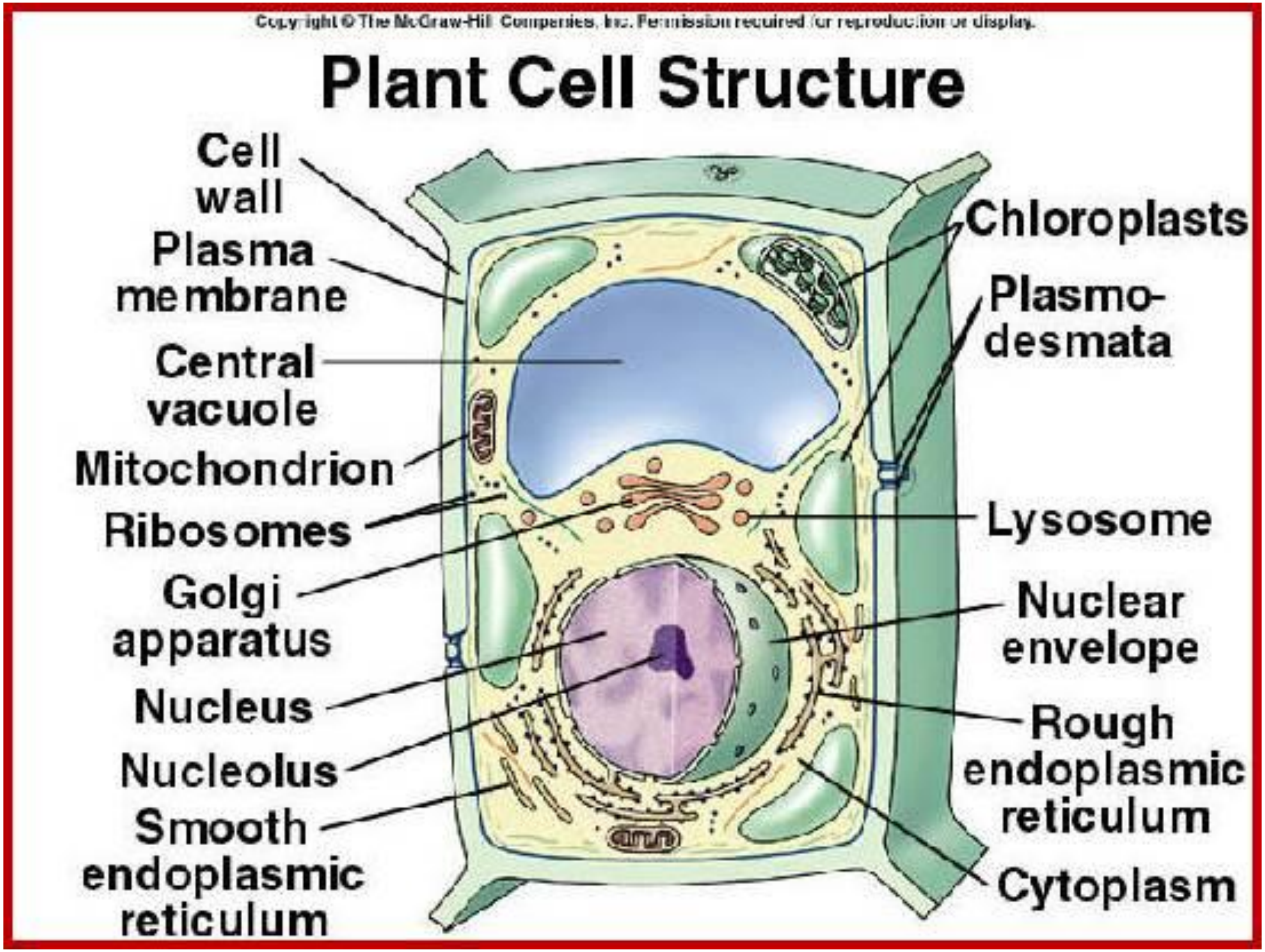


Diagram of a typical Eukaryotic cell

Prokaryotes	Eukaryotes
• Bacteria & archaea	• Fungi, protozoa, algae, helminths
• Lack a nucleus, one circular chromosome, no nuclear membrane	• True nucleus, several linear chromosomes, in nuclear membrane
• No histones	• Histones
• 70S ribosomes	• 80S ribosomes
• No organelles	• Organelles
• Peptidoglycan cell walls most bacteria (archaea cell walls are not PG)	• Polysaccharide cell walls (if any) / sterols in cell membranes
• Divide by binary fission	• Divide by mitosis

Lec. Three
Plant Cell

Dr. Anaam F. Hussain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Plant Cell Structure
Cell wall
Plasma membrane
Central vacuole
Mitochondrion
Ribosomes
Golgi apparatus
Nucleus
Nucleolus
Smooth endoplasmic reticulum
Chloroplasts
Plasmo-desmata
Lysosome
Nuclear envelope
Rough endoplasmic reticulum
Cytoplasm

Botany the scientific study of plants

Plants are multicellular organisms composed of millions of cells with specialized function.

All plant cells have the same basic eukaryotic organization.

plant cell parts

1. Cell wall

A fundamental difference between plant and animal cells is that the plant cell is surrounded by a rigid cell wall, mostly made of polysaccharides (cellulose, hemi-cellulose, pectin) and lignin.

Cell wall consist of 3 types of layers:

1.Middle lamella: This is the first layer formed during cell division. It makes up the outer wall of the cell and is shared by adjacent cells.
It is composed of pectic compounds and protein.

2.Primary wall: This is formed after the middle lamella and consists of a rigid skeleton of cellulose microfibrils embedded in a gel-like matrix composed of :
pectic compounds, hemicellulose, and glycoproteins.

3.Secondary wall: formed after cell enlargement is completed. The secondary wall is extremely rigid and provides compression strength.
It is made of cellulose, hemicellulose and lignin. The secondary wall is often layered.

Macromolecules of the cell wall

1.Cellulose – the most abundant plant polysacharide (15-30% of the dry mass of the cell wall)Microfibrills – several dozen of (1à4) b-D-glucan chains.

Cellulose polymers associate through H-bonds. The H-bonding of many cellulose molecules to each other results in the formation of micro fibers and the micro fibers can interact to form fibers. Certain cells, like those in cotton ovules, can grow cellulose fibers of enormous lengths.

2. Callose

Differ from cellulose in consisting of (1à3) b-D-glucan chains that can form helical duplexes. Callose is made in a few cells at specific stages of development (growing pollen tubes, cell plates of dividing cells).

It is made in response to wounding or to penetration by invading fungal hyphae.

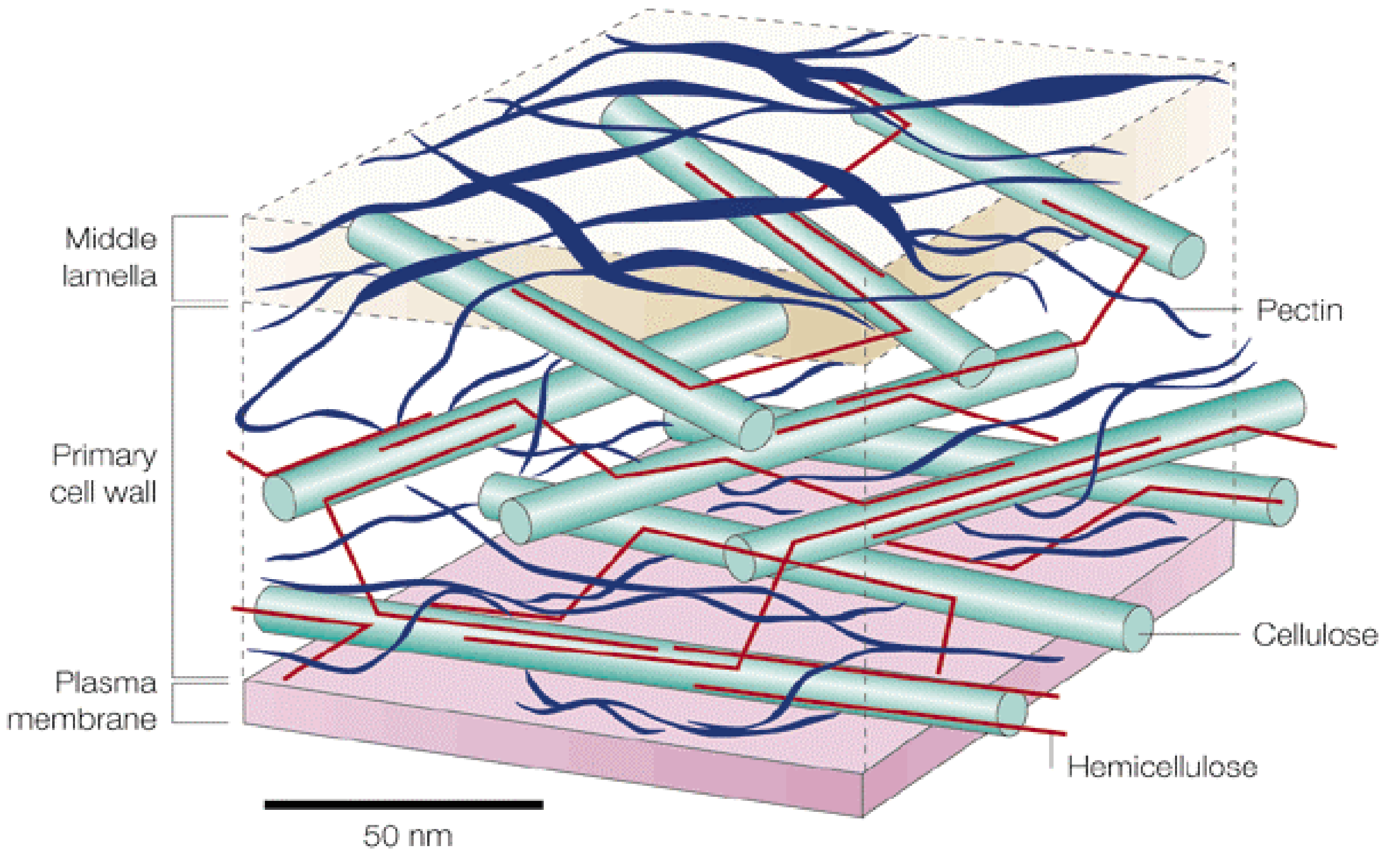
3. Pectic acid

polymer of around 100 galacturonic acid molecules - very hydrophilic and soluble - become very hydrated - forms salts and salt bridges with Ca++ and Mg++ that are insoluble gels - major component of middle lamella but also found in primary walls\

4. Pectin

polymer of around 200 galacturonic acid - molecules - many of the carboxyl groups are methylated (COOCH3) - less hydrated then pectic acid but soluble in hot water - another major component of middle lamella but also found in primary walls.

Cross-linking glycans Make hydrogen-bond to - cellulose. •XyGs – xyloglucans •GAXs - glucuronoarabinoxylans



Middle lamella
Primary cell wall
Plasma membrane
Pectin
Cellulose
Hemicellulose
50 nm

Specialized functions of the cell wall

1.Structural:

a. Cell walls as food, feed, and fibers : Cell walls directly affect the raw material quality of human and animal food, textiles, wood, and paper and may play a role in human medicine.

b. Cross-linked matrix

2.Molecules affecting developmental pattern

3. Molecules defining cell’s position within the plant.

4. Molecules of cell-cell and cell-nucleus communication

5. Defense against pathogens (impregnation with lignin)

6. Recognition of symbiotic nitrogen-fixing bacteria

Cell walls also contain functional proteins. Enzymatic activities in cell walls include:

- Oxidative enzymes – peroxidases
- Hydrolytic enzymes - pectinases, cellulases
- "Expansins" - enzymes that catalyze cell wall

General functions of cell wall enzymes include: protection against pathogens, cell expansion, cell wall maturation.

2.Cell (plasma)Membrane

Introduction

*It is the thin layer of protein and fat that surrounds the cell, but is inside the cell wall. The cell membrane is semi permeable, allowing some substances to pass into the cell and blocking others.

*No living cells on earth one finds without plasma membrane.

*Cell membrane: defines cell boundaries

*Internal membranes define a variety of cell organelles

Fluid Mosaic Model of membrane structure

*Mosaic: an object comprised of bits and pieces embedded in a supporting structure

1.membrane lipids form the supporting structure (phospholipids, glycolipids and cholesterol)

2.membrane proteins provide the bits and pieces :

integral (intrinsic) proteins , peripheral (extrinsic) proteins

3.both lipids and proteins may be mobile or fluid

The Membrane Lipids

A. phospholipids

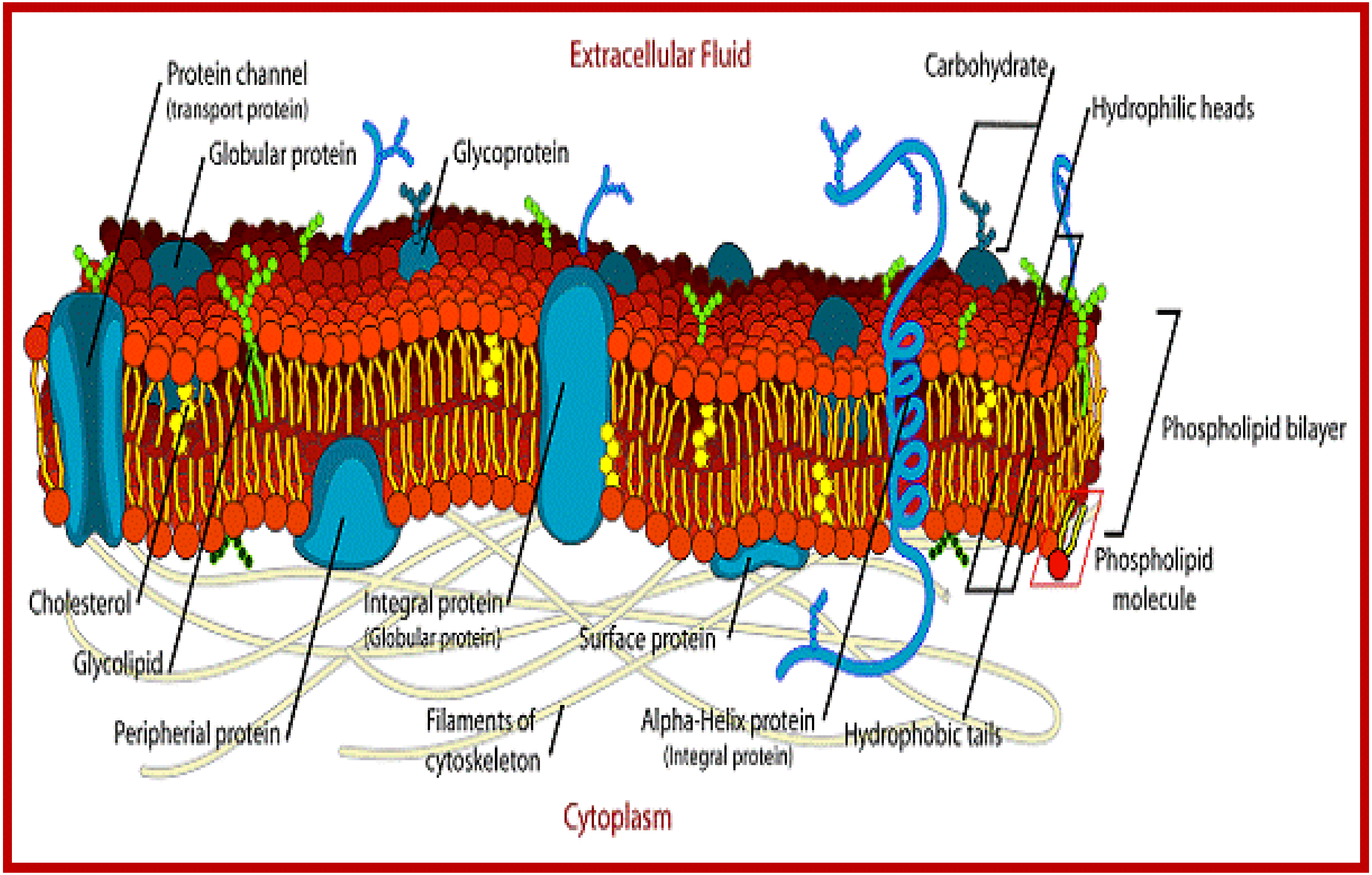
*most abundant of the lipids in membranes form a lipid layer

*Phospholipid layer may contain cholesterol; Lipid to protein molar ration is ~50:1 to 100:1; the kind of phospholipids vary from one plant tissue to the other.

B. Glycolipids

1.least common of the membrane lipids (~2%)

2. always found in outer leaflet of plasma membrane



Extracellular Fluid
Protein channel
(transport protein)
Globular protein
Glycoprotein
Carbohydrate
Hydrophilic heads
Phospholipid bilayer
Phospholipid
molecule
Cholesterol
Glycolipid
Integral protein
(Globular protein)
Surface protein
Peripherial protein
Filaments of
cytoskeleton
Alpha-Helix protein
(Integral protein)
Hydrophobic tails
Cytoplasm

Membrane Functions

*Form selectively permeable barriers

*Transport phenomena

*Cell communication and signaling

*Cell-cell adhesion and cellular attachment

*Cell identity and antigenicity

*Conductivity

Lec. Four
Plant Cell Protoplast

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Plant Cell

The Plant Cell consists of a more or less rigid cell wall and the protoplast, The protoplast consists of the cytoplasm and a nucleus, The cytoplasm-Viscous fluid-includes distinct membrane-bound organelles such as plastids and mitochondria; systems of membranes (endoplasmic reticulum and dictyosomes); non membranous entities such as ribosomes, actin filaments and microtubules

The rest of the cytoplasm is a liquid matrix in which the nucleus, various entities and membrane systems are suspended - it is typically referred to as the cytosol or ground substance .

Components of cytoplasm

*Interconnected filaments & fibers

* Fluid = cytosol

* Organelles (not nucleus)

 * storage substances

Cytoskeleton:

Made of 3 fiber types

* Microfilaments, Microtubules and Intermediate filaments

functions:

1 .mechanical support, 2.anchor organelles and 3.help move substances

Centrioles :Pairs of microtubular structures

Play a role in cell division

Lysosomes

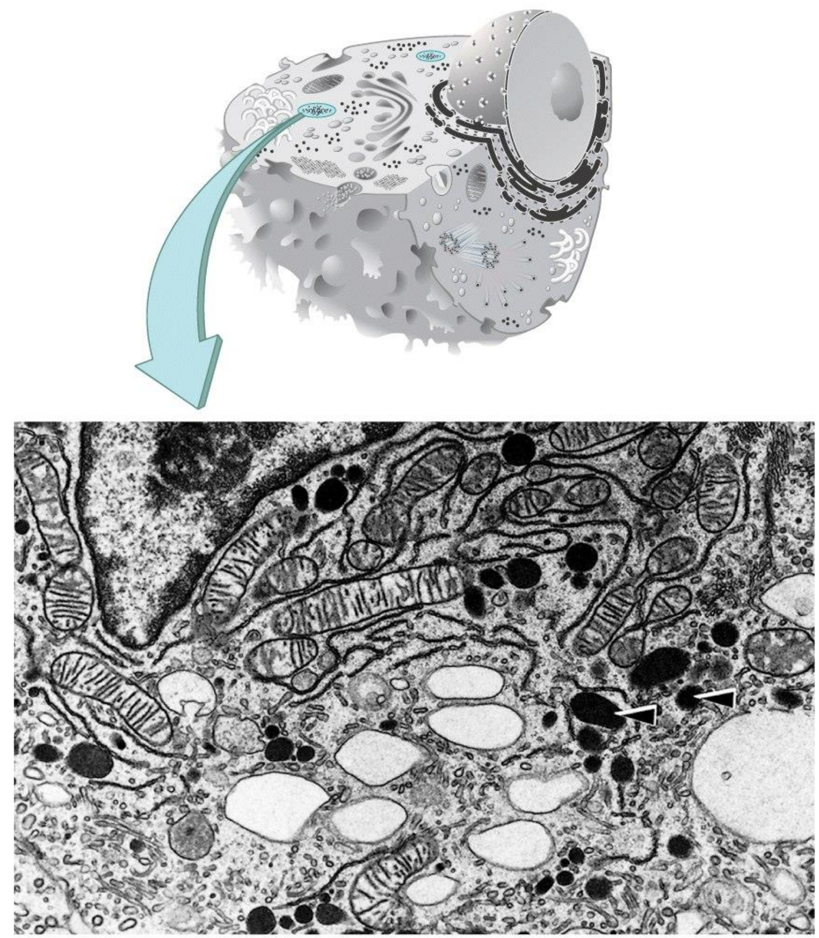
Contain digestive enzymes

Functions

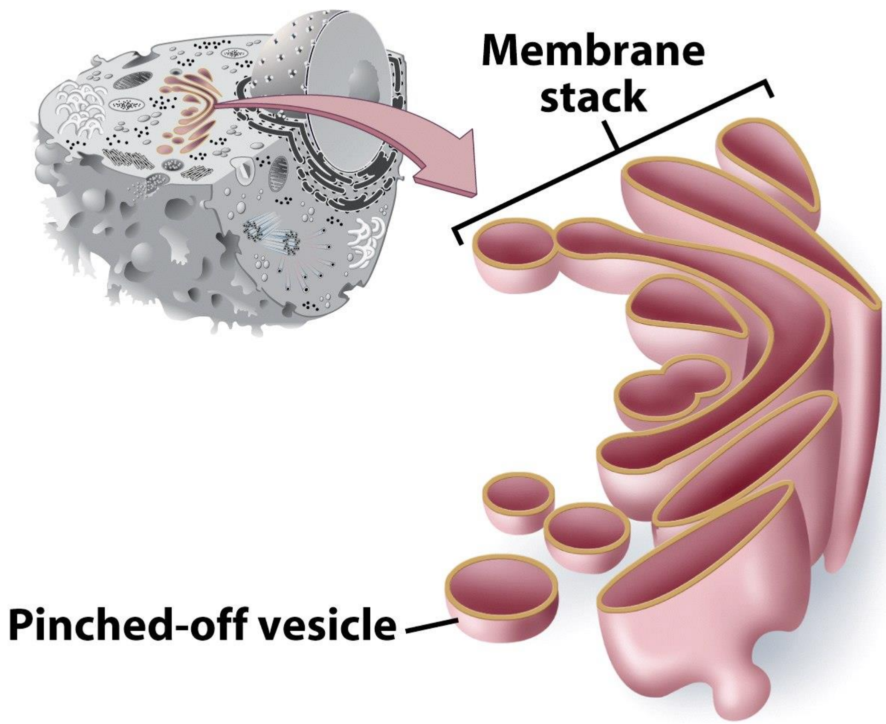
Aid in cell renewal

Break down old cell parts

Digests invaders



Golgi Apparatus: Involved in synthesis of plant cell wall
Packaging & shipping station of cell



Golgi Apparatus Function

1. Molecules come in vesicles
2. Vesicles fuse with Golgi membrane
3. Molecules may be modified by Golgi

Cell Nucleus: The nucleus is usually the most prominent structure in the protoplast of eukaryote cells , it is the genetic control center of the cell.

1. it controls the ongoing activities of the cell by determining which protein molecules are produced by the cell and when they are produced
2. it stores genetic information(DNA), passing it onto daughter cells during cell division

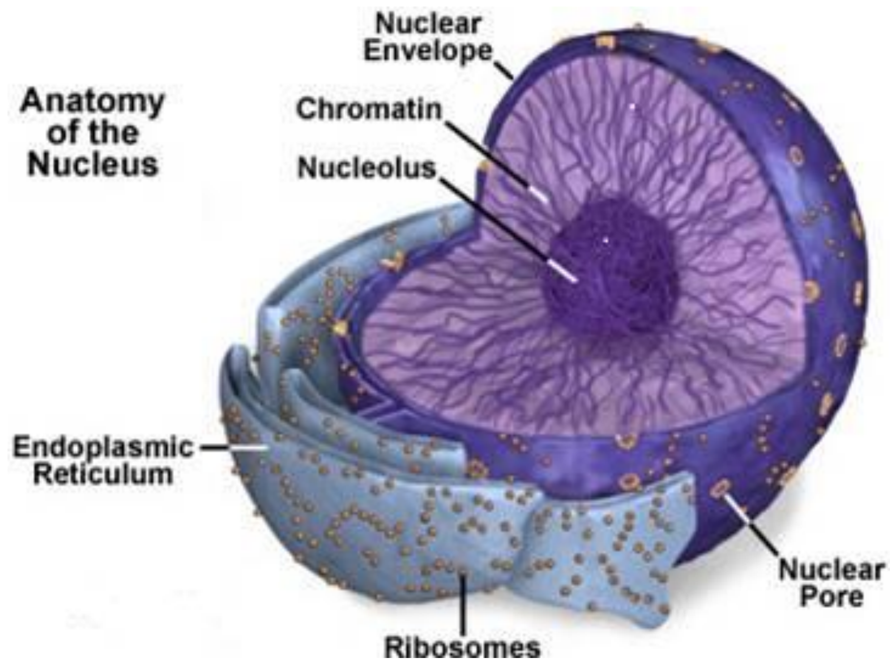
Structure of the Nucleus :

*Nuclear envelope

*Nucleoplasm

*Chromatin

*The nucleolus



DNA, or deoxyribonucleic acid: contains the information needed for the creation of proteins (which include enzymes and hormones) and is stored in the nucleus, as already said, in the form of chromatin or chromosomes.

Nuclear Envelope: is a double-layered membrane perforated with pores, which control the flow of material going in and out of the nucleus.

Nucleoplasm: A jelly-like (made mostly of water) matrix within the nucleus, helps the nucleus keep its shape and serves as the median for the transportation of important molecules within the nucleus

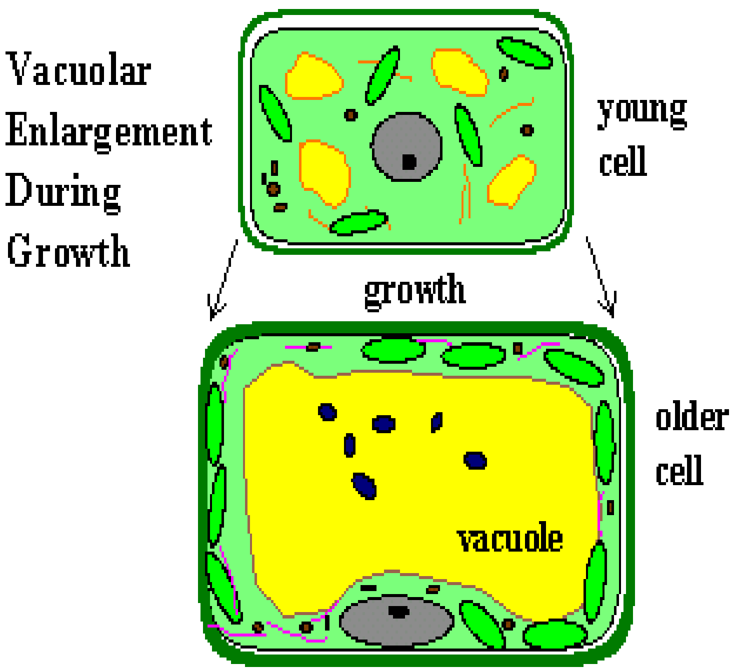
Chromatin & Chromosomes

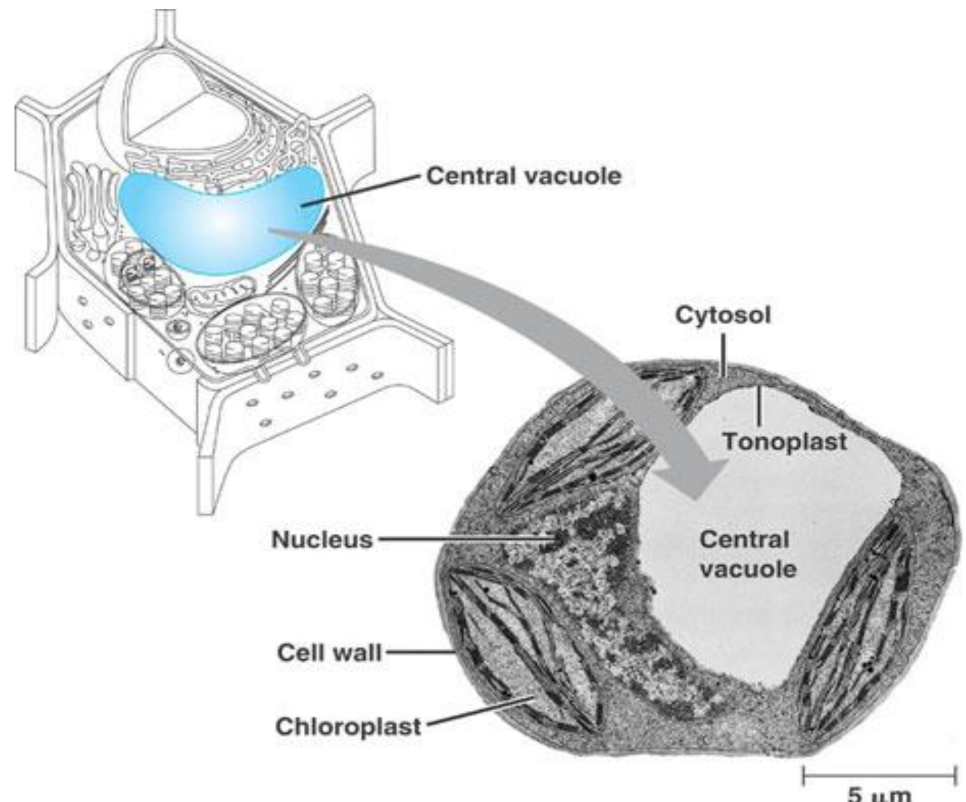
Chromosomes contain DNA in a condensed form attached to a histone protein.

Chromatin is comprised of DNA. There are two types based on function :Heterochromatin & Eurochromatin

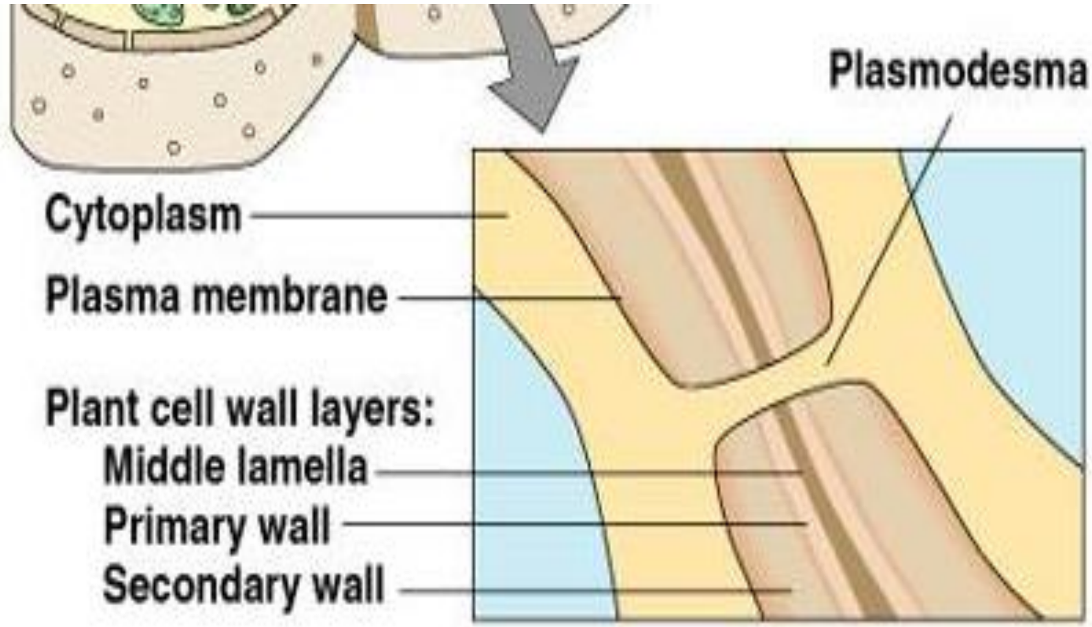
Endoplasmic reticulum (**ER**): is a type of organelle in eukaryotic cells that forms an interconnected network of flattened, membrane-enclosed sacs or tube-like structures known as cisternae. The membranes of the ER are continuous with the outer nuclear membrane. There are two types of endoplasmic reticulum: rough and smooth. The outer (cytosolic) face of the rough endoplasmic reticulum is studded with **ribosomes** that are the sites of protein synthesis. The smooth endoplasmic reticulum lacks ribosomes and functions in lipid manufacture and metabolism, the production of steroid hormones, and detoxification. The lacy membranes of the endoplasmic reticulum were first seen in 1945 using electron microscopy.

Vacuole: It is present at the centre and is water-filled volume enclosed by a membrane known as the tonoplast. The function is to maintain the cell's turgor, pressure by controlling movement of molecules between the cytosol and sap, stores useful material and digests waste proteins and organelles. Along with water based cell sap, vacuoles typically contain salts, sugars and some dissolved proteins. Ex. Beetroot cell vacuoles





Plasmodesmata: Pores in the primary cell wall through which the plasmalemma and endoplasmic reticulum of adjacent cells are continuous. Plasmodesmata allow the transport of substances from one cell to the next They are cytoplasmic threads which connect the living protoplasts of adjoining cells



Plastids: are a characteristic component of plant cells, Plastids are classified and named based on the kinds of pigments they contain

1.Chloroplast: is surrounded by two membranes and internally the plastid has a system of membranes which form flattened sacs called thylakoids and a substance called stroma ground (fluid)

2.Chromoplasts: lack chlorophyll but synthesize and retain carotenoid pigments which are responsible for the yellow, orange or red colors of many and some roots flowers, old leaves, some fruits

3.Leucoplasts: are non pigmented plastids some of which synthesize starch exposure to light they may while others produce oils or proteins(Upon develop into chloroplasts)

4.Proplastids: Proplastids are small, colorless or pale green undifferentiated plastids that occur in meristematic cells of roots and shoots - they will eventually develop into other, differentiated plastids such as the chloroplasts, chromoplasts or leucoplasts

As in mitochondria, which have a genome encoding 37 genes, plastids have their own genomes of about 100– 120 unique genes and, it is presumed, arose as prokaryotic endosymbionts living in the cells of an early eukaryotic ancestor of the land plants and algae.

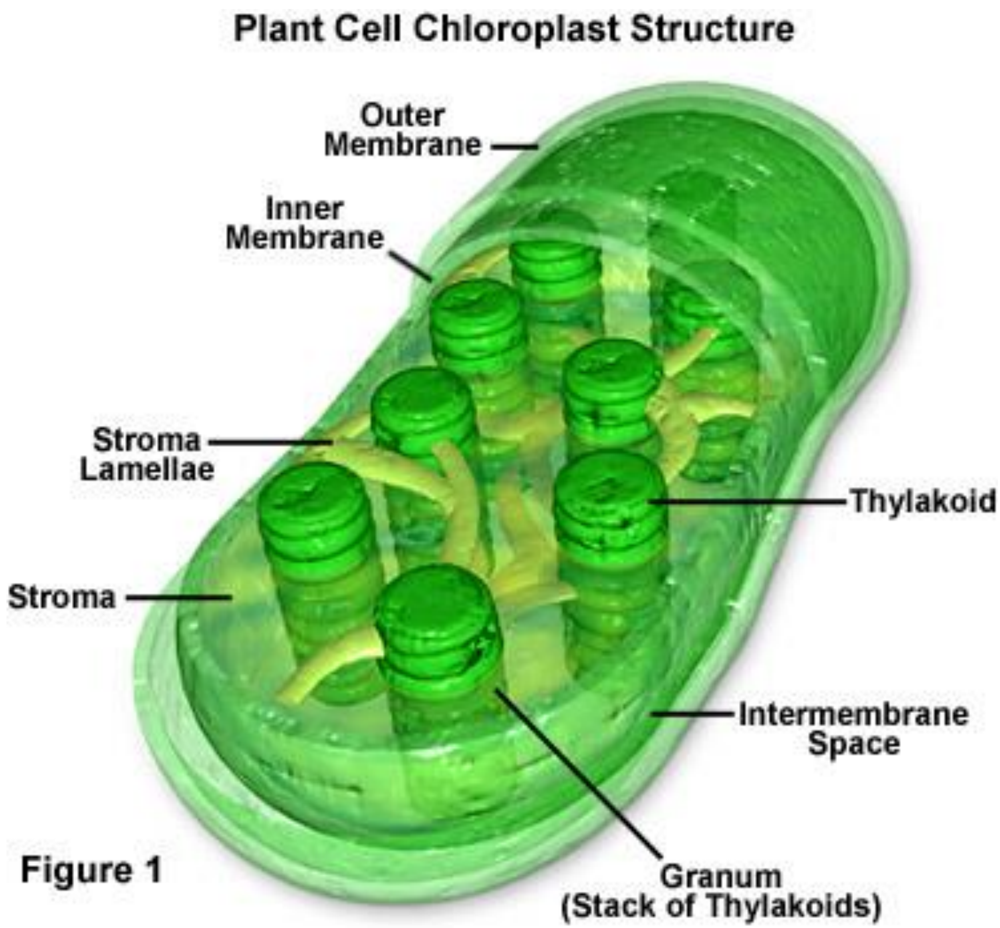
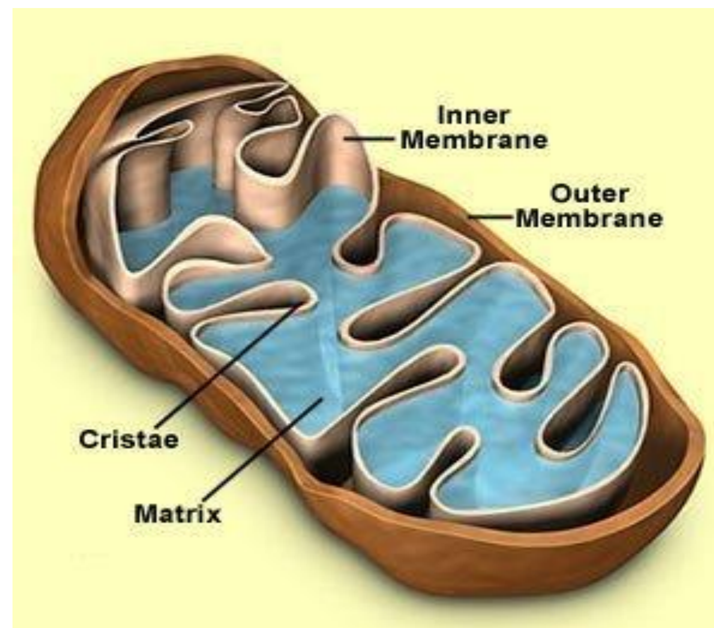


Figure 1

***Mitochondrion** is another organelle bounded by two membranes,the inner membrane is folded into many pleats called cristae

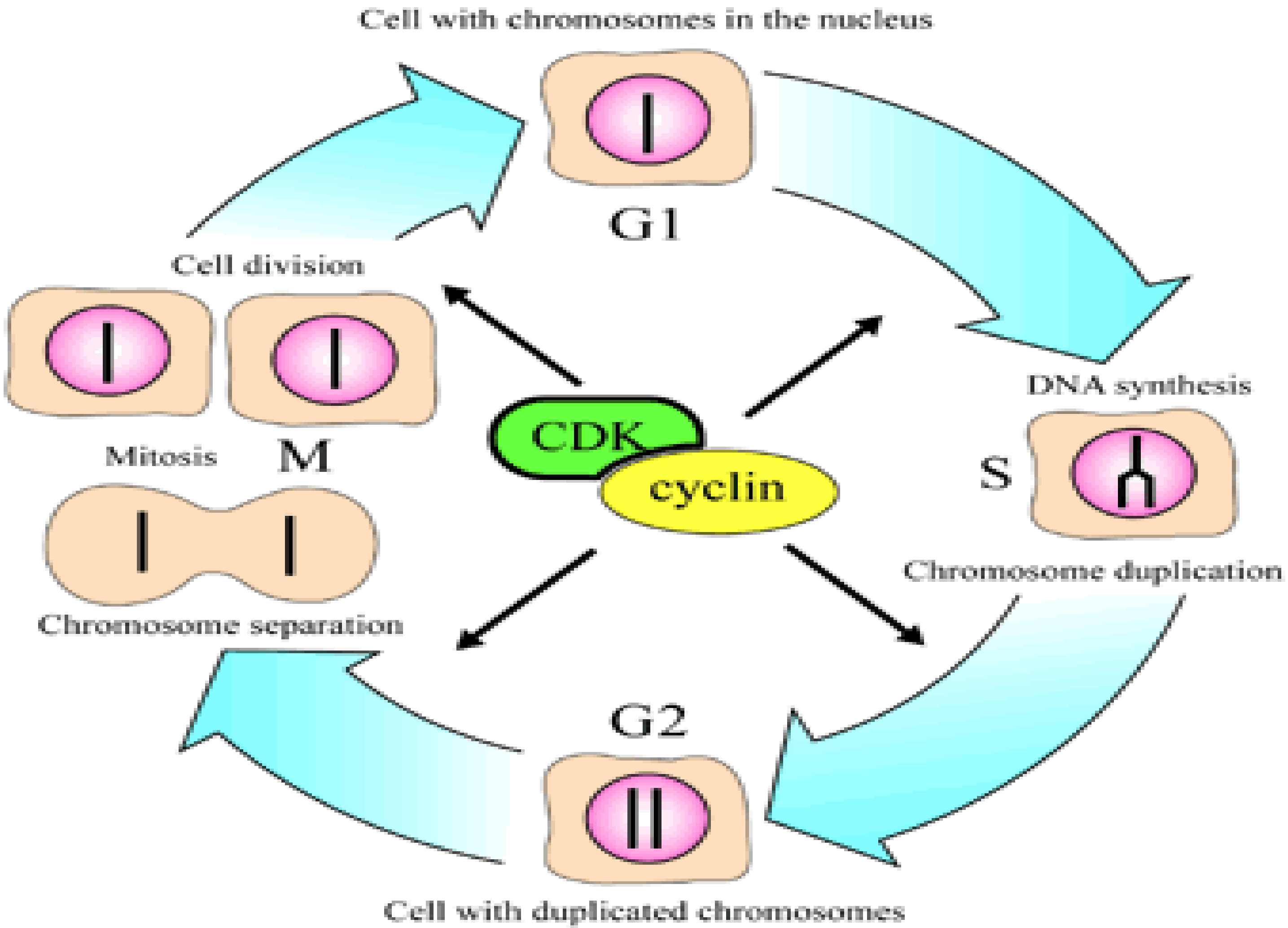
*Mitochondria are the sites of cellular respiration - converting organic molecules to ATP the main immediate energy source for living eukaryote cells - hundreds to thousands of plant cells may have mitochondria.



Lec. 5
The Cell Cycle
and
Cell Division

Dr. Anaam F. Hussain

The Cell Cycle



Mitosis

The process of cell division which results in the production of two daughter cells from a single parent cell.

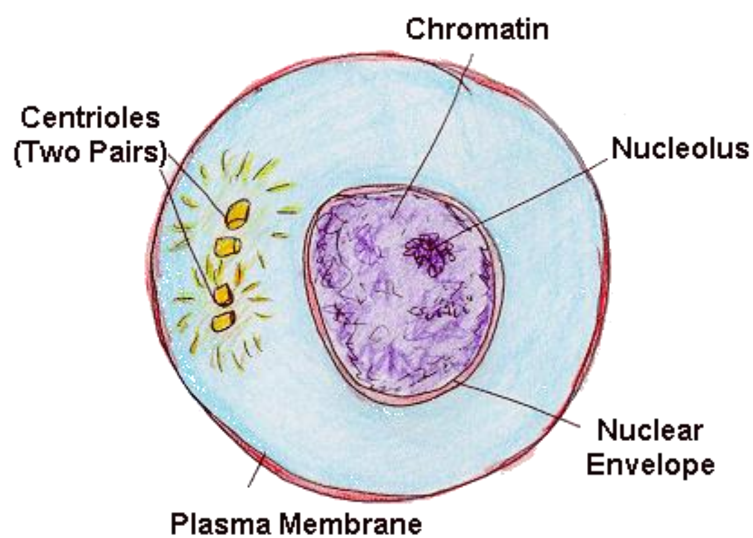
The daughter cells are identical to one another and to the original parent cell.

Mitosis can be divided into stages :

- **Interphase**
- **Prophase**
- **Metaphase**
- **Anaphase**
- **Telophase and Cytokinesis**

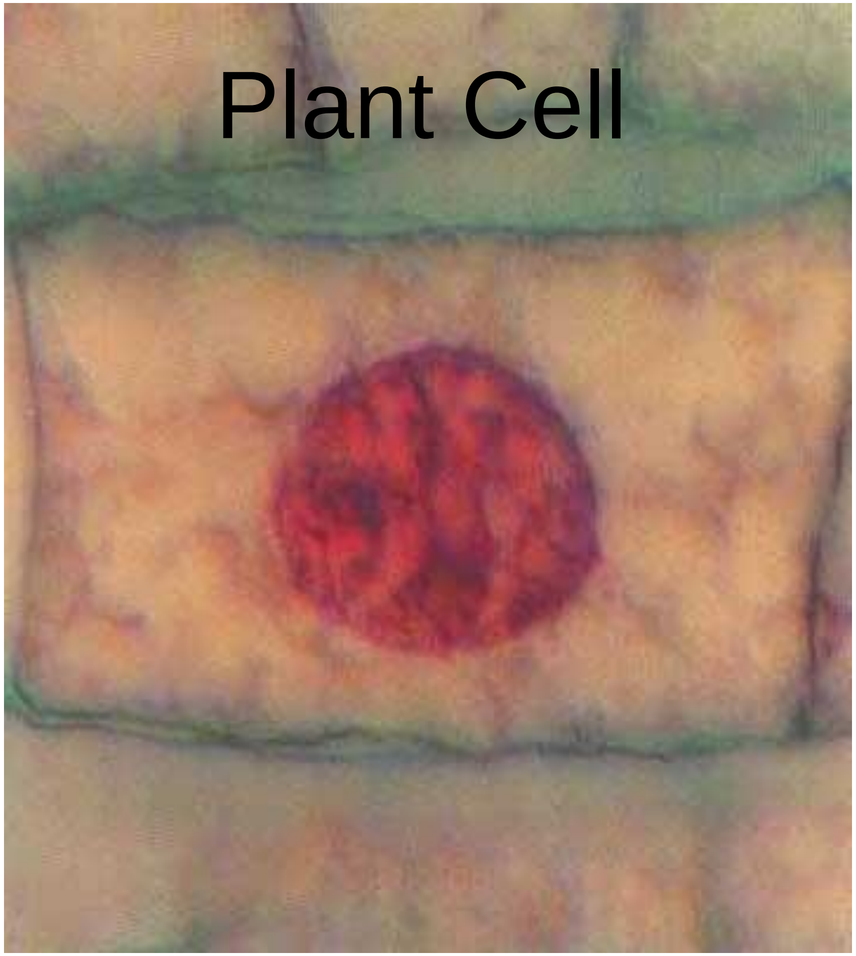
Interphase
The cell prepares for division

- Animal Cell
  - DNA replicated
  - Organelles replicated
  - Cell increases in size
- Plant Cell
  - DNA replicated
  - Organelles replicated
  - Cell increases in size



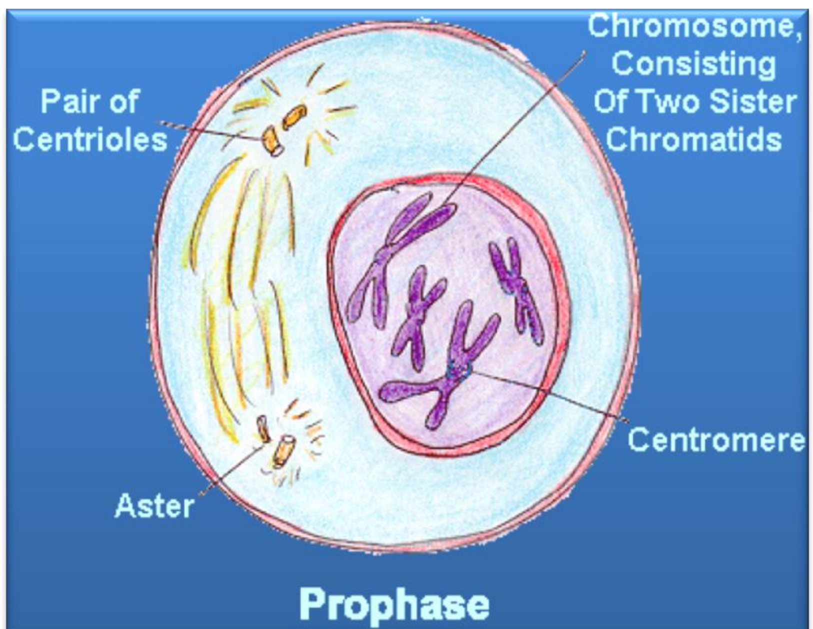
Interphase

Interphase

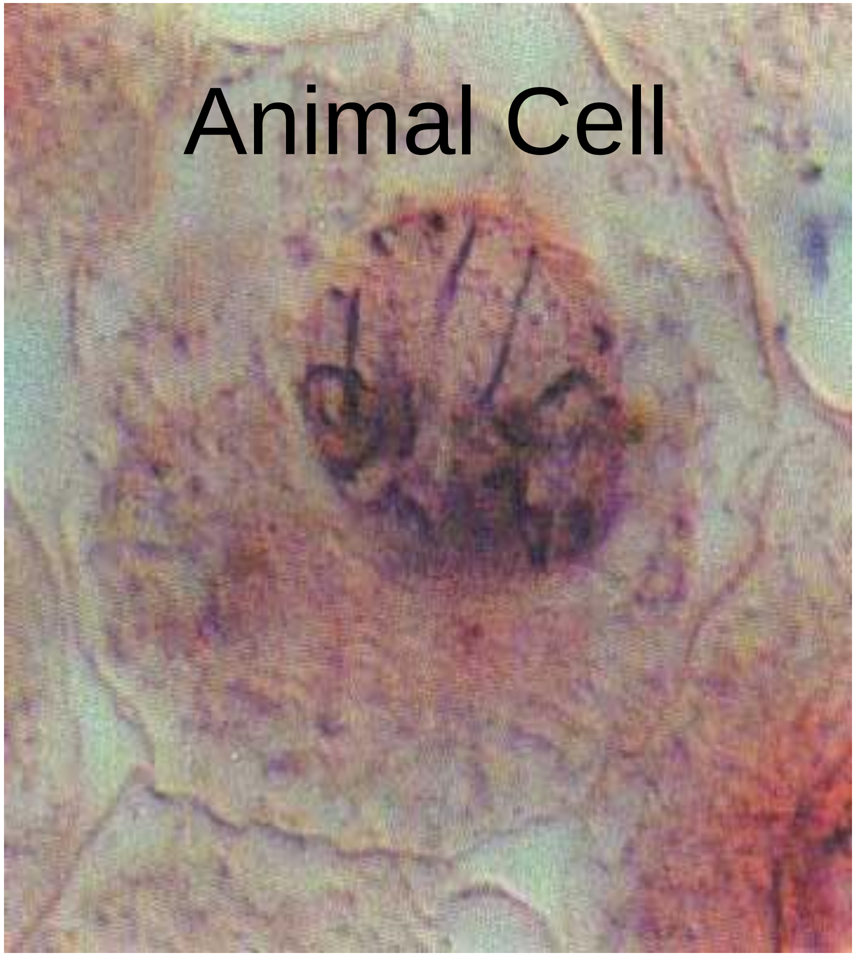


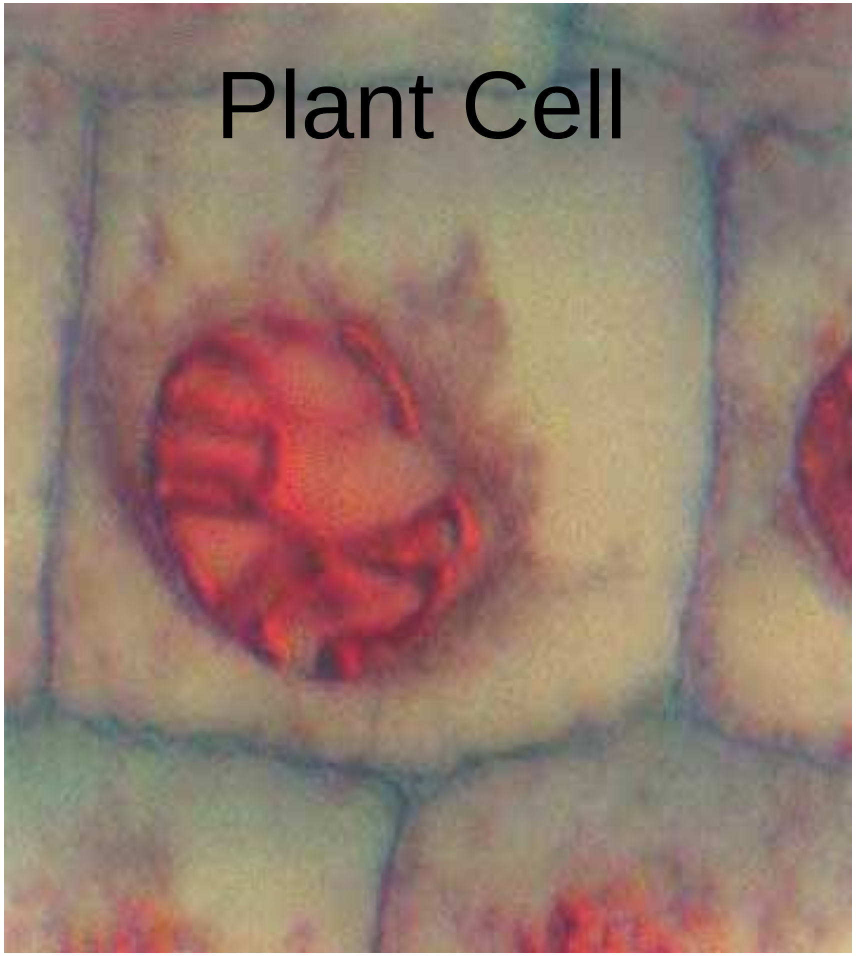
Prophase
The cell prepares for nuclear division

- Animal Cell
  - Packages DNA into chromosomes
- Plant cell
  - Packages DNA into chromosomes



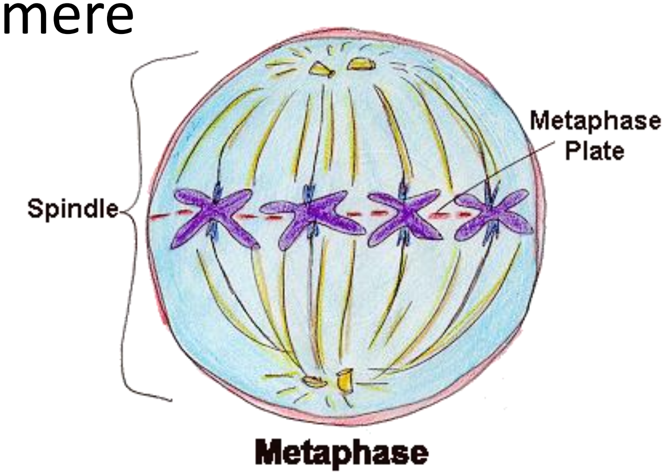
Prophase



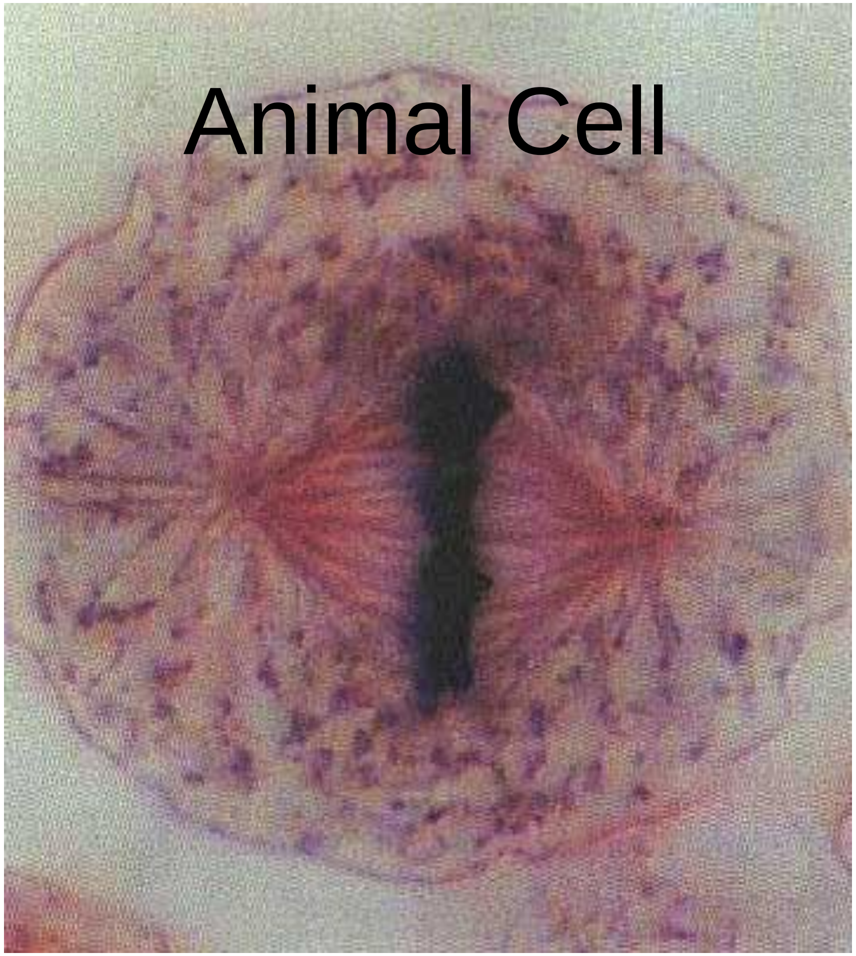


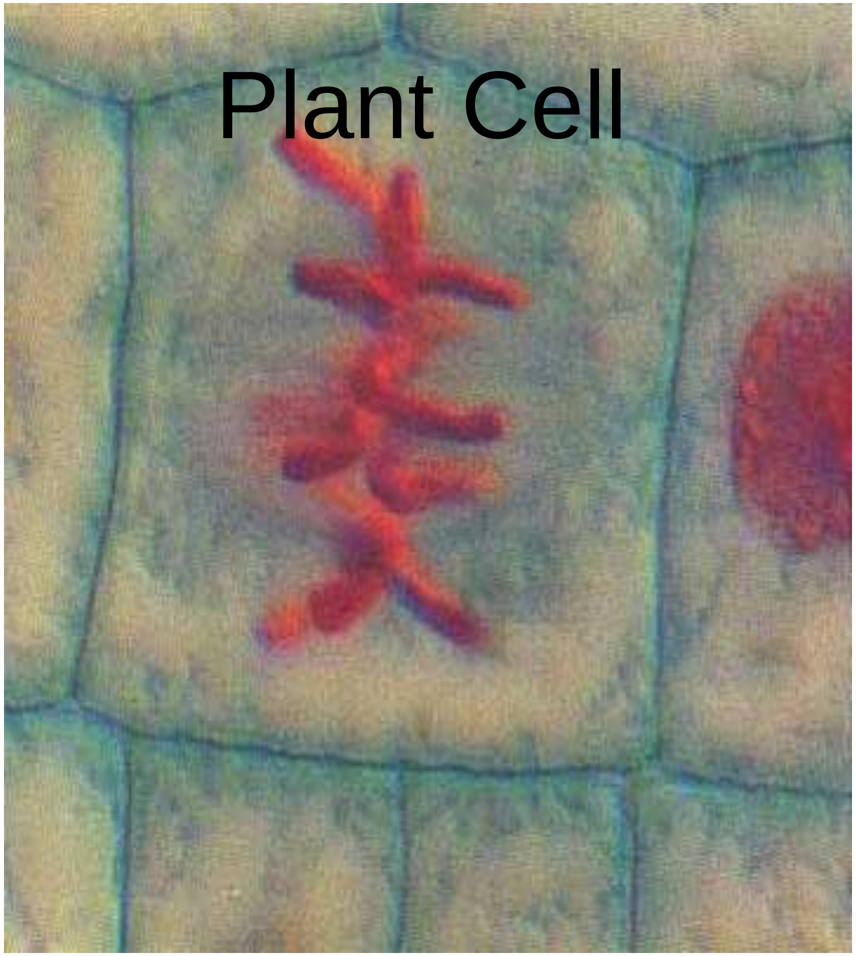
Metaphase
The cell prepares chromosomes for division

- Animal Cell
  - Chromosomes line up at the center of the cell
  - Spindle fibers attach from daughter cells to chromosomes at the centromere
- Plant Cell
  - Chromosomes line up at the center of the cell
  - Spindle fibers attach from daughter cells to chromosomes at the centromere



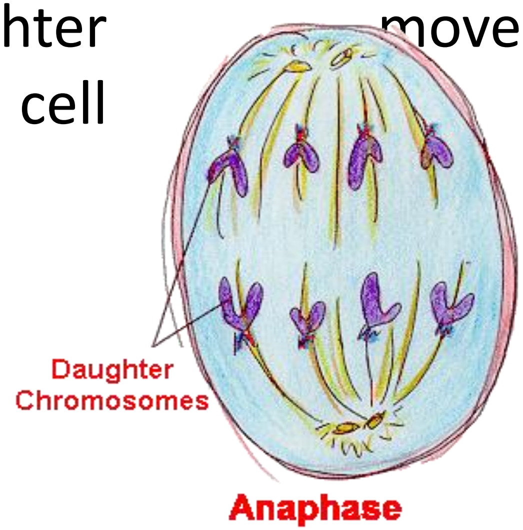
Metaphase



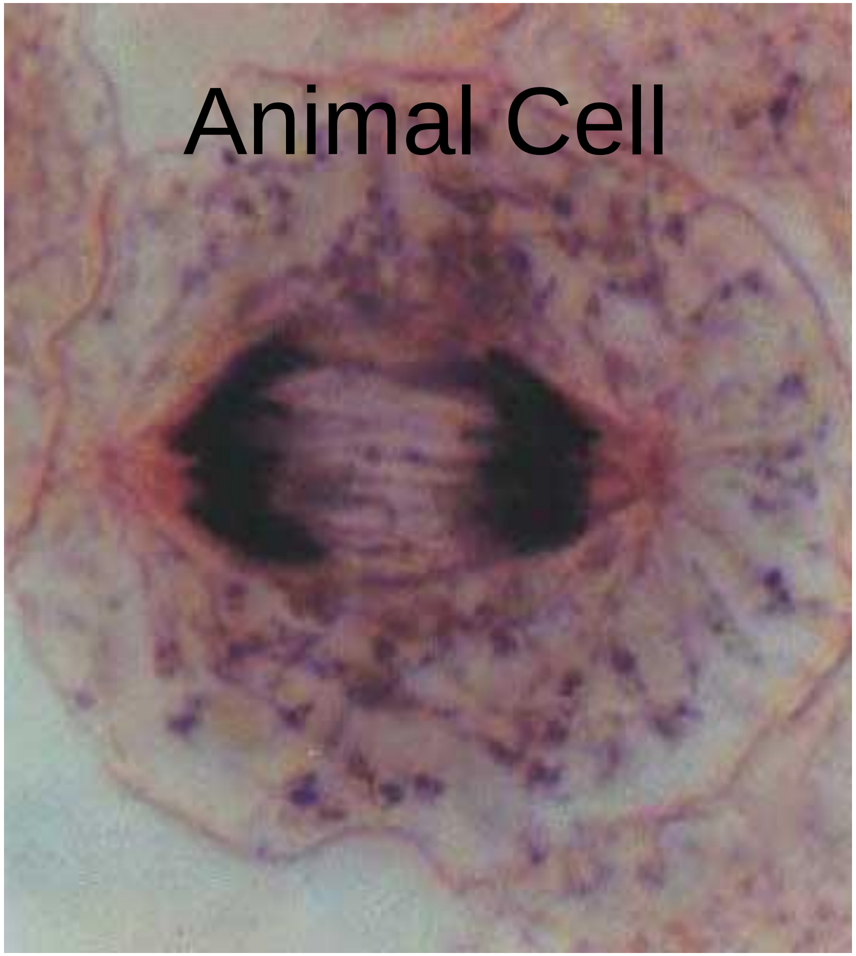


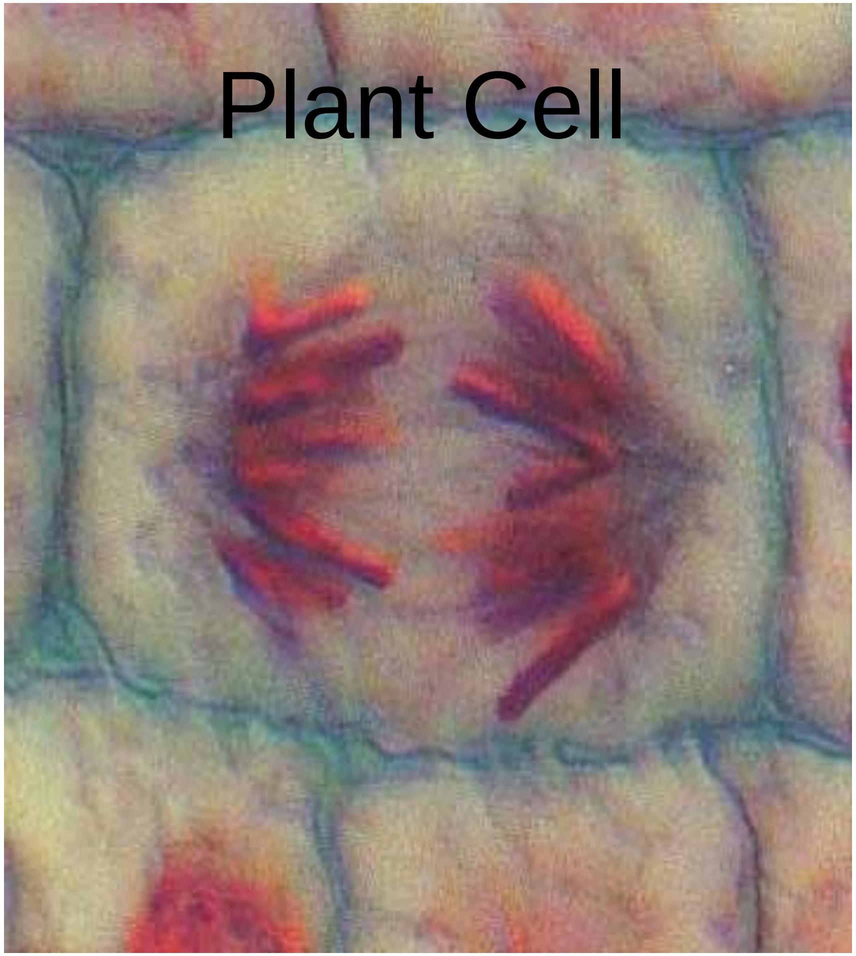
Anaphase
The chromosomes divide

- Animal Cell
  - Spindle fibers pull chromosomes apart
  - ½ of each chromosome (called chromotid) moves to each daughter cell
- Plant Cell
  - Spindle fibers pull chromosomes apart
  - ½ of each chromosome (called chromotid) moves to each daughter cell



Anaphase

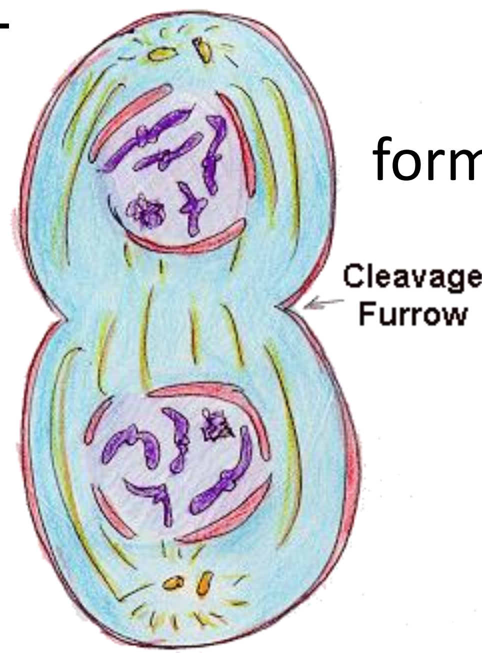




Telophase

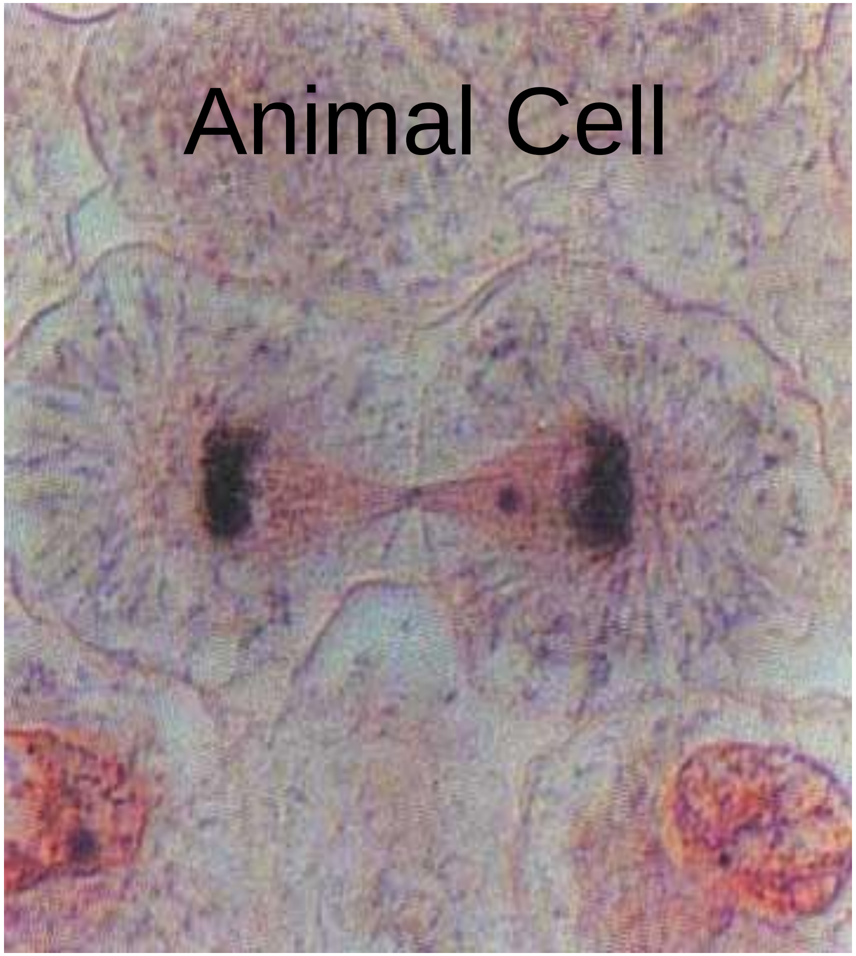
The cytoplasm divides

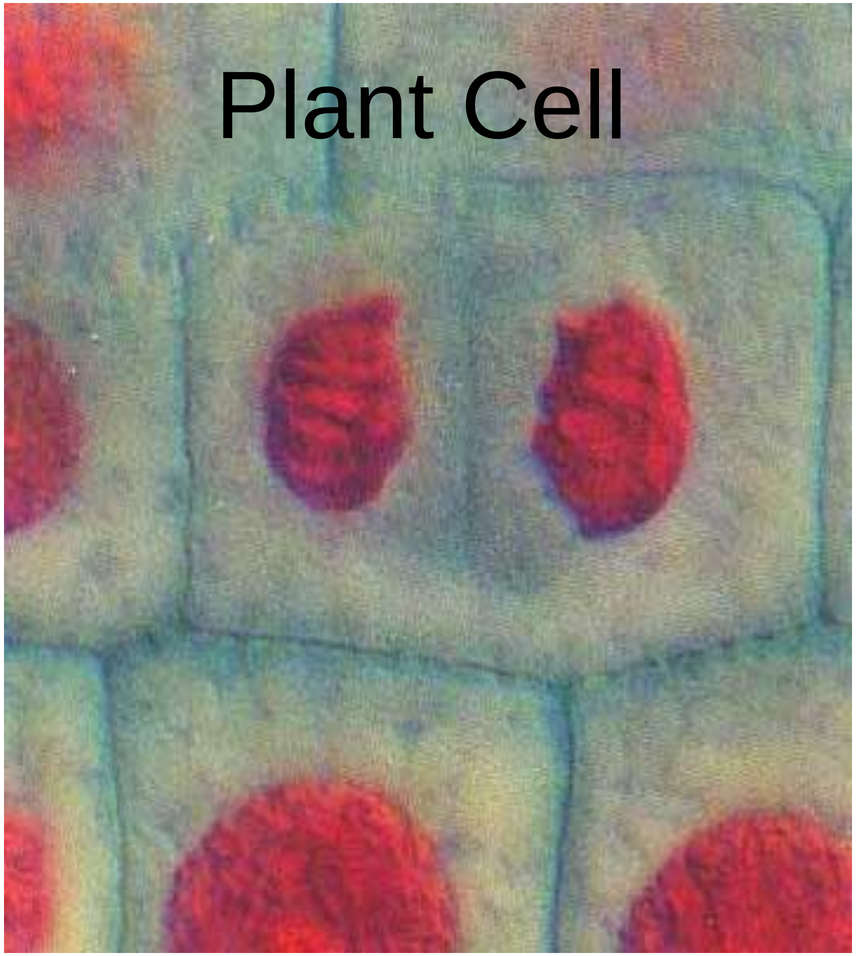
- Animal Cell
  - DNA spreads out
  - 2 nuclei form
  - Cell wall pinches in to form the 2 new daughter cells
- Plant Cell
  - DNA spreads out
  - 2 nuclei form
  - New cell wall forms between to nuclei to form the 2 new daughter cells



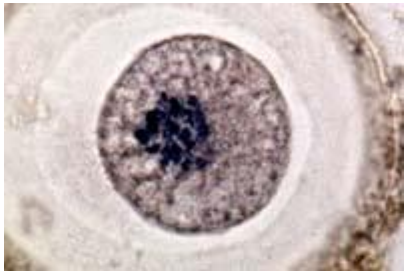
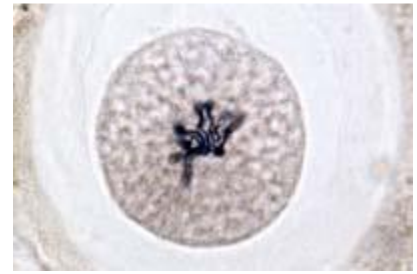
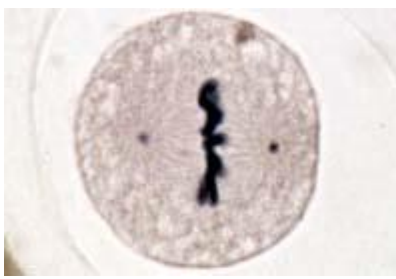
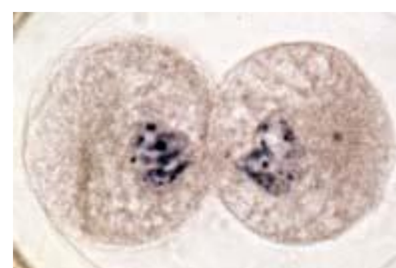
Telophase and Cytokinesis

Telophase

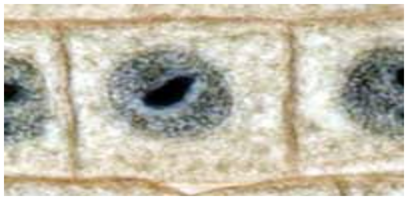
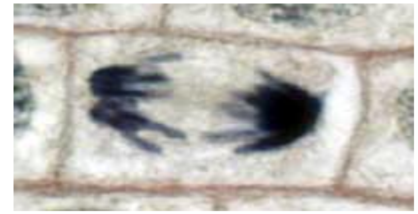
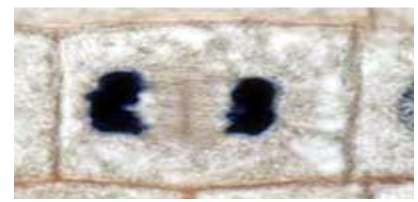




Animal Mitosis -- Review

Interphase 	**Prophase** 
Metaphase 	**Anaphase** 
Telophase 	**Interphase** 

Plant Mitosis -- Review

Interphase 	**Anaphase** 
Prophase 	**Telophase** 
Metaphase 	**Interphase** 

Meiosis

Meiosis is the type of cell division by which germ cells (eggs and sperm) are produced.

One parent cell produces four daughter cells.

Daughter cells have half the number of chromosomes found in the original parent cell

During meiosis, DNA replicates <u>once</u>, but the nucleus divides <u>twice</u>.

Four stages can be described for each division of the nucleus.

First Division of Meiosis (Meiosis I)

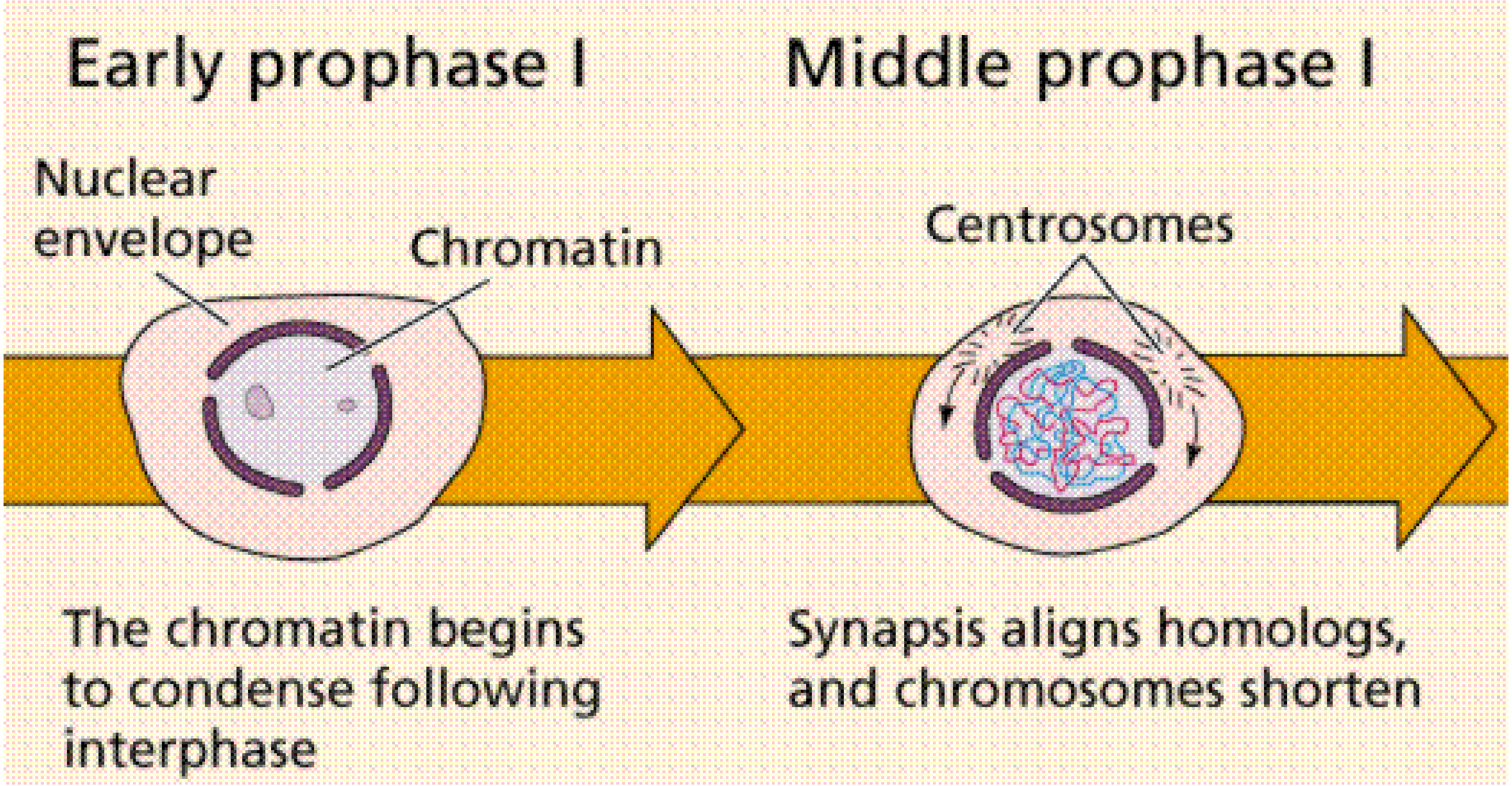
Prophase 1: Each chromosome duplicates and remains closely associated. These are called sister chromatids.

Metaphase 1: Chromosomes align at the center of the cell.

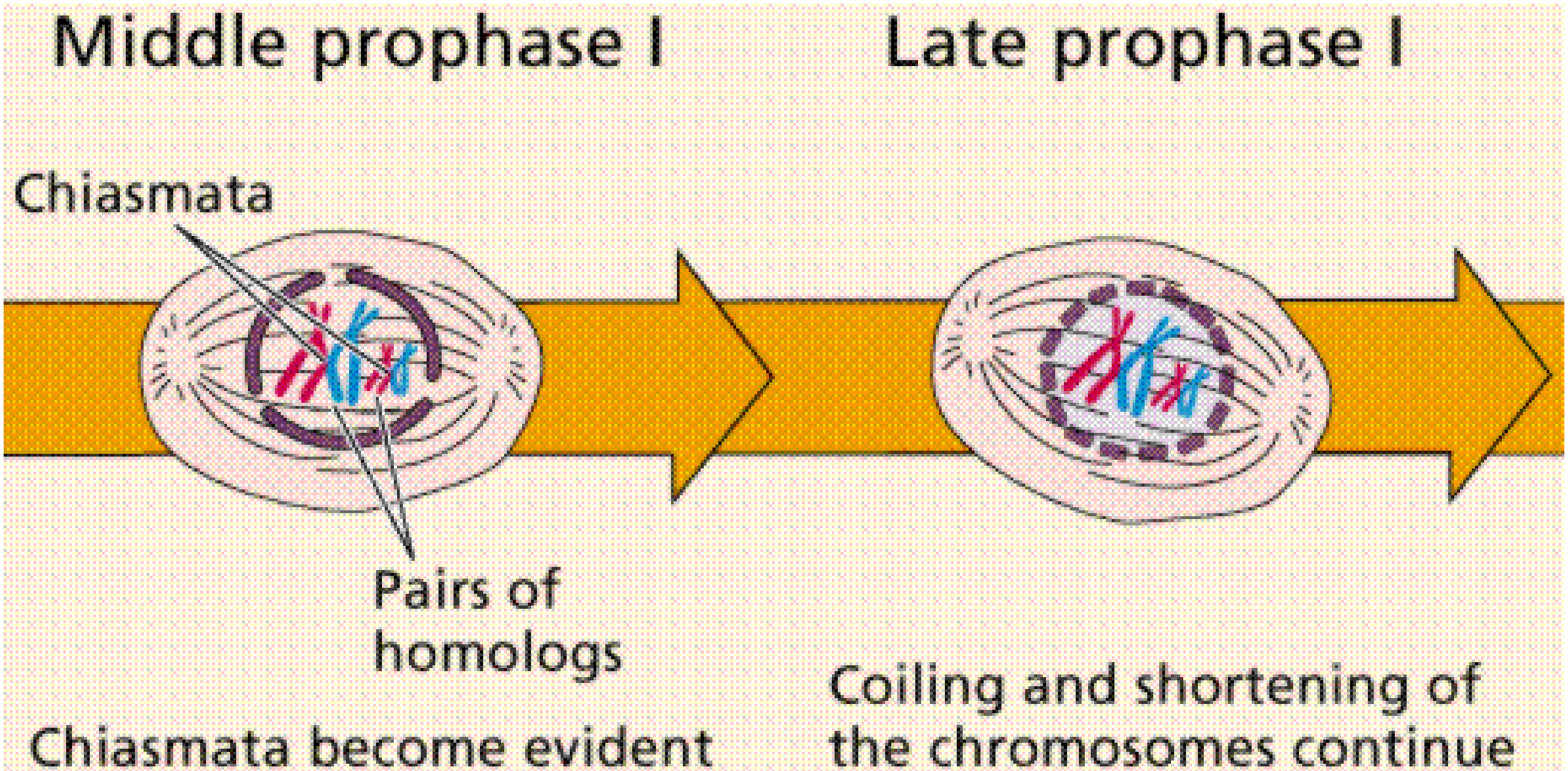
Anaphase 1: Chromosome pairs separate with sister chromatids remaining together.

Telophase 1: Two daughter cells are formed with each daughter containing only one chromosome of the chromosome pair.

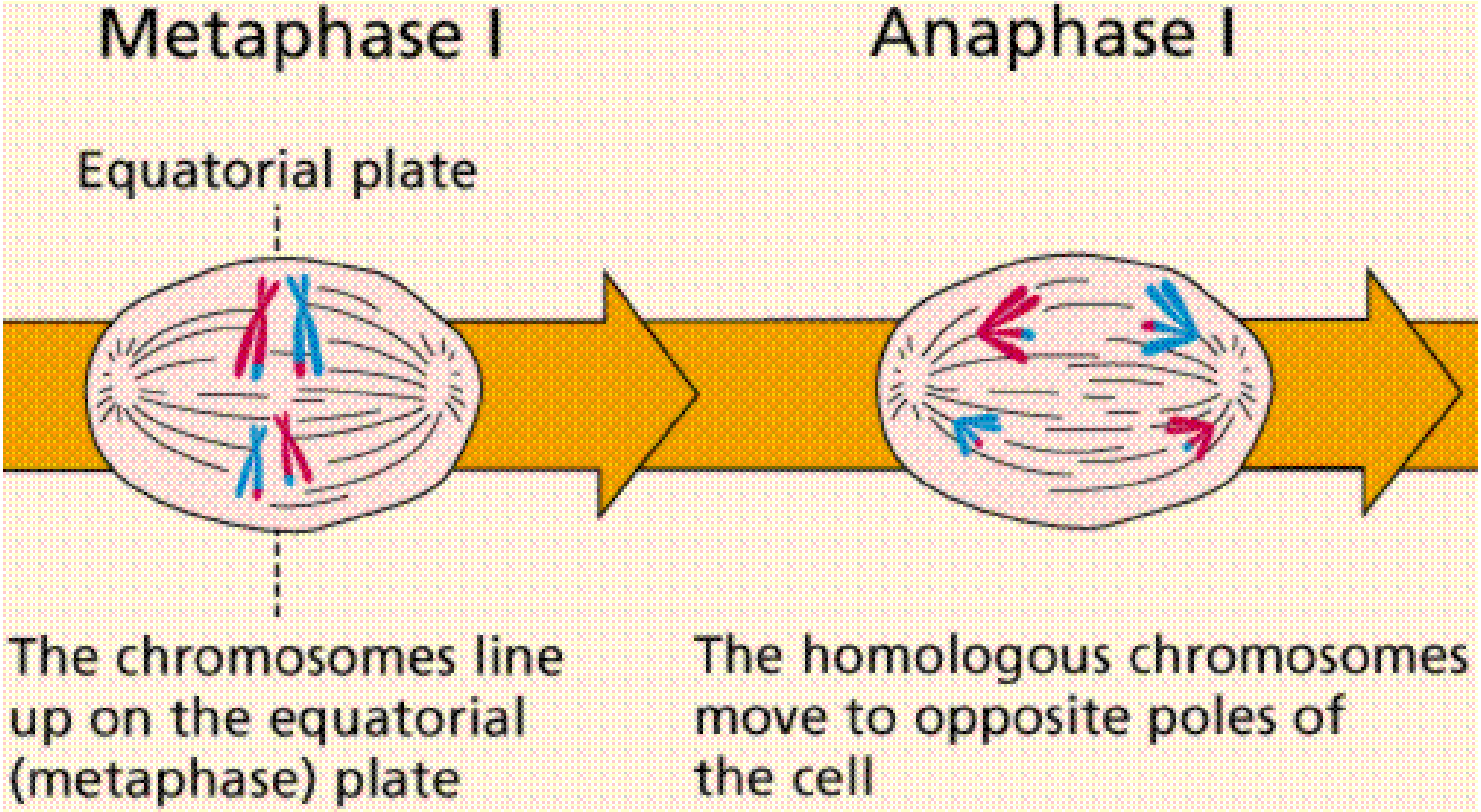
Prophase I


Early prophase I
Middle prophase I
Nuclear envelope
Chromatin
Centrosomes
The chromatin begins to condense following interphase
Synapsis aligns homologs, and chromosomes shorten

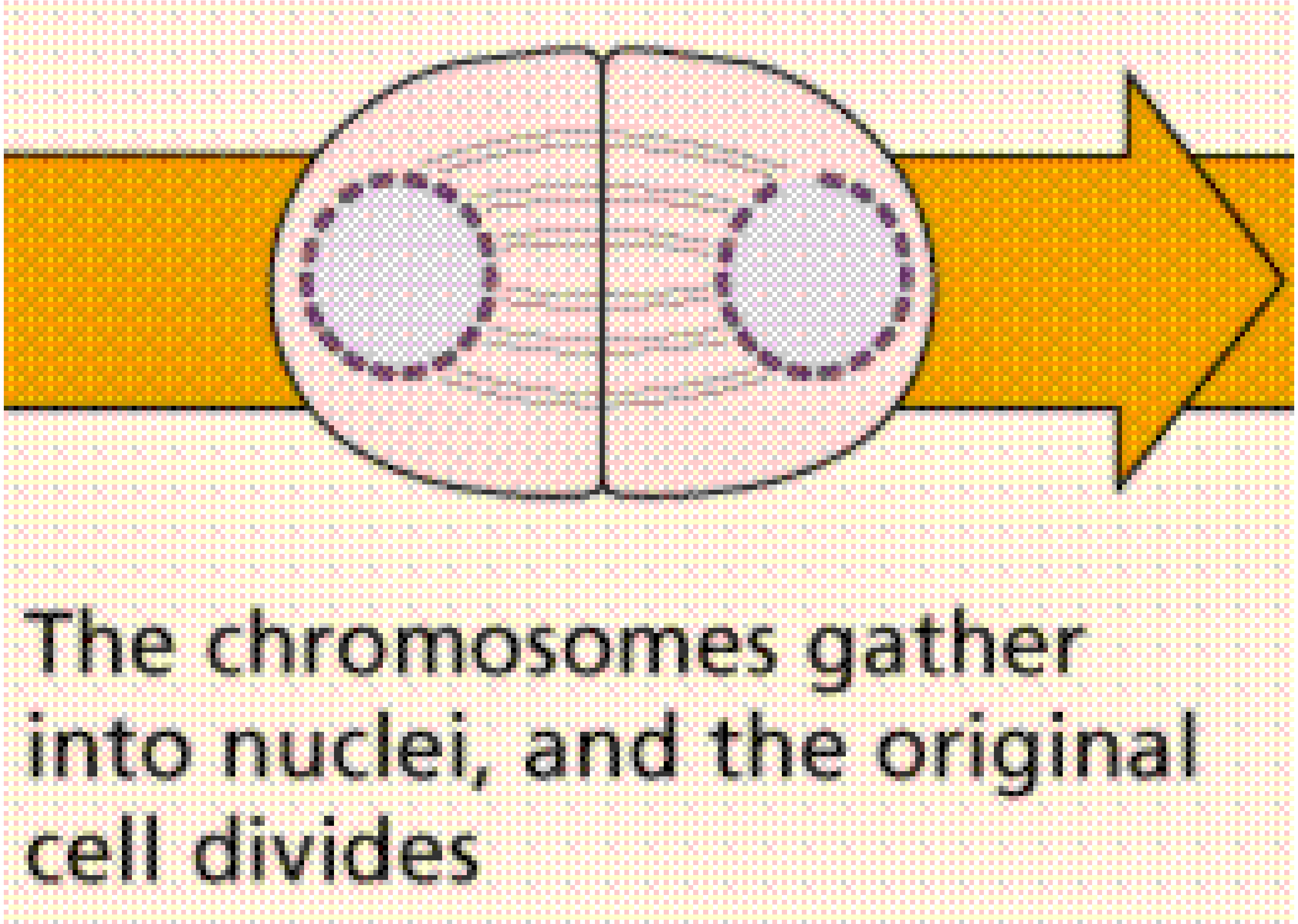
Prophase I


Middle prophase I
Late prophase I
Chiasmata
Pairs of
homologs
Chiasmata become evident
Coiling and shortening of
the chromosomes continue

Metaphase I


Metaphase I
Anaphase I
Equatorial plate
The chromosomes line up on the equatorial (metaphase) plate
The homologous chromosomes move to opposite poles of the cell

Telophase I


The chromosomes gather into nuclei, and the original cell divides

Second Division of Meiosis (Meiosis2)

Prophase 2: DNA does not replicate.

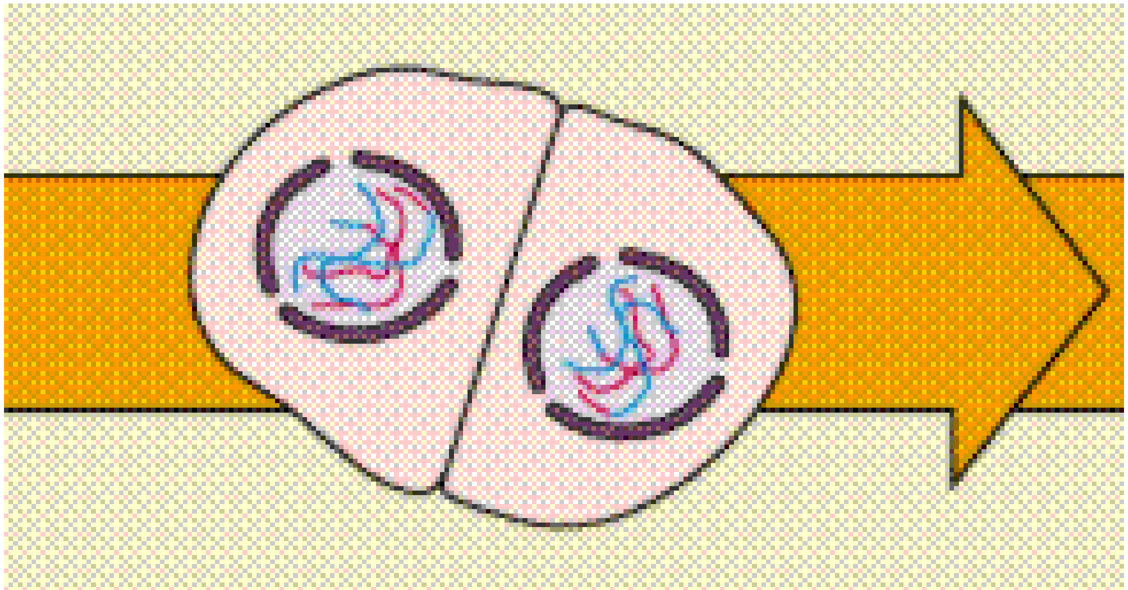
Metaphase 2: Chromosomes line up at the center of the cell

Anaphase 2: Centromeres divide and sister chromatids move separately to each pole.

Telophase 2: Cell division is complete.

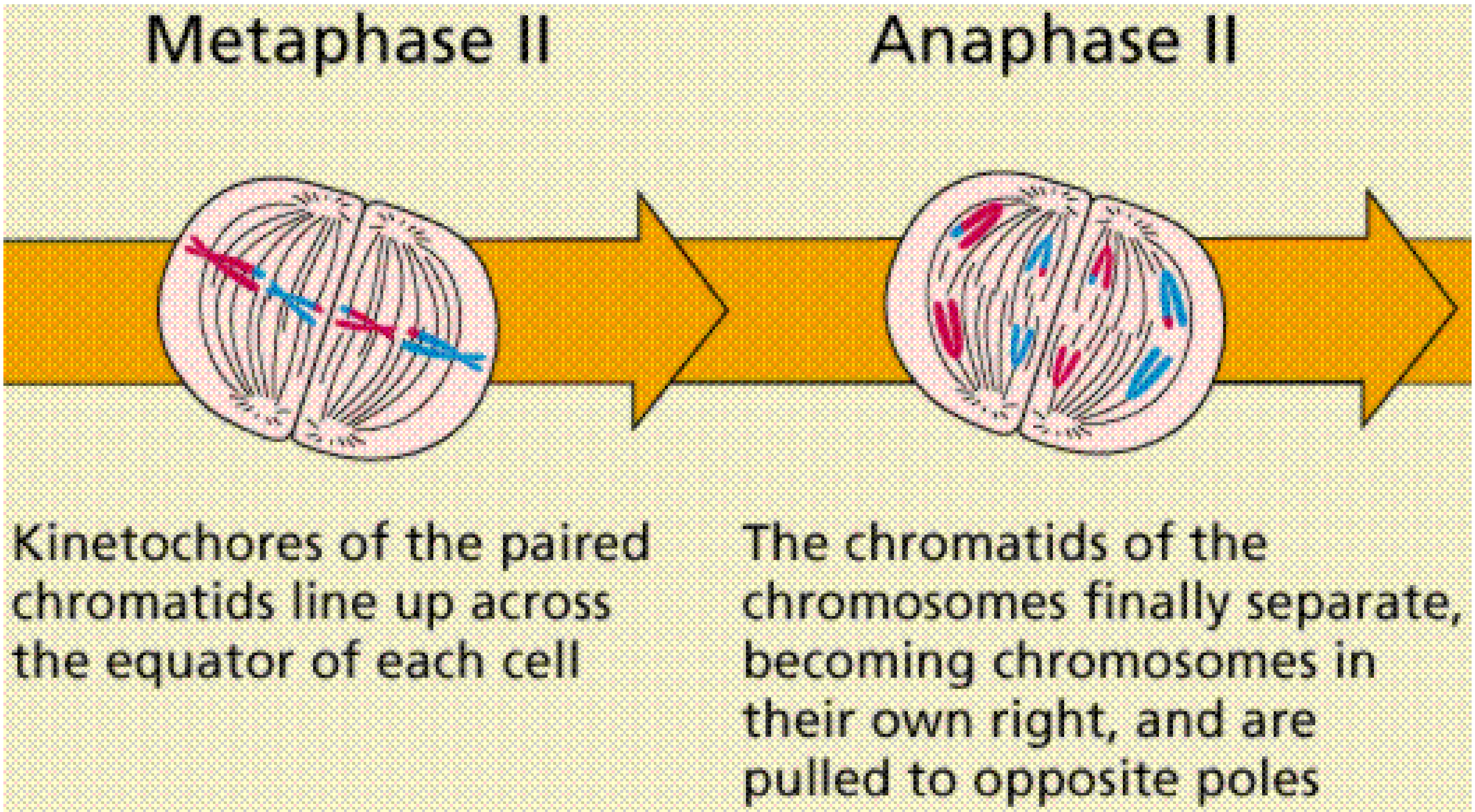
Four haploid daughter cells are formed.

Prophase II

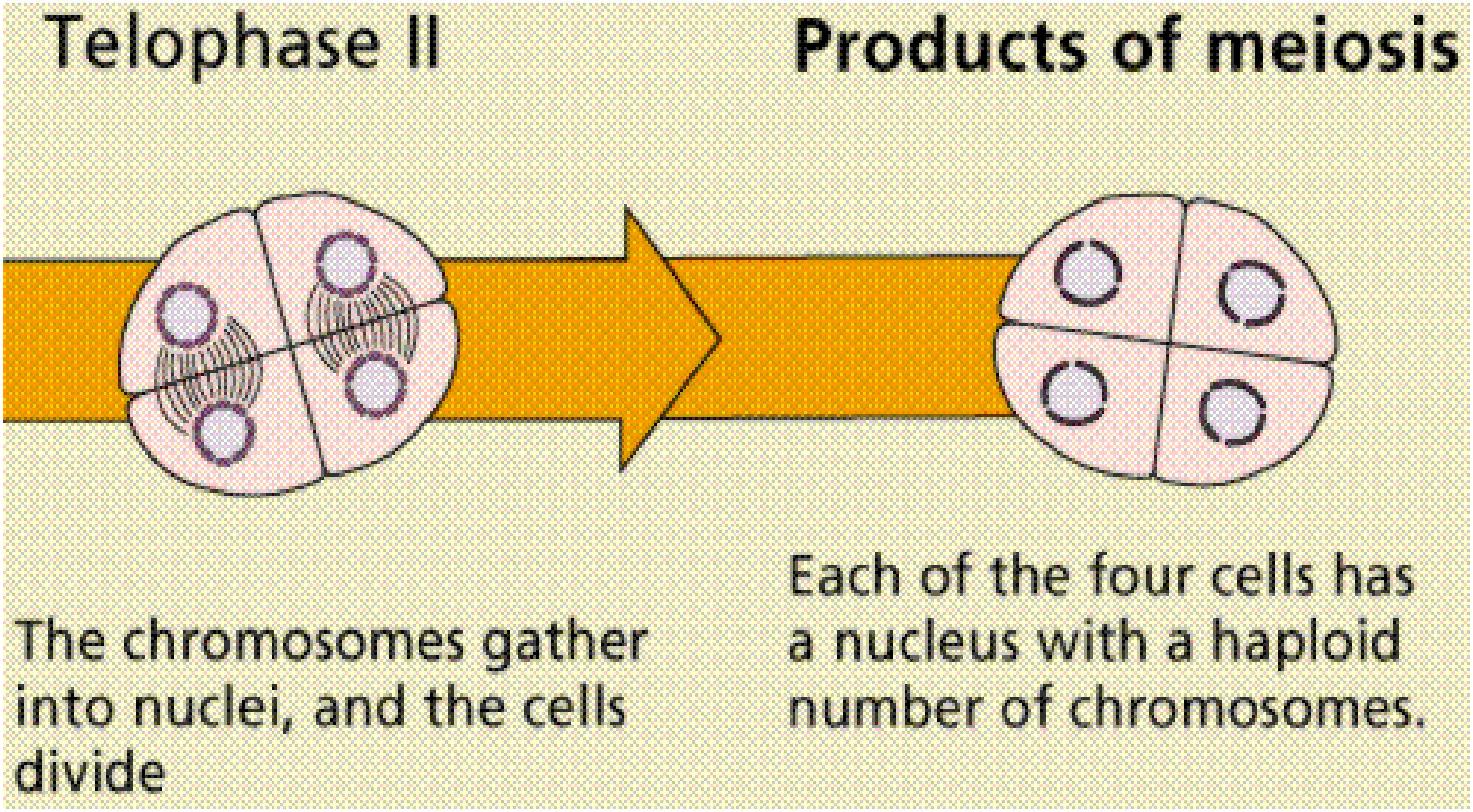


The chromosomes condense again, following a brief interphase in which DNA does not replicate

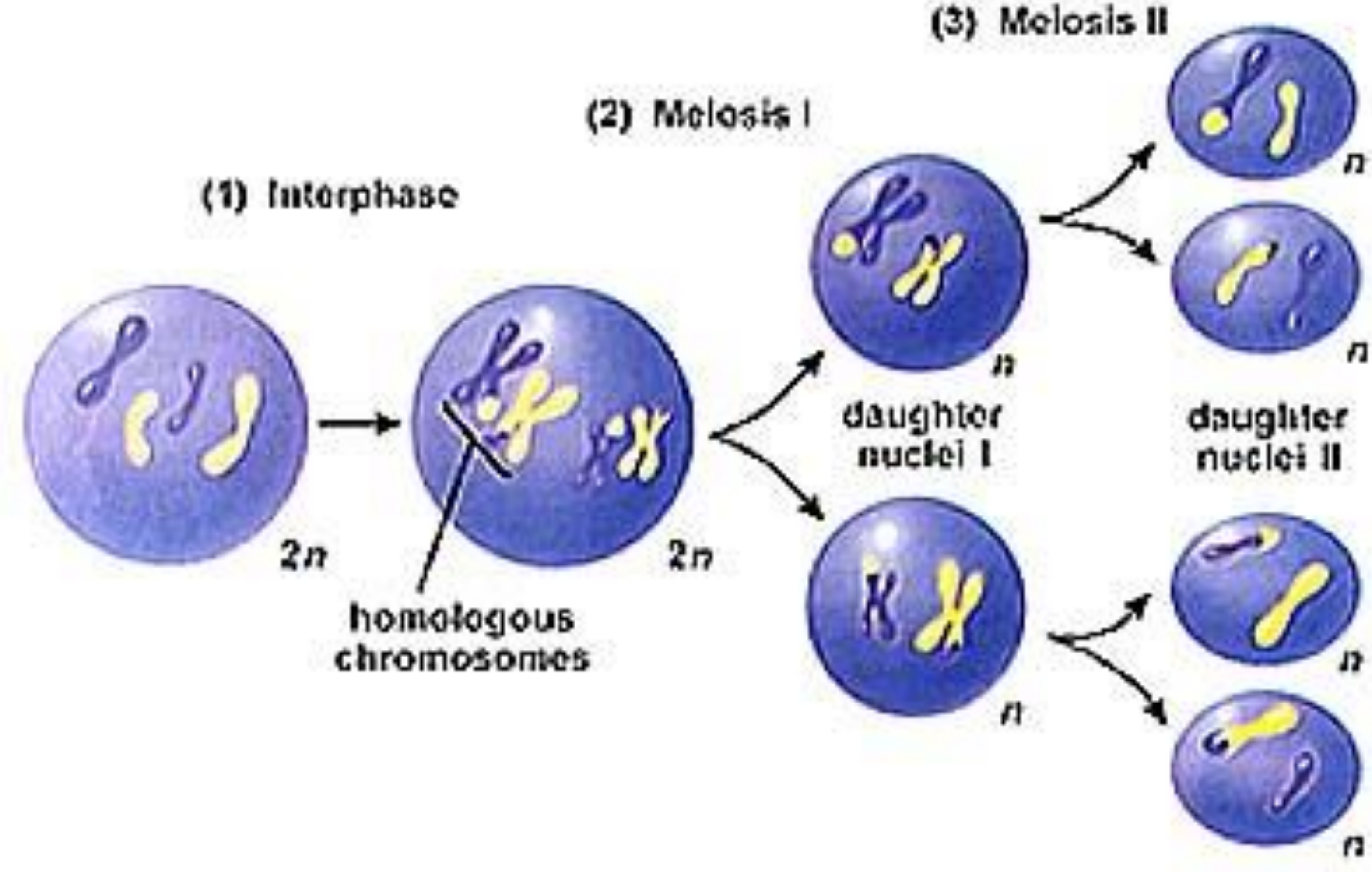
Metaphase II



Telophase II



Meiosis



(3) Meiosis II
(2) Meiosis I
(1) Interphase
n
n
n
daughter
nuclei I
daughter
nuclei II
2n
2n
homologous
chromosomes
n
n
n

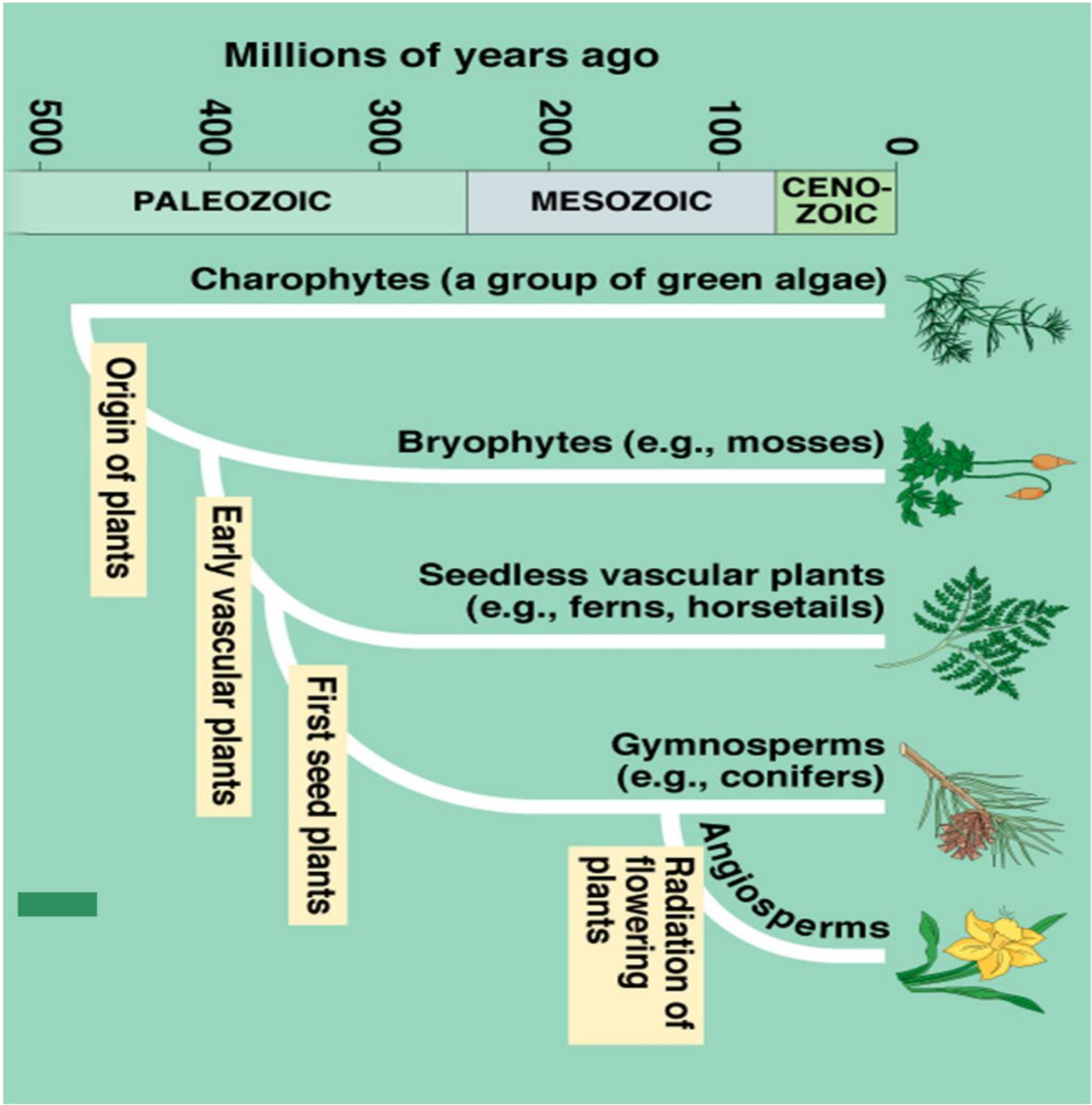
Differences in Mitosis & Meiosis

Mitosis	**Meiosis**
Asexual	Sexual
Cell divides once	Cell divides twice
Two daughter cells	Four haploid daughter cells
Genetic information is identical	Genetic information is different

Lec.6
The Plant Body

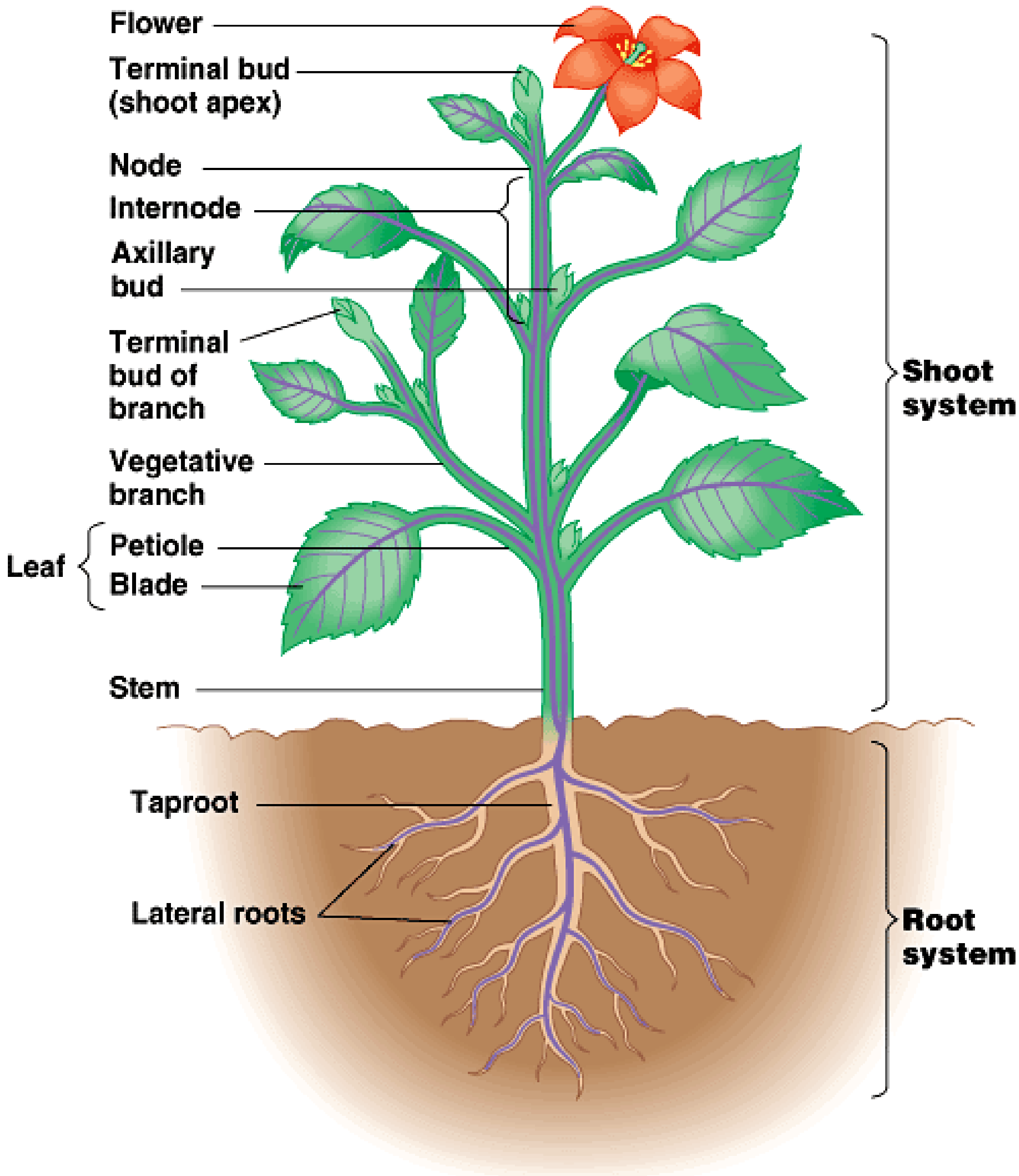
Dr. Anaam F. Hussain

Groups of plants



Principal differences between Angiosperms and Gymnosperms

1. Angiosperm leaves have finely divided venation; typically gymnosperm foliage e.g., conifer needles, have a single vascular strand
2. Angiosperm xylem contains vessels as well as tracheids and parenchyma
3. Angiosperm phloem contains sieve elements with companion cells rather than albuminous cells
4. Angiosperm ovules are protected within an enclosed structure rather sitting on a modified leaf
5. Double fertilization in the angiosperms produces a diploid zygote and triploid endosperm nucleus
6. In the angiosperms there are generally hermaphrodite flowers and cross pollinating (70%). Wind pollination is typical in the gymnosperms animal pollination widespread in angiosperms


Flower
Terminal bud
(shoot apex)
Node
Internode
Axillary
bud
Terminal
bud of
branch
Vegetative
branch
Leaf
Petiole
Blade
Stem
Taproot
Lateral roots
Shoot
system
Root
system

- With about 250,000 known species, the angiosperms are by far the most diverse and widespread group of land plants.
- As primary producers, flowering plants are at the base of the food web of nearly every terrestrial ecosystem.

  -Most land animals, including humans, depend on plants directly or indirectly for sustenance.

  - The architecture of a plant is a dynamic process, continuously shaped by plant's genetically directed growth pattern along with fine-tuning to the environment.
  - A plant's structure reflects interactions with the environment of two time scales.

- Over the long term, entire plant species have, by natural selection, accumulated morphological adaptations that enhance survival and reproductive success.
  - -For example, some desert plants have so reduced their leaves that the stem is actually the primary photosynthetic organ.
  - -This is a morphological adaptation that reduces water loss.
- Over the short term, individual plants, even more than individual animals, exhibit structural responses to their specific environments.
  - -For example, the submerged aquatic leaves of *Cabomba* are feathery, enhancing the surface area available for the uptake of bicarbonate ion (HCO_3^-), the form of CO_2 in water.
  - -Leaves that extend above the surface form oval pads that aid in flotation.

Plants have three basic organs: roots, stems, and leaves

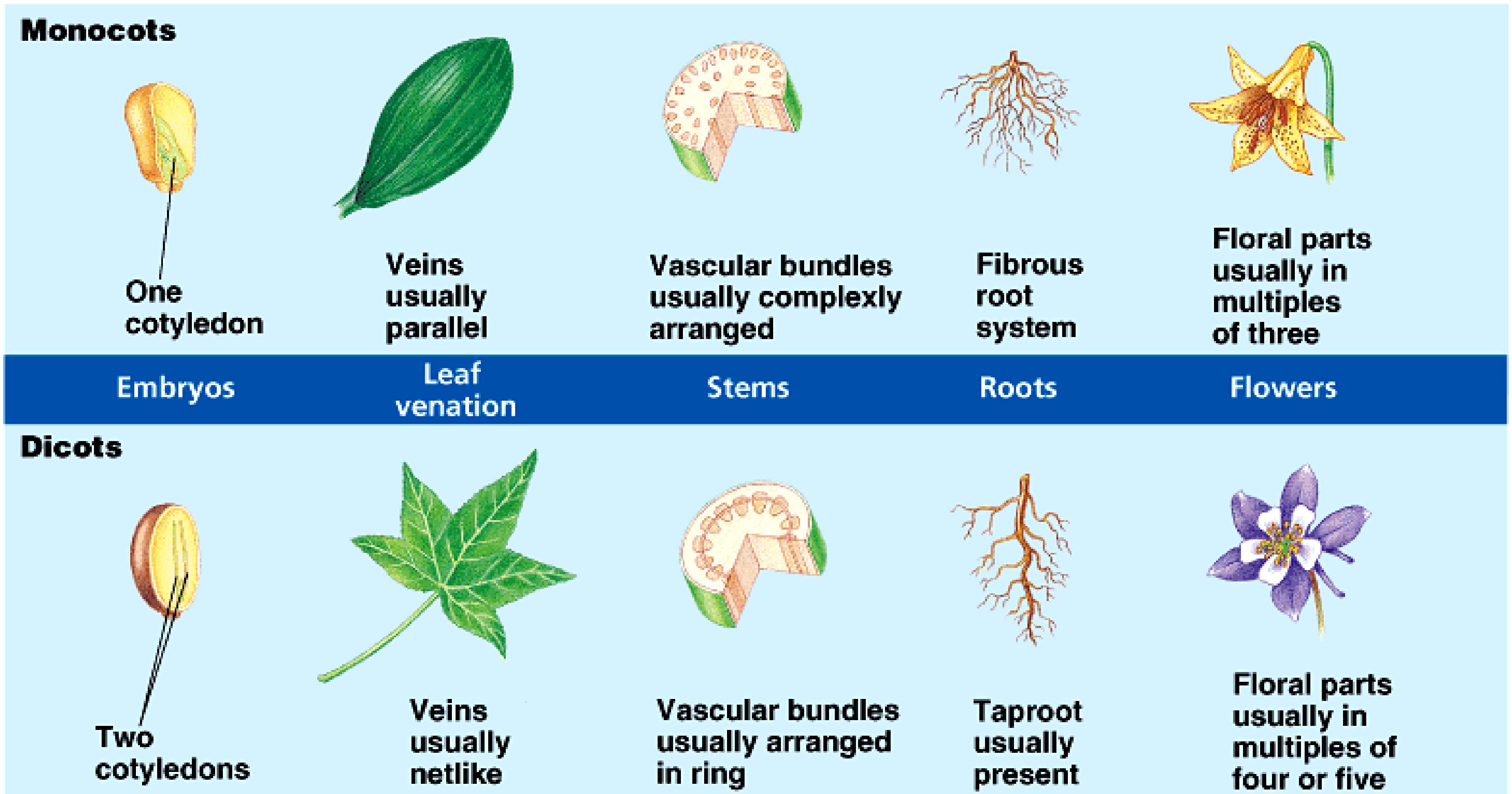
- The plant body is a hierarchy of structural levels, with emergent properties arising from the ordered arrangement and interactions of component parts.
- The plant body consists of organs that are composed of different tissues, and these tissues are teams of different cell types.

- **Roots:** anchor the plant in the soil, absorb minerals and water, and store food.
  - Monocots, including grasses, generally have **fibrous root** systems, consisting of a mat of thin roots that spread out below the soil surface. Ex: ***Phoenix dactylifera*** **(date-palms)**
    - This extends the plant's exposure to soil water and minerals and anchors it tenaciously to the ground.
  - Many dicots have a **taproot** system, consisting of a one large vertical root (the taproot) that produces many small lateral, or branch roots.
    - The taproots not only anchor the plant in the soil, but they often store food that supports flowering and fruit production later. Ex**:** ***Daucus carota*** **(Carrot)**

- Both systems depend on the other.
  - Lacking chloroplasts and living in the dark, roots would star without the sugar and other organic nutrients imported from the photosynthetic tissues of the shoot system. Conversely, the shoot system (and its reproductive tissues, flowers) depends on water and minerals absorbed from the soil by the roots.

- The basic morphology of plants reflects their evolutionary history as terrestrial organisms that must simultaneously inhabit and draw resources from two very different environments.
  - Soil provides water and minerals, but air is the main source of CO_2 and light does not penetrate far into soil.
  - Plants have evolved two systems: a subterranean **root system** and an aerial **shoot system** of stems and leaves.

- Although all angiosperms have a number of features in common, two plants groups, the monocots and dicots, differ in many anatomical details.



- Even faster than a plant’s structural responses to environmental changes are its physiological (functional) adjustments.
  - Most plants are rarely exposed to severe drought and rely mainly on physiological adaptations to cope with drought stress.
    - In the most common response, the plant produces a hormone that cause the stomata, the pores in the leaves through which most of the water is lost, to close.

- Most absorption of water and minerals in both systems occurs near the root tips, where vast numbers of tiny **root hairs** increase the surface area enormously.
  - Root hairs are extensions of individual epidermal cells on the root surface.

- Shoots consist of stems and leaves.
  - Shoot systems may be vegetative (leaf bearing) or reproductive (flower bearing).
  - A stem is an alternative system of **nodes**, the points at which leaves are attached, and **internodes**, the stem segments between nodes.
  - At the angle formed by each leaf and the stem is an **axillary bud**, with the potential to form a vegetative branch.
  - Growth of a young shoot is usually concentrated at its apex, where there is a **terminal bud** with developing leaves and a compact series of nodes and internodes.

- Some plants have roots, **adventitious** roots, arising aboveground from stems or even from leaves.In some plants, including corn, these adventitious roots function as props that help support tall stems.
  - **Leaves** are the main photosynthetic organs of most plants, but green stems are also photosynthetic.
  - While leaves vary extensively in form, they generally consist of a flattened **blade** and a stalk, the **petiole**, which joins the leaf to a stem node.
  - In the absence of petioles in grasses and many other monocots, the base of the leaf forms a sheath that envelops the stem.
  - Most monocots have parallel major veins that run the length of the blade, while dicot leaves have a multibranched network of major veins.

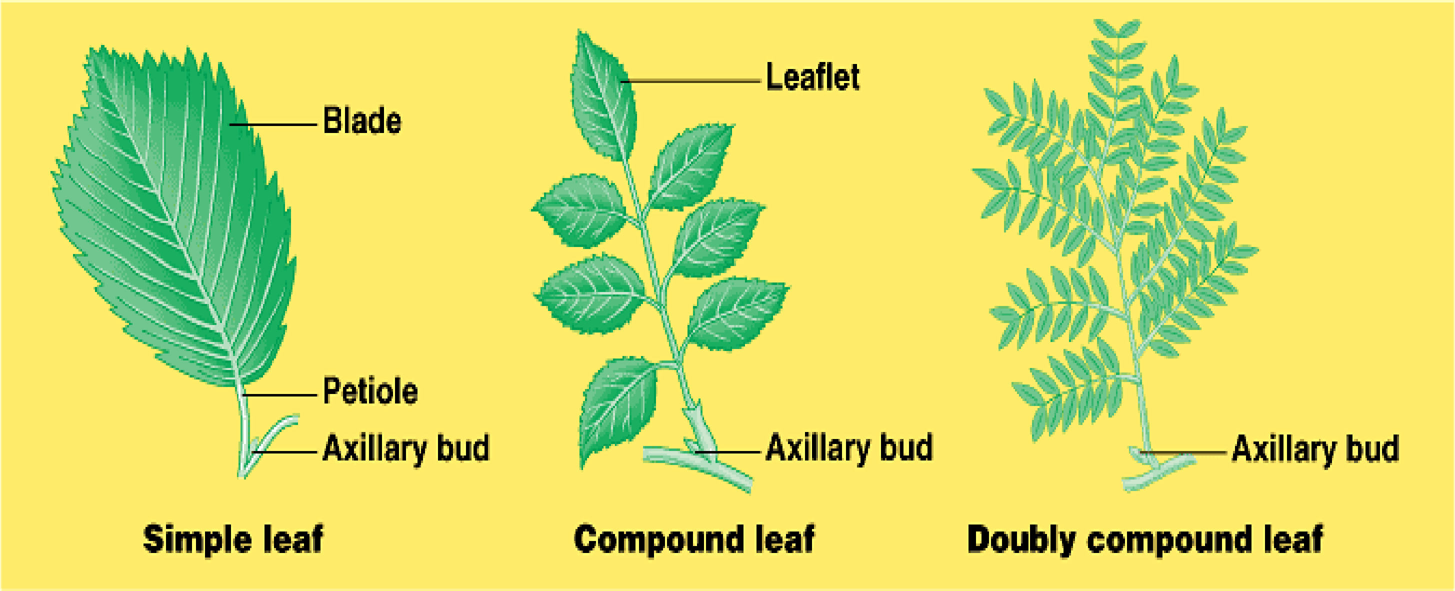
- Modified shoots with diverse functions have evolved in many plants.
  - These shoots, which include stolons, rhizomes, tubers, Corms, Tendrils and bulbs, are often mistaken for roots.
  - Stolons, such as the "runners" of **Strawberry** plants, grow on the surface and enable a plant to colonize large areas asexually when a parent plant fragments into many smaller offspring.
  - Rhizomes, like those of ginger, are horizontal stems that grow underground.

– Tubers, including potatoes, are the swollen ends of rhizomes specialized for food storage. Ex***: Solanum tuberosum*** **(potato)**

– Bulbs, such as ***Allium cepa*** **onions** , are vertical, underground shoots consisting mostly of the swollen bases of leaves that store food.

- The presence of a terminal bud is partly responsible for inhibiting the growth of axillary buds, a phenomenon called **apical dominance**.
  - By concentrating resources on growing taller, apical dominance increases the plant's exposure to light.
  - In the absence of a terminal bud, the axillary buds break dominance and gives rise to a vegetative branch complete with its own terminal bud, leaves, and axillary buds.
  - Plant taxonomists use leaf shape, spatial arrangement of leaves, and the pattern of veins to help identify and classify plants.

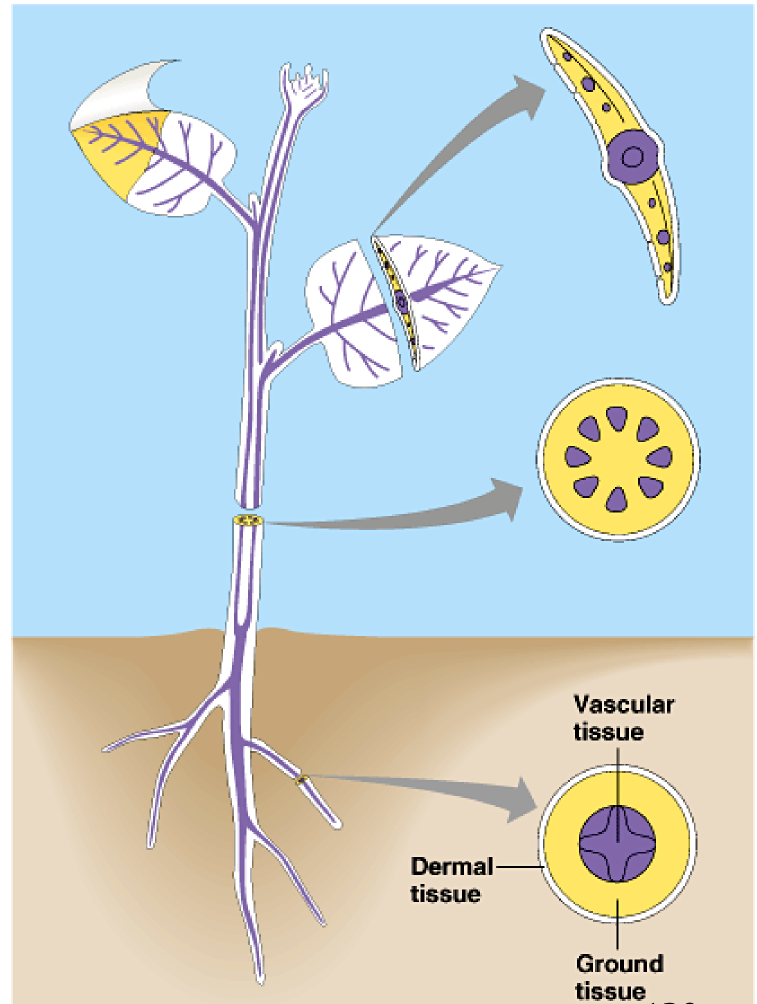
– For example, simple leaves have a single, undivided blade, while compound leaves have several leaflets attached to the petiole.
– A compound leaf has a bud where its petiole attaches to the stem, not at the base of the leaflets.



- Some plants have leaves that have become adapted by evolution for other functions.
- This includes tendrils to cling to supports, spines of cacti for defense, leaves modified for water storage, and brightly colored leaves that attract pollinators.

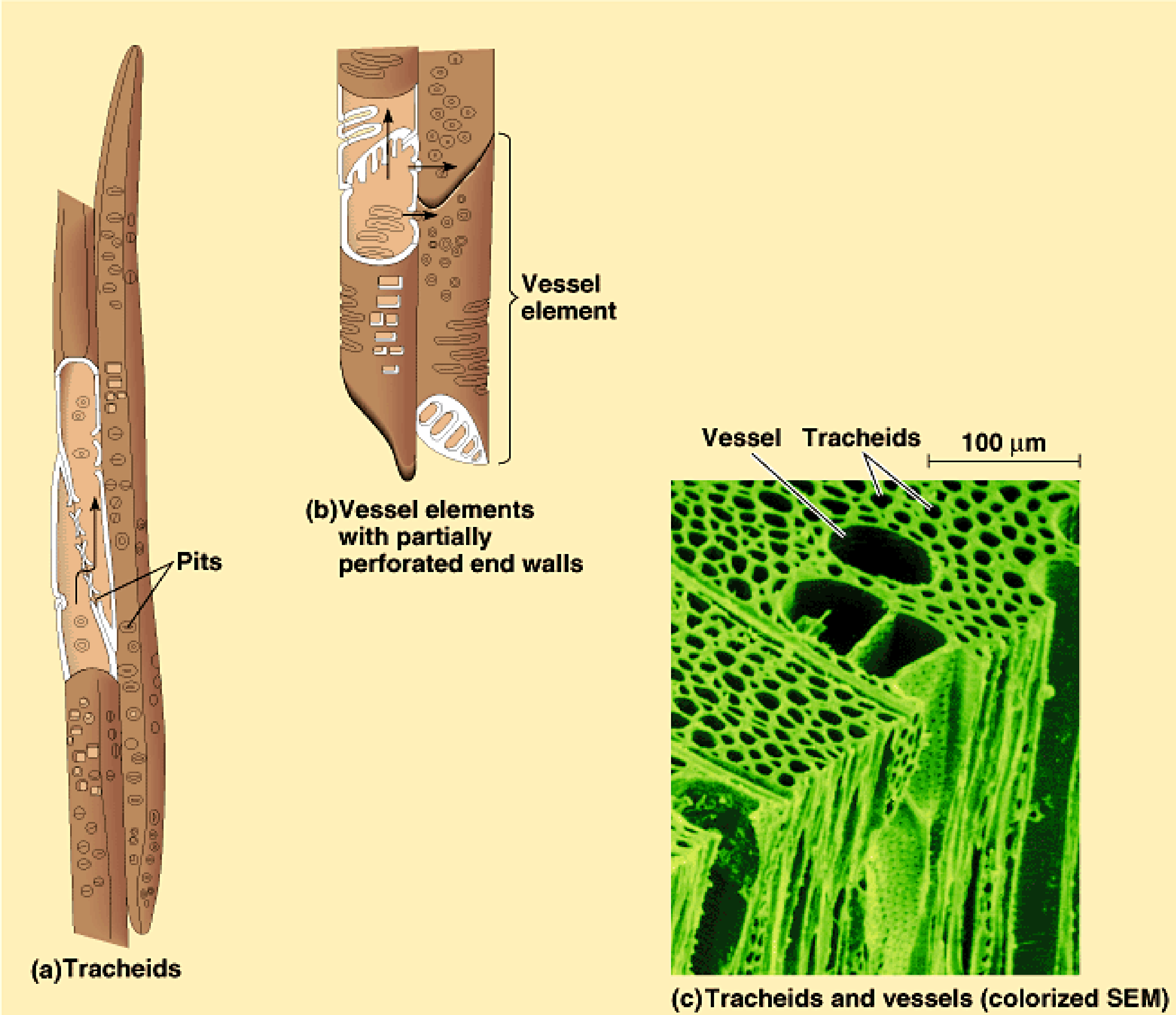
Plant Organs are Composed of ThreeTissue Systems: Dermal, Vascular, and Ground

- Each organ of a plant has three tissue systems: the dermal, vascular, and ground tissue systems.
  - Each system is continuous throughout the plant body.



- The **dermal tissue**, or **epidermis**, is generally a single layer of tightly packed cells that covers and protects all young parts of the plant.
- The epidermis has other specialized characteristics consistent with the function of the organ it covers.
  - For example, the roots hairs are extensions of epidermal cells near the tips of the roots.
  - The epidermis of leaves and most stems secretes a waxy coating, the **cuticle**, that helps the aerial parts of the plant retain water.

- **Vascular tissue**, continuous throughout the plant, is involved in the transport of materials between roots and shoots.
  - **Xylem** conveys water and dissolved minerals upward from roots into the shoots.
  - **Phloem** transports food made in mature leaves to the roots and to nonphotosynthetic parts of the shoot system.
- The water conducting elements of xylem, the **tracheids** and **vessel elements**, are elongated cells that are dead at functional maturity, when these cells are fully specialized for their function.
  - The thickened cell walls form a nonliving conduit through which water can flow.



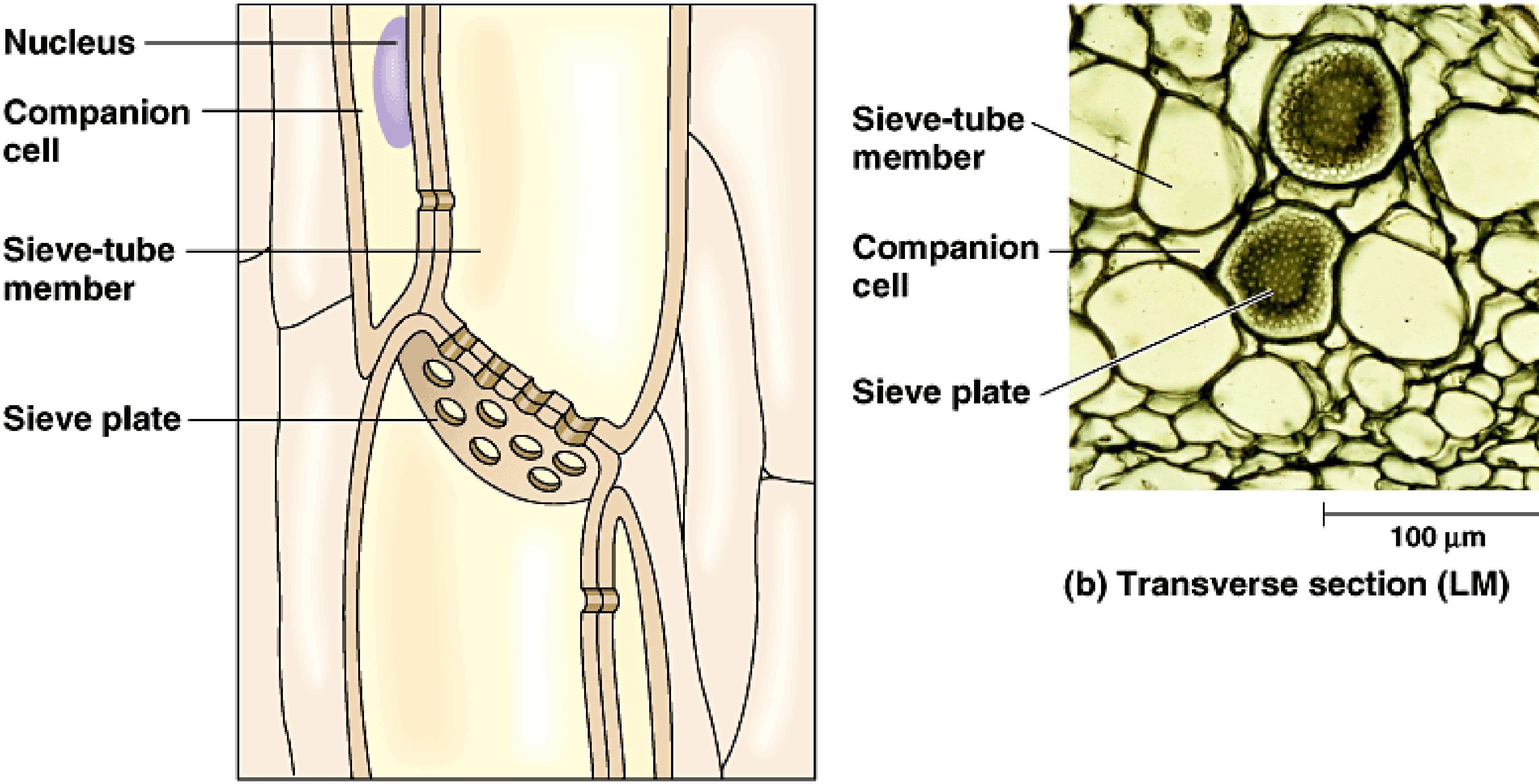
(a) Tracheids

(b) Vessel elements with partially perforated end walls

(c) Tracheids and vessels (colorized SEM)

- Both tracheids and vessels have secondary walls interrupted by **pits**, thinner regions where only primary walls are present.
- Tracheids are long, thin cells with tapered ends.
  - Water moves from cell to cell mainly through pits.
  - Because their secondary walls are hardened with lignin, tracheids function in support as well as transport.
- Vessel elements are generally wider, shorter, thinner walled, and less tapered than tracheids.
  - Vessel elements are aligned end to end, forming long micropipes, **xylem vessels**.
  - The ends are perforated, enabling water to flow freely.

- In the phloem, sucrose, other organic compounds, and some mineral ions move through tubes formed by chains of cells, **sieve-tube members**.
  - These are alive at functional maturity, although they lack the nucleus, ribosomes, and a distinct vacuole.
  - The end walls, the **sieve plates**, have pores that presumably facilitate the flow of fluid between cells.
  - A nonconducting nucleated **companion cell**, connected to the sieve-tube member, may assist the sieve-tube cell.



(a) Longitudinal view

(b) Transverse section (LM)

- **Ground tissue** is tissue that is neither dermal tissue nor vascular tissue.
  - In dicot stems, ground tissue is divided into **pith**, internal to vascular tissue, and **cortex**, external to the vascular tissue.
  - The functions of ground tissue include photosynthesis, storage, and support.
  - For example, the cortex of a dicot stem, typically consists of both fleshy storage cells and thick-walled support cells.

Lec.7
Flowers, Seeds and Fruits

Dr. Anaam F. Hussain

Flowers

- Flowers, which are the showiest part of a plant, have sexual reproduction as their sole function. Their beauty and fragrance have evolved not to please humans but to ensure continuance of the species. Fragrance and color attract pollinators (insects or birds) that play an important role in the reproductive process.

- Flowers are important for plant classification. The system of plant nomenclature we use today was developed by Carl Linnaeus and is based on flowers and/or reproductive parts of plants

- **Flower´s Structure:**
- Flowers contain a stamen (male part) and/or pistil (female part), plus accessory parts such as sepals, petals and nectar glands.

The stamen is the male reproductive organ, consists of a pollen sac (*anther*) and a long supporting filament. This filament holds the anther in position, making the pollen available for dispersement by wind, insects, or birds.

The pistil is a female part. ,is shaped like a bowling pin and located in the flower’s center. It consists of a stigma, style and ovary.

The stigma is located at the top and is connected by the **style** to the ovary. The *ovary* contains eggs, which reside in ovules. If an egg is fertilized, the ovule develops into a seed.

- **Sepals** are small, green, leaf-like structures located at the base of a flower. They protect the flower bud. Collectively, the sepals are called a *calyx*.
- **Petals (corolla)**are the highly colored portions of a flower. Like nectar glands, petals may contain perfume. The number of petals on a flower is used to help identify plant families and genera.

- **Types of flowers:**
- If a flower has a stamen, pistil, petals and sepals, it is called a **complete flower**. Roses are an example. If one of these parts is missing, the flower is called **incomplete.**
- The stamen and pistil are the essential parts of a flower and are involved in seed production. If a flower contains both functional stamens and pistils, it is called a **perfect flower**, even if it does not contain petals and sepals. If either stamens or pistils are lacking, the flower is called **imperfect.** *Pistillate* (female) flowers possess a functional pistil or pistils,

- but lack stamens. *Staminate* (male) flowers contain stamens, but no pistils.
- Plants with imperfect flowers are further classified as monoecious or dioecious. *Monoecious* plants have separate male and female flowers on the same plant (e.g., corn and pecans). Monoecious is sometimes referred to as one house for both sexes. Some monoecious plants bear only male flowers at the beginning of the growing season, but later develop both sexes (e.g., cucumbers and squash).

- Dioecious species have separate male and female plants. Examples include kiwi, ginkgos and cottonwood. In order to set fruit, male and female plants must be planted close enough together for pollination to occur. In some instances the fruit is desirable. In the case of ginkgos, the fruit is not desirable due to its putrid smell when ripe. Kiwis are complicated because they may have one plant with bisexual flowers and another plant with only male flowers. The plant world doesn’t always have absolutes

- **Seeds**
- Pollination is the transfer of pollen from an anther to a stigma, either by wind or pollinators. Species pollinated by insects, animals or birds often have brightly colored or patterned flowers that contain fragrance or nectar. While searching for nectar, pollinators transfer pollen from flower to flower, either on the same plant or on different plants. Plants evolved this ingenious mechanism to ensure species survival.
-

- , **Zucchini flowers (** ***Cucurbita pepo*** **var.** ***cylindrica***) which are normally pollinated by bees, may have to be hand pollinated in cool wet summers. Wind-pollinated flowers often lack showy floral parts and nectar because they don't need to attract pollinators. A chemical in the stigma stimulates pollen to grow a long tube down the style to the ovules inside the ovary. The stigma recognizes pollen, which has a chemical specific to that type of plant. The wrong pollen will not germinate because it lacks the chemical signature.

- When pollen reaches the ovules, it releases sperm and fertilization occurs. *Fertilization* is the union of a male sperm nucleus from a pollen grain with a female egg. If fertilization is successful, the ovule develops into a seed. Pollination does not guarantee that fertilization will occur. Moisture and temperature stresses can cause a lack of fertilization. High temperature in greenhouse settings can reduce fruit set in tomatoes and cucumbers.
-

- *Cross-fertilization* combines genetic material from two similar parent plants from the same species. The resulting seed has a broader genetic base, which may enable the population to survive under a wider range of environmental conditions. Cross-pollinated plants usually are more successful than self-pollinated plants. Consequently, more plants reproduce by cross than by self-pollination.

Fruit

- consists of fertilized, mature ovules (seeds) plus the ovary wall. Fruit may be fleshy, as in an apple, or dry and hard, as in an acorn. In some fruits, the seeds are enclosed within the ovary (e.g., apples, peaches, oranges, squash and cucumbers). In others, seeds are situated on the outside of fruit tissue (e.g., corn and strawberries).
- The only part of the fruit that contains genes from both the male and female flowers is the seed. The rest of the fruit arises from the maternal plant and is genetically identical to it.
-

- **Types of fruit:-**
- Fruits are classified as simple, aggregate or multiple .*Simple* fruits develop from a single ovary. They include fleshy fruits such as cherries and peaches (drupe), pears and apples (pome) and tomatoes (berries). Although generally referred to as a vegetable, tomatoes technically are a fruit because they develop from a flower. Squash, cucumbers and eggplants also develop from a single ovary and are classified botanically as fruits.

- Other types of simple fruit are dry. Their wall is either papery or leathery and hard, as opposed to the fleshy examples just mentioned. Examples are peanuts (legume), poppies (capsule), maples (samara) and walnuts (nut).

- An *aggregate* fruit develops from a single flower with many ovaries. Examples are strawberries, raspberries and blackberries. The flower is a simple flower with one corolla, one calyx and one stem, but it has many pistils or ovaries. Each ovary is fertilized separately. If some ovules are not pollinated successfully, the fruit will be misshapen.

- *Multiple* fruits are derived from a tight cluster of separate, independent flowers borne on a single structure. Each flower has its own calyx and corolla. Pineapples and figs are examples.

- **Types of fruit:-**
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Lec.8
Meristems and Simple Tissues

Dr. Anaam Fuad

Meristematic tissues – localized regions of cell division

Apical Meristem

Primary or Transitional Meristem ➔ Primary growth

Protoderm ➔ gives rise to epidermis

Ground meristem ➔ gives rise to ground tissue

Procambium ➔ gives rise to vascular tissue

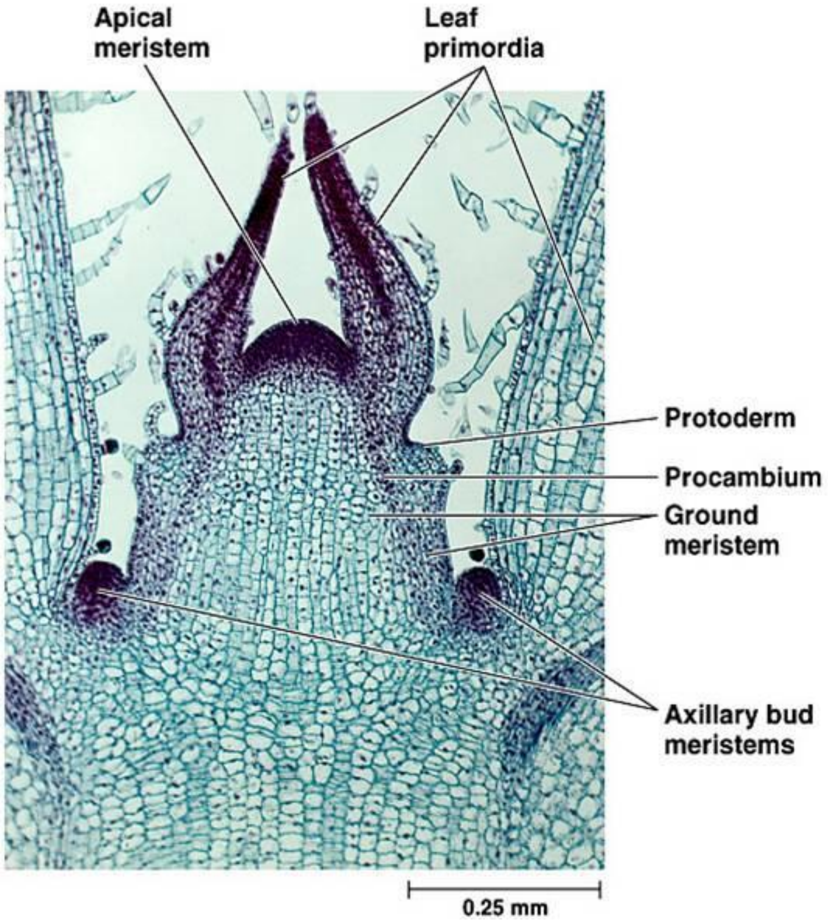
Lateral Meristems

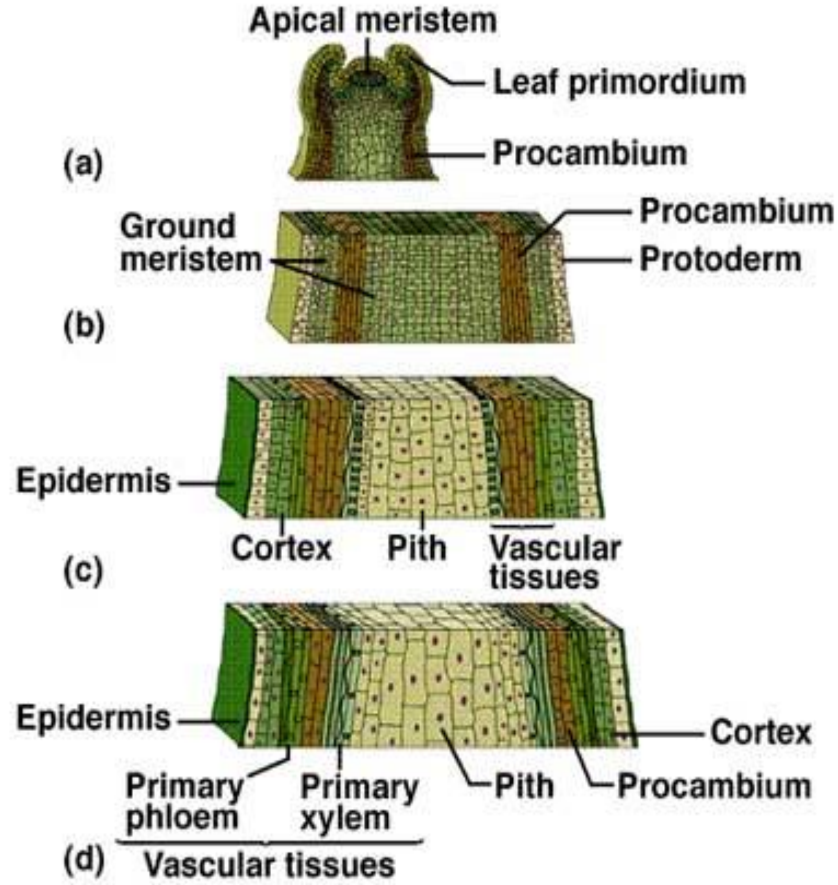
Vascular cambium ➔ vascular tissue

Cork cambium or phellogen ➔ periderm

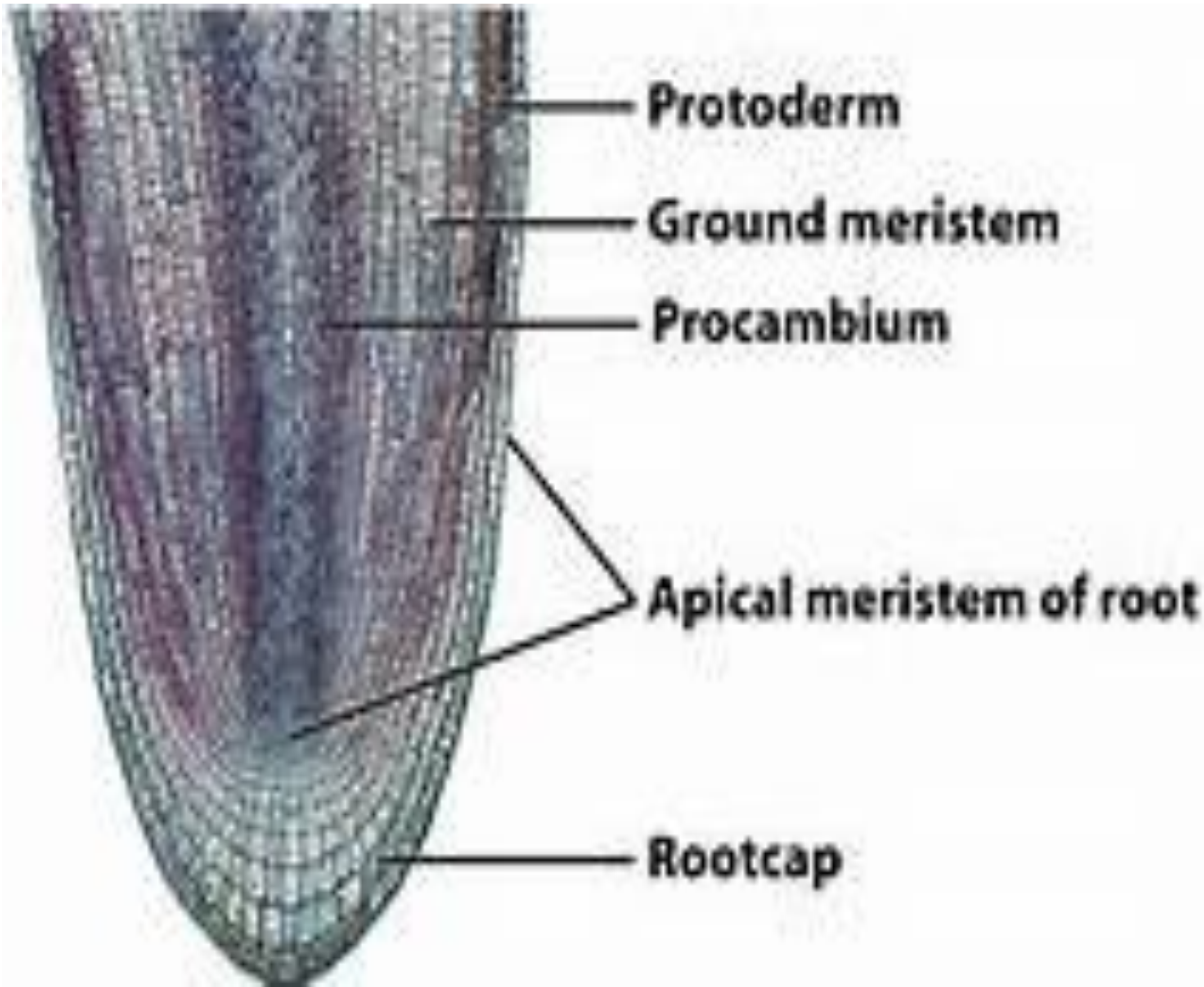
Intercalary Meristems (found in the nodes of grasses)

Shoot Apical Meristem

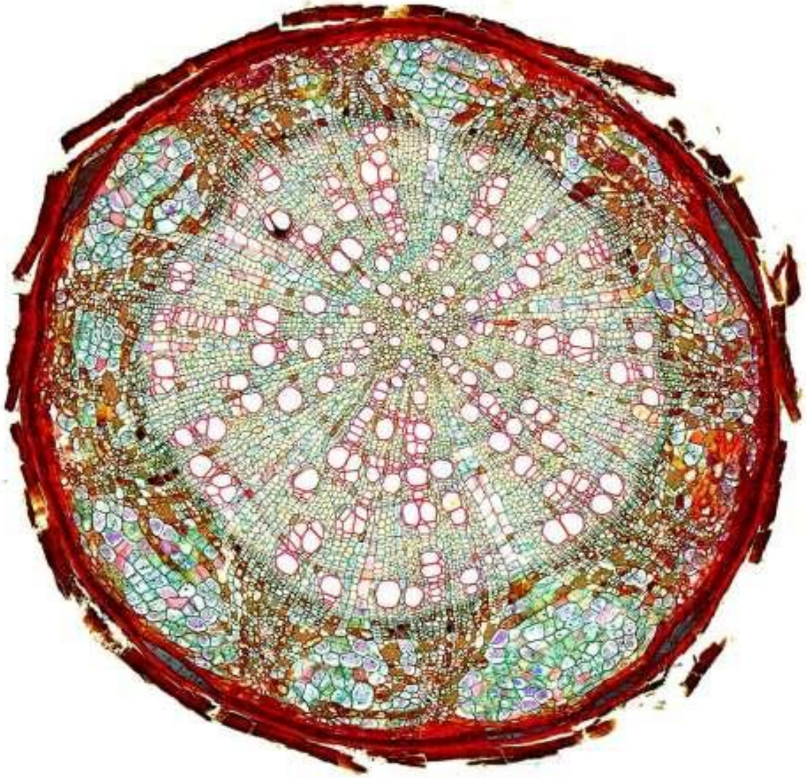




Root Apical Meristem



Lateral Meristems – secondary growth in woody plants



root in cross section

stem in cross section

Simple Tissues – consisting of one cell type

Parenchyma : thin walled & alive at maturity; often multifaceted.
Collenchyma : thick walled & alive at maturity
Sclerenchyma : thick walled and dead at maturity
Aerenchyma: Parenchyma in aquatic plants
Sclerids or stone cells : cells as long as they are wide
Fibers : cells longer than they are wide
Epidermis : alive at maturity
Trichomes : "pubescence" or hairs on epidermis
Root Hairs : tubular extensions of epidermal cells

Parenchyma

*Parenchyma cells are typically thin-walled and often polyhedral or otherwise variously shaped, sometimes lobed.

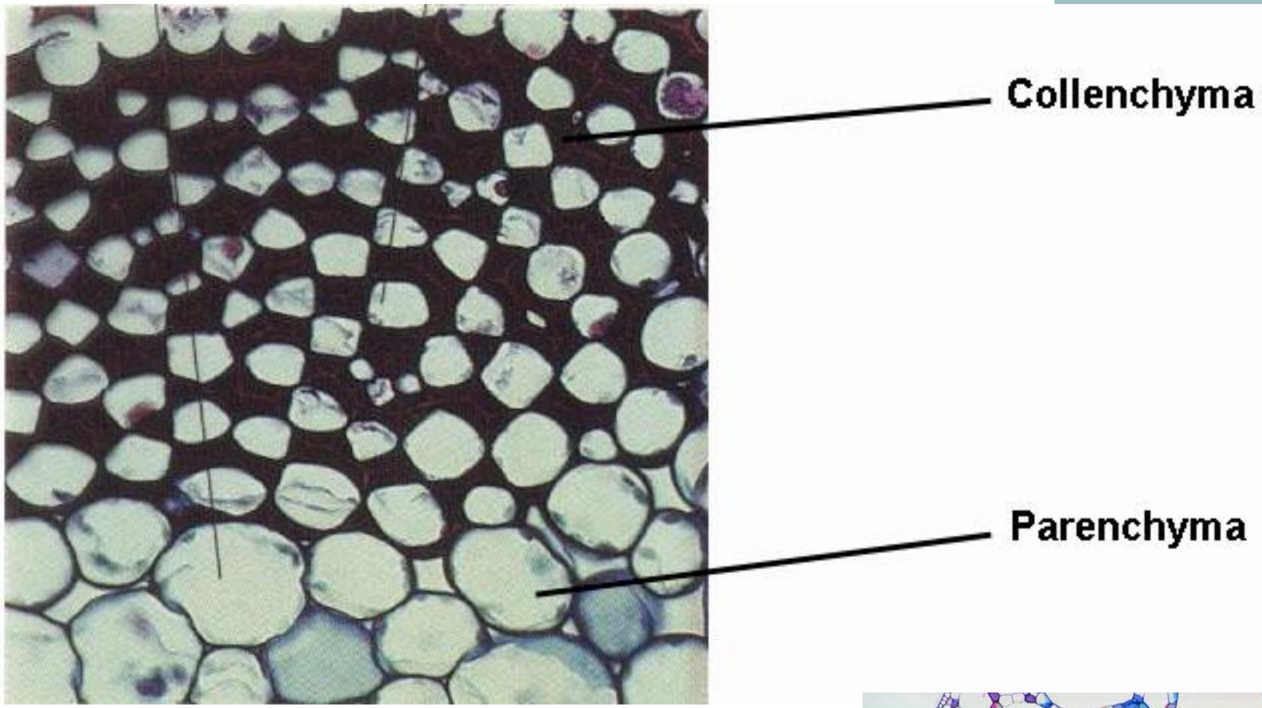
*Cells with living contents that do not fit readily into other categories are often termed parenchyma cells. They are the body and often least specialized cells of the mature plant resemble enlarged meristematic cells.

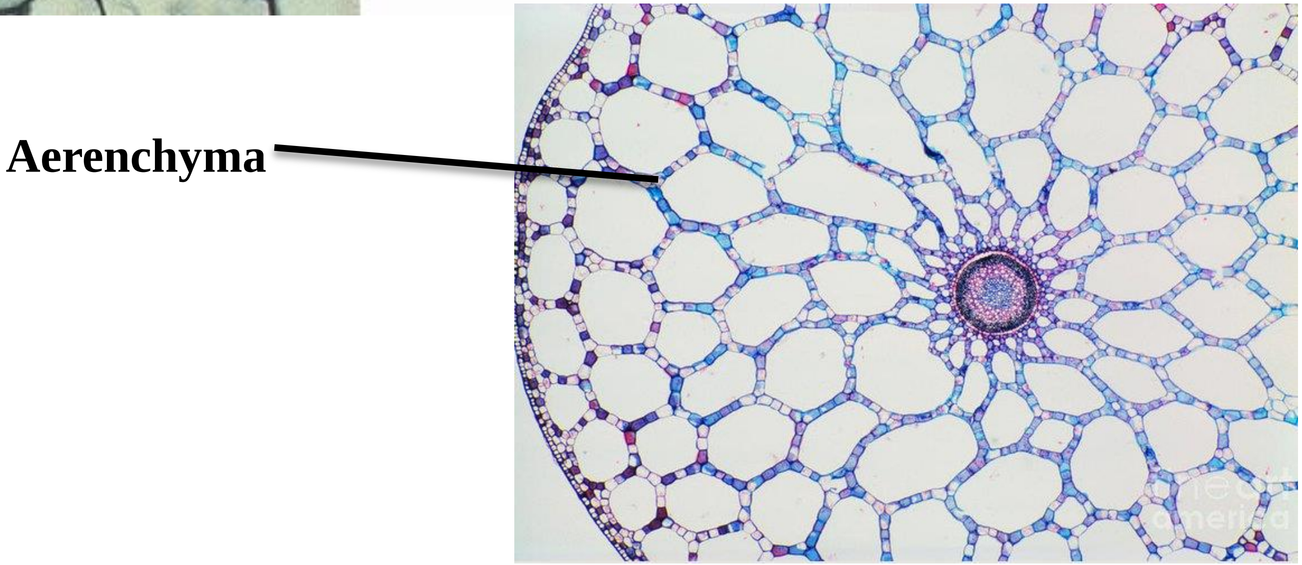
*Parenchyma cells may occur in primary or secondary tissues. Relatively specialized types of parenchyma chlorenchyma, which include certain secretory tissues and contains chloroplasts for photosynthesis.

*Parenchymatous cells may be tightly packed or may be interspersed with intercellular air spaces. Callus tissue is a cellular proliferation that is often produced at the site of a wound by divisions in parenchyma cells that have retained the ability to divide at maturity. (A single isolated callus cell can be used to artificially grow a new plant using tissue culture methods.)

Aerenchyma

Aerenchyma is a specialized parenchymatous tissue that often occurs in aquatic plants (hydrophytes). It possesses a regular, well developed system of large intercellular air spaces that facilitates internal diffusion of gases. In leaves, stems and roots of some water plants (e.g. ***Hydrocharis***), aerenchyma is associated with a system of transverse septa or diaphragms that provide mechanical resistance to compression. These septa are uniseriate layers of parenchyma cells that are thicker-walled than neighbouring aerenchyma cells.


Collenchyma
Parenchyma


Aerenchyma

Collenchyma

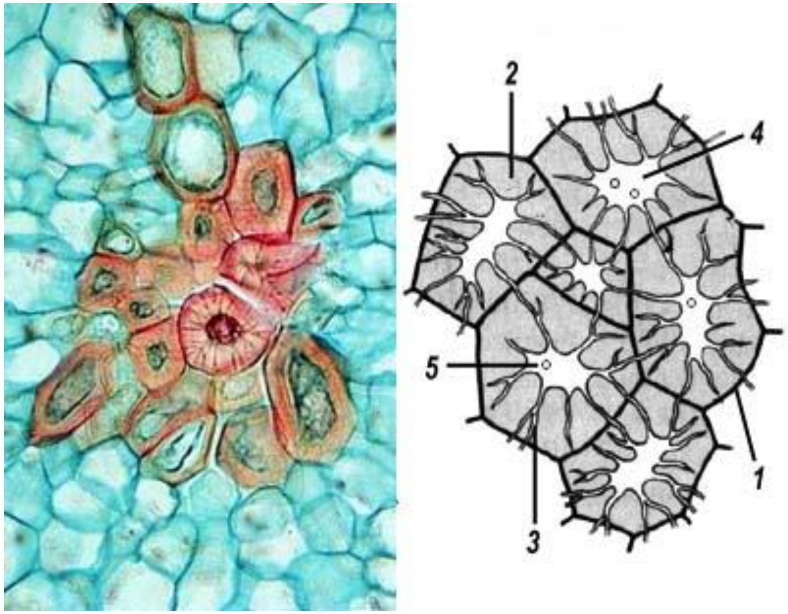
Collenchyma consists of groups of axially elongated, tightly packed cells with unevenly thickened walls. This tissue has a strengthening function and often occurs in the angles of young stems, or in the midribs of leaves, normally in primary ground tissue. Collenchyma cells differ from fibres in that they often retain cells. their contents at maturity and do not generally have lignified walls, though they may ultimately become lignified.

Sclerenchyma

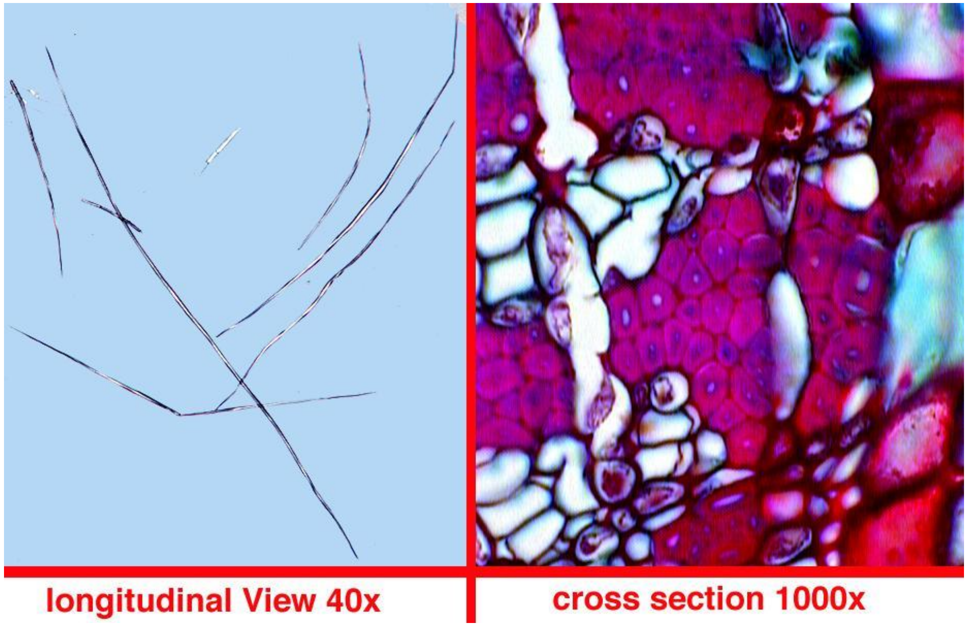
Sclerenchyma, also a supporting or protective tissue, consists of cells with thickened, often lignified, walls, which usually lack contents at maturity. Sclerenchyma cells occur in primary or secondary tissue, either in groups or individually interspersed in other tissue types. They are categorized as either fibres or sclereids, though transitional forms occur. Fibres are long narrow cells that are elongated along the long axis of the organ concerned; they normally occur in groups. ***Cyperus papyrus*** **.** Tissues 11 fibres are extraxylary cortical fibres which can be of economic use, as in **flax** and **hemp.**

Sclereids: are variously shaped and may occur throughout the plant. Brachy sclereids (stone cells) are isolated, approximately isodiametric cells dispersed among parenchyma cells; they develop thick secondary walls as the plant matures. Astrosclereids are highly branched cells with projections that grow intrusively into surrounding intercellular air spaces or along middle lamellae during the growth phase of the organ. Their shapes are to some extent dictated by the nature of the surrounding tissues; for example, they are often star-shaped (astrosclereids) or bone-shaped (osteosclereids).

Sclerenchyma



Sclerids



Fibers

Epiderms :

The epidermis, the outermost (dermal) cell layer, is a complex tissue that covers the entire plant surface. The epidermis is a primary tissue derived from the outermost layer of the apical meristem. It includes many specialized cell types, such as root hairs ,stomata, trichomes and secretory tissues such as nectaries.

The aerial plant surface is covered with a non-cellular cuticle and sometimes with epicuticular waxes . Undifferentiated epidermal cells are termed pavement cells.

Trichomes : are epidermal outgrowths that occur on all parts of the plant surface. They vary widely in both form and function, and include unicellular or multicellular, branched or unbranched forms, and also scales, glandular (secretory) hairs, hooked hairs and stinging hairs. (Flower bud of a ***Capsicum pubescens*** plant, with many trichomes)

Papillae: are generally smaller than trichomes and unicellular, though the distinction is not always clear. In cases where there are several small outgrowths on each epidermal cell, these outgrowths are termed papillae, but where there is only one unicellular outgrowth per cell, the distinction is dependent on size.

Glandular trichomes usually possess a unicellular or multicellular stalk and a secretory head with one to several cells. Secreted substances such as volatile oils collect between the secretory cells and a raised cuticle, which later breaks to release them.

Capsicum pubescens

There are many different types of glandular hair, and they secrete a variety of substances, including essential oils and salt; some carnivorous plants' digestive juices contain proteolytic enzymes . Leaf glandular hairs of ***Cannabis sativa*** secrete a resinous substance containing the mild hallucinogen tetrahydrocannabinol.

Glandular hairs of ***Drosera*** secrete both sticky mucilage and proteolytic enzymes. The stinging hairs of ***Urtica dioica*** (stinging nettle) are rigid, hollow structures that contain a poisonous substance . The spherical tip of the hair is readily broken off in contact with an outside body, and the he skin and release the fluid.

Other examples of specialized hair types include water-absorptive leaf scales in many Bromeliaceae, and salt secreting glands of species of ***Avicennia*.**

Drosera

Urtica dioica

Avicennia

Stomata are specialized pores in the epidermis through which gaseous exchange (water release and carbon dioxide uptake) takes place. They occur on most plant surfaces above ground, especially on green photosynthetic stems and leaves, but also on floral parts. Each stoma consists of two guard cells surrounding a central pore.

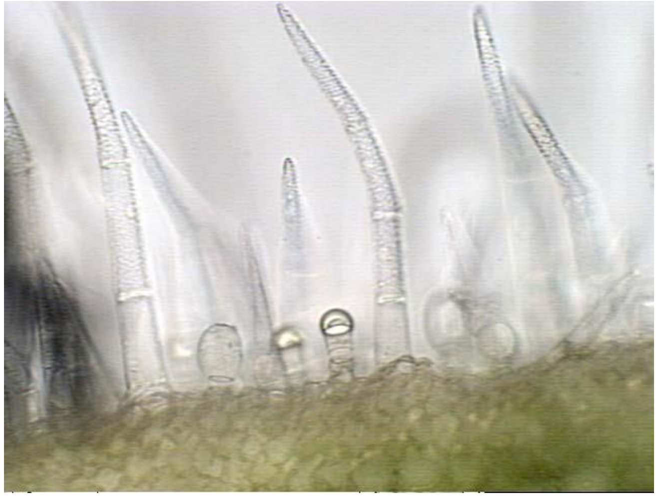
Cuticular ridges extend over or under the pore from the outer or inner edges of the adjacent guard cell walls.

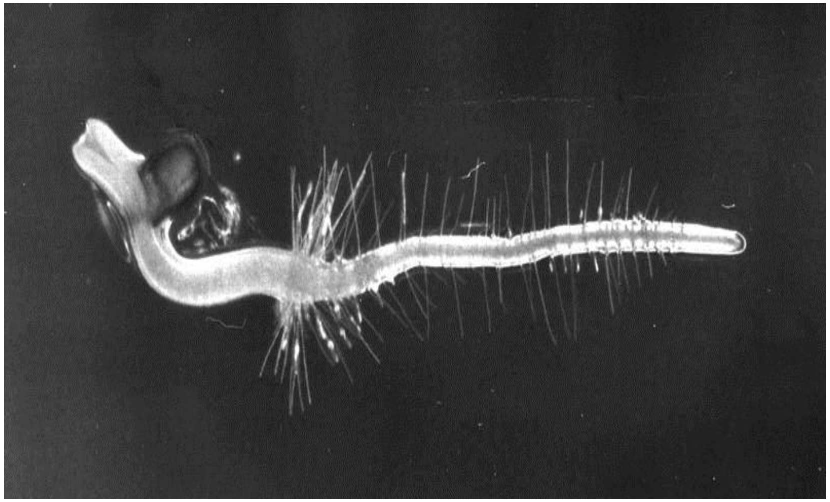
Guard cells are either kidney-shaped (in most plants) or dumbbell-shaped (in Cyperaceae). Stomata may be sunken or raised, and are often associated with a substomatal cavity in the mesophyll, which is caused by differential expansion between the guard cell mother cell and the developing underlying mesophyll cells.

The epidermal cells immediately adjacent to the guard cells are termed subsidiary cells if they differ morphologically from surrounding epidermal cells.

Classifications of stomatal types are based either on the arrangement of mature subsidiary cells, or on their patterns of development. Types of mature stomata include anomocytic, anisocytic, diacytic and paracytic. Anomocytic stomata lack subsidiary cells entirely; anisocytic stomata possess three unequal subsidiary cells; diacytic stomata possess one or more pairs of subsidiary cells with their common walls at right angles to the guard cells; and paracytic stomata possess one.

Epidermis – stoma, trichomes, & root hairs





Secretory Structures

Nectar(flowers) from nectaries oils (peanuts, oranges, citrus) from accumulation of glands and elaioplasts.

Resins (conifers) from resin canals

Lacticifers (e.g. latex-milkweed, rubber plants, opium poppy).

Hydathodes (openings for secretion of water).

Digestive glands of carnivorous plants (enzymes).

Salt glands that shed salt (especial in plants adapted to environments laden with salt).

Lec. 9

Water Absorption mechanisms, Movements and Factors Affecting in Plants

Dr. Anaam F. Hussain

Water Potential

organisms are comprised of at least 70% or more water. Some plants, like a head of lettuce *Lactuca sativa*, are made up of nearly 95% water. When organisms go dormant, they loose most of their water. For example, seeds and buds are typically less than 10% water, as are desiccated rotifers, nematodes and yeast cells. Earth is the water planet (that's why astronomers get so excited about finding water in space). Water is the limiting resource for crop productivity in most agricultural systems.

How Water Enters The Root

There are two ways for water to enter into the plant roots

Active Transport and Passive Transport.

Active Transport:

Water is absorbed due to activities going on in roots. Absorption of water occurs with the help of energy in the form of ATP. Absorption takes place against concentration gradient - even when the concentration of cell sap is lower than that of soil water.

Passive Transport:

Passive absorption is by osmosis. Passive absorption takes place along the concentration gradient - when the concentration of cell sap is higher than that of soil water. Water is absorbed.

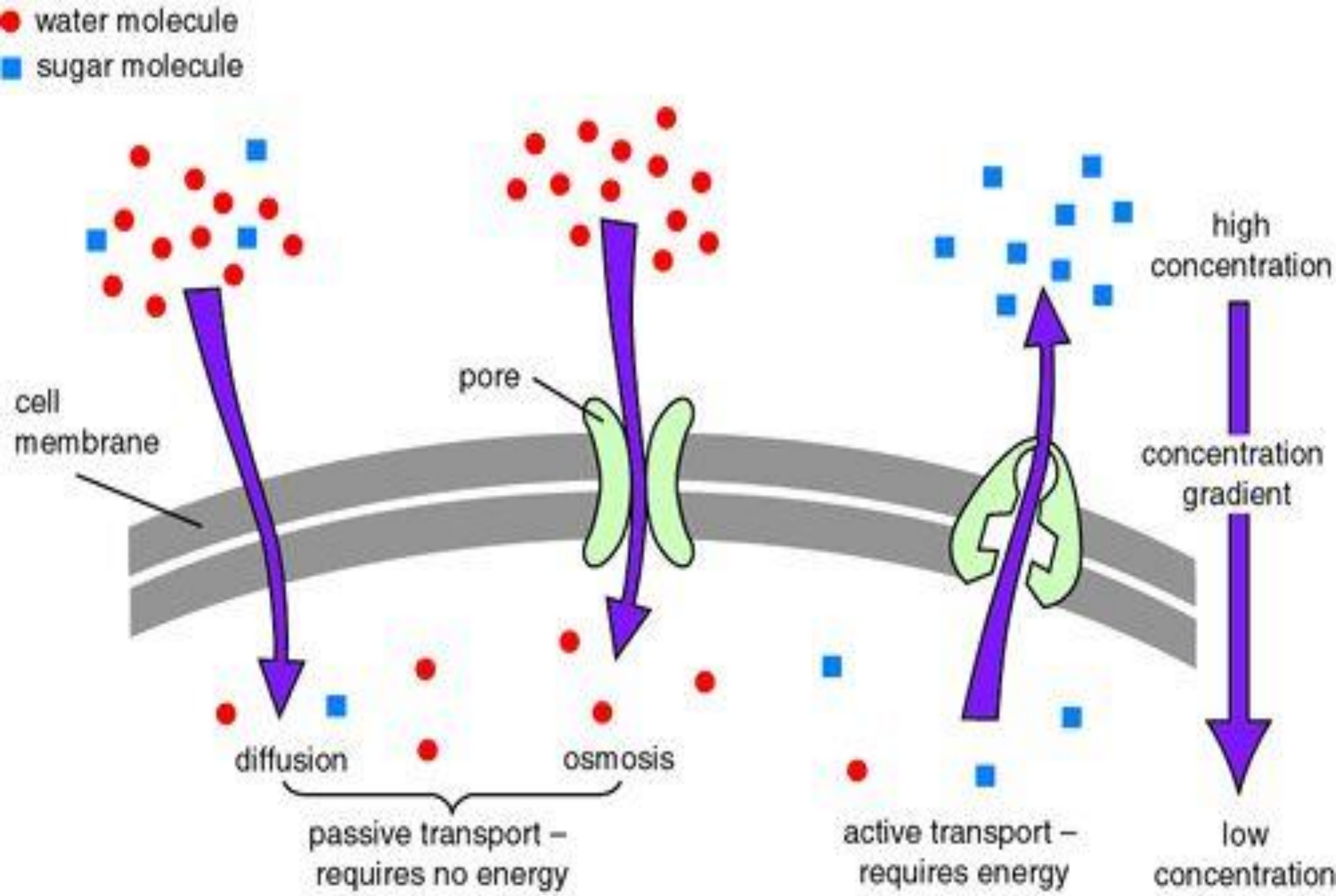
when transpiration rate is high or soil is dry. Due to high transpiration rate, water deficit is created in transpiring cells. Rapid transpiration removes water and reduces turgor pressure in living cells of root. The suction force thus developed is transmitted to root xylem. It pulls water from surrounding root cells to make up water deficit.

Diffusion:

Diffusion is the movement of molecules from a region of high concentration to a region of low concentration by means of random molecular motion. Diffusion requires kinetic energy from the environment but does not require cellular energy. Hence diffusion is a form of passive transport.

Osmosis: is diffusion of water across a semi permeable membrane. ,like diffusion in general does not require any cellular energy but either side of the just the kinetic energy related to the heat on membrane. Hence its also a passive transport .

Aquaporins: Are transport proteins in the cell membrane that allow the passage of water.


water molecule
sugar molecule
cell membrane
pore
diffusion
osmosis
passive transport – requires no energy
active transport – requires energy
high concentration
concentration gradient
low concentration

Water Movement in Roots

Most of the water absorbed by plants comes in through **root hairs** enormous surface area, Almost always Collectively provide of soil. turgid because their water potential is greater than that

An expenditure of energy is required for ions to accumulate in root cells

Once in the roots, the ions are transported via the xylem throughout the plant.

Surface area for water and mineral absorption is further increased by mycorrhizal fungi (Particularly helpful in phosphorus uptake)

Three transport routes exist through cells: **Apoplast route** : Movement through the cell walls and the space between cells

Symplast route: A cytoplasm continuum between cells connected by plasmodesmata

Transmembrane route: Membrane transport between cells and across the membranes of vacuoles within cells Permits the greatest control.

Water Movement (Root to Stomata)

*Water first enters the roots and then moves to the xylem, the innermost vascular tissue. Water rises through the xylem because of a combination of factors.

*There are tow types of movement on the basis of distance covered.

Short-distance movement:

Movement of water at the cellular level plays a major role in bulk water transport. Water can diffuse through cell membranes. (Herbaceous)

Long-distance movement:

Water movement in most of the vascular plants from roots to leaves. (Sometimes more than 100m)

Mechanisms of Water Movement Through Xylem

There are three main forces for water movement through xylem

1.Transpiration Pull:

It is the pulling force responsible for lifting the water column. As water is lost in form of water vapor to atmosphere from the mesophyll cells by transpiration, a negative hydrostatic pressure is created in the mesophyll cells which in turn draw water from veins of the leaves

2.Cohesion Adhesion Forces (Cohesive Tension Theory) :

The water molecules in the chain are held together by hydrogen bonds which exist between neighboring water molecules. (cohesion) The chain of molecules is prevented from being pulled down because each water molecule in the chain is attracted to the walls of the xylem by hydropyllic attraction between water and the cellulose in the cell walls. (Adhesion) Hence the water column which is held together by cohesion and prevented from lowering by adhesion is pulled up by the tension generated from above by transpiration.

Note: It is valuable both for herbaceous grasses as well as vascular plant.

3.Root Pressure

is caused by active transport of mineral nutrient ions into the root xylem. Without transpiration to carry the ions up the stem, they accumulate in the root xylem and lower the water potential. Water then diffuses from the soil into the root xylem due to osmosis. Root pressure is caused by this accumulation of water in the xylem pushing on the rigid cells. Root pressure provides a force, which pushes water up the stem, at the top of the tallest trees. but it is not enough to account for the movement of water to leaves

Factors Affecting The Water Absorption in Plants

1. Physical Factors:

a) Soil Factors

Soil water contents

Soil Temperature

Soil Aeration

Flooding

Texture and Structure

Speed of Water Movement

Effective Root Zone

b) Atmospheric Factors:

Temperature

Relative Humidity

VDP

Wind Speed

Stress (chemical)

2. Biological Factors

Plant Class (Herbaceous or Vascular)

Root Length

Lec 10
Photosynthesis, Respiration and Transpiration

Dr. Anaam F. Hussain

Photosynthesis is an anabolic, endergonic, carbon dioxide (CO_2) (H_2O) requiring process that uses light energy (photons) and water to produce organic macromolecules (glucose) .

Some landmark experiments about photosynthesis were given in the box below:

•**Joseph Priestley (1772)** and later **Jan Ingenhousz (1779)** showed that plants have the ability to take up CO2 from the atmosphere and release O2.**Ingenhousz** also discovered that release of O2 by plants was possible only in presence of sunlight and by the green parts of the plant.

•**Robert Hill (1939)** demonstrated that isolated chloroplasts evolve O2 when they are illuminated in the presence of electron acceptor which gets reduced. This reaction called Hill reaction accounts for the use of water as a source of electrons and protons for CO2 fixation and release of O2 as product.

Photosynthesis is represented by the following overall chemical equation:

$$6CO_2 + 12H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

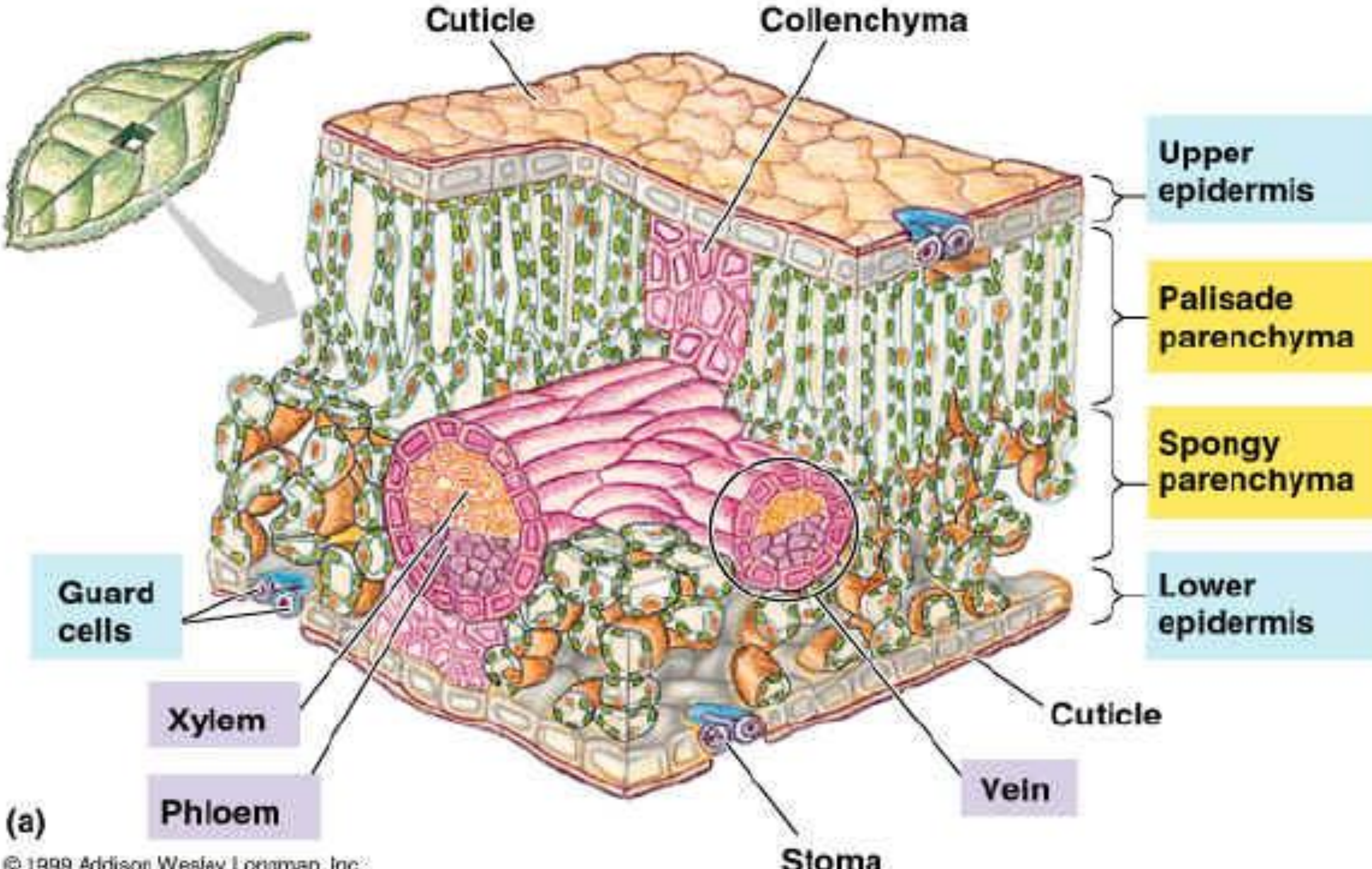
*In photosynthesis, CO_2 is fixed (or reduced) to carbohydrates (glucose $C_6H_{12}O_6$).

*Water is split in the presence of light (called photolysis of water) to release O_2. Note that O_2 released comes from the water molecule and not from CO_2.

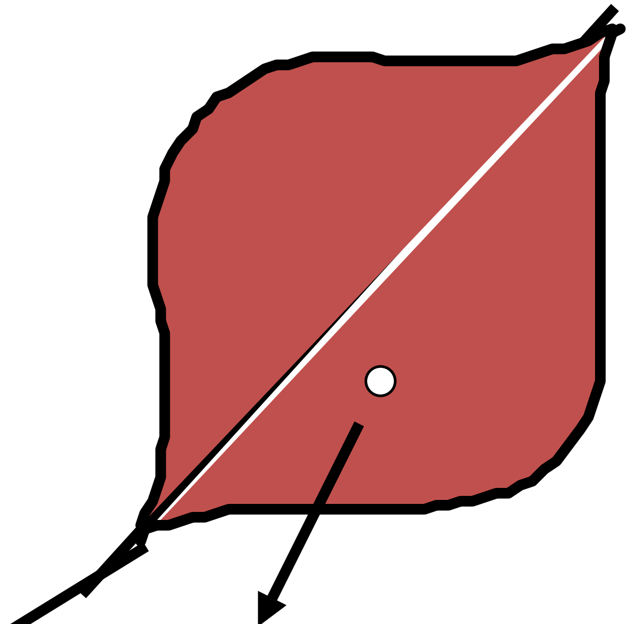
*__Where does photosynthesis take place?__

Photosynthesis occurs in green parts of the plant, mostly the leaves, sometimes the green stems and floral buds. The leaves contain specialized cells called mesophyll cells which contain the chloroplast– the pigment containing organelle. These are the actual sites for photosynthesis.

Plant leaves have many types of cells!



Plants



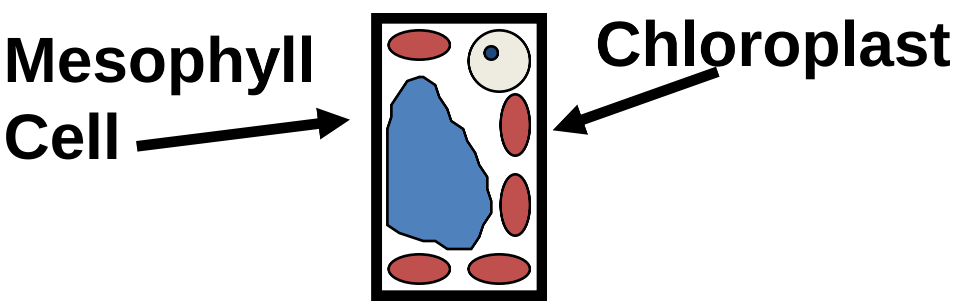
Autotrophs: self-producers.

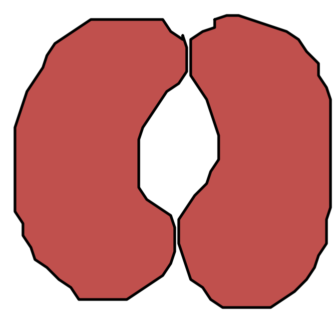
Location:

Leaves

stoma

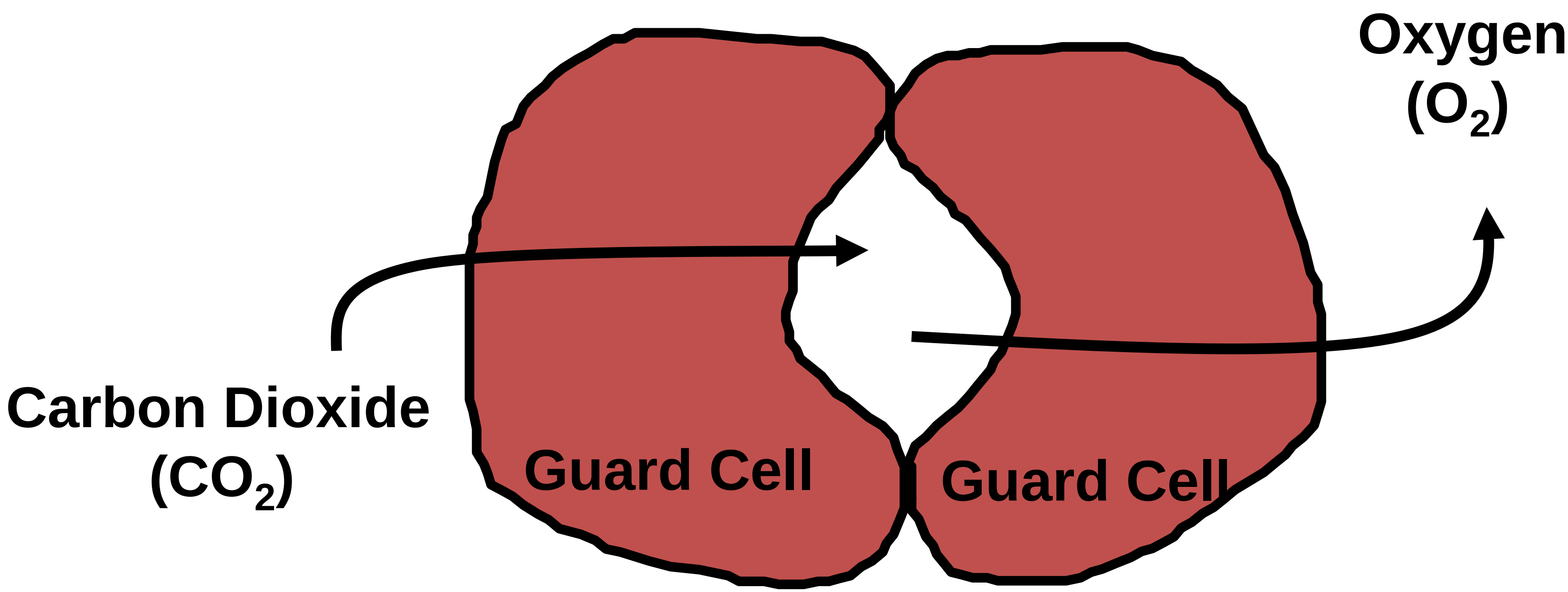
mesophyll cells



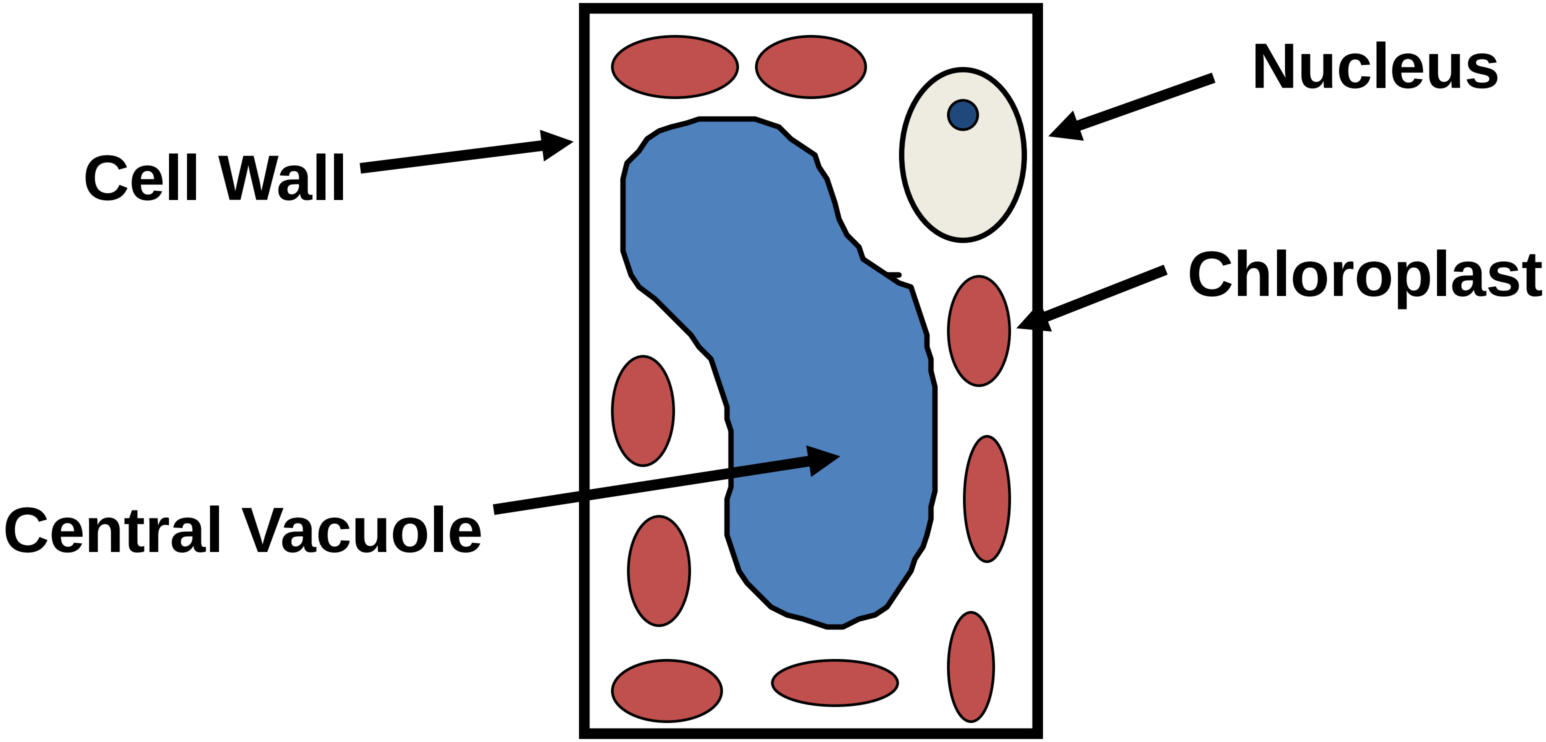


Stomata (stoma)

Pores in a plant's cuticle through which **water** and **gases** are exchanged between the plant and the atmosphere.

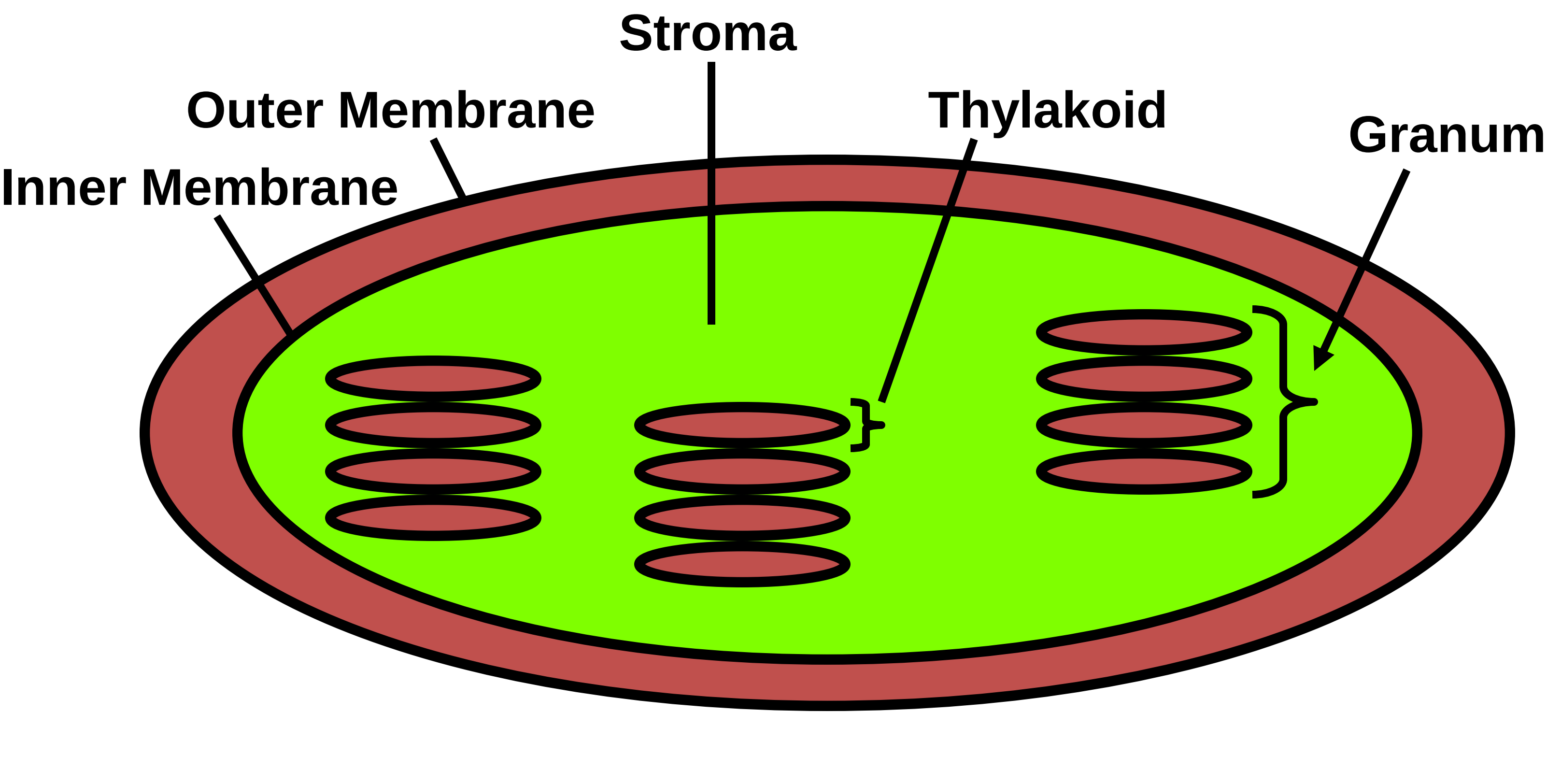


Mesophyll Cell



Chloroplast

Organelle where **photosynthesis** takes place



Chlorophyll Molecules

$C_{55}H_{72}O_5N_4Mg$

Located in the **thylakoid membranes**.

Chlorophyll have **Mg^+** in the center.

Chlorophyll pigments harvest energy (photons) by **absorbing** certain **wavelengths** (**blue-420 nm** and **red 660nm** are most important).

Plants are **green** because the **green wavelength** is **reflected**, **not absorbed**.

Fall Colors

In addition to the chlorophyll pigments, there are other **pigments** present.

During the fall, the **green chlorophyll** pigments are **greatly reduced** revealing the other **pigments**.

Carotenoids ($C_{40}H_{56}$) are pigments that are either **orange or red**

Xanthophylls ($C_{40}H_{56}O_2$) are pigments that are **yellow**.

Redox Reaction

The transfer of one or more electrons from one reactant to another

Two types:

Oxidation

Reduction

Oxidation Reaction

The **loss** of **electrons** from a **substance** or the **gain** of **oxygen**.

Oxidation

$$6CO_2 + 6H_2O \rightarrow \underbrace{C_6H_{12}O_6}_{\text{glucose}} + 6O_2$$

Reduction Reaction

The **gain** of **electrons** to a **substance** or the **loss** of **oxygen**.

Reduction

$$6CO_2 + 6H_2O \rightarrow \underbrace{C_6H_{12}O_6}_{\text{glucose}} + 6O_2$$

Breakdown of Photosynthesis

Two main parts (reactions)

1. Light Reaction or Light Dependent Reaction

Produces **energy** from **solar power (photons)** in the form of **ATP** and **NADPH**.

2. Calvin Cycle or Light Independent Reaction or Carbon Fixation or C_3 Fixation

Uses **energy (ATP and NADPH)** from **light** to make **sugar (glucose).**

1. Light Reaction (Electron Flow)

Occurs in the **Thylakoid membranes**

During the **light reaction**, there are **two possible** routes for **electron flow**.

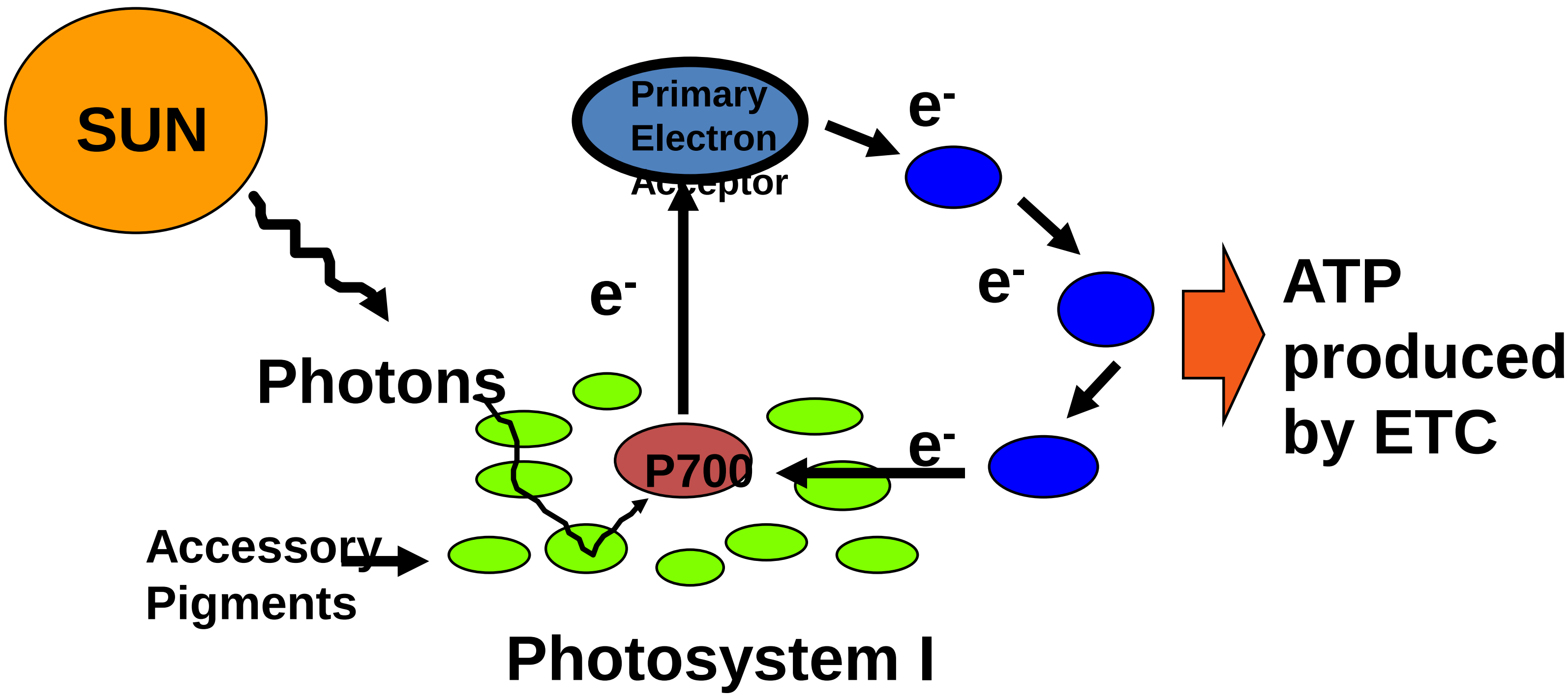
A. Cyclic Electron Flow

B. Noncyclic Electron Flow

A. Cyclic Electron Flow

Occurs in the **thylakoid membrane,** uses **Photosystem I only** P700 reaction center- chlorophyll a, uses **Electron Transport Chain (ETC)** Generates ATP only

ATP P → ADP +

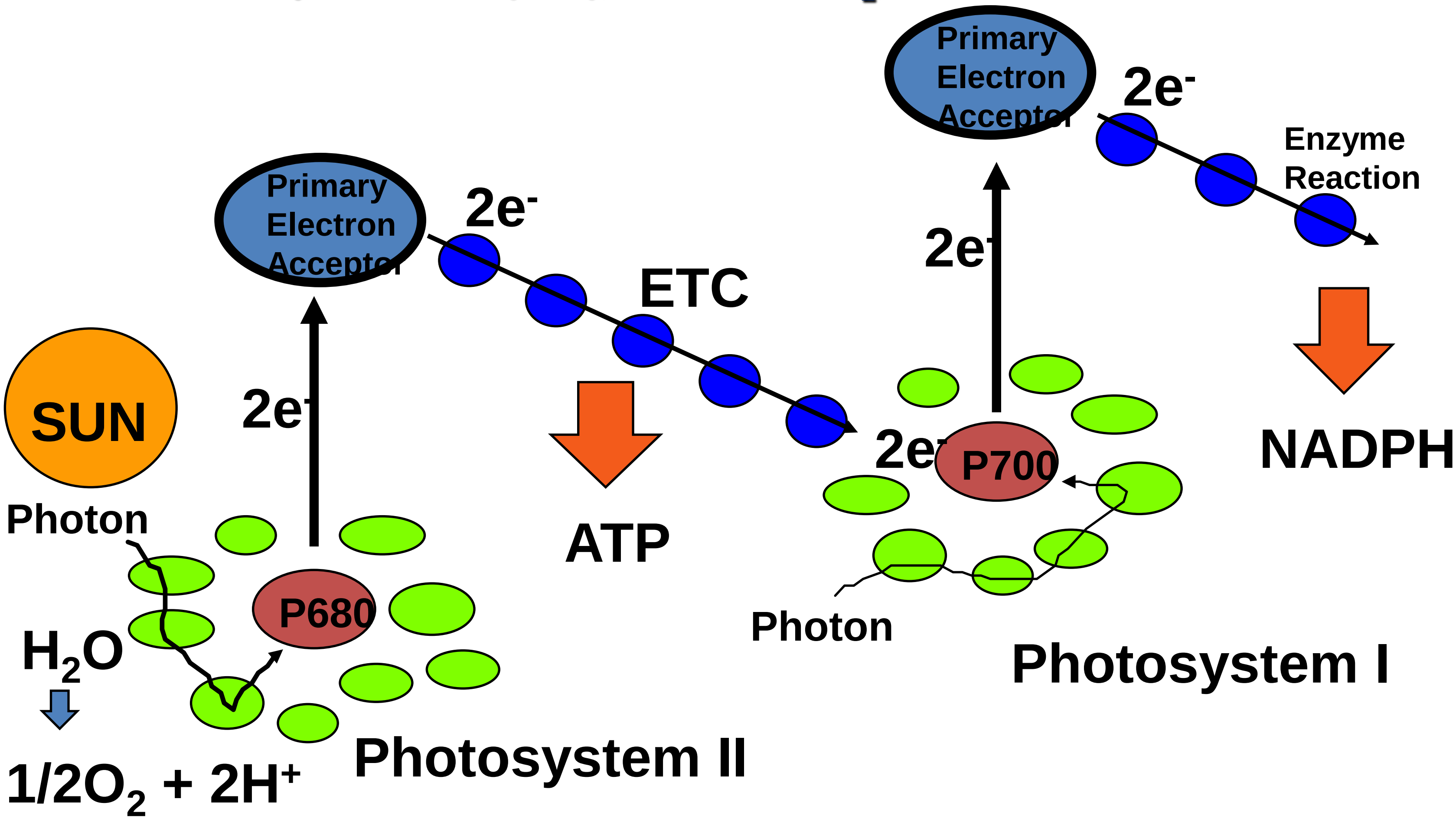


B. Noncyclic Electron Flow

Occurs in the **thylakoid membrane** , Uses **PS II** and **PS I**

Uses P680 center (PSII) - chlorophyll a, P700 center (PS I) - chlorophyll a

Electron Transport Chain (ETC), Generates O_2, ATP and NADPH



B. Noncyclic Electron Flow

ATP $\rightarrow$ (Reduced) P ADP +

NADPH $\rightarrow$ (Reduced) $NADP^+$ + H

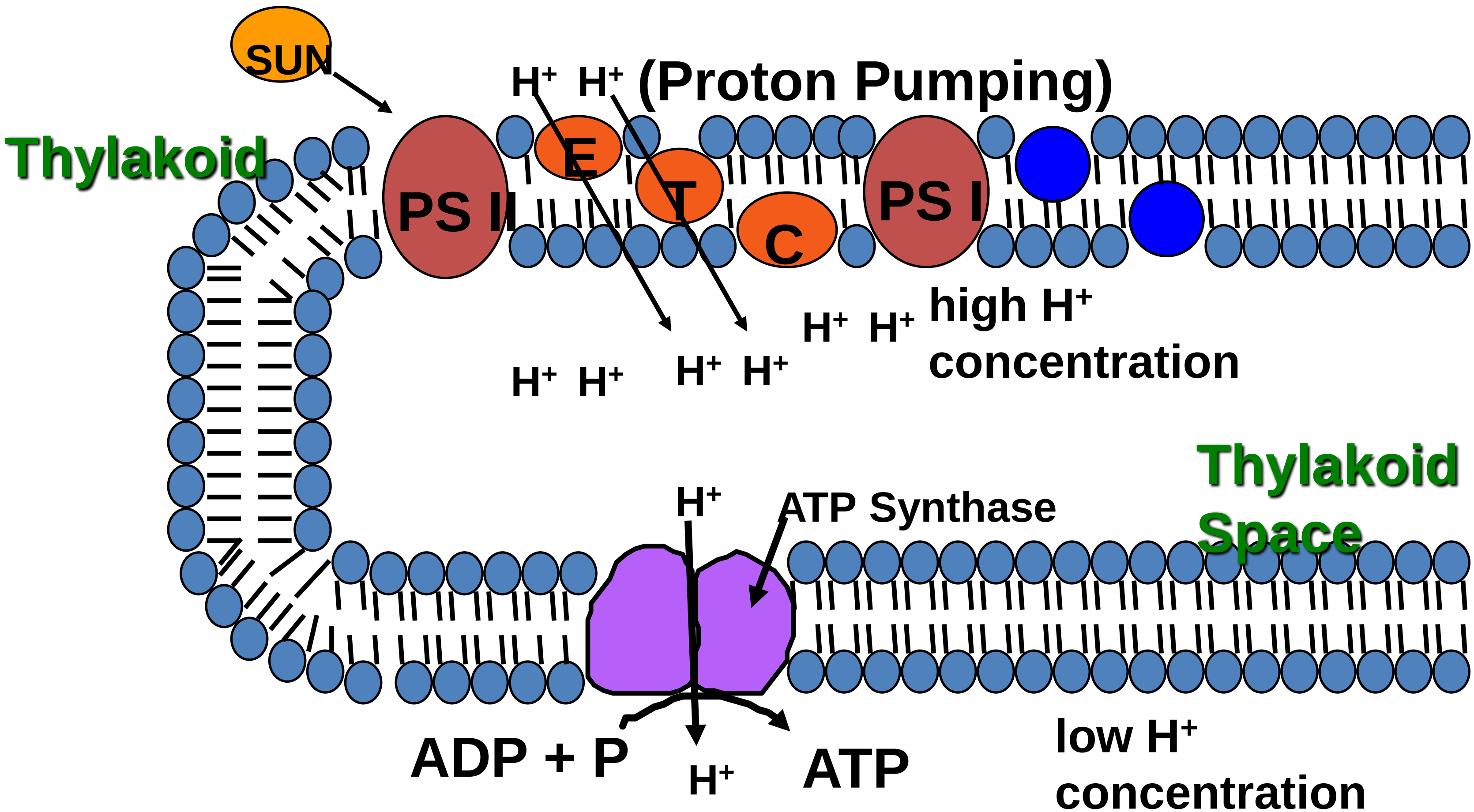
Oxygen comes from the splitting of H_2O, not CO_2

H_2O $\rightarrow$ $1/2\ O_2 + 2H^+$

(Oxidized)

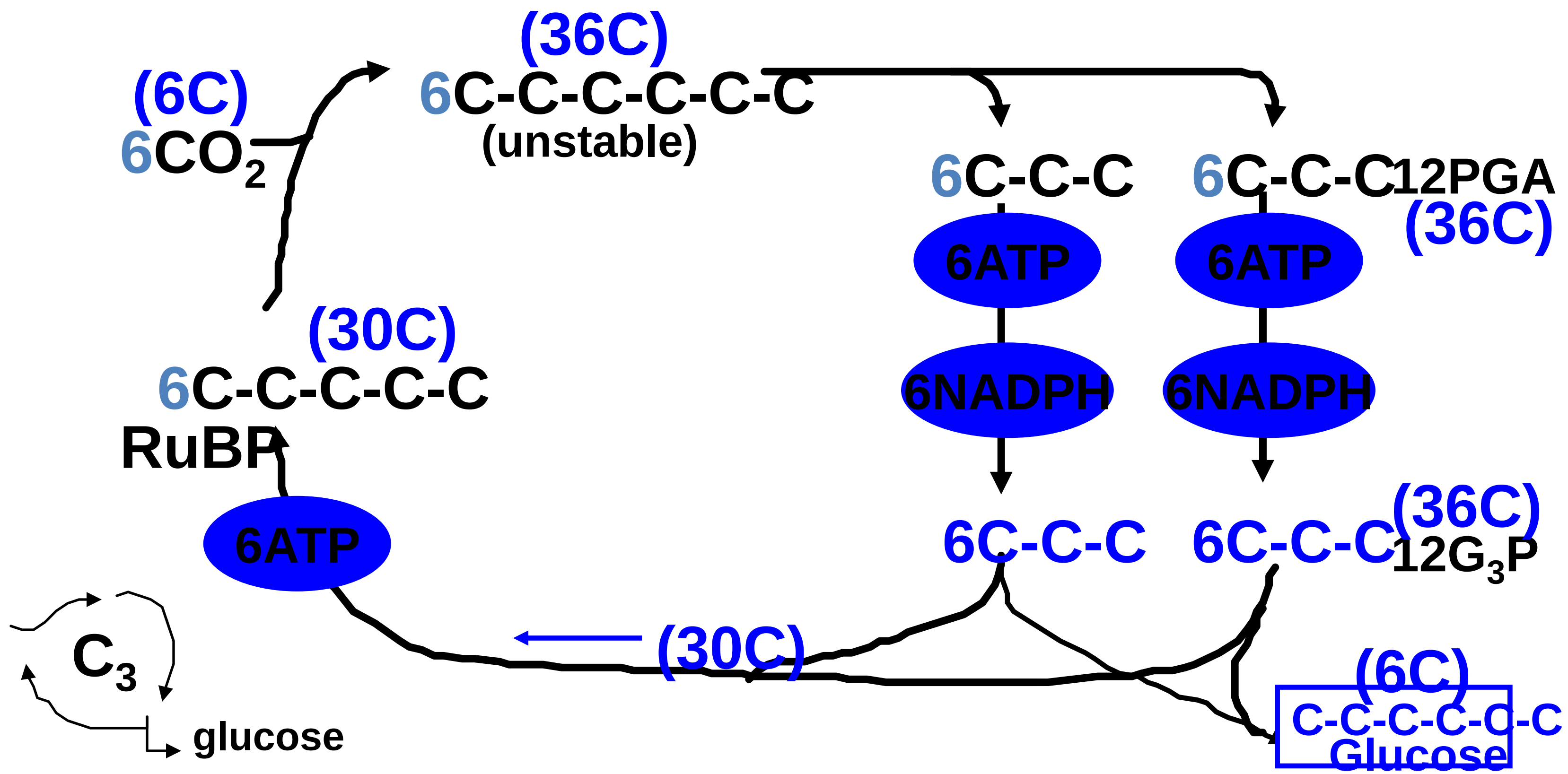
Chemiosmosis

Powers ATP synthesis, Located in the **thylakoid membranes**. Uses **ETC** and **ATP synthase (enzyme)** to **make ATP**. **Photophosphorylation:** addition of **phosphate** to **ADP** to make **ATP**.



2. Calvin Cycle or Light Independent Reaction or Carbon Fixation or C_3 Fixation

C_3 plants (80% of plants on earth), occurs in the **stroma,** **u**ses **ATP** and **NADPH** from light rxn, uses **CO_2**. To produce **glucose**: it takes **6 turns** and **uses 18 ATP and 12 NADPH**.



Photorespiration

Occurs on **hot, dry, bright days, Stomates close,** Fixation of **O_2 instead of CO_2**, Produces **2-C, molecules** instead of **3-C sugar molecules,** Produces **no sugar molecules or no ATP.**

Because of photorespiration: **Plants** have **special adaptations** to limit the effect of **photorespiration**.

1.C4 plants

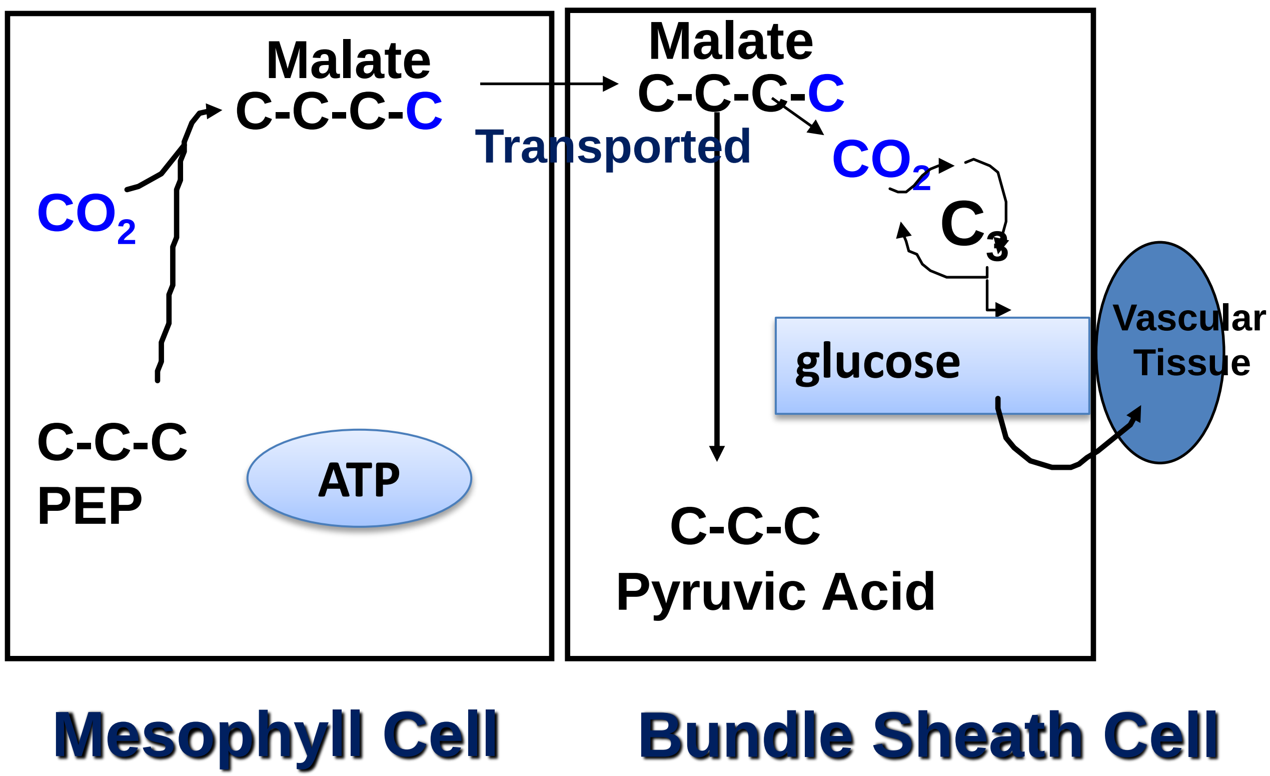
2.CAM plants

C4 Plants

Hot, moist environments. 15% of plants (grasses, corn, sugarcane). Divides photosynthesis spatially.

Light rxn - mesophyll cells.

Calvin cycle - bundle sheath cells.

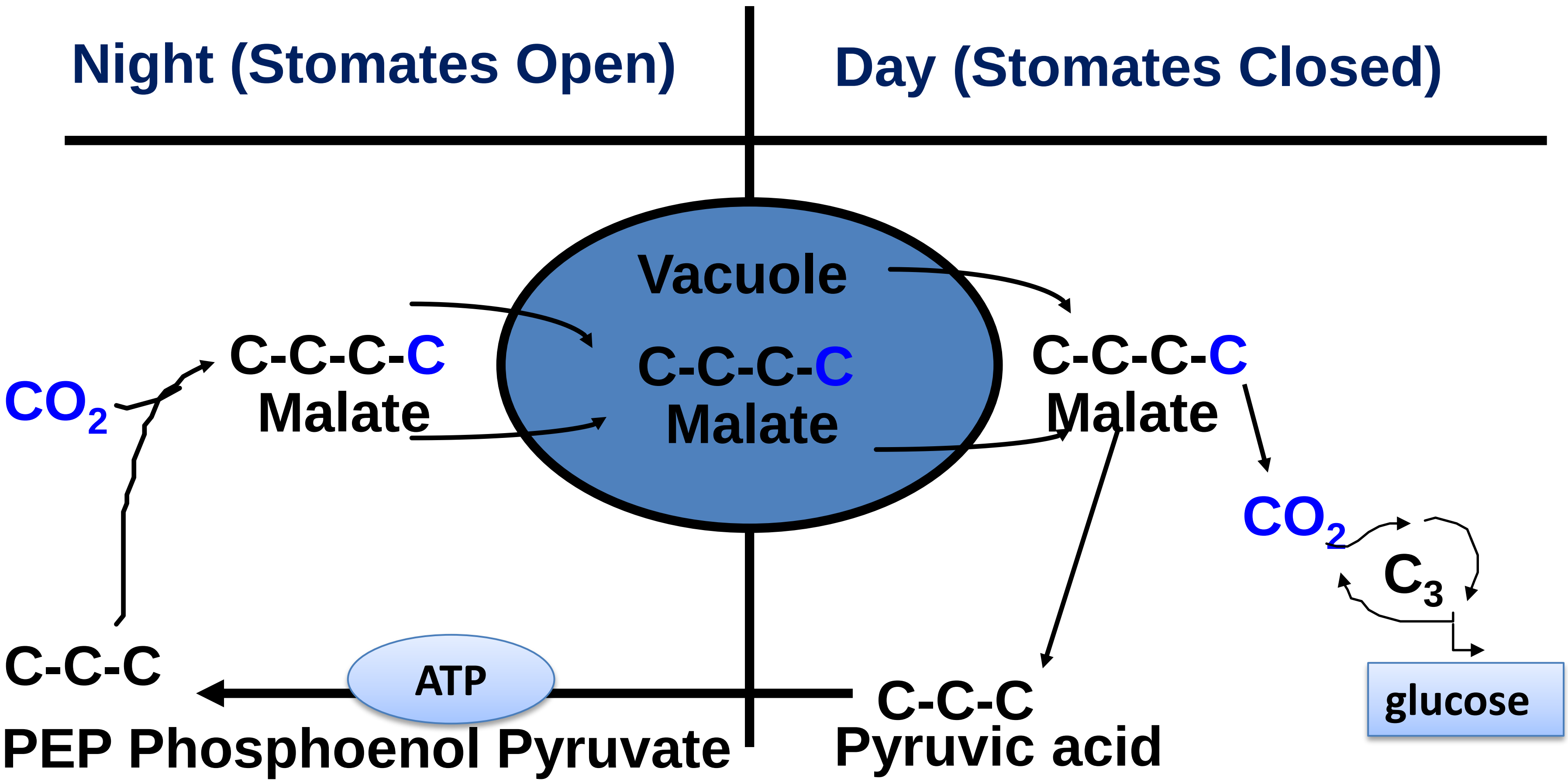


CAM Plants

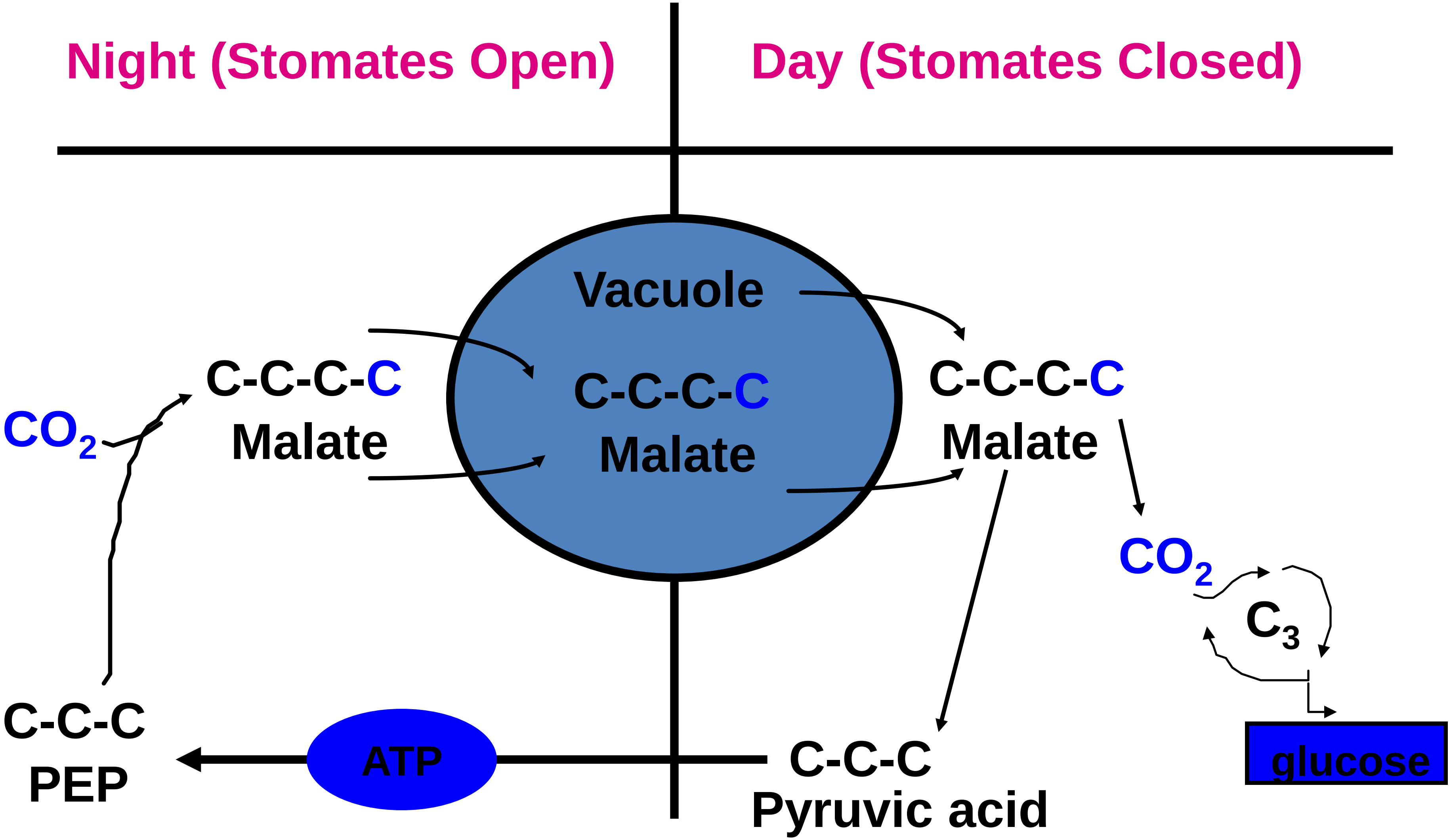
Hot, dry environments, 5% of plants (cactus and ice plants), Stomata closed during day and open during the night.

Light rxn - occurs during the **day**.

Calvin Cycle - occurs when CO_2 is present.



CAM Plants



Night (Stomates Open)
Day (Stomates Closed)
Vacuole
C-C-C-C
Malate
C-C-C-C
Malate
C-C-C-C
Malate
CO_2
C-C-C
PEP
ATP
C-C-C
Pyruvic acid
CO_2
C_3
glucose

•Respiration:

Carbohydrates made during photosynthesis are of value to a plant when converted to energy. This energy is used for cell growth and building new tissues. The chemical process by which sugars and starches are converted to energy is called *oxidation*. It is similar to the burning of wood or coal to produce heat. Controlled oxidation in a living cell is called *respiration* and is shown by this equation:

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + \text{Energy}$$

This equation is essentially the opposite of photosynthesis. Photosynthesis is a building process, while respiration is abreaking-down process, unlike photosynthesis, respiration does not depend on light, so it occurs at night as well as during the day. Respiration occurs in all life forms and in all cells.

Transpiration:

When a leaf's guard cells shrink, the stomata open and water vapor is lost. This process is called *transpiration*. Evaporating water causes a negative water pressure in the plant and more water is pulled up from the roots. Dissolved nutrients are pulled in with the water from the roots. The rate of transpiration is directly related to whether stomata are open or closed. Stomata account for only 1 percent of a leaf's surface but 90 percent of the water transpired.

Transpiration is a necessary process and uses about 90 percent of the water that enters a plant's roots. The other 10 percent is used in chemical reactions and in plant tissues. Water moving via the transpiration stream is responsible for several things:
Transporting minerals from the soil throughout the plant
Cooling the plant through evaporation
Moving sugars and plant chemicals
Maintaining cell firmness

The amount and rate of water loss depends on factors such as temperature, humidity and wind or air movement. Transpiration is greatest in hot, dry (low relative humidity), windy weather.

Differences between Photosynthesis and respiration.

Photosynthesis	**Respiration**
• Produces food.	•Uses food.
• Stores energy.	•Releases energy.
• Uses water.	•Produces water.
• Uses carbon dioxide. Dioxide.	•Produces carbon
• Releases oxygen.	• Uses oxygen.
• Occurs in sunlight.	• Occurs in dark as well as in light