جامعة بغداد
كلية العلوم
قسم التقنيات الاحيائية

علم الاحياء ٢

المرحلة الاولى

الفصل الثاني

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Lec-1 /OBJECTIVES

After reading this lecture students will be able-

- **To study about some biology terms, biology discipline, and botany discipline.**
- **To have preliminary idea about the difference between Prokaryotic and Eukaryotic cells.**
- **Role and major composition and functions of cell wall & cell membrane.**
- **To understand about the differences between cell membrane & cell wall.**

Introduction to Biology

"Definition Biology": Bio mean life and Logy mean study. The study of living organisms is called Biology or The science of life and living organisms is called Biology.

➢ Biology is divided into several specific fields that cover their **morphology**, **physiology**, **anatomy**, **Genetics**, **behavior**, **origin** and **distribution**.

➢The main functions of Biology: Study **diversity**, Study **diseases**, **develop techniques**, **agriculture improvement**

- An organism is a living entity containing of one cell e.g. bacteria
- An organism is a living entity containing of several cells e.g. animals, plants and fungi.

➢**Characteristics of life include:**

1. Living organisms are responsiveness to the environment (nerve impulses).
2. They grow and change their body size and shape (cell division).
3. The have the ability to reproduce and increase their population (reproduction).
4. They are performing the function of metabolism and respiration (metabolisms).
5. They have ability to maintain homeostasis (excretion and Absorption).
6. They are made from cells.
7. There traits pass to offspring.

➢ **Some branches of biology:**

1. **Botany(plant science):** is the scientific study of plant life. As a branch of biology, it is also called plant science(s) or plant biology. Botany covers a wide range of scientific disciplines that study plants including: structure, growth, reproduction, metabolism, development and diseases of plants, chemical properties and evolutionary relationships between different plant groups.
2. **Zoology:** The study of animals and their futures.
3. **Microbiology:** The study of Microorganisms and their features.

➢ **Some botany discipline (branches):**

- **Morphology**: It deals with the study and description of different organs of plant. Morphology is divided into **two parts**: <u>**External Morphology**</u> **(** It is the study and description of external characters of plant organs like root, stem, leaf, flower, fruit, seed etc.). And <u>**Internal Morphology**</u>: (It is the study of internal structure of different plant organs). Also the internal morphology has **two branches:**
    - <u>**Histology**</u> : It is the study of different tissues present in the plant body.
    - <u>**Anatomy**</u> : It deals with the study of gross internal details of plant organs like root, stem, leaf, flower etc.
- **Plant Physiology**. This branch deals with the study of different vital activities of plants like absorption of water and minerals, photosynthesis, respiration, nitrogen metabolism, growth etc.
- **Taxonomy** "**plant classification**": It deals with the identification, nomenclature and classification of plants into related groups on the basis of information obtained from different fields of Botany.
- **Plant Ecology:** It is the study of reciprocal relationship between the plants and the environment in which they are living "evolutionary relationship".
- **Genetics:** This branch deals with all aspects related to genes such as their structure, synthesis, inheritance, mutations etc.

- The main discipline that researches focus on botany is:

-Plant population groups,

-Evolution, physiology,

-Structure, systematic.

➢ Importance of plants:

-Prevent soil erosion.

-Cool the atmosphere.

-Provide wildlife habitat.

-They provide fuel.

-Slow down wind movement.

-Replenish the earth's oxygen supply.

-Supply medicinal compounds and beautify our surroundings.

Plants are unique and essential to life on earth.

-Unlike most living things, plants make their own food from sunlight and water. Either directly or indirectly.

-They are the primary food source for humans and other animals.

➢ Key scientists in botany:

1-Theopharastus (371 - 287 BC): He was a scholar, botanist, biologist, and physicist.

2-Ibn al-Baitar (1197–1248 AD): the Muslim botanists, also known as the pioneer of botanists and pharmacist.

3-Carl Linnaeus (1707 – 1778): introduced taxonomic Hierarchy categories during the 18th Century.

4-Gregor Mendal (1822 - 1884): discovered the basic principles of heredity through experiments with pea plants.

5-Norman Borlaug (1914 – 2009): was an American agricultural scientist, and humanitarian.

There is a huge difference between Prokaryotic and Eukaryotic cells as given below:

	Properties	Prokaryote	Eukaryote
Basics	Size	Generally small < 2 µm in diameter	Usually larger. 2 to 100µm in diameter
	Origin	Most primitive	Relative new, or evolved from the prokaryote
	Phylogenetic group	Bacteria, Archaea	Algae, fungi, protozoa, plnt and animal cell
Forms of motility	Flagellar movement	Flagella composed of single type of protein arrange in a fiber; flagella rotate	Flagella or cillia; composed of microtubues; do not rotate
	Nonflagellar movement	Gliding motility; gas vesicle mediated	Cytoplasmic streamlining and ameboid movement; gliding motility
Nuclear structure and function	Nuclear membrane	Absent	Present
	Nucleolus	Absent	Present
	DNA	Single molecule generally covalently closed and circular, not complexed with histones	Linear, present in several chromosomes, usually complexed with histones.
	Division	No mitosis	Mitosis, mitotic apparatus with microtubular spindle
	Sexual reproduction	Fragmentary process, unidirectional, no meiosis, usually only portions of genetic complement reassorted	Regular process, meiosis reassortment whole chromosome complement
	Introns in genes	Rare	Common
Cytoplasmic structure and organization	Cytoplasmic membrane	Usually lacks sterols: hopanoids may be present	Sterols usually present; hopanoids absent
	Internal membrane	Relative simple, limited to specific group	Complex, endoplasmic reticulum and Golgi complex
	Ribosomes	70S in size	80S, excepts for ribosome of mitochondria and chloroplasts, which are 70S
	Membranous organelles	Absent	Several present
	Photosynthetic pigments	In internal membranes of chromosomes, chloroplast are absent	In chloroplasts
	Respiratory system	Part of cytoplasmic membrane	In mitochondria
	Cell wall	Present (in most), composed f peptidoglycan (bacteria), other polysaccharides, protein, glycoprotein	Present in plant, algae, fungi, usually polysaccharid, absent in animals and most protozoa
	Endospores	Present (in some), very heat resistant	Absent
	Gas vesicles	Present (in some)	Absent

➢ **Plant body** is constructed from millions of tiny cells, each having a characteristic shape and function. Meristems are the sites of cell division and differentiation in the plant body. The shoot system of most plants consists of **stems**, **leaves**, **buds**, **flowers**, and **fruits**, while the root system, composed of main **roots** and **branches.**

-**Angiosperm**, also called **flowering plant**, are vascular seed plants in which the ovule (egg) is fertilized and develops into a seed in an enclosed hollow ovary. The ovary itself is usually enclosed in a flower, that part of the angiospermous plant that contains the male or female reproductive organs or both.

-**Fruits** are derived from the maturing floral organs of the angiospermous plant and are therefore characteristic of angiosperms.

-By contrast, in **Gymnosperms** (e.g., conifers and cycads), the other large group of vascular seed plants, the seeds do not develop enclosed within an ovary but are usually borne exposed on the surfaces of reproductive structures, such as cones.

-**Woody plants:** undergo secondary growth resulting into additional types of tissues wood (secondary xylem) and bark (secondary phloem and cork).

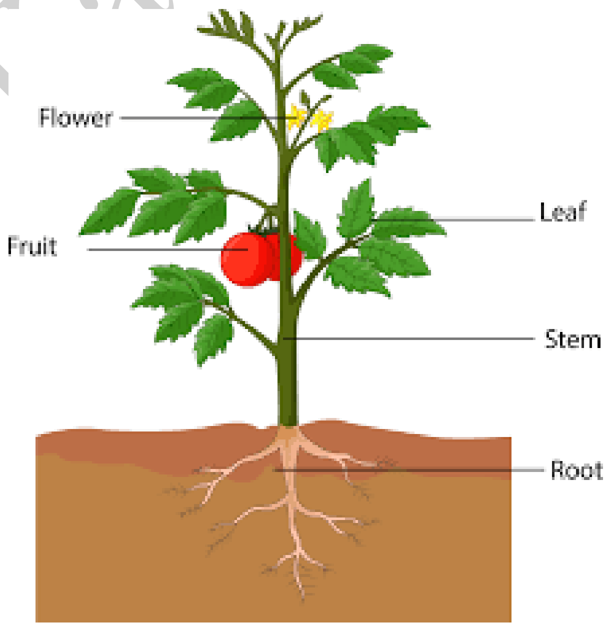


Fig. Plant body

Lec-2 ➢ Plant cell structure

- **Cell** is described as fundamental unit and building blocks of an organism.

- Every plant cell has a cell wall that surrounds the protoplasm.

-**All cells** have an **outer plasma membrane**

- Cytosol: is a fluid that contains a variety of bodies known as organelles.

- Cytoplasm: Cell substance between the cell membrane and the nucleus, containing the cytosol, organelles, cytoskeleton, and various particles.

- A membrane surrounds most organelles. The cells vary in its shape and size. Its thickness varies in different types of cells from 0.1 µm to 10 µm.

-Some green alga (mermaids wineglass) cells are 2 to 5 cm long, while fiber cells of some nettles are 20 cm long.

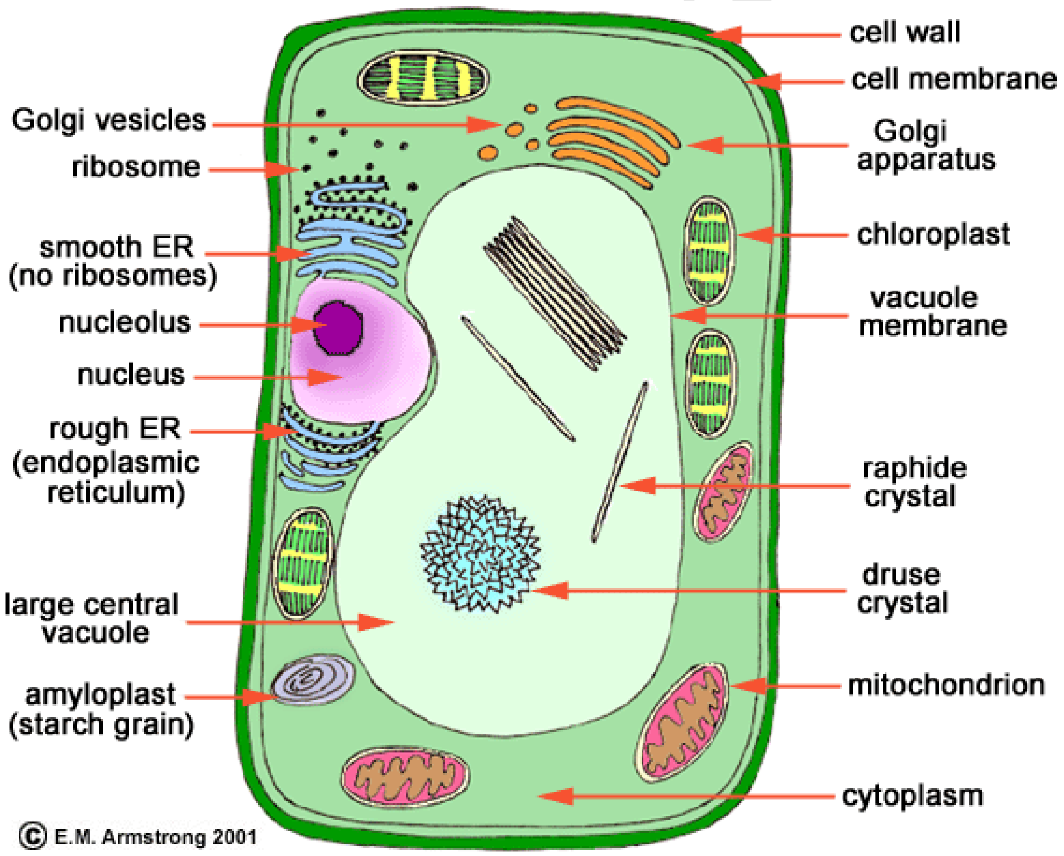


Fig. Plant cell

➢The cell wall

-Discovered by an English natural philosopher ‘Robert Hooke’ in the year 1665.

-Cell wall is a non-living, extracellular secretion or matrix of the cell which is closely apprised to it.

- The plant cell wall is mainly composed of cellulose, which is a polysaccharide consisting of a linear chain of β linked D-glucose units. Along with cellulose (long fibers of carbohydrates), plant cell wall also contains hemicelluloses, pectin, and lignin.

- **hemicellulose** :Any of several branched polysaccharides that are composed of a variety of different monosaccharides and form a matrix with cellulose and lignin or pectin in plant cell walls.

- **Pectin**: Any of a group of water-soluble colloidal carbohydrates of high molecular weight found in ripe fruits, such as apples, plums, and grapefruit, and used to jell various foods, drugs, and cosmetics.

-**Lignin**: A complex polymer, the chief non-carbohydrate constituent of wood, which binds to cellulose fibers and hardens and strengthens the cell walls of plants. Membrane potential: The difference in electric potential between the interior and the exterior of a biological cell.

- Cell wall can be flexible or tough, and sometimes rigid in its texture. It provides: strength, protection, structural support to the cell, and can also control the movement of molecules entering or leaving the cell to some extent, acts as a filtering mechanism.

- A multilayer plant cell wall is primarily made up of **three parts** i.e., **middle lamella** (outer layer of cell wall), **primary cell wall** and **secondary cell wall** (inner layers of cell wall).

- Growing and dividing plant cells have **primary cell walls**, and once the cells get fully grown, they develop into **secondary cell walls**.

-Primary walls get less rigid and thinner, to allow cell wall development during growth.

-A secondary cell wall is formed on the inner side of primary cell wall which is a thick layer and this layer is generally referred to a plant cell wall.

-Middle lamella is as well another layer in between plant cells which is pectin rich and helps the plant cells stick together.

-Primary cell wall and middle lamella are found in all plant cells but secondary cell wall Is not found in all.

-In some tissues a tertiary cell wall is formed on the inner surface of the secondary cell wall. This layer is very thin and is found in the xylem tracheids of gymnosperms, it is not found in all the cells. It is mainly composed of chemical substances xylan instead of cellulose. Typically, it does not contain any cellulose microfibrils.

- The cell wall of plant cells help them to maintain the turgor pressure, and cell wall holds water in efficiently so that the cell does not rupture. Preferably, plants cells must have a lot of water within them (a condition of high. But a plant cell without a cell wall cause bulging and get rupture, since much water diffuses into it.

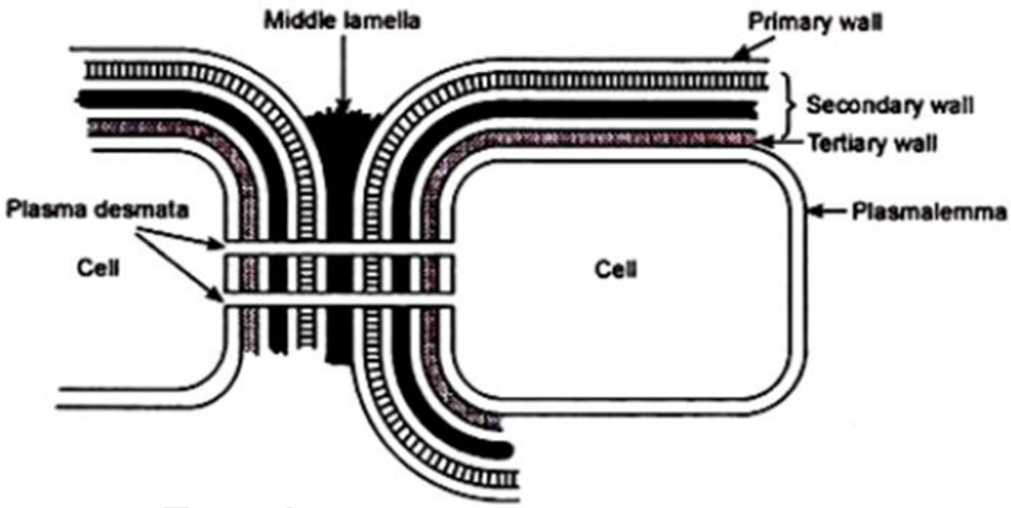


Fig. Organization of plant cell wall

The cell wall serves a variety of functions which includes the following:

1- **Protection:** It protects the cell against physical damage, the protoplasm against mechanical injury and protects the cell from attack of invading pathogens. Cell wall also helps to stop water loss and acts as a physical obstacle to guard against viruses and other plant pathogens.
2- **Support:** It provides structural support and maintains the shape of the cell.

3- **Regulate growth:** It controls the direction of cell growth and regulate cell volume. The cell wall has some enzymatic activity along with metabolism.

4- **Regulate diffusion:** The porous cell wall allows certain substances, including proteins, to pass into the cell, keeping the other substances out. It, therefore, acts as a selective permeable membrane that allows the small molecules to enter and also counteracts the osmotic pressure. Also, the cell wall reduce the loss of water through transpiration.

5- **Communication:** Cells communicate via plasmodesmata; these are pathways or pores found in plant cell walls, which allow communication signals and molecules to pass from one cell to another.

6- **Storage:** It also functions as a storage component as it stores carbohydrates like starch and glycogen, which are mainly used at growing period of a plant, especially in germination of seeds.

➢Cell communication

Fluids and dissolved substances can pass through the primary walls of adjacent cells via plasmodesmata.

-**Plasmodesmata**: (singular: plasmodesma) are intercellular organelles found only in plant and algal cells. The animal cell "equivalent" is called the gap junction.

-Plasmodesmata are narrow channels that act as intercellular cytoplasmic bridges to facilitate communication and transport of materials between adjacent plant cells.

-The plasmodesmata consist of minute pores or channels lying between individual plant cells, and connect the symplastic space in the plant.

-They form a protoplasmic continuum called symplast.

- Cell wall and intercellular spaces of cells form a non-living component of the plant body called apoplasm.

-The actual air space separating the cells is called the desmotubule.

-The desmotubule possesses a rigid membrane that runs the length of the plasmodesma.

-Cytoplasm lies between the cell membrane and the desmotubule.

-Plasmodesmata are extremely specialized channels that allow for intercellular movement of water, various nutrients, and other molecules (including signalling molecules).

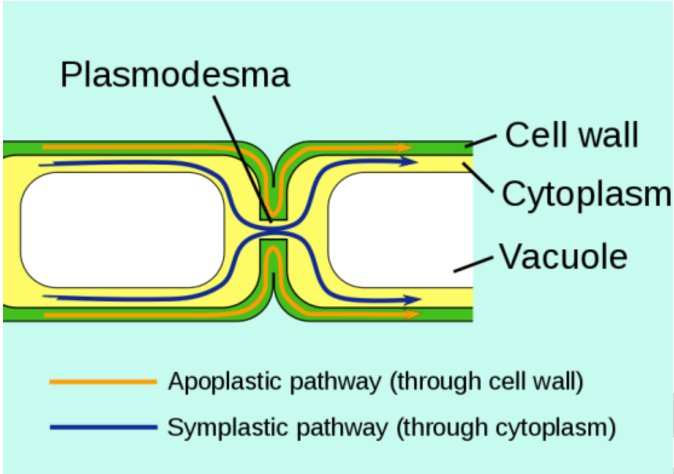


Figure. Plasmodesmata

➢Plant cell wall pits

-They are un-thickened areas in the secondary walls of plant cells. Therefore, they appear as depressions. Generally pits occur in pairs on the wall of two adjacent cells.

-A pit has a cavity or and a pit membrane which consists of middle lamella and primary wall.

-There are two types of pits, simple and bordered. Pit membrane is permeable. Therefore, pits help in rapid translocation between two adjacent cells.

-The **key difference** between pits and plasmodesmata is that **pits are the thin regions of the plant cell wall that facilitate communication and exchange of substances with neighbouring cells while plasmodesmata are microscopic intercellular bridges that connect the** cytoplasm **of neighbouring cells with each other, facilitate communication and transport of materials between plant cells.**

➢ The cell membrane (plasma membrane)

- The plasma membrane is made up of two layers of phospholipids with proteins interspersed throughout; some proteins span the entire width of the membrane, while others are embedded or loosely bound to the outer surface.
- Boundary of all the living part of the cell, which is also **selectively permeable**, regulates the movement of any given substance in and out of the cell, organize cells and gave them protection as well.

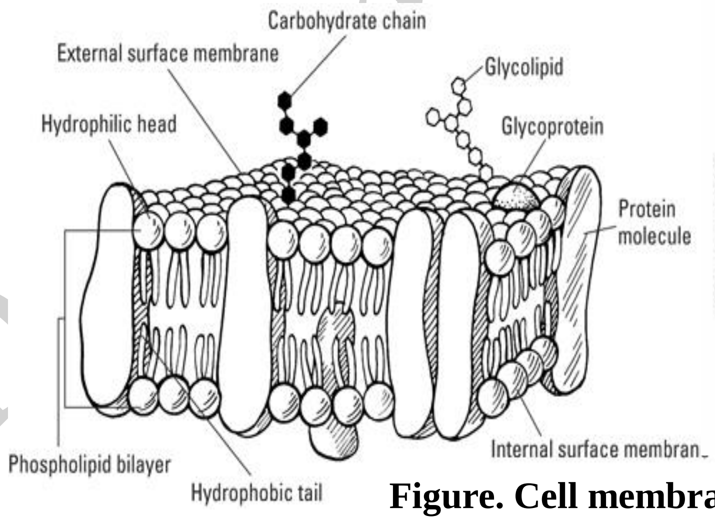
- The receptor proteins of the cell membrane help in communication with surrounding cells using signaling molecules such as neurotransmitters and hormones.

- Transport molecules across cell membranes facilitate diffusion such as transportation of globular proteins.

- Glycoproteins have a carbohydrate chain attached to it. They are embedded in the cell membrane and help in cell to cell communications and molecule transport across the membrane.

- It regulates cell growth by balancing exocytosis and endocytosis. In endocytosis, lipids and proteins are eliminated, as the material is internalized, whereas in exocytosis vesicles contain proteins and lipids, which fuse along the cell membrane increasing the cell size.

-Cell membrane lipids provide flexibility to the membrane structure, while membrane proteins probe the chemical environment of the cell and also help to move molecules across the membrane.



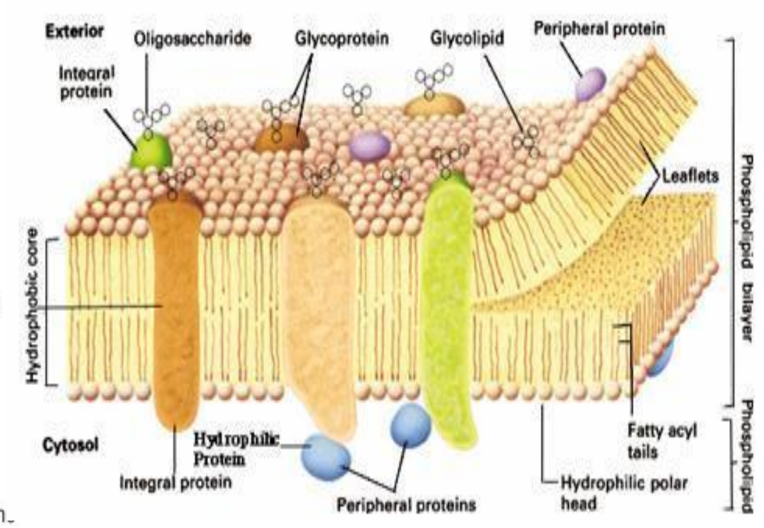


Figure. Cell membrane (plasma membrane)

Lec-3 /Eukaryotic cells Structure

Eukaryotic cells are distinct cells. It is divided into the following elements:

(A)Cell wall and plasma membrane, (B) Cytoplasm, and (C) Nucleus.

(A) Cell wall and plasma membrane

-Cell wall is a distinguishing feature of plant cells that is completely lacking in animal cells.

-The protoplasm of plant cells is separated from the external environment by a cell wall, which is a laminated, semi-rigid layer of non-living cells.

-The composition of the cell wall is determined by the species, cell type, function, and developmental process.

-The plant cell wall is composed of the: polysaccharides, cellulose, hemicellulose, and pectin.

-Plant cell walls contain some polymers **[lignin** (is a class of complex organic polymers that form key structural materials in the support tissues of most plants), **suberin** (lipophilic macromolecule found in specialized plant cell walls), and **cutin** (is a high molecular weight biopolyster and is the main component of plant cuticle)**]**.

-Glycoproteins and polysaccharides such as carrageenan and agar exclusively occur in the cell wall of few algae which are completely lacking in land plants. The cell wall of diatoms is composed of biogenic silica. The composition of fungal cell wall is quite different from the plant which is made up of N-acetylglucosamine polymer chitin.

-The cell wall functions: are to provide shape, support, strength, rigidity, and protection against mechanical/biological stress. Certain plants' cell walls contain **plasmodesmata** (which help to connect the cell to the adjacent cell).

-The plasma membrane or cell membrane is an external covering of living, thin, porous, semipermeable cells that covers the majority of plant and animal cells. This membrane is made up of **three layers:** protein in the inner and outer layers, and lipid in the middle. Technically, the plasma membrane provides the cell with mechanical strength. It is permeable to ions and organic molecules selectively, allowing it to regulate the movement of substances within cells.

(B) Cytoplasm

Following the plasma membrane is cytoplasm, which is divided into two parts:

(1) cytoplasmic matrix , and (2) cytoplasmic structures.

(1) Cytoplasmic matrix

-The cytoplasmic matrix or hyaloplasm takes up the space between the plasma membrane and the nucleus. It is a gel-like, translucent, and homogeneous colloidal liquid.

-Water comprises 90% of the cytoplasm. The remaining 10% is made up of inorganic compounds like Na, K, and mineral salts, as well as organic compounds like carbohydrates, lipids, fats, proteins, vitamins, nucleoproteins, nucleic acids (RNA and DNA), and enzymes.

-The plasma gel, cortex or cortical layer, and ectoplasm are cytoplasmic matrix peripheral regions that are non-granular, viscous, clear, and rigid.

-The inner region, on the other hand, is granular, less viscous, and is known as endoplasm.

The main function of the cytoplasmic matrix is to conduct the various vital activities of the cells. Some important functions are listed as:

•Biosynthesis of biochemical substances (proteins, carbohydrates, proteins, nucleic acid etc.)

•The process of glycolysis, anaerobic respiration and pentose pathway type of respiration occur in the matrix part of cytoplasm.

•The cell organs are usually unconnected.They exchange materials through the cytoplasmic matrix.

•The products of cell organelles are passed out into the matrix.

•The cytoplasmic matrix is always in motion. It is autonomic and is called cytoplasmic or protoplasmic streaming. This helps in distribution of various materials inside the cell.

(2) Cytoplasmic structures:

Some non-living and living substances are suspended in the cytoplasmic matrix. Non-living substances are classified as paraplasm, deutoplasm, or cytoplasmic inclusions, whereas living, membrane-bound structures are classified as organoids or organelles (see Fig. below).

(i) Cytoplasmic inclusions: The cell's stored food and secretory substances remain suspended in the cytoplasmic matrix as granules, which form cytoplasmic inclusions. It consists of oil drops, yolk granules, pigments, secretory granules, starch granules, and glycogen granules in plant cells and glycogen granules in animal cells.

(ii) Cytoplasmic organelles: Organelles are living structures in the cytoplasm with a double membrane. They carry out vital biosynthesis and metabolic functions such as respiration, transportation, support, storage, and reproduction.

Some of the most important cell organs are discussed below:

a. **Microtubules:** The cytoplasm of eukaryotic cells is traversed by many ultrafine tubes of tubulin protein known as microtubules (Fig.A). It is a complex structure made up of thirteen individual protofilaments arranged to form a hollow cylinder. Microtubules are intracellular filamentous structures that transport water, ions, or small molecules, as well as cytoplasmic streaming, in all eukaryotic cells. Microtubules are also involved in the formation of asters in the mitotic and meiotic spindle during cell division. Furthermore, they are the structural units of centrioles, basal granules, cilia, and flagella.

b. **Cytoplasmic filaments:** The cytoplasm is held together with ultrafine tubes of varying sizes. Cytoplasm filaments come in three varieties. The smallest are microfilaments 40 to 60 A° in diameter that occur next to the plasma membrane and form the web in ectoplasm. The second type is myosin filament. Actin filaments are another name for it. Microfilaments are typically 7 nm in diameter and made up of two actin strands. This filament is involved in a variety of cell movements, including division and various extensions of the cell surface, such as microvilli. In addition to the two previously mentioned filaments, there is a third type of filament known as 100 A° filaments. These filaments are involved in cell movement as well as material movement within the cell.

Note: Cytoskeleton

The cytoskeleton is a network of fibers that is involved in cell movement. Constructed mainly of two kinds of fibers: 1- microtubules 2- microfilaments

e. **Endoplasmic reticulum:** Endoplasmic reticulum (ER) is a reticulated cytoplasmic organelle in eukaryotic cells. They connect to form a network of flattened, tubular structures known as cisternae (Fig. E). Endoplasmic reticulum is found in all eukaryotic cells except spermatozoa and red blood cells. The ER continues to the nucleus' outer membrane. Endoplasmic reticulum can be divided into two types based on structural differences: I Rough Endoplasmic Reticulum (RER) and (ii) Smooth Endoplasmic Reticulum (SER) (SER). Ribosomes remain attached to the RER's outer surface, giving it a rough appearance; thus, it is known as rough endoplasmic reticulum. It is commonly found in cells such as hepatocytes and protein synthesis sites. The smooth endoplasmic reticulum, on the other hand, lacks ribosomes and is responsible for lipid synthesis but not metabolism, steroid hormone production, or detoxification. Smooth ER is particularly abundant in mammalian liver and gonad cells. In addition to the functions listed above, endoplasmic reticulum serves as the cytoplasmic network's ultrastructure skeletal framework and provides mechanical support.

   Note: Lysosomes are known to contain more than 60 different enzymes, and have more than 50 membrane proteins. Enzymes of the lysosomes are synthesized in the rough endoplasmic reticulum. The lysosomes of plant cells are storage granules containing hydrolytic enzymes and are comprised of spherosomes, aleurone grain and vacuoles.

f. **Golgi complex:** The Golgi complex, also known as the Golgi body, Golgi apparatus, or Golgi, is a cytoplasmic organelle found in most eukaryotes (Fig. G). Camillo Golgi first discovered it in 1897. The Golgi complex is a collection of fused, flattened membrane-enclosed disks known as cisternae that originate from vesicular clusters that branch off the endoplasmic reticulum. Each Golgi is made up of many lamellae, tubules, vesicles, and vacuoles. The functions of Golgi complex are storage of proteins and enzymes secreted by ribosomes and transported by endoplasmic reticulum. In plants cells the Golgi complex is known as dictyosome that secretes necessary materials for cell wall formation during cell division. The Golgi apparatus tends to be larger and more numerous in cells that synthesize and secrete large amounts of substances for example, the antibody-secreting plasma B cells of the immune system have prominent Golgi complexes.

h. **Cytoplasmic vacuoles:** A vacuole is a membrane-bound, closed sac of membranes filled with organic or inorganic molecules. They are not fixed in size or shape; wither cell can change them. Cell sap is a watery substance that pervades the entire vacuole. They are far more important in plant and fungus cells than in animal cells. Some of the most common functions of a vacuole are to grasp waste products, maintain the amount of water in plant cells, balance internal hydrostatic pressure or turgor in a cell, maintain pH inside the cell, and hold small molecules. Vacuoles are also important in autophagy. In protists, vacuoles also store and help digested food. The vacuoles of the plant cells are bounded by a single, semipermeable membrane known as tonoplast. These vacuoles contain water, phenols, flavonols, anthocyanins, alkaloids, and stored product such as sugar and proteins.

i. **Microbodies:** Many types of cells' cytoplasmic matrix (yeast, protozoa, higher plant cells, etc.) contain roughly spherical, membrane-bound particles (0.3-1.5 µm diameter). Microbodies are particles that have a central granular or crystalloid core containing some enzymes and exist in close proximity to the endoplasmic reticulum, mitochondria, and chloroplast. It contains enzymes that aid in the preliminary or intermediate stages of biochemical reactions within the cell. This helps to break down fats, alcohols, and amino acids. In general, microbodies are involved in peroxide detoxification and photorespiration in plants.

j. **Ribosomes:** Ribosomes are cytoplasmic organs that are small, spherical in shape, and minute (Fig. F). It can be found in all living organisms (including prokaryotes and eukaryotes). Ribosomes are formed in the nucleolus and are primarily composed of ribonucleic acids (RNA) and proteins. In eukaryotic cells, they are either attached to the endoplasmic reticulum membrane or exist freely in the cytoplasm. Although eukaryotic ribosomes differ structurally from prokaryotic ribosomes, it is the site of protein synthesis in both types of cells. Ribosomes (70S type) in prokaryotic cells are made up of two ribosomal subunits: small (30S) and large (50S). Eukaryotic ribosomal subunits (80S type) are made up of 40S as small subunits and 60S as a large subunit.

k. **Mitochondria:** The shape, size, and number of mitochondria varied from cell to cell. They are generally rod or round in shape with a double membrane bound structure and are found in most eukaryotic cells; however, some cells lack them (for example, mature mammalian red blood cells). The inner and outer layers, as well as the central region, are filled with a viscous fluid known as mitochondrial matrix. The outer membrane forms a bag-like structure around the inner membrane, resulting in numerous finger-like folds in the mitochondrial lumen. Cristae are the inner membrane folds (Fig. I). Many oxidative enzymes and coenzymes can be found in the matrix, outer and inner membranes. The primary functions of mitochondria are respiration, food oxidation, and energy metabolism. They store energy and release it when needed in the various vital activities of life. Mitochondria produce the majority of the cell's supply of adenosine triphosphate (ATP), which is used as a source of chemical energy; they are known as the "power house of the cell."

l. **Plastids:** Plastids are known as the "kitchen of the cell." Plastids are only found in plant cells and are completely absent in animal cells. They give the plants their distinctive color. Plastids range in size from 4 to 6 μm and color from colorless to many colours. Leucoplast refers to colorless plastids. They are known as amyloplasts, lipoplasts, and proteinoplasts because they specialize in the storage of starch, lipids, and proteins. Colored or pigmented plastids, also known as chromoplasts, come in a variety of colors, the most common of which is green. The chloroplast is a green-colored plastid that aids in the biosynthesis of food through the process of photosynthesis. The chloroplasts are highly organized and contain DNA, ribosomes, and the entire protein synthesis machinery. (Fig. J).

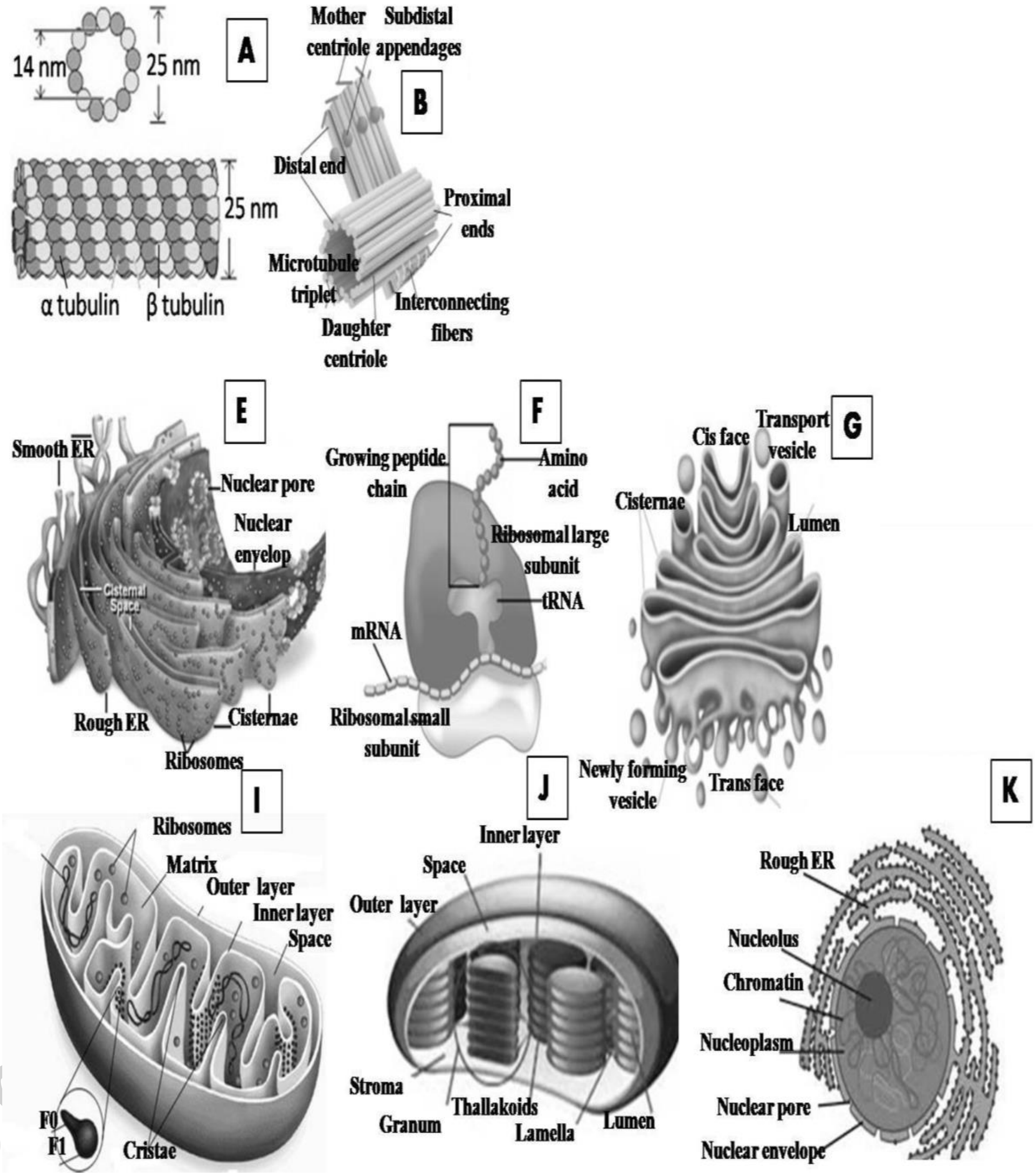
(C) Nucleus:

The nucleus is a well-defined, centrally located, spherical cellular component that regulates all of the cell's vigorous processes. The nucleus is made up of three structures (Fig K).

a. **Nuclear membrane:** The nuclear membrane is the outermost layer of the nucleus and is found in both plant and animal cells. The nuclear membrane is composed of two layers of lipoprotein. It forms an envelope-like structure around the nucleus known as the nuclear envelop. The nuclear envelop contains numerous tiny pores that regulate the movement of the chemical substance. The outer nuclear membrane of nuclear remains continues with the endoplasmic reticulum membrane and plasma membrane. The primary function of the nuclear membrane is to form a barrier that physically protects the cell's genetic material from the chemical reactions that occur elsewhere in the cell.

b. **Nucleoplasm and chromosomes:** The nucleus, like the cytoplasm, contains a watery substance called nucleoplasm or karyoplasm. Nucleoplasm fills the space between the nuclear membrane and nucleolus. It contains dissolved phosphorus, ribose sugar, proteins, nucleotides, and nucleic acids. The nucleoplasm contains chromosomes, which are thread-like structures. Chromosomes are only visible during cell division; otherwise, they exist as chromatin granules. The genetic materials, as well as numerous nucleoproteins, are found in the chromosomes and chromatin granules.

c. **Nucleolus:** The nucleoplasm contains a prominent darkly stained spherical body known as the nucleolus. Nucleolus is chemically made up of a large amount of ribosomal protein and ribosomal RNA. The nucleolus stores the rRNA molecules synthesized by the nucleolar organizer region of DNA and provides raw material for the biogenesis of ribosomes, such as various types of rRNAs and ribosomal proteins.


A
14 nm
25 nm
25 nm
α tubulin
β tubulin
B
Mother centriole
Subdistal appendages
Distal end
Proximal ends
Microtubule triplet
Interconnecting fibers
Daughter centriole
E
Smooth ER
Nuclear pore
Nuclear envelop
Cisternal Space
Rough ER
Cisternae
Ribosomes
F
Growing peptide chain
Amino acid
Ribosomal large subunit
tRNA
mRNA
Ribosomal small subunit
G
Cis face
Transport vesicle
Cisternae
Lumen
Newly forming vesicle
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Outer layer
Stroma
Granum
Thallakoids
Lamella
Lumen
K
Rough ER
Nucleolus
Chromatin
Nucleoplasm
Nuclear pore
Nuclear envelope

Differences between animal and plant cells:

1. Size and shape: Plant cells are 10-100 micrometers in length and typically rectangular or cubic in shape, while animal cells are 10-30 micrometers in length and irregular in shape.

2. Energy storage: Starch is used by plant cells to store energy. Glycogen(complex carbohydrate) is used to store energy in animal cells.

3. Differentiation: Most plant cell types can differentiate, while only stem cells in animal cells have the ability to differentiate into other cell types.

4. Growth: Plant cells grow in size primarily by absorbing more water into the central vacuole. Animal cells grow in size as the number of cells increases.

5. Cell Wall: Animal cells lack a cell wall but have a cell membrane. Plant cells have a cellulose cell wall as well as a cell membrane.

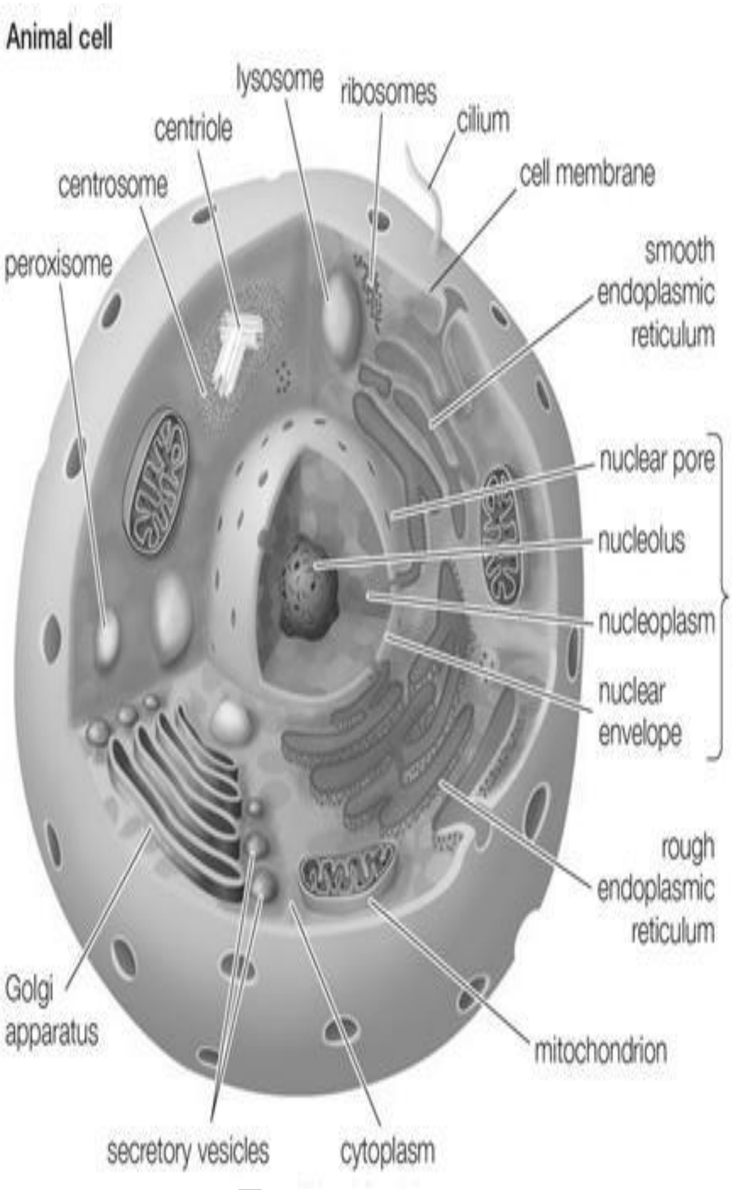
6. Centrioles: Centrioles are cylindrical structures found in animal cells that organize the assembly of microtubules during cell division. Centrioles are not found in plant cells.

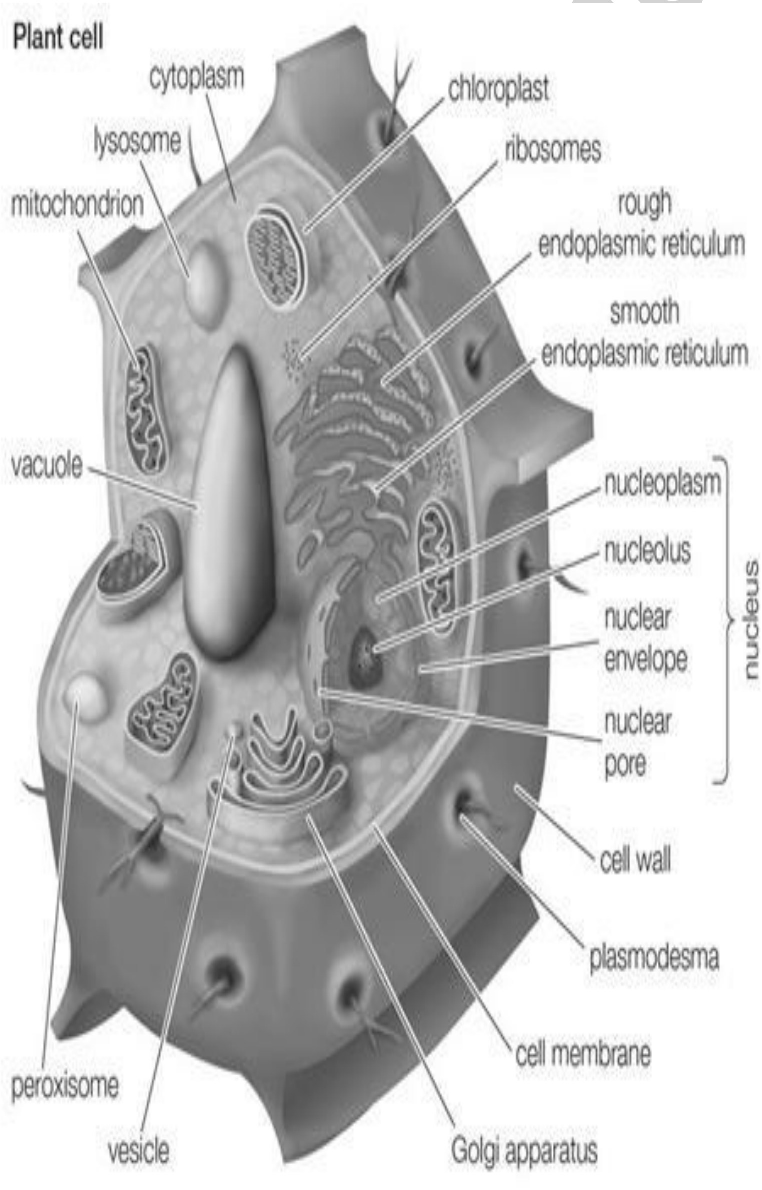
7. Lysosomes: Lysosomes are structures found in animal cells that contain enzymes that digest cellular macromolecules. In plant cells, the vacuole handles molecular degradation.

8. Plastids: Animal cells lack plastids. Plant cells contain plastids, such as chloroplasts, which are required for photosynthesis.

9. Plasmodesmata: Plasmodesmata do not exist in animal cells. Plant cells have plasmodesmata, which are pores between the cell walls that allow molecules and communication signals to pass between them.

10. Vacuole: Many small vacuoles are found in animal cells. A large central vacuole in plant cells can occupy up to 90% of the cell's volume.


Animal cell
lysosome
ribosomes
centriole
cilium
centrosome
cell membrane
peroxisome
smooth endoplasmic reticulum
nuclear pore
nucleolus
nucleoplasm
nuclear envelope
nucleus
rough endoplasmic reticulum
Golgi apparatus
mitochondrion
secretory vesicles
cytoplasm


Plant cell
cytoplasm
chloroplast
lysosome
ribosomes
mitochondrion
rough endoplasmic reticulum
smooth endoplasmic reticulum
vacuole
nucleoplasm
nucleolus
nuclear envelope
nuclear pore
nucleus
cell wall
plasmodesma
cell membrane
peroxisome
vesicle
Golgi apparatus

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The Cell Cycle

OBJECTIVES

- Understand the fundamental concept of the cell cycle
-Mitosis, its various stages, and its importance
-Meiosis, its different phases, significance and cytokinesis.

Chromosomal DNA molecules in eukaryotic.

-Each chromosome is made up of chromatin, which is a long DNA molecule with proteins attached to it. During cell division, chromatin is packaged into dense chromosomes. When cells are not dividing, the chromosomes are unpacked (decondensed), which helps to ensure proper DNA distribution during cell division.

-Hundreds to thousands of genes are found on each chromosome.

- The functional units of heredity are genes. The genome is an organism's complete DNA sequence. The number of chromosomes in each species is different. The number varies depending on the species. The number of chromosomes does not represent the organism's complexity. Humans are made up of 46 chromosomes. Chromosomes carry the genetic information to the next generation and offspring.

Eukaryotic cell cycle

The cell cycle, also known as cell division, is a series of changes that occur in dividing cells. It includes growth, development, and division. **Howard** and **Pelc** described it in detail in **1953**.

Cells either stop growing or must divide when they reach a certain size. Most, but not all, eukaryotic cells are capable of dividing. In general, Eukaryotic cell generation to take from 8 to 20 hours.

-It consists of two parts: **interphase** (I phase) and **dividing** (**M phase**).

-**Interphase** is divided into three parts, each of which is characterized by the replication of DNA:

1- During the synthesis process, or **S phase**, the DNA is fully replicated (genetic information is duplicated).

2- The **G1 phase**, which occurs before the S phase, is a "gap" phase. Most cellular growth occurs in this phase, this phase is normally the most variable in time, which is also the longest phase. In this phase, cells that do not divide are referred to as G0 cells.

3- The **G2 phase** occurs between the S phase and cell division. The G2 phase is usually short; cells are committed to and preparing for cell division.

-The **two primary stages** of **cell division** are **mitosis** and **cytokinesis**.

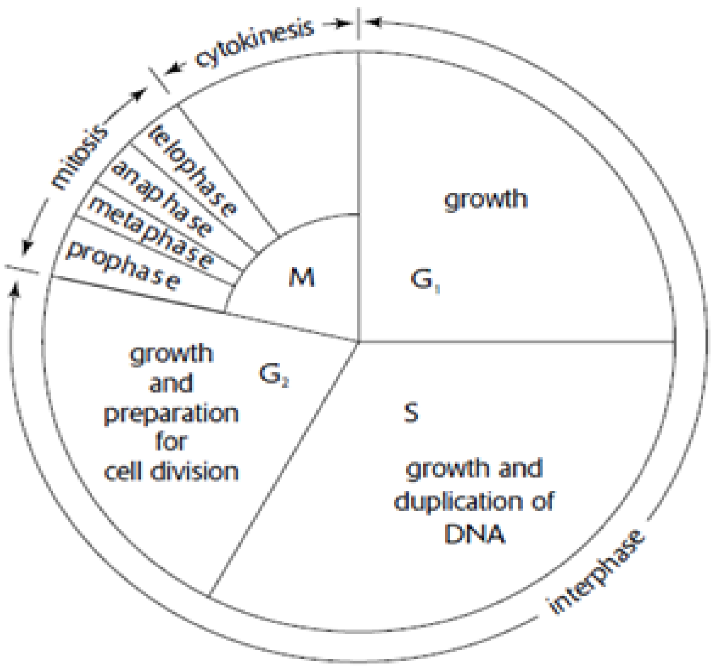
Mitosis: is the process by which each daughter cell receives a complete copy of the genetic material that has been duplicated.

Cytokinesis: is the mechanism of dividing the cytoplasm into two separate cells. Some cells are capable of undergoing mitosis without undergoing cytokinesis (most common in fungi and slime molds)

- The existing cell cycle regulation system is based on a genetically regulated, highly conserved system that can be affected by external signals. In G1, G2, and Mitosis, the key regulators of **checkpoints** are **Cyclins** and **cyclin-dependent protein kinases**.

- Under the right circumstances, growth factors in animals can induce development through checkpoints in the right cells. Other factors can function as cell division suppressors.

- Cancer cells do not respond to normal cell division suppressors and expand without the assistance of external growth factors.



Mitosis

Prophase, metaphase, anaphase, and telophase are the four stages of mitosis, respectively (**PMAT**)

Prophase: Chromosomes are formed when chromatin condenses in the prophase. Sister chromatids are formed when chromosomes are duplicated during S phase. At a centromere, sister chromatids are related. Microtubules can bind to the kinetochore in centromeres.

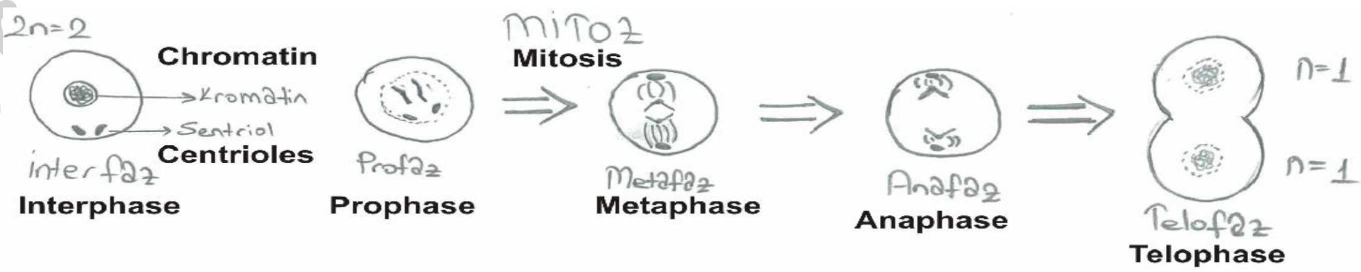
The mitotic spindle organizes microtubules between the cell's two poles (opposite ends). A microtubule organizing core is present in each pole (MTOC) Centrioles are present in the MTOC of animals and other eukaryotes.

The nuclear membrane has disappeared (actually divided into several small vesicles) and the nucleoli have disintegrated by the end of prophase. Sister chromatids are associated with microtubules from opposite poles by their kinetochores. Prometaphase is a term used to describe the later stages of prophase, which are usually defined as the vascularization of the nuclear membrane and the attachment of kinetochores to microtubules.

Metaphase: The chromosomes that line up along the cell's midplane are the most condensed, visible, and distinguishable. Kinetochore microtubules attach a pole to a kinetochore, while polar microtubules attach a pole to the midplane area, often overlapping with polar microtubules from the opposite pole. The mitosis checkpoint appears to be here; progression past metaphase is typically preventing at this stage.

Anaphase: Sister chromatids separate and move to opposite poles during anaphase. Performer sister chromatid is now referred to as a chromosome. This mechanism ensures that each daughter cell receives one of the chromosomes' duplicate sets of genetic material.

Telophase: telophase is characterized by the reversal of prophase processes. The chromosomes decondense after the mitotic spindle dissolves. Nuclear membranes reform around the genetic material, resulting in two nuclei, each with an identical copy of the genetic information. Interphase cellular functions resume after nucleoli reappear.



Meiosis

-Is the mechanism of cell division that produces germ cells (eggs and sperm).

-The amount of genetic material decreases during meiosis.

-Two haploid sex cells are combined to create a new individual (gametes). Each gamete is haploid.

-A zygote is a new individual with two sets of chromosomes (diploid).

-Meiosis is the process by which a diploid cell becomes a haploid gamete.

Chromosomes in a Diploid Cell

Chromosome characteristics:

- Diploid set for humans; 2n = 46
- Autosomes; homologous chromosomes, one from each parent (humans = 22 sets of 2)
- Sex chromosomes (humans have 1 set of 2)
- Female-sex chromosomes are homologous (XX)
- Male-sex chromosomes are non-homologous (XY)

Karyotyping

Karyotype

- A pictorial display of metaphase chromosomes from a mitotic cell.
- Homologous chromosomes- pairs.

- **Ploidy:** Number of sets of chromosomes in a cell.
  - Haploid (n) - one set chromosomes
  - Diploid (2n) - two sets chromosomes
  - Most plant and animal adults are diploid (2n)
  - Eggs and sperm are haploid (n)

Meiosis I & II

Prophase, prometaphase, metaphase, anaphase, and telophase are all stages of cell division. In these stages, chromosomes behave similarly but not identically.

Meiosis I:

Chromosomes in a diploid cell resegregate during meiosis I , resulting in four haploid daughter cells. Genetic variation is generated during this stage of meiosis.

The phases of meiosis I & II

Prophase I

Meiosis I begins with the replication of DNA. Homologous chromosomes pair and form synapses during prophase I, this step is unique in meiosis. Bivalents are paired chromosomes, and genetic recombination results in the creation of chiasmata. These can be viewed in the microscope due to chromosomal condensation.

Note: Each parent contributes one chromosome to the bivalent, which has two chromosomes and four chromatids.

Prometaphase I

The nuclear membrane is no longer visible. The chromosomes attached to spindle fibers begin to move as one kinetochore forms per chromosome rather than one per chromatid.

Metaphase I

At the metaphase plate, bivalents with two chromosomes (four chromatids) align. With either parental homologue on one side, the orientation is random. This means that the daughter cells have a 50/50 chance of inheriting either the mother's or father's homologue for each chromosome.

Anaphase I

Separate chiasmata. Chromosomes of two chromatids each move to separate poles. Each of the daughter cells is now haploid (23 chromosomes), with two chromatids on each chromosome.

Telophase I

Nuclear envelopes may reform, or the cell may enter meiosis II very quickly.

Cytokinesis

Similar to mitosis, in which two full daughter cells are formed.

Meiosis II

Mitosis and meiosis II are similar. The "S" phase does not exist. Recombination also caused the chromatids of each chromosome to become non-identical. Meiosis II divides the chromatids into two daughter cells, each with 23 chromosomes (haploid), but only one chromatid per chromosome.

Meiosis vs. Mitosis

- **Chromosome behavior**

1- Mitosis: Independent of homologous chromosomes

2- Meiosis: Until anaphase I, homologous chromosomes pair forming bivalents.

- **In meiosis, the number of chromosomes is reduced.**

1- Mitosis: daughter cells that are similar

2- Meiosis: haploid daughter cells

- **Progeny's genetic identity:**

1-Mitosis: daughter cells that are similar.

2-Meiosis: The parental chromosomes in daughter cells are rearranged.

3- Meiosis: Crossing over of chromatids, not similar.

Meiotic errors

- **Homologues do not differentiate in meiosis 1 due to nondisjunction**

1- Aneuploidy is the result.

2- Embryos are usually lethal.

3- Downs syndrome is caused by the trisomy 21 exception.

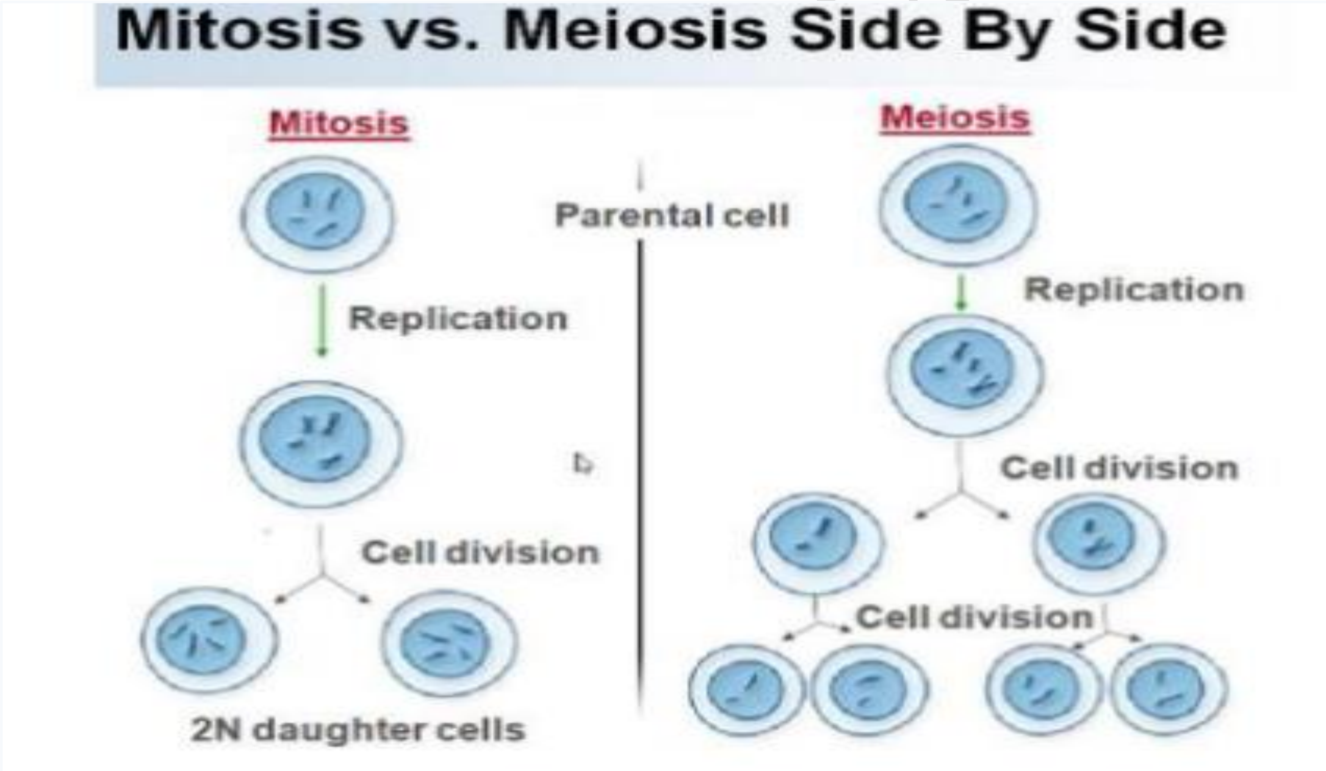
4- Sex chromosomes

- Turner syndrome: monosomy X
- Klinefelter syndrome: XXY

- Deletion & translocation: A portion of one chromosome is transferred to another, or a fragment of a chromosome is lost.

Ploidy, Mitosis, and Meiosis

- Mitosis can proceed independent of ploidy of cell, homologous chromosomes behave independently.
- Meiosis can only proceed if the nucleus contains an even number of chromosomes (diploid, tetraploid).
- Trisomy 21 does not prevent meiosis.



The Three Key Differences bewteen Mitosis and Moisis

	Mitosis	Meiosis
Number of Daughter Cells	2	4
Chromosome Number	Same	Half
Genes of Daughter Nuclei	Identical	Different

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Plant Tissues

Tissues

•A tissue is a group of cells having a common origin, similar structure and function and held together by a cementing substance. Example: Connective tissue.

Organ

•Different types of tissues working together and contributing to specific functions inside the body constitute an organ. Example: Stomach.

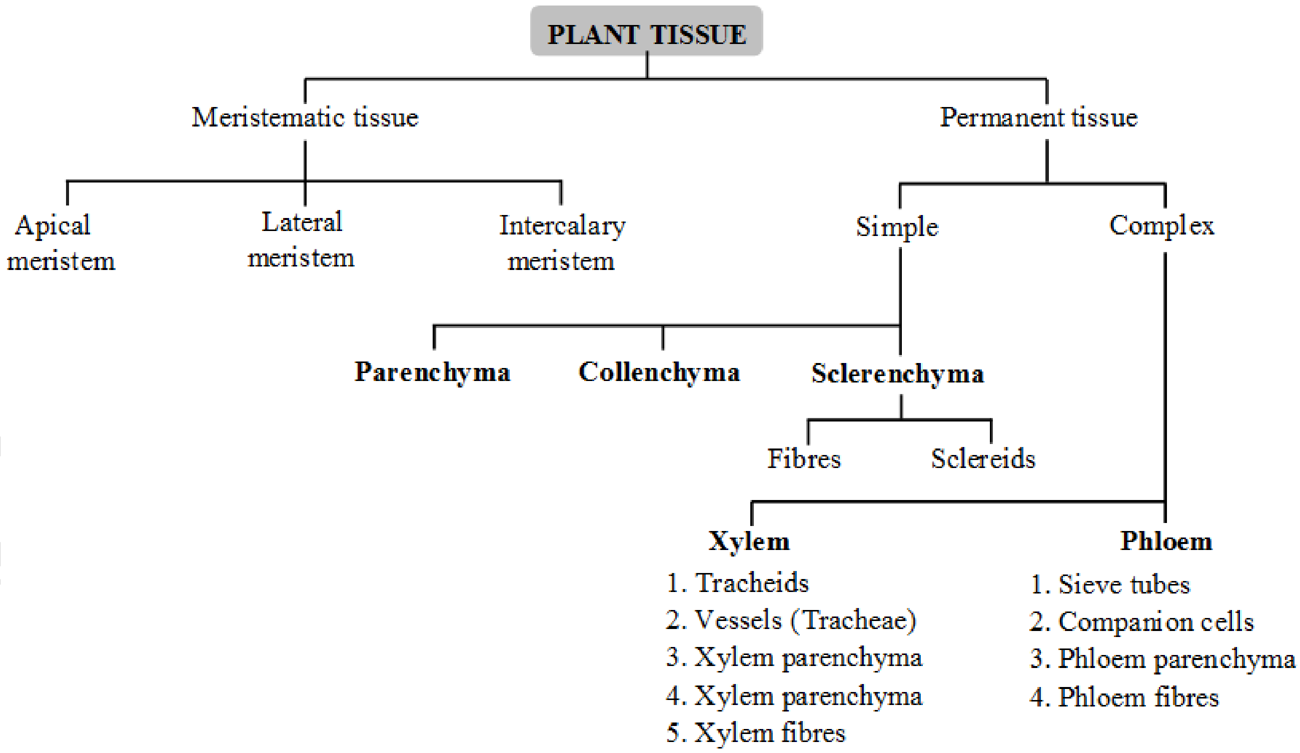
Organ system

•Different organs coordinate to perform a specific life process and form an organ system. Example:Digestive system

Organism

•Various organ systems working simultaneously together constitute an organism. Example: Plants

Most plants have three or four major groups of organs—**roots, stems, leaves,** and in some instances, **flowers.** Each of these organs is composed of tissues, which are defined as "groups of cells performing a similar function." Any plant organ may be composed of several different tissues; each tissue is classified according to its structure, origin, or function. The following are major kinds of tissues found in higher plants.

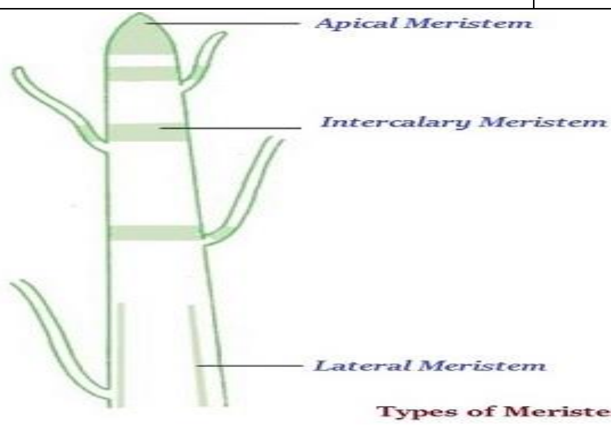


- Following are the major types of plant tissue −
  - **Meristematic Tissues**
  - **Permanent Tissues**
    - **Simple Permanent Tissues**
      - Parenchyma
      - Collenchyma
      - Sclerenchyma
      - Epidermis
    - **Complex Permanent Tissue**
      - Xylem
      - Phloem

Meristematic Tissue

- Meristematic tissue mainly consists of actively dividing cells, and helps in increasing the length and thickening the stems of the plant.
- Meristematic tissue, commonly, present in the primary growth regions of a plant, for example, in the tips of stems or roots.
- Depending on the region (where the meristematic tissues are found); meristematic tissues are classified as **apical, lateral,** and **intercalary** (see the table & image given below).

Type	Location	Function
Apical meristem	Located at the growing points of the stem, roots, branches and in growing young leaves near the tips of stems and axillary buds	Enables the root and stem to grow by increasing the length of plants
Intercalary meristem	Located at the internodes or stem regions between the places at which the leaves attach and at leaf bases	The cells are active and they continuously form several new cells
Lateral meristem/ Cambium	Present laterally (on the sides) on the roots and stem and is situated parallel to the longitudinal axis below the bark	The girth and width/diameter/thickness of the stem or root increases because of the lateral meristem



Types of Meristematic Tissue

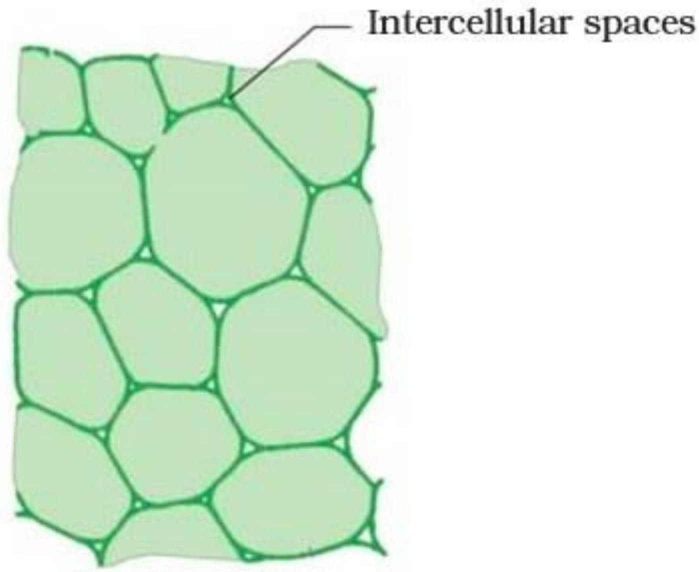
Permanent Tissue

- Cells of meristematic tissue later differentiate to form different types of permanent tissue.
- Permanent Tissue is further categorized as −
    - **Simple Permanent Tissue** and
    - **Complex Permanent Tissue**

Simple Permanent Tissue

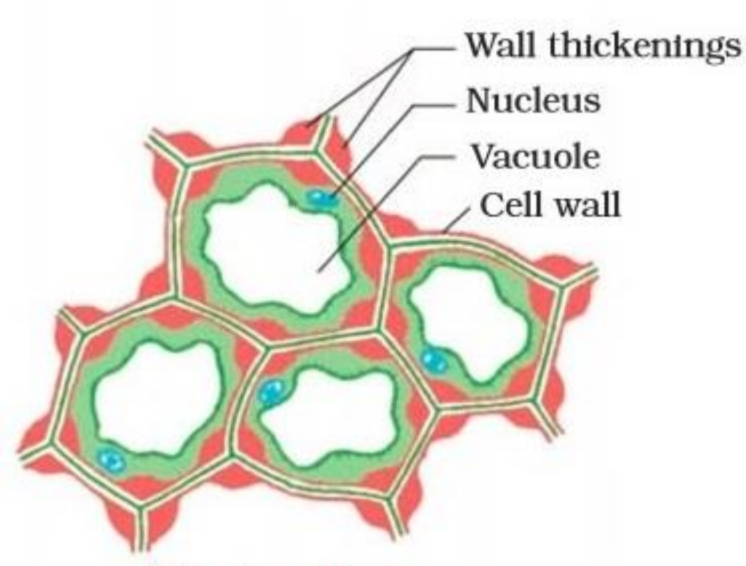
- Simple Permanent Tissue further categorized as −
    - **Parenchyma**
    - **Collenchyma**
    - **Sclerenchyma**
    - **Epidermis**

- **Parenchyma tissue** provides support to plants and also stores food.



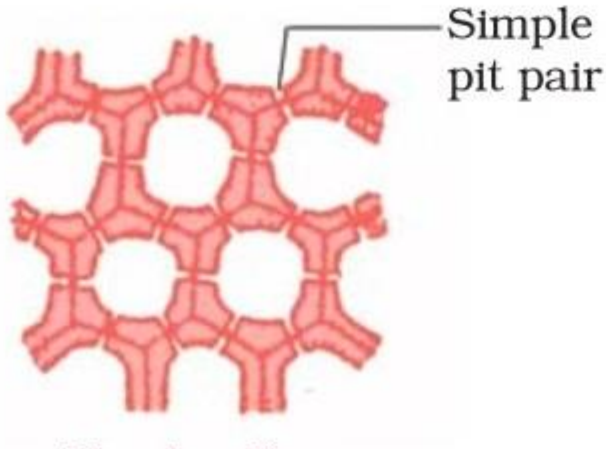
Parenchyma Tissue

- Sometimes, parenchyma tissue contains chlorophyll and performs photosynthesis, in such a condition, it is known as **collenchyma**.



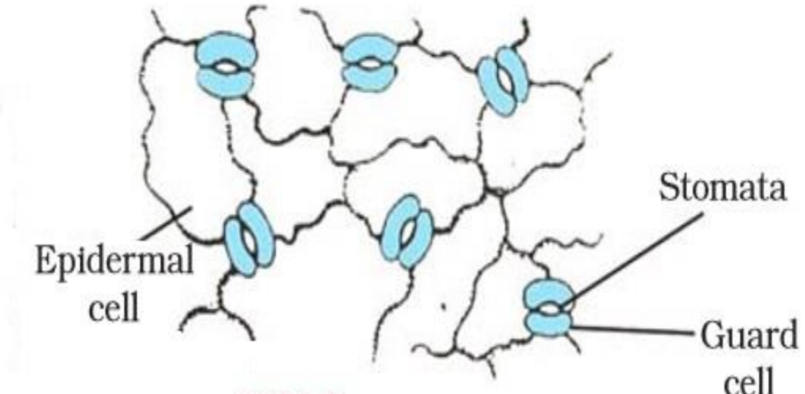
Collenchyma Tissue

- The collenchyma tissue provides flexibility to plant and also provides mechanical support (to plant).
- The large air cavities, which are present in parenchyma of aquatic plants, give buoyancy to the plants and also help them float, are known as **aerenchyma**.
- The **Sclerenchyma** tissue makes the plant hard and stiff. For example, the husk of a coconut is made up of **sclerenchymatous tissue**.



Sclerenchyma Tissue

- The cells of Sclerenchyma tissue normally are dead.
- Two forms of sclerenchyma occur: **sclereids** and **fibers**.
- The outermost layer of cells is known as **epidermis**.
- The epidermis is usually made up of a single layer of cells.

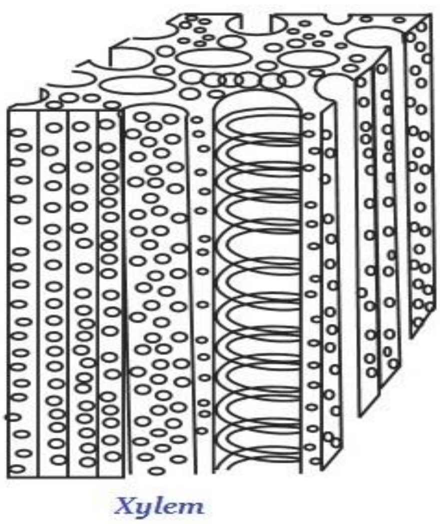


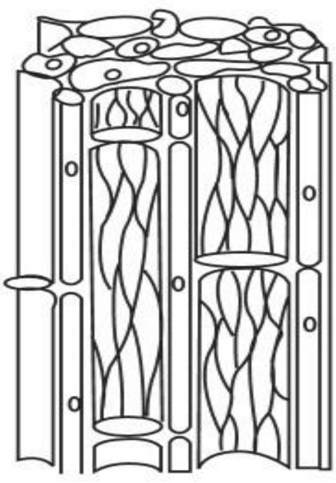
Epidermis

- The entire surface of a plant has the outer covering of epidermis, which protects all the parts of the plant.
- Stomata are structures present in the epidermis of leaves. Stomata regulate the process of transpiration and gaseous exchange. Each stoma is composed of two bean shaped cells known as **guard cells** which enclose stomatal pore.

Complex Permanent Tissue

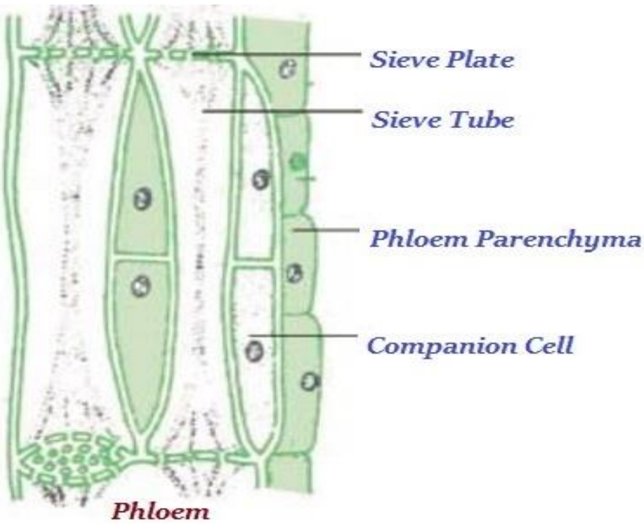
- The complex tissue, normally, consists of more than one type of cells which work together as a unit.
- Complex tissues help in the transportation by carrying organic material, water, and minerals up and down in the plants.
- Complex Permanent Tissue is categorized as;
  - **Xylem** and
  - **Phloem**


Xylem


Phloem

- Xylem, normally, consists of tracheid, vessels, xylem parenchyma, and xylem fibers.
- Xylem is accountable for the conduction of water and mineral ions/salt.

- Phloem, normally, is made up of four types of elements namely −
    - **Sieve tubes**
    - **Companion cells**
    - **Phloem fibers** and
    - **Phloem parenchyma**

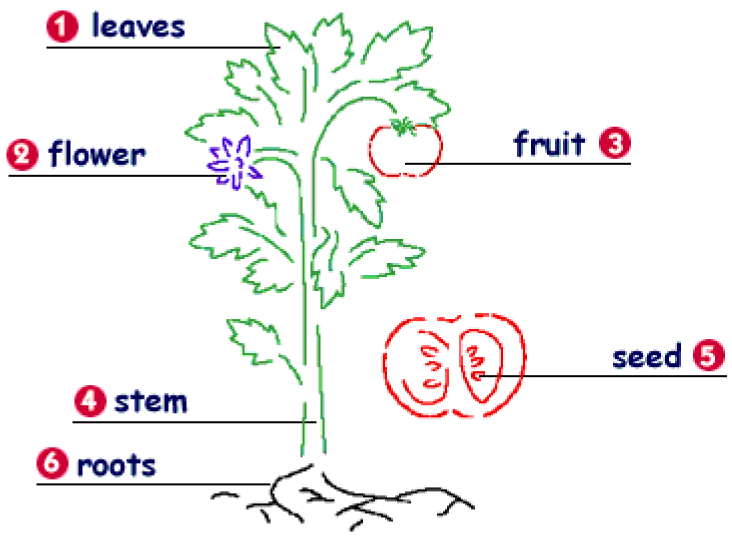


- Phloem tissue transports food from leaves to other parts of the plant.

Differences between Plant and Animal Tissues

PLANT TISSUES	ANIMAL TISSUES
1- Dead supportive tissues are more abundant as compared to living tissues.	**1-** Living supportive tissues are more abundant as compared to dead tissues.
2- Require less maintenance energy.	**2-** Require more maintenance energy.
3- Differentiation of meristematic and permanent tissues.	**3-** No differentiation of meristematic and permanent tissues.
4- Organisation is simple.	**4-** Organisation is relatively complex.
5- Tissue organisation is meant for stationary habit of plants.	**5-** Tissue organisation is meant for high mobility of animals.

- Plants have different parts. Each part serves different functions that help the plant survive.



- Roots

Roots lies below the surface of the soil and hold the plant firmly in place. Its main function is to absorb water and nutrients for the plant. It store food and nutrients and provide support to the plant. Roots of many plants are eaten as food such as beetroot, radish, carrot etc.

<u>**Types of Root System Based on Structure:**</u>

Based on their structure, all plant root systemsare broadly classified into two main types:

1. Taproot or Primary Root System

It is the root system that develops from the growing embryo (radicle) of a germinating seed. The taproot is the true root that grows vertically downwards and produces many lateral roots called root hairs. The taproot system is present in all dicot plants.

Examples: Mango, carrot, radish, sugar beet, and parsnip

2. Adventitious Root System

It is the root system that develops from any part of the plant other than the radicle – usually a stem and sometimes a leaf. The adventitious roots are found in monocot plants where the taproot is short-lived.

Examples: Grass, sugarcane, oak, and ivy.

Based on the origin of the adventitious root, they are further classified into:

a) Fibrous Roots

They are slender, branched, bushy roots that grow directly from the stem of the plant. Fibrous roots are formed from moderate branching of the taproot and do not penetrate deep into the soil.

Examples: Grass, rice, wheat, maize, and banana.

b) Foliar Roots

They arise naturally from leaf veins or petioles due to some injury on the leaf. The injured region develops new buds called foliar buds, which later give rise to these roots for new plants to grow. Sometimes, artificial application of plant growth hormones can also stimulate the plant to develop new foliar buds from the region where it is applied.

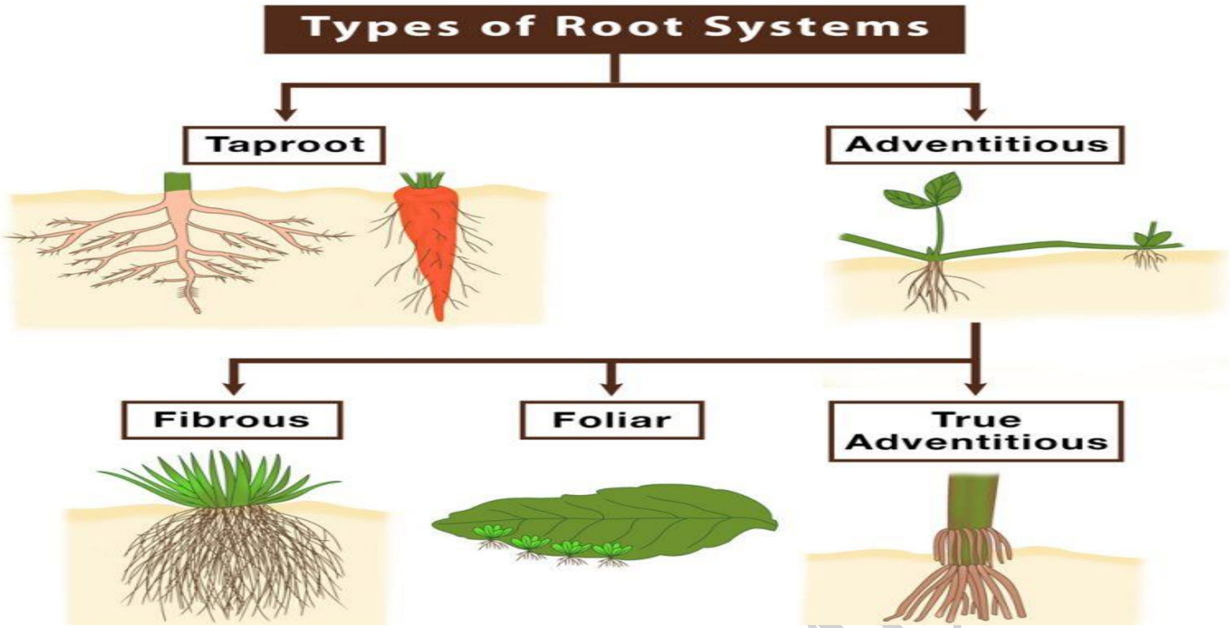
Examples: Pogostemon, rubber plant, Bryophyllum, and Begonia.

c) True Adventitious Roots

Lateral buds that arise from parts of the stem (at the nodes and internodes) are called true adventitious roots.

Examples: Aerial roots of a banyan tree, stilt roots of sugarcane, and clasping roots of the money plant.

Although all plant roots are mainly classified into two main types based on their structure, some roots undergo further modifications to carry out other dedicated functions, based on which they are classified below.



-Types of Root Modifications

Roots of some plants undergo a change in their shape and structure to perform specialized functions, other than the basic ones. The different types of those modifications are listed below:

Based on Physiological Functions

Sometimes roots are modified to perform the basic chemical and physical processes needed by the plant to grow and survive, based on which roots are classified into the **following types:**

1) Storage roots: They become fleshy to store reserve food materials. Examples: Radish, carrot, beet, Mirabilis, and Echinocystis

2) Aerial roots: Also called epiphytic roots, they are found above the ground and helps plants to absorb moisture from the air. Examples: Mangroves, banyan trees, common ivy, and poison ivy.

3) Assimilatory roots: Also called photosynthetic roots, they are green roots which prepare food for the plants by photosynthesis. Examples: Taeniophyllum,Trapa, and Tinospora.

4) Reproductive roots: Some fleshy adventitious roots develop buds that can grow into a new plant. Examples: Sweet potato and dahlia.

5) Respiratory roots: Also called pneumatophores or breathing roots, they are found above the ground and helps plants in gas exchange. Examples: Mangrove plant, Heritiera, Sonneratia, Avicennia, and Ceriops.

6) Epiphytic roots: Also called hygroscopic roots, they grow on the trunk and branches of trees and help to absorb moisture using special sponge-like tissue called velamen. They act as the main root systems of epiphytic plants. Examples: Venda and Dendrobium.

7) Saprophytic roots: Also called mycorrhizal roots, they are associated with fungal hyphae for the absorption of water and minerals. Examples: Monotropa and Sarcodes.

8) Parasitic roots: Also called haustorial roots, they grow on other plants and depend partially or totally on the host to derive nutrients for their own survival. Examples: Cuscuta and Viscum

- Classified Based on Roots Mechanical Functions:

Some roots get modified to provide strength and protection to the plant, based on which roots are classified into the following types:

1) Prop roots: These are adventitious roots that arise from the aerial branches of trees and help in their additional support. Examples: Banyan tree, rubber plant, and corn

2) Stilt roots: They are obliquely growing adventitious roots that develop from the lower nodes of the stem to give additional support to the plant. Examples: Sugarcane, maize, sorghum, Pandanus, and Rhizophora.

3) Buttress roots: The horizontal plank-like aerial, adventitious roots that develop at the base of the stem to give additional support to the plant. Examples: Terminalia and Salmalia.

4) Climbing roots: The adventitious aerial roots that arise from the nodes or internodes of weak stemmed plants that need support to climb. Examples: Pothos, Piper betel, Vanilla, and Hedera.

5) Contractile roots: Also called pull roots, they are modified, underground stem that adjusts itself to contract or swell according to the depth of the soil for the absorption of water and minerals. Examples: Canna, Crocus, Allium, Lilium, and Freesia.

6) Floating roots: They develop from the nodes of floating plants that help the plant to float in water. Examples: Water lily and duckweed.

7) Root-thorns: The adventitious roots sometimes become hard and pointed to help reduce water absorption in the plant to adapt to the environment with low water content, as found in the arid and semiarid regions. Examples: Pothos, Acanthorhiza, and Iriartea.

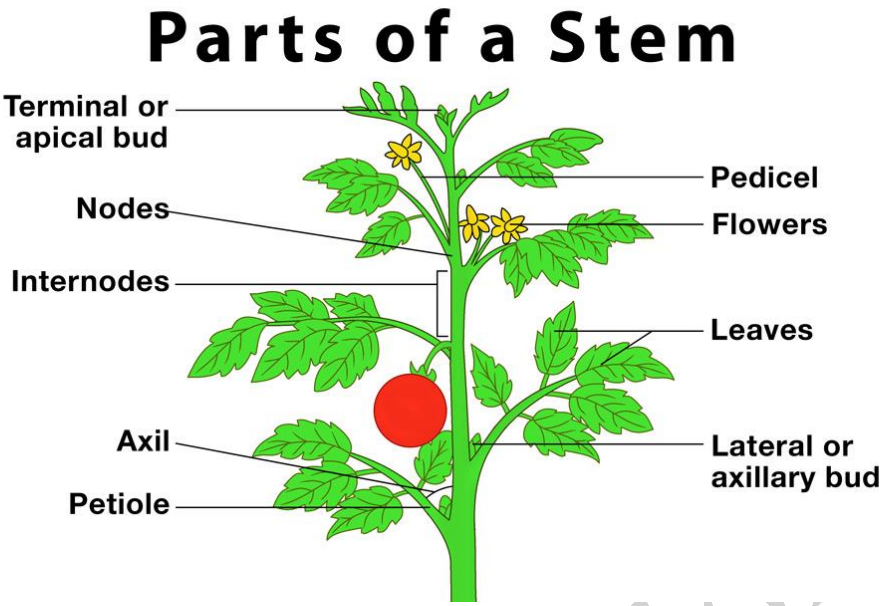
Although roots are one of the fundamental structures in a plant that carries out a variety of functions either naturally or through modifications, some group of plants called bryophytes (e.g., mosses and liverworts) does not have roots. They require direct contact with water to absorb water and minerals through their leaves.

- Stem

The stem is the central axis of the plant, which is mostly found above the ground, the root being the other part. They may be unbranched like those in a palm tree or branched like that of rose plants.

The stem is the connecting medium between the roots, the leaves, and the flowers, whose primary function is to provide mechanical support to the plant. The main woody stem of a plant is called the 'trunk'. Stems of many plants are eaten as food such as potato, ginger etc.

A typical plant stem consists of eight distinct parts, containing six elements and two organs. The six elements are: 1) nodes, 2) internodes, 3) terminal or apical bud, 4) lateral or axillary bud, 5) petiole and 6) pedicel. While the two organs are: 7) leaves and 8) flowers.



1) Nodes

They are the region of active division where the buds, leaves, aerial roots, and the branches originate. Nodes can hold several leaves and buds together in a stem.

Functions:

Helping the plant to form buds, leaves, and branching twigs

Helping plants to heal from injury

Providing additional structural support to the plant

Reproducing new plant parts or even a complete plant by the process of stem cutting, like rose, salvia, dahlia, boxwood, etc.

2) Internodes

Also known as the 'internodal' zone, they are the regions between two successive nodes. Internodes are widely spaced between the nodes in most plants, while in few others, they are short, making the two adjacent nodes to be closely separated as found in dwarf conifers.

Functions:

Acting like blood vessels that carry and distributes food, water, and minerals from one node to another

Providing height to the plant, greater the inter-nodal space more the height of the plant

3) Terminal or Apical Bud

It is the small extension found at the tip of the plant. Terminal buds are always in a state of division, thus contributing directly to the growth of the plant.

Functions:

Acting as the primary growing point in the stem

Producing growth hormones that inhibit the growth of other buds in the stem (apical dominance), thus helping the plant to grow vertically upwards

4) Lateral Bud or Axillary Bud

It is the small bud that develops from the region between the stem and a leaf called axil. Lateral buds later give rise to a new stem. Although they mostly remain inactive, under favorable conditions of growth they develop into shoot, leaf or a flower, based on the requirement of a plant.

Functions:

Helping the plant to develop its lateral branches and leaves, the vegetative parts of a plant

Helping the plant to develop flowers, the reproductive part of a plant

5) Petiole

The thin stalk of the leaf that connects the leaf to the node of the stem is called a petiole. A leaf with a petiole is called a petiolate leaf, whereas leaves without them are called sessile.

Functions:

Attaching the leaf to the stem and thus providing strength and support to the leaf

Transporting water and minerals from the stem to enter the leaf and photosynthetic products to be distributed from the leaf to the rest of the plant

6) Pedicel

The short, slender stalk that attaches an individual flower in a cluster of flowers (inflorescence) is called a pedicel. A flower without a pedicel is called a sessile.

Functions:

Exposing flowers to the sun and wind so that they can attract pollinators like bees and insects for the purpose of sexual reproduction in plants

7) Leaves

They are the thin, flat organ of a plant that is generally green in color. Leaves are the main lateral appendage of the stem that arises from the nodes.

Functions:

Helping plants to produce food with the help of sunlight, carbon dioxide and water by a process called photosynthesis

Helping the plant to cool down by losing water in the form of water vapor by a process known as transpiration

There are large number of minute openings present on the leaves, called stomata, through which gaseous exchange takes place between the atmosphere and the plant body. Non green plants such as mushroom do not prepare their food. Leaves of many plants are eaten as food such as spinach, lettuce, cabbage etc.

8) Flowers

They are the most colorful and attractive organ of a plant which varies widely in shape and size with every plant species.

Functions:

Helping in the sexual reproduction of plants

Attracting pollinators like bees and other animals that help to transfer pollen grains from the male to the female reproductive part of the flower, a process known as pollination.

Sweet smelling flowers petals are used for making perfumes. Flowers are widely used for decoration and for making garlands. Some of the common flowers are lotus, rose, marigold, jasmine, sunflower, hibiscus etc. Flowers that we eat are broccoli and cauliflower.

-<u>Fruits</u>

The fruit is a fleshy or dry ripened part of a plant, enclosing the seed or seeds. Some of the fruits that we eat are orange, mango, apple, grapes, etc.

-Seeds

The hard part inside the fruit is called seed. Most plants grow from seeds. Some fruit seeds we eat are pomegranate, banana, fig, guava, kiwi, grapes etc. We do not eat seed of apple, chikoo and many other fruits.

❖ Monocots and Dicots

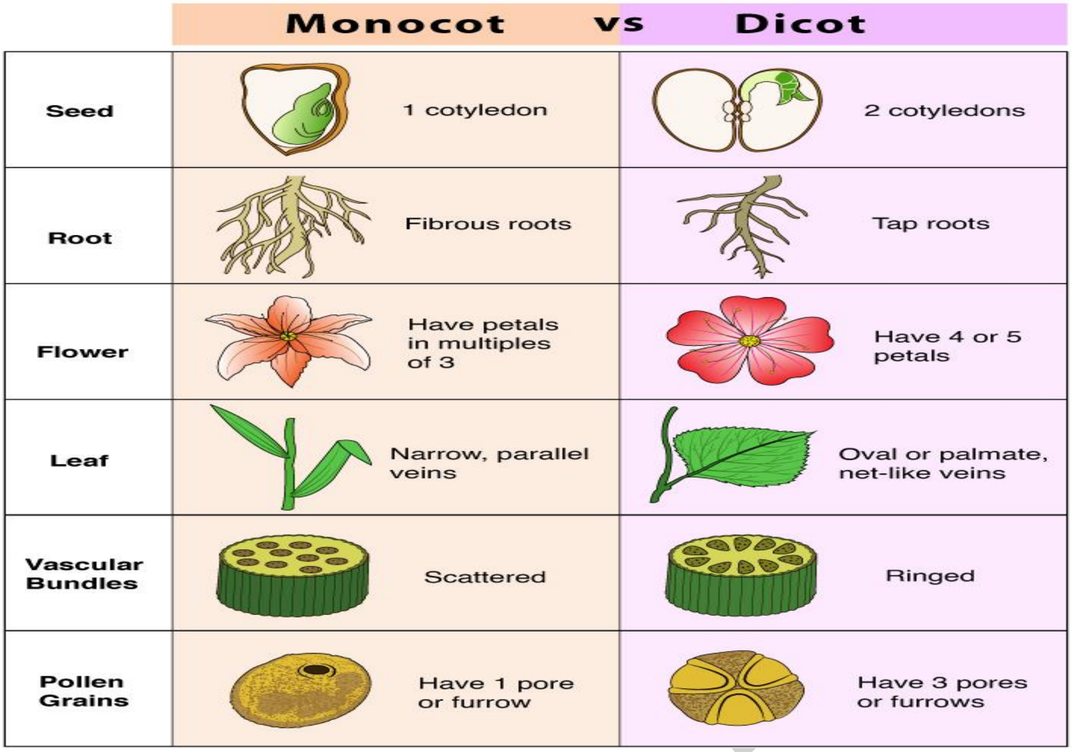
Monocots are flowering plants having seeds with a single cotyledon or embryonic leaf. There are as many as 60,000 plant species found worldwide. The orchids (Family: Orchidaceae) and the grasses (Family: Poaceae) form the largest and the second most abundant group, respectively. All monocots share a common evolutionary history, thus are a monophyletic group.

Dicots are flowering plants having seeds with two cotyledons or embryonic leaves. They are the largest group within angiosperms consisting of about 200,000 species. Unlike monocots, dicots are not plants arising from a single ancestor but have evolved from different lineages. Thus dicots are paraphyletic.

The Difference between Monocot and Dicot

Monocots and dicots differ in four distinct structural features: seeds, leaves, stems, roots, and flowers.

However, the difference starts from the very beginning of their life cycle in the form of a seed. Within the seed lies the embryo or the baby plant. At the start of their life cycle, the difference in their embryo leads each plant to develop vast differences.



Plant Needs

Plants are living organism and need food for growth. Plants prepare their own food. The necessary ingredients plants need to make their food are:-

- Sunlight – Plants leaves absorb sunlight as required by the plant. Some plants need more sunlight and some need less. There are plants that need shade as they require very limited amount of sunlight.

-Sufficient water – Adequate water is required for the healthy growth of plants. Too much or too little water will harm the plants and plant may die. Plant absorbs water by roots. The amount of water needed varies between all types of plants.

-Adequate air and temperature – Plants take in carbon dioxide through leaves and gives out oxygen in the process of photosynthesis. The plants should be around little wind to help sustain their structural components.

-Rich soil - Plants derive nutrients or minerals that they need from the soil where they are planted. These minerals are taken in by the roots.

-Space– Plants need sufficient space to grow and expand their roots to bind them to the ground. Overcrowded plants are more likely to die.

Lec-8/

Mendel's Laws of Inheritance

-Mendel discovered that crossing plants with white flowers and purple flowers did not produce hybrid offspring. The offspring was purple flowered, rather than a mixture of the two.

Mendel's results were condensed into three inheritance laws: the Law of Dominance, the Law of Segregation, and the Law of Independent Assortment.

-He then came up with the concept of "factors," which are two types of heredity units, one recessive and the other dominant. Factors, later called genes, are usually found in pairs in ordinary body cells, but segregate during the development of sex cells, according to Mendel.

Laws of Genetics

- **Segregation**
- **Independent Assortment**

- **<u>Segregationist (Purity of Gametes)</u>**

"Each gene separates from the others during gamete formation, resulting in only one allele for each gene in each gamete."

-According to the Law of Segregation, when an individual creates gametes, the copies of a gene separate so that each gamete only receives one copy.

-One allele or the other will be received by a gamete. The direct proof of this was later found the process of meiosis.

-The paternal and maternal chromosomes are separated during meiosis, and the alleles with the characters are divided into two gametes.

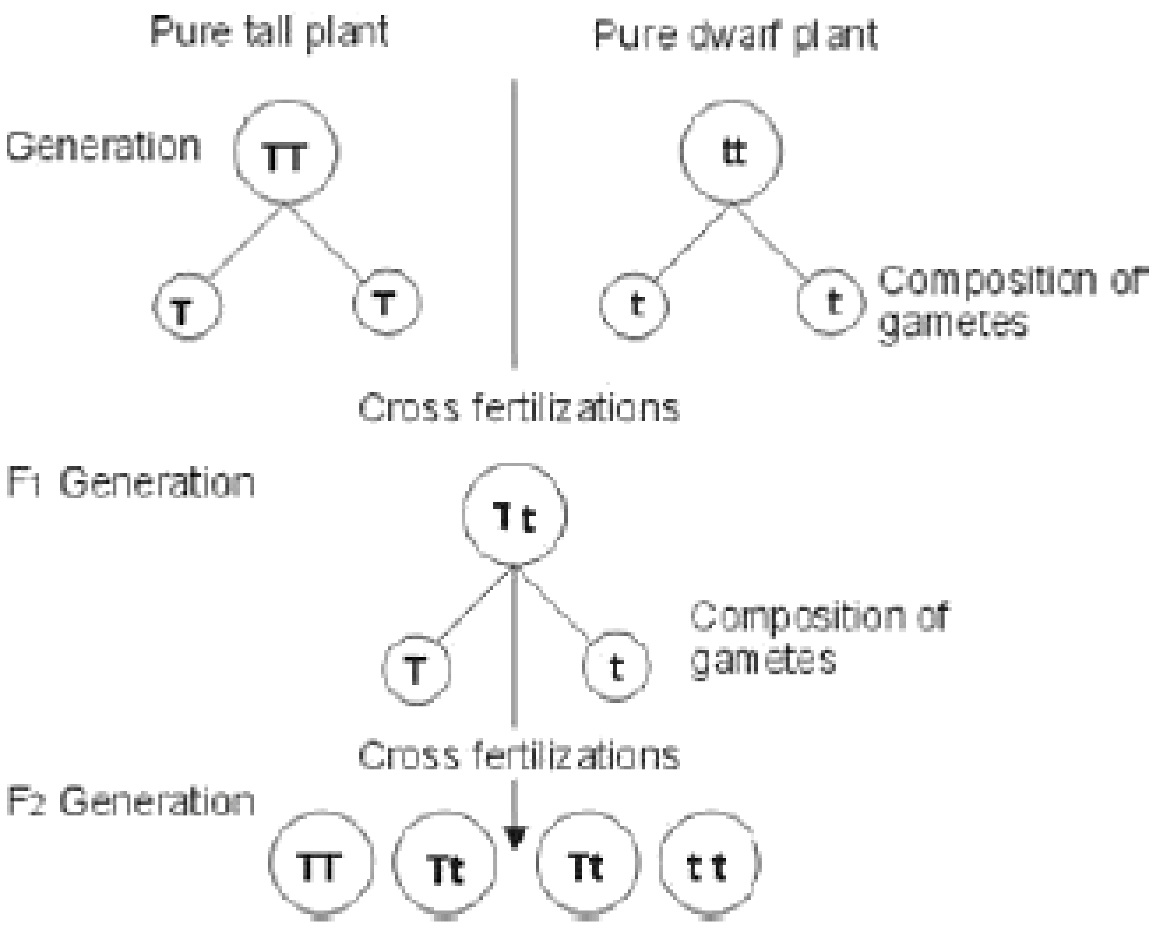
For example, pure tall plants are homozygous for genes (factors) TT, while dwarf plants have genes tt. Tallness and dwarfism are two distinct but related variables or

determinants. Pure tall plants produce T type gametes, while dwarf plants produce t type gametes.

-Gametes with T and t combine during cross fertilization to create F1 hybrids. Tt is the genotype of these hybrids. It means that F1 plants have one gene for tallness and one gene for dwarfness, despite the fact that they are tall phenotypically. It seems that the tall and dwarf characters have been contaminated, with just the tall character remaining.

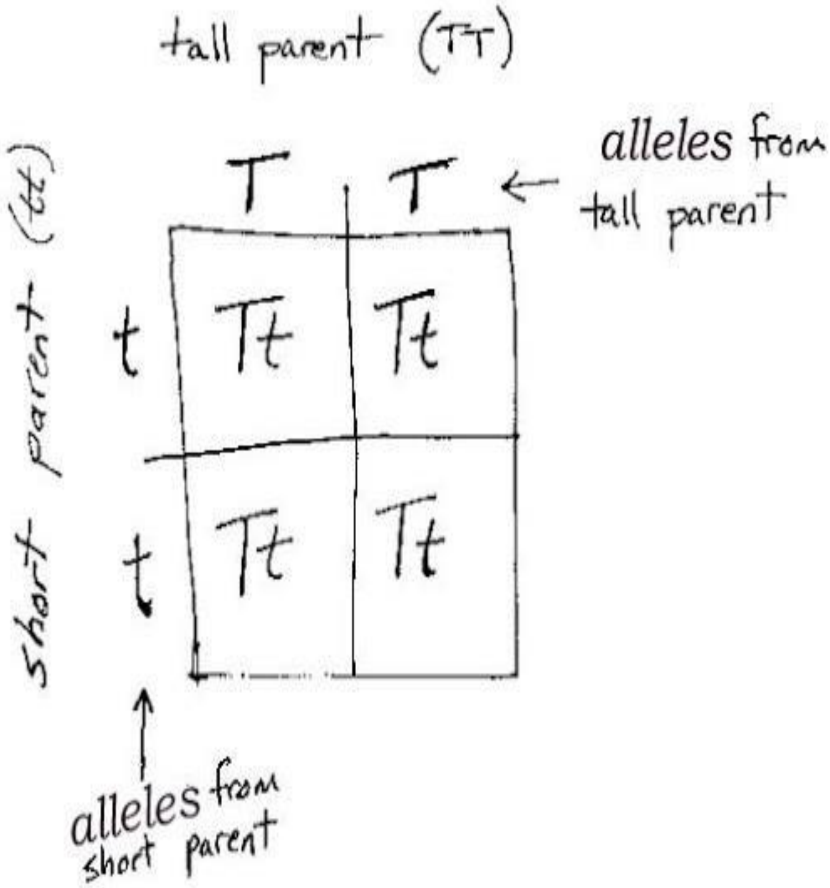
-The genes T (for tallness) and t (for dwarfness) separate and are passed on to separate gametes during gamete formation. As a result, the heterozygote produces two forms of gametes in equal numbers. Gene T is present in 50% of the gametes, while gene t is present in 50% of the gametes.

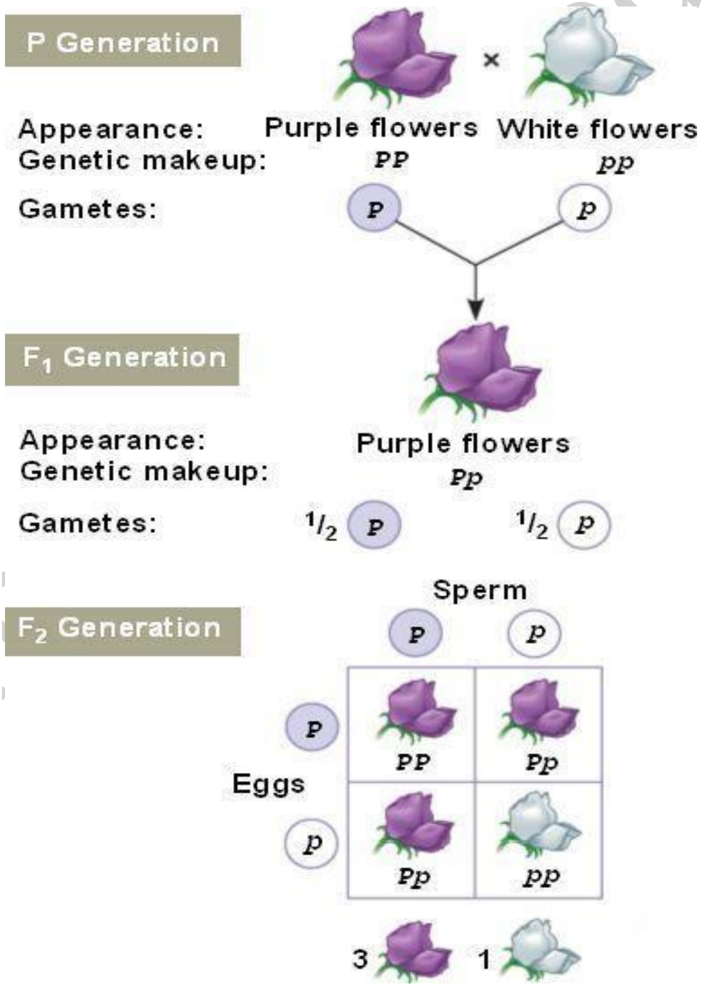
-As a result, these gametes are either pure for height or pure for dwarfism. (This is why the low of segregation is also known as the law of gamete purity.)



-Gametes unite at random, and when there are several gametes, all possible combinations will occur, resulting in a 3: 1 ratio of tall to dwarf.

The following is a common Punnett square representation of the results:





-Alleles: are different forms of the same gene. Alleles for a trait are located in homologous chromosomes at corresponding positions.

- Genotype: genes present in an organism (usually abbreviated as two letters).

- Phenotype refers to the physical appearance of a trait in an organism.

-Homozygous means having two similar alleles.

-Heterozygous refers to an individual who carries two different alleles.

-TT: homozygous Dominant or pure tall. (phenotype tall)

-Tt: heterozygous or hybrid. (phenotype tall)

-tt: homozygous RECESSIVE or pure short. (phenotype short)

- **Independent Assortment**

"The law of independent assortment states that the allels of different genes are inherited independently within the organisms that reproduce sexually."

-The inheritance of several pairs of characters (two or more) is studied at the same time, with the factors or genes for each pair sorting out independently of the others. From the results of a dihybrid cross, Mendel formulated this law.

-In eukaryotic species, independent assortment occurs during meiosis I, specifically metaphase I of meiosis, to produce a gamete with a mixture of maternal and paternal chromosomes. This process, like chromosomal crossover, adds to genetic diversity by forming genetic combinations.

-The chromosomes that end up in a newly formed gamete are selected randomly from all possible combinations of maternal and paternal chromosomes in independent assortment.

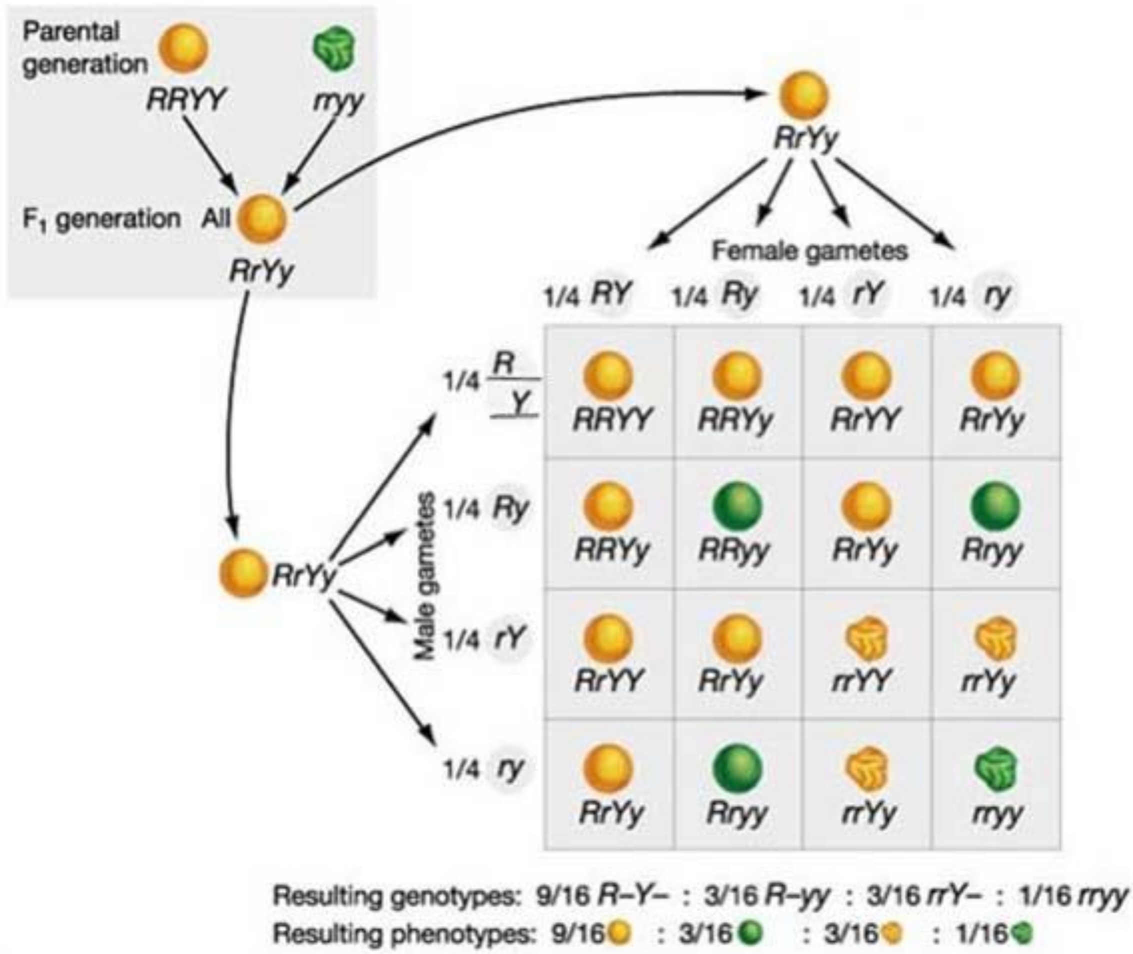
-Gametes assorted individually since they end up with a random mix rather than a pre-defined "set" from either parent. As a result, the gamete may have any mix of paternal and maternal chromosomes.

-He selected round-yellow seed and wrinkled green seed for the dihybrid cross and crossed them. In the F1 generation, he only got round yellow seeds. Self-pollination of F1 progeny in four separate seed combinations in the F2 generation. In the phenotypic ratio 9: 3: 3: 1, he obtained round-yellow, wrinkled-yellow, round green, and wrinkled green seeds.

-The phenotypic ratios of 3: 1, yellow: green color and ratios of 3: 1, round: wrinkled seed form from the monohybrid cross were also retained in the dihybrid cross. As a result, he came to the conclusion that characters are distributed and inherited in separate ways. He came up with his third law, the Law of Independent Assortment, based on this discovery.

-The rule is explained by dihybrid crosses of the parental genotype RRYY (round yellow seeds) and (rryy) (green wrinkled seeds). The chances of gametes forming with the gene R and the gene(r)are 50:50 in this case. Additionally, the gene (Y)and the gene (y) have a 50:50 chance of forming gametes. As a result, each gamete should have (R) or (r)and(Y) or (y).

-According to the Law of Independent Assortment, the segregation of R and r is unrelated to the separation of Y and y. As a result, there are four different types of gametes: (RY, Ry, rY, and ry). These allele combinations are different from their combinations of their parents (RR, YY, rr and yy).

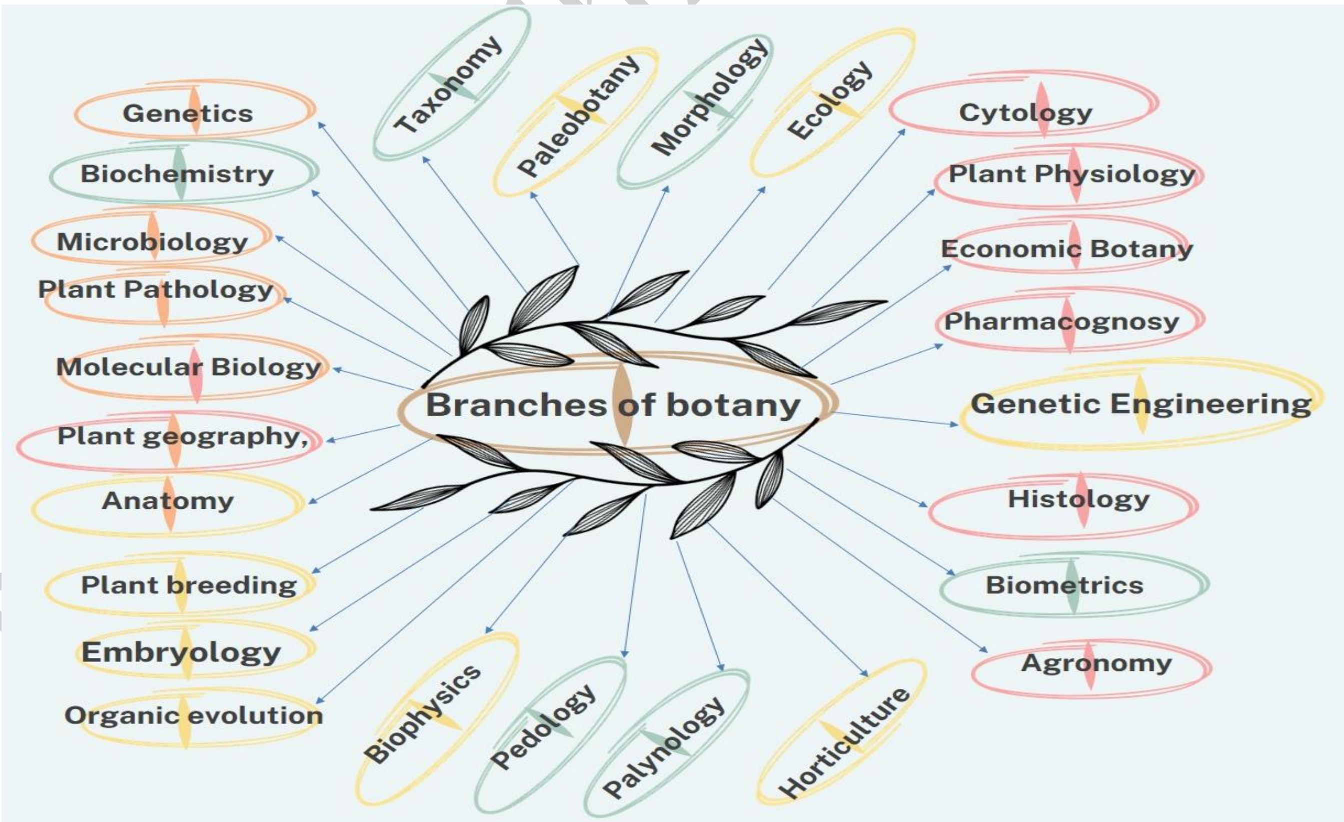


Lab-1/

BOTANY

Introduction

The early botanical knowledge leads to the development and evolution of multidisciplinary subject as modern botany in recent years. The inputs from various sources of science and technology have tremendously enriched the subject Botany. Today this subject is a fusion of traditional and classical components with that of modern disciplines resulting in to a splendid natural science. We have today the various branches of Botany which have been enriched through inputs from extensive studies and researches, **e.g.:** Taxonomy, Paleobotany, Morphology, Ecology, Cytology, Genetics, Plant Physiology , Biochemistry, Molecular Biology, Microbiology, Plant Pathology, Embryology, Economic Botany, Pharmacognosy, Histology, Plant geography, Anatomy ,Plant breeding, Organic evolution , Biophysics, Biometrics , Genetic Engineering , Agronomy , Horticulture , Palynology, Pedology.



❖ Branches of botany:

1.Morphology (Morphe=form, logos=science) : Under this branch we study the form and structure of plants. That branch of morphology which is based upon the external form and structure of plant is called External Morphology.

2.Anatomy : The study of internal structure of the plants with the help of section cutting, is called Internal Morphology or Anatomy.

3.Histology : The study of cells and tissues with the help of microscope is called histology.

4.Cytology : Detailed study of the cells is called cytology. It includes structure, function of different cell organelles, nucleus and cell inclusions. Different types of cell divisions are included in this branch. The study of this branch has become possible only with the help of electron microscope.

5.Plant Physiology : This branch includes the study of various vital activities of the plant. All chemical and physical changes taking place in the cell and any exchange of substances between the cell and its environment are called vital activities of the cell, e.g., photosynthesis, respiration etc.

6.Taxonomy : In this branch the plants are classified according to their characteristics and interrelationship. With the help of plant taxonomy we are able to identify the plants and know their characters.

7.Ecology (Oikos = house; logos = science) : This branch deals with the study of environment of plants and their communities and vice-versa. Included in this branch are the studies of adaptations of plants with reference to their environment. This branch also includes the studies of soil erosion, soil conservation and pollution.

8.Plant geography : This branch deals with the distribution of plants on the earth and reasons thereof.

9.Genetics : Is the study of heredity and variations. What are the Laws of inheritance and why the offspring resembles or differs from the parent are studied under this branch.

10.Plant breeding : Branch of botany dealing with the development of improved varieties of plants.

11.Embryology : The male and female gametes of a plant fuse to form the zygote. Zygote develops into an embryo (in embryophyta) with plumule, cotyledons and radicle.When germination of seed takes place, the entire plant develops from these organs. We study all these developments inembryology.

12.Paleobotany: Paleobotany is the study of fossil plants. Plants which flourished and lived on the surface of globe several million year ago but are not living now and are found as rocks. In which rocks and parts of the world they are found, what is their structure and how they are interrelated to the plants of the present day.

13. **Economic Botany :** In this branch of Botany we study the plants with reference to their products. Which plants produce medicines, gums,oils,fibers, fuel,wood etc.,are studied under this branch.

14. Plant Pathology : This branch includes different types of disease of plants, their symptoms, causal agent and methods of control.

15.Organic evolution : This is the branch of Botany in which we study the evolution of complex organisms from simple ones and the principles involved in it. Some new aspects of Botany based on modern technology are as follows.

16.Biochemistry (Phytochemistry) :Study of chemistry of plants.

17.Biophysics : Study of plant activities on the basis of principles of physics.

18.Microbiology : Study of microorganisms. It includes the study of viruses, bacteria, microfungi,microalgae and protozoa in relation to plants.

19.Molecular biology : Study of biochemistry at molecular level.

20.Palynology : Study of pollen grains in relation to taxonomy and evolution etc.

21.Biometrics : Statistical analysis of different results of biological experiments.

22.Genetic Engineering : Adding, removing or repairing part of genetic material, thereby changing the phenotype of organism as desired.

Lab-2/

Branches allied to Botany :

23.Agronomy : Is the science which deals with the crop plants.

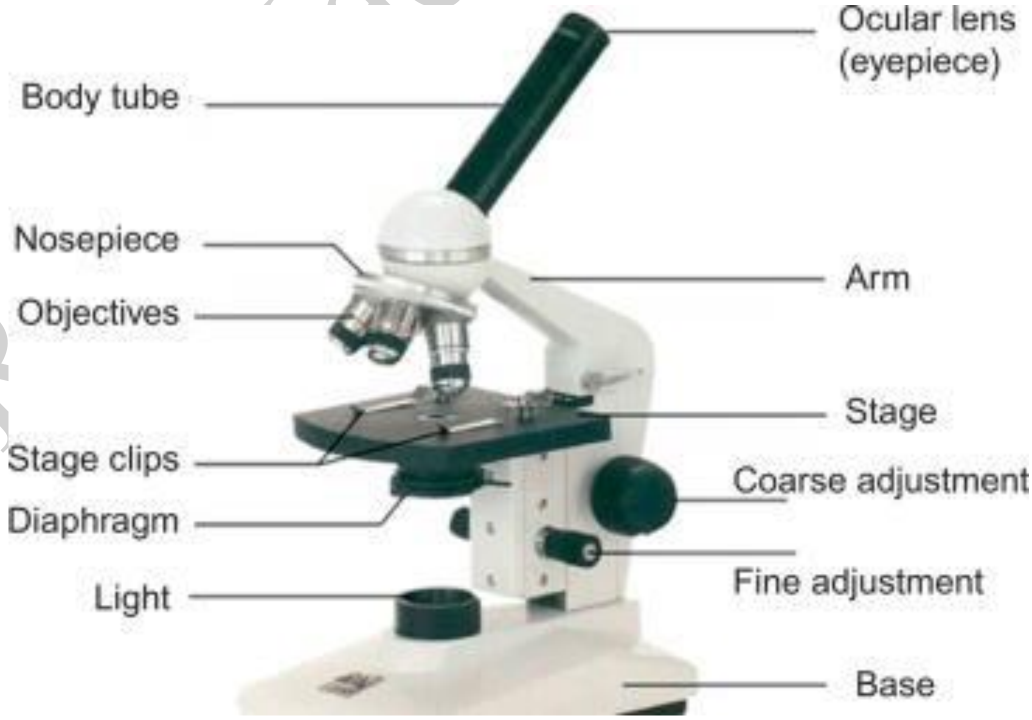
24.Horticulture : Is the science which deals with the study of flowering and fruiting plants.

25.Pharmacognosy : Is the branch of science dealing with the medicinal plants.

26.Pedology : Is the science dealing with the study of soils.

❖ The Light microscope

Light microscopy (the use of light to magnify objects) is one of the oldest and most powerful scientific techniques. Microscopes are used by many scientists to study the structure of matter, such as plant cells and bacteria. A light microscope's power allows scientists to view and examine small features of matter as well as study the relationships between them. Using a light microscope to examine objects allows scientists to make more accurate predictions about the structure and behavior of matter. Furthermore, using light microscopes allows researchers to study living organisms more precisely and quickly than other methods.



- First microscope was discovered by Zacharia Janssen (1595) from Thailand.

-**Magnification**: The increase the image size of an object is called magnification.

- **Resolution**: The instrument which show object separately is called resolution. (Human eye resolution power is 0.1)

- The magnification of a light microscope is formed using a mixture of the powers of the eyepiece and the objective lens. The eyepiece produces a power of 10x and the objective lens can produce various different powers, so if it were to produce a power of 100x, the final magnification would be 1000x (10 x 100).

❖ Comparing Prokaryotic and Eukaryotic Cells

- All cells have several basic features in common: They are all bounded by membrane, called a plasma membrane. Within the membrane is a semifluid substance, **cytosol**, in which organelles are found. All cells contain chromosomes, tiny organelles that make proteins according to instructions from the genes.
- A major difference between prokaryotic and **eukaryotic cells**, indicated by their **names**, is that the chromosomes **of a** eukaryotic cell **are located in a membrane-enclosed** organelle called the *nucleus*.
- The word *prokaryotic* is **from** the Greek***pro***, meaning "before,"*and* ***karyon,*** meaning "kernel,"referring here **to the nucleus**. In a **Prokaryotic cell,** the DNA is concentrated in a region called the **nucleoid**, but no membrane separate this region from the rest of the cell.
- In contrast. The **eukaryotic cell** (Greek *eu*, true, and *karyon*) has a **true** nuclear envelope.
- The entire region between the nucleus and the plasma membrane is called the cytoplasm, a term also used for the prokaryotic cell. Within the cytoplasm of a eukaryotic cell, suspended in cytosol, are a variety of membrane- bounded organelles of specialized form and function. These are <u>absence of a true nucleus </u>is just one example of the <u>disparity in structural complexity between the two types of cells.</u>

❖ Experiment:

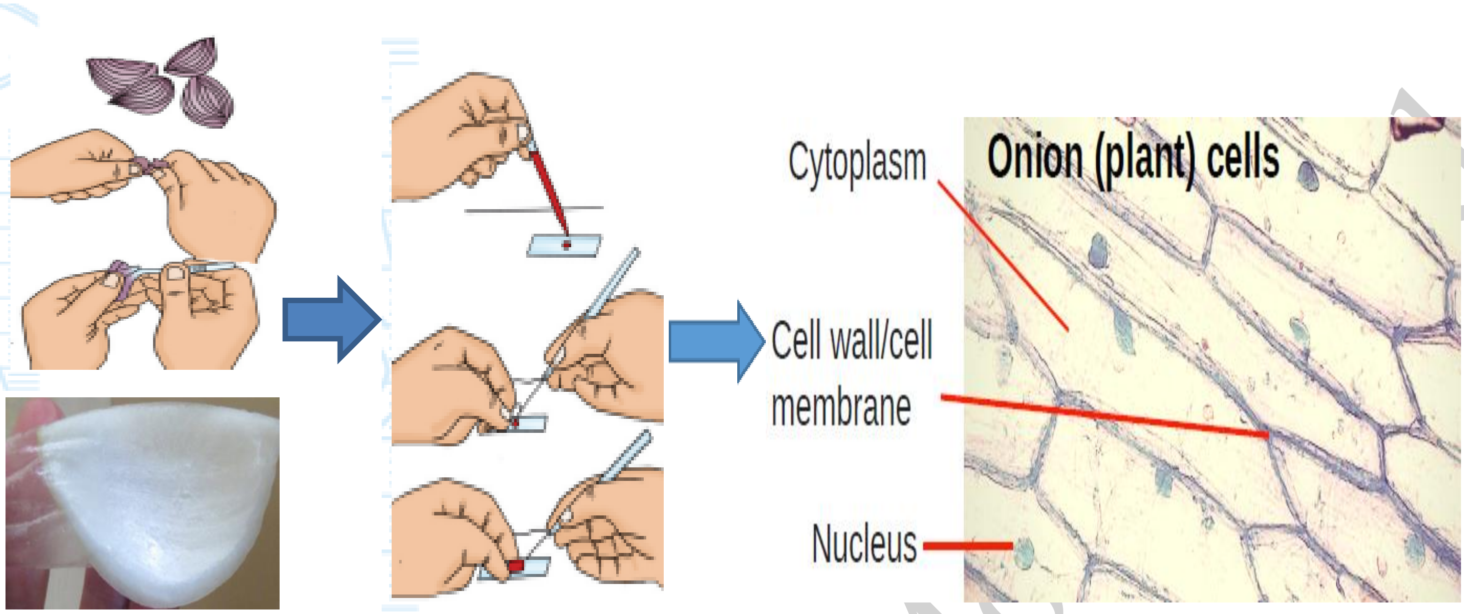
-AIM : To prepare a stained, temporary mount of onion peel and to study its cells.

-THEORY : All living organisms are composed of cells. New cells arise by the division of pre-existing cells. Cell is the structural and functional unit of life. In plants, cells have an outermost rigid cell wall beneath which is a cell membrane. The cell membrane encloses cytoplasm, cell organelles, and a nucleus.

-MATERIALS REQUIRED: An onion bulb, slides, cover slips, two watch glasses, needle, brush, forceps, razor blade, compound microscope, blotting paper, methylene blue (or safranin) solution, glycerine, and water.

-PROCEDURE:-

1. Take one fleshy scale leaf of an onion. Break it into two and using a forcep pull out a thin membranous peel adhering to the inner surface of the leaf. This is the epidermal peel.
2. Place the peel in a watch glass containing water and cut it into small rectangular pieces.
3. Mix 1 or 2 drops of methylene blue or safrarin in a small quantity of water taken in another watch glass and transfer the peels into it. Leave the peels for about 3 minutes. Dip the peel in water to remove excess stain.
4. Take a clean slide with a drop of glycerine in the middle and using a brush transfer the washed and stained peel on to it.
5. Place a cover slip over it by slowly lowering it with a needle. Avoid entry of air bubbles.
6. Remove excess glycerine from the edges of cover slip with the help of a piece of blotting paper.
7. Observe the slide under the microscope, first in low power and then in high power.
8. Draw a labelled diagram of the cells as seen under microscope.
9. Note the features listed in the observation table.



(a) **(b)** **(c)**

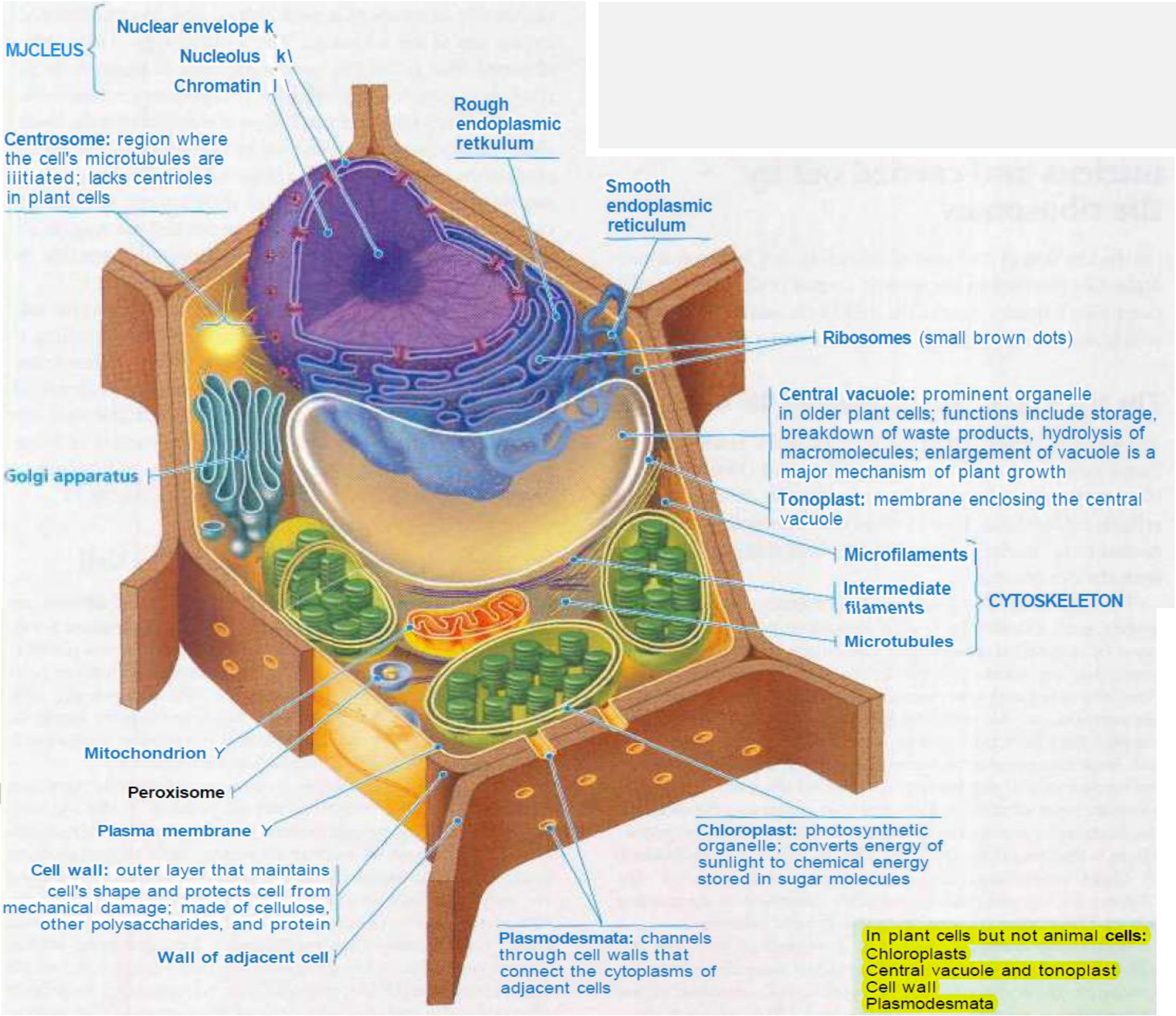
Fig. (a) Method of removing an epidermal peel from onion leaf**. (b)** Staining and mounting the onion peel**. (c)** Onion (plant) cells under microscope**.**

OBSERVATION TABLE

NO.	Feature	Observation
1.	Shape of cells	spherical/oval/rectangular/square
2.	Arrangement of cells	compact/loose
3.	Inter-cellular spaces	present/absent
4.	Nucleus present	absent
5.	Cell wall present	absent
6.	Stained portions of cell	cell wall/cytoplasm/nucleus
7.	Unstained portions of cell	cell wall/cytoplasm/vacuole

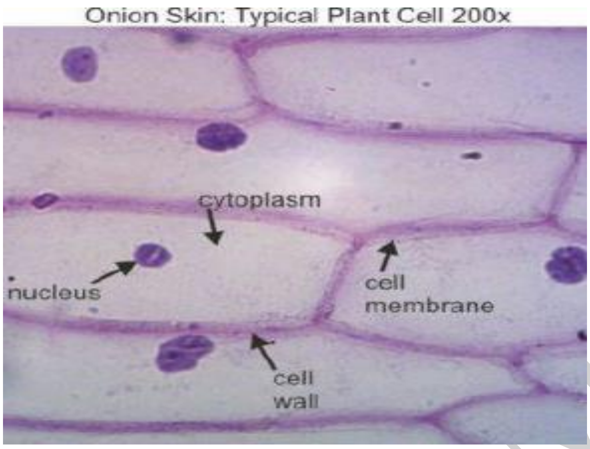
Lab-3 / Plant Cell Structure

- Plants are multicellular organisms composed of millions of cells with specialized function. All plant cells have the same basic eukaryotic organization.
- The plant cell consists of a more or less rigid cell wall. The protoplast consists of the cytoplasm and a nucleus (the most visible structure in the protoplast of eukaryote cells).
- The cytoplasm includes: distinct membrane-bound organelles such as plastids and mitochondria; systems of membranes (endoplasmic reticulum and dictyosomes); nonmembranous 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 Plasma Membrane.



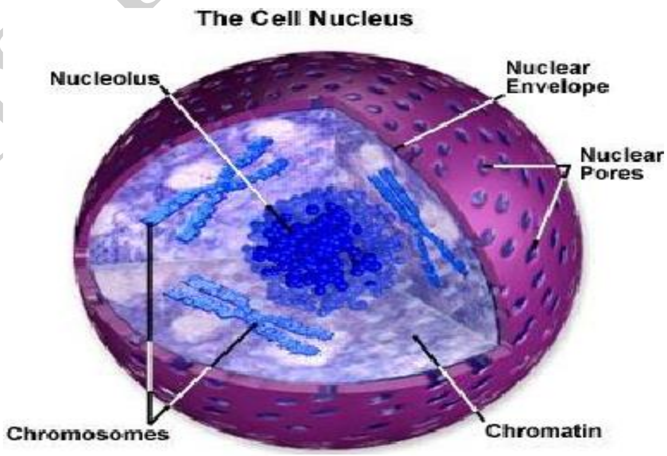
Plasma Membrane Functions

- It allows substances to move into and out of the protoplasm.
- It regulates cellulose microfibril synthesis and assembly.
- It transmits hormonal and environmental signals that regulate cell growth and differentiation.



Nucleus Functions

- Control of the cell's genetic information.
- Control protein and enzyme synthesis in the cells.
- Control the cell division and growth.
- Storage DNA, RNA, and ribosomes.
- Regulation of the transcription of mRNA to protein.



Plastids Functions

Plastids are a characteristic component of plant cells:

-Chloroplasts help in synthesizing food by the process of photosynthesis

-Chromoplasts attract pollinators and thus aid in pollination

-Gerontoplasts helps in breaking down the photosynthetic apparatus during plant cell death

-Amyloplasts stores starch

-Proteinoplasts stores protein

-Elaioplasts stores fat and oil

-Plastids are classified and named based on the kinds of pigments they contain.

Different Types of Plastids with Examples

1- **Proplastids**: Colorless and immature plastids that develop into any mature plastid, depending on the organ where they function. Proplastids are always in a state of active division. They later develop into chloroplast or leucoplast.

2- **Chloroplasts**: Present in all the green parts of the plant, and blue-green algae. They are green in color due to the presence of the pigment chlorophyll.

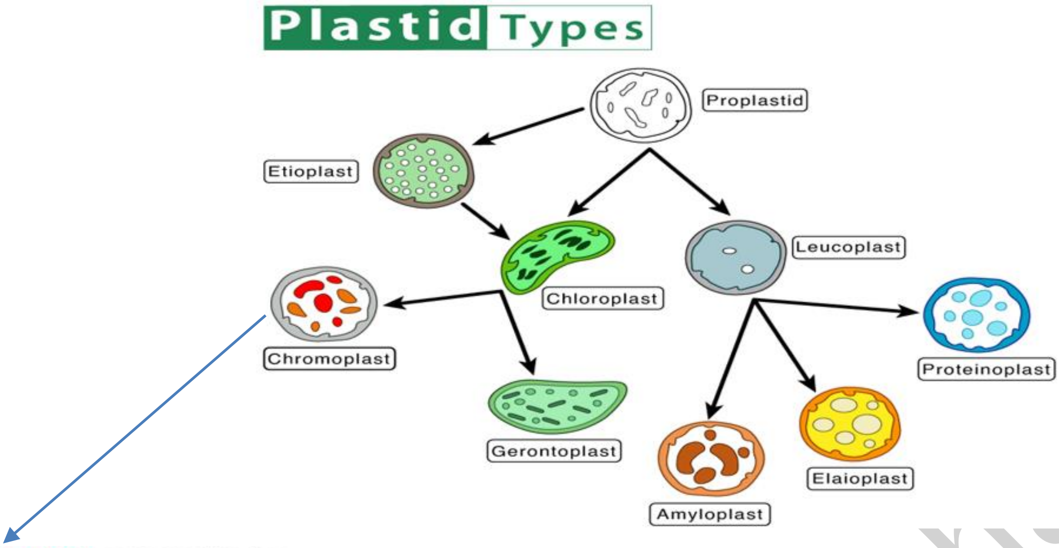
3- **Leucoplasts**: Non-pigmented organelles that are colorless and are found in the endosperm of seeds, roots, and other non-photosynthetic plant parts. Based on the type of food they store, leucoplasts are classified into the following 3 types:

- amyloplasts
- Proteinoplasts
- Elaioplasts

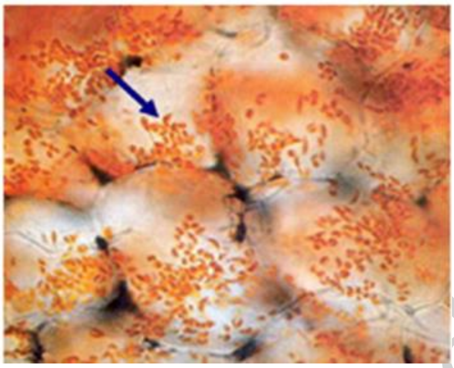
4- **Etioplasts**: They are chloroplasts that have not been exposed to light and are a transitional stage between the proplastid and the chloroplast during the greening process.

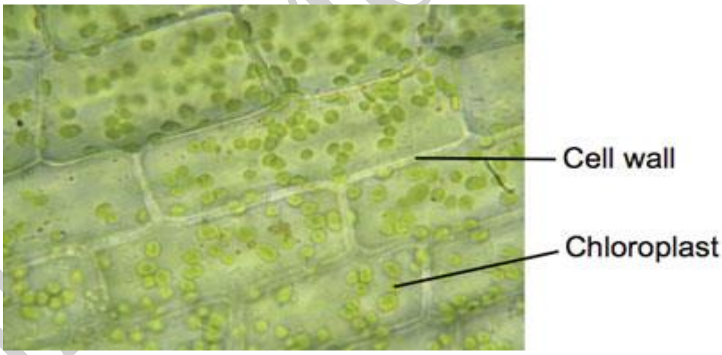
5- **Chromoplasts**: Present in flowering plants, aging leaves, and fruits. They are colored plastids assuming different colors that develop gradually from chloroplasts with time.

6- **Gerontoplasts**: They are chloroplasts that are going through the aging process. Gerontoplasts are present in the old leaves that are no longer performing photosynthesis.



Chromoplast– responsible for carotene(orange), xanthophylls (yellow) and red pigments.



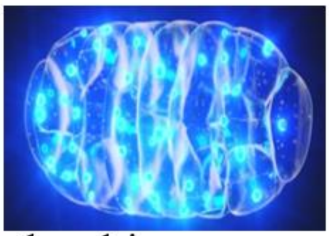


Mitochondria

-Mitochondria bounded by two membranes (inner & outer membrane),the inner membrane is folded into many pleats called <u>cristae.</u>

- Mitochondria are the sites of cellular respiration, where organic molecules are converted into <u>ATP</u>(the energy source for living eukaryote cells).

- plant cells may have hundreds to thousands of mitochondria.



Slide of plant mitochondria

Lab-4 / <u>Cell Division</u>

-Cell division is an important process in all living organisms. There are two types of division: mitosis and meiosis.

-**Mitosis**: Is nuclear division, which produces nuclei with the same number of chromosomes as the original nucleus, and the resulting two cells are known as daughter cells.

*In multicellular organisms, mitosis allows for tissue growth and repair.

-Meiosis: is a form of nuclear division in which the chromosome number is reduced by half. The same stage of nuclear division are present in meiosis as in mitosis, but these stage occur twice –meiosis (1) and meiosis (2) has two divisions, so in meiosis results four nuclei with haploid number of chromosomes.

Meiosis is a form of sexual reproduction in sexually reproducing organisms.

<u>Cell division undergo a sequence that includes three stages:-</u>

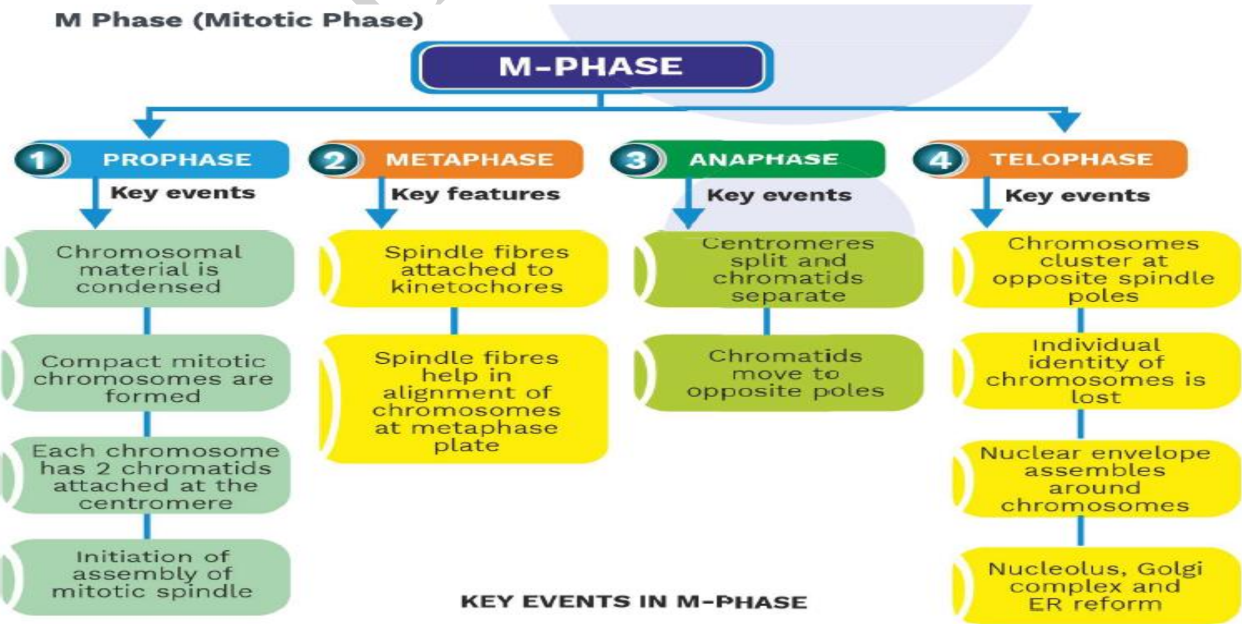
1- Interphase
2- Karyokinesis or (mitosis)(nuclear division)
3- Cytokinesis (cytoplasmic division)

1] **<u>Interphase</u>**: During interphase, a cell doubles all of its nuclear components and DNA replicates, which occurs before mitosis and cytokinesis.

- The cell performs its normal cellular function, and the nuclear structure appears normal.
- Cell increases all of its components including organelles such as the mitochondria, ribosomes and centrioles if present DNA replication, look **cell cycle figure**

2] **<u>Karyokinesis</u>** or (**mitosis**) or (**M-phase**):

The stages of plant mitosis: prophase, metaphase, anaphase, and telophase.



Note:
-Plant mitosis stages are identical to animal mitosis, but plant cells lack centrioles and asters.

-plant cell do have centrosome,

-the cell's central microtubule organizing center, which accounts for the formation of a spindle.

- In plants, the root tip contains tissue that is constantly dividing and producing new cells; a slide of (onion) root tip cell is an excellent specimen for mitosis cell division.

Each onion cell's microscopic chromosome contains a highly folded DNA molecule. so it is used as a good specimen for studying mitosis in plant cell.

3] Cytokinesis:

When cytoplasm divides after the stage of nuclear division that is called cytokinesis, the duplicated contents are separated and the daughter cell form.

Note:

- Animal cells produce a (cleavage furrow) in cytokinesis, forming two daughter cells.
- Plant cells undergo cytokinesis, which results in the formation of a (cell plate) in the center of the cell and the formation of a new plasma membrane for each daughter cell.

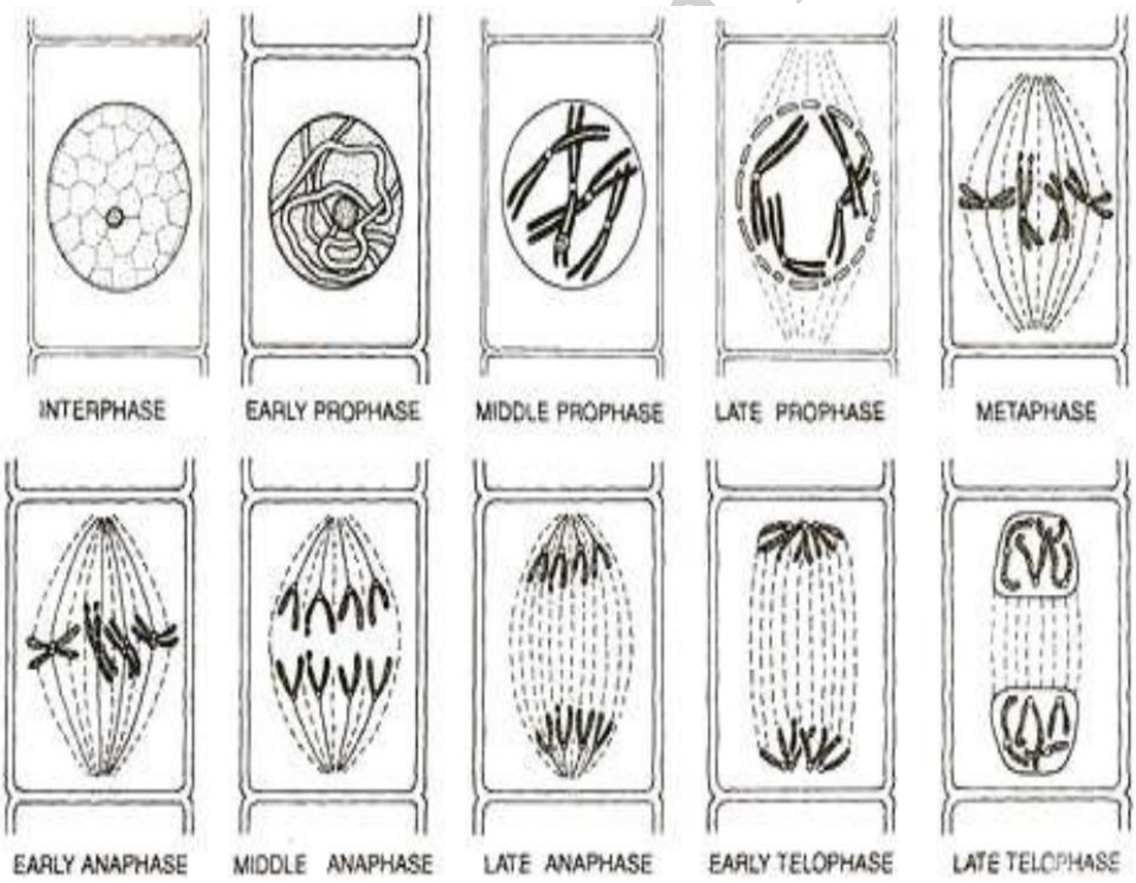


Fig. Different stages of mitosis in plant cell

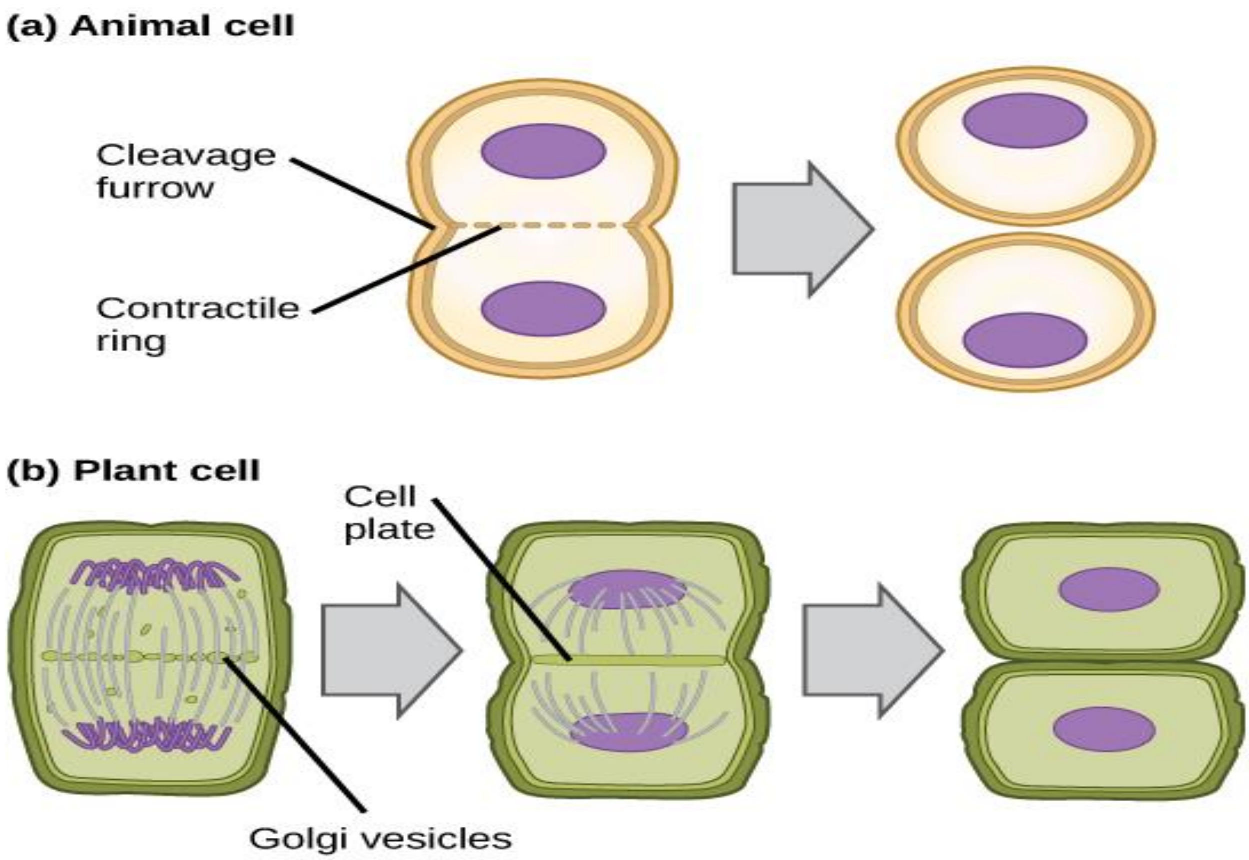


Fig. cytokinesis in animal and plant cells.

Difference between animal and plant cytokinesis:

Animal cytokinesis	Plant cytokinesis
It occurs by cleavage	Commonly by cell plate formation
Spindle starts disapperaring	Spindle persists till half cytokinesis
A mid body is formed at the middle of the cell	Mid body is not found

Lab-5 / <u>Plant tissue</u>

-A tissue is a group of specialized cells that work together to perform specific functions.

-These tissues are divided into <u>two categories</u>: **Meristematic** Tissues and **Permanent** Tissues.

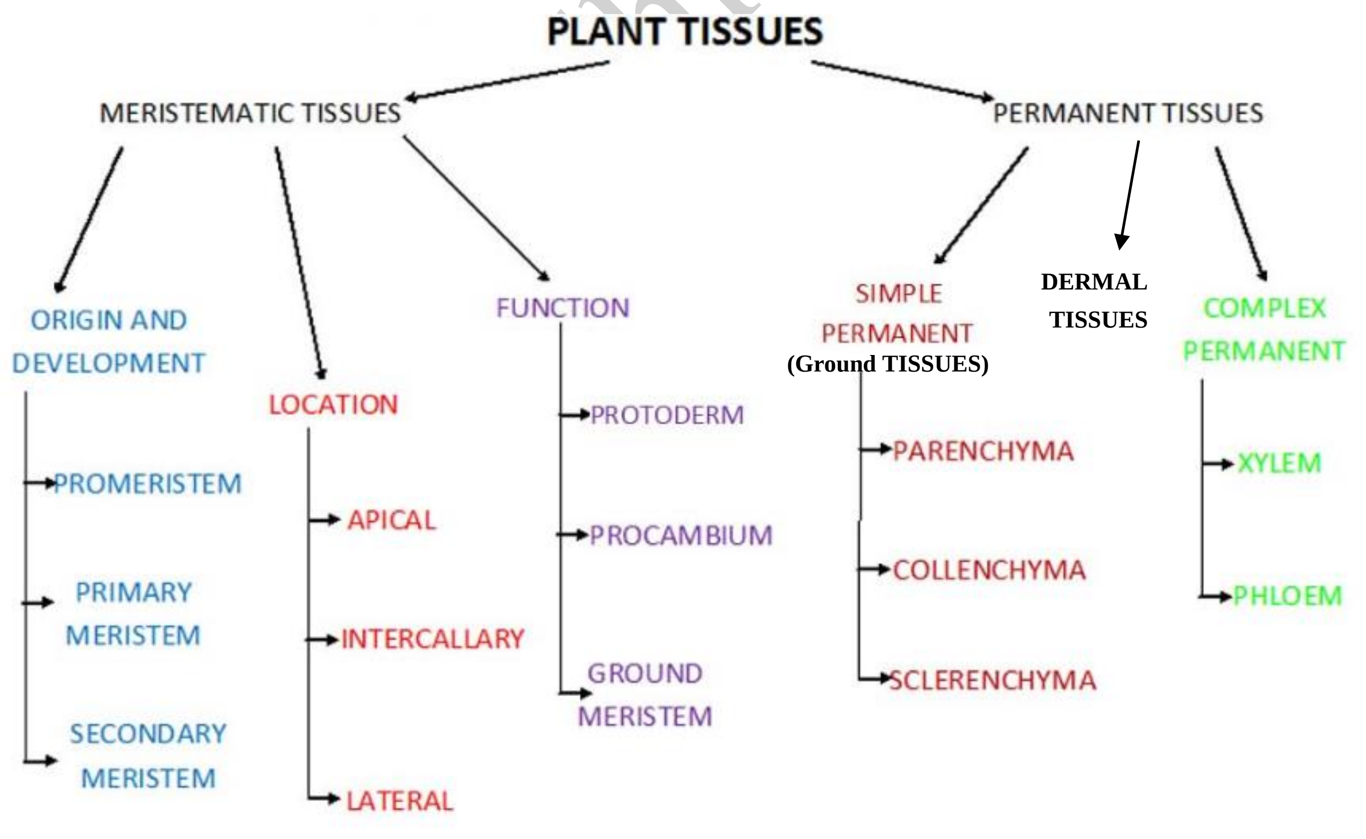
I] **Meristematic tissues**: can grow and have cells that continue to divide.These cell tissues can be found in various parts of a plant's structure.

-Meristematic tissues divided into <u>three types based on where they are located:</u>

a) <u>Lateral Meristem</u>: Found in radial fractions or a root. Lateral meristem aids in the development of a plant's thick solid structure.

b) <u>Intercalary Meristem</u>: This type of meristem is found at the base or internodes of a leaf structure in plants and trees. This meristem contributes to the internode's size being strengthened.

c) <u>Apical Meristem</u>: This is found on the tips of growing roots, stems and aids in plant lengthening.



Characteristics of Meristematic Tissues

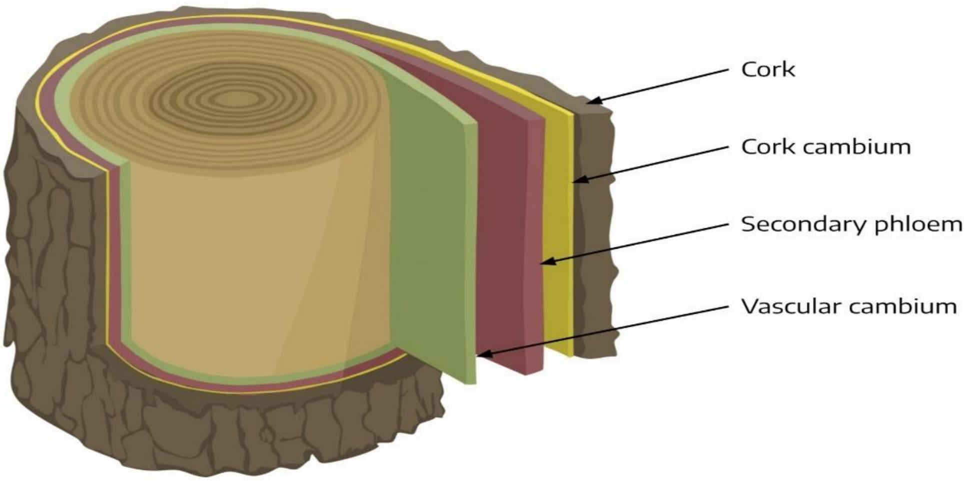
- They have a small number of vacuoles.
- Meristematic tissue is alive and thin-walled, with the ability to self-renew.
- When a cell divides, one cell remains identical to the parent cell, while the others develop specialized structures.
- The protoplasm of the cells is very dense, and the meristematic tissues heal an injured plant's wounds.
- Meristematic tissue cells are immature and young.
- They do not store food and have a high metabolic rate.

- **<u>The vascular cambium</u>** :

- It is a cylindrical secondary meristem that produces secondary growth.
-Is a layer of meristematic cells (or initials) that forms between the primary xylem and phloem.
- The vascular cambium is responsible for expanding the diameter of stems and the roots producing woody tissue.

<u>Cork cambium(phellogen)</u>:

-It is a lateral meristem.
-Type of epidermal tissue found in many vascular plants.
- It is responsible for secondary development that replaces the epidermis in the roots and stem.
- This cambium's activity will result in the production of cork cells (phellem) on the outside and secondary cortex (phelloderm) on the side.
- Cork cambium activity results in the formation of (periderm) gymnosperm plants.



The differences between Cork cambium and Vascular Cambium

Cork cambium	Vascular Cambium
1. Cork cambium develops from the secondary lateral meristem.	1. Vascular cambium develops from the apical meristem.
2. It gives rise to the bark and the secondary cortex.	2. It gives rise to the secondary xylem and phloem.
3. It is located outside the vascular tissues.	3. It is located between the primary xylem and primary phloem.
4. It produces lenticels.	4. It produces the medullary rays.
5. It provides protection against physical damage and prevents water loss.	5. It produces vascular tissue to help the conduction inside the plant and provide structural support to the plant.

2] **Permanent tissues**: are tissues whose cells can no longer distribute themselves but can still help a plant or tree be protective, strong, and flexible. These tissues can be divided into two types: **Simple Permanent Tissue** and **Complex Permanent Tissue**.

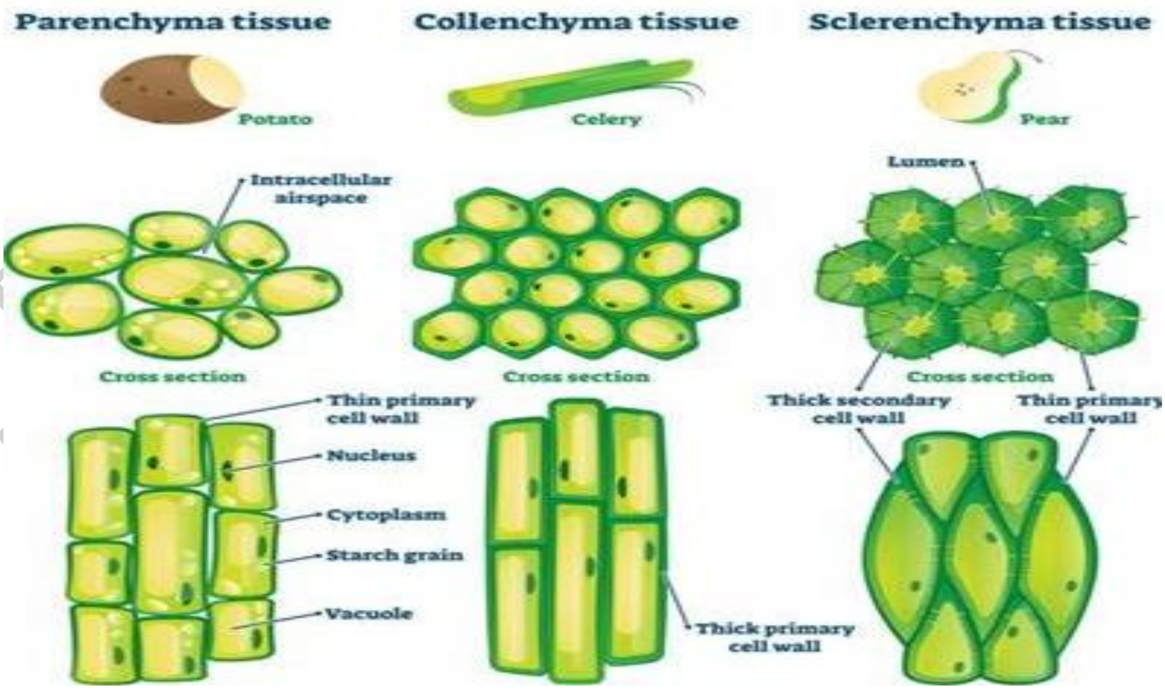
A] **Simple Permanent Tissue:**

1- **Sclerenchyma:** Dead and elongated tissues with lignin deposits on their cell walls. They are found in seed coverings, nuts, leaf veins, and stem vascular tissues, and they provide strength to the plant. They have no intercellular spaces.

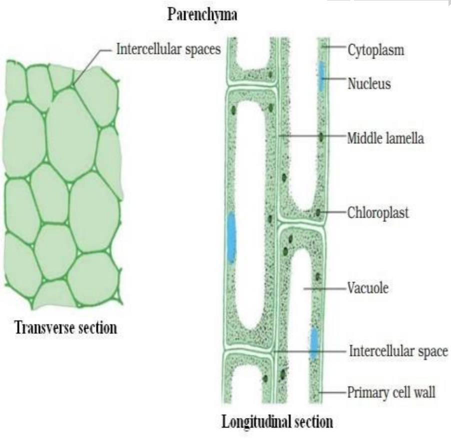
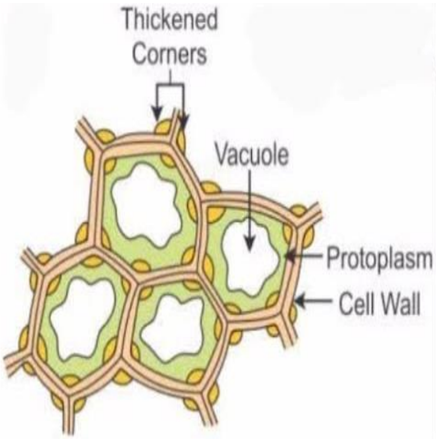
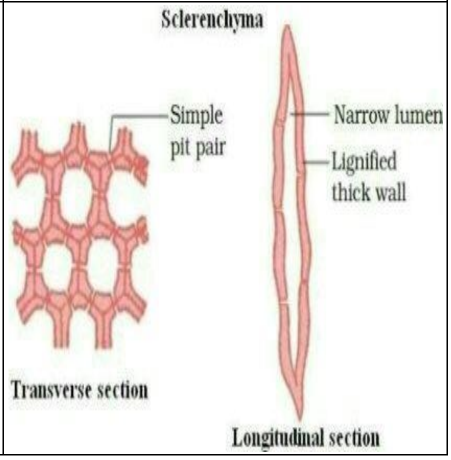
2- **Collenchyma**: These tissues are made of pectin and cellulose and are intercellular living cells with minuscule gaps between them. They can be found in the borderline regions of stems and leaves; they provide flexibility to plants by providing a structural framework and mechanical support.

3- **Parenchyma**: These tissues also have living cells that are polygonal in shape with a large central vacuole. There are intercellular spaces between them. They are developers of a plant's pith and ground tissue. Their structure **consists of:**

- Chloroplasts, also known as **chlorenchyma**, help plants in photosynthesis.
- **Aerenchyma** consists of huge air gaps that provide buoyancy to the plant.
- Some cells also serve as storage cells for the plant, storing starch for the fruits and vegetables.



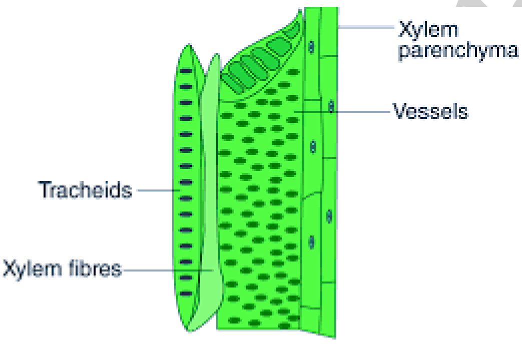
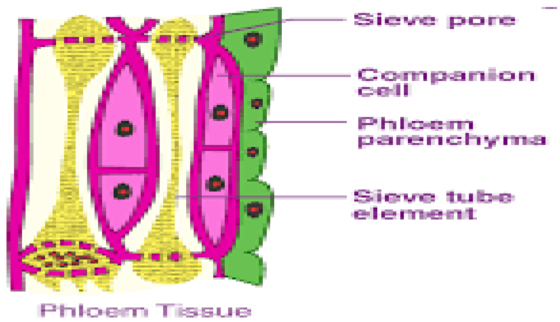
The Differences Between Parenchyma , Collenchyma and Sclerenchyma

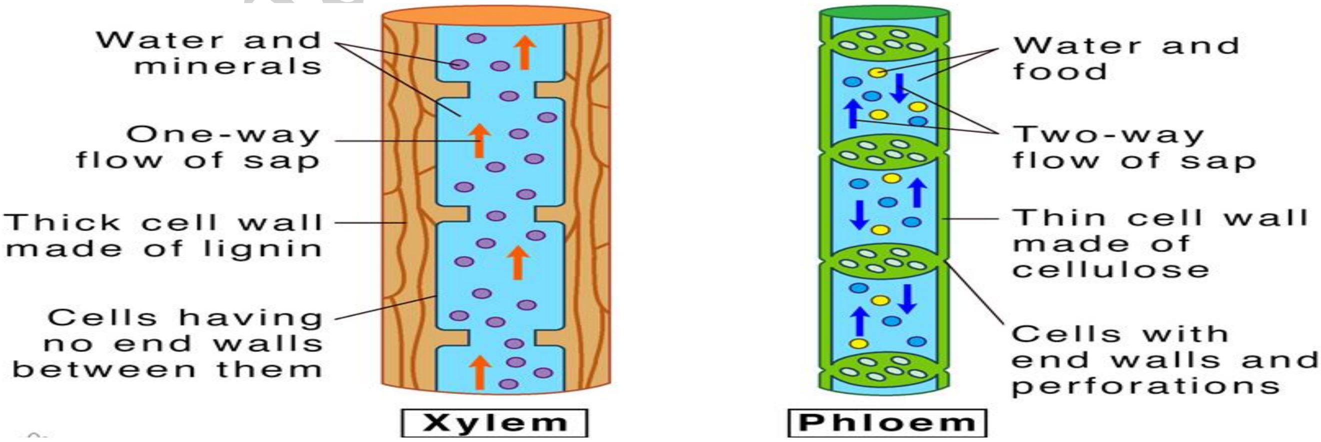
	Parenchyma	Collenchyma	Sclerenchyma
1	They are plant's **simple tissue cells.**	They are plant's **simple tissue cells.**	They are plant's **simple tissue cells.**
2	They are **living cells**.	They are **living cells.**	They are **dead cells**.
3	The cells of parenchyma have **thin walls**	Cells of collenchyma have **slightly thick walls**.	Sclerenchyma tissue cells have **thick cell walls.**
4	Cells of parenchyma are **uniformly thin**.	Cells of collenchyma **elongated**.	Cells are **long and narrow**.
5	The cells are **loosely packed.**	Cells of these tissues are **irregularly thickened at the corners.**	The cell walls of Sclerenchyma are **thickened due to** Lignin**.**
6	The cells of parenchyma have **large intercellular spaces**.	The cells of collenchyma have **very little intercellular spaces.**	The cells of sclerenchyma have **no internal space inside the cells.**
7			

B] Complex Permanent Tissue

1- **Phloem**: This tissue is responsible for the proper flow of nutrients throughout the plant.

2- **Xylem**: This tissue is responsible for the proper flow of water and other dissolved substances throughout the plant.

	Xylem	**Phloem**
	Xylos; wood	Phlois; inner bark
	Water conducting tissue	Food conducting tissue
	There are different types of cells that form as: Xylem vessels, Tracheids, Xylem parenchyma, Xylem fibres.	There are different types of cells that form as: companion cells, sieve tubes, phloem parenchyma, and phloem fibres.
	Except for Xylem parenchyma, all other cells are dead.	Except for phloem fibres, all Phloem cells are living.
		



C] Dermal tissues

Dermal tissues are the system that makes up a plant's outer covering.

Dermal tissue functions include the following:

Protection against water loss; regulation of gas exchange; secretion; and absorption of water and mineral nutrients.

-Dermal tissues include the: **epidermis** and **periderm**.

Epidermis : All surface of the plant consist of a single layer of cells called epidermis or surface tissue . most of the epidermal cells are relatively flat , the outer and the lateral walls are often thicker than thinner wall , it is including **guard cells and trichomes** , the cells form a continuous sheet without cellular spaces .

Epidermis Play a role in :

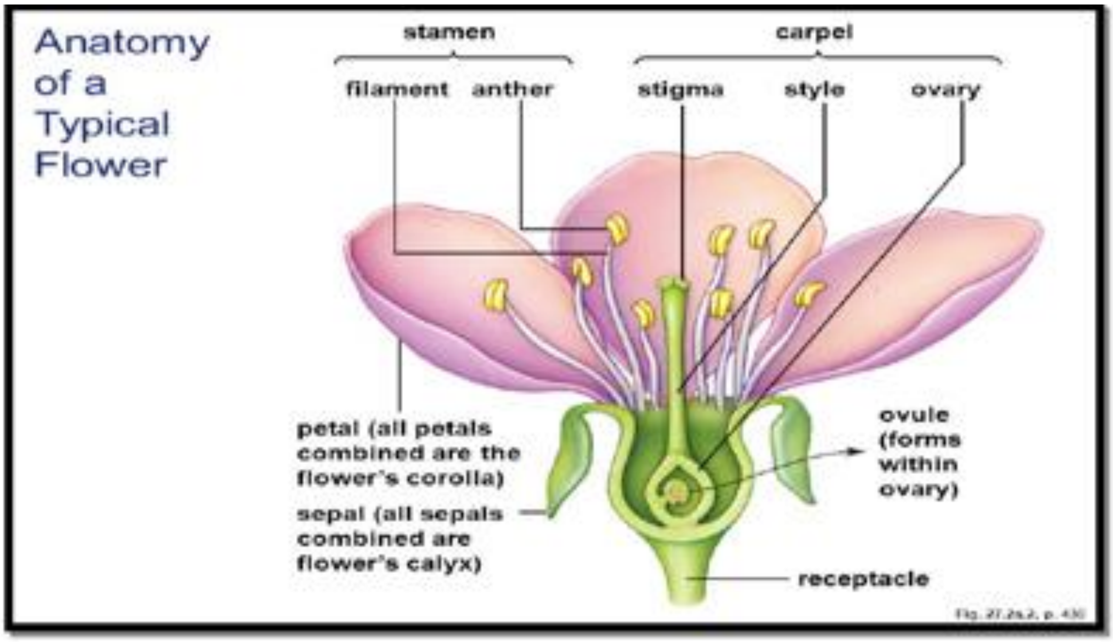
- a- protects all parts of the plant

b- support c- reduction of water loss .

periderm (Bark) : when plants increase the girth due to secondary growth, then slough off their epidermal tissue and replace them with priderm it is composed of cork cells (phellem) that hare thick walls with suberin (cutin + lignine) substance which protects the surface of cells , also contains secondary cortex (phelloderm) and cork cambium all them are called periderm.

Lab-6 / Flower plant

They are the dominant plants that can occur as trees, shrubs, vines, or garden plants.



Structures of a flower consists of:

-Receptacle: the part of stalk to which the flower parts are attached.

-Sepals: An outermost whorl of modified leaves, collectively known as the calyx, the sepals are green in most flowers, and it serves to protect a bud before it opens.

-Petals: usually colored leaves that collectively constitute the corolla.

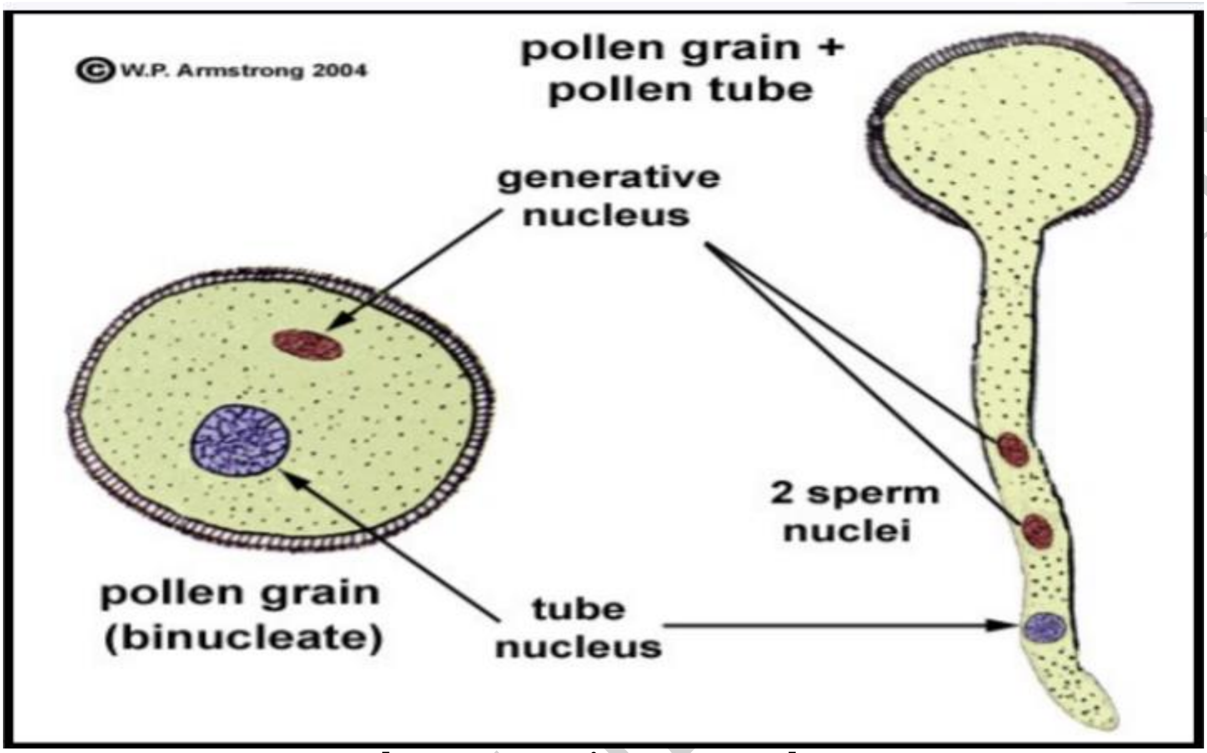
-Stamen: consisting of a swollen terminal called the anther and a slender supporting structure called the filament, the anther contains two pollen sacs, each of which contains microspores that develop into (pollen grains) (microgametophtes).

Pollen grain has two cells:

Tube cell (the larger cell)

Generative cell (the smaller cell)

When the pollen grain germinates, the tube cell gives rise to the pollen tube, and the pollen grain generative cell divides to produce two sperm cells.

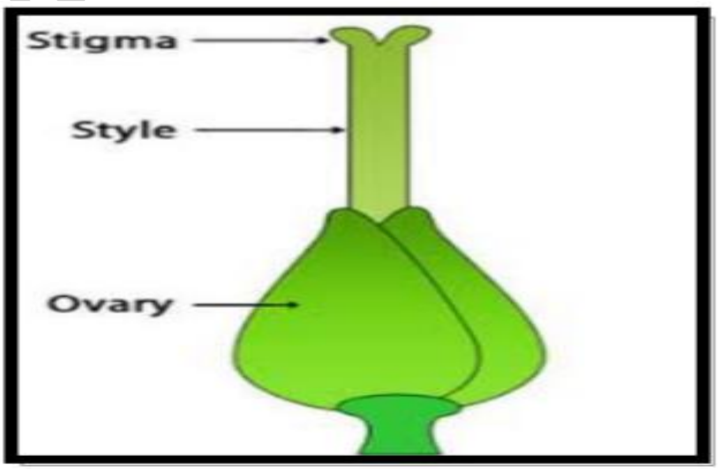


The Mature microgametophtes

□**Pistil:** This structure, also known as a carpel,

is made up of:

a. **Ovary: swollen basal enlarged part of the pistil.**
b. **Stigma:** Terminal part, such as the sticky knob that aids pollen grain coherence
c. **Style**: longer and slender, between stigma and ovary.

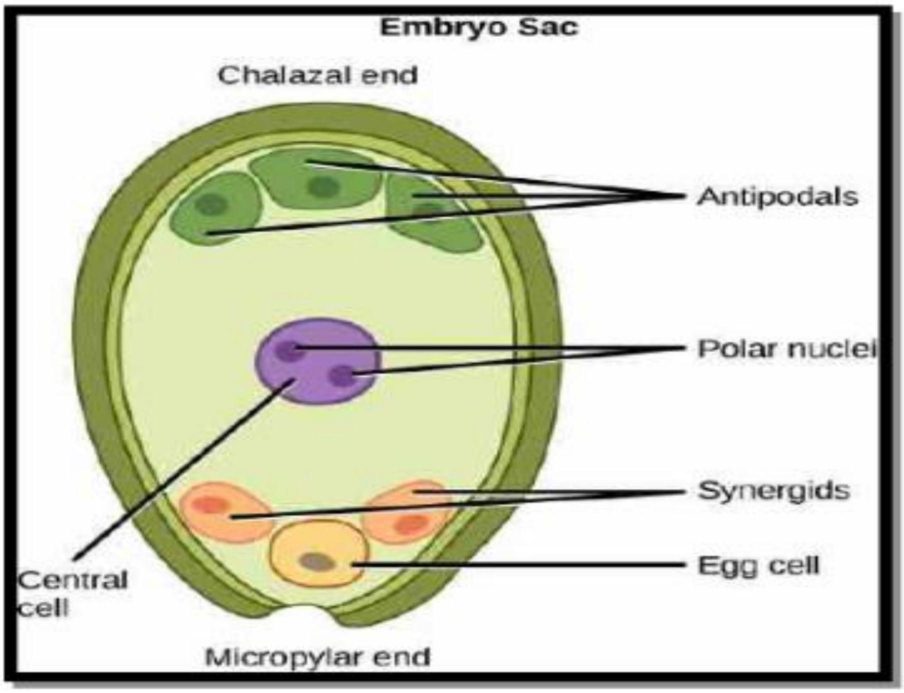


The Consists of pistil

-The ovary has a (ovule structure), which has a (megaspore).

-Megaspores go through three mitotic divisions to produce a seven-cell structure with eight nuclei known as an embryo sac or mega gametophytes.

-One of these cells is known as an **egg** cell, three others are known as **antipodal cells,** and the largest, which contains two polar nuclei, is known as a **polar** cell, and the other two are known as **synergistic** cells.



Pollination operation:

Pollination: The transfer of pollen grains from the anther to the stigma.As it grows, the pollen tube passes through the stigma and grows through the style into the ovary, and the two sperm cells migrate through the pollen tube into the embryo sac.

Fertilization: Flowering plants practice (double fertilization) after pollination and the passage of the pollen tube to the stigma, and one sperm fertilizes the egg and the other joins with the two polar nuclei to form endosperm, which serves as food for the developing embryo. Finally, the ovary develops into a fruit, and the ovule develops into a seed, which contains an embryonic sporophyte and stored food.

Lab-7 / Seed

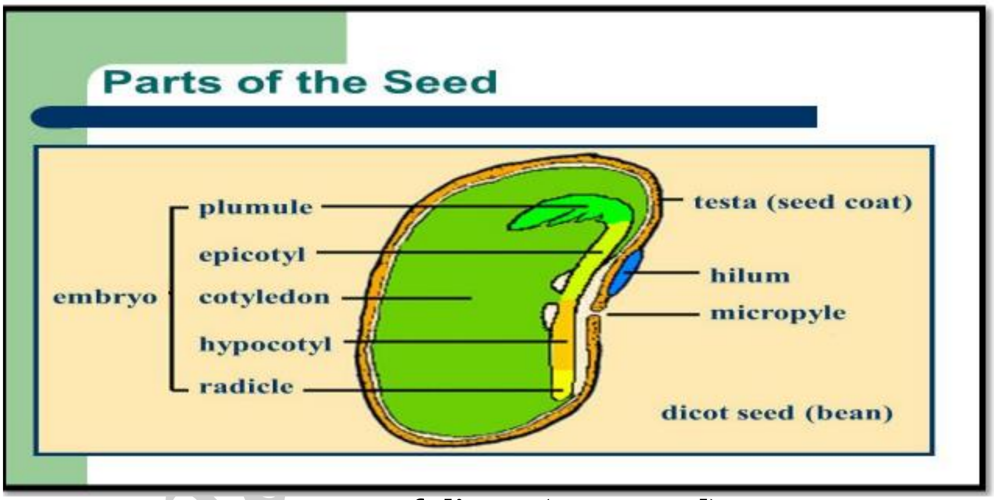
a- The mature ovule, which consists of a seed coat (testa), a food supply (endosperm), and an embryo. ex. Dicote (Bean seed) :-

Experiment: Collect some dried beans that have been soaked in water for 24 hours. Using your fingernail, remove the seed coat and separate the two cotyledons. The see the Dicote Seed Composition:

- Micropyle : a small opening on the surface through which the pollen tube grew .
- Hilum : the elliptical area at which the ovule was attached to the ovarian wall .
- Cotyledon : Food storage organs for the embryo .
- Embryo : develops into the new sporophyte and contained :-

• **Epicotyle** : the small portion of the embryo located above the attachment of the cotyledons to develop first true leaves (plumules) .

• **Hypocotyle** : the small portion of the embryo located below the attachment of the cotyledons to develop lower end (radical).



Part of dicote (Bean seed)

b- Monocote (Corn seed)

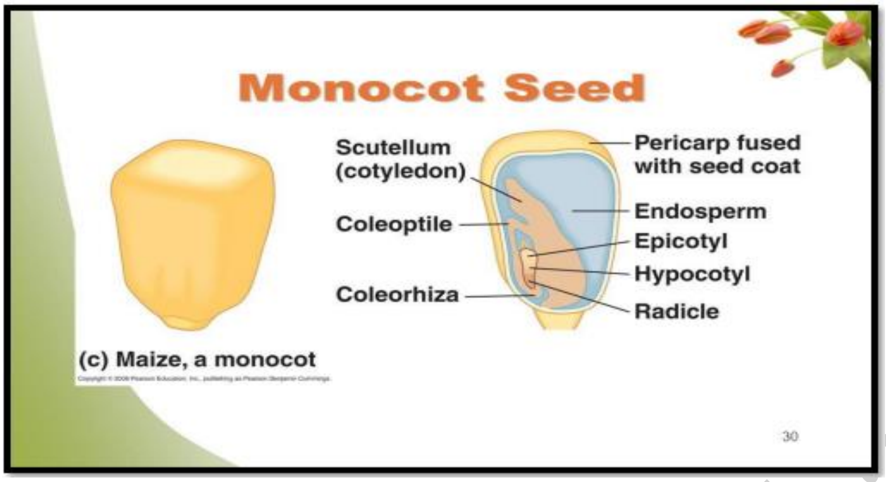
Experiment: Collect some dried beans that have been soaked in water for 24 hours. Then make a longitudinal split with a razor blade. The see the monocote Seed Composition:

-Cotyledon :plumule and radical in addition:

-Endosperm : stored food for the embryo.

-Coleorhizae : sheath enclosing embryonic root of grass embryo.

-Coleoptile : a sheath the covers the emerging leaves .



Part of Monocote (Maize seed)

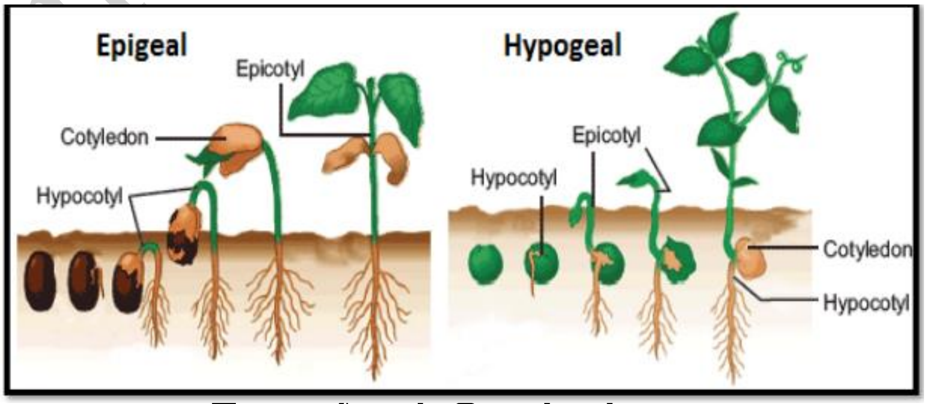
Seed Germination : Is a programmed developmental process during which the embryo breaks dormancy and continues its development. This operation only occurs when sufficient conditions like moisture ,temperature and oxygen .

-Mature seeds are dry, and for germination to begin the dry tissue must take up water in a process called **imbibition**.

- After water has been imbibed, enzymes break down, the food source into molecules that can provide energy be used as building blocks until the seedling is ready to photosynthesize.

Germination classified two types:

1- **Epigeal Germination**: growth hypocotyl more epicotyls and move cotyledons to up and change to green color to photosynthesis like Bean seed.
2- **Hypogeal Germination**: growth epicotyls more hypocotyl therefore cotyledons remind in soil to provide food storage from embryo like corn seed.



Types of seeds Germination

Lab-8 / Mendelian inheritance

- **Gregor Johann Mendel (1822-1884):** Austrian scientist, also known as the father of genetic because of his genetic experiment with pea plants (*Pisum sativum*).

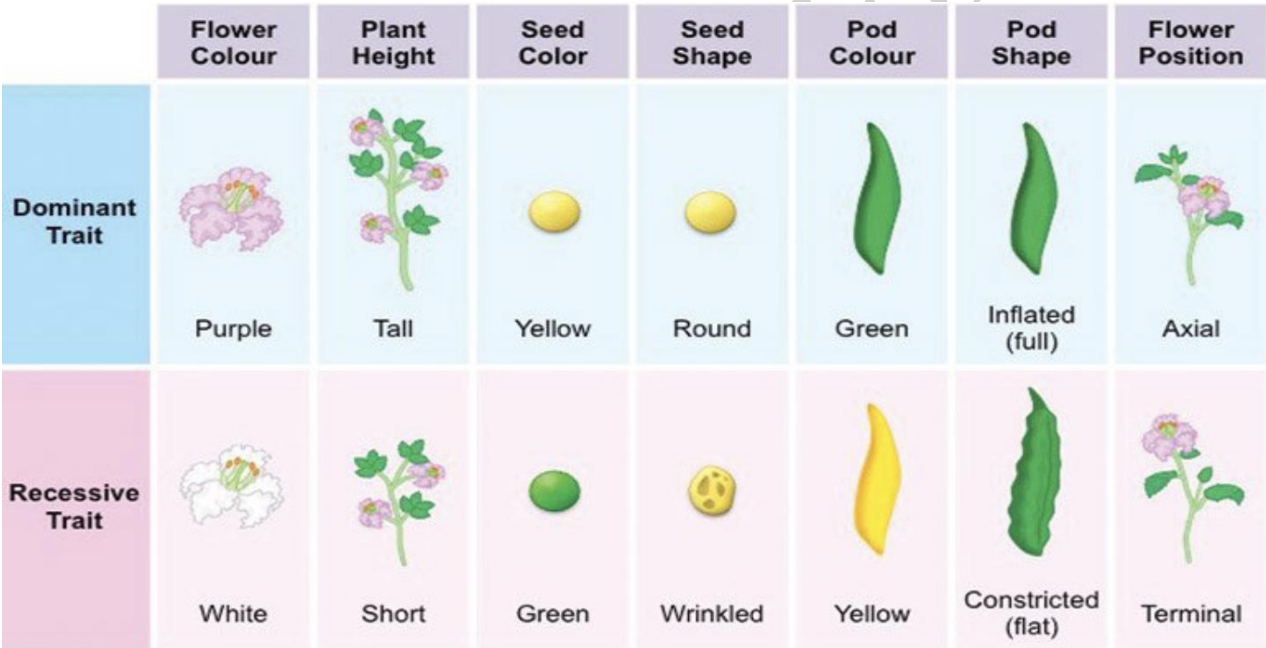
Mendel cultivated and tested 28,000 pea plants, then developed the laws of inheritance.

- The reasons for the selection of pea plants for his genetic experiments are:

  1- They grow quickly and have a short life-cycle.

  2- They can either self-pollinated or be cross-pollinated and produce many offspring in one cross.

  3- They have easily observed contrasting characteristics as shown below:



Hereditable material

DNA

↓

GENE

↓

ALLELE

↙ ↘

Dominant Recessive

Mendel's Laws:

1- Law of Segregation

Mendel states "each gene alleles segregate from other during the formation of the gamete to allow the gamete to carry one allele only for each gene."

- One allele is given by the female parent and the other is given by the male parent.
- **Monohybrid cross**: is a genetic cross involving a single trait.
- **P** = Parental generation
- $\mathbf{F_1}$ = First filial generation; offspring from a genetic cross.
- $\mathbf{F_2}$ = Second filial generation of a genetic cross.

<u>Monohybrid cross questions:</u>

To answer the monohybrid cross questions you need to follow the steps below:

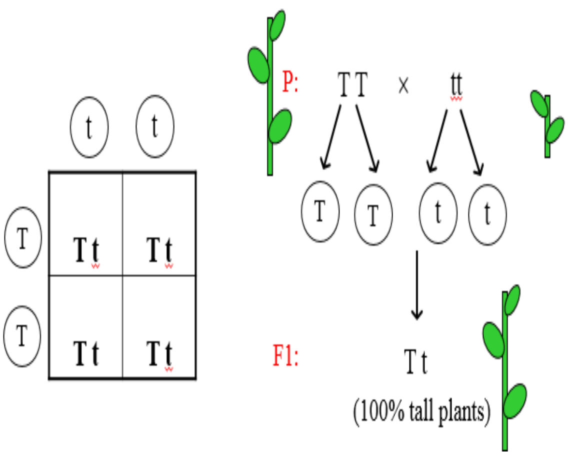
1-Determine the genotypes of the parent organisms
2- Write down your "cross" (mating)
3- Draw a p-square and split the letters of the genotype for each parent and put them "outside " the p- square.

4- Determine the possible genotypes of the offspring by filling in the p-square

5- Summarize results (Calculate genotypes and phenotypes of offspring).

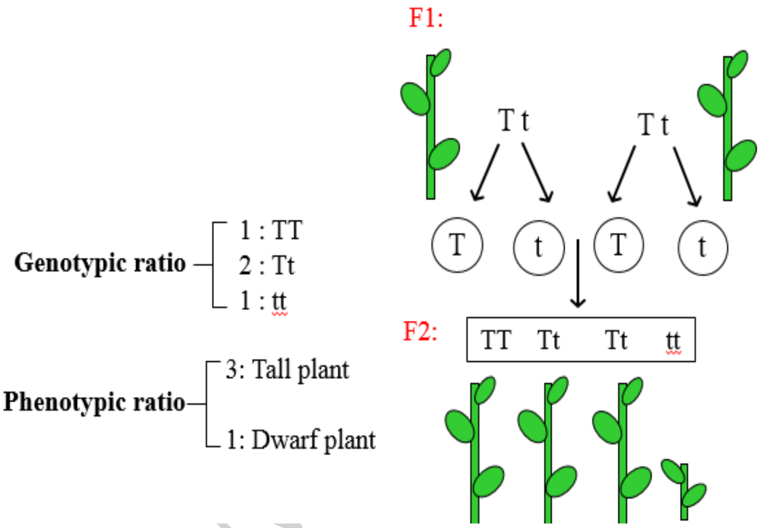
<u>Monohybrid crosses review:</u>

- P = parentals true breeding, homozygous plants
- Homozygous dominant x Homozygous recessive
- F1 generation all Heterozygous (hybrids).
- Genotypic & Phenotypic ratio is all alike.
- Example: Stem length



F1 Monohybrid crosses review:

- P = parentals true breeding, homozygous plants
- Heterozygous dominant x Heterozygous dominant
- F2 generation:
- 25% Homozygous dominant
- 50% Heterozygous dominant
- 25% Homozygous recessive

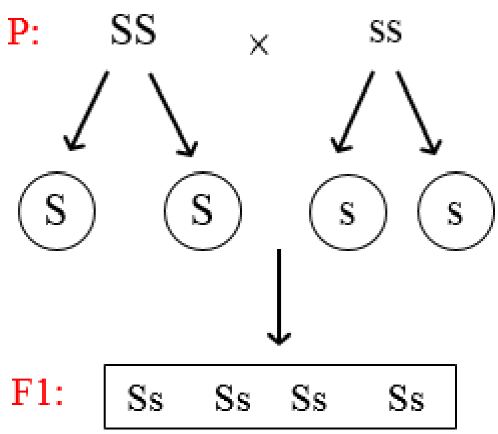


Monohybrid crosses examples:

Q1/ Curly hair is recessive, and straight hair is dominant. A woman with curly hair marries a man who is **homozygous dominant for straight hair**. Predict the outcomes for their children.

Man: Homozygous dominant for straight hair (SS)

Woman: Curly hair (recessive) (ss)



Genotype: 100 % Heterozygous dominant (Ss)

Phenotype: 100% Straight hair

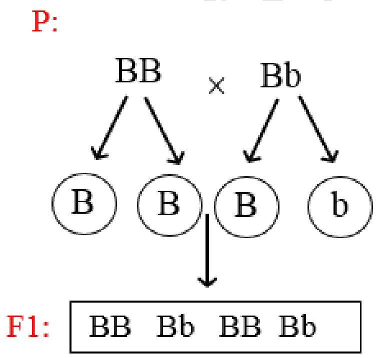
Q2/ Complete the following Punnett square, include the ratios of the genotype and phenotype. What are the eye color possibilities for the children if the dad's eye color is brown (**homozygous dominant)** and the mom's eye color is brown **(heterozygous dominant).** Is there a possibility to have a child with blue eye color?

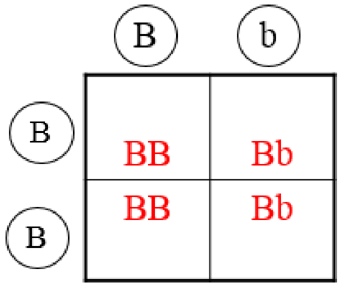
Trait: eye color

B: brown eye (dominant), b: blue eye (recessive).

Dad: BB

Mom: Bb





Genotypic ratio: 50% Homozygous dominant

50% Heterozygous dominant

Phenotypic ratio: 100% Brown eye

There is no possibility to have a child with blue eye color

2- Law of Independent Assortment

- This law "states that the alleles of different genes are inherited independently within the organisms that reproduce sexually."
- **Dihybrid cross:** is a cross between two different gene that differ in two observed traits. We compare two different characteristics in a dihybrid cross.

- **Dihybrid cross questions:**

To answer the dihybrid cross questions you need to follow the steps below:

1)Write down your "cross" (mating). 2)The dihybrid cross is easy to visualize using a Punnett square of 16 dimensions. 3)Figure out the possible gametes of the parents and put them "outside " the p- square. 4)Fill in the offspring by combining the gametes. 5) Calculate phenotypic and genotypic ratios.

Q / In guinea pigs, the allele for black fur (B) is dominant over that for brown fur (b). Similarly, the allele for short fur (S) is dominant over that for long fur (s). What are the ratios of the genotype and phenotype if a cross happen between BbSs and BBss.

BbSs: Black and short fur (Heterozygous)

BBss: Black and long fur (Homozygous)

	BS	Bs	bS	bs
Bs	**BBSs** black fur, short fur	**BBss** black fur, long fur	**BbSs** black fur, short fur	**Bbss** black fur, long fur
Bs	**BBSs** black fur, short fur	**BBss** black fur, long fur	**BbSs** black fur, short fur	**Bbss** black fur, long fur
Bs	**BBSs** black fur, short fur	**BBss** black fur, long fur	**BbSs** black fur, short fur	**Bbss** black fur, long fur
Bs	**BBSs** black fur, short fur	**BBss** black fur, long fur	**BbSs** black fur, short fur	**Bbss** black fur, long fur

-The phenotypic ratio for this dihybrid cross will be:

8 (black fur, short fur) : 8 (black fur, long fur) = 2 Phenotypes

- The genotypic ratio will be:

$$\underbrace{\overset{4}{BBSs}\ ,\ \overset{:\ \ 4}{BBss}\ ,\ \overset{:\ \ 4}{BbSs}\ ,\ \overset{:\ \ 4}{Bbss}}_{4\ \text{Genotypes}}$$