Botany

Botany: branch of biology that deals with the study of plants, including their structure, properties, and biochemical processes. Also included are plant classification and the study of plant diseases and of interactions with the environment.

Botany is the scientific study of plants, including their structure, growth, reproduction, metabolism, diseases, and evolution. It covers a wide range of plant life, from tiny algae to massive trees.

Some branches of botany include:

- **Plant Physiology** : study plants function (e.g., photosynthesis, respiration).
- **Plant Morphology** : The study of plant structures and forms.
- **Plant Taxonomy** : Classification and naming of plants.
- **Plant Ecology** : Study plants interact with their environment.
- **Ethnobotany** : The study of how humans use plants (e.g., for medicine, food).
- **Agricultural Botany** – Focused on crops and food production.

Why study Botany

Studying botany is important for several reasons, as plants play a important role in life on Earth. Here are some reasons to study botany:

1. Plants Are Essential for Life

- They produce oxygen through photosynthesis.
- They form the base of the food chain.
- They provide food, medicine, fuel, and raw materials.

2. Understanding Ecosystems & Biodiversity

- Plants regulate the environment, prevent soil erosion, and maintain biodiversity.
- Studying plants helps in conservation efforts and combating deforestation.

3. Agriculture & Food Security

- Botany helps improve crop production, quality, and resistance to pests and diseases.
- It contributes to sustainable farming practices and food supply management.

4. Medicinal & Pharmaceutical Advances

- Many medicines are derived from plants (e.g., aspirin from willow bark, quinine from cinchona).

- Understanding plant biochemistry leads to new drugs and treatments.

5. Climate Change & Environmental Protection

6. Economic Importance

- Plants are crucial for industries like agriculture, forestry, horticulture, and biotechnology.
- They provide raw materials for textiles, paper, biofuels, and essential oils.

7. Scientific Discovery & Curiosity

- Studying plant evolution helps us understand the history of life on Earth.
- Plant genetics and biotechnology lead to innovations in agriculture and medicine.

Changes occurred at the level of Kingdoms

Historically, the number of kingdoms in widely accepted classifications has grown from two to six.

Two Kingdoms (Aristotle, during 4th century BC)

Classification system based on: Observation (phenetics)

- **Plantae** – plants
- **Animalia** – animals

Three Kingdoms (Ernst Haeckel, 1894)

Classification system based on: Observation (phenetics)

Ernst Haeckel in (1894) added third kingdom, Protista that included single-celled eukaryotes and bacteria (prokaryotes).

- **Plantae** – plants (mostly autotrophic, multicelluar eukaryotes, production by spores)
- **Animalia** – animals (heterotrophic, multicelluar eukaryotes)
- **Protista** – single celled eukaryotes and bacteria (prokaryotes)

Four Kingdoms (Herbert Copeland, 1956)

Classification system based on: Observation (phenetics) he important changed introduced by this classification scheme was the introduction of the Kingdom Bacteria. This reflected the growing understanding that bacteria (single-celled prokaryotes) were very much different from single- celled eukaryotes.

- **Plantae**–plants (mostly autotrophic, multicelluar eukaryotes, reproduction by spores)
- **Animalia** – animals (heterotrophic, multicelluar eukaryotes)

- **Protista** – single-celled eukaryotes (lack tissues or extensive cellular differentiation)
- **Bacteria** – bacteria (single-celled prokaryotes)

Five Kingdoms (Robert Whittaker, 1959)

Classification system based on: Observation (phenetics)

Robert Whittaker's 1959 classification scheme added a fifth kingdom to Copeland's four kingdoms, the Kindom Fungi (single and multi-celluarosmotrophic eukaryotes)

- **Plantae** – plants (mostly autotrophic, multicelluar eukaryotes, reproduction by spores)
- **Animalia** – animals (heterotrophic, multicelluar eukaryotes)
- **Protista** – single-celled eukaryotes (lack tissues or extensive cellular differentiation)
- **Monera** – bacteria (single-celled prokaryotes)
- **Fungi** (single and multi-celluarosmotrophic eukaryotes)

Six Kingdoms (Carl Woese, 1977)

- **Plantae** – plants (mostly autotrophic, multicelluar eukaryotes, reproduction by spores)
- **Animalia** – animals (heterotrophic, multicelluar eukaryotes)
- **Eubacteria** – bacteria (single-celled prokaryotes)
- **Archaebacteria** – prokaryotes (differ from bacteria in their genetic transcription and translation, more similar to eukaryotes)
- **Protista** – single-celled eukaryotes (lack tissues or extensive cellular differentiation)
- **Fungi** – single and multi-cellular eukaryotes

Three Domains (Carl Woese, 1990)

Classification system based on: Evolution and molecular genetics (Cladistics/Phylogeny)

- **Bacteria**: Domain bacteria includes one kingdom only that is bacteria
- **Archaea** Domain Archae includes one kingdom only that is Archae Domain

Eukarya :Euykaria includes the following four kingdoms

Kingdom Protista , Fungi, Plantae, & Animalia.

Part of Plant

The essential parts of most plants are roots, stems, leaves, flowers, fruits, and seeds. The function of each plant part is described below.

Root : The root system is below ground. This system includes roots, **tubers** (an enlarged, fleshy, underground stem with buds capable of producing new plants) and **rhizomes** (a horizontal stem that is usually underground and roots grow from it.) .

Main functions of Root

1- It absorbs the water and minerals from the soil .
2- Anchoring of the plant body to the ground, and supporting it .
3- Storage of food and nutrients .
4- Vegetative reproduction and competition with other plants.

Stem : Stems are usually above ground, although the stems of some plants, such as the potato, also grow underground. Stems may be herbaceous (soft) or woody in nature.

The main function of stem :

1- provide support to the plant, holding leaves, flowers, and buds .
2- Stems also store food for the plant example potato, ginger.
3- The stem of the plant connects the roots to the leaves, helping to transport absorbed water and minerals to different parts of the plant
4- The stem also helps to transport the products of photosynthesis

Leaves : leaf refers to the organ that forms the main lateral appendage on the stem of vascular plants. In general, leaves are thin, flat organs responsible for the photosynthesis of the plant .

The main function of leaves :

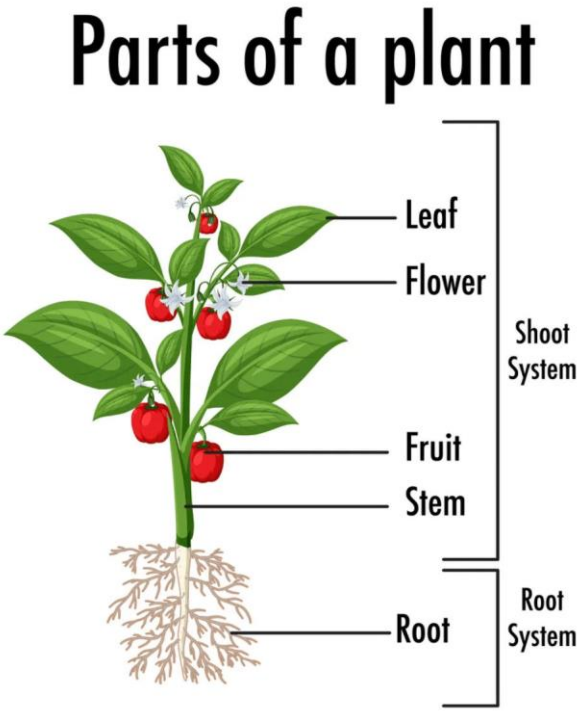
1- The parts of the plant where photosynthesis usually occurs(where food for the plant is made).
2- Transpiration : refers to the movement of water through the plant, and subsequent evaporation via the leaves.
3- Storage : leaves are a primary site of water and energy storage

since they provide the site of photosynthesis.

Flowers: A flower is the reproductive part of a plant that produces seeds. Plants that produce flowers and fruit are known as angiosperms. They often have showy petals and fragrances to attract pollinators such as birds, bees, and other insects. Most flowers have four main parts: petals, stamen (anther and filament), pistil (stigma, style and ovary), and sepals. After flowers are pollinated and fertilized, they produce seeds in the ovary of the flower.

Fruits: Fruits are the fleshy substances that usually surround seeds, They ripen as seeds mature.. They protect the seeds and attract animals to eat them. This helps in seed dispersal.

Seeds contain plant material that can develop into another plant. This plant material is called an embryo. Seeds are covered with a protective seed coat and have one or two cotyledons. Cotyledons are the food for the tiny plant until it can make its food from light and are often the first embryonic leaves of the plant.



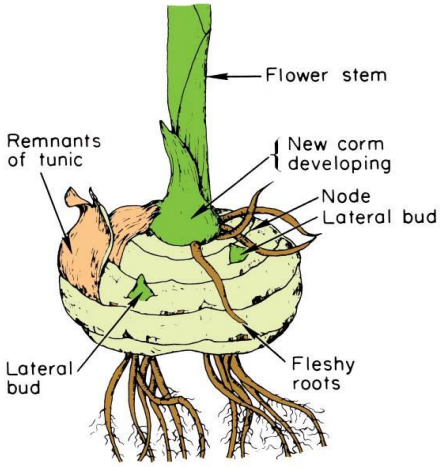
Reproduction in plant

There are two types of reproduction in plants.

1. **Sexual reproduction:** This occurs through the formation of specialized cells called gametes. This process is called gametogenesis. When the male and female gametes fuse, an embryo is formed in the seed.
2. **Asexual Reproduction**: is done through vegetative parts (and occurs without the union of male and female gametes). A new plant is formed consisting of specialized vegetative parts such as tubers, rhizomes, stolons, bulbs, or corms, or by other parts such as roots, in addition to grafting and layering.

   a. **Rhizome:** It is an underground stem that has been modified to store stored materials. It grows horizontally from the main axis of the mother plant. It produces buds that grow to produce a new plant, as in ginger and turmeric.

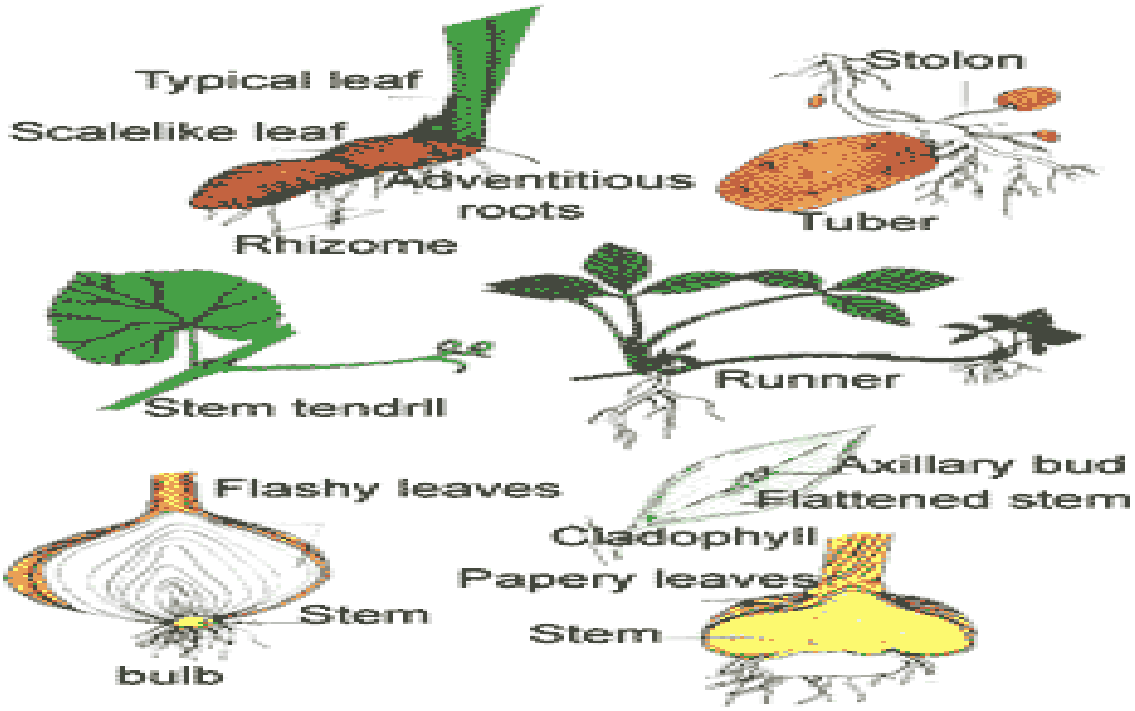
   b. **Corm**: A short, swollen, vertical, modified stem found in the soil that stores nutrients. It contains bud nodes surrounded by modified leaves in the form of a protective shield. These nodes are capable of growing to form a new plant when the appropriate conditions are met, as in crocus and lily plants.



   c. **Tubers:** These can be either modified stems, as in the potato, where a potato tuber has many eyes containing buds that give rise to a new plant. Tubers can also be tubers formed from the

roots of the parent plant after they have stored food and remain connected to the mother plant by a short stalk, as in the sweet potato. Buds develop from the end connected to the mother plant, while the other end produces roots.

d. **Bulbs:** a modified stem surrounded by fleshy, storage leaves that store food. Roots grow from the bottom of the bulb, and the tops of the shoots begin to grow using the nutrients stored in the leaves, as in onions and daffodils.



Artificial methods of asexual propagation in plants:

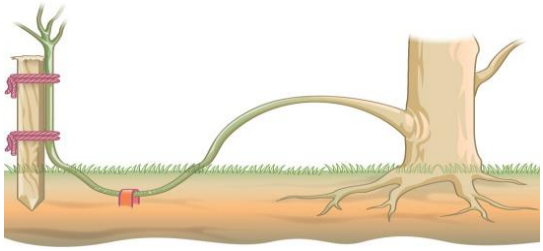
1. **Propagation by cuttings**: This involves separating a portion of the stem, root, or leaf from the mother plant and planting it under suitable environmental conditions to stimulate it to form a root and vegetative system to produce new plants that are genetically identical to the mother plant.

Types of cuttings: There are different types of cuttings, divided according to the type of plant or the part from which they are taken.

1) Stem cuttings
2) Leaf cuttings
3) Bud - Leaf cuttings
4) Root cuttings

2. Layering

The stem is stimulated to form lateral roots while still in contact with the parent plant. After the roots develop on the layered branch, it becomes a new plant that can be separated from the parent plant. Water and other nutrients allow the layered stem to survive the entire layering period because it is still in contact with the parent plant. Therefore, layering is considered one of the most successful vegetative propagation methods.

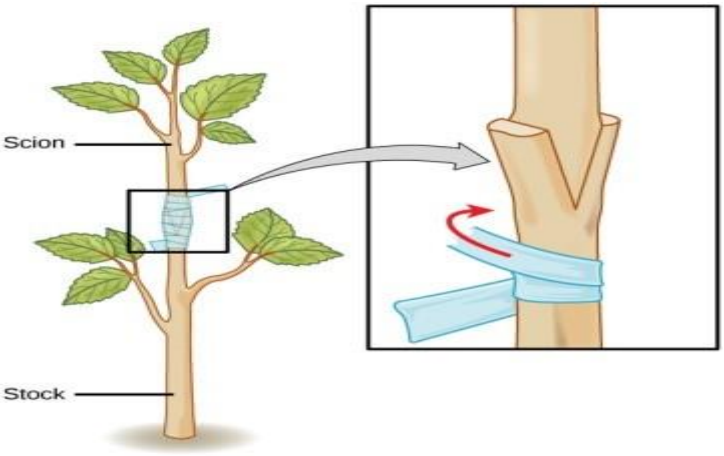


Layering methods: There are several methods depending on the specifications of the plants being propagated, including:

- **Ground layering**
- **Air layering**

3. Grafting

This method is used on many plants and trees, such as citrus fruits. In this method, we use two types of plants, transferring a portion of one plant to grow on another to improve their traits. One branch of the parent plant is cut diagonally, or in a V-shape. Then, we transport in the other plant, called the graft, and secure it to the cut site on the parent plant, aligning the bark with the bark and the wood with the wood. This secures the two plants together. This results in a new plant.

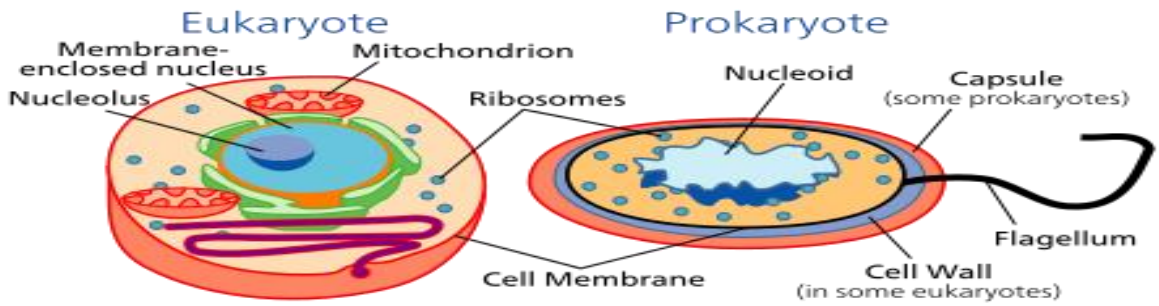


Plant cell

Cells are the fundamental unit of life – both structure and function .

All cells share in tow essential features that is: cell membrane (plasma membrane) and genetic material , there are two types of cell according to genetic material , Prokaryotic cells and Eukaryotic cells.

- **Prokaryotic cells** are cells without true nucleus. The DNA in prokaryotic cells is in the cytoplasm rather than enclosed within a nuclear membrane,and the only organelles in a prokaryotic cell are ribosomes suchas bacteria.
- **Eukaryotic cells** are cells that contain a nucleus with a nucleus membrane. Eukaryotic cells are usually larger than prokaryotic cells, Eukaryotic cells have other organelles besides the nucleus and they are found mainly in multicellular organisms such as plant ,animals ,fungi.



There are a number of differences between plant and animal cells.

1. Plant cells are generally larger than animal cells, While animal cells come in various sizes and tend to have irregular shapes, plant cells are more similar in size and are typically rectangular or cube shaped.
2. A plant cell also contains structures not found in an animal cell Some of these include a cell wall , a large vacuole, and plastids but animals cells also contain structures such as centrioles, lysosomes, cilia and flagella that are not typically found in plant cells.

Plant Cell Structures and Organelles

Cells are composed

A/ living components

B/ non-living components

A/ living components

1. Nucleus

The cell nucleus is spherical or irregular organelle supposed to be the most important organelle. The nucleus contains a deoxyribonucleic acid (DNA), its genetic material. DNA contains instructions for making proteins, which

controls all of the body's activities. The nucleus also regulates the growth and division of the cell.

2. **Cytoplasm**

The liquid within cells is the cytosol. It is mostly made of water, and also contains ions like potassium, proteins, and small molecules. Cytosol and all the organelles within it, except for the nucleus, are called the cytoplasm, It is a gel-like appearance , Cytoplasm is composed mainly ofwater and contains: enzymes, salts, organelles, and various organic molecules .

The cytoplasm functions :

1. support and suspend organelles and cellular molecules.
2. Many cellular processes also occur in the cytoplasm include: protein synthesis, the first stage of cellular respiration (known as glycolysis), mitosis, and meiosis.
3. cytoplasm helps to move materials.

2-Plastids

found in the cells of plants chloroplasts are the centers of synthesis and metabolism of carbohydrates and it contains of :

The chloroplasts have a system of :

1. **three membranes**

A-Outer- membrane: this membrane is semi-permeable and allows only small molecules and ion's to diffuse through it

B- Inter-membrane space

C- Inner membrane: this membrane forms a boarder to the stroma and regulates the activity of the chloroplasts.

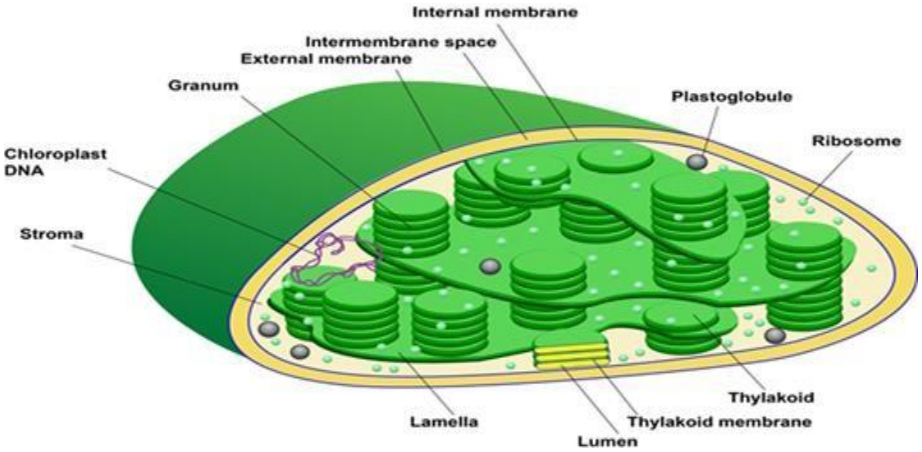
2. The stroma : it is a semi gel-like fluid within the inner membrane of the chloroplast , it contains a number of products of photosynthesis. Its support the thylakoid system and the circular DNA , RNA and ribosomes of chloroplast.
3. Thylakoid system: is suspended in the stromal. It's a collection of membranous fattened disc like sacs called thylakoids, The thylakoid membrane contains all the enzymatic components required for photosynthesis. Interaction between chlorophyll, electron carriers, coupling factors, and other components takes place within the thylakoid membrane.

2. Chromoplasts

Chromoplasts are brightly colored plastids that act as the site of pigment accumulation. They are typically found in the fleshy fruits, flowers as well as various other pigmented parts of the plant such as leaves.

With such pigments as carotenoids accumulating in chromoplasts, the plastids play an important role in pollination given that they act as visual attractors for animals involved in pollination.

While chromoplasts can develop directly from chloroplasts during maturing of fleshy fruits.



3.Leucoplasts

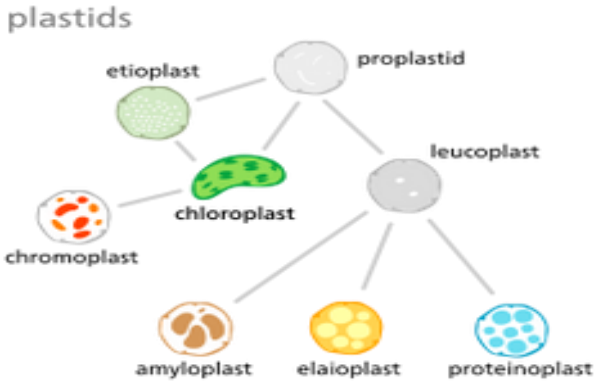
leucoplasts are colorless plastids that are commonly found in colorless leaves and rapidly growing tissues (tubers, stems, roots etc).

The following are the three major types of leucoplasts:

3- Amyloplasts are a type of plastid involved in long term storage of starch.

4- Elaioplasts are a type of leucoplast that contain oil.

5- Proteinoplasts contain higher levels of protein as compared to the other plastids.



Mitochondria : is a double membrane-bound organelle found in most eukaryotic organisms, These are cylindrical bodies ,. And called as energy homes. The main function is the oxidation of carbohydrates, amino acids and fatty acids and the production of ATP.

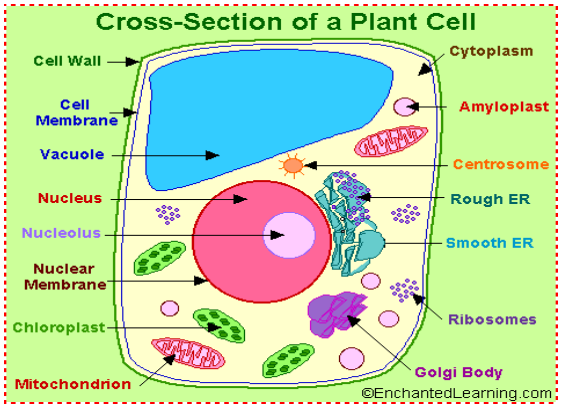
3. **Ribosomes :** is a site of protein synthesis, they contain RNA. Ribosome linked to endoplasmic reticulum.

4. **Golgi apparatus** : a group of flat disk-shaped ,smooth located near the middle of the cell ,its function processing , packaging and distribution of proteins and lipids .

5. **Endoplasmic reticulum**: Cytoplasm contains an extensive network of membrane flattened channel's and tubular canals enclosed spaces; these spaces along with the membranes synthesis or and medication of protein.
Type of Endoplasmic reticulum
a. Rough(ER) manufacturing proteins for export , which are densely coated with ribosomes
B-Smooth (ER) organization internal activates, contain enzyme

6. **Lysosomes**: membranes vesicles containing lyses enzymes, intracellular digestion enzymes, they play a role in cell death and organelles lyses.

7. **Microtubules:** are microscopic hollow tubes made of the proteins alphaand beta tubulin that are part of a cell's gives the cell shape, and keeps its organelles in place.



2. Nonliving components

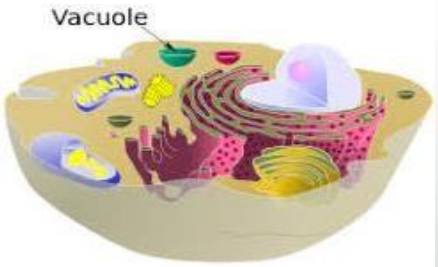
A- Crystals : are inorganic salts formed within vacuoles and vary in chemical composition , form as calcium oxalate and calcium carbonate chemical composition , form as calcium oxalate and calcium carbonate.

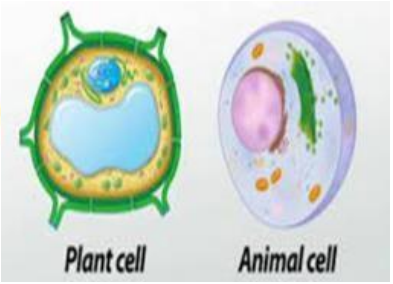
B- Starch grains : when leaf cells are actively producing sugar by photosynthesis, they keep some of this sugar in the cells called starch grains.

C- Vacuoles : a large membrane bounded sac , stores proteins , pigments and waste materials. that function, the central vacuole stores salts, minerals, nutrients, proteins, pigments, helps in plant growth, and plays an important structural role for the plant.

3) Cell sap:

Cell sap is relatively less dense than the surrounding cytoplasm. It contains sugars, salts, proteins and phenols as well as some specific pigments e.g.anthocyanin.





A cell wall

Cell wall is a semi-permeable protective layer in some cell types.This outer covering is positioned next to the cell membrane (plasma membrane) in most plant cells, fungi, bacteria, algae, and some archaea.

Plant Cell Wall Structure

The plant cell wall is multi-layered and consists of up to three sections:

1. **Middle lamella:** This outer cell wall layer contains polysaccharides called pectins. Pectins aid in cell adhesion by helping the cell walls of adjacent cells to bind to one another.

2. **Primary cell wall:** This layer is formed between the middle lamella and plasma membrane in growing plant cells. It is primarily composed of cellulose ,hemicellulose fibers and pectin polysaccharides. The primary cell wall provides the strength and flexibility needed to allow for cell growth.

3. **Secondary cell wall:** This layer is formed between the primary cell wall and plasma membrane in some plant cells. Once the primary cell wall has stopped dividing and growing, it may thicken to form a secondary cell wall. This rigid layer strengthens and supports the cell. In addition to cellulose and hemicellulose, some secondary cell walls contain lignin. Lignin strengthens the cell wall and aids in water conductivity in plant vascular tissue cells.

The cell membrane

The cell membrane (also known as the plasma membrane (PM) or cytoplasmic membrane): is a biological membrane that separates the interior of all cells from the outside environment (theextracellular space).

Function of the cell membrane:

1. Protects the cell from its environment.

2. The cell membrane controls the movement of substances in and out of cells and organelles. In this way, it is selectively permeable to ions and organic molecules.

3. cell membranes are involved in a variety of cellular processes such as cell adhesion, ion conductivity and serve as the attachment surface for several extracellular structures, including the cell wall.

Structure of the plasma membrane

The fluid mosaic model of the plasma membrane. Protein, lipid,and carbohydrate components of the membrane.

Fluid mosaic model

According to the fluid mosaic model of S. J. Singer and G. L. Nicolson (1972), which replaced the earlier model of Davson and Danielli, biological membranes can be considered as a two dimensional liquid in which lipid and protein molecules diffuse more or less easily. lipid bilayers that form the basis of the membranes do form two-dimensional liquids

Lipid bilayer

Lipid bilayers form through the process of self-assembly. The cell membrane consists primarily of a thin layer of amphipathic phospholipids that arrange so that the hydrophobic "tail" regions are isolated from the surrounding water while the hydrophilic "head" regions interact with the intracellular and extracellular faces of the resulting bilayer. This forms a continuous, spherical lipid bilayer.

Hydrophobic interactions (also known as the hydrophobic effect) are the major driving forces in the formation of lipid bilayers. An increase in interactions between hydrophobic molecules (causing clustering of hydrophobic regions) allows water molecules to bond more freely with each other, increasing the entropy of the system.

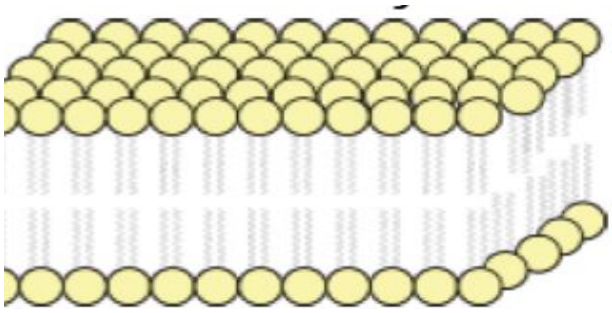


Diagram of the arrangement of amphipathic lipid molecules to form a lipid bilayer. The yellow polar head groups separate the grey hydrophobic tails from the aqueous cytosolic and extracellular environments.

Lipid bilayers are generally impermeable ions and polar molecules. The arrangement of hydrophilic heads and hydrophobic tails of the lipid bilayer prevent polar solutes (ex. amino acids, nucleic acids, carbohydrates, proteins, and ions) from diffusing across the membrane, but generally allows for the passive diffusion of hydrophobic molecules. This affords the cell the ability to control the movement of these substances via trans membrane protein complexes such as pores, channels

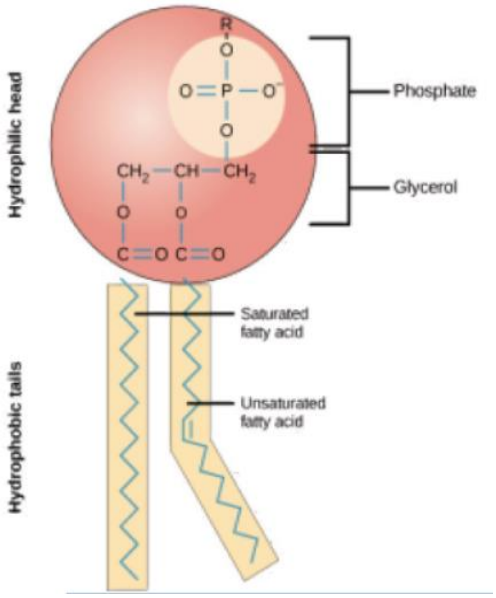
Lipid bilayer

The principal components of the plasma membrane are lipids (phospholipids and cholesterol), proteins, and carbohydrate groups

1. **A phospholipid** is a lipid made of glycerol, two fatty acid tails, and a phosphate-linked head group.

Chemical structure of a phospholipid‹showing the hydrophilic head and hydrophobic tails. The hydrophilic, portion of a phospholipid is ahead, which contains a negatively charged phosphate group The hydrophobic, part of a phospholipid consists of its long, nonpolar fatty acid tails.

The phospholipid bilayer formed by these interactions makes a good barrier between the interior and exterior of the cell, because water and other polar or charged substances cannot easily cross the hydrophobic core of the membrane.



Cholesterol: another type of lipid that is embedded among the phospholipids of the membrane, helps to minimize the effects of temperature on fluidity.

"Cholesterol At low temperatures, cholesterol increases fluidity by keeping phospholipids from packing tightly together, while at high temperatures, it actually reduces fluidity In this way, cholesterol expands the range of temperatures at which a membrane maintains a functional.

2. Proteins

Proteins are the second major component of plasma membranes.

There The proportions of proteins, lipids, and carbohydrates in the plasma membrane vary between different types of cells.

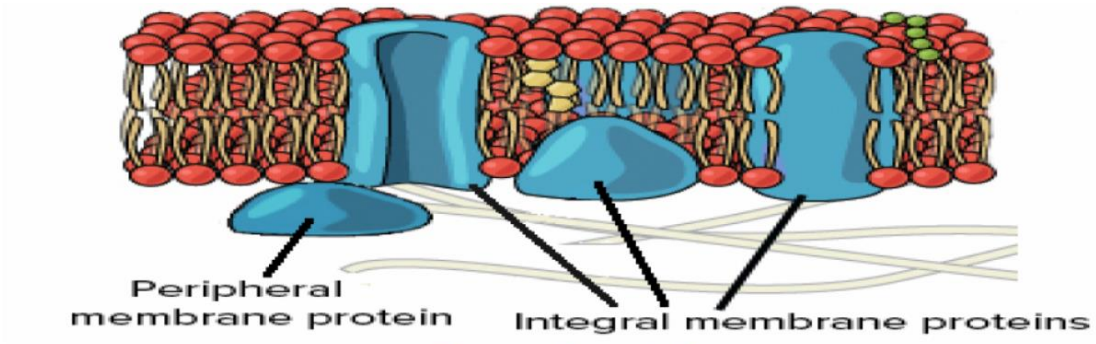
There are two main categories of membrane proteins: integral and peripheral.

A- Peripheral : Proteins include proteins that cover certain areas of the lipid bilayer **characterized by the following:**

1. They are poorly connected to the plasma membrane so that they can be easily separated.
2- Dissolve in aqueous solutions.
3 - be rich in amino acids have water-loving side chains (Hydrophilic) that allows interaction with the surrounding water and the polar surface of the bilayer molecular fat.
4. When dispersed in solutions with a pH of 7 (pH = 7).
5. Peripheral proteins at the outer surface of the membrane have chains of sugars

B - Proteins Integral These proteins are parts immersed in the binary fat layer and other parts facing one of the surfaces (external or internal) or both.

1. They are closely linked to the plasma membrane and therefore require complex methods of isolation
2- Do not dissolve in aqueous solutions.
3 - protruding parts of it on the outside of the membrane linked with carbohydrates to form glycoproteins.
4 - are rich in amino acids that have water-loving side chains (Hydrophilc) ((especially those parts of the protein protrusion of the lipid bilayer)) and hydrophobic (especially those parts of the protein immersed in the lipid bilayer) ie it Membrane fats are similar to amphoteric.



"Type of protein

The proteins that make up the cell membrane have the following functions:

1. **Structural proteins** give support and shape to the cell.
2. **Receptor proteins** help the cell membrane communicate with the external environment, using hormones, neurotransmitters and other molecules.
3. **Transport proteins**, such as spherical proteins, transport molecules through cell membranes through simple diffusion.

4. **Related to glycoproteins**, a series of carbohydrates, They are integrated into the cell membrane and help the cell communicate with other cells, and in the transport of molecules across the membrane.

3.Carbohydrate groups are present only on the outer surface of the plasma membrane and are attached to proteins, forming **glycoproteins**, or lipids, forming **glycolipids**. The proportions of proteins, lipids, and carbohydrates in the plasma membrane vary between different types of cells.