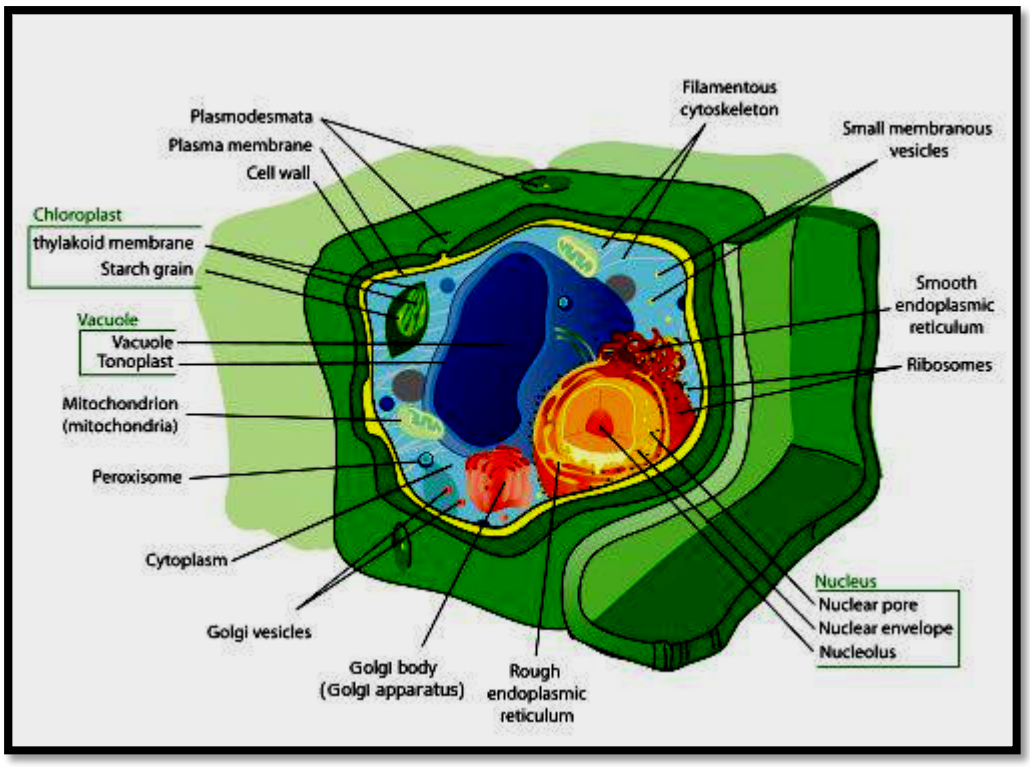
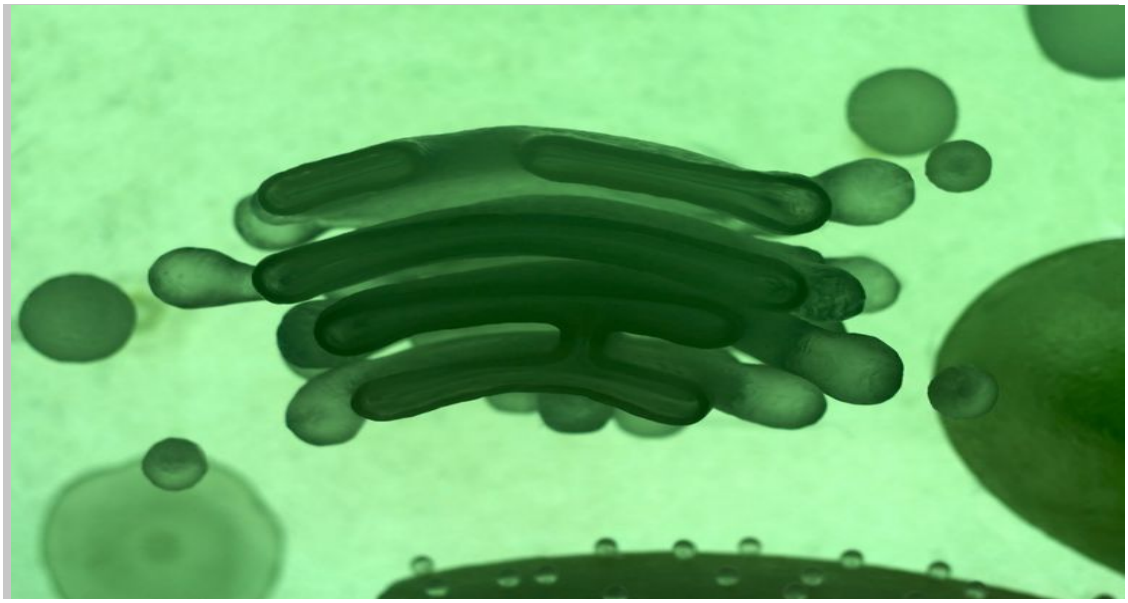


Plant cells are eukaryotic cells, or cells with a membrane-bound nucleus. Unlike prokaryotic cells, the DNA in a plant cell is housed within a nucleus that is enveloped by a membrane. In addition to having a nucleus, plant cells also contain other membrane-bound organelles (tiny cellular structures) that carry out specific functions necessary for normal cellular operation. Organelles have a wide range of responsibilities that include everything from producing hormones and enzymes to providing energy for a plant cell.

Plant cells are similar to animal cells in that they are both eukaryotic cells and have similar organelles. However, there are a number of differences between plant and animal cells. 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. A plant cell also contains structures not found in an animal cell. Some of these include a cell wall, a large vacuole, and plastids. Plastids, such as chloroplasts, assist in storing and harvesting needed substances for the plant. Animal cells also contain structures such as centrioles, lysosomes, and cilia and flagella that are not typically found in plant cells.

Question : 2
Structures and Organelles

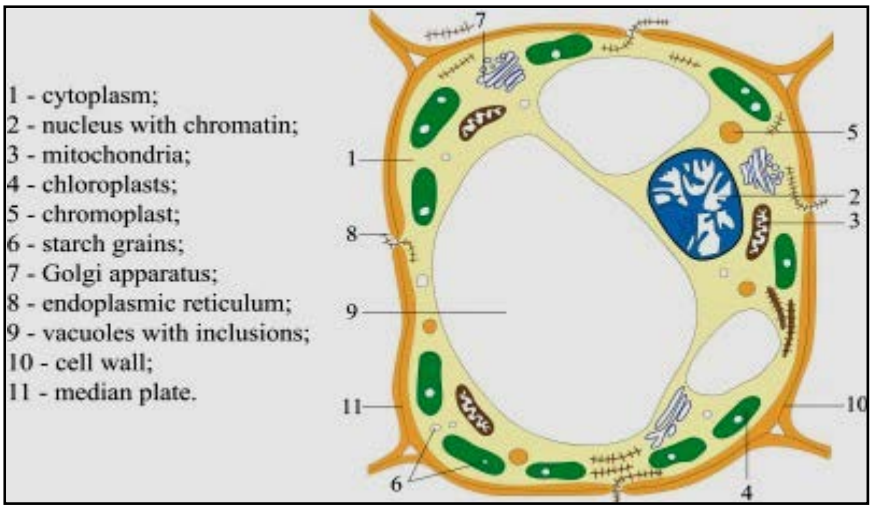


The Golgi Apparatus Model. David Gunn / Getty Images

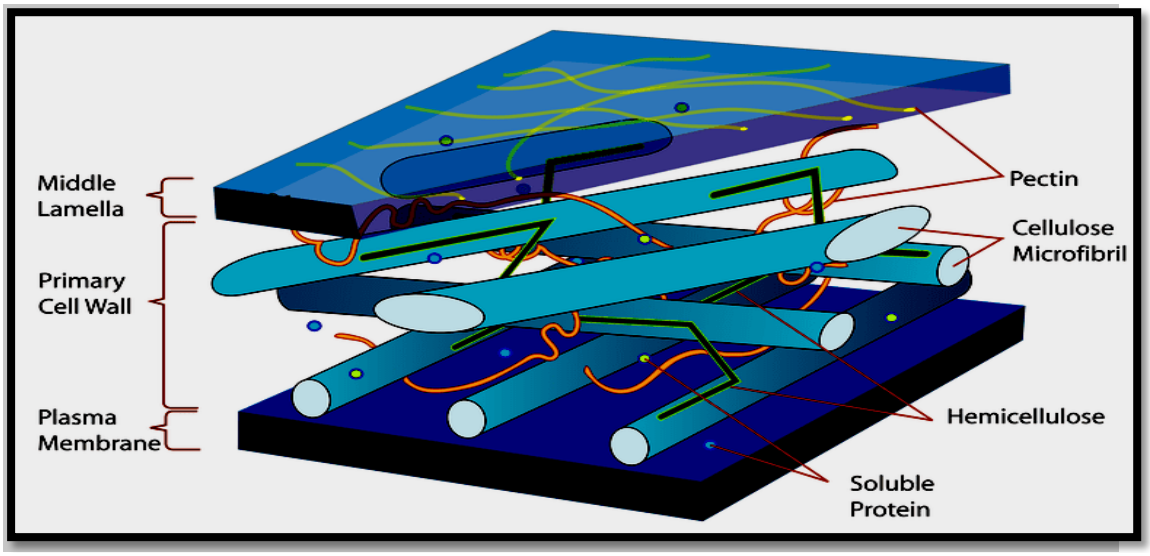
The following are examples of structures and organelles that can be found in typical plant cells:

- **Cell (Plasma) Membrane - a thin, semi-permeable membrane that surrounds the cytoplasm of a cell, enclosing its contents.**
- **Cell Wall - outer covering of the cell that protects the plant cell and gives it shape.**
- **Chloroplast - the sites of photosynthesis in a plant cell. They contain chlorophyll, a green pigment that absorbs energy from sunlight.**
- **Cytoplasm - gel-like substance within the cell membrane containing water, enzymes, salts, organelles, and various organic molecules.**
- **Cytoskeleton - a network of fibers throughout the cytoplasm that helps the cell maintain its shape and gives support to the cell.**
- **Endoplasmic Reticulum (ER) - extensive network of membranes composed of both regions with ribosomes (rough ER) and regions without ribosomes (smooth ER). The ER synthesizes proteins and lipids.**
- **Golgi Complex - responsible for manufacturing, storing and shipping certain cellular products including proteins.**

- **Microtubules - hollow rods that function primarily to help support and shape the cell. They are important for chromosome movement in mitosis and meiosis, as well as cytosol movement within a cell.**
- **Mitochondria - these organelles generates energy for the cell by converting glucose (produced by photosynthesis) and oxygen to ATP. This process is known as respiration.**
- **Nucleus - membrane bound structure that contains the cell's hereditary information (DNA).**
    - **Nucleolus - structure within the nucleus that helps in the synthesis of ribosomes.**
    - **Nucleopore - tiny hole within the nuclear membrane that allows nucleic acids and proteins to move into and out of the nucleus.**
- **Peroxisomes - tiny structures bound by a single membrane that contain enzymes that produce hydrogen peroxide as a by-product. These structures are involved in plant processes such as photorespiration.**
- **Plasmodesmata - pores or channels between plant cell walls that allow molecules and communication signals to pass between individual plant cells.**
- **Ribosomes - consisting of RNA and proteins, ribosomes are responsible for protein assembly. They can be found either attached to the rough ER or free in the cytoplasm.**
- **Vacuole - structure in a plant cell that provides support and participates in a variety of cellular functions including storage, detoxification, protection, and growth. When a plant cell matures, it typically contains one large liquid-filled vacuole.**



Cell Wall



The cell wall is the rigid, 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. Animal cells however, do not have a cell wall. The cell wall conducts many important functions in

a cell including protection, structure, and support. Cell wall composition varies depending on the organism. In plants, the cell wall is composed mainly of strong fibers of the carbohydrate polymer **cellulose**. Cellulose is the major component of cotton fiber and wood and is used in paper production.

Plant Cell Wall Structure

The plant cell wall is multi-layered and consists of up to three sections. From the outermost layer of the cell wall, these layers are identified as the middle lamella, primary cell wall, and secondary cell wall. While all plant cells have a middle lamella and primary cell wall, not all have a secondary cell wall.

- **Middle lamella** - outer cell wall layer that contains polysaccharides called pectins. Pectins aid in cell adhesion by helping the cell walls of adjacent cells to bind to one another.
- **Primary cell wall** - layer formed between the middle lamella and plasma membrane in growing plant cells. It is primarily composed of cellulose microfibrils contained within a gel-like matrix of hemicellulose fibers and pectin polysaccharides. The primary cell wall provides the strength and flexibility needed to allow for cell growth.
- **Secondary cell wall** - layer 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.

Plant Cell Wall Function

A major role of the cell wall is to form a framework for the cell to prevent over expansion. Cellulose fibers, structural proteins, and other polysaccharides help to maintain the shape and form of the cell. Additional functions of the cell wall include:

- **Support** - the cell wall provides mechanical strength and support. It also controls the direction of cell growth.
- **Withstand turgor pressure** - turgor pressure is the force exerted against the cell wall as the contents of the cell push the plasma membrane against the cell wall. This pressure helps a plant to remain rigid and erect, but can also cause a cell to rupture.
- **Regulate growth** - sends signals for the cell to enter the cell cycle in order to divide and grow.

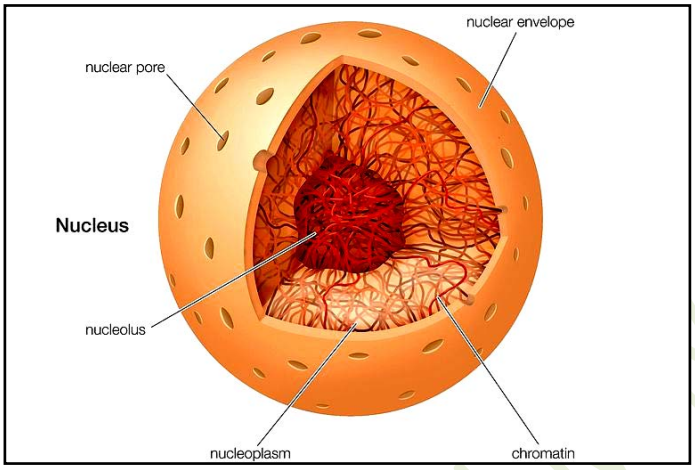
- **Regulate diffusion** - the cell wall is porous allowing some substances, including proteins, to pass into the cell while keeping other substances out.
- **Communication** - cells communicate with one another via plasmodesmata (pores or channels between plant cell walls that allow molecules and communication signals to pass between individual plant cells).
- **Protection** - provides a barrier to protect against plant viruses and other pathogens. It also helps to prevent water loss.
- **Storage** - stores carbohydrates for use in plant growth, especially in seeds.

Plant Cell: Structures and Organelles

To learn more about organelles that can be found in typical plant cells, see:

- Cell (Plasma) Membrane - surrounds the cytoplasm of a cell, enclosing its contents.
- **Cell Wall** - outer covering of the cell that protects the plant cell and gives it shape.
- Centrioles - organize the assembly of microtubules during cell division.
- Chloroplasts - the sites of photosynthesis in a plant cell.
- Cytoplasm - gel-like substance within the cell membrane composed.
- Cytoskeleton - a network of fibers throughout the cytoplasm.
- Endoplasmic Reticulum - extensive network of membranes composed of both regions with ribosomes (rough ER) and regions without ribosomes (smooth ER).
- Golgi Complex - responsible for manufacturing, storing and shipping certain cellular products.
- Lysosomes - sacs of enzymes that digest cellular macromolecules.
- Microtubules - hollow rods that function primarily to help support and shape the cell.
- Mitochondria - generate energy for the cell through respiration.
- Nucleus - membrane bound structure that contains the cell's hereditary information.
- **Nucleolus** - structure within the nucleus that helps in the synthesis of ribosomes.
- **Nucleopore** - tiny hole within the nuclear membrane that allows nucleic acids and proteins to move into and out of the nucleus.
- Peroxisomes - tiny structures bound by a single membrane that contain enzymes that produce hydrogen peroxide as a by-product.
- **Plasmodesmata** - pores or channels between plant cell walls that allow molecules and communication signals to pass between individual plant cells.

- Ribosomes - consisting of RNA and proteins, ribosomes are responsible for protein assembly.
- Vacuole - typically large structure in a plant cell that provides support and participates in a variety of cellular functions including storage, detoxification, protection, and growth.



The cell nucleus is a membrane bound structure that contains the cell's hereditary information and controls the cell's growth and reproduction. It is the command center of a eukaryotic cell and is commonly the most prominent organelle in a cell.

Distinguishing Characteristics

The cell nucleus is bound by a double membrane called the **nuclear envelope**. This membrane separates the contents of the nucleus from the cytoplasm.

Like the cell membrane, the nuclear envelope consists of phospholipids that form a lipid bilayer. The envelope helps to maintain the shape of the nucleus and assists in regulating the flow of molecules into and out of the nucleus through **nuclear pores**. The nuclear envelope is connected with the **endoplasmic reticulum (ER)**in such a way that the internal compartment of the nuclear envelope is continuous with the lumen of the ER.

The nucleus is the organelle which houses chromosomes. Chromosomes consist of DNA, which contains heredity information and instructions for cell growth, development, and reproduction. When a cell is "resting" i.e. not dividing, the chromosomes are organized into long entangled

structures called chromatin and not into individual chromosomes as we typically think of them.

Nucleoplasm

Nucleoplasm is the gelatinous substance within the nuclear envelope. Also called karyoplasm, this semi-aqueous material is similar to cytoplasm and is composed mainly of water with dissolved salts, enzymes, and organic molecules suspended within.

The nucleolus and chromosomes are surrounded by nucleoplasm, which functions to cushion and protect the contents of the nucleus. Nucleoplasm also supports the nucleus by helping to maintain its shape. Additionally, nucleoplasm provides a medium by which materials, such as enzymes and nucleotides (DNA and RNA subunits), can be transported throughout the nucleus.

Substances are exchanged between the cytoplasm and nucleoplasm through nuclear pores.

The Nucleolus

Contained within the nucleus is a dense, membrane-less structure composed of RNAand proteins called the nucleolus.
The **nucleolus** contains nucleolar organizers, which are parts of chromosomes with the genes for ribosome synthesis on them. The nucleolus helps to synthesize ribosomes by transcribing and assembling ribosomal RNA subunits. These subunits join together to form a ribosome during protein synthesis.

Protein Synthesis

The nucleus regulates the synthesis of proteins in the cytoplasm through the use of messenger RNA (mRNA). Messenger RNA is a transcribed DNA segment that serves as a template for protein production. It is produced in the nucleus and travels to the cytoplasm through the nuclear pores of the nuclear envelope. Once in the cytoplasm, ribosomes and another RNA molecule called transfer RNA work together to translatemRNA to produce proteins.

Eukaryotic Cell Structures

The cell nucleus is only one type of cell organelle. The following cell structures can also be found in a typical animal eukaryotic cell:

- Centrioles - help to organize the assembly of microtubules.
- Chromosomes - house cellular DNA.

- Cilia and Flagella - aid in cellular locomotion.
- Cell Membrane - protects the integrity of the interior of the cell.
- Endoplasmic Reticulum - synthesizes carbohydrates and lipids.
- Golgi Complex - manufactures, stores and ships certain cellular products.
- Lysosomes - digest cellular macromolecules.
- Mitochondria - provide energy for the cell.
- Ribosomes - responsible for protein production.
- Peroxisomes - detoxify alcohol, form bile acid, and use oxygen to break down fats.

Parts of Plant Cell

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Plants cell constitute of membrane bound nucleus and many cellular structures. These organelles carry out functions that are necessary for the proper functioning and survival of the cell. The cell organelles of the plant are enclosed by a cell wall and cell membrane. The constituents of the cell are suspended in the cytoplasm or cytosol.

The parts of the plant cell are as follows:

Cell wall is the outermost rigid covering of the plant cell. It is a salient feature of plant cell.

Cell membrane or the plasma membrane is the outer lining of the cell inside the cell wall.

Cytosol or cytoplasm is the gel-like matrix inside the cell membrane which constitutes all other cell organelles.

Nucleus is the control center of the cell. It is a membrane bound structure which contains the hereditary material of the cell - the DNA

Chloroplast *is a plastid with green pigment chlorophyll. It traps light energy and converts it to chemical energy by the process of photosynthesis.*

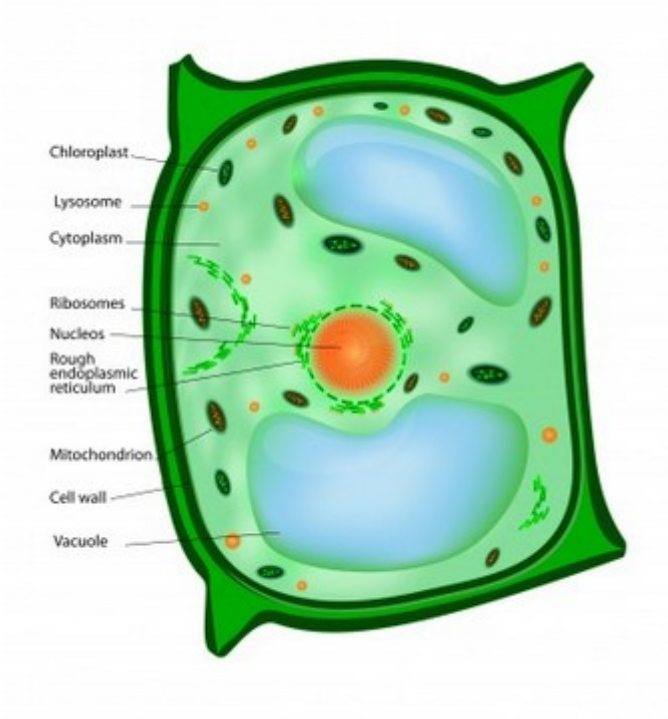
Mitochondria carries out cellular respiration and provides energy to the cells.

Vacuoles are the temporary storage center of the cell.

Golgi body is the unit where proteins are sorted and packed.

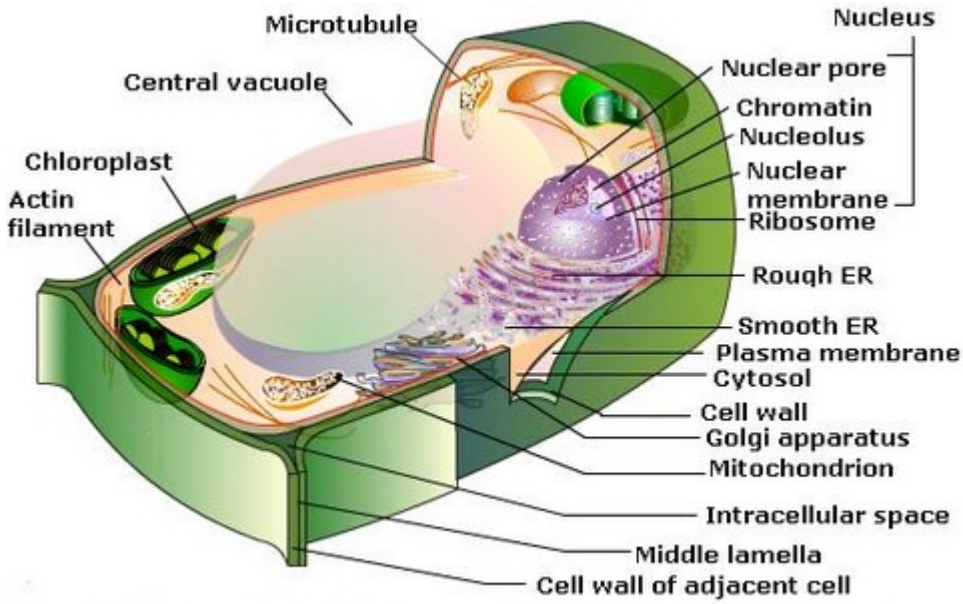
Ribosomes are structures that assemble proteins.

Endoplasmic reticulum are membrane covered organelles that transport materials.



Plant Cell Structure and Function

All parts of the plant play a significant role in the proper functioning of the cell. Unlike animals, plant cells are surrounded by a rigid cell wall.

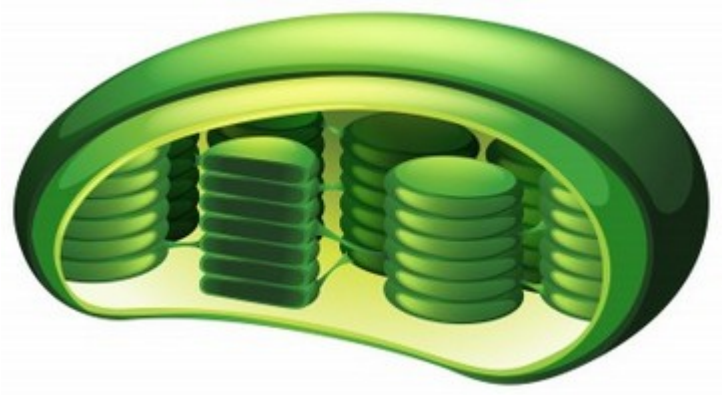


Section of plant cell as seen under the electron microscope

***Cell wall*:** The cell wall is a rigid layer that surrounds the plant cells. It is made up of cellulose. Cell wall is a characteristic feature to cells of plants. Plant cell walls are primarily made up of cellulose. Plant cell wall consists of three layers: the primary cell wall, secondary cell wall and the middle lamella. It is located outside the cell membrane whose main function is to provide rigidity, strength, protection against mechanical stress and infection. Cell wall is made up of cellulose, pectins,glycoproteins, hemicellulose and lignin.

***Cell membrane*:** It is the outer boundary of the cell, it encloses the cytoplasm and the organelles of the cells. In plants cells it is inside the cell wall. The cell membrane is semi permeable, allowing only specific substances to pass through and blocking others.

***Chloroplasts*:** It is an elongated or disc-shaped organelle containing chlorophyll. They have two membranes and have structures that look like stack of coins. They are flattened structures which contain chemical chlorophyll. The process of photosynthesis occurs in this region of the plant cell. The chlorophyll is a green pigment that absorbs energy from sunlight to make food for the plants by converting light energy into chemical energy.



***Cytoskeleton*:** It is a network of fibers made up of micro-tubule and micro-filament. They maintain the shape and gives support to the cell.

***Microtubules*:** They are hollow cylinder like structures found in the cytoplasm of the cells. Its function is transport and structural support.

***Microfilaments*:** Microfialments are solid rod like structures whose primary function is structural support.

***Plasmodesmata*:** They are microscopic channels which traverse the cell walls of plant cells and enables transport and communication between them.

***Vacuole*:** Vacuoles are known as cells storage center. Plant cells have large membrane bound chamber called vacuole. Its main function is storage. Vacuoles are found in the cytoplasm of most plant cells. They are membrane bound organelles, they perform functions of secretion, excretion and storage.

***Tonoplast*:** A vacuole that is surrounded by a membrane is called tonoplast.

Plastids: Plastids are storage organelles. They store products like starch for synthesis of fatty acids and terpenes.

Leucoplast: They are a type of plastid which are non-pigmented.

***Chromoplast*:** They are plastids responsible for pigment synthesis and storage. They are found in photosynthetic eukaryotic species. They are found in colored organs of plants like fruits and flowers.

***Golgi complex*:** The Golgi bodies look like the endoplasmic reticulum and are situated near the nucleus. They are found in almost all eukaryotic cells. Their main function is to process and package macromolecules synthesized from other parts of the cell. The Golgi apparatus is referred to as the cell's packaging center.

Ribosomes: Ribosomes are smallest and the most abundant cell organelle. It comprises of RNA and protein. Ribosomes are sites for protein synthesis. They are found in all cells because protein are necessary for the survival of the cell. The ribososomes are known as the protein factories of the cell.

***Endoplasmic reticulum*:** Endoplasmic reticulum is a membrane bound compartment, which look like flattened sacs lined side by side. It is a large network of interconnecting membrane tunnels. It is composed of both rough endoplasmic reticulum and smooth endoplasmic reticulum.

They are responsible for protein translation, and protein transport to be used in the cell membrane. They also aid in sequestration of calcium, and production and storage of glycogen and other macromolecules.

***Mitochondria*:** Mitochondria are surrounded by two membranes. They are described as the 'power plants' of the cell as they convert glucose to energy molecules (ATP). They possess their own hereditary material which help in self duplication and multiplication.

***Lysosome*:** Lysosome contain digestive enzymes. They digest excess or worn out organelles, food particles and any foreign bodies.

***Microbody*:** It is a single membrane bound organelle that comprises of degradative enzymes

***Cytoplasm*:** It is a gel-like matrix inside enclosed by the cell membrane. The cytoplasm supports cell organelles and also prevents the cell from bursting or shrinking.

***Nucleus*:** It is the control center of the cell. It is bound by a double membrane known as the nuclear envelope. It is a porous membrane, it allows passage of substances and is a distinctive characteristic of the eukaryotic cell. Most of the genetic material is organized as multiple long linear DNA molecules. The nucleus directs all the activities of the cell and also help in protein formation.

Plastids in Plant Cell

Plastids are cell organelles that store specific things found only in plant cell but absent in animal cells.In plant cell they are found in the cytoplasm. Plastids are spherical or ovoid in shape. They are involved in manufacture and storage of certain important chemical compounds.

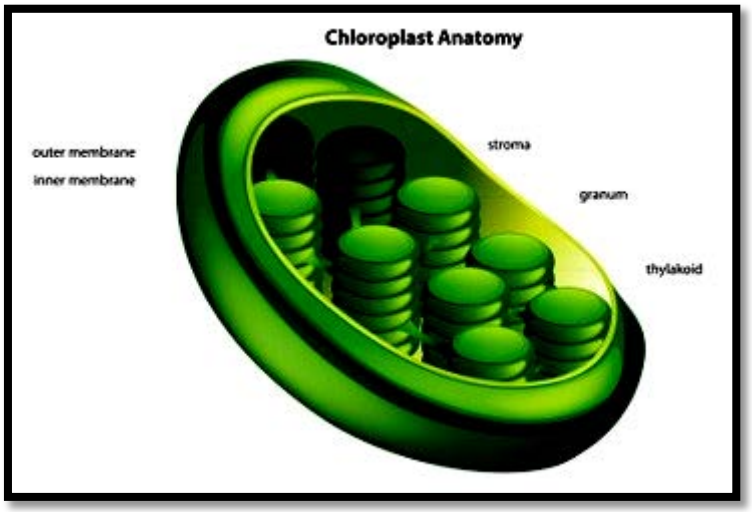
The term plastids was coined by Schimper in 1885 and was derived from a *Greek* word *'plastikas'* which means *formed* or *moulded*.

Plastids in plants include chloroplasts, chromoplasts, leucoplasts, amyloplast, elaioplast and proteinoplast/aleuronoplast depending on the function they play.

Chloroplasts

The word chloroplast is derived from the *Greek* word *chloros* meaning green and *plast* meaning form or entity. It is the most important plastid as they are involved in photosynthesis. The chloroplasts are situated near the surface of the cell and in parts where there is sufficient reception of sunlight. The shape of the cholorplast varies, it may be spheroid or ovoid or discoid.

For a given cell type the size of plastid is constant but it differs from species to species.It is about 4-5 microns in length and 1-3 microns in thickness. The number of chloroplast may be 20 to 40 per cell may be upto 1000, the number varies from species to species but is constant for a plant.



Structure
Chloroplasts are disc-shaped and are enclosed by a double membrane.

Within the inner membrane is a protein-rich substance known as stroma, it is embedded in a membrane system. This membrane system forms membrane bound vesicles called thylakoids.

The thylakoids lie in stacks called grana. This contains the photosynthetic pigments - chlorophyll a and b and carotenoids. Lamellae are tubular membranes which interconnect the grana.

Functions
Photosynthesis is carried out in the chloroplast.

The enzymes and co-enzymes necessary for photosynthesis is present.

Chromoplast
Chromo means color; plast means living. Chromoplasts are colored plastids and they contain various pigments like yellow,orange and red.

They are found commonly in flowers and fruits. The color is due ot pigement, carotenes and xanthophylls.

Functions
In flowers the main function is attract agents for pollination.

In fruits it is to attract agents for dispersal.

Leucoplasts
These are colorless plastids and occur in parts of plants that are not exposed to light like roots and seeds.

The absence of color is due to the lack of pigments.

Functions
Starch grain formations are seen in leucoplast.

Oils and proteins are synthesized here.

The Study of how plants function : includes carbon assimilation , translocation of nutrients , growth and development, reaction to environmental responses and stress .

The Differences between Eukaryotic Cell and Prokaryotic Cell

Nucleus	Present	Absent
Number of chromosomes	More than one	One--but not true chromosome: Plasmids
Cell Type	Usually multicellular	Usually unicellular (some cyanobacteria may be multicellular)
True Membrane bound Nucleus	Present	Absent
Example	Animals and Plants	Bacteria and Archaea
Genetic Recombination	Meiosis and fusion of gametes	Partial, undirectional transfers DNA
Lysosomes and peroxisomes	Present	Absent
Microtubules	Present	Absent or rare
Endoplasmic reticulum	Present	Absent
Mitochondria	Present	Absent
DNA wrapping on proteins.	Eukaryotes wrap their DNA around proteins called histones.	Multiple proteins act together to fold and condense prokaryotic DNA. Folded DNA is then organized into a variety of conformations that are supercoiled and wound around tetramers of the HU protein.
Ribosomes	larger	smaller
Vesicles	Present	Present
Golgi apparatus	Present	Absent
Chloroplasts	Present (in plants)	Absent; chlorophyll scattered in the cytoplasm
Permeability of Nuclear Membrane	Selective	not present
Plasma membrane with steroid	Yes	Usually no
Cell wall	Only in plant cells and fungi (chemically simpler)	Usually chemically complexed
Vacuoles	Present	Present
Cell size	10-100um	1-10um