Semestre : 3 ème Semestre

UE : Unité d'Enseignement Fondamentale 1

Matière 1: Plant physiology

Crédits : 4 / Coefficients : 2

General introduction

Plant physiology is the science which is connected to the material and energy exchange, growth and development, as well as movement of plant. Plant physiology is the science that studies plant function: what is going on in plants. Another definition of plant physiology: is the study of plant function, encompassing the dynamic processes of growth, metabolism and reproduction in living plants.

Plant physiology is overlapped with its related branch of knowledge: biochemistry, biophysics, and molecular biology. The basic knowledge of plant physiology, that is necessary for experts in **agriculture**. Uptake and **transport of water** and **minerals** are explained in general. The **nutrient supply of plant** is presented in details **(essential elements, solute transport, nutritional deficiencies).** Most common processes of plant biochemistry and metabolism, such as **photosynthesis**, are highlighted. Plant **growth and development.**

Content of the subject

Chapter 1 : Structure and Function of different cell organelles.

Chapter 2 : Absorption, Transport and water loss in plants (water and nutriments in plant).

Chapter 3 : Transpiration.

Chapter 4 : Mineral nutriments.

Chapter 5 : Nitrogen nutriments.

Chapter 6 :Photosynthesis.

Chapter 7 : Growth and Development.

Chapter 1 : structure and function of different cell organelles

The cell is the basic unit of life in all organisms. Like humans and animals, plants are also composed of several cells. The plant cell is surrounded by a cell wall which is involved in providing shape to the plant cell. Apart from the cell wall, there are other organelles that are associated with different cellular activities.

Let us have a detailed look at the plant cell, its structure, and functions of different plant cell organelles.

1. Plant Cell Definition

"Plant cells are eukaryotic cells with a true nucleus along with specialized structures called organelles that carry out certain specific functions."

2. Plant Cell Diagram

The plant cell is rectangular and comparatively larger than the animal cell. Even though plant and animal cells are eukaryotic and share a few cell organelles, plant cells are quite distinct when compared to animal cell as they perform different functions. Some of these differences can be clearly understood when the cells are examined under an electron microscope.

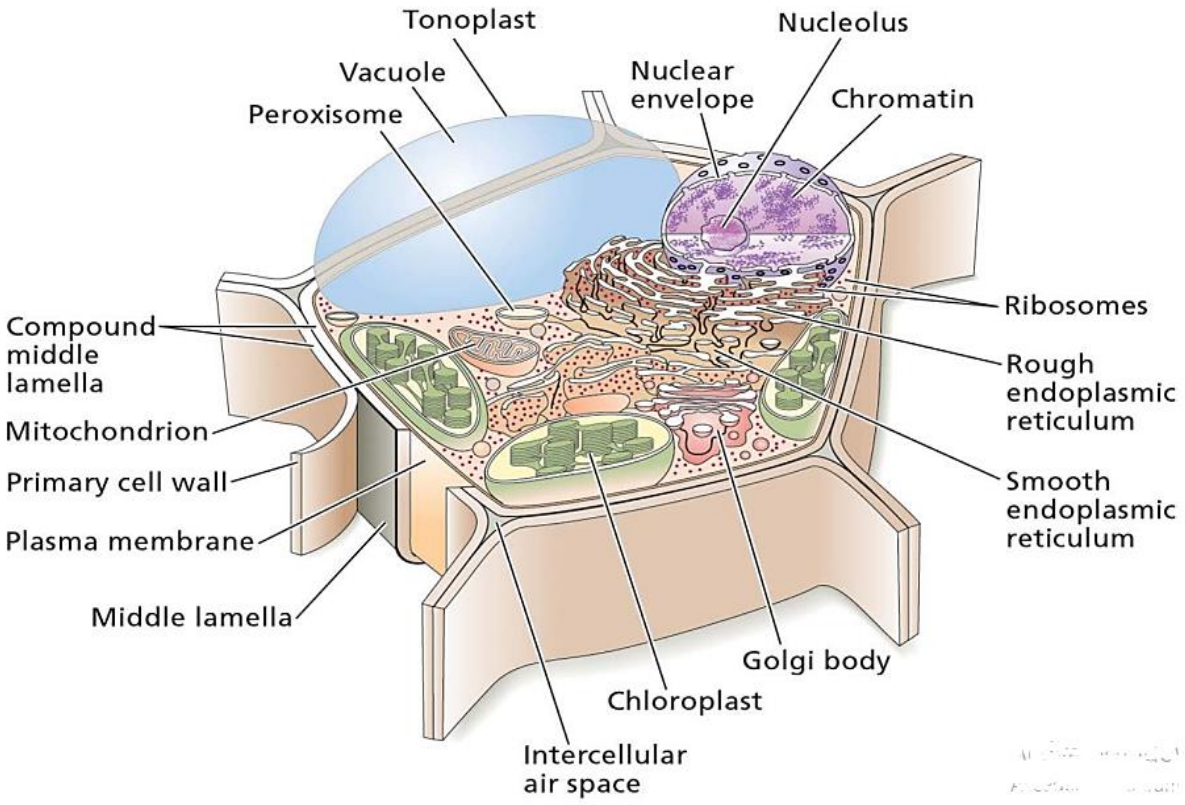


Fig : Plant Cell Diagram showing different cell organelles

3. Plant Cell Structure

Just like different organs within the body, plant cell structure includes various components known as cell organelles that perform different functions to sustain itself.

A general outline of a plant cell is as follows:

I. Cell Wall

II. Protoplast

A. Protoplasmic reticulum

1. Cytoplasm
2. Endoplasmic reticulum
3. Ribosomes
4. Mitochondria
5. Golgi apparatus
6. Plastids
7. Nucleus
8. Plant cell vacuoles
9. Peroxisomes
10. Lysosomes
11. spherosomes

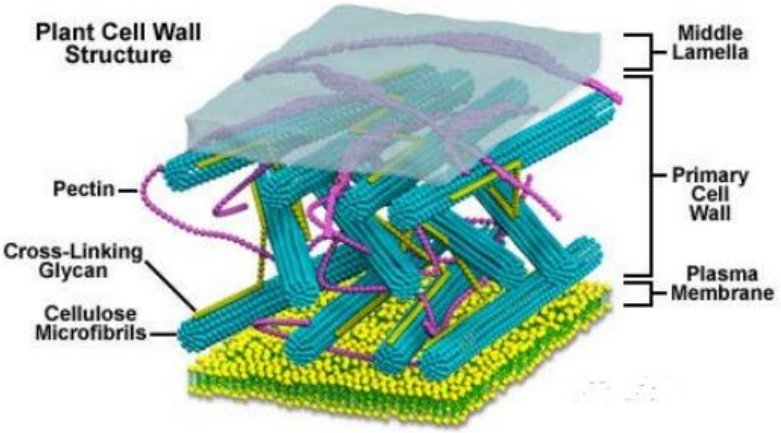
B. Non-protoplasmic components

1. Starch grains

Cell wall

It is a rigid layer which is composed of polysaccharides cellulose, pectin and hemicellulose. It is located outside the cell membrane. It also comprises glycoproteins and polymers such as lignin, cutin, or suberin.

The primary function of the cell wall is to protect and provide structural support to the cell. The plant cell wall is also involved in protecting the cell against mechanical stress and providing form and structure to the cell. It also filters the molecules passing in and out of it.

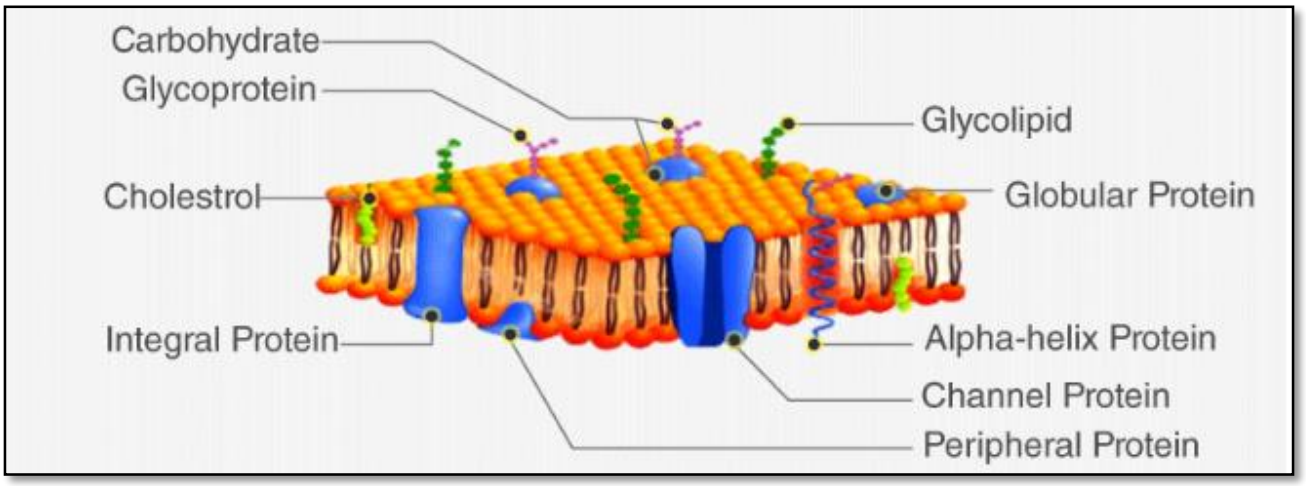


The formation of the cell wall is guided by microtubules. It consists of three layers**,** namely**, primary, secondary and the middle lamella**. The primary cell wall is formed by cellulose laid down by enzymes.

Cell membrane

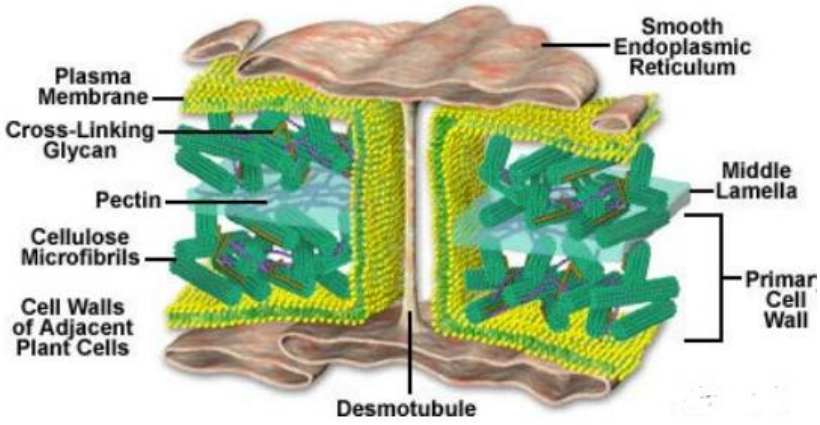
- It is the semi-permeable membrane that is present within the cell wall. It is composed of a thin layer of protein and fat.

- The cell membrane plays an important role in regulating the entry and exit of specific substances within the cell.
- For instance, cell membrane keeps toxins from entering inside, while nutrients and essential minerals are transported across.



Plasmodesmata

Plasmodesmata (singular, plasmodesma) are small channels that directly connect the cytoplasm of neighboring plant cells to each other, establishing living bridges between cells. The plasmodesmata, which penetrate both the primary and secondary cell walls allow certain molecules to pass directly from one cell to another and are important in cellular communication.

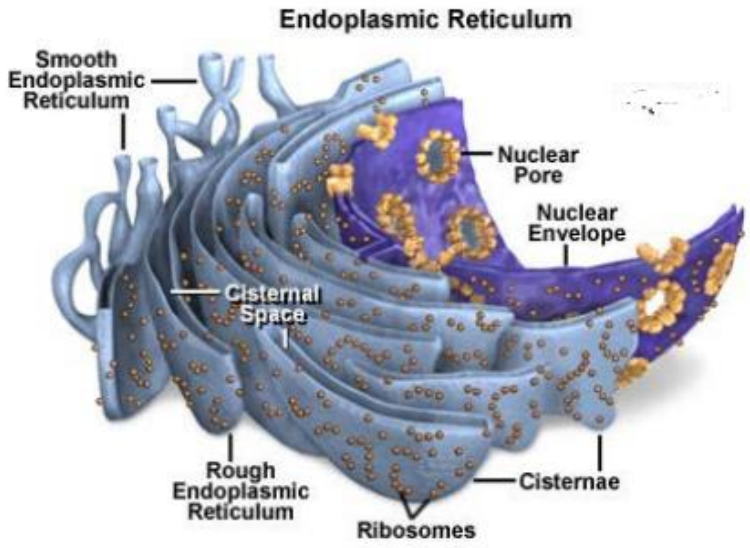


❖ **Cytoplasm**

Part of plant cells outside the nucleus (and outside the large vacuole of plant cells) is called cytoplasm. Strictly speaking, this includes all the organelles (mitochondria, chloroplasts, and so on) and is the area in which most cell activities take place. However, cytoplasm is often used to refer to the jellylike matter in which the organelles are embedded (correctly termed the cytosol). Most of the activities in the cytoplasm are chemical reactions (metabolism), for example, protein synthesis. In many cells, the cytoplasm is made up of two parts: the ectoplasm (or plasmagel), a dense gelatinous outer layer concerned with cell movement, and the endoplasm (or plasmasol), a more fluid inner

part where most of the organelles are found. The semifluid medium between the nucleus and the plasma membrane is called cytosol.

❖ The Endoplasmic Reticulum



- Connected to the nuclear envelope
- 3D-network of continuous tubules that course through the cytoplasm.
- **Rough ER:** Synthesize, process, and sort proteins targeted to membranes, vacuoles, or the secretory pathway.
- **Smooth ER:** Synthesize lipids and oils.
- Also: – Acts as an anchor points for actin filaments – Controls cytosolic concentrations of calcium ions The Endoplasmic reticulum.
- Proteins are made in the Rough ER lumen by an attached ribosome.
- Protein detaches from the ribosome.
- The ER folds in on itself to form a transport vesicle.
- This transport vesicle "buds off" and moves to the cytoplasm.
- Either: – Fuses with plasma membrane – Fuses with Golgi Apparatus.

❖ Ribosomes

Ribosomes are organelles that are found in all living cells and work as a macro-molecular machine that synthesizes biological proteins. Ribosomes are also called the "Protein Factories of The Cell".

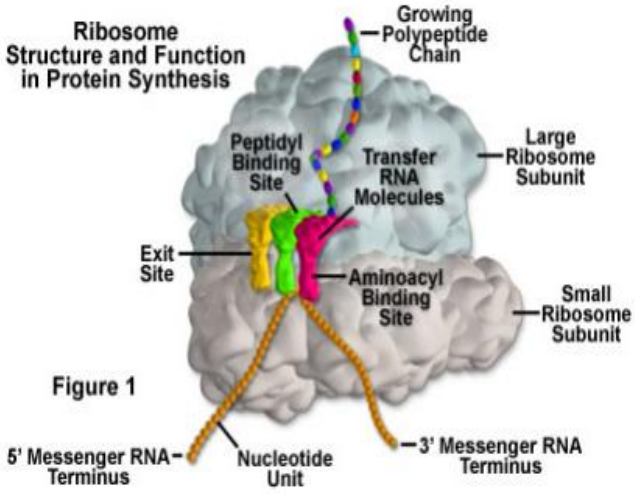
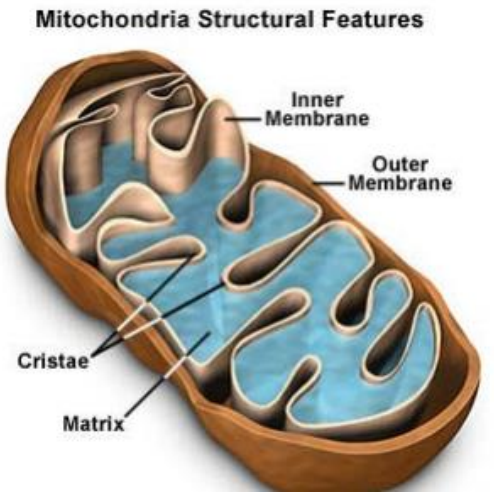


Figure 1

Function: A Ribosome is a macro-molecular machine that synthesizes biological proteins.

Structure: Ribosomes appear flattened and spherical in shape and consist of two major components: the small and large ribosomal subunits.

❖ Mitochondria

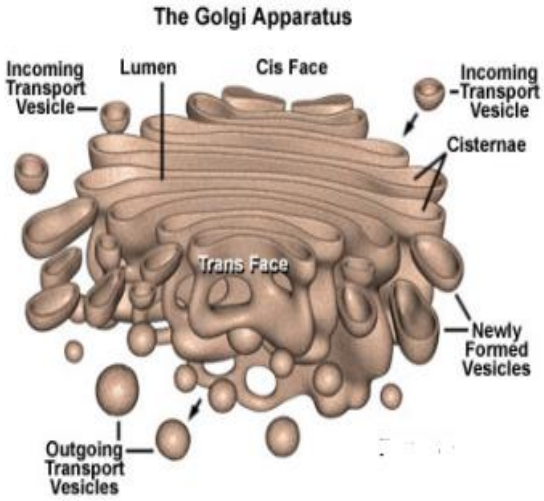


Often referred to as the "powerhouse of the cell," mitochondria are the double-membraned organelles that provide energy to the cell by breaking down carbs and sugar molecules. We can find them in the cytoplasm part of all the eukaryotic cells.

Function: It breaks down carbohydrates and sugar molecules to generate energy.

Structure: Mitochondria are oval, tubular-shaped, double-membrane organelles.

❖ Golgi Apparatus



Golgi apparatus also known as Golgi Complex or Golgi body. Golgi apparatus is an organelle found in eukaryotic cells and are responsible for distributing synthesized macro-molecules to the different parts of the cell.

Function: Distributing synthesized macro-molecules to the different parts of the cell.

Structure: It comprises a series of stacked and flattened pouches called Cisternae.

❖ Plastids

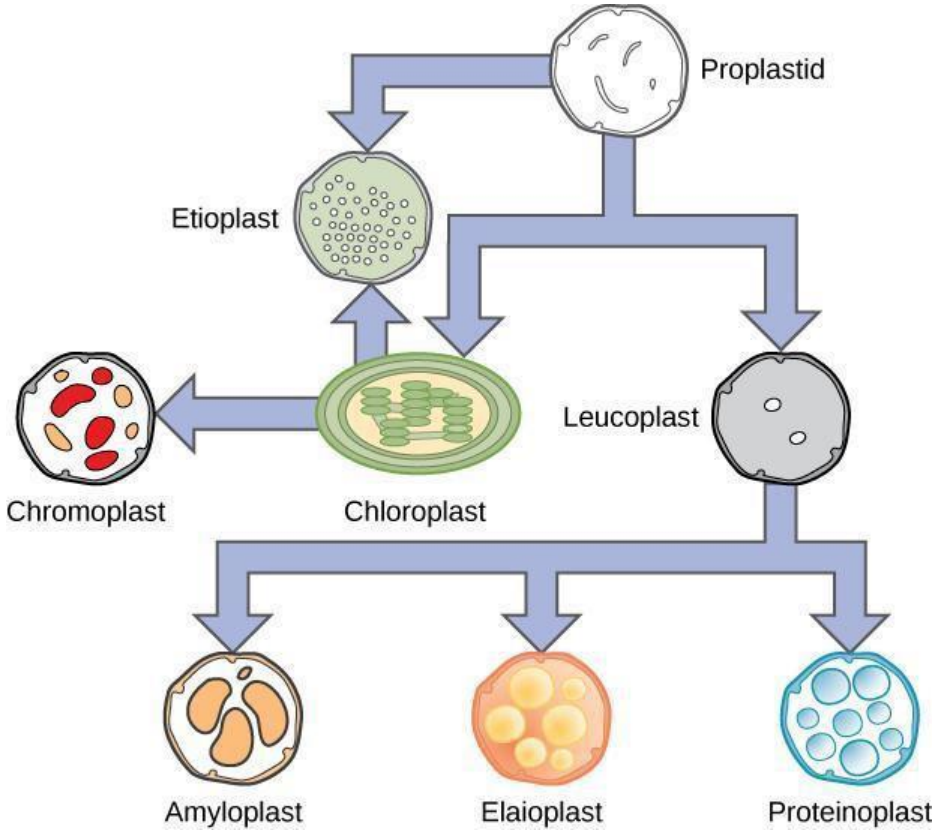
Plastids are double-membrane organelles that are found in the cells of plants and algae. It plays a vital role in photosynthesis.

Function: These organelles play a crucial role in the manufacturing and storage of food. It also contains pigments that contribute to the process of photosynthesis.

Structure: The pigments in plastids not only help in photosynthesis but can also change the color of the cell.

Types of Plastids:

To understand the different types of plastids, we will have to go into more detail.



- **Leucoplasts:** Leucoplasts are organelles in non-photosynthetic tissues of plants that store protein, lipid, and starch.

- **Chloroplasts:** Chloroplasts are an elongated organelle enclosed by phospholipid membrane. Chloroplasts are disc-shaped organelles and filled with fluid called stroma that comprises the circular DNA. They also include the green-coloured pigment called chlorophyll, which the plants use in photosynthesis by transforming carbon dioxide and water into glucose.

- **Chromoplasts:** Chromoplasts are diversely coloured plastic. They synthesize the pigments and store essential nutrients in photosynthetic eukaryotic organisms. They have red, orange, and yellow coloured pigments which provide color to all the ripe fruits and flowers we see in our day-to-day lives.

❖ **Nucleus**

The nucleus is a membrane-based organelle that is found in eukaryotic cells. The nucleus is a highly specialized organelle that serves as the information processing and administrative center of the cell. This organelle has two major functions: it stores the cell's hereditary material, or DNA, and

it coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division).

Function: This organelle helps produce ribosomes, protein-manufacturing structures and allows proteins and nucleic acids to pass through.

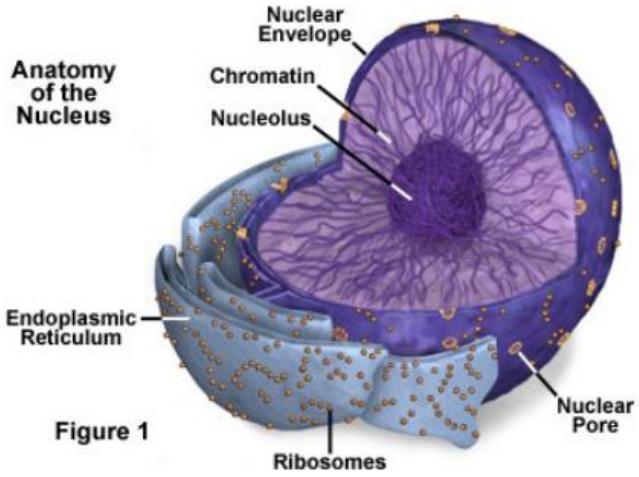


Figure 1

Structure: Eukaryotes generally have a single nucleus, but a few cell types, such as mammalian red blood cells, have no nuclei, and a few others including osteoclasts have many.

The nucleus has two parts:

- **The Nucleolus:** It helps in producing the ribosomes and protein manufacturing structures.
- **The Nucleopore:** The holes that penetrate the membrane of a nucleus are called the nucleopores and these allow proteins and nucleic acids to pass through.

❖ Peroxisomes

Microbodies are a diverse group of organelles that are found in the cytoplasm of almost all cells, roughly spherical, and bound by a single membrane. There are several types of microbodies, including lysosomes, but peroxisomes are the most common. All eukaryotes are comprised of one or more cells that contain peroxisomes. The organelles were first discovered by the Belgian scientist Christian de Duve, who also discovered lysosomes.

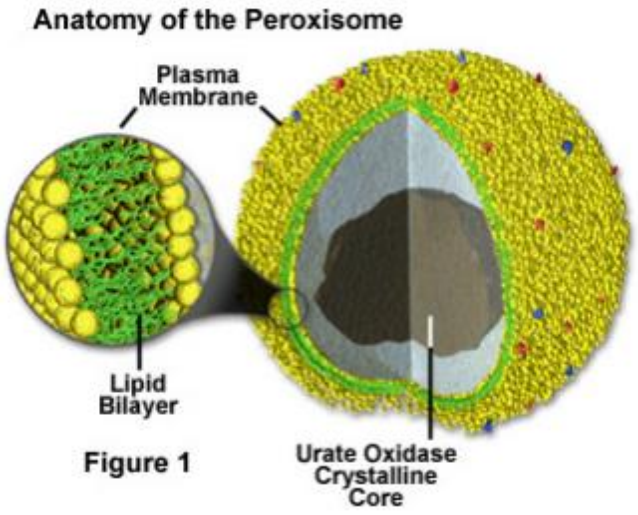


Figure 1

❖ Plant Cell Vacuoles

Vacuoles are membrane-bound sacs within the cytoplasm of a cell that function in several different ways. In mature plant cells, vacuoles tend to be very large and are extremely important in providing structural support, as well as serving functions such as storage, waste disposal, protection, and growth. Many plant cells have a large, single central vacuole that typically takes up most of the

room in the cell (80 percent or more). Vacuoles in animal cells, however, tend to be much smaller, and are more commonly used to temporarily store materials or to transport substances.

Function: It not only stores materials and wastes but also provides proper structure to the plant, which maintains a proper pressure for a growing plant.

Structure: It takes up to 30% of the cell's volume in a fully mature plant cell.

Different Types of Plant Cells

Plant cells are a type of eukaryotic cell which are found in organisms of the Plant Kingdom. As an organism grows, its cells become mature enough to perform specific functions.
There are various types of plant cells namely: parenchyma cells, sclerenchyma cells, collenchyma cells, xylem cells, and phloem cells. Let's know about the functions of these cells in detail:

- **Parenchyma Cells**: These are the cells that are majorly present in plants. They help in the metabolism and food production of a plant. These cells are very flexible as compared to other cells because of their thinness.
- **Sclerenchyma Cells:** Sclerenchyma cells give the maximum support to the plant because of their hardness. These cells are usually found in plant roots and do not live past maturity.
- **Collenchyma Cells:** These cells are also hard but not as hard as sclerenchyma cells. They also provide support to the plants when they are young. Their growth takes place with the plant's growth and stretch.
- **Xylem Cells:** Xylem cells, also known as water conducting cells, are hard cells that bring water up to the leaves. They do not live past maturity but their cell wall continues to allow the water to flow freely through the plant.
- **Phloem Cells:** A sugar transporting cell produced by the leaves throughout the plant. These cells live past maturity.

Functions of a Plant Cell

Photosynthesis is the major function performed by plant cells, and therefore these are known as the building blocks of plants. Photosynthesis is the process that occurs in the chloroplasts of the plant cell. It is the process by which plants prepare their food utilizing sunlight, water, and carbon dioxide.

A Brief Summary on Cell Organelles

Cell Organelles	**Structure**	**Functions**
Cell membrane	A double membrane composed of lipids and proteins. Present both in plant and animal cells.	Provides shape, protects the inner organelles of the cell and acts as a selectively permeable membrane.
Centrosomes	Composed of centrioles and found only in the animal cells.	It plays a major role in organizing the microtubule and cell division.
Chloroplasts	Present only in plant cells and contains a green-coloured pigment known as chlorophyll.	Sites of photosynthesis.
Cytoplasm	A jelly-like substance, which consists of water, dissolved nutrients and waste products of the cell.	Responsible for the cell's metabolic activities.
Endoplasmic Reticulum	A network of membranous tubules, present within the cytoplasm of a cell.	Forms the skeletal framework of the cell, involved in the detoxification, production of lipids and proteins.
Golgi apparatus	Membrane-bound, sac-like organelles, present within the cytoplasm of the eukaryotic cells.	It is mainly involved in secretion and intracellular transport.
Lysosomes	A tiny, circular-shaped, single membrane-bound organelles, filled with digestive enzymes.	Helps in the digestion and removes wastes and digests dead and damaged cells. Therefore, it is also called as the "suicidal bags".
Mitochondria	An oval-shaped, membrane-bound organelle, also called as the "Powerhouse of The Cell".	The main site of cellular respiration and also involved in storing energy in the form of ATP molecules.
Nucleus	The largest, double membrane-bound organelles, which contains all the cell's genetic information.	Controls the activity of the cell, helps in cell division and controls the hereditary characters.
Peroxisome	A membrane-bound cellular organelle present in the cytoplasm, which contains the reducing enzyme.	Involved in the metabolism of lipids and catabolism of long-chain fatty acids.
Plastids	Double membrane-bound organelles. There are 3 types of plastids: 1. **Leucoplast** –Colourless plastids.	Helps in the process of photosynthesis and pollination, imparts colour to leaves, flowers, fruits and stores starch, proteins and fats.

	2. **Chromoplast**–Blue, red, and yellow colour plastids. 3. **Chloroplast** – Green coloured plastids.	
Ribosomes	Non-membrane organelles, found floating freely in the cell's cytoplasm or embedded within the endoplasmic reticulum.	Involved in the synthesis of proteins.
Vacuoles	A membrane-bound, fluid-filled organelle found within the cytoplasm.	Provide shape and rigidity to the plant cell and help in digestion, excretion, and storage of substances.