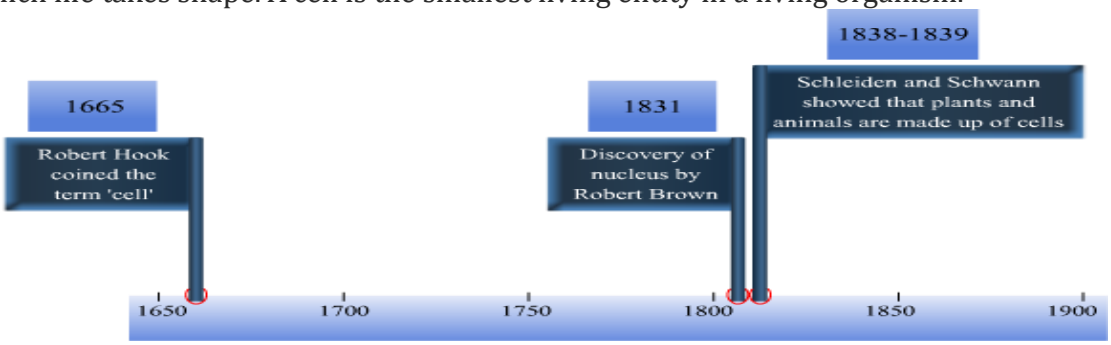
The Fundamental Unit of Life

Cell

Cells: An Overview

- Diverse forms of living organisms are present in our surroundings. All of them are made up of tiny structures called **cells**.
- Cells are the building blocks of life. They are the basic structural and functional units from which life takes shape. A cell is the smallest living entity in a living organism.



How cells are formed

- In 1838 & 1839, the two German scientists **Matthias Schleiden (1838)** and **Theodor Schwann (1839)** proposed the cell theory and formulated that all plant and animal tissues are made up of cells.
- They, however, were unsuccessful in explaining how new cells are formed. Later, in 1855, Rudolf Virchow further expanded the **cell theory** by suggesting that all cells arise from pre-existing cells.

The cell theory states that:

- All living organisms are composed of cells and products of cells.
- Cells are the basic units of structure and function in an organism.
- All cells arise from pre-existing cells.

Know Your Scientist

Robert Hooke (1635-1703)

The term 'cell' was introduced by Robert Hooke in **1665** after observing the cellular structure of cork (a substance obtained from the bark of a tree). While examining a thin slice of cork under a compound microscope, Hooke observed many small compartments resembling honeycombs. These he termed as cells.

Robert Brown (1773-1858)

In **1831**, Robert Brown discovered the presence of nucleus in the centre of a plant cell.

Theodor Schwann (1810-1882) and Matthias Schleiden (1804-1881)

In **1838**, Matthias Schleiden, a German physiologist, discovered that all plant tissues are made up of cells, i.e., cells are the fundamental units of all plants. In the next year**(1839)**, Theodor Schwann, a German physiologist, discovered that all animal tissues are made up of cells, i.e., cells are the fundamental units of all animals.

Invention of Microscope

Cells are very small living entities that are not visible to the naked eyes. The invention of microscopes hence played the key role in the discovery of cells.

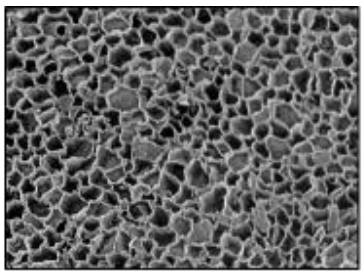
Simple Microscopes

- First simple microscopes were constructed by **Antony van Leeuwenhoek** (1632-1723).
- They consisted of single biconvex lens.
- Their magnifying power was up to 200 times.

Compound Microscopes

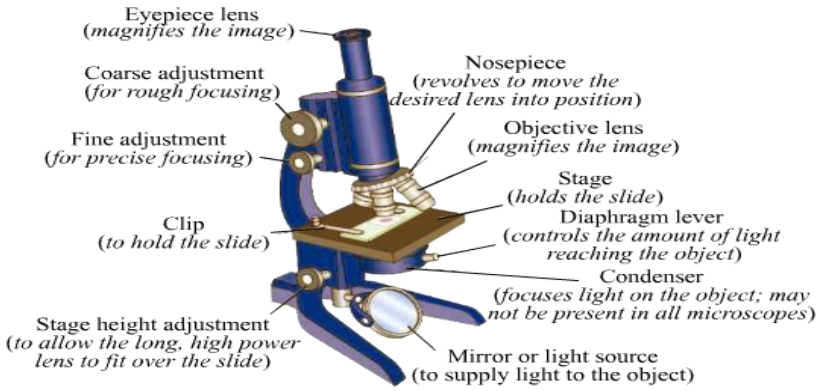
- These were first constructed by Robert Hooke (1635-1703).
- He developed the compound microscope using two lenses for increasing the magnifying power.
- He examined a thin slice of cork under it and observed tiny, box-like compartments, that he named 'cells'.

Microscope Constructed by Robert Hooke



Thin Slice of Cork As Observed Under Microscope

The modern ordinary compound microscope has greatly improved in design and magnification power (up to 2,000 times).



Compound Microscope

Electron Microscopes

- The invention of electron microscope has led to great advancements in the study of cells.
- Electron microscopes use beams of electrons which are bent by magnets to magnify the images.
- They can magnify an object up to 200,000 times.

Properties of Living Cells

Some important properties of living cells are as follows:

- Generally, a cell is so small that it is not visible to the naked eye.
- Cell shape and size vary both within an organism and between different organisms. The shape and size of a cell is related to the specific function it performs.
- All living cells exhibit certain basic properties like respiration, growth and metabolism.
- Nerve cells are some of the longest cells.

Examples of cells with different shapes and sizes

Red blood cells (Round and biconcave) | White blood cells (Amoeboid) | Columnar epithelial cells (Long and narrow) | Nerve cell (Branched and long)

Did You Know?

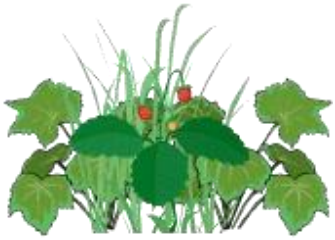
- **The smallest unicellular organism we know is the *Mycoplasma*, a type of bacteria. Its diameter is 0.1 µm.**
- There are more red blood cells in our body than any other type of cell.

Problem: Illustrate how the shape and size of a cell is related to the specific function it performs.
Solution: Different types of cells with different shapes and sizes are present in our body. A cell's shape and size are relevant to the specific function it performs. The irregularly shaped white blood cell is a case in point. A white blood cell protects the body by killing harmful foreign bodies. Whenever it encounters any antigen, it changes its shape accordingly and engulfs the antigen. Thus, the shape of the white blood cell is directly related to the function it performs.

Classification of Cells

Based on the number of cells: Unicellular and multicellular

Unicellular organism



Multicellular organism

- A cell is the smallest living entity capable of independent existence. There are certain organisms that are made **up of only a single cell**; such organisms are known as **unicellular organisms**. Examples of unicellular organisms include *Amoeba* and yeast.
- All other organisms (i.e. those **made up of more than one cell**) are known as **multicellular organisms**. Examples of multicellular organisms include humans, plants and animals.
- Multicellular organisms can perform a variety of tasks efficiently due to **division of labour**.
- This gives the organisms a wide range of adaptabilities to survive.

- In multicellular organisms, dead cells play an important role. For example, the dead epidermal cells in animal skin protect the underlying cells.

Division of labour

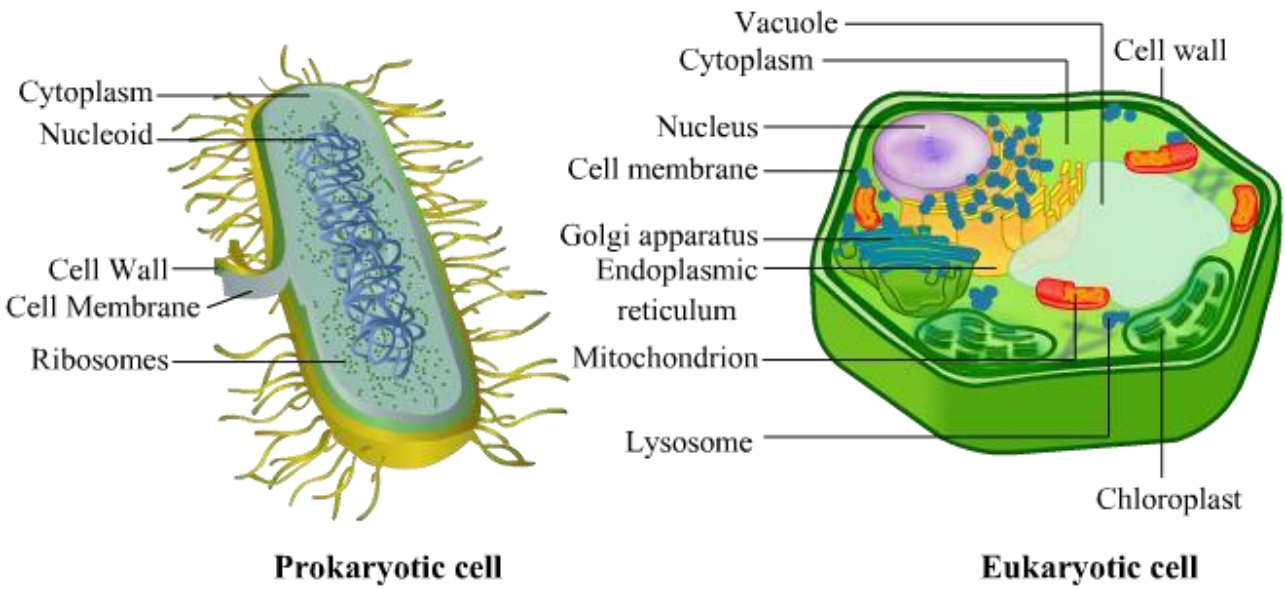
- Division of labour refers to the specialized roles of the different organs present in a multicellular organism.
- All organs, tissues or cells of a multicellular organism cannot carry out all the functions. Each of them is evolved to carry out a specific set of tasks.
- Each organ system coordinates with the others to perform the activities required for life.
- This division of labour minimizes the load of carrying out all the functions and, consequently, it allows the organs to operate efficiently.
- For example, the digestive system is assigned to carry out digestion, while the excretory system is assigned to carry out excretion. This is division of labour. Ultimately, a healthy body is one in which the different organ systems perform their respective functions properly.

Classification of Cells

- Based on the cellular complexity: prokaryotes and eukaryotes
- This type of classification is based on the sub-cellular organization of a cell.
  The given table lists the characteristic features of prokaryotes and eukaryotes.

Characteristics	**Prokaryotes**	**Eukaryotes**
Size of the cell	Cells are small in size.	Cells vary in size and are generally larger than those in prokaryotes.
Nucleus	No nucleus with a nuclear membrane is present.	There is a well-defined nucleus with a nuclear membrane.
Membrane-enclosed organelles	Organelles having a membrane around them (e.g., mitochondria, plastids) are absent.	Membrane-enclosed organelles are present.
Cell wall	Cell wall is usually present. It is composed of **peptidoglycan**.	Cell wall is usually present in plant cells. It is composed of **cellulose**.
Genetic material	The genetic material is present as nucleoid, i.e., a properly defined nucleus is absent.	The genetic material is present inside the welldefined nucleus.

Structure of Eukaryotic and Prokaryotic Cell



Prokaryotic cell **Eukaryotic cell**

Cell Wall, Plasma Membrane and Cytoplasm

Basic Components of a Cell

- The two basic components of a cell are the protoplasm and plasma/cell membrane. The protoplasm consists of the cytoplasm and nucleus.
- The cell membrane is the outermost covering in animal cells, and is next to the cell wall in plant cells.
- The term 'protoplasm' refers to the living contents of a cell, i.e., the nucleus and cytoplasm enclosed by a membrane. The cytoplasm is a jelly-like **matrix** surrounding the nucleus.

Plasma Membrane

- In animal cells (which lack the cell wall), the cell membrane is the outermost covering.
- It acts as a barrier between the internal cell machinery and the harsh external environment. Hence, it functions as a protecting agent.

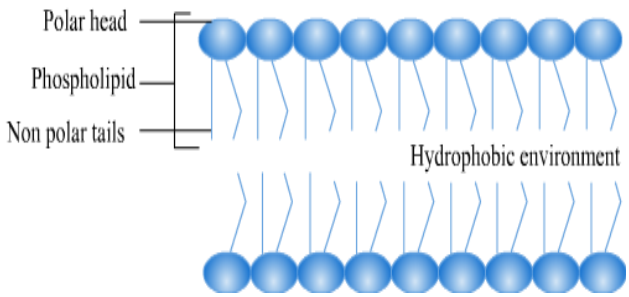
Basic structure of the plasma membrane

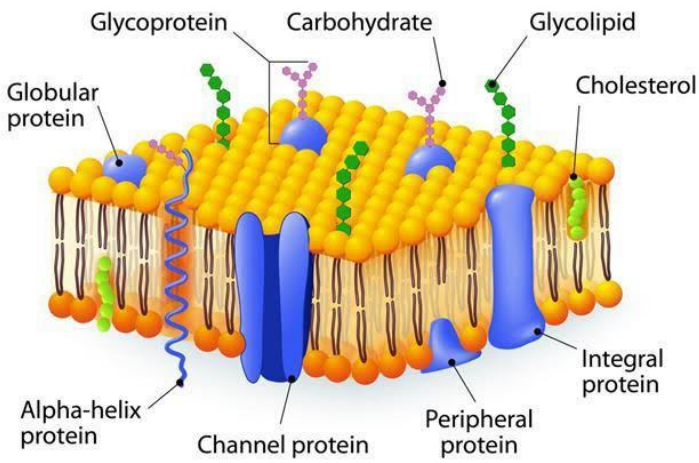
- Conceived by Singer and Nicolson in 1972, the **fluid mosaic model** is used for describing the structure of the plasma membrane.
- According to this model, the major components of the plasma membrane are **lipids** and proteins. A small amount of carbohydrates can also be found in it.
- The plasma membrane is flexible in nature and allows the entry and exit of selective molecules.
- The cell membrane is extremely delicate, thin and elastic. It is the living membrane of the cell.
- It surrounds the cytoplasm and regulates the movement of substances into and out of the cell. This means that the cell membrane allows only certain substances to enter and exit. For this reason it is known as a selectively permeable membrane.

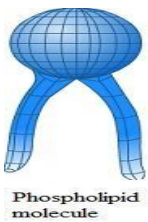
Functions of the plasma membrane

- It protects the cellular organelles from the outside environment.
- It selectively allows molecules to move into and out of the cell.
- It can engulf substances within a cell through **endocytosis**. It can also expel substances out of the cell through **exocytosis**.
- It establishes communication between cells.

What makes the plasma membrane selectively permeable?







- The plasma membrane is made up of several organic molecules, but the major component is phospholipid.
- A phospholipid is a lipid molecule containing phosphorus. It has two parts—the head region and the tail region.

- The former is hydrophilic in nature, i.e., it has a strong affinity for water. The latter is hydrophobic in nature, i.e., it lacks the affinity for water.
- The phospholipids arrange themselves in such a way that the polar heads face toward the outside (i.e., toward water) and the fatty-acid tails face toward the inner side of the bilayer.
- Consequently, the hydrophobic region remains protected from the aqueous environment (as shown in the figure).
- Due to this special arrangement, all molecules cannot pass through the membrane.
- Polar molecules like glucose and water can easily pass through the membrane, but non-polar molecules like oils cannot pass through.
- This structural arrangement that allows only selective molecules to pass through the plasma membrane is what makes it a selectively permeable membrane.

Transport through cell membrane:

In order to maintain a proper balance in the internal environment of the body, cells need to take in useful substances and release harmful materials.

How food, waste matter and water are transported across a cell?

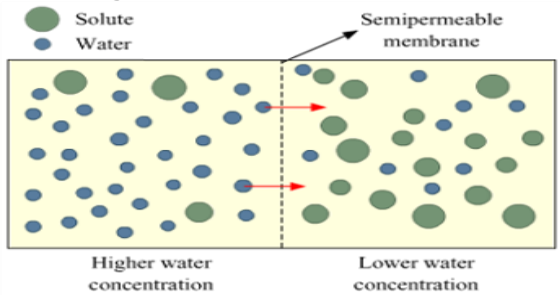
Such transportation occurs mainly because of two processes—**diffusion** and **osmosis**.

DIFFUSION

- Diffusion is the movement of individual molecules from a region of higher concentration to a region of lower concentration.
- The larger the difference in concentration, the more rapid is the flow of molecules.
- In diffusion, the movement of molecules is random and independent of each other.
- The most common example of diffusion is the transportation of gases and absorption of nutrients in the human body.
- The inhaled air contains oxygen. In the lungs, oxygen diffuses through the blood capillaries and reaches the red blood cells. There, it binds with the haemoglobin to form oxyhaemoglobin.
- Oxy-haemoglobin is then circulated throughout the body.
- Oxygen concentration is lesser in tissues than in the blood or the red blood cells. Thus, oxygen diffuses out of the blood and enters the tissues and, later, the cells.
- Similarly, in the digestive tract, food is broken down into simpler products such as glucose. Nutrients are then absorbed by the intestinal cells through diffusion.

Osmosis: A Special Case of Diffusion

- Osmosis describes a special case of diffusion in which two solutions having different concentrations are separated by a semi-permeable membrane. Some features of osmosis are as follows:
- The movement of water (i.e., the solvent) takes place from the region of lower concentration of the solute to the region where there is a higher concentration of the solute.
- In other words, the movement of the solvent takes place from the region where its concentration is higher to the region where its concentration is lower.



Significance of osmosis in living organisms

- Plant roots absorb soil water through osmosis. Water concentration is higher in soil than in root cells. Therefore, water moves from the soil to the cells
- Water is re-absorbed in the tubules of nephrons of the kidneys through osmosis.

Distinguish between diffusion and osmosis

The basic differences between diffusion and osmosis are given in the table.

Diffusion	Osmosis
Solute molecules move across a concentration gradient.	Water molecules move across a concentration gradient
It does not require a semi-permeable membrane.	It requires a semi-permeable membrane.

Cell Wall

- As mentioned before, in animal cells, the plasma membrane is the outermost covering. In plant cells, however, the outermost covering is the cell wall.
- Now, you might wonder why the cell wall is present only in plant cells. Let us first understand what the cell wall is and then we will ascertain as to why it is found solely in plant cells.
- The cell wall is the hard, protective outermost covering of plants, fungi and bacteria.
- It is a rigid structure that gives support to a plant cell.
- It allows a plant to stand upright and maintain the shape of the cell when placed in a hypotonic or hypertonic solution.
- Its constituent compounds are different in case of different organisms. The cell wall of plants, fungi and bacteria is made up of **cellulose**, **chitin** and **peptidoglycan** respectively.
- The cell wall connects the internal environment of a cell to the external environment.
- It can withstand dilute hypotonic media and prevent bursting of cells. For this reason plant cells can withstand changes in environmental concentration better than animal cells.

Problem: **Why is the cell wall not necessary in animal cells?**
Solution:
The cell wall is the tough and rigid layer around the cells of plants and bacteria. It provides both structural support and protection to the cells. Animal cells do not require the cell wall for the following reasons.

1) Animal cells have other forms of support such as the exoskeleton and endoskeleton.
2) Animal cells can regulate osmotic pressure by pumping ions and salts across the cell membrane. So, they do not require the cell wall to protect themselves from bursting due to endosmosis.
3) Animal cells require flexibility for function and movement, which would not have been possible if the cells were surrounded by the cell wall. This is because the cell wall restricts flexibility.

Cytoplasm

- Cytoplasm is the inner content of the cell membrane which separates the cell membrane from the nucleus. Some important features of cytoplasm are as follows:
- It is composed of cytosol, organelles and inclusions.
- Cytosol is the soft, sticky and semi-transparent fluid in which various cell organelles are suspended.
- Cytoplasm is not a simple clear fluid. Rather, it is a complex viscous fluid that contains 70% water. The remaining portion is made up of proteins, carbohydrates and lipids.

- Cytoplasm is one of the most active parts of a cell. While it does not take part in the cellular processes, it does host most of the metabolic reactions.
- It helps a cell to perform several vital functions by transporting essential nutrients to the required destinations.
- One of the important components of the cytoplasm is the cytoskeleton. Cytoskeleton is a network of proteins (microtubules and microfilaments) which together form the skeleton of the cytoplasm. The cytoskeleton is responsible for the shape and movement of a cell.

Cytoplasmic Streaming

Cytoplasmic streaming refers to the movement of the viscous fluid of a cell (i.e., cytoplasm) in order to perform a particular function. This phenomenon can be easily understood with the help of the unicellular eukaryotic organism *Amoeba*.

Amoeba can constantly change its shape. It forms finger-like projections called **pseudopodia** (meaning 'false feet') as shown in figures 1 and 2. These pseudopodia are nothing but the flowing projections of cytoplasm.

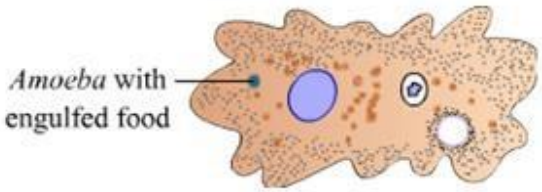


Figure 1

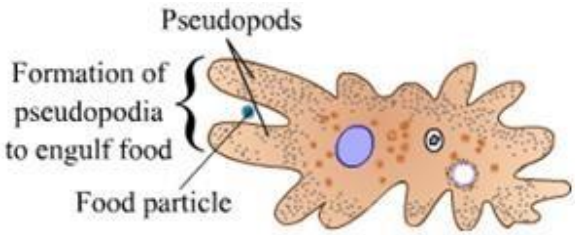


Figure 2

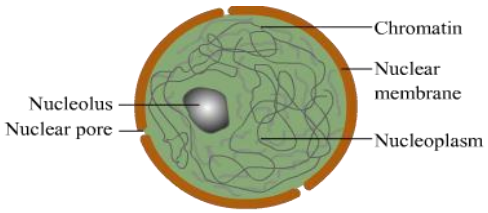
When *Amoeba* senses its prey, it uses its pseudopodia to engulf the prey. These cytoplasmic projections not only help *Amoeba* in engulfing food but also in locomotion. Thus, they exemplify the phenomenon of cytoplasmic streaming.

Did You Know?

- Cells can be grown outside the body through a process known as cell culture.
- Cell culture media is always isotonic in nature. The salt concentration of an isotonic solution is 0.9% of NaCl, which is equivalent to the intracellular salt concentration.
- Viruses do not have the plasma membrane and cytoplasm.

Nucleus: General Introduction

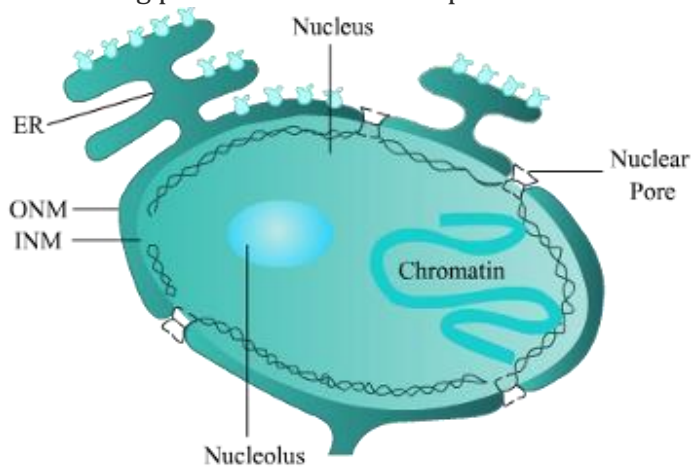
- In the centre of all eukaryotic cells, there is a large prominent membrane-bound organelle known as the **nucleus**. Some features of nucleus are as follows:
- The nucleus is visible under a light microscope. It is acidic in nature. Any basic stain can be used to see the nucleus.
- It is also present in prokaryotes, but it lacks a well-defined membrane.
- Generally, one nucleus is present in a cell; however, there are certain eukaryotic cells which do not contain even a single nucleus (e.g., red blood cell) and there are certain others that contain more than one nucleus i.e. they are **multinucleate** (e.g., slime mould).
- In some organisms like bacteria, the nuclear region of the cell may be poorly defined due to the absence of a nuclear membrane. Such an undefined nuclear region containing only nucleic acids is called the **nucleoid**. It is found in prokaryotes.



Structure of a Nucleus

Structure of the Nucleus

The following points list the various parts of the nucleus with their respective functions.



Nuclear envelope:

- The nucleus is enclosed by a double-layered cellular membrane called the nuclear envelope. The space between the two layers is known as the perinuclear space and is filled with fluid.
- The nuclear envelope separates the contents of the nucleus from the cytoplasm.
- The nuclear membrane is pierced with holes known as the nuclear pores. These pores allow the nucleus to communicate with the rest of the cell.
- The outer nuclear membrane (ONM) is connected to a network of tubules and sacs i.e., the endoplasmic reticulum.

Nucleolus: The centre of the nucleus has a dark dense spherical area known as the nucleolus. The nucleolus is the production factory of **ribosomes**, which in turn manufacture proteins. Thus, it can be said that the nucleolus is indirectly involved in protein and RNA synthesis.

Nucleoplasm: The nucleus contains nuclear sap or a semi-fluid **matrix** enclosed by the nuclear envelope. This is known as the nucleoplasm or karyoplasm. It holds the nucleolus and the suspended chromatin.

Chromatin network: The nucleus contains the genetic material of an organism in the form of a network of **chromatin**. DNA gets associated with protein molecules to form chromatin. This chromatin gets folded and coiled to form chromosomes.

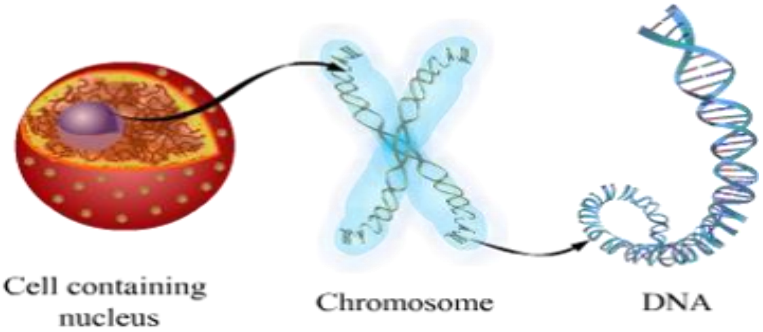
Distinguish between the nucleus and nucleolus.

Solution: The following table illustrates the differences between nucleus and nucleolus.

Nucleus	**Nucleolus**
The nucleus is the main organelle of a cell.	The nucleolus is present inside the nucleus.
It is surrounded by the nuclear envelope.	It is not covered by any membrane.
It contains DNA, proteins and the nucleolus.	It contains RNA and proteins.

It is the control centre of a cell, controlling important functions such as DNA replication and protein synthesis.	It performs the function of ribosome synthesis.

Nucleus: The Director of a Cell



- Inside the nucleus, rod-shaped structures called **chromosomes** are present. These chromosomes bear the hereditary units known as **genes**.
- Genes are the segments of DNA which provide information for carrying out the regular metabolic activity of a cell.
- DNA contains the information on how to make the proteins of the cells. The proteins, in turn, control the chemical reactions of the cells and provide structural support to both the cells and tissues.
- The nucleus also plays a crucial part, along with the environment, in determining the way a cell will develop and the form that it will exhibit at maturity by directing the chemical activities of the cell.
- Thus, also known as the director of a cell.

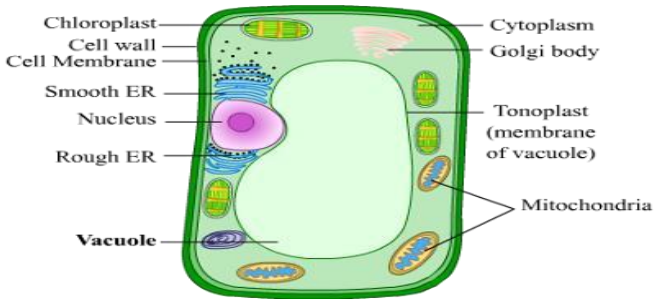
Functions of the nucleus:

- The nucleus controls all metabolic activities of a cell.
- It is It plays an important role in cellular reproduction—the process by which a single cell divides to form two new cells.
- It also plays a crucial part in determining the way a cell will develop and the form it will exhibit at maturity. It does this by directing the chemical activities of the cell.
- concerned with the transmission of hereditary traits from the parent to the offspring.
- The nucleus is the largest organelle in a cell.

Vacuoles: An Overview

- A vacuole is a storage sac (for solid or liquid contents) found in a cell.
- Its enclosing membrane is known as **tonoplast** which has a large number of pores on its surface.
- Vacuoles are found in both plant and animal cells, but are much larger in plant cells.
- The central vacuole of some plant cells may occupy 50%–90% of the cell volume. In plant cells, vacuoles are full of **cell sap**.
- They provide turgidity and rigidity to the cells.

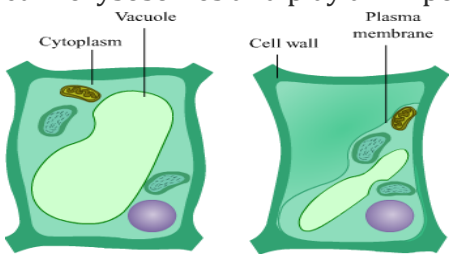
- A vacuole stores food and nutrients that a cell needs to survive. These include amino acids, sugars, various organic acids and some proteins. It may store the waste products of a cell. In single-celled organisms like *Amoeba,* the food vacuole contains the food items that *Amoeba* consumes.
- In some unicellular organisms, a specialized vacuole plays an important role in expelling excess water and some wastes from the cell.



Vacuole in a plant cell

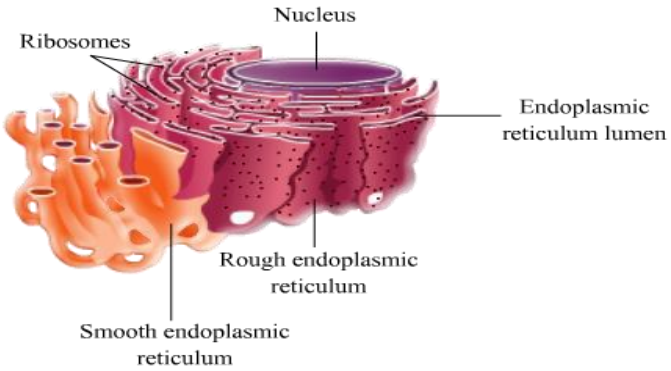
Functions of Vacuoles

- Some important functions of vacuoles are as follows:
- They help in the removal of unwanted structural debris.
- They maintain the **turgor pressure** within cells.
- In *Amoeba*, the food vacuole stores food.
- They help in maintaining the proper pH of cells.
- In some fungal cells, vacuoles act like lysosomes and play an important role in **autophagy**.



Endoplasmic Reticulum: Introduction

- In 'endoplasmic reticulum', 'endo' means 'inside', 'plasmic' means 'plasm' and 'reticulum' means 'network'. The endoplasmic reticulum (ER) is a system or network of folded membranes—**tubules, vesicles** and **cisternae—**that form channels.
- Cisternae are flattened disc-like membranous structures.
- Tubules are tubular in shape, while vesicles are sac-like structures.
- ER is found fused with the nuclear membrane inside eukaryotic cells.
- It is the site where many important chemical reactions take place, including the synthesis of important proteins, **lipids** and many other materials.
- It functions as a packaging system. However, it does not work alone; it works closely with the Golgi apparatus and ribosomes.ER may look different from cell to cell, but it always forms a network system.



Types of Endoplasmic Reticulum

- When seen under an electron microscope, two types of endoplasmic reticulum can be observed—the **rough endoplasmic reticulum (RER)** and the **smooth endoplasmic reticulum (SER)**.
- Rough endoplasmic reticulum: When ribosomes get attached to the surface of ER, it becomes RER.
- Smooth endoplasmic reticulum: When ribosomes are absent from the surface of ER, it is called SER. This type of ER is found in liver cells, interstitial cells, adipose cells and muscle cells.

Difference between RER and SER

Smooth endoplasmic reticulum (SER)	Rough endoplasmic reticulum (RER)
It is the endoplasmic reticulum that does not bear ribosomes and appears smooth.	It is the endoplasmic reticulum that bears ribosomes on the surface.
It is the major site for the synthesis of lipids.	It is actively involved in protein synthesis.
It maintains the calcium ion concentration in cytosol.	It transports proteins to different destinations like the plasma membrane.

Functions of the Endoplasmic Reticulum

Some important functions performed by endoplasmic reticulum are as follows-

- ER serves as a channel for the transport of materials (especially proteins) between various regions of the cytoplasm or between the cytoplasm and the nucleus.
- It functions as a cytoplasmic framework, providing a surface for some of the biochemical activities of the cell.

- ER gives mechanical support by forming a network in the cytoplasm.

Smooth endoplasmic reticulum

- SER acts as a storage organelle.
- It stores those steroids and ions in solution which the cell may need at a later time.
- It helps in manufacturing fat molecules or lipids that are important for cell functioning.
- Some of these proteins and lipids help in building the cell membrane. This process is known as membrane biogenesis.
- It actively participates in **drug detoxification**.
- It maintains the calcium ion concentration in cytosol.

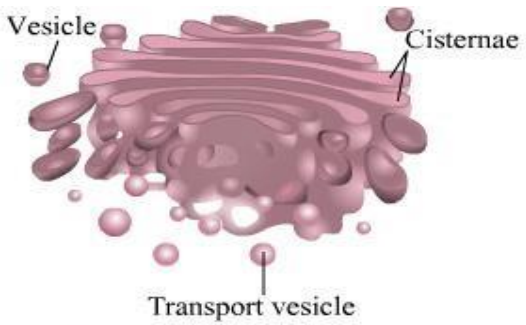
Rough endoplasmic reticulum

- RER is important for the synthesis and packaging of proteins. Most of the lysosomal proteins are produced in RER.
- These proteins might be used in the cell or sent out to various destinations depending upon the needs of the other processes.
- RER is the major site of glycosylation (addition of carbohydrates in protein).

Ribosomes

- Ribosomes are the organelles found in all living cells.
- These are found attached to the membrane of rough endoplasmic reticulum, nuclear membrane and even in the nucleolus.
- They are the sites of protein synthesis. Hence, are also known as the protein factories of the cell.

Golgi Apparatus:



Structure of Golgi apparatus

- The Golgi apparatus is another packaging organelle like the endoplasmic reticulum.
- It consists of a system of membrane-bound vesicles arranged approximately parallel to each other in stacks of cisternae.
- The Golgi apparatus was discovered by Camillo Golgi in 1898.
- A Golgi body is usually composed of five–eight stacks of cisternae.
- Vesicles leave the Golgi body from the end known as the **cis** face. The other end is known as the **trans** face.
- Plant cells contain many freely distributed subunits of the Golgi apparatus, called **dictyosomes**.

Functions of the Golgi apparatus:

- It is involved in the transport of lipids in cells.
- It is involved in the formation of lysosomes.
- It also takes part in **glycosylation** and **phosphorylation** of certain proteins.

Mitochondria: General Introduction

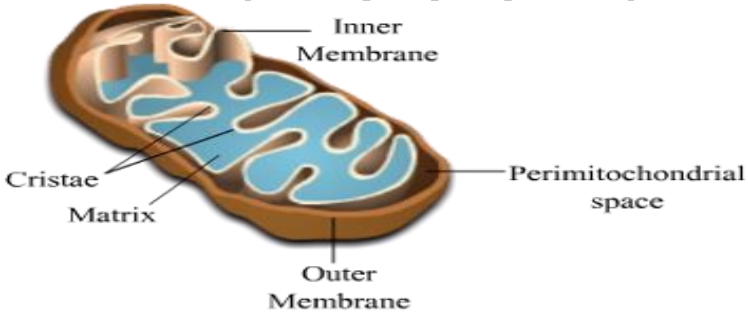
We know that our body needs energy to perform various activities. We get this energy from the food we eat. But have you ever given thought to how this energy is produced from the food inside our body? This energy is produced by the organelle called **mitochondrion**.

Features of mitochondria

- Mitochondria are responsible for the production of most of the energy in cells. For this reason, they are also known as the **powerhouse** of cells.
- Energy is produced as a result of the breaking of sugar. This process occurs in mitochondria.
- The energy released by mitochondria is stored in the form of **ATP** molecules. ATP is known as the energy currency of a cell.
- The number of mitochondria in a cell is dependent upon the nature of the physiological activity carried out by it. For example, in humans, the red blood cells do not contain any mitochondria, while liver and muscle cells may contain hundreds or even thousands of them.

Structure of Mitochondria

Mitochondria are present in both plant and animal cells. Mitochondria are typically round to oval in shape. Their sizes range from 0.5 μm to10 μm. A mitochondrion is enclosed by two membranes—the outer membrane and the inner membrane, which are composed of **phospholipids** and proteins.



1. Outer membrane: The entire mitochondrion is enclosed by a smooth outer membrane. Like the plasma membrane, it is made up of phospholipids and proteins.

2. Inner membrane: The inner membrane is more complex. Except for oxygen, carbon dioxide and water, it does not allow any molecules to pass through it. This membrane is the main site for the production of ATP (energy currency of the cell)

3. Peri mitochondrial space: The space between the inner and outer membranes is known as the peri mitochondrial space.

4. Cristae: These are the structures formed by the folding of the inner membrane (as shown in the figure). They contain several enzymes and provide enough area for chemical reactions to occur.

5. Matrix: Just like the cytoplasm inside a cell, a mitochondrion contains a viscous fluid enclosed by its inner membrane. This fluid is a mixture of dissolved carbon dioxide, oxygen, proteins, water, enzymes and many other important compounds required for various chemical reactions that take place in the organelle. This matrix contains mitochondrial DNA and ribosomes. The presence of DNA and ribosomes allows the mitochondria to make some of their own proteins.

<u>Functions of Mitochondria</u>

- They produce the energy (in the form of ATP) required for the functioning of cells.
- They regulate the free calcium ion concentration in cytosol.
- They participate in **apoptosis** or programmed cell death.

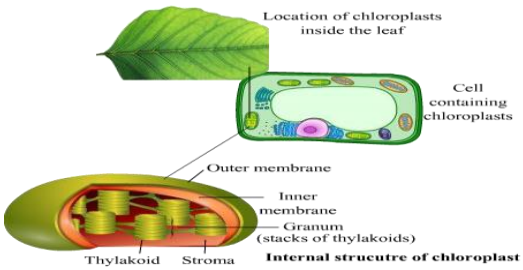
They provide intermediates for the synthesis of various chemicals such as fatty acids, steroids and amino acids **Lysosomes**

- **Lysosomes** are membrane-bound vesicles that are usually found in animal cells. Some important features of lysosomes are as follows:
- They are formed by budding off from the endoplasmic reticulum and Golgi bodies.
- They contain digestive **hydrolytic enzymes** such as acid hydrolase. With the help of these enzymes, they are able to digest a variety of substances including worn out organelles, proteins, nucleic acids, lipids and carbohydrates.

- They are also known as the '**suicide bags'** of cells. This is because they burst out and release hydrolytic enzymes into cytosol when a cell is damaged.
- Lysosomes provide energy during starvation by controlled breakdown of stored food.

Problem: **Mitochondria are semi-autonomous organelles. Justify this statement.**
Solution: Mitochondria contain their own genetic material, i.e., DNA (which is known as mitochondrial genome) and ribosomes. They are considered as semi-autonomous organelles because they are only partially dependent upon the nucleus for the proteins required for their functioning. The presence of the DNA and ribosomes allows them to synthesize some of these proteins. This is in contrast to other organelles which wholly depend upon the nucleus for the proteins required for their functioning.

Plastids:



- Green plants and trees appear so because of the presence of the green colour pigment called **chlorophyll**. This pigment is actually present inside the organelle called **chloroplast**.
- Chloroplast is a type of **plastid which in turn** is a major organelle found in plant cells and algae. The presence of plastids allows plants to prepare their own food through photosynthesis.
- Animals cannot make their own food because they lack plastids.
- Plastids are present in the cytoplasmic matrix of a plant cell. They are round- or oval shaped bodies.
- **Like mitochondria, chloroplasts have their own DNA and, thus, have the ability to self-replicate.**

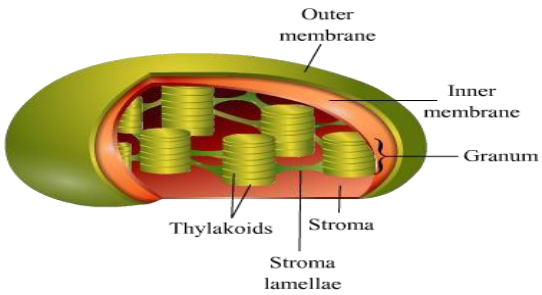
Types of Plastids
The two major types of plastids are **Leucoplasts** and **chromoplasts**. They are the major sites for the production and storage of food and many other useful chemical compounds.
Leucoplasts: They are white or colourless plastids; hence, they do not contain any coloured pigments. They are found in those plant regions wherein photosynthesis is not carried out, e.g., the roots. Their main function is storage and synthesis of various important compounds such as fatty acids and amino acids.

- **Amyloplast**: Responsible for the storage and synthesis of starch.
- **Elaioplast**: Elaioplast stores lipids or fats and are found in seeds of many plants.
- **Aleuroplast**: These store proteins so also called as proteinoplast.

Chromoplasts: They are the coloured plastids containing coloured pigments such as xanthophylls (yellow) and carotene (orange). These pigments are responsible for the colour of a plant. Chloroplast is the most common type of coloured plastid.

Functions of plastids:

- They carry out photosynthesis.
- They contribute to the colours of leaves and flowers.
- Some plastids perform the function of storage and production of many important compounds like lipids and proteins.



Chloroplasts

Location: Chloroplasts are the main sites for photosynthesis. As we know, photosynthesis efficiently takes place in the green parts of a plant, i.e., in leaves (and to a lesser extent in green stems or floral parts). This is because leaves have specialized cells that contain chloroplasts. These cells are called **mesophyll cells**.

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

- A plastid has two distinct regions—grana and stroma.
- **Grana** are the stacks of flattened discs containing chlorophyll molecules.
- The inner membrane of the chloroplast encloses the protein-rich fluid-like ground substance known as stroma.
- **Stroma** is the homogeneous mixture in which the grana are embedded.
- **Thylakoids** usually lie in stacks (like coins in piles) called grana.
- Thylakoids are believed to be the main sites for photosynthesis. The grana are interconnected by tubular membranes called **lamellae**.
- **Cell Inclusions**

Cell inclusions are the result of various chemical reactions that take place inside the cell, either in the cytoplasm or in the vacuole.

Cell inclusions may be the food products like starch or oil globules or the waste materials like gums, resins, tannins, and latex.

Cell Division

Cells undergo division to form new cells. These new cells are used to grow, replace old, dead and injured cells, and to form gametes required for reproduction. There are two types of division a cell undergoes -

Mitosis - Each cell divides to form two daughter cells. The daughter cells have the same chromosome number as the mother cell.

Meiosis - This type of division is shown by specific cells of the reproductive organs or tissues in animals and plants. These cells divide to form gametes, which after fertilisation give rise to new offsprings. In meiosis, four cells are produced from a single cell and the new cells have half the chromosome number than the mother cell.