FUNDAMENTAL UNIT OF LIFE: CELL

Cell:

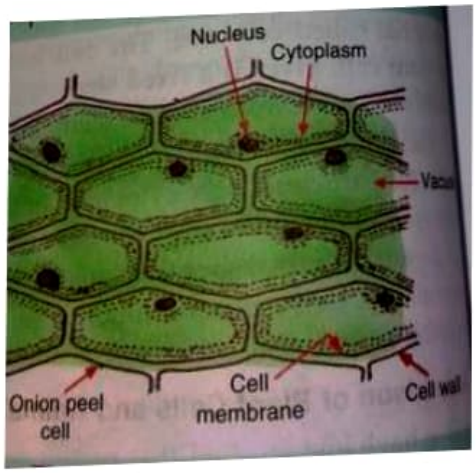
- It is known as the structural and fundamental unit of life because it is the basic building unit of an organism and is capable to perform basic functions of all living organisms.
- Cytology is the scientific study dedicated to understanding the structure and composition of cells.
- In 1665, Robert Hooke first observed cells in a thin slice of cork, marking the beginning of our understanding of cellular existence.
- A. V. Leeuwenhoek, in 1674, made the groundbreaking discovery of the first free-living cell.
- Protoplasm, the essential substance within cells, comprises water, ions, salts, organic molecules, cell organelles, and a nucleus, existing in sol-gel states.

Discovery of Living Cell ⟶ Anton Van Leeuwenhock (1674)
Discovery of Nucleus ⟶ Robert Brown (1831)
Discovery of Protoplasm ⟶ J. E. Purkinje (1839)

Cell Theory:

The cell theory was given by Schleiden and Schwann, in 1838 which states that:

1. All living things are made up of cells.
2. The cell is the basic unit of structure and function in living organisms.
3. Cells come from pre-existing cells through the process of cell division.



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Types of Cells and Organisms

- **On basis of number of cells:**

Unicellular Organisms	Multicellular Organisms
Unicellular organisms are composed of a single cell	Multicellular organisms are composed of more than one cell
Simple body organization	Complex body organization
A single cell carries out all necessary life processes	Multiple cells perform different functions
The total cell body is exposed to the environment	Only the outer cells are exposed to the environment
Division of labour is at the organelle level'	Division of labour is at cellular, tissue, organs and organ system level
Includes both eukaryotes and prokaryotes.	Includes only eukaryotes
A lifespan of a unicellular organism is usually short.	Multicellular organisms have a comparatively longer lifespan
e.g. Amoeba, Chlamydomonas, Paramoecium and bacteria.	*e.g. fungi, plants and animals*

- **On the basis of type of organizational cells:**

Prokaryotic Cells	Eukaryotic Cells
Very minute in size	Fairly large in size
Nuclear region (nucleoid) not surrounded by a nuclear membrane	Nuclear material surrounded by a nuclear membrane
Single chromosome present	More than one chromosome present
Nucleolus absent	Nucleolus present
Membrane bound cell organelles are absent	Membrane bound cell organelles are present
Cell division by fission or budding (no mitosis)	Cell division by mitosis or meiosis

- **Cell Shape**

Cells exhibit diverse shapes and sizes, influenced by their specific functions and locations within an organism. While some cells are typically spherical, such as in a general context, others take on distinct forms like elongated nerve cells, branched pigmented cells, discoidal red blood cells, or spindle-shaped muscle cells. The variability in cell shape is a reflection of their specialized roles and adaptations in different tissues.

Different shapes of cells: Circular, Filamentous or spiral, Branched ,Disc

- ***Sizes of Cells:***

- Smallest cell: Bacteria and Mycoplasma
- Largest Cells: Bird Egg Cells and Nerve Cells

Components of Cell:

The three basic components of cells are: Plasma membrane, Nucleus, Cytoplasm

Plasma Membrane

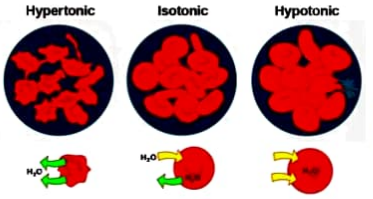
- The plasma membrane is the outermost covering of the cell that separates the contents of the cell from its external environment. It is selectively permeable, allowing the entry and exit of some materials while preventing the movement of others. The plasma membrane is made of lipids and proteins and can be observed only with an electron microscope.

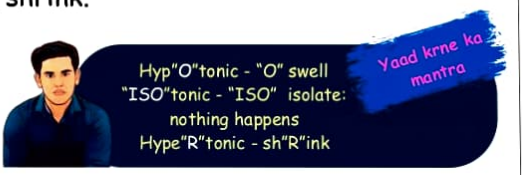
Movement of Substances

- **Diffusion:** Diffusion is the movement of a substance from a region of high concentration to a region of low concentration. For example, carbon dioxide (CO_2) moves out of the cell when its concentration inside the cell is higher than outside. Similarly, oxygen (O_2) enters the cell when its concentration inside the cell is lower than outside. Diffusion is crucial for gaseous exchange between cells and their external environment.
- **Osmosis:** Osmosis is the movement of water molecules through a selectively permeable membrane toward a higher solute concentration. It is a special case of diffusion where water moves from an area of lower solute concentration to an area of higher solute concentration.

Effects of Osmosis on Cells

1. **Hypotonic Solution**: If the surrounding medium has a higher water concentration (more dilute) than the cell, water enters the cell by osmosis, causing the cell to swell.
2. **Isotonic Solution**: If the surrounding medium has the same water concentration as the cell, there is no net movement of water, and the cell remains the same size.
3. **Hypertonic Solution**: If the surrounding medium has a lower water concentration (more concentrated) than the cell, water leaves the cell by osmosis, causing the cell to shrink.





The plasma membrane's flexibility allows the cell to engulf food and other materials from its external environment through a process known as **endocytosis**. Amoeba acquires its food through this process.

Cell Wall:

- Plant cells have a rigid outer covering called the cell wall, in addition to the plasma membrane.
- The cell wall is located outside the plasma membrane. and it is mainly composed of cellulose, a complex substance that provides structural strength to plants.

Function and Properties

- The cell wall allows plant, fungal, and bacterial cells to withstand very dilute (hypotonic) external media without bursting.
- In hypotonic media, cells take up water by osmosis, causing them to swell and build up pressure against the cell wall. The cell wall exerts an equal pressure to prevent the cell from bursting.

Plasmolysis

- When a living plant cell loses water through osmosis, the cell contents shrink away from the cell wall. This phenomenon is known as plasmolysis.
- Plasmolysis can only occur in living cells, as dead cells are not able to absorb water by osmosis.

Plants have cell walls for structural support, protection, water regulation, and transportation of nutrients. Animals lack cell walls because they need flexibility for mobility, specialized tissues, and efficient osmoregulation.

Nucleus

- The nucleus is a membrane-bound organelle that serves as the control center of eukaryotic cells, containing genetic material in the form of DNA.
- It is surrounded by a double membrane called the nuclear envelope, which has nuclear pores that allow the exchange of materials between the nucleus and the cytoplasm.
- The nucleus contains chromosomes composed of DNA and proteins. DNA carries genetic information in the form of genes. Chromatin material appears as a tangled mass of thread-like structures in non-dividing cells.
- The nucleus plays a central role in cellular reproduction and directs the chemical activities of the cell. It also determines the cell's development and mature form.

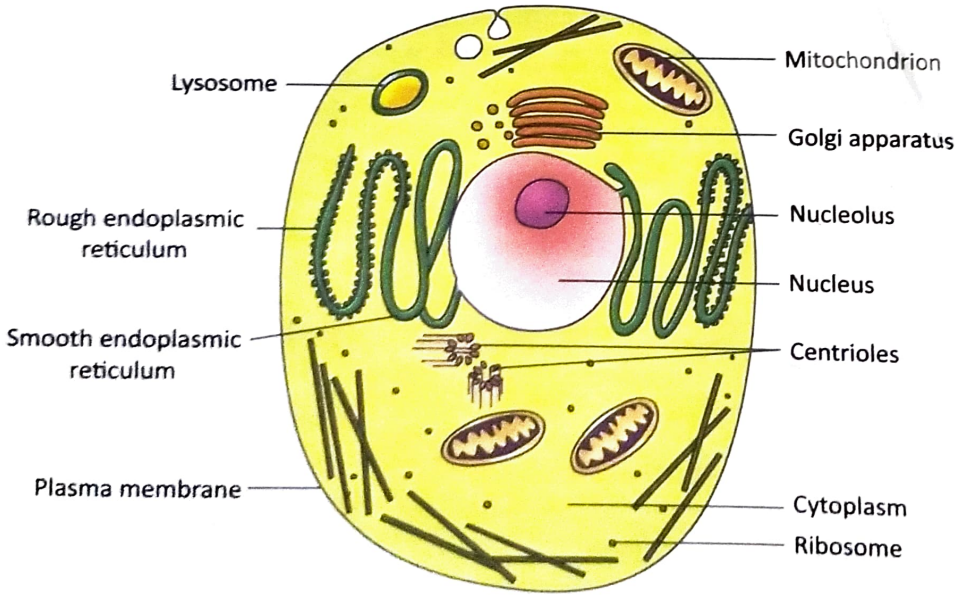


Fig. 1.10: An animal cell

The term **cell membrane** was coined by Carl Naegeli and C. Cramer in 1855. In 1931, **Plowe** replaced the term by **plasma membrane** or **plasmalemma**.

Cell Membrane or Plasma Membrane

of plants also depends on the movement of water.

Table 1.5: Differences between Diffusion and Osmosis

Diffusion	Osmosis
• Movement of substances occurs from the region of higher concentration to the region of lower concentration.	• Movement of substances occurs from the area of higher concentration to the area of lower concentration through a selectively permeable membrane.
• It can occur in solid, liquid and gaseous mediums.	• It can occur only in the liquid medium.
• It does not require selectively permeable membrane.	• It requires selectively permeable membrane.
• It helps to equalise the concentration of diffusing molecules throughout the available space in a medium.	• It does not equalise the concentration of molecules in a medium.
• It depends on the kinetic energy of the molecules of diffusing substance only. Presence of other substances does not influence the process of diffusion.	• Presence of solute molecules in the system influences the osmosis process, though osmosis is the diffusion of solvent molecules only.

• **Fluid Mosaic Model.** This model is the most recent and accepted model proposed by Singer and Nicolson in 1972. According to this model, the cell membrane is made up of a lipid bilayer and two types of protein molecules. The lipid bilayer forms highly viscous fluid in which the two types of protein molecules (**intrinsic proteins** and **extrinsic proteins**) are organized in a mosaic manner. **Intrinsic proteins** are embeded in the lipid bilayer incompletely or completely, and the **extrinsic proteins** occur superficially (Fig. 1.9).

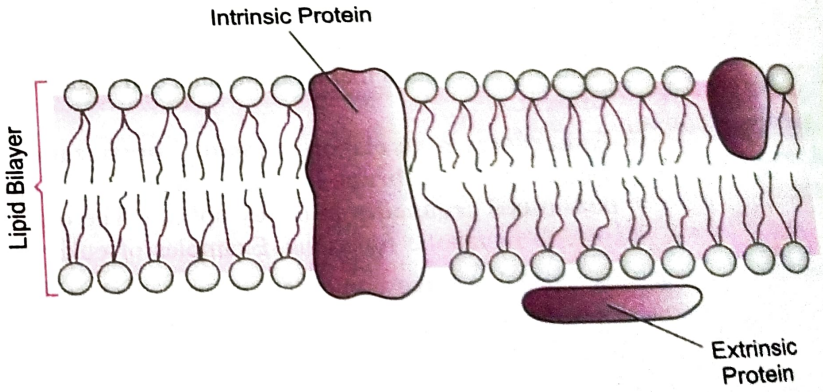


FIGURE 1.9. Structural detail of plasma membrane according t Fluid Mosaic Model

Fluid mosaic model provides satisfactory explanation of the structure and functions of pl

Active Transport

The **active transport** is a fast process and requires expenditure of metabolic energy to transport molecules across the cell membrane. The energy required is obtained from the ATP. Active transport of molecules occurs in only one direction, i.e., it is unidirectional. It can transport molecules through a cell membrane against the concentration gradient and needs carrier or transport proteins to occur. It is the most common method of salt absorption in plant cells. In animal cells, it occurs in some ions, sugars and amino acids.

Table 1.6: Differences between Active Transport and Passive Transport

Active Transport	Passive Transport
• It needs energy to transport materials.	• It does not require energy to transport materials.
• It takes place against the concentration gradient.	• It occurs along the concentration gradient.
• It is a biochemical process.	• It is a physical process.
• It is mediated through carriers.	• Carriers are not involved in this process.
• It is a rapid process.	• It is comparatively a slower process.
• It is unidirectional.	• It is bidirectional.
• It involves selective uptake of materials.	• It allows all transmissible molecules to enter into the cell.
• The materials accumulate in the cells.	• The materials do not accumulate in the cells.

Bulk Transport

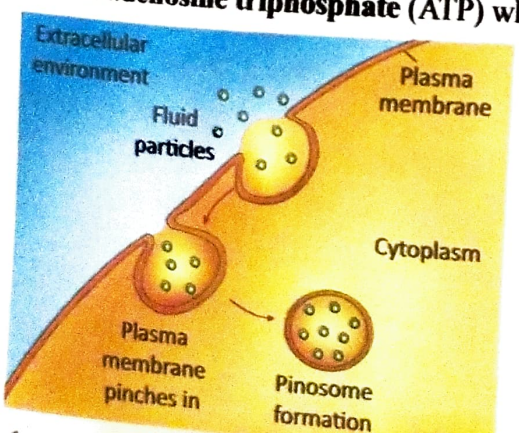
The **bulk transport** is a mode of transport of large quantities of materials such as macromolecules and food particles across the cell membrane. The transport occurs both inwards and outwards. Accordingly, it occurs by two ways, i.e., endocytosis and exocytosis.

Endocytosis

The ingestion (engulfing) of food and other substances by the plasma membrane of the cell from the external medium is called **endocytosis**. Depending upon the substances involved in transport, endocytosis is of two types – pinocytosis and phagocytosis.

- **Pinocytosis:** The intake of minute droplets of extracellular fluids by a cell through the plasma membrane is called **pinocytosis** or **cell drinking** (Fig. 1.18). Pinocytosis was first observed in *Amoeba*. It is important for the transport of proteins, lipoproteins and hormones within and outside the cell.

  In pinocytosis, the plasma membrane invaginates around the fluid particles and forms a pocket. This pocket then deepens and pinches off to form a vesicle or **pinosome** in the cytoplasm. The pinosomes subsequently fuse with **lysosomes** to liberate their contents. The energy demands for this process is high which comes from **adenosine triphosphate** (ATP) which is an energy-rich chemical compound present in cells.



KEY POINT

Pinocytosis also occurs in many types of cells of multicellular organisms. For example, a human egg cell matures in the ovary and is surrounded by many other cells. These cells pass nutrients to the egg cell which engulfs them using pinocytosis. Pinocytosis has also been observed in white blood cells (macrophages and leukocytes), kidney cells,

- **Phagocytosis**: The intake of solid particles by a cell through the plasma membrane is called **phagocytosis** or **cell eating** (Fig. 1.19). It is a common method of feeding in unicellular organisms such as *Amoeba* and lower metazoan (sponges). Only certain cells in the living organisms perform phagocytosis. For example, Kupffer cells (liver), macrophages, reticular cells (spleen), and leucocytes or white blood cells engulf harmful microbes (bacteria and viruses), cellular debris and degenerating cells.

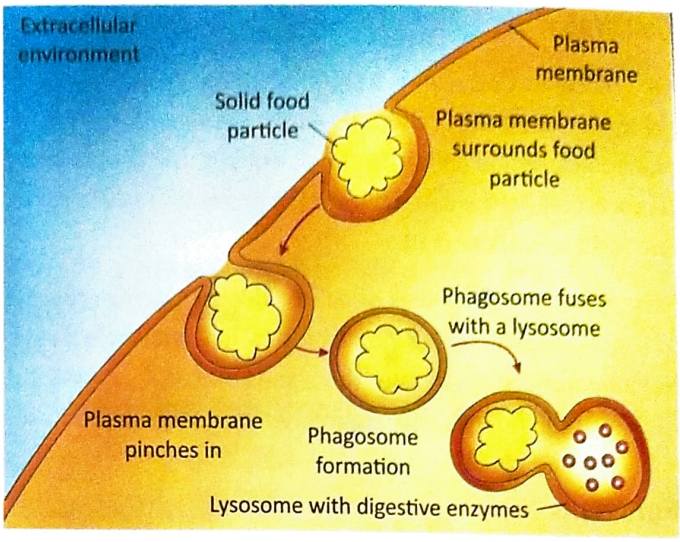


Fig. 1.19: Diagrammatic representation of phagocytosis

In phagocytosis, the solid food particles get surrounded by the edges of plasma membrane. A tiny vesicle or phagosome in formed that engulfs the solid material. As a result, the phagosome detaches itself from the cell membrane surface into the cytoplasm. The lysosomes present in the cell fuse with the phagosome and form a digestive or food vacuole. The solid food present in the food vacuole is digested by the powerful digestive enzymes of the lysosomes.

Exocytosis

The process in which the membrane of a food vacuole fuses with the plasma membrane to eliminate its waste contents into the surrounding medium is called **exocytosis** or **cellular vomiting** or **ephagy** (Fig. 1.20).

Phagocytosis is followed by exocytosis.

The food vacuole left with undigested material moves out from the interior of the cell and attaches itself with the cell membrane. The membranes of both food vacuole and cell membrane fuse with each other and release the undigested contents outside the cell. Thus, exocytosis helps to remove undigested food/substances left in the food vacuole.

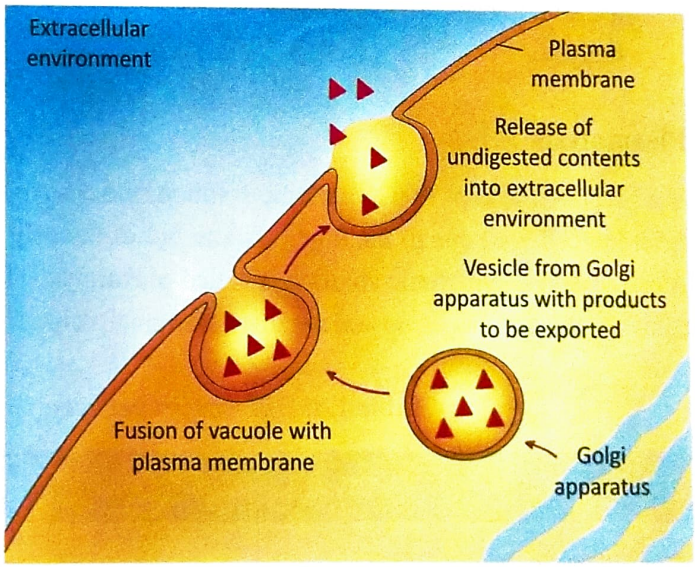


Fig. 1.20: Diagrammatic representation of exocytosis

Table 1.7: Differences between Pinocytosis and Phagocytosis

Pinocytosis	Phagocytosis
• It involves intake of extracellular fluids.	• It involves intake of solid food particles.
• Cell membrane does not develop invaginations around the absorbed molecules.	• Cell membrane invaginates around the food particles.
• Lysosomes are not involved in digestion.	• Lysosomes are important for the digestion of food particles.
• Exocytosis is not needed.	• Exocytosis is required to remove undigested particles.

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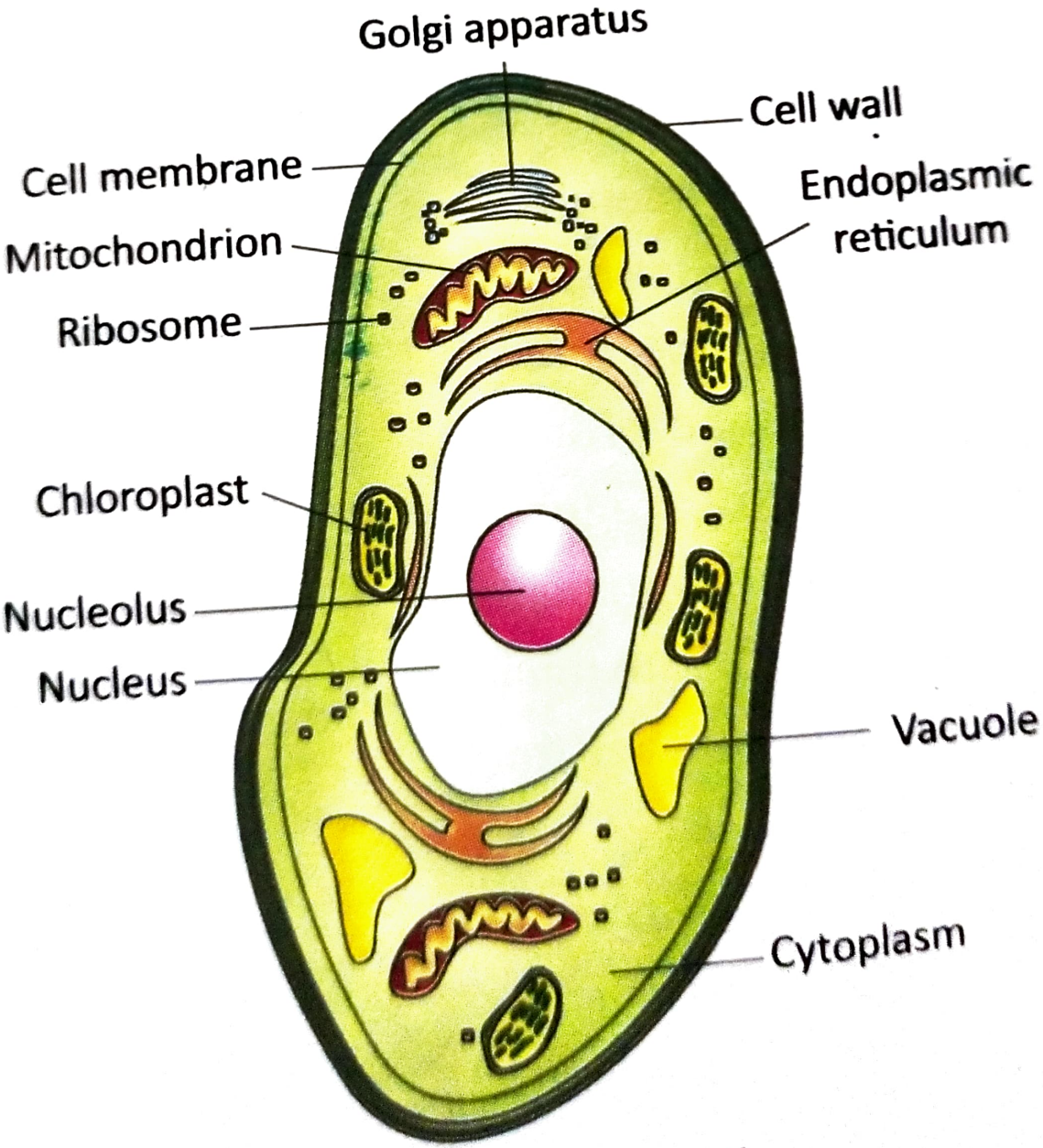

Fig. 1.9: A plant cell

Cell Wall	Plasma Membrane
• It is present in plant cells.	• It is present in both animal and plant cells.
• It lies on the outer side of the cells.	• It lies on the exterior of the animal cells and on the inner to the cell wall in plant cells.
• It is thick and non-living in plant cells.	• It is thin and living.
• It is rigid.	• It is flexible.
• It is generally permeable.	• It is selectively permeable.
• It is made up of pectin, cellulose and hemicellulose.	• It is made up of lipids, proteins and carbohydrates present in a small number.
• It provides strength and protection to the cell.	• It holds the cellular contents, and controls the passage of materials in and out of the cell.