**In biology, a cell is the basic membrane-bound unit that contains the fundamental molecules of life* and forms the basis of all living things that maintain proper homeostasis.**

The first time the word *'cell'* was used to refer to these tiny units of life was in 1665 by a British scientist named **Robert Hooke.** By the early 1800s, scientists had observed the cells of many different organisms. These observations led two German scientists to propose that cells are the basic building blocks of all living things. Around 1850, a German doctor was studying cells under a microscope when he happened to see them dividing and forming new cells. He realised that living cells produce new cells through division. The ideas of all three scientists, **Schwann, Schleiden,** and **Virchow,** led to cell theory, which is one of the fundamental theories unifying all of biology.

**Cell theory states that:**

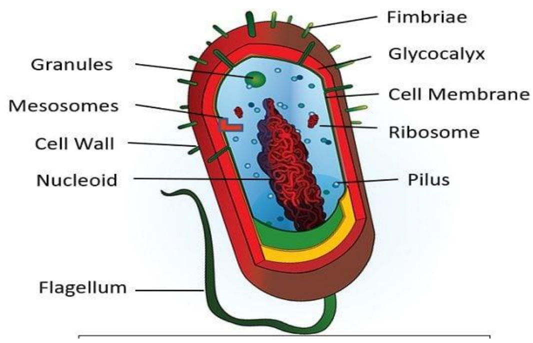
1. All organisms are made of one or more cells.
2. All the life functions of organisms occur within cells.
3. All cells come from already existing cells.

**The science that studies the microscopic appearance of cells is known as cytology.**

The scientist classifies living organisms according to the number of cells; a single cell is often a complete organism in itself, a **"unicellular organism",** such as a bacterium or yeast. Other cells acquire specialised functions as they mature. These cells cooperate with other specialised cells and become the building blocks of large **multicellular organisms**, such as humans and other animals.

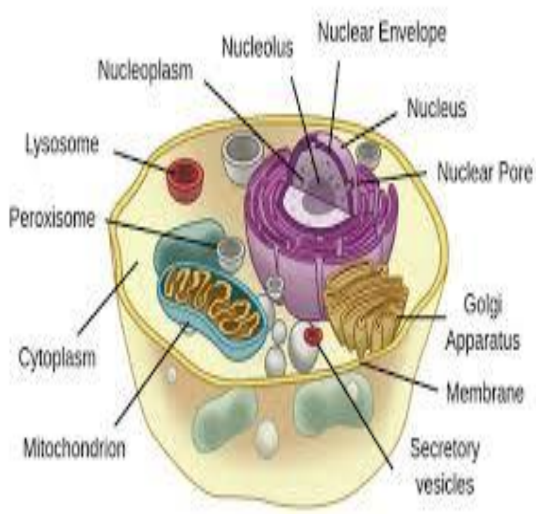
Also, biologists classify the living organism according to the presence of a nucleus to:

1. **Prokaryotic organisms** are cells that do not have a true nucleus or membrane-bound organelles. Characterized as:




- Small size (1-5 µm).
- Have a cell wall outside the cell membrane.
- Lack a nuclear envelope separating the genetic material (DNA) from other cellular constituents.
- Have no histones (specific basic proteins) bound to their DNA.
- Have no organelles except ribosomes.
- Prokaryotic cells divide by binary fission.
- Include: Bacteria (bacterium, singular), Cyanophyta, and Archaea (archaeon, singular).

2. **Eukaryotic organisms** are cells that contain a nucleus and organelles and are enclosed by a plasma membrane. Organisms that have eukaryotic cells include protozoa, fungi, plants, and animals. Characterized by:




- Larger than prokaryotic cells (10-100 µm).

- Have a distinct nucleus surrounded by a nuclear envelope.
- Histones are associated with the genetic material.
- Numerous membrane-limited organelles are found in the cytoplasm.
- Eukaryotic cells are divided by mitosis and meiosis.

Certain structural features are common to all human cells, but there are some differences between cells according to cell types and cell functions. **In general, the basic human cell components are:**

1. Plasma membrane (plasmalemma, cell membrane).
2. Cytoplasm: that includes cytosol, cell organelles, cytoskeleton and inclusions.
3. Nucleus

## Plasma membrane

- A human cell, like all cells, is surrounded by an outer border that encloses its cytoplasmic compartments, called the **plasma membrane**, **plasmalemma,** or **cell membrane**.
- **It is a thin semi permeable membrane, composed of lipids (40%), proteins (50%) and carbohydrates (5%), that surrounded cytoplasm of a cell and control the passage of substances into and out of the cell.**
- The integrity and function of the plasma membrane are necessary to the life of the cell.
- Membranes range from 7.5 to 10 nm in thickness so that it's visible only with the transmission electron microscope (TEM).
- **Light microscope (LM):** appears as a very thin limiting border line**.**
- **Electron microscope (EM):** the cell membrane has **a trilaminar** appearance under TEM after fixation in osmium tetroxide, two electron-dense lines (2.5 nm each) separated by an electron-lucent intermediate zone (2.5-3 nm). Due to the deposition of reduced osmium on the polar heads of the phospholipids, the outer sugar chains, and associated membrane proteins produces the two dark outer lines enclosing the light band of osmium-free fatty acids (Figure3).

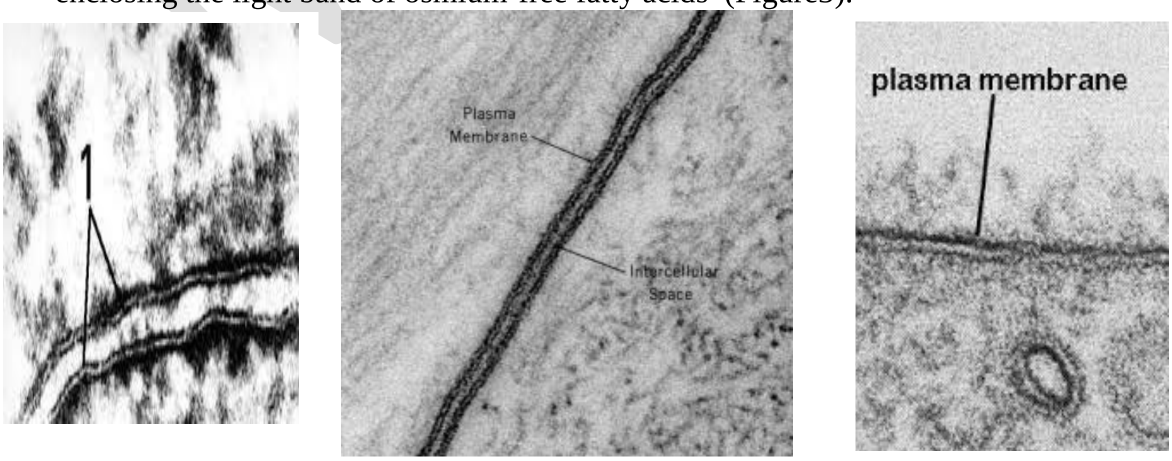



***Figure 3: The cell membrane can stain as two dark layers plus one clear layer from the gap between them, similar to two stacked bread sandwiches with space between them.***

- ✓ The first widely accepted model of the plasma membrane's structure was proposed in 1935 by Hugh Davson and James Danielli; it was based on the appearance of the plasma membrane in early electron micrographs. They theorised that the structure of the plasma membrane resembles a **sandwich**, with protein being analogous to the bread and lipids being analogous to the filling. In the 1950s, advances in microscopy, notably transmission electron microscopy (TEM), allowed researchers to see that the core of the plasma membrane consisted of a double, rather than a single, layer. A new model that better explains both the microscopic observations and the function of that plasma membrane was proposed by S.J. Singer and Garth L. Nicolson in 1972.
- ✓ The explanation proposed by Singer and Nicolson is called the **fluid mosaic model**. **The fluid mosaic model** describes the structure of the plasma membrane as a mosaic of components including phospholipids, cholesterol, proteins, and carbohydrates that gives the membrane a fluid character (Figure 4).

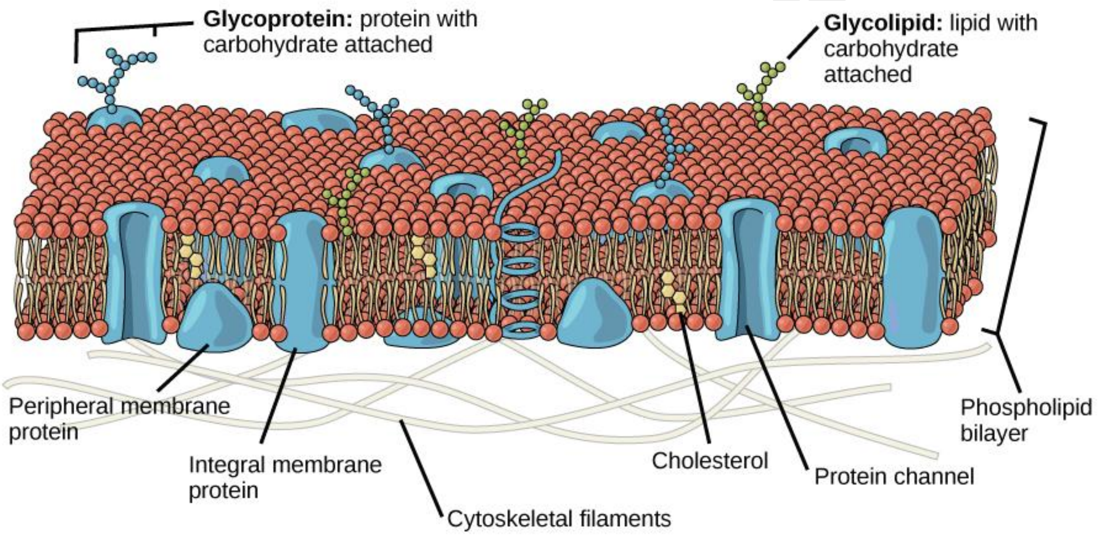



**Figure 4:** ***The fluid mosaic model of the plasma membrane describes the plasma membrane as a fluid combination of phospholipids, cholesterol, and proteins. Carbohydrates attached to lipids (glycolipids) and proteins (glycoproteins) extend from the outward-facing surface of the membrane.***

- ✓ The plasma membrane is a phospholipid bilayer (fluid at body temperature) with attached or embedded proteins. The proteins are able to change their position by moving laterally; the **fluid-mosaic model** is a working description of membrane structure. It states that the protein molecules form a shifting pattern within the fluid phospholipid bilayer. (Figure 4).
- ✓ The plasma membrane must be very flexible to allow certain cells, such as red blood cells and white blood cells, to change shape as they pass through narrow capillaries.

**Chemical structure of plasma membrane**

1. **Membrane lipids:** lipid constitutes 40% of the mass of most cell membranes, although this proportion varies depending on the type of cell. Include phospholipids and cholesterol.

i. **Phospholipids**: The fundamental building blocks of all cell membranes, which are amphipathic molecules, consisting of two hydrophobic fatty acid chains linked to a phosphate- containing hydrophilic head group (Figure 5).

A. The hydrophilic (**polar**) **heads** of the phospholipids molecules face the intracellular and extracellular fluids, consisting of:
   - Phosphoric acid group
   - Glycerol backbone

B. The hydrophobic (**non polar**) **tails** face each other in the membrane interior, consist of:
   - Saturated fatty acid
   - Unsaturated fatty acid, this double bond introduces a kink in the chain which reduces phospholipid packing (double bond increase fluidity).

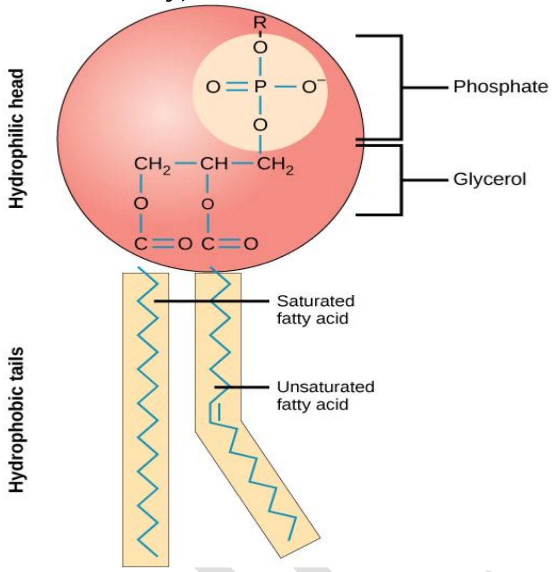



**Figure 5:** ***This phospholipid molecule is composed of a hydrophilic head and two hydrophobic tails. The hydrophilic head group consists of a phosphate-containing group attached to a glycerol molecule. The hydrophobic tails, each containing either a saturated or an unsaturated fatty acid, are long hydrocarbon chains.***

At body temperature (37C), the phospholipid bilayer of the plasma membrane has the consistency of olive oil. The entire phospholipids molecules can move side away, all these means that the cell is pliable.

**ii. Cholesterol**: (see the yellow structure in figure 4)
- Cholesterol represent approximately 50% of  the total membrane lipids
- Cholesterol is reduces the permeability of the membrane to the most biological molecules.
- Regulate and reduce the fluidity of phospholipids bilayer.
- Have important role in stability of cell membrane and make it more rigid, without cholesterol the membrane easily split apart.

***The ratio of phospholipid to cholesterol is 1:1.***

**2. Membrane proteins**: (see the blue structure in figure 4)
Proteins constituting approximately 50% of the mass of most cell membranes. Membrane proteins carry out the specific functions of the different membranes of the cell. These proteins are divided into **two** general classes, based on the nature of their association with the membrane:

I. **Integral membrane proteins**: (closely attached protein) are large protein molecules and embedded directly within the lipid bilayer, integral membrane proteins called **transmembrane proteins or called integrins** span the lipid bilayer with proteins exposed on both sides of the membrane proteins linked to both cytoplasmic protein filaments and extracellular matrix (ECM) components. These linkages produce a continuous exchange of influences, in both directions, between the ECM and the cytoplasm. And represent important structures for transportation of various molecules though cell membrane includes protein channels, protein carrier or called transporter, or specific receptors such as G-protein specific receptor. (Will discussed these types in lecture 4).

II. **Peripheral membrane proteins**: are small protein molecules and not inserted into the lipid bilayer but are associated with the membrane indirectly (loosely attached), found on the exterior and interior surfaces of membranes, attached either to integral proteins or to phospholipids (head group). Peripheral proteins, along with integral proteins, may serve as enzymes, as structural attachments for the fibers of the cytoskeleton, or as part of the cell's recognition sites. These are sometimes referred to as "cell-specific" proteins.

3. **Membrane glycolipids and glycoprotiens:** Short chains of sugars (oligosaccride) are attached to the outer surface of some protein or lipid molecules. The carbohydrate chains of glycoproteins are serving as the **fingerprints** of the cell. These carbohydrate chains, specific to each cell, help mark the cell as belonging to a particular individual. They account for why people have different blood types, for example.

i. **Glycolipids**:

- Have a structure similar to phospholipids except that the hydrophilic head is a variety of sugars joined to form a straight or branching carbohydrate chain.
- Glycolipids have a protective function.

ii. **Glycoprotein (glycocalyx):**

- The carbohydrate chains of the glycoproteins form a carbohydrate coat that envelops the outer surface of the plasma membrane. On the inside, proteins serve as links to the cytoskeletal filaments and on the outside carbohydrate some serve as links to extracellular matrix.

- Have an important role in cell recognition, cell to cell attachment or adhesions and act as receptor for chemical messenger or binding sites for different protein hormones.
- Cell coat present on special type of cell and don't present on others make some cell effect with virus, bacteria, hormones and drugs.

**Medical applications of glycoproteins in cell membranes include use in**

**Diagnostics and disease monitoring**

- **Infectious diseases:** Glycoproteins are used to develop diagnostic tests. For example, specific glycoproteins on viruses like HIV (gp160 and gp41) and Ebola (GP1-2) are used to detect the presence of the virus.

- **Cancer:** Glycoproteins, including those that are altered in cancer cells (neoantigens), can act as biomarkers for diagnosis and monitoring of cancer progression.

**Therapeutic targets and drug development**

- **Cancer therapy:** P-glycoprotein, a transporter that pumps drugs out of cells, is a major target. Inhibiting P-glycoprotein is an active area of research to make chemotherapy more effective by preventing cancer cells from resisting drugs.
- **Viral infections:** Viruses like SARS-CoV-2 use glycoproteins to infect host cells. Studying these glycoproteins is crucial for developing vaccines and neutralizing antibodies that can block viral entry.

** The four fundamental molecules of life are proteins, carbohydrates, lipids, and nucleic acids, with each of the four groups vital for every single living organism.*
***prokaryote: pro mean before, kary mean nucleus*
****eukaryote: eu mean true, kary mean nucleus*



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