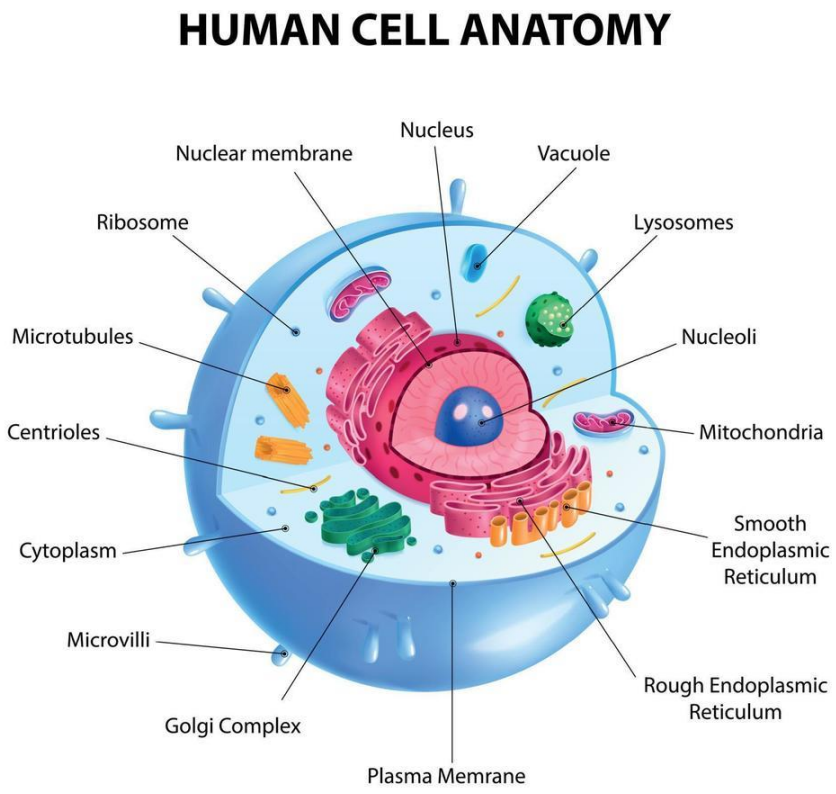
Chapter-2 CELL AND ITS COMPONENTS

Cells are the body's smallest structural and functional units. Cells are the basic building blocks of all living things. The human body is composed of trillions of cells. They provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions.

- Cells are grouped together to form tissues, each of which has a specialized function, e.g. blood, muscle, bone.
- Different tissues are grouped together to form organs, e.g. the heart, stomach and brain.
- Organs are grouped together to form systems, each of which performs a particular function that maintains homeostasis and contributes to the health of the individual.

A cell consists of a plasma membrane enclosing a number of organelles suspended in a watery fluid called **cytosol.**



1. CYTOSOL:

- The cytosol is the liquid medium contained within a cell and constitutes about 55% of total cell volume.
- The cytosol is a component of the cytoplasm. The cytoplasm includes the cytosol, all the organelles, and the liquid contents inside the organelles.
- The cytoplasm does not include the nucleus.
- The main component of cytosol is water (90%). It also contains dissolved ions, small molecules (glucose, amino acids, fatty acids, lipids, ATP, and waste products.) and proteins.

- The cytosol is not uniform throughout the cell. Protein complexes and the cytoskeleton give it structure.

  Function: The cytosol serves several functions. It is the site of most metabolic processes, transports metabolites, and is involved in signal transduction within the cell.

2. ORGANELLES:

- Organelles are specialized structures within the cell that have characteristic shapes; they perform specific functions in cellular growth, maintenance, and reproduction.
- They include: the nucleus, mitochondria, ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes and the cytoskeleton.
- The cell content excluding the nucleus is the cytoplasm, i.e. the cytosol and other organelles.

3. THE CYTOSKELETON:

The cytoskeleton is a complex, dynamic network of interlinking protein filaments present in the cytoplasm of all cells. It extends from the cell nucleus to the cell membrane and is composed of similar proteins in the various organisms. Three types of filamentous proteins contribute to the cytoskeleton's structure, as well as the structure of other organelles.

Functions:

1. Serves as a scaffold that helps to determine a cell's shape and to organize the cellular contents.
2. Aids movement of organelles within the cell, of chromosomes during cell division, and of whole cells such as phagocytes.

In the order of their increasing diameter, these structures are:

i) Microfilaments

ii) Intermediate filaments

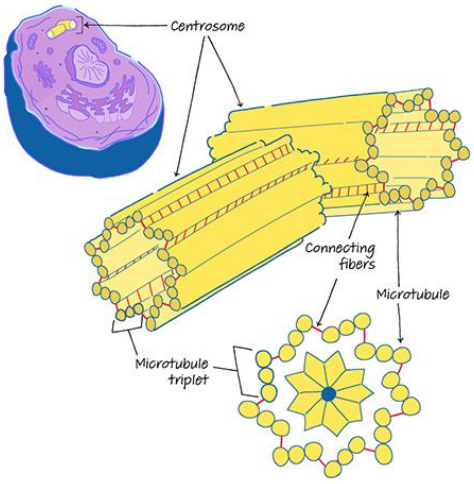
iii) Microtubules

4. CENTROSOME:

- The centrosome, located near the nucleus, consists of two components: a pair of centrioles and pericentriolar material.
- The two centrioles are cylindrical structures, each composed of nine clusters of three microtubules (triplets) arranged in a circular pattern.
- The long axis of one centriole is at a right angle to the long axis of the other.
- Surrounding the centrioles is pericentriolar material, which contains hundreds of ring-shaped complexes composed of the protein tubulin.
- These tubulin complexes are the organizing centers for growth of the mitotic spindle, which plays a critical role in cell division, and for microtubule formation in nondividing cells.

- During cell division, centrosomes replicate so that succeeding generations of cells have the capacity for cell division.

Function: The pericentriolar material of the centrosome contains tubulins that build microtubules in nondividing cells and form the mitotic spindle during cell division.



5. CILIA AND FLAGELLA:

- Microtubules are the dominant components of cilia and flagella, which are motile projections of the cell surface.
- Cilia are numerous, short, hair like projections that extend from the surface of the cell. Each cilium contains a core of 20 microtubules surrounded by plasma membrane.
- Flagella are similar in structure to cilia but are typically much longer. Flagella usually move an entire cell.
- A flagellum generates forward motion along its axis by rapidly wiggling in a wavelike pattern.
- The only example of a flagellum in the human body is a sperm cell's tail, which propels the sperm toward the oocyte in the uterine tube.

Functions:

1. Cilia move fluids along a cell's surface.
2. A flagellum moves an entire cell.

6. RIBOSOMES:

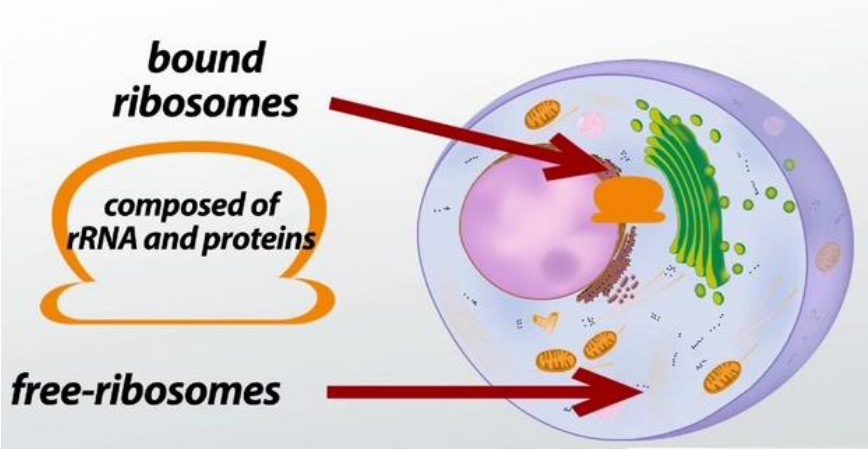
- A ribosome is an intercellular structure made of both RNA and protein, and it is the site of protein synthesis in the cell.
- The ribosome reads the messenger RNA (mRNA) sequence and translates that genetic code into a specified string of amino acids, which grow into long chains that fold to form proteins. Ribosomes are the sites of protein synthesis.
- Structurally, a ribosome consists of two subunits, one about half the size of the other. The large and small subunits are made separately in the nucleolus, a spherical body inside the nucleus.

- Some ribosomes are attached to the outer surface of the nuclear membrane and to an extensively folded membrane called the endoplasmic reticulum. These ribosomes synthesize proteins destined for specific organelles, for insertion in the plasma membrane, or for export from the cell. Other ribosomes are “free” or unattached to other cytoplasmic structures.
- Free ribosomes synthesize proteins used in the cytosol.

Ribosomes are also located within mitochondria, where they synthesize mitochondrial proteins.

Functions:

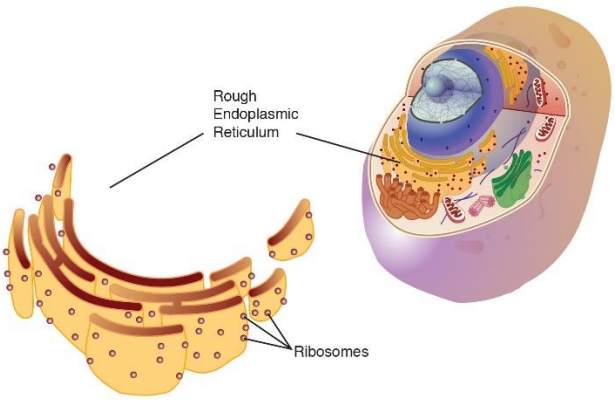
1. Ribosomes associated with endoplasmic reticulum synthesize proteins destined for insertion in the plasma membrane or secretion from the cell.
2. Free ribosomes synthesize proteins used in the cytosol.



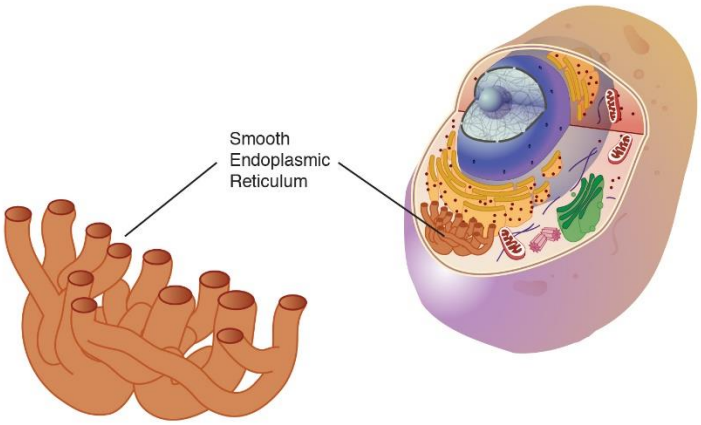
7. ENDOPLASMIC RETICULUM:

- The endoplasmic reticulum or ER is a network of membranes in the form of flattened sacs or tubules.
- The ER extends from the nuclear envelope (membrane around the nucleus), to which it is connected, throughout the cytoplasm.
- Cells contain two distinct forms of ER, which differ in structure and function.

  Rough ER is continuous with the nuclear membrane and usually is folded into a series of flattened sacs. The outer surface of rough ER is studded with ribosomes, the sites of protein synthesis. Rough ER produces secretory proteins, membrane proteins, and many organellar proteins.



Smooth ER extends from the rough ER to form a network of membrane tubules. Unlike rough ER, smooth ER does not have ribosomes on the outer surfaces of its membrane. Smooth ER does not synthesize proteins, but it does synthesize fatty acids and steroids, such as estrogens and testosterone. In liver cells, enzymes of the smooth ER help release glucose into the bloodstream and inactivate or detoxify lipid-soluble drugs or potentially harmful substances.



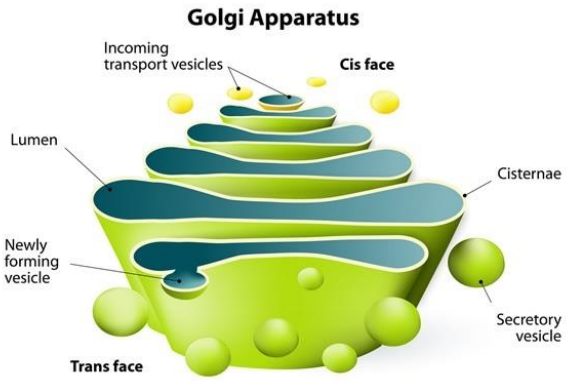
Functions:

1. Rough ER synthesizes glycoproteins and phospholipids that are transferred into cellular organelles, inserted into the plasma membrane, or secreted during exocytosis.
2. Smooth ER synthesizes fatty acids and steroids, such as estrogens and testosterone; inactivates or detoxifies drugs and other potentially harmful substances; removes the phosphate group from glucose-6phosphate; and stores and releases calcium ions that trigger contraction in muscle cells.

8. GOLGI COMPLEX:

- The Golgi apparatus, or Golgi complex, functions as a factory in which proteins received from the ER are further processed and sorted for transport to their eventual destinations: lysosomes, the plasma membrane, or secretion.
- In addition, as noted earlier, glycolipids and sphingomyelin are synthesized within the Golgi. Most of the proteins synthesized by ribosomes attached to rough ER are ultimately transported to other regions of the cell.
- The first step in the transport pathway is through an organelle called the Golgi complex. It consists of 3 to 20 cisternae, small, flattened membranous sacs with bulging edges that resemble a stack of pita bread.

The cisternae are often curved, giving the Golgi complex a cuplike shape.



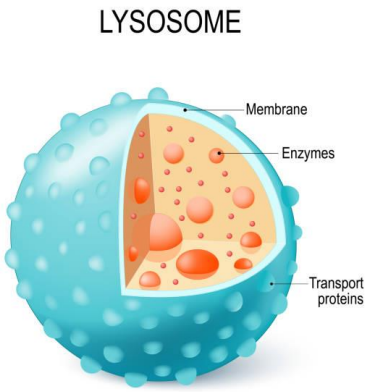
The convex entry or cis face is a cisterna that faces the rough ER. The concave exit or trans face is a cisterna that faces the plasma membrane. Sacs between the entry and exit faces are called medial cisternae.

Functions:

1. Modifies, sorts, packages, and transports proteins received from the rough ER.
2. Forms secretory vesicles that discharge processed proteins via exocytosis into extracellular fluid; forms membrane vesicles that ferry new molecules to the plasma membrane; forms transport vesicles that carry molecules to other organelles, such as lysosomes.

8. LYSOSOMES:

- Lysosomes are membrane-enclosed vesicles that form from the Golgi complex.
- A lysosome can engulf another organelle, digest it, and return the digested components to the cytosol for reuse.
- In this way, old organelles are continually replaced. The process by which entire worn-out organelles are digested is called autophagy.



Functions:

1. Digest substances that enter a cell via endocytosis and transport final products of digestion into cytosol.
2. Carry out autophagy, the digestion of worn-out organelles.
3. Carry out autolysis, the digestion of entire cell.

4. Carry out extracellular digestion.

9. PEROXISOMES:

Another group of organelles similar in structure to lysosomes, but smaller, are the peroxisomes

Peroxisomes, also called microbodies, contain several oxidases, enzymes that can oxidize (remove hydrogen atoms from) various organic substances.

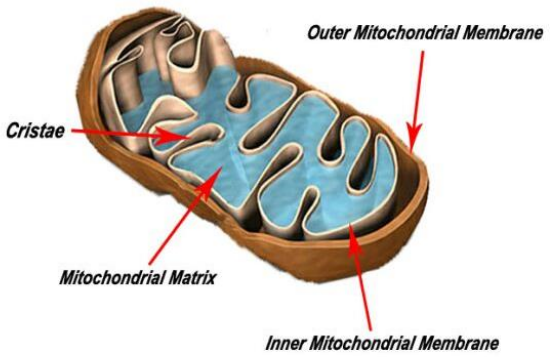
10. PROTEASOMES:

- Lysosomes degrade proteins delivered to them in vesicles. Cytosolic proteins also require disposal at certain times in the life of a cell.
- Continuous destruction of unneeded, damaged, or faulty proteins is the function of tiny barrel-shaped structures consisting of four stacked rings of proteins around a central core called proteasomes.

Proteasomes were so named because they contain myriad proteases, enzymes that cut proteins into small peptides.

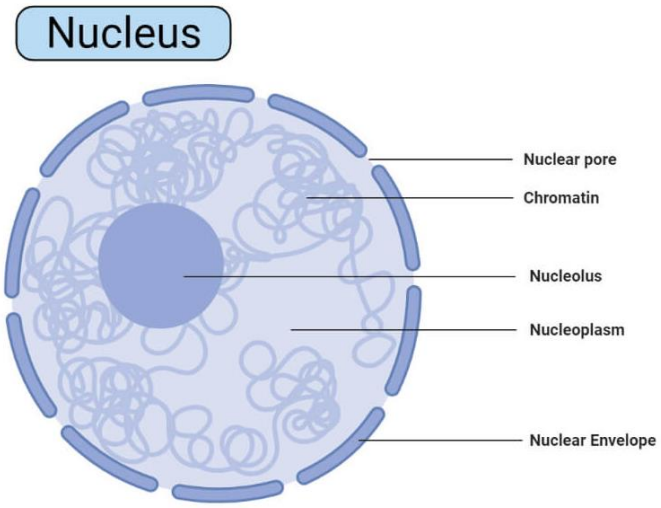
11. MITOCHONDRIA:

- Mitochondria are essential components of nearly all cells in the body.
- These organelles are the “powerhouses” for cells, providing energy to carry out biochemical reactions and other cellular processes.
- Mitochondria make energy for cells from the chemical energy.
- A mitochondrion consists of an outer mitochondrial membrane and an inner mitochondrial membrane with a small fluid-filled space between them. Both membranes are similar in structure to the plasma membrane.
- The inner mitochondrial membrane contains a series of folds called cristae. The central fluidfilled cavity of a mitochondrion, enclosed by the inner mitochondrial membrane, is the matrix.
- The enzymes that catalyze these reactions are located on the cristae and in the matrix of the mitochondria.



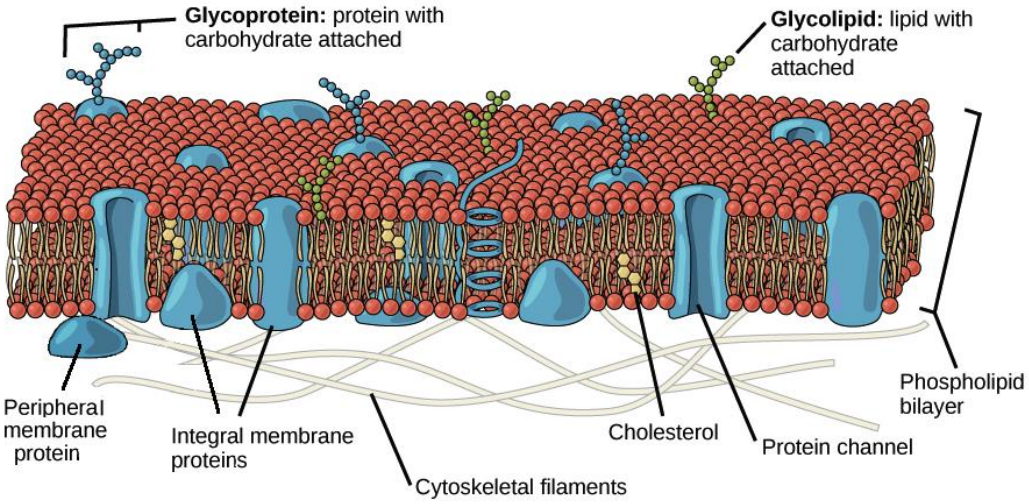
12. NUCLEUS:

- The nucleus is found in the middle of the cells, and it contains DNA arranged in chromosomes.
- It is surrounded by the nuclear envelope, a double nuclear membrane (outer and inner), which separates the nucleus from the cytoplasm.
- The outer membrane is continuous with the rough endoplasmic reticulum. The nuclear envelope contains pores which control the movement of substances in and out of the nucleus.
- RNA is selectively transported into the cytoplasm, and proteins are selectively transported into the nucleus. The nuclear membrane is supported by a meshwork of intermediate filaments, called nuclear lamins.
- One or more darkly staining spherical bodies called the nucleoli are found inside the nucleus. These are the sites at which ribosomes are assembled. Nucleoli are most prominent in cells that are synthesising large amounts of protein.
- Inside the nucleus are one or more spherical bodies called nucleoli that function in producing ribosomes. Each nucleolus is simply a cluster of protein, DNA, and RNA; it is not enclosed by a membrane. Nucleoli are the sites of synthesis of rRNA and assembly of rRNA and proteins into ribosomal subunits. Nucleoli are quite prominent in cells that synthesize large amounts of protein, such as muscle and liver cells. Nucleoli disperse and disappear during cell division and reorganize once new cells are formed.
- Within the nucleus are most of the cell's hereditary units, called genes, which control cellular structure and direct cellular activities. Genes are arranged along chromosomes. Human somatic (body) cells have 46 chromosomes, 23 inherited from each parent. Each chromosome is a long molecule of DNA that is coiled together with several proteins. This complex of DNA, proteins, and some RNA is called chromatin. The total genetic information carried in a cell or an organism is its genome.



13. PLASMA MEMBRANE:

- The plasma membrane is a structure that forms a barrier between the cytoplasm inside the cell and the environment outside the cell.
- Without the plasma membrane, there would be no cell. Although it is very thin and flexible.
- The plasma membrane protects and supports the cell by controlling everything that enters and leaves it. It allows only certain substances to pass through, while keeping others in or out.
- To understand how the plasma membrane controls what passes into or out of the cell, you need to know its basic structure. The plasma membrane, a flexible yet sturdy barrier that surrounds and contains the cytoplasm of a cell, is described by using a structural model called the fluid mosaic model.



Structure of the Plasma Membrane:

- The Lipid Bilayer: The basic structural framework of the plasma membrane is the lipid bilayer, two back-to-back layers made up of three types of lipid molecules—phospholipids, cholesterol, and glycolipids. About 75% of the membrane lipids are phospholipids (lipids that contain phosphorus).
- Present in smaller amounts are cholesterol (about 20%), a steroid with an attached -OH (hydroxyl) group, and various glycolipids (about 5%), lipids with attached carbohydrate groups.
- The bilayer arrangement occurs because the lipids are amphipathic molecules, which means that they have both polar and nonpolar parts.
- In phospholipids, the polar part is the phosphate containing “head,” which is hydrophilic (water loving). The nonpolar parts are the two long fatty acid “tails,” which are hydrophobic (water fearing) hydrocarbon chains. Because “like seeks like,” the phospholipid molecules orient themselves in the bilayer with their hydrophilic heads facing outward.