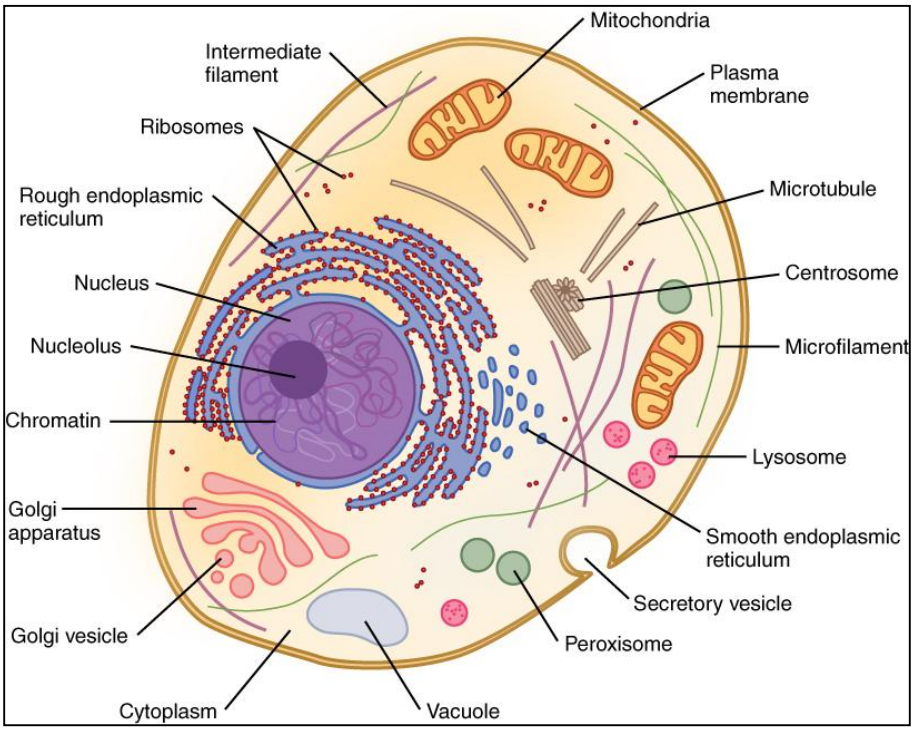
STUCTURE AND FUNCTION OF CELL

Cell is the basic living structural and functional unit of the body. Average human body consists of more than 100 trillion cells. Scientific study of cell is called ***cell biology or cytology***

Parts of a cell:

A cell has following parts –

1. ***Plasma membrane*** – flexible outer surface enclosing organelles
2. ***Cytoplasm*** – includes cytosol and organelles
3. ***Nucleus*** – largest organelle



Plasma Membrane

- Fluid structure – contains lipids and many of the proteins that are free to rotate and move sideways
- Structure explained by fluid mosaic model

Structure:

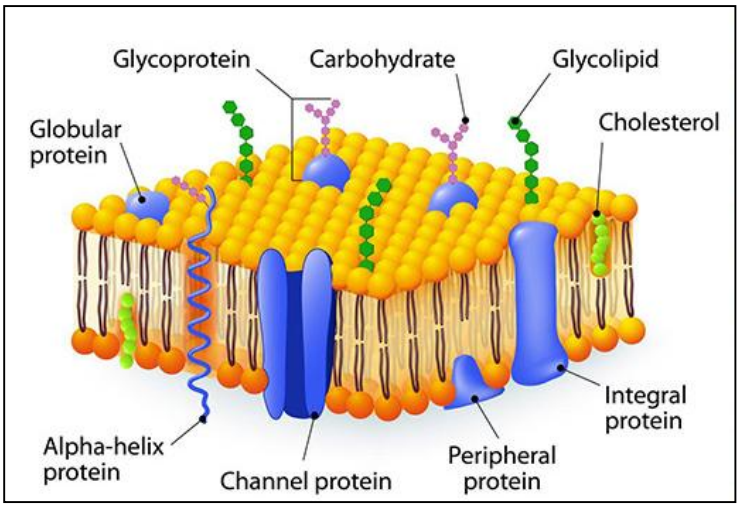
Plasma membrane is a lipid bilayer – consists of 2 layers of phospholipids with proteins & sugars embedded in them. It is made up of three types of lipid molecules – phospholipids (75%), cholesterol (20%) and glycolipids (5%).

Phospholipids are amphipathic molecules i.e. have both polar & nonpolar parts – contain head and tail. Head is electrically charged, hydrophilic and aligned on outer surface whereas tail has no charge, hydrophobic and forms central water repelling layer.

Plasma membrane also contains two types of membrane proteins – ***integral and peripheral proteins***. Integral proteins extend into or through lipid bilayer and firmly embedded in it. Most of them are transmembrane proteins that span entire lipid bilayer protruding into both cytosol and ECF. Peripheral proteins are not firmly embedded in the layer, they are either attached to polar heads or to integral proteins. Main peripheral proteins are glycoproteins.

Functions of plasma membrane

1. Acts as a barrier separating inside & outside of the cell
2. Controls flow of substances into and out of the cell
3. Helps identify the cell to other cells
4. Participates in intracellular signaling



Functions of Membrane proteins

1. Form ion channels, pores or holes through which specific ions (K+) flow in or out of the cell

2. Act as carriers/ transporters – selectively move a polar substance or ion from one side of the membrane to other
3. Some called receptors – serve as cellular recognition sites for hormones and other chemical messengers
4. Some are enzymes – catalyze specific chemical reactions
5. Also serve as linkers – anchor proteins in plasma membranes of neighboring cells to one another or to protein filaments inside & outside the cell
6. Some are involved in pumps that transport substances across the membrane
7. Some have branched carbohydrate molecules (cell identity markers) attached to the outside of the cell, giving the cell its immunological identity

Cytoplasm

It consists of all the cellular contents between the plasma membrane and the nucleus. It has 2 components –

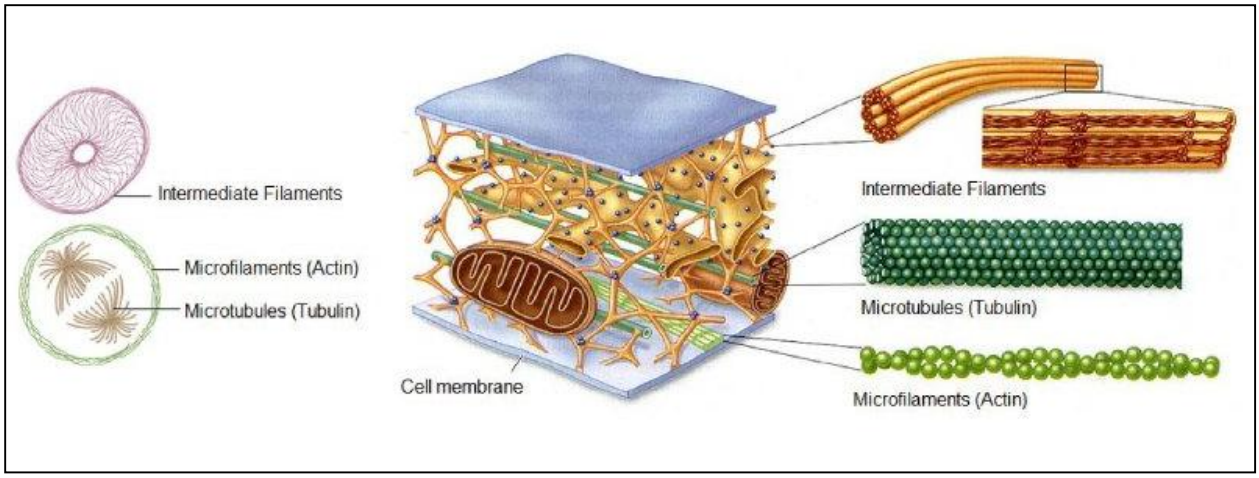
1. The cytosol and
2. Organelles

Cytosol

- Fluid portion of the cytoplasm that surrounds organelles
- Constitutes about 55% of total cell volume
- 75-90% is made up of water and various dissolved & suspended components like ions, glucose, aminoacids, fattyacids, proteins, lipids, ATP, waste products etc.
- Site of many chemical reactions required for a cell's existence

Cytoskeleton

- A network of three types of protein filaments that extend throughout the cytoplasm.
    1. Microfilaments
    2. Intermediate filaments
    3. Microtubules



Functions of cytoskeleton

1. Serves as a scaffold that helps determine a cell's shape and organize the cellular contents i.e. provides an internal support system for cell
2. Aids movement of organelles within the cell, of chromosomes during cell division, and of whole cells such as phagocytes

Organelles

Specialized structures within the cell – have characteristic shapes and perform specific functions.

Centrosome

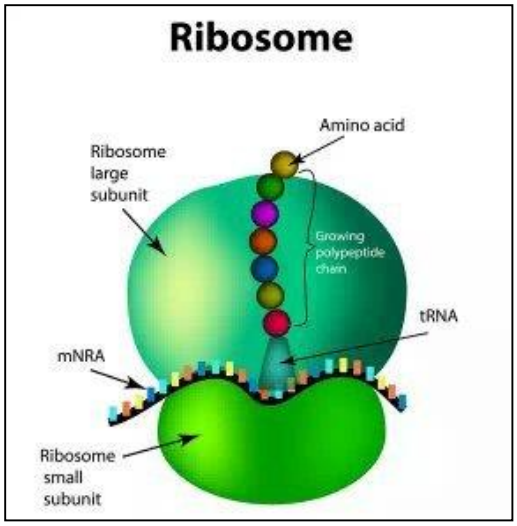
- Located near the nucleus, consists of a pair of centrioles and the pericentriolar matrix
- Pericentriolar matrix contains tubulins, which are used for growth of the mitotic spindle and microtubule formation

Cilia and flagella

- Motile cell surface projections that contain 20 microtubules and a basal body
- Cilia – move fluids over cell's surface
- Flagella – move entire cell

Ribosomes

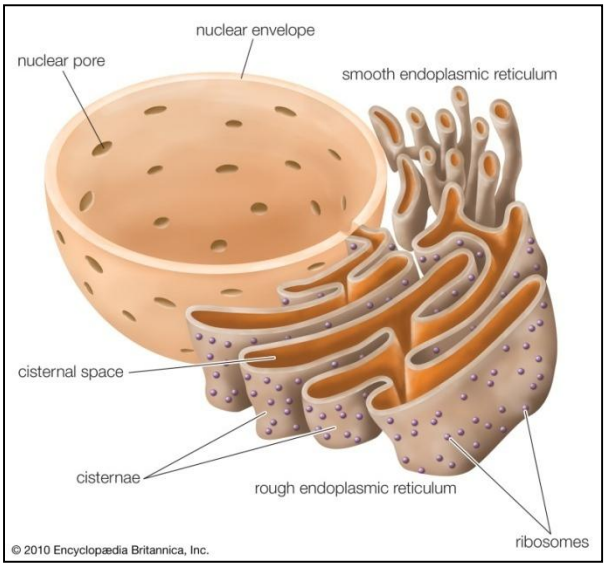
- Tiny granules composed of RNA and protein and are sites of protein synthesis
- Structurally, a ribosome consists of two subunits – large & small
- Subunits made separately in the nucleolus, exit separately then come together in the cytoplasm
- Some are attached to the outer surface of the nuclear membrane and to endoplasmic reticulum; some are free



Functions

1. Those associated with endoplasmic reticulum synthesise proteins destined for insertion in the plasma membrane or secretion from the cell
2. Free ribosomes synthesise proteins used in cytosol
3. Those within mitochondria, synthesise mitochondrial proteins

Endoplasmic Reticulum (ER)



- It is a network of membrane-enclosed sacs or tubules that form interconnecting membranous canals
- Extend from nuclear envelope & spreads/ extends throughout the cytoplasm
- It is of two types – Rough & Smooth

Rough Endoplasmic Reticulum (RER)

- Studded with ribosomes and continuous with nuclear membrane
- Usually folded into a series of flattened sacs
- Sites of protein synthesis

Functions

1. Produces secretory proteins, membrane proteins and many organellar proteins that are transferred into cellular organelles, inserted into the plasma membrane or secreted during exocytosis
2. ***Ex:*** Glycoproteins, phospholipids, enzymes and hormones

Smooth Endoplasmic Reticulum (SER)

- Extends from the RER to form a network of membrane tubules
- Does not have ribosomes

Functions

1. Synthesizes fattyacids/ lipids and steroid hormones such as estrogens and testosterone
2. Inactivates or detoxifies drugs and other potentially harmful substances (alcohol, pesticides etc.)
3. Removes the phosphate group from glucose-6-phosphate
4. Stores and releases calcium ions that trigger contraction in muscle cells (sarcoplasmic reticulum)

Golgi complex/ apparatus

- Consists of stacks of closely folded flattened membranous sacs with bulging ends called cisterns (3-20)
- Present in all cells but is larger in those that synthesise and export proteins

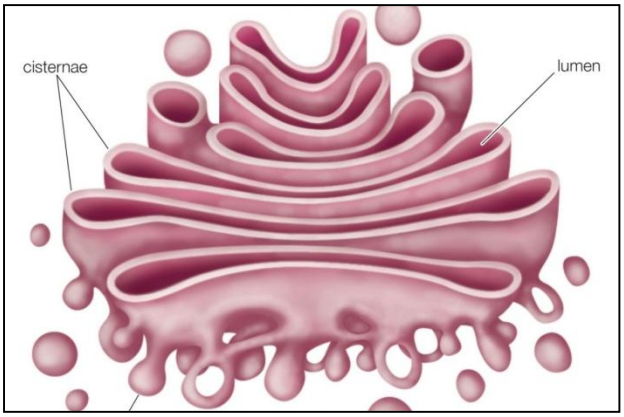
Functions

1. Modifies, sorts, packages and transports proteins received from the RER
2. Forms

   Secretory vesicles – discharge processed proteins via exocytosis into ECF

   Membrane vesicles – carry new molecules to PM

   Transport vesicles – carry molecules to other organelles, such as lysosomes



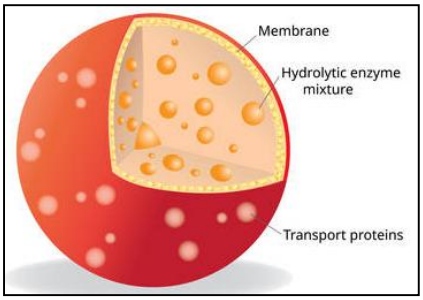
Lysosomes

- One type of membrane-bound sceretory vesicles formed by the golgi apparatus
- Contain a variety of digestive and hydrolytic enzymes that can break down a wide variety of molecules inside the cell into smaller particles, which are either recycled or extruded from cell as waste material

Functions

1. Digest substances that enter a cell via endocytosis and transport final products of digestion into cytosol
2. Perform autophagy (self eating) – process by which entire worn-out organelles are digested

3. Lysosomes in WBC contain enzymes that digest entire cell by a process known as autolysis
4. Some lysosomal enzymes operate in extracellular digestion. ***Ex:*** Release of lysosomal enzymes by head of sperm



Peroxisomes

- Also called microbodies, similar in structure to lysosomes but smaller
- Vesicles containing oxidases and catalase (decomposes H_2O_2)
- New peroxisomes bud from preexisting ones – self replicating
- Rich in liver cells

Functions

1. Oxidizes aminoacids and fatty acids
2. Detoxifies harmful substance, such as H_2O_2 & associated free radicals

Proteasomes

- These are tiny barrel-shaped structures that contains four stacked rings of proteins around a central core
- Contain proteases (proteolytic enzymes)

Functions

1. Degrades unneeded, damaged or faulty proteins by breaking them into small peptides

Mitochondria

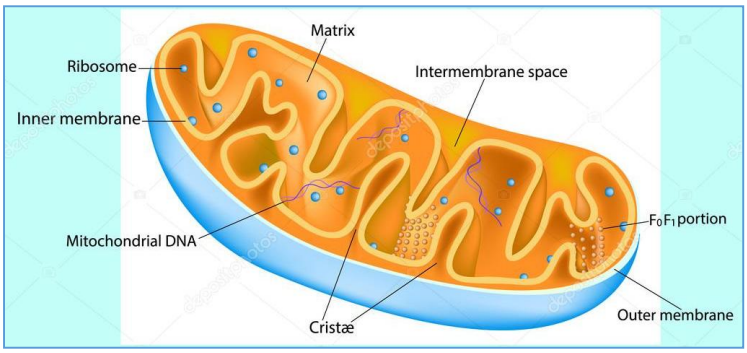
- Called "powerhouses" of the cell – generate most of the ATP through aerobic respiration
- Located where oxygen enters the cell or where ATP is used. Ex: Among contractile proteins in muscle cells

Structure

1. Consists of external & internal mitochondrial membranes separated by a small fluid-filled space between them
2. Internal membrane contains a series of folds called mitochondrial cristae
3. Central fluid filled cavity enclosed by internal mitochondrial membrane – mitochondrial matrix
4. They can self replicate

Functions

1. Site of aerobic cellular respiration that produce most of cell's ATP
2. Plays an important early role in apoptosis



Nucleus

- Largest organelle, spherical or oval-shaped structure and contains most of cell's genes which are located on chromosomes
- Most of the cells contain single nucleus; mature RBC has no nucleus, whereas skeletal cells have multiple nuclei
- Consists of following parts
    1. Nuclear envelope and nuclear pores
    2. Nucleolus
    3. Chromosomes

    Functions

    1. Controls cellular structure
    2. Directs cellular activities
    3. Produces ribosomes in nucleoli

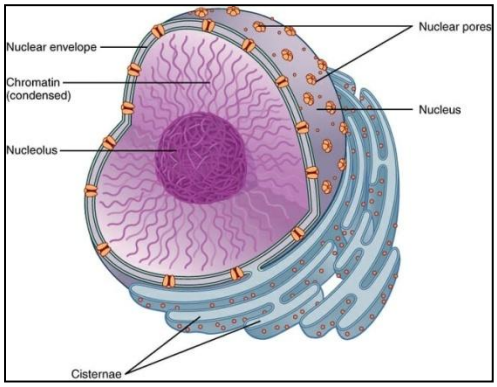
Nuclear envelope

- A membrane similar to plasma membrane but has tiny pores called nuclear pores that extend though out the envelope
- Separates nucleus from the cytoplasm
- Outer membrane is continuous with RER

    Functions

    1. Nuclear pores control the movement of substances between the nucleus and cytoplasm

2. Allow movement of small molecules & ions by diffusion and large molecules like RNA & proteins by active transport



Nucleolus

- Spherical body/ bodies present inside the nucleus
- It's a cluster of protein, DNA & RNA and not enclosed by a membrane
- Usually one or more in number
- Disperse and disappear during cell division, reorganize once new cells are formed

Functions

1. Produce ribosomes

Chromosomes

- Chromosome is a highly coiled and folded DNA molecule that is combined with protein molecules
- Genes are cell's hereditary units present within the nucleus and are arranged along chromosomes
- Complex of DNA, proteins & some RNA is called chromatin
- During cell division, chromatin is more condensed and form a pair of chromatids

Functions

1. Consist of genes that control cellular structure and direct cellular functions