TOPIC- 1. The Cell (the unit of life)

Nucleus-
The Cell (from Latin cella, meaning "Small Room") is the basic Structural, Functional, and Biological unit of all known Living Organisms. A cell is the Smallest Unit of life that can replicate independently, and cells are often called the "Building Blocks of Life". The study of cells is called Cell Biology.

What is a Cell in Biology (in Human Body)?
Cell is the fundamental structural and functional unit of all living organisms.

Discovery of a cell-
Anton Von Leeuwenhoek first saw and described a Live Cell. Robert Brown later discovered the Nucleus.

Types of Cells or different types of Cells-
There are different types of cells present in human body. The largest cell in the human body is Ovum in females. And the smallest cell in the human body is Sperm.

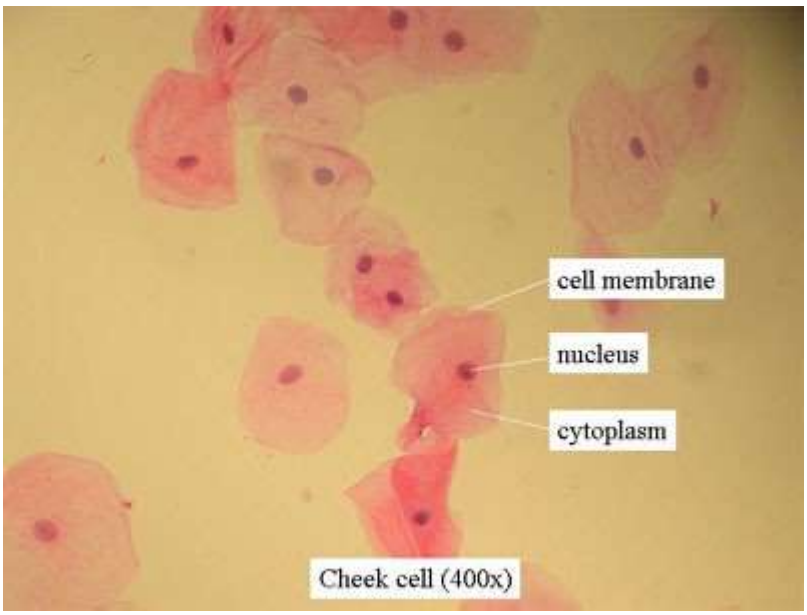

Fig.1. Image of a cheek cells under the microscope

Apart from these, brain contain nerve cell or neurons, liver cells are known as Hepatocytes, Kidney cells are known as Nephron etc.

Why the Cell is the basic Unit of Life?
Every living organism such as plants and animals are made up of cells. So, cell is considered as the basic unit of life.

Functions of Cell-
Cells perform different functions in different parts of the body. For Example: Neuron transmits information from brain to different parts of the body. Nephron is a structural and functional unit of kidney. Nephron helps in removal of nitrogenous waste from the body. Cells perform variety of metabolic reactions such as breakdown of complex molecules to release energy. Cells also synthesizes new molecules required by the body.

Cell theory-

In 1838, Matthias Schleiden, a German botanist, examined that plants are made up of large number of cells. Theodore Schwann (1839), a British Zoologist, examined that animals are also made up of cells. Later on, Rudolf Virchow explains that cells arise from pre-existing cell. This is known as Omnis cellula-e cellula.

Characteristics of Cell Theory-

Cell is the structural and functional unit of life
All organisms: plants and animals are made up of cells.
All cells arise from the pre-existing cells.

An Overview of Cell

1. Prokaryotes-

Bacteria, blue green algae, mycoplasma and PPLO (Pleuro Pneumonia Like Organisms) represents prokaryotes. The cell of prokaryotes is known as Prokaryotic Cells. These cells are small in size and multiply at a faster rate. Prokaryotes have outermost covering known as Cell Wall, except in mycoplasma.

2. Eukaryotes-

It includes protists, plants, fungi and animals.They have cell organelles separated by a membrane. They have well developed nucleus separated by a nuclear membrane.

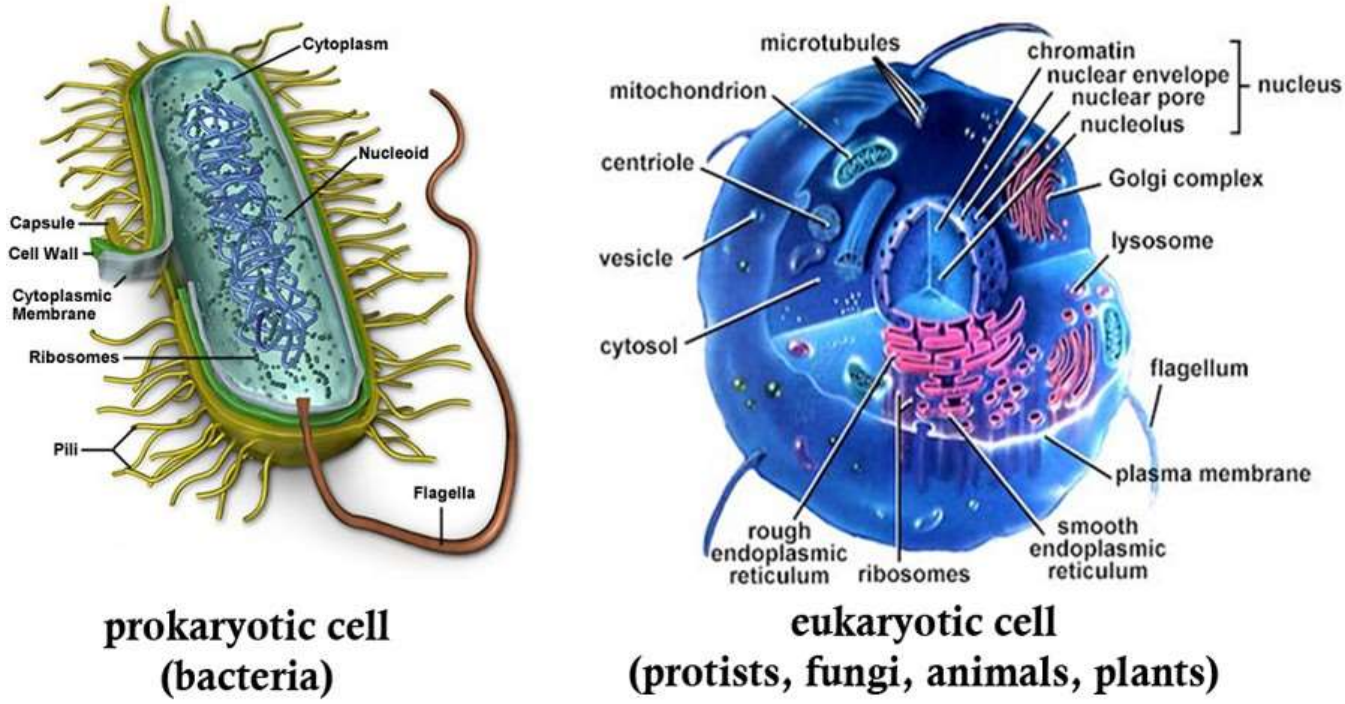

Fig.2. Prokaryotic and Eukaryotic Cell

What are Cell Organelles?

The cellular components are called cell organelles. These cell organelles include both membrane and non-membrane bound organelles, present within the cells and are distinct in their structures and functions. They coordinate and function efficiently for the normal functioning of the cell. A few of them function by providing shape and support, whereas some are involved in the locomotion and

reproduction of a cell. There are various organelles present within the cell and are classified into three categories based on the presence or absence of membrane.

Organelles without membrane: The Cell wall, Ribosomes, and Cytoskeleton are non-membrane-bound cell organelles. They are present both in prokaryotic cell and the eukaryotic cell.

Single membrane-bound organelles: Vacuole, Lysosome, Golgi Apparatus, Endoplasmic Reticulum are single membrane-bound organelles present only in a eukaryotic cell.

Double membrane-bound organelles: Nucleus, mitochondria and chloroplast are double membrane-bound organelles present only in a eukaryotic cell.

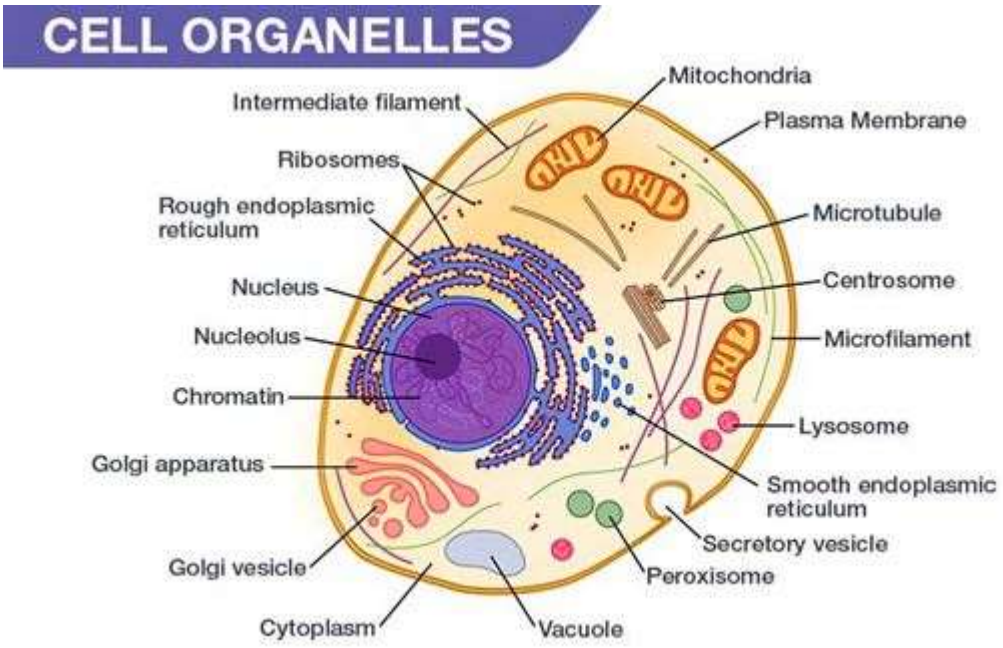

Fig.3a. Structure of Eukaryotic Cell(showing cell organelles)

Parts of Cell / Human Cell / Human Cell Structure

Plasma Membrane

In eukaryotes (higher organisms), cell is surrounded by a membrane known as Plasma Membrane or Cell Membrane. Plasma membrane is made up of lipids and protein. This membrane is selective or semi-permeable in nature, that is, it allows only certain molecules to enter the cell while remaining left outside the cell.

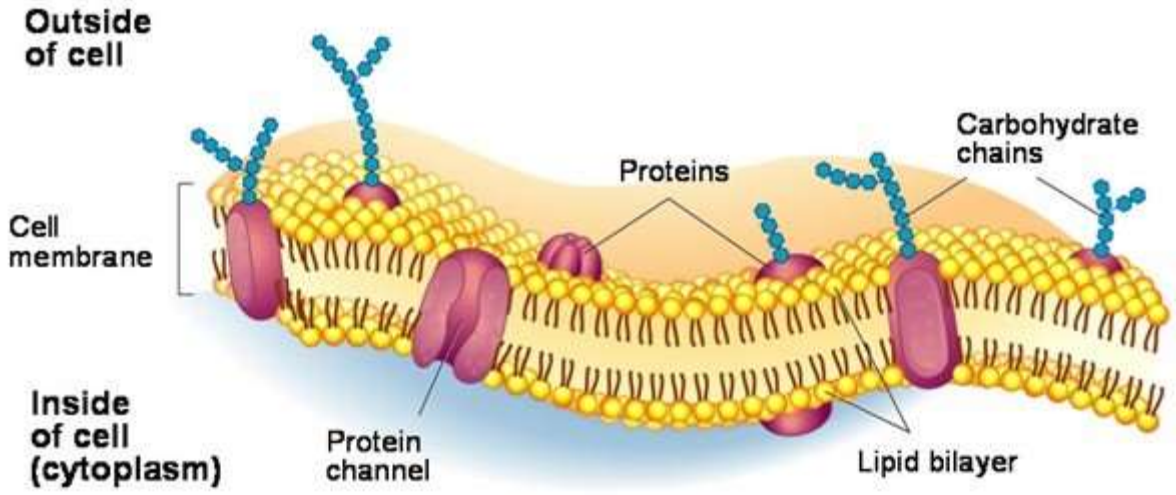

Fig.3b. Structure of Plasma Membrane

Plant cell is surrounded by cell wall. Cell wall is made up of polysaccharide known as Cellulose. Cellulose provides strength and rigidity to the cell.

There are certain modification of Plasma Membrane such as:

Bacteria have outermost envelope known as **Glycocalyx. Glycocalyx** is followed by cell wall and then plasma membrane. It is protective in nature. According to cell envelope or staining procedure, bacteria is classified as gram negative and gram positive. Bacteria that can be stained using Gram stain are known as Gram Positive bacteria whereas those which are not stained are considered Gram Negative bacteria.

If **Glycocalyx** is a loose sheath, then it is known as Slime Layer whereas if it is thick and tough it is known as Capsule.

Fluid Mosaic Model-
According to this model, plasma membrane is composed of phospholipids, cholesterol, and proteins and exists in fluid state. The outer face of membrane contains glycoproteins ad glycolipids.
Glycolipids are carbohydrates attached to lipids whereas glycoproteins are carbohydrates attached to carbohydrates.Glycolipids are carbohydrates attached to lipids whereas glycoproteins are carbohydrates attached to carbohydrates.

Cytoplasm-
The cytoplasm is present both in plant and animal cells. They are jelly-like substances, found between the cell membrane and nucleus. They are mainly composed of water, organic and inorganic compounds. The cytoplasm is one of the essential components of the cell, where all the cell organelles are embedded. These cell organelles contain enzymes, mainly responsible for controlling all metabolic activity taking place within the cell and are the site for most of the chemical reactions within a cell.

Ribosomes-
These are the sites of protein synthesis. They are composed of two subunits- 50S and 30S subunit. These subunits together form 70S unit. 70S ribosome is present in bacteria. Eukaryotes contain 80S ribosome. The subunit of eukaryotic ribosomes is 60S and 40S. In prokaryotes, reserve material is stored in cytoplasm is the form of inclusion bodies.

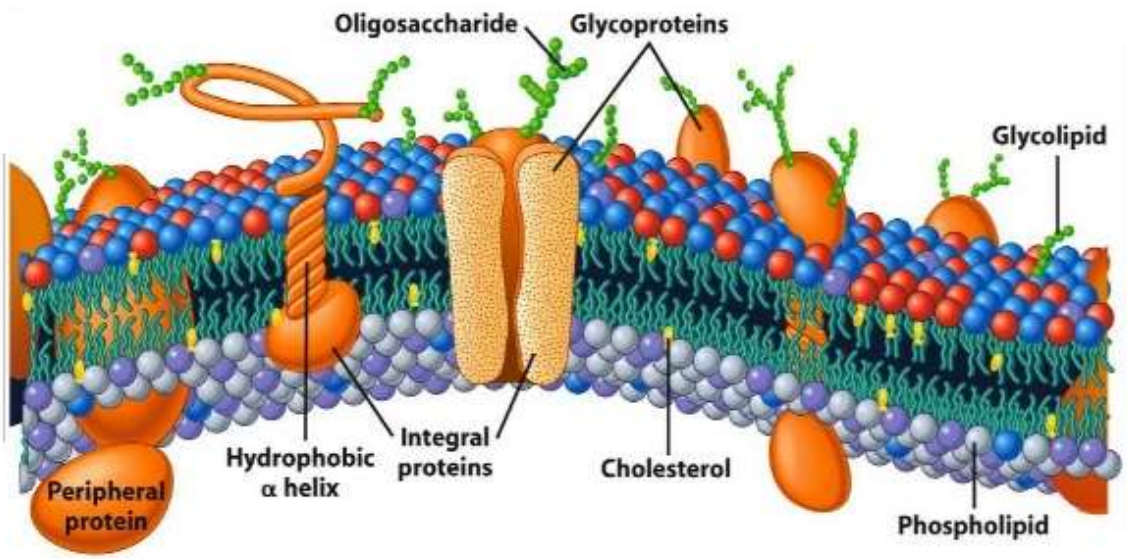

Fig.4. Fluid mosaic model

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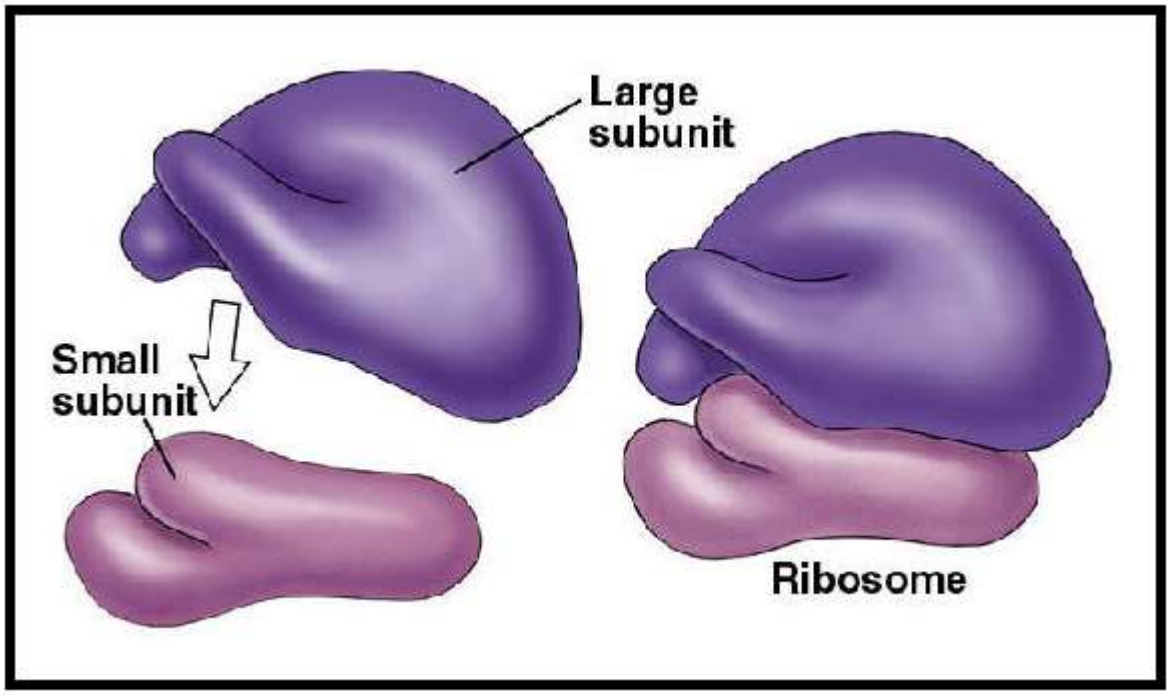


Fig.5. Subunits of Ribosomes

Endomembrane System-
It includes nucleus, Endoplasmic Reticulum, Mitochondria, Lysosomes, Golgi Apparatus, Plastids in plants and vacuole.

Endoplasmic Reticulum-
A network of tubules spread in a cytoplasm is known as Endoplasmic Reticulum or ER. Inside of the ER is known as Lumen whereas outside the lumen is known as Extra Luminal. There are two types of ER- Rough ER and Smooth ER. Rough ER is covered by ribosomes whereas smooth ER do not contain ribosomes.Rough ER is involved in protein synthesis and smooth ER is involved in fatty acid synthesis and detoxification.

Golgi Apparatus-
Camillo Golgi first observed this structure. They consist of many flat, disc-shaped sacs or cisternae of 0.5µm to 1.0µm diameter. They are arranged near the nucleus. The side facing the nucleus is known as Cis Face whereas side away from the nucleus is known as Trans Face. It is primarily involved in secretion process.

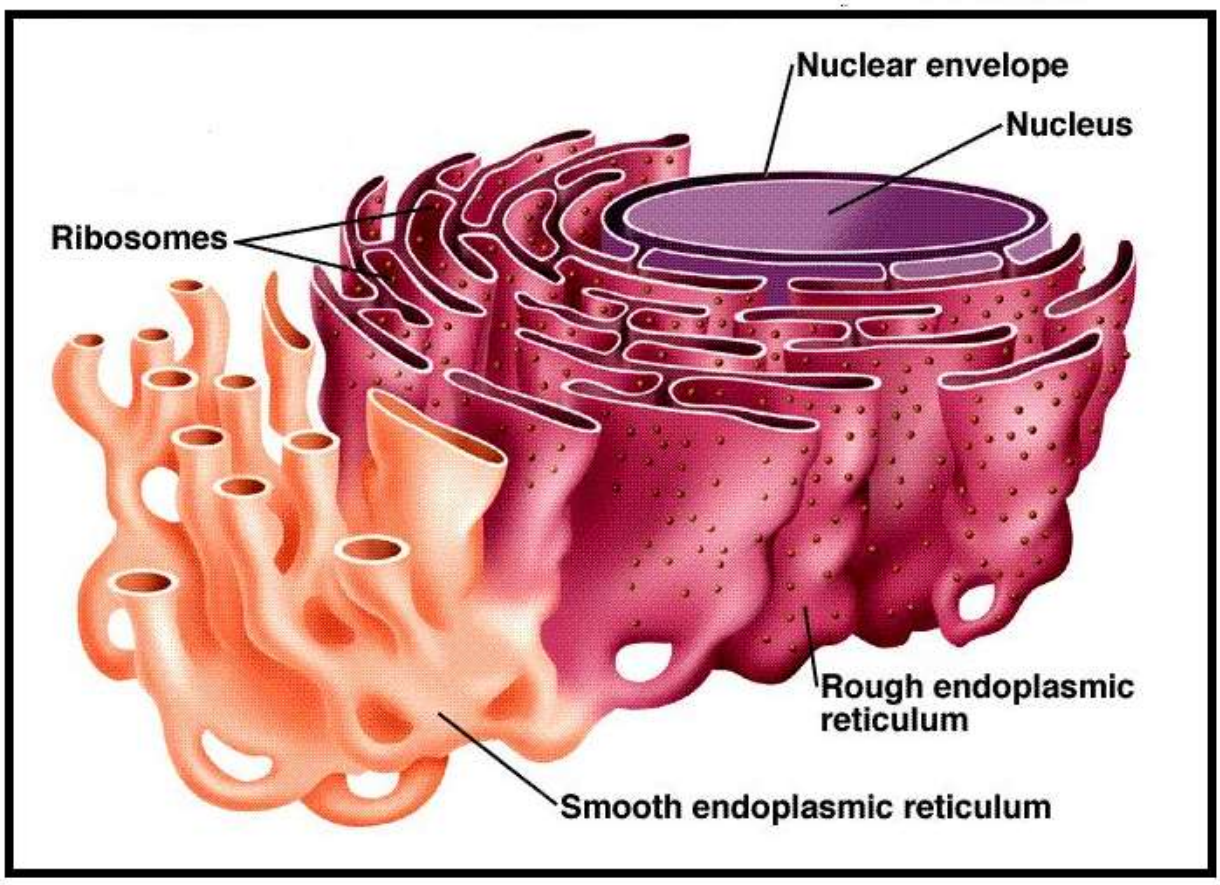


Fig.6. 3D Structure of ER

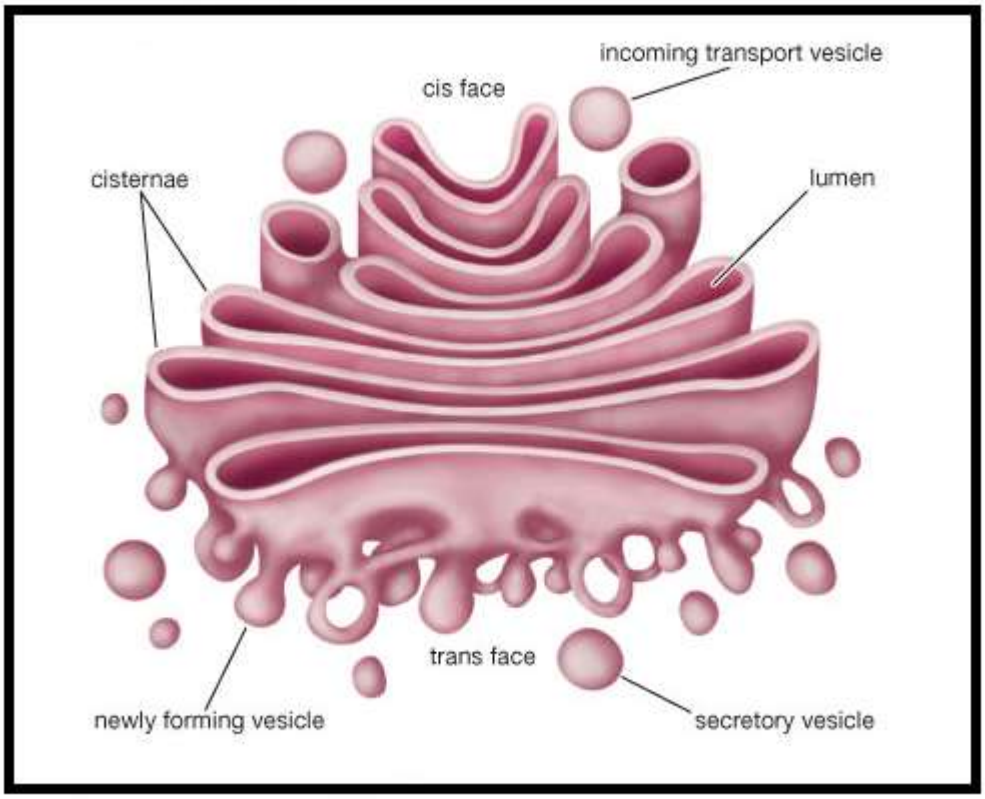


Fig.7. Structure of Golgi Apparatus

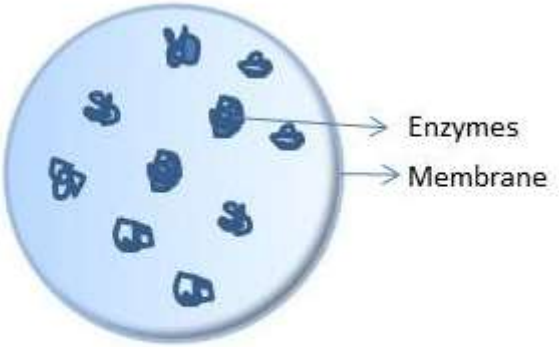
It packages the materials in vesicles and helps in transportation to different cell organelles as well as outside the cell organelle.

Structure of lysosomes-

It is a membranous structure formed from golgi apparatus. It is garbage collector of the cell. It contains various hydrolytic enzymes such as lipases, proteases which works at acidic environment. They help in digestion of lipids, Proteins and Carbohydrates

Vacuoles-

These are more prominent in plant cells as compared to animal cells. It contains water, sap and excretory product. The vacuole is bound by a membrane known as Tonoplast.



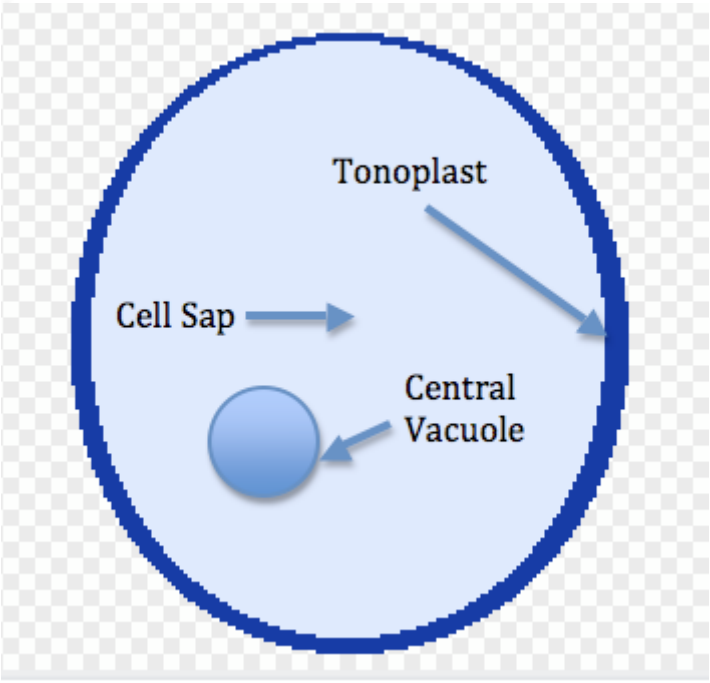


Fig.9. Structure of Vacuole

Amoeba contain vacuole-like structure known as Contractile Vacuole. This is essential for excretion.

Structure of MitochondriaMitochondria-

It has a double membrane structure – The Outer membrane and Inner membrane. The inner membrane is folded to form a structure known as Cristae. It is a site for ATP synthesis. The outer membrane and inner membrane is separated by intermembrane space.The inner compartment is known as Matrix. DNA and ribosomes are present in the matrix of the mitochondria.

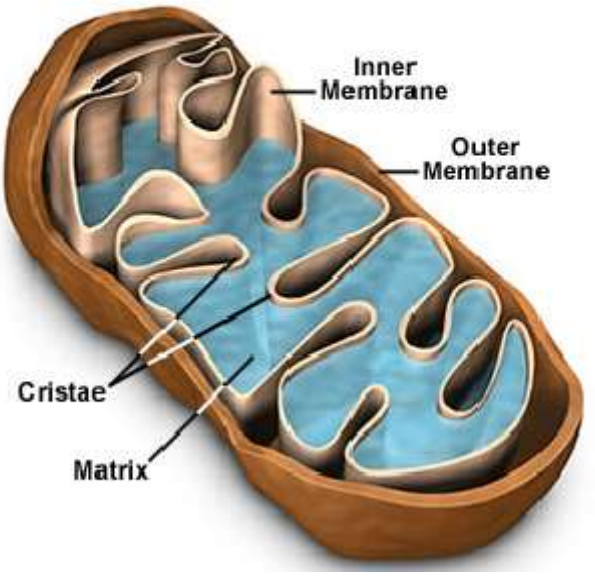


Fig 10: Mitochondria

Plastids-
These are found in plant cells. There are three types of plastids- Chloroplast, Chromoplast and Leucoplast.

Structure of Chloroplast- Chloroplast contain a green pigment known as Chlorophyll. The leaves appear green due to the presence of chlorophyll in it. The central atom present in chlorophyll is magnesium ion. Chlorophyll is essential for photosynthesis.

Chloroplast is double membrane structure-inner membrane and outer membrane. The space limited by the inner membrane of the chloroplast is called the stroma. Stroma contain flattened sac-like structure known as Thylakoids.

It is site of photosynthesis. Thylakoids are stacked upon each other to form grana. Each granum is connected with another granum by a lamella. Similar to mitochondria, chloroplast contain DNA and ribosomes.

Chromoplast provides color to flower and fruits. The pigment present in chromoplast are carotene which provides red color and xanthophyll which provides yellow-orange color.

Leucoplast are of different types such as amyloplast for storage of starch, aleuroplast store proteins and elaioplast stores oil and fats.

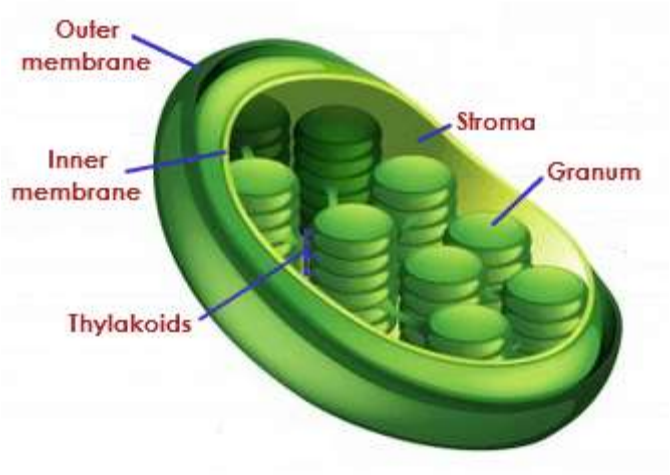


Fig.-11 Chloroplast

Structure of a Nucleus-

It is a double membrane structure. The outer membrane is continuous with the ER and contain ribosomes on it. The space between the two membrane is known as Perinuclear Space. The two nuclear membrane are interrupted by minute pores known as Nuclear Pores, which allow only certain molecules of particular size to enter the nucleus. The nuclear matrix is known as Nucleoplasm.

Nucleoplasm is composed of chromatin and nucleolus.

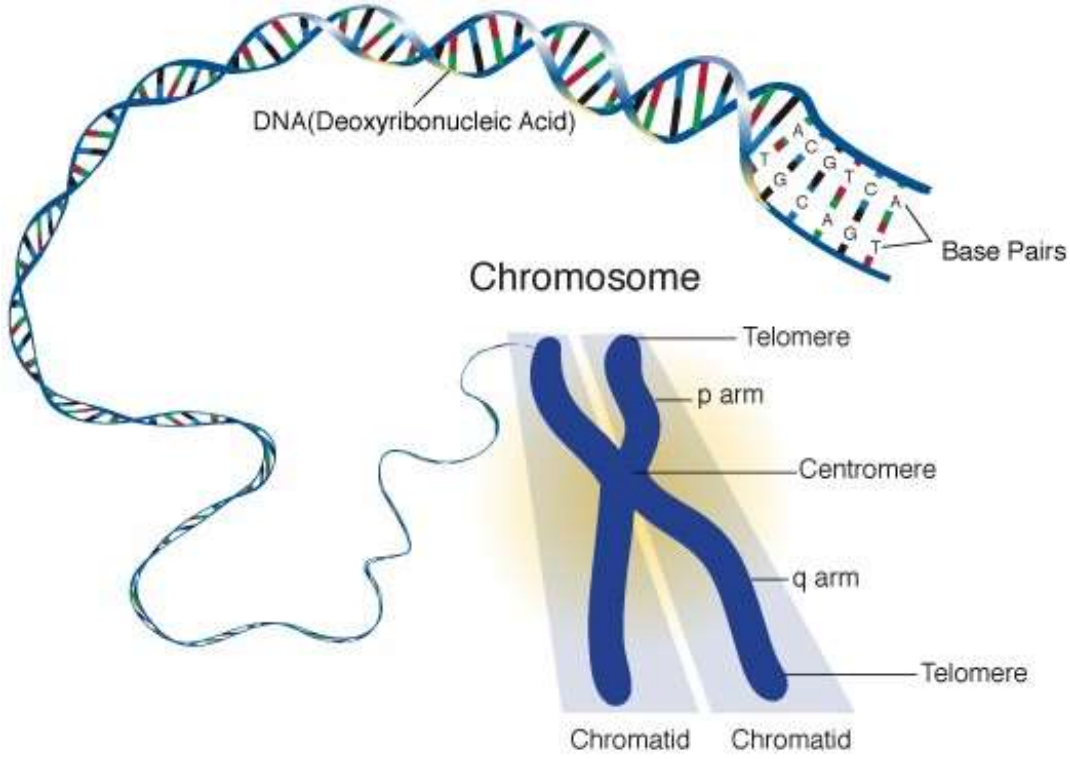


Fig.12. Structure of Chromosome and DNA

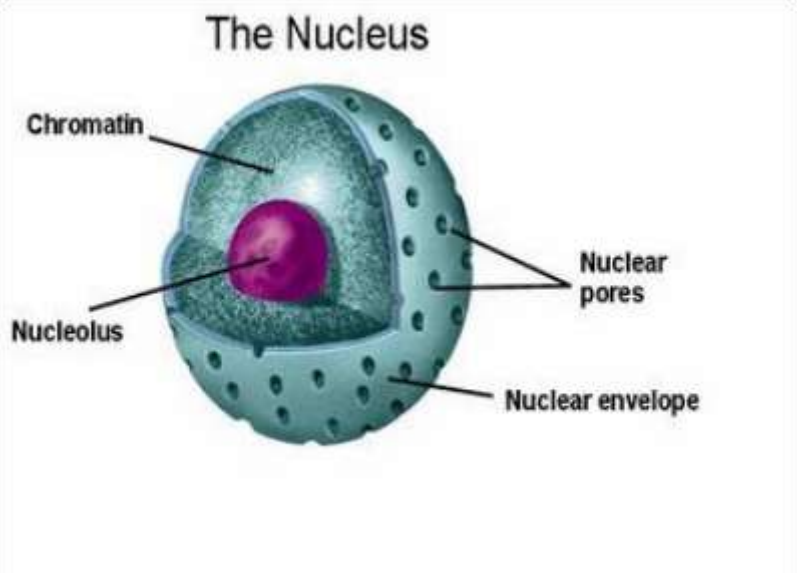


Fig.-13 Nucleus

Chromatin is a network of DNA surrounded by proteins known as Histone Proteins. During interphase (no cell division), the genetic material exists in the form of chromatin. At the time of cell division, the chromatin becomes compact and forms chromosomes. Chromosomes contain constriction known as Centromere. RNA synthesis occurs in the nucleolus.

Microbodies-
Microbodies are membrane-bound, minute, vesicular organelles, found in both plant and animal cell. They contain various enzymes and proteins and can be visualized only under the electron microscope.

Cytoskeleton-
It is a continuous network of filamentous proteinaceous structures that run throughout the cytoplasm, from the nucleus to the plasma membrane. It is found in all living cells, notably in the eukaryotes. The cytoskeleton matrix is composed of different types of proteins that can divide rapidly or disassemble depending on the requirement of the cells. The primary functions include providing the shape and mechanical resistance to the cell against deformation, the contractile nature of the filaments helps in motility and during cytokinesis.

Cilia and Flagella-
Cilia are hair-like projections, small structures, present outside the cell wall and work like oars to either move the cell or the extracellular fluid. Flagella are slightly bigger and are responsible for the cell movements. The eukaryotic flagellum structurally differs from its prokaryotic counterpart. The core of the cilium and flagellum is called an axoneme, which contains nine pairs of gradually arranged peripheral microtubules and a set of central microtubules running parallel to the axis. The central tubules are interconnected by a bridge and are embedded by a central sheath. One of the peripheral microtubular pairs is also interconnected to the central sheath by a radial spoke. Hence there is a total of 9 radial spokes. The cilia and flagella emerge from centriole-like structures called basal bodies.

Centrosome and Centrioles-
The centrosome organelle is made up of two mutually perpendicular structures known as centrioles. Each centriole is composed of 9 equally spaced peripheral fibrils of tubulin protein, and the fibril is a set of interlinked triplets. The core part of the centriole is known as a hub and is proteinaceous. The hub connects the peripheral fibrils via radial spoke, which is made up of proteins. The centrioles from

the basal bodies of the cilia and flagella give rise to spindle fibres during cell division.

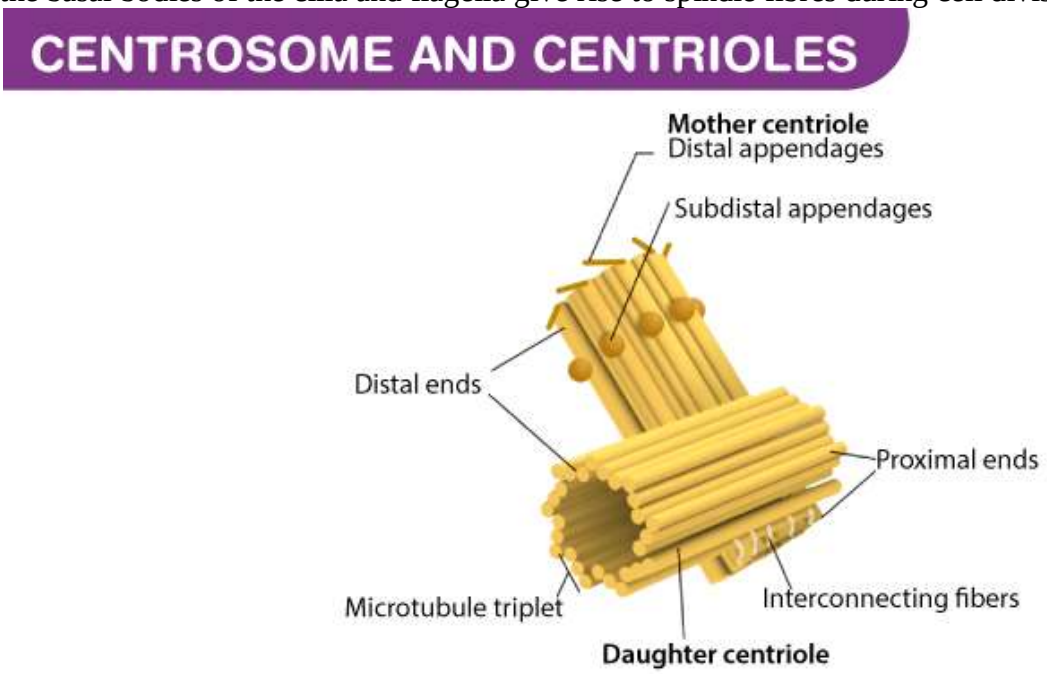


Fig.14-Centrosome and Centriole

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Vacuoles-

Vacuoles are mostly defined as storage bubbles of irregular shapes which are found in cells. They are fluid-filled organelles enclosed by a membrane. The vacuole stores the food or a variety of nutrients that a cell might need to survive. In addition to this, it also stores waste products. The waste products are eventually thrown out by vacuoles. Thus, the rest of the cell is protected from contamination. The animal and plant cell have different size and number of vacuoles. Compared to the animals, plant cell have larger vacuoles.

A Brief Summary on Cell Organelles-

Cell Organelles Structure and their Functions-

Cell membrane- A double membrane composed of lipids and proteins. Present both in plant and animal cell. Provides shape, protects the inner organelle of the cell and acts as a selectively permeable membrane.

Centrosomes- Composed of Centrioles and found only in the animal cells. It plays a major role in organizing the microtubule and Cell division.

Chloroplasts- Present only in plant cells and contains a green-coloured pigment known as chlorophyll. Sites of photosynthesis.

Cytoplasm- A jelly-like substance, which consists of water, dissolved nutrients and waste products of the cell. Responsible for the cell's metabolic activities.

Endoplasmic Reticulum-A network of membranous tubules, present within the cytoplasm of a cell. Forms the skeletal framework of the cell, involved in the Detoxification, production of Lipids and proteins.

Golgi apparatus-Membrane-bound, sac-like organelles, present within the cytoplasm of the eukaryotic cells.It is mainly involved in secretion and intracellular transport.

Lysosomes- A tiny, circular-shaped, single membrane-bound organelles, filled with digestive enzymes.Helps in the digestion and removes wastes and digests dead and damaged cells. Therefore, it is also called as the "suicidal bags".

Mitochondria-An oval-shaped, membrane-bound organelle, also called as the "Power House of The Cell". The main sites of cellular respiration and also involved in storing energy in the form of ATP molecules.
Nucleus-A largest, double membrane-bound organelles, which contains all the cell's genetic information. Controls the activity of the cell, helps in cell division and controls the hereditary characters.
Peroxisome-A membrane-bound cellular organelle present in the cytoplasm, which contains the reducing enzyme.Involved in the metabolism of lipids and catabolism of long-chain fatty acids.
Plastids-Double membrane-bound organelles. There are 3 types of plastids:
Leucoplast –Colourless plastids.
Chromoplast–Blue, Red, and Yellow colour plastids.
Chloroplast – Green coloured plastids.
Helps in the process of photosynthesis and pollination, Imparts colour for leaves, flowers and fruits and stores starch, proteins and fats.
Ribosomes-Non-membrane organelles, found floating freely in the cell's cytoplasm or embedded within the endoplasmic reticulum.Involved in the Synthesis of Proteins.
Vacuoles-A membrane-bound, fluid-filled organelle found within the cytoplasm. Provide shape and rigidity to the plant cell and helps in digestion, excretion, and storage of substances.

Important Question on Cell Organelles:

Which cell organelle is called the Powerhouse of the cell?
Mitochondria is the cell organelle and is called the Powerhouse of the cell as they carry out the cellular respiration and generate the energy molecules called ATP or Adenosine Triphosphate.

Where do we find Chloroplasts and Chromoplast pigments in plants?
Chloroplasts and Chromoplasts are the plastids present in all plant cells. Chloroplasts are the green colour pigments, present in the leaves, green-coloured stems, etc. Chromoplasts are the colourful pigments present in all colourful parts of the plant like flowers and fruits, etc.

Why Lysosomes are known as suicide bags?
Lysosomes are called the suicidal bags because they are capable of breaking down or digesting all the wastes, dead and damaged cells.

What is Nucleoid?
Nucleoid is a non-membrane, irregular shaped cell organelle present in all prokaryotic cells. They are

the carriers of the genetic material of a cell.

REFERENCES-

1.https://www.askiitians.com/biology/cell-the-unit-of-life/
2.https://byjus.com/biology/cell-organelles/
(The above mentioned description including the figures are taken from the above mentioned references and are used for teaching and learning purposes only.)