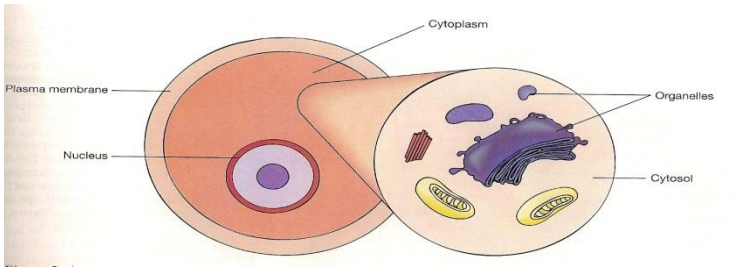
Cell

Cell is defined as the structural and functional unit of the living body because it has all the characteristics of life



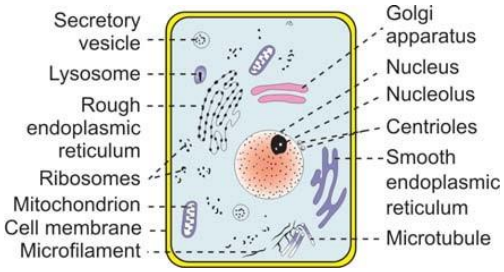
The cell membrane is a protective sheath that envelops the cell body. It separates the fluid outside the cell called extracellular fluid (ECF) and the fluid inside the cell called intracellular fluid (ICF). It is a semipermeable membrane and allows free exchange of certain substances between ECF and ICF

The cell membrane is composed of three types of substances

1. Proteins (55%)
2. Lipids (40%)
3. Carbohydrates (5%).

Each cell is formed by a cell body and a cell membrane or plasma membrane that covers the cell body. The important parts of the cell are

a. Cell membrane
b. Nucleus
c. Cytoplasm with organelles



The cell membrane is a unit membrane having the 'fluid mosaic model' i.e., the membrane is a fluid with mosaic of proteins (mosaic means pattern formed by arrangement of different colored pieces of stone, tile, glass or other such materials , lipids and carbohydrates. The electron microscopic study reveals three layers in the cell membrane namely, one electron lucent lipid layer in the center and two electron dense layers on either side of the central layer. Carbohydrate molecules are found on the surface of the cell membrane.

FUNCTIONS OF CELL MEMBRANE

1. Protective function: Cell membrane protects the cytoplasm and the organelles present

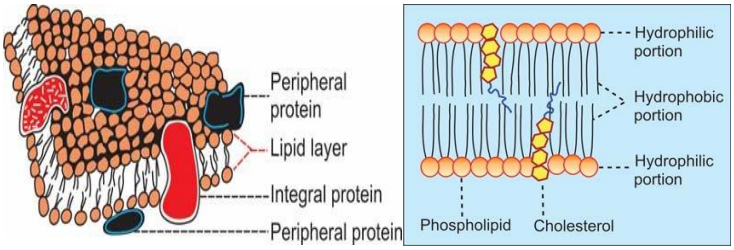
in the cytoplasm.

2. Selective permeability: Cell membrane acts as a semipermeable membrane which allows only some substances to pass through it and acts as a barrier for other substances.
3. Absorptive function: Nutrients are absorbed into the cell through the cell membrane.
4. Excretory function: Metabolites and other waste products from the cell are excreted out through the cell membrane.
5. Exchange of gases: Oxygen enters the cell from the blood and carbon dioxide leaves the cell and enters the blood through the cell membrane.
6. Maintenance of shape and size of the cell: Cell membrane is responsible for the maintenance of shape and size of the cell.

Lipid Layer of Cell Membrane

It is a bilayered structure formed by a thin film of lipids. It is fluid in nature and the portions of the membrane along with the dissolved substances move to all areas of the cell membrane. The major lipids are:

a. Phospholipids
b. Cholesterol



Functions of lipid layer

The lipid layer is semi permeable in nature and allows only the fat soluble substances like oxygen, carbon dioxide and alcohol to pass through it. It does not allow the water soluble materials like glucose, urea and electrolytes to pass through it.

Protein Layers of the Cell Membrane

The protein layers of the cell membrane are the electron dense layers situated on either side of the central lipid layer. The protein substances present in these layers are mostly glycoproteins. These protein molecules are classified into two categories:

a. Integral proteins
b. Peripheral proteins.

Functions of protein layers

Functionally, the proteins in the cell membrane exist in different forms such as integral proteins, channel proteins, carrier proteins etc.

1. *Integral proteins* provide structural integrity of the cell membrane
2. *Channel proteins* provide route for diffusion of water soluble substances like glucose and electrolytes
3. *Carrier proteins* help in transport of substances across the cell membrane
4. *Receptor proteins* serve as receptor sites for hormones and neurotransmitters
5. *Enzymes:* some of the protein molecules form the enzymes which control chemical reactions within the cell membrane

6. *Antigens:* Some proteins act as antigens and induce the process of antibody formation.

Carbohydrate of the Cell Membrane

Carbohydrate molecules form a thin loose covering over the entire surface of the cell membrane called glycocalyx. Some carbohydrate molecules are attached with proteins and form glycoproteins and some are attached with lipids and form glycolipids.

Functions of carbohydrates

1. The carbohydrate molecules are negatively charged and do not permit the negatively charged substances to move in and out of the cell.
2. The glycocalyx from the neighboring cells helps in the tight fixation of cells with one another.
3. Some of the carbohydrate molecules form the receptors for some hormones.

CYTOPLASM

The cytoplasm is the fluid present inside the cell. It contains a clear liquid portion called cytosol which contains various substances like proteins, carbohydrates, lipids and electrolytes. Apart from these substances, many organelles are also present in cytoplasm. The cytoplasm is distributed as peripheral ectoplasm just beneath the cell membrane and inner endoplasm between the ectoplasm and the nucleus.

ORGANELLES IN CYTOPLASM

All the cells in the body contain some common structures called organelles in the cytoplasm. Some organelles are bound by limiting membrane and others do not have limiting membrane .

1. ENDOPLASMIC RETICULUM

Endoplasmic reticulum is made up of tubules and microsomal vesicles. These structures form an interconnected network which acts as the link between the organelles and cell membrane.

The endoplasmic reticulum is of two types namely, rough endoplasmic reticulum and smooth endoplasmic reticulum.

Functions of rough endoplasmic reticulum

It is concerned with the protein synthesis in the cell, especially those secreted from the cell such as insulin from □ cells of islets of Langerhans in pancreas and antibodies in leukocytes.

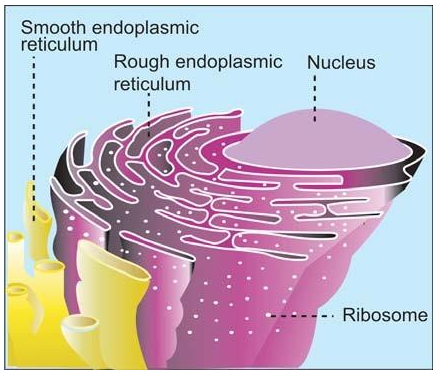
It also plays an important role in degradation of worn out cytoplasmic organelles like mitochondria. It wraps itself around the worn out organelles and forms a vacuole which is often called the autophagosome. It is digested by lysosomal enzymes

Functions of smooth endoplasmic reticulum

i. It is responsible for synthesis of cholesterol and steroid
ii. It is concerned with various metabolic processes of the cell because of the presence of many enzymes on the outer surface
iii. It is concerned with the storage and metabolism of calcium
iv. It is also concerned with catabolism and detoxification of toxic substances

like some drugs and carcinogens (cancer producing substances) in liver.

Rough endoplasmic reticulum and smooth endoplasmic reticulum are interconnected and continuous with one another. Depending upon the activities of the cells, the rough endoplasmic reticulum changes to smooth endoplasmic reticulum and *vice versa*.

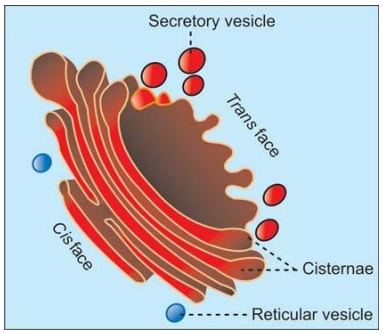


GOIGI APPARATUS

The Golgi apparatus is situated near the nucleus. It has two ends or faces namely, *cis* face and *trans* face. The *cis* face is positioned near the endoplasmic reticulum. The reticular vesicles from endoplasmic reticulum enter the Golgi apparatus through *cis* face. The *trans* face is situated near the cell membrane. The processed substances make their exit from Golgi apparatus through *trans* face.

Functions of Golgi Apparatus

i. It is concerned with the processing and delivery of substances like proteins and lipids to different parts of the cell.
ii. It functions like a post office because, it packs the processed materials into the secretory granules, secretory vesicles, and lysosomes
iii. It also functions like a shipping department of the cell because it sorts out and labels the materials for distribution to their proper destinations.



Lysosomes

These are small globular structures filled with enzymes. These enzymes are

synthesized in rough endoplasmic reticulum and transported to the Golgi apparatus.

Lysosomes are of two types:

i. Primary lysosome which is pinched off from Golgi apparatus. It is inactive in spite of having the hydrolytic enzymes.
ii. Secondary lysosome which is active lysosome formed by the fusion of a primary lysosome with phagosome or endosome.

Functions of Lysosomes

i. Digestion of unwanted substances

With the help of hydrolytic enzymes like proteases, lipases, amylases and nucleases, lysosome digests and removes the unwanted substances.

ii. Removal of excess secretory products in the cells

Lysosomes in the cells of the secretory glands play an important role in the removal of excess secretory products by degrading the secretory granules.

iii. Secretory function – Secretory lysosomes

Recently, lysosomes having secretory function called secretory lysosomes are found in some of the cells, particularly in the cells of immune system. The conventional lysosomes are modified into secretory lysosomes by combining with secretory granules

Peroxisomes

Peroxisomes are otherwise called as microbodies. These are pinched off from endoplasmic reticulum. Peroxisomes contain some oxidative enzymes such as catalase, urate oxidase and D-amino acid oxidase.

Functions of Peroxisomes

i. Degrade the toxic substances like hydrogen peroxide and other metabolic products by means of detoxification
ii. Form the major site of oxygen utilization in the cells
iii. Break down the excess fatty acids
iv. Accelerate gluconeogenesis from fats
v. Degrade purine to uric acid
vi. Participate in the formation of myelin and bile acids.

Centrosome AND CENTRIOLES

The centrosome is situated near the center of the cell close to the nucleus. It consists of two cylindrical structures called centrioles which are responsible for the movement of chromosomes during cell division.

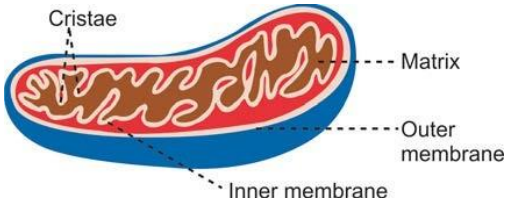
Secretory VESICLES

The secretory vesicles are globular structures, formed in the endoplasmic reticulum, and processed and packed in Golgi apparatus. When necessary, the secretory vesicles rupture and release the secretory substances into the cytoplasm.

MITOCHONDRION

The mitochondrion is a rod or oval shaped structure with a diameter of 0.5 to 1

μ. It is covered by a double layered membrane .



Functions of Mitochondrion

i. The mitochondrion is called the 'power house of the cell' because it produces the energy required for the cellular functions. The energy is produced by oxidation of the food substances like proteins, carbohydrates and lipids by the oxidative enzymes in cristae. During oxidation, water and carbon dioxide are produced with release of energy. The released energy is stored in mitochondria and used later for synthesis of ATP.

ii. The components of respiratory chain in the mitochondrion are responsible for the synthesis of ATP by utilizing the energy through oxidative phosphorylation. The ATP molecules defuse throughout the cell from mitochondrion. Whenever energy is needed for cellular activity, the ATP molecules are broken down

iii.Apoptosis

ORGANELLES WITHOUT LIMITING MEMBRANE

RIBOSOMES

The ribosomes are small granular structures with a diameter of 15 nm. The ribosomes are made up of proteins (35%) and RNA (65%). The RNA present in ribosomes is called ribosomal RNA (rRNA).

Functions of Ribosomes

Ribosomes are called protein factories because of their role in the synthesis of proteins. Messenger RNA (mRNA) passes the genetic code for protein synthesis from nucleus to the ribosomes. The ribosomes, in turn arrange the amino acids into small units of proteins. The ribosomes attached with endoplasmic reticulum are involved in the synthesis of proteins like the enzymatic proteins, hormonal proteins, lysosomal proteins and the proteins of the cell membrane. The free ribosomes are responsible for the synthesis of proteins in hemoglobin, peroxisome and mitochondria.

Cytoskeleton

The cytoskeleton of the cell is a complex network that gives shape, support and stability to the cell. It is also essential for the cellular movements and the response of the cell to external stimuli. The cytoskeleton consists of three major protein components viz.

a. Microtubules
b. Intermediate filaments
c. Microfilaments

Microtubules

Microtubules are straight and hollow tubular structures formed by bundles of globular protein called □ and □ tubulin

Functions of microtubules

Microtubules:

i. Determine the shape of the cell
ii. Give structural strength to the cell
iii. Responsible for the movements of centrioles and the complex cellular structures like cilia
iv. Act like conveyer belts which allow the movement of granules, vesicles, protein molecules and some organelles like mitochondria to different parts of the cell
v. Form the spindle fibers which separate the chromosomes during mitosis

Intermediate Filaments

The intermediate filaments form a network around the nucleus and extend to the periphery of the cell. These filaments are formed by fibrous proteins and help to maintain the shape of the cell. The adjacent cells are connected by intermediate filaments by desmosomes.

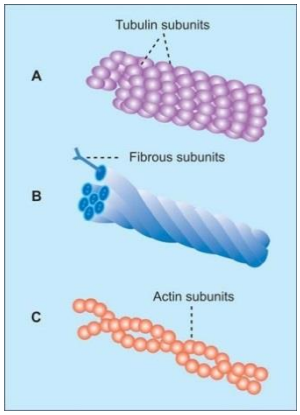
Microfilaments

Microfilaments are long and fine thread like structures which are made up of non tubular contractile proteins called actin and myosin. Actin is more abundant than myosin.

Functions of microfilaments

Microfilaments:

i. Give structural strength to the cell
ii. Provide resistance to the cell against the pulling forces
iii. Responsible for cellular movements like contraction, gliding and cytokinesis (partition of cytoplasm during cell division).



NUCLEUS

Nucleus is present in those cells which divide and produce enzymes. The cells with nucleus are called eukaryotes and those without nucleus are known as

prokaryotes (e.g. red blood cells). Prokaryotes do not divide or synthesize the enzymes.

Most of the cells have only one nucleus (uninucleated). Few types of cells like skeletal muscle cells have many nuclei (multinucleated). Generally the nucleus is located near the center of the cell. It is mostly spherical in shape. However, the shape and situation of nucleus vary in different cells.

Nuclear Membrane

The nucleus is covered by a double layered membrane called nuclear membrane. It encloses the fluid called nucleoplasm. Nuclear membrane is porous and permeable in nature and it allows nucleoplasm to communicate with the cytoplasm

Nucleoplasm

It is a gel like ground substance and contains large quantities of the genetic material in the form of DNA. The DNA is made up of chromatin threads. These chromatin threads become the rod shaped chromosomes just before the cell division.

Nucleoli

One or more nucleoli are present in each nucleus. The nucleolus contains RNA and some proteins, which are similar to those found in ribosomes. The RNA is synthesized by chromosomes and stored in the nucleolus.

FUNCTIONS OF NUCLEUS

1. Controls all the activities of the cell
2. Synthesizes RNA
3. Forms subunits of ribosomes
4. Sends genetic instruction to the cytoplasm for protein synthesis through mRNA
5. Controls the cell division through genes
6. Stores the hereditary information (in genes) and transforms this information from one generation of the species to the next.

CELL DEATH

The cell death occurs by two distinct processes:

1. Necrosis
2. Apoptosis.

APOPTOSIS

Apoptosis is defined as the programmed cell death under genetic control. Originally apoptosis (means ‘falling leaves’ in Greek) refers to the process by which the leaves fall from trees in autumn. It is also called ‘cell suicide’ since the genes of the cell play a major role in the death. This type of programmed cell death is a normal phenomenon and it is essential for normal development of the body.

NECROSIS

Necrosis (means ‘dead’ in Greek) is the uncontrolled and unprogrammed death of cells due to unexpected and accidental damage. It is also called ‘cell murder’ because the cell is killed by extracellular or external events. After necrosis, the harmful chemical substances released from the dead cells cause damage and inflammation of neighboring tissues.

Cell Junctions

The connection between the cells or the contact between the cell and extracellular matrix is called the cell junction. It is also called as membrane junction. It is generally classified into three types:

1. Occluding junction
2. Communicating junction
3. Anchoring junction

OCCLUDING JUNCTION

The junction which prevents the movement of ions and molecules from one cell to another cell is called the occluding junction.

Tight junctions belong to this category. It is formed by the tight fusion of the cell membranes from the adjacent cells. The area of the fusion is very tight and forms a ridge. This type of junction is present in the apical margins of epithelial cells in intestinal mucosa, wall of renal tubule, capillary wall and choroid plexus

Functions of Tight Junctions

1. The tight junctions hold the neighboring cells of the tissues firmly and thus provide strength and stability to the tissues.
2. It provides the barrier or gate function by which the interchange of ions, water and macromolecules between the cells is regulated.
3. It acts like a fence by preventing the lateral movement of integral membrane proteinsand lipids from cell membrane

4,By the fencing function, the tight junctions maintains the cell polarity by keeping the proteins in the apical region of the cell membrane.

5..Tight junctions in the brain capillaries form the blood-brain barrier (BBB) which prevents the entrance of many harmful substances from the blood into the brain tissues

COMMUNICATING JUNCTIONS

The junctions, which permit the movement of ions and molecules from one cell to another cell, are called communicating junctions. Gap junction and chemical synapse are the communicating junctions.

GAP JUNCTION OR NEXUS

The gap junction is also called nexus. It is present in heart, basal part of epithelial cells of intestinal mucosa, etc.

Functions of Gap Junction

1. The diameter of the channel in the gap junction is about 1.5 to 3 nm. So, the substances having molecular weight less than 1000 such as glucose also can pass through this junction easily

2. It helps in the exchange of chemical messengers between the cells
3. It helps in rapid propagation of action potential from one cell to another cell

CHEMICAL SYNAPSE

Chemical synapse is the junction between a nerve fiber and a muscle fiber or between two nerve fibers, through which the signals are transmitted by the release of chemical transmitter

ANCHORING JUNCTIONS

Anchoring junctions are the junctions, which provide firm structural attachment between two cells or between a cell and the extracellular matrix. There are four types of anchoring junctions

i. Adherens junctions (cell to cell)
ii. Focal adhesions (cell to matrix)
iii. Desmosomes (cell to cell)
iv. Hemidesmosomes (cell to matrix)