CELL **Medical physiology**

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

TISSUES

The tissue is defined as the group of cells having similar function. The tissues are classified into four major types which are called the primary tissues.

1- The primary tissues include1. Muscle tissue – skeletal muscle, smooth muscle and cardiac muscle

2. Nervous tissue – neurons and supporting cells

3. Epithelial tissue – squamous, columnar and cuboidal epithelial cells

4. Connective tissue – connective tissue proper, cartilage, bone and blood.

ORGANS

An organ is defined as the structure that is formed by two or more primary tissues. Some organs are composed of all the four types of primary tissues. The organs may be tubular like intestine or hollow like stomach.

SYSTEMS

The system is defined as group of organs functioning together to perform a specific function of the body. For example, digestive system is made out of groups of organs like esophagus, stomach, intestine etc., which is concerned with digestion of food particles.

STRUCTURE OF THE CELL

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

CELL MEMBRANE

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 .

COMPOSITION OF CELL MEMBRANE

The cell membrane is composed of three types of substances:

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

STRUCTURE OF CELL MEMBRANE

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.

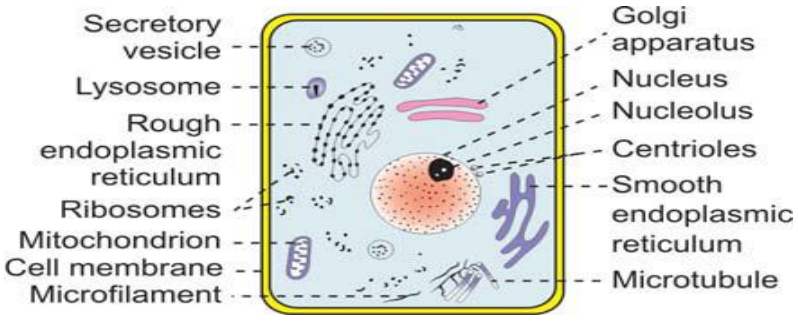
Lipid Layer of Cell Membrane

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

1. *Phospholipids*

The phospholipid molecules are formed by phosphorus and fatty acids. The outer part of the phospholipid molecule is the head portion which is water soluble (hydrophilic) and the inner part is the tail



Structure of the cell

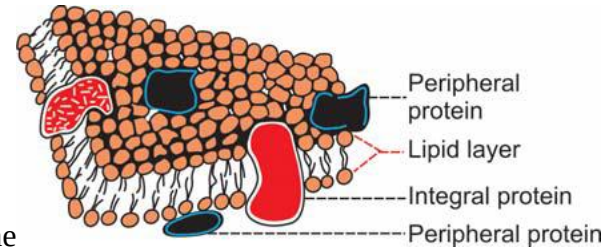
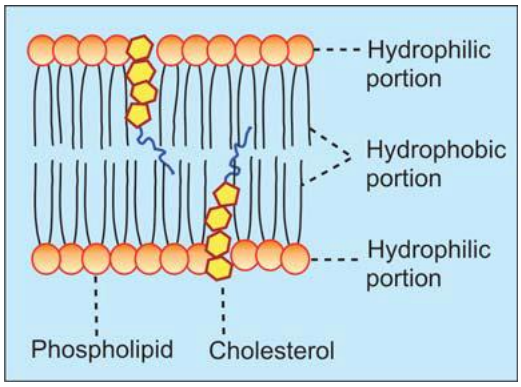


Diagram of the cell membrane



Lipids of the cell membrane

portion that is not soluble in water (hydrophobic). The hydrophobic tail portions meet in the center of the membrane. The hydrophilic head portions of outer layer face the ECF and those of the inner layer face the cytoplasm.

2. Cholesterol

The cholesterol molecules are arranged in between the phospholipid molecules. As phospholipids are soft and oily in nature, cholesterol helps to "pack" the phospholipids in the membrane and maintain the structural integrity of cell membrane.

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

a. Integral proteins

The integral proteins, also known as transmembrane proteins, are tightly bound with the cell membrane. These protein molecules pass through the entire thickness of the cell membrane from one side to the other side.

b. *Peripheral proteins*

The peripheral proteins, also known as peripheral membrane proteins do not penetrate the cell membrane but are embedded partially in the outer and inner surfaces of the cell membrane. These protein molecules are loosely bound with the cell membrane and so dissociate readily from the cell membrane. *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.

Carbohydrates 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.

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.

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. The organelles carry out the various functions of the cell.

ORGANELLES WITH 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.

Types of Endoplasmic Reticulum

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

Cytoplasmic organelles

The organelles with limiting membrane

1. Endoplasmic reticulum
2. Golgi apparatus
3. Lysosome
4. Peroxisome
5. Centrosome and centrioles

6. Secretory vesicles
7. Mitochondria
8. Nucleus

The organelles without limiting membrane

1. Ribosomes
2. Cytoskeleton

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.

STRUCTURE OF NUCLEUS

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 cytoplasme

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

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. The main function of apoptosis is to remove
unwanted cells without causing any stress or damage to the neighboring cells. The functional significance of apoptosis:
1. Plays a vital role in cellular homeostasis. About 10 million cells are produced everyday in human body by mitosis. An equal number of cells die by apoptosis. This helps in cellular homeostasis
2. Useful for removal of a cell that is damaged by a virus or a toxin beyond repair
3. An essential event during the development and in adult stage.
Examples:
i. A large number of neurons are produced during the development of central nervous system. But up to 50% of the
neurons are removed by apoptosis during the formation of synapses between neurons
ii. Apoptosis is responsible for the removal of tissues of webs between fingers and toes during developmental stage in fetus
iii. It is necessary for regression and disappearance of duct systems during sex differentiation in fetus
iv. The cell that looses the contact with neighboring cells or basal lamina in the epithelial tissue dies by apoptosis. This is essential for the death of old enterocytes shed into the lumen of intestinal glands
v. It plays an important role in the cyclic sloughing of the inner layer of endometrium resulting in menstruation
vi. Apoptosis removes the auto-aggressive T cells and prevents autoimmune diseases.

NECROSIS

Necrosis (means 'dead' in Greek) is the uncontrolled and unprogrammed death of cells 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.

Causes for Necrosis

Common causes of necrosis are injury, infection, inflammation, infarction and cancer. Necrosis is induced by both physical and chemical events such as heat, radiation, trauma, hypoxia due to lack of blood flow, and exposure to toxins