

www.dreamtopper.in

DREAM TOPPER

Best E-learning Platform

Download pdf..

www.dreamtopper.in

SACHIN DAKSH

Cellmembrane and Cell Organelle

Q.4. Describe the nucleolus is brief.

Ans.

Nucleolus

It was first observed by Schleiden, 1938. The nucleoli are of two types :

(1) **Plasmosomes** : These are **true nucleoli** stainable with acidic dyes. The term nucleolus is generally used to denote these bodies only.

(2) **Karyosomes** : These are **false nucleoli** stainable with basic dyes. Perhaps they are broken segments of chromatin.

Usually a nucleus contains just one nucleolus. Increase in the number and the size of the nucleolus indicates the high rate of metabolism in the cell. A nucleolus is distinguishable into the following regions :

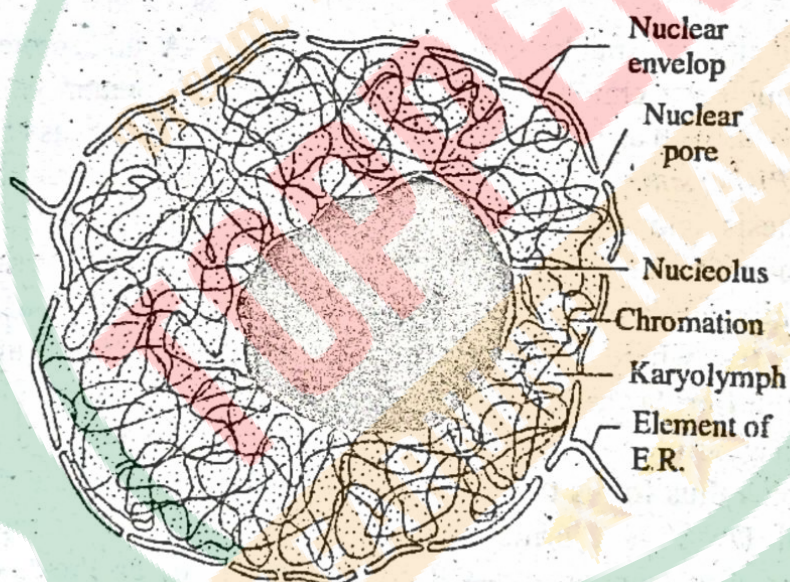


Fig. The Nucleus

- (1) **Pars fibrosa** : Fibrils of 80-100 Å size form a part of the nucleolus.
- (2) **Chromatin** : The nucleolus is surrounded by **perinucleolar chromatin**. Heterochromatic intrusions are also seen in the nucleolus which constitutes the **intranucleolar chromatin**.
- (3) **Pars granulosa** : Granules of 150-200 Å diameter constitute the granular part of the nucleolus. They appear like vesicle with a light central core. The granules may be joined by a filament forming a beaded **primary**

nucleolonema. The fibrils may also be associated to it. The primary nucleolonema may further coil to form the **secondary nucleolonema.**

(4) **Pars amorpha :** The granules and the fibrils lie dispersed in an amorphous proteinaceous matrix.

The nucleolus is formed around the **nucleolus organiser** and is located in the **secondary constriction** on that chromosome. This part of chromosome is less condensed during mitosis. The nucleolus remains permanently attached to that chromosome which also forms a part of the nucleolar gained at telophase by the nucleolus organiser. The formation of nucleolus occurs around the DNA loop that extends from the nucleolar organiser. After prophase this DNA loop retracts and coils into that chromosome. The fibrillar and granular components are first dispersed in the nucleoplasm which later re-assemble to form the nucleolus. During disappearance phase, several **non-ribosomal nucleolar proteins** and **small nucleolar RNAs** lie scattered around the chromosomes. Before re-organization **per-nucleolar bodies** appear first.

Chemically the nucleolus is made-up of RNA and proteins. The associated nucleolar chromatin contains DNA. The chromatin is present at the periphery as well as inside. This DNA makes 70% of the mass of isolated nucleoli in *Pisum sativum* and 37% in *Vicia faba*. The nucleolus is the site for RNA synthesis and in particular the source of r-RNA. The nucleolar chromatin contains genes for ribosomal DNA (rDNA) which gives rise to r-RNA. The biogenesis of ribosomes proceeds through three regions i.e., from **fibrillar centre**, where r-RNA is formed, to **dense fibrillar centre** which surrounds the fibrillar centre. Here RNA synthesis takes place. The third is the **cortical granular component** where ribosome precursors are formed. The nucleolus thus forms the ribosome precursors and then the ribosomes. (Ribosomal DNA → Fibrillar centre → Dense fibrillar component → Cortical granular component → Ribosome precursor or Pre-ribosome → Ribosome).

Q.2. Give a detailed classification of cell types within an organism. Describe the structure of a plant cell.

Or

What is cell ? How many cell types are found in the living world ? Give main characteristic features of a prokaryotic cell.

Ans.

Definition of Cell

A cell is the smallest and complete expression of the fundamental structure and functions of all living organisms. It represents unit of structure,

function and heredity. It is also described as the unit of protoplasm enclosed in a thin semipermeable plasma membrane and has a nucleus within.

Types of Cells

Cells are of following three types :

1. Prokaryotic cells (Gr. *pro*, primitive + *karyon*, nucleus) : These are relatively simple cells having only cell membrane. The membrane bound organelles such as ER, Golgi complex, mitochondria, chloroplasts and lysosome are absent. The well-formed nucleus is also absent. The hereditary material is a highly coiled circular chromosome lying naked in the cytoplasm. It is formed of DNA alone and is called **nucleoid**. Bacteria, blue green algae and pleuropneumococci are prokaryotic cells.

2. Mesokaryotic cells : In these cells nuclear membrane is present around the nuclear or hereditary material, but DNA is not associated with histones (proteins). Thus these are more advanced than prokaryotes but less advanced than eukaryotes. Dinoflagellate protozoans are mesokaryotes.

3. Eukaryotic cells : These contain a true nucleus, *i.e.*, the hereditary material (DNA) is associated with basic proteins and forms nucleoprotein and is separated from the cytoplasm by nuclear envelope. The membrane bound organelles are present. From evolutionary point of view, prokaryotes are primitive and eukaryotes have evolved from them.

Characteristics of a Prokaryotic Cell

Main characteristic features of prokaryotic cells are :

1. These are very small in size, about the size of mitochondria.
2. These are without a distinct nucleus, *i.e.*, the nucleolus and nuclear envelope are absent.
3. Hereditary material forms a single chromosome. The prokaryotic chromosome is single circular chromosome, formed of double stranded molecule of DNA.
4. Basic proteins-histones are absent.
5. A cell wall or a capsule may be present outside the plasma membrane, but it is noncellulosic. It is formed of carbohydrates and amino acids.
6. Membrane bound organelles, such as endoplasmic reticulum, Golgi complex, lysosomes, mitochondria and chloroplasts are absent.
7. Plasma membrane in some cases is folded inward and forms mesosomes and chromatophores.
8. Inner surface of plasma membrane contains enzymes of respiratory metabolism, photosynthesis and lipid metabolism.

9. Prokaryotic ribosomes are 70S type.

10. : Their cytoplasm does not exhibit streaming movement.

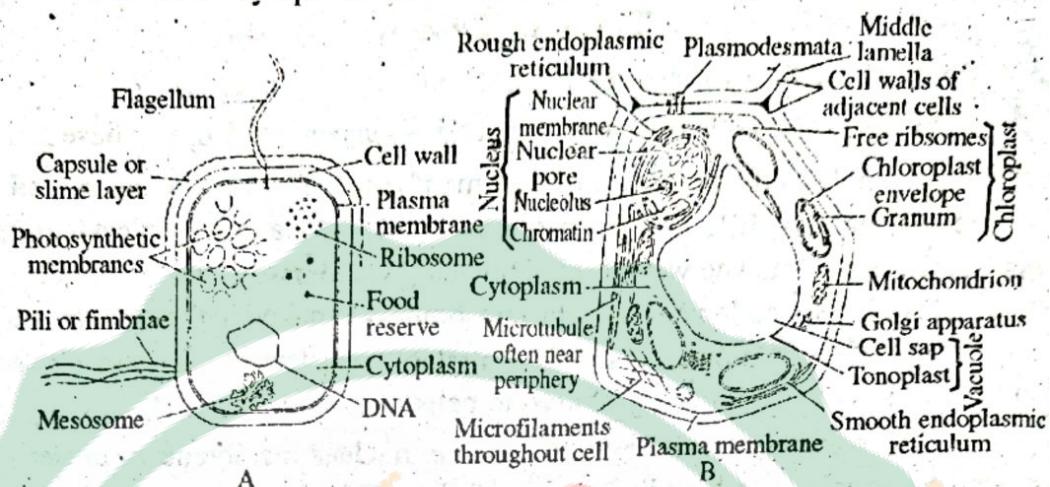


Fig. Cell Types : A. Prokaryotic Cell, B. Eukaryotic Cell.

11. Prokaryotic cells may contain flagella and pili.

12. These store polymerised fatty acids like β -hydroxy-butyrate, glycogen and phosphate granules.

Q.3. Describe the principal chemical substances found in a living cell.

Ans. Principal Chemical Substances of the Cell

The chemical constituents of protoplasm are classified in two categories:

(A) Inorganic or mineral compounds; and

(B) Organic compounds. The protoplasm of a plant or animal cell contains 78 to 85% water, 10 to 20% protein, 2 to 3% lipid, 1% carbohydrates and 1% inorganic materials.

(A) The Inorganic Components

These substances are those that do not have carbon-hydrogen bonds. The common inorganic compounds in cytoplasm are : water, dissolved gases (O_2 and CO_2), salts and ions of various elements.

(i) **Water** : The main component of living substance is water which is present in ranging from 5 to 90%. eg, the cellular water content of tooth enamel is about 5%; of bone, about 25 to 40%; of muscles, 75%; of brain or milk, 80 to 90%. Mostly animals and plants contains 65 to 90% water. The adult human body is about 80% water.

In the cell water exists in two forms : *free* and *bound*. *Free water* shows 95% of the total cellular water and is the principal part used as a solvent for solutes. *Bound water*, shows only 4 to 5% of the total cellular water, is loosely held to the proteins by hydrogen bonds and other forces.

All physiological processes found exclusively in aqueous media, therefore water is indispensable for metabolic activity. Water molecules participate in many enzymatic reactions in the cell and can be formed as a result of metabolic processes. Water is used to eliminate substances from the cell and to absorb heat. In this way it prevents drastic temperature changes in the cell.

(ii) **Salts and Ions** : Mineral solids constitute organic component of cells, ranging from about 1 to 5%. They may found as *hard bulk deposits*, or in the form of *solution*.

Silicon or calcium containing *hard deposits* are occurred either as crystals within cells or as secreted precipitates on the exterior of cells. eg, certain protozoa are surrounded by shells of glass like silica, whereas the hard part of bone is largely a deposit of calcium phosphate, secreted in layers around osteoblasts.

The majority of cellular minerals are in *solution*, existing largely in the form of *ions*.

Sodium, potassium and chloride ions are important in maintaining osmotic pressure and the acid-base balance of the body.

Calcium ions are occurred in the circulating blood and in cells. In bone they combine with phosphate and carbonate ions.

Magnesium ions are indispensable as cofactors in enzymatic activities.

Phosphate found in the blood and tissue fluids as a free ion but much of the phosphate of the body is occurred in the form of phospholipids, nucleotides, phosphoprotein, and phosphorylated sugars.

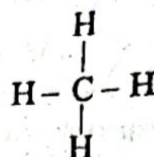
Many inorganic components are found in a non-ionized form. e.g, iron, bound by metal-carbon linkages, is found in haemoglobin, ferritin, the cytochromes and same enzymes such as catalase and cytochrome oxidase.

(B) The Organic Components

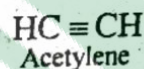
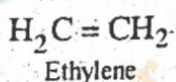
Organic substances are compounds of carbon in which the principal bonds are carbon-to-carbon and carbon-to-hydrogen links. A carbon atom has a covalence of 4 and, therefore, it has a greater bonding potential. It may combine with a practically unlimited number of other carbon atoms to form

chainlike molecules $\left(\begin{array}{cccc} | & | & | & | \\ -C & -C & -C & -C- \\ | & | & | & | \end{array} \right)$ of varying lengths. Such chains

shows a molecular skeleton or "back bone" of carbon atoms to which other atoms like hydrogen, nitrogen, and sulphur may be linked. eg hydrogen may be joined to all free bonds :



The sharing of one pair of electrons between any two carbon atoms—known as a *single bond*, is the most prevalent covalent bond in organic compounds. The carbons of most proteins; nucleic acids, carbohydrates and fats are combined in this way. Two carbon atoms also may be chemically bound to one another by *double* and *triple bonds*. e.g., ethylene possesses a carbon-carbon double bond, and acetylene a carbon-carbon triple bond :



In addition to forming bonds with itself and with the electro-positive element hydrogen, carbon is able to react with electronegative elements such as oxygen, nitrogen, phosphorus, sulphur and chlorine making it the most reactive of all elements. Compounds of carbon, oxygen, nitrogen and hydrogen alone account for about 99% of the dry weight of all living cells.

Carbon chains can be straight or branched. Chains and rings can become joined to one another, giving rise to various "patterns in carbon". For convenience organic molecules are shown on paper as two-dimensional structures.

Four broad categories of organic components are found in all types of cells. These are as :

1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleotides.

Carbohydrates are the major suppliers of energy. Lipids are a high-energy stuff and a component of tissues and membranes. Proteins make up half the bulk of animal tissue. Enzymes, hormones and transfer agents of both oxidising and reducing power are also proteins.

Q.4. Give an account of the structure of an animal cell giving functions of various organelles.

Ans. A typical animal cell has three main components : The cell membrane, the cytoplasm, and the nucleus.

(I) The plasma membrane or cell membrane or plasmalemma

Plasma membrane separates the cell contents from the surroundings. It is composed of protein, lipid and carbohydrates. In some tissue cells, parts of plasma membrane are modified to form a large number of fingerlike projections called microvilli. These greatly increase the surface area of the cell. The plasma membrane of a cell remains connected with the neighbouring cells through tight junctions, desmosomes, and gap junctions.

Functions : It controls the entrance and exit of materials selectively. Water and large molecules enter through endocytosis, and cell products come out by exocytosis. In most animals the plasma membrane is covered by a cell coat. It is composed of glycoproteins, glycolipids and polysaccharides. It provides protection to the cell. It contains enzymes and antigens and is involved in molecular recognition between cells.

(II) The cytoplasm

Inside the plasma membrane and outside the nucleus, the entire matter is called cytoplasm. The cytoplasm contains endomembrane system and the ground cytoplasm or the cytoplasmic matrix. Various components of cytoplasm are as under :

(1) The cytoskeleton and the microtrabecular lattice : The cytoskeleton consists of thin filaments, intermediate filaments, thick filaments and microtubules. These structures give shape to the cell and are also involved in the cell movement. These cytoskeletal structures remain interconnected by a network of fine thread like structures, called microtrabecular lattice. This lattice also interconnects many membranous organelles and ribosomes.

(2) The endoplasmic reticulum and ribosomes : The ER (endoplasmic reticulum) is made of tubules and flattened sacs or cisternae. The membranes of ER divide the cytoplasm into two : The **lumenal or intracisternal phase** (the cytoplasm enclosed in the ER tubules) and the **hyaloplasmic phase or cytosol** (the cytoplasm that surrounds ER).

There are large number of small particles called ribosomes. Some ribosomes remain attached with the outer surface of ER ("attached" ribosomes) while others remain free in the cytosol ("free" ribosomes).

The ER having attached ribosomes are called rough ER (RER) and the ER without ribosomes are called smooth ER (SER). Some parts of ER remain connected with the plasma membrane and the nuclear envelope.

Functions : (i) Ribosomes are the site of protein synthesis.

(ii) Proteins and other substances are transported through ER.

(iii) Initial break down of fats to release energy, and synthesis of lipids and break down of toxic substances occur on smooth ER membranes.

(iv) SER is connected with the synthesis and storage of cholesterol and steroid hormones.

(v) ER provides mechanical support to the cell.

(3) The golgi complex : It consists of a set of smooth, flattened sacs (cisternae) arranged in parallel rows.

Functions : (i) It is involved in the processing and packaging of the products which come through ER.

(ii) ER and the Golgi complex are also involved in the formation of lysosomes and peroxisomes.

(4) The mitochondria : These are cylindrical structures, less than $1\text{ }\mu\text{m}$ in diameter. It consists of a double membrane. The outer membrane is smooth but the inner membrane is folded. The folds are called cristae or crests. The cavity of the mitochondria contains matrix. The matrix contains numerous enzymes. Mitochondria are partially autonomous and contain their own DNA and ribosomes which resemble the DNA and ribosomes of bacteria.

Functions : Many metabolic functions like energy producing phases of carbohydrate and fat metabolism (called respiration), ATP synthesis, and porphyrin synthesis occur in mitochondria. It is called power house of the cell.

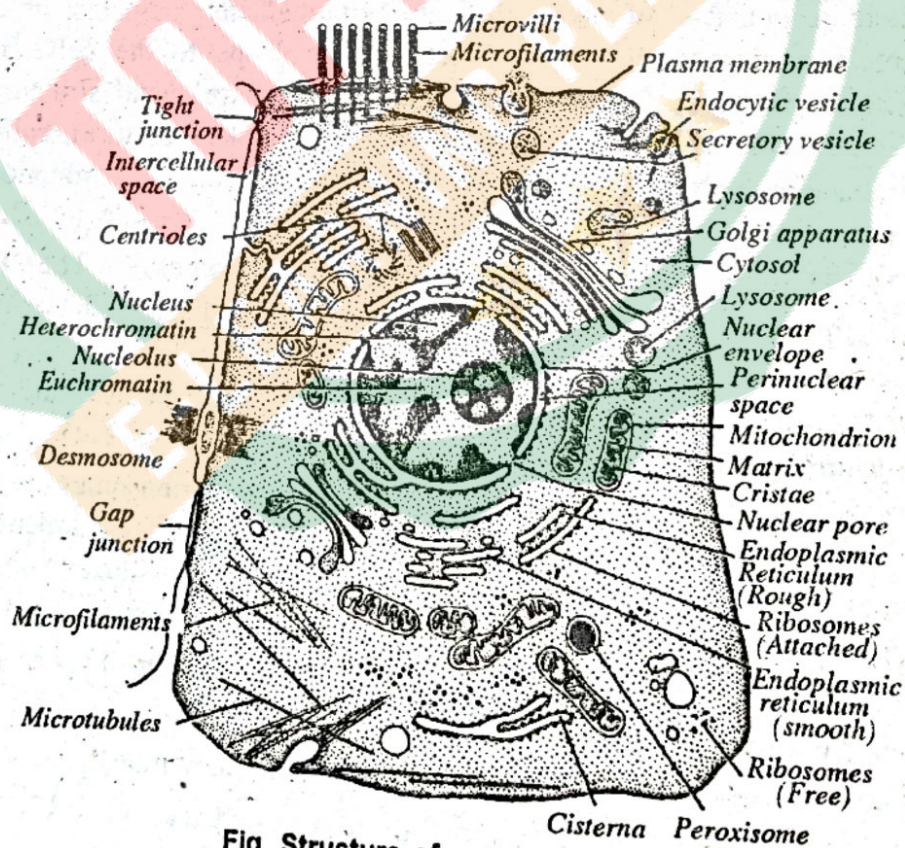


Fig. Structure of an animal cell.

Cell Biology

(5) **The lysosomes** : Lysosomes are vesicular structures enclosed by a single membrane. They originate from the ER and the Golgi complex. They contain hydrolytic enzymes.

Functions : Its enzymes digest protein, nucleic acids, poly-saccharides and other materials. If the lysosome membrane is ruptured. Its enzymes can quickly digest the cell. Due to this reason these are called **suicide bags**. Lysosomes take part in the intracellular digestion of particles that are taken in by the cell during **endocytosis**. Lysosomes are called **cellular scavengers** because these digest the useless and poorly functioning cell organelles.

(6) **Peroxisomes** : It is bounded by a single membrane and contains enzymes which break the peroxides (H_2O_2). They are protective.

(7) **The centrosome and the centrioles** : The centrosome is located near the nucleus. The cytoplasmic microtubules terminate in it. It is also called as the cell center or the microtubule organizing center. It contains a pair of centrioles in all animal cells. The two centrioles lie at right angles to each other. These are not found in the cells of angiosperm plants.

(III) The nucleus

The nucleus is a relatively large structure usually (but not always) present near the center of the cell.

(1) **Nuclear envelope** : The contents of the nucleus (nucleoplasm) are separated from the cytosol by the nuclear envelope. It is double walled : an outer and an inner membrane. The two membranes fuse at places to form pores. The cytosol and the nucleoplasm remain continuous through these pores. Often the pores are plugged by a granular material. Ribosomes often remain attached with the outer surface of outer membrane. The outer nuclear membrane remains connected with the ER. The space between the two nuclear membranes (the perinuclear space) remains continuous with the lumen of ER. The inner membrane remains in contact with the chromatin.

(2) **Genetic material** : The nucleus contains genetic material of the cell, the Chromosomal DNA and Chromosomal proteins etc. The nucleus often contains one or more dense granules called nucleoli.

Functions : (i) It contains hereditary informations.

(ii) It controls the metabolic activities of the cell.

(iii) It takes an active part in cell division.

(IV) Flagella and Cilia

Many free living cells (as protozoa) contain organs for locomotion. These organs project out from the cell surface. These are flagella or cilia. In other animal cells these organs are used to move a substance (as mucus in the respiratory tract, eggs in the oviduct, etc.). The organelles are called cilia when they are short but in large number. When they are long and few in number they are called flagella. Externally these are covered by the plasma membrane. Internally these contain microtubules which run from the basal body or kinetosome towards the tip of the structure.

(V) Reserve food

Various granular structures or droplets are found in the cells. These contain reserve foods.

Q.5. Give an account of biochemical and structural organization of cell membrane.

Ans.

Ultrastructure

Plasma membrane is about 75 Å thick, but its thickness varies in different types of cells and ranges from 75–105 Å or upto 215 Å. Under electron microscope three distinct layers could be divided in the plasma membrane :

- (1) Outer dense layer of protein : about 20–25 Å.
- (2) Middle bimolecular layer of lipids : about 30–35 Å.
- (3) Inner dense layer of protein : about 20–25 Å.

The plasma membrane consists of bimolecular layer of lipids sandwiched between two monomolecular protein layers. These membrane

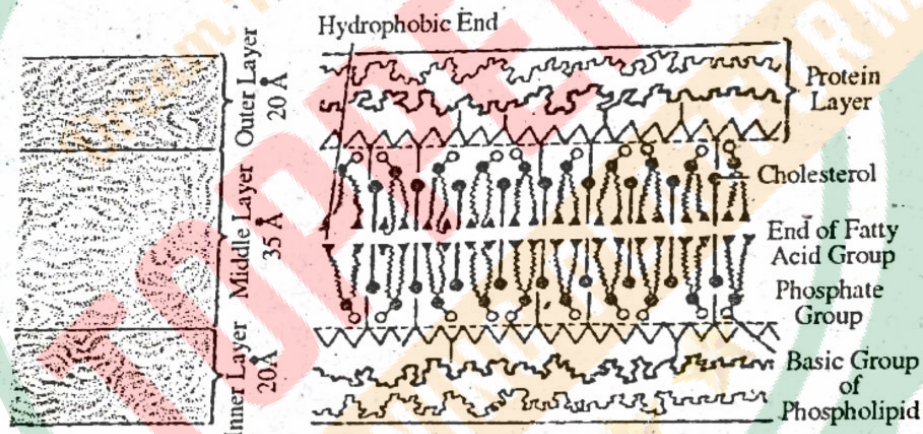


Fig. Ultrastructure of plasma membrane.

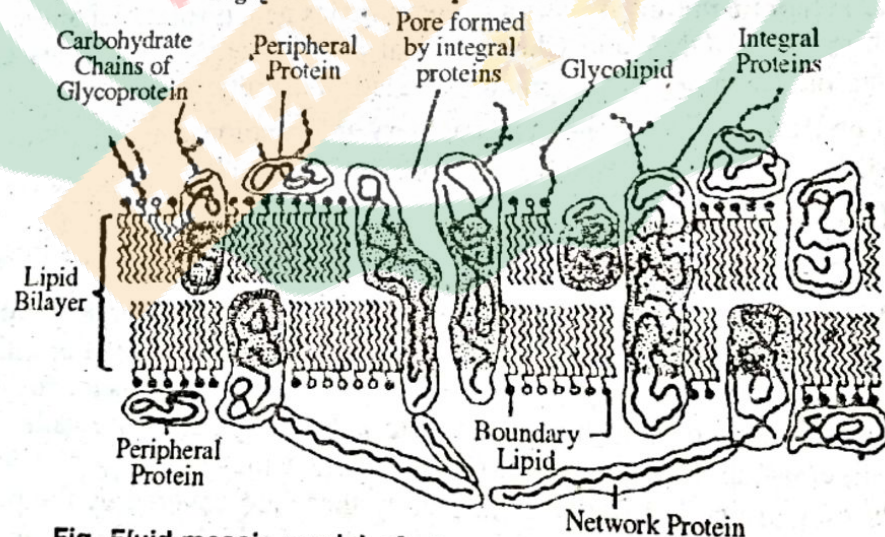


Fig. Fluid-mosaic model of plasma membrane showing extrinsic and intrinsic.

has been described as **unit membrane** by **Robertson**. He found that a variety of cell structure like endoplasmic reticulum, Golgi complex, nuclear membrane, mitochondria, plastids and lysosome are surrounded with unit membrane.

Chemical Composition

The plasma membrane of animal cells consists of proteins, lipids and small amount of carbohydrates.

1. Proteins

The proteins separated from the plasma membrane of R.B.C. are collectively known as **tektins**. These are of two different types.

1. Peripheral or extrinsic proteins : These form outer and inner layers of the middle lipid layer of plasma membrane. These are loosely connected and can be separated even by mild treatment. **Spectrin** in erythrocytes, **cytochrome C** occur in mitochondria and **acetylcholine-sterase** in electroplex membrane are peripheral proteins.

2. Integral or intrinsic proteins : These proteins penetrate the lipid layer partially or wholly. These are insoluble in water. Some detergents or organic solvents are required to separate them from the membrane. These are attached either to the oligosaccharides or to phospholipids.

2. Lipids

The plasma membrane consists about 20–40% of lipids. The lipid components are of three types : (i) **phospholipids** like lecithin, serine, cephalin and sphingomyelin; (ii) **cholesterol** and (iii) **glycolipids**.

(a) **Phospholipids are amphipathic.** These have hydrophilic head and hydrophobic tail.

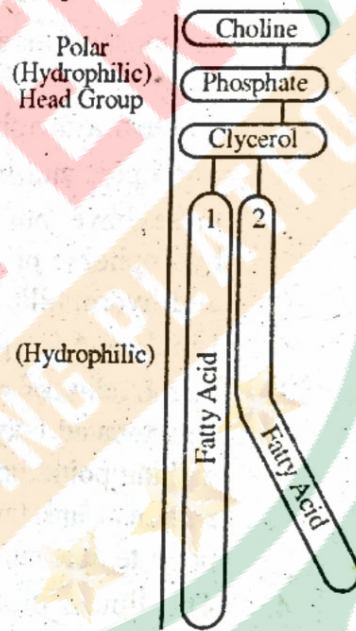


Fig. A single phospholipid

1. Hydrophilic head end : It is water-loving part of phospholipid molecules and is known **polar end**. It is formed of **choline phosphate**.

2. Hydrophobic tail end : It is water hating part which moves away from water is called as **nonpolar end**. It is formed of two molecules of fatty acids. Both these molecules are joined to the backbone of glycerol through their carboxyl group ($-\text{COOH}$).

These phospholipid molecules are arranged radially into two parallel layers. The **nonpolar hydrophobic ends** and **polar hydrophilic ends**.

(b) **Cholesterol** is occur in the plasma membrane and other intracellular membranes in eukaryotic cells. It is usually present in the tails of phospholipid molecules. It provides rigidity to tails and mechanical stability to the lipid bilayer.

(c) Glycolipids are occur only in the outer lipid layer. These carry carbohydrate chains.

Functions of Lipids :

1. It forms permeability barrier to the ions and polar molecules entering the cell.
2. Lipid layer forms structural frame-work of plasma membrane.

3. Carbohydrates

The plasma membrane contains 2 to 10 percent carbohydrates. These are hexose, hexosamine, fucose and sialic acid. These found in two different combinations :

- (i) attached to lipids—glycolipids;
- (ii) attached to proteins—glycoproteins.

Fluid Mosaic Model of Cell Membrane

The fluid mosaic model was proposed by Singer and Nicholson (1972). According to this all the biological membranes possess a quasifluid structure. In such a membrane :

1. The lipids and integral proteins are amphipathic in nature, i.e., these have both hydrophobic and hydrophilic groups. Their hydrophobic or non-polar groups are situated inside the bilayer and hydrophilic groups are directed towards the water phase.
2. Lipids and integral proteins are arranged in a mosaic fashion.
3. The fluidity of membrane is associated with the fluidity of lipids. Unsaturated fatty acids having double or triple bonds have a lower melting point than saturated ones. Most biological membranes have sufficient unsaturated lipids so that the lipid bilayer is quasifluid at body temperature.
4. The lipids, proteins and oligosaccharides are held together in plasma membrane by non-covalent interaction (Gitler 1972).

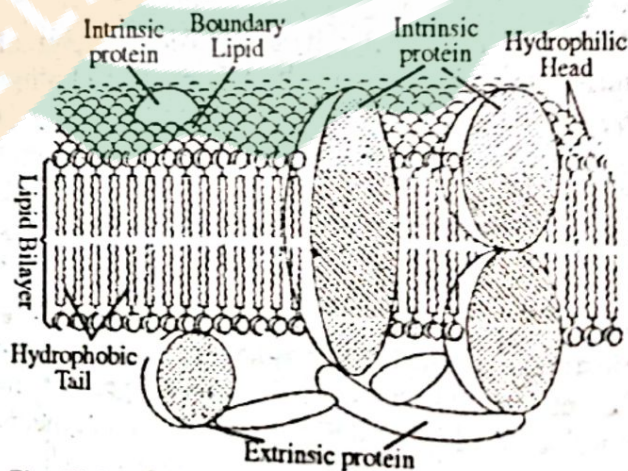


Fig. Fluid mosaic structure of plasma membrane.

5. The integral proteins exhibit three types of movements inside the fluid layer : (i) lateral diffusion, (ii) rotational diffusion, (iii) rotational diffusion.
6. The lipids and protein molecules are able to perform lateral movements within the lipid bilayers. The lipid molecules may show (i) intramolecular movement, (ii) may rotate about their axis, (iii) Rarely these exhibit 'flip-flop' movement which includes transfer from one side of bilayer to the other.
7. Because of quasifluid structure protein macromolecules are able to diffuse through the plasma membrane.

Functions of Plasma Membrane

1. Regulation of Passage of Materials or Selective Transport of Substances

The plasma membrane is selectively permeable. It facilitates the entrance of needed nutrients into the cells and permits the exit of nitrogenous wastes and prevents the exist of substances from the cell. The transport of materials into and out of the cell found :

1. **Passive transport** : It includes transport of substances by diffusion, osmosis and facilitated diffusion.

2. **Endocytosis** : It includes pinocytosis and phagocytosis by which solid material is taken in.

3. **Active transport**.

4. **Exocytosis** : It expels out the waste or cell secretion.

2. Maintenance of Differential Distribution of Ions

Plasma membrane controls and maintains the differential distribution of ions inside and outside the cell. eg., potassium ions are concentrated inside a living cell, and sodium and chloride ions are distributed outside. The unequal distribution of ions leads to a potential difference. This electric potential energy in all living cells is called **membrane potential**.

The distribution of ions between inside and outside of living cell is in a state of low entropy.

3. Contact with Neighbouring Cells

The plasma membrane maintains structural and chemical relationship with the neighbouring cells. Several glycoproteins of plasma membrane help in recognition, maintaining communication and exchange of material.

4. Response to Environment

The plasma membrane responds to changes in its environment with the help of receptor proteins. These receive chemical messages from other cells and help in cell recognition. the receptor proteins respond to hormones, growth factors and neuro-transmitters.

5. Communication between Neighbouring Cells

Animal cells communicate with the neighbouring cells through gap junctions. Salts, amino acids, sugars vitamins, hormones, etc, pass through gap junction.

6. Cell Recognition

Cells of defence system of body recognize the **self** and **nonsself** and by recognizing the foreign intruders like bacteria etc. help in self protection.

7. Protection

Plasma membrane protects the cell and may be involved in cell movement, cell secretion and transmitting impulses.

8. Cellular Adhesion

All cells of body remains in close association with other cells. There are many types of cell contacts and adhesion.

9. Excretion

Plasma membrane permits the exit of nitrogenous wastes and other wastes either by diffusion or by emiocytosis.

Q.6. Discuss the different models of cell membrane or plasma membrane and explain which of these models is dynamic and why.

Or

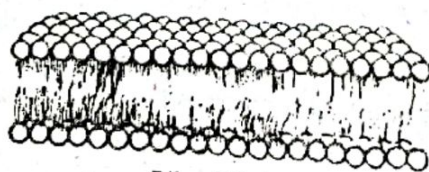
Discuss one experimental evidence in support of fluid mosaic models.

Ans. 1. Danielli and Dawson Membrane Models
(Lamellar Theory)

Danielli and Dawson, 1935 proposed a lipoprotein model. The plasma membrane is formed of a bimolecular layer of phospholipids with a layer of protein on both polar surfaces. The non-polar hydrophobic ends of phospholipids of two layers lie facing each other, while the polar hydrophilic ends are associated with protein molecules by electrostatic interactions between polar ends of lipid molecules and charged amino acid side chains.

2. Garter and Grendel's Bimolecular Lipid Leaflet Model

In 1926 Garter and Grendel measured the lipid content of haemolyzed RBCs from mammals and concluded that the cell membrane was mainly formed of phospholipids arranged to form bimolecular lipid sheet. The polar ends of lipid molecules of one layer were directed outward and other layer were directed towards cell cytoplasm.



Bilayer Sheet

Fig. Bimolecular lipid leaflet model of Garter and Grendel.

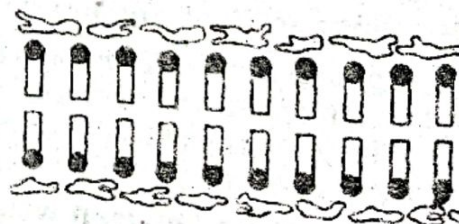


Fig. Molecular structure of plasma membrane according to Danielli lamellar theory

When lipid molecules are surrounded by water, they bury hydrophobic tails towards centre and their hydrophilic heads remain exposed to water. By these arrangement either they form spherical **micelles** or form bimolecular layer with hydrophobic tails sandwiched between the hydrophilic head ends.

Modifications of Danielli-Dawson Membrane Model

- (i) Some plasma membranes have folded chains of proteins on both the surfaces of lipid bilayers.
- (ii) With globular proteins on both the surfaces.
- (iii) Coiled chains of helical protein on both the surfaces of lipid bilayers.
- (iv) With folded chain protein on one side and globular protein on the other side.
- (v) With folded proteins on both the surfaces and helical proteins extending into the pores.

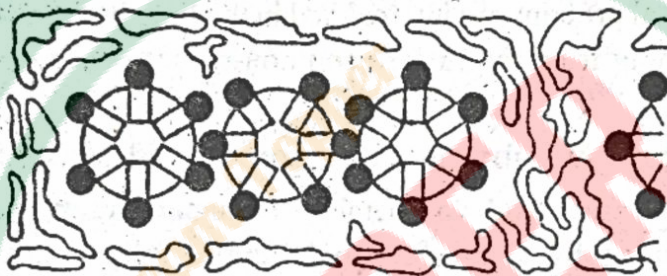


Fig. Structure of plasma membrane according to micellar theory.

3. Robertson's Unit Membrane Model

In 1959 Robertson described trilaminar structure of plasma membrane consisting of two parallel outer dense osmophilic layers, which correspond to the two protein layers and a middle light coloured osmophobic layer to the hydrocarbon chains of the lipids.

Robertson and others demonstrated that all biomembranes present inside the cells and around several cell organelles had similar trilaminar structure. On the basis of the similarity, for all the cell membranes, Robertson proposed 'unit membrane model'.

4. Micellar Theory

In 1953 Hilleir and Hoffman porposed that the plasma membrane contains of a mosaic of globular subunits. In each subunit hydrophilic polar

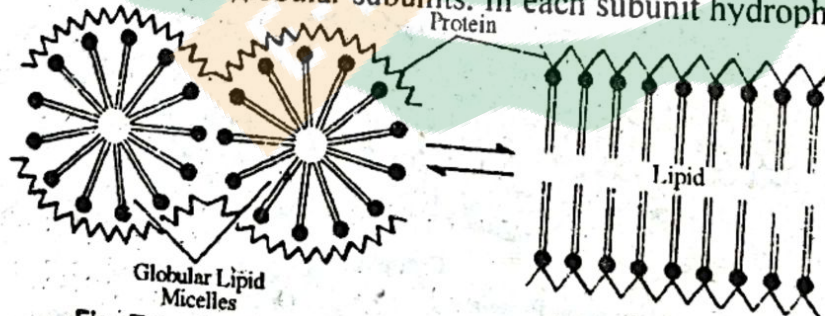


Fig. Transformation between micellar and lamellar states of plasma membrane.

ends of its lipid molecules are directed towards the periphery of the subunit. The globular proteins form a mono layer on either side of the lipid micelles. The space between globular micelles shows pores bounded partly by the polar groups of micelles and partly by polar groups of associated proteins.

Different membranes may show different types of structures or there may be transformation of lamellar structure to micellar state.

5. Fluid Mosaic Model

This model was proposed by **Singer** and **Nicolson** (1972). The lipid molecules form a rather continuous bilayer that forms the structural frame-work of plasma membrane. The protein molecules are arranged as extrinsic protein on the surface of lipid bilayer and as integral or intrinsic proteins that penetrate lipid bilayer partially or wholly.

The integral proteins are intercalated in the lipid bilayer, with their polar regions protruding from the surface and non-polar regions embedded in the lipid bilayer.

Freeze-Fracture Membrane to Support Fluid Mosaic Model

The fluid mosaic model of membrane structure is supported by a visual evidence provided by freeze-fractured samples of erythrocytes. Branton represents that membranes rapidly fracture along specific planes. When the plane of fracture intersects the plane of membrane, the membrane is splitted along the centre of the lipid bilayer, producing two 'half membranes', are called **E-leaflet** and **P-leaflet**. The E-half faces the cell exterior while P half faces the protoplasm. Visible on the fractured face are numerous small

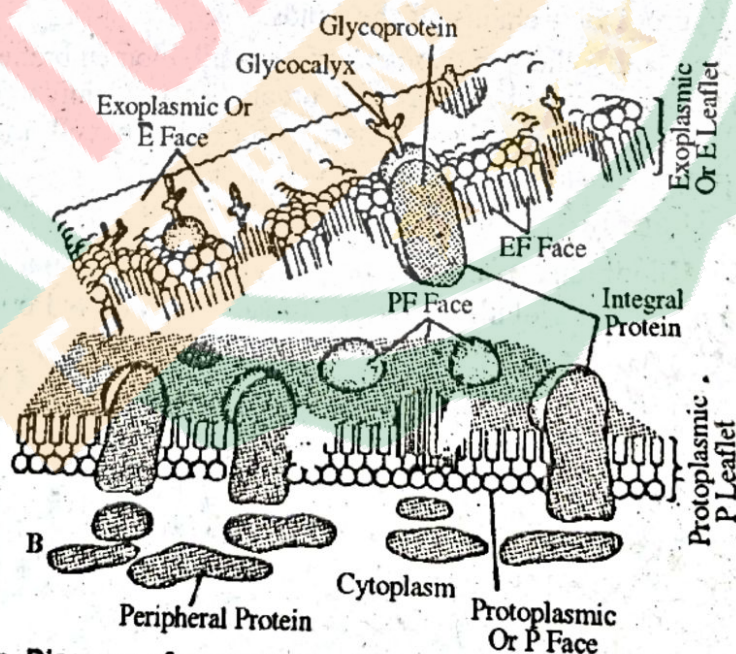


Fig. Diagram of an erythrocyte membrane freeze-fractured.

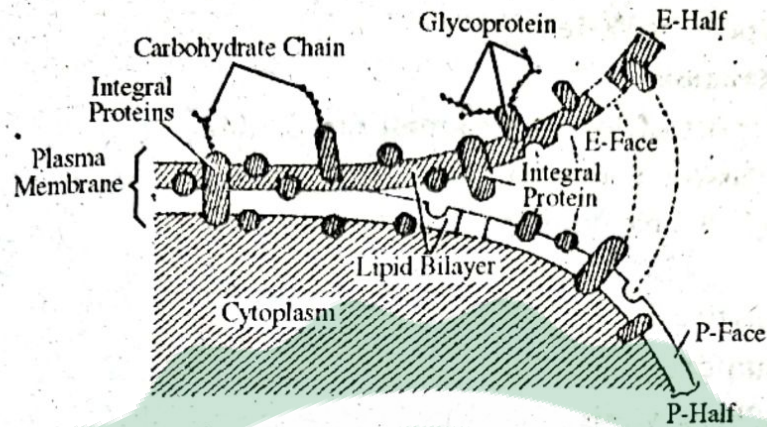


Fig. Diagram of an erythrocyte membrane freeze-fractured.

particles. These represent protein molecules embedded within the lipid bilayer.

Q.7. Discuss how materials are transported into the cell through cell membrane.

Or

Explain mechanism of pinocytosis, phagocytosis and active transport through plasma membrane.

Ans. The transport of substances into the cell is brought about by following methods :

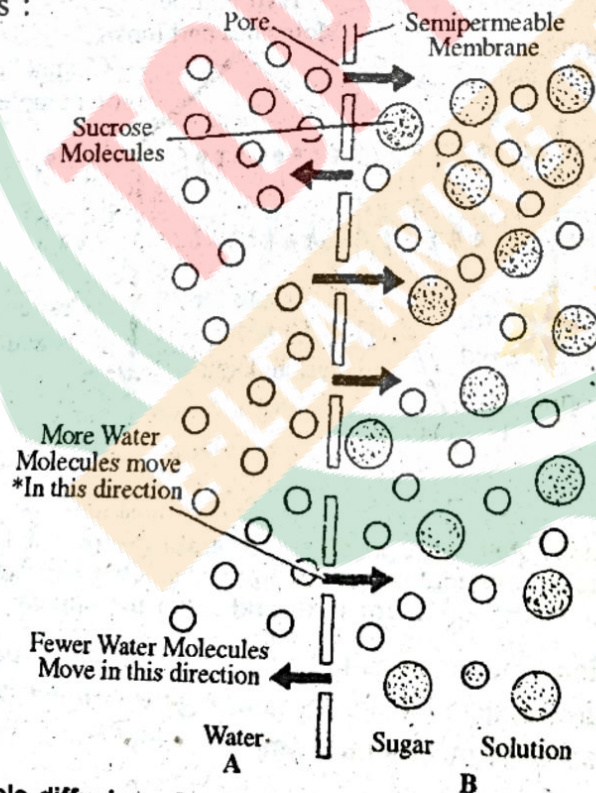


Fig. Simple diffusion of substances through plasma membrane.

I. Transport of Water

1. Osmosis

II. Transport of ions and small molecules

2. Passive Transport

(1) Simple diffusion

(2) Facilitated diffusion

3. Active Transport

III. Transport of solid particles

4. Phagocytosis

1. Osmosis

Osmosis is the diffusion of water or solvent molecules through plasma membrane from low osmotic pressure to high osmotic pressure *i.e.*, from a region of low solute concentration to a region of higher solute concentration. It acts as a differential membrane permitting the movement of water molecules in and out and retaining the metabolites.

2. Passive Transport

The passage of molecules of different substances through the plasma membrane from a region of high concentration to low concentration *i.e.*,

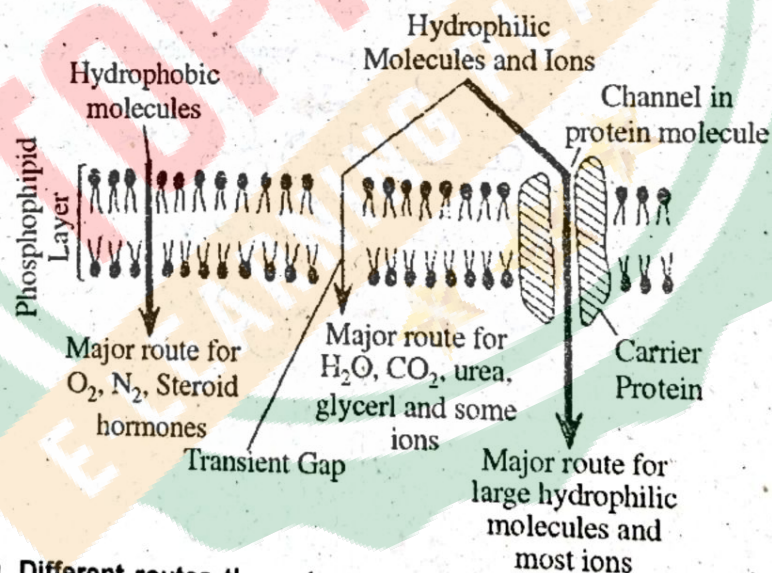


Fig. Different routes through plasma membrane (a) for fat soluble hydrophobic molecules, (b) for lipid insoluble hydrophilic substances, (c) for ions and large molecules.

along concentration gradient is called passive transport. In passive transport no energy is required and molecules move along the concentration gradient. The Passive transport of metabolites can be accomplished by the following methods :

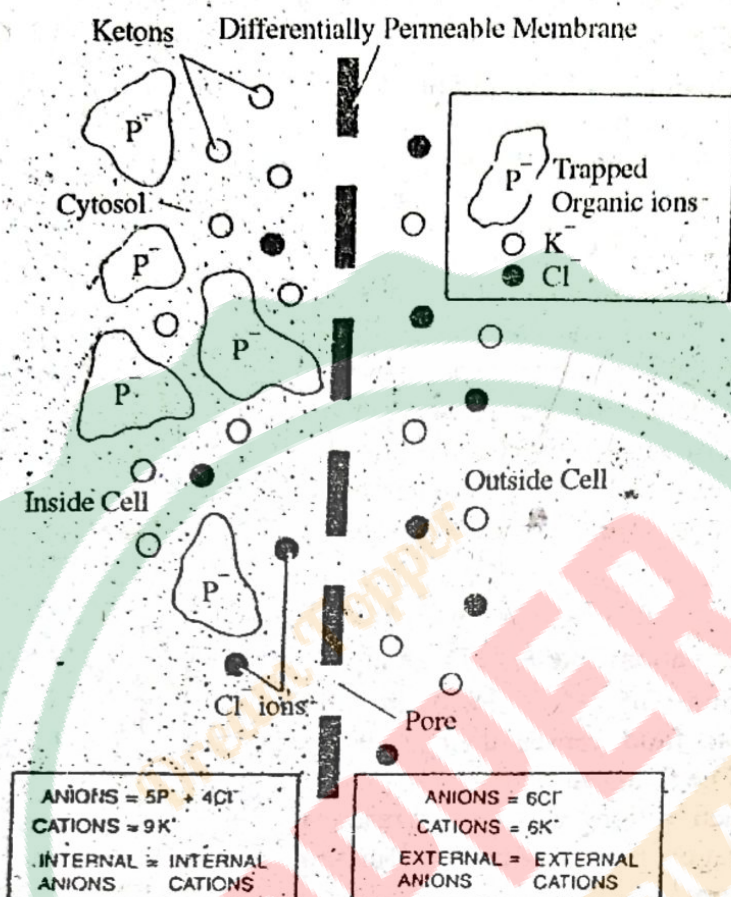


Fig. Donnan effect on the differential distribution of K^+ and Cl^- ions.

1. Simple diffusion : Transport of metabolites across the membrane along the concentration gradient and without the carrier molecule is known as simple diffusion. The molecules of substances pass through the gaps or channels of membrane transport proteins, known as channel proteins.

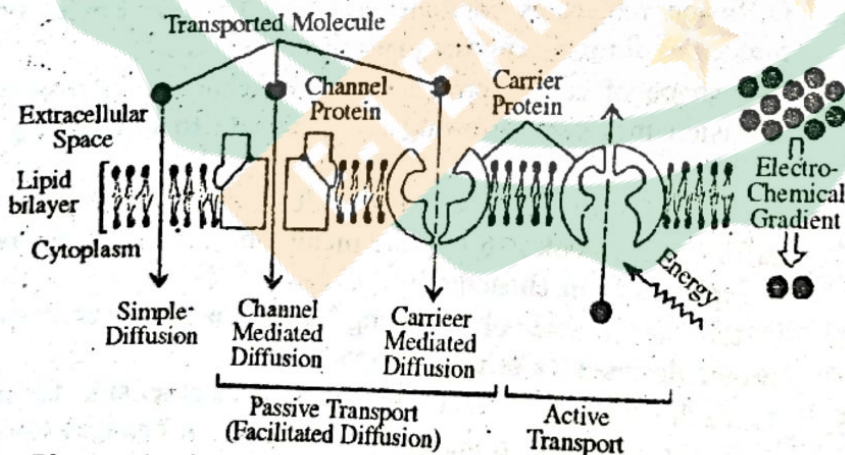


Fig. Diagram to show difference between different types of diffusion and transport of substances through plasma membrane.

(a) **Diffusion of lipid soluble molecules :** Lipid soluble molecules diffuse rapidly by dissolving through lipid bilayer of plasma membrane.

(b) **Diffusion of small lipid insoluble molecules :** Small molecules that are insoluble in lipids move slowly and pass through channels or tunnels bounded by integral protein molecules.

(c) **Diffusion of ions :** It depends on two factors : on their concentration gradient and on the electrical gradient. The diffusion of ions is a balancing act between these two forces because negatively charged organic anions and extracellular fluid or interstitial fluid contains more positive inorganic cations.

Internal anions favour inward diffusion of cations like K^+ . But a higher concentration of K^+ ions in the intracellular fluid causes their diffusion outward. The final result of these opposing forces when cations and anions reach a stable stage is known as Donnan equilibrium.

2. **Facilitated diffusion :** In facilitated diffusion, diffusion of metabolites across the plasma membrane is facilitated by proteins of plasma membrane. These proteins are known as permeases. These act as carriers. The process involves following steps :

1. Diffusing molecules combine with the specific carrier proteins forming carrier-protein complexes.
2. The shape of carrier protein molecule changes in response to the diffusing molecule, allowing the molecule to cross the plasma membrane.
3. The shape of carrier protein molecule changes in response to the diffusing molecules so that the membrane bound carrier protein complexes form channels.
4. After the release of the diffusing molecule, the carrier-protein molecule resumes its original shape.
5. Once the diffusing molecule has reached the other side, the change in shape of the carrier molecule (conformational change) lowers its affinity with the diffusing molecules, and allows it to be released.

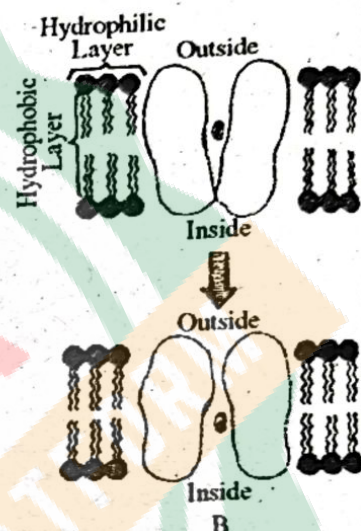
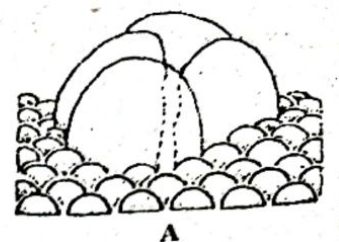


Fig. Transport of metabolite facilitated diffusion through protein carrier complex.

The facilitated diffusion enables molecules to cross the impermeable or poorly permeable membrane.

The transportation continues as long as there is a concentration gradient. It is similar to simple diffusion in that it does not require energy and takes place along the concentration gradient. But it differs from :

- It shows **saturation kinetics**.
- Facilitated diffusion is **stereospecific**.
- Facilitated diffusion requires a **carrier** for transport across the membrane. The carrier protein molecules move to and fro across the membrane by thermal diffusion.

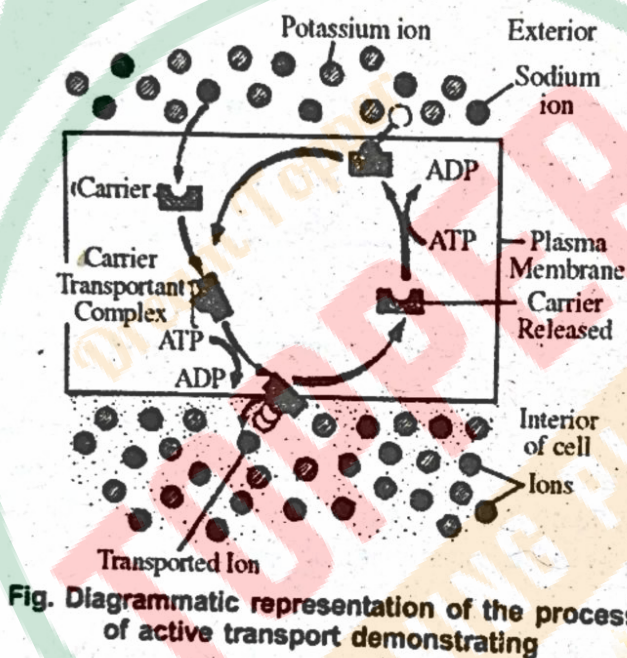


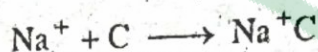
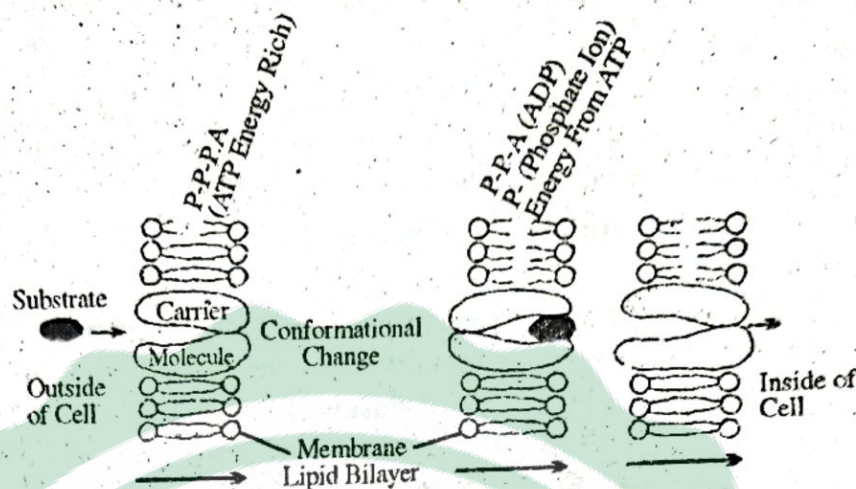
Fig. Diagrammatic representation of the process of active transport demonstrating

3. Active Transport

Active transport is the movement of molecules the molecules or ions move from region of low concentration towards region of high concentration. The movement of molecules can be compared with the uphill movement of water. Therefore, during active transport energy is required. The energy is provided by ATP.

Mechanism

1. Carrier molecule mechanism : It is presumed that a carrier molecule which is a protein of the plasma membrane picks up the transportant molecule and forms a carrier-transportant complex. e.g. in the active transport of Na^+ ions, Mg^{++} activated ATPase acts as a carrier. The sodium ion is picked up from the interstitial fluid forming a temporary complex which is carried to the opposite side of plasma membrane and is released within the cell. The transportant undergoes metabolic changes along with carrier. The carrier is called as **translocase** or **permease**.



where C is carrier.

2. Revolving door model for active transport : Monod and Cohen have described that, during the transport of lactose across the plasma membrane in *E. coli*, the carrier protein has a slot facing outside. The carrier protein changes its shape as the substance enters the slot and rotates so that the slot comes to lie on the inner side. The substance is released in the cell and the protein rotates back to its original form.

4. Pinocytosis

Substances of high molecular weight like proteins, etc. which cannot pass through the plasma membrane by osmosis, are taken up by this method. The plasma membrane with macromolecules of such substances invaginates into tiny pockets or invaginations and finally pinches off into small vesicles known as pinosomes. These float freely, invaginate in the cytoplasm and distribute food.

5. Phagocytosis

In this process, solid particles are picked up and digested by the cell through plasma membrane similar to that as *Amoeba* ingests its food.

Example : W.B.Cs pick up foreign proteins from the blood stream by this process.

Q.8. Describe the ultrastructure, chemical composition and functions of golgi complex.

Ans.

Golgi Complex

It is the differentiated portion of the vacuolar system of the cell. Both morphologically and functionally it is related to the endoplasmic reticulum of

Cell Biology

one side and to the secretory vesicles on the other side. Golgi complex was discovered by Camillo Golgi in 1898 in the nerve cells by silver staining method. After discoverer's name it is known as **Golgi complex**, **Golgi apparatus** or **Golgi element**.

Occurrence

Golgi complex found in all living cells except the prokaryotic cells and R. B. Cs, mature sperin and sieve tubes in plants, etc. In plant cells, it is known as **dictyosome**.

Ultrastructure

Golgi complex comprises of stacks of membrane bound spaces. These are of the following types :

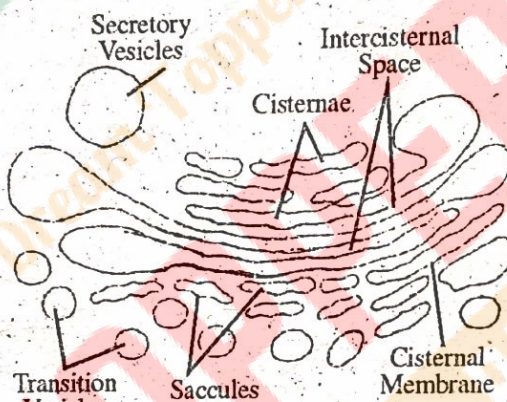


Fig. Ultrastructure of Golgi complex.

1. Cisternae : Cisternae form the central plate-like part. It comprises of stacks of tubular or flattened compartments about 20\AA wide and enclosed by unit membrane. These are stacked in parallel bundles one above the other and separated by intercisternal space of about $20\text{--}30\mu$ ($200\text{--}300\text{\AA}$).

The cisternae in a stack are arranged in a specific order. Those on the convex side are small. This side shows the **forming face** of Golgi apparatus. The transition vesicles and tubules that detach from E.R. fuse here to form new cisternae. The opposite concave face of cisternal sack shows the **maturing face**. It is associated with the secretory vesicles and vacuoles. These are formed by the dilation of the edges of cisternae due to the accumulation of secretory products formed by the concentration in Golgi cisternae.

2. Transition vesicles : These are small drop-like structures about 400\AA – 800\AA in diameter. These are associated with the convex forming face of Golgi cisternae. These develop from the cisternae of ER and fuse to form Golgi cisternae. This region shows the **zone of exclusion**, a region of transition from ER to Golgi cisternae.

3. Secretory vesicles : These are present on the sides and on the maturing face of Golgi. These are pinched off from the trans face of Golgi

cisternae. These consist of secretory products of Golgi and converted into zymogen granules or lysosomes.

4. Coated vesicles : In some cell types, the secretory vesicles are coated with a bristly layer of protein clathrin. These are known as coated vesicles and associated with the secretion of highly specialised cell products.

5. Golgi vacuoles : These are large rounded sacs that occur on the maturing face of Golgi. These are formed either by the expanded cisternae or by the fusion of secretory vesicles. The vacuoles are filled with some amorphous or granular substance.

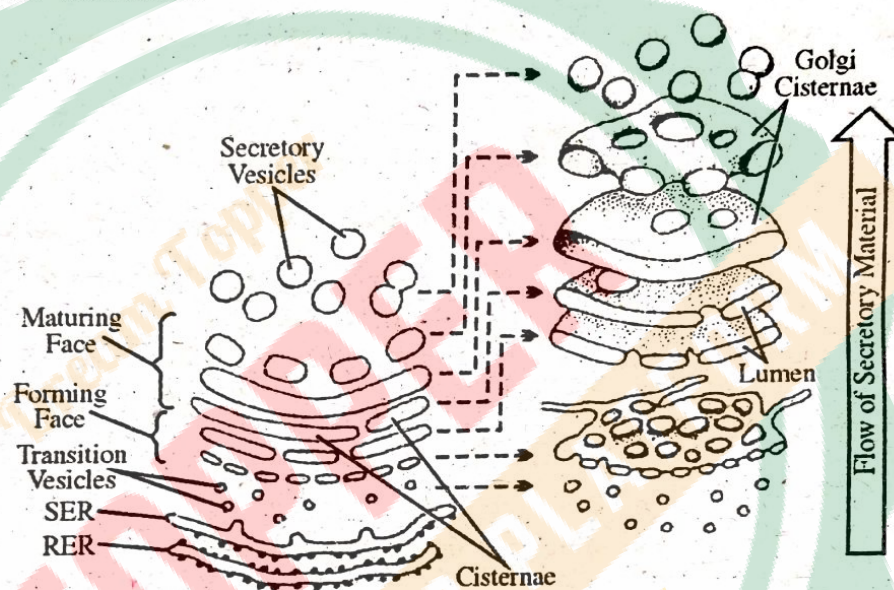


Fig. Diagram showing polarity and membrane flow in Golgi Cisternae.

Polarity and Membrane Flow in Golgi

The Golgi bodies are polarized structures. Their forming face lies close to the nuclear membrane or SER, the new Golgi cisternae continue to be formed from the coalescing of transition vesicles. On the maturing face or trans face the cisternae break down into secretory vesicles or vacuoles or zymogen granules.

The association of Golgi, endoplasmic reticulum and lysosome is reflected in the GERL region. It is the region between Golgi and plasma membrane where secretory vesicles are converted into zymogen granules by the concentration of products synthesised in RER.

Chemical Composition

Phospholipids, Enzymes and Carbohydrates.

Functions

Golgi complex performs a variety of function in different types of cells. Some of them have been :

Cell Biology

1. Secretion : It is mainly associated with the secretory activity of the cell. Through the channels of Golgi there is a continuous traffic of substances from cell to the outside. Finally these are secreted outside. These include enzymes, hormones, endocrine secretion and mucus, etc.

2. Formation of lysosomes and vacuoles : Primary lysosomes are formed from Golgi cisternae in the same way as the secretory vesicles.

3. Concentration and Storage of Secretory Products : Golgi is associated with the concentration, storage, condensation and packaging of materials. The glycoproteins and lipoproteins are concentrated and packed in secretory vesicles.

4. Synthesis of glycoproteins : For some years Golgi was believed to be a passive channel for the transportation of materials, synthesised elsewhere in the cell. Now it is established that Golgi facilitates linking of carbohydrates and proteins in the formation of glycoproteins.

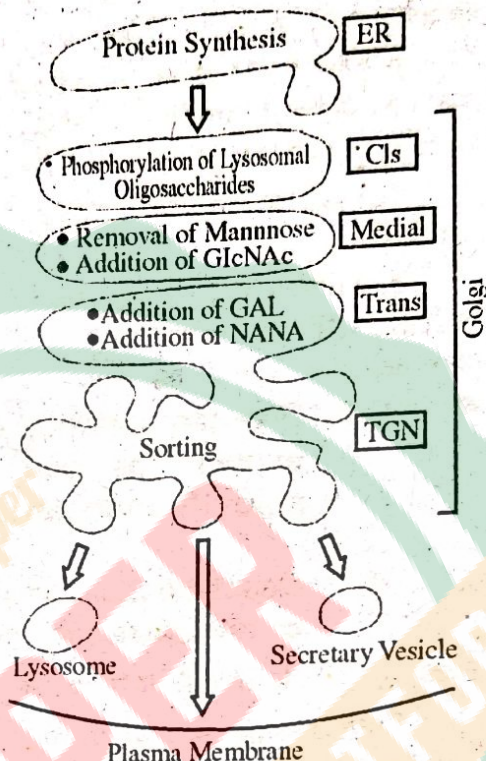


Fig. 3. Diagram showing secretory function of Golgi complex.

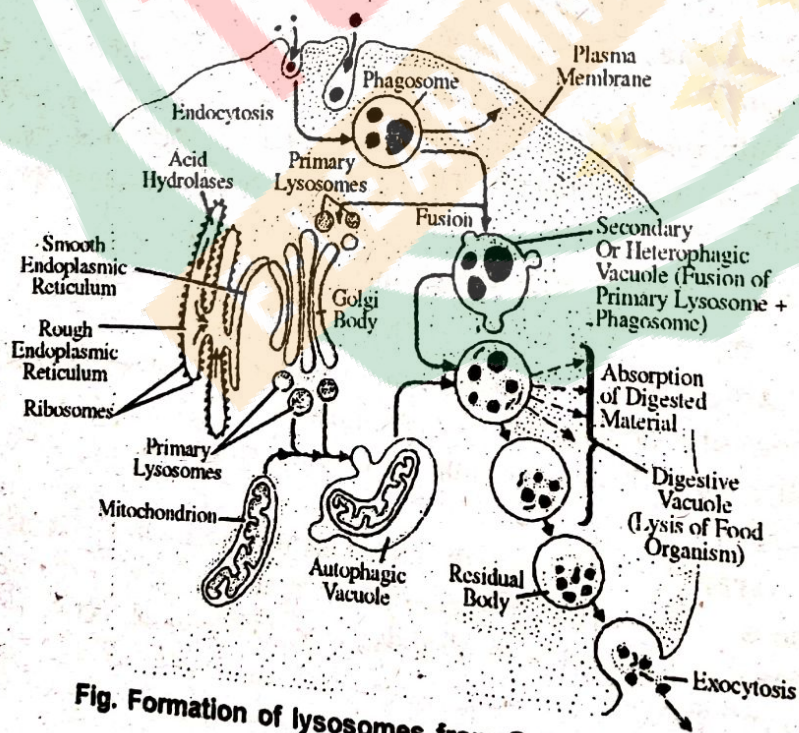


Fig. Formation of lysosomes from Golgi complex.

5. **Formation of cell plate** : Golgi complex produces vesicles during anaphase of mitosis. These vesicles fuse to form the cell plate.

6. **Synthesis of carbohydrates** : Golgi apparatus is considered to be the main agency of building of large molecules of complex carbohydrates from simple sugars.

7. **Formation of acrosome** : Acrosome of sperm develops from Golgi complex.

8. **Formation of cell wall** : The pectic material and other substances necessary for the formation of cell wall are synthesised and secreted by Golgi complex.

Q.9. Discuss various types of endoplasmic reticulum and explain the common and specialized function of smooth endoplasmic reticulum.

Or

Describe the ultrastructure, development and function of endoplasmic reticulum.

Ans. **Ultrastructure of Endoplasmic Reticulum**

Endoplasmic reticulum forms an elaborate system of flattened tubules or channels in the ground substance of the cells. These channels are bounded by membranes that have the same basic structure as the plasma membrane.

The endoplasmic reticulum comprises of three different components :

1. **Vesicles** : These are rounded, spherical or ovoidal spaces which measure from 25 to 500 μ .

2. **Cisternae** : These are long and flattened lamellar vesicles about 40-60 μ thick.

3. **Tubules** : These are in the form of irregularly branched tubules, having a diameter of about 50-100 μ . These are most common in the cells that carry synthesis of steroid.

Types of Endoplasmic Reticulum

Two types of endoplasmic reticulum are found :

1. **Agranular or smooth endoplasmic reticulum (SER)** : The membranes of reticulum are without ribosomes. SER found in cells that do not synthesise proteins like adipose cells, glycogen storing cells and the muscle cells.

2. **Granular or rough endoplasmic reticulum (RER)** : The membranes of rough endoplasmic reticulum are deposited with ribosomes. SER is occurs in all those cells that play an active role in the protein synthesis.

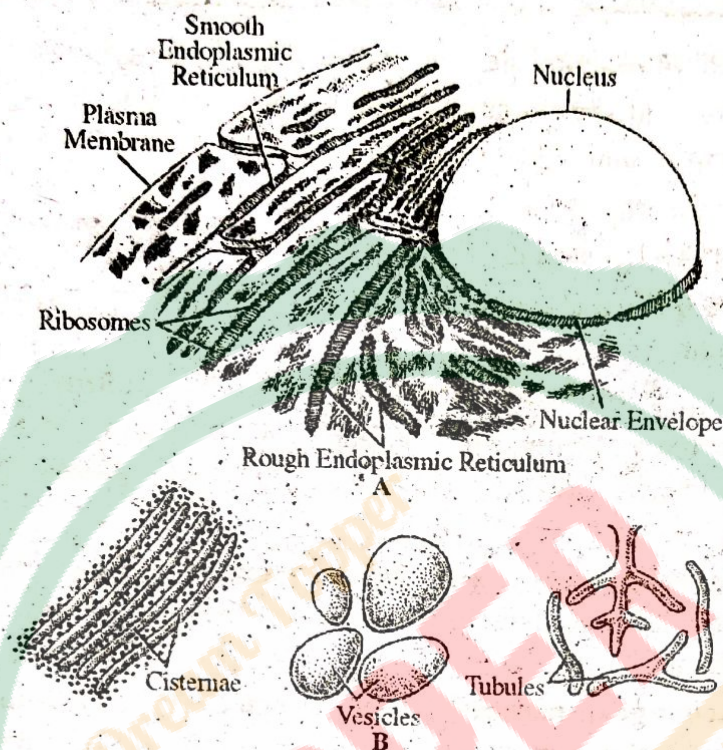


Fig. A Endoplasmic reticulum, B. Components of ER : cisternae, vesicles and tubules.

Enzymes Associated with Endoplasmic Reticulum

Approximately 30-40 enzymes are located on the membranes of endoplasmic reticulum. These may be associated with the cytoplasmic surface or luminal surface. These are :

1. Nucleoside pyrophosphatase
2. Glucose-6-phosphate
3. Mg-activated ATPase
4. GDP mannosyl transferase
5. Nucleoside diphosphatase
6. Cytochrome P-450
7. β -Glucuronidase
8. NADH-cytochrome b_5 reductase
9. Acetanilide-hydrolysing esterase
10. NADH-doaphorase
11. NADPH-cytochrome C reductase

These enzymes perform following functions :

- (a) Synthesis of glycerides and phospholipids.
- (b) Metabolism of plasmalogen.
- (c) Synthesis of fatty acids.

- (d) Biosynthesis of steroids and cholestrol biosynthesis.
- (e) Aryl and steroid sulfates synthesis.
- (f) UDP uronic acid metabolism.
- (g) L-Ascorbic acid synthesis.
- (h) UDP glucose diphosphorylation.
- (i) $\text{NADPH}_2 + \text{O}_2$ requiring steroid transformation, aromatization and hydroxylation.

Functions of Endoplasmic Reticulum

1. **Mechanical function** : The endoplasmic reticulum forms a skeletal framework and provides supplementary mechanical support to the colloidal matrix.

2. **Intracellular transport** : The endoplasmic reticulum is said to act as a kind of circulatory system for the transport of several substances inside the cell cytoplasm.

3. **Exchange of material** : The membranes of endoplasmic reticulum act as a **segregation apparatus**, i.e., these maintain osmotic pressure within the cell, isolate the material, synthesised and regulate exchange between the inner compartments and the outer compartments and cytoplasmic matrix.

4. **Intracellular transport** : The endoplasmic reticulum provides an increased inner surface for several metabolic reactions and they themselves take an active part in them by means of attached enzymes.

5. **Synthesis of secretory proteins** : The microsome fractions attached with the endoplasmic reticulum are intimately associated with the protein synthesis.

6. **Glycogen metabolism** : In liver cells SER is intimately associated with glycogen metabolism.

7. **Formation of other cytomembranes** : Endoplasmic reticulum takes part in the formation of other membranous structures of cell, like mitochondria and Golgi bodies.

8. **ATP synthesis** : Membranes of endoplasmic reticulum are the sites of ATP synthesis in the cell. The ATP is used as a source of energy for all the intracellular metabolism and transport of material.

9. **Transport of message from genetic material** : It also provides passage for the message in the form of various RNAs from the genetic material to pass from the nucleus to the various organelles in the cytoplasm, thereby controlling the synthesis of proteins, fats and carbohydrates.

Cell Biology

Q.10. Describe the location ultrastructure, chemistry and function of eukaryotic ribosomes.

Ans. **Occurrence and Locations**

Ribosomes are submicroscopic granules about 150–200Å in diameter and occur in all the living cells either attached to the outer membrane of endoplasmic reticulum. These are describe as 'protein factories of the cell' because these synthesise proteins of the cell.

In 1955 Ribosomes were first observed by Palade under electron microscope as dense particles.

Types of Ribosomes

Ribosomes occur in prokaryotes and eukaryotes are of different sizes and have different sedimentation rate.

Ribosomes are generally oblate, spheroidal measuring 18 nm in bacteria and 20–22 nm in eukaryotic cells. These occur in two categories :

- 70s ribosomes occur in bacteria (prokaryotic cells), mitochondria and chloroplasts.
- 80S ribosomes occur in eukaryotic cells.

Ultrastructure of Ribosomes

Basic design of both prokaryotic and eukaryotic chromosomes is same. These have a small and a large subunit. The small subunit forms a cap on the large subunit.

1. Prokaryotic Ribosomes (70S Ribosomes)

Prokaryotic ribosomes have about 18 nm diameter and 2.8 million daltons particles weight. Their two subunits are 50S and 30S.

Lake's Model of 70S Prokaryotic Ribosomes

(a) 30S subunit : The small subunit of prokaryotic ribosomes is 30S. It is asymmetrical and rod-like and partially divided into two lobes by a deep transverse cleft or groove. The smaller segment is known as head and larger one base. A small outgrowth arises from the base segment and is known as platform.

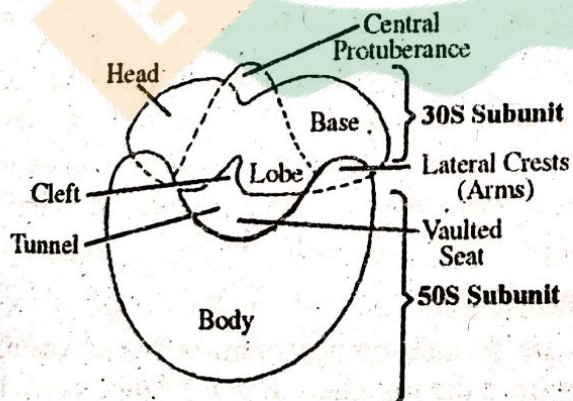


Fig. Ultrastructure of a prokaryotic ribosome.

The 30S subunit formed of one molecule of 16S rRNA and 21 proteins.

(b) 50S subunit : It is more or less spherical and forms the body. All its flat anterior end are present three projections- one central projection and two lateral projections.

It is formed of one molecule of 23S rRNA, one molecule of 5S rRNA and 34 proteins.

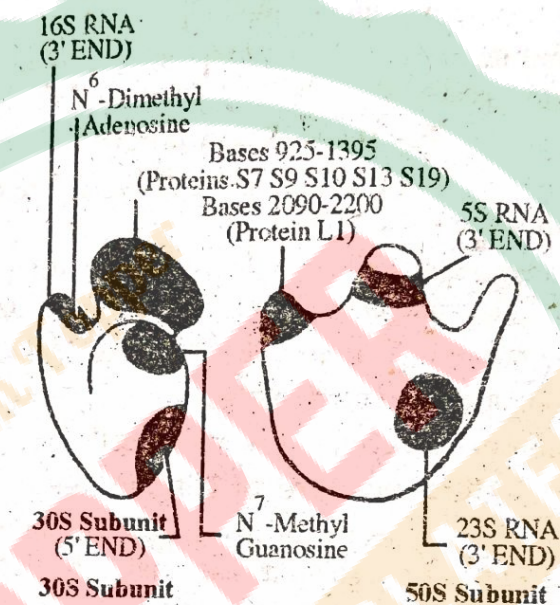


Fig. Lake's model of prokaryotic ribosome.

2 Eukaryotic Ribosomes (80S Ribosomes)

The 80S ribosomes have a diameter about 20-22 nm and particle weight 4.2 million daltons. Their two subunits are 60S and 40S.

- > The 60S subunit contains 28S, 5S and 5.8S rRNA and about forty different proteins. It has a broad anterior flat surface and three projections.
- > The 40S subunit has 18S rRNA and 30 different polypeptides.

Attachment of Ribosomes to ER

The large subunits get attached to the membrane of endoplasmic reticulum and bear two slots for two molecules of transfer RNA, are called P-site and A-site. The aminoacyl tRNA complex is attached to the acceptor site and the rRNA carrying peptide chain is attached to the peptidyl or donor site. The smaller subunit receives the messenger RNA.

Chemical Composition

Ribosomes are formed of approximately equal amount of RNA and proteins. Proteins from the periphery and RNA lies in the interior remaining intertwined within the two subunits.

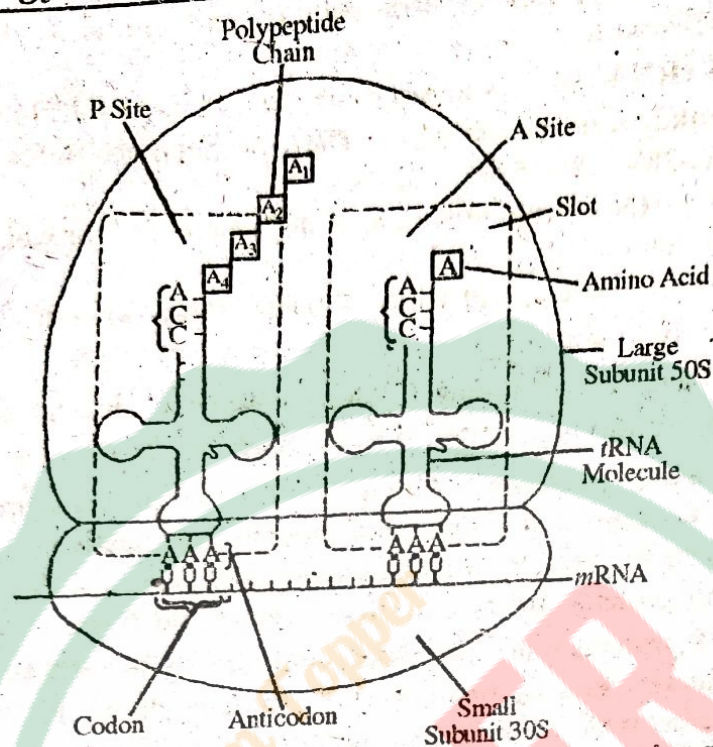


Fig. Ribosomes showing P-site for attachment of tRNA carrying polypeptide chain, A-site for tRNA with amino acid.

1. Ribosomal RNA :

(1) In prokaryotic ribosomes : Ribosomal RNA (rRNA) found in three different forms as 23S rRNA, 16S rRNA and 5S rRNA.

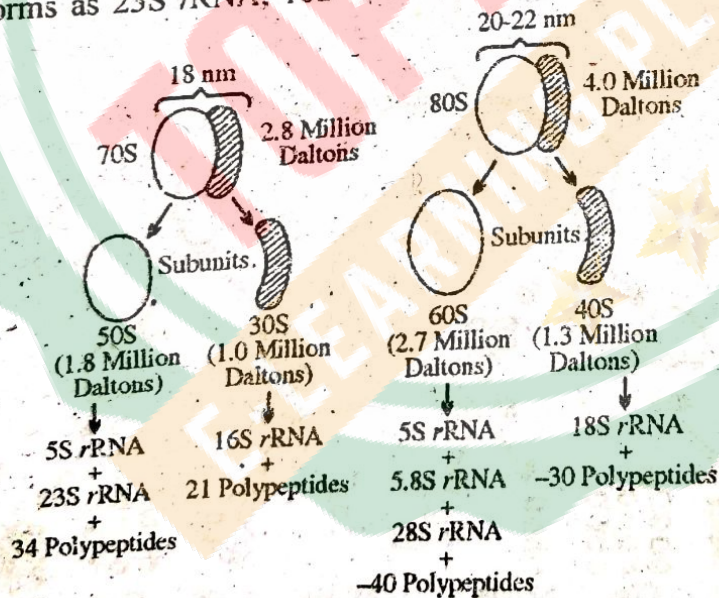


Fig. Diagram to show the composition of prokaryotic and eukaryotic ribosomes and their differences.

- The 23S rRNA found in 50S subunit, and contains about 3200 nucleotides.

- > 16S rRNA lies in 30S subunit and contains about 1600 nucleotides.
- > 5S rRNA also lies in large subunit and having 120 nucleotides.

(2) In eukaryotic ribosomes : The ribosomal RNA found in four different forms-28S, 18S, 5.8S, and 5S.

- > 28S rRNA lies in 60S subunit. It has a molecular weight 1.5-1.8 million daltons.
- > The 18S ribosomal RNA is occur in 40S subunit and weights $.8 \times 10^6$ daltons.
- > 5S and 5.8S ribosomal RNA are also occur in large subunit and have molecular weight 3.2×10^4 and 5×10^4 daltons.

2. Ribosomal proteins : About 55 different proteins are occur in ribosomes. At the time of dissociation of subunits into inactive core particles, some proteins are released from each particle. These are called **split proteins (SP)**. The split proteins are of two types, **acidic** and **basic**.

About 28 proteins bind specifically and directly to rRNAs. These are known as **primary binding proteins**. Split proteins do not bind directly to rRNA but interact with the primary binding proteins. These are also known as **secondary binding proteins**.

Biogenesis of Ribosomes

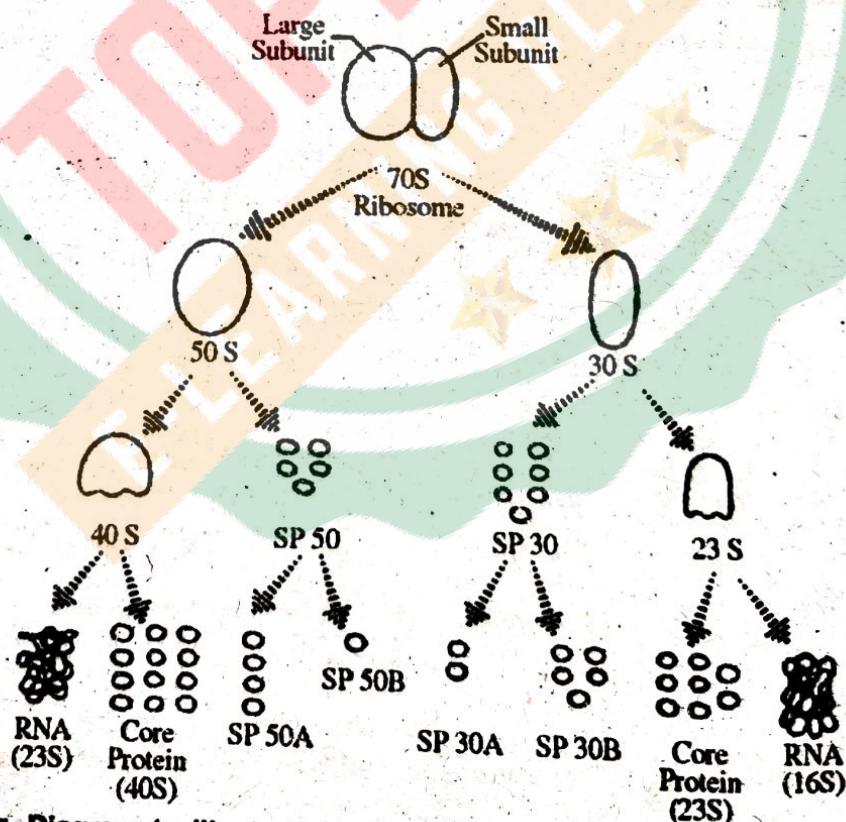


Fig. Diagram to illustrate the results of dissociation of ribosome and the formation of different types of proteins.

The ribosomes in bacteria occur inside the cytoplasm. Because of the absence of nucleolus, the **ribosomal RNA** are coded from the specific cistrons of the genome. In the beginning 45S RNA is formed from the nucleolar organiser region of the chromosome. This 45S RNA is precursor of both 28S and 18S rRNAs. The process of conversion of 45S RNA into 28S and 18S ribosomal RNA.

The proteins synthesised in the cytoplasm assemble in the nucleolus and get associated with RNA to form ribonucleoprotein particles (RNP).

Function

Ribosomes are concerned with the synthesis of proteins. With the help of mRNA and rRNA ribosomes are able to form long polypeptide chain of amino acids from cytoplasm.

Q.11. Give the structure, chemical composition and function of centriole.

Ans. Centriole : Centrioles are two spindle-shaped or cylindrical bodies that lie at right angles to each other and surrounded by a zone of hyaline cytoplasm, the centrosphere.

Centrioles are found in most algae, bryophytes, ferns and in all animal cells. Red algae, gymnosperms and angiosperms and also the nonflagellated and nonciliated protozoans do not have centrioles.

Structure : Its size varies from 150-250 nm in diameter and 3,000-20,000 Å in length.

A centriole is formed of nine triplets of microtubules or fibres. These are arranged equidistant in a circle around an imaginary central axis.

1. Microtubules : The triplet microtubules are all identical. Each triplet is composed of three subfibres, designated as A, B and C. Each subfibre is about 250 Å in diameter.

2. Linkers : The subfibre A of each triplet is linked with the subfibre C of the neighbouring triplet by a connection of some dense material. But in some cases the connection may be between A-A or C-C subunits.

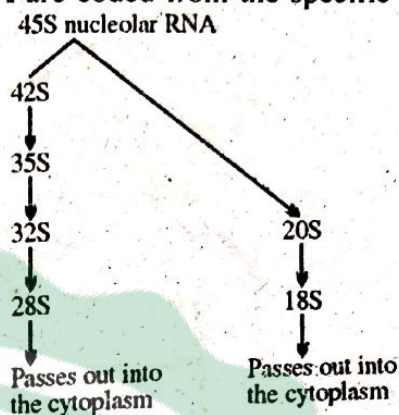


Fig. Diagrammatic representation of the steps involved in the conversion of 45S nucleolar RNA into 28S and 18S ribosomal RNA.

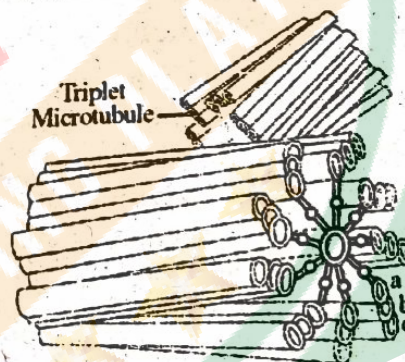


Fig. Structure of a centriole in side view.

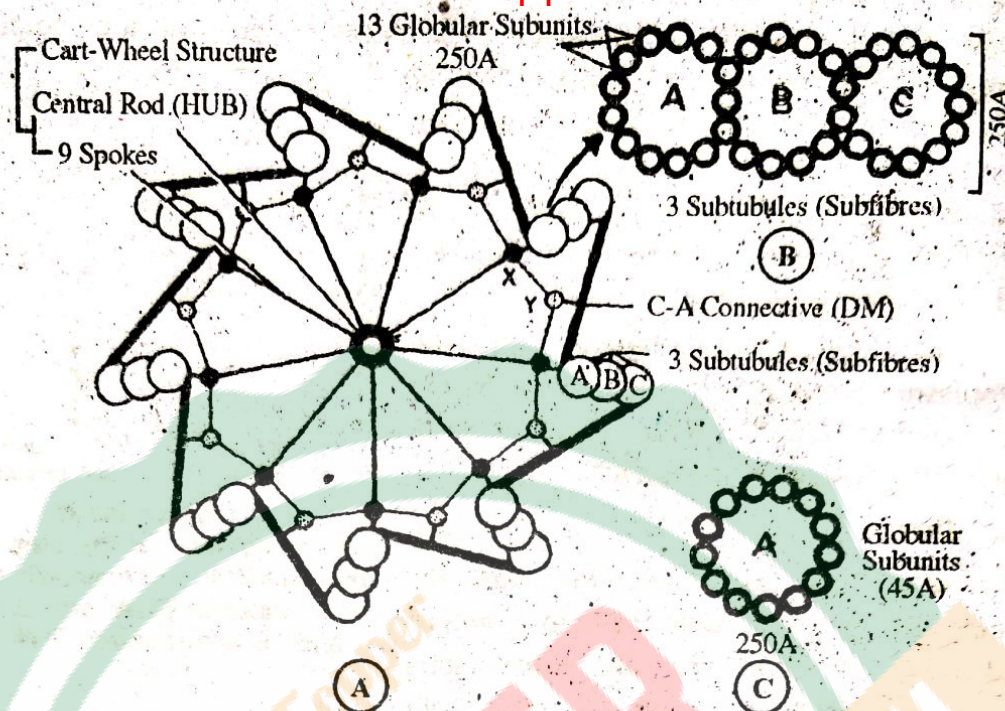


Fig. Cross Section of Centriole.

3. Cartwheel structure : It is occur at the proximal end of centrioles and the basal bodies. It consists of a central rod or hub in the centre and 9 spokes radiating from it. Each spoke is connected to subfibre-A.

Associated Structures (Pericentriolar Structures)

Satellites : Each centriole is surrounded by two crowns. Each crown consists of 9 amorphous spheres. These are rounded bodies attached to the centriole by short bridges of dense material. These bodies are known as corpuscles or massules or pericentriole satellite. The shape, size and position of satellites changes during spermiogenesis.

Biochemical Composition

Centrioles are formed of structural proteins, tubulin, lipids, ATPase and RNA.

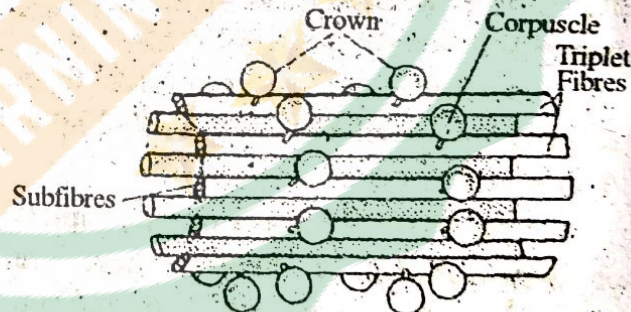


Fig. Centriole with satellite.

Functions :

1. They form basal bodies of cilia and flagella.
2. Distal centriole present in the spermatid forms the axial filament of the flagellum of the spermatozoon.
3. Centrioles play an important role in the formation of spindle and therefore, in cell division.

Q.12. Write note on the mitochondria.

Ans.

Shape, size and Number

The mitochondria appear as small granules, thin filaments or short rods. These may be ribbon-like sausage-shaped or club-shaped. These size ranges from 1μ to 5μ in length and 0.2 to 1.0μ in diameter. A few animal cells may have several hundred to thousands of mitochondria. More active cells have more number of mitochondria. These are occur scattered in the cytoplasm exhibiting independent movement.

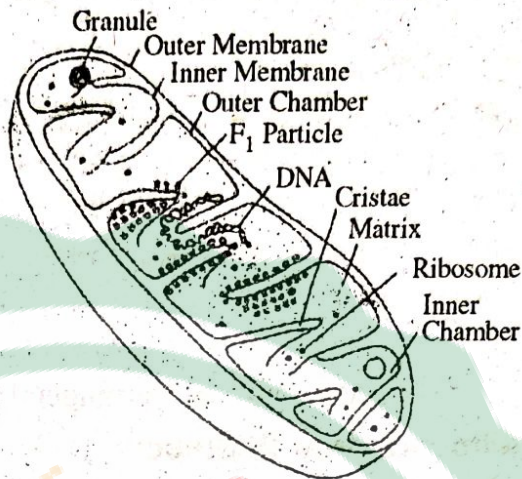


Fig. A Mitochondrion in section.

Structure : The mitochondrion consists of two membranes and two chambers.

Mitochondrial Membranes

1. Outer membrane : Outer membrane is smooth, about 60\AA thick and surrounds the mitochondrion. It exhibits homology with the membranes of endoplasmic reticulum.

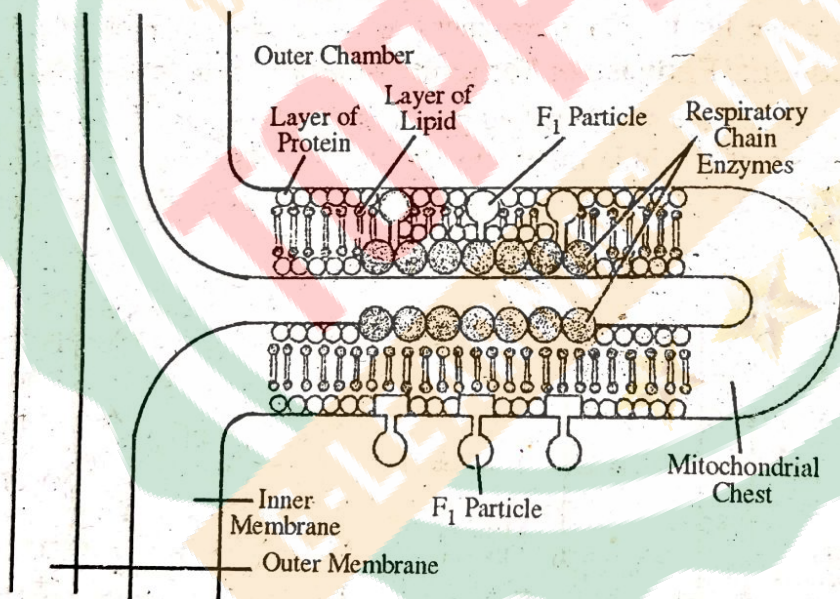


Fig. Ultrastructure of mitochondrion to show the molecular organisation of mitochondrial crests.

2. Inner membrane : Inner membrane is 60\AA thick and lies within the outer membrane. The two are separated by a space about $60-80\text{\AA}$ wide. Inner mitochondrial membrane projects into mitochondrial cavity in the form of ridges or septa. These are called mitochondrial crests or cristae.

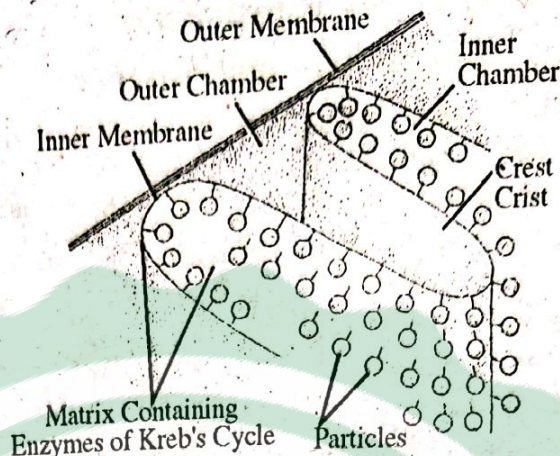


Fig.

The shape, size and arrangement of cristae varies.

Mitochondrial Chambers

1. **Outer chamber or intermembranous space** : It is also known as perimitochondrial space. It is the space between two mitochondrial membranes and in the core of the cristae. It is about 60-70Å wide.

2. **Inner chamber or matrix space** : It is a wide space surrounded by inner mitochondrial membrane and filled with a gel-like homogeneous mitochondrial matrix.

The matrix is gel-like and contains high concentration of soluble proteins, some lipids, 70S ribosomes and circular DNA molecule.

Mitochondrial Particles or Fernandez-Moran Particles (F_1 Particles)

F_1 particles are small stalked particles. These are about 8.5 nm in size. These are situated within the thickness of inner membrane at a distance of 100Å. These are seen only when mitochondria are opened by hypotonic treatment.

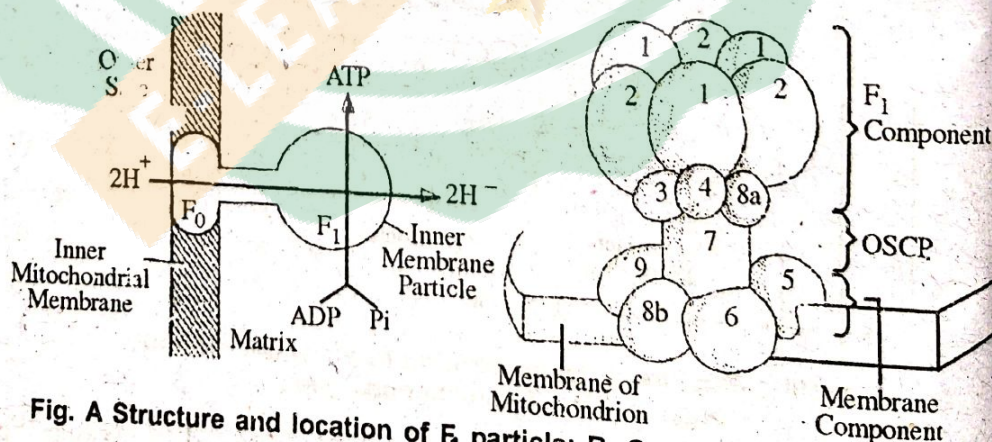


Fig. A Structure and location of F_1 particle; B. Components of F_1 particle.

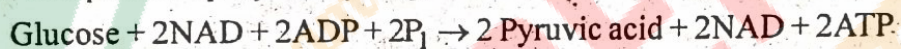
These particles are also known as elementary particles $F_0 - F_1$ complex or ATPase complex or Fernandez-Moran particles. Each particle consists of base piece, stalk and head.

Chemical Composition

Mitochondria consist of 70% proteins and 25-30% lipids. The respiratory enzymes such as cytochrome oxidase, cytochrome reductase, transaminase, coenzyme octanoxidase and fatty acid oxidase are present both in the matrix and inner mitochondrial membrane. A small amount of DNA and RNA are also present in the matrix. Mitochondria have their own DNA, mRNA, tRNA, RNA-polymerase, ribosomes, amino-acid-activating enzymes.

Functions : 1. **Cellular respiration or oxidation of food :** Mitochondria are sites of oxidation of food in the presence of oxygen. During oxidation of food, mitochondria convert potential energy of different food stuffs into a form of energy. Cellular respiration and release of energy found in the following stages :

(i) **Glycolysis :** It found in the cytoplasm *i.e.*, outside mitochondria. During glycolysis, each molecule of glucose splits up into two molecules of pyruvic acid and two molecules of ATP. Two hydrogen ions are also released which are picked up by an hydrogen acceptor NAD



(ii) **Oxidation of Pyruvic acid :** It found is mitochondria in the presence of oxygen. When pyruvic acid molecules enter mitochondrial matrix, these are oxidised to Acetyl coenzyme A with the help of enzyme pyruvate dehydrogenase complex. Hydrogen ions are transferred to NAD which is reduced to NADH_2 .



Acetyl CoA with oxaloacetic acid forms citric acid and starts Krebs's cycle. During Krebs's cycle seven enzymatically controlled reactions found in a definite sequence and oxaloacetic acid is produced in the end of cycle. In this cycle 3 molecules of water, 3 molecules of NAD, one FAD and one molecule of ADP and inorganic phosphate are used and 3 molecules of NADH_2 , one molecule of FADH_2 and one ATP are formed.

(iii) **Oxidative phosphorylation :** The energy rich NADH_2 and FADH_2 are oxidised by removing hydrogen. This hydrogen undergoes ionization splitting into proton (H^+) and electron (e^-).



These electrons are transferred to molecular oxygen through a chain of enzymes and coenzyme complexes. These form the electron transport system or respiratory chain. The total number of ATP formed from the oxidation of one molecule of glucose is 38.

2. **Heat production (Thermogenesis)** : During the process of oxidation of glucose both energy and heat are produced 38 ATP molecules provide 117 KJ of energy per glucose molecule.

3. **Metabolism of fat** : Wothon has associated them with fat metabolism. This view has been supported by Bensley.

4. **Secretion** : According to Horming mitochondria also contain proteolytic enzyme and actively govern both lytic and synthetic activities.

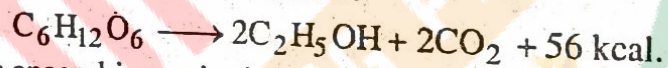
5. In the sperm, mitochondria form a mitochondrial spiral around the flagellum in the middle part of the body of sperm.

6. According to Levi and Chevermont, the myofibrils develop from mitochondria.

Q.13. Describe the process of fermentation (Anaerobic respiration). Or Describe Glycolysis or EMP pathway.

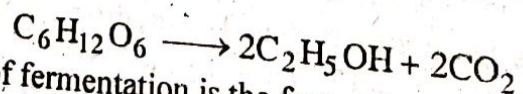
Ans. **Anaerobic Respiration (Fermentation)**

Oxidation of respiratory substrates in absence of atmospheric oxygen is termed as *anaerobic respiration*. It involves incomplete break down of respiratory substrates in which the end products, such as ethanol or lactic acid are produced and CO_2 is released. Anaerobic respiration is common among certain microorganisms. The following equation is usually given for anaerobic respiration and fermentation :



The term anaerobic respiration and fermentation should not be confused with each other. Although both the processes are defined as a complex series of cellular oxidation-reduction reactions in which energy is made available to the cell in the absence of oxygen. While fermentation can also occur outside the cell by extracellular enzymes, the anaerobic respiration occurs inside the cell.

Many microorganisms, such as fungi and bacteria, can grow and flourish in the complete absence of oxygen. Such microorganisms can utilize sugars to convert it into ethanol and evolve CO_2 . The overall equation for fermentation, as described by the French chemist Gay-Lussac in 1815, is as follows :



The process of fermentation is the form of anaerobic respiration carried by some micro-organisms and plants. The fermentation can literally be distinguished from anaerobic respiration that it may occur outside the living cells by the extra cellular enzymes secreted by some micro-organisms. Previously it was believed that the process of fermentation was strictly a chemical process, but Pasteur established that it is directly associated with

Cell Biology

living organisms. Pasteur (1870) described that fermentation is directly associated with the growth and metabolism of living matter. Pasteur further observed that the rate of fermentation (or anaerobic break down of sugars) was considerably higher under anaerobic conditions as compared to aerobic conditions. The inhibition of anaerobic breakdown of sugars into CO_2 and ethylalcohol (fermentation) due to the presence of O_2 under aerobic condition was named Pasteur effect. This effect was further confirmed by Mayerhof and Warburg.

In the year 1897, the German chemist **Buchner**, while attempting to preserve yeast extract in sugar media, demonstrated that a cell free extract of yeast converted glucose to ethanol and CO_2 . The yeast extract was first analysed by **Harden and Young** in 1905. The two scientists discovered that yeast juice loses its activity when it is dialyzed. It was later known that the yeast extract contained an enzyme zymase, which is nondialyzable and its coenzyme which is dialyzable. It is now well known that the *zymase is a complex mixture of many enzymes* and that several coenzymes are necessary for their function. The activity of this enzyme was lost because the main enzyme was separated from its coenzyme during dialyzation. Thus, it was established later that extracellular enzyme zymases secreted by yeast cells, carry out the process of fermentation.

Here in this text, we shall discuss the mechanism of anaerobic respiration and fermentation under the same heading because of the following similarities between the two :

- (i) The respiratory substrate is same in both.
- (ii) The end products are same (*i.e.*, CO_2 and ethyl alcohol or lactic acid). However, a variety of end products may be produced in different kinds of fermentations.
- (iii) Both processes occur in absence of O_2 (with a few exceptions).
- (iv) The enzyme complex zymase is found to catalyze both processes and found in cells performing anaerobic respiration.
- (v) Phosphate is required in both the cases.

Mechanism of Anaerobic Respiration (Fermentation) : Anaerobic respiration involves conversion of glucose to ethanol plus CO_2 in the alcoholic fermentation and the conversion of glucose to lactic acid in the muscles of animals and certain lactic acid bacteria. The processes does not require oxygen. The glucose is first converted to pyruvic acid through *Embden-Meyerhof-Paranas Pathway (glycolysis)*, which is then converted to ethyl alcohol or lactic acid depending upon the organisms in which it occurs. The complete pathway of anaerobic respiration occurs in the cytoplasm.

Embden-Meyerhof-Paranas Pathway (Glycolysis) : These steps are described as follows :

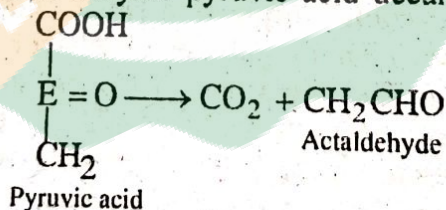
- (1) Glucose molecule is phosphorylated in presence of ATP to form glucose-6 phosphate. The reaction is catalysed by enzyme *hexokinase* which requires a divalent Mg^{++} as cofactor.

- (2) Glucose-6-phosphate (Robinson's ester) is isomerized to fructose-6-phosphate in presence of enzyme phosphoglucose isomerase :
- (3) Fructose-6-phosphate (Newberg's ester) is then phosphorylated by ATP to form fructose-1, 6-diphosphate in presence of enzyme *phosphofructokinase*.
- (4) Fructose-1, 6-diphosphate breaks up into 1 mol of dihydroxyacetone phosphate and 3-phosphoglyceraldehyde.
- (5) 3-phosphoglyceraldehyde is converted to 1,3-diphosphoglyceraldehyde.
- (6) 1,3-diphosphoglyceraldehyde is oxidised to form 1,3-diphosphoglyceric acid. NAD is reduced to $\text{NADH} + \text{H}^+$
- (7) 1,3-diphosphoglyceric acid is then converted to 3-phosphoglyceric acid. 1 mole of ADP is converted into ATP
- (8) 3-phosphoglyceric acid is transformed into 2-phosphoglyceric acid in presence of enzyme phospho-glyceromutase.
- (9) 2-phosphoglyceric acid in presence of enzyme enolase is converted into 2-phosphoenol pyruvic acid.
- (10) This 2-phosphoenol pyruvic acid is converted into pyruvic acid and a mole of ATP.

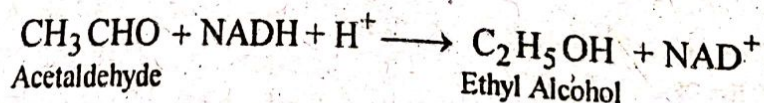
Various micro-organisms, bacteria, animals and plants are known to catabolise pyruvic acid into various organic compounds depending upon the specific enzymes they possess. Some of these types are described below :

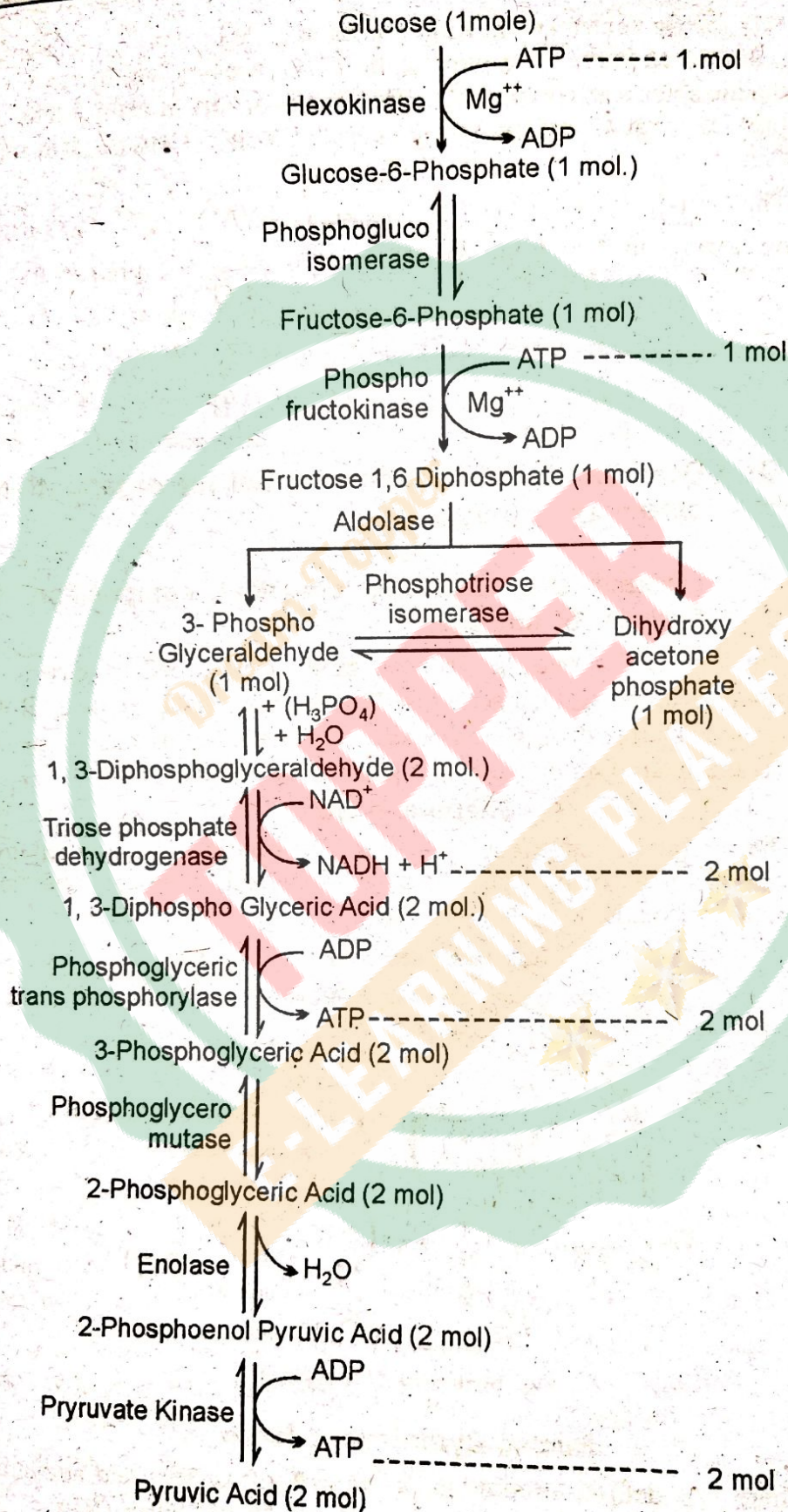
(I) Alcoholic fermentation (In yeast and higher plants) : Alcoholic fermentation occurs in some fungi, (e.g., yeast) and higher plants under anaerobic conditions. Pyruvic acid is broken down to ethyl alcohol and CO_2 in two steps :

- (1) The pyruvic acid is first of all decarboxylated to acetaldehyde in the presence of enzyme pyruvic acid decarboxylase :



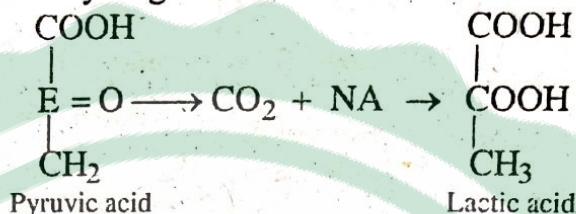
- (2) Acetaldehyde is reduced to ethyl alcohol by $\text{NADH} + \text{H}^+$ produced in glycolysis, in presence of enzyme alcohol dehydrogenase.





(II) **Lactic acid fermentation (In bacteria).** Lactic acid fermentation is also known as homolactic fermentation. The breakdown of pyruvic acid yields lactic acid as an end product. The process occurs in many bacteria, for example, Lactobacilli, Bacilli, Streptococci, Clostridia etc., and in muscle glycolysis.

The pyruvic acid is reduced to lactic acid by $\text{NADH} + \text{H}^+$ in presence of enzyme lactic acid dehydrogenase :



Q.14. Describe the nucleosome model for organization of chromatin in nucleus.

Or

Discuss the structure, chemical composition and function of nucleus.

Ans. Nucleus is described as 'control room' of the cell. It directs and controls all the cellular activities. In 1931, it was discovered by Robert Brown. During the life span of a cell, the nucleus exists in two places : (i) the interphase or metabolic phase, (ii) division phase.

Shape and Size

The interphase nucleus is known as metabolic nucleus as it controls metabolic activities of the cell. It may be spherical, rounded, spheroidal, cylindrical, prismatic, branched or lobed.

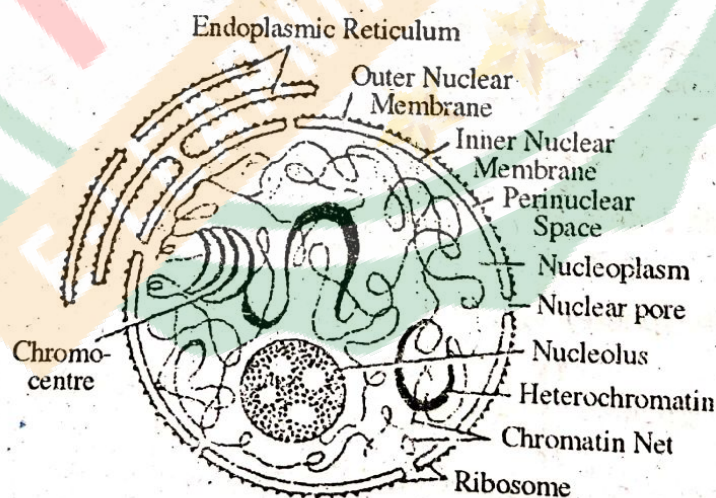


Fig. Structure of a typical

Nucleo-Cytoplasmic Ratio

There is a definite proportion in the size of nucleus and amount of cytoplasm, and represented by the nucleocytoplasmic index (NP).

$$NP = \frac{V_n}{V_c - V_n}$$

where, V_n = Volume of nucleus,

V_c = Volume of cytoplasm

Structure

The interphase nucleus can be separated into the following parts :

- (1) Nuclear envelope
- (2) Nucleoplasm or ground substance
- (3) Nuclear reticulum or chromatin net
- (4) Nucleolus
- (5) Chromocentres

(1) Nuclear Envelope or Karyotheca

The nuclear envelope is a double membranous sheath and separates the nuclear material from the cytoplasm. It acts as a dynamic gateway between nucleus and cytoplasm and regulates nucleocytoplasmic interaction.

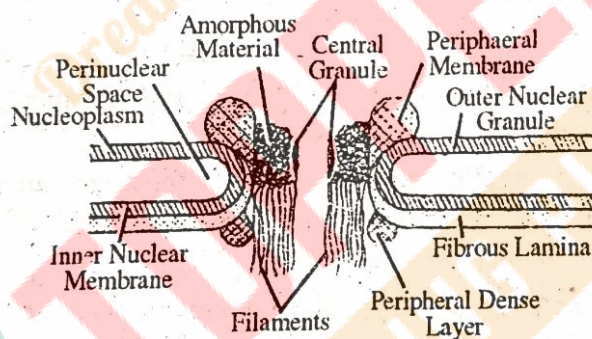


Fig. Ultrastructure of a nuclear envelope and nuclear pore.

(i) **Nuclear membranes** : The two nuclear membranes of nuclear envelope are separated by a perinuclear space. The nuclear membranes are 7-8 nm thick. The outer membrane has attached ribosomes. The nuclear surface of inner membrane is coated with filaments and fibres. These form a fibrous lamina or nuclear cortex.

(ii) **Nuclear pores** : The nuclear envelope is perforated by pores. At the margin of these pores, the outer and inner nuclear membranes are continuous.

(iii) **Annulus** : Annulus appears as a ring or cylinder of electron dense material of nuclear pore. It is formed of two sets of eight evenly spaced annular granules and a central granule. Fine fibres extend from the central granule to peripheral annular granules. Annuli around the pores regulate the exchange of macromolecules in relation to their size.

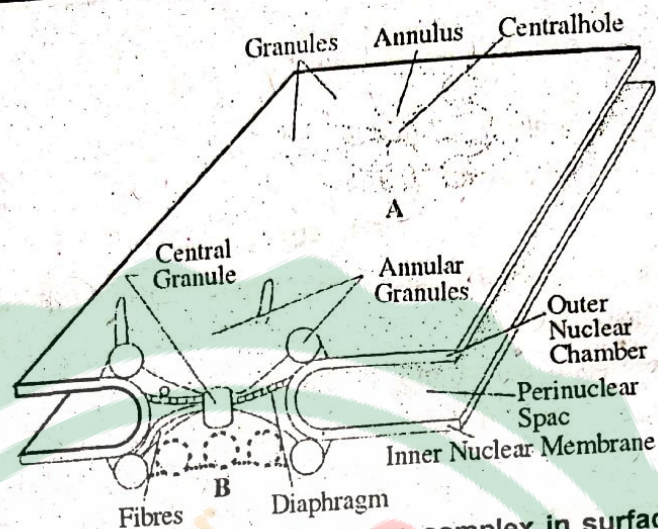


Fig. A Frank's model of nuclear pore complex in surface view.

(iv) **Fibrous lamina of internal dense lamella** : The inner surface of nuclear envelope is plastered with a fibrous coating, known as nuclear cortex. Its fibres are proteinaceous and similar to actin polymers. The fibres form funnel-shaped whorls.

Functions :

1. Nuclear envelope separates the genetic components of the cell from the protein synthesis machinery.
2. Nuclear envelope provides surface for attachment to structural elements of cytoplasm such as myofilament, microtubules and microfilaments.
3. Nuclear pores serve for the transfer of macromolecules.
4. Interphase chromatin remains attached to the inner nuclear membrane.
5. Nuclear envelope carries enzymes of electron transport system similar to those of endoplasmic reticulum.
6. Nuclear envelope gives rise to membranes of ER and Golgi and participates in membrane flow.

(2) Nucleoplasm or Nuclear Sap or Karyolymps

It is the transparent ground substance. It is a mixture of proteins, large amount of phosphorus and some nucleic acids (RNA). A number of hydrolytic enzymes like ribonuclease, alkaline phosphatase and dipeptidase are also found in the nucleoplasm.

Functions :

1. Nucleoplasm is associated with the processing of newly synthesized RNA and their transport from nucleus to cytoplasm.

2. It contains enzymes and proteins needed in the replication of DNA, synthesis of RNA and ribosomes.
3. Nucleoplasm acts as a skeleton of nucleus and maintains the nucleus.

(3) Nucleolus

Generally, there are two nucleoli in a nucleus of diploid cell and only one in gametes. The size of nucleolus is related with the synthetic activities of the cell.

Structure : Nucleolus consists of following parts :

- (a) Pars amorpha or amorphous matrix.
- (b) Fibrillar zone formed of fibrils of rRNA and ribonucleoproteins.
- (c) Granular zone consists of ribonucleoprotein (RNP) granules. These are precursors to ribosomes.
- (d) Perinucleolar chromatin formed of chromatin granules. The different zones of nucleus are related in the following manner :

Nuclear DNA → Fibrillar zone → Granular zone → Cytoplasmic ribosomes

Functions of Nucleolus

1. RNA synthesis : Synthesis of ribosomal RNA (rRNA) takes place inside the nucleolus. The chromatin associated with the nucleolus contains ribosomal genes. The ribosomal RNA is synthesised as 28S and 18S RNAs present in the large and small subunits of ribosomes of eukaryotic cells.

2. Biogenesis of ribosomes : The two types of rRNA's synthesised in nucleolus get associated with the proteins that migrate into the nucleolus from the cytoplasm. These precursors come out of the nucleolus into the cytoplasm and join together to form ribosomes.

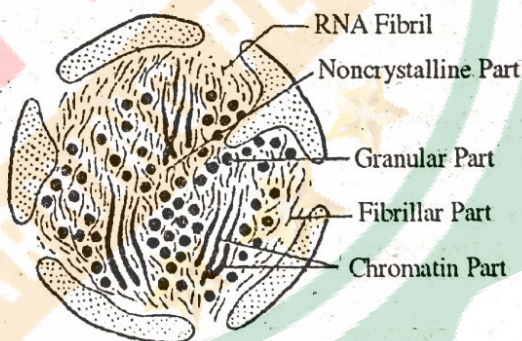


Fig. Structure of nucleolus

Chromatin → Fibrils → Granules → Ribosomes

(4) Nuclear Reticulum or Chromatin Net

Embedded in the nuclear sap is the network of twisted filaments or threads, which are called chromonemata and their network as nuclear reticulum or chromatin net. It contracts and organises into distinct chromosomes during cell division.

Euchromatin and heterochromatin : The cell chromatin can be divided into two types. The fine thread-like lines of the chromatin, which stains lightly with basic dyes is called euchromatin. The heterochromatin regions can be seen in the interphase and prophase.

The euchromatin exhibits different affinities to the dyes. The line of the chromatin which is in the form of lightly stained threads is composed of achromatin and the darkly stained-granules present on the line are formed of basichromatin or chromatin proper.

In some cases, large regions of nucleus take dark stain with basic fuchsin. These are known as chromocentres of karyosomes.

(5) Chromocentres

In the interphase nucleus of certain cells, some areas of considerable size take darker stain than the rest of the chromatin. These darkly stained areas are actually heterochromatic regions of the chromosomes. There can be only one or many heterochromatic regions of several chromosomes or of all the chromosomes of the nucleus.

Functions of Nucleus

The nucleus is the controlling centre of the cell. It controls all the metabolic activities of the cell by controlling the synthesis of enzyme required there in. The nucleus control the inheritance of characters from parents of offsprings. It is responsible for the development of characters.

Q.15. Write an essay on Cilia and flagella.

Ans. **Cilia and Flagella : Structure and Function**

Distribution : Cilia and flagella are specially divided into minute filamentous appendages which are external to the cell, but have their origin in the cytoplasm. These are related to the movement and are associated with a variety of plant and animal cells, gametes and zoospores.

Comparison between cilia and flagella : Cilia and flagella appear morphologically similar but have many differences

Cilia	Flagella
1. Each cell has hundreds or thousands number of cilia.	Each cell has one or two or rarely more number of flagella.
2. They occur all over the cell surface	They occur at one or the other end of cell.
3. These are short, varying from 5-10 μ	Flagella are longer, upto 150 μ .
4. Movement (i) Show pendular or sweeping movement	Each flagellum shows undulatory movement.
(ii) Show co-ordinated movement.	Each flagellum shows an independent movement.



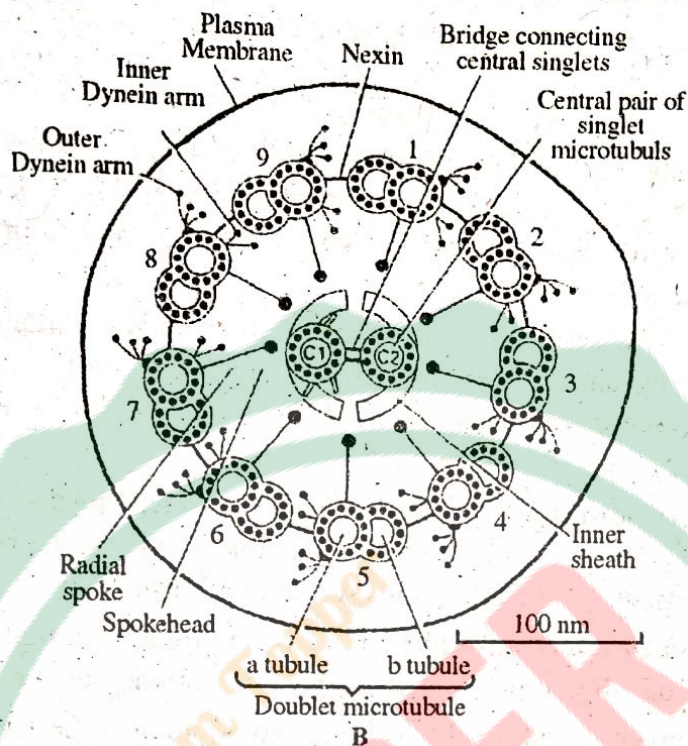


Fig. A-B. Flagellum : A. Diagrammatic representation of a flagellum. B.

Structure

The cilia and flagella have the same basic internal structure. A typical flagellum is enveloped by a 95 Å thick unit membrane. The flagellar structure is complex and consists of a **shaft or axoneme**, **basal plate**, **basal body** and the **rootlets**.

All eukaryotic cilia and flagella are similar in having a central bundle of microtubules known as **axoneme** or **shaft**. It is made of nine outer or peripheral doublet microtubules which surround a central pair of singlet microtubules. This is called '9 + 2' arrangement. Each peripheral microtubule is about 360 Å in diameter and consists of sub fibres or A & B tubes. A is a complete microtubule with 13 protofilaments while the tubule B contains 10 protofilaments. The central microtubule is about 250 Å in diameter.

The central pair of singlet microtubules are surrounded by a fibrous structure called the **inner sheath**. These are also connected with each other by bridges. A second set of linkers, composed of the protein **nexin** joins adjacent outer doublet microtubules. Radial spokes radiating from central singlets to each A tubule of outer doublets form the third linkage system.

At its point of attachment to the cell, the axoneme connects with the **basal body**, **centrioles**, **basal bodies** are cylindrical structures about 0.4 µm long and 0.2 µm wide. Each is made of nine triplet microtubules. Each triplet contains one complete 13-protofilament microtubule termed as the A tubule.

It is fused to the incomplete B tubule which in turn is fused to the incomplete C tubule.

Movement

1. Flagellar movement : Flagella show undulatory movement. These beat independently to produce planer or helical waves which begin either at the base or the tip. When the wave moves from base to the tip, the cell is pushed along.

In some cases flagella possess lateral hair called flimmer filaments. When a flagellum shows movement towards the tip, the cell is pulled and not pushed. This type of flagellum is called tinsel type while the other without hair is known as whiplash type of flagellum.

2. Ciliary movement : These beat transversely placed cilia beat in co-ordination or synchronously i.e. longitudinal rows of cilia beat together. Ciliary movement shows following two types of strokes :

(i) **Power or effective stroke :** The cilium propels through surrounding fluids like a oar thus propelling the organism forward in the water.

(ii) **Recovery stroke :** The cilium bends along its length while it is pulled forward in a flexed position.

Functions :

- (1) Locomotion of cell or organism.
- (2) To create water and food currents.
- (3) Elimination of solid particles.

Q.16. Differentiate between extrinsic (peripheral) and intrinsic (integral) proteins of plasma membrane.

Ans.

	Peripheral Protein	Integral Protein
1.	Present on the surface of plasma membrane.	Buried in the lipid bilayer either partially or completely.
2.	Spectrin of erythrocytes, cytochrome C and ATPase of mitochondria and acetyl cholinesterase in electroplax membranes.	Membrane-bound enzymes, drug and hormone receptors, rhodopsin
3.	Free of lipids	Associated with lipids
4.	Can be isolated from plasma membrane by mild treatment.	Cannot be isolated easily by mild agents.

Q.17. Give differences between passive transport, facilitated diffusion and active transport.

Ans.

	Passive Transport	Facilitated Diffusion	Active Transport
1.	Movement of metabolites is from high to low concentration	Same	Movement of metabolites is from low to high concentration
2.	No carrier protein participates, plasma membrane remains passive.	Carrier protein molecules pick up the metabolites forming carrier-protein transportant complex and carry it through plasma membrane to release it inside the cell	Same
3.	No energy is spent during this process		Energy is spent for the process and is obtained from ATP.

Q.18. Write a note on sodium-potassium pump.

Ans. Pumping of sodium and potassium ions through the plasma membrane found against electrochemical gradient. The enzyme $\text{Na}^+ - \text{K}^+ \text{Na ATPase}$ actively transports Na^+ and K^+ ions. Enzyme ATPase hydrolyses ATP to ADP and releases energy. Three Na^+ ions are pumped out of the cell and two K^+ ions are pumped into the cell.

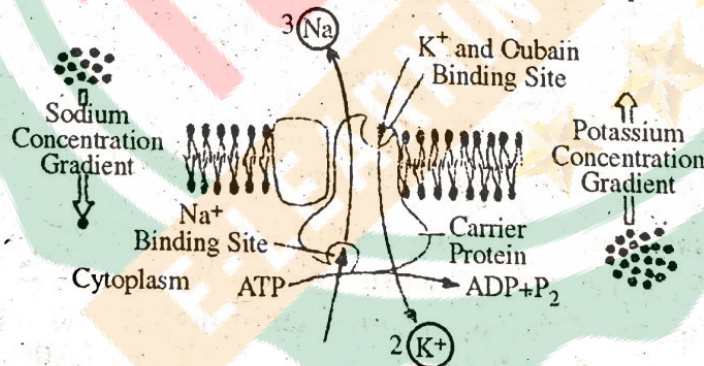


Fig. Transport of Na^+ and K^+ ions across the plasma membrane.

Q.19. What do you mean by membrane system?

Ans. **Cytoplasmic Endomembrane System**

The cytoplasmic endomembrane system or vacuolar system shows the entire system of intracellular membranes and membrane bound vesicles that traverse the cell cytoplasm. Its main components are :

1. Endoplasmic reticulum
2. Lysosomes
3. Nuclear envelope
4. Peroxisomes
5. Golgi complex
6. Glyoxisomes

The endomembrane system is associated with the sequencing, packaging and transport of substances produced either for use within the cell or for export to the outside.

☛ **Q.20. What is 'unit membrane concept' ?**

Ans. Robertson's Unit Membrane Concept

Robertson (1959) described 'trilaminar structure of plasma membrane consisting of two parallel outer dense osmophilic layers of 2.0-2.4 nm (20-25Å) and a middle light coloured osmophilic layer of 30-35Å thickness.

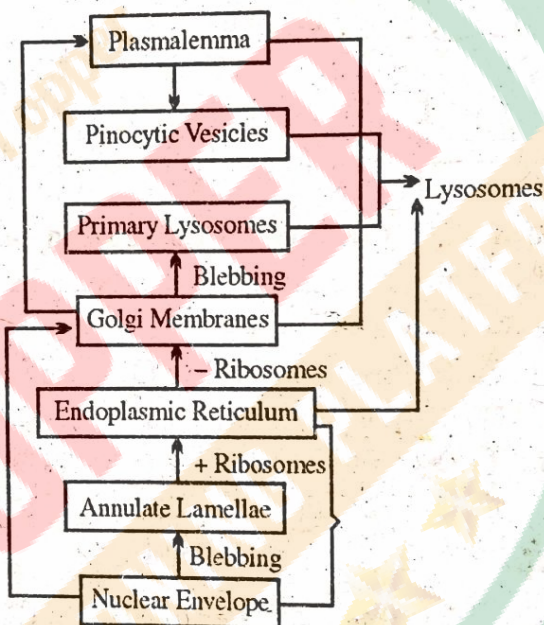
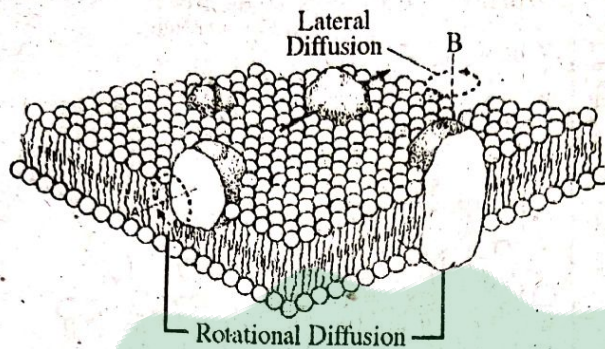


Fig. Inter-relationship of different cell membranes.

Robertson and others demonstrated that all biomembranes present inside the cells and around many cell organelles exhibit trilaminar structure. Robertson proposed 'Concept of Unit Membrane'. It indicates that various membranes found in the cell are inter-related and are basically derived either from nuclear membrane or plasma membrane.

☛ **Q.21. What do you understand by lipid fluidity or lipid mobility in relation to plasma membrane ? What factors contribute to lipid fluidity ?**

Ans. Lipid Fluidity or Lipid Mobility : Fluid mosaic model explains membrane structure reflects that lipids form a fluid crystalline bilayer at normal temperature. This provides flexibility to plasma membrane.



this permits transitional movements of lipid and intrinsic protein molecules inside the membrane.

Factors Contributing to Fluidity of Plasma Membrane : The fluidity of lipids depends on the transition of lipid molecules from crystalline gel-form to liquid crystalline form. This, in turn depends upon :

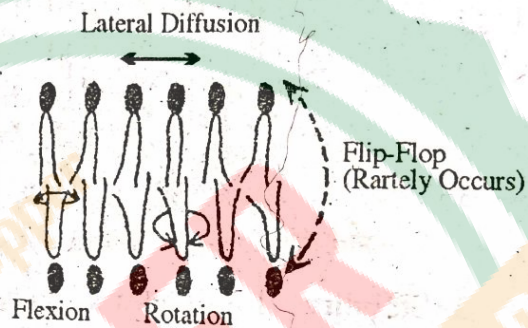


Fig. Different types of movement of protein molecules lipid bilayer.

1. **The degree of saturation of hydrocarbon chain in lipids :** The unsaturated fatty acids with double or triple bonds have lower melting point than saturated fatty acids.

2. **Cholesterol interferes with the formation of crystalline gel form :** The membranes containing cholesterol are fluid.

The lipid fluidity permits freedom for free molecular movement. The lipid molecules in the biomembranes may exhibit flexion, rapid lateral diffusion, flip-flop and rotation.

Q.22. Describe structure and importance of glycocalyx.

Ans. Structure : It is a thin film all along the cell surface except in the regions of tight junctions, occur in all animal cells. It forms a fuzzy coat on the free surface of intestinal absorptive cells and is formed of mucopoly- saccharides. The cell coat has negatively charged sialic acid termination which can bind Ca^{++} and Na^{++} ions.

Functions of Glycocalyx : Glycocalyx serves following functions :

1. **Protection :** It forms a protective covering on the cells of gastrointestinal tract preventing physical and chemical damage to their cell membranes.

2. **Filtration :** The glycocalyx surrounding the capillaries of kidney glomeruli acts as filter and regulates the passage of molecules.

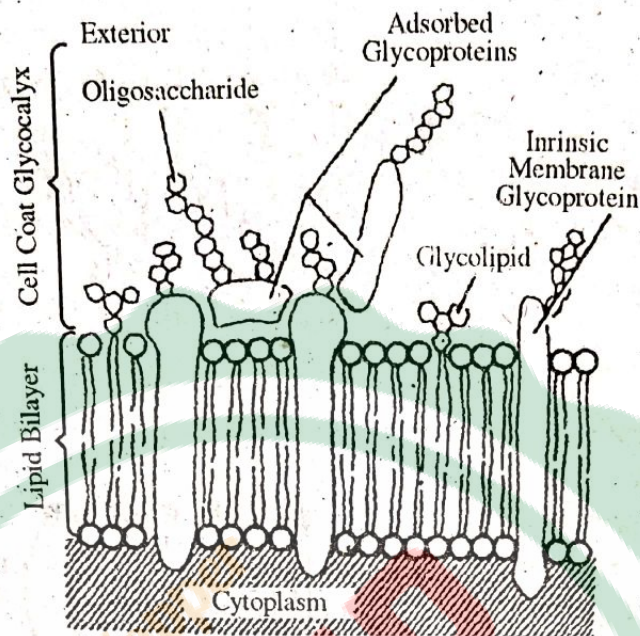


Fig. Glycocalyx on the surface of intestinal epithelium

3. **Stability** : It provides stability to be plasma membrane.

4. **Enzymes** : The glycocalyx on the surface of microvilli in the intestinal cells contains enzymes for the digestion of carbohydrates and proteins.

5. **Maintenance of microenvironment of the cell** : It confers an electrostatic charge on the cell surface and definite pH, and helps in establishing contacts with other cells.

6. **Molecular recognition** : The glycoproteins and glycolipids of cell coat contain many molecular entities e.g., formation of synaptic contact between the neurons.

7. **Antigenicity** : The plasma membrane of erythrocytes has specific antigens for A, B and O blood groups.

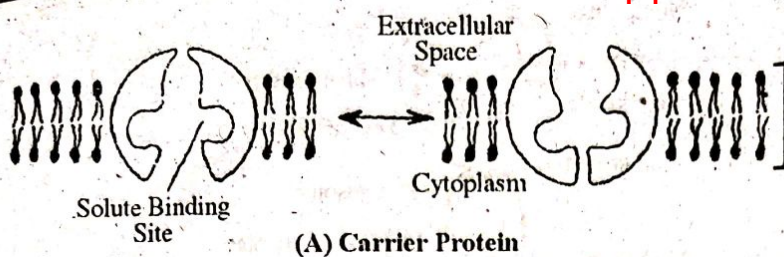
8. **Cellular recognition** : Glycoproteins bacteria recognize each other and male bacteria recognize female bacteria, the paramecia of different mating types recognize each other and the human body tissue recognizes a grafted heart, skin or kidney as being foreign entities to reject it.

Q.23. Summarise various functions of proteins of biological membranes.

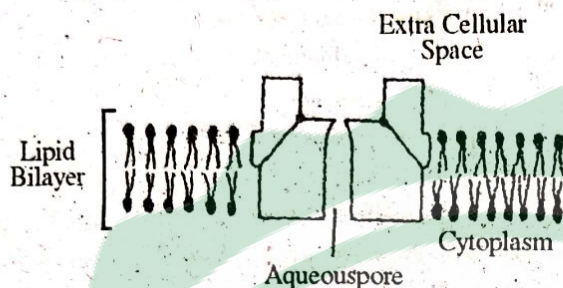
Ans. Biological membranes contain three different classes of proteins that carry out different functions.

1. **Structural proteins** form backbone of cell membrane. These provide elasticity and mechanical stability to plasma membrane. These have little catalytic activity.

2. **Enzyme** are catalytic proteins. In many parts of cells and in many types of cells these enzymes carry out different biological reactions.



(A) Carrier Protein



(B) Channel Protein

Fig. A simplified schematic representation of carrier protein and channel protein.

3. Membrane transport proteins or permeases serve for the transport of polar molecules of several substances like ions, monosaccharides, amino acids, nucleotides and certain metabolites across the plasma membrane in and out of the cell. Each transport protein is designed to transport a particular class of molecules. These are basically multipass transmembrane proteins, projecting on both the sides of lipid bilayer and traversing it multiple times. These are of two types :

(i) **Channel proteins** are water filled pores that extend across the lipid bilayer. When these pores are open, they allow specific solutes to pass through them across the membrane.

(ii) **Carrier proteins or carriers or transporters** bind the specific solute to be transported by active transport i.e., these undergo conformational change in order to transfer the solute across the membrane.

4. Glycoproteins act as cell receptors and cell antigens.

5. Lipoproteins are drug receptor proteins.

Q.24.. Discuss the role of golgi body in spermatogenesis.

Ans. Formation of Acrosome or Role of Golgi Body in Spermatogenesis: The acrosome of spermatozoon is derived from Golgi complex of the spermatid.

In a spermatid the Golgi complex is formed of many vesicles or small vacuoles in the centre surrounded by certain rows of concentrically arranged cisternae. As the differentiation proceeds, the arrangement of cisternae becomes irregular and one or two vacuoles enlarge to replace the vesicles.

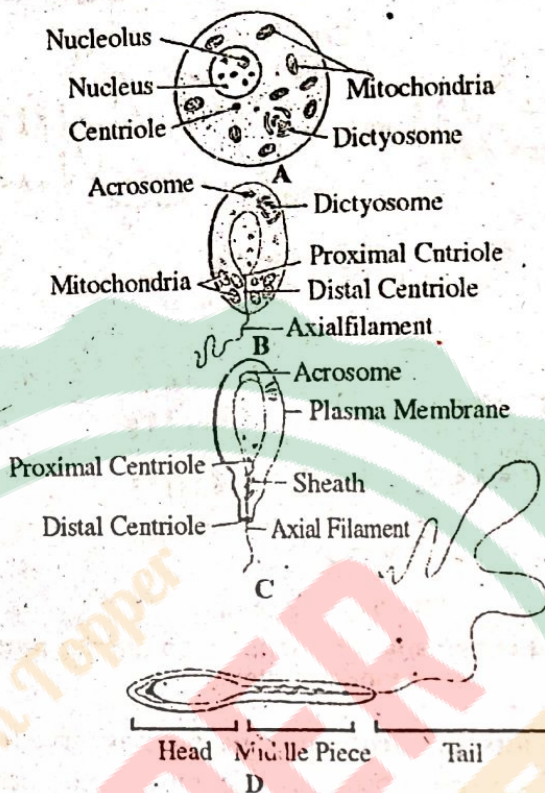


Fig. Formation of acrosome from Golgi complex

Inside each large vacuole appears a small dense body, the proacrosomal granule. If more than one vacuoles and proacrosomal granules are formed, these fuse together so that only one is left in the end. The vacuole, with its acrosomal granule enlarges in size, migrates towards the anterior pole and gets attached to the tip of elongated nucleus forming a sort of cap. The proacrosomal granule enlarges further and forms the acrosomal granule. It forms core of the acrosome. The vacuole loses its liquid content, spreads over the acrosomal granule and half of the nucleus forming a double sheath at the terminal end of the head of spermatozoon, is known as the acrosome cap. The remainder of Golgi body undergoes a gradual regression and is discarded as 'Golgi rest' together with the cytoplasm of spermatid.

Q.25. Write a note on annulate lamellate.

Ans. The membranes of endoplasmic reticulum are continuous without any pores and pore complexes. But in some cells some membranes of ER possess pores and pore complexes. These show annulate lamellae. These were first described by McCulloch (1952).

The annulate lamellae occur in the cells of invertebrates, in the immature oocytes and spermatocytes of vertebrates and the embryonic and foetal cells which have a high rate of metabolism.

These are double membrane sheets. About 2-12 lamellae are arranged to form stacks. Structurally, these are similar to the nuclear membrane. It is

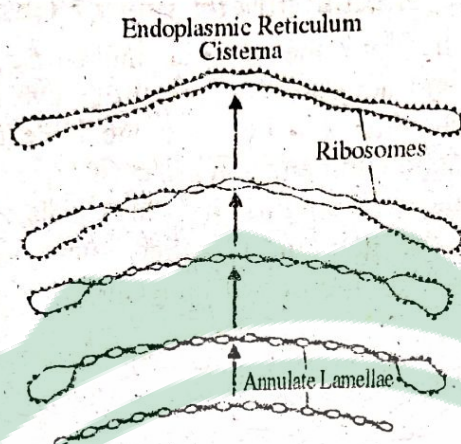


Fig. Formation of cisternae of endoplasmic reticulum from annulate lamellae.

evidenced that annulate lamellae arise from the nuclear membrane. The outer membrane of the nuclear envelope forms finger-like processes and pinched off into the cytoplasm in the form of vesicles known as blebs. This process is known as blebbing. These vesicles migrate towards the periphery of the cells in rows and fuse to form cisternae.

● **Q.26. Write a short note on Mitochondrial ribosomes.**

Ans. Mitochondrial Ribosomes (mt. ribosomes)

Mitochondrial ribosomes found either freely in the mitochondrial matrix or attached with the membranes of cristae. The sedimentation coefficient of mitochondrial ribosomes in yeast, fungi, protozoans and higher plants varies from 70S to 80S. In mitochondria of animal cells, the mit. ribosomes have 50-80S sedimentation coefficient. These contain only two types of ribosomal RNA. In animal mitochondria, the large subunit contains 16S to 18S rRNA and small subunit has 12S to 12S RNA.

Mitochondrial ribosomes synthesise mitochondrial proteins which form respiratory or oxidative enzymes.

● **Q.27. Write a short note on Chloroplast ribosomes.**

Ans. Chloroplast Ribosomes (chl. ribosomes) : Chloroplast ribosomes are similar to prokaryotic ribosomes. These have sedimentation coefficient of 70S and are formed of two subunits 50S and 30S. The large subunit contains 5S, 23S RNA and small subunit has 16S RNA. These are similar in all groups of plants.

● **Q.28. Define polysome or polyribosome.**

Ans. Polysome or Polyribosome : During protein synthesis, when a number of ribosomes are aligned in line on a molecule of mRNA, this structure is known as a polysome or polyribosome. The ribosomes dissociate off the mRNA after synthesising protein molecules.

Q.29. What is photosynthetic unit or Quantasome ?

Ans. A photosynthetic unit is the minimum number of pigment molecules in a chloroplast and act co-operatively to evolve one molecule of O_2 during photochemical synthesis of one molecule of glucose. It is known as a reaction unit and comprises of approximately 300 pigment molecules. Park and Biggins in (1964) isolated structures the unit membrane of the granum, is called quantasomes. A quantasome contain nearly 230 chlorophyll molecules and other pigments.

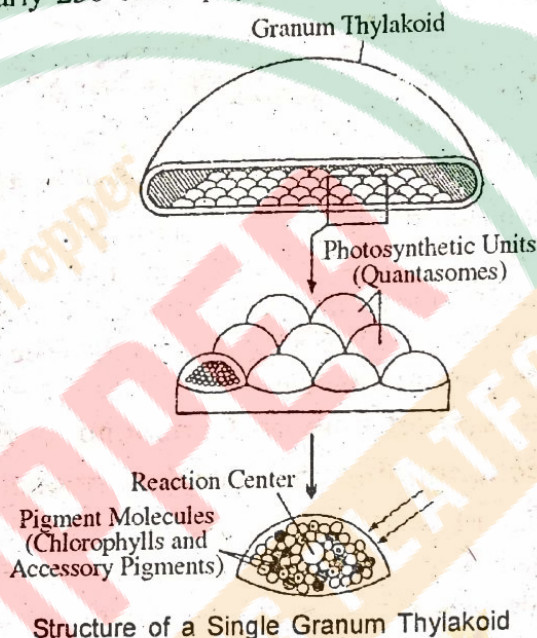


Fig. Single granum disc and photosynthetic units and its reaction centre.

A quantasome have one or two molecules of photosystem (P-700) and about 230 molecules of photosystem II. The molecules of pigment II absorb light energy, light harvesting unit. It transfer light to long wave absorbing pigment P700. P700 thus get oxidized and release an electron.

Two photosystems PS-I and PS-II are said to be associated with reaction of photosynthesis. The pigments of reaction centre and of light harvesting molecules together form one photosynthetic unit.

Q.30. Explain the phenomenon of cyclic electrons transport pathway.

Ans. Cyclic Electron Transport Pathway : Cyclic electrons transport found only when synthesis of carbohydrate is curtailed due to limited supply of CO_2 . As a result NADH begins accumulating. Cyclic electrons transport pathway is completed in the following steps :

(i) Light harvesting pigments of PS-I absorb solar energy and transfer to reaction centre P_{700} . Electrons of its outer circle get excited with the energy and are captured by primary acceptor of PS-I.

(ii) Primary acceptor transfers these electrons to ferredoxin.

(iii) Ferredoxin is unable to reduce NADP^+ and returns electrons to PS-I via electron acceptors of the chain, cytochrome b_6 , plastoquinone (PQ), cytochrome f and plastocyanin.

This electron transport in PS-I is known as cyclic because electron transmitted from PS-I returns back to PS-I passing through carriers. At each step, the electrons lose potential energy. The proton gradient helps in ATP synthesis. Therefore, this is also known as cyclic photophosphorylation. ●

☛ **Q.31. What is photophosphorylation or photosynthetic phosphorylation ?**

Ans. It is the process of transfer of phosphate group to ADP for synthesis ATP utilising solar energy. It is synthesised on ATPase complexes, present on the surfaces of thylakoid membranes.

In this period photosynthetic electron transport, hydrogen proton (H^+) released by photolysis of water accumulate in the intermembranous space of thylakoids. Their accumulation increase, proton gradient in the thylakoid space. Therefore, protons flow out through ATPase complex along the concentration gradient. During this flow, enzyme ATP-synthetase carries out synthesis of ATP from ADP and inorganic phosphate P_i . In this process one ATP molecule is generated from 3H^+ . ●

☛ **Q.32. Discuss a few common diseases produced due to defects in the normal functioning of lysosomes.**

Ans. Abnormal defects in the normal functioning of lysosomes produce following diseases :

1. **Silicosis** : In industrial workers inhalation of silica or asbestos fibres causes silicosis disease. The macrophages in the lung ingest silica fibres to remove them from the air we respire. The fibres become enclosed of silica fibres in the lysosomes make their plasma membrane leaky. The hydrolytic enzyme causes damage.

2. **Rheumatoid arthrities** : Rheumatoid arthrities is inflammatory disease of body joints. This is caused by the release of lysosomal enzymes from the cell into the extracellular space, causing damage to the material. ●

☛ **Q.33. Differentiate between autophagic vacuoles and digestive vacuoles.**

Ans. Autophagic Vacuoles and Digestive Vacuoles : Autophagic vacuoles digest intracellular cell organelle and formed only in special physiological conditions. These contain hydrolytic enzymes of primary lysosome and some cell membranes of their own cell. These result in autodissolution or autodigestion.

Digestive vacuoles digest some foreign substances or organism. These are formed by the fusion of primary lysosomes and phagosomes. ●

Q.34. Write a short note on peroxisomes.

Ans. These are found in all eukaryotic cells. These were first observed by **Rhodin (1954)** in kidney cells of rat and were named peroxisomes by **deDuve** in 1965.

Structure : These are microbodies having a diameter 0.5–1.5 μm . These are bounded by single membrane and enclose enzymes peroxidases and catalases. They produce hydrogen peroxide by their degradative activity. The enzymes present are

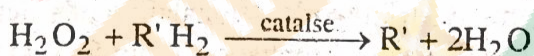
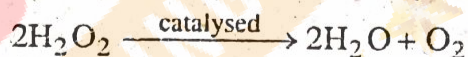
1. D-amino acid oxidase, 2. NADH-glyoxylate reductase, 3. catalase, 4. uric acid oxidase, 5. -hydrolytic acid oxidase.

Functions : Peroxisomes are associated with following activities :

1. Oxidation or respiration : Mitochondria, peroxisomes also help in cell respiration. In green plants, these carry out photorespiration. The peroxisomal enzymes are of two types :

(i) Peroxisomal oxidases : Such as urate oxidase, glycolate oxidase and amino acid oxidase catalyse oxidation or variety of substrates and transfer hydrogen atoms to molecular oxygen, forming hydrogen peroxide is highly toxic.

(ii) Peroxisomal catalase enzyme immediately breaks down H_2O_2 to H_2O and oxygen or uses H_2O_2 to oxidise substances such as phenols, formic acid, formaldehyde and alcohol, etc.



2. Permeability : Membrane binding the peroxisomes are highly permeable and allows inorganic ions and substances with low molecular weight pass through its membrane.

Q.35. Write a note on nucleolar cycle.

Ans. The nucleolus as an organised bdy is lacking in continuity. During mitosis, it undergoes cyclic changes and disappears at the starting of cell division and is formed again at the end of cell division in telophase.

The nucleolus is formed at a definite region by one or more chromosomes of a haploid set. These chromosomes are known as nucleolar chromosomes. Diploid species majority possess two nucleolar chromosomes in each diploid or somatic cell. But in man chromosomes numbering 13, 14, 15, 21 and 22 participate in the formation of nucleolus. The specific region of these chromosomes active in nucleolar formation is called as nucleolar organiser zone or nucleolar zone. The nucleolar organiser carries genes for 18S and 28S ribosomal RNA.

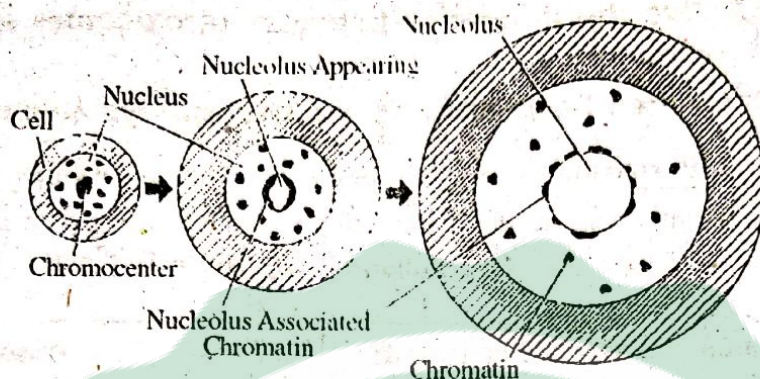


Fig. Different steps in the biogenesis of nucleolus after cell division.

During prophase, the amorphous part of nucleolus disappears, and chromatin loop is withdrawn into the nucleolar organiser. During telophase nucleolus is reorganised in the following two steps :

1. The convoluted chromatin loop uncoils from the nucleolar organiser and gets surrounded by fibrillar and granular material.
2. The nucleolus matrix and its basic proteins and RNA are produced within the chromocentre and are liberated in small perinucleolar bodies.

Q.36. Write the difference between non-cyclic and cyclic electron transport pathway.

Ans. Difference between Non-cyclic and Cyclic Electron Transport Pathway

Non-cyclic Electron Transport	Cyclic Electron Transport
1. It involves participation of both PS-II and PS-I.	It involves participation of only PS-I.
2. Electron transfer occur from PS-II to PS-I through an electron transport chain and from PS-I to NADP^+ . Thus transport of electrons is noncyclic.	Electron transfer occurs from PS-I and returns back to PS-I through electron transport chain. So the transport of electron is cyclic.
3. Photo-oxidation or photolysis of water results in splitting of water into H^+ and e^- and O_2 .	Photo-oxidation of water does not occur.
4. It produces ATP and reduction of NADP to NADPH, which are used by dark reaction for sugar synthesis.	It produces only ATP.
5. It found under normal conditions.	It found only when NADPH is accumulated.

Q.37. Give the difference between peroxisomes and lysosomes.

Ans. Difference between peroxisomes and lysosomes.

Peroxisomes	Lysosomes
1. Peroxisomes are occur in animal cells and in leaves of higher plants.	Lysosome are occur in animal cells and a few plant cells.
2. Contain peroxidases and catalases enzymes	Contain tissue dissolving or hydrolytic enzymes.
3. Help in release of energy.	Help in intracellular digestion or cell dissolution
4. Carry out photorespiration in green plants.	Are responsible for hydrolysis of organic molecules and dissolving of hydrolytic enzymes.

Q.38. Compare Calvin cycle and Hatch-Slack Cycle.

Ans. Comparison between Calvin Cycle and Hatch-Slack Cycle

Calvin Cycle	Hatch-Slack Cycle
1. The primary acceptor of CO_2 is RuBP, a 5-carbon compound.	The primary acceptor of CO_2 is PEP, a 3-carbon compound.
2. It can not operate under very low CO_2 concentration.	It can operate under very low CO_2 concentration.
3. The first stable product is 3-PGA, a 3-carbon compound.	The first stable product is OAA, a 4-carbon compound.
4. CO_2 once fixed is not released back.	Fixed CO_2 is released back in bundle sheath cells where it is finally fixed and reduced by Calvin cycle.
5. There is a net gain of one hexose sugar of 6 CO_2 molecules fixed and reduced.	There is no such gain.
6. It operates in all the plants.	It operates in C_4 plants only.
7. It has a slower rate of CO_2 fixation.	It has a faster rate of CO_2 fixation.

8. Fixation of one molecule of CO_2 requires 3 ATP and 2 NADPH_2 molecules.	Fixation of one molecule of CO_2 requires 2 ATP molecules in addition to that required in C_3 cycle.
9. Optimum temperature for the operation of C_3 cycle is $10-25^\circ\text{C}$	Optimum temperature for the operation of C_4 cycle is $30-45^\circ\text{C}$.

Q.39. Compare peroxisomes and glyoxysomes.

Ans.

Peroxisomes and Glyoxysomes

Peroxisomes	Glyoxysomes
1. Peroxisomes are found in animal cells and leaves of higher plants.	Glyoxysomes are found in plant cells and are abundant in endosperm of germinating seeds.
2. It contain enzymes-peroxidases and catalases.	It contain enzymes peroxidases, catalases and enzymes of glyoxylate cycle.
3. They carry out photorespiration.	These are associated with triglyceride metabolism.
4. In peroxisomes hydrogen atoms are oxidised to hydrogen peroxide (H_2O_2) which is degraded into H_2O and oxygen.	Transform stored fat into carbohydrates by glyoxylate cycle.

Q.40. Write the difference between primary and secondary lysosomes.

Ans.

Primary and Secondary Lysosomes

Primary Lysosomes	Secondary Lysosomes
1. Primary lysosomes or lysosomes are newly formed lysosomes.	Secondary lysosomes are formed by the fusion of phagosome and primary lysosome
2. These are also called storage granules	These are also called heterolysosomes, phagolysosomes or heterophagic vacuoles.
3. These contain hydrolytic enzymes	These contain lysosomal enzymes and substance or organism to be digestion or dissolved.

Q.41. Give the difference between Centrosomes and Centriole.

Ans. Centrosome and Centriole : Centrosome also known as microcentrum is the clear zone of cytoplasm surrounding the centriole. Centriole also known as cell centre is a cylindrical body formed of 9 microtubules of fibres that are arranged equidistant in a circle around an imaginary axis. These help in spindle formation during cell division and form basal bodies of cilia and flagella.

Q.42. Compare ribosome and lysosome.

Ans. Ribosome and Lysosome : Ribosomes are the granules of protein and RNA occur in the cytoplasm. These are often attached to endoplasmic reticulum. These are the site of protein synthesis.

Lysosomes are cytoplasmic organelles of cells and contain digestive enzymes for intracellular digestion of bacteria and other foreign bodies those enter the cells by the process of phagocytosis or pinocytosis. They may cause cell destruction.

Q.43. Write the difference between SER and RER.

Ans. Difference between SER and RER

SER	RER
1. Ribosomes are not associated with this type of ER.	Ribosomes are associated.
2. These are made of vesicles and tubules.	Mostly made of cisternae and a few tubules.
3. If Develops from RER due to movement of ribosomes.	Generally formed by the outer nuclear membrane.
4. Ribophorins absent.	Ribophorins help in association of ribosomes with RER.
5. Mainly present in lipid forming cells. e.g., adipocytes.	Mainly occur in protein forming cells, e.g., goblet cells, plasma cells, etc.

Q.44. How would you distinguish between microtubules and microfilaments.

Ans. Difference Between Microtubules and Microfilaments

Microtubules	Microfilaments
1. It occur in centrioles, basal bodies, cilia, flagella, astral rays, spindle fibres, etc.	It occur below the cell membrane.

2. Its is hollow and made of 13 protofilaments and consist of α & β tubulin protein	Hollow, and Longitudinal sub-units lacking and Formed of protein actin.
3. It's diameter about 25 nm.	Diameter about 6 nm.
4. Its functions are : Non-contractile, Microcirculation, No role in endocytosis	Contractile, Cytoplasmic streaming, Involved in endocytosis.

Q.45. Write the difference between primary and secondary Cell wall.

Ans. Difference between Primary and Secondary Cell Wall

Characters	Primary cell wall	Secondary cell wall
1. Distribution	In all plant cells	Only in some plant cells.
2. Position	Formed inner to middle lamella.	Deposited inside the primary wall.
3. The process of deposition	Materials deposited by intussuception or addition of materials inside the wall.	By apposition or deposition of material on materials already present.
4. Chemical nature	(a) Low cellulose content.	(a) Relatively high amount of cellulose.
	(b) High amount of proteins	(b) Relatively low amount of proteins.
	(c) High amount of hemicellulose.	(c) Relatively lesser in amount.
	(d) Deposits of other substances not common.	(d) Additional depositions of lignin, suberin, etc. are common.
5. Thickness	Thin	Thick

Q.46. Discribe the detailed account of the structure and function of chloroplast.

Ans.

Chloroplast

The chloroplasts in green plants constitute the photosynthetic apparatus. Typically, the chloroplasts of higher plants are discoid or ellipsoidal in shapes. 4-6 μ in length and 1-2 μ thick. The chloroplast is bounded by two unit membranes each app. 50 Å thick and consisting of lipids and proteins. The thickness of the two membranes including the space

enclosed by them is app. 300 Å. Internally the chloroplast is filled with a hydrophilic matrix called as **stroma** in which are embedded **grana**. Each granum has a diameter of .25-.8 μ and consists of 5-25 disk shaped **granulamellae** placed one above the other like the stack of coins. In cross section these lamellae are paired to form sac like structures and have been called as **thylakoids**. Each grana lamella or thylakoid encloses a space, the **loculus**. The ends of disk-shaped thylakoids are called as **margins** (which are fused to form sac like structure) while the contiguous membranes between two thylakoids form the **partition**. The grana lamellae or thylakoids consist of alternating layers of **lipids** and **proteins**.

Some of the grana-lamellae or thylakoids of a granum are connected with thylakoids of other grana by somewhat thinner **stroma-lamellae** or **fret membranes**. These also enclose spaces which are called as **fret-channels**.

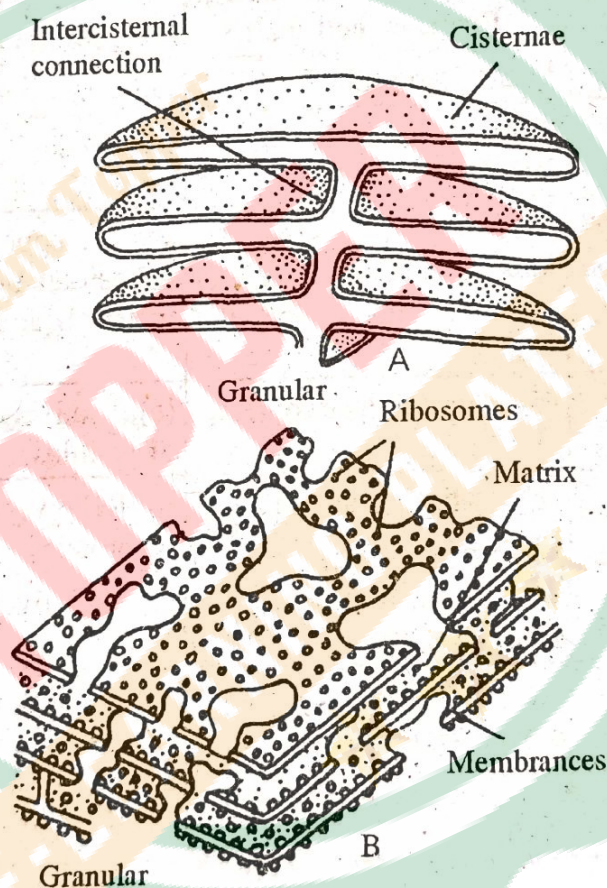


Fig. (A) Internal structure of a chloroplast,
(B) Enlarged thylakoids from two grana.

Chlorophylls and other photosynthetic pigments are confined to grana. The latter are the sites of **primary photochemical reaction**. **Weier and Benson** (1966, 1967) have also included chlorophyll molecules in the fret membranes in their model of the chloroplasts.

Besides necessary enzymes, some ribosomes and DNA have also been found in chloroplasts which give them (chloroplasts) a **partial genetic autonomy**.