# CELL BIOLOGY

# CELL : THE UNIT OF LIFE

## WHAT IS A CELL?

- All organisms are composed of cells. Some are composed of a single cell and are called unicellular organisms while others, like us, composed of many cells are called multicellular organisms.
- Unicellular organisms are capable of (i) independent existence and (ii) performing the essential functions of life.
  Anything less than a complete structure of a cell does not ensure independent living. Hence cell is the fundamental structural and functional unit of all living organisms.
- First cell discovered by - Robert Hooke in Cork
- Anton Von Leeuwenhoek first saw and described a live cell. Robert Brown later discovered the nucleus. The invention of the microscope and its improvement leading to the electron microscope revealed all the structural details of the cell.

## CELL THEORY

- In 1838, Matthias Schleiden, a botanist, examined a large number of plants and observed that all plants are composed of different kinds of cells which form the tissues of the plant. At about the same time, Theodore Schwann (1839), Zoologist studied different types of animal cells and reported that cells had a thin outer layer which is today known as the 'plasma membrane'. He also concluded based on his studies on plant tissues that the presence of cell wall is a unique character of the plant cells.
- Schwann proposed the hypothesis that the bodies of animals and plants are composed of cells and products of cells.
- Schleiden and Schwann together formulated the cell theory. This theory however did not explain as to how new cells were formed. Rudolf Virchow (1855) first explained that cells divided and new cells are formed from pre-existing cells (Omnis cellula-e cellula). He modified the hypothesis of Schleiden and Schwann to give the cell theory a final shape. Cell theory as understood today is:
  (i) All living organisms are composed of cells and products of cells.
  (ii) All cells arise from pre-existing cells.

## AN OVERVIEW OF CELL

- The onion cell which is a typical plant cell, has a distinct cell wall as its outer boundary and just within it is the cell membrane.
- Cells that have membrane bound nuclei are called eukaryotic whereas cells that lack a membrane bound nucleus are prokaryotic.
- In both prokaryotic and eukaryotic cells a semi-fluid matrix called cytoplasm occupies the volume of the cell.
- The cytoplasm is the main arena (zone) of cellular activities in both the plant and animal cells. Various chemical reactions occur in it to keep the cell in the 'living state'.
- Besides the nucleus the eukaryotic cells have other membrane bound distinct structures called organelles like the endoplasmic reticulum (ER), the golgi complex, lysosomes, mitochondria, microbodies. The prokaryotic cells lack such membrane bound organelles.

- ♦ Ribosomes are non-membrane bound organelles found in all cells both eukaryotic as well as prokaryotic cell. Within the cell, ribosomes are found not only in the cytoplasm but also within the two organelles chloroplasts (in plants) and mitochondria and on rough ER.
- ♦ Animal cells contain another non-membrane bound organelle called centriole which helps in cell division.

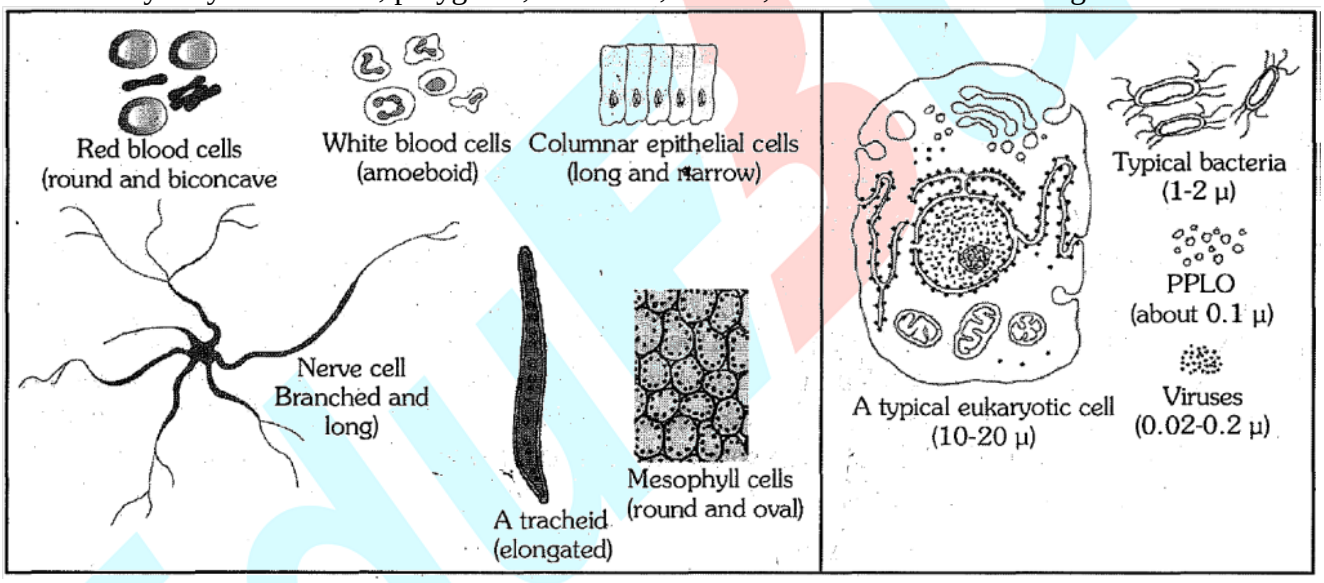
## SIZE AND SHAPE OF CELL

**Size :**

- Cell differ greatly in size, shape and activities.
- Mycoplasma (Smallest cells) Only 0.3 μm in length
- Bacteria = 3 to 5 μm
- Largest isolated single cell = egg of an ostrich.
- Human red blood cell ≈ 7.0 μm in diameter
- Nerve cell = longest cell

**Shape:**

- The shape of the cell may vary with the function they perform.
- They may be disc-like, polygonal, columnar, cuboid, thread like or even irregular.



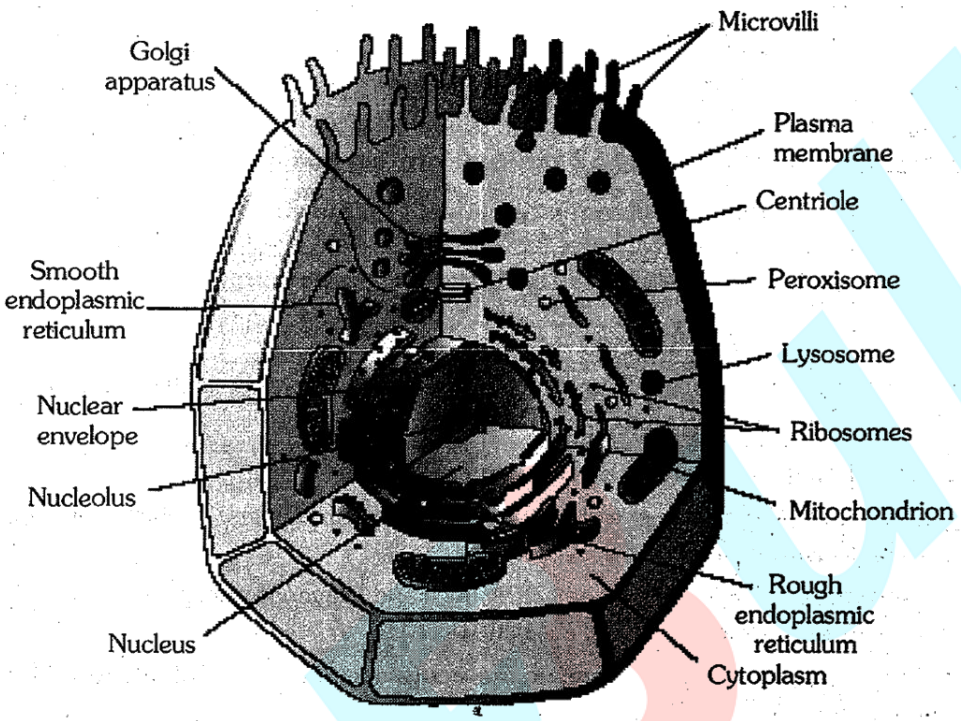

## PROKARYOTIC CELLS

- The prokaryotic cells are represented by bacteria, blue-green algae, mycoplasma or PPLO (Pleuro Pneumonia Like Organisms). They are generally smaller and multiply more rapidly than the eukaryotic cells.
- The organisation of the prokaryotic cell is fundamentally similar even though prokaryotes exhibit a wide variety of shapes and functions.

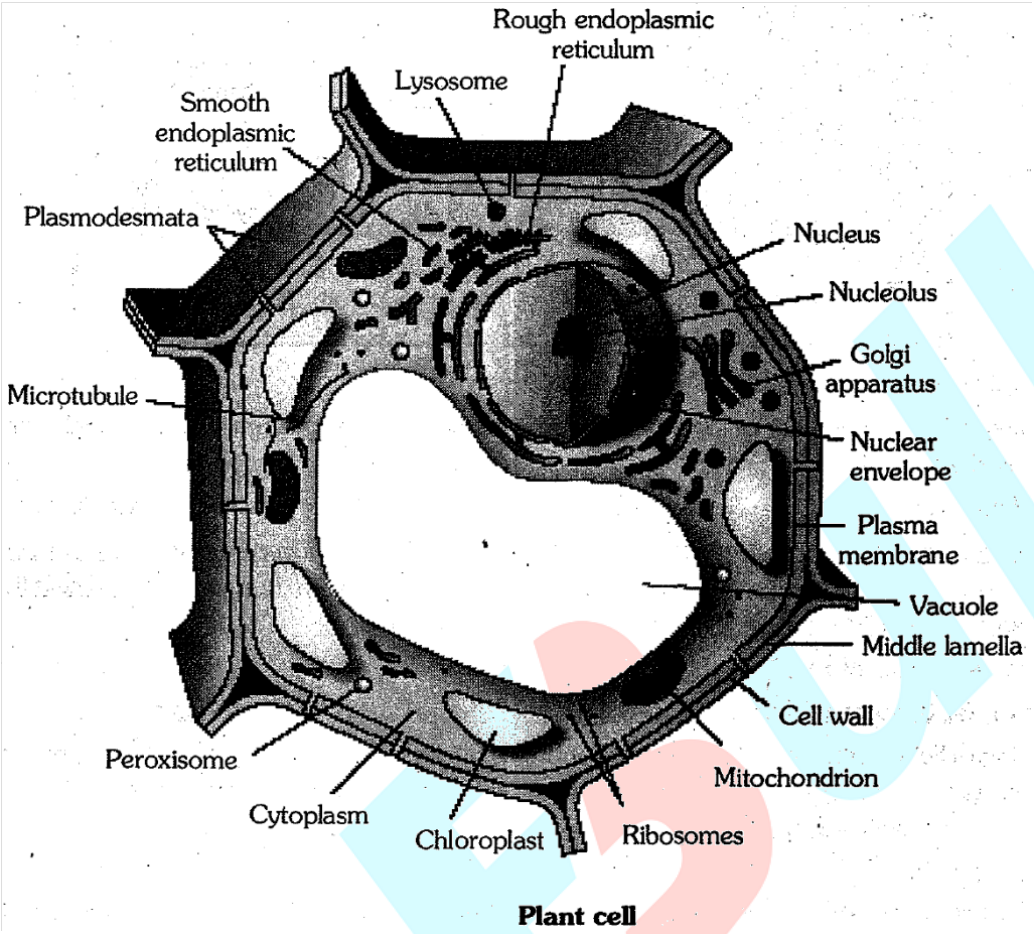
## EUKARYOTIC CELLS

- The eukaryotes include all the protists, plants, animals and fungi. In eukaryotic cells there is an extensive compartmentalisation of cytoplasm through the presence of membrane bound organelles.
- Eukaryotic cells possess an organised nucleus with a nuclear envelope. In addition eukaryotic cells have a variety of complex locomotory and cytoskeletal structures. Their genetic material is organised into chromosomes.

- All eukaryotic cells are not identical. Plant and animal cells are different as the former possess cell walls, plastids and a large central vacuole which are absent in animal cells. On the other hand, animal cells have centrioles which are absent in almost all higher plant cells.




**Animal cell**




**Plant cell**

## BIOMEMBRANES OR CELL-MEMBRAN

- Biochemical investigation clearly revealed that the cell membranes possess lipid, protein and carbohydrate. The ratio of protein and lipid varies considerably iri different cell types. In human beings the membrane of the erythrocyte has approximately 52 per cent protein and 40 per cent lipids

**Average composition of cell membrane**

Lipids = 40% (Phospholipid, Cholestrol, Glycolipids)
Proteins = 58-59% (Arginine, Lysine rich)
Carbohydrates = 1-2%

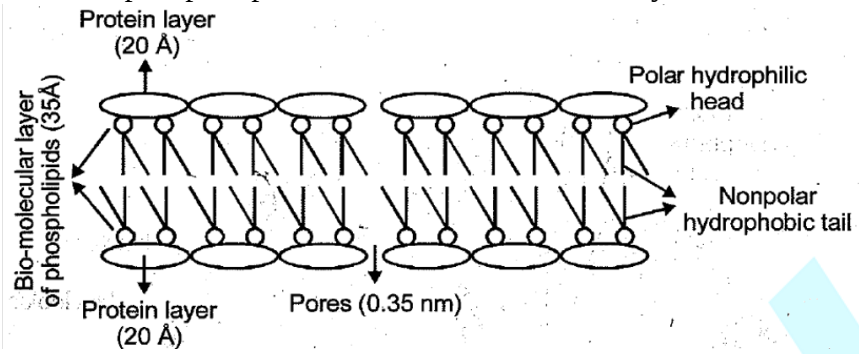
- It is a universal structure and structurally cell membrane of prokaryotes is similar to the eukaryotes.

**STRUCTURE. OF BIOMEMBRANES :**

**(1) Sandwitch or Trilamellar model :-** By Davson & Danielli (1935).

- According td this model, the plasma-membrane is made up of three layers in which a bimolecular layer of lipid is sandwitched between two single layers of proteins.
- According to this model each protein layer is 20Å thick and bilayer of phospholipid is 35Å thick. Thus total thickness is 75Å (PLLP – structure, range 75–100Å)
- Phospholipid molecule called as amphipathic molecule due to presence of two type of parts (hydrophilic head and hydrophobic tail).
- Hydrophilic head of the phospholipid binds with protein layer by hydrogen and ionic bonds.

- Hydrophobic tail of phospholipid are attached to each other by vanderwal force.




**(2) Unit membrane model :-** By Robertson 1959.

- According to this model all the cellular and organeller membranes are structurally & functionally similar (difference in chemically & size).
- Both of the above models are rejected because they fails to explain the selective permeability of plasmalemma.
- The detailed structure of the membrane was studied only after the advent of the electron microscope in the 1950s. Meanwhile, chemical studies on the cell membrane, especially in human red blood cells (RBCs), enabled the scientists to deduce the possible structure of plasma membrane.

**(3) Fluid mosaic model :-** By Singer & Nicolson (1972)

- This is latest & most widely accepted model for the structure of plasmalemma.
- According to fluid mosaic model proteins are arranged in phospholipid layer as mosaic pattern. Thus membrane is termed as "protein iceberg in a sea of phospholipid" or "Gulab Jamun (protein) in a concenterated solution (phospholipid) of sugar".

**(1) Phospholipids :**

- Phospholipid is the main component of cell membrane because it forms continuous structural frame of cell membrane.
- The studies showed that the cell membrane is composed of lipids that are arranged in a bilayer. Also the lipids are arranged within the membrane with the polar head towards the outer sides and the hydrophobic tails towards the inner part. This ensures that the nonpolar tail of saturated and unsaturated hydrocarbons is protected from the aqueous environment. The lipid component of the membrane mainly consists of phosphoglycerides (phospholipids).
- Phospholipid layer provides fluidity to plasma membrane because phospholipids are rich in unsaturated fatty acid which are liquid in nature.
- The Ouasifluid nature of lipid enable lateral movement of protein with in the overall bilayer. This ability to move within the membrane is measured as its fluidity.
- The fluid nature of the membrane is also important in various function like cell growth, formation of intercellular junction, endocytosis, secretion, cell division etc.
- Cholesterol is also present in plasma membrane. Cholesterol are more rigid than phospholipid. So it helps in stability of membrane structure.
- Cholesterol is absent in membrane of prokaryote. Thus Hopanoids (Pentacyclic sterol) provides stability to prokaryotic cell membrane.

**(2) Proteins :**

- Two types of protein are present in plasma membrane. (On the basis of ease of extraction)

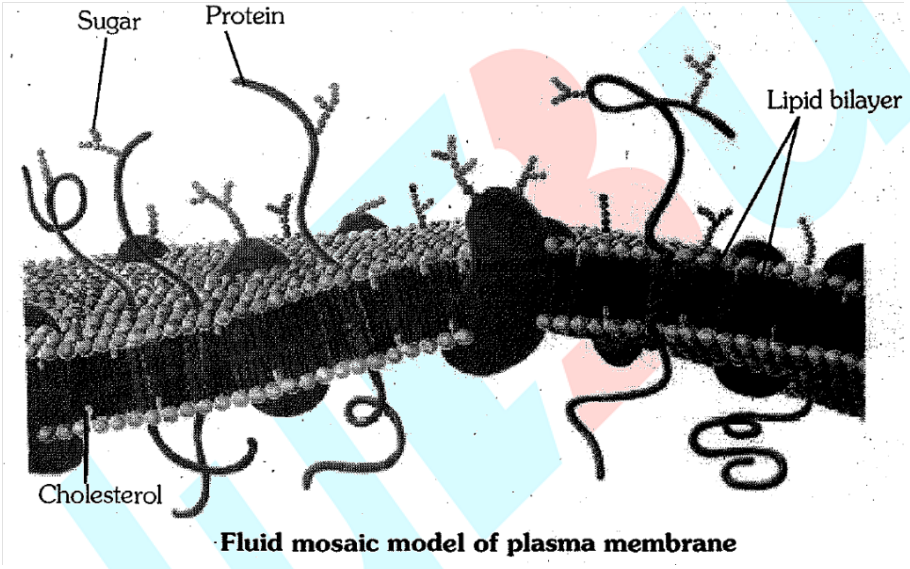
**(a) Integral or intrinsic protein**

- These protein are tightly binds with phospholipid. Thus, they can not easily removed from membrane.
- Integral proteins are of 2 types :
  (i) Partially buried (ii) Totally buried
- Some integral proteins which are totally buried through the complete thickness of membrane. These type of protein are called as tunnel (channel) protein which provide a passage for movement of water soluble material across the membrane.

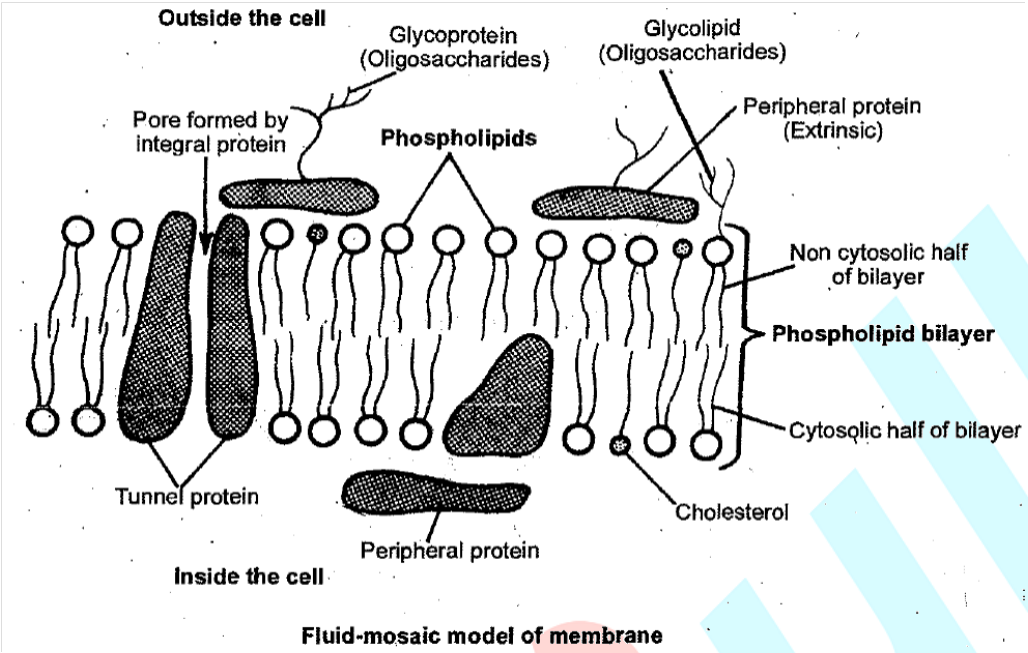
**(b) Peripheral or extrinsic protein**

- These are superficially arranged on the surface of lipid layer and can be separated easily. These protein have enzymatic activity.

- Oligosaccharides (sugar) of the glycolipids & glycoproteins on the outer surface of plasma membranes are involved in cell to cell recognition mechanism. Best example of cell recognition is fertilisation, (where sperm & egg recognize to each other) and blood - Antigens.



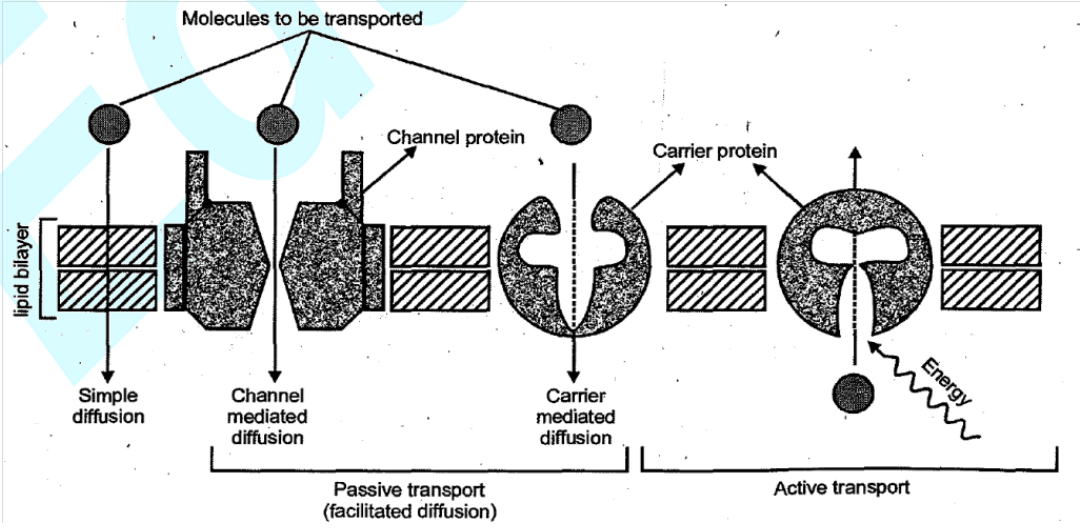

**Fluid mosaic model of plasma membrane**




**Fluid-mosaic model of membrane**

## TRANSPORT THROUGH PLASMA MEMBRANE

- One of the most important functions of the plasma membrane is the transport of the molecules across it. The membrane is selectively permeable to some molecules present on either side of it. Many molecules can move briefly across the membrane without any requirement of energy and this is called the passive transport.
- Neutral solutes may move across the membrane by the process of simple diffusion along the concentration gradient i.e. from higher concentration to the lower. Water may also move across this membrane from higher to lower concentration. Movement of water by diffusion is called osmosis.
- As the polar molecules cannot pass through the nonpolar lipid bilayer, they require a carrier protein of the membrane to facilitate their transport across the membrane.
- A few ions or molecules are transported across, the membrane against their concentration gradient. i.e. from lower to the higher concentration. Such a transport is an energy dependent process in which ATP is utilized and is called active transport, e.g. $Na^+$ / $K^+$ Pump.




### (i) Endocytosis (Bulk transport)

**(a) Pinocytosis or Cell Drinking :-** Ingestion of liquid material by plasmalemma in the form of vesicles or bag like structure (Pinosoine) is called pinocytosis.

**(b) Phagocytosis or Cell eating :-** Ingestion of solid complex materials by membranes in the form of vesicles (Phagosome) is called Phagocytosis.

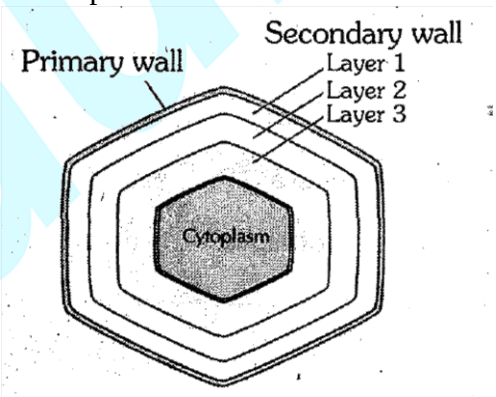
**(ii) Exocytosis/Emiocytosis/Cell vomitting :-** Egestion of waste materials from cell through plasma membrane.

## CELL WALL

- A non-living rigid structure called the cell wall forms an outer covering for the plasma membrane of Bacteria, Some protistan. Fungi, Algae and Plants.
- Algae have cell wall made of cellulose. galactans, mannans and minerals like calcium carbonate.
- In other plants cell wall consists of cellulose, hemicellulose, pectins and proteins.

| | | | |
|---|---|---|---|
| Cell wall | Primary wall | : | Thin, elastic<br>Composed of cellulose, hemicellulose & pectin.<br>Gradually diminishes as cell matures.<br>Capable of growth. |
| | Secondary Wall ($S_1$, $S_2$, $S_3$) | : | Rigid, thick.<br>Composed of cellulose, hemi–cellulose, Pectin.<br>Absent in meristem cells.<br>Inner side of primary wall (toward cell membrane). |
| | Tertiary wall | : | Present only in tracheids of Gymnosperm.<br>Composed of hemi cellulose & xylan. |
| | Middle lamella | : | Common layer between two cells. |

- Middle lamella is consist of Ca & Mg pectates (Plant cement). Amount of Ca is more.
- Cellulose is a main constituent of cell wall but addition to cellulose–Hemicellulose, Cutin, Pectin, Lignin, Suberin are also presents in cell wall.




- Cell wall worked as frame or protective layer of cell (Exoskelton of cell)
- Cellulose microfibrils and macro fibrils are arranged in layers to form skeleton of cell wall. In between these layers other substances like pectin, hemicellulose may be present. These form matrix of cell wall.
- Cell wall materials (Hemicellulose, Pectin, lignin) are synthesized in plant golgibodies or dictyosomes. Formation of cellulose occurs by cell membrane.
- **PLASMODESMATA :-** Name proposed by Strasburger (1901). These are cytoplasmic connections between two adjacent plant cells. Plasmodesmata are characteristic of multi-

cellular plants. E.R. tubules (Desmotubules) help to maintain continuity of cytoplasm. The cell wall and middle lamella may be traversed by plasmodesmata which connect the cytoplasm of neighbouring cells.

♦ **FUNCTIONS OF CELL WAIL ⇒**

(i) Cell wall gives shape to the cell
(ii) It protects the cell from mechanical damage and infection
(iii) it also helps in cell-to-cell interaction
(iv) it provides barrier to undesirable macromolecules.

## GOLDEN KEY POINTS

- Plasma membrane is an asymmetrical structure.
- The lipid component of the membrane mainly consists of phosphoglycerides (Phospholipid).
- One of the most important function of the plasma membrane is the transport of the molecules across it.
- Unlike animal cells, every plant cell is surrounded by a polysaccharide cell wall. So plasmodesmata enable direct, regulated, intercellular transport of substances between neighbouring plant cells.
- In the cell membrane nonpolar tail of saturated and unsaturated hydrocarbons is protected from the aqueous environment.

## BEGINNER'S BOX - 1

### CELL WALL, CELL MEMBRANE, CYTOPLASM

**1.** Proteins, present in plasma membrane are classified as integral and peripheral on the basis of :-
(1) Density and size (2) Ease of extraction from membrane
(3) Structure (4) Quantity

**2.** Which of the following cell organelles is found in both eukaryotic as well as prokaryotic cells?
(1) Mesosome (2) Ribosome (3) Golgi complex (4) Mitochondria

**3.** According to most widely accepted model of plasma membrane :
(1) Liquid protein layer is surrounded by phospholipids
(2) Lipid are arranged in fluid layer of proteins
(3) Proteins are arranged in fluid layer of phospholipids
(4) Liquid phospholipid layer is surrounded by proteins

**4.** Which of the following layers of cell wall is found closest to the plasma membrane?
(1) Middle lamella (2) Primary wall (3) Tertiary wall (4) Secondary wall

**5.** The cell wall of algae is made up of :
(a) Cellulose (b) Galactans
(c) $CaCO_3$ (Calcium carbonate) (d) Hemicellulose
(e) Suberin (f) Mannans
Choose correct combination :-
(1) a, e, d, f (2) a, b, c, d (3) a, b, d, e (4) a, b, c, f

## CYTOPLASM

- Term "Cytoplasm", was given by Strasburger for the part of cell, presents between the nucleus and cell membrane. Cytoplasm can be divided into two parts :- Cytosol and Trophoplasm
- Cytosol → Liquid matrix of cytoplasm except organelles
- Trophoplasm → Part of cytoplasm containing organelles and non living inclusions (Deutoplasm).

## CEIL ORGANELLES

- Metabolically active and living structures of cytoplasm are called organelles.

## ENDOMEMBRANESYSTEM

- While each of the membranous organelles is distinct in terms of its structure and function, many of these are considered together as an endomembrane system because their functions are coordinated.
- The endomembrance system include endoplasmic reticulum (ER). golgi complex. lysosomes and vacuoles. Since the functions of the mitochondria chloroplast and peroxisomes are not coordinated with the above components these are not considered as part of the endomembrane system.

## ENDOPLASMIC RETICULUM

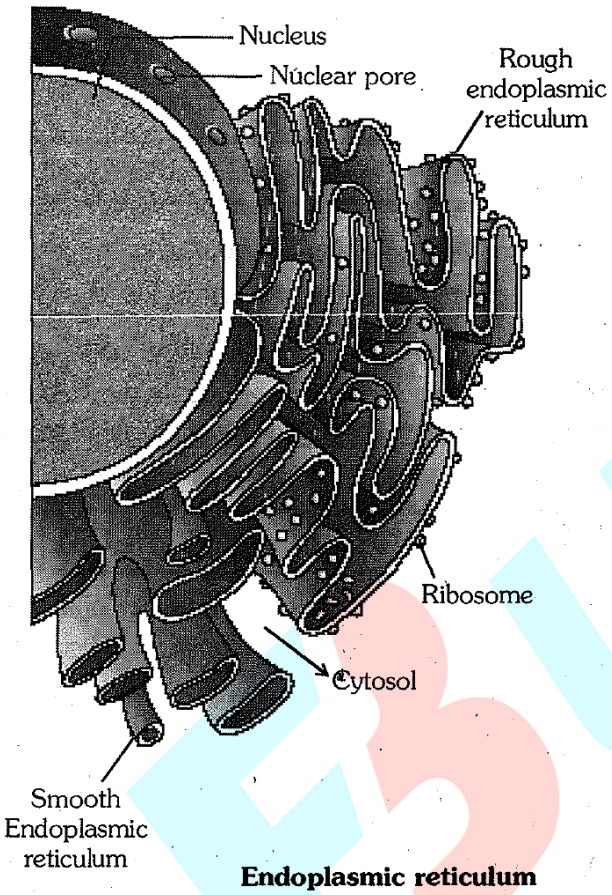
- Electron microscopic studies of eukaryotic cells reveal the presence of a network of reticulum of tiny tubular structures scattered in the cytoplasm that is called the endoplasmic reticulum (ER)

**Components of E.R. :-**

(1) **Cisternae -** These are long flattened and unbranched units arranged in stacks.
(2) **Vesicles -** These are oval membrane bound structures.
(3) **Tubules-** These are irregular, often branched tubes bounded by membrane. Tubules may free or associated with cisternae.

- Structure of E.R. is like the golgi body but in E.R. cisternae, vesicles and tubules are isolated in cytoplasm and these do not form complex.
- Golgi body is localised cell organelle while E.R. is widespread in cytoplasm. E.R. is often termed as "System of Membranes"
- ER divide the intracellular space into two distinct compartment i.e. Luminal (inside ER) and extra luminal (cytoplasm) compartments.

| Rough E.R. (Granular) | Smooth E.R. (Agranular) |
|---|---|
| (1) 80s ribosomes binds by their larger subunit, with the help of two glycoproteins (Ribophorin I and II on the surface of Rough E.R.) | (1) Ribosomes and Ribophorins absent |
| (2) Mainly composed of cisternae. | (2) Mainly composed of tubules. |
| (3) Abundantly occurs in cells which are actively engaged in protein synthesis and secretion. | (3) Abundantly occurs in cells concerned with glycogen and lipid metabolism. |
| e.g. liver, pancreas, goblet cells. | ⇒ In animal cell lipid like steroidal hormones are synthesized in SER. |
| | e.g. Adipose tissue, Interstitial cells, muscles, Glycogen storing liver cells and adrenal cortex. |




**Endoplasmic reticulum**

**MODIFICATIONS OF E.R.**

**(1)** **Sarcoplasmic Reticulum (S.R.) :-** These smooth E.R. occurs in skeletal and cardiac muscles. S.R. Stores $Ca^{+2}$ and energy rich compounds required for muscle contraction.

**(2)** **Microsomes :-** These are pieces of E.R. with associated ribosomal particles. These can be obtained by fragementation and high speed centrifugation of cell. They do not exist as such in the living cell. Scientist used microsome for in vitro protein synthesis study.

**FUNCTIONS OF E.R.**

**(1)** **Mechanical support :-** Micro filaments, Microtubules and E.R. forms endoskeleton of cell.

**(2)** **Intracellular exchange :-** E.R. forms intracellular conducting system. Transport of materials in cytoplasm from one place to another may occurs through the E.R.

♦ At some places E.R. is also connected to P.M. So E.R. can secrete the materials outside the cell.

**(3)** **Rough E.R. :-** Provides site for the protein synthesis, because rough E.R., has ribosomes on its surface.

**(4)** **Lipid Synthesis :-** Lipids (cholesterol & phospholipids) synthesized by the agranular portion of E.R. (Smooth E.R.).

**(5)** ER also helps in the synthesis of lipoproteins and glycogen.

**(6)** **Cellular metabolism :-** The membranes of the reticulum provides an increased surface for metabolic activities within the cytoplasm.

**(7)** **Formation of nuclear membrane :-** Fragmented vesicles of disintegrated nuclear membrane arid ER elements arranged around the chromosomes to form a new nuclear membrane during cell division.

**(8)** Formation of lysosomes, Golgi body & some Micro bodies.

**(9)** **Detoxification :-** Smooth ER concerned with detoxification of drugs, pollutants and steroids. Cytochrome $P_{450}$ in E.R. act as enzyme which function in detoxification of drugs and other toxins

**(10)** E.R. provides the precursor of secretory material to golgi body.

## GOLGI COMPLEX

- Camillo Golgi (1898) first observed densely stained reticular structure near the nucleus. These were later named Gogi bodies after him.
- Golgi body also named as :-
  - Lipochondria ( rich in lipids)
  - Dictyosome (plant golgi body)
- The cytoplasm surrounding Golgi body have fewer or no other organelles. It is called Golgi ground substance or zone of exclusion.

### STRUCTURE

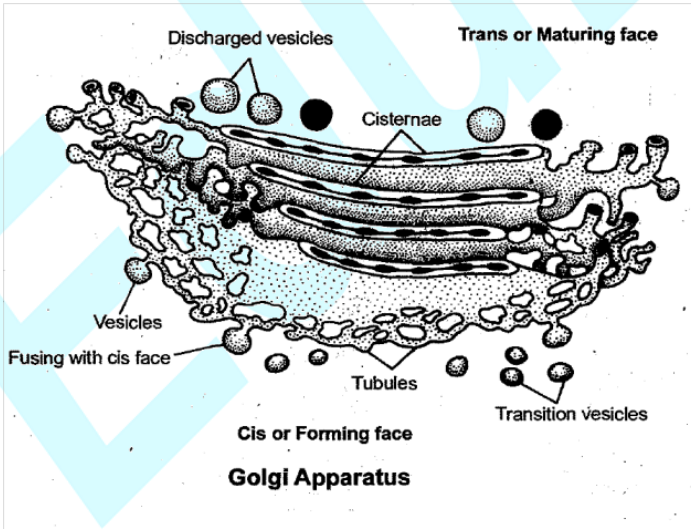
- Golgi complex is made up of three parts -

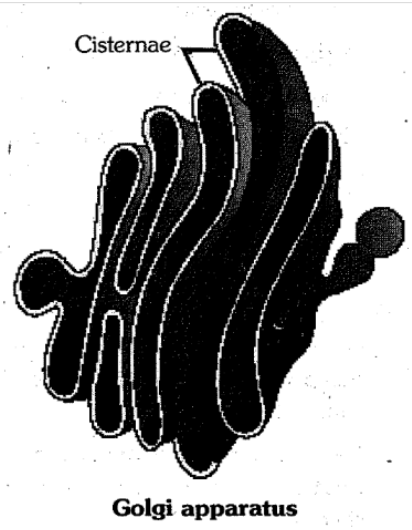
**(1)** **Cisternae :-** These are flat disc shaped, sacs like structure many cistenae are arranged in a stack (parallel to each other). Diameter 0.5 μm to 1.0 μm. Dense opaque material inside cisternae is called Nodes.

- Varied number of cisternae are present in Golgi complex.
- The Golgi cisternae are concentrically arranged near the nucleus.
- Convex surface of cisternae which is towards the nucleus is called cis- face or forming face.
- Concave surface of cisternae which is towards the membrane is called Transface or maturing face.
- The cis and trans faces of the organelle are entirely different but inner connected.

**(2)** **Tubules :-** These are branched and irregular tube like structures associated with cisternae.

**(3)** **Vesicles :-** Transition vesicle and Mature vesicle.




### FUNCTIONS OF GOLGI COMPLEX

**(1)** **Cell Secretion :-** Chief function of golgi body is secretion (export) of macromolecules.

**Secretion involve three steps :**

(a) Golgi body recieves the materials from E.R. through it's cis - face.

(b) These materials are chemically modified by golgi body. For e.g. glycosylation or glycosidation of proteins and lipids takes place in golgi body and it yields glycoprotiens and glycolipids.

(c) After chemical modifications materials are packed in vesicles. These vesicles are pinched off from trans face of golgi body and discharged out side the cell.

- All the macromolecules which are to be sent out side the cell, move through the golgi body. So golgi body is termed as "Director of macromolecular traffic in cell" or middle men of cell.
- The golgi apparatus principally performs the function of packaging materials to be delivered either to the intra-cellular targets or secreted outside the cell. Materials to be packaged in the form of vesicles from the ER fuse with the cis face of the golgi apparatus and move towards the maturing face. This explains, why the golgi apparatus remains in close association with the endoplasmic reticulum.

  A number of proteins synthesised by ribosomes on the endoplasmic reticulum are modified in the cisternae of the golgi apparatus before they are released from its trans face. Golgi apparatus is the important site of formation of glycoproteins and glycolipids.

**(2)** Formation of Lysosome = It is collective function of golgi body and E.R.

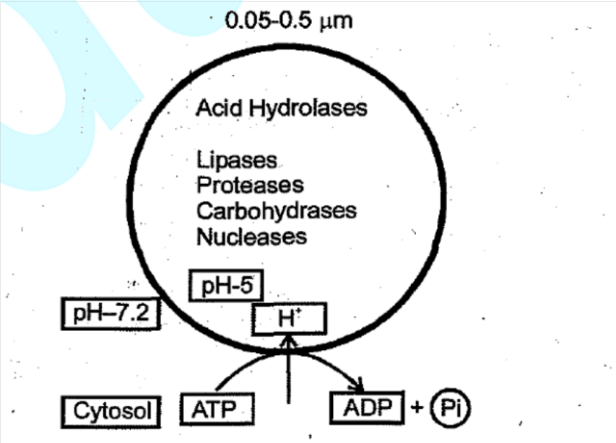
**(3)** Synthesis of cell wall Material (Polysaccharidlsynthesis)

**(4)** Cell plate formation (Phragmoplast) during cell formation.

**(5)** Formation of acrosome during spermfogenesis. (formation of male gametes)

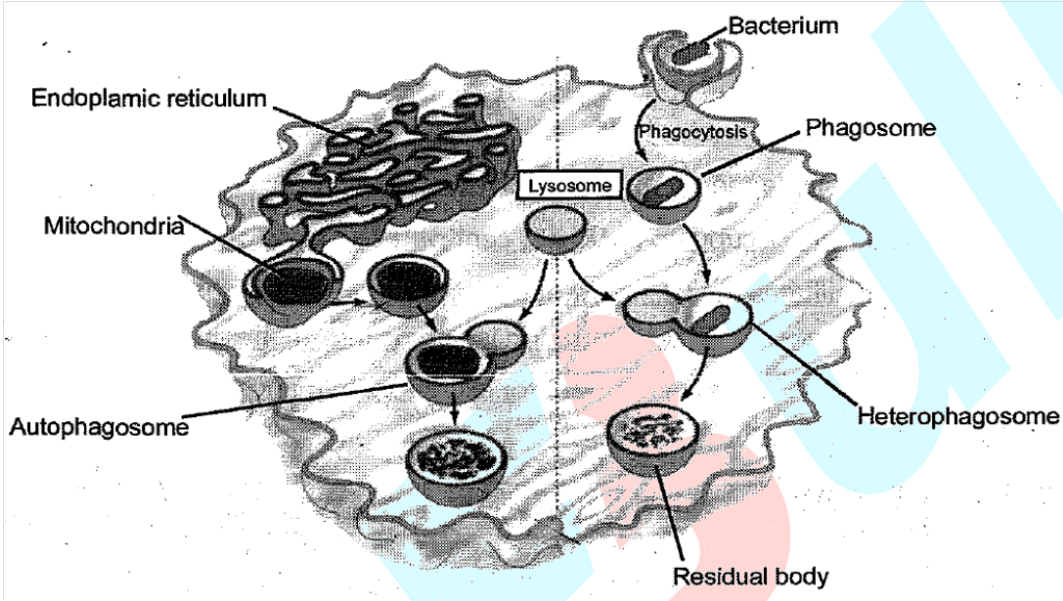
## LYSOSOME

- These are membrane bound vesicular structures formed by the process of packaging in the golgi apparatus. The isolated lysosomal vesicles have been found to be very rich in almost all types of hydrolytic enzymes (hydrolases - lipases, proteases, carbohydrases) optimally active at the acidic pH (pH = 5). These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.
- With the exception of mammalian RBC they were reported in all animal cells.
- In plant cells large central vacuole functions as Lysosome. So in higher plants lysosomes are less frequent. But number of lysosomes is high in fungi.
- **Periplasmic Space :-** space between cell wall and cell membrane in bacteria, may play similar role.




**A lysosome containing a number of acid hydrolases that are active under acidic condition, which is maintained by an $H^+$ ATPase in the membrane**

- Lysosomes are spherical bag like structures, which is covered by single unit membrane. They are large sized in Phagocytes (WBC).
- Lysosomes are filled with 50 different type of digestive enzymes termed as Acid hydrolases for digestion of all type of macromolecules.
  These acid hydrolases function in acidic medium ( pH = 5). Membrane of lysosome has an active $H^+$ pump mechanism which produce acidic pH in lumen of lysosome.
- Lysosomes are highly polymorphic cell organelle. Because, lysosomes have different physiological states.




**TYPES OF LYSOSOMES**

**(1)** **Primary Lysosomes or storage granules -** These lysosomes store enzyme Acid Hydrolases in the inactive form (Enzymes synthesized on ribosomes in cytoplasm) these are newly formed lysosome.

**(2)** **Digestive vacuoles or Heterophagosomes -** These lysosome formed by the fusion of primary lysosomes and phagosomes. These are secondary Lysosomes.

**(3)** **Residual bodies :-** Lysosomes containing undigested material are c:alled residual bodies. These may be eliminated by exocytosis.

**(4)** **Autophagic Lysosomes or autophagosomes :-** Lysosomes containing cell organelles to be digested are known as Autophagosomes.

**FUNCTIONS**

**(l)** **Intracellular digestion :-**

**(a)** **Heterophagy :-** This is digestion of foreign materials received in cell by phagocytosis and pinocytosis.

**(b)** **Autophagy :-** Digestion of old or dead cell organelles. Autophagy also takes place during starvation of cell.

**(2)** **Extracellular digestion :-**

Lysosomes of osteoclast (bone eating cells) dissolve unwanted part of bones.
(Extracellular digestion also occurs by fungal lysosomes.)

**(3) Cellular digestion (Autolysis) :-** Sometimes all lysosomes of a cell burst to dissolve the cell completely. (so Lysosome called as suicidal bags of cell).

- Old cells are removed by autolysis unwanted organs of embryo are destroyed by autolysis. Cathepsin of lysosome digests the tail of tadpole of frog during metamorphosis.

## VACUOLES

- The vacuole· is the membrane-bound space found in the cytoplasm. It contains water, sap, excretory product and other materials not useful for the cell.
- The vacuole is bound by a single membrane called tonoplast.
- In plant cells the vacuoles can occupy up to 90 per cent of the volume of the cell.
- In plants the tonoplast facilitates the transport of a number of ions and other materials against concentration gradients into the vacuole hence their concentration is significantly higher in the vacuole than in the cytoplasm.
- In Amoeba the contractile vacuole is important for excretion. In many cells as in protists, food vacuoles are formed by engulfing the food particles.

## GOLDEN KEY POINTS

- ER, Golgibody, Lysosome and Vacuoles are considered together as an endomembrane system because their function are co-ordinated.
- The Vacuoles store and concentrate waste products. The same are segregated from the living part of the plant cell.
- RER, frequently observed in the cells actively involved in protein synthesis and secretion. Where as SER is observed in the cells actively involved in lipid and steroidal hormone synthesis.
- Golgi body recieve the materials from E.R. through its cis face and these material are modified by golgibody for e.g. Formation of glycolipid and glycoproteins i.e. glycosylation.
- The isolated lysosomal vesicles have been found to be very rich in almost all types of hydrolytic enzymes (hydrolases-lipases, proteases, carbohydrases) optimally active at the acidic pH. (pH = 5)
- In plant cell the vacuoles can occupy upto 90 percent of the volume of the cell. It contains water, sap, excretory product and other materials not useful for the cell.

## BEGINEER'S BOX - 2

### ENDOMEMBRANE SYSTEM

**1.** Surface of Golgi cisternae towards nucleus is ..... face and towards plasma membrane is..... face.

(1) trans, cis (2) maturing, forming
(3) maturing, trans (4) cis, maturing

**2.** The Golgi apparatus remains in close association with the endoplasmic reticulum, because -

(1) materials packaged by Golgi apparatus are transported to the ER
(2) materials to be packaged by Golgi body transported to the Golgi body from ER
(3) both Golgi apparatus and ER have cisternae
(4) both Golgi apparatus and ER possess ribosomes

**3.** ER divides the intracellular space into two distinct compartments, luminal ..... and extra luminal ..... compartments.
(1) Cytoplasm, inside ER (2) Inside ER, cytoplasm
(3) Nucleus, cytoplasm (4) Inside ER, nucleus

**4.** Which of the following combination is correct for the enzymes of lysosomes ?
(1) Oxidative, Active at acidic pH (2) Hydrolytic, Active at basic pH
(3) Synthetic, Active at neutral pH (4) Hydrolytic, Active at acidic pH

**5.** Which of the following statement is not correct for the vacuoles ?
(1) Contractile vacuoles are helpful in excretion
(2) Tonoplast facilitates the transport of ions against the concentration gradient into the cytoplasm
(3) Food vacuoles are formed by engulfing the food particles
(4) Sap vacuole is bound by a single membrane

## MITOCHONDRIA

- Number of mitochondria depends upon physiological activity of cell.
- One in Microasterias, Chlorella fusca (alga).
- All the mitochondria present in a cell are collectively called chondriome.
- Usually plant cells have fewer mitochondria as compared to animal cell.
- In higher animals maximum mitochondria are found in flight muscles of birds.
- Mitochondria are differ in size and shape and can make its shape sausage or cylindrical.
- Diameter 0.2–1.0 μm (average 0.5 μm), length 1.0–4.1 μm.

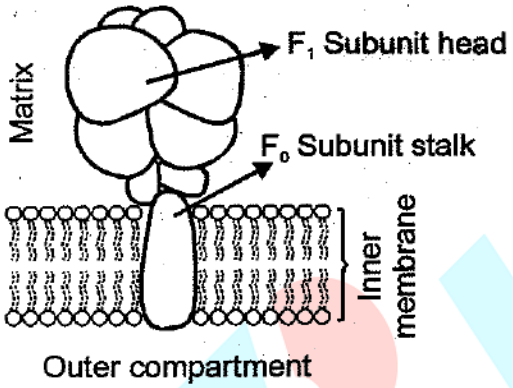
**Mitochondria is also named as –**

- Power house of cell or ATP-mill in cell
- **Cell within cell**
- Most busy and active organelle in cell
- Semi autonomous cell organelle
- Endo-symbionts of cell

**STRUCTURE:**

- Mitochondria unless specifically stained are not easily visible under the microscope. Mitochondria are stained by Janus green B.
- Mitochondria is covered by double unit membrane the outer membrane is smooth and inner one folds into several cristae. Outer membrane has more phospholipids (Phosphatidyl choline) and cholesterol as compared to inner membrane. Phospholipid in inner membrane is mainly dipoosphatidyl glycerol and Inner membrane have more protein.
- The outer membrane and the inner membrane dividing its lumen distinctly into two aqueous compartments, i.e. the outer compartment and the inner compartment. The inner compartment filled with a dense homogenous substance is called the matrix. The outer membrane forms the continuous limiting boundary of the organelle.
  The two membranes have their own specific enzymes associated with the mitochondrial function.
- Both membrane are separated by a space called perimitochondrial (lntermembrane) space.
- Inner membrane is folded into a number of finger like cristae.
- In metabolically active mitochondria number of cristae is higher.

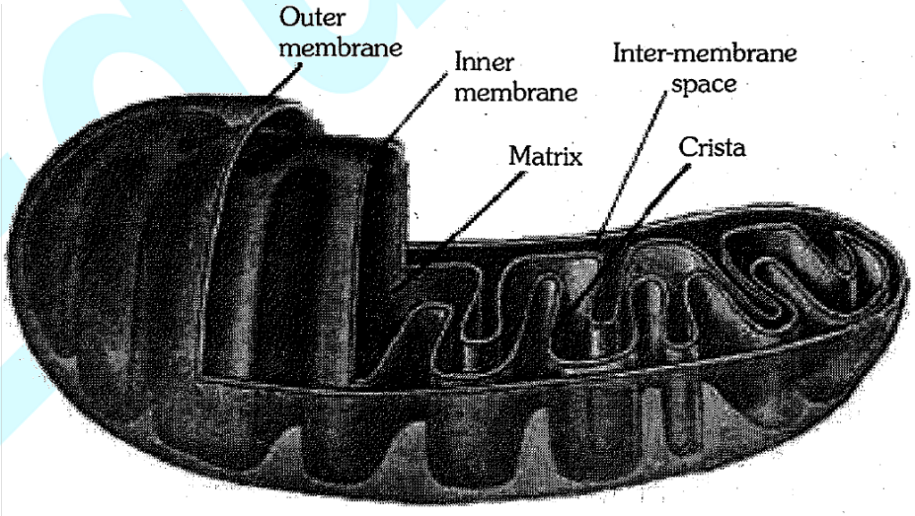
- Many electron carrier cytochromes are arranged in a definite sequence in Inner membrane of mitochondria, which forms Electron transport system (ETS).
- Inner membrane is studded with pin head particles called oxysomes or elementary particles or $F_0 – F_1$ particles or ATP Synthase. These particles first described by Fernandez Moran.
- Head of Oxysomes or $F_1$ is concerned with Oxidative phosphorylation (formation of ATP by energy of oxidation)
- Mitochondrial matrix have enzyme for Kreb's cycle (Aerobic respiration). Beside these enzymes matrix have a complete protein synthesis apparatus (Ribosome (70-s), DNA, few RNA's & enzymes) so mitochondria called as semi autonomous cell organelles.



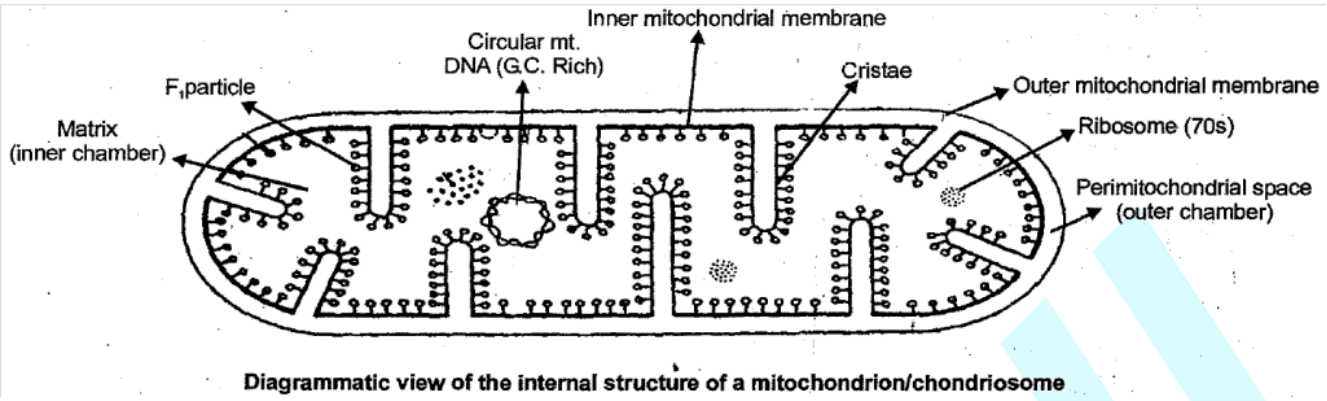

- Single, double stranded and circular naked DNA present in mitochondrial matrix.
- Mitochondrial DNA is 1% of total DNA in a cell. It is rich in G-C content.
- Mitochondrial DNA can code the synthesis of some types of proteins. Rest of the proteins and enzymes of mitochondria are synthesized under the control of nuclear genes.
- Enzymes for replication and transcription of DNA like DNA- polymerase and RNA-polymerase are found in mitochondrial matrix.

**FUNCTION OF MITOCHONDRIA :**

- Mitochondria are site of aerobic respiration and ATP production.




**Structure of mitochondrion (Longitudinal section)**




**Diagrammatic view of the internal structure of a mitochondrion/chondriosome**

**Biogenesis of mitochondria -**

- New mitochondria arise from division of pre-existing mitochondria (Mitochondria divide by binary fission)
- Endosymbiotic origin from prokaryotic cells.
  - (i) Type of DNA (DNA sequences, double stranded, circular, G-C rich).
  - (ii) Type of ribosome (70s).
  - (iii) Divided by binary fission.

## PLASTIDS

- Plastids are found in all plant cells and in euglenoides. These are easily observed under the microscope as they are large. They bear some specific pigments thus imparting specific colours to the plants. Based on the presence or absence and type of pigments plastids can be classified into chloroplasts chromoplasts and leucoplasts.

### TYPES OF PLASTIDS

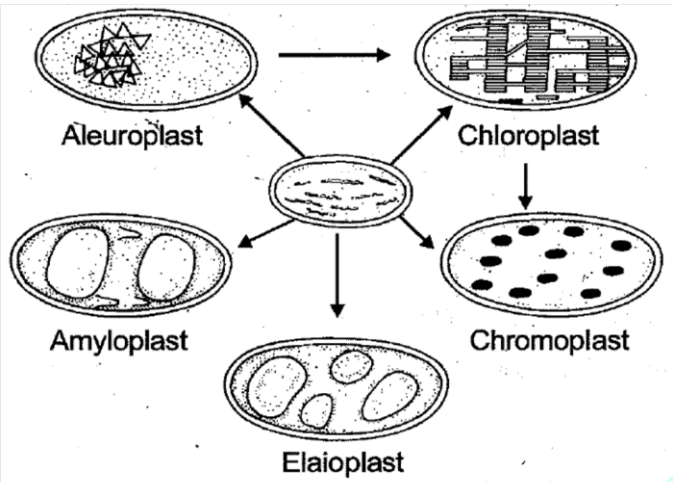
**(1)** **Chromoplasts :-** In chromoplasts fat soluble carotenoid pigments like carotene, xanthophyllas and others are present. This gives yellow; orange or red colour to the part of the plant. Chlorophylls either absent or occur in very less amount. Chromoplasts occurs mainly in pericarp and petals. Red colour of tomatoes is due to the red pigment "Lycopene" of chromoplasts.

- Chromoplasts occur in petals but colour in petals is mainly due to water soluble pigments which are found in cell sap. eg. :- Anthocyanin

**(2)** **Chloroplasts :-** The chloroplasts contain chlorophyll and carotenoid pigments which are responsible for trapping light energy essential for photosynthesis.

**(3)** **Leucoplasts :-** The leucoplasts are the colourless plastids of varied shapes and sizes with stored nutrients: Amyloplasts store carbohydrates (starch). e.g. potato; elaioplasts store oils and fats whereas the aleuroplasts store proteins. Pigments and lamellar structure absents in Leucoplasts. Generally occurs in non green and underground plant cells.

- Different types of plastids may transform from one form to another. Because genetic meteral is similar.




**Interconversion of plastids**

**Number, Shape & Size of chloroplasts :**

- Majority of the chloroplasts of the green plants are found in the mesophyll cells of the leaves.
- Number varies from 1 per cell of the Chlamydomonas a green alga to 20-40 per cell in the mesophyll.
- These are lens-shaped, oval, spherical, discoid, or even ribbon shaped.
- Length and width are also variable.

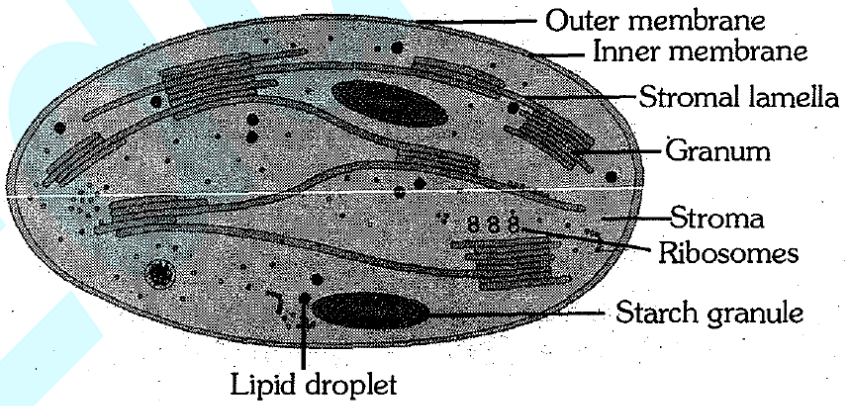
  Length = 5-10 μm

  Width = 2-4 μm

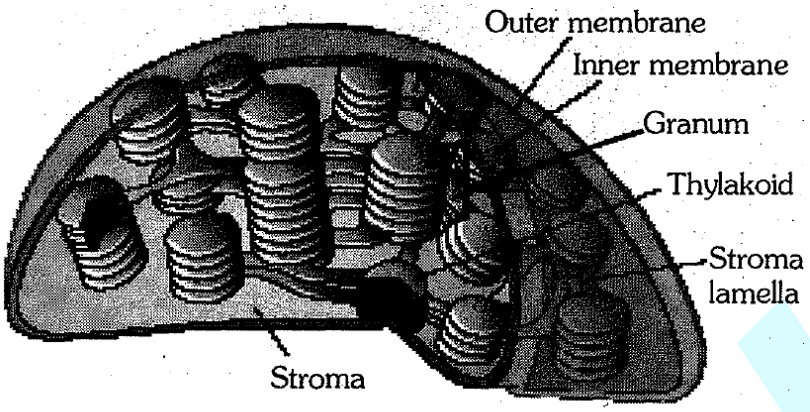
**STRUCTURE OF CHLOROPLAST**

**Membrane :** Like mitochondria the chloroplast are also double membrane bound. Out of the two the inner membrane is relative less permeble. (Outer membane contain porins)

- The space limited by the inner membrane is called the stroma.




**Chloroplast**




**Sectional view of chloroplast**

**Components of stroma :**

**(a) Thylakoids :**

- In the stroma a number of organised flatted membranous sacs are present called thylakoids.
- Thylakoids are arranged in stacks like the piles of coins called grana (singular : granum) or the intragranal thylakoids.
- Each chloroplast contains about 40-60 granum.
- Stroma lamellae or Fret channel or Stroma thylakoids are flat membranous tubules connecting the thylakoids of the different granum.
- The membrane of the thylokoids Eindose a space called lumen.
- Chlorophyll (photosynthtic pigments) are present in the thylakoids membrane.
- A photosynthesis functional unit (Located in thylakoids membrane) contains of about 250 to 400 molecules of various pigments (Chl-a, Chl-b, Carotenes, Xanthophylls etc.) is called as Quantasome.

**(b) Enzymes:**

- The stroma of the chloroplast contains enzymes required for the synthesis of carbohydrate. (i.e. enzymes of Calvin cycle or Dark reaction) and protein synthesis.

**(c) DNA :**

- Stroma contain small double-stranded circular DNA molecules.

**(d) Ribosome :**

- The Ribosome of the chloroplast are smaller (70s) than the cytoplasmic ribosomes (80s)
- Chloroplasts have their own genetic system & complete protein synthesis machinery (ds - DNA, RNA, Ribosome, Enzymes, Amino acids) but enzymes for photosynthesis are synthesised by both genes of nucleus and chloroplast thus chloroplasts are also called as semi autonomous organelle of the cell.

**FUNCTION :-**

**Photosynthesis :** The chloroplasts trap the light energy of sun and transform it into the chemical energy in the form glucose.

**BIOGENESIS**

**(1)** From Proplastid

**(2)** From binary fission of pre-existing plastids.

**ORIGIN :** Endosymbiotic origin by a cyanobacterium.

## GOLDEN KEY POINTS

- Mitochondria supply most of the necessary biological energy through oxiding substrates of TCA cycle (Krebs cycle).
- Mitochondria are the site of aerobic respiration.
- Mitochondria produce cellular energy in the form of ATP, hence they are called 'power houses' of the cell.
- Based on the type of pigments plastids can be classified into chloroplasts. chromoplasts and leucoplasts.
- Chloroplast and mitochondria both are semiautonomous organelles of the cell.

## BEGINNER'S BOX - 3

### MITOCHONDRIA AND PLASTIDS

**1.** Cells which are metabolically more active, have-
(1) less number of mitochondria
(2) more number of mitochondria
(3) no relation between metabolic activities and number of mitochondria
(4) no mitochondria, to provide more space in cytoplasm for metabolic activities

**2.** Mitochondria and Chloroplasts are similar in having-
(a) two membranes (b) Cristae (c) DNA (d) Ribosomes
(e) Thylakoids
(1) a, c and d (2) a, band d (3) a and d (4) a, c, d and e

**3.** Which of the following plastids store Fat?
(1) Chromoplast (2) Elaioplast (3) Leucoplast (4) Amyloplast

**4.** The ribosomes of the chloroplasts are -
(1) Smaller than the cytoplasmic ribosomes (2) Bigger than the cytoplasmic ribosomes
(3) of similar size to that of cytoplasm's (4) size of ribosomes cannot be measured

**5.** The inner membrane of mitochondria bears folding/finger like projections, these -
(1) increase surface area (2) increase thickness of mitochondria
(3) keep all the substances away (4) increase protein oxidation

## RIBOSOMES (ENGINE OF CELL)

- Ribosomes are the granular structures first observed under the electron microscope as dense particles by George Palade (1953). They are composed of ribonucleic acid (RNA) and proteins and are not surrounded by any membrane.
- Except mammalian RBC all living cells have ribosomes. (Both prokaryotes & Eukaryotes)
- Ribosomes are smallest cell organelles
- Ribosomes are also called as "Organelle within organelle" and "Protein factory of cell"

**Types of Ribosomes :-**

**(1)** **Eukaryotic ribosomes :-** 80 S - Occur in cytoplasm of eukaryotic cells.

**(2)** **Prokaryotic ribosomes :-** 70 S - Occur in cytoplasm and associated with plasma membrane of prokaryotic cell. Their size is 15 to 20 nanometer.

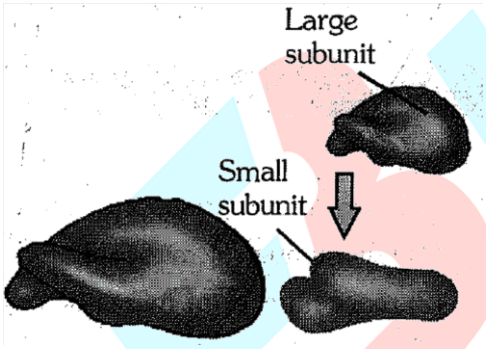
- 70 Sribosome also present in mitochondria and chloroplast of eukaryotes.
- Each ribosome composed of two subunits i.e. larger and smaller subunits.

  80 S = 60 S + 40 S

  70 S = 50 S + 30 S
- Magnesium ion is essential for the binding the ribosome sub units. $Mg^{+2}$ form ionic bond with phosphate groups of r– RNA of two subunits. Minimum 0.001 M $Mg^{+2}$ concentration is required for structural formation of ribosomes.

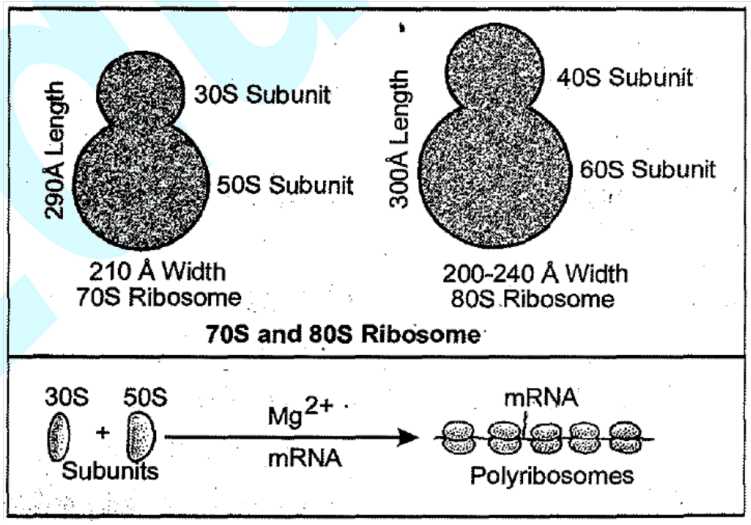
**Chemical Composition of Ribosomes :**

70 S - 60% r-RNA + 40% proteins
80 S - 40% r-RNA + 60% proteins
60 S - r-RNA 28 S, 5.8 S, 5 S
40 S - r-RNA 18 S
50 S - r-RNA 23 S, 5 S
30 S - r-RNA 16 S




- At the time of protein synthesis, several 70 S ribosomes become attached to m-RNA with the help of smaller subunits. This structure is called polyribosome or polysome or Ergosome. Larger subunit (50s) contains peptidyl transferase enzyme (23S rRNA) which helps in the formation of peptide bond during protein synthesis.

  This is an example of Ribozyme. (Noller 1992)




## CYTOSKELETON

- An elaborate network of filamentous proteinaceous structures present in the cytoplasm is collectively referred to as the cytoskeleton. The cytoskeleton in a cell are involved in many functions such as mechanic motility, maintenance of the shape of the cell.

## MICROTUBULES

- Microtubules are composed of protien, Tubulin [Size 25 nm.]
- In plants microtubules often found associated with cell wall. Probably these transport cell wall material from Golgi body to outside of cell. During cell division these microtubules form spindle fibers.

## MICRO FILAMENTS

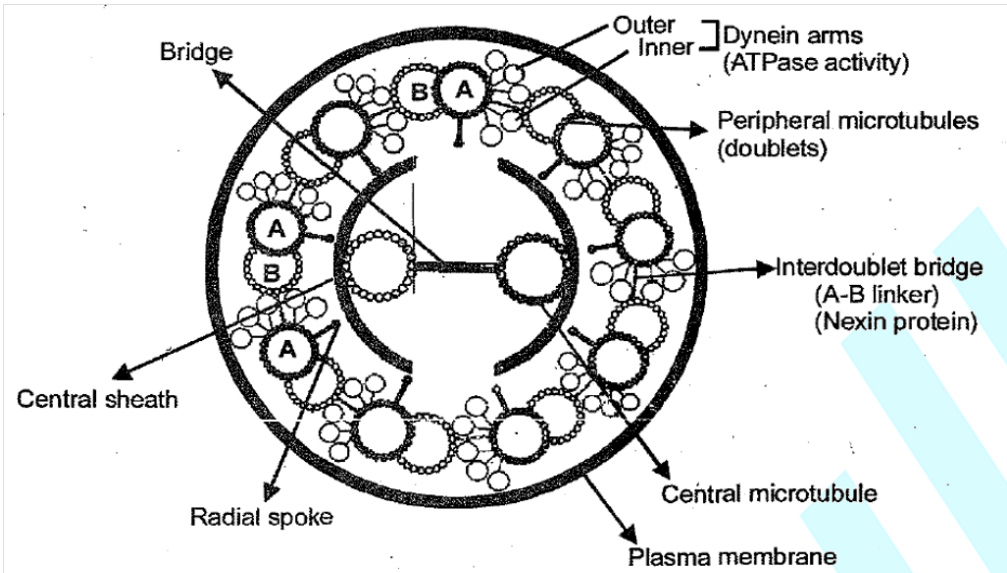
- They are composed of contractile protien, Actin which concern with muscle contraction, Microtubules and microfilament are part of cytoskeleton-base of cell. [Size 6-7 nm]

## INTERMEDIATE FILAMENT

- Intermediate filaments has size/diameter in between microfilaments and microtubules. These filaments form basket like structure around the nucleus. [Size 8-12 nm]

## CILIA AND FLAGELLA

- Cilia (sing. : cilium) and flagella (sin, : flagellum) are hair-like outgrowths of the cell membrane. Cilia are small structures which work like oars, causing the movement of either the cell or the surrounding fluid. Flagella are comparatively longer and responsible for cell movement. The bacteria (prokaryotic cell) also possess flagella but these are structurally different from that of the eukaryotic flagella.
- The electron microscopic study of a cilium or the flagellum show that they are covered with plasma membrane. Their core called the axoneme, possesses a number of microtubules running parallel to the long axis. The axoneme usually has nine doublets of radially arranged peripheral microtubules and a pair of centrally located microtubules. Such an arrangement of axonemal microtubules is referred to as the 9+2 array.
  (9 doublet + 2 singlet)
- Arms of A tubules consist of an enzymatic protein dynein similar to myosin of muscle cells. Dynein have ability of hydrolysis of ATP & liberates energy for ciliary or flagellar movement.
- The central tubules are connected by bridges and is also enclosed by a central sheath, which is connected to one of the tubules of each peripheral doublets by radial spoke. Thus there are nine radial spokes. The peripheral doublets are also interconnected by linkers. Both the cilium & flgellum emerge from centriole-like structure called the basal bodies or blepheroplast.

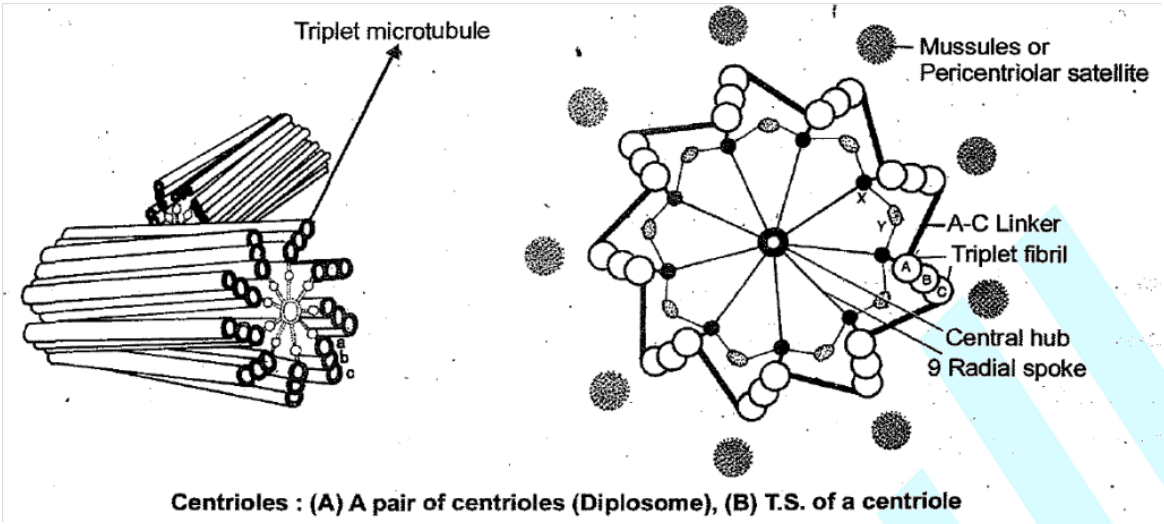



**Diagrammatic representation of internal structure of Cilia or Flagella**

| Cilia | Flagella |
|---|---|
| 1. The Cilia are small in size (5-10μm) | 1. Flagella are long (up to 150 μm) |
| 2. Number of cilia per cell is very large. | 2. Few in number |
| 3. Cilia beat in a coordinated manner (Pendular movement) | 3. Flagella beats independently (Undulating movement) |
| 4. They take part in locomotion, attachment, feeding and sensation. | 4. Flagella involved only in locomotion |

## CENTROSOME & CENTRIOLES

- Centrosome is absent in higher plants.
- Centrosome containing two centroioles (diplosome) located just outside the nucleus and lie at right angle (90°) to each other. Each centriole is surrounded by amorphous pericentriolar materials.
- Centrioles are membraneless cylindrical structure which exhibit cart wheel structure in transverse section.
- Centriole mainly consist of 9 evenly spaced peripheral triplet fibrils of tubulin. These triplets are linked with the help of A-C linker.
- The central part of the centriole is proteinaceous and called the hub which is connected with peripheral triplets by radial spokes made of protein. (9 + 0 arrangement)
- Centrioles are self duplicating units.




**Centrioles : (A) A pair of centrioles (Diplosome), (B) T.S. of a centriole**

**Function :-**

(i) In animal cells, centrioles play important role in cell division by arranging spindle fibres between two poles of cell. The location of centrioles during cell division decides the plane of division. The plane of division is always at right angle to the spindle.

(ii) Centrioles form the basal body of cilia or flagella.

## MICRO-BODIES

- These are many membrane bound minute vesicle contain various enzyme that are present in both plant and animal cells.

**(1) Peroxisomes or Uricosomes :-**

- These are found in both plant and animal cells. Peroxisomes contain catalase enzyme which is concerned with peroxide ($H_2O_2$) metabolism. Catalase degrade the $H_2O_2$ into water and oxygen.
- In plants, peroxisomes occurs in cells of green tissues and concerned with photorespiration (glycolate pathway).
- Peroxisomes are also involved in β-oxidation of fatty acids.

**(2) Glyoxysomes** :-

- Glyoxysomes occurs only in plants especially in fatty seeds (castor seed, ground nut seed etc.).
- Glyoxysomes are considered as a highly specialized peroxisomes. Glyoxylate acid cycle takes place in glyoxysomes. This cycle convert fats into carbohydrats.

## GOLDEN KEY POINTS

- Cilia and flagella both have 9+2 arrangement of microtubules.
- Arrangement of microtubules in centriole is 9+0.
- Ribosomes are composed of ribonucleic acid (RNA) and proteins and are not surrounded by any membrane.
- Ribosomes are composed of two sub units and magnesium ion is essential for the binding of ribosomal sub units.
- Several ribosomes attached to a single mRNA, form polysome.
- In germinating seeds, fatty acids are degraded exclusively in the glyoxysome.
- Peroxisome associated with chloroplast and mitochondria perform photorespiration or glycolate cycle.

## BEGINNER'S BOX - 4

### CENTROSOME, CILIA, FLAGELLA, RIBOSOME, MICROBODIES

**1.** Conversion of $H_2O_2$ into $H_2O$ and $O_2$ occurs in ..... by the enzyme .....
(1) Glyoxysome, Catalase (2) Peroxisome, Urease
(3) Sphaerosome, Lipase (4) Uricosome, Catalase

**2.** An elaborate network of filamentous ..... structures present in the cytoplasm is collectively referred to as the ..... .
(1) Cytoskeleton, proteinaceous (2) Proteinaceous, Cytoskelaton
(3) Lipoidal, Mitochondria (4) Lipoidal, plasma membrane

**3.** Which of the following arrangements of microtubules is correct for flagellum ?
(1) 9 peripheral singlets + 2 central doublets (2) 9 peripheral triplets + 2 central singlets
(3) 9 peripheral doublets + 2 central singlets (4) 9 periph~tirldoublets + 2 central triplets

**4.** Cell organelle which exhibit cart wheel structure in transverse section :-
(A) is helpful in cell division in almost all plant cells
(B) is not covered by any membrane
(C) is a self duplicating unit
(D) contain microtubules composed of Dynien protein
(1) A and Care incorrect (2) B and C are correct
(3) Only A is incorrect (4) Only B is correct

**5.** The eukaryotic ribosomes are 80 S, while the prokaryotic ribosomes are 70 S. Here 'S' stands for ..... , it indirectly is a measure of ..... :-
(1) Svedberg unit, number of r-RNA in ribosome
(2) Smooth surface, surface area of ribosome
(3) Shortest organelle, size
(4) Sedimentation coefficient, size and density

## NUCLEUS

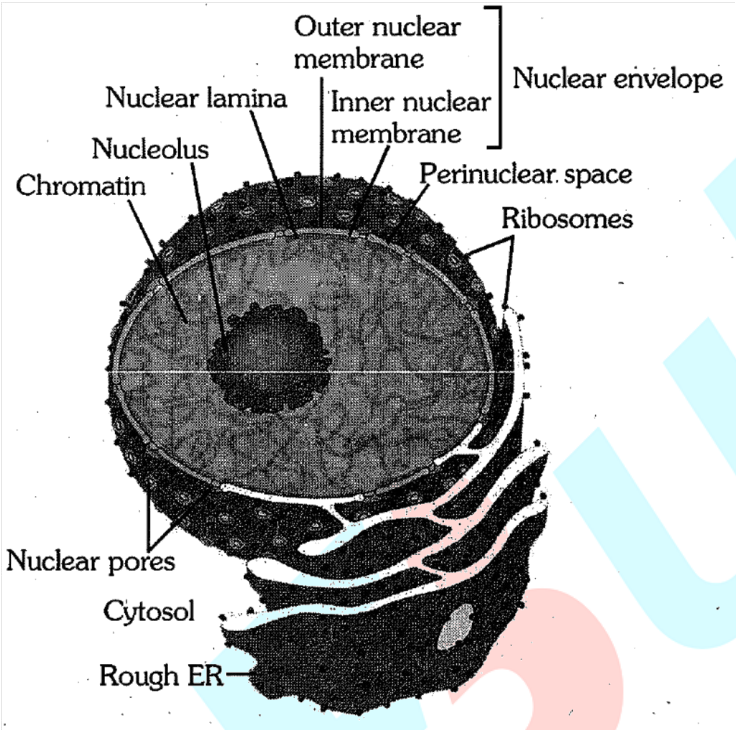
### INTRODUCTION :

- Nucleus as a cell organelle was first described by Robert Brown as early as 1831. Later the material of the nucleus stained by the basic dyes (Acefocarmine) was given the name chromatin by Flemming.
- "Nucleus is double membrane bound dense protoplasmic body, which controls all cellular metabolism and encloses the genetic information of cell".
- Nucleus is consider as controller or director of cell. Importance of nucleus in control of heredity, growth and metabolism was experimentally proved by Hammerling. (Experiment was on Acetabularia a single cell largest alga).
- Generally eukaryotic cell contain at least one nucleus but nucleus is absents in mature phloem sieve tube elements and mature RBCs of mammals.
- Dikaryotic (Paramoecium) and multikaryotic cells are also known.

### STRUCTURE OF INTERPHASE NUCLEUS :

- Interphase nucleus : Nucleus of cell when it is not dividing.
  (i) Nuclear membrane or karyotheca.

(ii) Nuclear matrix / Nucleoplasm / Karyolymph / Karyoplasm.
(iii) Chromatin net
(iv) Nucleolus / little nucleus / Ribosome factory




**(i) Nuclear membrane :-**

- Electron microscopy has revealed that the nuclear envelope, which consists of two parallel membranes with a space between (10 to 50 nm) called the perinuclear space. These membrane forms a barrier between the materials present inside the nucleus and that of the cytoplasm.
- The outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.
- At a number of places the nuclear envelope is interrupted .by minute pores, which are formed by the fusion of its two membranes. These nuclear pores are the passages through which movement of RNA and protein molecules takes place in both directions between the nucleus and the cytoplasm.
- The nuclear pore is guarded by a octagonal discoid structure of nucleoplasmin protein.
- The inner side of inner nuclear membrane is lined by nuclear lamina. This structure is formed by filaments of lamin protein.

**(ii) Nucleoplasm or Karyolymph :-**

- Nucleoplasm or Nuclear sap is a ground substance of nucleus, which is a complex colloidal formed of a number of chemicals like nucleotides, nucleosides, ATPs, proteins & enzymes.
- Chromatin net and nucleolus are components of nucleoplasm.

**(A) Chromatin net :-** (Term given by Flemming)

- ♦ Interphase nudes has a loose and indistinct network of nucleoprotein fibers called chromatin, which embeded in nucleoplasm. Chromatin net is mainly formed of DNA and histone protein complexes.
- ♦ Chromatin fibres contain genetic information and condensed to form chromosomes during cell division.
- ♦ During different stages of cell division cells show structured chromosomes in place of nucleus.
- ♦ Chemically chromatin consists of DNA, RNA, Histone protein (basic proteins, rich in arginine and lysin) and non histone proteins.
- ♦ Chromatin net has two type of chromatins :-

**(a)** **Euchromatin :-** This is lightly stained and diffused part of chromatin. Which is transcriptionally or genetically more active.

**(b)** **Heterochromatin :-** This is dark stained, thick and condensed part of chromatin. Heterochromatin is genetically less active or inactive chromatin.

(i) **Constitutive heterochromatin :-** Occurs in all cells in all stages e.g. centromeric region.

(ii) **Facultative heterochromatin:-** Occurs in some cells in some stages e.g. barr body in females.

**(B)** **Nucleolus :-**

- ♦ The nucleoli are spherical and membraneless structure so that the content of nucleous is continuous with the rest of the nucleoplasm.
- ♦ It is a site for active ribosomal RNA (r-RNA) synthesis.
- ♦ Nucleolus usually attached to chromatin (or chromosomes) at specific site called Nucleolar organizer region / NOR.
- ♦ Nucleolus is called Ribosome factory of cell.

♦ Larger and more numerous nucleoli are present in cells actively carrying out protein synthesis.

## CHROMOSOMES

**GENERAL INTRODUCTION :**

- ♦ At the time of cell division the chromatin material get condensed to form chromosomes, thus chromosome is highly condensed form of the chromatin. Chromosomes are not visible during interphase stage but during different stages of cell division, cells show structured chromosomes in place of the nucleus.
- ♦ Chromosomes can be best studied at metaphase stage because size of chromosomes is the shortest during metaphase (Shape of chromosome is studied at Anaphase stage)

**Chromosome Numbers in Meiocytes (diploid, 2n) and Gametes (haploid, n) of Some Organisms**

| Name of organism | Charomosome number in meiocyte (2n) | Chromosome number in gamete (n) |
|---|---|---|
| Human beings | 46 | 23 |
| House fly | 12 | 6 |
| Rat | 42 | 21 |
| Dog | 78 | 39 |
| Cat | 38 | 19 |
| Fruit fly | 8 | 4 |

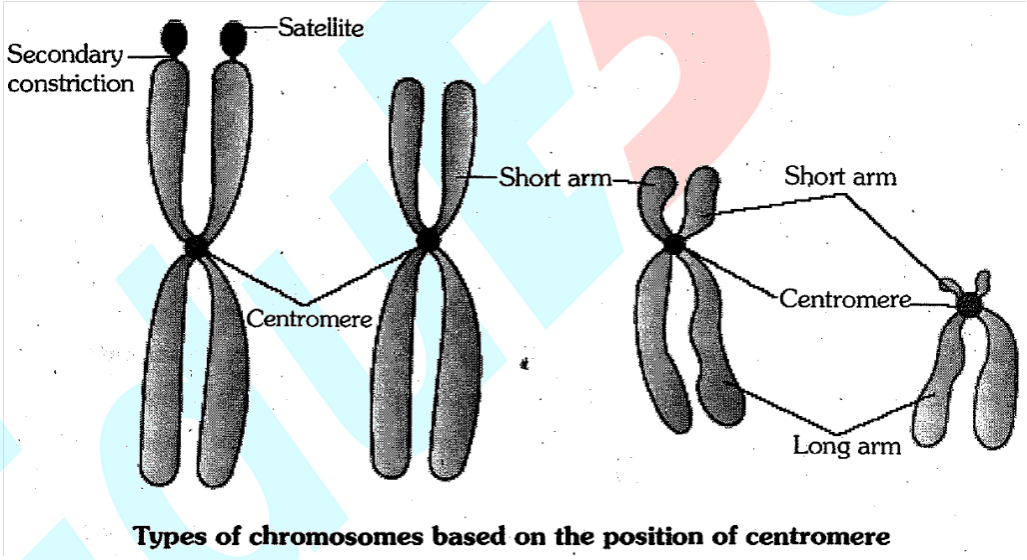
| | | |
|---|---|---|
| Ophioglossum (a fern) | 1260 | 630 |
| Apple | 34 | 17 |
| Rice | 24 | 12 |
| Maize | 20 | 10 |
| Potato | 48 | 24 |
| Butterfly | 380 | 190 |
| Onion | 16 | 8 |

- The number of chromosomes in a gamete is called "Genome" or "A complete set (n) of chromosomes inherited as a unit from one parent is known as genome.
- A single human cell has approximately two meter long thread of DNA distributed among its 46 (23 pairs) chromosomes.

## TYPES OF CHROMOSOMES ON THE BASIS OF POSITION OF CENTROMERE

(i) **Telocentric:-** When centromere is terminal or located at the tip of chromosome.
(ii) Acrocentric :- When the centromere is sub-terminal or located near the tip.
(iii) Metacentric :- When the centromere is located at mid of the chromosome.
(iv) Sub metacentric:- When the centromere located near centre or mid point of chromosome.

- The ratio of length of the long arm to the short arm of a chromosome is called arm ratio. Arm ratio is maximum in acrocentric chromosome.



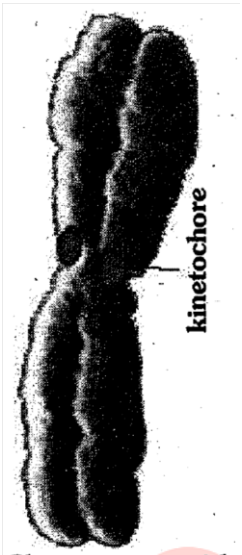

**Types of chromosomes based on the position of centromere**

- **Karyotype** ⇒ Karyotype is external morphology of all Chromosomes of a cell which is specific for each species of living organisms. Karyotype can be studied in metaphase of mitosis. Karyotype includes the number of chromosomes, relative size, position of centromere, length of the arms, secondary constrictions and banding patterns.
- **Idiogram :-** Diagrammatic representation of Karyotype. In idiogram chromosomes are arranged in decreasing order of size. Sex chromosomes are placed in last. Idiogram is specific for every species.

## STRUCTURE OF CHROMOSOME

1. **Chromatid :-** At metaphase stage each chromosome is consist of two cylindrical structures - called chromatids. Both sister chromatids are joined together by a common centromere. A

chromosome, may have single chromatid (in Anaphase or Telophase) or two chromatid. (as in prophase and metaphase)




**Chromosome with kinetochore**

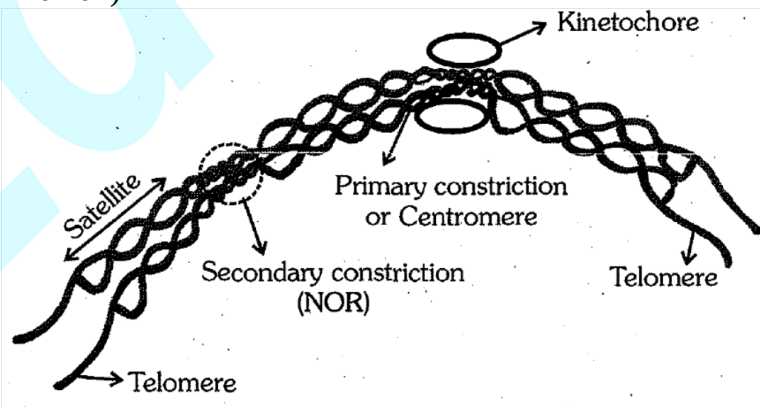
- Each chromatid is consist of a single long thread of DNA associated with histone. Non histone proteins and RNA are also present.

**2. Centromere :-**

- Each chromosome (at prophase or metaphase) is consist of two chromatids. Both the chromatids of a chromosome are joined or connected by a structure called Centromere. At centromere two protein discs are present which is called Kinetochore.
- Kinetochores constitute the actual site of attachement of spindles to chromosomes during cell division.
- At the region of centromere the chromosome is comparatively narrower than remaining part of chromosome thus it is termed as Primary constriction.

**3. Secondary constriction :-** Besides primary constrictions other constriction may also occurs on some chromosome, which are known as secondary constriction. These constriction are non staining and found at a constant location.

- Secondary constriction is also known as NOR (Nucleolar organizer region) (13, 14, 15, 21, 22 chromosomes inhuman)




**Schematic Diagram of Double Chromatid Chromosome**

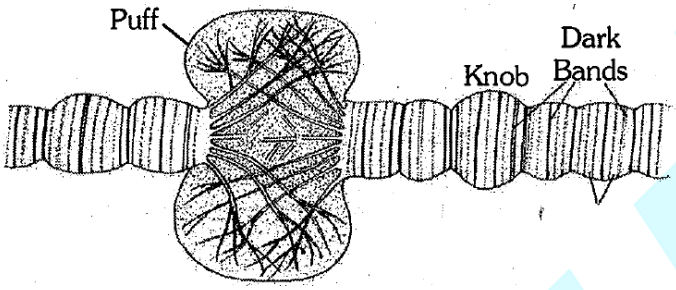
**4. Satellite :** Part of chromosome remains after the NQR is known as chromosomes satellite.

**5. Telomere :** Chromosomes have polarity and polar ends of chromosomes are known as Telomeres.

- Telomere prevents fusion of one chromosomes to other chromosome. Telomere rich in Guanine base. (5' - TTAGGG-3')
- Enzyme Telomerase synthesize telomere part of chromosome, which is a Ribonucleoprotein. Telomeres of chromosomes becomes shatter during ageing process.

## APECIAL TYPE OF CHROMOSOMES

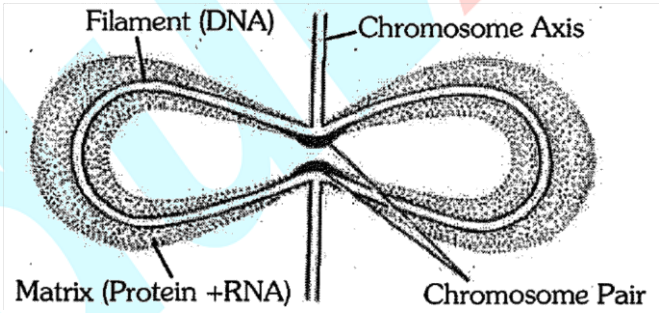
1. **Salivary gland chromosome :-** This type of chromosome was discovered by E.G. Balbiani, in Chironomous larva.




- This chromosome is called Polytene chromosome, because number of chromatids are very high.
- Swollen areas present at some places in polytene chromosome, which are called as Balbiani rings or puffs. These puffs helps in synthesis of RNA and proteins.
- Salivary gland chromosome concerns with metamorphosis and moulting process of insect larva.

2. **Lamp brush chromosome :-** Discovered by Flemming and Ruckert from oocytes of vertebrates (Amphibia) during diplotene stage of cell division. These chromosomes look like lamp-brush, thus called as lamp brush chromosomes.

- Axis of lamp-brush chromosome is consist of DNA, while matrix is consist of RNA & proteins.
- Lamp brush chromosome is concerned with "Vitellogenesis" (Yolk formation)




## GOLDEN KEY POINTS

- Role of nucleus in morphology of plant was first discovered in Acetabularia.
- Chromatin fibre represents de-condensed chromosomes, which become condensed at the time of cell division time form chromosome.
- SAT chromosomes have a secondary constriction and the part of chromosome beyond that is known as satellite.
- Larger and more numerous nucleoli are present in cells actively carrying out protein synthesis.

## BEGINEER'S BOX - 5

**NUCLEUS, CHROMOSOME**

**1.** The nucleus is separated from surrounding cytoplasm by a nuclear membrane, which is:-
(1) Double layered without pores (2) Single layered with pores
(3) Double layered with pores (4) Single layered without pores

**2.** The interphase nucleus (nucleus of cell when it is not dividing) has highly extended and elaborate nucleoprotein fibres called :-
(1) Chromatin (2) Nuclear matrix (3) Chromosomes (4) Nucleoli

**3.** Nucleolus is the site for :
(1) Protein synthesis (2) Ribosomal RNA synthesis
(3) Massenger RNA synthesis (4) Chromatin synthesis

**4.** Which of the following cells lack the structure discovered by Robert Brown in orchid plants?
(1) Erythrocyte of mammals (2) Sieve tube cells
(3) Both (1) and (2) (4) Liquid endosperm of coconut

**5.** Match the following :-

| | Chromosome | | Position of centromere |
|---|---|---|---|
| (A) | Metacentric | (a) | At the tip |
| (B) | Acrocentric | (b) | Slightly away from the middle |
| (C) | Telocentric | (c) | At the middle |
| (D) | Submetacentric | (d) | Almost near the tip |

Choose the correct match:-
(1) A - a, B - b, C - c, D - d (2) A - c, B - d, C - a, D - b
(3) A - d, B - c, C - b, D - a (4) A - b, B - a, C - d, D - c

## DIFFERENCES BETWEEN PROKARYOTIC & EUKARYOTIC CELL

| CHARACTERS | PROKARYOTIC CELL | EUKARYOTIC CELL |
|---|---|---|
| **(1) Nuclear Membrane** | Nuclear membrane absent<br>Incipient nucleus/prokaryon/ Genophore/nucleoid present | Nuclear membrance present<br>Nucleus well organized |
| **(2) Cell organelles** | Membranous cell organalles are absent (like Mitochondria, plastids E.R., golgibody, Microbody) | Membranous cell organalles are present. (Plastids only in plants) |
| **(3) Ribosome** | 70 S type | 80 S type and<br>70 S (Mitochondria & chloroplast) |
| **(4) Resp. Enzymes** | Presents in Mesosome or in cell membrane | Found in cytoplasm and Mitochondria |
| **(5) Flagella** | Flagella are Made up of Flagellin protein. | Flagella are eleven stranded, Made up of tubulin protein (9+1 arrangement) |

| | | |
|---|---|---|
| **(6) Cyclosis** | Cytoplasmic streaming absent | Present |
| **(7) Chromosomes** | Naked or folded genome made by Mainly circular-ds DNA (G-C Rich) (Histone protein absent) | True chromosomes (Histone associated with DNA) |
| **(8) Ploidy level** | Consider as haploid | Haploid, Diploid, Polyploid |
| **(9) Vacuoles** | Sap vacuole absent but gas vacuole may present | Present as sap vacuoles in plant cell. |
| **10) Example :-** | Bacteria, Cyanobacteria (BGA) Mycoplasma (PPLO), Ricketsias, Actinomycetes. [Monera kingdom] | All plant & Animal cells, Protista and fungi |

## ANSWER KEY

### BEGINNER'S BOX-1

**1.** (2) **2.** (2) **3.** (3) **4.** (3) **5.** (4)

### BEGINNER'S BOX-2

**1.** (4) **2.** (2) **3.** (2) **4.** (4) **5.** (2)

### BEGINNER'S BOX-3

**1.** (2) **2.** (1) **3.** (2) **4.** (1) **5.** (1)

### BEGINNER'S BOX-4

**1.** (4) **2.** (2) **3.** (3) **4.** (2) **5.** (4)

### BEGINNER'S BOX-5

**1.** (3) **2.** (1) **3.** (2) **4.** (3) **5.** (2)