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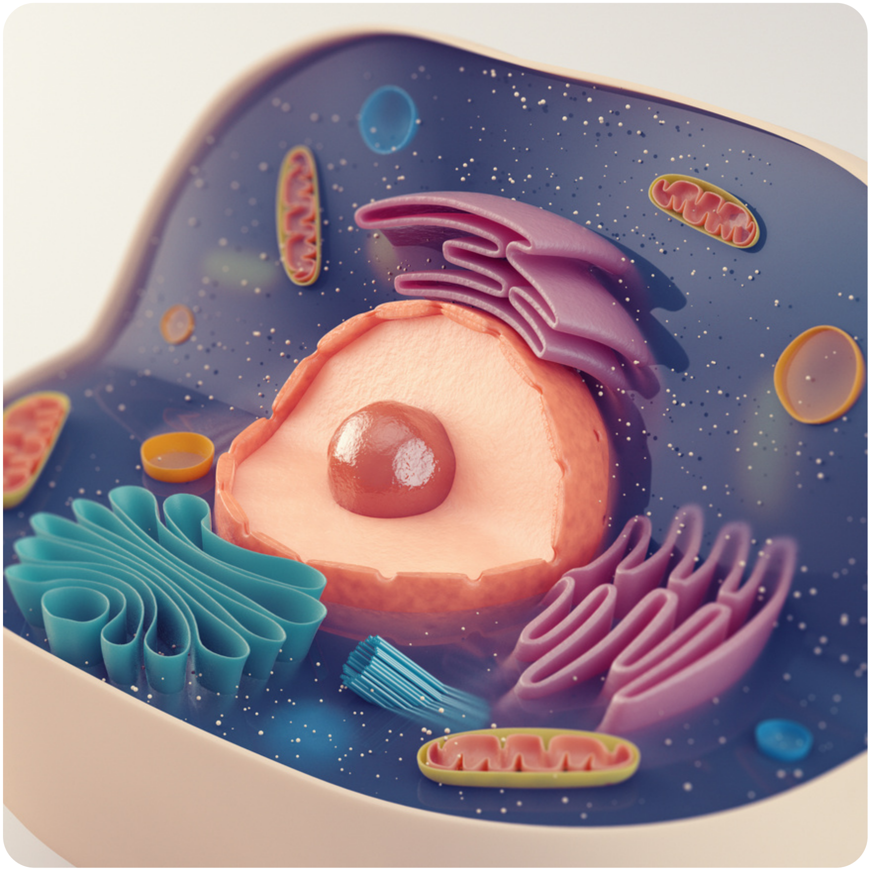

STUDY MATERIAL

Cell : The unit of life

ENGLISH MEDIUM

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Matthias Jakob Schleiden (1804-1881)

Theodore Schwann (1810-1882)

Rudolf Carl Virchow (1821-1902)

In 1837, **Matthias Jakob Schleiden** viewed and stated that new plant cells are formed from the nuclei of old plant cells. While dining that year with **Schwann,** the conversation turned on the nuclei of plant and animal cells. **Schwann** remembered seeing similar structures (nuclei) in the cells of the notochord and instantly realized the importance of connecting the two phenomena (presence of nuclei and new cell formation). The resemblance was confirmed without delay by both observers, and the results soon appeared in **Schwann's** famous microscopic investigations on the accordance in the structure and growth of plants and animals, in which he declared that **"All living things are composed of cells and cell products".** This became **cell theory.**

In 1855, pathologist **Rudolf Virchow** posed the maxim ***Omnis cellula e cellula*** **that every cell arises from pre-existing cells.**

CELL : THE UNIT OF LIFE

01. INTRODUCTION

- Introduction
- What is a Cell?
- Cell Theory
- An Overview of Cell
- Prokaryotic Cells
- Eukaryotic Cells

- **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.**

02. WHAT IS A CELL?

- 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.

03. CELL THEORY

- In 1838, **Matthias Schleiden,** a German 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), British 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.

04. 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.
- The cells of the human cheek have an outer membrane as the delimiting structure of the cell. Inside each cell is a dense membrane bound structure called nucleus. This nucleus contains the chromosomes which in turn contain the genetic material, DNA.
- Cells that have membrane bound nuclei are called eukaryotic whereas cells that lack a membrane bound nucleus are prokaryotic.

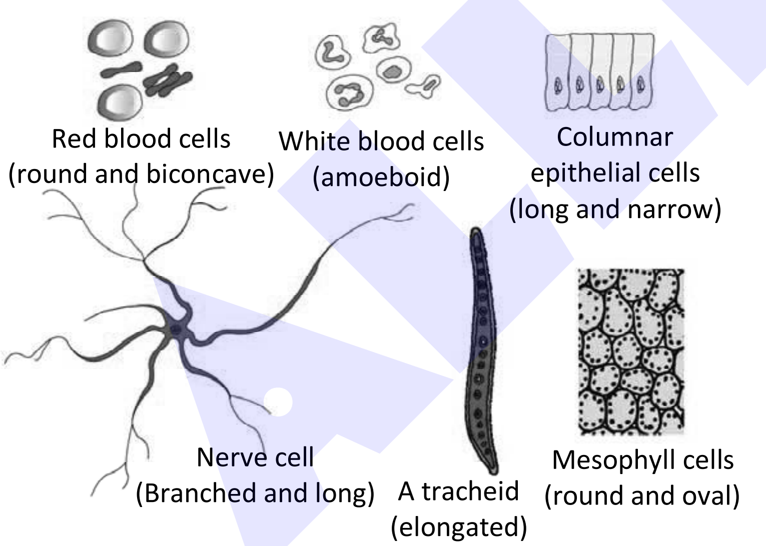
- In both prokaryotic and eukaryotic cells, a semi-fluid matrix called cytoplasm occupies the volume of the cell.
- **The cytoplasm is the main arena (zone) of cellular activities in both the plant and animal cells. Various chemical reactions occur in it to keep the cell in the 'living state'.**
- **Besides the nucleus, the eukaryotic cells have other membrane bound distinct structures called organelles like the endoplasmic reticulum (ER), the golgi complex, lysosomes, mitochondria, microbodies and vacuoles. 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.

(1) SIZE

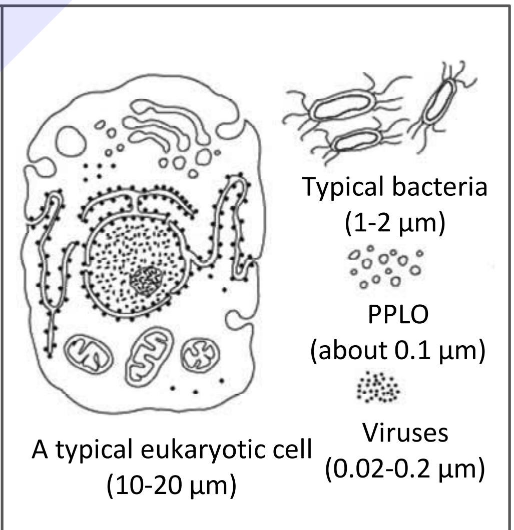
- Cell differ greatly in size, shape and activites.
- *Mycoplasma* (Smallest cell) : Only 0.3 μm in length
- Bacteria = 3 to 5 μm
- Largest isolated single cell = egg of an ostrich.
- Human red blood cell ≈ 7.0 μm in diameter
- Nerve cell = longest cell

(2) 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.



NCERT XI Page No. 127, Fig. 8.1

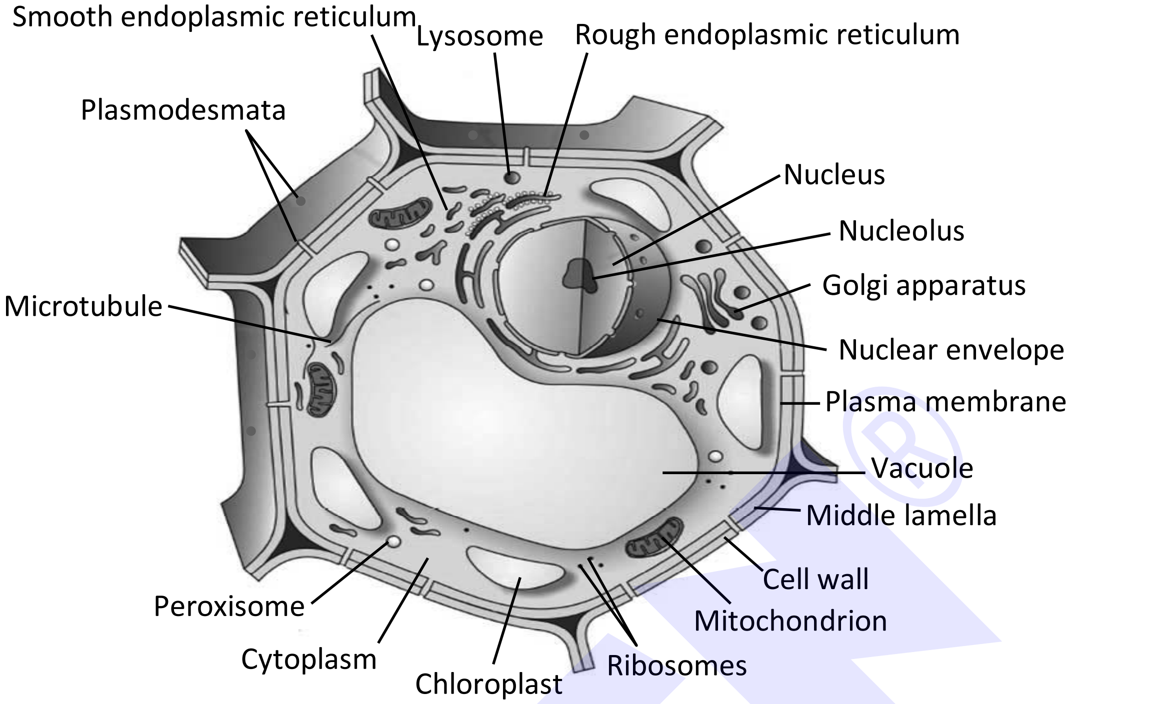


NCERT XI Page No. 128, Fig. 8.2

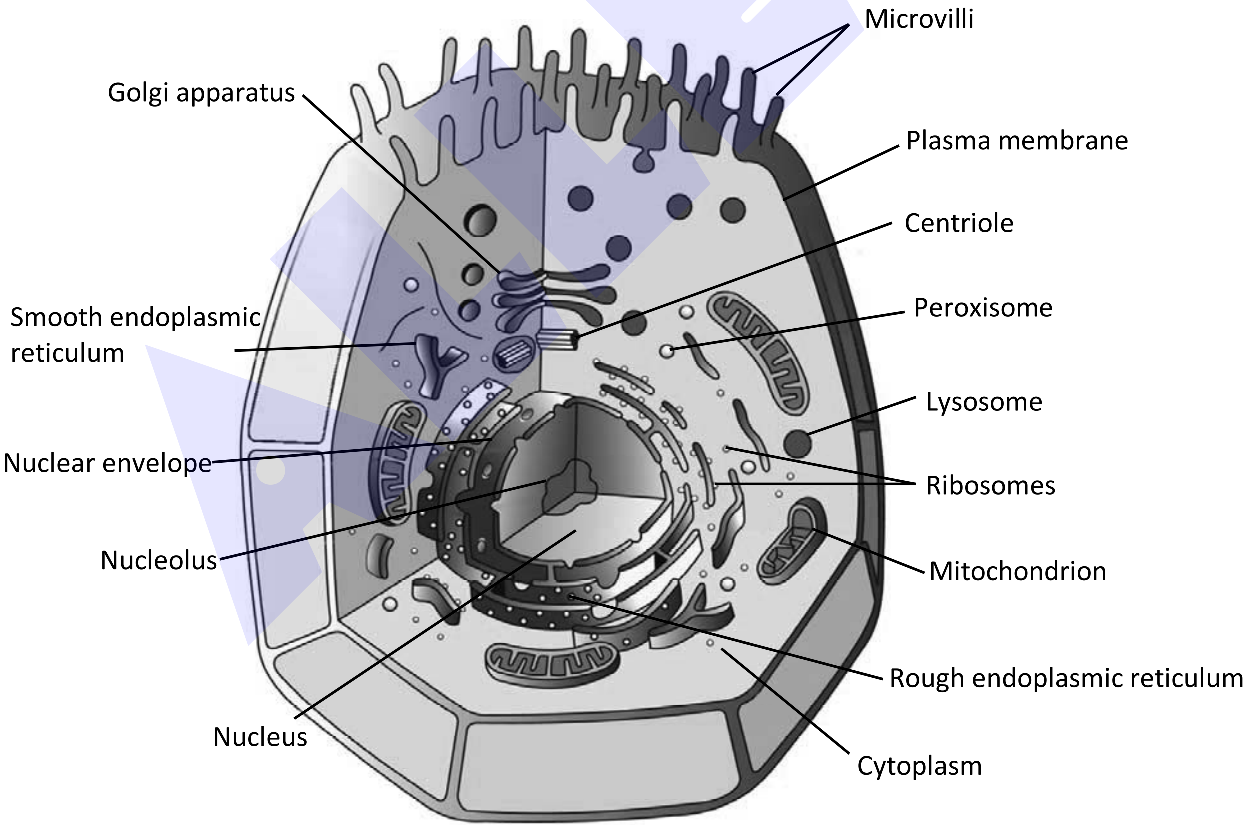
05. PROKARYOTIC CELLS

- 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. They may vary greatly in shape and size. The four basic shapes of bacteria are bacillus (rod like), coccus (spherical), vibrio (comma shaped) and spirillum (spiral).
- The organisation of the prokaryotic cell is fundamentally similar even though prokaryotes exhibit a wide variety of shapes and functions.

06. EUKARYOTIC CELLS



(a)



(b)

Diagram showing : (a) Plant cell (b) Animal cell

NCERT XI Page No. 130, Figure No. 8.3

- 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 plant cells.**

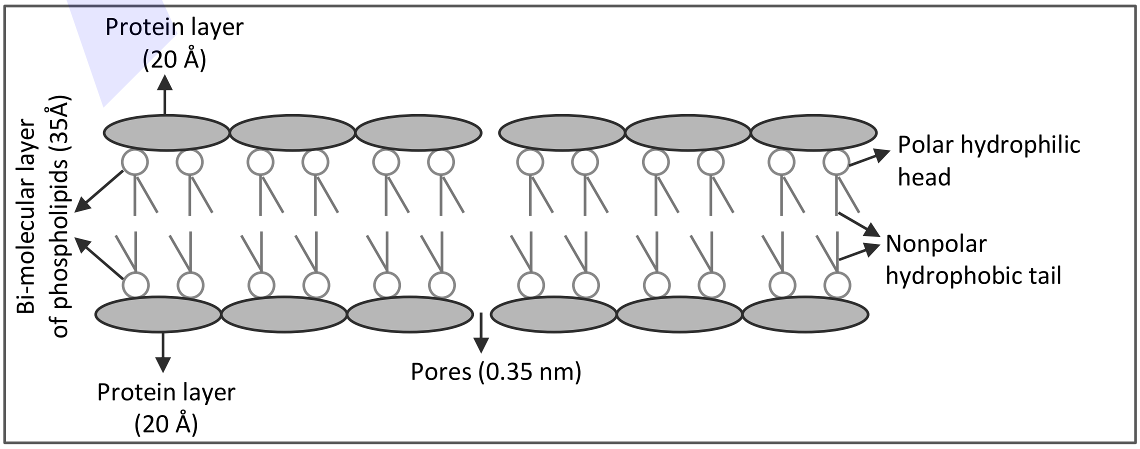
(1) BIOMEMBRANE OR CELL–MEMBRANE

- Biochemical investigation clearly revealed that the cell membranes possess lipid, protein and carbohydrate. The ratio of protein and lipid varies considerably in different cell types. **In human beings, the membrane of the erythrocyte has approximately 52 per cent protein and 40 per cent lipids**
- It is a universal structure and structurally cell membrane of prokaryotes is similar to the eukaryotes.

(A) Structure of Biomembranes :

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

- According to 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 (hydrophillic 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 vanderwaal force.



(ii) Unit membrane model :- By **Robertson**.

- According to this model all the cellular and organeller membranes are structurally & functionally similar.
- 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.

(iii) Fluid mosaic model : Proposed by **Singer** & **Nicolson** (1972)

- This is **latest & most widely accepted** model for the structure of cell membrane.
- 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 concentrated solution **(phospholipid)** of sugar**"**.

(a) Lipids :

- 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 acids.**
- **The Quasifluid 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.**

- In addition to phospholipid membrane also contain **cholesterol**. 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.

(b) Proteins :

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

(i) Integral or intrinsic protein :-

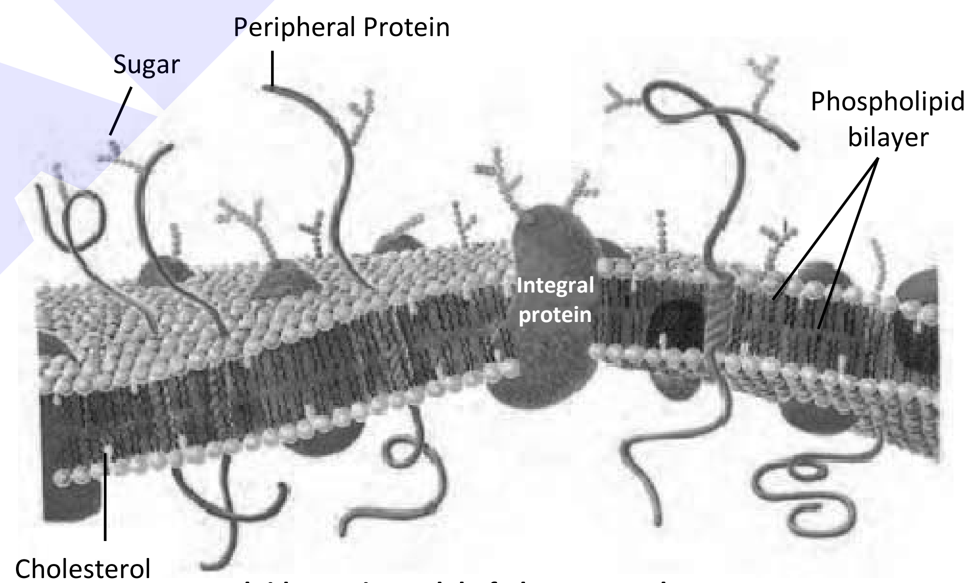
- These protein are tightly binds with phospholipid. Thus, they can not easily removed from membrane.
- Integral proteins are of 2 types : Partially buried or Totally buried
- Some integral proteins are totally buried through the complete thickness of membrane, these type of proteins are called as **tunnel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

(ii) Peripheral or extrinsic protein :-

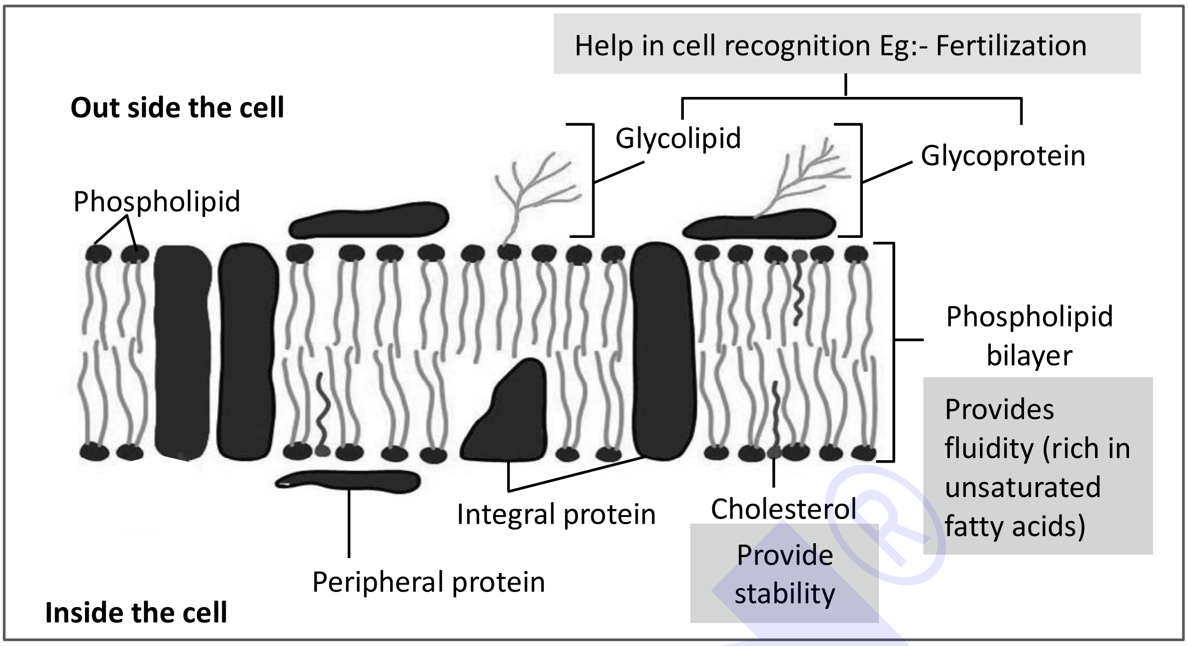
- These are superficially arranged on the surface of lipid layer and can be separated easily. These protein have enzymatic activity.

(c) Carbohydrates :

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



Fluid mosaic model of plasma membrane
NCERT XI Page No. 131, Figure No. 8.4



(B) 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 utilised 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 (Pinosome) 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 :

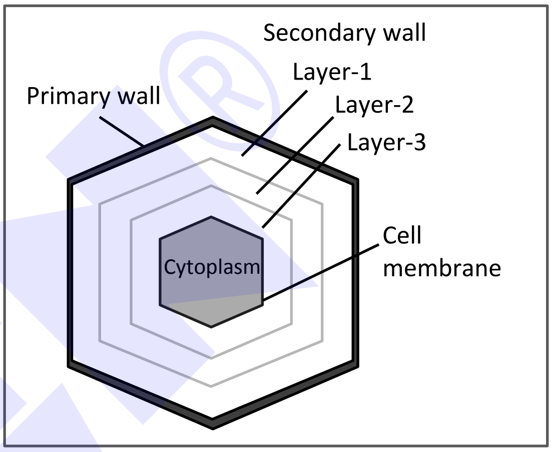
Egestion of waste materials from cell through plasma membrane.

(2) 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.

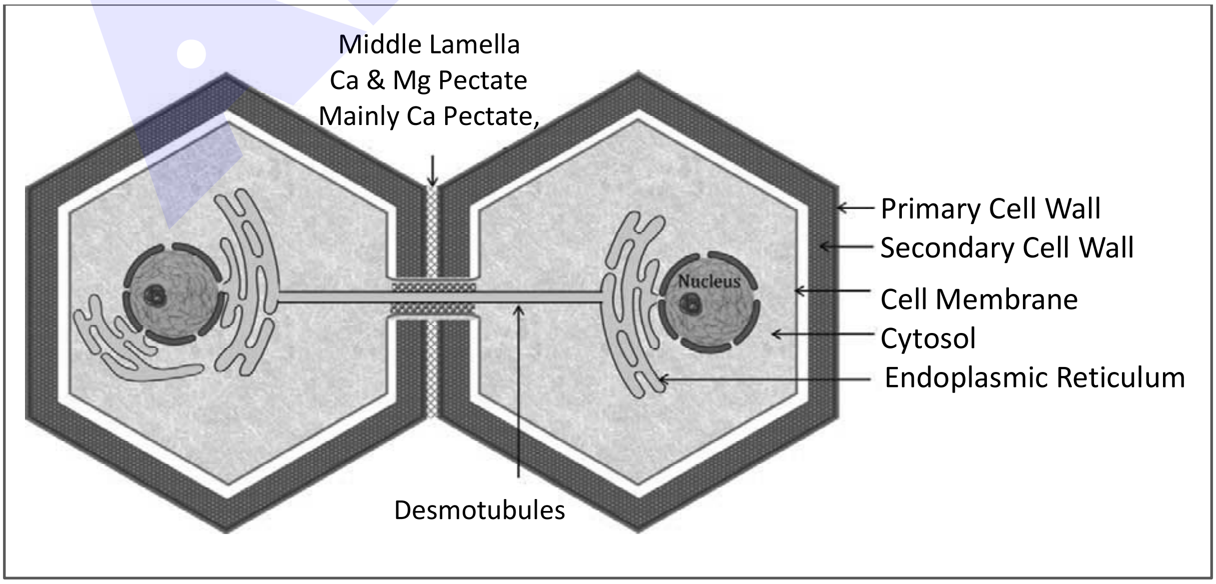
(A) Layers of cell wall :

Cell wall
- **Primary wall** : Thin, elastic
  Composed of cellulose, hemicellulose, pectin & proteins.
  Gradually diminishes as cell matures.
  Capable of growth.
- **Secondary Wall (S_1, S_2, S_3)** : Rigid, thick.
  Composed of cellulose, hemicellulose, Pectin.
  Absent in meristem cells.
  Inner side of primary wall (toward cell membrane).
- **Middle lamella** : Common layer between two cells.



- Middle lamella is consist of Ca & Mg pectate (Plant cement). Mainly Ca pectate.
- Cellulose is a main constituent of cell wall but addition to cellulose, hemicellulose, cutin, pectin, suberin are also present in cell wall.
- Cell wall worked as frame or protective layer of cell.
- Cellulose **microfibrils** 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) are synthesized in plant golgibodies or **dictyosomes**. Formation of cellulose occurs by cell membrane.

(B) 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.**



(C) Functions of Cell Wall :

- Cell wall gives shape to the cell
- It protects the cell from mechanical damage and infection
- It also helps in cell-to-cell interaction
- It provides barrier to undesirable macromolecules.

Golden Key Points

- The lipid component of the membrane mainly consists of phosphoglycerides (Phospholipid).
- One of the most important functions of the plasma membrane is the transport of the molecules across it.
- In the cell membrane, nonpolar tail of saturated and unsaturated hydrocarbons is protected from the aqueous environment.

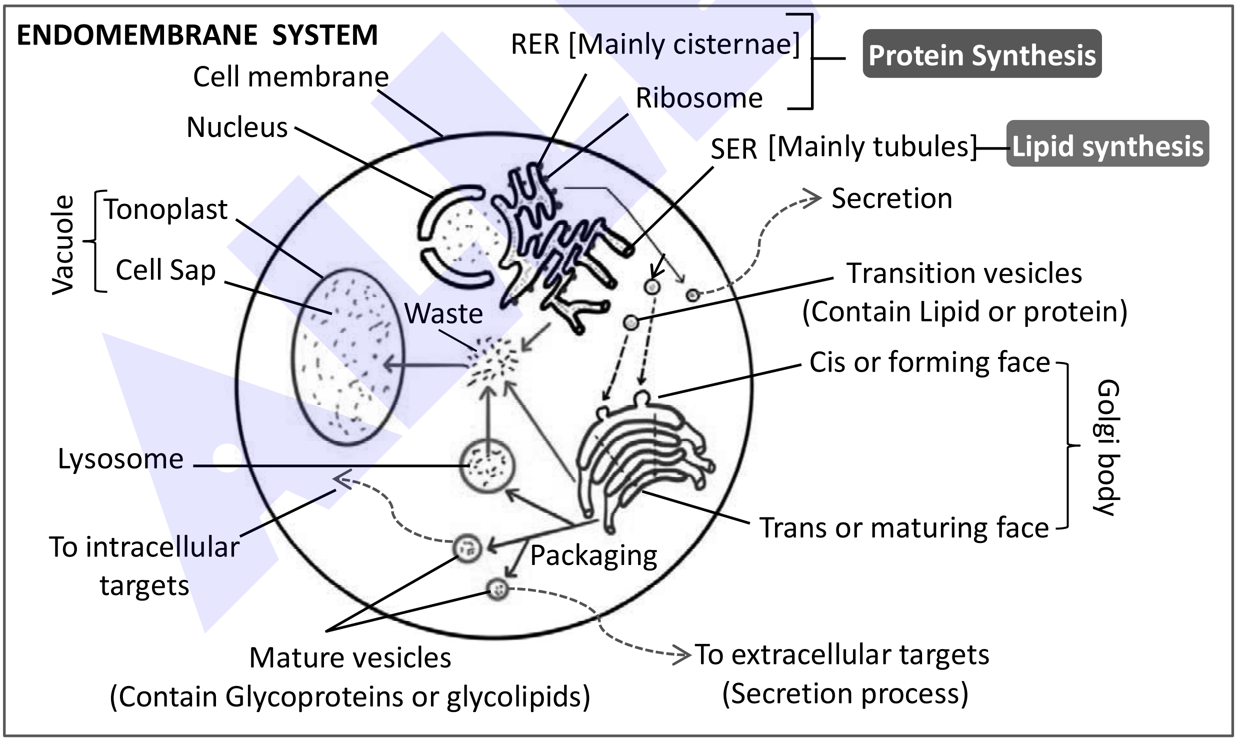
BEGINNER'S BOX — INTRODUCTION, WHAT IS A CELL ? , CELL THEORY, AN OVERVIEW OF CELL, PROKARYOTIC CELLS, EUKARYOTIC CELLS (CELL WALL, CELL MEMBRANE)

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) Lysosome (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 is found closest to the cytoplasm?
   (1) Middle lamella (2) Primary wall
   (3) Cell membrane (4) Secondary wall
5. Who first saw and described a living cell?
   (1) Robert Hooke (2) Robert Brown
   (3) Matthias Schleiden (4) Anthon Von Leeuwenhoek

- **Plant cell – Cell wall = Protoplast**
- **Protoplast – Cell membrane = Protoplasm**
- **Protoplasm = Cytoplasm + Nucleus**
- **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
- **Trophoplasm** → Part of cytoplasm containing **organelles** and non living inclusions **(Deutoplasm)**.

(3) ENDOMEMBRANE SYSTEM

- 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 endomembrane 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.



(A) The Endoplasmic Reticulum (E.R.) :

- 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)

(i) Components of E.R. :

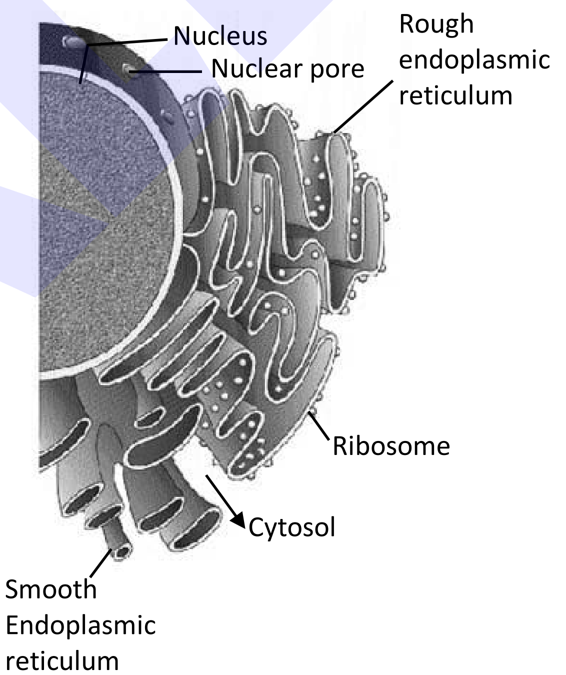
(a) Cisternae - These are long flattened and unbranched units arranged in stacks.

(b) Vesicles - These are oval membrane bound structures.

(c) Tubules - These are irregular, often branched tubes bounded by membrane. Tubules may remain free or associated with cisternae.

- E.R. is often termed as **"System of Membranes".**
- ER divide the intracellular space into two distinct compartments 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)	Frequently observed in cells which are actively involved in **protein synthesis** and **secretion**. They are extensive and continuous with the outer membrane of the nucleus.	(3)	Abundantly occurs in cells concerned with **glycogen** and **lipid metabolism**. ● In animal cell lipid like **steroidal hormones** are synthesised in SER.



Endoplasmic reticulum

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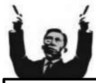
(ii) Modification of E.R. :

- **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.



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

(iii) Functions of E.R. :

- **Mechanical support :–** E.R. provide support to cell from inner side.
- **Intracellular transport :–** 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 plasma membrane, so E.R. can secrete the materials outside the cell.
- **Protein synthesis :- Rough E.R.** provides site for the protein synthesis, because rough E.R., has ribosomes on its surface.
- **Lipid Synthesis :–** Lipids (cholesterol & phospholipids) synthesized by the **Smooth E.R.**
- E.R. also helps in the synthesis of lipoproteins and glycogen.
- **Cellular metabolism :–** The membranes of the reticulum provides an increased surface for metabolic activities within the cytoplasm.
- **Formation of nuclear membrane :–** Fragmented vesicles of disintegrated nuclear membrane and ER elements arranged around the chromosomes to form a new nuclear membrane during cell division.
- **Formation of Golgi body.**
- **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
- E.R. provides the precursor of secretory material to golgi body.

(B) Golgi Apparatus or Golgi Complex :

- **Camillo Golgi** (1898) first observed densely stained reticular structure near the nucleus. These were later named Gogi bodies after him.

- The cytoplasm surrounding Golgi body have fewer or no other organelles. It is called Golgi ground substance or **zone of exclusion.**

(i) Structure :

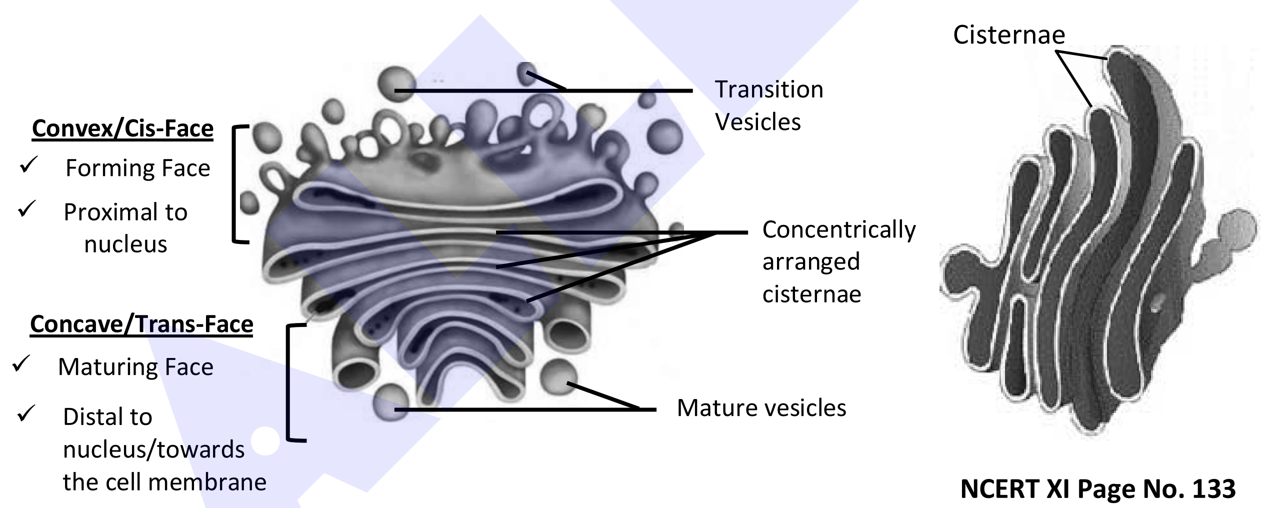
- Golgi complex is made up of **three** parts –

(a) Cisternae :– These are flat disc shaped sac like structures with diameter of 0.5 μm to 1.0 μm. Many cisternae are arranged in a stack parallel to each other.

- 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 **Trans face** or **maturing face**.
- The cis and trans faces of the organelle are entirely different but inter connected.

(b) Tubules :– These are branched and irregular tube like structures associated with cisternae.

(c) Vesicles :– Transition vesicle and Mature vesicle.



Golgi apparatus

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Figure No. 8.6

(ii) Function of Golgi Complex :

- 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.**

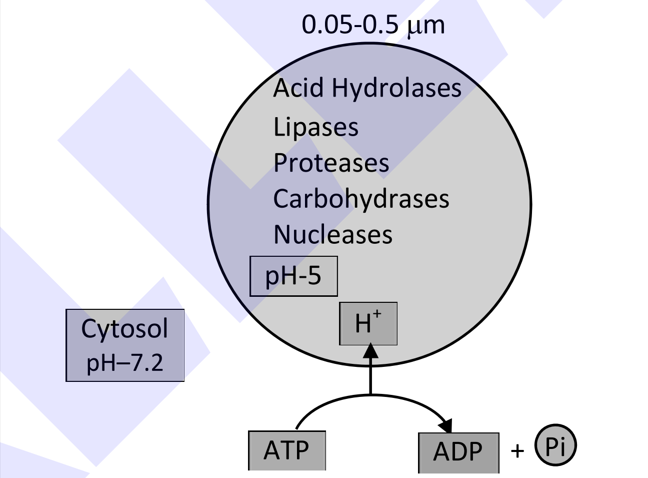
Most of the macromolecules which are to be sent out side the cell, move through the golgi body. So golgi body is termed as **"Director of macromolecular traffic in cell"** or **middle men of cell**.

- Formation of Lysosome – It is collective function of golgi body and E.R.
- Synthesis of some cell wall materials.
- Cell plate formation during cytokinesis.
- Formation of acrosome on sperms.

(C) Lysosome :

(i) Structure :

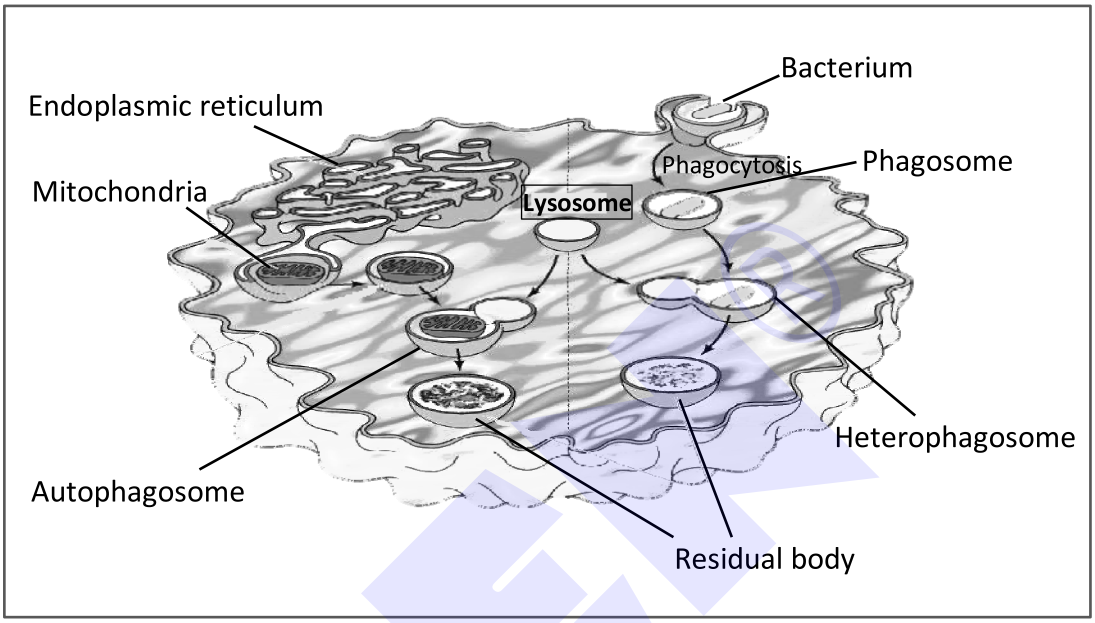
- These are membrane bound vesicular structures formed by the process of packaging in the golgi apparatus. The isolated lysosomal vesicles have been found to be very rich in almost all types of hydrolytic enzymes (hydrolases – lipases, proteases, carbohydrases) optimally active at the acidic pH (pH = 5). These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.



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

- **With the exception of mammalian RBC they were reported in all animal cells.**
- *In plant cells large central vacuole may functions as Lysosome by storing hydrolytic enzymes so in higher plants lysosomes are less frequent. But number of lysosomes is high in fungi.*
- Space between cell wall and cell membrane **(periplasmic space)** in bacteria,may play role of lysosome.

- Lysosomes are abundantly found in phagocytic cells.
- Membrane of lysosome has an active H^+ pump mechanism which produce acidic pH in lumen of lysosome.
- Lysosomes are **polymorphic** cell organelles. Because, lysosomes have different physiological forms.



(ii) Types /Forms of lysosomes :

(a) **Primary Lysosomes or storage granules** - These lysosomes store enzyme *Acid Hydrolases* in the inactive form. These are newly formed lysosome.

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

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

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

(iii) Functions :

(a) **Intracellular digestion :-**

- **Heterophagy :–** This is digestion of foreign materials received in cell by phagocytosis and pinocytosis.
- **Autophagy :–** Digestion of old or dead cell organelles. Autophagy also takes place during starvation of cell.

(b) **Extracellular digestion :–** During osteogenesis, lysosomes of osteoclast (bone eating cells) dissolve unwanted part of bones.

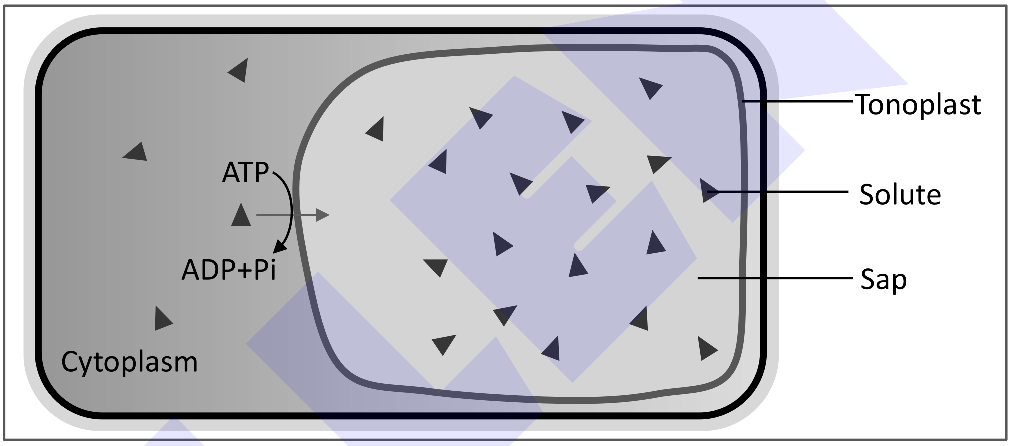
- Extracellular digestion also occurs by fungal lysosomes.

(c) **Cellular digestion/Autolysis/Autodissolution** :– Sometimes all lysosomes of a cell burst to dissolve the cell completely, it is Autolysis. That's why lysosome called as **suicidal bags** of cell.

- *Old cells,* unwanted organs of embryo or larva are destroyed by autolysis. Eg :- **Cathepsin** enzyme of lysosome digests the tail of tadpole larva of frog during metamorphosis.

(D) 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 osmoregulation and 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 functions are co-ordinated.
- 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 it's cis face and these material are modified by golgibody for e.g. Formation of glycolipid and glycoproteins i.e. glycosylation/glycosidation.
- Golgi body is also known as **dictyosome** in plant cells.
- 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.
- Water soluble pigment **anthocyanin** is found in cell sap/vacuole.

BEGINNER'S BOX — EUKARYOTIC CELL (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 statements 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

(4) MITOCHONDRIA

(A) Number, Size And Shape :

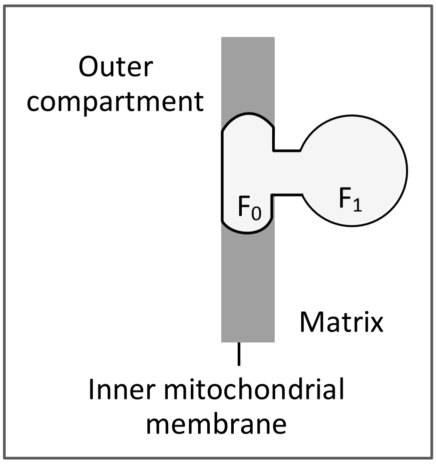
- Number of mitochondria depends upon physiological activity of cell.
- One in ***Microasterias, Chlorella fusca*** (alga).
- Usually plant cells have fewer mitochondria as compared to animal cell.
- In higher animals maximum mitochondria are found in flight muscles of birds.
- Mitochondria are differ 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

(B) Structure :

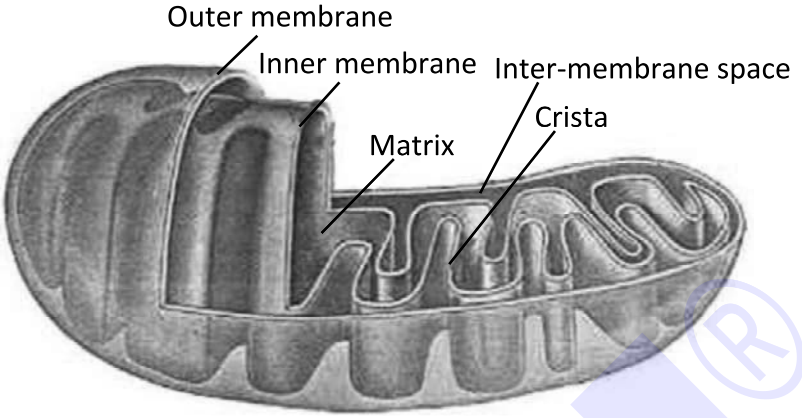
- Mitochondria (sing.: mitochondrion) unless specifically stained are not easily visible under the microscope. Mitochondria are stained by Janus green B.
- Mitochondria is a double membrane bound structure with the outer membrane and the inner membrane dividing its lumen distinctly into two aqueous compartments, 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 (Intermembrane) space**.
- Inner membrane is folded into a number of finger like ***cristae***.
- In metabolically active mitochondria, cristae are higher in number and bigger in size.
- 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 **Krebs cycle (Aerobic respiration)**. Beside these enzymes matrix have a complete protein synthesis apparatus (70S **Ribosomes, DNA**, few **RNA & enzymes**) so mitochondria called as **semi autonomous cell organelles**. 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.
- Single, circular **DNA** molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins present in mitochondria matrix.
- Mitochondrial DNA is 1% of total DNA in a cell. It is rich in G-C content.

(C) Function of Mitochondria :

- Mitochondria are site of aerobic respiration.
- They produce cellular energy in the form of ATP, hence they are called 'power houses' of the cell.



Structure of mitochondrion (Longitudinal section)

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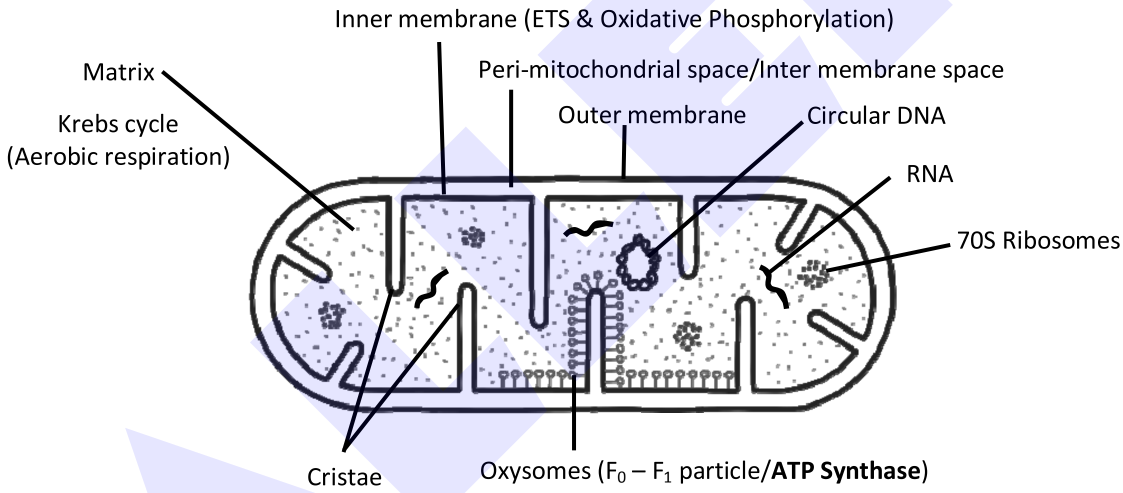


Diagrammatic view of the internal structure of a Mitochondrion

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 fission.**

(5) 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**.

(A) Chromoplasts : In chromoplasts fat soluble carotenoid pigments like carotene, xanthophylls 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.

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

(C) 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 material is similar.

(B) CHLOROPLAST :

(i) 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 (***Chlamydomonas*** a green alga) to 20-40 per cell (mesophyll cell).
- These are lens-shaped, oval, spherical, discoid, or even ribbon shaped.
- Length and width are also variable.

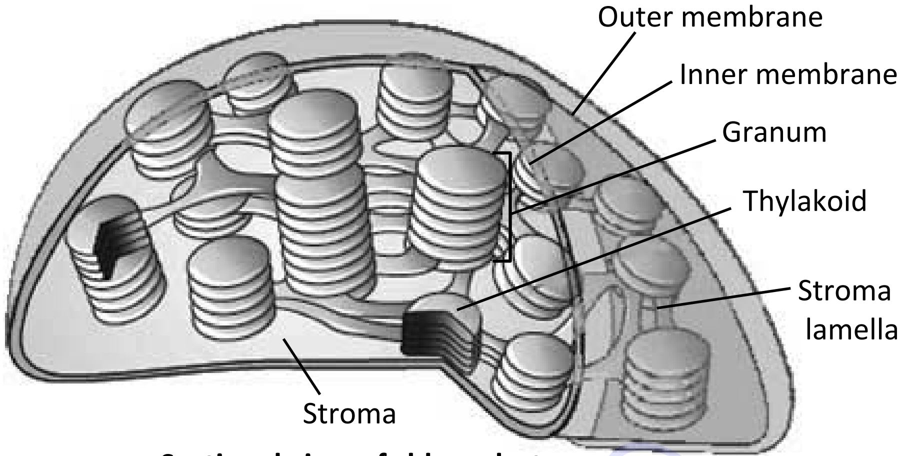
  Length = 5-10 μm

  Width = 2-4 μm

(ii) Structure of Chloroplast :

(a) Membrane : Like mitochondria, the chloroplast are also double membrane bound. Out of the two, the inner membrane is relatively less permeable. (Outer membane contain porins)

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



Sectional view of chloroplast
NCERT XI Page No. 136, Figure No. 8.8

(b) Thylakoids :

- In the stroma a number of organised flattened 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 **Frets channel or Stroma thylakoids** are flat membranous tubules connecting the thylakoids of the different granum.
- The membrane of the thylokoids enclose a space called **lumen**.
- Chlorophyll pigments are present in the thylakoid membranes.
- A photosynthetic functional unit (located in thylakoids membrane) Consist of about 250 to 400 molecules of various pigments (Chl-a, Chl-b, Carotenes, Xanthophylls etc.) is called as ***Quantasome.***

(c) 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**.

(d) DNA :

- Stroma contain small double-stranded circular DNA molecule.

(e) Ribosome :

- The Ribosomes 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 etc.) but enzymes for photosynthesis are synthesised by both genes of nucleus and chloroplast thus chloroplasts are also called as **semi autonomous cell organelle**.

(iii) Function of Chloroplast :

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

BIOGENESIS

(1) From Proplastid

(2) From fission of pre-existing plastids.

ORIGIN : Endosymbiotic origin by a cyanobacterium.

Golden Key Points

- Mitochondria supply most of the necessary biological energy through oxidising 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 — **EUKARYOTIC CELL (MITOCHONDRIA, 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, b and 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–
   (1) are smaller than the cytoplasmic ribosomes
   (2) are bigger than the cytoplasmic ribosomes
   (3) are of similar size to that of cytoplasmic ribosomes
   (4) may be bigger or smaller than the cytoplasmic ribosomes
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

(6) RIBOSOMES

(A) Introduction :

- 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", "Protein factory of cell" and "engine of cell"***

(B) Types of Ribosomes :

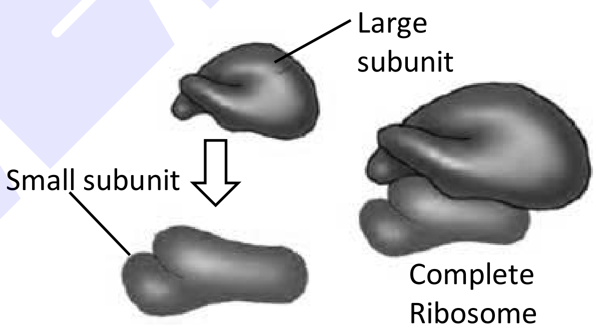
(i) **Eukaryotic ribosomes :–** 80 S - Occur in cytoplasm of eukaryotic cells.

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

- 70 S ribosome also present in mitochondria and chloroplast of eukaryotes.
- **S = Svedberg** unit or Sedimentation rate. **It indirectly is a measure of density and size.**
- Each ribosome composed of two subunits i.e. larger and smaller subunits.

$$80\text{ S} = 60\text{ S} + 40\text{ S}$$
$$70\text{ S} = 50\text{ S} + 30\text{ S}$$

- **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.
- Several ribosomes may attach to a single mRNA and form a chain called **polyribosome** or **polysome or ergosome**.



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(C) Chemical Composition of Ribosomes :

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

- Larger subunit (50S) of 70S ribosome contains **peptidyl transferase enzyme** (23S rRNA) which helps in the formation of peptide bond during protein synthesis. This is an example of Ribozyme.

(7) CYTOSKELETON

- An elaborate network of filamentous proteinaceous structures consisting of microtubules, microfilaments and intermediate filaments present in the cytoplasm is collectively referred to as the **cytoskeleton**. The cytoskeleton in a cell are involved in many functions such as mechanical support, motility, maintenance of the shape of the cell.

(A) Microtubules

- Microtubules are composed of protein, **Tubulin. [Diameter 25 nm]**
- During cell division these microtubules form **spindle fibers.**

(B) Microfilaments

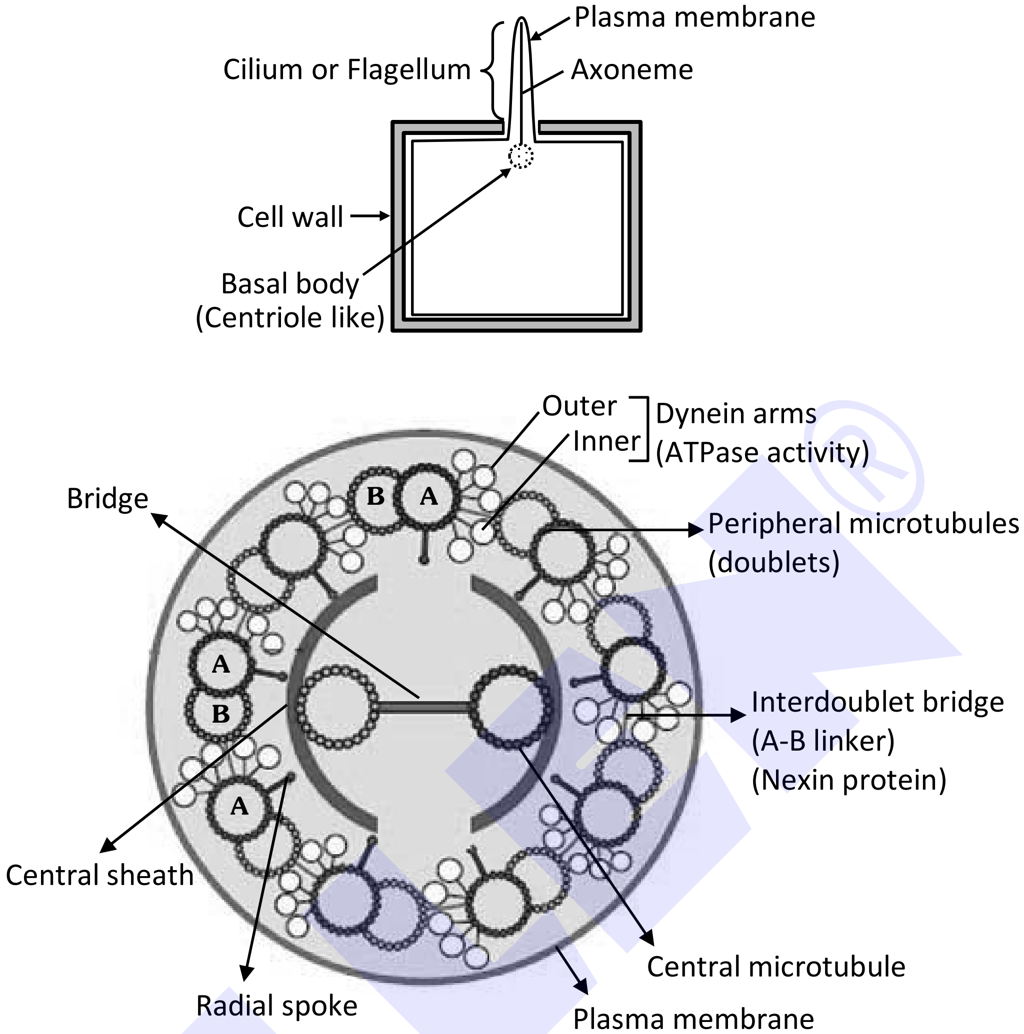
- Microfilaments are composed of contractile protein, **Actin. [Diameter 6-7 nm]**
- These are concerned with **muscle contraction**. Along with microtubules, microfilaments are part of cytoskeleton of cell.

(C) Intermediate Filaments

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

(8) CILIA AND FLAGELLA

- Cilia (sing.: cilium) and flagella (sing.: 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** 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 & flagellum emerge from centriole like structure called the **basal bodies or blepheroplast**.



Diagrammatic representation of internal structure of Cilia or Flagella

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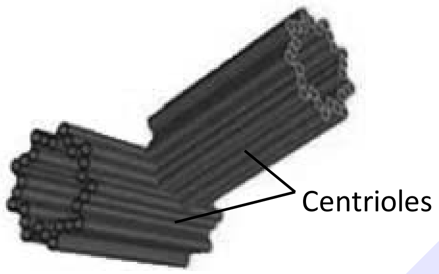
	Cilia		**Flagella**
1.	The cilia are small in size (5–10μm)	1.	Flagella are long (up to 150 μm)
2.	Number of cilia per cell is very high.	2.	Few in number
3.	Cilia beat in a coordinated manner (Pendular movement) / oar like movement	3.	Flagella beats independently (Undulating movement)
4.	They take part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

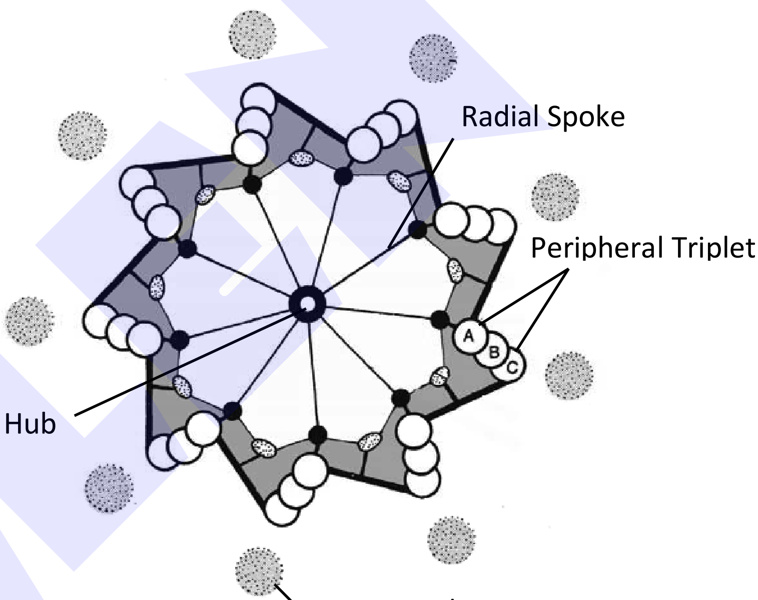
(9) CENTROSOME AND CENTRIOLES

(A) Structure :

- Centrosome is absent in higher plants.
- Centrosome containing two centrioles located just outside the nucleus and lie perpendicular 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 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.



A pair of centrioles



T.S. of a centriole

(B) Function :

- 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.
- Centrioles form the basal body of cilia or flagella.

(10) MICROBODIES

- Many, membrane bound minute vesicles called microbodies that contain various enzymes are present in both plant and animal cells.

(A) Peroxisomes :

- 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** are found in cells of green tissues and concerned with **photorespiration** (glycolate pathway).
- Peroxisomes are also involved in **β-oxidation** of fatty acids.

(B) Glyoxysomes :

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

(C) Spherosomes :

- These are present only in fatty seeds of plants.
- They are involved in synthesis and storage of lipids.

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

EUKARYOTIC CELL (RIBOSOME, CYTOSKELETON, CILIA, FLAGELLA, CENTROSOME AND CENTRIOLE, 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) Golgi body, Lipase (4) Uricosome, Catalase
2. Which of the following cellular structure is found only in plant cells?
(1) Peroxisome (2) Glyoxysome (3) Mitochondria (4) 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 peripheral doublets + 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 C are 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

(11) NUCLEUS

(A) Introduction :

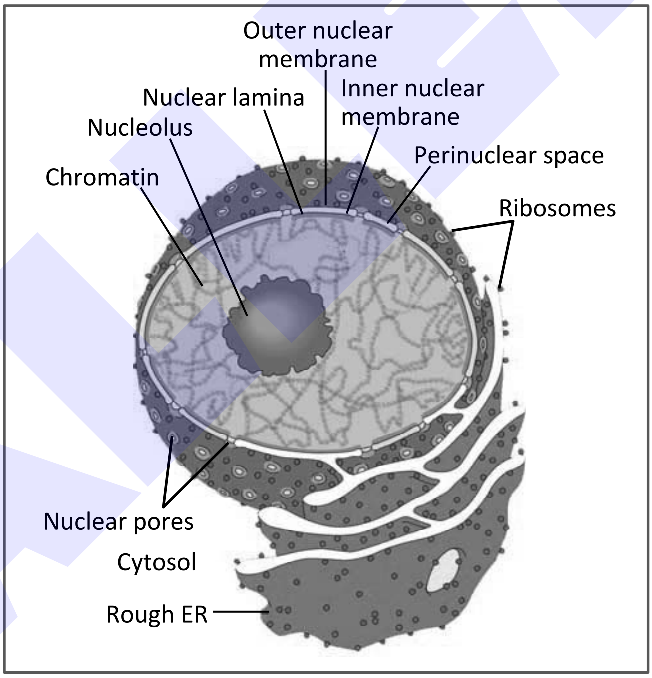
- Nucleus as a cell organelle was first described by **Robert Brown as early as 1831.** Later the material of the nucleus stained by the basic dyes (Acetocarmine) was given the name **chromatin** by **Flemming**.
- "Nucleus is double membrane bound dense protoplasmic body, which controls all cellular metabolism and encloses the genetic information of cell".
- Nucleus is considered 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 absent in mature **sieve tube** cells of vascular plants and mature **erythrocytes** of many mammals.
- Dikaryotic *(Paramoecium)* and multikaryotic cells (Phycomycetes fungus) are also known.

(B) Structure Of Interphase Nucleus :

- Interphase nucleus : Nucleus of cell when it is not dividing.

  (i) Nuclear envelope/Nuclear membrane or karyotheca.

  (ii) Nucleoplasm / Nuclear matrix / Karyolymph/Karyoplasm.



(i) Nuclear envelope :

- 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.** This envelope 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:

- Nucleoplasm is a ground substance of nucleus, which is a complex colloidal form of a number of chemicals like nucleotides, nucleosides, ATPs, proteins & enzymes.
- Nucleoplasm contains **nucleolus** and **Chromatin net**.

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

- Interphase nucleus has a loose and indistinct network of **nucleoprotein fibres** called chromatin, which embeded in nucleoplasm.
- **Chemically chromatin consists of DNA, RNA, Histone protein (basic proteins, rich in arginine and lysine) and non histone proteins.**
- Chromatin net has **two type of chromatins** :-

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

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

(b) Nucleolus :

- The nucleolus is spherical and membraneless structure so that the content of nucleolus 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 organiser** region/NOR.
- Nucleolus is called **Ribosome factory of cell.**
- **Larger and more numerous nucleoli are present in cells actively carrying out protein synthesis.**

(12) CHROMOSOMES

(A) 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.

Name of organism	Chromosome 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 metre long thread of DNA distributed among its 46 (23 pairs) chromosomes.

(B) Types Of Chromosomes On The Basis Of Position Of Centromere :

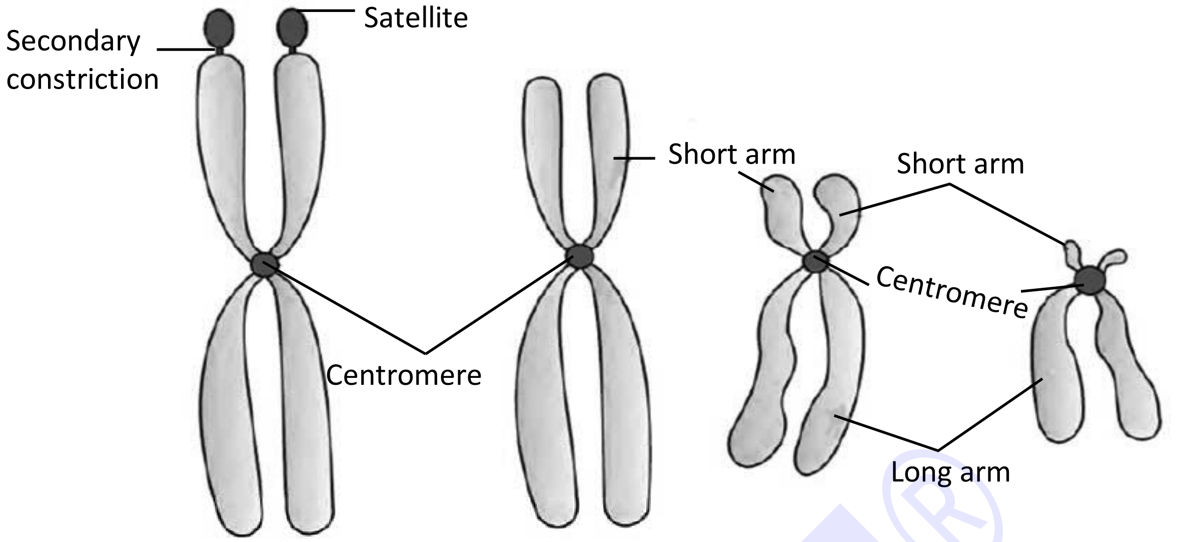
(i) **Metacentric :** When the centromere is located at mid of the chromosome.

(ii) **Sub metacentric :** When the centromere located slightly away from the middle of the chromosome.

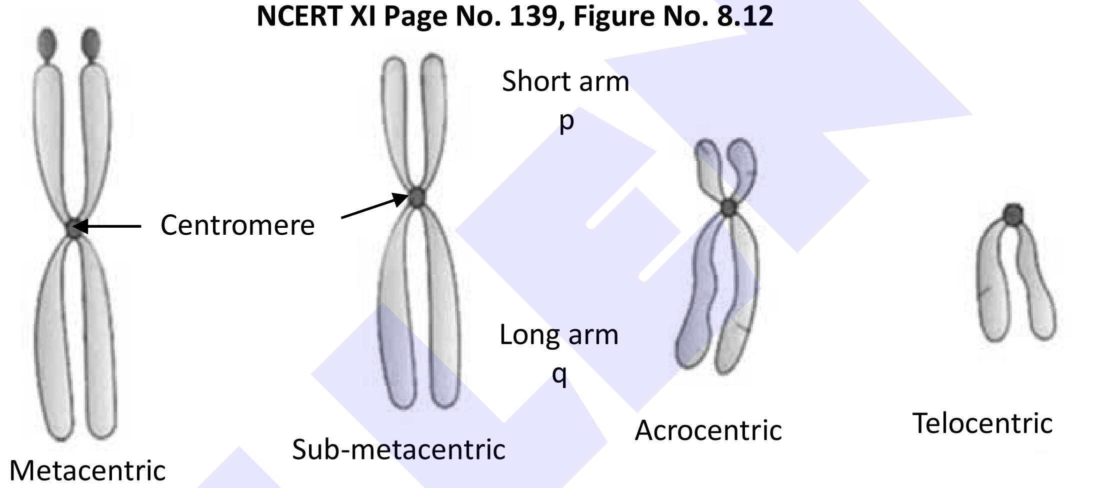
(iii) **Acrocentric :** When the centromere is **sub-terminal** or close to chromosome's end

(iv) **Telocentric :** When centromere is terminal or located at the tip of chromosome.

- The ratio of length of the long arm(q) to the short arm(p) of a chromosome is called **arm ratio**. Arm ratio is maximum in acrocentric chromosome.



Types of chromosomes based on the position of centromere
NCERT XI Page No. 139, Figure No. 8.12



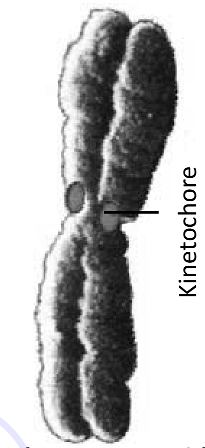
Types of chromosomes based on the position of centromere

- **Karyotype :-** Karyotype is external morphology of all chromosomes of a cell which is specific for each species of living organisms. Karyotype 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.

(C) Structure Of Chromosome:

(i) 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 two chromatids (as in prophase and metaphase)



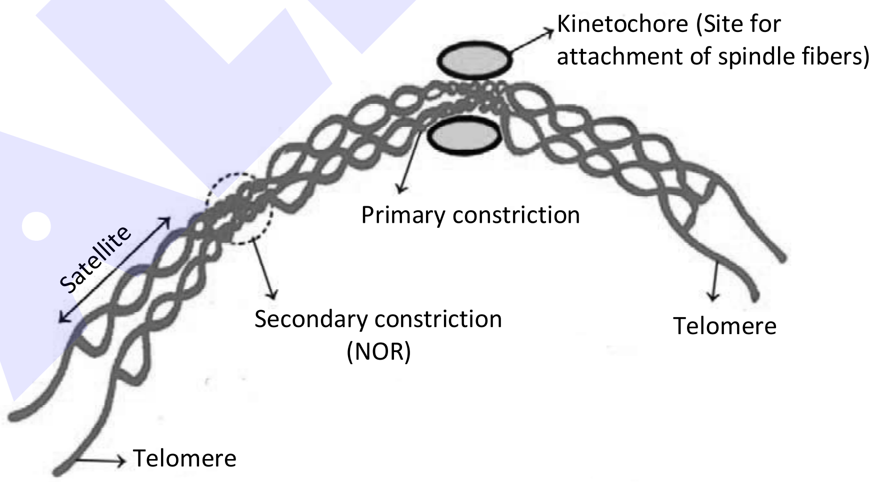
Chromosome with kinetochore
NCERT XI Page No.139, Figure No. 8.13

(ii) Centromere :

- Every chromosome (visible only in dividing cells) essentially has a **primary constriction or the centromere** on the sides of which disc shaped structures called **kinetochores** are present.
- **Kinetochores** constitute the actual site of attachment 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**.

(iii) Secondary constriction : Besides primary constrictions, other constrictions may also occur on few chromosomes, which are known as secondary constrictions. These constrictions are non staining and found at a constant location.

- Some secondary constrictions are also known as **NOR** (**Nucleolar organizer region**). In humans NOR is found in chromosome number 13,14,15,21 and 22.



Schematic Diagram of a Double Chromatid Chromosome

(iv) Satellite : Secondary constriction gives the appearance of a small fragment called the **satellite**.

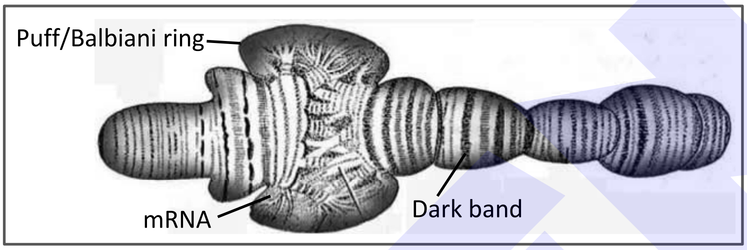
(v) Telomere : Chromosomes have polarity and polar ends of chromosomes are known as Telomeres.

- Telomere prevents fusion or sticking of one chromosome to other chromosome. Telomeres are rich in **Guanine base.** (5' -TTAGGG-3')
- **Enzyme Telomerase** which is a **Ribonucleoprotein** synthesize telomere part of chromosome.

Telomeres of chromosomes become shorter during ageing process.

(D) Special Type of Chromosomes :

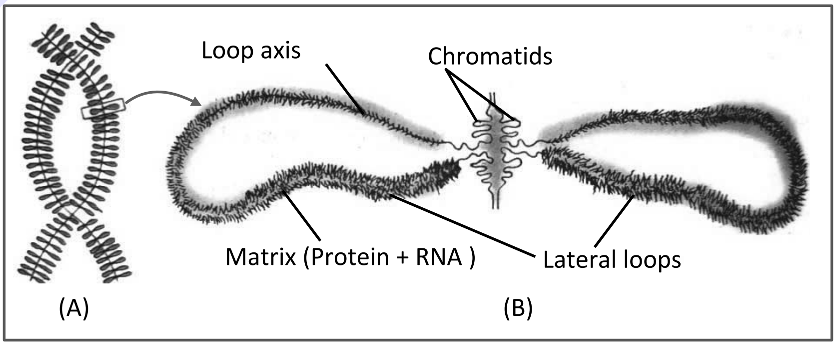
(i) Salivary gland chromosome : This type of chromosome was discovered by E.G. Balbiani, in *Chironomous* larva



- 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.

(ii) Lampbrush chromosome : Discovered by **Flemming and Ruckert** from oocytes of vertebrates (Amphibia) during diplotene stage of cell division. These chromosomes look like lampbrush, thus called as **lampbrush chromosomes**.

- Axis of lamp-brush chromosome is consist of DNA, while matrix is consist of RNA & proteins.
- Lampbrush 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 to form chromosome.
- Every chromosome (visible only in dividing cells) essentially has a primary constriction or the centromere on the sides of which disc shaped structures called kinetochores are present.
- 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.

BEGINNER'S BOX — EUKARYOTIC CELL (NUCLEUS, CHROMOSOME)

1. The nucleus is separated from surrounding cytoplasm by a nuclear envelope, 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) Messenger 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

CHARACTERS	PROKARYOTIC CELL	EUKARYOTIC CELL
(1) Nuclear Membrane	Nuclear membrane absent **Incipient nucleus/prokaryon/ genophore/nucleoid** present	Nuclear membrane present, Nucleus well organised
(2) Cell organelles	Membranous cell organelles (like mitochondria, plastids, E.R., golgibody, microbody) are absent	Membranous cell organelles are present. (Plastids are present only in plants)
(3) Ribosome	70S type	80S type in cytoplasm and 70S type in mitochondria & chloroplast
(4) Respiratory Enzymes	Present in mesosome or in cell membrane and in cytoplasm	Found in cytoplasm and mitochondria
(5) Flagella	Flagella are Made up of **Flagellin** Protein	Flagella are eleven stranded, Made up of tubulin protein (9+2 arrangement)
(6) Cyclosis	Cytoplasmic streaming absent	Present
(7) Chromosomes	**Naked** or **folded genome** made by mainly **ds circular DNA** (G–C rich), (Histone protein absent)	True chromosomes (Histone associated with DNA)
(8) Ploidy level	Considered 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**

BEGINNER'S BOX — ANSWER KEY

INTRODUCTION, WHAT IS A CELL ? , CELL THEORY, AN OVERVIEW OF CELL, PROKARYOTIC CELLS, EUKARYOTIC CELL (CELL WALL, CELL MEMBRANE)

Que.	1	2	3	4	5
Ans.	2	2	3	3	4

EUKARYOTIC CELL (ENDOMEMBRANE SYSTEM)

Que.	1	2	3	4	5
Ans.	4	2	2	4	2

EUKARYOTIC CELL (MITOCHONDRIA, PLASTIDS)

Que.	1	2	3	4	5
Ans.	2	1	2	1	1

EUKARYOTIC CELL (RIBOSOME, CYTOSKELETON, CILIA, FLAGELLA, CENTROSOME AND CENTRIOLE, MICROBODIES)

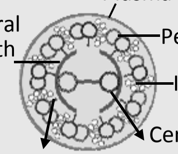
Que.	1	2	3	4	5
Ans.	4	2	3	2	4

EUKARYOTIC CELL (NUCLEUS, CHROMOSOME)

Que.	1	2	3	4	5
Ans.	3	1	2	3	2

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. These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.

- First observed under the electron microscope by George Palade (1953) so ribosome is also called 'Palade Particle'.
- Composed of Ribonucleic Acid (RNA) and proteins.
- Membrane less (not surrounded by membrane)
- Organelle within organelle
- 'S' (Svedberg's Unit) stands for the sedimentation coefficient, it indirectly is a measure of density and size.

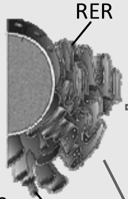


- Composed of two type of monomers-α-tubulin & β-tubulin protein.
- Size-25 nm

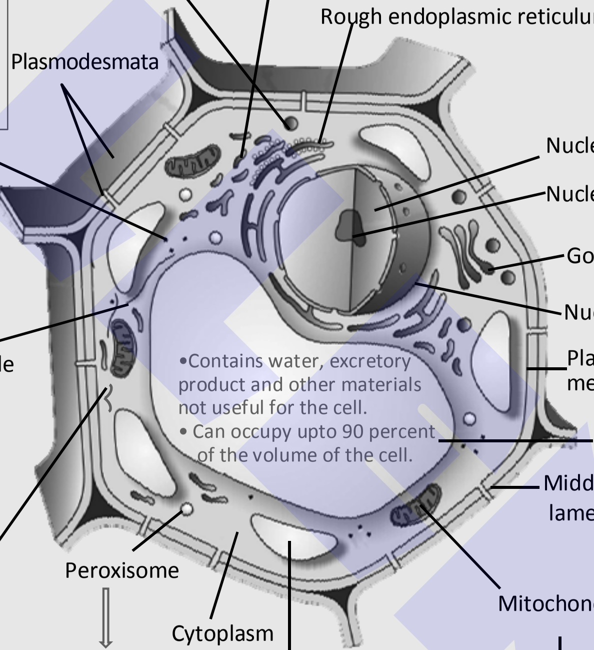
Microfilaments
- Composed of single type of monomers-Actin protein.
- Size-6 to 7 nm

- Found in both plant and animal cells. Involved in photorespiration/Glycolate cycle in plants alongwith chloroplast and mitochondria.
- Breakdown of H_2O_2 by catalase enzyme.

- Length - 5 to 10 μm, width - 2 to 4 μm
- Double membrane bound, inner membrane relatively less permeable.
- Contains enzyme require for the synthesis of carbohydrates and proteins.



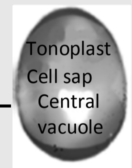
- SER - major site for synthesis of lipid.
- In animal cells steroidal hormones are synthesized in SER.
- RER - involved in protein synthesis and secretion.
- ER divides the intracellular space into two distinct compartments i.e. luminal (inside ER) and extra luminal (Cytoplasm) compartments)



- First described by Robert Brown as early as 1831.
- Material of the nucleus - chromatin (termed by Flemming) stained by the basic dyes.
- Nucleus can be seen during interphase but during different stages of cell division cell show chromosomes in place of the nucleus.
- Perinuclear space -10 to 50 nm.
- Nucleolus is Membraneless structure and it is a site for r-RNA synthesis.

- Important site of formation of glyproteins and glycolipids.
- Principal function-Packaging materials.

- Bound by a single membrane called tonoplast.
- Tonoplast facilitates a number of ions against concentration gradient into the vacuole so their concentration is higher in the vacuole than in the cytoplasm.



- Diameter 0.2 to 1.0 and length 1.0 to 4.1 μm,
- Number, shape & size of mitochondria is variable.
- Number of mitochondria depends on the physiological activity of the cell.
- Cristae increase the surface area of inner membrane so that more enzymes regarding respiration & ATP formation can be placed.
- Matrix possess circular DNA molecule, few RNA molecules, 70s ribosomes and the components required for the synthesis of proteins.