ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

STUDY MATERIAL -2

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Topic - CELL AND IT'S ORGANELLES

CELL AND IT'S ORGANELLES

CELL (INTRODUCTION)

The living body of plant and animal are made up of certain tiny (usually microscopic) structural units called cells. Generally most of the organisms that are commonly visible to us are **multicellular** i.e., they are composed of many cells. A vast number of organisms are there who are formed of only single cell, called **unicellular organisms**. The single cell exhibits all the characteristics of life and maintains its independent existence.

DISCOVERY OF CELL

The term "cell" was first used by **Robert Hooke**, an English engineer, in 1665. While he was examining a section of bottle cork under a microscope, he saw many honeycomb like empty chambers (hollow spaces) in it. He named each of these hollow space as cell. Hooke used a very simple type of self made compound microscope. After his discovery of cell, considerable progress has been made in the development of powerful and more sophisticated microscopes that reveal details of cytology.

CELL – DEFINITION

A cell may be defined as the structural as well as functional of living organism.

- **Size of cells** : Cells are usually small in size and are not visible by the naked eye. Different parts of cell can be viewed under microscope. But a few cells are quite large and are thus visible even to the naked eye.
  RBC is the smallest cell of human body. What is the largest cell in human body? Do you know ostrich egg is the largest single cell of the earth.

STRUCTURE OF CELL – Cell consists of cell wall (in plants only), cell membrane and cytoplasm and cell organelles.

CELL WALL

- The thick rigid, porous, permeable non-living, outer envelope of plant cells made up of cellulose is called the cell wall.

- Most plant cells (but not in animal cells) have a cell wall. It is lying just outside the cell membrane.

STRUCTURE

The main constituent of cell wall is cellulose, a type of carbohydrate. The cell wall of mature plant cell consists of two parts-

(i) **Primary cell wall** – It is the outer permeable and thinner wall in comparison to the secondary cell wall. It is made up of cellulose.

(ii) **Secondary cell wall** – It is the thicker inner part of the cell wall formed after the primary cell wall.It is chemically made up cellulose and hemicellulose. It has three layers- thin **outer layer**, thick **middle layer** and thin **inner layer**. The common first formed wall lying between the two adjacent cells is called the **middle lamella**. The middle lamella made up calcium pectate .There are some minute pores present in the cell wall through which protoplasmic connections between the adjacent cells are established. These intercellular connections are known as the **plasmodesmata**.

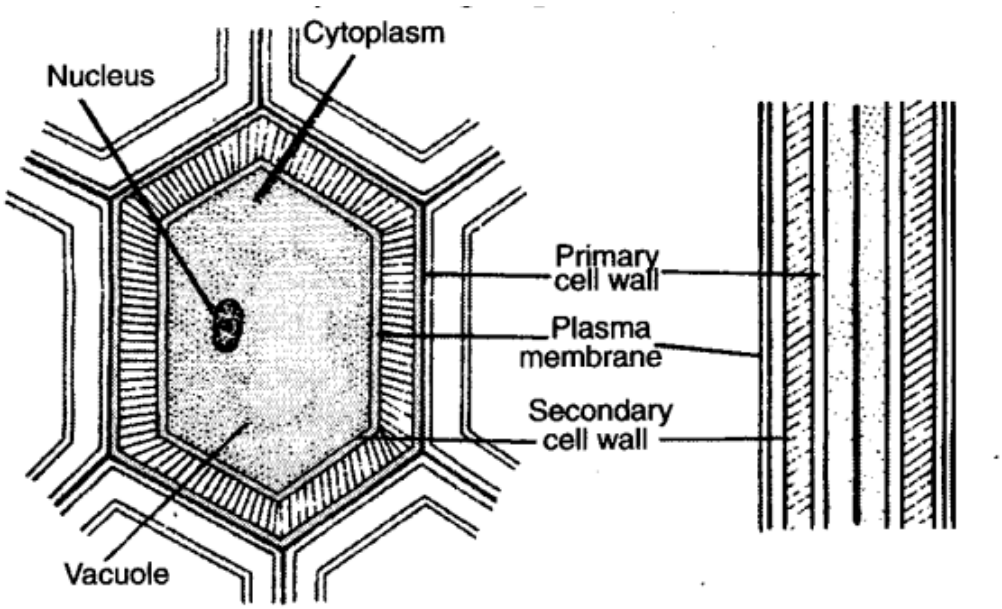


Fig. Structure of the cell wall

FUNCTION

- The cell wall gives shape and rigidity to the cell.
- It protects the protoplasm from external injury.
- Unless deposition of special chemical substances occur (as in the cells of bark), the cell wall is free permeable to the molecules i.e. allows them to pass through in and out freely.

- The plasmodesmata are meant for cell to cell conduction of water and different chemical substances.

CELL MEMBRANE OR PLASMA MEMBRANE

The thin flexible semi-permeable living membrane that surrounds the protoplasm of a cell is called the cell membrane or plasma membrane. Cell membrane lies as the external covering layer of the animal cells. In plant cells the membrane lies between the protoplasm and the cell wall.

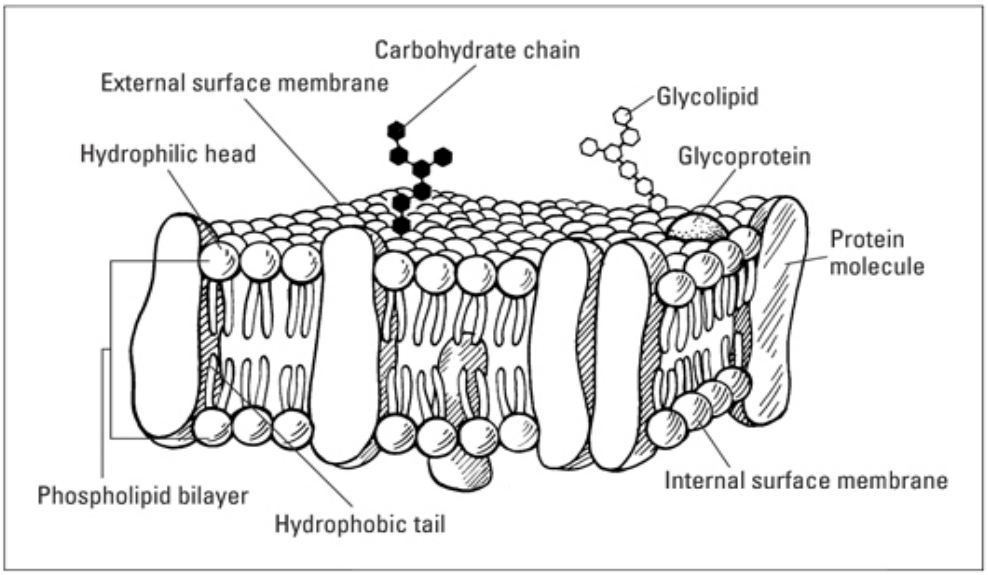
STRUCTURE

The cell membrane is a thin limiting membrane. Under electron microscope (EM), the cell membrane is found to be made up of three layers – a layer of lipid is present between two protein layers. Such a membrane is called the **unit membrane (P-L-P)** by J.D. Robertson.

Different models related to structure of cell membrane have been proposed by various scientists of which **most accepted one is Fluid-Mosaic Model as proposed by Singer and Nicolson (1972).**

FLUID MOSAIC MODEL OF CELL MEMBRANE:

- It is known as the quasi fluid model of cell membrane.
- Lipids are present as a continuous bilayer and there are intermittent globular protein present just like icebergs floating in the sea of lipids.
- The type of lipids are phospholipids (glycerol is linked with two fatty acids and one phosphoric acid molecule).Glycerol along with phosphoric acid forms water soluble head (hydrophilic) while the two fatty acid chains form the water hating hydrophobic tails.
- There are two types of proteins present- Extrinsic proteins (which are present a floating ice bergs on the lipid bilayer) and Intrinsic proteins (which traverse through the lipid bilayer)
- The hydrophobic tails face each other while the hydrophilic heads are present on the external and internal side of the cell membrane.
- Glycolipids are also present on the external side of the cell membrane



Fluid Mosaic Model of Plasma Membrane

FUNCTION

- Cell membrane protects the protoplasm and the cell organelles from external injury.
- It maintains the normal structure of the cell.
- It retains the cell contents and controls the transfer of food materials and waste products inside and outside the cell respectively.
- It allows the entry and exit of selected molecules.
- Cell membrane gives mechanical support

PROTOPLASM (PROTOS = FIRST, PLASMA = SHAPE)

Protoplasm is translucent jelly like viscid material constituting the essential substance of living cells. **Protoplasm = Cytoplasm + nucleus**

Max Schultze and Thomax Huxley proposed protoplasm as the physical basis of life because all the vital functions like nutrition, secretion, growth, reproduction, irritability, mortality etc. of the living cells are controlled by the **protoplasm**. **It is made up of cytoplasm and nucleus**. The term protoplasm was coined by Purkinje. **Protoplasm exhibits streaming movement called cyclosis or Brownian movement.**

CYTOPLASM

A thick, semi-transparent, elastic fluid containing suspended particles and a series of minute tubules and filaments is known as cytoplasm.

Cytoplasm is the matrix or ground substance which is present in between the membrane and nuclear membrane of the cell. **Cytoplasm = Protoplasm – nucleus**.

STRUCTURE

Under ordinary compound microscope the cytoplasm appears to be a semi-fluid,

apparently transparent and homogenous substance. The outer denser portion of the cytoplasm, is known as the **ectoplasm**. It is relatively non-granular and transparent

part. The inner less denser portion is lying towards the nucleus and is called the **endoplasm**. It is granular and viscous. The fluid part of the cytoplasm is known as the **hyaloplasm** or **cytoplasmic matrix**. This fluid part contains various cell organelles (mitochondria, gogi bodies, endoplasmic reticulum, chloroplasts etc. non-living inclusions and vacuoles. **Hyaloplasm = Cytoplasm – cellular organelles**.

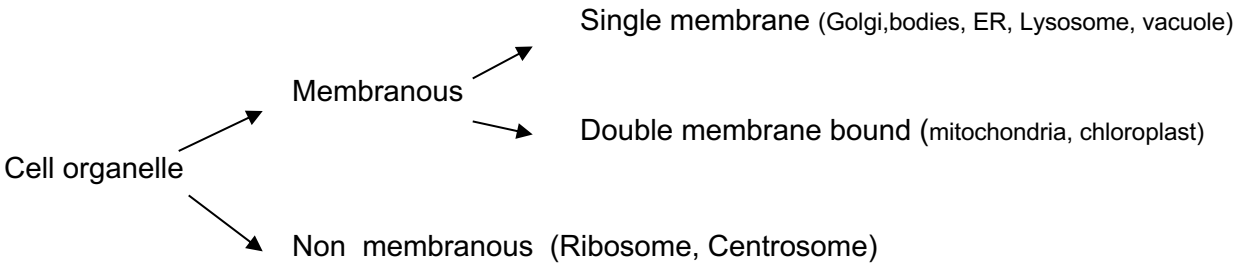
FUNCTIONS

- Various cytoplasmic organelles, the nucleus and non-living cytoplasmic inclusions remain embedded in the cytoplasm.
- The cytoplasm is the site of a number of chemical reactions which are essential for life (e.g. part of respiration).

CYTOPLASMIC ORGANELLES:

The tiny specialized subunit of a cell which remains embedded in the cytoplasm having a specific physiological function of the cell are called cytoplasmic organelles.

Examples – Nuclueus, Mitochondria, plastids, Golgi bodies, centrosome, ribosomes, endoplasmic reticulum, lysosome, vacuole etc. are such structures.



1) NUCLEUS :

The double membrane bound dense spherical protoplasmic body (largest cellular organelle) containing chromosomes is called the nucleus.Also known as the 'brain of the cell'.

The nucleus is usually present at the centre of the cell, but in mature plant cells it is pushed towards periphery by the vacuole. Generally a single nucleus is present in most cells (uninucleate). In some cases, however, more than one nucleus may be present in each cells (multinucleate). Examples – skeletal muscle, certain algae and fungi. In bacteria organized nucleus is totally absent.

Human mature erythrocytes and plant's sleve tube (cell) do not contain nucleus.

STRUCTURE

The nucleus is a specialized protoplasmic denser body lying embedded in the cytoplasm.

(i) **Nuclear membrane** – The porous delicate double membrane (Outer membrane and inner membrane) bound

structure which surrounds the nucleus is called **nuclear membrane**. The space between two membranes is called **perinuclear space**.

Functions : Nuclear membrane separates the nucleus from the surrounding cytoplasm.

(ii) **Nucleoplasm or Nuclear sap** – It is a dense but clear fluid present in the nucleus, forming the matrix.

Functions – It stores reserve materials that are used up at the time of the cell division.

(iii) **Nuclear reticulum** – Suspended in the nuclear sap there lies an irregular network of delicate threads called the nuclear reticulum or chromatin reticulum.

Functions : During cell division, thread like bodies, called chromosomes are developed from this reticulum. They contain the hereditary material (DNA and genes) and control the characters of the organism.

(iv) **Nucleolus** – The highly refractile, dense and non-membranous spherical body present within the nucleus is called nucleolus.

Functions- Nucleolus helps in the formation of ribosomes. It helps in the synthesis of ribosomal RNA and protein.

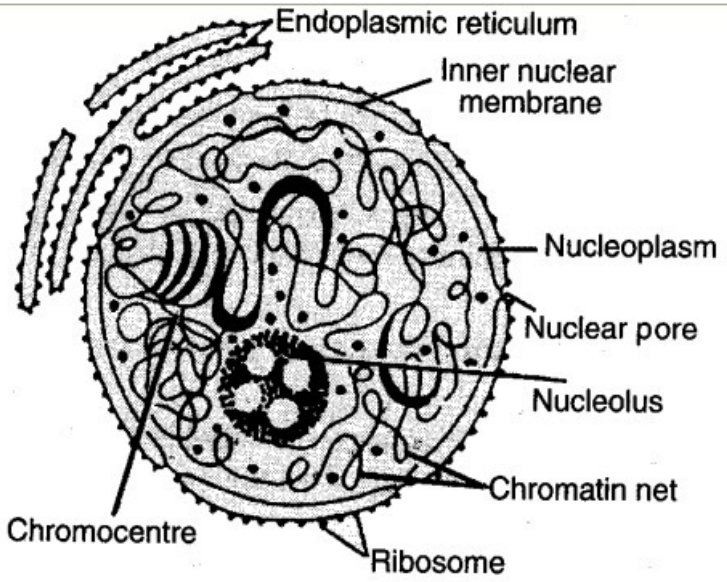


Fig. Eukaryotic nucleus

FUNCTION OF NUCLEUS

- Nucleus is thought to be the centre of all chemical activities of the cell-so called as brain of cell.
- It acts as the controlling centre of the major physiological process taking place within the cell.
- It contains chromosomes the bearers of hereditary characters called gtenes and helps in transmission of this hereditary characters from parents to offspring.
- It also initiates and regulates the cell division.

2) MITOCHONDRIA (sing. MITOCHONDRION)

The spherical or elongated double membrane bound filamentous cytoplasmic bodies associated with cellular respiration are called as mitochondria. The number of mitochondria in a cell depends on the metabolic activity of the cell.

STRUCTURE

The oval or rod like mitochondria possesses two unit membranes. The outer membrane of the mitochondria is smooth but the inner membrane remains folded inwards to form finger like projections at several points to form a number of partitions or shelves called **cristae** (sing. Crista). The two membranes lie apart from each other and the space (peri mitochondrial space) between them is filled up with a fluid. The central

cavity of the mitochondrian enclosed by the inner membrane and cristae is filled up with ground substance called **matrix**.On the cristae there are tennis racket shaped structures called **Oxysomes or F_1 F_0 particles or Fernandez Moron particles** which help in the production of ATP by oxidative phosphorylation. Matrix also contains **Mitochondrial DNA** (double stranded circular DNA) **AND 70s Ribosomes.**

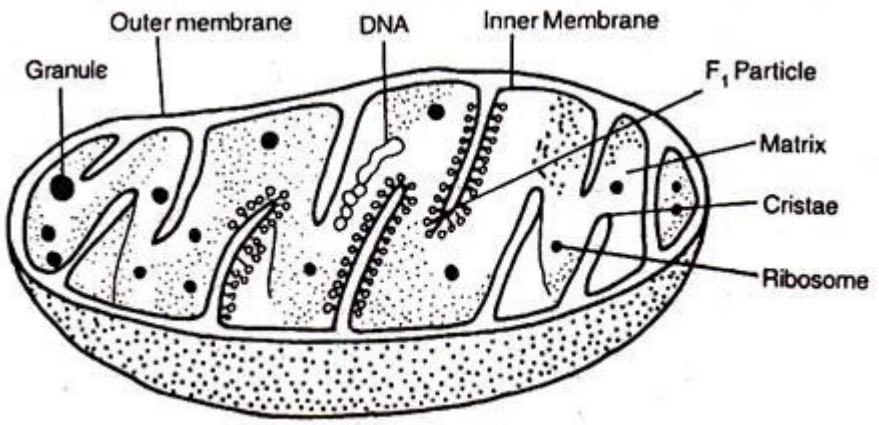


Fig. 1.19 (*a*) Mitochondrion cut open to show the inner structures.

FUNCTION

The mitochondria are associated with the cellular respiration. During respiration food is oxidized and considerable amount of energy is liberated in form of ATP. As mitochondrion acts as a source of energy generator, it is regarded as the 'power-house of the cell'.

3) **PLASTIDS**

The pigmented or non-pigmented double membrane cytoplasmic bodies in plant cell associated with the preparation or the storage of food materials are called plastids.

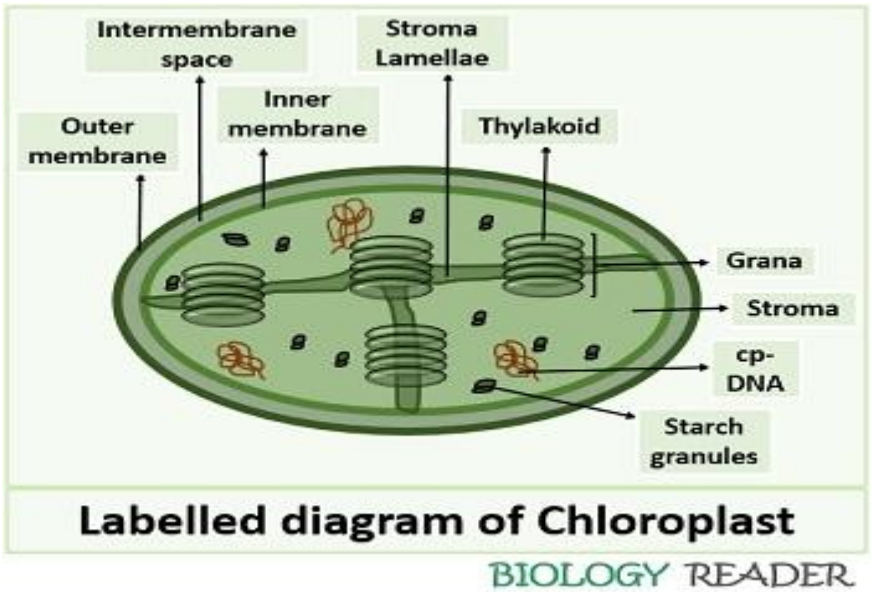
Plastids are present in the cytoplasm of the most plant cells. The plastids do not occur in the cells of bacteria, blue-green algae, fungi and animals (exception-Euglena). Plastids are of three types – (i) Chloroplasts (ii) Chromoplasts (iii) leucoplasts)

A) CHLOROPLASTS : Gr Chloro = green ; plastos = formed) : **Green coloured plastids are called chloroplasts.**

They are found in most green parts of plants, such as foliage leaf, young stem, calyx of flower etc.

STRUCTURE

The chloroplasts are double membrane – bound structures containing granular bodies known as the **grana** and a ground substance of fluid nature called the **stroma**. Each granum is made up of a stack of minute bag-like structures, each of which is called a **thylakoid**.Each granum is interconnected by frets or intergranal thylakoids or stroma lamellae. Stroma consists of **Chloroplast DNA** (double stranded circular DNA) and **70 S Ribosomes.** Green photosynthetic pigment, called chlorophyll, is present in high concentration in the thylakoids. They also contain other photosynthetic pigments, such as orange carotene, yellow xanthophyll etc.



FUNCTION

The chloroplasts are meant for photosynthesis. Chlorophyll is present in the thylakoid of grana of chloroplast.

B) CHROMOPLAST :

(Gr Chromo = Colour ; plastos = formed) : The plastids having colour other than green are called chromoplasts.

STRUCTURE

It is almost similar to that of the chloroplasts but they contain membranous tubes instead of thylakoids. It contains pigments like carotene, xanthophylls etc. but never chlorophyll.

FUNCTIONS

It attracts insects for pollination and impart various colours to the various plant organs like petals, fruits etc.

C) LEUCOPLASTS : (Gr Leuco = white; plastos = formed) : The colorless plastids are called the leucoplasts.

Leucoplasts are found in roots, underground stems (e.g. potato) etc.

STRUCTURE

Leucoplasts are double membrane bound rod like or sphere – shaped colorless plastid.

FUNCTION

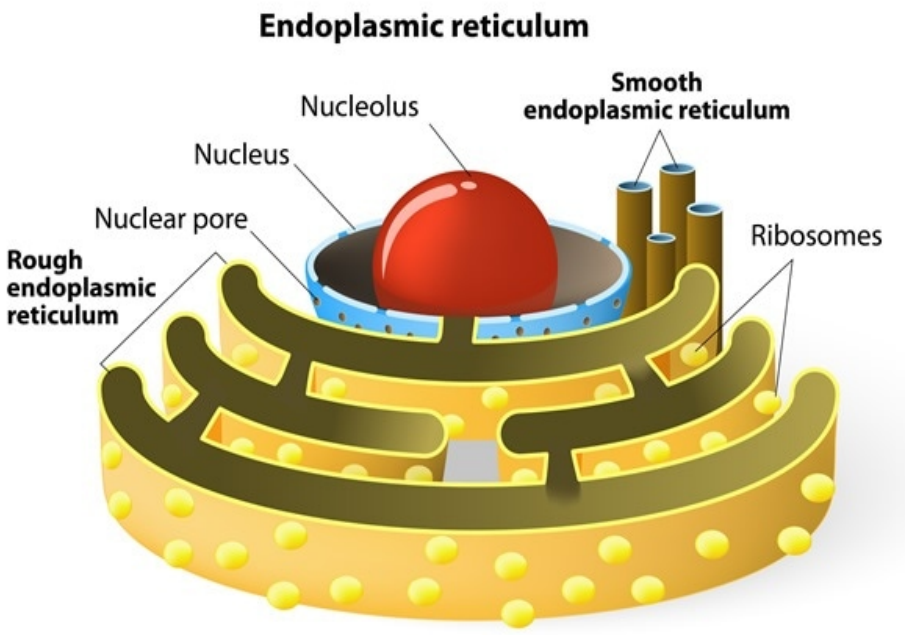
Leucoplast can be converted to chloroplasts on exposure to sunlight and reconverted to leucoplast when kept in dark for a long time. The leucoplasts are concerned with the storage of food materials like carbohydrate (starch), protein, lipid within the cell.

4) ENDOPLASMIC RETICULUM (ER)

The membrane-bound channels of various shapes which forms irregular net work in the cytoplasm is called endoplasmic reticulum (ER).

STRUCTURE

The structure is associated with ribosomes. ER is divided into two types. Granular (rough) RER or GER is studded with ribosome. Ribosomes are attached with membrane of RER by a protein called ribophorin. Agranular (smooth) SER is free of ribosome. Agranular ER is synthesized from granular ER. Each type of endoplasmic reticulum consists of inter communicating narrow tubes, the tubules. Small spherical or oval sac-like structure, the vesicles and large flat sacs the cisternae. All these structures are filled up with fluid called endoplasmic matrix and are surrounded by a single lipoprotein membrane.



FUNCTION

- Proteins are synthesized by ribosomes attached to the membranes of granular ER (RER).
- The agranular ER (SER) synthesizes sterol, fats and phospholipids.
- The ER is also involved in intracellular exchange of materials between nucleus and cytoplasm.

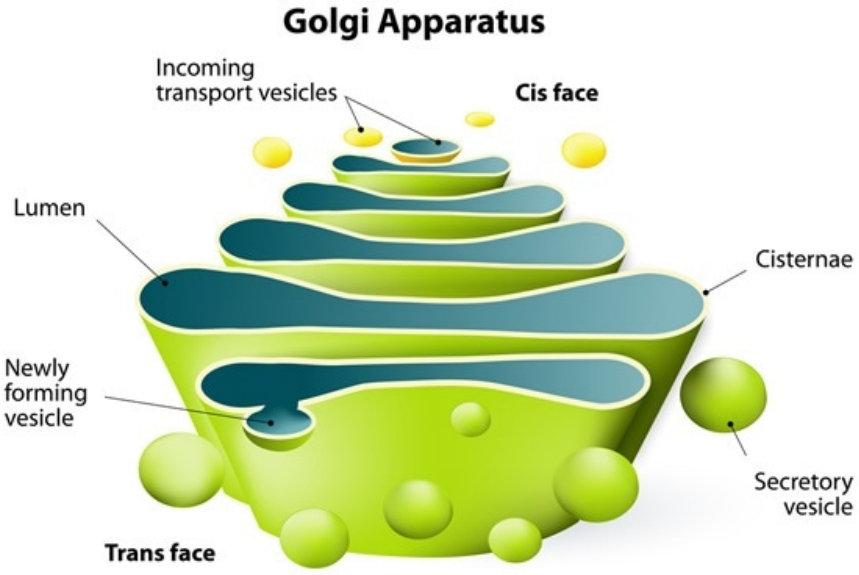
5) GOLGI BODY

The parallelly arranged membrane bound cytoplasmic bodies occurring near the nucleus and participating in the secretory process of cell are known as the Golgi bodies.

The Golgi bodies are abundant in animal cells and are less frequently found in plant cells. In plants these organelles are called as dictryosomes.

STRUCTURE

The Golgi bodies consists of four to eight thin membrane-bound flattened sacs, stacked upon each other like a pile of dishes with expanded areas at their end. The stacked elements are called cisternae. In the peripheral part of cisternae small droplet-like sacs, known as the vesicles buldge out. They also possess vacuoles.The part of golgi bodies which is close to endoplasmic reticulum and nucleus is called **cis face** and the part of golgi bodies opposite to the nucleus is called **trans face.**



FUNCTIONS

- Golgi bodies are associated with the secretory activity of the cell.
- They help in the formation of plant cell walls, plasma membrane and secretory vesicles.

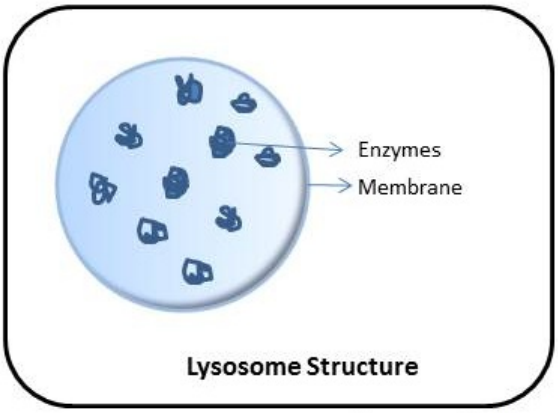
6) LYSOSOME:

The single membrane enclosed tiny spheroid or irregular vesicles containing hydrolytic enzymes which help in both intracellular and extracellular digestion are known as lysosome.

Lysosome remains scattered in the cytoplasm of animal cell. The number increases in the secretory cells.

STRUCTURE

A mature spherical lysosome is surrounded by lipoprotein membrane. Inside the membrane, the finely granular regions of different density are observed. Within it different hydrolytic enzymes are present.



FUNCTIONS

- Lysosome helps in cellular digestion.
- It helps in autolysis (digest the various organelles of the cells) – hence lysosome is called “suicidal bag of the cell”.

Golgibodies, ER and Lysosome together called as GERL system.

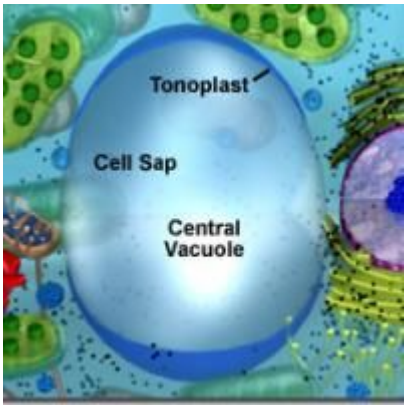
7) VACUOLE

The single membrane bound cavities containing a kind of watery fluid (cell sap) present within the cytoplasm are called the vacuoles.

The vacuoles are considered as one of the non-living bodies of the cell and contains stored food materials, certain secretory and excretory products. Vacuoles can occasionally be seen in animal cells but they are quite common and larger in plant cells.

STRUCTURE

In a young plant cell, several vacuoles are found. But as the cell matures the vacuoles fuse together forming a large central vacuole which pushes the cytoplasm along with nucleus against the cell wall. Each vacuole is filled up with a watery fluid known as the cell sap. Vacuole is surrounded by a single membrane similar to plasma-membrane called as **tonoplast**. The cell sap (Tonoplasm) may contain mineral salts, sugar etc. dissolved in water.



Structure of a vacuole in plant cell

FUNCTIONS

The vacuoles are different types which perform different functions :

- **Food vacuole** acts as the store-houses of water, mineral salts, sugar etc.
- **Gas vacuole** store gases which helps the aquatic plant remain floating on the water.

- **Water vacuole** formed by pinocytosis contains water.
- **Contractile vacuole** contains water which is expelled to the outside by its contraction and relaxation (e.g. Amoeba).
- **Excretory vacuole** contains excretory products, gases, etc. and maintains cell turgidity.

8) RIBOSOME

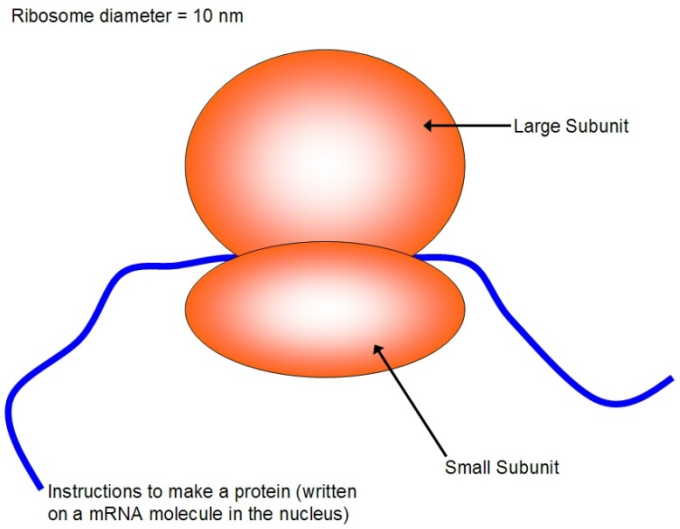
Ribosomes are non-membranous small, dense, round and granular particles of ribonucleo-protein.

Ribosomes are present freely in the cytoplasm. The free ribosomes occur singly or in clusters (**polyribosomes**). The ribosomes also remain attached with the membranes of endoplasmic reticulum, (bound ribosome), mitochondria, chloroplast etc.

STRUCTURE

A ribosome consists of two sub-units, one about half the size of the other. The larger sub-unit is dome shaped and the smaller sub-unit forms a cap like structure. These two sub-units are situated to the flat surface of the other. In eukaryotic cells the sub-units of the ribosome consists of 60S and 40S (jointly 80S). In prokaryotic cell the sub-units of ribosome consists of 50Sand 30S (jointly 70S). It possess a chamber of mRNA and a notch.

'S' in ribosome stands for 'Sedimentation coefficient' or Svedberg's unit.



Structure of a ribosome

FUNCTION

Ribosome helps in protein synthesis and are called protein factories.

9) CENTROSOME

In animal cells two tiny hollow cylindrical bodies, the centrioles, remains surrounded by a recognizable clear zone of cytoplasm and form a complex which is known as the centrosome.

Centrosome is generally present in animal cells and occasionally in the cells of some lower plants.

STRUCTURE

The centrosome consists of two parts – the **centriole** and the **centrospheres**. The centrioles are usually two in number which are tiny cylindrical bodies arranged at right angle to each other. The **centrosphere** is the dense cytoplasm surrounding the centrioles.

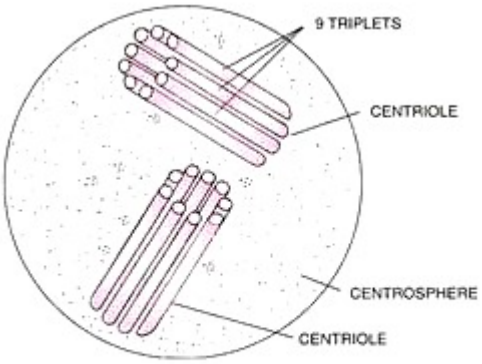


Fig. 8.49. Centrosome with pair of centroles (Diplosome).

FUNCTIONS

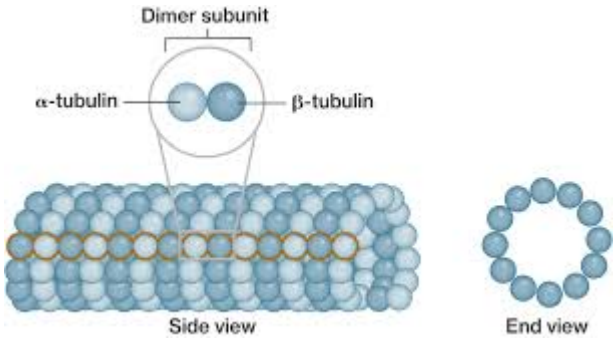
- Centrosome plays an important role during animal cell division.
- It also plays an important part in the formation of cilia and flagella.

10) MICROTUBULE

In the cytoplasm of eukaryotic cell, there are numerous non-membranous hollow cylinders known as microtubule.

STRUCTURE

Microtubule have variable length. They are formed of special type of protein called **tubulin**. Each tubulin consists of two sub-units (dimer) –α and β.

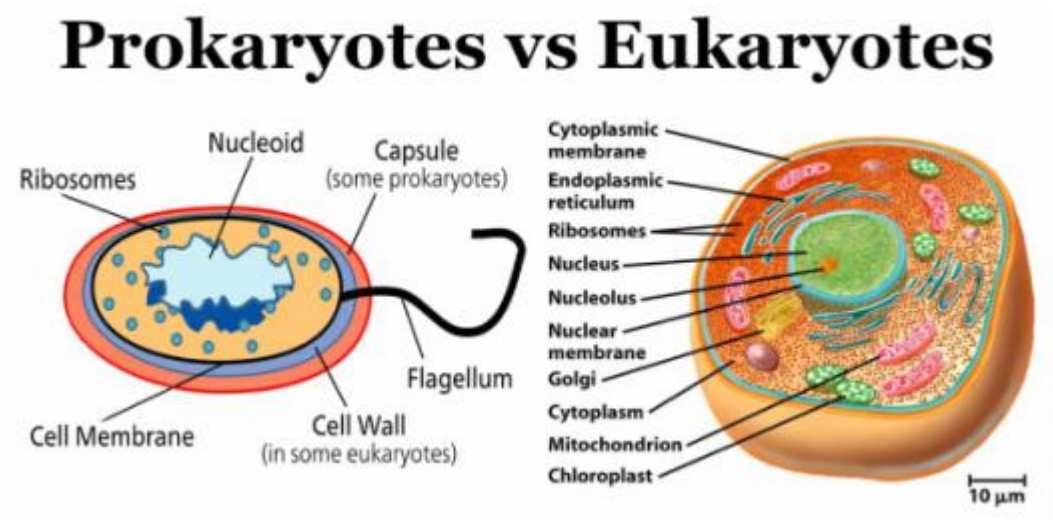


FUNCTIONS

- They form a supporting framework or cytoskeleton and give shape to the cell.
- Microtubules form spindle during mitotic / meiotic cell division.
- They form cilia and flagella that help in movement.

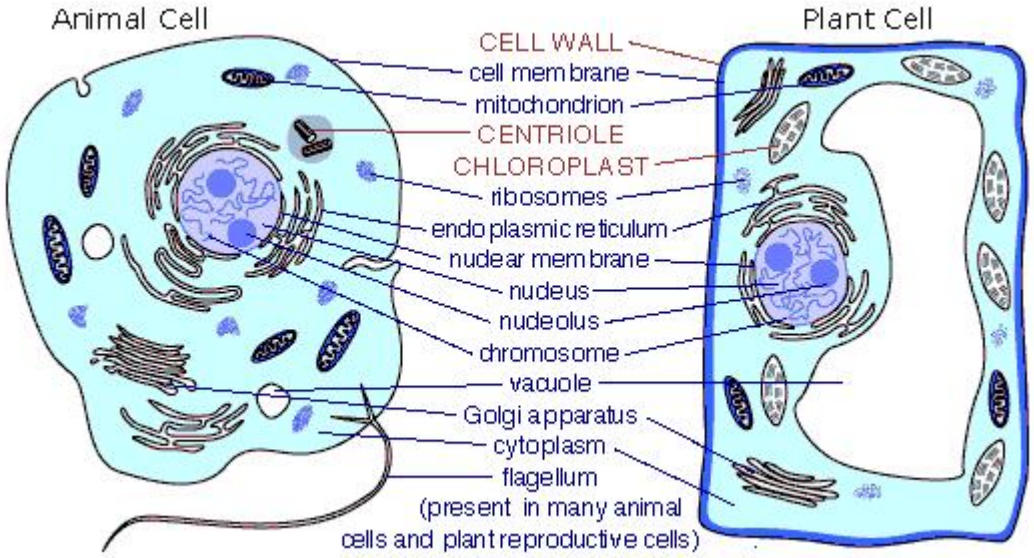
DIFFERENCE BETWEEN PROKARYOTIC AND EUKARYOTIC CELLS

Prokaryotic cell	Eukaryotic cell
(i) Cells are simple	(i) Cells are complex.
(ii) Cell wall composed of aminosugar and muramic acid (but not cellulose).	(ii) Plant cell wall composed of cellulose.
(iii) Cytoplasmic organelles – Endoplasmic reticulum, mitochondria, Golgi bodies, etc. absent.	(iii) Cytoplasmic organelles – Endoplasmic reticulum, mitochondria Golgi bodies, etc. present.
(iv) True nucleus absent, but nucleoid is present which is not covered by nuclear membrane.	(iv) Present of true nucleus with nuclear membrane and nucleoli.



DIFFERENCE BETWEEN PLANT CELLS AND ANIMAL CELLS

Plant cell	Animal cell
(i) Plant cell is externally covered by thick cell wall.	(i) Animal cell is externally covered by thin cell membrane.
(ii) Centrosome, centriole and astral rays are absent.	(ii) Centrosome, centriole and astral rays are present.
(iii) Different types of plastids (chloroplast, chromoplast, leucoplast) are present.	(iii)No plastid is present in animal cell.
(iv) Lysosome is absent in plant cell.	(iv) Lysosome is present in animal cell.
(v) Big size vacuoles are generally present in cytoplasm.	(v) Vacuoles are generally absent (but if it is present, it must be very small in size).



Organelles present in plant cell but not in animal cell – Plastid, cell wall
Organelles present in animal cell but not in plant cell – Centrosome, Lysosome.

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