THE FUNDAMENTAL UNIT OF LIFE

- The cell is the basic structural and functional unit of life.
- Study of cells –Cell biology (Cytology)
- These were discovered by Robert Hooke in 1665
- Anton Van Leeuwenhoek (1674), observed red blood cells.
- Robert Brown described nucleus in the cells
- J.E. Purkinje and Von Mohl (1936) named the living substance of the cell as protoplasm.

Cells acts as life-supporting chambers to provide such a special balanced environment to the living organisms (homeostasis). It keeps its chemical composition steady within its boundary and, thus, is capable of performing the activities in a desired manner. Therefore, cell is the structural and functional unit of living organisms.

Cell Theory

M.J. Schleiden (1838) and ***Theodor Schwann*** (1839) collectively formulated 'Cell Theory' for plants and animals respectively. In 1885, ***Rudolf Virchow***, added the principle, all cells arise from pre- existing cells.

Features of cell Theory

- Cell is the basic unit of structure of all plants and animals.
- Cell is the basic unit of function as all the metabolic reactions take place inside the body.
- Cell is a unit of heredity as it contains hereditary material inside the nucleus.
- All living cells arise only from the pre-existing cells.

Exception of cell Theory

Viruses are not cells. They are nucleo-protein particles.

Bacteria and Blue-green Algae (Cyanobacteria) are not true cells. They are without nuclear membrane and cell organelles.

Some mould fungi have acellular body. Their protoplasm has many nuclei.

All living organisms classified into

Non- cellular - do not contain any cell in their body organisation

Cellular - contain either one or many cells in their body

- Cellular organisms divided into:-

Prokaryotes : These organisms lack nuclear membrane around their genetic material and hence are called prokaryotic cells. The genetic material lies in direct contact with cytoplasm and is called **nucleoid.**

Eukaryotes : Advanced and complete cells having membrane bound nuclei and other cell organelles. The organelles divide the cytoplasm into compartments to facilitate specific metabolic functions.

PROKARYOTIC CELL	EUKARYOTIC CELL
1. Nucleus absent (nuclear region or nucleoid is not surrounded by a nuclear membrane)	Nucleus present (nuclear material surrounded by a nuclear membrane)
2. Contain single chromosome	More than one chromosome
3. Nucleolus is absent	Nucleolus is present
4. Membrane bounded cell organelles are absent	Membrane bounded cell organelles are present
5. Cell division by fission or budding	Cell division by mitosis or meiosis

Based on the number of cells the living organisms can be classified as unicellular or multicellular.

In unicellular organisms, a single cell is capable of carrying out all the essential life processes.

In multicellular organisms are formed of many cells. The cell itself has got division of labour. In fact each cell has got certain specific components within it known as cell organelles. Each kind of cell organelle performs a special function.

Cells generally have a small size to maintain a large surface area. Advantages of small size of cells are

- Nutrients can diffuse smoothly into the cell.
- Elimination of metabolic wastes can easily pass out of the cell.
- Exchange of respiratory gases occurs easily within a cell.
- In case of any damage to the cell, repair can be done.

According to the shape, cells are classified into – Polyhedral, spherical, spindle shaped, elongated, branched, and discoid.

The number of cells in organism is based on the size of the body. The phenomenon having a fixed, genetically constant number of cells is called **eutely.**

Three essential characteristics of the cell

1. **Plasma membrane**
2. **Nuclear material**
3. **Cytoplasm**

1. PLASMA MEMBRANE/ PLASMALEMMA/ CELL MEMBRANE

Plasma membrane is a living ultrathin, dynamic, elastic, semi permeable membrane that encloses the protoplasm of a cell.

Chemical composition of plasma membrane:-

Lipids (20-40 %), proteins (60-75%) and carbohydrates (1-5%)

Carbohydrates in the form of glycoprotein or Glycolipids and restricted in outer surface of PM

Types of lipids

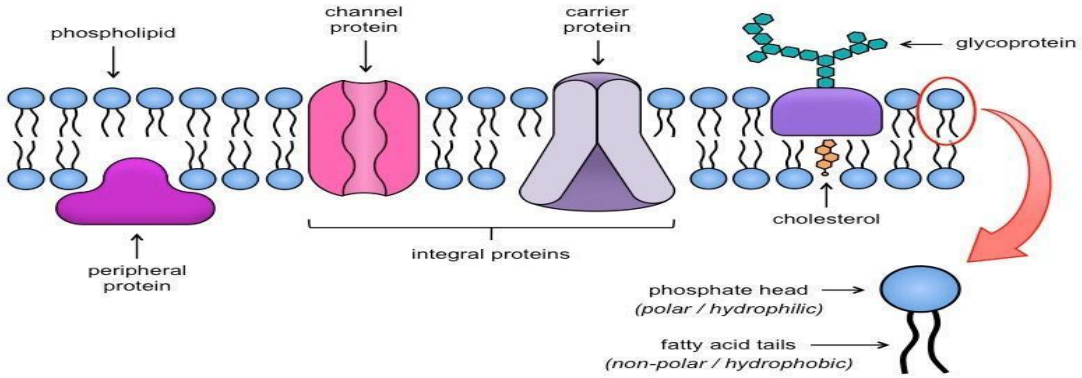
- (A) Phospholipids,
- (B) Glycolipids, and
- (C) Sterols

All of them are amphipathic or amphiatic molecules because they possess both hydrophilic (polar) and hydrophobic (non- polar) ends.

Structural Models of Plasma Membrane

- 1. Lipid bilayer Model (Gorter and Grendell,1926):
- 2. Sandwich model or 'Protein- Lipid- Protein' model (Daniclli and Davson,1935)
- 3. Unit membrane model(Robertson, 1959)
- 4. Fluid mosaic model (Singer and Nicolson,1972)

Fluid mosaic model of PM



Postulations of Fluid mosaic model

i) The biological membranes are quasi –fluid (semi – fluid) structures in which both lipids and integral proteins are free to move laterally as well as within the bilayer.

ii) The lipids and proteins are arranged in a mosaic manner.

iii) The integral or intrinsic proteins are embedded in the lipid bilayer while the extrinsic or peripheral proteins are superficially attached on both surface of the membrane.

iv) The exoplasmic face (E-Face) of the cell membrane often possesses carbohydrates chains or oligosaccharides. They are bound to both proteins and phospholipids producing glycoprotein and glycolipids. The carbohydrate coat present on the E-face of plasma membrane constitute glycocalyx or cell coat. The oligosaccharides gives a negative charge to outer surface. They act as cell surface markers, receptors, blood grouping etc…

Functions of cell membrane

- The plasma membrane is selectively permeable, so it regulates the entry and exit of substances in the cell.
- Gives a definite shape to the animal cell.
- It provides protection to the internal components.
- It allows the intra cellular communication.
- Its junctions keep the cells together.
- It is flexible enough to engulf large molecules and food particles.

Transport of molecules across cell membrane.

- Passive transport

Here molecules can move across the membrane without any requirement of energy.

Osmosis – movement of water molecules from its higher concentration to its lower concentration through a semi permeable membrane (liquid medium)

When water diffuses into the cell due the higher concentration outside the cell, it is called ***endosmosis***. When water diffuses out of the cell due to the higher concentration inside the cell, it is called ***exosmosis***.

Osmotic Solutions and types of Osmosis

Isotonic solutions – both side of the semipermeable membrane have same solute concentration.

Hypotonic solutions – one have less solute or more water as compared to the other.

Hypertonic solution – one have more solute and less water as compared to the other.

In hypotonic solution- due to endosmosis of water molecules-plant cells become swollen and are called turgid cells. In animal cells the excessive swollen cells burst or get haemolysed.

In isotonic solution – there will be no net movement of water molecules – cells will retain the same shape.

In hypertonic solution – due to exosmosis of water molecules – in plant cells, the protoplasm shrinks and separates from the cell wall (plasmolysed cell) and the phenomenon is called ***plasmolysis***. In animal cells, the water flows out of the cell causing it to shrink. This phenomenon of shrinkage of cells in hypertonic solution is called ***crenation.***

Diffusion- movement of molecules from higher to lower concentration. (any medium)

Diffusion of gases in the cell – the cell membrane allows entry and exit of gases like CO_2 and O_2 by diffusion. CO_2 is a cellular waste that accumulates in the cell in high concentration due to metabolic activities and need to be removed out of the cell. CO_2 in the external environment of the cell is very less in concentration. Due to the difference in the concentration CO_2 inside and outside a cell, the gas moves out of the cell. In the same way, oxygen enters the cell when the concentration of O_2 decreases inside the cell by the process of diffusion.

- Active transport

Ions are transported across the membrane against the concentration gradient i.e., from lower to higher concentration. Such transport is energy dependent process in which ATP is utilised. Eg:-Na+/K+ pump.

Facilitated transport

Protein molecules help to carry molecules across the membrane.

- Bulk transport

Endocytosis

Ingestion of material by the cells through the plasma membrane, solid-phagocytosis (cell eating), and liquid-pinocytosis (cell drinking).

Exocytosis (cell vomiting or ephagy)

To eject any material from the cell, invagination and formation of vesicle, the membrane of the vesicle can fuse with the plasma membrane and extrude its content to outside.

CELL WALL

The outermost non-living rigid boundary of plants and fungi is known as the cell wall. The cell wall is made up of cellulose in plants and chitin in fungi.

Functions

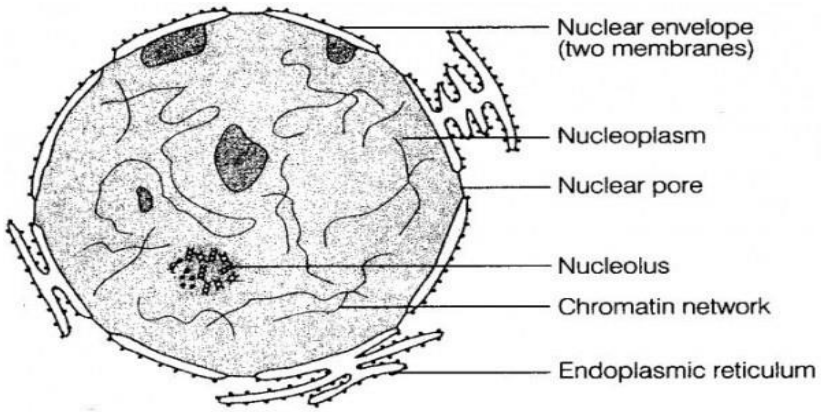
- Gives rigidity and support to the tissues and organs of plant body.
- Gives shape to the cell
- Protect from mechanical damage
- Helps cell- to – cell interaction.
- Act as barrier to undesirable macromolecules.

Structure

The cell wall consists of two regions primary cell wall and secondary cell wall. Primary cell wall produce secondary cell internally. Adjacent cells in a plant tissue is held together by a cementing factor called middle lamella. At places the secondary cell wall is not formed and the region is called pits or pores. Through this pits the strands of cytoplasm which connected to adjacent cells for inter cellular communication, called ***Plasmodesmata.***

NUCLEUS

- Discovered by Robert Brown (1831)
- Largest cell organelle of eukaryotic cell.
- Normally one nucleus in a cell
- Some cells even lack of nucleus(sieve tube, erythrocytes)
- Multinucleate cells are called coenocytes.
- It contain:-
    - Nuclear envelop
    - Nucleoplasm
    - Nucleoli
    - Chromatin reticulum



Nuclear envelop

- It consists two nuclear membranes with a space between called perinuclear spaces.
- The outer membrane bears ribosomes. It is continuous with endoplasmic reticulum.
- The nuclear envelop is perforated by nuclear pores.
- Movement of RNA and protein take place through the nuclear pores.

Nucleoplasm or Nuclear sap

- The interior of the nucleus is filled with a proteinaceous fluid called the nucleoplasm.
- It contains nucleolus and chromatin.
- It also contains proteins, enzymes, RNA, minerals etc.

Nucleolus

These are spherical, not membrane bound and actively performing protein synthesis. Act as a site for biosynthesis of ribosomes.

Chromatin Reticulum

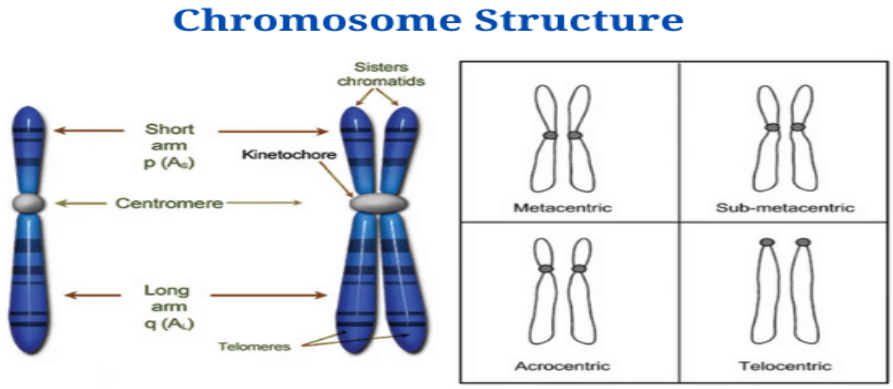
- Nucleoplasm contains network of nucleoprotein fibres. Which is made up of DNA, histone (basic proteins), non-histone proteins, and RNA. DNA bears the hereditary units called genes.

CHROMOSOMES

- They are rod shaped or thread like condensed chromatin fibres
- Carry hereditary information.
- They are made up of DNA, histone and non-histone proteins and RNA.
- A chromosome consists of two identical halves called chromatids.
- Chromatids held together at one point called ***centromere*** or primary constriction.
- The terminal regions on either side of the chromosomes are called telomers.
- On set of cell division, the chromosome duplicates itself and forms its identical copies called sister chromatids. At the time of cell division, both the sister chromatids separate and each of them becomes an independent daughter chromosome.
- A cell having paired chromosomes is called a diploid cell.
- A cell comprising half the number of chromosomes is called a haploid cell.
- In humans, the diploid number of chromosomes are 46 (23 pair). The gametes in human beings are haploid.
- 22 of these pairs are called autosomes, same in both males and females. The 23rd pair, the sex chromosome looks different. Female have two copies of the ***X chromosome***, whereas males have one ***X chromosome*** and one ***Y chromosome***.

Based on the position of centromere chromosomes are four types;

1. Metacentric: centromere at the centre of the chromatids
2. Sub-metacentric : centromere is slightly away from the centre (one arm is short)
3. Acrocentric : centromere is away from the centre (one arm is very short)
4. Telocentric: centromere is almost the terminal position. (one arm absent)



CYTOPLASM

- Part of cell which occurs between the plasma membrane and nuclear envelope.
- Inner granular mass – endoplasm
- Outer glassy layer - ectoplasm

- An aqueous ground substance, the cytosol or cytoplasmic matrix. It is the soluble part of cytoplasm located between the cell organelles.
- Cytosol contains a system of protein fibres called cytoskeleton, which help in cellular movement and to help the cells maintain their shapes.
- Act as a storage area of vital chemical such as amino acids, glucose, vitamins, enzymes, carbohydrates, lipids, mineral ions etc.
- Active site of glycolysis.
- Biosynthesis of fatty acids, nucleotides and some amino acids.
- Help to exchange of materials between different cell organelles and also with the external environment.
- Dynamic in nature.

CELL ORGANELLES

ENDOPLASMIC RETICULUM (ER)

Present only in eukaryotes (except mammalian RBCs). ER is continuous with plasma membrane and nuclear membrane. Found free in cytoplasm.

ER is composed of three type of structures

Cisternae – Flattened sac- like structures

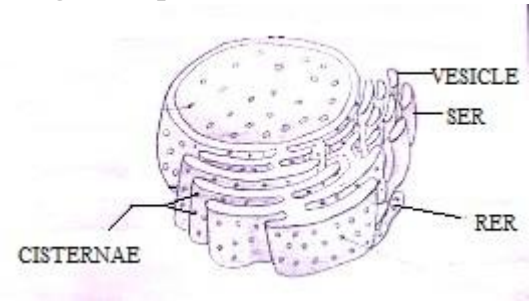
Tubules – Tube like structures

Vesicles – Round or oval structures.

Types and functions of ER

- Based on the presence or absence of ribosomes on the surface , ER is of two types
- Rough ER –with ribosomes for synthesis of proteins. It is found in cells like plasma cells, goblet cells and fibroblasts.
- Smooth ER – without ribosomes for synthesis of lipids. Found in liver cells, interstitial cells and adipose cells

Functions – mechanical support, intracellular transport, synthesis of enzymes, formation of middle lamella and nuclear membrane (membrane biogenesis), RER synthesises proteins, SER synthesises lipids, SER of liver cells of vertebrates takes part in detoxification of many drugs and poisons.



RIBOSOMES

- They are granular structures found in both eukaryotes and prokaryotes, except in mature sperms and mammalian red blood cells.
- First observed by George Palade (1953), So its also called Palade particles.
- They are seen in the cytoplasm, mitochondria, chloroplast, and attached to the ER
- Composed of RNA and proteins
- Not surrounded by membrane

- They are known as factories for the synthesis of proteins.
- In eukaryotes 80S (60S+40S sub units) and prokaryotes 70S (50S+30S)

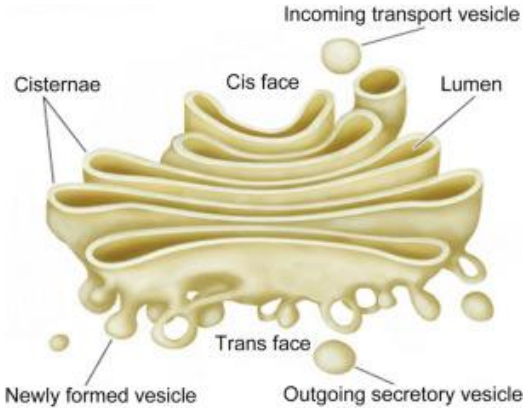
GOLGI APPARATUS

- A system of membrane-bound secretory structures found near the nucleus. Present in all eukaryotic cells except RBCs
- Discovered by Camillo Golgi(1898)
- Golgi complex of plant cell are called dictyosomes
- The Golgi complex composed of 3 types of structures:
  -cisternae
  -tubules
  -vesicles

  Cisternae – Flat disc shaped sacs. These are stacked parallel to each other. They are concentrically arranged near the nucleus. Cisternae are of two sides (face)
  - Cis face (forming face) -convex side. Secretory vesicles from ER fuse with the cis face
  - Trans face (maturing face)- concave side

  Tubules – tube like structures

  Vesicles – secretory products of cisternae are packed in the vesicles. Later these vesicles are budded off.



Functions:-

- Secretory in function
- Vesicles act as storage site for proteins and lipids
- Protein synthesised by ribosomes on the RER are modified in the cisternae of the Golgi complex before they released from its trans face
- Helps in the formation of cell membrane and middle lamella.

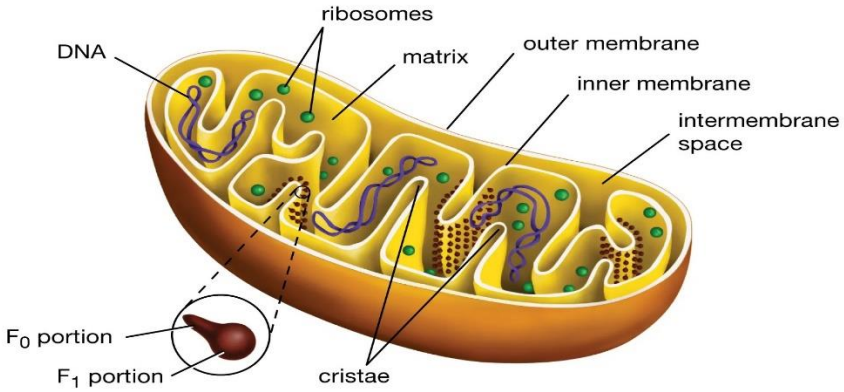
LYSOSOMES

- The small spherical bodies containing digestive enzymes found in animal cell, protozoans, and fungi.
- Lysosomes contain digestive (hydrolytic) enzymes like proteases, carbohydrases, lipases. These enzymes are made by RER.
- The enzyme digest the cell organelle and this process called autophagy or autolysis.
- Lysosomes help in the removal of worn-out cells, sometimes the whole cell itself may be digested. So, the lysosomes are also called the ‘suicidal bags’ or ‘disposal bags’

- They are like a waste disposal system of the cell that keep the cell clean by digesting any foreign materials such as bacteria as well as worn out cell organelles. It breaks complex substances into simpler substances. Therefore, they are known as digestive bags.
- They help in recycling of metabolites for the formation of new organelles. Hence, they are also called recycling centres.

MITOCHODRIA

- They are sausage-shaped, cylindrical, spherical or rod-shaped organelles
- Found in all aerobic eukaryotes and absent in mammalian red blood cells, anaerobic protozoans and prokaryotes.
- It is a double membrane bound structure
- Outer membrane is smooth and porous and permeable to a number of metabolites and solutes.
- Inner membrane is selectively permeable and having a number of infolding (cristae) towards the matrix and dotted with small rounded ATP synthesising bodies called oxysomes or F_1 particles or elementary particles.
- The mitochondrial matrix contains proteins, lipids, circular DNA and RNA.



Functions: -

- Aerobic respiration.
- Produce cellular energy in the form of ATP, hence called “power house of cell”.
- They can synthesis some of the proteins and multiply by division. Since its contain DNA, RNA and ribosomes, so they are semi-autonomous organelles.
- They help in the synthesis of several biochemical like cytochromes, steroids, fatty acids, chlorophyll and phospholipids.

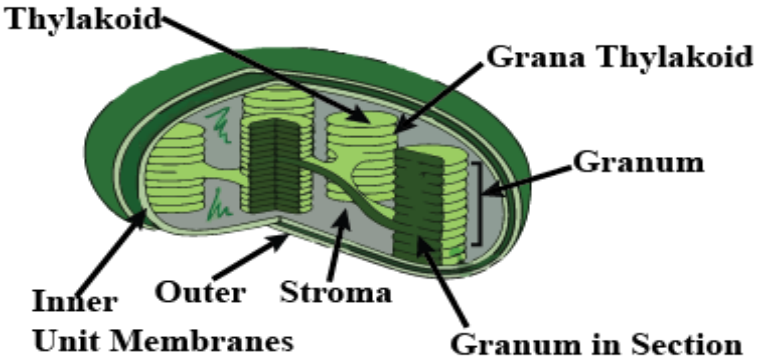
PLASTIDS

- Plastids are the cytoplasmic organelles of the plant cells.
- They are double membrane bound cell organells.
- Plastids are semi-autonomous, since they possess their own genetic material and ribosomes. Therefore, they can synthesis their own proteins by using genetic material.
- They contain pigments. According to the pigments, plastids are of three types
- Chloroplast – Green plastids contains chlorophyll.

- Chromoplasts – coloured plastids except green. (pigments like carotene and xanthophyll)
- Leucoplast – colourless plastids occur in fruits and storage regions.
    Amyloplast –store carbohydrate in the form of starch
    Aleuroplast – store proteins
    Elaioplast –stores oil or fats
    Etioplast – crystalline pro-lamellar bodies.

Chloroplast

- The plastids having a green pigment called chlorophyll.
- It is double membranous structure.
- The space inside the chloroplast is filled with a matrix called stroma. Which contains photosynthetic enzymes, starch grains, DNA and ribosomes.
- Thylakoids are flattened membranous sacs present in the stroma. Chlorophyll pigment located in the thylakoids.
- Thylakoids are arranged in stacks like the piles of coin called grana.
- Granum is the site of light reaction and stroma is the site of dark reaction.



Chloroplast

Functions: Photosynthesis, Protein synthesis due to the presence of DNA and ribosomes

VACUOLES

- Selectively permeable membrane (tonoplast) bound organelle present in eukaryotic cells such as plants and fungi.
- In plant cells, either fluid filled (cell sap or tonoplasm) or solid filled.
- In animals short and temporary but in plant large and permanent.
- In unicellular organisms such as Amoeba or Paramecium, there are special vacuoles called contractile vacuoles that help in controlling the osmotic pressure.
- Storage region for toxic metabolic by-products in plants.
- They help in osmoregulation, i.e., the maintenance of internal pressure in the cell.
- They are associated with the maintenance of water balance.
- They help in the growth of plant parts by increasing in size and causing cell elongation.

PEROXISOMES

- Membrane bounded spherical organelles also called microbodies. Present in both animal and plant cells.

- Containing powerful oxidative enzymes, therefore, they are involved in the metabolism of many bichemicals. In plants, they involved in photorespiration.
- Mainly present in Kidney and Liver cells in animals and in plants commonly present in photosynthetic cells.
- The enzymes of peroxisomes are derived from ribosomes attached to the RER.
- Responsible for detoxification (removal of toxin), storage, turgidity and rigidity.

CENTROSOME

- Found only in animal cells. In plant cells polar caps present instead of it.
- Not bounded by membrane having two granule like centrioles right angles to each other is called diplosome. (In plants polar caps).
- Centrioles made up of microtubules.
- Helps in cell division in animal cells (In plant cell polar caps) and are involved in the spindle formation.
- Help in the formation of cilia and flagella.
- Centrioles take part in the formation of sperm tail.

Plant and Animal cells

	ANIMAL CELL	PLANT CELL
1	Usually smaller in size	Comparatively larger in size
2	Generally oval in shape	Usually rectangular in shape
3	Cell wall absent	Cell wall formed of cellulose and present outside the cell membrane.
4	Cytoplasm fills the entire cell and is dense	Cytoplasm forms a thin lining, as it is pushed to the periphery by vacuole.
5	Vacuoles, if present, are smaller and many in number and scattered	In mature cell, single large centrally located vacuole is found
6	Nucleus usually present in the centre	Present towards the periphery
7	Golgi bodies Highly elaborated, present near nucleus	Simpler units of Golgi bodies called dictyosomes.
8	Plastids absent except protozoan, *Euglena*	Present in cytoplasm
9	Possesses centrioles	Absent
10	Stored food is in the form of glycogen	Stored food is in the form of starch.