Lecture No: 2
PLANT CELL – STRUCTURE, CELL ORGANELLES AND THEIR ROLE

The cell is the common basic, structural and functional unit of living organisms. It is the smallest unit of life that is classified as a living thing and is often called the building block of life.

What is a Cell?

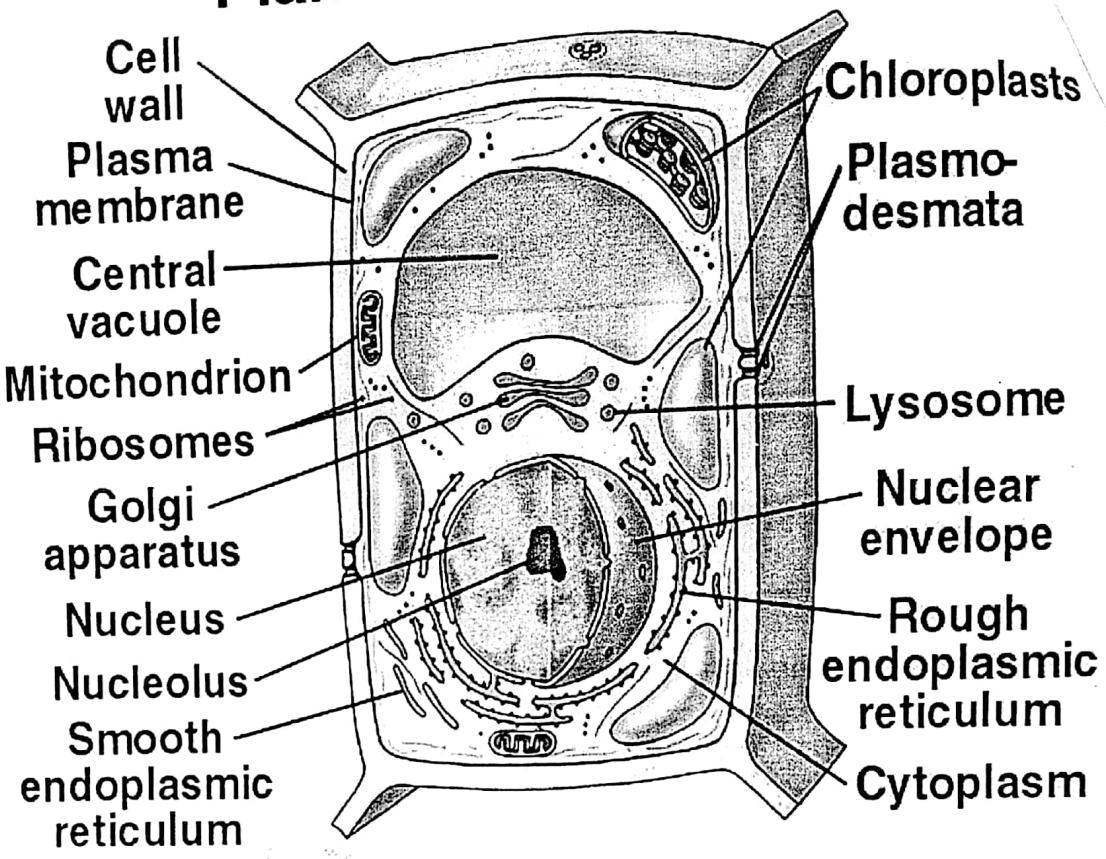
- Latin word for "**small room**"
- A cell is the **functional and structural unit** of all living organisms

Cell History:

- *Cytology*- study of cells
- 1665 English Scientist *Robert Hooke*
- Used a microscope to examine cork (plant)
- Why stoppers made of cork were suited to hold air in the bottle?
- Hooke called what he saw "Cells"

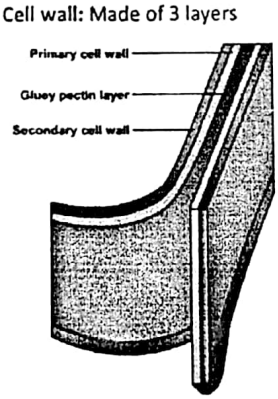
Robert Hooke
(1635-1703)

Plant Cell Structure



Cell Organelles

Cell Wall:



Cell wall: In plants cell is always (including bacteria) a wall lined surrounded by a cell plasma throughout with is found in lemma. The cell wall plants and is absent in animals. In case of animal cells, the outermost layer of cell is plasma lemma, which is also occasionally called 'cell membrane' or 'plasma membrane'. Cell wall is the outermost part of the cell and is always non-living, though produced and maintained by living protoplasm. It is a rigid structure and protects the inner parts of a cell. It maintains the shape of the cell and provides mechanical support to the tissues. It

originates from the phragmoplast (phragma = fence, separation). Endoplasmic reticulum, Golgi complex, mitochondria and microtubules play an important role in the formation of the cell wall. It is mainly composed of cellulose. However it may also contain hemicellulose, pectin, chitin, cutin and lignins. The composition of these substances varies from cell to cell. The cell wall is complex in nature and is differentiated into middle lamella, primary cell wall and secondary cell wall.

1. Middle lamella: It is the outmost layer of plant cell wall and connects the two adjacent cells. It is composed of calcium and magnesium pectate and does not contain any cellulose. Some consider middle lamella as intercellular substance or intercellular matrix.

2. Primary cell wall: It is thin, elastic and lies between middle lamella and secondary cell wall. It is mainly composed of cellulose. It develops after middle lamella by deposition of hemicellulose, cellulose and pectin substances.

3. Secondary cell wall: It is the inner most layer of cell wall and lies between primary cell wall and plasma membrane. It is relatively thick and is primarily composed of microfibrils of cellulose. In some tissues, besides cellulose, lignin and suberin are also found in the secondary cell wall. The cell wall has minute apertures through which the cells of a tissue are interconnected. These apertures of cell wall are known as plasmodesmata. They are also referred to as canals of the cell wall.

The main functions of cell wall:

1. It determines the shape and size of a cell.
2. It provides protection to the inner parts of a cell from the attack by pathogens.
3. It provides mechanical support to the tissues and act as a skeletal framework of plants.
4. It helps in transport of substances between two cells.

Plasma lemma or plasma membrane:

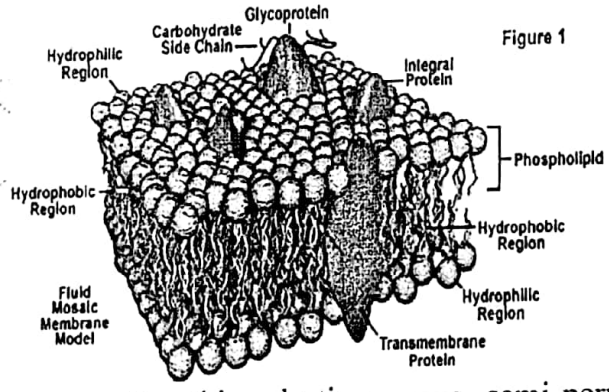


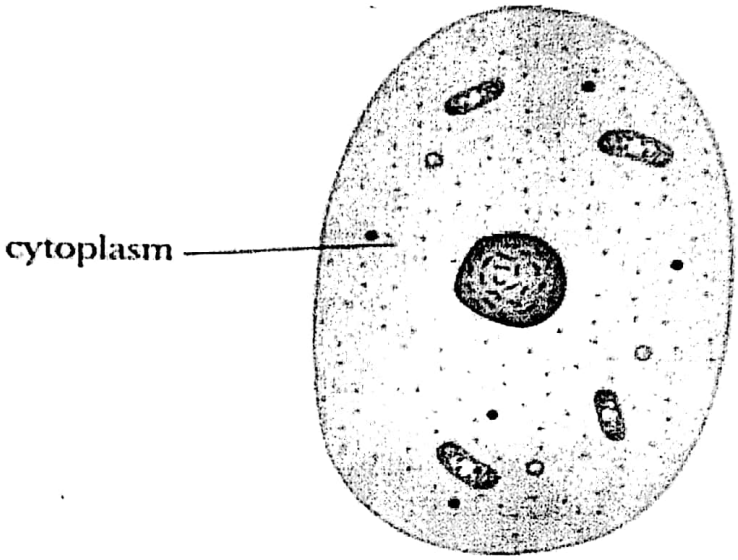
Figure 1

The term was coined by J.Q. Plower in 1931. This membrane is present just beneath the cell wall in plant cells, while it is the outer membrane in animal cell. In plants, it lies between the cytoplasm and the cell wall. It is a living, ultra thin, elastic, porous, semi-permeable membrane covering of cell. The plasma membrane is about 75-100 angstroms thick.

The main functions of plasma membrane

1. Primarily the plasma membrane provides mechanical support and external form to the protoplasm (cytoplasm and nucleus) and it also delimits the protoplasm from the exterior.
2. It checks the entry and exit of undesirable substances.
3. Due to its semipermeability, it transmits necessary materials to and from the cell (selective permeability).
4. Moreover, it permits only one way passage for molecules like minerals into the cell and restricts their outward movement.

Cytoplasm:



The plasma membrane is followed by cytoplasm which is distinguished into Cytoplasmic matrix / hyaloplasm and Cytoplasmic structures.

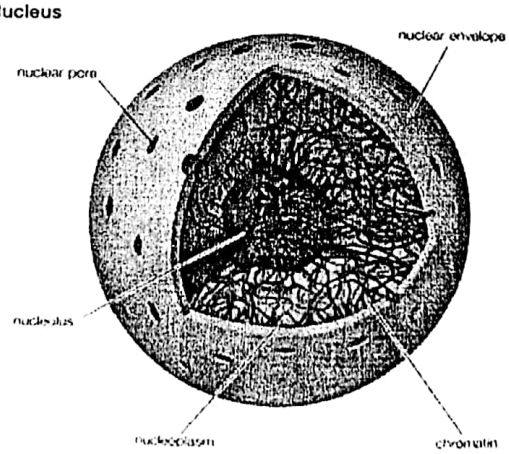
Cytoplasmic matrix:

The space between the plasma membrane and the nucleus is filled by amorphous, translucent, homogeneous colloidal liquid known as hyaloplasm or cytoplasmic matrix. The portion of cytoplasm other than cell organelles is known as hyaloplasm. When the cell is active, the cytoplasm is in fluid state. The cytoplasm is in gel condition, when the cell is dormant. The cytoplasmic matrix consists of various inorganic molecules such as water, salts of sodium and other metals and various organic compounds viz., carbohybrates, lipids, nucleoproteins, nucleic acids (RNA and DNA) and variety of enzymes. The peripheral layer of cytoplasmic matrix is relatively nongranular, viscous, clear and rigid and is known as ectoplasm. The inner portion of cytoplasmic matrix is granular, less viscous and is known as endoplasm.

Cytoplasmic structures:

In the cytoplasmic matrix certain non-living and living structures remain suspended. The living structures or cytoplasmic organoids are membrane bound and are called organelles or organoids. These living structures include plastids, mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, ribosomes, microtubules, microfilaments, centrosome, basal granules, sphaerosomes, microbodies, cilia and flagella etc. The non living structures or cytoplasmic inclusions called paraplasm or deutoplasm include ergastic substances, crystals, fats, oil droplets, starch granules glycogen granules, vacuole etc.

Nucleus:



Robert Brown first observed a cell nucleus in flowering plants in 1837. Generally a cell contains single nucleus. However there are a number of exceptions in which more than one nucleus is present. Plant cells with more than one nucleus are called coenocytes. Eg: Certain algae, fungi, Vaucharia, Rhizopus, where as animal cells with this character are called syncytia. Eg: striated muscle cells of higher animals. The position of the nucleus in the cell varies according to cell type, although it is often in the centre of the cell. The nucleus is surrounded on all sides by cytoplasm from which it is separated by the nuclear envelope or nuclear membrane.

Morphology:

The shape of the nucleus varies according to the species or cell type. The range of variation is limited, although in addition to the common spherical nuclei, ellipsoid or flattened nuclei occur. In majority of cells, the margin of the nucleus is quite regular, but some cells like leukocytes contain nuclei with lobes or infoldings of the margins. Nuclear size is a function of chromosome number. Size of the nucleus varies with ploidy level. The size of the nucleus is also correlated with the DNA content. Variation in the nuclear size is observed at different times during the cycle of cellular activities. The nucleus includes (a) Nuclear envelop / membrane, (b) Nucleoplasm or karyoplasms, (c) Nucleolus and (d) Chromatin

1. Nuclear envelop / nuclear membrane :

It is a double membrane, semipermeable structure broken at numerous intervals by pores or openings. Under light microscope, it appears as a thin line between nucleus and cytoplasm. The space between the inner and outer membrane is known as the perinuclear space. In many places the nuclear membrane joins the membrane of endoplasmic reticulum. The main function of nuclear membrane is to provide a pathway for the transport of materials between the nucleus and cytoplasm

2. Nucleoplasm / Karyolymph:

It is a fluid substance which escapes, if the nucleus is punctured. It fills the nuclear space around the chromosomes and the nucleolus. The karyolymph is composed primarily of protein materials and is rich in acidic proteins and RNA rich in bases, adenine and uracil. It is the site of certain enzymes in the nucleus.

3. Nucleolus:

Fontana first described the nucleolus in 1871. It is a relatively large, generally spherical body present within the nucleus. The number of nucleoli present in each nucleus depends upon the species and the number of the chromosomes or sets of chromosomes. In many plant and animal cells there is one nucleolus for each haploid set of chromosomes. Heterochromatic portions of specific chromosomes are found to be in contact with the nucleolus during interphase. These are called nucleolar organizing regions of the chromosomes and are responsible for producing much of nucleolar RNA. Generally, the nucleolus disappears during cell division and reappears in daughter cells at the end of cell division in each daughter nucleus. However, a persistent nucleolus is found to present in Spirogyra and Euglena. The important functions of nucleolus are formation of ribosomes and synthesis of RNA.

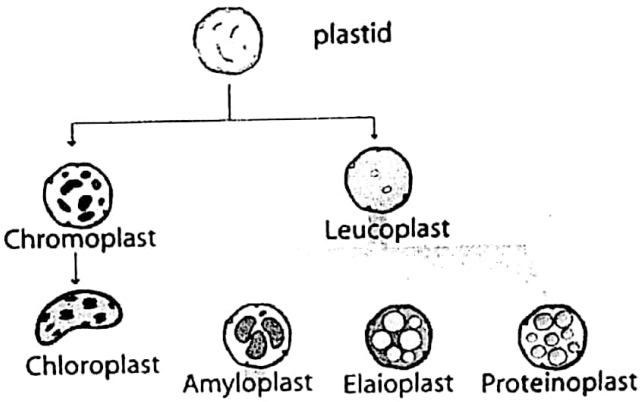
4. Chromatin:

The nucleus contain a darkly stained material called chromatin (Greek word, chromatin = colour), which is a combination of DNA, histone and other proteins that make up chromosomes. During interphase, the chromatin material is organized into a number of long, loosely coiled, irregular strands or threads called chromatin reticulum. When the cell begins to divide, the chromatin bodies condense to form shorter and thicker threads, which were termed chromosomes (Greek word, soma = body) by W. Waldeyer.

The main functions of chromatin:

- To package DNA into a smaller volume to fit in the cell
- To strengthen the DNA to allow mitosis and meiosis and
- To control gene expression and DNA replication

Plastids:



Plastids are the cytoplasmic organelles of the cells of plants and some protozoans such as Euglena. Whereas, the cells of the bacteria, fungi and animals contain chromatophores instead of plastids. Plastids perform most important biological activities such as the synthesis of food and storage of carbohydrates, lipids and proteins. The term plastid is derived from the Greek word "plastikas" means formed or moulded and was used by A.P.W. Schimper in 1885. He classified the plastids into the following types based on their structure, pigments and function. 1. Chromoplasts (coloured) 2. Leucoplasts (colourless)

1. **Chromoplasts**: (Greek words, chroma = colour; plast = living) These are the coloured plastids of plant cells. They contain a variety of pigments and synthesize the food through photosynthesis. Based on the type of pigment present in them, the chromoplasts of microorganisms and plant cells are as follows:

a) **Chloroplasts:**

(Greek words, chlor = green; plast = living) These are most widely occurring chromoplasts of the plants. They occur mostly in the green algae and higher plants. The chloroplasts contain the pigments chlorophyll 'a' and chlorophyll 'b'. They also contain DNA and RNA.

b) **Phaeoplasts:**

(Greek words, phaeo = dark brown; plast = living) These contain the pigment "Fucoxanthin", which absorbs the light. They occur in the diatoms, dinoflagellates and brown algae.

c) Rhodoplast:

(Greek words, rhodo = red; plast = living) The rhodoplast contains the pigment phycoerythrin which absorbs light. The rhodoplast occur in red algae.

2. **Leucoplasts:** (Greek words, leuco = white; plast = living) These are the colorless plastids which store the food material such as carbohydrates, lipids and proteins. The leucoplasts are rod like or spheroid in shape and occur in the embryonic cells, sex cells and meristematic cells. The most common leucoplasts of the plants cells are as follows:

a) **Amyloplasts:**

(Greek word, amyl = starch) These synthesize and store starch and occur in those cells which store starch.

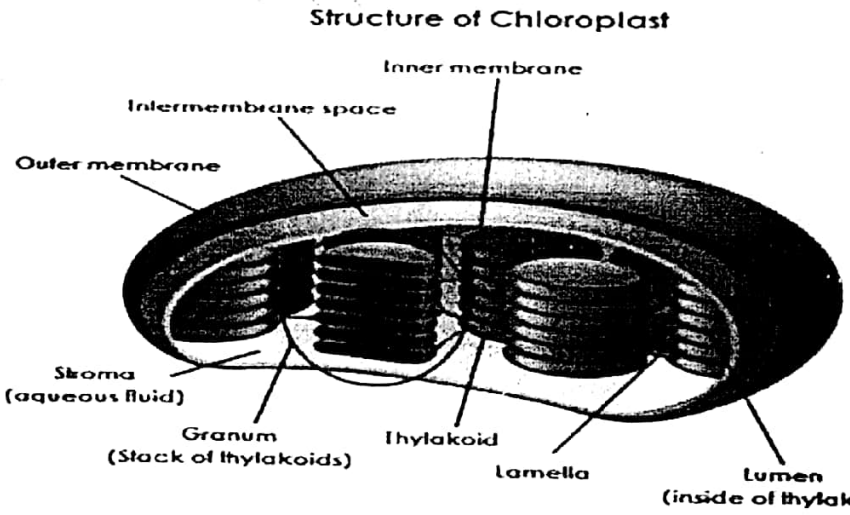
b) Elaioplasts:

These store lipids and occur in seeds of monocotyledons and dicotyledons.

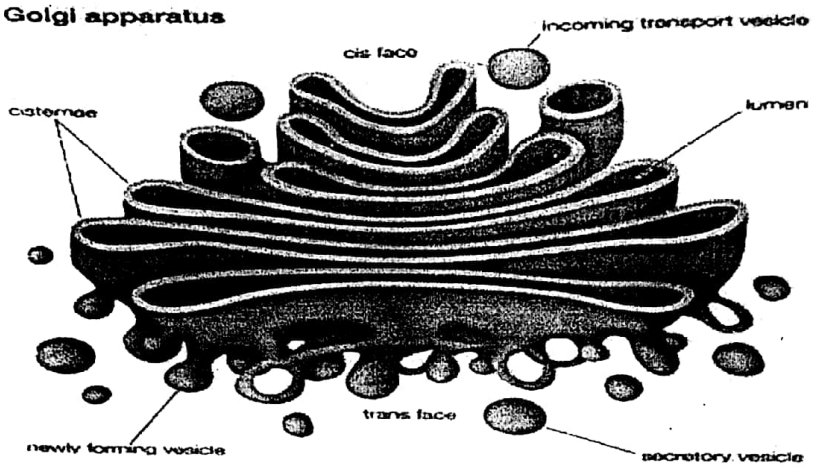
c) Proteinoplasts or proteoplasts:

These are the protein storing plastids which mostly occur in seed and contain few thylakoids.

Chloroplasts:



These are the most common plastids of many plant cells and perform the function of photosynthesis. **Distribution:** The chloroplasts remain distributed homogeneously in the cytoplasm of plant cells. But in certain cells, the chloroplasts become concentrated around the nucleus or just beneath the plasma membrane. **Shape:** Higher plant chloroplasts are generally biconvex or plano-convex. However in different plant cells, chloroplasts may have various shapes viz., filamentous, saucer shape, spheroid, ovoid, discoid or club-shaped. They are vesicular and have a colourless centre. **Size:** Generally 2-3 μ in thickness and 5-10 μ in diameter. Polyploid plant cells have larger chloroplasts

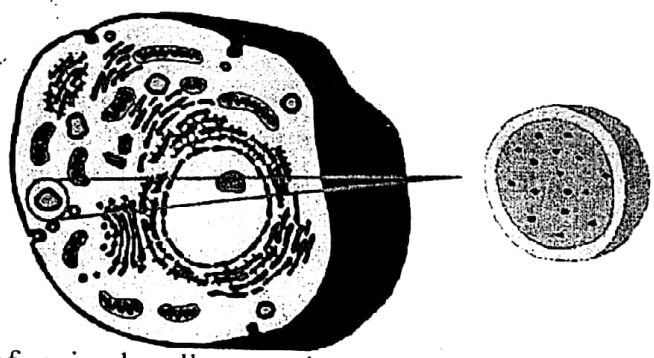


It occurs in all cells except prokaryotic cells. In plant cells, they are called dictyosomes, which secrete necessary material for the formation of new cell wall during cell division. First reported by C. Golgi in 1898. It is a polymorphic structure having cisternae, vesicles and vacuoles. It is disc shaped and consists of central flattened platelike compartments / cisternae with a peripheral network of interconnecting tubules and peripherally occurring vesicles and golgian vacuoles. The membranes of Golgi complex are lipoproteinaceous and originate from membranes of endoplasmic reticulum.

Functions:

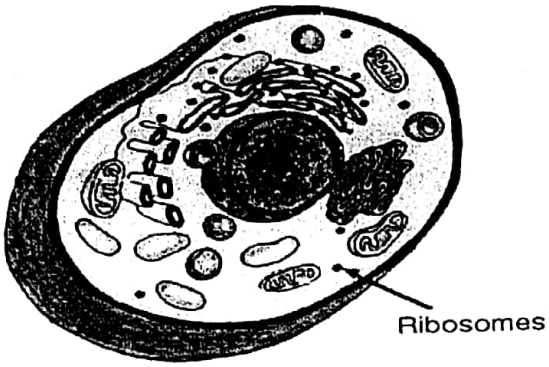
1. Storage of proteins and enzymes which are secreted by ribosomes and transported by endoplasmic reticulum.
2. Secretory in function
3. The dictyosomes secrete necessary material for cell wall formation during cell division.
4. It has a role in the formation of plasma membrane.
5. It activates mitochondria to produce ATP, which is later utilized in respiratory cycle.

Lysosomes:



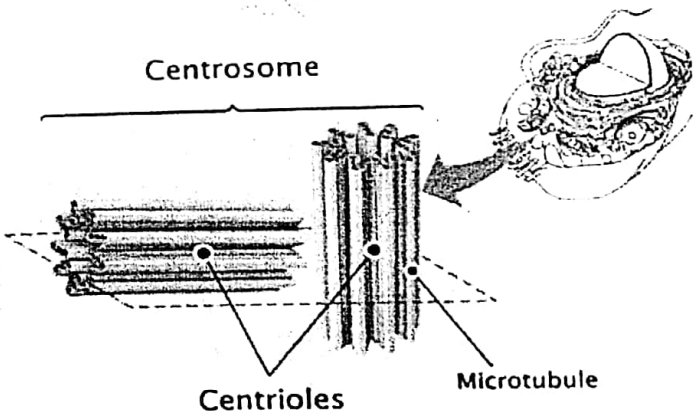
The cytoplasm of animal cells contains many speroid or irregular shaped membrane bound vesicles known as lysosomes. The lysosomes originate from Golgi complex and contain many digestive enzymes. Their function is the digestion of food material which comes into the cell by pinocytosis and phagocytosis. The lysosomes of plant cells are membrane bound storage organs containing hydrolytic digestive enzymes and are comprised of sphaerosomes, aleuron grains and vacuoles. Lysosomes are useful in the process of fertilization. They are also useful in autodissolution of cells.

Ribosomes:



Robinson and Brown in 1953 first observed ribosomes in plant cells, while Palade in 1955 first observed them in animal cells. They are small, dense, round and granular particles occurring either freely in mitochondrial matrix, cytoplasm, and chloroplasts or remain attached to membrane of endoplasmic reticulum forming the rough endoplasmic reticulum. They occur in all prokaryotic and eukaryotic cells and are hence called "universal components of all biological organisms". They originate in the nucleus and consist of mainly RNA and proteins. Each ribosome is composed of two structural sub units viz., larger sub unit and smaller sub unit. The ribosomes are 70 S type in prokaryotes containing 50 S and 30 S subunits, while in eukryotes, they are 80 S type consisting of 60 S and 40 S subunits. The ribosome remains attached with the membranes of endoplasmic reticulum by larger subunit. The smaller subunit of ribosome is placed onto the larger subunit like a cap on the head. The ribosomes are essential for protein synthesis.

Centrosome:



The centrosomes contain dense cytoplasm and are located near the nucleus of animal cells. During the cell division, the centrosome is found to contain two rod shaped granules known as centrioles. Each centriole consists of nine microfibrillar units and each microfibrillary unit is found to contain three microtubules. During cell division, microtubules help in the separation and movement of chromosomes.