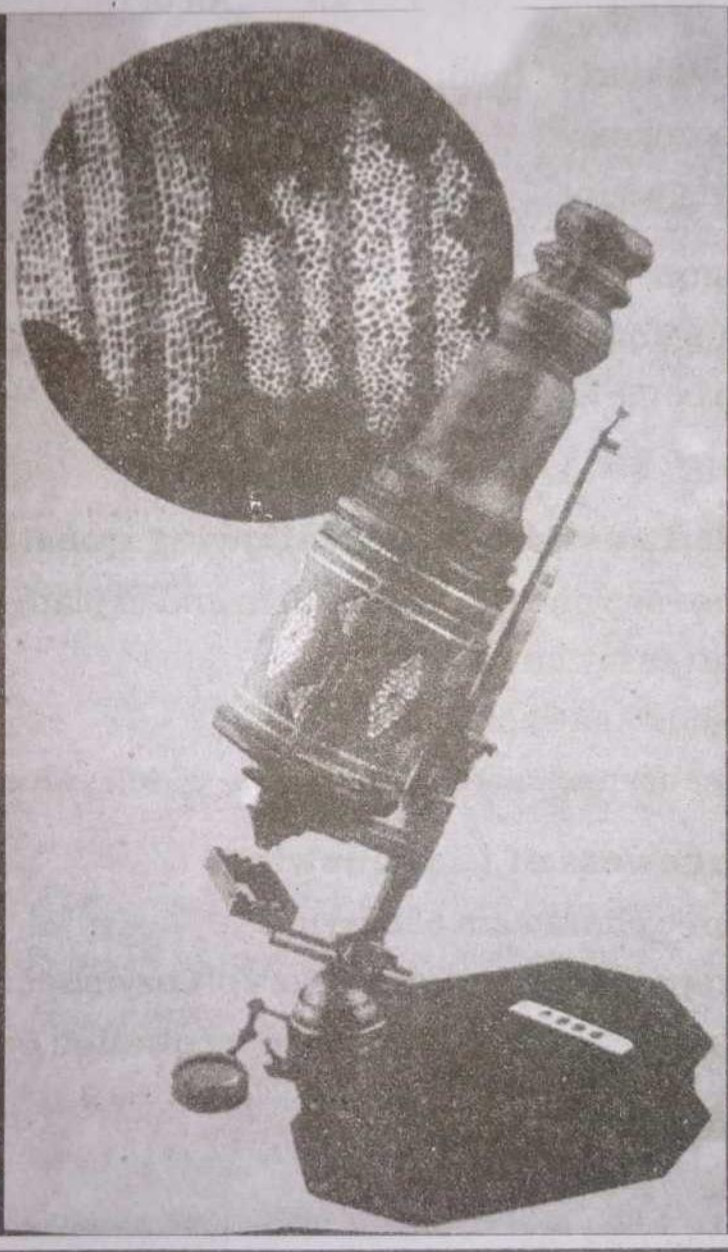
CHAPTER 4

THE CELL



Cell is the smallest entity in which life can exist. It is the least set of chemicals that with the help of "life" turns into a stable, living systems with the self replication property.

4.1 CELL AS BASIC UNIT OF LIFE

Cell is the most puzzling mystery of nature about which it is believed that the day scientist will understand it fully, they would be able to unravel the secret of life and death. The discovery of cells and their structure became possible with the development of optical lenses and with the construction of compound microscope (Gr-mikros-small, skopein-to see, to look), which was invented by David Jansen in 1590 and in 1610 *Galileo* an Italian astronomer and physicist designed it properly.

The term Cell *(Greek, Kytos-cell; La; Cella-hollow space)* was first used by *Robert Hooke* (1665) to describe his investigations on the structure of cork. *Later, Robert Brown* (1831) discovered a spherical body, *the nucleus*, in the cells of *orchids*. The fact that living organisms have a cellular organization was emphasized by *Schleiden* (1838) and *Schwann* (1839). *Schwann*, observed that the nucleus was surrounded by a fluid in the cell. His observation thus, changed the definition of cell and he described the "Cell as a structure which consists of a nucleus surrounded by a semifluid substance enclosed by a membrane". Later, it was pointed out, that the structure of a cell in animals and plants is similar with only one difference, that plant cell has a *cell-wall* in addition to the cell membrane.

When Robert Hooke first discovered the cell as basic unit of life in 1663, he calculated over 1-billion of cells in a "cubic inch" of cork. One encounters such astonishing numbers contain frequently in the study of cell biology. A new born human baby contain 2 trillion cells; an adult 60 trillion. When you donate blood, you give away 5.4 billion cells. Each day, infact, a human body sloughs off and replaces 1 percent of its cells or about 600 billion.

4.1.1 Emergence of Cell Theory:

In 1838, Schleiden, a German botanist, concluded that, despite differences in the structure of various tissues, plants were made of cells. In 1839, a German zoologist, T. Schwann, published a comprehensive report on the cellular basis of animals. Both of them proposed the cell theory which state that:

i) All organisms are composed of one or more cells.

ii) The cell is the structural and functional unit of life.

Schleiden and Schwann's ideas on the origin of cell was not convincing; both agreed that cell is a *'de novo'* structure, could arise from non-cellular materials. In 1855 Rudolf Virchow a German pathologist, had made a convincing case and added a third point to the cell theory.

iii) Cells can arise only by division of pre-existing cell, it is not a *'de novo'* structure .

Cell theory brought a great revolution in the field of biology which established that the function of an organism is the result of activities and interaction of the cell units.

Now, a cell is defined as the structural and functional unit of living organisms, made up of **protoplasm** containing **nucleus** surrounded by **cytoplasm** and bounded by **cell membrane**.

4.1.2 Microscopes:

The study of cells and micro-organism is dependent upon the use of an instrument called microscope. Our knowledge of sub-cellular organisation has been improved by the development of better and more powerful microscopes.

Kinds of microscopes:

Various types of microscopes have been designed by scientist. According to the source of light following types of microscopes can be recognised.

i) **Light microscope** — in which visible light is used as source of illumination.

ii) **X-ray microscope** — in which short wave length X-rays are used as source of illumination.

iii) **Electron microscope** — in which electron beam is used as a source of illumination.

Resolution Vs Magnification:

Three attributes of microscopes are of particular importance, these are magnification, resolution and contrast. Magnification is a means of increasing the apparent size of the object. With a light microscope a specimen could quite easily be magnified by as much as 10,000x. Magnification of a microscope is calculated by multiplying the power of its eye pieces with its magnifying power of its objective.

Resolution or more correctly the minimum resolved distance, is the capacity to separate adjacent form or object. Contrast is important in distinguishing one part of cell from another. In light microscopes contrast is often obtained by fixing and staining the material.

A very high magnification can be obtained by ordinary light microscope but their resolving power is limited. It is about 500 times better than unaided human eye, but this is still not enough for viewing some of the smaller sub-cellular structures. Electron beams have much shorter wavelength than visible light, electron microscopes are capable of resolving objects about 10,000 times better than unaided human eye. Therefore most of the sub-cellular structures are studied by electron microscope.

4.1.3 Techniques to Isolate Components of Cell:

Isolation of cellular components to determine their chemical composition, is called cell **fractionation**. For cell fractionation, first of all it is necessary to break/

open a large number of similar type of cells in ice cold environment. The cells are usually placed in a homogenizer or mortor are broken. The 'freed' content of the cells are subjected to a spinning action known as **centrifugation**. At a low speed, large particles like, cell nuclei, settle down are in the sediment. Smaller particles are still in the supernatant (fluid) which can be poured into a fresh tube and subjected to centrifugation at a higher speed until the smallest particles have been separated out, the various cell fractions can then be biochemically analysed.

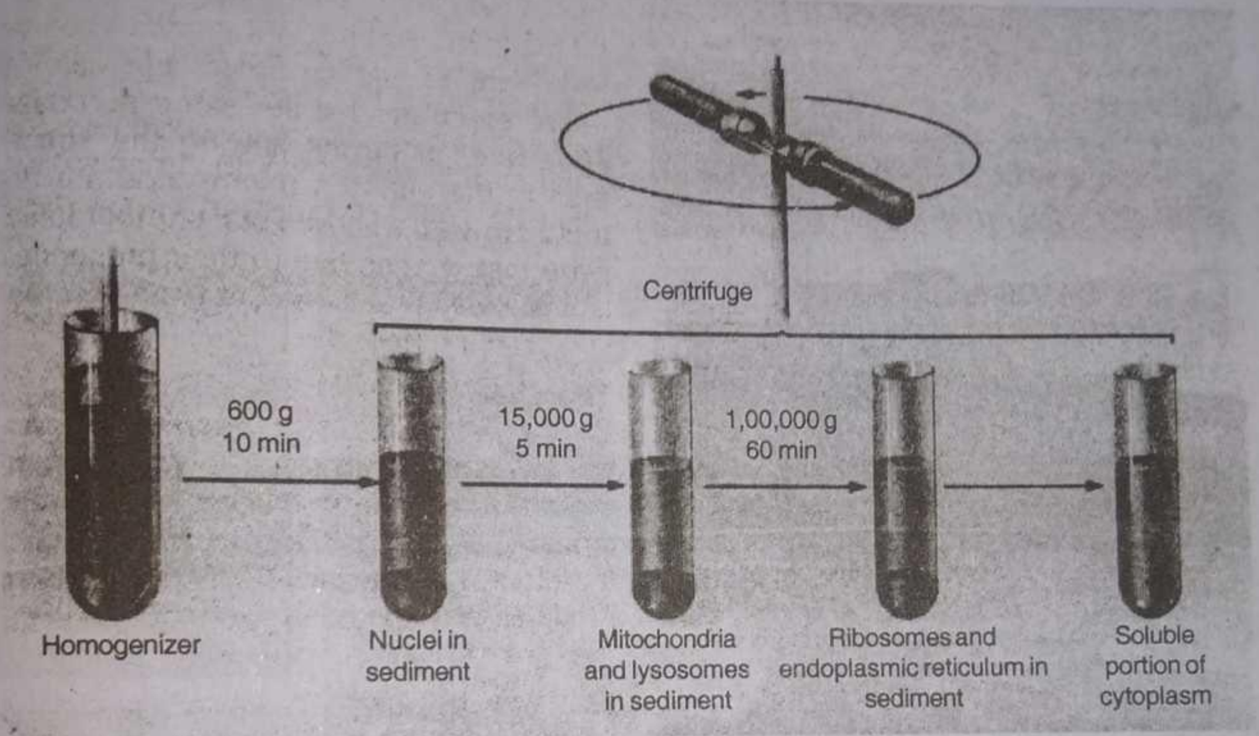


Fig. 4.1 Isolation of components of cell by means of centrifugation.

4.1.4 Eukaryotes and Prokaryotes:

Eukaryotes are those organisms having a true nucleus (Eu=true, karyon=nucleus) in their cells. They also contain chromosomes and a variety of membrane bound organelles like mitochondria, Golgi apparatus, lysosomes, plastids etc. in their cells, which contribute structural and functional organisation to the cells. They may be unicellular or multicellular organisms. On the other hand prokaryotes (Pro=early, karyon=nucleus) are those organisms which do not contain membrane bound nucleus in their cells, their nucleic material is usually coiled and concentrated in a region of the cell called the **nucleoid**. More over genetic material (DNA) never associated with histone protien and hence no true chromosome. These organisms also do not contain other membrane bounded structures like, mitochondria, chloroplast, lysosome, etc. in their cells. They only contain mesosomes, which are simple infoldings of the Plasma membrane responsible for respiration, photosynthesis, nitrogen fixation etc. They are unicellular organisms like bacteria and cyanobacteria.

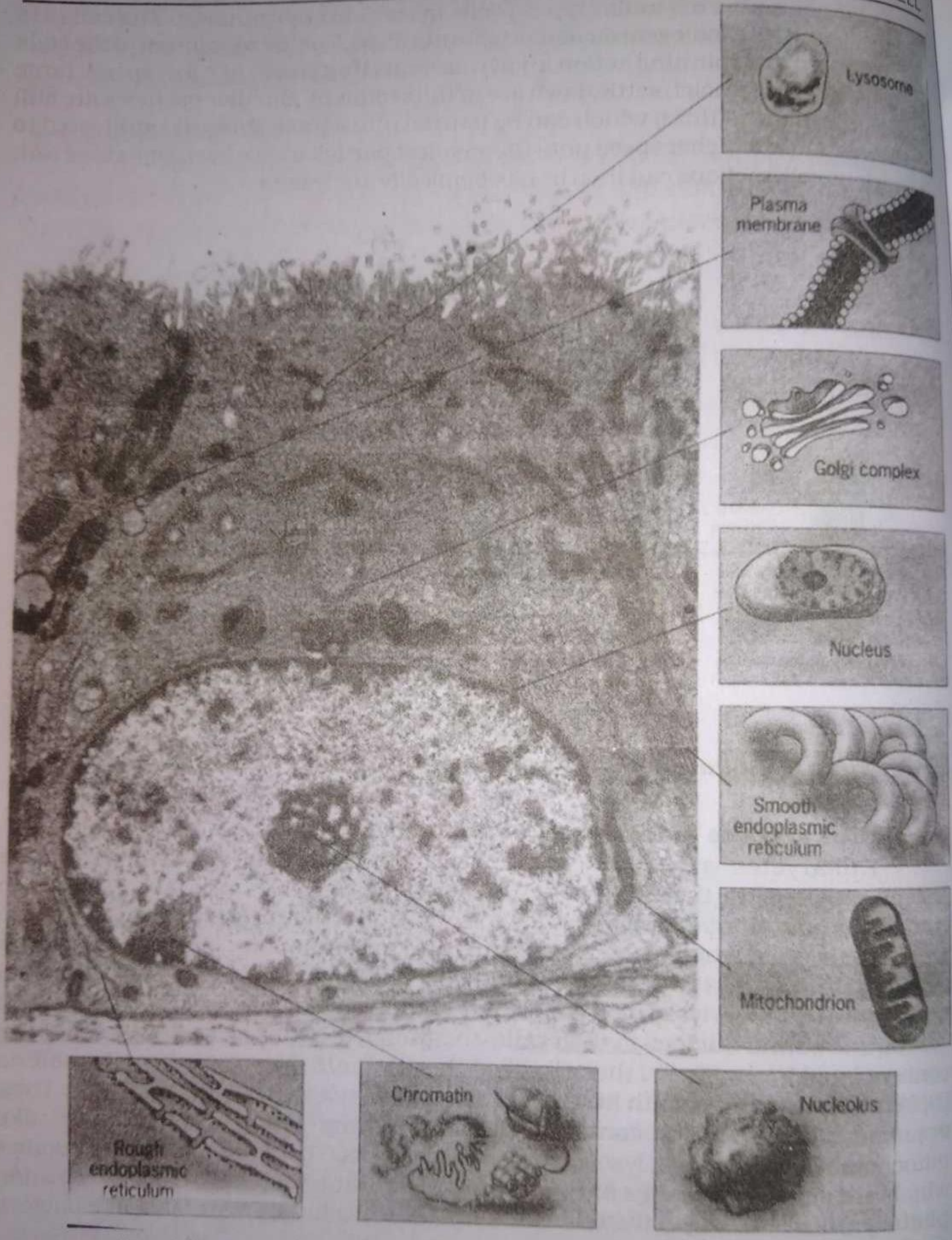


Fig. 4.2 Three dimensional structure of cell and its organelles.

4.2 EUKARYOTIC CELL

The typical Eukaryotic cells contain three major parts, but 4th component i.e. cell wall is only found in plant cells.

1. Plasma membrane.
2. Nucleus.
3. Cytoplasm and Cytoplasmic Organelles.
4. Cell Wall.

4.2.1 Plasma membrane:

All cells are enclosed in a membrane that serves as their outer boundary, separating the cytoplasm from the external environment. This membrane is known as the plasma membrane. It allows the cell to take up and retain certain substances while excluding others.

All biological membranes have the same basic molecular organization. They consist of a double layer (bilayer) of phospholipids interspersed with proteins.

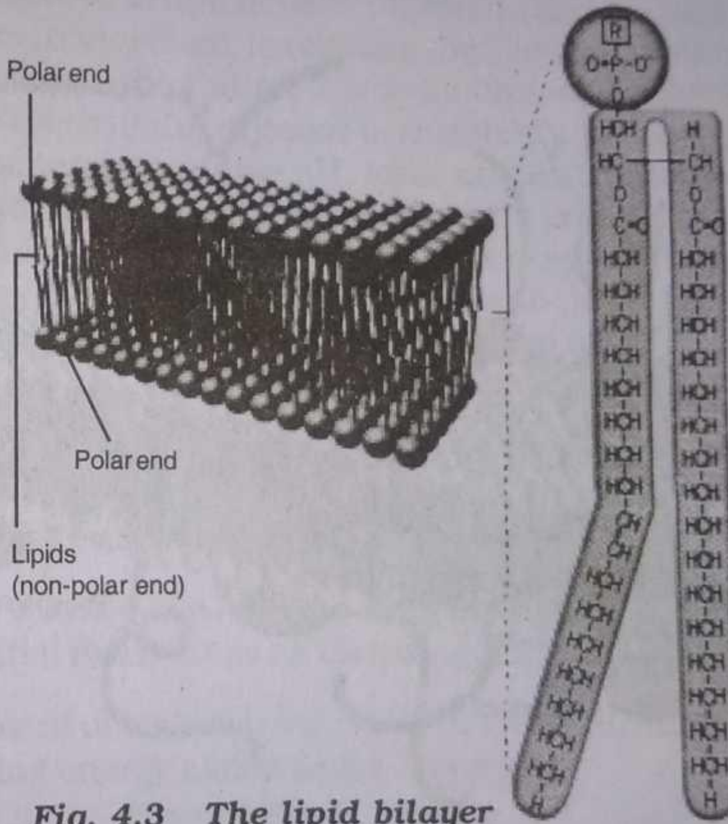


Fig. 4.3 The lipid bilayer

The phospholipid molecules in the plasma membrane are arranged in two parallel layers. Their non-polar hydrophobic ends face each other, whereas their polar hydrophillic ends are associated with carbohydrate, protein etc. Plasma membrane also contains several types of lipids like cholesterol. In certain animal cells cholesterol may constitute upto 50 percent of the lipid molecules in plasma membrane. It is absent from the plasma membrane of most plant and bacterial cells.

Fluid Mosaic Model; characteristics, properties and functions:

In 1972 Singer and Nicolson proposed a working model of plasma membrane known as fluid mosaic model. In the fluid mosaic model, the lipid bilayer is retained as the core of the membrane. These lipid molecules are present in a fluid state apable of rotating and moving laterally within the membrane.

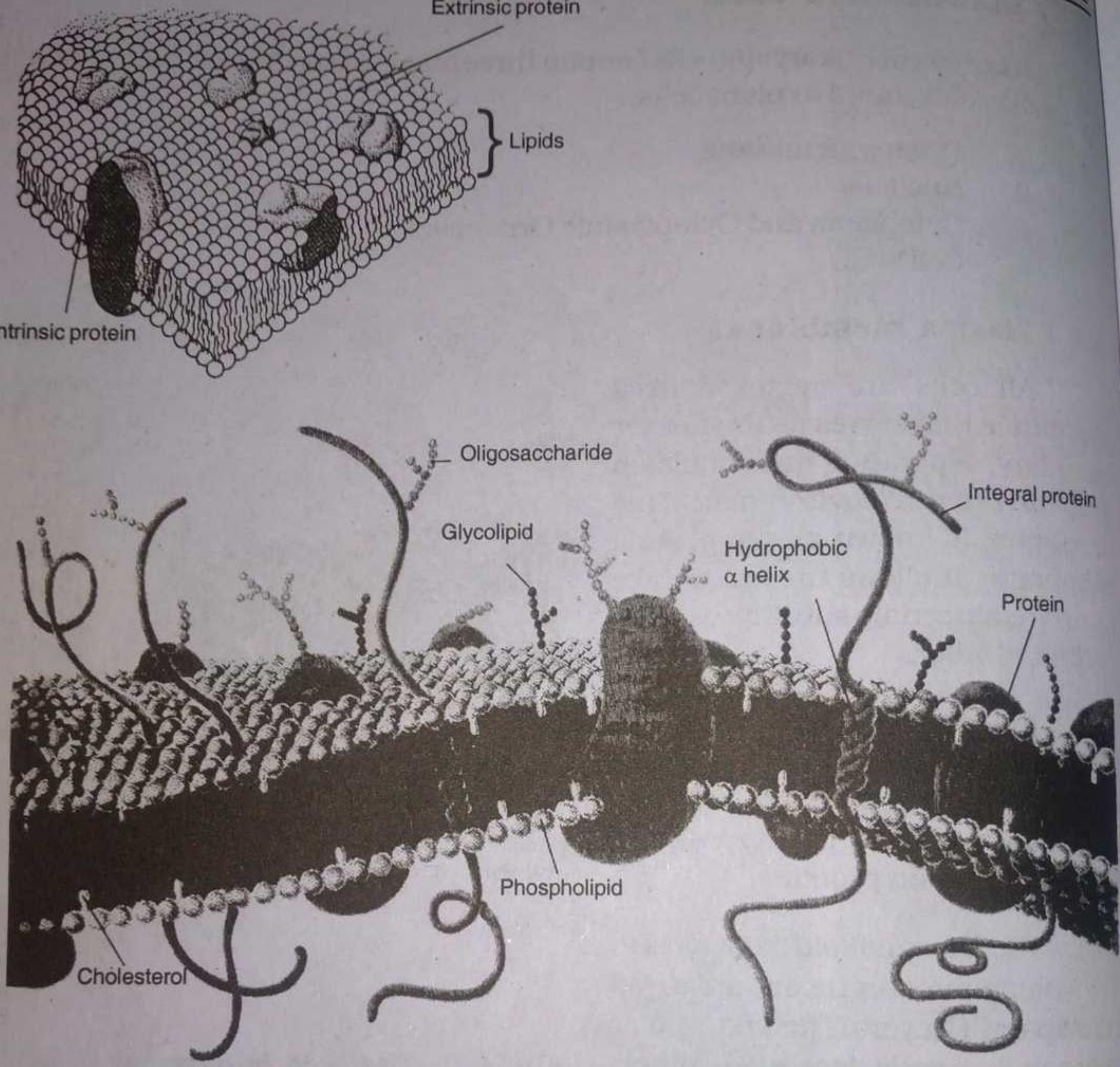


Fig. 4.4 The structure of the plasma membrane

The structure and arrangement of membrane proteins in the fluid-mosaic model are like icebergs in the sea. The proteins occur as a 'mosaic' of discontinuous particles that penetrate deeply into and even completely through the lipid sheet. The components of plasma membrane are mobile and capable of coming together to engage in various types of transient or semipermanent interaction.

The proteins associated with the lipid bilayer can be divided into two groups.

a) Integral proteins (intrinsic proteins): A class of proteins that are directly incorporated within the lipid bilayer. Some of these proteins are believed to provide a channel through which water-soluble substances, such as ions, can pass back and forth between the extracellular and intracellular compartment.

b) Peripheral proteins (extrinsic proteins): A class of protein located entirely outside of the lipid bilayer on either the extracellular or cytoplasmic surface, exhibit a loose association with membrane surface.

These proteins which may possess lipid (lipoprotein) or carbohydrate (glycoproteins) side chains, are arranged as mosaics with in the cell-membrane.

> Different types of cells contain different population of membrane proteins e.g. Red blood cells have special membrane proteins that label the cell, giving it A, B, AB or O blood type. Other molecular labels lead to either acceptance or rejection of a transplanted kidney, heart or other organ.

The plasma membrane performs several functions but the main and the most important functions are protection of cell cytoplasm, to regulate the flow of solutions and material in an out of the cell with certain limitation. These limitations or check in flow across the membrane is called differential or selective permeability. Transport across membranes is necessary to maintain suitable pH, ionic concentration for enzyme activity and excrete toxic substances etc. For entry or exit there are two main processes, **passive transport** i.e. diffusion and osmosis and **active transport**, the passive processes do not require energy while active require energy with these, there are two other phenonmenon i.e. endocytosis and exocytosis. Definition of diffusion and osmosis is discussed in chapter 14.

i) Diffusion: It occurs spontaneously, and no extra energy is required to bring it about. A few substances freely diffuse across plasma membrane e.g. the respiratory gases (O_2 and CO_2) diffuse in and out of the cells.

ii) Osmosis: It maintains a balance between the osmotic pressure of the intracellular fluid and that of interstitial fluid, know as Osmoregulation.

iii) Active transport: Movement of molecules from lower concentration to the higher concentration by consuming energy called active transport.

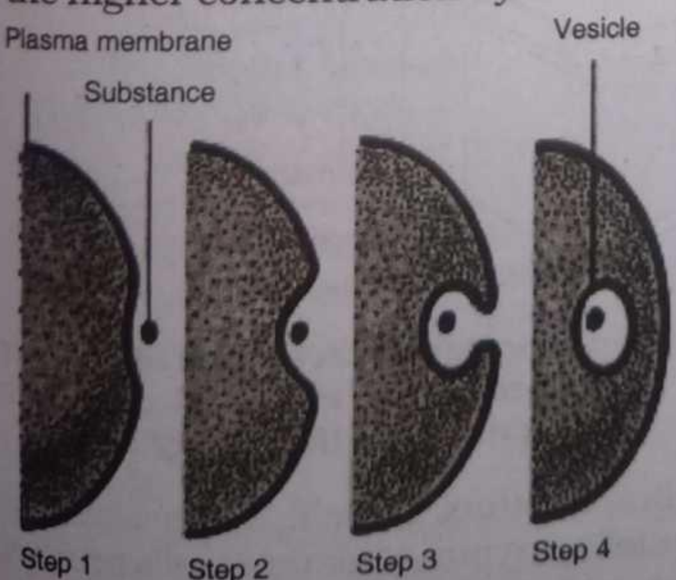


Fig. 4.5-a Stages of endocytosis

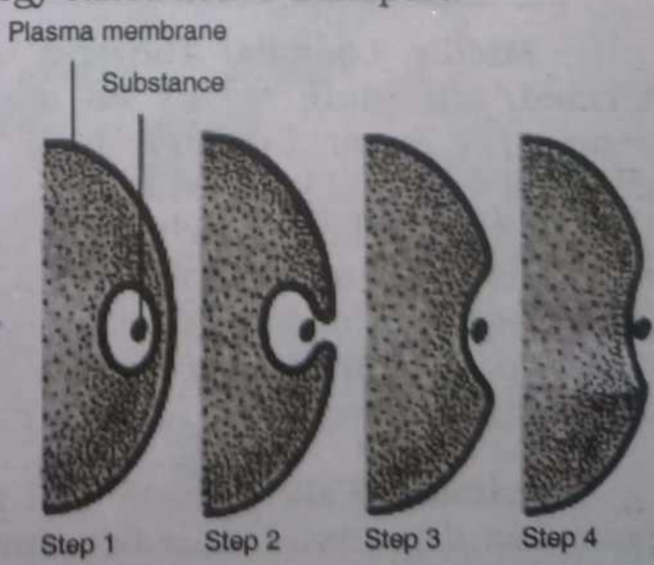


Fig. 4.5-b Stages of exocytosis

iv) Endocytosis: It is the process in which the cell membrane helps to take in material by infolding in the form of vacuole. Endocytosis may be ***(a) phagocytosis*** in which solid particles are picked and ingested by the cell e.g. W.B.C picked up foreign bodies from the blood stream. In this way they destroy the harmful bacteria which enter into our body. It is also called cell eating process ***(b) pinocytosis*** when liquid material in bulk, in the form of vesicles is taken in by endocytosis, the process is called pinocytosis which is also called cell drinking process.

v) Exocytosis: The process of membrane fusion and the movement of material out of a cell is called exocytosis.

4.2.2 Cell-Wall:

Cell-wall is the non-living component of cell. It is secreted and maintained by living portion of cell called protoplasm. The chief structural component of plant cell-wall is cellulose, a polysaccharide. In addition to cellulose, pectin and a few other compounds may also be found in cell-wall.

A plant cell-wall can be differentiated into three layers, (i) middle lamella (ii) primary wall (1.3 μm thick and elastic) (iii) secondary wall (5-10 μ m thick and rigid).

Cellulose the main constituent of plant cell-wall is use in the manufacture of paper. It is also the main component of many other house hold goods. The seed hairs of the cotton plant (Gossypium) are almost pure cellulose and their natural twist make them easy to spin for use in a variety of textiles from clothes to curtains.

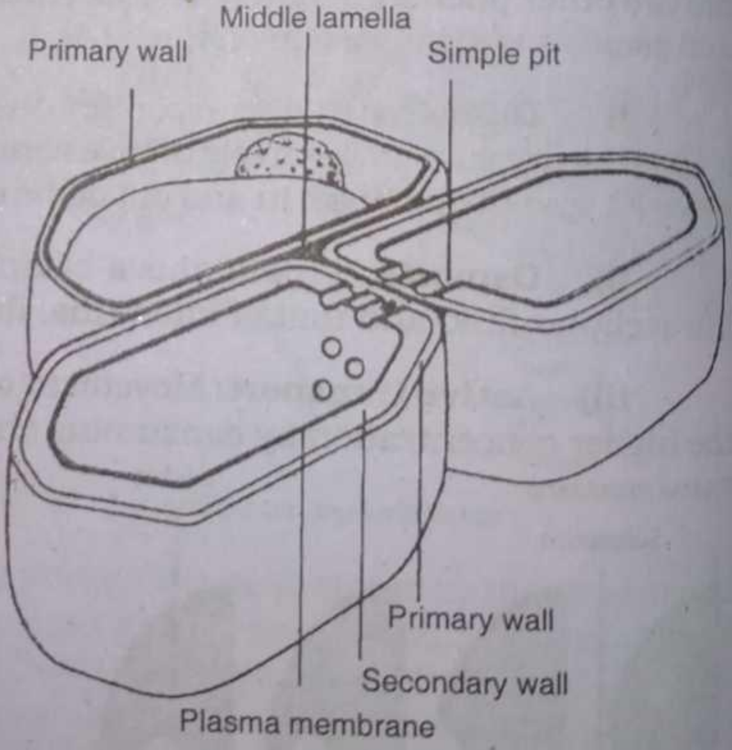


Fig. 4.6 Schematic representation of primary and secondary cell wall and their relationship to the rest of cell.

Middle Lamella: The first formed cell plate works as a cementing layer between two daughter cells and is called middle lamella. It is a common layer between two cells and the two cells are separated when middle lamella is dissolved. It is composed of calcium and magnesium pectates.

Primary Wall: Primary wall is the first product of cell, synthesised by protoplast, deposits on either side of middle lamella. In young enlarging cells primary wall remains thin and elastic, becoming thick and rigid with the approach of cell maturity. Primary wall contains hemicellulose up to 50 percent, cellulose up to 25 percent and smaller amount of pectic substances. Hemicellulose forms matrix of the wall in which cellulose micro fibrils are embedded.

Secondary Wall: Secondary wall is formed by deposition of cellulose at the inside of primary wall. It mainly consists of cellulose or varying mixtures of cellulose. Secondary wall may be modified through the deposition of Lignin and other substances.

In the cell wall cellulose deposits in the form of fibres. The cellulose fibres of each successive layer lie at different angles, increasing the strength of the cell-wall. At some places in the cell wall, the deposition of wall material does not take place, these places are known as **plasmodesmata** (Singular-plasmodesma), through which cellular contents of neighbouring cells remain in communication with each other.

Functions of cell-wall:

It performs two important functions, firstly it provides a mechanical support and gives a definite shape and protection to the cell. It acts like a skeletal frame work of plants, particularly in vascular plants the cell walls provide the major supporting frame work. Secondly, being hydrophilic in nature it is capable of imbibing water and thus helps in the movement of water and solutes towards protoplasm i.e. Cell wall acts as permeable structure.

4.3 NUCLEUS

Nucleus was discovered by ***Robert Brown*** in 1831. It is the most important and prominent part of the cell which controls all its activities. It is commonly spherical or oval in shape, but may be lobed or elongated and is surrounded by a membrane called *nuclear membrane*. It is double-membraned structure. Usually cells have one, some have two or more nuclei. Some small organisms have several small nuclei per cell (coenocytic). The nuclear membrane is not a complete barrier. It is perforated by ***nuclear pores***. Certain substances pass freely through these pores between the nucleus and the surrounding cellular substances.

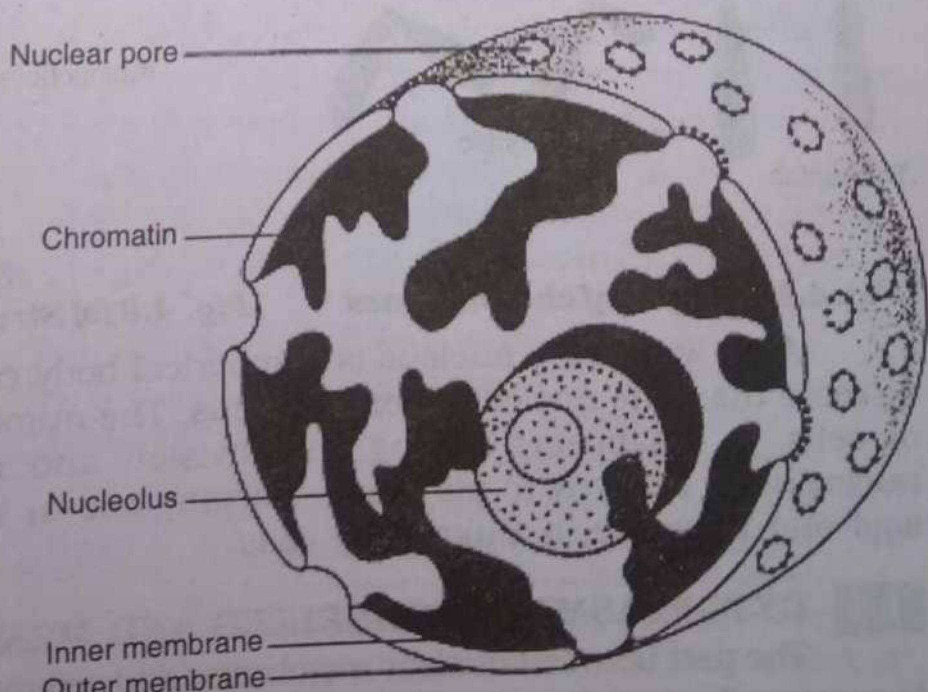


Fig. 4.7 Structure of nucleus and its components.

The Nucleus is filled with a protein rich substance called the ***Nucleoplasm*** or ***Karyolymph***. In the nucleoplasm are numerous fine strands in the form of net work called ***chromatin net work or nuclear reticulum***, which is composed of ***nucleic acid***, *Deoxyribo-nucleic acid* (DNA) and protein. During cell division, the chromatin changes to form *chromosomes*. Chromosomes contain the hereditary units called *genes* that carry the hereditary information from generation to generation. The chromosomes vary in number from species to species, e.g. 8 in the fruitfully, 46 in humans, 20 in corn etc. Chromosomes are elongated structure, visible during cell-division. A typical chromosome is composed of two parts the **arm** and **centromere**. Before cell division each chromosome consists of two threads called **chromatids**. These two chromatids are joined by centromere. Each chromatid has one DNA molecule. The part of chromatids from centromere to end is called **arm.** The chromosomes are of different types, depending on the position of centromere. These types are:

(i) **Metacentric:** Chromosome with equal arms.

(ii) **Sub-metacentric:** Chromosome with unequal arms.

(iii) **Acrocentric or Subtelocentric:** Rod like chromosome with one arm very small and the other very long. The centromere is subterminal.

(iv) **Telocentric:** Location of centromere at the end of chromosome.

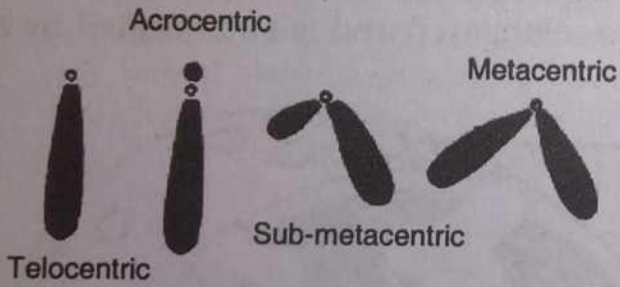


Fig. 4.8 (a) Types of chromosomes

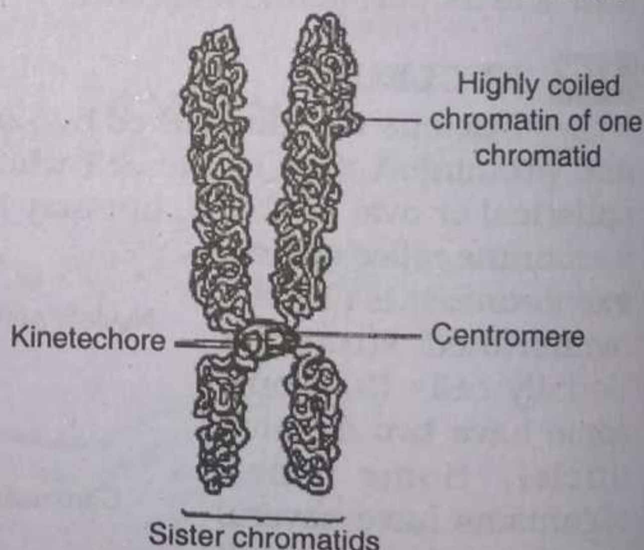


Fig. 4.8 (b) Structure of chromosome

Also, within the nucleus is a spherical body called **nucleolus**. There may be more than one nucleoli in one nucleus. The number varies in different kinds of cells. It disappears during cell division and reappears afterwards. The nucleolus is believed to play an important role in the synthesis of ribonucleic acid and ribosome in Eukaryotic cells.

4.4 CYTOPLASMIC ORGANELLES AND MEMBRANE SYSTEM

The part between nuclear membrane and cell membrane is called cytoplasm. In some cells, e.g. *Amoeba*, the cytoplasm has two distinct parts, an outer clear ectoplasm and an inner granular endoplasm in most cells. Under light microscope, cytoplasm appears as a semi-fluid colloid that fills the cell. The cytoplasm exhibits active streaming movements around the inner surface of the cell. This movement is known as *cyclosis*.

Cytoplasm is consist of several types of organelles, occupying as much as half of the volume of the cell, and a fluid matrix, the cytosol (literally 'cell solution') in which the organelles reside. The cytosol is a watery solution of salts, sugar, amino acids, proteins, fatty acids, nucleotides and other materials.

Observations under electron microscope, however, reveal that cytoplasm is not a simple colloid since it contains many different kinds of minute organelles and also a mesh of tiny filaments, the microfibrils that form a sort of skeleton, giving rigidity to cell and helping unicellular organisms in movement. Many of the orgenelles and even individual molecules of the cytoplasm are thought to be attached to the cytoskeleton.

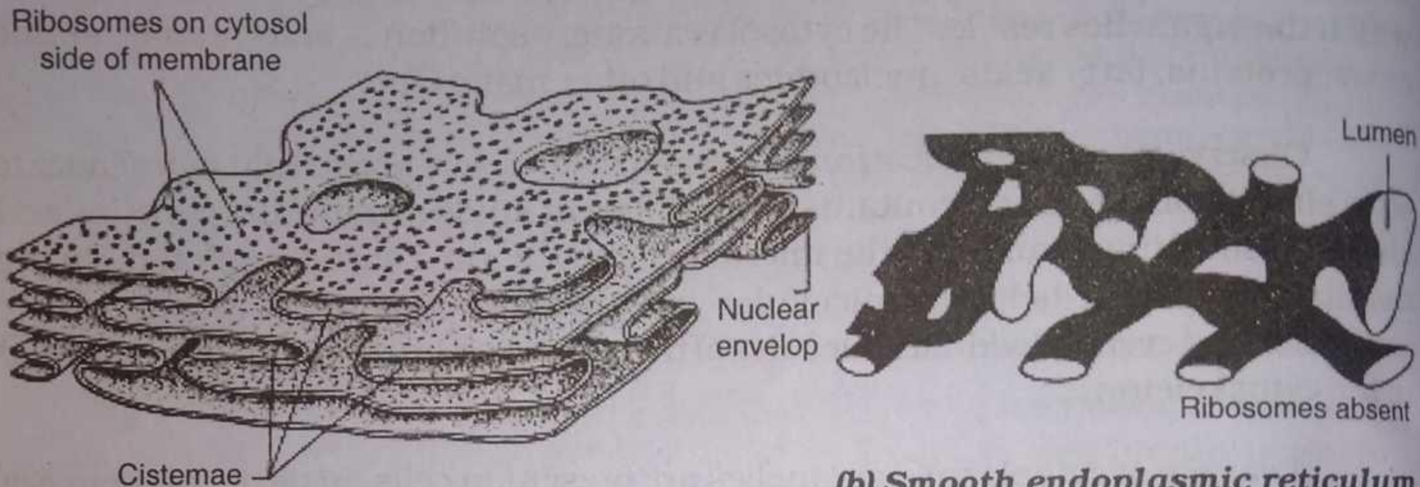
A variety of cytoplasmic organelles are present in cells, majority of them are membrane bound.

(i) *Endoplasmic Reticulum:*

The electron microscope reveals a complex network of channels, the endoplasmic reticulum (ER) which extends from plasma membrane to the nuclear membrane. It is an elaborate, tube like system of lipoprotein. There are two types of endoplasmic reticulum: (a) Agranulated or Smooth endoplasmic reticulum (SER) and (b) Rough or granulated endoplasmic reticulum (RER). Smooth endoplasmic reticulum is not associated with ribosomes. It is found in steroid producing cells like adipose cells (fat cells), interstitial cells, glycogen storing cells (liver) and the muscle cells. Rough or granular endoplasmic reticulum (RER), is heavily coated with ribosomes on its outer surface towards cytoplasmic surface. Rough ER, occurs mostly in protein synthesising cells. Such as those of the mammalian salivary glands and pancreas. Although most cells contain both rough and smooth ER but they vary from cell to cell.

> Smooth E.R. in the skin converts cholesterol into the lipid compound called vitamin D whenever sunlight strikes the skin; this vitamin helps to maintain strong, healthy bones. North African women of Bedouin tribe, who wear dark, full length garment get very little exposure to sun light and thus the smooth E.R. in their skin cells cannot make vitamin D. As a result, these women sometimes develop soft, weak bones.

The endoplasmic reticulum has many important functions. Primarily, it serves as a supporting platform for the ribosomes. The ER, forms a structural framework of the cell with increased surface for various metabolic reactions, and they themselves take an active part by means of attached enzymes. ER also provide conducting pathways for import—export and intracellular circulation of various substances. ER also provides passage for Ribonucleic acid (RNA) to pass from the nucleus to various organelles in the cytoplasm, thereby, controlling chiefly the synthesis of proteins. It also helps in detoxification of harmful drugs, storage and release of Ca^{+2} ions and manufacture lipids.



(a) Rough endoplasmic reticulum

(b) Smooth endoplasmic reticulum lacks ribosomes

Fig. 4.9 Endoplasmic reticulum

(ii) **Mitochondria:**

Mitochondria or Chondriosomes are universally present in the cytoplasm of animals and plants. They appear as minute granules, vesicles, rodlets, threads or strings depending upon physiological conditions of the cells. They are seen to be in constant motion in living cells Mitochondria are the centre of aerobic respiration.

Each mitochondrion is approximately about 0.2 to 1.0 nm in diameter and about 10 μm long. There are two thin membranes which form the boundary of the mitochondrion. Both membranes are formed of lipids and proteins. The inner membrane forms irregular, incomplete partitions called *Cristae*. The interior of the mitochondrion contains fluid like

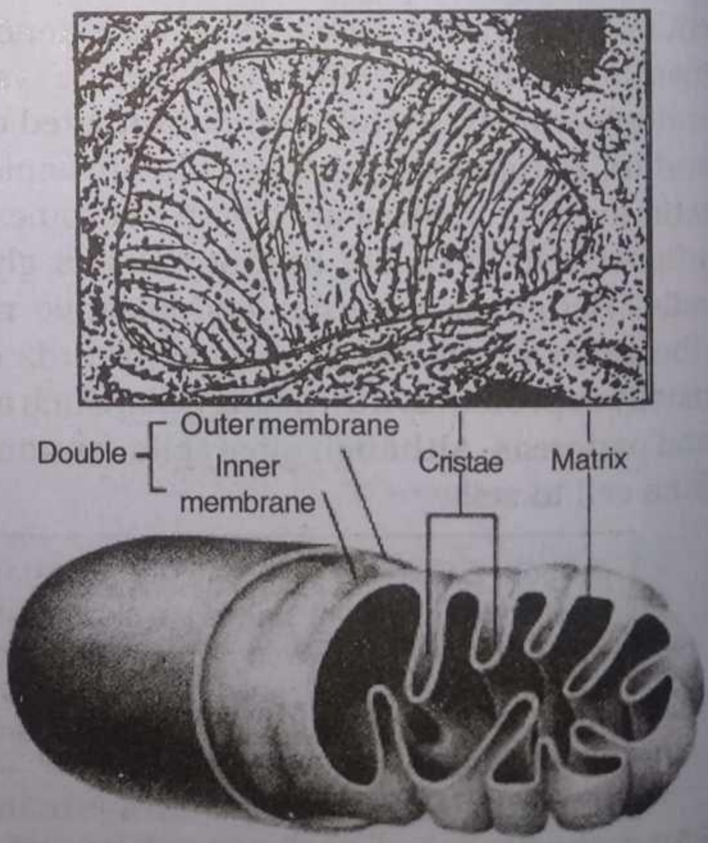


Fig. 4.10 Mitochondria showing

organic matrix, with a number of chemical compounds in it. On the cristae are located enzymes and co-enzymes by means of which carbohydrates (starch) fatty acids (lipids) and amino acids (proteins) are metabolized to CO_2 and H_2O. Energy in the form of ATP is released in this process which is stored within mitochondria. Adenosine triphosphate (ATP) is energy rich compound and it provides energy to the cells of organs for various activities. Hence mitochondria are known as *"Power House"* where energy is stored and released wherever and whenever required by a living body.

Mitochondria have a semi-autonomous existence in the cell; they have their own DNA that directs production of some of their component proteins and they can divide in half and thus reproduce independently of the cell's normal cell-division cycle.

> Surprisingly, mitochondria are passed to an animal only by mother, since mitochondria are present in eggs but not in the part of the sperm that enters the egg. Thus, people can trace their mitochondria back to their mothers, grand mothers, great grand mother etc.

(iii) Golgi apparatus (Dictyosome) :

The Golgi apparatus, like the endoplasmic reticulum, is a canalicular system with sacs, but unlike the endoplasmic reticulum it has parallel arranged, flattened, membrane bound vesicles which lack ribosomes. After the name of its discoverer Golgi, it was named as Golgi-body. The Golgi complex of the plants and lower invertebrates cells is usually referred as dictyosome.

The Golgi bodies of plant cells and Golgi complex of animal cells basically have same morphology. Each of them is disc-shaped and consists of central, flattened,

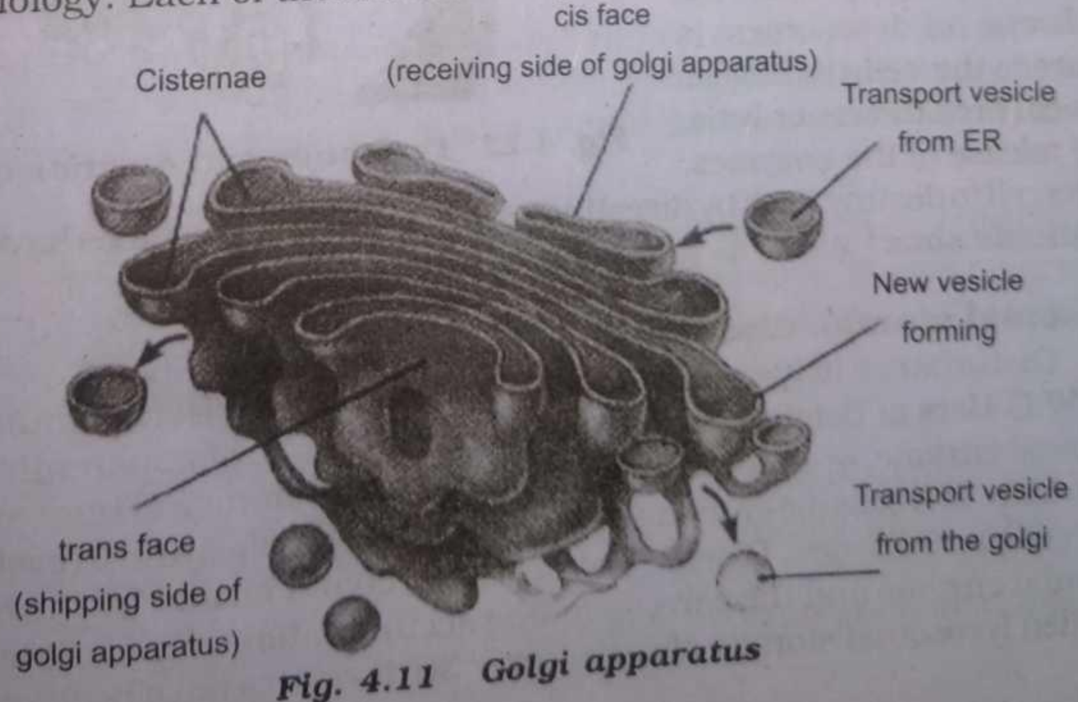


Fig. 4.11 Golgi apparatus

plate like compartments called **cisternae**, peripheral network of inter connecting tubules and peripherally occuring vesicles and Golgian vacuoles.

Usually in animal cells single Golgi apparatus is found in each cell, in plant cell, they may be more. Golgi apparatus are especially prominent in glandular cells. The products of E.R. are modified and stored, and then sent to other destinations.

They perform the function of collection, packaging and distribution. In addition to its finishing work, the Golgi apparatus manufacture certain macromolecules by itself. Many polysaccharides secreted by cells, like cell-wall and cell plate material in plant cell are Golgi products.

(iv) Lysosomes:

These are spherical bodies, a few micrometer in diameter, surrounded by a single membrane, originated by Golgi apparatus and containing digestive enzymes. They occur only in the cytoplasm of animal cells, and function in the digestion of material taken into the cell by phagocytosis, as bacteria are ingested by white blood corpuscles. Normally they function as destroyers of foreign particles and worn out cellular components. When the membrane of lysosomes is ruptured, the cell undergoes chemical breakdown, or lysis. Since release of the enzymes, cause a cell to destroy itself by digesting its own proteins, lysosomes have been referred as ***"suicide sacs"*** and this process is called ***autophagy***.

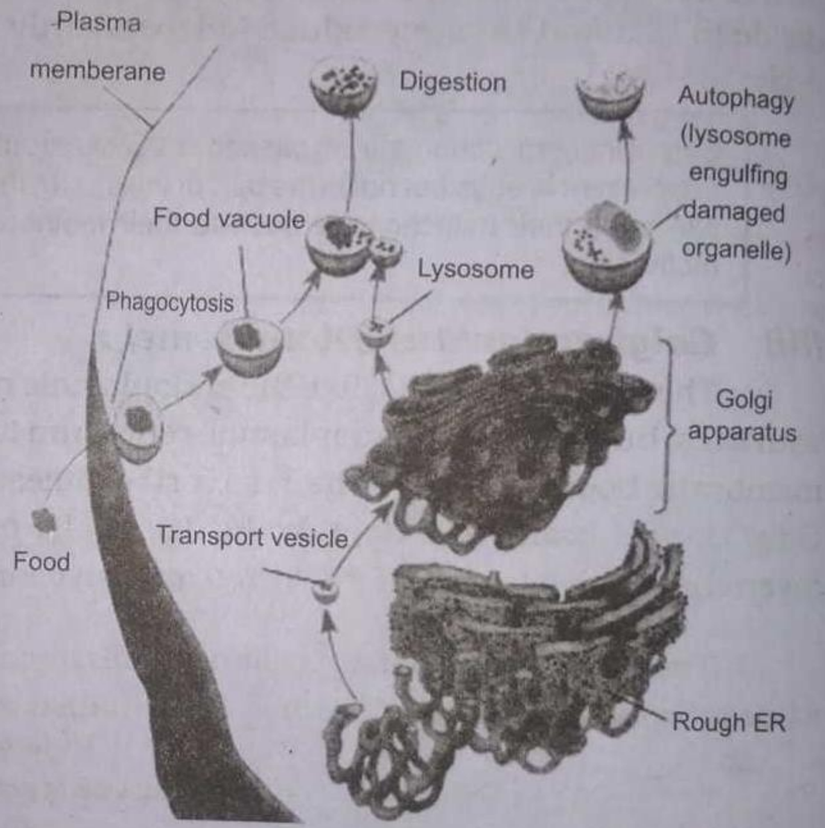


Fig. 4.12 Formation and function of lysosomes

Lysosomal storage diseases:

Disturbance in lysosome function has profound effects on human health. In 1965 W.G.Hers of Belgium explained how the absence of apparently unimportant lysosomal enzyme, α-glucosidase, could lead to the storage of undigested glycogen accumulate in lysosome causing swelling of the organelles and irreversible damage to the cells and tissues. Diseases of this type, characterized by the deficiency of a lysosomal enzyme and the corresponding accumulation of undergraded substrate are called lysosomal storage disorder, over 30 disorders have been reported, out of them some are described in the following table.

Table 4.1 Sphingolipid storage diseases

Disease	Consequences
- Tay-sachs disease	- Mental retardation, blindness, death by age 3.
- Gaucher's disease	- Liver and spleen enlargement, erosion of long bones, mental retardation in infantile form only.
- Krabbe's disease	- Loss of myelin, mental retardation, death by age 2.

(v) Plastids:

They are especial protoplasmic double membrane bound organelles which function as chemical synthesizers and storage bodies. Plastids occur in greatest number in cells of plants and in the primitive single celled organisms, the Protoctists.

There are three types of plastids e.g. Chloroplast, Chromoplast and Leucoplast.

i) Chloroplast (Gr: Chloro=green, Plast=living): The most common type of plastid is chloroplast containing chlorophyll which gives plant their green colour and is of great importance in the manufacture of food by the process of photosynthesis.

Chloroplasts contain a substantial amount of DNA and are capable of programming synthesis of some other new structural components. It has its own DNA and RNA.

ii) Chromoplast (Gr: Chroma=colour, Plast=living): They have pigments like xanthophyll, and carotene. The chromoplasts are responsible for the various colour combinations found in flowers, fruits and other coloured parts except green.

iii) Leucoplast (Gr: Leuco=white): These are colourless plastids which develop in the absence of sunlight and are thus commonly found in all under-ground parts of the plants. They store the food material as carbohydrates, lipids and proteins.

Proplastids: Proplastids are immature, colourless plastids occuring in cells of meristematic tissues. They consist of double membrane enclosing granular stroma. They multiply by division. In mature cells proplastids develop into chloroplast or chromoplast or leucoplast.

Chloroplasts as energy converting Organelles:

A typical plant cell has especial type of energy converting organelles, chloroplasts. They have an ability to convert solar energy (light energy) into chemical/food energy by the process of photosynthesis, therefore called site of photosynthesis. Chloroplasts belong to a group of double-membrane bound orgenelles. They contain chlorophyll and its associated proteins.

Inside the chloroplast other membranous system, arranged into flattend sac called **thylokoids**. In some regions thylokoids are stacked forming structure called **grana** (sing: granum). The fluid outside the thylokoid called **stroma**.

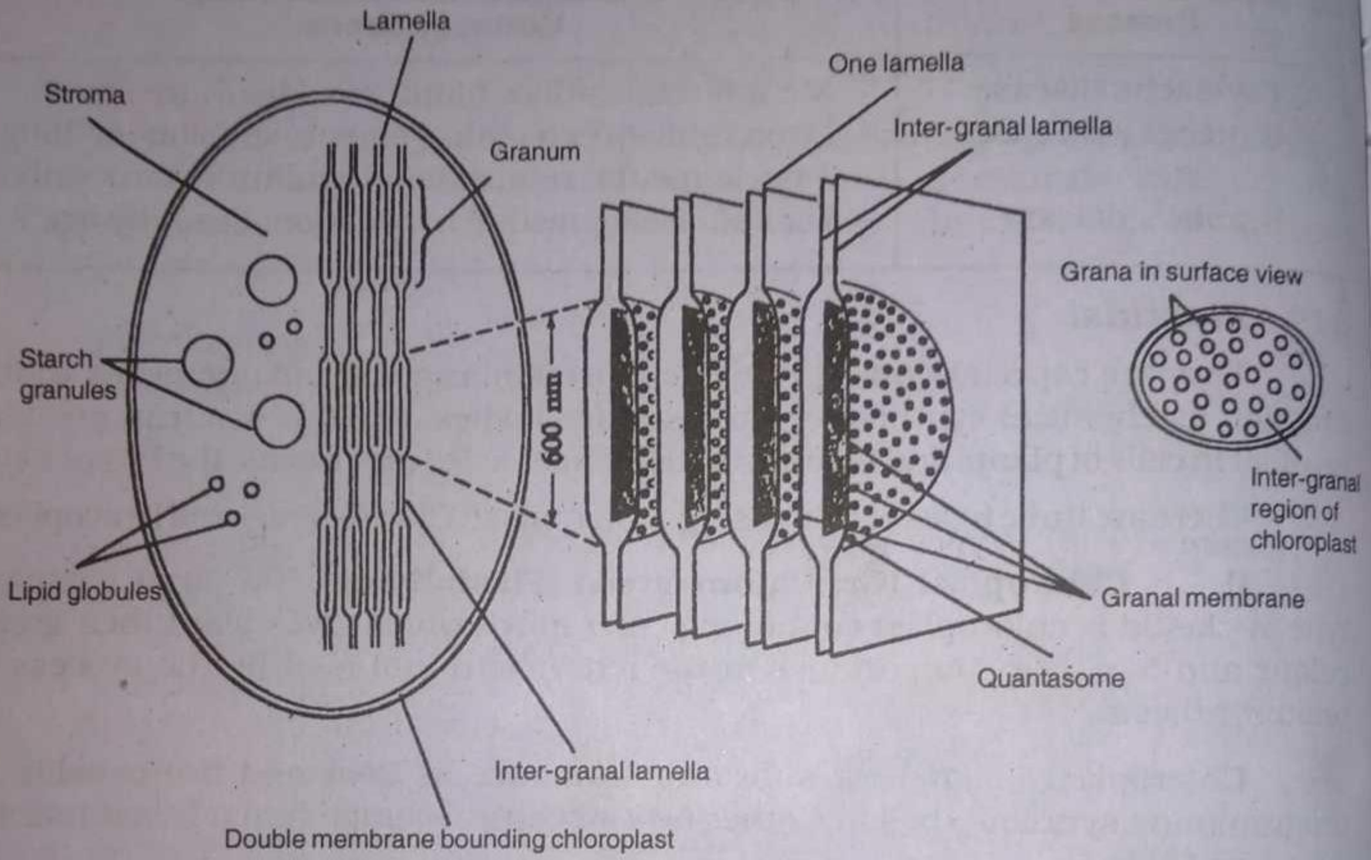


Fig. 4.13 The site of photosynthesis in a plant

During photosynthesis, chlorophyll captures the energy of sunlight and transfers it to other molecules in the thylakoid membranes. These molecules in turn transfer the energy to ATP and other energy-carrier molecules. The energy carriers diffuse into stroma, where their energy is used to derive the synthesis of sugar from carbon dioxide. Due to this movement of energy from one form to another, chloroplast is an energy converting organelle.

(vi) Peroxisome:

Peroxisome are single membrane bounded microbodies that contain enzymes for transferring hydrogen atom to oxygen, forming hydrogen peroxide (H_2O_2), a toxic molecule that is immediately broken down to water by the enzyme catalase. Peroxisome are abundant in cells that are metabolizing alcohol. Peroxisome are believed to help in detoxification of alcohol. They are found in plants and animals.

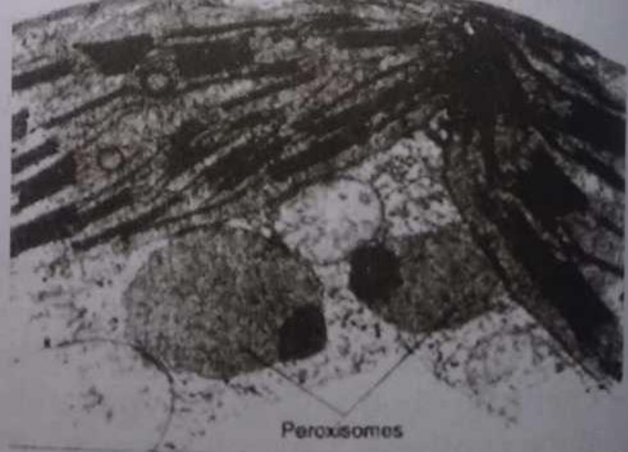


Fig. 4.14 Peroxisome in a tobacco leaf.

Peroxisomes contain enzymes that breakdown damaging compounds e.g. peroxisomes within liver and kidney cells breakdown and detoxify fully, half of the alcohol a person drink.

(vii) *Glyoxysome:*

Another type of microbodies found in plants only which are also consider as specialized peroxisomes called **glyoxysomes**. They are found in the fat storing tissues. Each glyoxysome has a single layered bounding membrane enclosing a fine granular stroma. Glyoxysome contain enzymes that initiate the conversion of fatty acid into sugar.

Cytoskeleton: The cytosol is organised into a three dimensional network of fibrous proteins called cytoskeleton. It plays fundamental roles in mitosis, meiosis, cytokinesis, cell-wall deposition, the maintenance of cell-shape and cell differentiation.

There are three types of cytoskeleton elements found in cells.

a) **Microfilaments** are solid strand of about 7 nm in diameter and several cm in length especially in muscle cells. They are consists of two actin chain that intertwine in a helical fashion, some microfilaments also contain myosin protein with actin. They perform function of muscle contraction, changes in cell shape, including division of cytoplasmic in dividing animal cells, cytoplasmic streaming movement of pseudopodia.

b) **Intermediate filaments** are solid strands of 8 to 11 nm in diameter, 10 to 100 um in length. They are intermediate in between microtubules and microfilaments. They are made up of atleast five different types of protein, form rope like polymer of fibrous protein. Unlike the other two types of cytoskeleton elements, intermediate filaments do not assemble and disassemble. Therefore, they are important in maintaining the shape of cell, attachment of muscle cells, support of nerve cell processes (axon).

c) **Microtubules** are hollow tubes with an outer diameter of 25 nm, may be more than 50 um in length. They are composed of protein, tublulin. A single micro tubule consists of hundreds of thousands of tubulin sub-units usually arranged in 13 columns called proto filaments, they are responsible for the movement of chromosomes during cell division, movement of organelles within cytoplasm, movement of cilia and flagella.

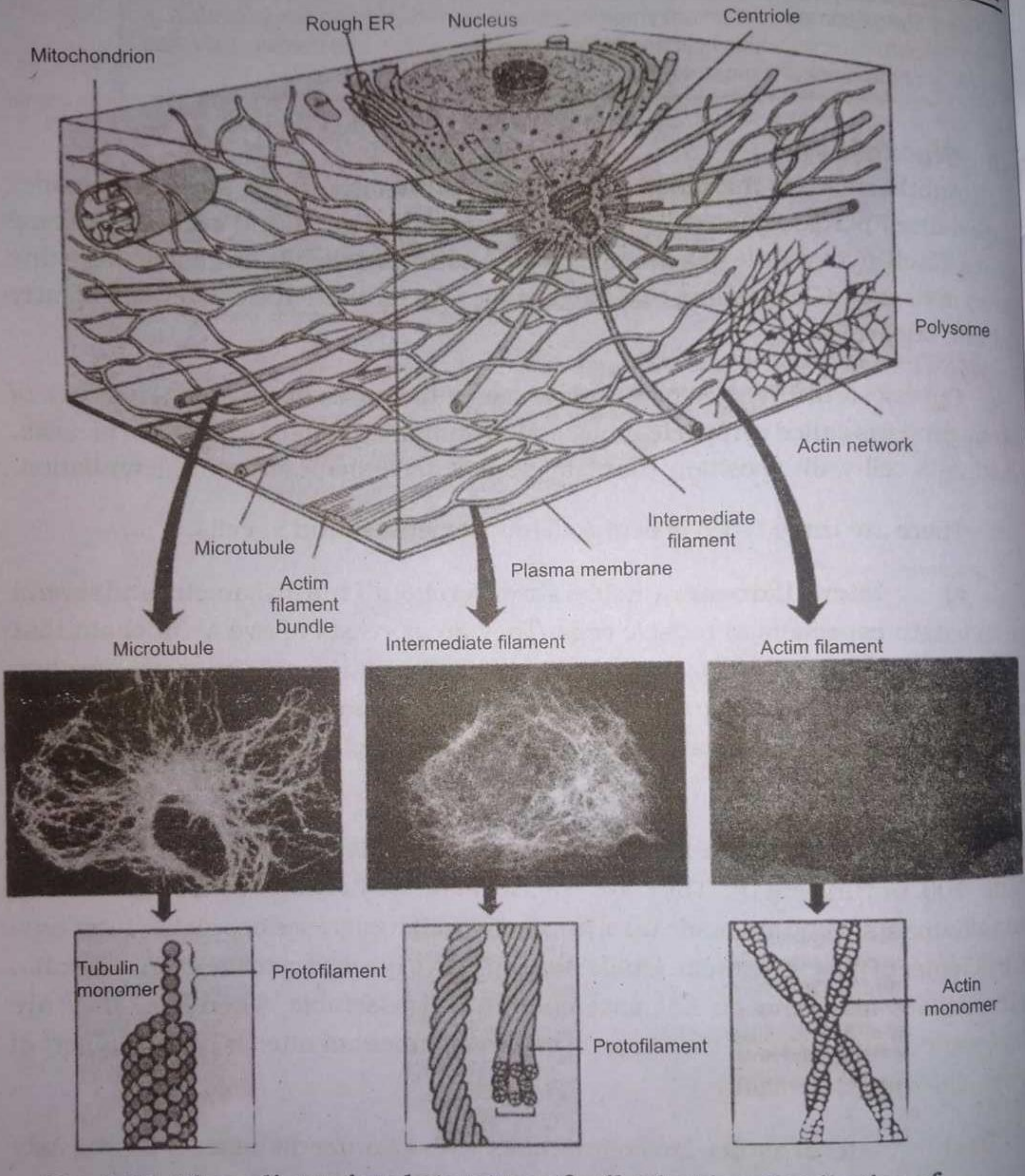


Fig. 4.15 Three dimensional structure of cell. Showing distribution of cytoskeleton and structure of micro tubules and micro filament.

(viii) Ribosomes:

These are so named because they contain high concentration of Ribonucleic acid (RNA). These small structures are sites of protein synthesis in all cell types, prokaryotic as well as eukaryotic cells. Ribosomes are found freely dispersed in the cytoplasm in prokaryotic cells. But in eukaryotic cells they are found free as well as attached to endoplasmic reticulum. They are composed of about 50 or more different kinds of proteins. There are millions of these per cell, and they are all identical. Ribosomes may be regarded as ***"Protein factories"***. Under the direction of the nucleus they produce the protein needed by the cell.

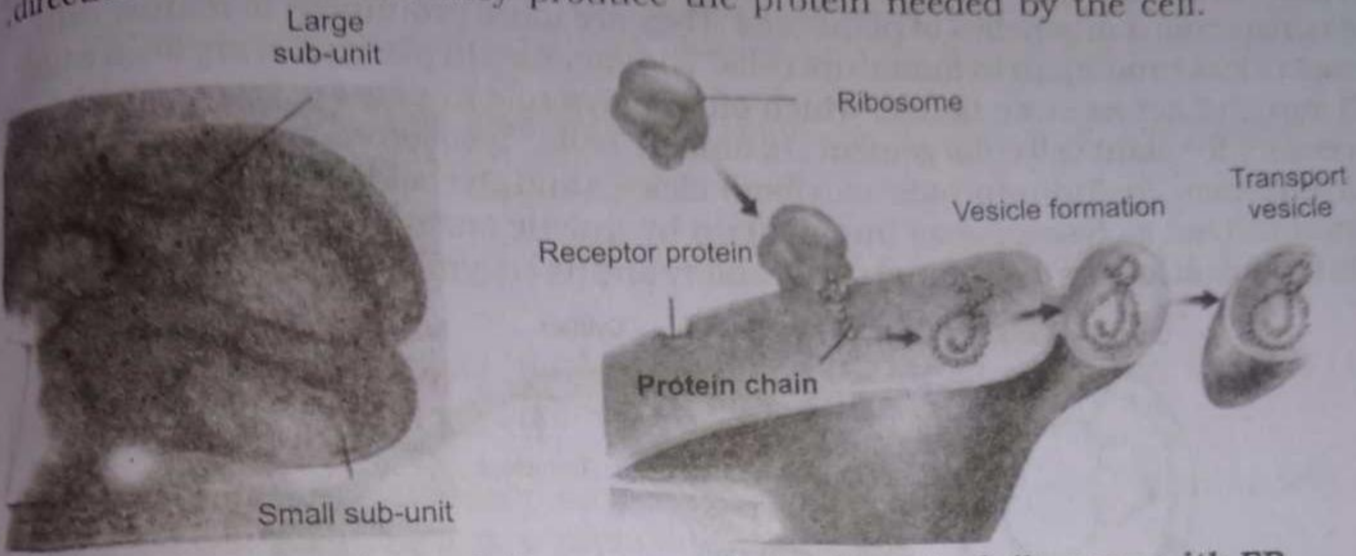


Fig. 4.16 Structure of ribosomes and attachment of ribosome with ER.

Each ribosome consists of two unequal subunits. The larger subunit is dome-shaped and smaller one forms a cap on the flat surface of larger subunit. Some ribosomes adhere themselves to endoplasmic reticulum by the larger subunits.

Although ribosomes are among the smallest organelles, they are among the most vital cellular components. Recent investigations reveal that the ribosomes are manufactured in the nucleolus from where they are transferred to the cytoplasm through nucleopores.

(ix) Centriole:

In animal cell, microtubules radiate from a microtubule organizing centre near the nucleus called **centrosome** (centro = nucleus, soma = body). Within the centrosome of an animal cell is a pair of centrioles. Centrioles are short; barrel - shaped structures of microtubules, lying perpendicular to one another. Each centriole is composed of nine sets of triplet microtubules arranged in a ring. When a cell divides, the centrioles replicate, move to opposite side of the cell and thread like fibres begin to radiate from centrioles in all directions called astral rays.

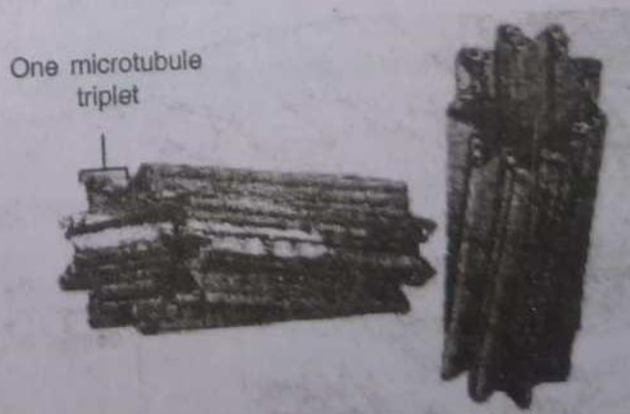


Fig. 4.17 Structure of centrosome with two cylinders of centriole.

(x) Vacuoles:

Genrally vacuoles (except food vacuole) are nonprotoplasmic liquid filled cavities in the cytoplasm and are surrounded by a membrane called the **tonoplast**. The tonoplast is selectively permeable, it allows certain substances to enter in the vacuole. In animal cells they are temporarily formed at the time of their need. These are conspicuous organelles of plant cells. They are more prominent in mature cells whereas less prominent in immature cells. The vacuoles in plant cells are filled with cell sap and act as store house, which often plays role in plant defence. which is necessary for plant cell enlargement. In animal cells, lysosomes are rich in hydro lytic enzymes, including proteases, ribonucleases and glycosidases. Plant vacuoles sometimes act as lysosome as they contain hydrolytic enzymes and after death of cells tonoplast lose its differential permeability and its enzyme causes lysis of the cell.

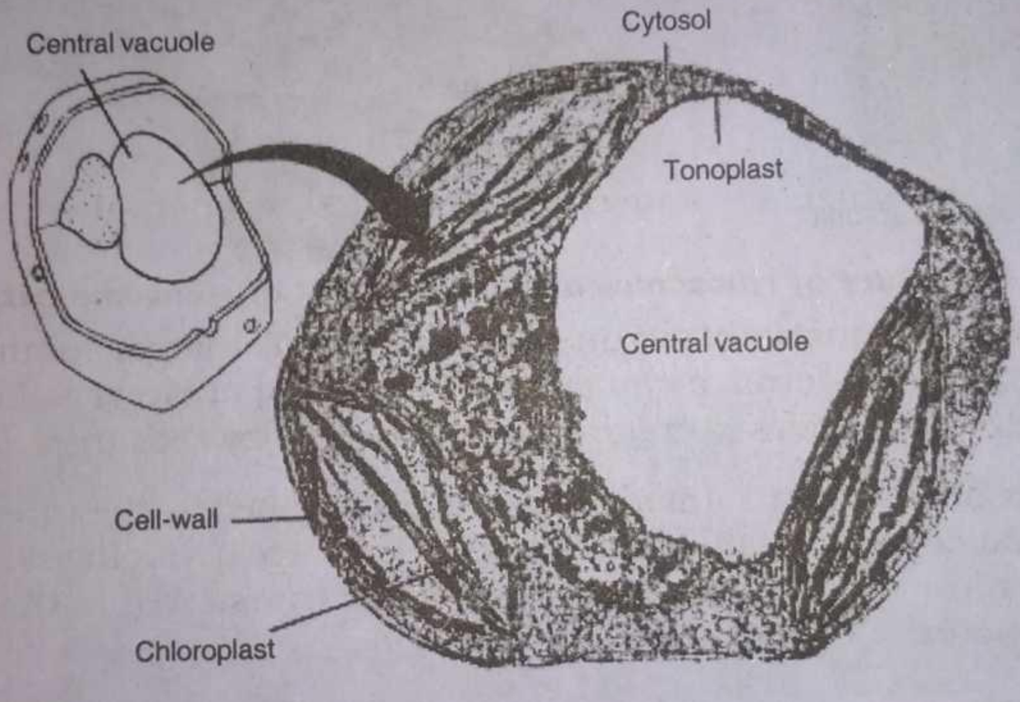


Fig. 4.18 Plant cell vacuole.

KEY POINTS

- Cell is a basic structural and functional unit of living organism consist of membrane and protoplasm.
- Microscope is an instrument to observe very small objects.
- Electron microscope use electron beam as a source of illimination to increase the resolution of object.
- Cell-fractionation is the isolation of cellular component by breaking and spinning the cell.
- There are two types of cells on the basis of the structure of their nucleus i.e. prokaryotic and eukaryotic.
- The membrane which separate cytoplasm from the external environment is called cell-membrane or plasma membrane.
- Singer and Nicholson proposed working model of plasma membrane called fluid mosaic model.
- There are two components of plasma membrane, phospholipid and proteins. Glycolipids and glycoproteins are involved in making the cell specific.
- Important functions of cell membrane are protection of protoplasm and regulation of flow of solutes and material across it, due to its selective permeability.
- Plant cell has non-living part, made of mainly cellulose called cell-wall.
- Nucleus is a central, and controlling part of the cell.
- Nucleus having thread like structure called chromosomes, their number are specific in the cells of specific species.
- Endoplasmic organelles are complex network of channels extend from plasma membrane to nuclear membrane.
- Golgi apparatus is a canalicular system with sacs, parallel arranged, flattened, membrane bound.
- Lysosome are spherical, single membrane bounded saccules, containing digestive enzymes also called 'suicide sacs'.

- Plastids are found in plant cells as chemical synthesizers and storage bodies.
- Mitochondria or chondriosomes act as the power house of cell because they are the site of Aerobic respiration specially kreb's cycle.
- Peroxisomes are microbodies that contain enzyme for transfering hydrogen atom to oxygen, forming hydrogen peroxide (H_2O_2).
- Glyoxysome another type of microbodies responsible for conversion of molecules of fatty acid into sugar.
- Network of fibrous protein give three dimensional structure to cell called cytoskeleton.
- Ribosome may be regarded as 'protein factories' made up of two unit, large and small.
- Centriole are the dark bodies appear near nucleus before cell-division in animal and low plant's cell.
- Vacuoles are non-protoplasmic liquid filled cavities surrounded by tonoplast.

EXERCISE

1. Encicrle the correct choice:

(i) A phospholipid molecule has a head and 2 tails. The tails are found:

(a) at the surface of membrane

(b) in the interior of the membrane

(c) both at the surfaces and the interior of membrane

(d) spanning of the membrane

(ii) Energy is required for:

(a) active transport (b) diffusion

(c) facillated transport (d) all of these

(iii) Which of these best distinguishes a prokaryotic cell from a eukaryotic cell?

(a) prokaryotic cells have a cell-wall but eukaryotic cells do not.

(b) prokaryotic cells are larger than eukaryotes.

(c) prokaryotic cells have flagella but eukaryotes do not.

(d) prokaryotic cells do not have a membrane-bounded nucleus but eukaryotic cells do have such a nucleus.

(iv) Lysosomes function in:

(a) protein synthesis (b) processing and packaging

(c) intracellular digestion (d) lipid synthesis

(v) Which organelle releases oxygen:

(a) ribosome (b) golgi apparatus

(c) mitochondria (d) chloroplasts

(vi) The protein presents in microtubules

(a) actin (b) tubulin

(c) keratin (d) myosin

(vii) Characteristics associated with peroxisome only:

(a) membrane bound cell organelles

(b) having single membrane

(c) found only in eukaryotic cells

(d) contain enzymes for transferring H atoms to oxygen form H_2O_2.

(viii) Lysosomal storage disease resulting in blindness

(a) Tay-sachs (b) Gaucher's

(c) Krabbe's (d) none of them

(ix) Cormosomes with equal arms are

(a) metacentric (b) sub-metacentric

(c) acrocentric (d) telocentric

(x) Endocytosis which involve ingestion of solid material is called

(a) pinocytosis (b) phagocytosis

(c) solidocytosis (d) exocytosis

2. Write detailed answers of the following questions:

(i) What is the composition of plasma membrane? What types of protein are present on it?

(ii) What is endoplasmic reticulum? What is its function? How does rough ER differ from smooth ER?

(iii) What is the function of nucleolus? Where it is located? Is it a permanent structure?

(iv) Which of the two organelles are involved in cellular energetics? Which of them are found in plants in animals?

(v) What is cytoskeleton? Describe the types and function of cytoskeleton.

3. Write short answers of the following questions:

(i) What is function of nucleolus? Where is it located? Is it a permanent structure?

(ii) Which organelle is considered the substitute of lysosome in plant cells? Why?

(iii) Why ribosomes are called protein factories and lysosome are suicide sacs?

(iv) What type of cells contain more Golgi bodies and why?

(v) What are the three principles of cell theory?

4. Distinguish between the following:

(i) Cell-wall and cell-membrane.

(ii) Osmosis and diffusion.

(iii) Mitochondria and plastids.

(iv) Prokaryotic and eukaryotic cell.

(v) Animal and plant cell.

(vi) Lysosome and vacuole.

5. Define the following terms:

(i)	Cell	(ii)	Protoplasm	(iii)	Cell-wall
(iv)	Endoplasmic reticulum	(v)	Golgi bodies	(vi)	Lysosome
(vii)	Mitochondria	(viii)	Plastids	(ix)	Vacuole
(x)	Peroxisome	(xi)	Glyoxysome	(xii)	Centrosome
(xiii)	Chromosome	(xiv)	Nucleus		