

Structure and function of Cell

- The cell is the basic unit of life. All organisms are made up of cells (or in some cases, a single cell) and depend on cells to function normally.
- There are two major classifications of cells: the prokaryotes and eukaryotes.
- The prokaryotes (Greek “**pro**” -primitive; “**karyon**” – nucleus) lack a nucleus. e.g. bacteria.
- Eukaryotic cells (Greek “**eu**” -good; “**karyon**” - nucleus) have a membrane enclosed nucleus encapsulating their DNA. e. g. Cells of animals, plants and fungi

a.Prokaryotes

- They lack a membrane-bound nucleus
e.g. bacteria.
- Prokaryotes are almost always single-celled, except when they exist in colonies
- Reproduce by means of binary fission
- Cells carry out metabolic reactions.

b. Eukaryotes

Eukaryotic cells range in size from 1 to 100 micrometers in diameter and have volume a thousand to a million times that of a typical prokaryotic cell.

Cells are covered by a cell membrane and come in many different shapes.

The contents of a cell are called the protoplasm.

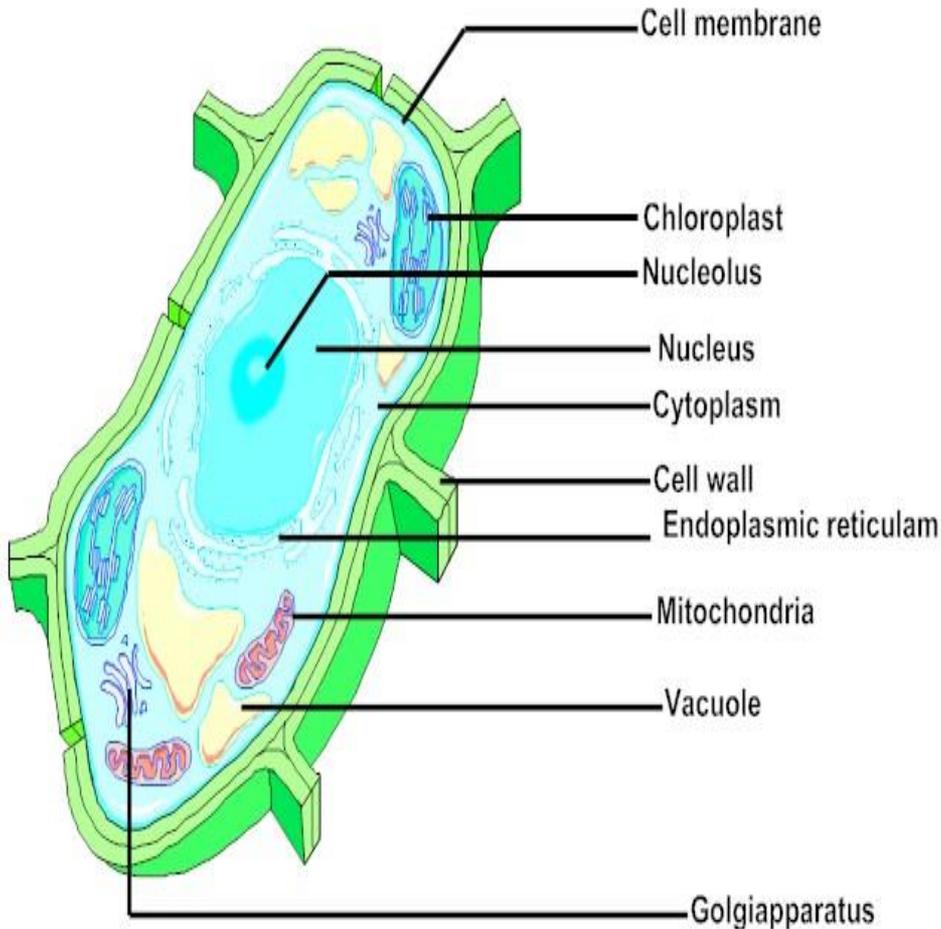
i. Protoplasm

- It is differentiated into plasma membrane (=plasmalemma or cell membrane), cytoplasm, nucleus and vacuoles.
- Cytoplasm is distinguishable into cytoplasmic matrix and endoplasmic reticulum.
- Cytoplasmic matrix is also called hyaloplasm. It is a polyphasic colloidal system which exists in two states, sol and gel.
- The gel form usually occurs near the plasma membrane.
- This region is sometimes called ectoplast in contrast to sol region known as endoplast.
- Ectoplast is firmer. It is quite conspicuous on the free sides of the cells. In protozoans, ectoplast is prominent on all sides. Cytoplasmic matrix is generally in perpetual motion.
- The phenomenon is called cyclosis, cytoplasmic or protoplasmic streaming. In the cytoplasmic matrix are embedded a large number of cell organelles or organised protoplasmic subunits having specific functions.

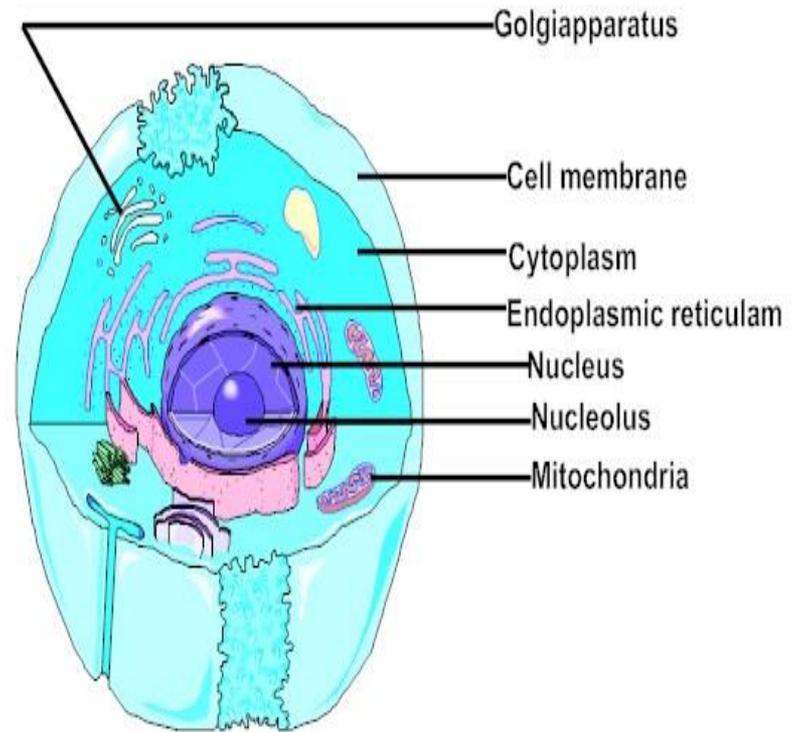
li Organelle

- An **organelle** is a specialized subunit within a cell that has a specific function, and is usually separately enclosed within its own membrane.
- Organelles are identified by microscopy, and can also be purified by cell fractionation.
- Eukaryotic cells contain several types of organelles, while prokaryotic cells contain a few organelles (ribosomes) and none that are bound by a membrane.
- There are also differences between the kinds of organelles found within different eukaryotic cell types.
- Plant cells for example, contain structures such as a cell wall and chloroplasts that are not found in animal cells.
- The parts of a plant cell and an animal cell, important organelles and their functions are described herewith.

Parts of a Plant and an animal cell



Plant Cell



Animal Cell

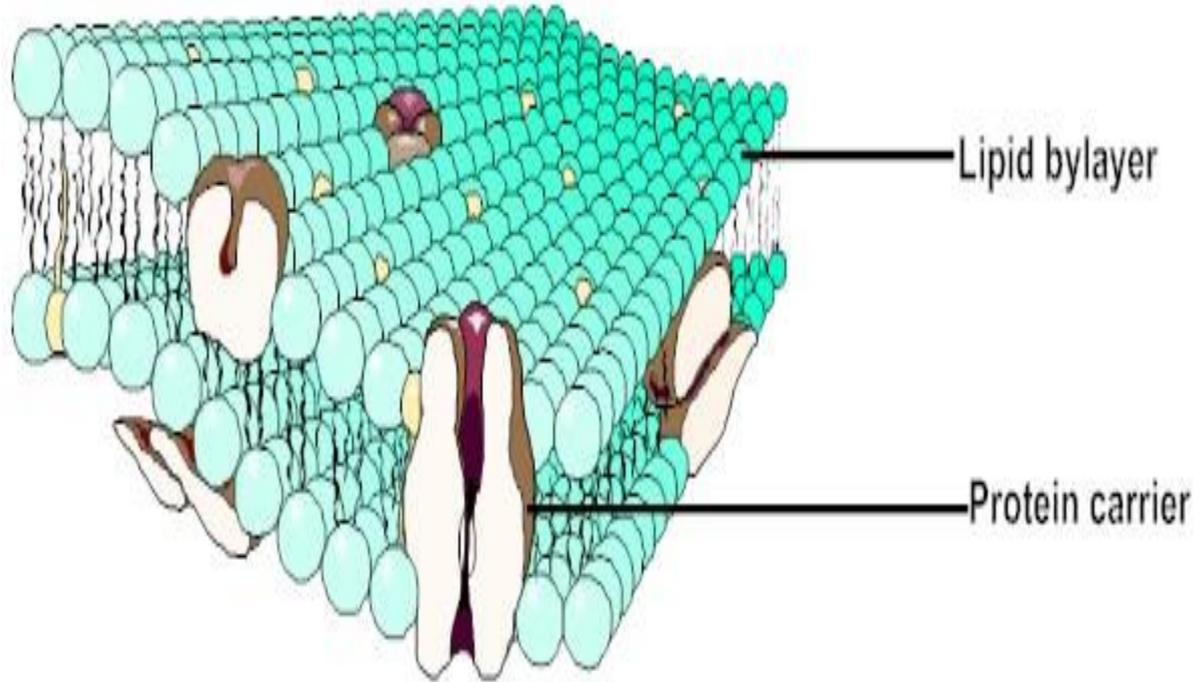
3. 1. Cell membrane

- The **cell membrane** is a biological membrane that separates the interior of all cells from the outside environment.
- The cell membrane is semi-permeable to ions and organic molecules and controls the movement of substances in and out of cells.
- It consists of the phospholipid bilayer with embedded proteins, which are involved in a variety of cellular processes such as cell signalling, cell adhesion and ion conductivity.
- According to Selby (1959) plasma membrane often exhibits certain specialized structures. e.g. microvilli, plasmodesmata, caveolae, desmosomes etc.

- The plasma membrane also serves as the attachment surface for the extracellular glycocalyx and cell wall of plant cell and intracellular cytoskeleton.
- The tripartite structure of plasma membrane was proposed by Darson, Danielli and Picken (1960).
- The fluid mosaic model of plasma membrane was proposed by Singer and Nicolson (1972).
- According to this model, the membrane consists of a double layer of amphipathic lipids which form a liquid lipid matrix with globular integral proteins dispersed in it.
- The proteins and components of the membrane are not fixed but may float in and on the phospholipids, thus creating a mosaic of substances there.

- In the bilayer, the lipid molecules are arranged in such a way that their hydrophilic tails point towards each other.
- Both the surfaces of the bilayer are composed of hydrophilic heads.
- The globular integral proteins are also amphipathic molecules.
- Their hydrophobic ends protrude into the aqueous phase on either side of the bilayer and their hydrophobic ends remain embedded in the non-polar regions.
- Of the lipid bilayer, phospholipids bilayer with rapid lateral motion of its component molecules (but only occasional 'flip-flop' from one layer to another); rather less mobility of some of the intrinsic proteins (usually either confined to one layer or permeating both).

Structure of Cell membrane



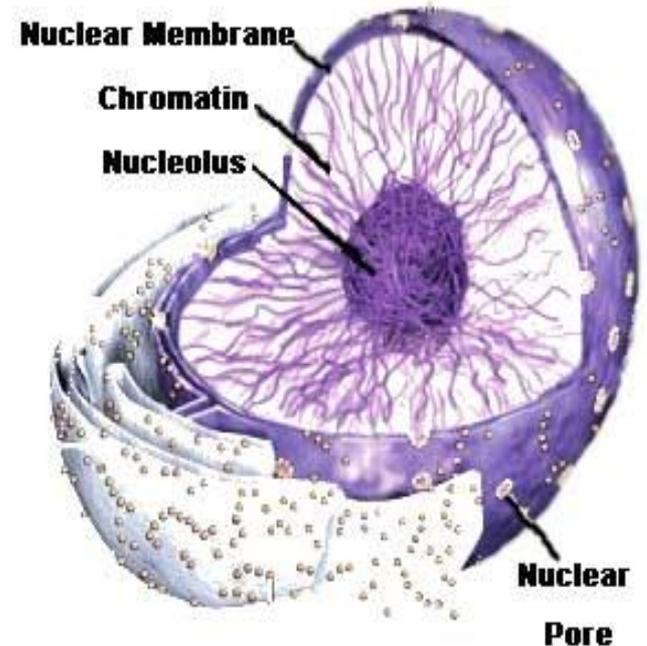
3. 2. Cytoplasm

- The **cytoplasm** is the part of a cell that is enclosed within the cell membrane. In the cells of **prokaryote** organisms, which lack a nucleus, the contents of are contained within the cytoplasm.
- In the cells of **eukaryote** organisms the contents of the cell nucleus are separated from the cytoplasm, and are there called the nucleoplasm.
- The cytoplasm contains **organelles**, which are filled with liquid that is kept separate from the rest of the cytoplasm by biological membranes.
- It is within the cytoplasm that most cellular activities occur, such as the matrix is the seat of synthesis of a number of biomolecules like fat, nucleotides, some carbohydrates, proteins, enzymes etc., many metabolic pathways including glycolysis, anaerobic respiration, pentose pathway and processes such as cell division.

- The inner, granular mass is called the endoplasm and the outer, clear and glassy layer is called the ectoplasm.
- The part of the cytoplasm that is not held within organelles is called the **cytosol**.
- The cytosol is a complex mixture of cytoskeleton filaments, dissolved molecules, and water that fills much of the volume of a cell.
- It helps in the distribution of various materials inside the cell.
- The cell organelles exchange materials through cytoplasmic matrix.

3. 3. Nucleus

- A membrane-enclosed organelle found in eukaryotic cells.
- Contains most of the cell's genetic material, organized as multiple long linear DNA molecules in complex.
- Contains a large variety of proteins, such as histones, to form chromosomes.
- DNA directs the protein biosynthesis inside the cell.



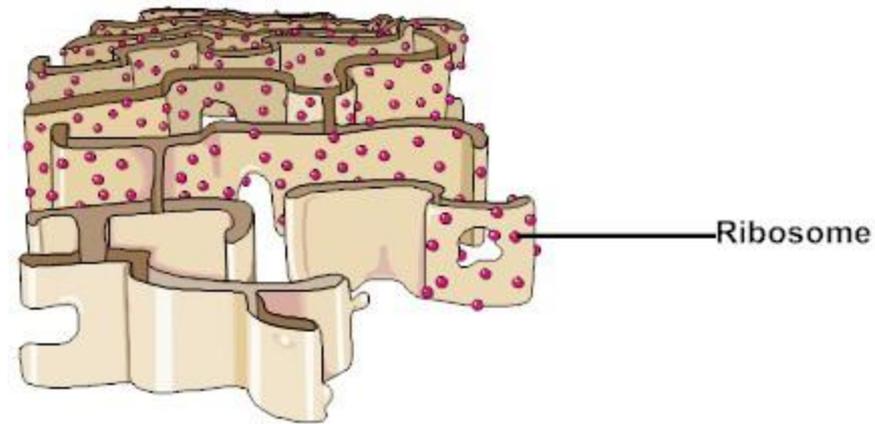
Structure of nucleus

- The main structures making up the nucleus are the Nuclear membrane, a double membrane that encloses the entire organelle.
- It is made up of two lipoprotein and trilaminar membranes concentrically arranged, each of which is 60-90Å thick.
- The inner membrane is smooth whereas the outer membrane may be smooth or its cytoplasmic surface may bear ribosomes.
- The two membranes are separated by an electron transparent perinuclear space 100-700Å in width.
- The outer membrane is often connected to endoplasmic reticulum.

- **Nuclear pores:** Many nuclear pores are inserted in the nuclear membrane, which facilitate and regulate the exchange of materials (proteins, tRNA, mRNA and rRNA) between the nucleus and the cytoplasm.
- **Chromatin:** Nucleus is an integral part of eukaryotic cells as it contains hereditary material called chromatin. It is the combination of DNA and proteins. It is found inside the nuclei of eukaryotic cells. It possesses all the genetic information that is required for growth and development of the organism, its reproduction, metabolism and behaviour.
- **Nucleolus:** Nucleolus is an organelle within the nucleus from where ribosomal RNA is produced. Some cells have more than one nucleus. It was first discovered by Fontana in 1781.

3. 4. Endoplasmic reticulum (ER)

- A vast system of interconnected, membranous, infolded and convoluted sacks
- Located in the cell's cytoplasm (the ER is continuous with the outer nuclear membrane).



Endoplasmic reticulum

- **Two types**
- Rough endoplasmic reticulum
- Smooth endoplasmic reticulum

i) Rough endoplasmic reticulum (rough ER)

- Covered with ribosomes -give it a rough appearance.
- Bears the ribosomes during protein synthesis.
- Newly synthesized proteins are sequestered in sacs, called cisternae.
- Sends the proteins via small vesicles to the golgi apparatus.
- Membrane proteins are inserted into the membrane

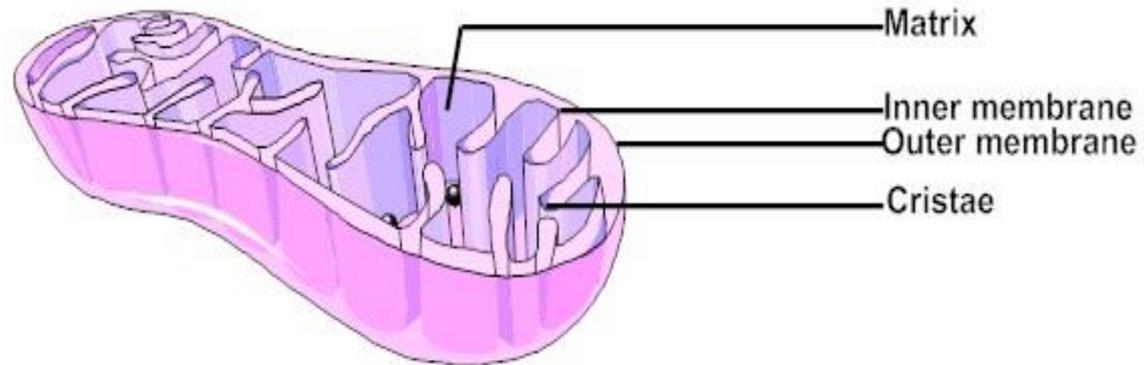
ii) Smooth endoplasmic reticulum (smooth ER)

- Buds off from rough ER. Space within the ER is called the ER lumen.
- Transports the proteins manufactured by the rough ER to other locations in the cell or outside the cell.
- Budding is the process, by which the small vesicles, which contain proteins -detached from the smooth ER - carried to other locations.
- Aids in converting glucose-6-phosphate to glucose- an important step in gluconeogenesis.

3.5. Mitochondrion

- It is spherical to rod-shaped organelle with a double membrane.
- The inner membrane is infolded many times, forming a series of projections (called cristae). The space between the two membranes is called “outer chamber” or “inter membrane space”.
- It is filled, with a watery fluid and is 40-70Å in width. The space bounded by inner membrane is called the “inner chamber” or “inner membrane space”.
- The inner membrane space is filled with a matrix.
- It is rich in enzymes and contains dense granules, ribosomes, and mitochondrial DNA.
- The granule consists of insoluble inorganic salts and are believed to be the binding sites of bivalent ions like Mg^{2+} and Ca^{2+} .
- The side of the inner membrane facing the matrix side is called M-side, while the side facing the outer chamber is called C-side

Structure of Mitochondrion



Mitochondria

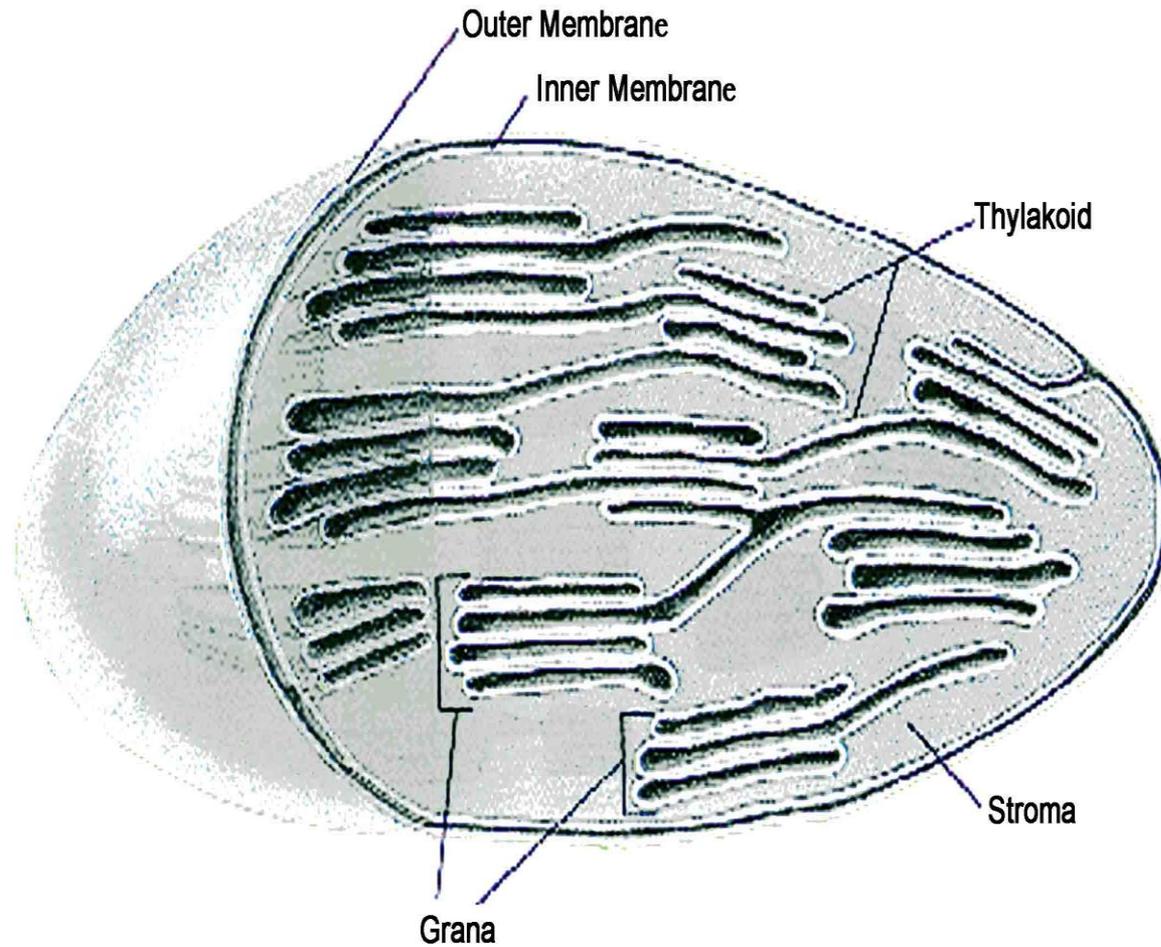
- Two to six circular DNA molecules have been identified within mitochondria.
- They may be present free in the matrix or may be attached to the membrane.
- The enzymes of the Krebs cycle are located in the matrix. In general the outer membrane contains more proteins and phospholipids than the inner membrane.
- Phosphatidylcholine is the predominant lipid of the outer membrane.
- The inner membrane on the other hand contains most of the diphosphatidylglycerol. On the inner layer of cristae are found stalked particles or repeating tripartite units which are sometimes called respiratory assemblies.
- Each stalked particle or repeating tripartite unit which is sometimes consists of a base, a stalk and a spherical head.
- The spherical soluble coupling particle called F₁ particle which is actually the enzyme ATPase, oxidative phosphorylation takes place on stalked particles.
- Mitochondria convert the energy stored in glucose into ATP (adenosine triphosphate) for the cell and hence are the **power house** of the cell.
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3. 6. Chloroplasts

- **Chloroplasts** are the green plastids. They are organelles found in plant cells and other eukaryotic organisms that conduct photosynthesis.
- They are usually disk-shaped and about 5-8 μm in diameter and 2-4 μm thick.
- A typical plant cell has 20-40 of them. Chloroplasts are green because they contain **chlorophylls**, the pigments that harvest the light used in photosynthesis.
- They capture light energy to conserve free energy in the form of ATP and reduce NADP to NADPH through a complex set of processes called **photosynthesis**.

- The dark reaction of photosynthesis takes place in stroma.
- The material within the chloroplast is called the **stroma**. Within the stroma are stacks of **thylakoids**, the sub-organelles, which are the site of photosynthesis.
- The thylakoids are arranged in stacks called **grana**.
- A thylakoid has a flattened disk shape. Inside it is an empty area called the thylakoid space or lumen.
- Photosynthesis takes place on the thylakoid membrane.

Structure of chloroplast



7. Cell Wall

- The cell wall gives a definite shape and provides protection to the protoplasm. It is non-living in nature and is permeable.
- Adjacent cells in the plant body remain interconnected by plasmaodesmata.
- The **cell wall** of plants is made of fibrils of **cellulose** embedded in a matrix of several other kinds of polymers such as **pectin** and **lignin** which provide mechanical strength to the cell.
- Cell wall consists of 3 parts:
 - i) Middle lamella-made of pectic acid in the form of Ca and Mg salts.
 - ii) Primary wall-made of cellulose
 - iii) Secondary wall-pronounced in dead cells, viz tracheids and sclerenchyma

3.8 Other organelles

i. Ribosome

- Ribosome- a small organelle composed of RNA-rich cytoplasmic granules that are sites of protein synthesis.
- Has a large and a small subunit.
- Each subunit contains about 65% RNA and 35% protein.

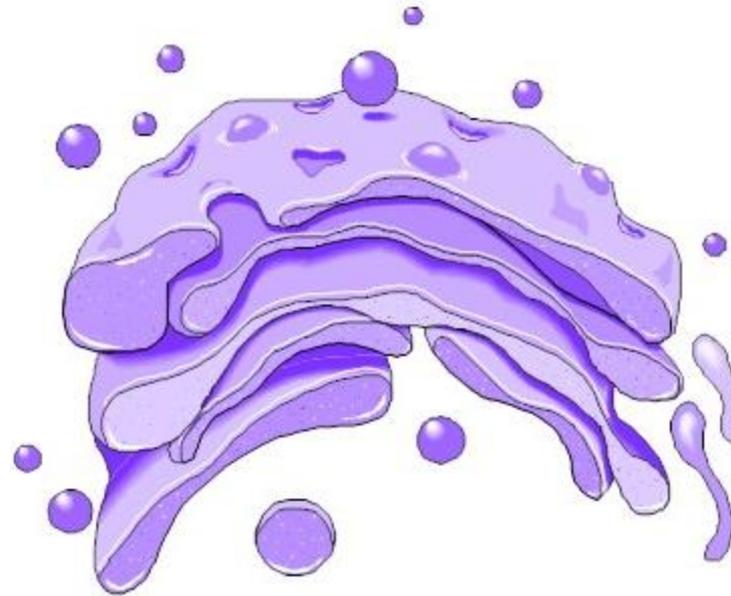
ii. Lysosome

- Round organelle surrounded by a membrane and containing digestive enzymes.
- Needed in the digestion of materials brought into cell by phagocytosis or pinocytosis.
- Digest cell components after cell death.

iii. The Golgi apparatus

- The Golgi apparatus consists of flattened, single membrane vesicles.
- Some become vacuoles in which secretory products are concentrated.
- The primary function of the Golgi apparatus is to process and package macromolecules, such as proteins and lipids, after their synthesis and before they make their way to their destination.
- It is important in the processing of proteins for secretion.
- It has a system of outer flattened cisternae which appear as roughly parallel membranes enclosing a space 60-90Å with a distance of about 200Å between them.

Structure of Golgi apparatus



iv. Vacuole

- A membrane bound organelle which is present in all plant and fungal cells and some animal and bacterial cells.
- Essentially enclosed compartments which are filled with water containing inorganic and organic molecules - enzymes in solution- may contain solids which have been engulfed.
- Formed by the fusion of multiple membrane vesicles and are effectively just larger forms of these.
- **Functions:** Isolates materials that might be harmful or a threat to the cell,
- Contains waste products
- Exporting unwanted substances from the cell,
- Maintains internal hydrostatic pressure or turgor within the cell
- Maintains internal pH