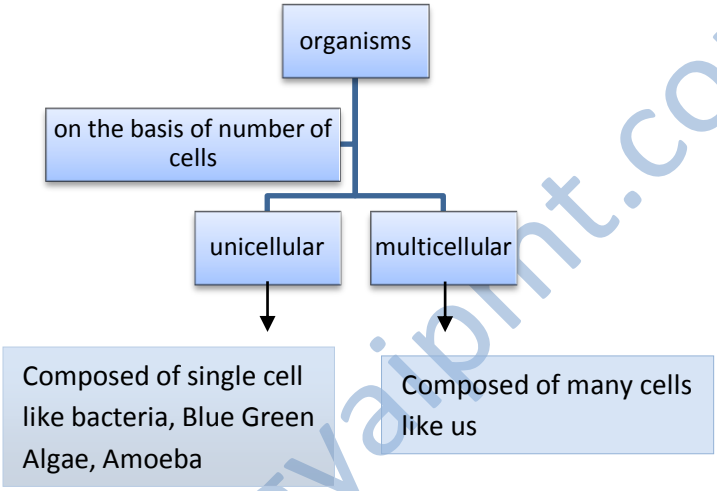
CELL: THE UNIT OF LIFE

- Cell → Basic unit of life.
  Fundamental structural and functional unit of all living organisms.
- Cytology – study of cell and cellular structures.
- Types of organisms –



- All unicellular organisms are capable of
  - Independent existence.
  - Performing the essential functions of life.

  Anything less than a complete structure of a cell does not ensure independent living. Hence, cell is the fundamental structural and functional unit of all living organisms.
- Some important scientists –

Name of scientist	**Their work**
Robert hooke	Discovered cell
Anton von Leeuwenhoek	first saw and described a live cell
Robert Brown	Discovered nucleus
Schleiden (German botanist), Schwann (British Zoologist)	Formulated Cell Theory

  - Robert hooke first time describe about cell in his book 'Micrographia'. He actually saw cell wall of dead cells not cell itself.
- **CELL THEORY**
  - Formulated by Schleiden and Schwann.
  - Modified by Rudolf Virchow – he explained that new cells develop from pre existing cells by cell division (*Omnis cellula-e cellula*).
  - Exception of cell theory - virus, viriods,

  i) All living organisms are composed of cells and products of cells.
  ii) Cell is structural unit of life.
  iii) All cells arise from pre-existing cells.

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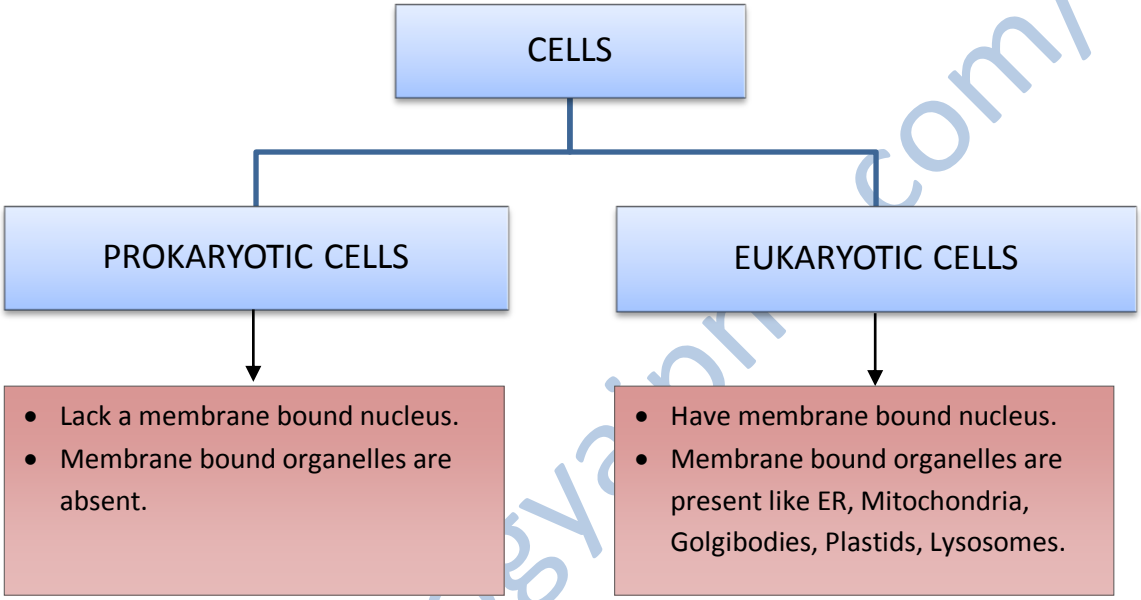
➢ CELL SIZE AND SHAPE

- Smallest cell – mycoplasmas (PPLO – Pleuro Pneumonia Like Organisms)
- Largest cell – egg of an ostrich.
- Smallest cell in human body – Red Blood Cell.
- Largest cell in human body – Ovum.
- Longest cell in human body – Nerve Cell.

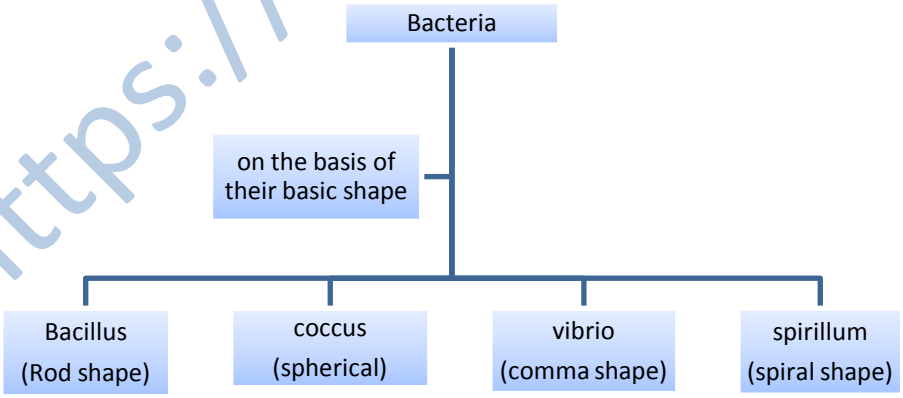
Even shape of cells may vary with the functions they perform.

➢ TYPES OF CELLS



PROKARYOTIC CELL

➢ Represented by Blue Green Algae, mycoplasmas, bacteria etc.



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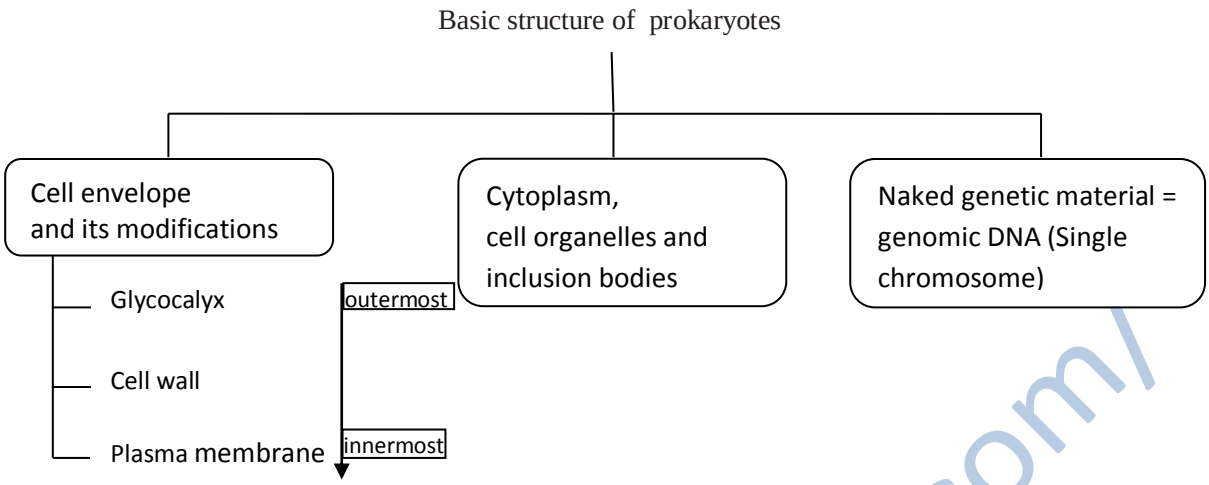
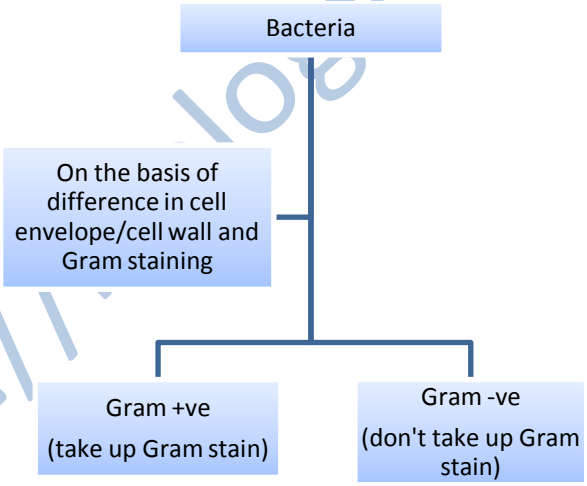


- Glycocalyx
  - If loose sheath → Slime layer
  - If thick and tough → Capsule

- Cell wall
  - Determine shape of cell.
  - Provide strong, structural support
  - Prevent bacteria from bursting or collapsing



- Plasma membrane
  - Semipermeable
  - Structurally similar to that of eukaryotes.

- Mesosomes
  - Formed by extension of plasma membrane into cell.
  - In the form of vesicles, tubules and lamella.
  - Help in cell wall formation, DNA replication and distribution to daughter cells.
  - Also help in respiration, secretion processes, to increase the surface area of the plasma membrane and enzymatic content.

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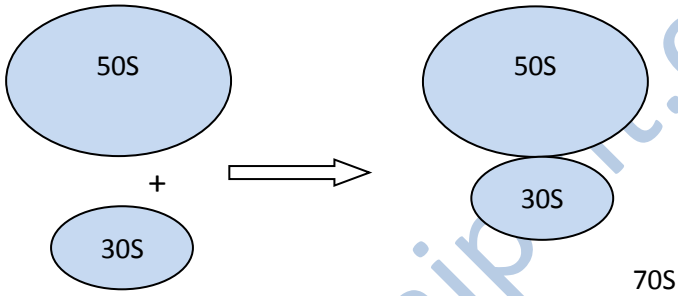
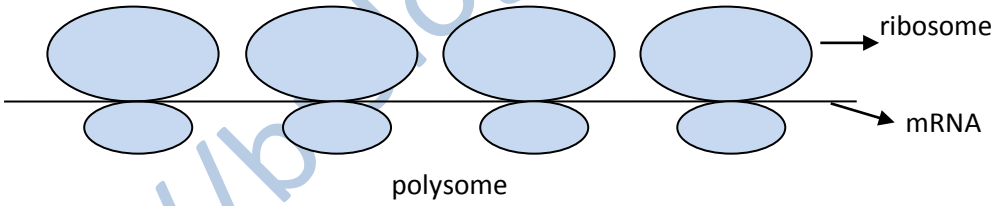
- Chromatophores
  - Membranous extensions into cytoplasm.
  - Contain pigments.
  - In cyanobacteria.
- Flagella
  - Present in motile cells.
  - Thin filamentous extensions from their cell wall.
  - Composed of three parts – **filament, hook** and **basal body**.
- Pili and Fimbriae
  - **Pili** are elongated tubular structure while **fimbriae** are small bristle like fibres.
  - Help in attachment of bacteria.
- Ribosomes
  - Associated with the plasma membrane of the cell.
  - Made of two subunits - 50S and 30S units which when present together form 70S.



  - Site of protein synthesis.
  - Ribosome of a polysome translate the mRNA into protein.



- Inclusion bodies
  - For storage of reserve material in prokaryotic cells.
  - These are not bounded by any membrane system and lie free in the cytoplasm.
  - e.g., phosphate granules, cyanophycean granules and glycogen granules.
  - Gas vacuoles are found in blue green and purple and green photosynthetic bacteria.

EUKARYOTIC CELLS

- Include all the protists, plants, animals and fungi.
- Extensive compartmentalisation of cytoplasm through the presence of membrane bound organelles present.
- possess an organised nucleus with a nuclear envelope.
- genetic material is organised into chromosomes.

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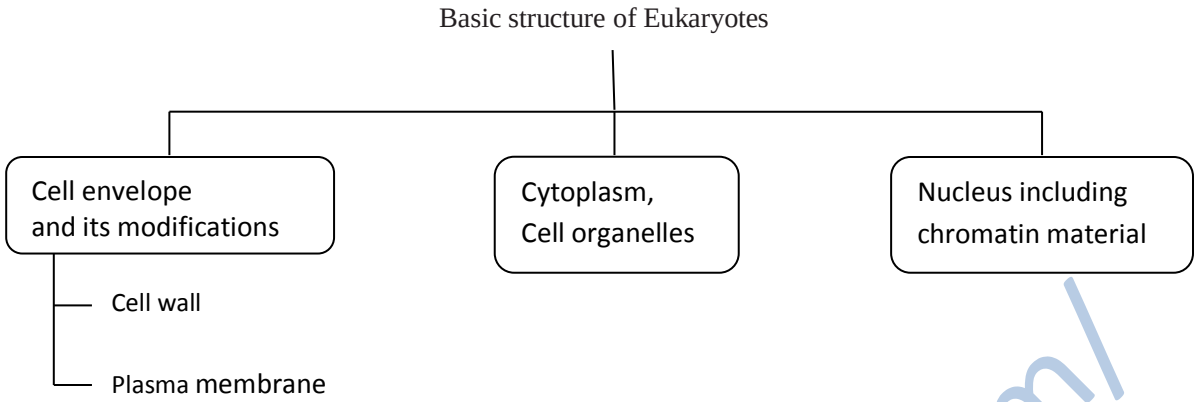
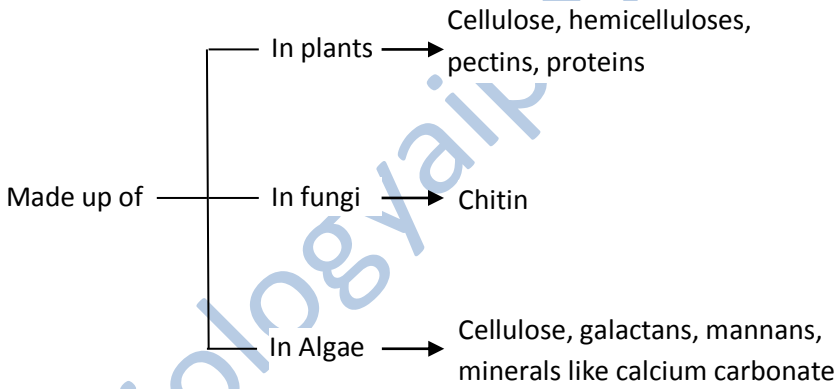


➢ Cell wall

- non-living, rigid structure
- forms an outer covering for the plasma membrane of fungi and plants.
- gives shape to the cell and protects the cell from mechanical damage and infection.
- it also helps in cell-to-cell interaction and provides barrier to undesirable macromolecules.



- Layers of cell wall
  a. Middle lamella
     - Outermost
     - Made up of mainly calcium pectate.
     - Holds or glues the different neighbouring cell together.
  b. Primary wall
     - Capable of growth.
     - Present in young cell.
     - Gradually diminishes as cell matures.
     - Madeup of cellulose, hemicelluloses.
     - Present in meristem, pith, cortex etc.
  c. Secondary wall
     - Innermost layer.
     - Hard.
     - Lignified (in sclerenchyma, vesels, tracheids), suberinised (casparian strips, endodermis)
     - Suberin, lignin make cell wall impermeable.
     - Present in sclerenchyma, collenchyma, and vessels, tracheids.
- Cell wall and middle lamella maybe traversed by plasmodesmata which connects the cytoplasm of neighbouring cells.

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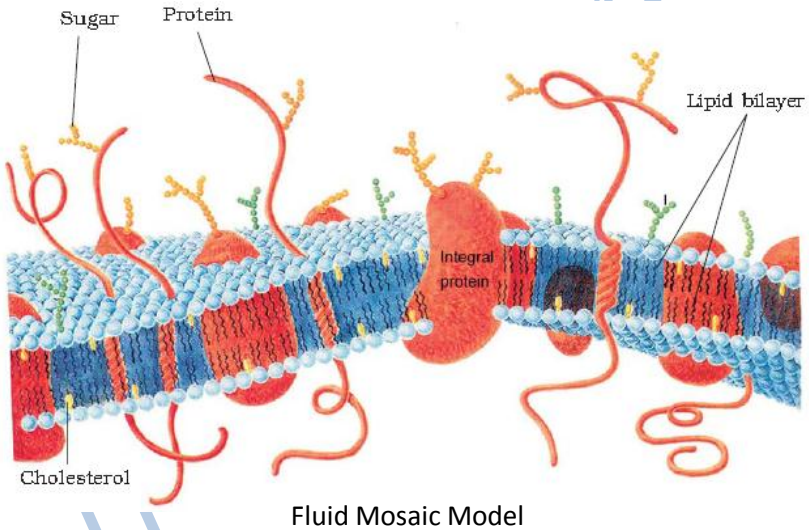
- Cell membrane
  - Mainly composed of bilayer phospholipids, also possess protein and carbohydrate.
  - lipids are arranged within the membrane with the polar head (hydrophilic) towards the outer sides and the nonpolar tails (hydrophobic) towards the inner part. This ensures that the nonpolar tail of saturated hydrocarbons is protected from the aqueous environment.
  - The ratio of protein and lipid varies in different cell types. (In human RBC membrane has 52% protein and 40% lipids.)
  - Proteins
    - Peripheral → Lie on the surface of membrane
    - Integral → Partially or totally buried in membrane
  - Structure of cell membrane is explained by **Fluid Mosaic Model** which was given by **Singer and Nicolsan**.
  - According to this model the quasi-fluid nature of lipid enables lateral movement of proteins within the overall bilayer.
  - The fluid nature of the membrane is important for functions like cell growth, formation of intercellular junctions, secretion, endocytosis, cell division etc.



Fluid Mosaic Model

- Transport across cell membrane

Passive transport	Active transport
• Energy is not utilised. (energy independent)	• Energy/ATP is utilised. (energy dependent)
• Movement of substances according to concentration gradient (from low conc. to high conc.)	• Movement of substances against the concentration gradient (from low conc. to high conc.)

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- Passive transport
  - Simple diffusion → Movement of neutral solute
  - Facilitate diffusion → Movement of polar molecule with the help of carrier protein
  - osmosis → Movement of water/solvent

- Cell organelles
  - Membrane bound
    - Single membrane → Endoplasmic Reticulum, Golgi bodies, Lysosome,Vacuoles, Cilia, Flagella, Microbodies.
    - Double membrane → Mitochondria, plastids, nucleus
  - Non-membrane bound → Ribosome, Centrioles

- Mitochondria
  - Double membrane bound cell organelle.
    - Outer membrane → Forms continuous limiting boundary of the
    - Inner membrane → Forms a number of infoldings called Cristae

  Divide mitochondrial lumen into 2 aqueous compartments.
    - Outer compartment → Peri Mitochondrial Space/ Inter membranous space
    - Inner compartment → Matrix

  - Mitochondria are site of aerobic respiration. They produce ATP, hence called 'Power House of Cell'.
  - The matrix also possesses single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins. So, mitochondria also known as 'semi autonomous organelle'.
  - The mitochondria divide by fission and produce new mitochondria.

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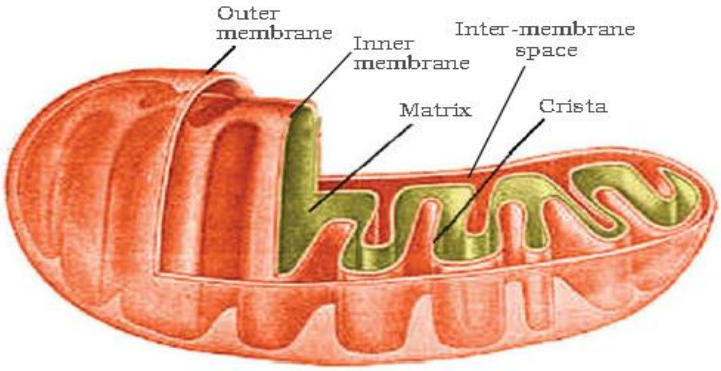
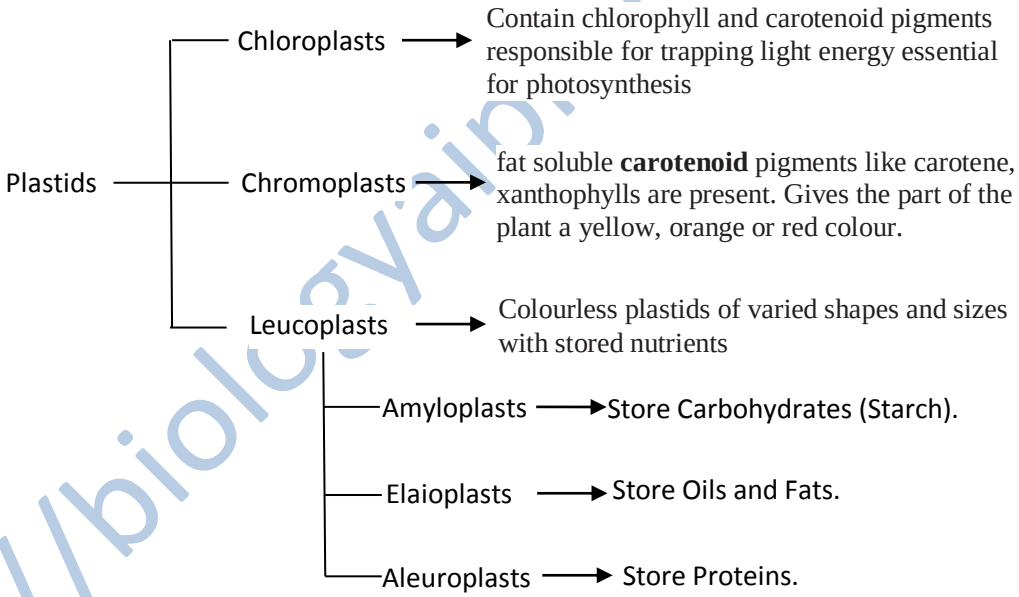


➢ Plastids

- Found in all plant cells and in euglenoides.
- They bear some specific pigments, thus imparting specific colours to the plants.



- Chloroplasts are mainly found in the mesophyll cells of the leaves.
- These are various shaped like lens, oval, spherical, discoid, ribbon.
- Double membrane bound Cell organelle. Inner is less permeable than outer.
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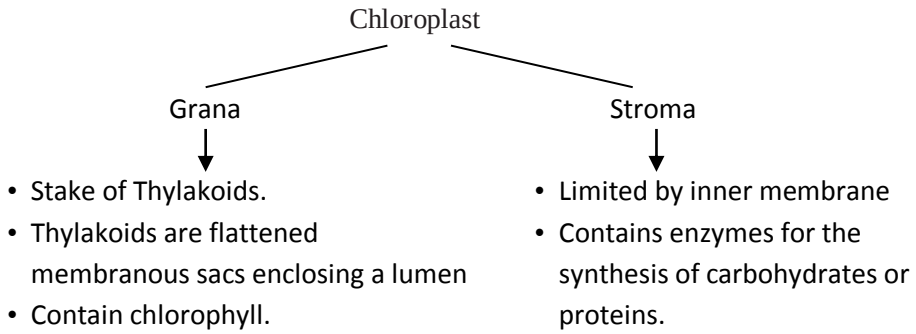

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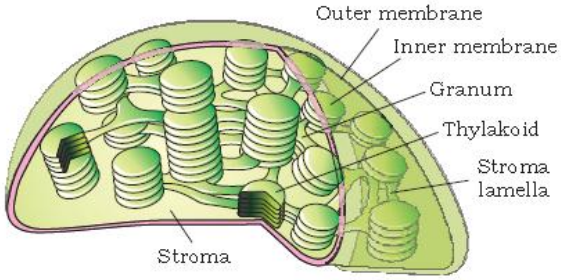
- There are also stroma lamellae connecting the thylakoids of the different grana.
- Stroma also contains small, double-stranded circular DNA molecules and ribosomes (70S). so, it is also known 'semi autonomous organelle'.



➢ Endoplasmic Reticulum

- a network or reticulum of tiny tubular structures scattered in the cytoplasm that is called the endoplasmic reticulum (ER)
- Hence, ER divides the intracellular space into two distinct compartments, i.e., luminal(inside ER) and extra luminal(cytoplasm).

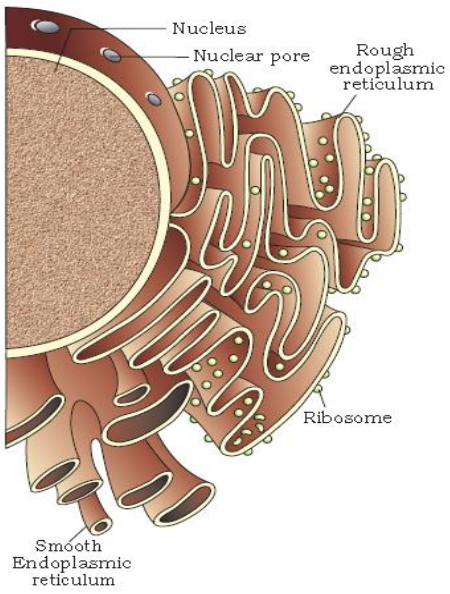
ER

Smooth (SER)

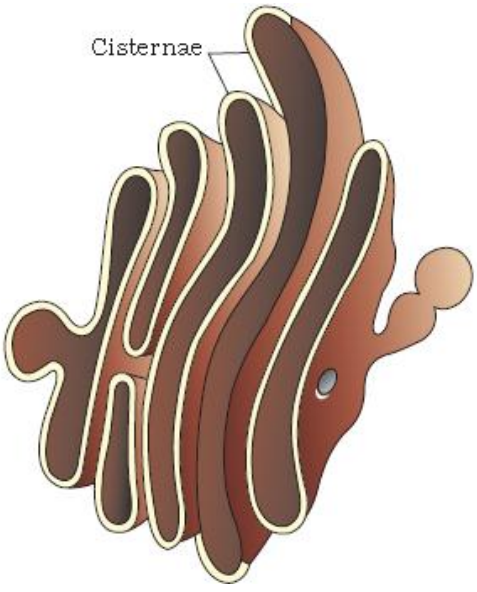
- absence of ribosomes they appear smooth.
- Major site for synthesis of lipid.
- In animal cells lipid-like steroidal hormones are synthesised in SER.

Rough (RER)

- bear ribosomes on their surface proteins.
- involved in protein synthesis and secretion.
- are extensive and continuous with the outer



Endoplasmic Reticulum



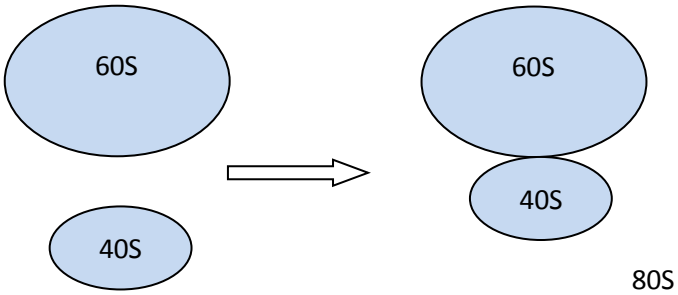
Golgi apparatus

- Golgi apparatus
  - Discovered by Camillo Golgi.
  - They consist of many flat, disc-shaped sacs or cisternae stacked parallely.
  - The Golgi cisternae are concentrically arranged near the nucleus with distinct convex *cis* or the forming face and concave *trans* or the maturing face, which are interconnected.
  - The golgi apparatus principally performs the function of packaging materials.
  - golgi apparatus remains in close association with the endoplasmic reticulum as materials to be packaged in the form of vesicles from the ER fuse with the *cis* face of the golgi apparatus and move towards the maturing face.
  - A number of proteins synthesised by ribosomes on the endoplasmic reticulum are modified in the cisternae of the golgi apparatus before they are released from its *trans* face.
  - Golgi apparatus is the important site of formation of glycoproteins and glycolipids

- Lysosomes
  - These are membrane bound vesicular structures formed by the process of packaging in the golgi apparatus.
  - The isolated lysosomal vesicles have been found to be very rich in almost all types of hydrolytic enzymes (hydrolases – lipases, proteases, carbohydrases) optimally active at the acidic pH.
  - These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.

- Vacuoles
  - Membrane-bound space found in the cytoplasm. Membrane known as tonoplast.
  - It contains water, sap, excretory product and other materials not useful for the cell.
  - In plant cells the vacuoles are very large.
  - In plants, the tonoplast facilitates the transport of a number of ions and other materials against concentration gradients into the vacuole.
  - In *Amoeba* the **contractile vacuole** is important for excretion.
  - In many cells **food vacuoles** are formed by engulfing the food particles.

- Ribosome
  - first observed under the electron microscope by George Palade.
  - They are composed of ribonucleic acid (RNA) and proteins.
  - Not Bounded by any membrane.
  - The eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S. ('S' stands for the sedimentation coefficient).



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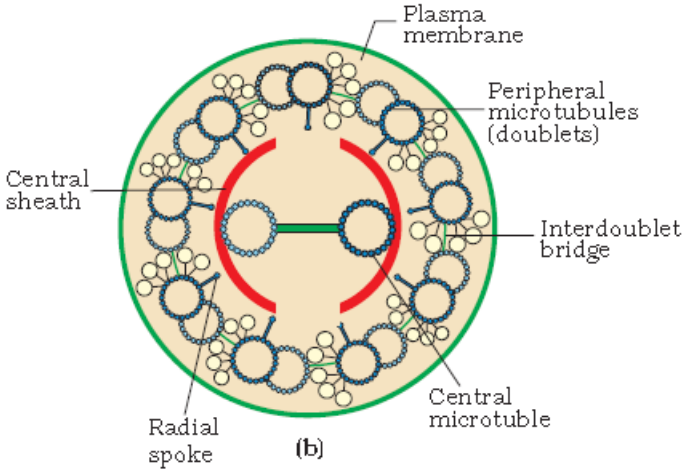
- Cytoskeleton
  - An elaborate network of filamentous proteinaceous structures present in the cytoplasm
  - Functions are mechanical support, motility, maintenance of the shape of the cell.

- Cilia and Flagella
  - They are hair like outgrowths of cell membrane responsible for locomotion and movement of cell.
  - Cilia are small structures which work like oars, causing the movement of either the cell or the surrounding fluid. Flagella are comparatively longer.
  - Eukaryotic cilium and flagellum are covered with plasma membrane.
  - Their core called the **axoneme,** possesses a number of microtubules running parallel to the long axis. The axoneme usually has nine pairs of doublets of radially arranged peripheral microtubules, and a pair of centrally located microtubules. (9+2)
  - Both the cilium and flagellum emerge from centriole-like structure called the basal bodies.



- Centrosome and centriole
  - Centrosome is an organelle usually containing two perpendicularly lying centrioles surrounded by amorphous pericentriolar materials.
  - Centriole has an organisation like the cartwheel. They are made up of nine evenly spaced triplet peripheral fibrils of tubulin.
  - The central part of the centriole is also proteinaceous and called the **hub**, connected with peripheral tubules by radial **spokes.**
  - The centrioles form the basal body of cilia or flagella, and spindle fibres that give rise to spindle apparatus during cell division in animal cells.

- Microbodies
  - Many membrane bound minute vesicles called microbodies that contain various enzymes.
  - They are present in both plant and animal cells.

- Nucleus
  - first described by Robert Brown.
  - the material of the nucleus stained by the basic dyes was given the name **chromatin** by Flemming.
  - The interphase nucleus has nucleoprotein fibres called chromatin, nuclear matrix and one or more spherical bodies called **nucleoli.**
  - the nuclear envelope is consists of two parallel membranes with a space inbetween called **perinuclear space.**
  - The outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.
  - At a number of places the nuclear envelope is interrupted by minute pores. These nuclear pores provide passages for movement of RNA and protein molecules.
  - Normally, there is only one nucleus per cell.Some mature cells even lack nucleus, e.g., erythrocytes of many mammals and sieve tube cells of vascular plants.
  - The nuclear matrix or the **nucleoplasm** contains nucleolus and chromatin.
  - The nucleoli are spherical structures present in the nucleoplasm. It is non-membrane bound. It is a site for active ribosomal RNA synthesis.
  - During cell division, chromatin network condenses into **chromosomes.**
  - Chromatin contains DNA and some basic proteins called **histones**, some non-histone proteins and also RNA.
  - Every chromosome essentially has a primary constriction or the **centromere** on the sides of which disc shaped structures called **kinetochores** are present.
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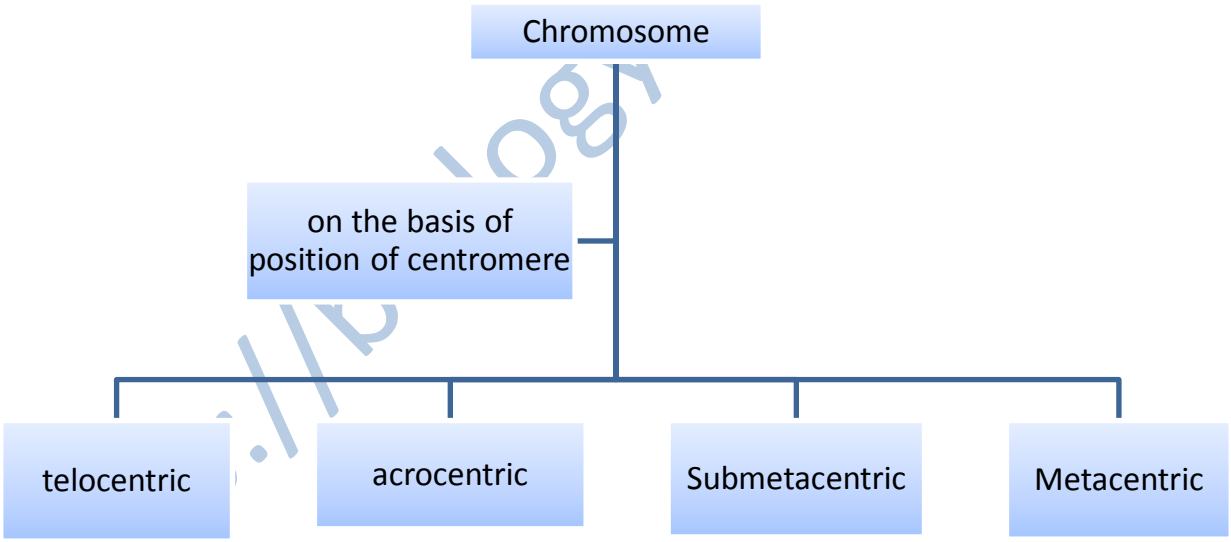

  - Sometimes a few chromosomes have non-staining secondary constrictions at a constant location. This gives the appearance of a small fragment called the **satellite**.

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