CLASS – 11

BIOLOGY

Chapter – 8

Cell and structure

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Cell

- It is basic ***structural and functional unit*** of living organism.

OR

It is ***fundamental structural and functional unit of life***.

- ***Robert hooke*** was the first scientist who observe cells for *first time in a piece of cork but the cells were dead*.
- ***Anton Von Leewenhock*** observes and *describes first living cells*.
- ***Robert brown*** discovers the *nucleus*.

Discovery of cells

Year	Scientist name	Contribution / discovery
1665	Robert Hooke	- Observe the cells in a thin slice of cork for the first time. - Cells were empty and dead
1676	Anton Von Leeuwenhoek	- Used improved microscope and observe nuclei and unicellular organism.
1831	Robert Brown	- Discovered the nucleus as a characteristic spherical body in the plant cells.
1839	M. Schleiden T. Schwann	- Gave cell theory that all tissue are composed of cells and cell is basic unit of life.

1840	J.E Purkinje	- Gave term protoplasm to living fluid substance of the cell.
1858	Virchow	- Further expanded the cell theory and proposed that all cells arise from pre-existing cells.

Classification of organism based on number of cells

- Organism classify in two type on the basis of number of cells.

1. **Unicellular organism: (i.e. made up of one cells)**

- It has single large cells by having various cell organelles to perform all necessary vital function for life.

Example: *Amoeba, Paramecium, Chlamydomonas, Bacteria, Yeast etc*.

2. **Multicellular organism: (made up of more than one cells)**

- It is made up of comparatively smaller cells that are differentiated to do specific function like ***Mucle cells*** (*i.e. Ovement of body part*) Nerve cells (*i.e. respond to stimuli*).

Example: *Plant and Animals*

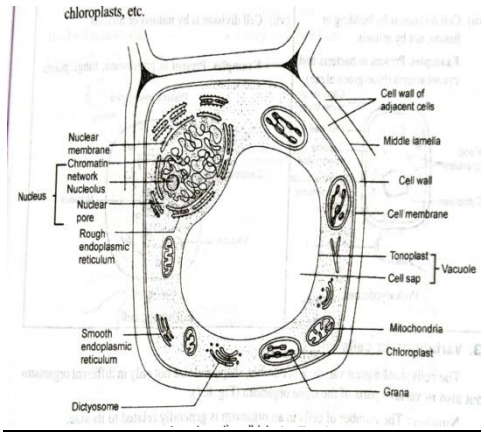
Cell theory

- In ***1838 M. schleiden*** examine a large number of plants and observe that *all plant are composed of different kinds of cells which form the tissue of the plants*.
- In ***1839 T. Schwan*** studied different type of animal cells and reported *that cell have thin outer layer (i.e. plasma membrane)*.
- In ***1855 Rudolf Virchow*** explained that *cells divide and new cells are form from pre-existing cells (i.e. Omnis cellulae cellula)*.
- ***Vircho*** modified the hypothesis and given by Scheiden and Schwan and gave cell theory *i.e. all living organism composed of cells and product f cells that arise from pre-existing cells*.

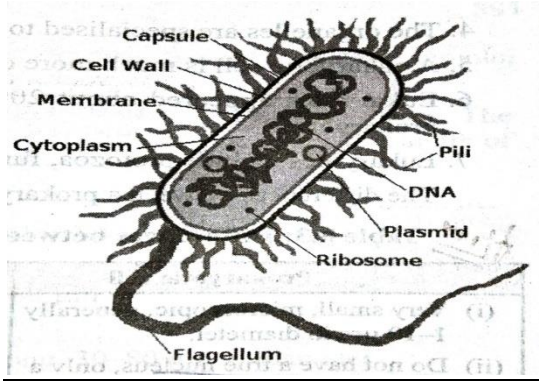
Types of cells

- Depending upon the nuclear material being enclosed by a membrane or not and other complexity of organism the cells are categorized into two categories like

1. **Eukaryotic cell:**



2. **Prokaryotic cell:**

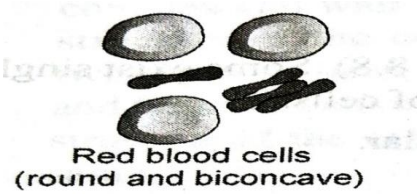
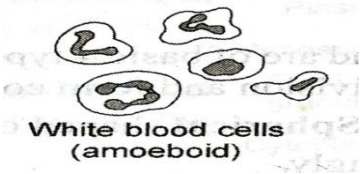
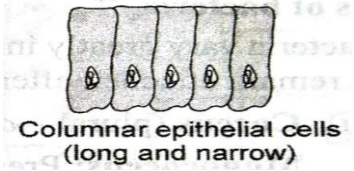
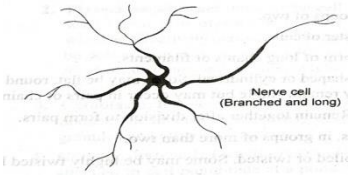
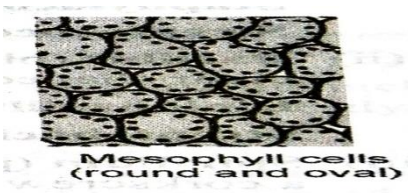


Variation in cells

Cells show grate variation in number of cell, size and shape.

Size of various cells	
Mycoplasma cells (i.e. smallest cell	0.3 micrometer in length
Bacteria	3 – 5 micrometer
Cell of plant and animals	10 – 100 micrometer
Human red blood cells	7 micrometer

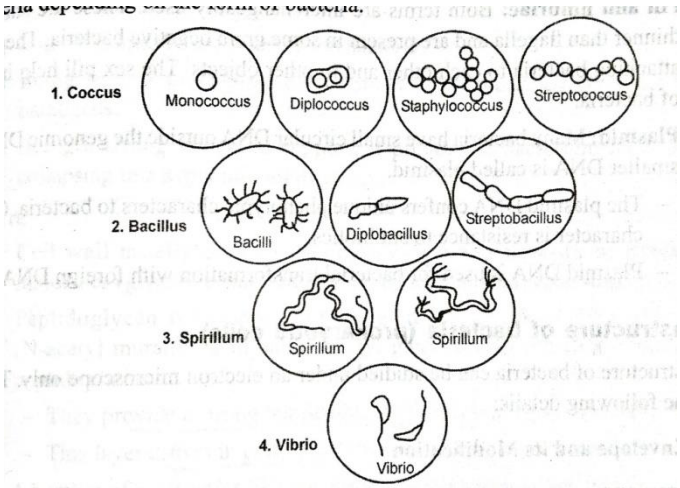
Striated muscle cell	1-40 mm long, 30-80 micrometer in diameter
Nerve cell	0.1 m to 1.0 m

Shape of cells		
Human RBCs	Round and biconcave	
Amoeba and WBCs	Irregular, have no shape	
Columnar epithelial cells	Column like, long and narrow	
Nerve cells	Star shape	
Tracheid (plant cell)	Elongated fiber like	
Mesophyll cells of leaf	Round and oval	

Prokaryotic cells

- They *lack true nucleus and membrane bound organelles.*
- It represented by ***bacteria, cynobacteria and mycoplasma*** etc.
- They can see in all kind of environment and could be ***free living, symbiotic or parasitic***.
- Bacterial cell vary in size like:

1. **Coccus** (i.e. spherical shaped)
2. **Bacillus** (i.e. rod shape or cylindrical in shape).
3. **Spirillum** (i.e. coiled or twisted).
4. **Vibria** (i.e. coma shaped)



General feature of prokaryotic cells

1. **Cell wall** – is rigid complex structure which bound bacteria cells and its ***thickness and structure differ in different bacteria*** (*i.e. gram positive and gram negative bacteria*).
2. **Plasma membrane** – lies inner to cell wall which is ***selectively permeable*** and some time it fold inward to form mesosome.
3. **Cytoplasm** – appear like ***granules*** due to ***presence of ribosome and inclusion body*** (*i.e. form of storage of food, lipid or glycogen granules etc.*).
4. **Genetic material –** is single circular DNA present in region of ***nucleoid*** (*i.e. not separated from cytoplasm by any membrane*).

5. **Flagella** present in one or more in number that help to ***movement and respond to stimulus***.

6. **Pilli and fimbriae** – are short and thin than flagella and present in ***some gram negative bacteria*** which help in *attachment to bacteria to each other and other object*.

7. **Plasmid –** is small circular ***extra genomic DNA*** which has unique characteristics like *resistance to antibiotic* and used for ***bacterial transformation with foreign DNA***.

Ultra structure of bacteria

Cell Envelop:

- Prokaryotic cell have chemically complex cell envelop which consist of 3 layers – Glycocalyx, cell wall and plasma membrane.

1. **Glycocalyx:**

- It is outermost layer which differ in thickness and chemical composition in different bacteria.
- It is mainly up of to type – ***capsule*** *(i.e. comparatively thicker, tougher and more compact*) and ***slime layer*** (*i.e. loose sheath which is more differed and less compact*).
- It is made up of polysaccharides and also may contain proteins.
- It provides additional protection from unfavorable condition and enable to stick to each other.

 # Presence of capsule is indication of virulence of some bacteria like Diplococcus cause pneumonia.

2. Cell wall:

- It consists of peptidoglycan and provide strong frame work and differ in gram positive bacteria as well as in gram negative bacteria.
- It provides characteristic shape, protection against mechanical and chemical injuries and pathogen prevent a bacteria from bursting or collapsing in a hypotonic solution.

3. Plasma membrane:

- It form boundaries of cytoplasm and present inner to cell wall.
- It has certain carrier molecule that binds to specific molecule and transports them in specific directions.
- It help in various way like:

i. Separate from external surrounding.

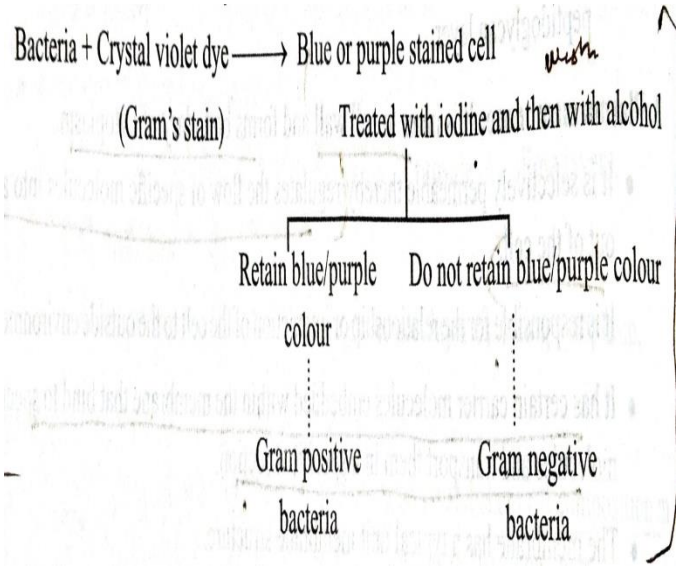
ii. Serve selective permeable barrier that allow particular ion and molecules.

iii. Serve as transport system of cells.

iv. Have receptor which detect and respond to chemical in surrounding.

Gram staining

- It is technique which uses to ***classify bacteria into group*** (*i.e. gram positive or gram negative*) by stating the bacteria with gram stain.
- The difference between gram positive or gram negative bacteria lies in their ***cell wall*** (*i.e. gram positive bacteria have thicker polypeptidoglycane wall while in gram negative have thin layer of peptidoglycane*).
- The reason of gram positive bacteria to stain blue or purple is that it have ***thick polypeptidogluycan*** that *trap the crystal violet dye* while gram negative bacteria have a ***thin polypeptidoglycan*** so they *do not retain the crystal violet dye*.
- The gram positive bacteria have resistance to antibiotic because ***outer membrane is lipid rich layer*** that make resistance to many antibiotic.



Modification or extension at prokaryotic cell surface

1. **Flagellum:**

- Many bacteria equipped with one or more flagella that help in movement and respond to certain stimuli.
- Flagellum is entirely different from the flagella of eukaryotic cells but have structural resemblance just one of the microtubule of eukaryotic flagella.
- It originate from ***basal body in plasma membrane*** and composed of three parts like *filament, hook and basal body*.

I. **Filament** – is hollow rigid cylindrical rod like structure that composed of protein ***flagellin*** (*i.e. arranged in the spiral manner in the filament*).

II. **Hook** - made up of different protein subunits.

III. **Basal body:**

- It is complex part of flagella which ***consist of 4 ring in case of gram negative bacteria*** and ***2 ring in case of gram positive bacteria***.
- In this ***the inner ring*** connected to *plasma membrane* while ***outer ring*** fixed to the *peptidoglycan portion of cell wall*.

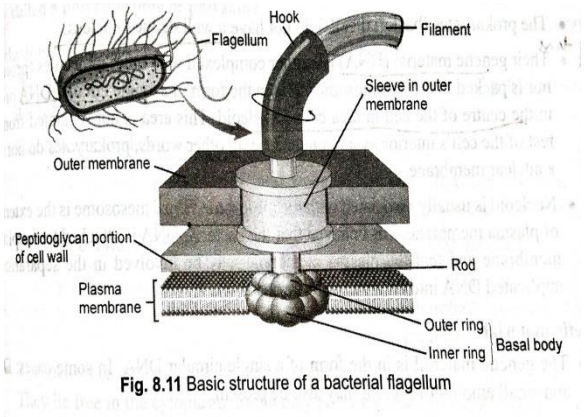


Fig. 8.11 Basic structure of a bacterial flagellum

Pilli and Fimbriae

- They are short thinner than flagella and projected from the wall of some ***gram negative bacteria***.
- They are ***not involve in motility*** if bacteria but help to sticks to each other and other surface and in mating.
- **Pili** are elongated tubular fine structure that made up of pilin protein and reported in gram negative bacteria.
- **Fimbriae** is small bristel like fibres that sprouting out of the bacterial cell that composed of helically arranged protein subunit (*i.e. 3-10 nm in diameter*).
- **Fimbriae** help to stick to each other or other cells or rock in streams and also responsible for mutual clinging of cells forming a film on the liquid as well as other thick aggregates.

Eukaryotic cells

- It show the grate variation in ***shape*** (*i.e. WBC and Amoeba are irregular in shape while muscle cells are cylindrical in shape*) ***size*** (*i.e. unicellular eukaryotic cell is about up to 1mm long while cells of muscle is about 1-40mm long*) and ***types*** like plant cell and animal cells.

Ultra structure of eukaryotic cells

Organelle	Structure	Function
Plasma membrane	*Membrane structure*	Allow selective movement of

		molecules
Nucleolus	*Has group of RNA molecules*	Involve in synthesis of ribosome and protein
Chromatin material	*Composed of DNA and proteins*	Contain heredity information that pass from one generation to another generation.
Nuclear membrane	*Typical membrane structure*	Separate the nucleus from cytoplasm
Endoplasmic reticulum	*Folds of membrane forming sheet and cabals*	Provide surface for chemical reaction and in mechanical strength
Vacuole	*Membranous sacs*	Contain material
Mitochondria	*Double membrane structure*	Site for cellular respiration
Chloroplast	*Double membranous structure contain chlorophyll*	Site for photosynthesis
Ribosome	*Protein and RNA structure*	Suite for protein synthesis

Cell membrane or plasma membrane

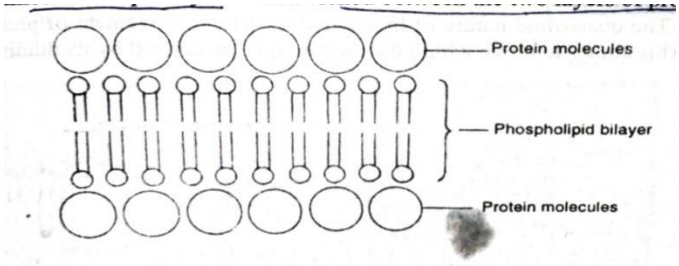
- Cell membrane is ***boundary between a cell and its surrounding*** which *separate the content of the cell from the external environment*.
- It is ***selectively permeable*** due to that they allow specific ions and molecule to pass through it.
- It has ***carrier molecule*** which embedded within the membrane that bind and transport the specific material in specific directions.
- Eukaryotic membrane contain cell organelles that compartmentalized by number of organelles so biological membrane are two type

1. ***Plasma membrane*** (i.e. covers the cell)
2. ***Sub cellular membrane*** (*covers organelles with in cell*).

Structure of plasma membrane

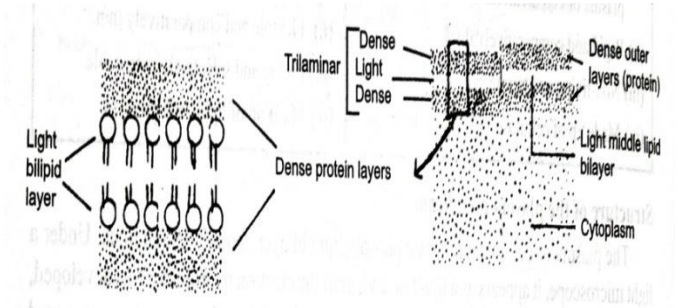
1. Model of denielli –Davson:

It is given in late 1930s and proposed that ***plasma membrane is made up of three layer*** in which *lipid layer is sandwiched the two layers of proteins*.



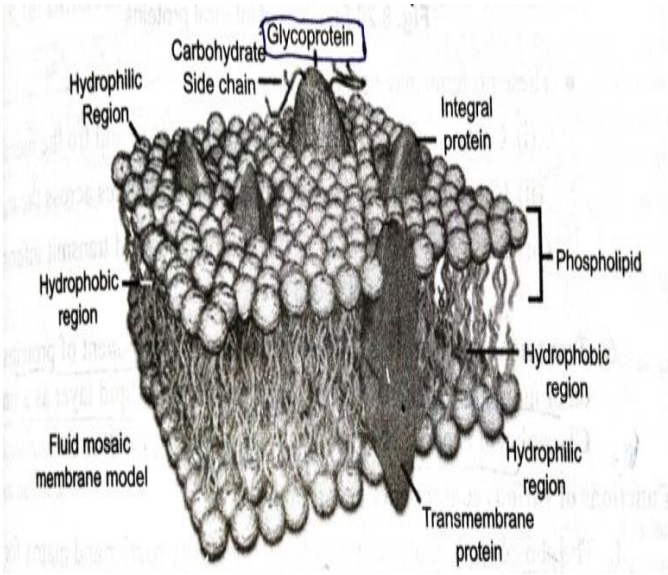
2. Model by Robertson:

He studies the membrane under electron microscope and confirmed the characteristics of ***trilamminar appearance***.



3. Model by Singer and Nicolson:

Fluid mosaic model was given by singer and Nicolson in 1972 in which they said that it is ***protein icebergs in a sea of lipids***



Important feature off plasma membrane

1. Lipid bilayer is composed of phospholipids and show amphipathicity (i.e. it show hydrophilic nature at polar end and hydrophobic at non-polar ends.
2. It has chemical composition like lipids 20-79%, protein 20-70%, oligosaccharides 1.5% and water 20%.
3. It contain globular protein like:

a. **Peripheral or extrinsic protein** – that associated with the surface and can be ***easily remove in aqueous solution***, it have a chain of sugar that attached to their surface and form ***glycoprotein***.

b. **Integral or intrinsic protein:** is embedded in the lipid layer which cannot easily release and ***insoluble in aqueous solution.***

c. **Transmembrane protein:** are major component of protein that float on in the lipid bilayer and extended through the bilipid layer as a single helix.

Example: *Glycophorin*

Function of various component of cell membrane

1. **Phospholipid molecule** – provide permeability barrier and matrix for proteins.
2. **Protein layer** – provide elasticity and mechanical support to lipid matrix.
3. **Protein molecules** – act as carrier molecules, receptor molecules and enzymes.
4. **Glycoprotein and glycolipids** – help in cellular interaction.

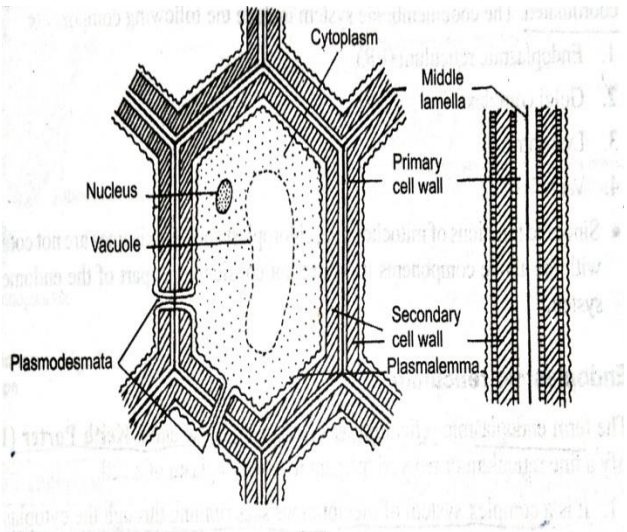
Cell wall

- It is rigid protective covering outside the plasma membrane of plant, bacteria, fungi and algae.
- The chemical composition differ in various group like:

1. **Higher plant cell wall** – *Cellulose, Pectin, Lignin and Hemicelluloses.*
2. **Bacteria** – *Polysaccharides with Amino acid*
3. **Fungi** – *murine and thin layer of mixed glycans*.
4. **Algae** – *cellulose, galactans, mannans and minerals*.

- The cell wall is differentiated into three layer:

1. **Middle lamella:** hold neighboring cell wall and composed of sticky gel like material.



2. Primary cell wall: form during cell division and consist of cellulose micro-fibrils running through the matrix.

3. **Secondary cell wall** build by addition of extra cellulose layers on the inside surface of primary cell wall and consist of three layers of micro-fibrils.

Plasmodesmata

- Cell wall is not a continuous layer it interrupted by ***plasmodesmata*** (*i.e. minute pores that allow the movement of substance between adjacent cells*).
- Sieve plate pore of phloem are derived from plasmodesmata.
- Plasmodesmata are ***fine cytoplasmic cannal*** that lined by plasma membrane and has ***desmotubule*** (*i.e. endoplasmic reticulum tubule*).
- **Symplasm:** is living matter and cytoplasm that form forms continuity between two cells.
- **Apoplasm :** it is non living matter in the intracellular space between the cells.

Function of cell wall

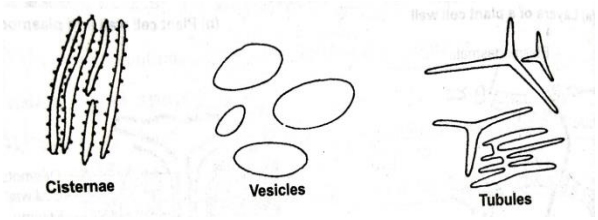
- Give mechanical strength to the cells and plant.
- Being rigid resistance to expansion that allow the cell to build a turgor pressure.
- Help in growth and shape due to presence of cellulose microfibrils.
- Prevent the osmotic bursting of the cell.

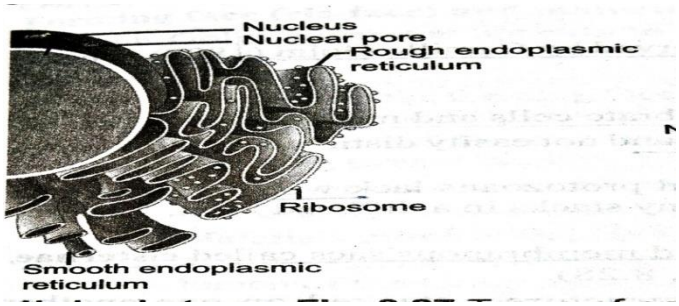
Endomembrane system

- It include the following component:

1. Endoplasmic reticulum:

- It is a complex membranous sacs running through the cytoplasm of all eukaryotic cells (accepts RBCs of mammals, eggs and embryonic cells).
- It occurs in three morphological forms like **cisternae** (*i.e. elongated flattened sac like unbranched structure*) , **vesicle** (*i.e. round spherical structure*) **tubule** (*i.e. branched irregular structure*).
- It is two type – ***smooth endoplasmic reticulum*** and ***rough endoplasmic reticulum***.





Function:

- It provides mechanical support and intracellular transport system.
- It contains many enzymes that help in various metabolic activities.
- SER involve in synthesis of lipid and steroid while RER help in transport and synthesis of proteins.
- It also associated with muscle contraction by release and uptake of calcium ions.

Golgi bodies

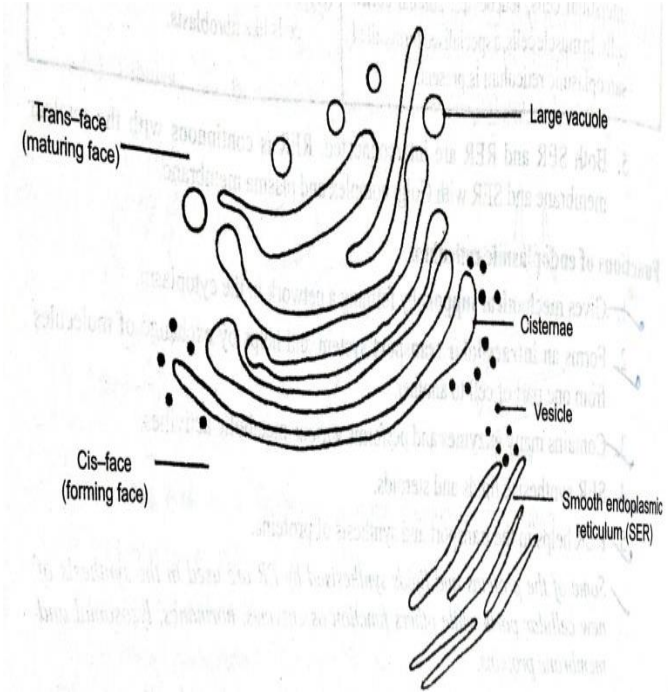
- It occurs in two forms like ***localized form*** (*i.e. near the nucleus*) and ***diffused form*** (*i.e. scattered in cytoplasm and known as dictiosomes*).
- It present in form-

1. **Cisternae** - flattened membranous sac-like structure that arrange in parallel row.

2. **Vesicle** - tiny vacuole that associated with the convex surface of cisternae.

3. **Large vacuole-** which is rounded sacs present on the maturing face of golgi apparatus.

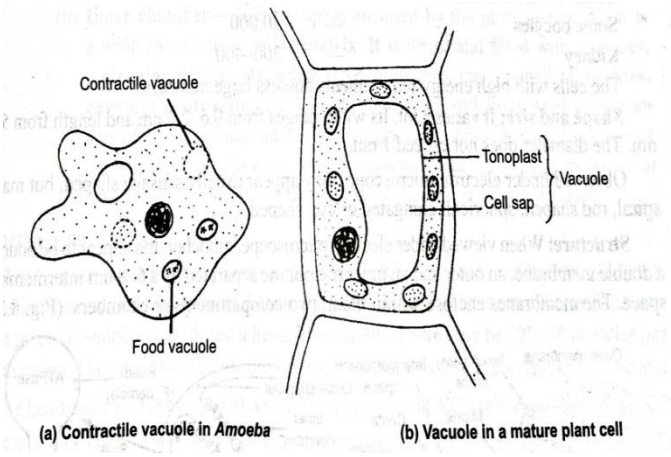
- It involves in collection, packing, secretion and transports of molecules that synthesis at one place in cell to another location in cell.
- It involve in transport and chemical modification of materials present in cells.
- Also involve in secretary vesicle, formation of glycoprotein, membrane transformations, cell wall formation and formation of lysosome.



Lysosome

- It preset in ***all animal cell and plant cell and most abundant in macrophages*** which *perform digestive function in liver, pancreas and WBCs*.
- They bound by single membrane and involve in intracellular digestion due to presence of number of digestive enzyme (***i.e. nuclease, protease, glycosidases, lipase, phosphates and sulphatases***).
- Digestive enzyme ***synthesis in rough endoplasmic reticulum*** and ***packed into the lysosomes***.
- On the basis of morphology of contents and functions lysosome are four main types – *Primary lysosome, Secondary lysosome, Residual body and autophagic vacuole*.
- It helps in ***digestion*** of *large extracellular particle, intracellular substance, digestion of cells and substance outside the cells*.

Vacoule

- It is ***non-cytoplasmic area*** present inside the cytoplasm.
- It present ***large in plant cell*** while ***small in plant cell***.
- Fluid present in vacuole is called ***cell sap*** (*i.e. contain minerals salts, sugars, organic acid etc*).
- Vacuole in plant is called ***tonoplast*** (*i.e. fluid filled sacs that covered by a single membrane*).
- Depending upon the content and function vacuoles can be classified in to following type: ***sap vacuole, contractile vacuole, food vacuole and air vacuole***.
- 

Function:

- They store waste products or plant metabolites.
- They act as food reserve by storing sucrose and mineral salt.
- Contractile vacuole acts as osmoregulatory in function as in protozoa.

Mitochondria

- It also known as power house of the cell and occurs in all type of cell except ***RBCs and prokaryotes*** (*i.e. respiratory enzyme present on cell membrane*).
- It distributed throughout the cytoplasm and localized at the ***site in higher metabolic activities*** (*i.e. base of cilia to provide energy for movement and light band of muscle to provide energy for constriction*).
- Its width ranges from 0.6 – 2.0 nm and length from 5-10 nm

- The number of mitochondria very in cell to cell and it depend upon the type of organism and nature of activities of cell.

Example	No. of mitochondria
Microsterias	1 large mitochondria
Yeast	Less than 10
Liver cells	1000 – 1600
Striated muscle fibers	Any thousands
Oocytes	30000
Kidney	300-400

Structure of mitochondria

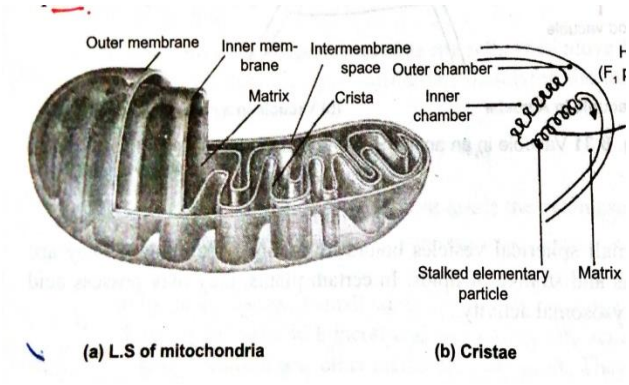
- It bounded by ***double membrane*** (*i.e. outer and inner membrane which is separated by inner membranous space*).
- **Mitochondrial membrane** (*i.e. trilaminar unit membrane structure but have different lipids*)

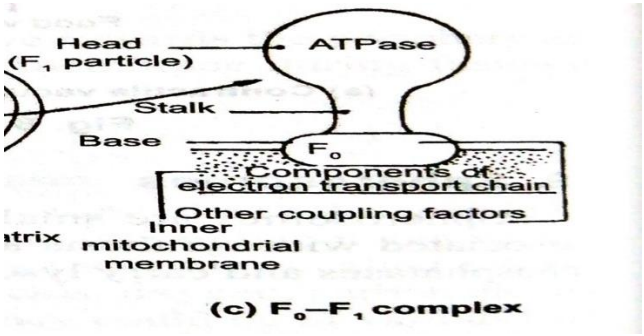
1. **Outer membrane** (*i.e. uninterrupted outer boundaries through which molecules can diffuse through it*).

2. **Inner membrane** –

✓ it projected into central space in the form of ***cristae*** (*i.e. finger like projection, increase surface area and provide abundant space for the metabolism*)

✓ It is selective permeable and contain all the enzyme of electron transport chain.





Mitochondrial chamber:

- **Outer chamber -** is ***intermembranous*** *(i.e. space between the outer and inner membrane of mitochondria and extending into the core of crests and contain enzyme adenylate kinase and nucleoside diphosphokinase*).
- **Inner chamber** (*i.e. enclose by inner membrane and called matrix which filed with enzyme, circular double stand molecules, ribosome, enzyme for TCA or Kerb cycle and fatty acid oxidation*)

Function of mitochondria

- Act as site of respiration.
- Help in yolk formation during the development of ovum.
- Form middle piece of sperm during spermatogenesis.
- Help in elongation of fatty acid.

Plastids

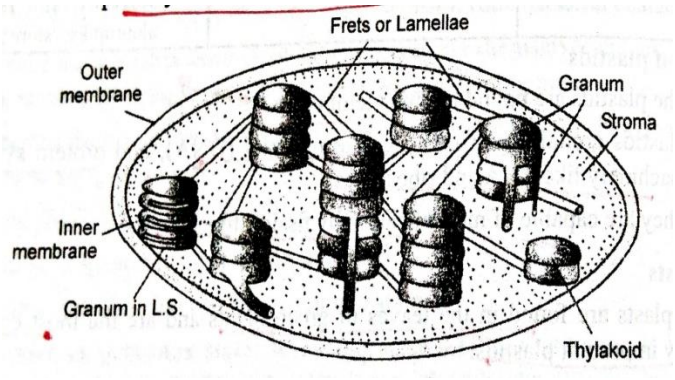
- It is organelles that found only in to plant cell and some unicellular organism (*i.e. Euglena*).

- It is surrounded by two membranes an develop from pro-plastids (*i.e. small bodies found in meristematic regions*).
- They are capable of multiplication by fission like process and have various in shapes (i.e. higher plant – biconcave and circular, spirogyra – spiral and chlamydomonas – cup shaped).
- They vary in number like parenchyma cell contain 20-40 chloroplast while algae have one large chloroplast and found in various type like:

Chloroplasts	Chromoplasts	Leucoplasts
- Carry photosynthesis. - Contain ***chlorophyll*** and ***carotenoid pigments***. - Found mainly in ***leaves*** and ***green stem*** that trap light energy for photosynthesis.	- Non photosynthetic - contain ***fat soluble carotenoid pigments*** (i.e. *carotene and xanthophyll*). - Give colour to ***fruits, flowers and*** also act as ***precursor of vitamin A in animal tissues***.	- Non photosynthetic - ***Lack any pigment***. - Abounda nt instorag e organs like ***root , seed, and young leaves*** like ***Amyloplast –*** *store starch* ***Elaioplast –*** *store fat and oils* ***Aleuroplast –*** *store protein*.

Structure of plastids

- It bounded by ***two membrane*** that form chloroplast envelop and contain own ***genetic material*** and ***protein synthesis machinery*** (*i.e. RNA and ribosome*).
- ***Outer membrane*** (*i.e. smooth and regulate the transport of material between the interior of organelle and the cytoplasm*) and ***inner membrane*** (*i.e. run parallel to the outer one and infolded inwards to form lamellae*).
- The two membranes is separated by 25-75 nm wide space called ***matrix or stroma***.

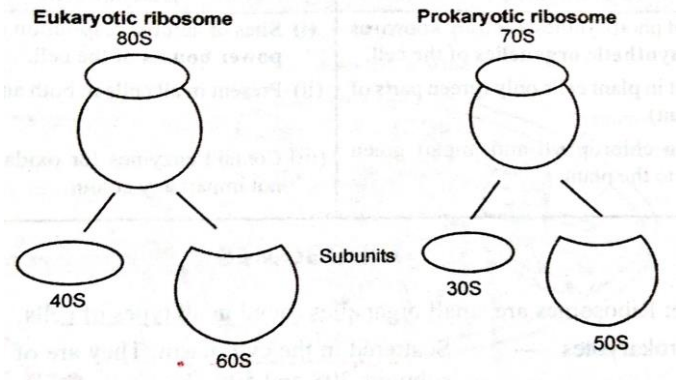


- Stoma contain ***thylakoids*** (*i.e. fluid filled space*) in which they stalk together and form ***grana***.
- The various grana joined together by ***lamellae***.
- The ***thalakoid*** (*i.e. contain photosynthetic pigments*) is ***site for light reaction*** an ***stroma*** (*i.e. contain soluble enzyme, small circular double helix DNA, ribosome, soluble proteins and chemical like sugar, organic acids etc*.) is ***site of dark reaction***.

Ribosome

- It is small organelles found in cytoplasm of all type of cells like :

1. **In prokaryotes –** contain ***70S type*** (*i.e. contain subunit of 50S and 30S*)
2. **In eukaryotes –** it attached to endoplasmic reticulum and have ***80S type*** (*i.e. contain subunit of 60S and 40S*).



- The ***number of ribose directly related to RNA content***.
- The size of the ribosome determine by the speed with which they sediment in a centrifugal field and ***Svedberg unit (S)*** is the unit to measure the sedimentation speed.
- Ribosome composed of approximately *equal amount of RNA and protein* with little amount *of lipids and certain metallic ions*.
- Both subunit ***occurs freely in cytoplasm but united at the time of protein synthesis*** in which ***large subunit*** is *attached to ER and mRNA* is bound to ***small subunit*** and ***polypeptide formation occurs in the large subunit***.

Cytoskeleton

- Under the electron microscope the cell seem to contain a *complex network of fibrous structure in the cytoplasm*
- It form structural ***frame work within the cell, maintains the shape of the cells and give the ability to eukaryotic cells to adopt a variety of shape***.
- There are three main type of cytoskeleton (*i.e. protein filaments*) are form:

1. **Microtubule:** are scattered or organized into a network or parallel arrays concentrated just below the plasma membrane in the cytoplasm which ***form the network in the cytoplasm*** that ***extended up to the core of microvilli*** and made up of ***protein actin***.

- They associated with ***cellular movement, endocytosis and exocytosis and responsible for muscle contractions***.

2. **Microtubule:** are made up of helically arranged chain of ***globular protein – tubulin*** in which each microtubule is composed of ***13 subunit*** that arranged side by side and for a tube.

- It form cytoskeleton and involve in ***maintaining the shape of cell, cell movements, intracellular transport in non-dividing cell and movement of cell organelles***.

3. **Intermediate filaments:** are made-up of tough and durable ***protein fibers or filaments*** in which thee fibrous protein are twinned together in overlapping form and this arrangement allow a rope like structure that impart inn mechanical strength of the cell.

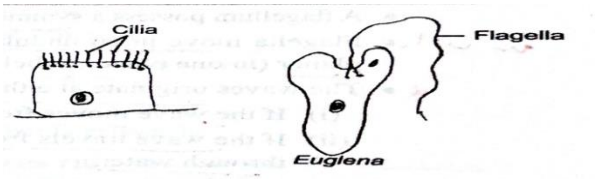
- They impart in ***mechanical strength of cell , form basket around the nucleus and present in cell-ell junction***.

Cilia and Flagella

- Both are projections from the surface of some cells and help in movement.

Cilia:

- It is fine hair like projection on the surface of some cells and may cover the entire surface of cells.



- Movement of cilia are ***asymmetrical*** and occurs in ***two distinct phase or strokes*** like ***power effective stroke*** (*i.e. in this cilia propel through the surrounding fluids like oars and thereby propelling the organism along*) and ***recovery stroke (****i.e. cilia return to their original position*).

Flagella:

- It whip like projection on the cell surface which is fewer in number than cilia.
- The movement of flagella posses a ***symmetrical beat with several undulations along the length*** in which flagella move in undulating manner and beat independently to generate planer helical waves.
- Flagella are two type - ***whiplash flagellum*** and ***tinsel type flagellum***.

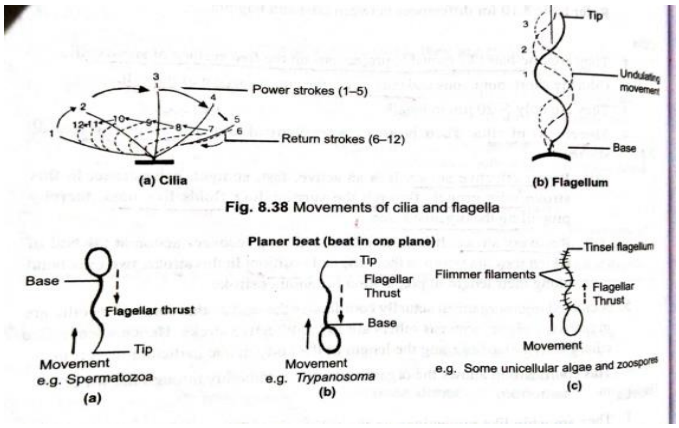
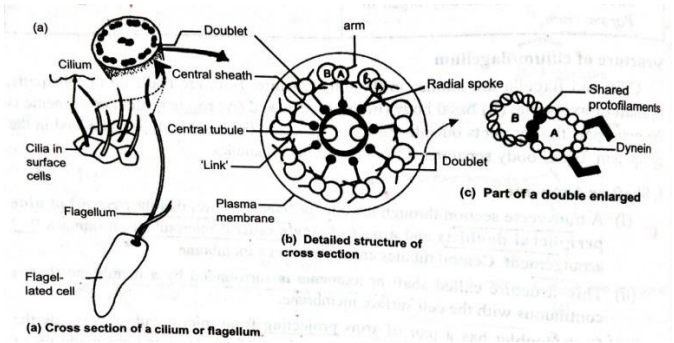


Fig. 8.38 Movements of cilia and flagella

Structure of Cilia and Flagella

- Both have similar in the ultra structure and made up of four parts like – shaft or axoneme, basal body, basal plate and rootlets.

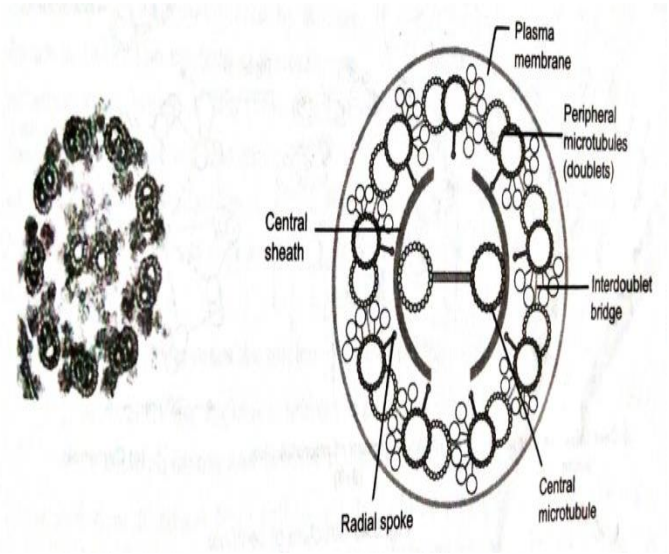


1. **Shaft or axoneme:**

- Transverse section of cilia or flagella shows that they consist of ***9 peripheral doublets*** and ***a pair of single central microtubule*** which show ***9+2 arrangement***.
- The shaft is surrounded by a membrane that continues with the cell surface membrane.
- Each doublet has ***a pair of arms*** (*i.e. made up of protein – dynein*) that ***projecting from microtubule A*** and ***towards the neighboring doublet.***
- These two arm of ***microtubule A*** form *cross-links with microtubule B of the adjacent doublet*.
- ***A radial stock*** also extends from ***microtubule A*** towards the *central microtubules enclosed in central sheath*.

2. **Basal body:**

- Basal body is ***present at the end of both cilium and flagellum*** and microtubules of the shaft are ***deriving from the basal body***.
- Basal body is short cylindrical with ***nine microtubule triplets*** in the periphery and ***without central microtubules*** i.e. 9+0 arrangement just like the centriole.



Nucleus

- It ***direct and control all the cellular activities*** and ***carries the hereditary information of the cell***.
- It discovered by Robert Brown in 1831.
- In present in ***prokaryotic cell*** in which the ***true nucleus is not present*** (*i.e. Nucleus without distinct nuclear membrane*) while in ***eukaryotic cell*** have ***true nucleus*** (*i.e. nucleus with distinct nuclear membrane*) while in ***mature phloem sieve tube elements*** and ***mature red blood cell of mammals***.
- Shape and size is differ in cell to cell like :

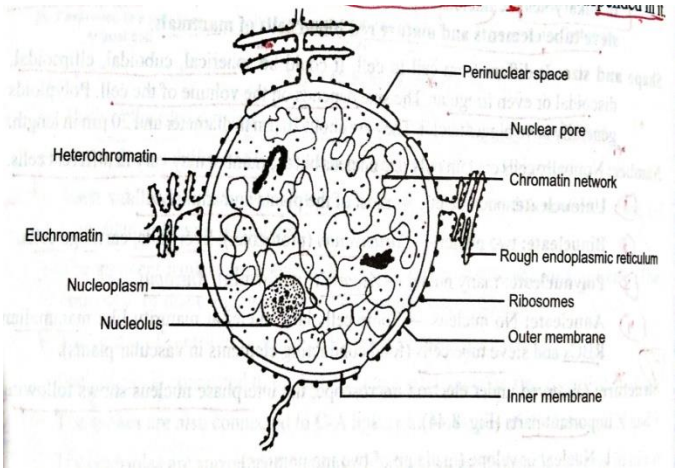
1. **Most of plant and animal cell** (*uninucleated*)
2. **Paramecium , liver cells, cartilage cells** (*binucleated*)
3. **Ascaris and Rhizopus** (*polynucleated)*
4. **Mamalian RBCs and seive tubbe cell** (*anucleated*)

Structure of nucleus

- Interphase nucleus show the following part :

Nuclear envelop:

- It composed of ***two membrane***(i.e***. rough outer membrane*** *due to presence of ribosome* that continue with unit membrane ER and ***smooth inner membrane*** because it *lack ribosome*) and are separated by ***perinuclear space***.
- Nuclear membrane contain ***nuclear pore*** that allow *the exchange of substance between nucleoplasm and cytoplasm* like *mRNA and ribosomal unit and entry of nucleotide, ribosomal protein and other macromolecules*.



Nucleoplasm:

- It is gel like matrix within the nucleus which has varieties of **substance** like (ions*, enzyme, nucleotides and protein*) and also called ***nuclear sap***.
- The *chromatin network* and *nucleoli* are suspended in it.

Chromatin network:

- ***During interphase*** stage the chromosome are present in the form of ***chromatin network*** (*i.e. uncoiled, indistinct and network like structure*).
- It composed of RNA coils of DNA bound to ***histones protein*** (*i.e. basic protein*).
- During cell division the chromatin network condense into thread or rod like structure called **chromosome** that form by tight coiled of chromatin fibers.

Nucleolus:

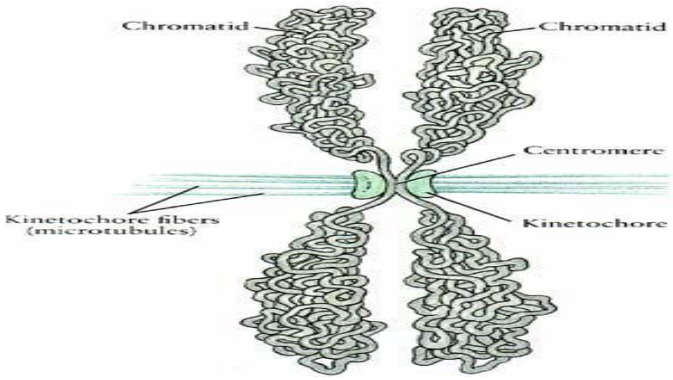
- It is site of **ribosomal RRNA synthesis** and contain DNA which form ***precursor RNA for the formation of protein.***

Function of nucleus:

- Due to presence of hereditary information of the cell it controls the reproduction, development, metabolism and behavior of organism.

Structure of chromosome

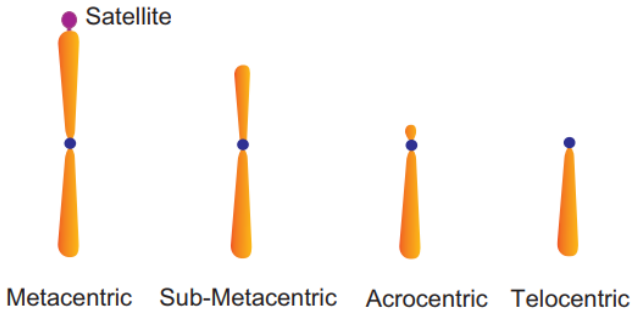
- **In the nucleus of each cell-** DNA molecules packed with thread like structure called chromosome.
- Chromosome made up of DNA tightly coiled many times around protein called ***histone protein***.



- **Kinetochore** is terminal plate which is situated at the centromere of chromosome.
- Kinetochore get attached to the chromosome and help in ***chromosome movements during anaphase .***
- Recent studies has shown that kinetochore is that *sites which generates force required for chromosome movements .*

Different shape of chromatids

- Depending upon the position of centromere – the chromosome acquired different shapes and have been classified into following four categories:



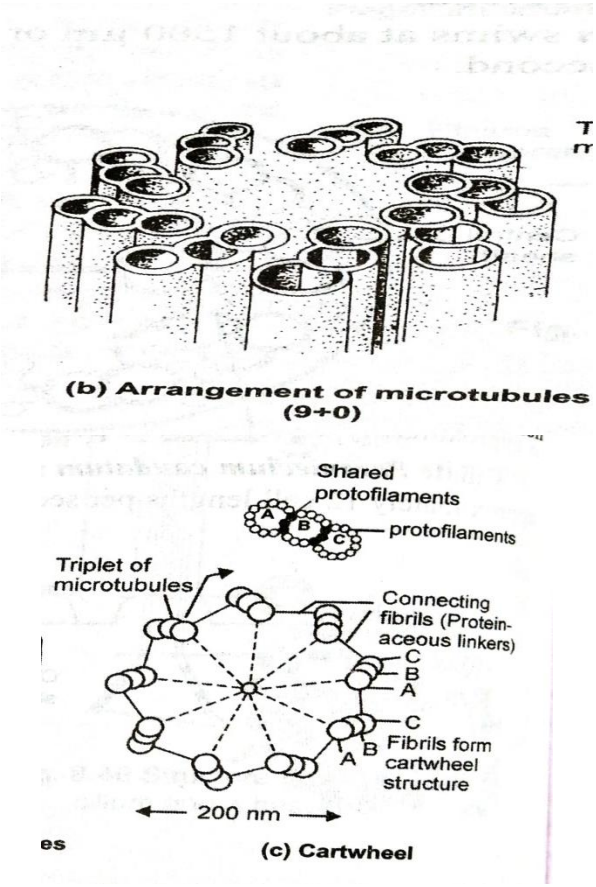
1. **Telocentric:** in this the centromere is present at one end and chormosome is like rod shape.
2. **Acrocentric:** centromere lie near one end and have a small arm beyond centromere which form I shaped.
3. **Meta centric:** centromere lies in the center of the chromosome and form V-shaped and two are equal in length.
4. **Sub metacentric:** chromosome have arms of unequal length as the centromere lies near the center and they form J or L shaped.

Centrosome

- It is an organelle that contain ***two centriole*** (*i.e. two cylindrical structure*) that surrounded by ***amorphous pericentriolar materials***
- It is submicroscopic, microtubule barrel- shape structure occurs in the form of ***diplosomes***.
- It is non membranous organelles situated in cytoplasm near the nucleus.
- It found in ***all animal cell and flagellated organism*** and ***absent in plant cell***.
- Centrosome occurs in the form of ***granules*** side by side at the right angle and the cetriole is present inside the ***centrosphere or kinoplasm*** (*i.e. specialized cytoplasm*).

Centrioles

- Each centriole made up of **nine group of microtubule** (*i.e. made up of tubulin protein*) that arrange in ***a circle like cartwheel organization (9+0)*** that tilted **at 40 degree angle** at the periphery.
- Each of nine set is **triplet** (*i.e. composed of 3 microtubule or sub-fibres*) and each triplet arrange from outside to inside as C, B and A in sequence.



- Each microtubule is made up of **13 protofilaments** in which *both C and A shares 2-3 protofilameent with B subfibre*.
- The adjecent triplet are connected to each other by **proteinaceous linkers** that connect C of one triplet to the A of other triplets.
- The center of centriole is occupied **by protenaceous hub** that *connected with each triplet* by **spokes** (*i.e. radial protenaceous strands*)
- The centriiole is also surrounded by ***massules or pericentriolar satellites*** (*i.e. dense amorphous protoplasmic spheres in one or more series*) which *help in the formation of new centrioles in G-2 hase of cell cycle*.

Function:

- It act as ***microtubule organizing centers (MTOCs)*** during formation of spindle formation.

- They act as ***basal bodies at the base of cilia and flagella***.

Microbodies

- They are small, spherical or oval vesicle that bounded by single membrane.
- Microbodies often posses a **crystalloid core** and **distinct granule matrix**.
- Microbodies contain **various enzyme** and present in ***both plant and anima cells***.
- It involves in ***oxidative reaction other than respiration*** and are mainly two type.

1. **Peroxisome:**

- It contain **powerful oxidative enzyme** (*i.e. catalase – decompose toxic hydrogen peroxide to harmless water and oxygen*) and also involve in peroxide biosynthesis.
- It occurs in ***most of plant and animals*** and are ***common in photosynthetic cell***s.

2. **Glyoxysome:**

- Occurs in **fat rich plant cells** that ***convert fats (i.e. lipid) into carbohydrate (i.ee. Sucrose) in the endosperm of castor oil seeds***.
- It also ***metabolizes the gyoxylate and triglyceride through glyoxylate cycle***.

Cell Inclusions

- It contains ***organic storage material*** and ***inorganic crystals*** and mainly present in ***plant cell***.

1. **Starch grain –** found ***in plant cell only*** stored in *rhizome, potato tuber, rice maize etc.*
2. **Glycogen granules** – occurs in ***animals cells*** and appear as small *spherical resettle shaped particle near SER in liver and muscle cells*.
3. **Fat droplets** – found in ***both plant cells*** (*fat globules in cell of endosperm of castor and coconut, cotyledon of groundnuts and mustard cells*) and **animal cells** (*i.e. adipose cells*).
4. **Aleurone grains** – store protein granules in **plant cells**.
5. **Crystal of various chemical compounds** occurs either in ***cell cavity or in cell wall of plant cells***.

   Example: ***calcium carbonate in rubber plat , banyan etc, calcium oxalate in balsom, dry scale of onion etc, silica in leave of grass***.