CHAPTER - 00
CELL: THE UNIT OF LIFE

Cytology → Study of cell

- ♦ Term coined by Hertwig
- ♦ Father of cytology - Robert Hooke
- ♦ Father of modern cytology - Swanson

Level of Organisation of cell

Cytosol + Organells → Cytoplasm

cytoplasm + Nucleus → Protoplasm

Protoplasm + Cell membrane → Protoplast

Protoplast + Cell wall → Cell

Cytosol: - (Hyaloplasm/Ground plasm)

- ♦ Fluid part
- ♦ Agranular part - fluid without organelle

Cytoplasm/ Trophoplasm

Main arena of cellular activities

- ♦ Cytosol + organelles
- ♦ Granular part - Fluid with organelles

Protoplasm

Cytoplasm + nucleus

Living area

Physical unit

Discovered by **Alfonso Corti**

Dujardin - gave the name **sarcode** to the living substance of the cell

T J Purkinje - coined the term protoplasm

T H Huxley - proposed that protoplasm is the physical unit of life

Robert Hooke - discovered cell in cork tissue (phellum)

Dead cell
Suberized
Waxy
Water proof

He revealed the details regarding his work in a book - **'Micrographia'**

Anton van Leeuwenhock

First examined living cell under the microscope-bacterial cell.

Robert Brown : Discovered nucleus in orchid root cells (1831)

Cell theory

Proposed by : Malthias Schleiden ; German Botanist (1838)
Theodore Schwaan ; British Zoologist (1839)

Postulates

1. All living organisms are made up of cells
2. Cell is the structural and functional unit of living organisms
3. All cells are arising from preexisting cells

Rudolf Virchow ; modified cell theory in (1855)

Modified theory → 'Omnis cellula-e-cellula'

- ♦ All cells are arising from parental cells due to cell division.
- ♦ Modified cell theory is also said to be cell principle/ cell doctrine

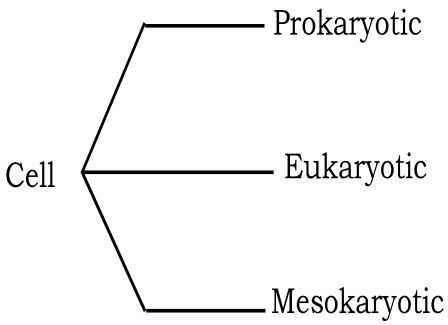
Exceptions to the cell theory

1. Mature RBC and sieve tube do not have nucleus
2. Organisms such as rhizopus having multinucleate condition
3. Viruses do not have protoplasm instead they have a nucleic acid with a protein coat

Demerit

There is no mention about cell division in the original at cell theory

Smallest cell → Mycoplasma
Largest cell → Ostrich egg
Largest plant cell → Acetabularia-Umbrella plant, Marine green algae
Longest plant cell → Sclerenchyma fibre
Longest human cell → Neuron
Largest bacterium → Thiomargerata namebiansis
Discovered in sulphur deposits of Namebia



Prokaryotic cell

Pro ⇒ Primitive

Karyon ⇒ Nucleus

- ♦ A cell with incipient nucleus (nucleoid)
- ♦ Circular double stranded DNA without nuclear membrane
  Associated with a basic protein **Protamins / Polyamines**
  eg: Kingdom monera

Eukaryotic cell

Eu $\Rightarrow$ true

Karyon $\Rightarrow$ Nucleus

- A cell with true nucleus
- Linear DNA with definite nuclear membrane
  Associated with a basic protein - Histone
  eg: Protista, Fungi, Plantae, Animalia

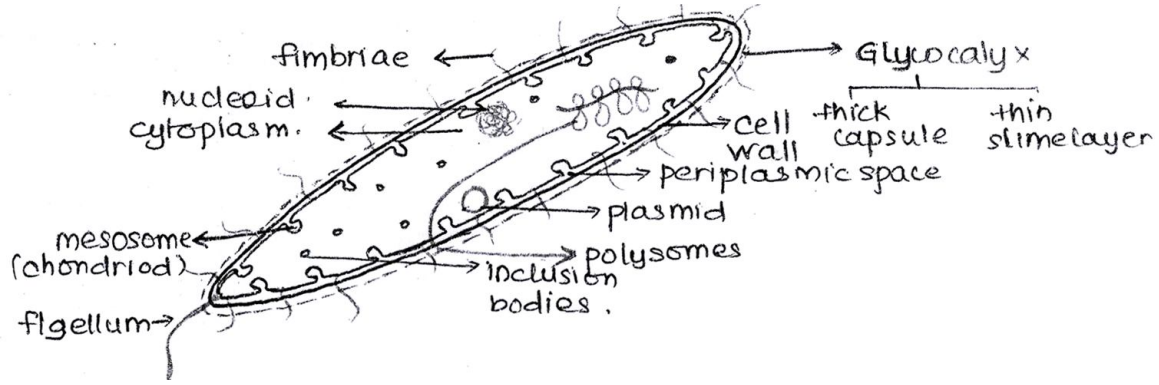
Mesokaryotic cell

- True nucleus with definite nuclear membrane and chromosome
- Chromosomes do not associated with histones
  Eg: Dinoflagellates $\rightarrow$ Desmocapsa, dinothrix

Structure of a Prokaryotic cell

eg: Bacteria

Length	: 3-5 micrometre
Diameter	: 1-2 micrometre



I) Glycocalyx

- Outer most membrane
- Heteropolysaccharide
  Monomers :
  1. glucose
  2. Glucuronic acid

A-Capsule

- Thick and rigid
- Firmly attached the cell wall
- Found predominantly in parasitic bacteria
- Protect from host immune system

B. Slime layer

- Thin and transparent
- Loosely attached to the cell wall
- Found in free living bacteria
- Provide protection from dessication

II) Cell Wall

Made up of murein/peptidoglycan

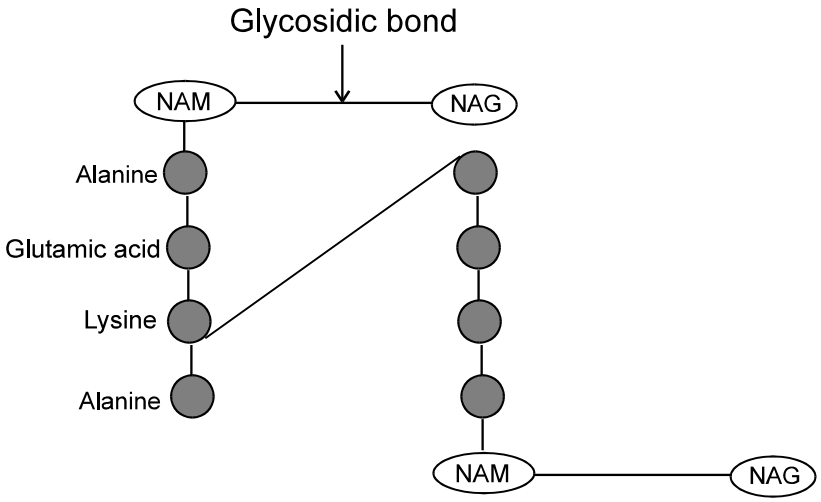
Peptido $\Rightarrow$ Amino acids

Glycan $\Rightarrow$ Heteropolysaccharide

Monomers

NAM: N-acetyl muramic acid

NAG: N-acetyl glucosamine



III) Cell membrane

- Selectively permeable

composed of:-

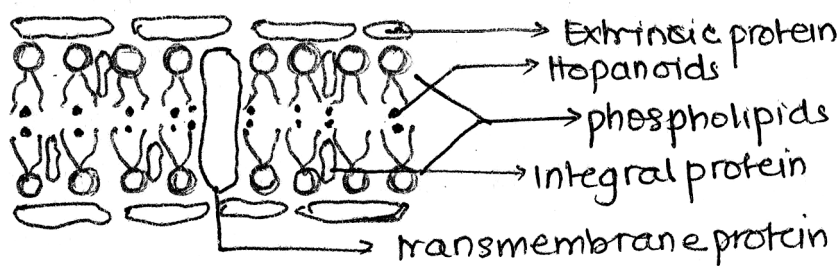
A) 2 layer of phospholipids

B) proteins

I) Integral protein or Intrinsic protein

II) Extrinsic protein

C) Hopanoids - Sterole (Cholesterol derivative) ; Provide stability of the membrane



Mesosome / Chondrioid

- Infoldings of plasma membrane

Functions:

- Cellular respiration → Functional analogous to mitochondria
- Secretion of enzyme
- DNA replication
- Cell wall synthesis
- Helps to increase surface area

Two types

1. Septal mesosome

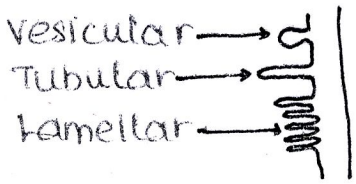
Associated with nucleoid

Function :- DNA replication

2. Lateral mesosome

Involved in secretion of enzymes, respiration etc

Form of mesosomes



IV. Periplasmic space

- Present in between cell wall and cell membrane
- Filled with a fluid - **Periplasm** contains enzymes and metabolites

V. Cytoplasm

- Membrane bounded organelles are absent

1. Nucleoid/ Genophore

- Incipient nucleus
- Single prochromosome
- Circular double stranded DNA without nuclear membrane

2. Plasmid

- Extrachromosomal circular double stranded DNA

F-Plasmid

- Fertility factor
- Contains genes responsible for sexual reproduction - conjugation
- If plasmid possess F-plasmid $\rightarrow F^+$ strain
- Do not posses F-plasmid $\rightarrow F^-$ strain

R-Plasmid

- Resistance factor
- Contains genes for resistance to antibiotics

Col-Plasmid

- Contains genes for colicin a, toxic protein produced by E-coli.

If plasmid DNA get associated with nucleoid - Episome

3. Ribosomes

70s type

50s, 30s $\rightarrow$ sub units / Monosomes

S stands for the sedimentation coefficient '**Swedberg**'. They may occur either singly or as polysome / polyribosome many ribosomes are attached on a common single mRNA to form a polysome.

Function: Protein synthesis

4. **Inclusion bodies**

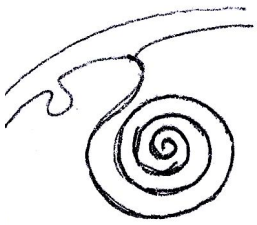
- Spherical granules
- Involved in the storage of food materials
  - Phosphate granules - volutin granules
  - Sulphur granule
  - Lipid granule
  - Glycogen granule (starch)

Cyanophycean granules - found in the cytoplasm of cyanobacteria.

Involved in the storage of cyanophycean starch.

5. Chromatophore

- Circular membrane
- Developed from plasmamembrane
- Involved in the storage of photosynthetic pigments → Bacterioviridin, Bacteriochlorophyll



6. Fimbriae

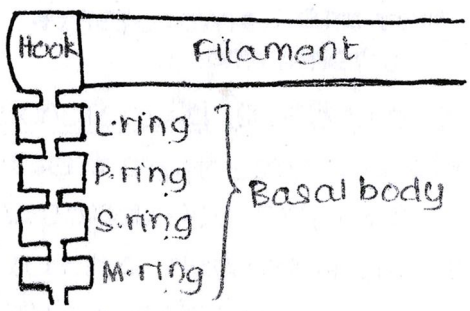
- ♦ Bristle like structures
- ♦ Made up of a protein-Fimbrin
- ♦ Helps the bacteria to attach on various surfaces

7. Pili/Pilus

- ♦ Long hollow tubular structure formed in between adjacent bacteria during conjugation
- ♦ Made up of a protein - pilin

8. Flagellum

- ♦ Locomotory structure
- ♦ Originate from plasma membrane
- ♦ Made up of a protein-flagellin
- ♦ No definite arrangement of fibrils



1. Filament

2. Middle Hook

3. Basal body

1) formed of ring shaped structures

2 rings - gram +ve bacteria

4 rings - gram –ve bacteria

L-ring: Attached to lipopolysaccharides

P-ring: Attached to peptidoglycan

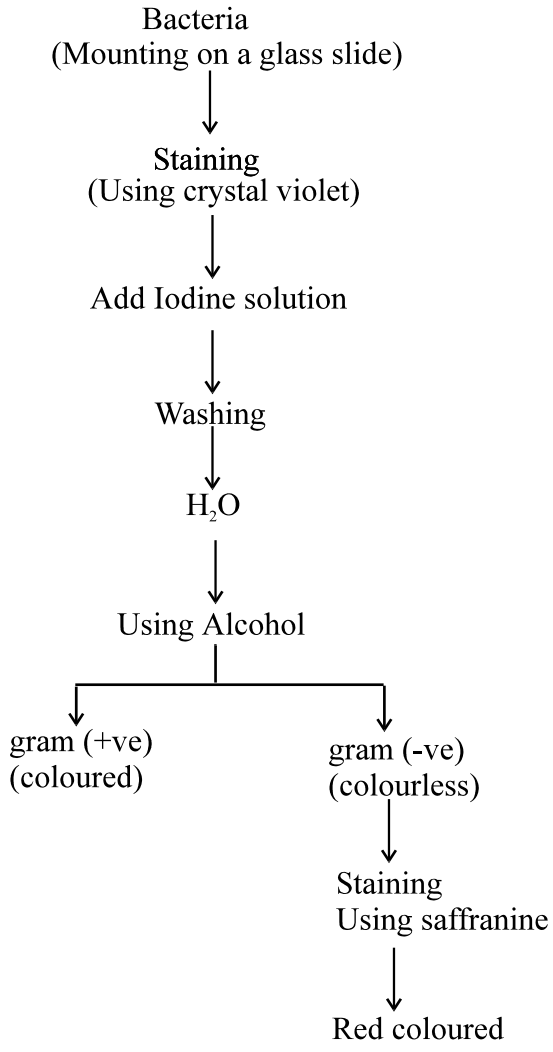
S-ring: embedded in plasma membrane

M-ring: directly attached to plasma membrane

Gram Staining Technique

Developed by Christian Gram

Stain : - Crystal violet



♦ The component of bacteria that absorb crystal violet stain during gram staining peptidoglycan (Retained by - Teichoic acid)

Gram (+ve) Bacteria	Gram (-ve) Bacteria
Thick walled	Thin walled
20 - 80 nm in thickness	8 - 12 nm thickness
Percentage of peptingoglycan 70 - 80%	Percentage of peptidoglycyan 20%
LIPID content 2 - 4%	LIPID content 20 - 30%
Porines are absent	Porines are present (Water channel)
2 rings in basal body	4 rings in the basal body
Mesosomes are very prominent	Mesosomes are less prominent
Teichoic acid (Surfaceantigen)	
Present on the surface of cell wall	Lipolpolysacchrides are present
Bacteria retains stain during gram staining	Do not retain stain
Less pathogenic	More pathogenic

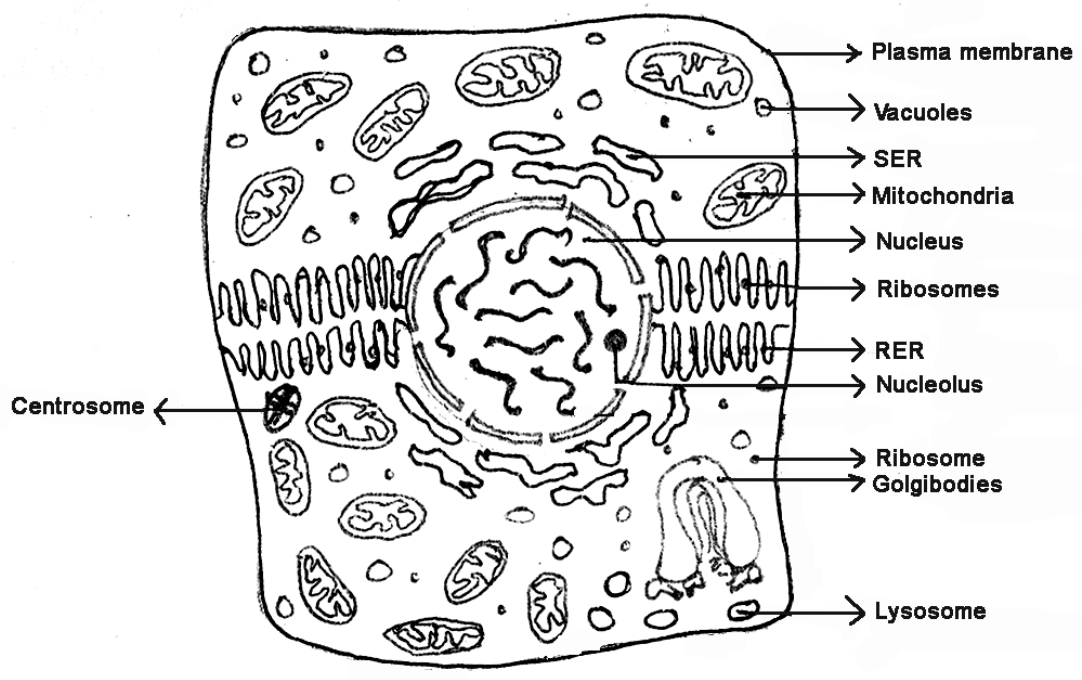
CLASSIFICATION OF EUBACTERIA ON THE BASIS OF SHAPE

Coccus $\rightarrow$ Spherical - most of them are non motile
Bacillus $\rightarrow$ Rod shaped - both motile and non motile forms
Vibrio $\rightarrow$ Coma shaped - motile and non motile
Spirillum $\rightarrow$ spiral -most of them motile

Difference between Prokaryotic and Eukaryotic Cell

Characteristics	Prokaryotic cell	Eukaryotic cell
Cell wall	Made up of peptidoglycan	Made up of cellulose and pectin
Mesosome	Present	Absent
Cholesterol	Absent	Present
Hopanoid	Present	Absent
DNA	Circular	Linear
Nuclear membrane	Absent	Present
Plasmid	Present	Absent
Histones	Absent	Present
Protamines	Present	Absent
Chromosome	Single prochromosome	Many chromosomes
Ribosome	70s	80s
Flagella	Made up of flagellin	Made up of tubulin
Compartmentalisation	Absent	Present

EUKARYOTIC CELL

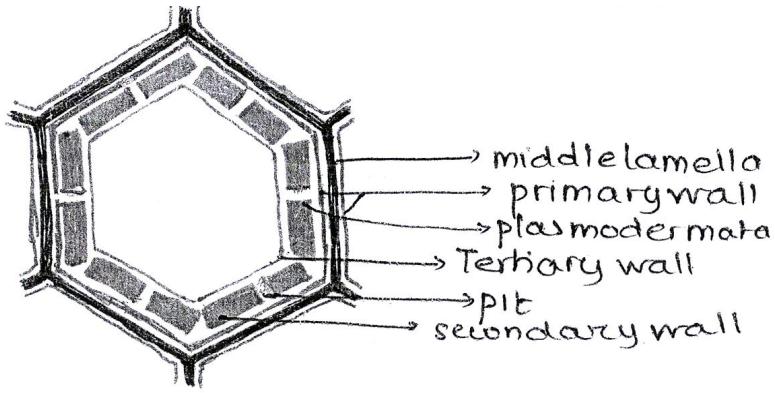


Plant cell wall ; Exoskeleton of plant cell

Cell wall materials / Ingradient

1. **Cellulose** (homopolysaccharide) → Synthesized in cell membrane
2. **Hemicellulose** (heterosaccharide) → Synthesized in dictyosomes
3. **Pectin** Heteropolysaccharide → Synthesized in dictyosomes
4. **Lignin**
   - ♦ Phenolic compound
   - ♦ Found in dead cells
   - ♦ Present in the secondary wall of sclereids, fibres, tracheids, vessels
   - ♦ Synthesised in dictyosomes
5. **Suberin**
   - ♦ Waxy
   - ♦ Water proof
   - ♦ Found in the secondary wall of cork cells and casparian strips of endodermis
   - ♦ Synthesized in sphaerosomes
6. **Cutin → lipid**
   - ♦ Found in cuticle of epidermis
   - ♦ synthesized in sphaerosomes
7. **Silica** -found in grasses
8. **Galactance** - found in algae carbohydrates
9. **Mannans** - found in algae carbohydrates
10. **Extensin** structural protein in cell wall
11. **Expansin**:- cell wall loosening enzyme during cell growth

LAYERS OF CELL WALL



Primary wall

- ♦ First formed wall
- ♦ Near to middle lamella
- ♦ Made up of cellulose, hemi cellulose and pectin
- ♦ Percentage of hemicellulose 50%

Secondary wall

- As the cell matures, secondary wall is laid in between primary wall and plasmamembrane
- Made up of cellulose, hemicellulose and pectin.
- Deposition of lignin in the secondary wall of sclerenchyma, tracheids and vessels
- Deposition of suberin in cork cells
- Provide mechanical strength
- Secondary wall formation absent in meristem
- % of Hemi cellulose 25%

Tertiary wall

- 3rd layer laid in between secondary wall and plasmamembrane
- Rare occurrence
- Already present in tracheids of gymnosperms
- Made up of xylan (monosaccharide)

Middle Lamella

- Cementing material laid in between primary wall of adjacent cells
- Composed of calcium and magnesium pectates
- More predominant - Calcium
- Present outerside of the 1^{o} wall

Plasmodesmata

- Cytoplasm of the adjacent cells are connected together through the pits by means of cytoplasmic strand
- Permit the movement of materials from cell to cell

Pit

- Depressions in 2^{o} wall
- Unthickened area of cell wall were cell wall materials are absent

Functions (Cell Wall)

- Provide shape of the cell
- Provide protection to protoplast
- Provide strength rigidity and flexibility
- Transport of materials

PLASMA MEMBRANE

(Cytoplasmic membrane / plasmalemma)

- Living outer boundary of protoplasm
- Plasmamembrane is vital to the cell as it controls the entry and exit of substances to and from the cell
- Some membranes are semi permeable. eg: egg membrane $\rightarrow$ allow solvent only
- In eukaryotes most membranes are selectively/differentially permeable

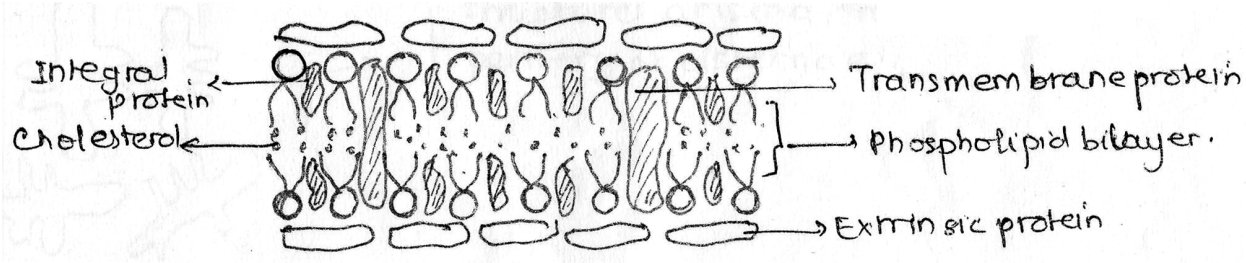
Allow solvent and some solutes

Models of cell membrane

I) Sandwhich model - Proposed by Danielli and Davison

II) Unit membrane model - Robertson

III) Fluid mosaic model - S.J Singer and G.L Nicolson (1972)



Protein icebergs in the sea of lipids

According to this model all biological membranes are quasi fluid structure where lipids and proteins are dispersed in a mosaic manner

1. Glycerophospholipids/ (Phosphoglycerides) → Major Phospholipids

- Amphipathic molecule due to hydrophilic head and hydrophobic tail
- Phospholipid layer provide fluidity to cell membrane.
- Lipid bilayer shows flip-flop movement (transverse diffusion)
- Quasi fluid nature of lipids enables lateral movement of proteins within lipids

2. Cholesterol

- Provide stability of membrane
- Human RBC; cell membrane contains;- 52% proteins and 40% lipids

3. Spectrin (Extrinsic protein)

- Extrinsic protein present in the cell membrane of RBC

4. Glycoprotein

- Act as recognition site
- Site for attachment and provide antigen specificity to cell membrane

Functions of Plasma membrane

❖ **Passive Transport**

Movement of molecules across the membrane along the concentration gradient without the expenditure of energy

eg: 1: Simple diffusion

Movement of lipphilic substances

eg: 2: Fasciliated diffusion

Movement of hydrophilic molecules across the membrane along the concentration gradient through transmembrane protein (have specialised gate ways)

❖ **Active Transport**

Movement of molecules across the membrane against the concentration gradient with expenditure of metabolic energy

eg 1: Absorption of mineral elements

❖ **Bulk transport**

Movement of materials across the membrane with the help of carrier vesicles

1) Endocytosis

Movement of materials into the cell

Phagocytosis:- Engulfing of solid materials

Pinocytosis:- Engulfing of liquid substances

2) Exocytosis/ Emiocytosis / Cell vomiting

Elimination of waste materials from cell

Note: Movement of molecules from a region of higher concentration to the region of lower concentration is called diffusion.

Osmosis

Diffusion takes place through a membrane

CYTOPLASM

Endomembrane system:-

1. ER
2. Golgi bodies
3. Lysosomes

} GERL complex

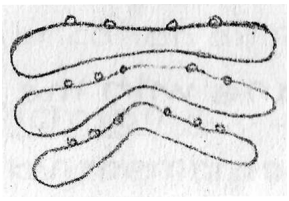
4. Vacuole

Endoplasmic Reticulum

- First reported by Keith Porter (1945)
- ER is more or less continuous with plasma membrane and Nuclear membrane
- Lipoproteinaceous
- Single membrane bounded

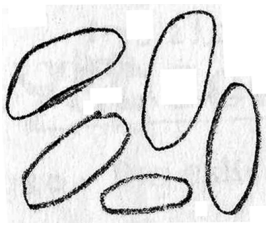
Structural components:-

1. Cisternae



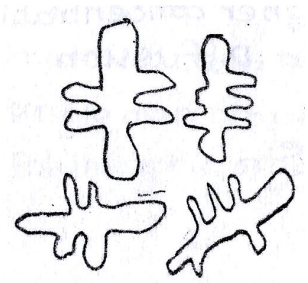
Elongated flattened. Single membrane bounded sac like structures arranged parallely in a bundle. If ribosomes are attached on their surface, they appear as granular or rough surfaced

2. Vesicles

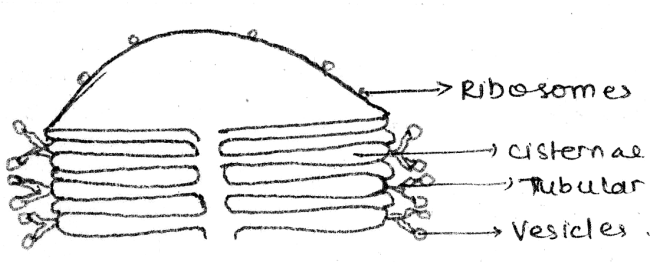


Circular oval or droplet like structures arranged at the terminal position of the tubule

3. Tubules



Cylindrical irregularly branched structures arising from the periphery of cisternae



RER	SER
Ribosomes ar attached to its surface	Ribosomes are absent
Ribophorin (protein) I & II are present (Helps to attach ribosomes on the membrane of ER)	Ribophorins are absent
Consists of cisternae and few tubules	Consist of vesicles and tubules
More stable	Less stable
Developed from nuclear membrane and plasmamembrane	Developed from RER
	Sarcoplasmic Reticulum
	SER present in muscles
Functions :	Functions : Storage of Ca^{2+} ions for contraction of muscles
Protein Synthesis	SER in liver
Secretion	Function : detoxification of toxic substances
	General functions :
	Synthesis of lipids
	Steroid hormones
	Glycogen
	Give rise to sphaerosomes
	Myeloid bodies : SER in retina of frog

GOLGI BODIES

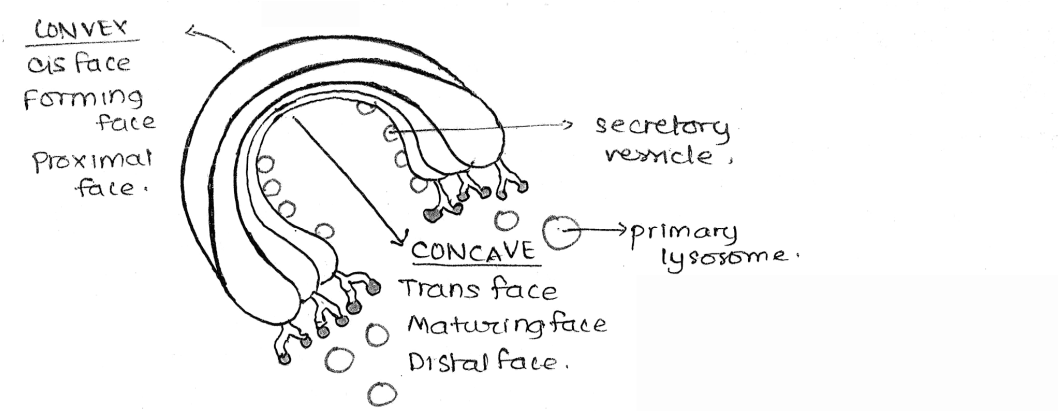
(Dictyosomes in plant cells)

- Middle man of the cell
- Lipochondria
- Trophospongium
- Idiosome
- Baker's Body

First discovered by **Camillo Golgi**

$(0.5\mu m - 1\mu m)$

- Pleomorphic organelle
- Composed of 4 structural components
  1. Cisternae
  2. Tubules
  3. Vesicles
  4. Golgian vacuoles /Golgian vesicles



cisternae possess i) convex face-

- cis face
- forming face
- proximal face

ii) concave face-

- Trans face
- Maturing face
- Distal face

Functions

1) Packaging of material
2) **Glycosilation**

   Conversion of protein and lipids into glycoproteins and glycolipids by the addition of carbohydrate
3) Formation of primary lysosomes
4) Formation of acrosome in sperm cell:- contains **Lytic enzyme** which helps to digests the envelope of ovum
5) Secretion of enzymes
6) Synthesis of Lignin
7) Synthesis of polysaccharides, hemicellulose, pectin
8) Transformation & Recycling of plasma membrane

Imp.point

Zone of exclusion

- Cytoplasm surrounding golgibodies having few or no organelles
- Golgi bodies are absent in male gamete of Bryophytes and pteridophytes, mammalian RBC, sieve tube of plant cell, and cell of fungi
- Golgibodies are considered as Macromolecular traffic in cell
- Root cap is rich in Golgi bodies to secrete mucilage for the lubrication of root tip

"Microsome"

Broken membrane of ER and Golgi bodies obtained by high speed centrifugation

LYSOSOME

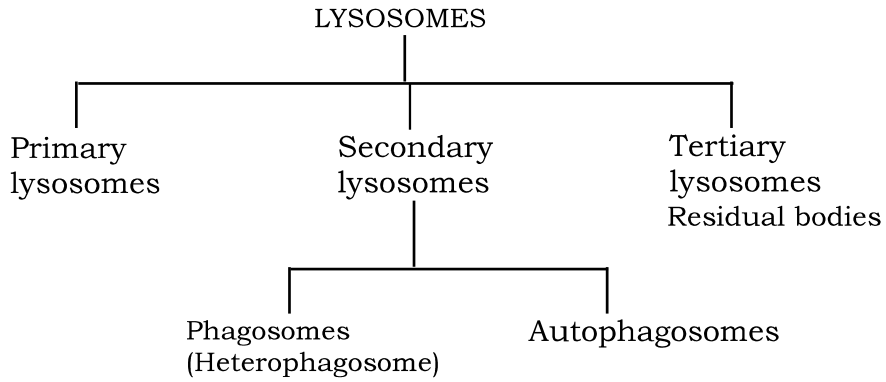
(Lyso-Digestive : Soma-body)

The term coined by christian de Duve (1965)

Saccate structures filled with digestive enzymes (hydrolases)

- Amylase
- Protease
- Lipase
- Sulphatases
- Phosphatases
- Nucleases

- Hydrolytic enzymes are active at acidic PH
- Single membrane bounded
- Polymorphic organelle



Primary Lysosomes

- Developed directly from Golgibodies in associate with ER
- Enzymes in primary lysosome are in inactive form

Secondary Lysosomes

Phagosomes (Heterophagosomes)

- When a foreign substance enters into cytoplasm, plasma membrane invaginates around that substance and form a sac and they are fused with primary lysosome.

Autophagosomes (cytolysosome)

- Vesicles formed by the fusion of many lysosomes with old or unwanted organelles

Residual Bodies (Telolysosomes)

- Vesicles containing undigested materials

Functions

1) Digestion of food materials
2) Digestion of harmful materials
3) Autophagy : A mechanism to digest a part of cell without destroying the entire cell
4) Autolysis : During cell death all the lysosomes in a cell breaks open and release their enzymes which digest the whole cell. So lysosomes are commonly known as suicidal bags in cells

Imp.point

Membrane stabilizer	Membrane labilizers
1) Cholesterol	Membrane become more fragile that
2) Chloroquine	increase the chance of autolysis
3) Cortisone	Vit A, Vit B, Vit E, Vit K
	Bile salt, Progesterone, Testosterone

Vacuole

1. Gas vacuole
Found in photosynthetic prokaryotes/Cyanobacteria
Function : Buoyancy

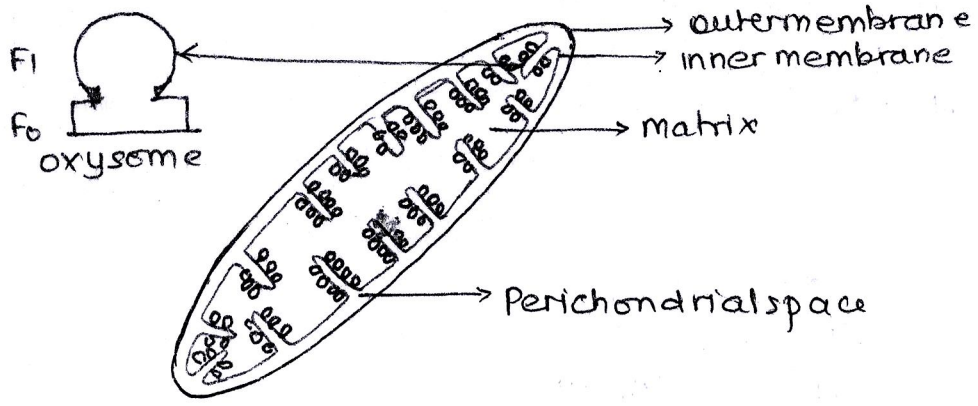
2. Sap vacuole
Found in plant cells
occupy 90% volume of cell enveloped by a membrane tonoplast,
Selectively permeable
Function : Storage K^+ ions, acetic acid, water, starch, anthocyanin, water soluble pigment which impart various colours to petals and varigated leaves

3. Contractile vacuole
Found in protistants such as Amoeba, Paramoecium, Euglena
Functions : excretion, osmoregulation

4. Food vacuole
Secondary lysosome involved in the digestion of food materials

MITOCHONDRIA

- First observed by kollicker in striated muscles of insects
- In plants, mitochondria were discovered by nerves In Nymphaea
- The term coined by C Benda
- Number of mitochondria found maximum in animals - (flight muscles of birds)
- Maximum enzymes are found in mitochondria
- semiautonomous due to the presence of DNA (circular double stranded) RNA, ribosomes(70s) → resemblance to bacteria.
- Endosymbiont
  Living inside the eukaryotic cell with symbiotic relationship
- Presence of porines in their membranes - Resemblance to gram -ve bacteria
- Stained by **Janus Green - B**
- Replicated by **fission method**



- Double membrane bounded
- Selectively permeable

- Perimitochondrial space - present in between outer & inner membrane
- Cristae : foldings of inner membrane
- Inner membrane more selectively permeable
- Matrix: fluid part contains genetic material, ribosomes & enzymes

  2 major phases of respiration takes place in mitochondria

  i) Krebs cycle $\rightarrow$ Matrix

  ii) Terminal oxidation $\rightarrow$ Inner membrane

Oxysome: ATP synthase complex / elementary particles/ F_0 - F_1 particles / Fernandez-Moran particles.

- Functional unit of mitochondria
- Discovered by Fernandez Moran
- Consists of 2 region

1) F1 - Spherical head

- Protrudes towards matrix
- Hydrophillic
- Catalytic site : ATP synthase present.
- Formed of 5 different polypeptides

2) F0-basal stalk

- Embedded in the membrane
- Hydrophobic
- A channel protein through which protons flow from perimitochondrial space towards matrix
- Formed of 4 different polypeptides

Mitochondria are commonly known as:

i) Powerhouse - site of cellular respiration
ii) ATP factory
iii) Cellular furnace
iv) Cellular battery energy distribution
v) Bioblast - Coined by **Altman**

- Total number of mitochondria in a cell: **Chondriosome**
- Mitochondria without outer membrane $\rightarrow$ Mitoplast

PLASTIDS

The term coined by Haeckal

- Storage organelles found in plants & euglena
- All plastids are developed from proplastids

1. Leucoplast

- First developed
- Colourless
- Abundantly found in underground storage organs

  a) Amyloplast store starch. eg. Potato

b) Aleuroplast (Protonoplast) store protein

c) Elaioplast stores Fat / Triglycerides. eg. Oil seed / Castor seed

2. Chloroplast

- ❖ Endosymbiont
- ❖ Semiautonomous
- ❖ Enveloped by 2 unit membrane, selectively permeable
- ❖ Periplastidal space present in between outer and inner membrane
- ❖ Internally chloroplast composed of a system of single membrane bounded flattened sac like

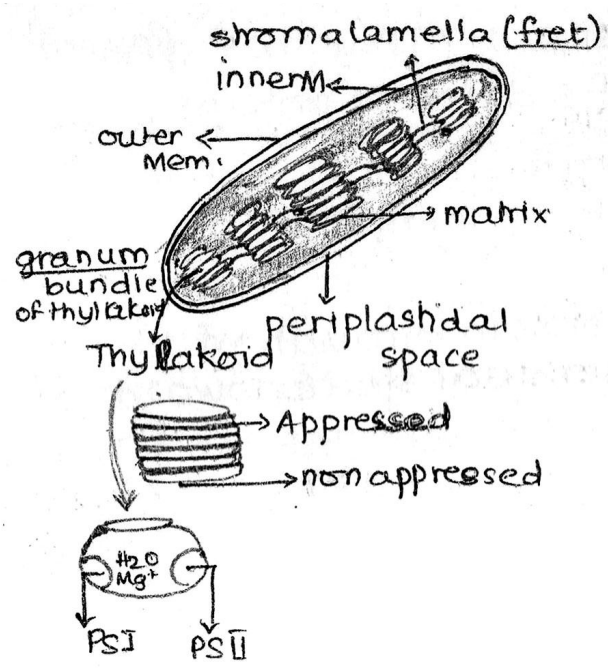
Thylakoid

- ❖ The term coined by Menke
- ❖ The space inside the thylakoid sac-lumen
- ❖ On the surface of thylakoid membrane oxysomes are arranged
- ❖ Grana are interconnected by frct/stroma lamellae

Granum

- ❖ Stacks of thylakoid.
- ❖ Grana are embedded in a colourless

Matrix stroma contains genetic materials, ribosomes and Photosynthetic enzymes (Rubisco)



Photosystem

It is an organised structure composed of pigments and proteins

Photosynthesis involves 2 major events.

i) Light phase:- (Photo chemical phase)

Site: grana, Metabolic energy production phase

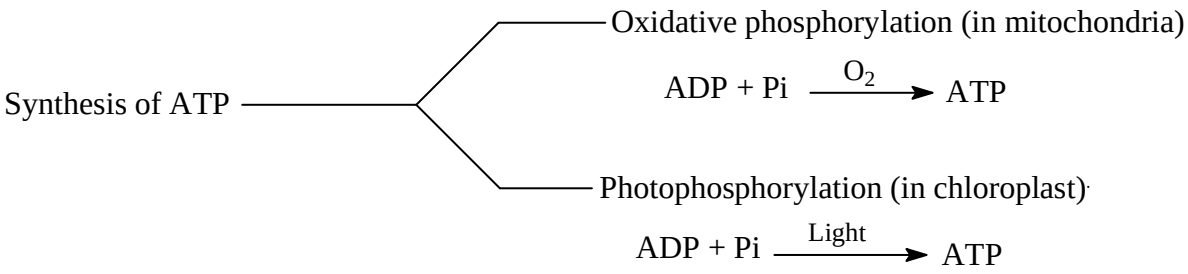
ii) Dark phase:- (biosynthetic phase)

Site: Stroma, Synthesis of carbohydrates

3. Chromoplast

- Various coloured
  - a) Carotene → Orange colour
  - b) Xanthophyll → Yellow colour
  - c) Lycopene → Red pigment that impart red colour to ripened chilli and tomato

Resemblance between chloroplast and Mitochondria
Double membrane bounded
Endosymbiont
Circular double stranded DNA
Semi autonomous
RNA
70s type of ribosomes



Ribosomes

- First discovered by George Palade
- Also called palade granule
- RNP particles. (Ribo Nucleoprotein particles) formed of Ribo Nucleic acid (RNA) + Protein
- rRNA-Ribosomal RNA
- Smallest organelle
- Nucleolus is the active site of ribosome synthesis
- Do not have a membrane surrounding them.

*Found in :- Cytoplasm of bacteria (prokaryote)
Matrix of mitochondria
Stroma of chloroplast
→ 70s type
Monosomes : 50s, 30s

Cytoplasm of eukaryote
on the surface of RER
→ 80s type
Monosomes : 60s, 40s

It is an organelle also found inside another organelle

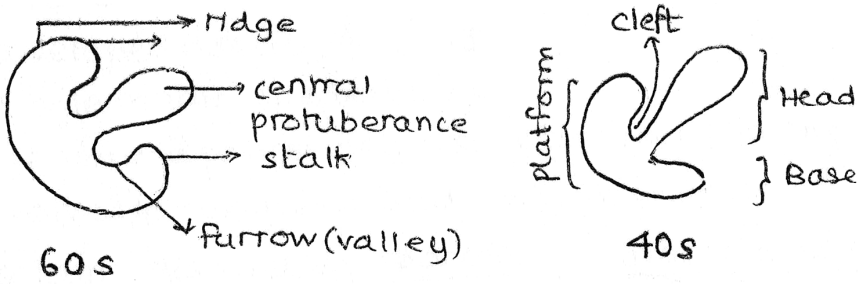
Chemical composition :

70s type:

60% RNA +40% Protein

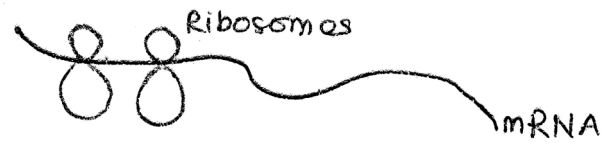
80s type:

40% RNA + 60% Protein



Magnesium ions form ionic bond with phosphate group of RNA of 2 subunits

- Minimum 0.001 micron Mg concentration is required for the structural formation of ribosomes.



Functions :

- Protein synthesis

Microbodies

Glyoxisomes

* Found only in plant cell
* Abundantly found in oil seeds

Functions :

* Glyoxilation
* Conversion of oils into glucose
* during germiantion of seed

Peroxisomes

* Found in both plant and animal cells
* Contains enzymes such as oxidases, catalases
* Involved in photorespiration in plant cells

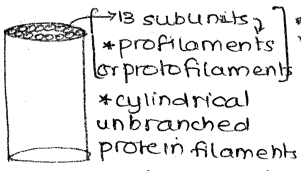
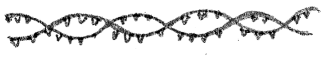
Sphaerosomes (only in plants)

- Plant lysosomes
- Oleosomes
- Developed directly from SER
- Single membrane bounded
- Membrane possess only a single layer of phospholipids
- Involved in synthesis and storage of lipids

Certain cells such as root cells of maize and endosperm cells of tobacco - Sphaerosomes store digestive enzyme . Hence called plant lysosome

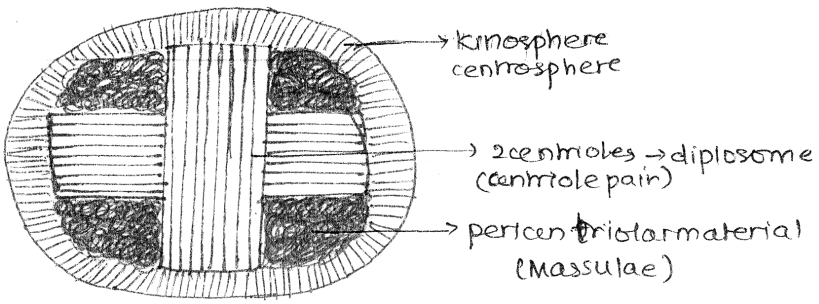
CYTOSKELETON

- Protein filament
- Present in the cytoplasm of eukaryote
- Responsible for * motility
  * support organelles
  * provide shape of the cell

Microtubule	Microfilament	Intermediate filament
		
formed of 13 subunits Profilaments / Protofilaments	made up of protein - actin	intermediate size between microtubules and microfilament
Profilaments are made up of protein - tubulin - both and tubulin	found in muscles and microvilli of intestine	hard and durable
found in centole spindle fibres - cilia size : 25nm	**Function : -** Contraction of muscles Movement of microvilli Cycloses movement Cycloplasmic streaming movement size : 6-10nm (diameter)	made up of protein, vimentin, lamin, desmin, keratin
microtubules rich in calcium ions		Found in neuron, nucleus, hair, nail size : 8 - 10 nm

Centrosome

- Found in animals and lower plants (Bryophytes)
- Located near nucleus



1. Centriole

Paired microtubule

- 27 microtubule are arranged as 9 triplet
- Non membraneous

Centriole along with centrosphere comprise a centrosome.

2. Diplosome

- Paired centriole

3. Pericentriolar material /Massulae

- Amorphous substance around diplosome.

4. Centrosphere / Kinoplasm

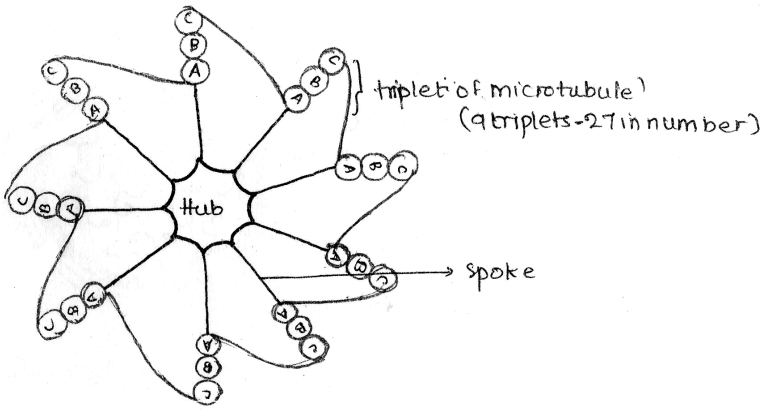
- Fluid part around diplosome.

MTOC

Microtubule organizing centre- Independent group of microtubules in plant cell.

- Spindle fibres are developed from microtubules present in MTOC in plant
- In animals spindle fibres are arising from microtubules present in centriole.

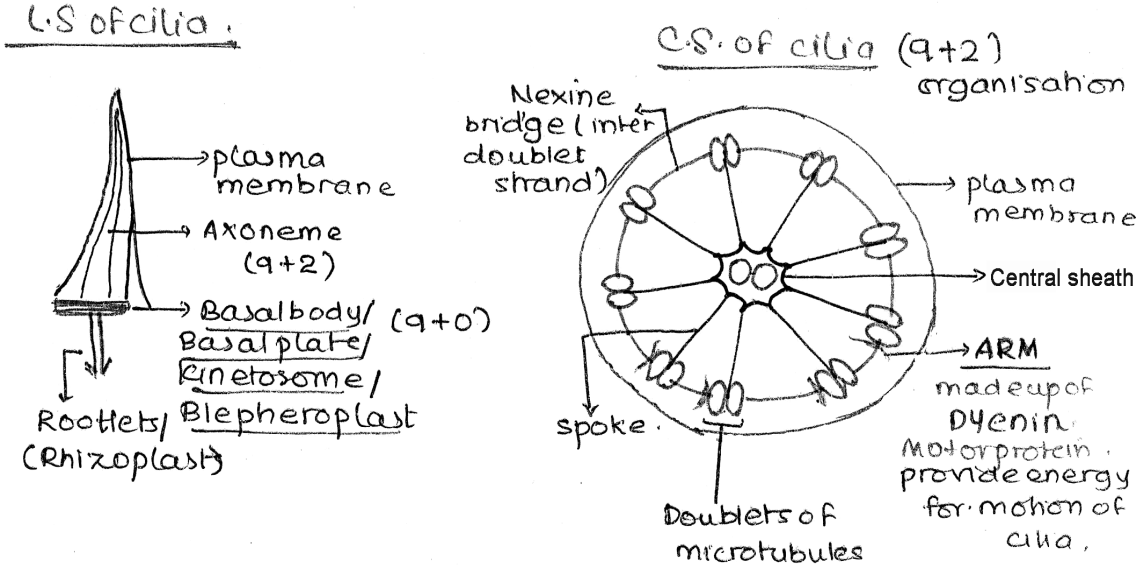
Generally spindle fibres are formed from microtubule.



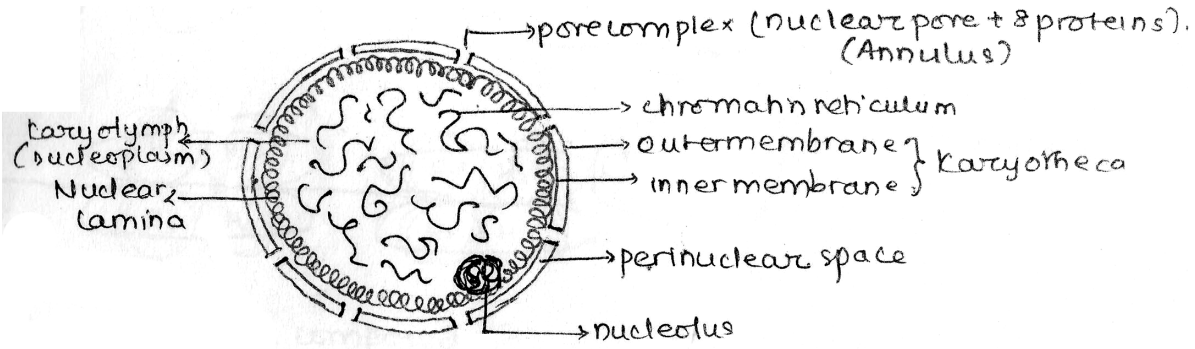
art wheel organisation:

- 9 + 0 arrangement
- **Hub** : Central proteinaceous part
- **Spoke** : A radiating protein strands arising from central hub.

At the terminal position of each spoke carry triplet of microtubules.



NUCLEUS



- Head Quarters of the cell
- Largest part of eukaryotic cell

Karyotheca

- Nuclear membrane is double layered with several pores.

Pore complex

- Nuclear pores is associated with 8 protein (Annuli)

Perinuclear space

- Present in between outer and inner membrane

Nuclear lamina

- Intermediate filaments in nucleus

Karyolymph / Nucleoplasm

- Fluid part in nucleus contains RNA polymerases, DNA and nucleolus

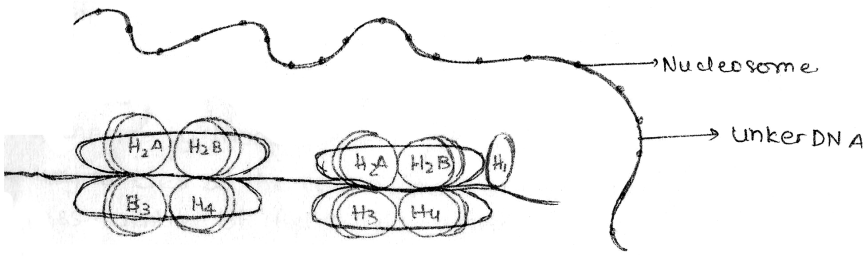
Nucleolus

Discovered by Fontana

Spherical structure which are the site of ribosome synthesis

Chromatin fibre

Term coined by **Walther Fleming**



Chromatin fibre composed of

i) DNA 31%

ii) RNA 2-5%

iii) Histone 36% $\rightarrow$ Basic protein

It is a basic protein

iv) Non Histone 28% $\rightarrow$ Acidic protein

- Strings and beaded appearance
- Nucleosome is formed of eight Histones

Histones are of 5 types:-

$H_1 \rightarrow$ Lysine rich

$\left.\begin{matrix} H_2A \\ H_2B \end{matrix}\right\}$ Slightly lysine

$\left.\begin{matrix} H_3 \\ H_4 \end{matrix}\right\}$ Argenine rich

Nucleosome consists of

1. One pair of H_2A
2. One pair of H_2B
3. One pair of H_3
4. One pair of H_4

Nucleosomes are the structural elements in chromatin.

Nucleosomes + H1 (sealing protein) ⟶ Chromatosome

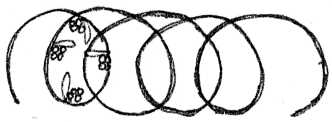
Euchromatin

- Light stained
- Diffused part of chromatin
- Genetically more active
- Lies at the central part of nucleus
- Less number of Histone proteins

Heterochromatin:

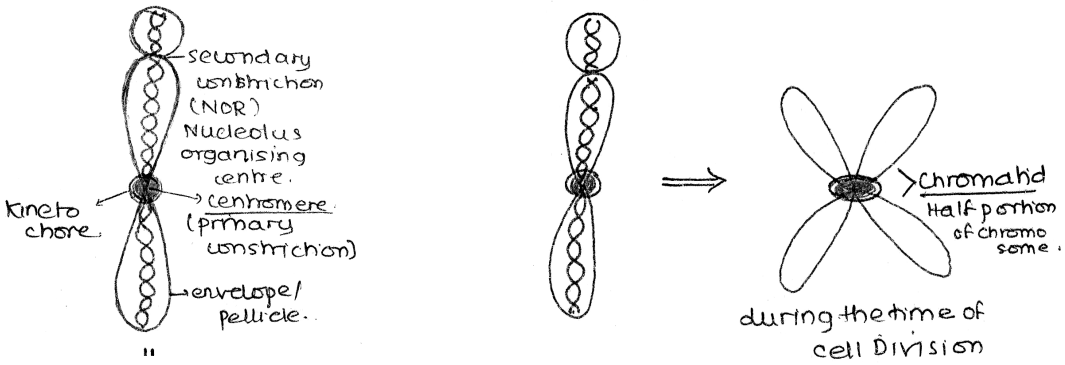
- Dark stains
- Condensed part of chromatin
- More histones
- Genetically less active
- Occur near nuclear membrane

Solenoid



- Coiled chromatin fibres in interphase nucleus
- Spirally coiled structures ,each coil possess nucleosomes
- All the H_1 histone project to the centre

CHROMOSOME



- Chromosomes were fist discovered by Hofemeister in the pollen grains of Tradescantia.
- Term coined by Waldeyer

Chromosome

Chromosome is a nucleoprotein structure

Nucleoprotein Structure

Nucleic Acid (DNA)

Protein (mainly histones)

- Chromosomes contains many genes
- Pellicle: envelope of chromosomes
- A chromosome consists of centromere (primary construction) with 2 arms
- Kinetochore: Disc shaped protein found on either side of the primary construction.

Telomere

- Terminal position of chromosome / Non-sticky end of chromosome
- Rich in guanine base
- It contains telomerase enzyme (Ribo nucleo protein)
- Some chromosomes contains secondary constructions.

Secondary construction I

- Found in chromosome no: 13, 14, 15, 21, 22

Secondary construction II

- Found in chromosome no: 1, 10, 13, 16 and Y chromosome
- The part after secondary construction area is called SAT.
- SAT [Sine Acid Thymonucleinico]
- The part which is present after secondary construction

Karyotype

- Morphology of chromosome
- Morphology of chromosomes can be best studied in metaphase
- Stain used for the study of karyotype analysis:-

  Acetocarmine

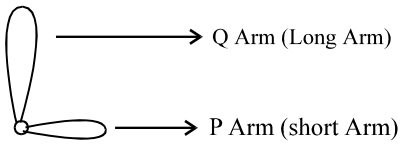
  Giesma

  Fuelgen

Classification of chromosomes on the basis of position of centromere

i) Metacentric - Centromere is in the median position of chromosome producing 2 equal arms.

ii) Submetacentric - Centromere is slightly displaced from the centre forming one long + another slightly short arm



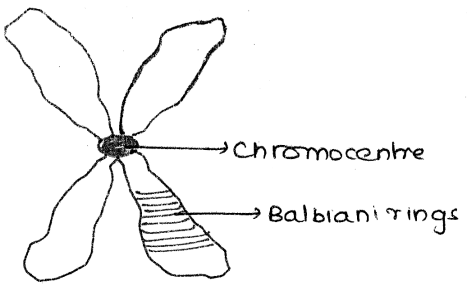
iii) Aerocentric - Centromere is located subterminally forming a very short and a long arm

iv) Telocentric - Centromere is situated at the end of chromosomes

Giant chromosome

1. Polytene

Present in the salivary gland of insects



Discovered by E G Balbiani

- Genetically more active
- Active site of the synthesis of mRNA and protein
- Best studied in interphase

2. Lamp Brush Chromosome

- Found in oocytes of amphibians
- Clearly visible in diplotene stage of meiosis

Plant Cell	Animal Cell
Cell wall present	Cell wall absent
Large vacuole	Small many vacuoles
Plastids present	Plastids absent
Centrosome absent	Centrosome present
Glyoxisome present	Glyoxisome absent
Mitochondria are fewer in number	Numerous mitochondria

Desmotubule

- ER of adjacent cell are connected together through a channel Desmotubule.
- pH of cytoplasm $\rightarrow$ Slightly acidic