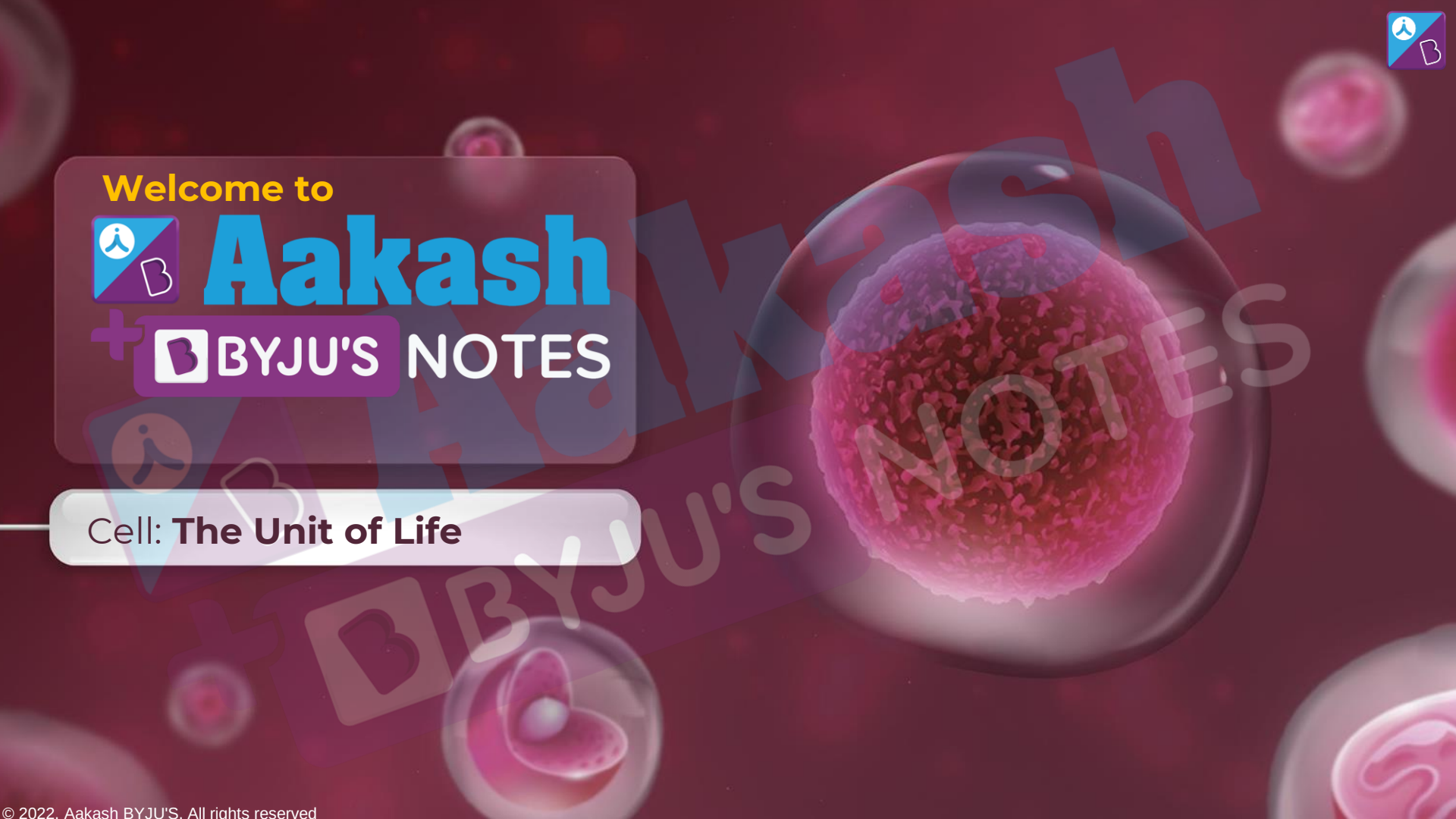
Welcome to

Aakash BYJU'S NOTES

Cell: **The Unit of Life**



© 2022, Aakash BYJU'S. All rights reserved

Key Takeaways

- Cell
  - Cell theory
  - Classification of cell
- Prokaryotic cell
  - Characteristics features
  - Cell envelope
  - Cytoplasm

© 2022. Aakash BYJU'S. All rights reserved

Eukaryotic Cell

- Characteristics features
- Cell membrane
- Endomembrane system
- Plastids
- Cytoskeleton
- Cilia and Flagella
- Microbodies
- Cell Wall
- Cytoplasm
- Mitochondria
- Ribosomes
- Centrosome and centrioles
- Nucleus

Summary

© 2022, Aakash BYJU'S. All rights reserved

Cell

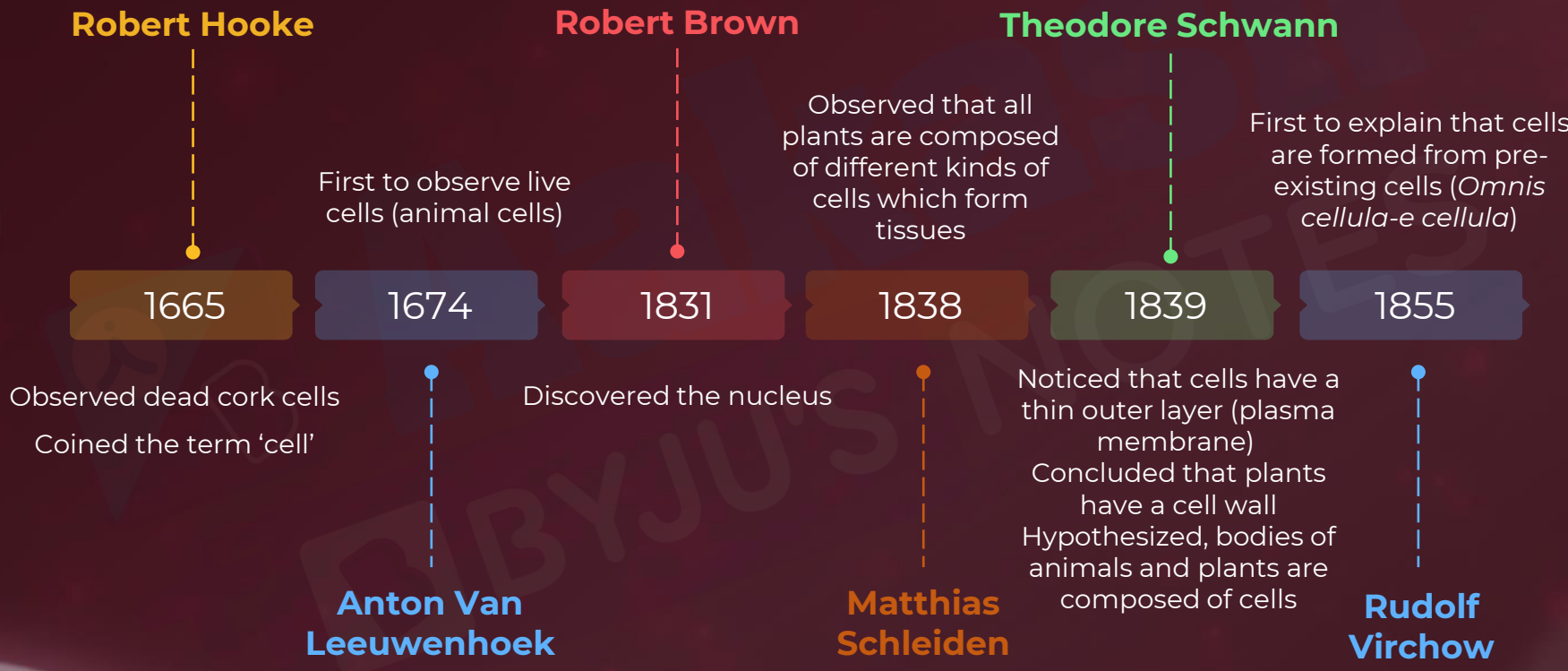
Cell is the **fundamental, structural,** and **functional** unit of life.

Cell is capable of

- independent existence
- performing essential functions of life

© 2022, Aakash BYJU'S. All rights reserved

Cell Theory



© 2022, Aakash BYJU'S. All rights reserved

Cell Theory

- **Matthias Schleiden** and **Theodore Schwann** identified key differences between the two cell types and put forth the idea that cells were the fundamental units of both plants and animals.

MATTHIAS SCHLEIDEN (1838)

Observed that all plants are made up of different types of cells

CELL THEORY

All plants and animals are composed of cells and cell products

THEODORE SCHWANN (1839)

Observed that all animals are made up of different types of cells

© 2022, Aakash BYJU'S. All rights reserved

Cell Theory

- **Rudolf Virchow** modified the hypothesis of Schleiden and Schwann to give the cell theory a final shape.
- Rudolf Virchow first explained that **cells divide,** and **new cells are formed from the pre-existing cells** (*Omnis cellula-e cellula*).

CELL THEORY

All plants and animals are composed of cells and cell products

MODERN CELL THEORY

All organisms are composed of cells and cell products

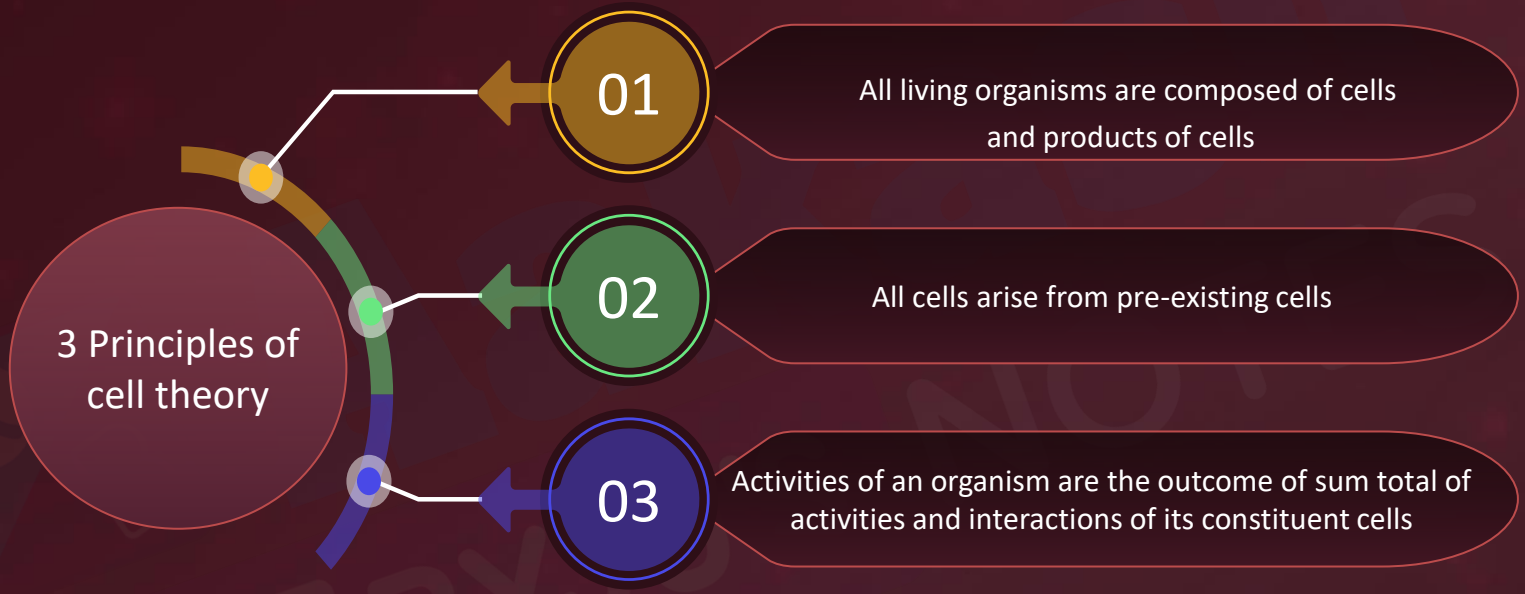
All cells arise from pre-existing cells

RUDOLF VIRCHOW (1855)

Omnis cellula e cellula

© 2022, Aakash BYJU'S. All rights reserved

Cell Theory



- Exception to cell theory:

  Viruses are not made up of cells. They are composed of nucleoprotein particles. Therefore, they are not considered either living or non-living.

© 2022, Aakash BYJU'S. All rights reserved

Did You Know?

The smallest cell

Mycoplasma
0.3 µm in length

The largest cell

Ostrich egg
Largest isolated single cell

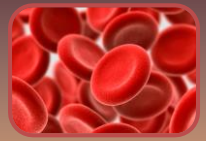
The longest cell

Nerve cell of giant squid

© 2022, Aakash BYJU'S. All rights reserved

Classification of Cell

Based on shape:



RBCs

Disc shaped

Skin cells

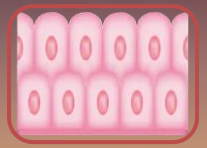
Polygonal

Neuron

Thread-like

Large intestine cells

Columnar

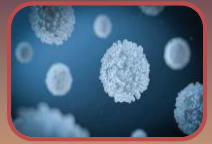


Salivary ducts lining

Cuboidal

Amoeba

Irregular

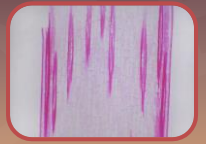


WBCs

Amoeboid

Mesophylls

Round and oval



Tracheids

Elongated

Based on size:

0.02 to 0.2 µm

Virus

Mycoplasma

0.3 or 0.1 µm

Bacterium

1 to 2 µm

Prokaryotic cell

Animal cell

Plant cell

10 to 20 µm

Eukaryotic cell

© 2022. Aakash BYJU'S. All rights reserved

Classification of Organisms

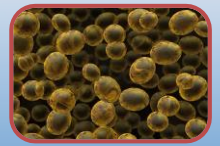
Based on number:

Unicellular organism:

- Made up of a single cell
- Functional unit which is capable of respiration, excretion, etc. and capable of independent existence


Bacteria


Amoeba


Yeast

Multicellular organism:

- Made up of more than one cell
- Specialised cells perform different functions
- Cells then interact with one another to maintain life


Plants


Animals

Based on the organisation of genetic material:

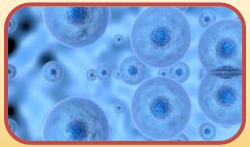
Prokaryotic organism:

- Cells without a well-defined nucleus
- Genetic material is not enclosed in well-defined membrane-bound structure


Prokaryotic organism

Eukaryotic organism:

- Cells with a true nucleus
- Genetic material is bound by well-defined structure

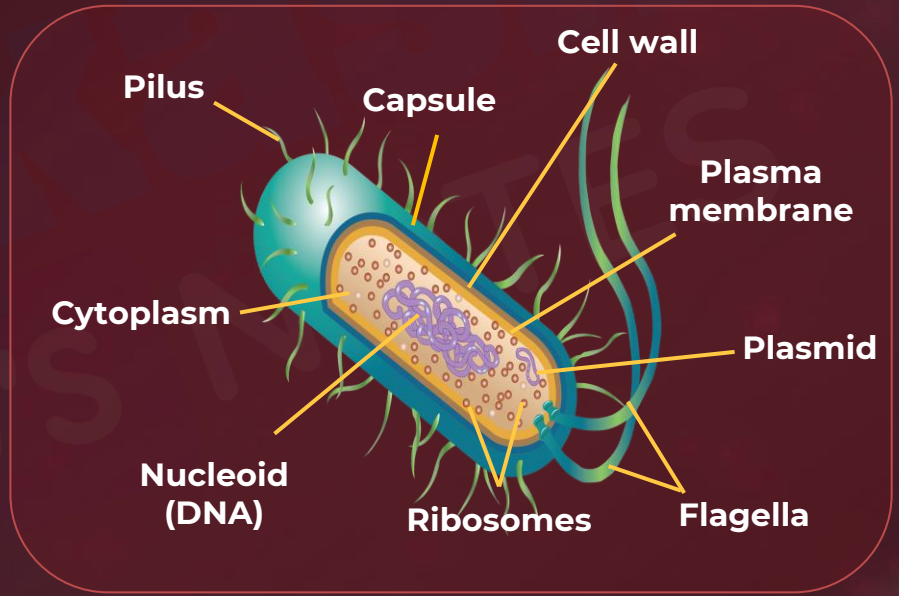

Eukaryotic organism

© 2022. Aakash BYJU'S. All rights reserved

Prokaryotic Cells

Characteristic features :

- Lack membrane-bound organelles such as endoplasmic reticulum (ER), Golgi complex, lysosomes, mitochondria, microbodies and vacuoles. **Exception: Ribosomes** (non-membrane bound)
- Represented by bacteria, Pleuropneumonia like Organisms (PPLO), blue green algae, *mycoplasma*
- Generally **smaller** in size and **multiply more rapidly** than eukaryotic cells
- Cell wall surrounds cell membrane (**except *Mycoplasma***)
- No **well-defined nucleus,** as it is not enveloped by a membrane. **Genetic material is naked**
- Fluid matrix filling the cell is **cytoplasm**
- Many bacteria have **smaller circular DNA** outside genomic DNA called **plasmids.**
- Unique characteristics - **antibiotic resistance** to bacteria

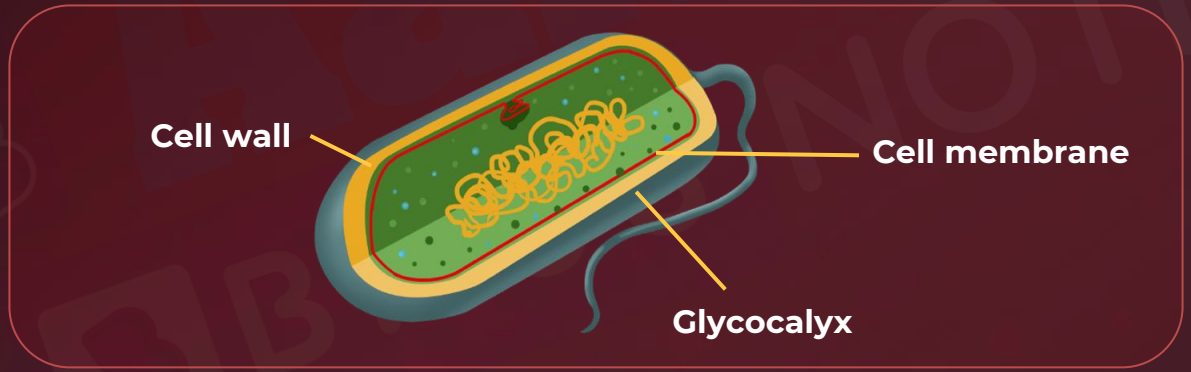


© 2022, Aakash BYJU'S. All rights reserved

Cell Envelope

Cell envelope
consists of complex, three-layered structure

- **Glycocalyx** (outer)
- **Cell wall** (middle)
- **Cell membrane** (inner)



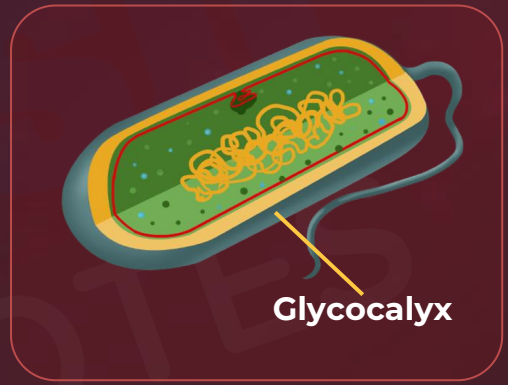
- Each perform different functions but act together as a single protective unit.

© 2022, Aakash BYJU'S. All rights reserved

Cell Envelope

1. Glycocalyx :

- **Outermost layer** of cell envelope
- Has a coating of mucous or polysaccharides macromolecules, which protects the cells and helps in adhesion
- **Composition -** (Carbohydrate + proteins) and thickness vary among different bacteria



Glycocalyx

Slime layer

- Loose sheath
- Protects from loss of water

Capsule

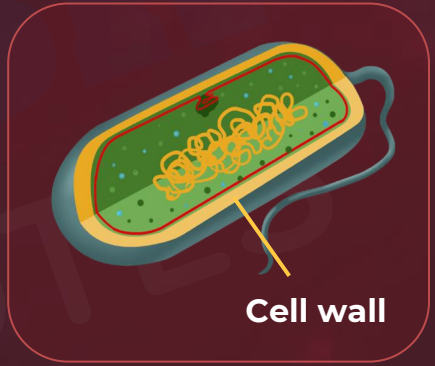
- Thick and tough layer
- Provides gummy and sticky character to the cell
- Allows bacterium to hide from host's immune system

© 2022, Aakash BYJU'S. All rights reserved

Cell Envelope

2. Cell wall :

- **Middle layer** of the cell envelope
- Provides **shape** and **strong structural support** to the bacteria from bursting or collapsing
- **Rigid** due to a special macromolecule called peptidoglycan (murein or mucopeptide), polymer of **N-acetylglucosamine (NAG)** and **N-acetylmuramic acid (NAM)**
- Number of antibiotics (e.g., penicillin) inhibits cross-linking of peptidoglycan strands. Therefore, cells undergo lysis in the presence of these antibiotics
- **Gram staining** is a special technique, which classified bacteria into two groups, viz. **Gram-positive** and **Gram-negative** bacteria.



© 2022, Aakash BYJU'S. All rights reserved

Cell Envelope

2. Cell wall :

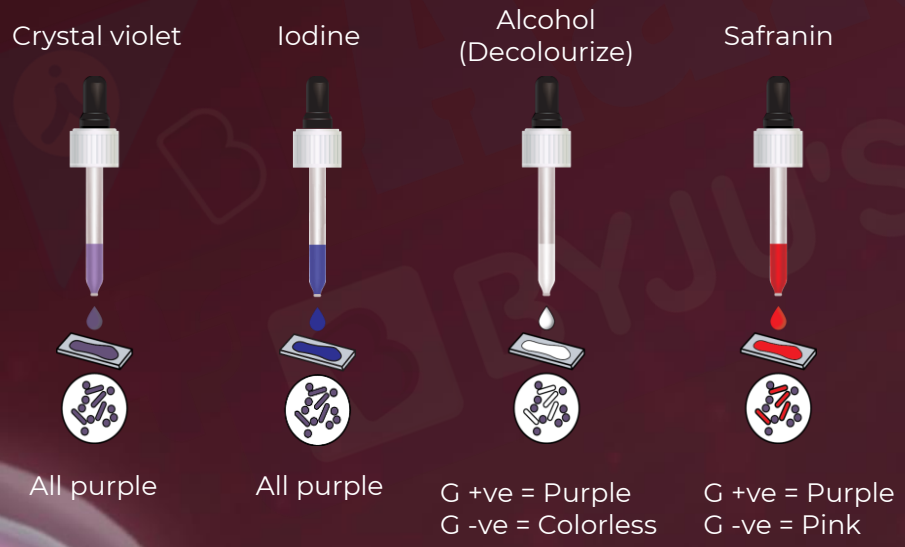
- **Hans Christian** devised a method to distinguish bacteria based on the differences they exhibit in their cell wall composition
- Method is called **Gram staining**, also known as **Gram's method**
- Application of gram staining:
  - Heat fixation of bacterial smear on the slide to affix the bacteria to the slide to avoid rinsing out during the staining procedure
  - Applying a primary stain (crystal violet)
  - Addition of KI solution, which binds to crystal violet and traps it in the cell
  - After staining, slide is washed with acetone or ethyl alcohol (Rapid decolorization)
  - Counterstaining with safranin

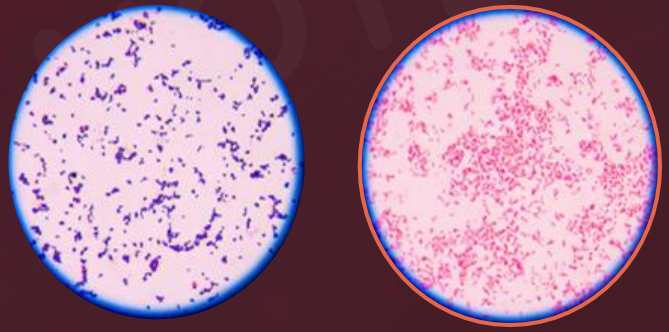
© 2022, Aakash BYJU'S. All rights reserved

Cell Envelope

2. Cell wall :

- Gram-positive bacteria have a thicker cell wall made of peptidoglycan and are stained purple by crystal violet.
- Gram-negative bacteria have a thinner layer so do not retain the purple stain and are counter-stained pink by safranin.





Gram Positive

Gram Negative

© 2022. Aakash BYJU'S. All rights reserved

Cell Envelope

2. Cell wall :

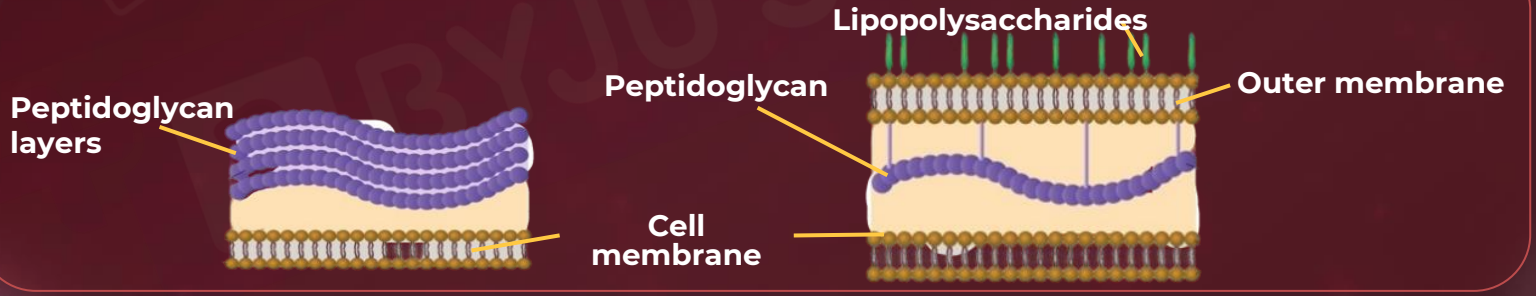
Gram staining

Gram positive

- Cell wall is single layered and smooth
- Have **larger/ thick amount of peptidoglycan** in their cell wall
- Take up the gram stain

Gram negative

- Cell wall is double layered and wavy
- Have **lesser/ thin amount of peptidoglycan** in their cell wall
- Do not take up the gram stain



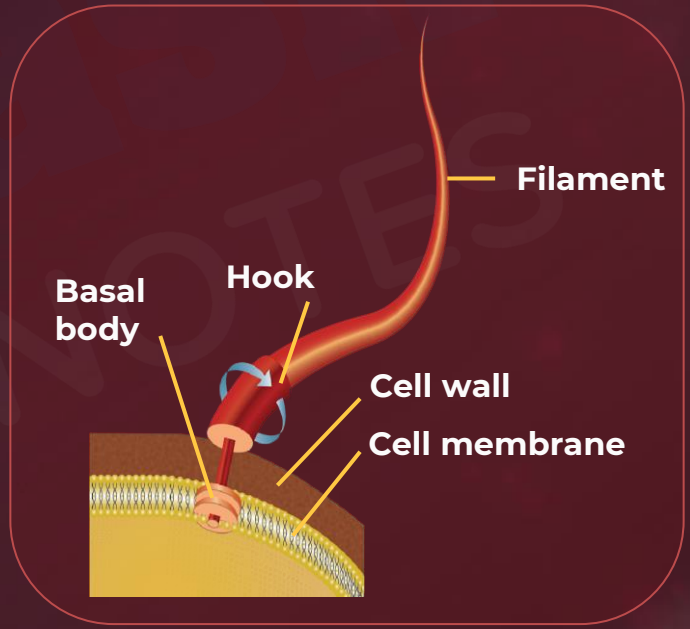
© 2022, Aakash BYJU'S. All rights reserved

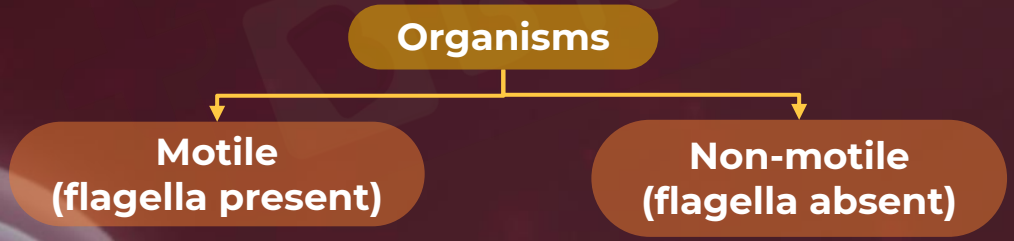
Cell Envelope

2. Cell wall : Extensions

Flagella:

- Thin filamentous extensions
- Play significant role in motility
- The flagellum is composed of three parts - **filaments, hook and basal body.** The filament is the longest portion and extends from the cell surface to the outside.
- It is a hollow rigid cylindrical structure made up of the protein called **flagellin**. Basal body is a rod-like structure which consists of rings.



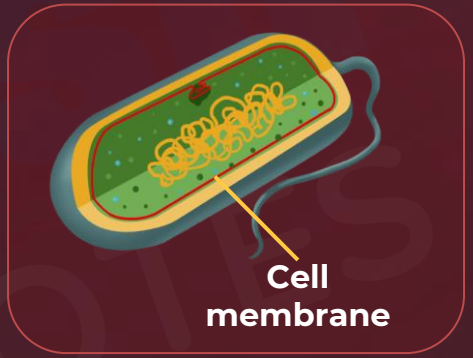


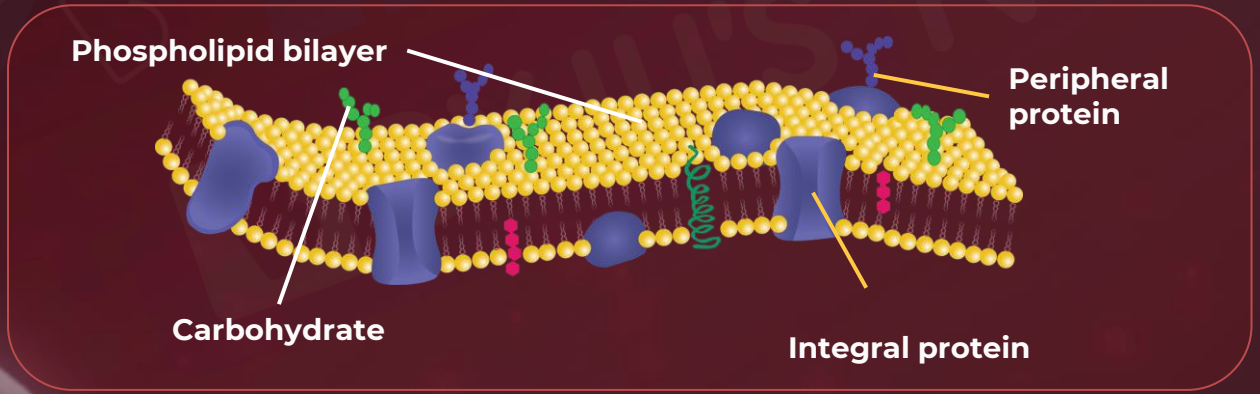
© 2022, Aakash BYJU'S. All rights reserved

Cell Envelope

3. Cell membrane / plasma membrane:

- **Innermost layer** of cell envelope
- **Selectively permeable** in nature and interacts with the outside world
- It is similar structurally to that of the eukaryotes
- **Composition**: Phospholipid bilayer, membrane proteins and carbohydrates





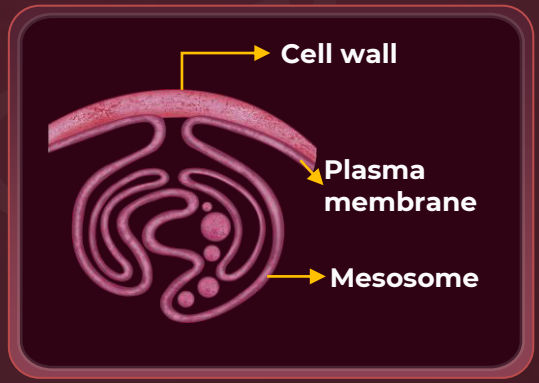
© 2022, Aakash BYJU'S. All rights reserved

Cell Envelope

3. Cell membrane / plasma membrane: Extensions

Mesosomes:

- Special membranous structure which are extensions of plasma membrane into the cell, in the form of **vesicles, tubules** and **lamellae**
- **Functions** - cell wall formation, DNA replication and distribution to daughter cells.
    - Also help in respiration, secretion process, to increase the surface area of the plasma membrane and enzymatic content
- Found in **gram positive bacteria**



Chromatophores:

- Membranous extensions into the cytoplasm, which **contain pigments**
- Found in **photosynthetic prokaryotes** like cyanobacteria (*Nostoc*), and purple bacteria

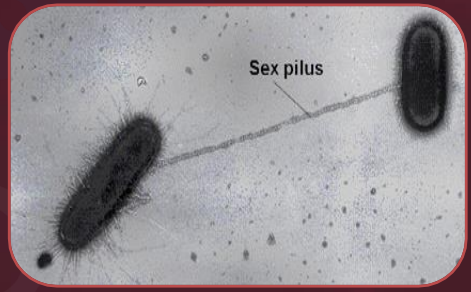
© 2022. Aakash BYJU'S. All rights reserved

Cell Envelope

3. Cell membrane / plasma membrane: Extensions

Pilli:

- Do not play a role in motility
- Elongated tubular structures, made up of a special protein i.e., **pilin**
- True pili are found only in **Gram-negative bacteria** so far and in these forms they are involved in mating process, (**conjugation**)



Fimbriae:

- Do not play a role in motility
- Small bristle-like fibres sprouting out of the cell
- In some bacteria, they are known to **help in attaching** the bacteria to rocks in streams and also to the host tissues.

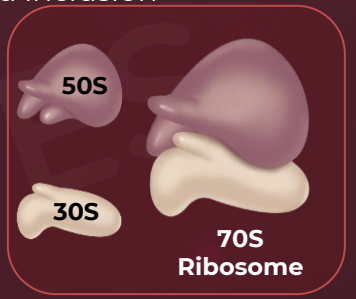
© 2022, Aakash BYJU'S. All rights reserved

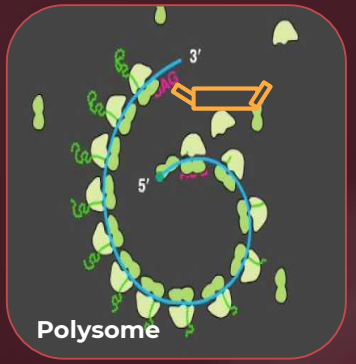
Cytoplasm

- Jelly-like, semi-fluid matrix inside the cell, where various biochemical reactions occurs
- Consists of enzymes, nutrients, gases, plasmid and nucleoid, storage bodies and other cell structures
- Membrane-bound organelles like mitochondria, Golgi bodies, chloroplast, and lysosomes are absent. Organelles without membranes are present, such as, Ribosomes (70S type) and inclusion bodies

1. Ribosomes

- Ribosomes, a non-membrane bound organelles size is 15 nm by 20 nm, associated with the plasma membrane of the cell
- Made up of **RNA and proteins**
- Consists of two subunits - **50 S (large)** and **30 S (small)** units which when present together form **70 S ribosomes**
- **Site of protein synthesis**
- Cytoplasmic ribosomes synthesise proteins, which remain within the cells
- Ribosomes on the plasma membrane make proteins that are transported out
- Several ribosomes may attach to a single mRNA and form a chain called **polysome** or **polyribosomes.** The ribosomes of a polysome **translate the mRNA into proteins.**





© 2022, Aakash BYJU'S. All rights reserved

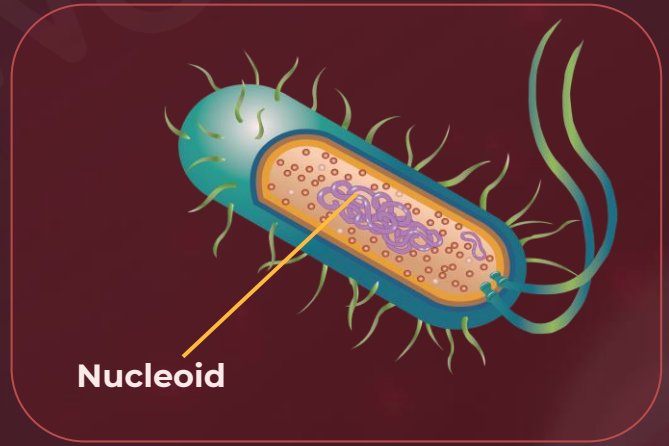
Cytoplasm

2. Inclusion bodies

- Lie freely in cytoplasm, non-membrane bound and **store reserve material**
  - E.g., phosphate granules, cyanophycean granules and glycogen granules
- Single layer, non-unit membrane, which is 2-4 nm thick
  - E.g., poly-ß-hydroxybutyrate granules, sulphur granules and gas vacuole
- **Gas vacuoles :** Found in blue-green algae, purple and green photosynthetic bacteria

3. Nucleoid

- No well-defined nucleus
- Presence of nucleoid: Dense area in the cell that contains the genetic material

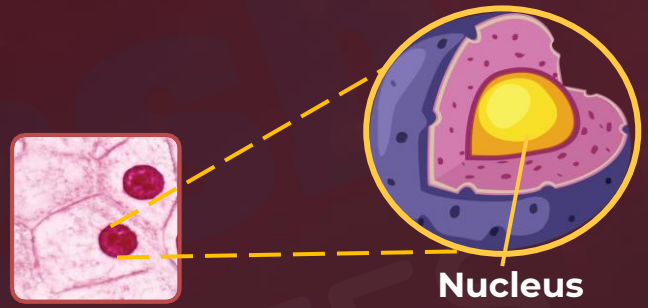


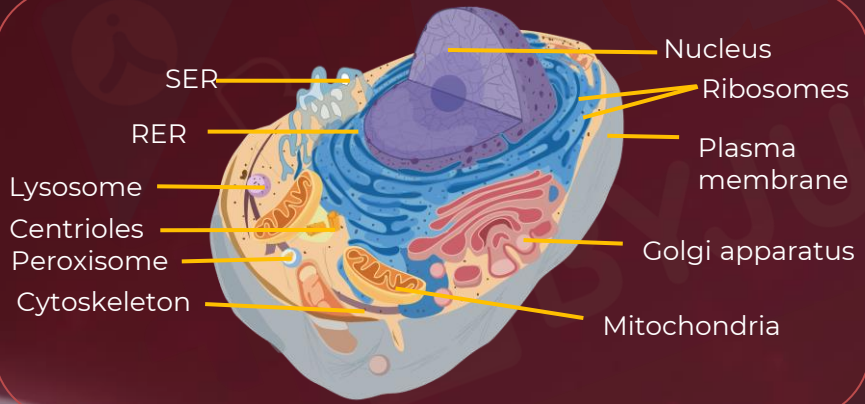
© 2022, Aakash BYJU'S. All rights reserved

Eukaryotic Cells

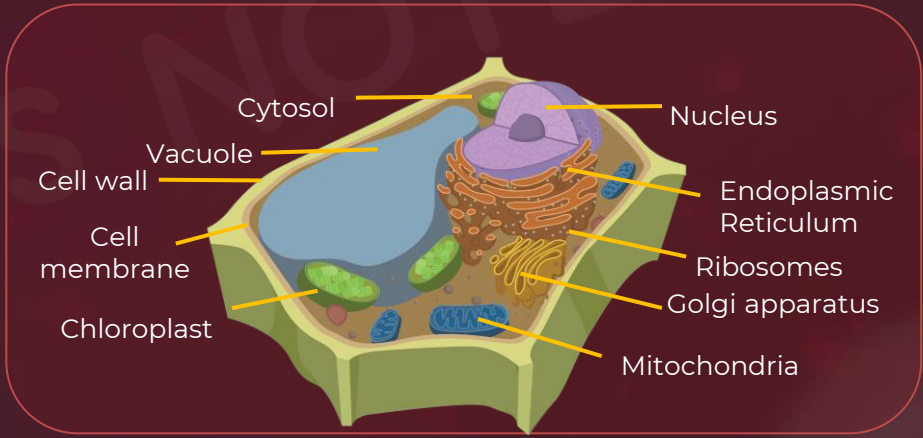
Characteristic features :

- Presence of **true nucleus** enclosed by a **nuclear envelope**
- Presence of **membrane bound organelles**
- **Genetic material** is **organised into chromosomes**
- Has a variety of complex **locomotory** and **cytoskeletal structures**
- These cells occur in protists, fungi, plants and animals





Animal cell



Plant cell

© 2022, Aakash BYJU'S. All rights reserved

Cell Wall

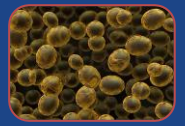
Characteristic features :

- An additional non-living, rigid structure which surrounds the plasma membrane of bacteria, fungi, algae and plant cells
- **Absent in animal cells**
- The composition of cell wall varies in different groups

Fungal cell wall

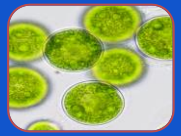
Chitin, a polymer of N-acetylglucosamine (NAG) units

Fungi



Algal cell wall

Galactans, mannans and minerals like calcium carbonate



Algae

Plant cell wall

Insoluble polysaccharides (cellulose) hemicellulose, pectins, proteins

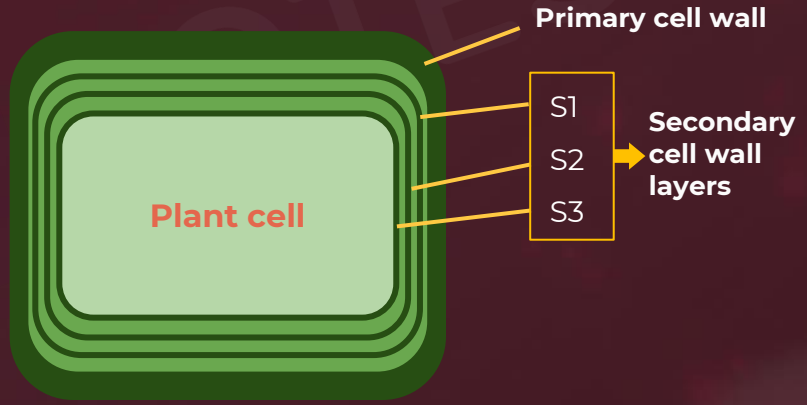
Plant

© 2022, Aakash BYJU'S. All rights reserved

Cell Wall

Characteristic features :

- The cell wall of plants consists of two regions : primary wall and secondary wall.
- **Primary wall:**
  - It is found in young plant cells.
  - It is a thin single layer which is elastic in nature and **capable of expanding in a growing cell** such as, meristematic and parenchymatous cells.
- **Secondary wall** :
  - It is found in mature cells.
  - It has more layers than primary wall, which brings about **thickening of the cell wall** such as, lignified and suberised cell wall.

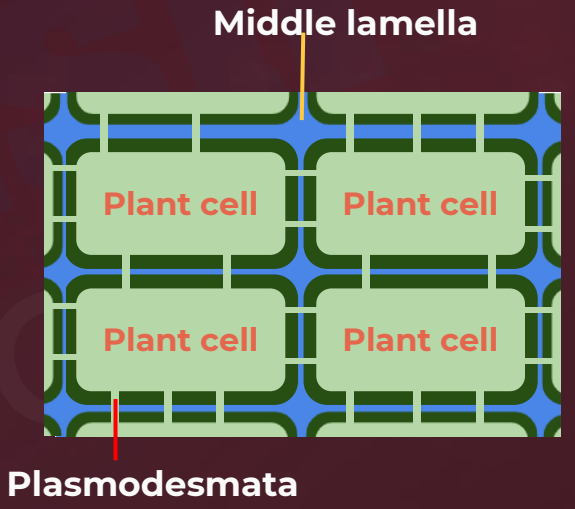


© 2022, Aakash BYJU'S. All rights reserved

Cell Wall

Characteristic features :

- **Middle lamella** : Hold adjacent cells together by a thin, sticky, amorphous layer of cementing material
    - Made up of **calcium and magnesium pectate**
- **Plasmodesmata** : Intercellular cytoplasmic connections
  Endoplasmic reticulum plays a role in origin of plasmodesmata



Functions :

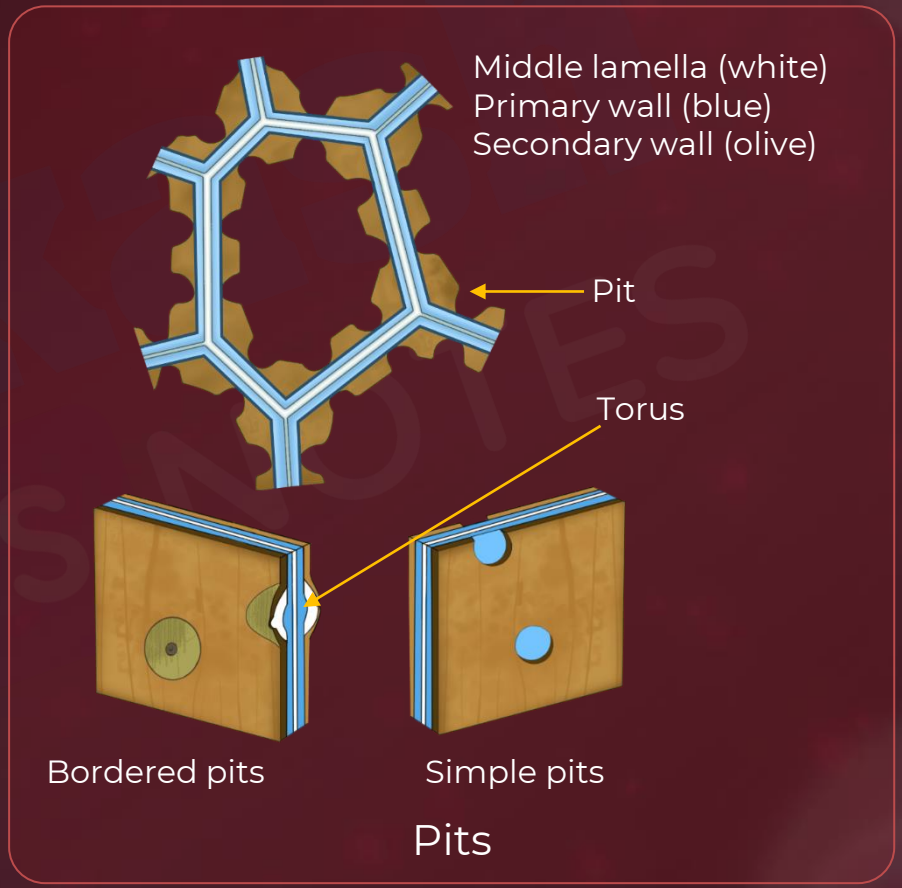
- It **maintains shape** of the cells.
- It protects the cell from **mechanical injury.**
- It wards off the **attacks of pathogens** like viruses, bacteria, fungi, etc.
- It **allows the materials to pass** in and out of the cell.
- It helps in **cell-to-cell interaction** and provides barrier to undesirable macromolecules.

© 2022, Aakash BYJU'S. All rights reserved

Cell Wall

Pits :

- At certain places secondary wall is not laid down. Such unthickened areas are called **pits**
- Adjacent cells are generally opposite to each other and form pit pairs
- Pits are of two types :
  - **Simple pit** : Uniform pit cavity in diameter
  - **Bordered pit**: Flask-shaped pit cavity as in tracheid
- Presence of number of plasmodesmata or cytoplasmic strands are in pit through which the cytoplasm of one cell is in contact with other
  - Lined by plasma membrane and contains a fine tubule called **desmotubule**



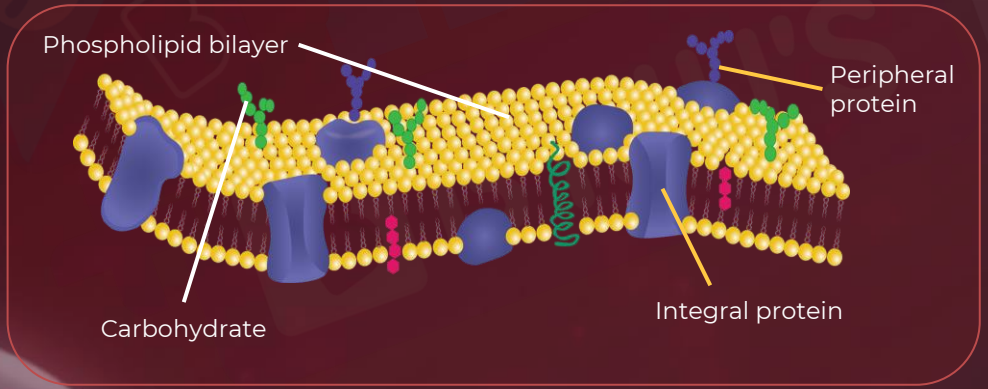
Pits

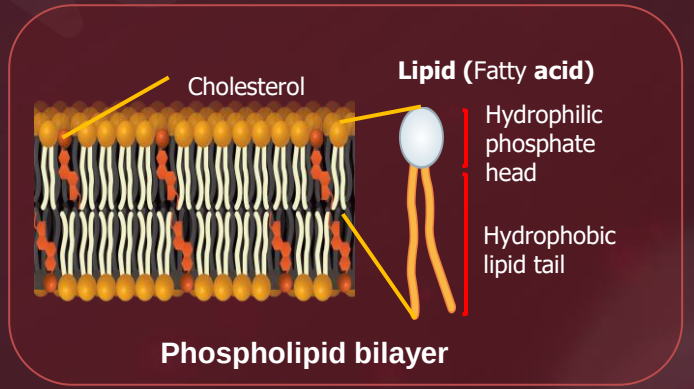
© 2022, Aakash BYJU'S. All rights reserved

Cell Membrane

Characteristics features :

- Cell membrane or plasma membrane is **selectively permeable.**
- Composition: **phospholipids, membrane proteins, carbohydrate groups** (glycolipids and glycoproteins)
- The ratio of protein and lipid varies considerably in different cell types.
- In human beings, the membrane of the erythrocyte (**RBC**) has approximately **52 % protein** and **40 % lipids.**
- **Bilayer lipid arrangement** – Polar head (**hydrophilic)** towards the outer sides, interacts with the water and the non-polar (**hydrophobic**) tails towards the inner sides. Hence, non-polar tail of saturated hydrocarbons or **hydrophobic** tail is protected from the aqueous environment.





© 2022, Aakash BYJU'S. All rights reserved

Cell Membrane

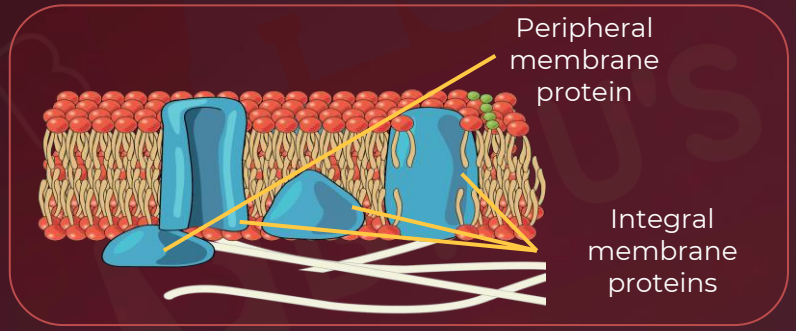
Characteristics features :

- In cell membrane, two types of membrane proteins are present, **depending on the ease of extraction**: peripheral and integral

Membrane proteins

Peripheral proteins

- Lie on the membrane surface



Integral proteins

- Partially or totally buried in membrane
- **Tunnel proteins**, which run through the lipid bilayer are known as **trans membrane proteins**

These proteins cannot be removed easily, and their removal requires crude methods of treatment like detergents. Thus, the membrane has been described as **protein icebergs floating in sea of phospholipids.**

© 2022, Aakash BYJU'S. All rights reserved

Cell Membrane

Characteristics features :

- **Structure:** **Fluid mosaic model** proposed by **Singer and Nicolson (1972)**
- **Fluidity:** **Quasi-fluid nature** of lipid allows lateral movement of proteins within the bilayer

Movement

Lateral

- Seen in lipids and proteins
- Occurs within the same monolayer
- More common

Flip-flop

- Seen in lipids (more common) but not in proteins due to their large size
- Slower than lateral movement
- Movement from one monolayer to the other

Functions :

- **Cell growth, formation of intercellular junctions, secretion, endocytosis, cell division, etc.**
- **Transport of the molecules**

© 2022, Aakash BYJU'S. All rights reserved

Cell Membrane

Membrane transport

Passive transport

- Movement of **neutral solutes along** the concentration gradient (Higher to lower concentration)
- By simple **diffusion**
- **No energy** utilised

Active transport

- Movement of ions or molecules **against** the concentration gradient (Lower to higher concentration)
- Transporters such as **Na^+/K^+ pump in animal cells**
- Energy dependant (**ATP is utilised**)

© 2022, Aakash BYJU'S. All rights reserved

Cytoplasm

- Jelly-like, semi-fluid matrix that fills the cell
- **Main arena of cellular activities** in both plants and animal cells
- Various **biochemical reactions occur** in it, to keep the cell in its living state

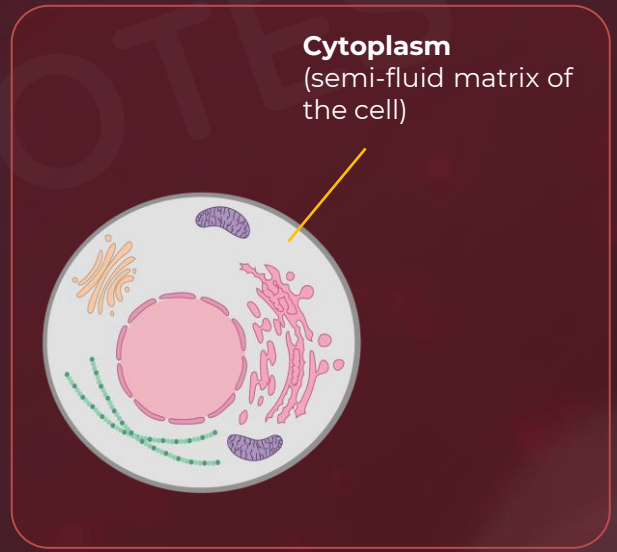
Components

Cytosol

- **Clear fluid** part of the cytoplasm
- Constitutes **90% of water**
- Consists of **proteins, lipids, and inorganic salts**

Organelles

- **Scattered** in the cytosol
- Suspended organelles are the **mitochondria, endoplasmic reticulum, Golgi apparatus, vacuoles, lysosomes, chloroplasts in plant cell**



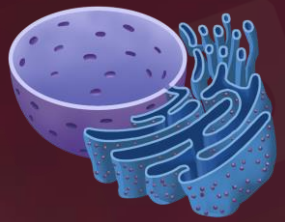
© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

- **Membranous cell organelles** which function in a coordinated manner
- Involved in the **packaging** and **transport** of materials
- **Absent** in **prokaryotic cells** and **RBCs of mammals**

Endomembrane system

- **Endoplasmic reticulum**



- **Golgi complex**

- **Lysosomes**

- **Vacuoles**

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Endoplasmic reticulum

- A network of reticulum of tiny tubular structures scattered in the cytoplasm.

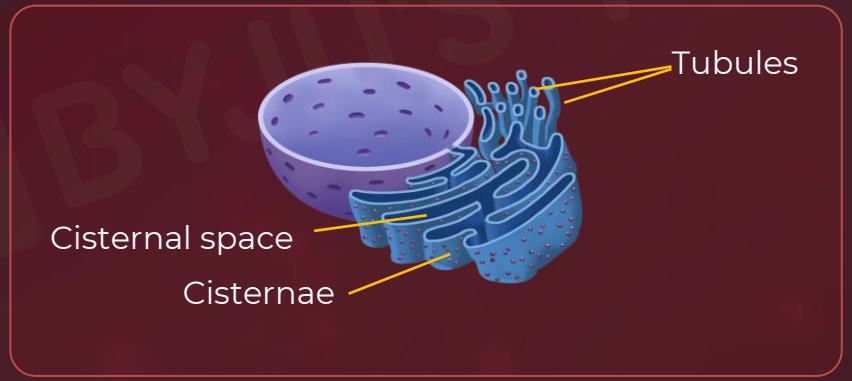
Endomembrane system
(composed of three kind of structures)

Cisternae

- Actively involved in protein synthesis; e.g., cells of pancreas and brain. Associated with large subunit (60 S)

Tubules

- Involved in lipid and sterol synthesis



Vesicles

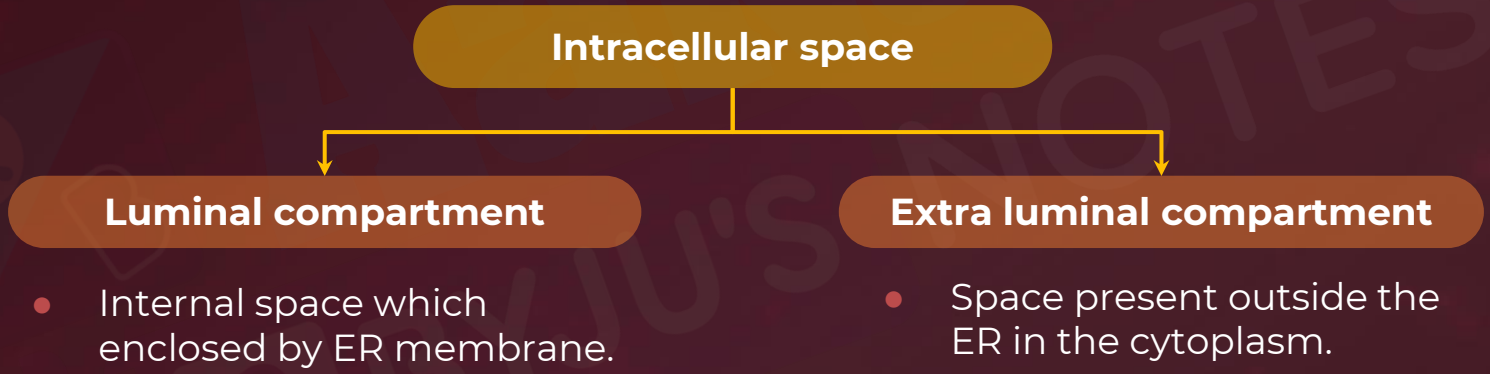
- Abundant in the pancreatic cells and these are the only ER structures found in spermatocytes

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Endoplasmic reticulum

- ER divides the intracellular space into two distinct compartments : **Luminal compartment** and **extra luminal compartment**.



- Internal space which enclosed by ER membrane.

- Space present outside the ER in the cytoplasm.

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Endoplasmic reticulum

ER are of two types on the basis of presence/ absence of ribosomes on the surface of ER.

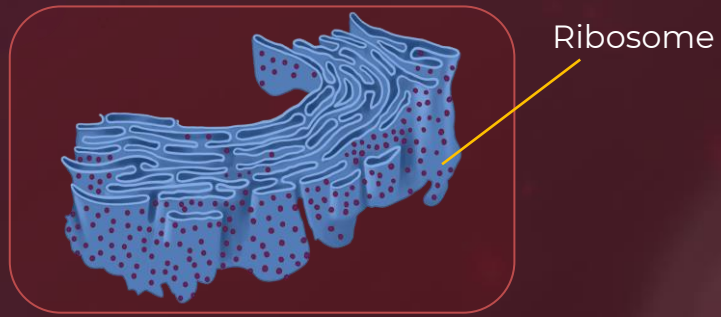
Endoplasmic reticulum

Smooth endoplasmic reticulum

- Absence of ribosomes
- Smooth tubular structures. Eg., Muscle cells, those ER known as sarcoplasmic reticulum.

Rough endoplasmic reticulum

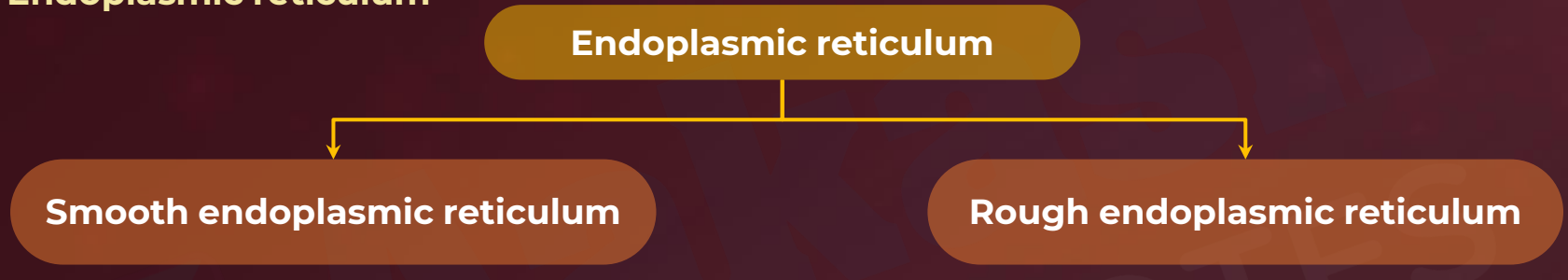
- Presence of ribosomes
- Contains two types of glycoproteins i.e., **Ribophorin-I** and **Ribophorin-II** for the attachment of 60S subunit of 80S ribosome.



© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Endoplasmic reticulum



Function :

- **Lipids and steroids synthesis**
- **Detoxification** of drugs and xenobiotics, as it is associated with cytochrome P 450
- **Muscle contraction** by release and uptake of Ca+ ions
- Synthetic products of RER pass onto Golgi complex through SER

Function :

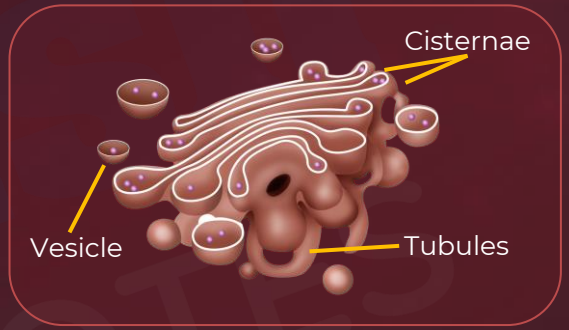
- **Site of protein synthesis**
- **Provides precursors** of enzymes for the formation of lysosomes in Golgi complex
- Gives rise to SER

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Golgi Apparatus

- First observed by **Camillo Golgi** in 1898
- Densely stained reticular structures; present near the nucleus of the cell
- Present in eukaryotic cells, **except in mature sieve tubes** of plants, **mature RBCs** of mammals, **sperm cells** of bryophytes and pteridophytes, etc
- In plants, it is called **dictyosomes** as Golgi apparatus is made up of unconnected units



Golgi apparatus

Cisternae
- Flattened sac-like structures stacked on one another

Tubules
- Small, flat, interconnecting structures

Vesicles
- Small rounded sacs present at the edges of cisternae in clusters

Golgian Vacuoles
- Large, spherical vacuoles produced at maturing face

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

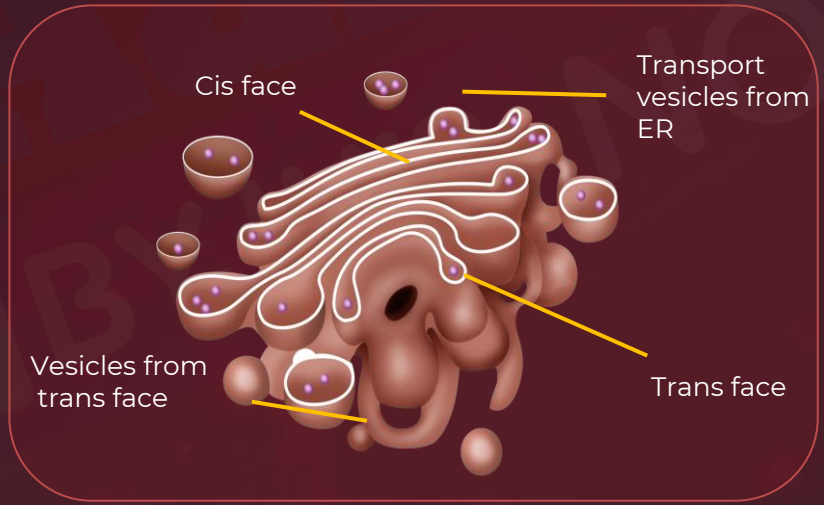
Golgi Apparatus

- Concentrically arranged near the nucleus as **convex cis** or the forming face and **concave trans** or the maturing face. Cis and trans are entirely different but interconnected.

Golgi apparatus arrangement

Cis face

- Faces the endoplasmic reticulum
- Convex in shape - forming face - **receiving end**
- Receives vesicles from the ER



Trans face

- Faces the cytoplasm
- Concave in shape - **maturing face**
- **Modified materials** are packed and **released from the trans face**

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Golgi Apparatus: Functions

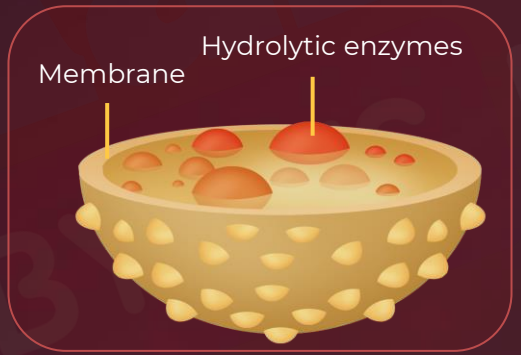
1. To process, package and transport the materials for secretions
2. Site of formation of glycoproteins and glycolipids
3. Root cap cells are rich in Golgi bodies which secrete mucilage for the lubrication of root tip
4. Acrosome of the sperm is modified Golgi apparatus
5. Formation of plasma membrane during cytokinesis

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Lysosomes

- Simple, tiny, spherical, sac-like and single membrane bound structures
- Formed by the process of packaging in the Golgi apparatus
- **Rich in hydrolytic enzymes**.
- Optimally **active at the acidic pH**
- Acidic conditions are maintained inside the lysosomes by pumping of H^+ ions into them



SUBSTANCES	HYDROLYTIC ENZYMES
1. Protein	Protease
2. Lipid	Lipase
3. Carbohydrates	Glycosidase
4. Nucleic acids	Nuclease
5. Phosphates	Acid phosphatase
6. Sulphates	Sulphatase

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Lysosomes

Lysosomes polymorphism

Primary	Secondary / Heterolysosomes	Residual	Autophagic/Vacuolar lysosomes
Newly formed	Primary lysosome + Phagosome	Undigested materials	• Formed by union of many primary lysosomes around old or dead organelles • Surrounds and digest them by autolysis or autodigestion

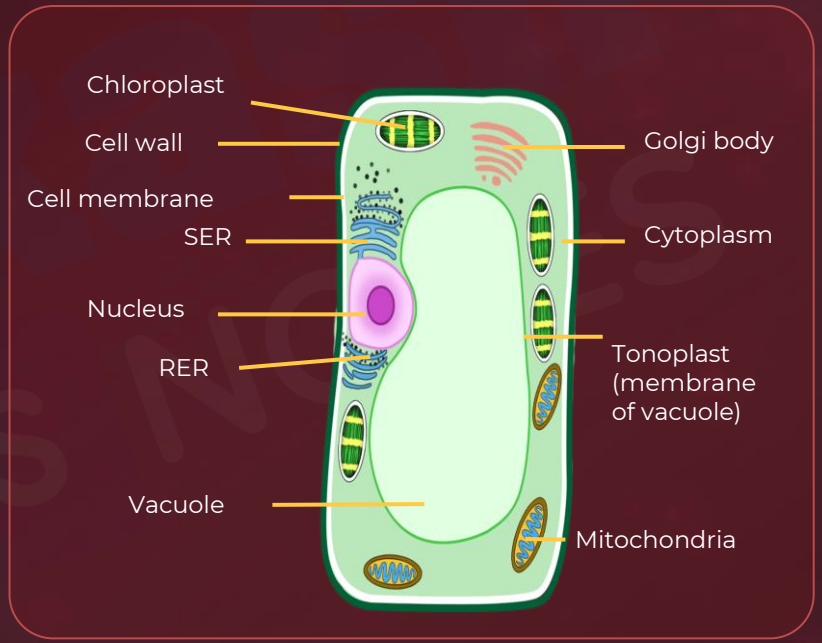
The disappearance of larval organs during metamorphosis (e.g., tail in frog) is due to autolysis. Hence, lysosomes are known as **“suicide bags”**

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Vacuoles

- Vacuoles are large membrane-bound space. They are prominently found in the cytoplasm.
- It contains water, sap, excretory products. These are also called **sap vacuoles**.
- Its membrane is called **tonoplast**.
- **Tonoplast** facilitates the transport of ions and other materials against concentration gradients into the vacuole.
- Thus, ions concentration is significantly higher in the vacuole than in the cytoplasm.
- In **plant cells**, the vacuoles can occupy upto **90 %** of the volume of the cell.



Plant cell

© 2022, Aakash BYJU'S. All rights reserved

Endomembrane System

Vacuoles

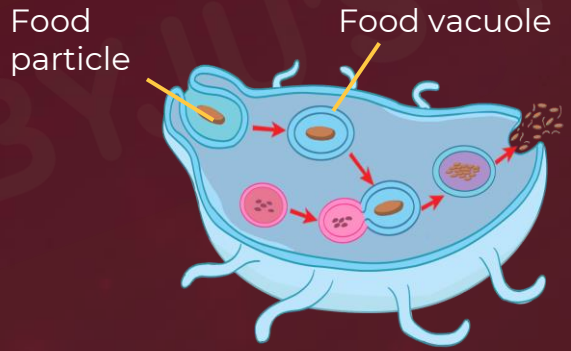
Types of vacuoles

Contractile vacuole

- In Amoeba, it helps in excretion
- Helps in osmoregulation

Food vacuole

- In many cells, as in protists, food vacuoles are formed by engulfing the food particles



Gas vacuole/ pseudo vacuoles

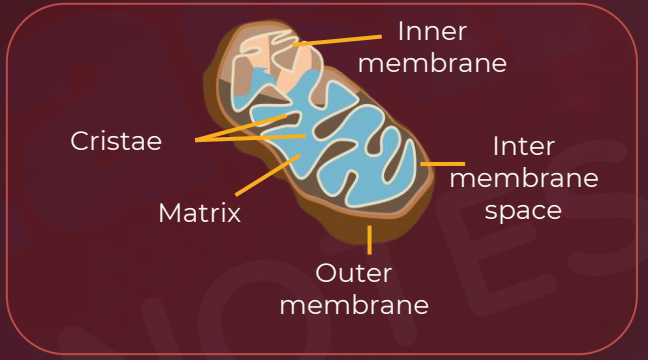
- Membrane less vacuoles found in prokaryotes
- Provides buoyancy

© 2022, Aakash BYJU'S. All rights reserved

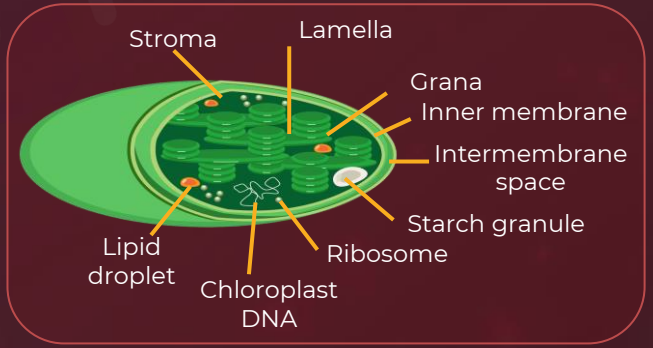
Did You Know?

Mitochondria and Chloroplast

- Mitochondria and chloroplast are **self-duplicating/ semi- autonomous** organelles
  - Mitochondria arise by the division of pre-existing mitochondria
  - Chloroplast arise from proplastids
- For duplication, they have **circular dsDNA, 70S ribosomes and different types of RNAs i.e., mRNA, tRNA, rRNA for protein synthesis**.
- They are also bacterial **endosymbionts of cells**, because
  - Have **own nucleic acids** (circular ds DNA and RNA) and 70S ribosomes
  - Membrane resembles that of bacteria (have proteins called **porins**)
  - ETS and ATP forming machinery is present



Mitochondria



Chloroplast

© 2022. Aakash BYJU'S. All rights reserved

Mitochondria

- Sausage-shaped double membraned organelles.
- Since they are not visible easily, they are **stained** by a vital stain **Janus Green.**

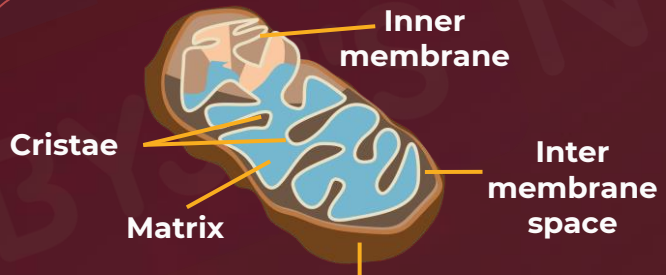
Number : Depends on the amount of work done by the cell and its energy requirement

Structure : Double membrane

Structure

Inner membrane

- Number of infoldings called the cristae
- Has 80% protein and 20% lipids and is rich in cardiolipins
- Contains ATP synthase/F_0-F_1



Outer membrane

- Smooth
- Chemically composed of 40% lipid and 60% proteins
- Contains transport proteins

© 2022, Aakash BYJU'S. All rights reserved

Mitochondria

Has two distinct chambers filled with aqueous fluid

Outer compartment or intermembrane space

- It is between the two mitochondrial membranes.
- It is also called **peri-mitochondrial space**.

Inner compartment or matrix

- It is inside the inner membrane.
- The **cristae** are formed from particle infolding of inner membrane towards the matrix which **increases the surface area for enzyme action**.

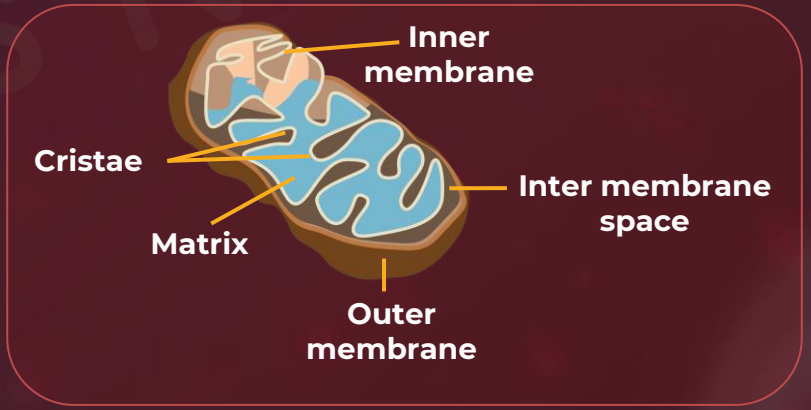
© 2022, Aakash BYJU'S. All rights reserved

Mitochondria

- **Matrix contains** single circular dsDNA molecule (with high G = C content), a few RNA molecules, 70S ribosomes and enzymes for TCA (Tricarboxylic acid) cycle.
- Mitochondria divide by fission.
- The cristae and inner surface of the inner membrane are studied with numerous spherical or knob like protuberances called **elementary particles** or **Particles of Fernandez and Moran** or **F, particles** or **oxysomes.**
- Each oxysome is differentiated into base, stalk and headpiece. The head piece contains enzyme ATP synthetase which brings about oxidative phosphorylation coupled with release of ATP.

Functions :

- Mitochondria are main sites of aerobic respiration and ATP synthesis, therefore **"Powerhouse of the cell"**.
- They bring about the oxidation of carbohydrates, proteins and ß-oxidation of fats.



© 2022, Aakash BYJU'S. All rights reserved

Plastids

Plastids

Chloroplasts

- Contain various pigments like **chlorophyll** and **carotenoids**
- **Greenish** in colour
- Take part in the synthesis of food
- Majorly found in mesophyll cells

Leucoplasts

- **Colourless** and store nutrients
- Granum is absent

Amyloplasts : store carbohydrates
e.g., potato tuber, rice etc.

Elaioplasts : store fats and oils e.g., castor

Aleuroplasts : store proteins
e.g., aleurone cells of maize

Chromoplasts

- Have fat soluble pigments (**carotene** and **xanthophylls**).
- **Yellow, orange** or **reddish** in colour
- Change of colour from green to reddish during the ripening of tomato and chilli is due to transformation of chloroplasts to chromoplasts
- Orange colour of carrot roots is due to chromoplasts

© 2022, Aakash BYJU'S. All rights reserved

Plastids

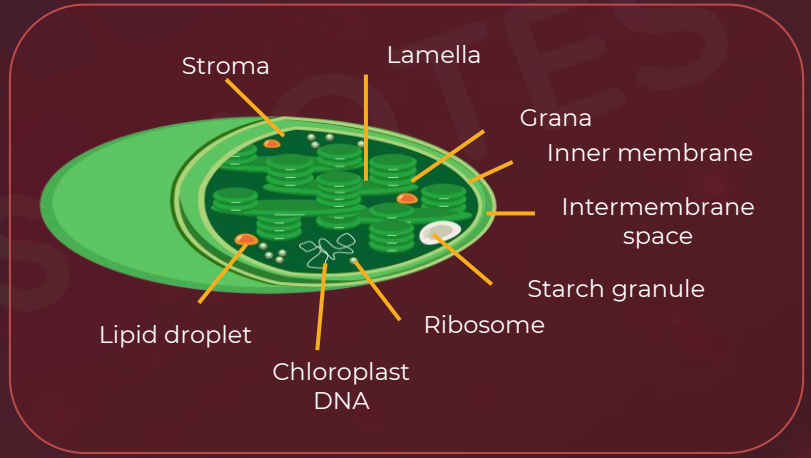
Chloroplast

- **Shape :** Spherical, lens shaped, oval, discoid or even ribbon-shaped in some plants
- **Structure:**

1. **Double membrane**
   Outer membrane : More permeable Inner membrane : Less permeable with more carrier proteins
2. **Stroma**: Fluid matrix bound by the inner membrane. Contains 70S ribosomes, circular DNA (dsDNA), starch granules and enzymes required for the synthesis of carbohydrates and proteins
3. **Thylakoids**: Coin like structures containing chlorophyll. Enclose a space called a lumen
4. **Grana/Intergranal thylakoids**: Appear like piles of coin. Stacked one over the other to form grana
5. **Stroma Lamellae** : Flat membranous tubules. Interconnect thylakoids of different grana

Functions:

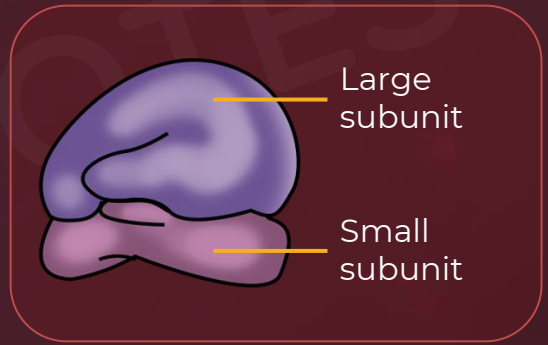
- Photosynthesis : **Light reaction** (in thylakoids), **dark reaction** (in stroma)
- **Storage of starch**



© 2022, Aakash BYJU'S. All rights reserved

Ribosomes

- Smallest non-membranous organelle, composed of RNA and protein
- Discovered by **George Palade in 1953**
- Structure: Composed of **two subunits,** one large dome shaped and other smaller cap shaped
- Both the subunits remain **united** with each other **due to a specific concentration of the Mg^{2+} ions**
- If concentration of Mg^{2+} ions reduces below a critical level, subunits get separated.
- If concentration of Mg^{2+} ions increases in the matrix, they unites and form dimer.
- During protein synthesis, many ribosomes form a chain on a common messenger RNA and form the polyribosomes or polysomes.
- **'S' (Svedberg unit) – sedimentation coefficient and Indirect measure of density and size**.



© 2022, Aakash BYJU'S. All rights reserved

Ribosomes

Types of ribosomes

70S

- Present in prokaryotic cells
- Subunits 30S and 50S
- 70 S ribosomes have ribonucleoproteins in the ratio of **60 : 40 (RNA : Protein)**
- 70 S ribosomes consist of:
  - 30 S smaller subunit - 21 proteins and 16 S rRNA
  - 50 S larger subunit- 34 proteins molecules and 23 S and 5 S rRNA

80S

- Present in eukaryotic cells
- Subunits 60S and 40S
- 80 S ribosomes have ribonucleoproteins in the ratio of **40 : 60 (RNA : Protein)**
- 80 S ribosomes consist of:
  - 40 S smaller subunit - with 33 protein and a single 18S-rRNA.
  - 60 S larger subunit - with 40 protein molecules and three types of rRNAs - 28S, 5.8S and 5S.

Functions : sites of protein synthesis.

- **Free Ribosomes** - synthesise **non-secretory proteins** (structural and enzymatic proteins)
- **ER bound ribosomes-** synthesis **secretory proteins** (proteins for transport)
- Thus, these organelles are also known as **protein factories**
- Newly synthesised proteins are processed with the help of **chaperone protein**

© 2022, Aakash BYJU'S. All rights reserved

Cytoskeleton

- Extremely minute, fibrous, filamentous and tubular proteinaceous structures.
- Main functions are, to **provide mechanical support, motility, maintenance of the shape of the cell.**

Cytoskeleton

Microtubules

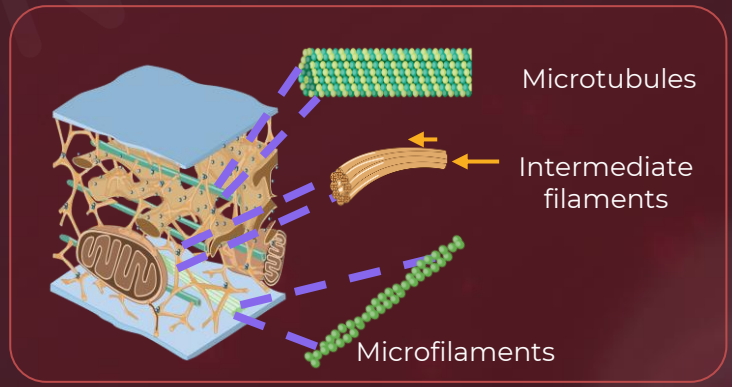
- Found in the cytoplasmic matrix
- Occurs in cilia, flagella, centrioles and basal bodies, mitotic apparatus etc
- Hollow, unbranched cylinders
- Composed of 13 parallel protofilaments {alpha and beta subunits of tubulin protein (non contractile protein)}
- The assembly and disassembly of microtubules require GTP and Ca_2^+

Microfilaments

- Solid, unbranched, rod-like fibrils of indefinite length
- Composed of a globular protein actin and filamentous protein myosin.
- Forms an extensive network in the cytoplasm of cells.

Intermediate filaments

- Non-contractile hollow filaments of acidic proteins.



© 2022, Aakash BYJU'S. All rights reserved

Cytoskeleton

Functions of Cytoskeleton

Microtubules

- **Functions** :
  - Formation of spindles and astral rays during cell division
  - Form the cytoskeleton of cilia and flagella
  - Provide shape, rigidity, motility, and anaphasic movement of chromosomes
  - Intracellular transport of nutrients and inorganic ions
  - Position of the future cell plate is determined by microtubules

Microfilaments

- **Functions:**
  - Provide support to plasma membrane
  - Involved in cytoplasmic streaming and amoeboid movements
  - Formation of pseudopodia and cleavage furrow during cell division

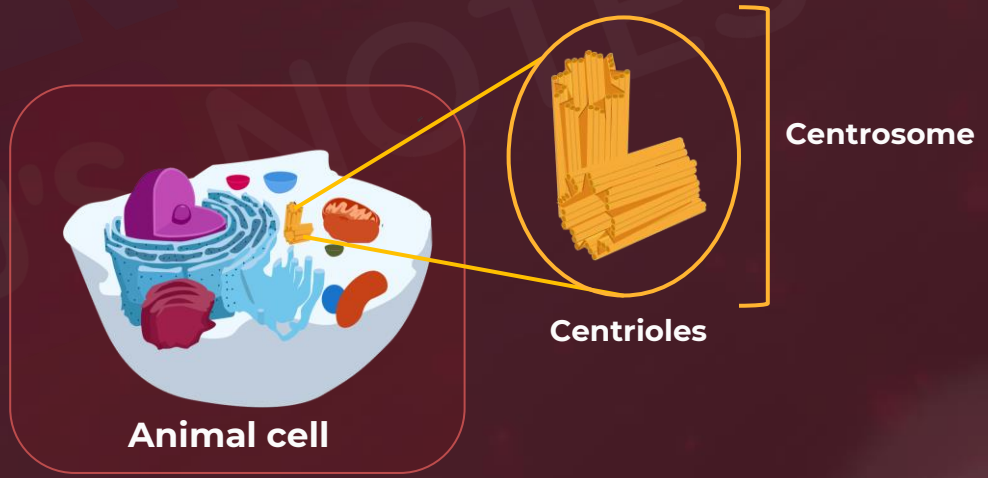
Intermediate filaments

- **Functions:**
  - Formation of scaffolds for chromatin and in forming a basket around nucleus

© 2022, Aakash BYJU'S. All rights reserved

Centrosome and Centrioles

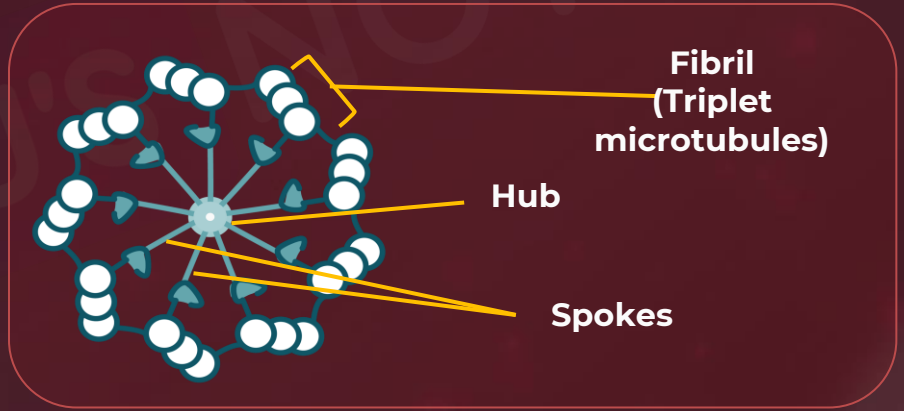
- They consist of **two** cylindrical structures called **centrioles.**
  - Surrounded by a cloud of amorphous pericentriolar material called **centrosphere** or **kinoplasm**
  - Two centrioles are together referred to as **diplosome**
- Centrioles are found in almost all eukaryotic cells like animal cells, fungi and algae but **not found in higher plant cells**.
- Structure of a Centriole:
  - A centriole possesses a whorl of nine evenly spaced peripheral fibrils of tubulin. It is absent in the centre. Therefore, the arrangement is called **9 + 0**.
  - Each fibril is made up of three subfibres called **triplet fibril.**
  - The adjacent triplet fibrils are connected by **proteinaceous linkers**.



© 2022, Aakash BYJU'S. All rights reserved

Centrosome and Centrioles

- The centre of the centriole possesses a rod-shaped proteinaceous mass known as **hub.** From the hub, **nine** proteinaceous strands are developed towards the **peripheral triplet fibrils**. These strands are called **radial spokes**.
- Due to the presence of radial spokes and peripheral fibrils, the centriole gives a **cartwheel appearance**.
- The centrioles are surrounded by dense amorphous, protoplasmic spheres in one or more series called as **massules** or **pericentriolar satellites**. They help in the formation of new centrioles.
- **Functions :**
  - Form **basal bodies** which **give rise to cilia and flagella**
  - Form **the spindle fibres** that **give rise to spindle apparatus** during cell division



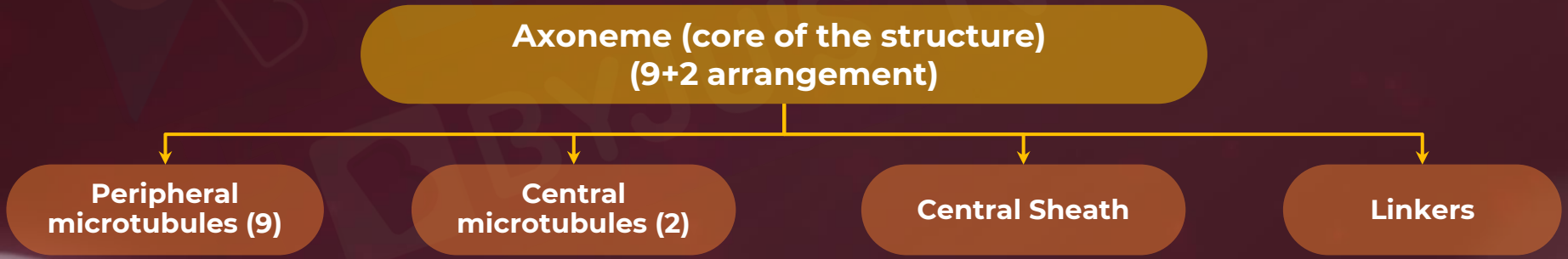
© 2022, Aakash BYJU'S. All rights reserved

Cilia and Flagella

- Fine **hairlike outgrowths** of the membrane
- Flagella are found in both prokaryotic and eukaryotic cells but, are structurally different
- Both are **membrane-bound extensions of the plasma membrane**

Structure:

- Made up of four parts, basal body, rootlets, basal plate and shaft.
- Core of the structure is known as the **axoneme**

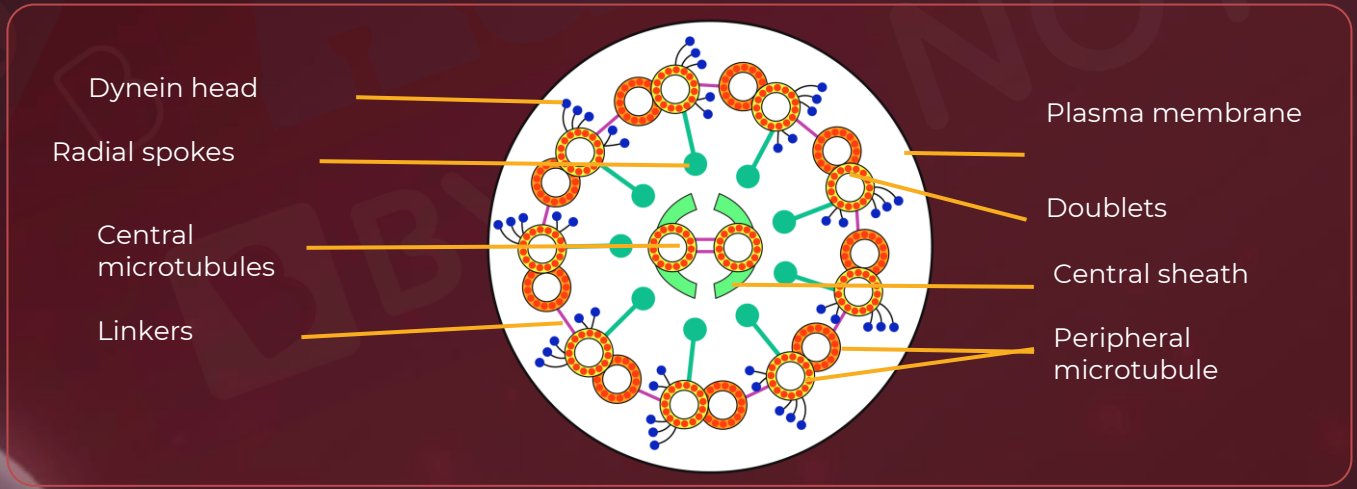


© 2022, Aakash BYJU'S. All rights reserved

Cilia and Flagella

Structure:

- Axoneme consists of **nine microtubule doublets** radially arranged known as, **peripheral microtubules**. They run parallel to the long axis around **one pair of central microtubules.**
- This is **9 + 2 pattern of microtubules.**
- **Central sheath** covers the central microtubules.
- **Linkers** join the microtubule doublets, made up of **Nexin protein**.
- **Dynein** are proteins of the subfril arms, that use ATP to drive the movement.

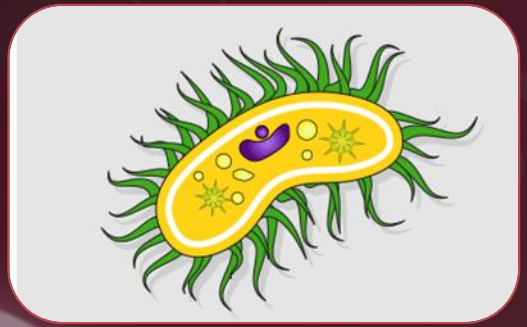


© 2022, Aakash BYJU'S. All rights reserved

Cilia and Flagella

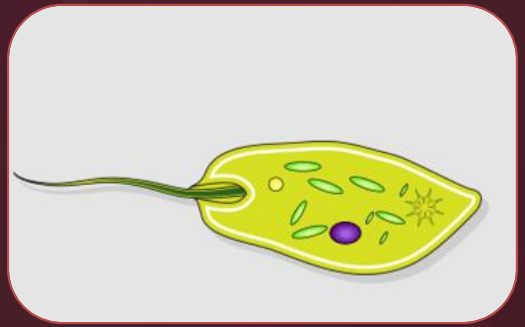
Cilia

- **Very large** in number and **smaller** in size.
- Occurs **throughout** or major part of surface of the cell
- Help in locomotion, feeding, circulation etc
- Oar like movements.



Flagella

- **1-4** in number and **longer** in size.
- Commonly found at the surface of a cell at the **one end of the cell**
- Help in locomotion
- Whip like structure



© 2022, Aakash BYJU'S. All rights reserved

Nucleus

- Described by **Robert Brown** as early as 1831

Types of cells (based on number of nucleus)

Binucleate

- Two nuclei per cell, e.g., *Paramecium*

Multinucleate

- Have many nuclei, e.g., *Opalina*.

Anucleate

- Lack nucleus at maturity, e.g., mammalian RBCs and sieve tube cells.

- **Store house of hereditary information**
  - Was proved by **Hammering (1953)**
- Flemming observed some intensely stained parts in nucleus and called them **'chromatin'**
- Known as **'brain'** of the cell as it controls the whole cell and its functions
- Contains the genetic material : **DNA**

© 2022, Aakash BYJU'S. All rights reserved

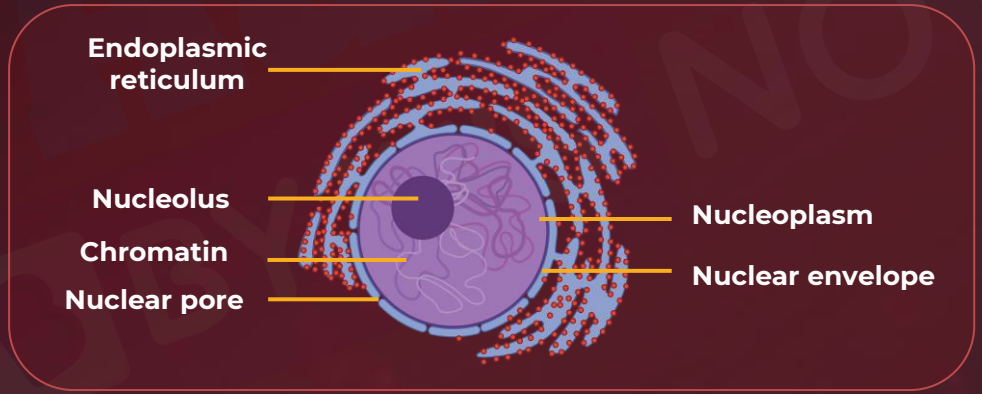
Nucleus

- **Structure :** Double membrane

Structure

Outer membrane

- May be smooth or rough
- Continuous with ER, associated with ribosomes



Inner membrane

- Smooth
- Two membranes are separated by fluid filled perinuclear space (10 to 50 nm)

© 2022, Aakash BYJU'S. All rights reserved

Nucleus

Structure : A nucleus in non-dividing phase is called **interphase** nucleus.

- **Outer membrane:** Smooth or with ribosomes
- **Inner membrane:** Smooth
- Separated by a space known as **perinuclear space**
- Contains complex pores

- Transparent, semi-fluid and colloidal substance
- Contains **nucleolus**

- Spherical structure found in the nucleoplasm
- **Site for ribosomal RNA synthesis**

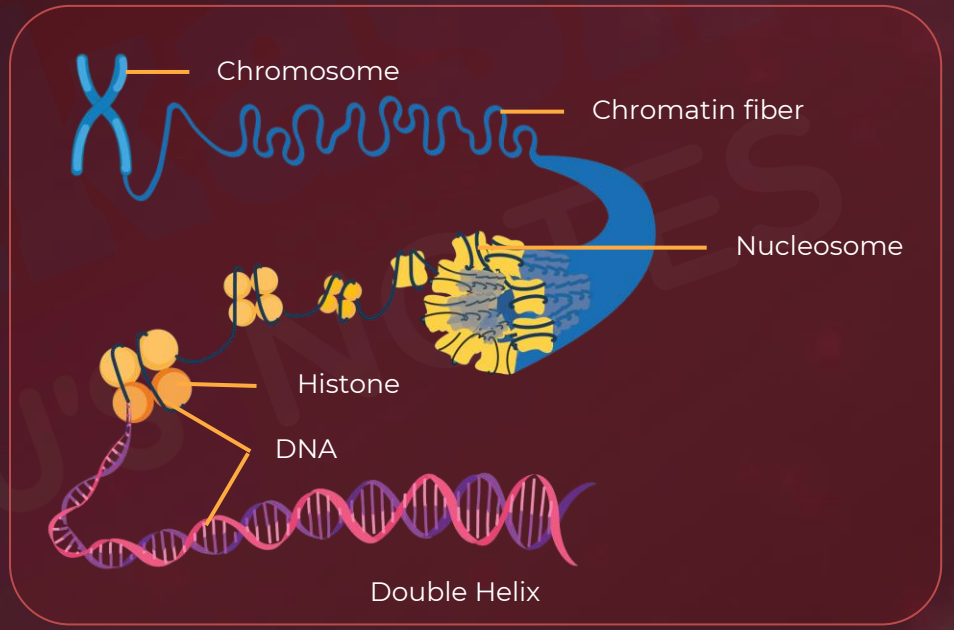
- Highly, extended and diffused network of nucleoprotein fibres called **chromatin**

© 2022, Aakash BYJU'S. All rights reserved

Nucleus

Chromatin : (Gk. chrorma - colour)

- Loose and diffused network of nucleoprotein fibres called **chromatin**
- Chromatin fibres condense to form **chromosomes**
- **Composition:** DNA, basic proteins histones, RNA and some non-histone proteins
- **Histone proteins** are the packaging proteins
    - Associated with packaging of DNA into compact structures called **chromosomes**
- Single human cell has approximately two-meter-long thread of DNA distributed among the chromosomes

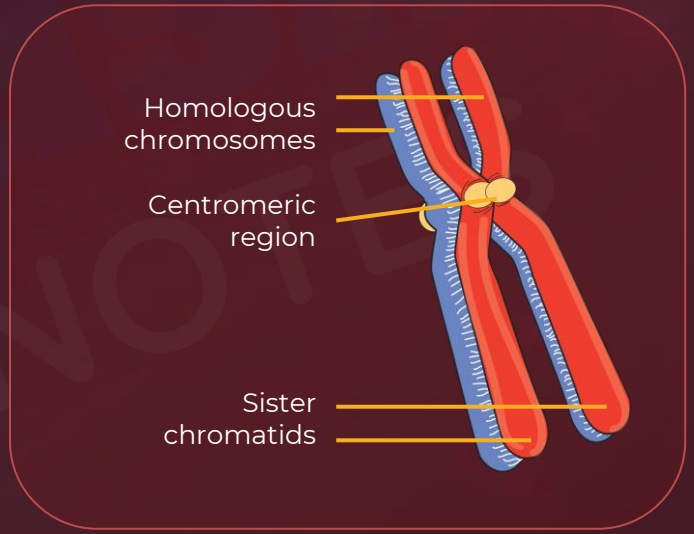


© 2022, Aakash BYJU'S. All rights reserved

Nucleus

Structure of a chromosome

- Has two identical halves called **chromatids**
- Held together at one point called **centromere**
  - Appears as a narrow region called **primary constriction** of the chromosome
  - On the sides of centromere, disc-shaped structures are present known as **kinetochores**
- Ends of chromosome are called **telomeres**
  - Seal the ends of chromosomes and prevent shortening or chromosome loss

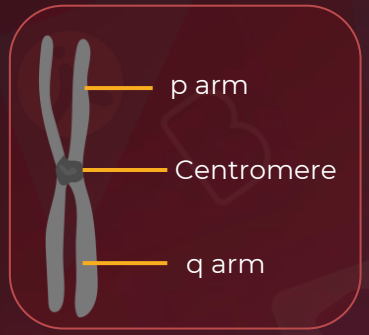


© 2022, Aakash BYJU'S. All rights reserved

Nucleus

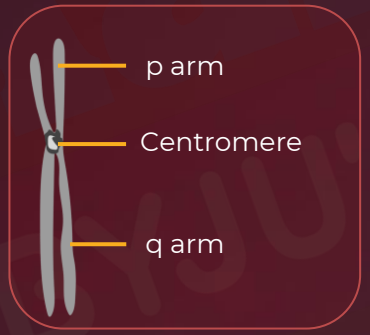
Classification of Chromosomes
(on the basis of centromere position)

Metacentric



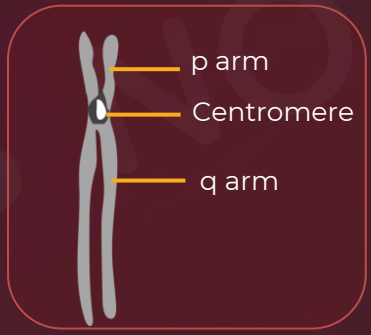
At the centre

Sub-metacentric



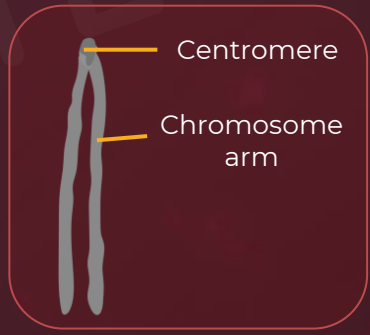
Slightly away from the centre

Acrocentric



Near the terminal

Telocentric



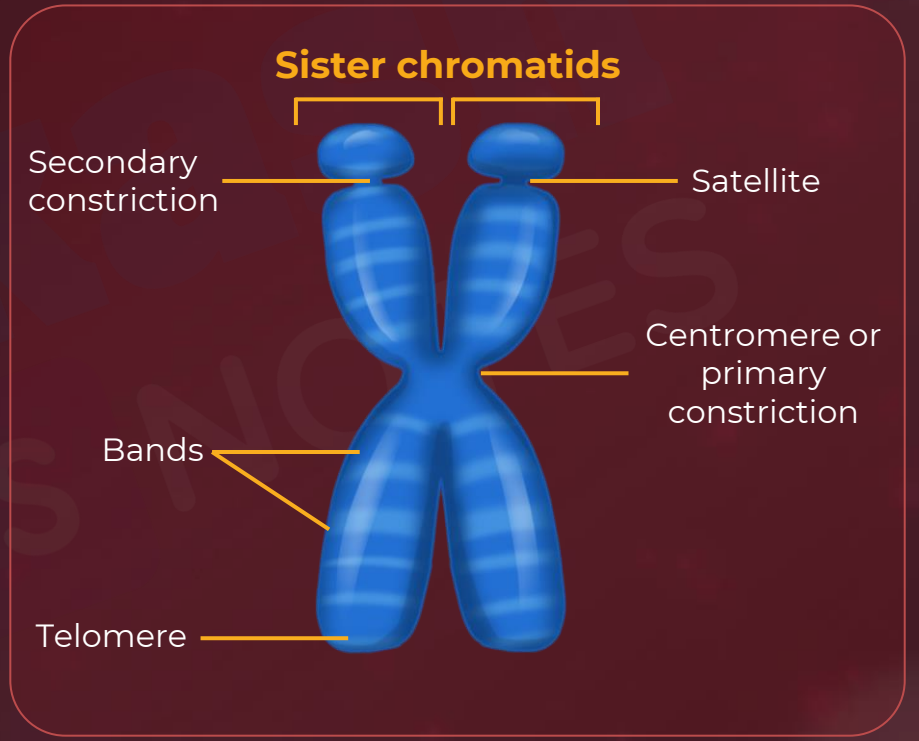
At the terminal

© 2022, Aakash BYJU'S. All rights reserved

Nucleus

Non-staining secondary constrictions or **NOR** (nucleolar organiser)

- Additional constrictions near their ends
  - Part of the chromosome beyond the secondary constriction is called **satellite**
- A chromosome having satellite is called **SAT-chromosome**
  - Considered as marker chromosome
- **In humans, 5 pairs of SAT chromosomes are present**



© 2022, Aakash BYJU'S. All rights reserved

Nucleus

Special types of chromosomes or giant chromosomes

Lampbrush chromosomes

- Described by **Ruckert (1892)**
- Present in **primary oocyte nuclei** of vertebrates and invertebrates
- Diplotene bivalent chromosomes joined at certain points called **chiasmata.** Their main axis is formed by DNA.
- **Nascent RNA molecules** are present
- Some of these are stored as **informosomes (mRNA + proteins)** for future use (development of embryo).

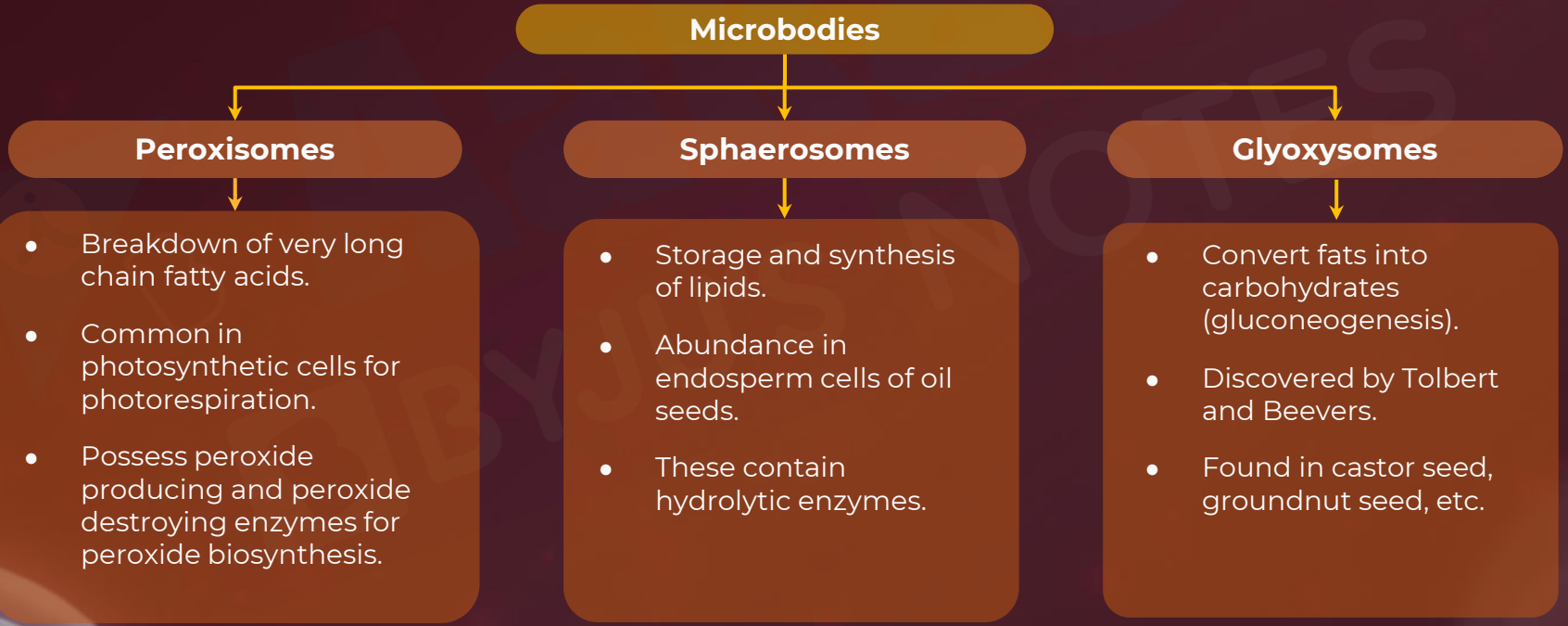
Salivary gland chromosomes or polytene chromosomes

- In insects of order Diptera (dipteran insects)
- Reported by **E.G. Balbiani (1881)**
- Studied in *Drosophila (*upto 2000 um (2 mm) another example Is *Chironomus*
- Number of chromonemata or fibrils increases upto 2000

© 2022, Aakash BYJU'S. All rights reserved

Microbodies

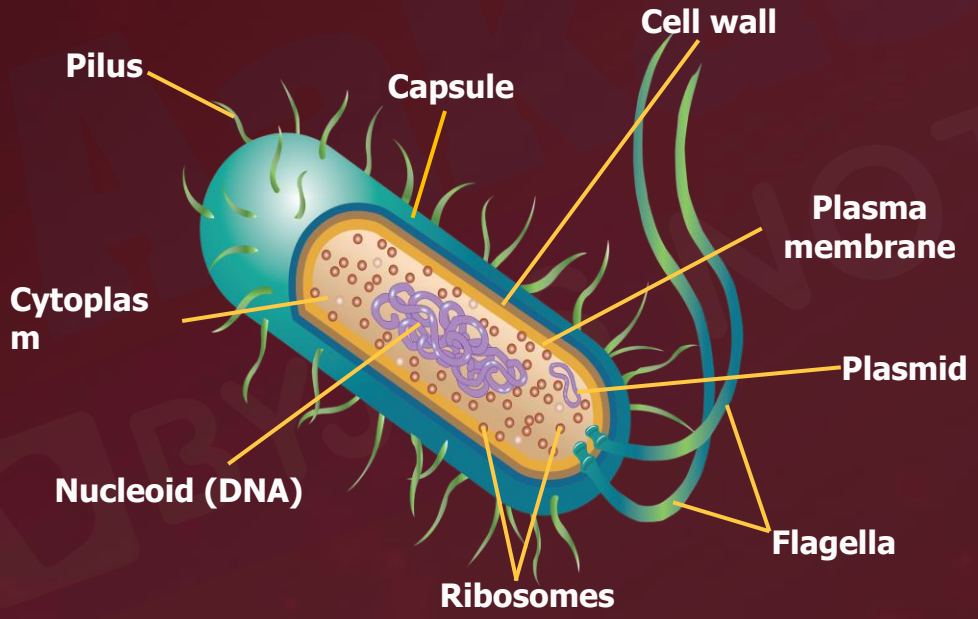
- Many single membrane-bound minute vesicles called microbodies.
- Rich in enzymes.
- Associated with oxidation reactions other than those of respiration.



© 2022, Aakash BYJU'S. All rights reserved

Summary

Prokaryotic cell



© 2022, Aakash BYJU'S. All rights reserved

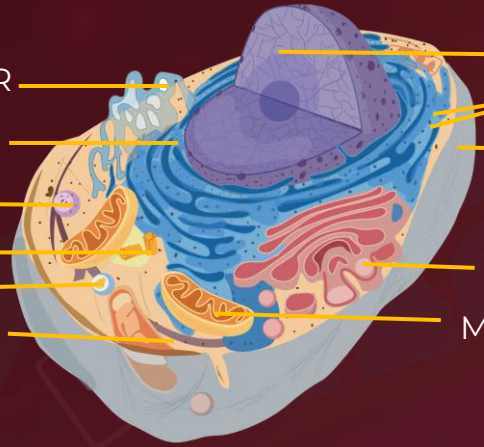
Summary

	Prokaryotic cell	Eukaryotic cell
Type of cell	Always unicellular	Unicellular or multicellular
Nucleus	Not well defined	Well defined
Ribosomes	Smaller in size (70S)	Larger in size (80S)
Mitochondria	Absent	Present
Lysosomes	Absent	Present
Example	Bacteria	Animal and plant cell

© 2022, Aakash BYJU'S. All rights reserved

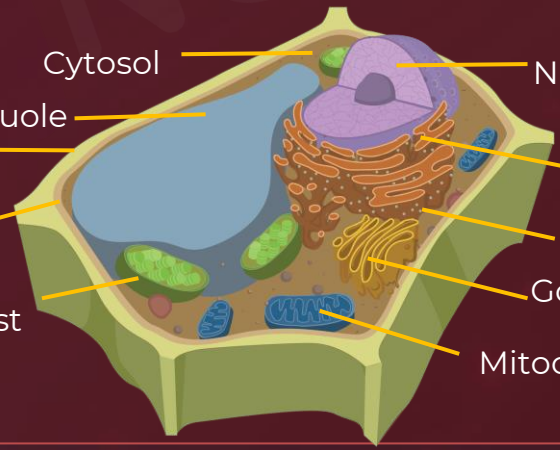
Summary

Eukaryotic cell



Animal cell

Plant cell



© 2022, Aakash BYJU'S. All rights reserved

Summary

	Plant cell	Animal cell
Cell shape	Square or rectangular	Irregular or round
Cell wall	Present	Absent
Plasma membrane	Present	Present
Endoplasmic Reticulum	Present	Present
Nucleus	Present and lies on one side of the cell	Present and lies in the centre of the cell
Lysosomes	Present but are very rare	Present
Centrosome	Absent	Present

© 2022, Aakash BYJU'S. All rights reserved

Summary

	Plant cell	Animal cell
Golgi Apparatus	Present	Present
Cytoplasm	Present	Present
Ribosomes	Present	Present
Plastids	Present	Absent
Vacuoles	Few large or a single, centrally positioned vacuole	Usually small and numerous
Cilia	Absent	Present in most of the animal cells
Mitochondria	Present but fewer in number	Present and are numerous

© 2022, Aakash BYJU'S. All rights reserved

Summary

Non - membrane bound organelle	Single membrane bound organelles	Double membrane bound organelles
Centrosomes	Endoplasmic reticulum	Mitochondria
Ribosomes	Microbodies Peroxisome Glyoxysome Sphaerosome	Plastids Chloroplast Chromoplast Leucoplast
	Lysosomes	Nucleus
	Golgi Complex	

© 2022, Aakash BYJU'S. All rights reserved