Cell: The Unit of Life

INTRODUCTION

- 'Cell' was first observed by **Robert Hooke** in 1665.
- In a 1665 publication called ***Micrographia***, Robert Hooke coined the term 'cell' for the box-like structures he observed while viewing cork tissue through a lens.
- The term 'cell' is derived from latin word '***cella***' which means 'small room' or 'compartment.'
- **Anton Von Leeuwenhoek** first saw and described a **live cell.** He was a Dutch shopkeeper who was skilled in crafting lenses. He observed the movements of a protist (a type of single-celled organism), bacteria, RBCs and sperm, which he collectively termed as 'animalcules.'
- In 1831, **Robert Brown** discovered the **nucleus** in the cells of orchid's root.
- Unicellular organisms like *Amoeba*, *Paramecium* bacteria, yeast etc. are capable of —
  - **independent existence, and**
  - **performing the essential functions of life.**
- Therefore, cell is the structural and functional unit of all life processes.

CELL THEORY

- In 1838, **Matthias Schleiden,** a German botanist, examined a large number of plants and he observed that—
  - All plants are composed of different kinds of cells which form the tissues of the plants.
- In 1839, **Theodore Schwann,** a British Zoologist, studied different types of animal cells and plant cells. His observation was —
  - All animal cells had a thin outer layer which is today known as the 'plasma membrane'.
  - Presence of cell wall is a unique character of the plant cells.
- On the basis of this, Schwann proposed the hypothesis that the bodies of animals and plants are composed of cells and products of cells.

Definition

Cell: It is the fundamental structural and functional unit of all living organisms.

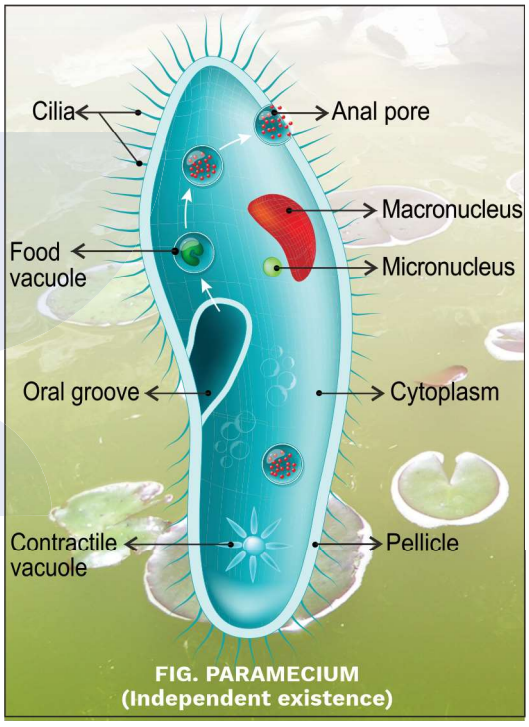


FIG. PARAMECIUM
(Independent existence)

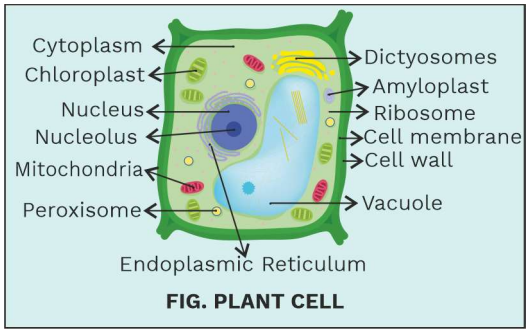


FIG. PLANT CELL

- Schleiden and Schwann together formulated the cell theory. It states that —
  - The cell is the fundamental unit of structure and function in living things.
  - All organisms are made up of one or more cells.

Note: This theory could not explain as to how new cells were formed.

- **Rudolf Virchow** (1855) first explained that cells divided and new cells are formed from pre-existing cells (***Omnis cellula-e cellula***).
- He modified the hypothesis of Schleiden and Schwann to give the cell theory a final shape.

Cell theory as understood today is-

- All living organisms are composed of cells and products of cells.
- All cells arise from pre-existing cells.

Expanded version of the cell theory can also include-

- All cells are essentially the same in chemical composition and metabolic activities
- The functions of an organism as a whole is the outcome of the activities and interaction of the constituent cells.

Definition

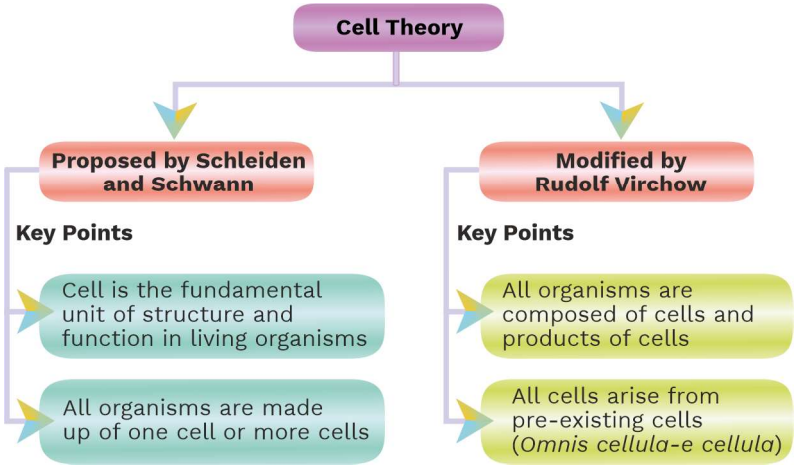
Cytology: The branch of Biology which deals with the study of cells, their formation and structure .

Rack Your Brain

What is the meaning of '*cella*', a Latin word from which term 'cell' was derived by Robert Hooke?

Previous Year's Question

Cell theory was put forward by
(1) Schleiden and Schwann
(2) Sutton and Boveri
(3) Watson and Crick
(4) Darwin and Wallace



- Cells carry genetic material passed to daughter cells during cellular division.

Exceptions to Cell Theory

- Viruses do not possess a cellular machinery even though are considered as organisms.
- The prokaryotic cells lack nuclear membrane around their genetic material.
- RBCs and sieve tubes lack nucleus and major cell organelles still these survive for considerable time.
- Certain fungi and algae are made up of undivided mass of protoplasm in which numerous nuclei lie scattered e.g. *Rhizopus* (fungus) and *Vaucheria* (alga).

SHAPE, SIZE AND LIFE SPAN OF THE CELLS

Cells differ greatly in size, shape, activities and life span.

- In plants parenchyma cells can be isodiametric, oval or irregular in shape and perform diverse functions.
- Guard cells in plants are dumb-bell shaped and bean shaped and regulate opening and closing of stomata.
- Xylem vessels are hollow pipe like structures for conduction of water and minerals. Phloem sieve tubes are elongated cells for translocation of organic substances.
- Human RBCs are circular and biconcave and transport gases.
- WBCs are amoeboid to squeeze out through the blood capillary walls.
- Neurons have hair like projections and long axons to conduct nerve impulses.
- Prokaryotic organisms like Mycoplasmas, the smallest cells, are only 0.3 µm in length while bacteria could be 1 to 5 µm.
- The single cell alga, *Acetabularia* measures up to 10 cm in height.

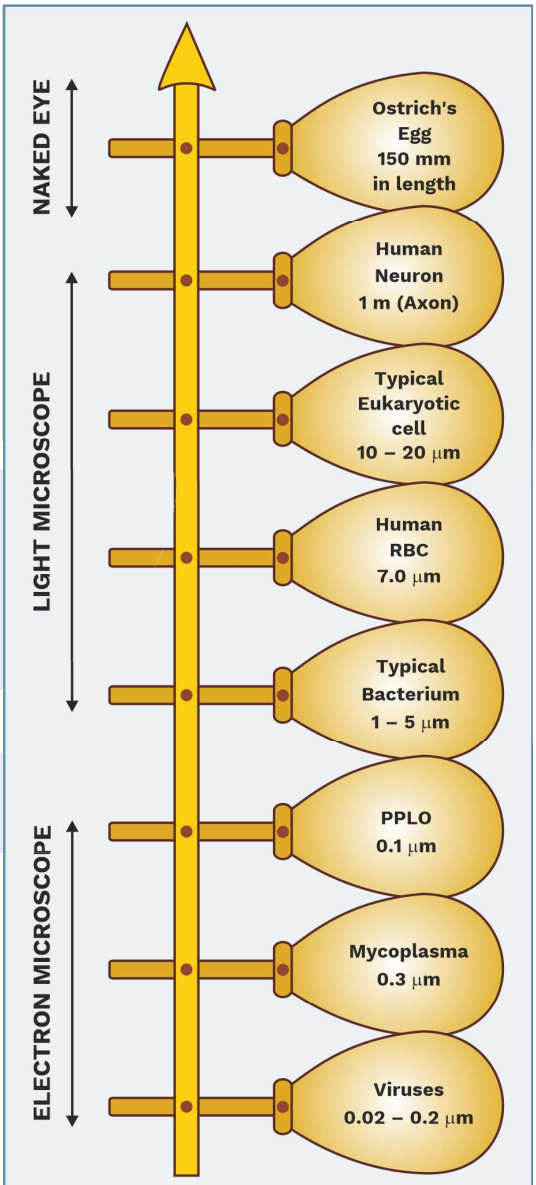


FIG. SIZE OF FEW CELLS

Previous Year's Question

Which one is an exception to cell theory?

(1) Virus (2) Mycoplasma
(3) Algae (4) All of these

- The largest isolated single cell is the egg of an ostrich.
- Human red blood cells are about 7.0 μm in diameter.
- Nerve cells are one of the longest cells, where the axon can reach up to 1 metre in length.

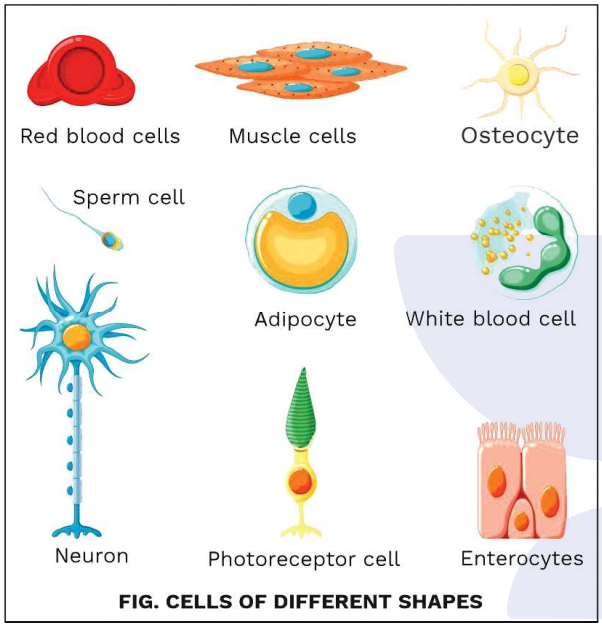


FIG. CELLS OF DIFFERENT SHAPES

Rack Your Brain

Name the longest cell in human body.

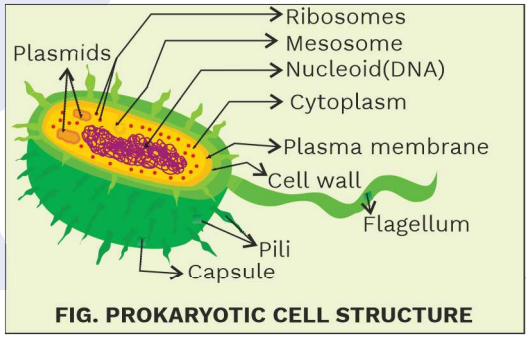


FIG. PROKARYOTIC CELL STRUCTURE

TYPE OF CELLS

On the basis of organisation of genetic material, the cells are of two types— prokaryotic cells and eukaryotic cells.

PROKARYOTIC CELL

- The prokaryotic cells are represented by— Bacteria, cyanobacteria or blue-green algae (BGA), Mycoplasma or PPLO (Pleuro Pneumonia Like Organisms), spirochaete and rickettsiae.
- They are generally smaller and multiply more rapidly than the eukaryotic cells. For example, *E.coli* bacteria multiply every 30 minutes.
- Prokaryotic cells vary greatly in shape and size than eukaryotic cells.

Note: All prokaryotes are haploid.

Definition

Prokaryotic cell: The cell which has undeveloped nucleus, its genetic material is single circular naked DNA and it lacks double membrane bound cell organelles.

BACTERIA

- Depending on shape bacteria are of following types:
  - Coccus (spherical)— Monococcus, diplococcus, streptococcus, staphylococcus and teracoccus
  - Bacillus (rod like) — Diplobacillus and streptobacillus
  - Vibrio (comma shaped)
  - Spirillum (spiral)

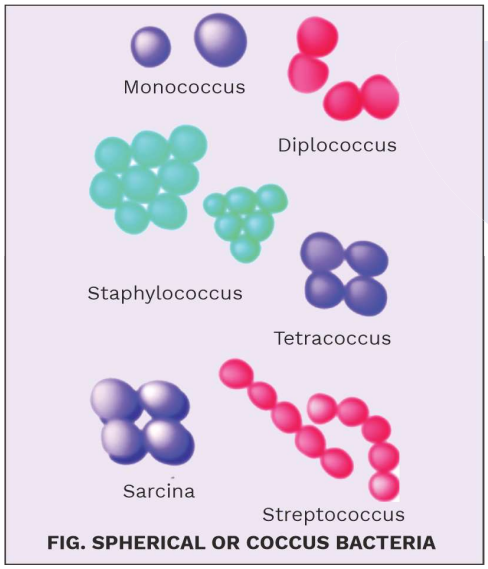


FIG. SPHERICAL OR COCCUS BACTERIA

- Depending on number of flagella bacteria are of following types:
  1. Atrichous
  2. Monotrichous,
  3. Lophotrichous
  4. Amphitrichous
  5. Peritrichous
  6. Amphilophotrichous

Rack your Brain

Which is the most appropriate term for the nuclear part of a prokaryotic cell? Nucleoid, naked chromosome or naked DNA.

Gray Matter Alert!!!

Hans and Zacharias Janssen invented the first compound microscope in the late 16th century.
But Robert Hooke was the first person to use his self made compound microscope to observe cells.

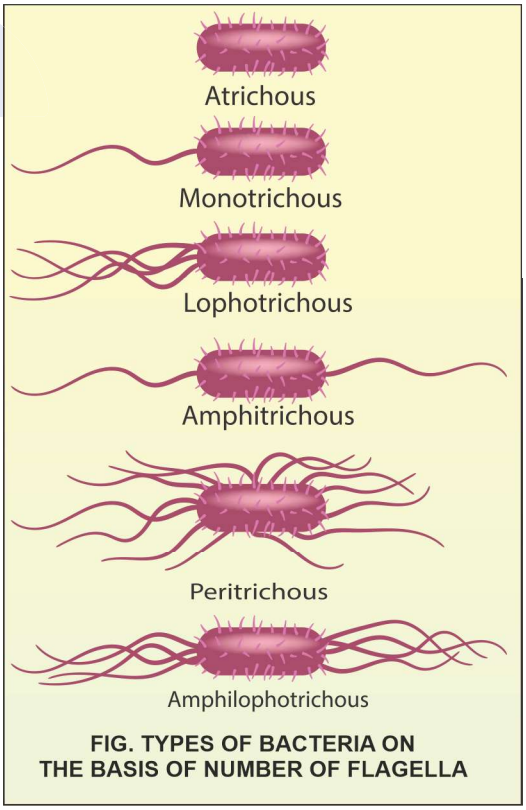
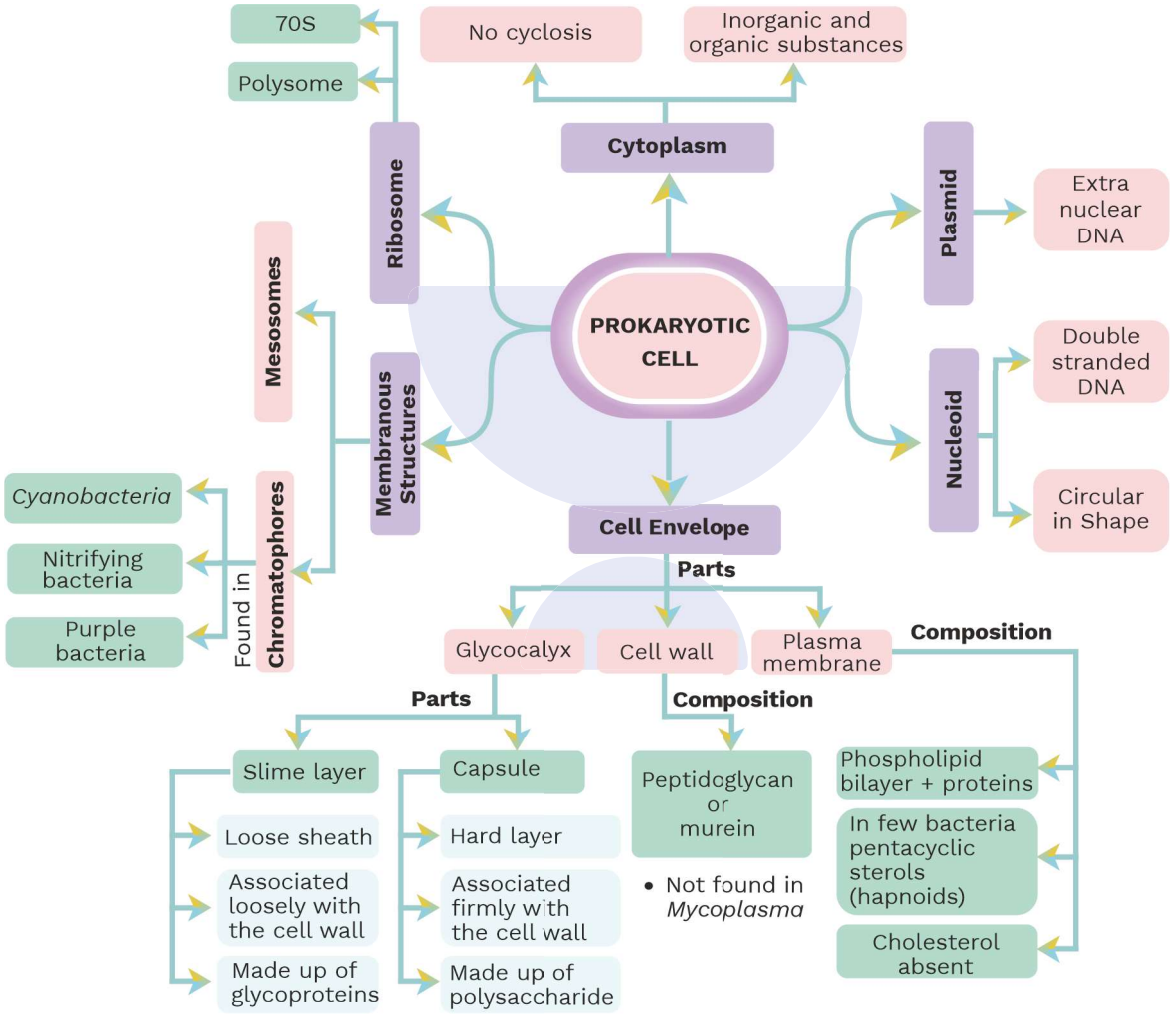


FIG. TYPES OF BACTERIA ON THE BASIS OF NUMBER OF FLAGELLA

STRUCTURAL ORGANISATION OF A TYPICAL PROKARYOTIC CELL

- The organisation of the prokaryotic cell is fundamentally similar even though prokaryotes exhibit a wide variety of shapes and functions.



CELL ENVELOPE

- It is the outer most covering of protoplasm of a typical bacterial cell. It consists of three layers viz glycocalyx, cell wall and plasma membrane.

Glycocalyx

- It is the outermost layer of cell envelope which is protective in nature.

Rack Your Brain

Name the smallest known cell.

- It can be a loose sheath called **slime layer** in some bacteria while in the form of a hard covering called **capsule** in others.
- Slime layer is composed of **glycoproteins** and is loosely attached to the cell wall.
- Capsule is made up of **polysaccharides** and is firmly attached to the bacterial cell wall.

Cell Wall

- In all eubacteria and cyanobacteria, cell wall is composed of **peptidoglycan** or **murein.**
- Peptidoglycan is composed of repeating framework of long glycan strands (N-acetyl muramic acid and N-acetyl glucosamine) which are cross linked by short peptide chains. This provides a strong yet flexible framework.
- Cell wall determines the shape and structural support to the bacterial cell. Thus, provides a strong structural support to prevent the bacterium from bursting or collapsing.
- All prokaryotes have a cell wall surrounding the cell membrane except in **Mycoplasma.**

Plasma Membrane

- Structurally the plasma membrane in prokaryotes is similar to that of the plasma membrane in eukaryotes (with few differences).
- Plasma membrane is present inner to cell envelope in all the prokaryotic cells.
- It forms the boundary of the cytoplasm and is semi permeable in nature.
- It is made up of phospholipid bilayer and proteins (various types).
- In general **cholesterol** is absent but in few bacteria instead of cholesterol, pentacyclic sterols called hapnoids are present. Hapnoids stabilise the membrane.

MEMBRANOUS STRUCTURES

- These are of two types— mesosomes and chromatophores.

Rack Your Brain

In our tears and saliva..... is present which is bactericidal in nature for certain bacteria.

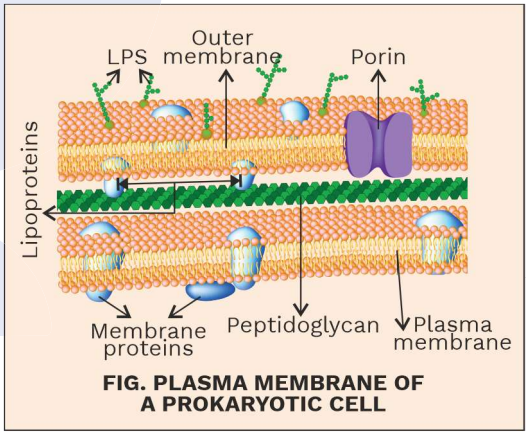


FIG. PLASMA MEMBRANE OF A PROKARYOTIC CELL

Rack Your Brain

List any two similarities and two dissimilarities between the plasma membrane of a prokaryotic cell and an eukaryotic cell.

Mesosome

- Mesosomes are the infolding extensions of cell membrane or plasma memebrane into the cell.
- These extensions are in the form of vesicles, tubules and lamellae.
- Mesosome is the characteristic feature of prokaryotes.

Functions of Mesosomes

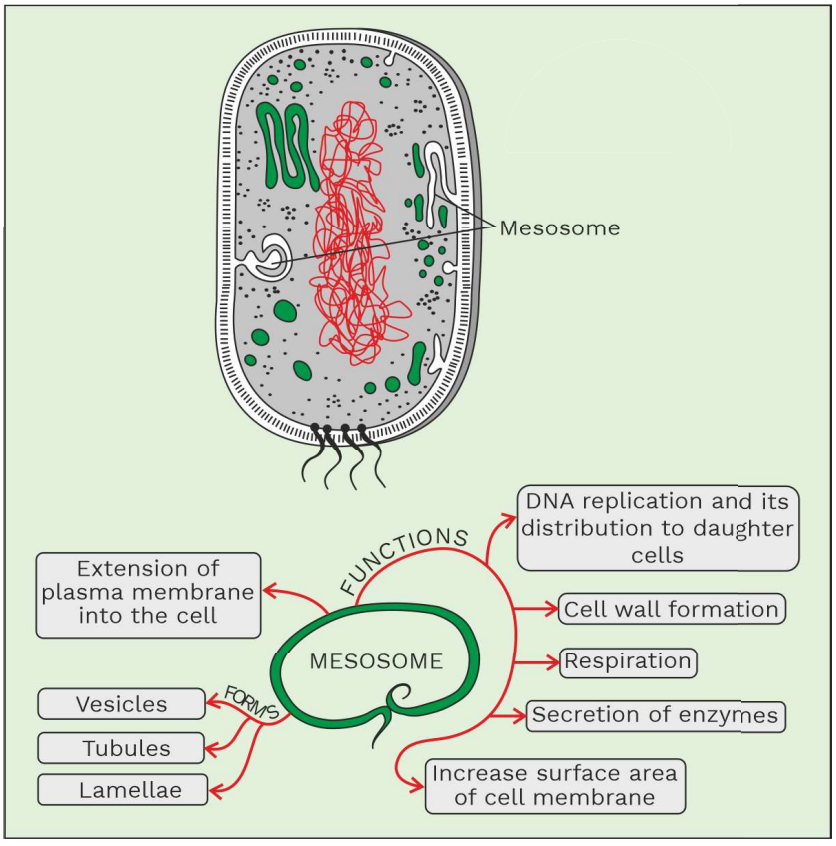
- They help in cell wall formation.
- DNA replication and distribution to daughter cells.
- They also help in respiration, secretion processes, increase the surface area of the plasma membrane and secretion of enzymatic content.

Definition

Cell Biology: The branch of Biology which deals with the study of structure of cell and its organelles along with the biochemical, physiological, genetic, developmental, pathological and evolutionary aspects.

Rack Your Brain

What is the significance of glycocalyx?



Note: Mesosomes are of two types- septal and lateral.

Septal mesosomes are either connected to the cell wall of a dividing cell or nucleoid. Lateral mesosomes are not connected with the nucleoid. Lateral mesosomes contain respiratory enzymes and are often referred as chondrioids.

In bacteria the respiratory enzymes are also present over the plasma membrane.

Chromatophores

- In some prokaryotes like cyanobacteria and purple bacteria there are other membranous extensions into the cytoplasm called chromatophores which contain pigments.
- Chromatophores are also called thylakoids which may be lamellar, tubular or vesicular in shape.
- In cyanobacteria, thylakoid membranes contain photosynthetic pigments — chlorophyll a and carotenoids. Small granules filled with phycobilins are also attached to the thylakoid membrane.
- In purple bacteria the thylakoid membranes contain photosynthetic pigments- bacteriochlorophyll, bacterio-viridin (bacteriophaeophytin) and carotenoids.
- In nitrifying bacteria these membranes may form aggregates of oval flattened or tubular vesicles which are attached to the plasma membrane and help in increasing the surface area for metabolic activities.

Rack Your Brain

Prokaryotic cells lack mitochondria then how do they generate ATPs?

Definition

Cyclosis: Cyclosis: Movement of protoplasm within the cell.

CYTOPLASM

- The fluid matrix filling the cell is the cytoplasm.
- It consists of inorganic and organic compounds.
- Cytoplasm does not show **cytoplasmic streaming** or **cyclosis** inprokaryotic cells.
- It lacks presence of membrane bound cell organelles.
- It is granular in appearance due to the presence of inclusion bodies and ribosomes.

Inclusion Bodies

- These include inorganic inclusions and gas vacuoles.

Inorganic Inclusions

- Food reserve materials are stored in the cytoplasm of bacteria in the inorganic inclusions.
- Phosphate granules (volutin granules) and sulphur granules, iron granules, magnetite are some of the major types of inorganic inclusions.

Rack Your Brain

Assertion. Prokaryotic cell lacks mitochondria.
Reason. Its cell membrane bears respiratory enzymes.

(1) Both statements are true and Reason is the correct explanation of the Assertion.
(2) Both statements are true but Reason is not the correct explanation of the Assertion.
(3) Assertion is true but Reason is a false statement .
(4) Both Assertion and Reason are false statements.

- Volutin granules store polymerised phosphates which are energy rich phosphates.
- These granules retain different colours with basic dyes, so are called **metachromatic granules.**

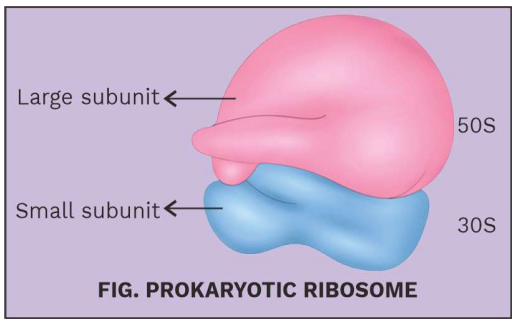


FIG. PROKARYOTIC RIBOSOME

Gas Vacuoles

- Gas vacuoles are hollow cylindrical gas vesicles, impermeable to water but permeable to atmospheric gases.
- These help aquatic autotrophic bacteria to float in water and help them to reach the areas of sunlight or protect themselves from the areas of intense sunlight.
- Gas vacuoles are found in cyanobacteria, purple and green photosynthetic bacteria and in some other aquatic bacteria.

Ribosome of *E. coli*

Ribosome	Subunit	rRNAs	r-proteins
70S	50S	23S (2904 nt)	31
		5S (120 nt)	
	30S	16S (1542 nt)	21

*** nt-Nucleotides**

RIBOSOMES

- In prokaryotes, ribosomes are associated with the plasma membrane of the cell.
- They are about **15 nm** by **20 nm** in size and are made of two subunits — **50S** and **30S** units which when present together form 70S prokaryotic ribosome. In 70S ('S' denotes sedimentation coefficient or sevedberg unit).
- Ribosomes are made up of RNA **(Ribose Nucleic Acid)** and proteins.
- Ribosomes are the site of protein synthesis.
- Several ribosomes may attach to a single mRNA and form a chain of ribosomes called **polyribosome** or **polysome.**
- The ribosomes of a polysome translate the mRNA into several proteins simultaneously.

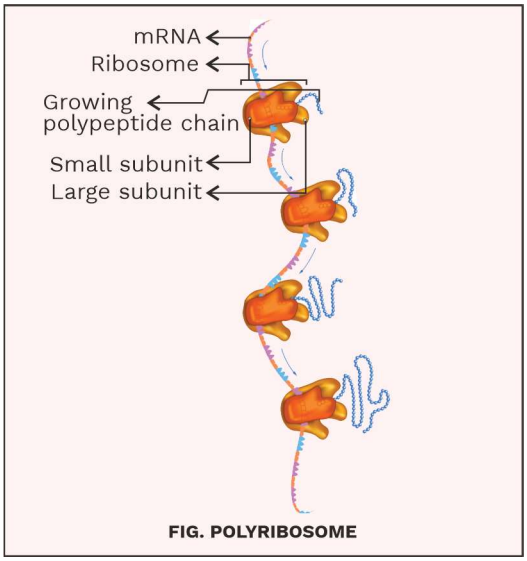


FIG. POLYRIBOSOME

NUCLEOID OR NUCLEAR BODY

- There is no well-defined nucleus.
- The genetic material of the prokaryotes consists of a **naked long double stranded circular DNA**.
- DNA is coiled with the help of nucleoid proteins.

- The nucleoid proteins are different than the histone proteins in eukaryotes.
- The genetic material is basically naked, not enveloped by a nuclear membrane.

Plasmid

- In addition to the genomic DNA many bacteria have small circular DNA outside the genomic DNA (extra chromosomal DNA). These smaller DNAs are called plasmids.
- The plasmids can replicate independently.
- The plasmid DNA confers certain unique phenotypic characters to bacteria. One character is resistance to antibiotics.
- Plasmid DNA is used to monitor bacterial transformation with foreign DNA.

FLAGELLA

- Bacterial cells may be motile or non-motile. If motile, they have thin filamentous extensions arising from their cell wall called flagella.
- Bacteria show a range in the number and arrangement of flagella.

Bacterial flagellum is composed of three parts—

- Filament
- Hook
- Basal body

Filament

- The filament is the longest portion which measures about 20 nm in diameter and 1 nm to 70 nm in length.
- It extends from the cell surface to the outside and is enchored to the cell by the basal body.
- It is hollow which is made up of protein called **flagellin**.

Hook

- It is curved hollow structure which hooks the filament to the inner side of the cell membrane

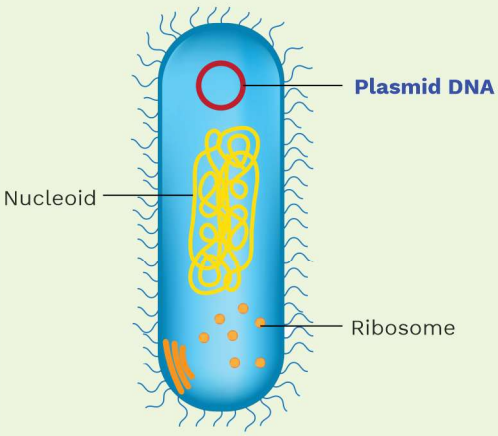


FIG. PROKARYOTIC CELL

Definitions

Nucleoid: Single, circular, naked DNA found in prokaryotes.

Plasmid: Extra chromosomal DNA found in prokaryotes.

Rack Your Brain

Surface appendages that have no role in motility in bacteria are proteinaceous structures. Name the proteins which form these appendages?

Basal Body

- In Gram-negative bacteria, the basal body is made up of four rings viz. L, P, S and M rings. L and P rings are attached to the lipopolysaccharide and peptidoglycan layers, respectively. The S ring lies in the periplasmic space and the M ring is connected to the plasma membrane.
- In Gram-positive bacteria, the basal body is made up of two rings. The outer ring is connected to the lipopolysaccharide and peptidoglycan layers and the inner unit with the plasma membrane.
- The three sub-units of the flagellum help it to rotate in all the directions.

Bacterial Surface Appendages

- These are pili, fimbriae and spinae which have no role in locomotion.

Pili

- The pili (Sing—pilus) are elongated, tubular structures made up of special protein called **pilin.**
- These are 3 nm to 25 nm in diameter and 0.5 µm to 20 µm in length.
- Pili are involved in conjugation (mating process) where the genetic material is exchanged partially between the two compatible bacteria.
- These have no role in motility of bacteria.
- These are usually found in Gram-negative bacteria.

Fimbriae

- Fimbriae are small bristle like fibres present on the bacterial surface and are composed of special proteins.
- These have no role in motility of the bacteria.
- These are helpful in clinging of bacteria to solid surfaces or attaching to the host body.

Spinae

- The spinae are tubular, rigid hair like outgrowths.
- These are made up of protein called **spinin.**

Rack Your Brain

Which nucleic acid is found in ribosomes?

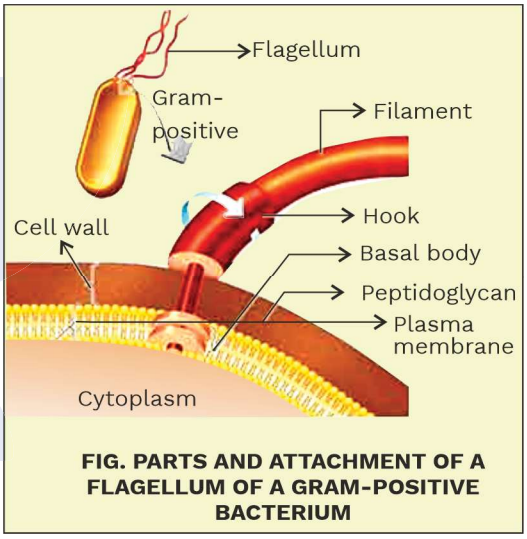


FIG. PARTS AND ATTACHMENT OF A FLAGELLUM OF A GRAM-POSITIVE BACTERIUM

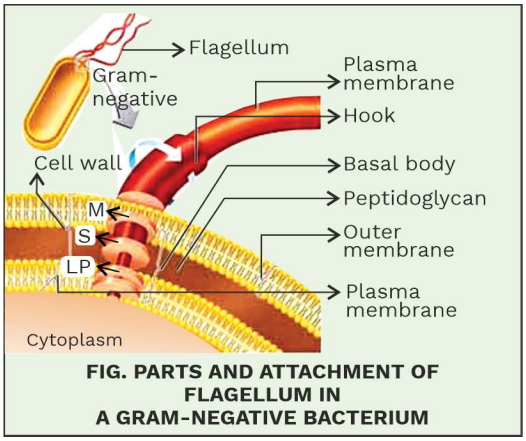


FIG. PARTS AND ATTACHMENT OF FLAGELLUM IN A GRAM-NEGATIVE BACTERIUM

- Usually spinae are found in Gram + bacteria.

CLASSIFICATION OF BACTERIA ON THE BASIS OF STAINING

- Bacteria can be classified into two groups on the basis of the differences in the cell envelopes and the manner in which they respond to the staining procedure developed by **Christian Gram,** 1884.
  - All bacteria stain blue with weak alkaline solution of crystal violet or Gram's stain.
  - The stained cells are treated with 0.5% iodine (KI) solution and washed with absolute alcohol or acetone.
  - The cells which retain the Gram's stain are Gram-positive bacteria.
  - The cells which do not retain the Gram's stain are called Gram-negative bacteria.

EUKARYOTIC CELL

- Protists, plants, animals and fungi are made up of eukaryotic cells.
- All eukaryotic cells are not identical.
- Eukaryotic cell mainly consists of protoplasm (living material) surrounded by a semipermeable membrane, i.e., plasma membrane.
- In addition to plasma membrane cell wall is present in fungal cells, plant cells and in few protists.
- In eukaryotic cells, there is an extensive compartmentalisation of cytoplasm through the presence of membrane bound organelles viz, mitochondria, plastids, ribosome, endoplasmic reticulum, golgi apparatus, lysosomes, vacuoles as well as some other cell inclusions.
- Eukaryotic cells possess an organised nucleus with a nuclear envelope. Their genetic material is organised into chromosomes and is present inside the nucleus.
- Eukaryotic cells have a variety of complex locomotory and cytoskeletal structures.

Gram-positive Bacteria	Gram-negative Bacteria
• Generally non-capsulated	• Generally capsulated
• Thickness of cell wall is 150-200 Å	• Thickness of cell wall is 75-120Å
• Cell wall single layered	• Cell wall two layered
• Cell wall is smooth	• Cell wall is wavy
• Porins absent in the cell wall	• Porins present in the cell wall
• Lipid content in the cell wall is 2-4%	• Lipid content in the cell wall is 20-30%
• Peptidoglycan content is 70-95%	• Peptidoglycan content is 5-20%
• Amount of Amino sugars is 10-20%	• Amount of Amino sugars is 2-8%
• Mesosomes are commonly present	• Mesosomes are less common
• Pili are rare	• Pili are common
• Flagellation is less common	• Flagellation is common
• Teichoic acid-present	• Teichoic acid-absent
• Produce exotoxin	• Produce endotoxin
• Susceptible to antibiotics like penicillin	• Less susceptible to antibiotics
• Mostly cocci	• Mostly bacilli
• Mostly non-pathogenic	• Mostly pathogenic

Difference between gram-negative and gram-positive bacteria

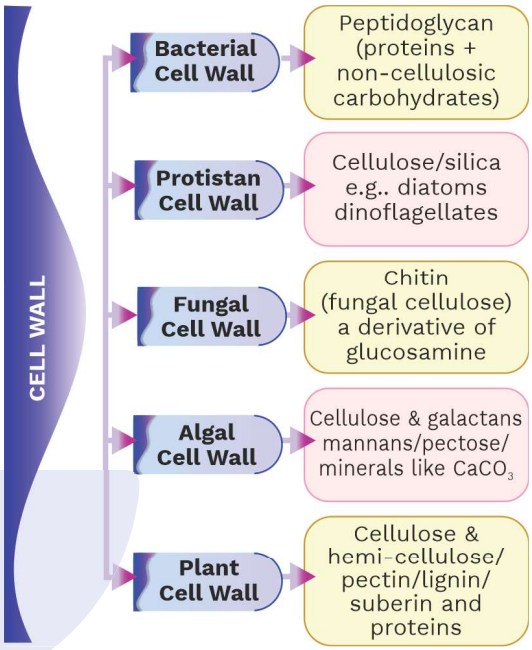
Definition

Eukaryotic cell: Cell with developed nucleus and membrane bound cell organelles.

CELL WALL

- 'Cell Wall' was first discovered by an English biologist, Robert Hooke (1665) in **Cork Cells.** It is about 0.1 µm to 10 µm in thickness. It is found in bacteria, fungi, algae and green plants.
- In bacteria, cell wall is made up of **peptidoglycan** which consists of proteins and non-cellulosic carbohydrates **(mucopolysaccharide).**
- In **fungi,** it is composed of fungus cellulose called **chitin.**
- In green plants, it mainly consists of cellulose, **hemicellulose, pectins** and proteins.
- **Algae** have cell wall, made of cellulose, **galactans, mannans** and minerals like calcium carbonate.
- In woody plants, cellulose is covered by **lignin** in the cell wall.

Parts of a Cell Wall: Cell wall is made up of primary cell wall, secondary cell wall (present in mature cells) and middle lamella.



Primary Cell Wall

- It is first formed wall which is thin, extensible and permeable.
- Primary cell wall of a young plant cell is capable of growth and gradually diminishes as the cell matures. It is the outermost layer, but inner to middle lamella.
- It is made up of **cellulose** and **hemicellulose** in green plants but in fungi it is of **chitin**.
- In bacteria and blue green algae it consists of mucopolypeptide and mucopolysaccharide.
- Cell wall is composed of microfibrils embedded in matrix, in plants. In matrix the pectin is the filler substance.

Note: The function of glycoproteins is to control the orientation of microfibrils and exert enzymatic influence on metabolic activities of the cell, whereas hemicellulose is involved in binding microfibrils with matrix e.g., leaf cells, fruit cells and cells of pith and cortex.

Previous Year's Question

Plant cell walls possess—
(1) Cellulose
(2) Hemicellulose
(3) Pectin
(4) All of these

Gray Matter Alert!!!

Micelle is made up of about 100 cellulose molecules and is the smallest unit of the plant cell wall.

Secondary Cell Wall

- It is formed inner to the primary cell wall (towards membrane).
- It is thick, rigid and permeable.
- It is composed of cellulose and hemicellulose and is covered by **lignin, cutin, suberin**, etc. **Silica** and **tannins** may also be present. Xylans are part of secondary wall.
- Lignin provides hardness to the wall.
- The **suberin,** present in cork cells and endodermal cells, imparts impermeability to it.
- In secondary wall, the cellulose content is comparatively more, e.g., vessels, tracheids, fibres and collenchyma.

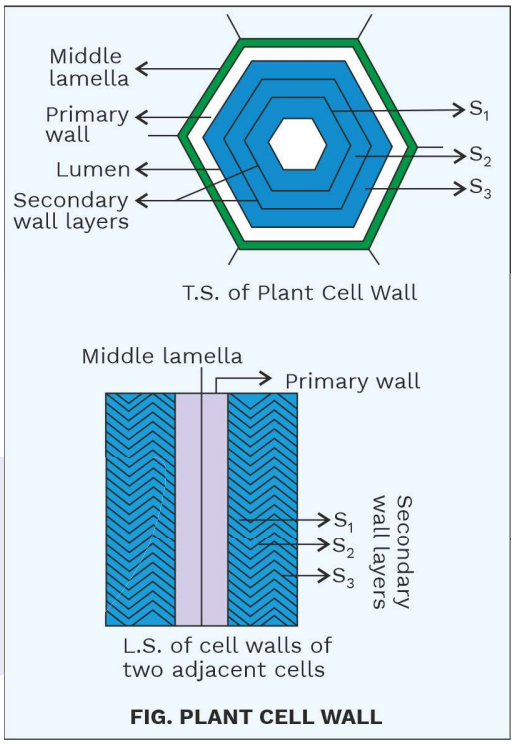


FIG. PLANT CELL WALL

Note: Tertiary Cell Wall: A wall containing xylan is called tertiary wall, for example, tension wood in gymnosperm. Though it is similar to primary wall in composition, it may additionally contain lignin (hydrophobic material). It provides hardness to the wall. Additional lignin is absent in tertiary cell walls in angiosperms.

Middle Lamella: It is a thick amorphous cementing layer in between the two adjacent plant cells. It is first layer formed at the time of cytokinesis. Middle lamella is composed of **calcium** or **magnesium pectate**.

PLASMODESMATA

These are cytoplasmic connections in the form of junctions of bridges in the cell wall and middle lamellae. They maintain the cytoplasmic continuity with other cells. They bind various components of cell wall through some pores.

Pits: These are the depressions in cell wall. They have secondary thickening. Pits do not have secondary wall and are made up of primary wall and middle

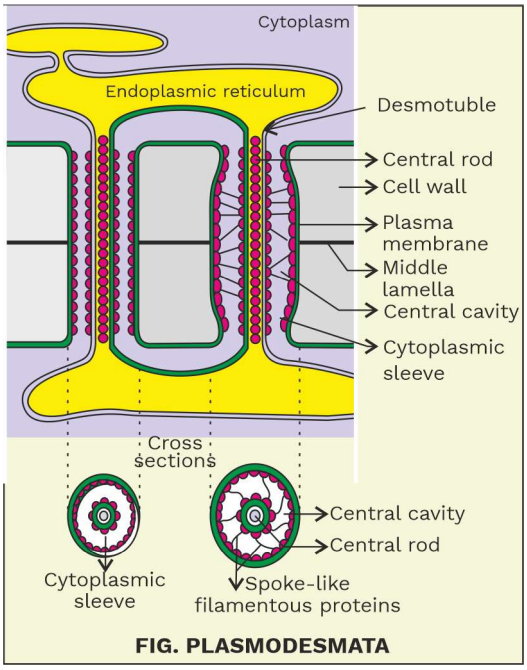


FIG. PLASMODESMATA

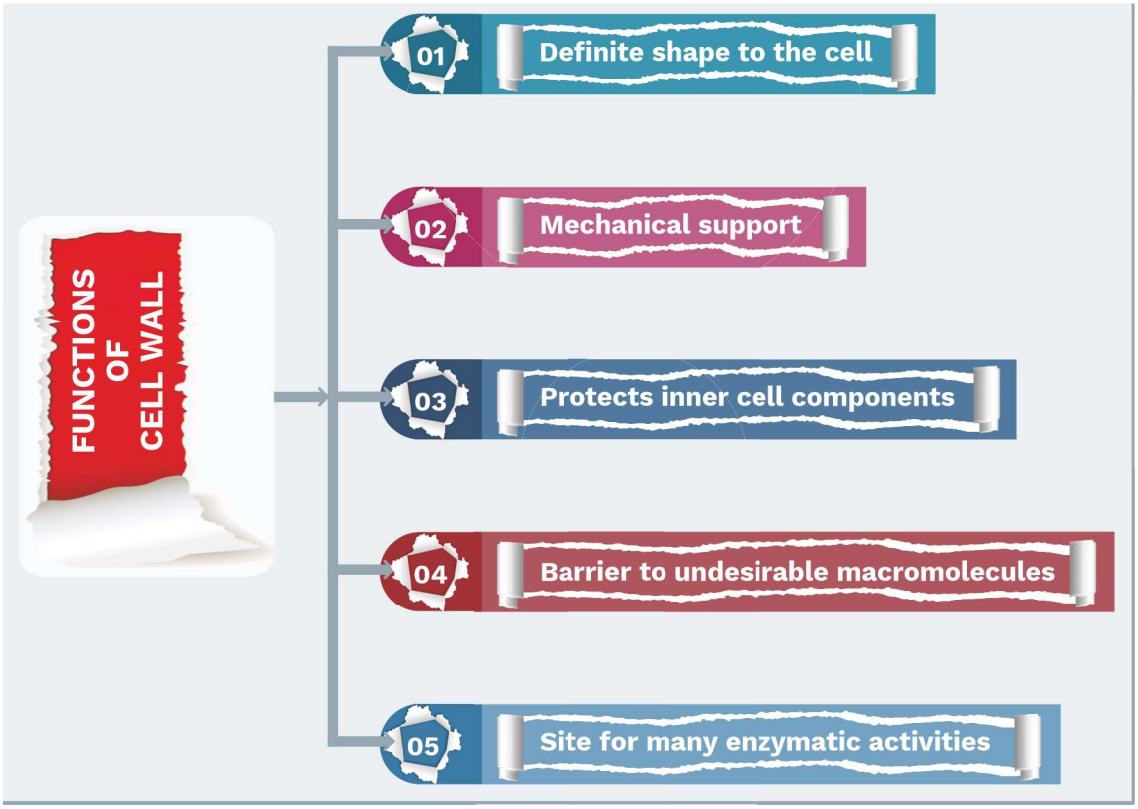
lamellae. Every pit consists of a cavity (pit chamber) and a pit membrane. Pits are of two types:

- **Simple pits:** They have uniform width of pit chamber.
- **Bordered pits:** Their pit membrane is flask shaped. They are involved in rapid translocation between two adjacent cells.

Rack Your Brain

Why does plant cell wall lack selective permeability?

FUNCTIONS OF CELL WALL



CELL COAT

- It is the outer layer of glycocalyx in many lower animals and protistans.
- It is a filamentous layer of oligosaccharide.
- In some animals, it also consists of silicon, calcium and other salts.
- It provides shape to the cell and protects the plasma membrane.

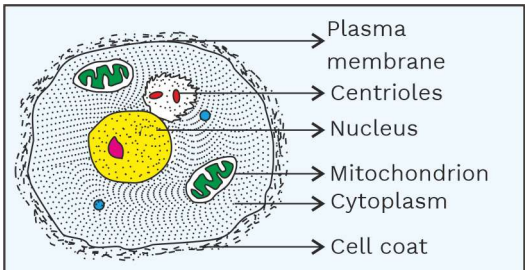


FIG. CELL COAT

- It is involved in recognising other cells and microbes during tissue formation, cells aggregation and histocompatibility.
- It supports and provides strength to the cell.

Rack Your Brain

Name one element present in the middle lamella.

Table. Difference between Cell Wall and Plasma Membrane

Cell Wall	Plasma Membrane
It is non-living, rigid and permeable.	It is living, flexible and semi-permeable.
It is made up of mainly cellulose or polysaccharide.	It is made up of proteins and phospholipids.
It consists of gums, resins, silica, etc., in the matrix.	Not present.
It is present in bacteria, plant cells, fungal cell and few protists.	It is present all type of cells.

CELL MEMBRANE OR PLASMA MEMBRANE

- All biomembranes are living structures. Cell membrane forms the outer most boundary of cytoplasm and controls the entry and exit of ions and molecules. Chemical studies on the cell membrane, especially in human red blood cells (RBCs), enabled the scientists to deduce the possible structure of plasma membrane.
- Following are some structural models of plasma membrane which are proposed by different scientists from time to time.
  - **Lamellar Model or Sandwich Model:** It was proposed by Davson and Danielle (1935).
  - **Unit Membrane Model:** It was proposed by J. Robertson in 1953.
  - **Fluid Mosaic Model:** It was proposed by Nicolson and Singer (1972).

Rack Your Brain

Which is the smallest unit in the plant cell wall?

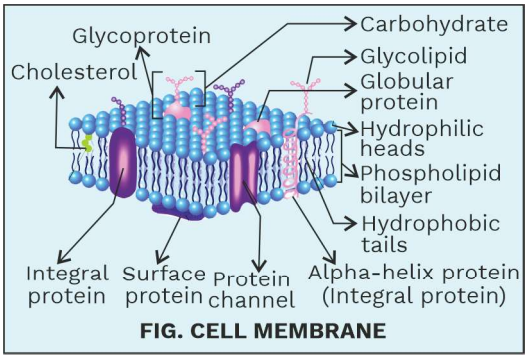


FIG. CELL MEMBRANE

Fluid Mosaic Model

- This model is considered most satisfying to most of the scientists and is widely accepted.
- According to this model, the phospholipid molecules are arranged in the form of a bimolecular layer, thereby their hydrophilic polar heads constitute the top and bottom surfaces where hydrophobic tails are buried in the membrane.
- Depending on the ease of extraction, membrane proteins can be classified as **peripheral or extrinsic** and **integral or intrinsic.**
- The extrinsic protein are easy to be removed by slight treatment due to the quasi-fluid nature of the lipid, the intrinsic protein cannot be removed easily.
- Many of these proteins are permeable (enzymes) as they permit the entry of some substances. The fluid mosaic model was explained by its authors as "protein icebergs in a sea of lipids".
- The lipid and integral proteins are arranged in a kind of mosaic pattern.

Fluid mosaic model of plasma membrane puts forth that-

- Due to amphipathic nature of plasma membrane, the integral proteins are intercalated, some large globular integral proteins project beyond the lipid layer on both sides, thought to have channels through which water soluble materials can pass; some smaller integral proteins partially penetrate the lipid bilayer on the surface only.
- The polar regions of membrane (phospholipids) protrude from the surface of the membrane.
- The non-polar (hydrophobic ends) regions of the cell-membrane (phospholipids) remains embedded in the interior of the membrane. This ensures that the non-polar tail of saturated hydrocarbons is protected from the aqueous environment.

Definitions

Protoplasm: Cytoplasm and nucleus constitutes protoplasm. It is the living part of the cell.

Protoplast: Protoplasm surrounded by cell membrane is termed as protoplast.

Gray Matter Alert!!!

The term 'protoplast' was given by Purkinje.

Previous Year's Question

Fluid mosaic model of cell membrane was proposed by
(1) Robertson
(2) Danielli and Davson
(3) Singer and Nicholson
(4) Watson and Crick

- The ratio of protein and lipid varies considerably in different cell types. In human beings, the membrane of the **erythrocyte** has approximately **52 per cent protein** and **40 per cent lipids.**

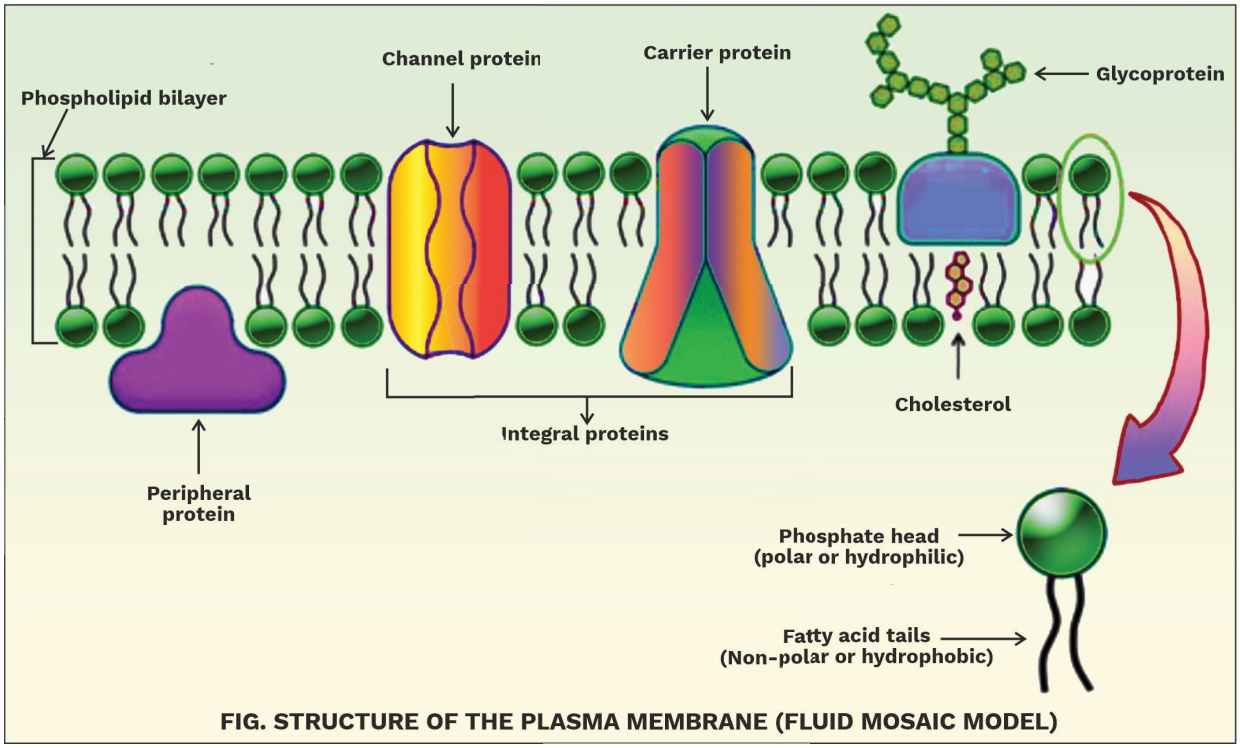


FIG. STRUCTURE OF THE PLASMA MEMBRANE (FLUID MOSAIC MODEL)

- Biological membranes are quasi-fluid in nature. It has both the lipids and the integral proteins that are capable to move within the overall bilayer.
- It is known, now, that lipids and also many of the intrinsic proteins and glycoproteins of the membrane are amphipathic molecules (i.e., contains both hydrophilic and hydrophobic groups in the same molecule).
- As the polar molecules cannot pass through the non-polar lipid bilayer, they require a carrier protein of the membrane to facilitate their transport across the membrane.
- The fluid nature of the membrane is also important from functions like cell growth, formation of **intercellular junctions,** secretion, **endocytosis,** cell division, etc.

Previous Year's Question

Previous Year's Question
The latest model or view about the molecular structure of plasma membrane is
(1) Sandwich model
(2) Unit membrane hypothesis
(3) Fluid mosaic model
(4) None of these

- These are the specific protein in the membrane called membrane receptors, which mediate in the flow of information and materials into the cells by binding specific molecules reaching the cell surface, e.g., hormone adrenaline.
- The fluid mosaic model explains that various enzymes and antigenic glycoproteins should have their active site exposed to the outer surface of the membrane.
- The membranes of mitochondria, endoplasmic reticulum, nucleus, etc., are all bio-membranes. These membranes are **semipermeable** and allow exchange of some of materials through them.

IMPORTANT TERMS AND PROCESSES RELATED TO PLASMA MEMBRANE

- One of the most important functions of the plasma membrane is the transport of the molecules across it.
- **Passive transport:** Passage of molecules without the expense of energy. The molecules or ions move from higher to lower concentration in an electrochemical gradient or in a chemical gradient (membrane plays a passive role).
- **Active transport:** Movement of molecules against the concentration gradient.
- **Carrier process:** Some kind of specific proteins or carrier proteins which act as permeases, facilitate the movements of the molecules across the membrane.
- **Energy dependent process:** Energy from ATP helps to speed up the transport of the molecules through the plasma membrane.

Example of Active Transport

- **Sodium-Potassium Exchange Pump:** It is a mechanism for transferring Na^+ and K^+ ions against their electrochemical gradient by utilizing energy from ATPs. The enzyme or the integral protein involved in this pump is a Na^+–K^+ dependent ATPase. For each molecule of ATP consumed,

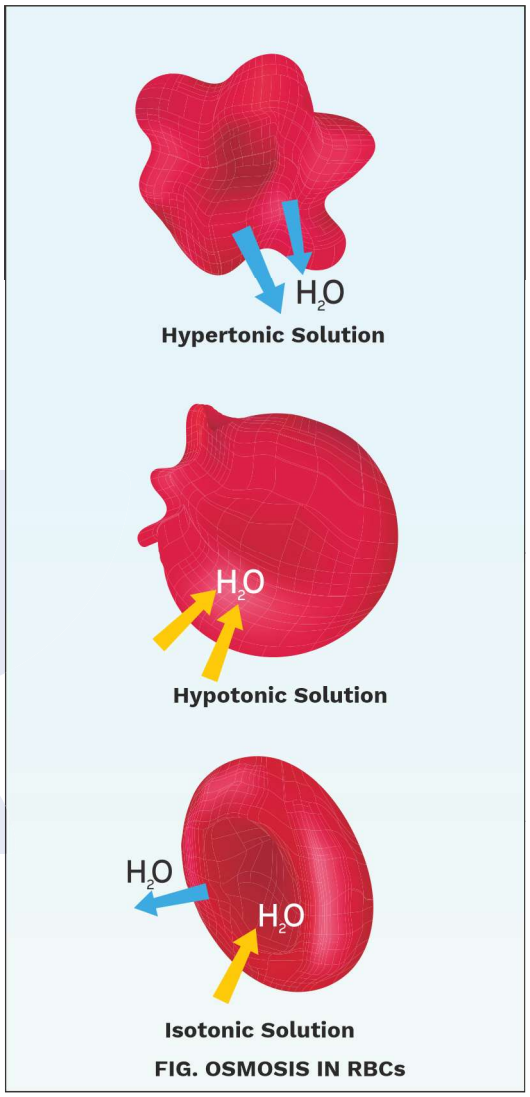


FIG. OSMOSIS IN RBCs

Previous Year's Question

Carrier proteins are connected with
(1) Water Transport
(2) Active Transport
(3) Passive Transport
(4) Facilitated Transport

three Na^+ ions are pumped out and two K^+ ions are pumped in. Thus, the cell maintains a more Na^+ concentration outside than inside the cell.

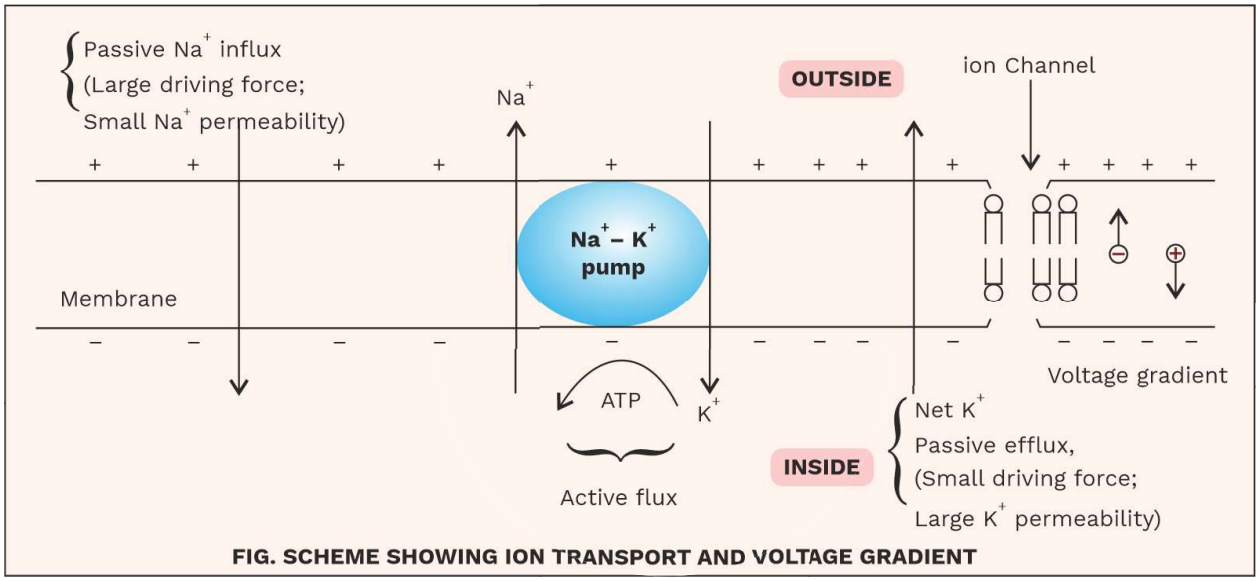


FIG. SCHEME SHOWING ION TRANSPORT AND VOLTAGE GRADIENT

- **Diffusion**
  - Process of movement of ions or molecules from the region of their **high concentration** or high chemical or electrochemical gradient to their low concentration, till they occupy the available space (no semipermeable membrane is required).
  - **Neutral solutes** may move across the membrane by the process of simple diffusion along the concentration gradient, i.e., from higher concentration to the lower.
- **Osmosis:** Diffusion of **water** molecule through plasma membrane from its lower concentration area to that of higher concentration.
- **Endocytosis:** Process in which the substances or molecules in bulk are taken in by the plasma membrane.
  - **Phagocytosis:** Engulfing of foreign solid food materials in bulk through plasma membrane.
  - **Pinocytosis:** Taking in (drinking) liquid material in a large amount through plasma membrane.

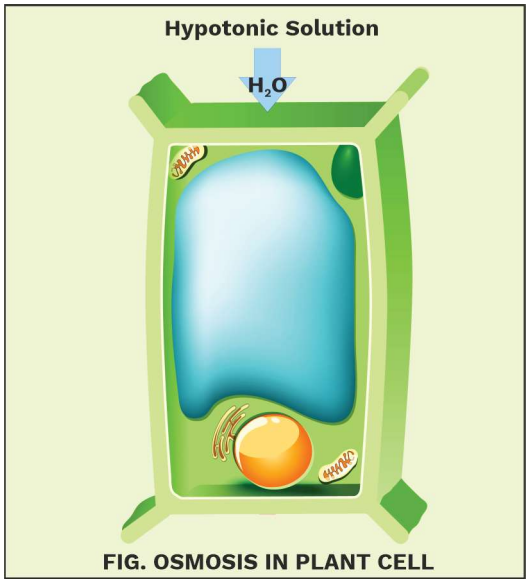


FIG. OSMOSIS IN PLANT CELL

- **Exocytosis:** The process by which secretions or waste material in bulk are thrown out through cell membrane.

CYTOPLASM

- It is a jellylike semi-fluid matrix outside the nucleus and covered by plasma membrane.
- It contains the organelles, nucleotides, vitamins, enzymes, t-RNA minerals, sugars and amino acids. Proteins are found in the cytoplasm and colloids.

Functions of cytoplasm

- The cytoplasm is the main arena of cellular activities in both the plant and animal cells. Various chemical reactions occur in cytoplasm to keep the cell in the 'living state'.
  - It participates in the intracellular distribution of nutrients, metabolites and enzymes, etc.
  - It helps in the exchange of materials between various organelles.
  - It provides the site for glycolysis and biosynthesis of fatty acids, nucleotides and many proteins.

Cytoplasmic Streaming (Cyclosis)

- It is the method of movement of cytoplasm in a definite cycle within the cells. It may be in one direction around a central vacuole or in several directions around vacuoles. Cyclosis depends upon the viscosity of cytoplasm and temperature.

ENDOMEMBRANE SYSTEM

- The membranous organelles are distinct in terms of their structure and function, many of these are considered together as an endomembrane system because their functions are coordinated.
- **The endomembrane system** includes— endoplasmic reticulum (ER), golgi complex, lysosomes and vacuoles.

Previous Year's Question

Cytoplasm of one cell is continuous with that of the adjacent one through

(1) Pits
(2) Plasmodesmata
(3) Endoplasmic reticulum
(4) Middle lamella

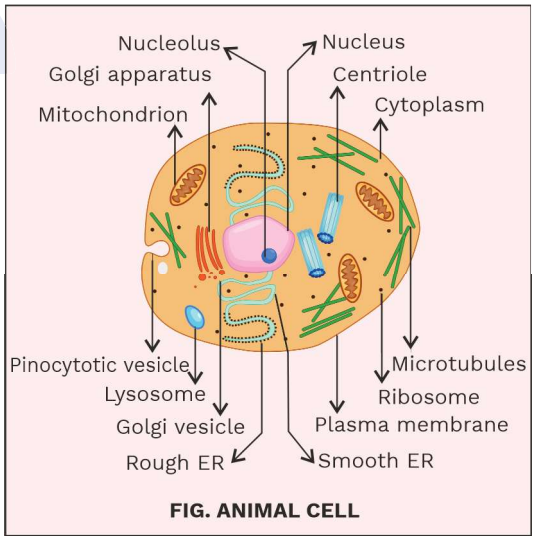


FIG. ANIMAL CELL

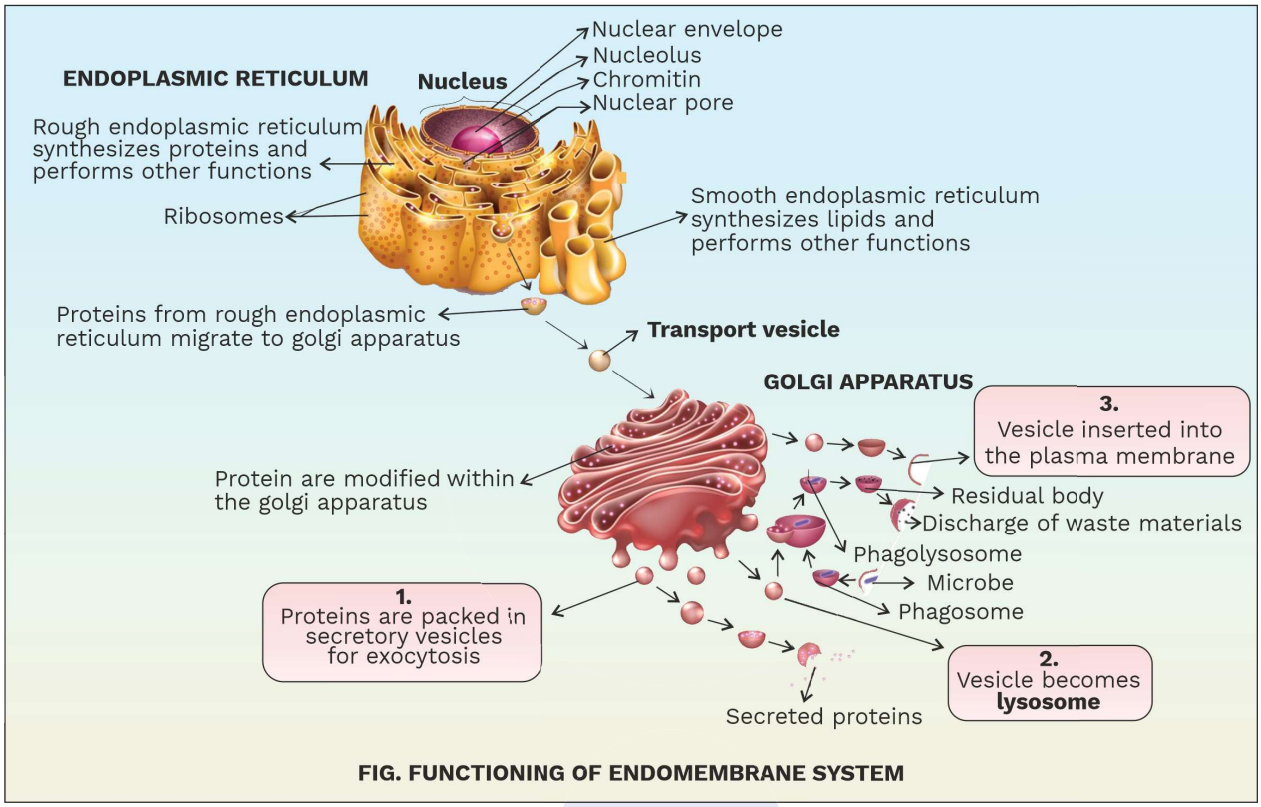


FIG. FUNCTIONING OF ENDOMEMBRANE SYSTEM

Endoplasmic Reticulum (ER)

- They were discovered for the first time by Porter and Thomson (1945) and were named as endoplasmic reticulum by Porter (1953).
- These are membranous organelle, complicated and interconnected system of channels. These are present in metabolically active cells and some other cells except eggs, mature RBCs, embryonic cells and prokaryotic cells.
- ER divides the intracellular space into two distinct compartments, i.e., luminal (inside ER) and extra luminal (cytoplasm) compartments.
- ER is extensive and continuous with the outer membrane of the nucleus.

Sarcoplasmic Reticulum

- ER is of special shape in striated muscle fibres and is called sarcoplasmic reticulum.

Gray Matter Alert!!!

Cell organelles with single membrane covering are–

- Endoplasmic reticulum
- Golgi complex
- Lysosome
- Peroxisome
- Glyoxysome
- Sphaerosome
- Thylakoid (lamella in chloroplast)

ER forms a network of three channels

- **Cisternae:** They are in the form of a network of flattened sacs which are 40-50 nm in diameter. These sacs are formed by the encircling of various membrane sheets. They are found in cells involved in synthetic activity.
- **Vesicles:** They are oval rounded sacs that remain isolated in cytoplasm. They are also called microsomes. They are found in liver and pancreas cells.
- **Tubules:** They are tube like extensions connected by cisternae or vesicles. They form a network like structure.

Types of ER— SER and RER

SER (Smooth Endoplasmic Reticulum)

- These ER does not contain ribosomes on their surface.
- They mainly consist of tubules and vesicles.
- SER is found in much about in lipid and steroid secreting cells like liver, fat cell and adrenal cortical cells. Thus, SER is the major site for synthesis of lipid.
- These ER form passage for the transport of secretary proteins, lipids and steroids.
- In animal cells, lipid-like steroidal hormones are synthesised in SER.

Specific Functions of SER

- Glycogen metabolism.
- Detoxification in liver.
- Formation of Golgi bodies.

RER (Rough Endoplasmic Reticulum)

- RER contains ribosomes on its surface (so is rough in appearance).
- RER is made up of cisternae and a few tubules.
- RER is frequently observed in the cells actively involved in **protein synthesis** and secretion.
- The cisternae of RER are found in protein secreting cells, e.g., cells of liver, pancreas and fibroblast.

Rack Your Brain

Which of the following belong to a different category?

(1) Lysosome (2) Mitochondria
(3) ER (4) Golgi bodies

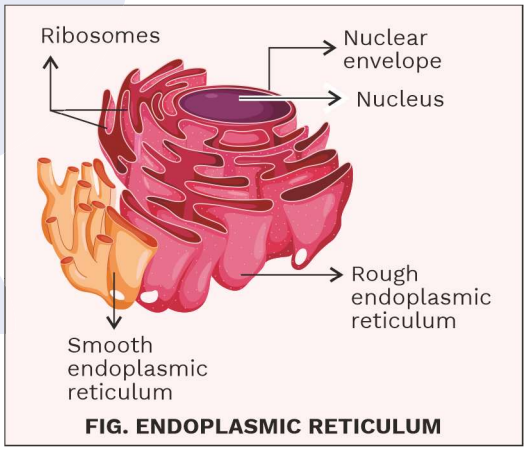
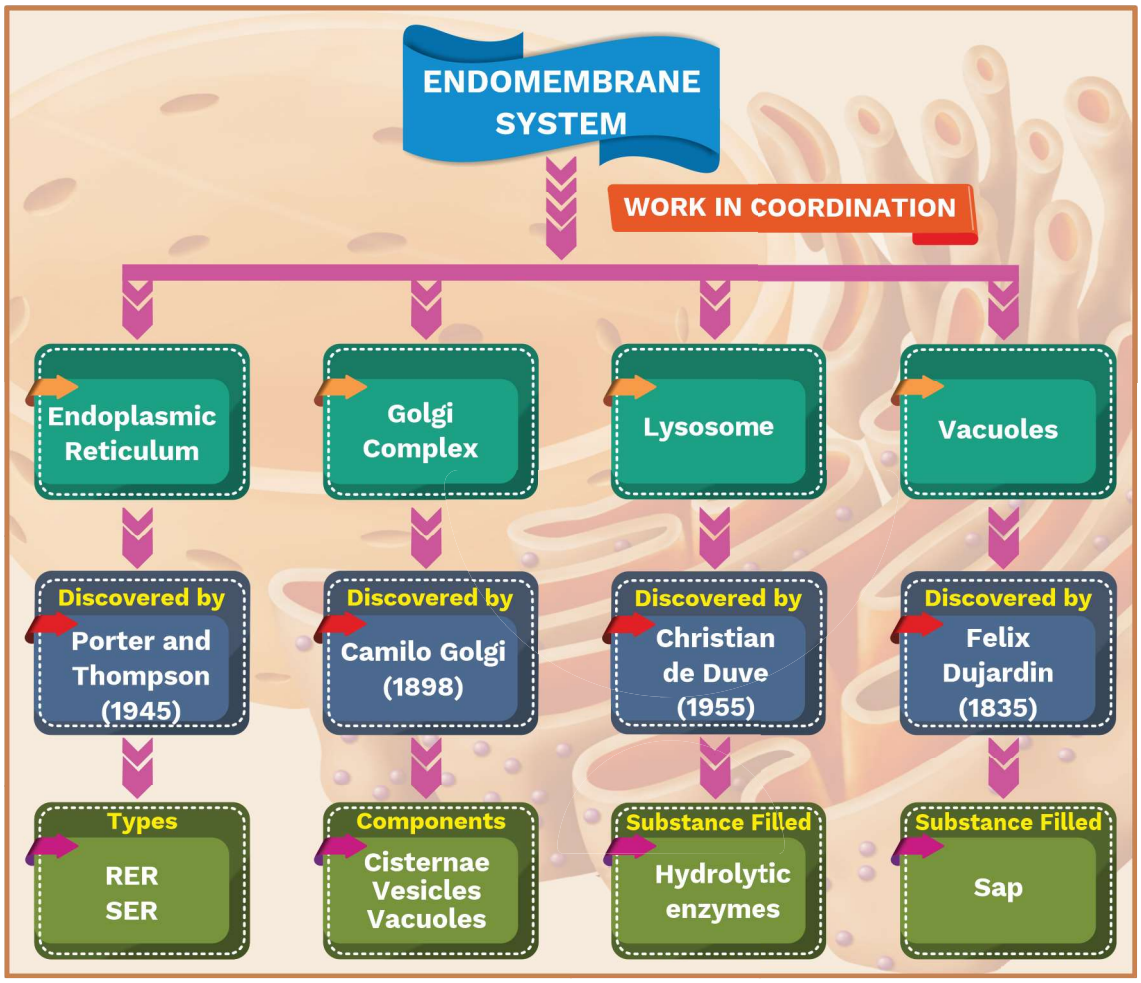


FIG. ENDOPLASMIC RETICULUM

Previous Year's Question

Detoxification site in the liver cell is

(1) Golgi apparatus
(2) Free ribosomes
(3) RER
(4) SER



Specific Functions of RER

- Packaging
- Surface for ribosome
- Surface for protein synthesis

Common Functions of ER

- Protein synthesis
- Transport of materials
- Mechanical support
- Glycogen metabolism.
- Hydrolysis of ATP (SER contains ATPase enzyme).
- Site for enzymatic activities.
- Acts as skeleton of cells.
- Detoxification.

Gray Matter Alert!!!

On RER two glycoproteins called ribophorin I and ribophorin II are present which help in the attachment of ribosomes.

- Formation of plasma membrane.
- Impulse conduction.

GOLGI COMPLEX

- **Camilo Golgi** (1898) discovered Golgi complex by means of metallic impregnation method in nerve cell (near the nucleus) of an owl. These were later named Golgi bodies after him.
- It is present in all eukaryotic cells except RBCs of mammals, sieve tubes, sperms of Bryophytes and Petridophytes.
- They may be 3–7 in animal cells and 10–20 in plant cells.
- Camillo Golgi (1898) first observed densely stained reticular structures.

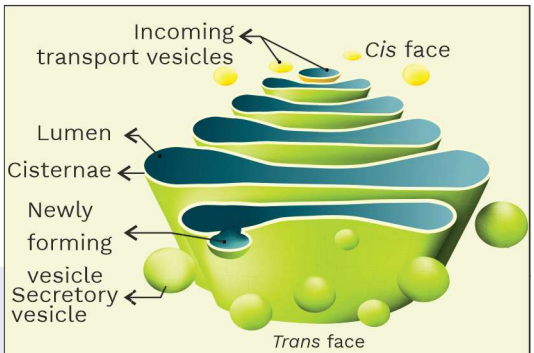


FIG. GOLGI APPARATUS

Dictyosomes

- These are unconnected units of Golgi apparatus in some plant cells. They are involved in synthesising pectin, cellulose, gums and mucilage for the formation of cell wall. These may be dozens to hundred in some plant cells.

Enzymes present in Golgi Complex

- Glycosyl transferases
- Thiamine pyrophosphatase

ULTRASTRUCTURE OF GOLGI COMPLEX

Golgi complex is composed of cisternae, vesicles and vacuoles.

Cisternae

- They are flattened, disc-shaped sacs or cisternae (0.5µm to 1.0µm diameter) in the form of stacks.
- The space between each cisterna is about 200Å–300Å in diameter.
- They contain intercisternal elements providing support and maintaining proper spacing.
- They do not have ribosomes but have swollen ends.

Previous Year's Question

The organelle having flattened cisternae near the nucleus is
(1) Mitochondria
(2) Nucleolus
(3) Centrosome
(4) Golgi apparatus

- The Golgi cisternae are concentrically arranged near the nucleus with distinct **convex, *cis*** or the **forming face** and **concave, *trans*** or the **maturing face.**
- The *cis* and the *trans* faces of the organelle are entirely different, but interconnected.
- The convex side of cisternae facing towards nucleus is called forming face and the concave side towards ER is called maturing face.

Vesicles

- These are small droplet like structure which are found attached to the outer ends of cisternae. Generally, they arise by pinching off by cisternae. They are of two types:
  - Smooth vesicles or secretory vesicles (20Å – 80Å in diameter).
  - Coated vesicles (50Å in diameter)
- Materials to be packaged in the form of vesicles from the ER fuse with the *cis* face of the golgi apparatus and move towards the *trans* or maturing face. This is the reason of golgi apparatus to remain in close association with the endoplasmic reticulum.

Vacuoles

- They are globular, irregular structures present in between the cisternae.
- They take spherical shape due to being filled with granular secretions.
- They are very large in size.

Golgian Vacuoles: These are modification of cisternae and develop from maturing face. Some of these vacuoles act as lysosomes.

Functions of Golgi Apparatus

- The golgi apparatus chiefly performs the function of packaging materials, to be delivered either to the intra-cellular targets or secreted outside the cell.

Rack Your Brain

Name the cell organelle which is found only in the plant cells?

Previous Year's Question

Which one takes part in acrosome formation?

(1) Golgi apparatus
(2) Lysosome
(3) Endoplasmic reticulum
(4) Mitochondria

- Secretion, storage and modification of proteins secreted by ribosomes present on RER are modified in the cisternae of the golgi apparatus before they are released from its *trans* face.
- Formation of glycoproteins, glycolipids and carbohydrates.
- Lysosome formation.
- Formation of cell wall by dictyosomes.
- Formation of secretory vesicles.
- Membrane transformation.
- Synthesis of enzymes.
- Formation of nematocyst, trichocyst, yolk and cortical granules in ovum.
- Acrosome formation in sperms.

LYSOSOMES

- Lysosomes were first discovered by a Belgian Biochemist **Christian de Duve** in 1955.
- These are single membrane bound vesicular structures formed for the process of packaging in the golgi apparatus.
- **Shape and size:** They are spherical to irregular in shape and 0.1µm to 1.2µm in size.
- **Enzymes:** Enzymes in lysosomes are hydrolyzing enzymes optimally active at the acidic pH.
  - Proteases (protein digesting enzymes).
  - Carbohydrases (carbohydrate digesting enzymes).
  - Lipases ((fats and lipid digesting enzymes, e.g., acid lipase, phospholipase).
  - Nucleases (nucleic acid digesting enzymes, e.g., ribonuclease, deoxyribonuclease).
  - Phosphatases (acid phosphatases).
  - Sulphates.

POLYMORPHISM IN LYSOSOMES (Different type of lysosomes).

- Polymorphism is the existence of an organelle into more than one form. The lysosomes are of the following types of on the basis of cell contents and morphology.

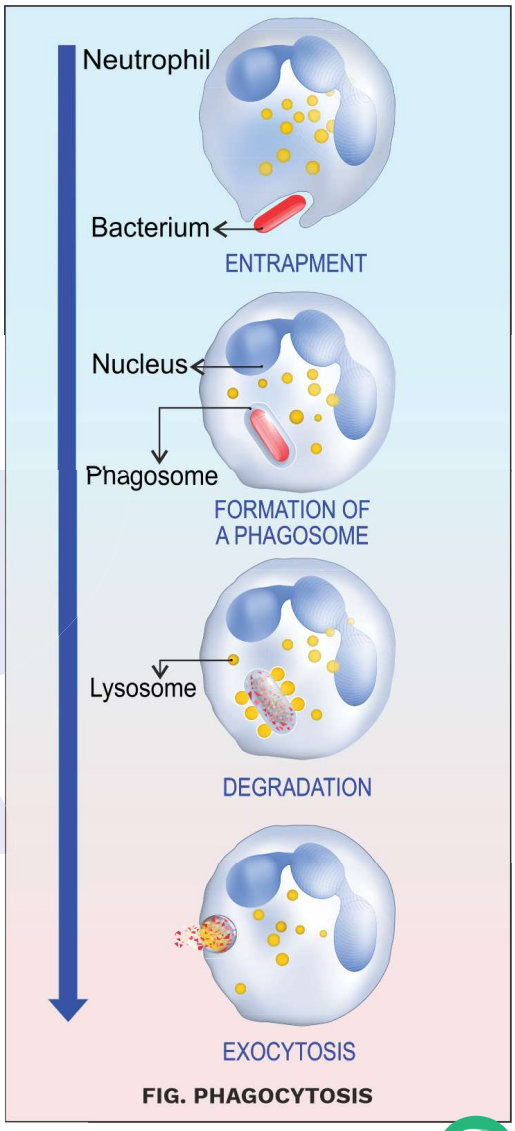


FIG. PHAGOCYTOSIS

Previous Year's Question

A membranous bag containing hydrolases used for intracellular digestion of macromolecules in a cell is called
(1) Phagosome
(2) Lysosome
(3) Nucleosome
(4) Chromosome

- **Primary Lysosomes:** Formed by Golgi apparatus, contain the enzymes which are in inactive stage.
- **Secondary Lysosomes:** Contain enzymes as well as food or foreign particles (phagosomes). They are also known as heterophagosomes or digestive vacuoles. These are the site for the digestion of food.
- **Autophagic Vacuoles:** These structures envelop other organelles, digest them by the process of autophagy. They are formed by the fusion of primary lysosomes around the wound or damaged cell organelles. They provide nourishment during starvation. These are also called as suicidal bag of cell.

Rack Your Brain

Which type of enzymes are found in lysosomes

LYSOSOMES AS SUICIDAL BAGS

In pathological conditions and on ageing, the digestive enzymes of lysosome act and digest their own organelle. This is called autophagy or autolysis. Protoplasm is dissolved resulting in the cell death condition hence, lysosomes are called suicidal bags of cell.

Previous Year's Question

Which cell organelle reduces the number of other organelles?
(1) Oxysome
(2) Mitochondria
(3) Lysosome
(4) None of these

Autolysis Or Cellular Autophagy

- In this process the lysosomes on ageing or in pathological conditions, get ruptured releasing enzymes in the cytoplasm. These enzymes digest all the cell organelles.
- **Example of Autolysis:** Lysosomal enzymes hydrolyse the substances in the tissues of the tail in frogs or toads during metamorphosis.

VACUOLES

- These are fluid filled vesicles in the cytoplasm covered by a membrane called '**tonoplast**'. The vacuolar sap consists of minerals, sugars, amino acids, esters, proteins, water soluble pigments, etc.

Previous Year's Question

Polymorphic cell organelle is
(1) Glyoxysome
(2) Golgi complex
(3) Lysosome
(4) Peroxisome

- They are less in number in animal cell and young plant cells but more in mature plants cell and form a large central vacuole.

Functions of Vacuoles

- Vacuoles facilitate the rapid exchange of solute and gases between the cytoplasm and nearby fluids.

Types of Vacuoles

There are four types of vacuoles —

- **Sap Vacuoles**
  - These are fluid filled sacs covered by **tonoplast** which acts as a semipermeable membrane.
  - They maintain a proper osmotic pressure for cell turgidity and water absorption.
  - They store and concentrate mineral salts and wastes also. Sometimes they may have pigments providing pigmentation and maintaining exchange between cytoplasm and outer environment.
  - In plant cells, the vacuoles can occupy up to 90 per cent of the volume of the cell.
  - In plants, the tonoplast facilitates the transport of a number of ions and other materials against concentration gradients into the vacuole. Hence, ion concentration is significantly higher inside the vacuole than in the cytoplasm.
- **Food vacuoles**
  - These vacuoles contain digestive enzymes for digesting food.
  - They are formed by fusion of phagosome and lysosome.
  - They are found in protists and lower animals and phagocytes of higher animals.
  - In many cells, as in protists, food vacuoles are formed by engulfing the food particles.
- **Contractile Vacuoles**
  - These vacuoles consist highly extensible and collapsible membrane.

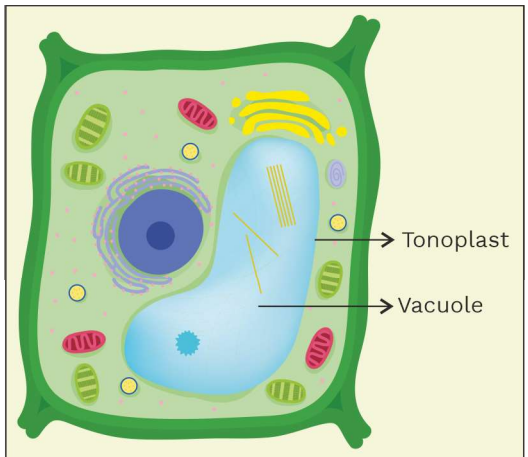


FIG. PLANT CELL

Rack Your Brain

Gas vacuoles are found in ..... cells.

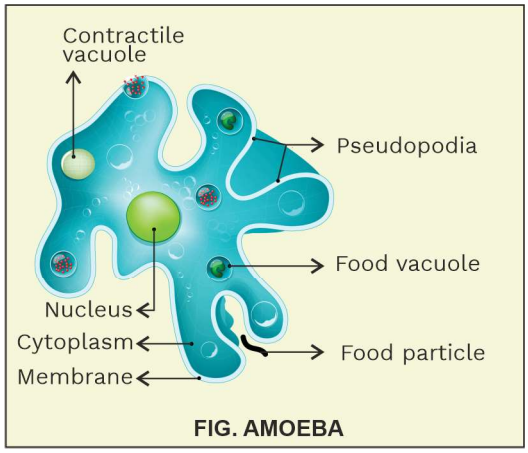


FIG. AMOEBA

- They are fed by many feeding canal which pour in water or waste products in them for elimination.
- They are important for maintaining **osmoregulation** and excretion. And so, vacuoles are called as '**osmoregulatory organelles**'.
- These are found in protists, algal cells *Amoeba* and other protozoans.

- **Air Vacuoles**
  - These vacuoles are without a specific membrane. They store several gases and protect the cell from harmful radiations.
  - They are involved in regulating buoyancy. They are found mainly in prokaryotes.

MITOCHONDRIA

- **Kolliker** (1880) observed mitochondria for the first time from insect muscle cells.
- **Altmann** (1886) called them 'bioplasts' (Altmann's granules).
- **Benda** (1898) stained them and called them mitochondria.
- **Hoogeboom** (1948) recognised them as sites or respiration.
- Mitochondria are also known as chondriosomes, parabasal bodies, and plasmasomes.
- They are found in every cell except in prokaryotes, and mature RBCs, etc.
- These are sausage shaped, spherical, oval, pear shaped, cylindrical or filamentous. Each measures about **0.2µm-1.0µm (average 0.5µm) in diameter** and **1.0µm-4.1µm in length.**
- The number of mitochondria per cell varies depending on the physiological activity of the cells.
- In *Microsterias* (an alga) there is only one mitochondrion, in human liver these may be 5000 in number; in kidney cells their number is about 500–1000, in chaos-chaos amoeba they may be

Previous Year's Question

Mitochondria are absent in—
(1) Green Algae (2) Bacteria
(3) Red Algae (4) Brown Algae

Gray Matter Alert!!!

Cell organelles with double membrane covering are-
- Plastids (leucoplasts, chromoplasts and chloroplasts)
- Mitochondria
- Nucleus

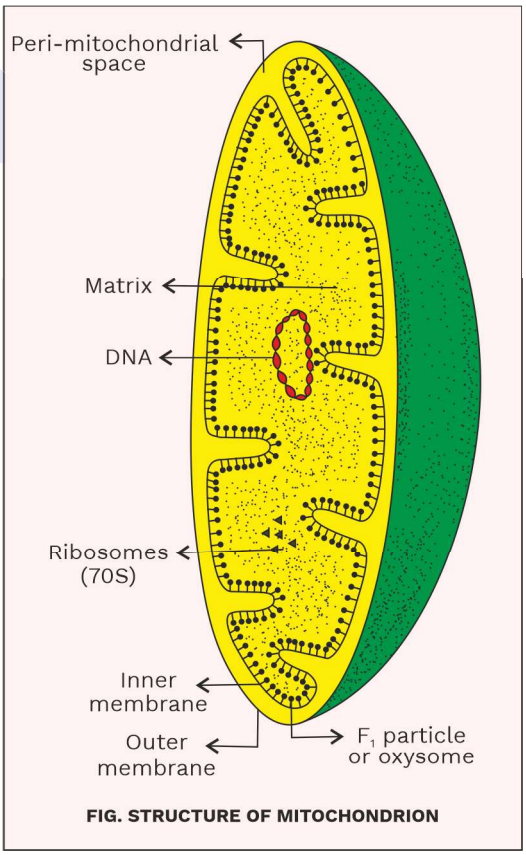


FIG. STRUCTURE OF MITOCHONDRION

about 50,000; in some oocytes the number may be about 30,000.

- These are not easily visible under the compound microscope unless specifically stained like with Fuchsin stain and with high magnification.

Mitochondria as Semi-Autonomous Organelle

- In mitochondria there is **DNA** (single and circular), **RNA** and **70S ribosomes** and the components required for the synthesis of proteins.
- The mitochondria arise by growth and division of pre existing mitochondria
- The mitochondria **divide by fission.**
- They generate energy with respiratory enzymes.
- Mitochondria are known as 'Power House' of the cell.
- Any power house stores, releases and transfers the energy, so does the mitochondria performs all these functions. Hence, nick named as 'Power House' of the cell.
- Mitrochondria help in oxidation of carbohydrates and fats. After oxidation the released energy is stored in the form of **ATP** (**Adenosine triphosphate**).

Ultrastructure of Mitochondria

- **Membranes**
  - Each mitochondrion is bound by two membranes outer membrane and inner membrane.
  - Each membrane is about **60Å** to **70Å** in thickness.
  - These two membranes are separated by a narrow fluid filled space of **80Å** in width.
  - Both the membranes have their own enzymes for mitochondrial function.
  - Outer membrane is smooth, whereas inner membrane is infolded into **'cristae'.**
  - Cristae increase surface area of the inner membrane.

Previous Year's Question

Mitochondria are absent in
(1) Green algae
(2) Bacteria
(3) Red algae
(4) Brown algae

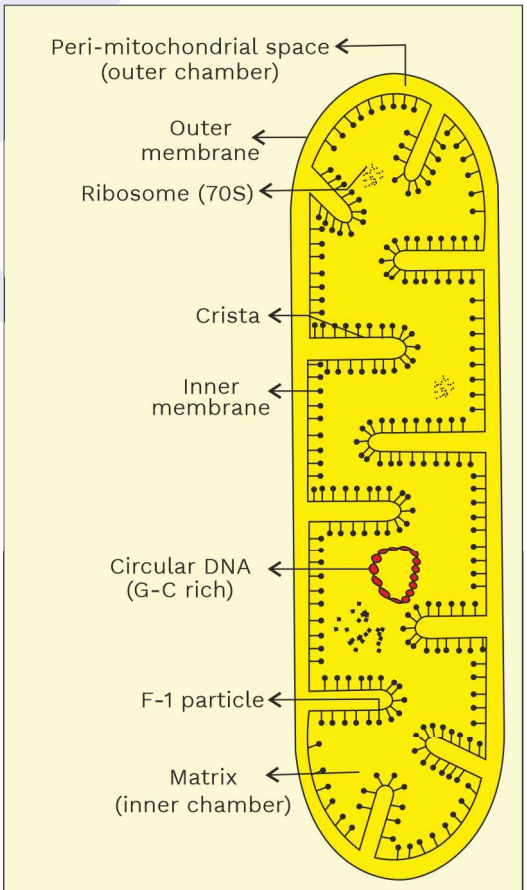


FIG. DIAGRAMMATIC VIEW OF THE INTERNAL STRUCTURE OF A MITOCHONDRION OR CHONDRIOSOME

- There are more cristae in active cells. Cristae have elementary particles **(oxisomes).**

- **Chambers**
  - The space between outer and inner membrane of mitochondria is called outer chamber.
  - The space inside inner chamber is called inner chamber or matrix.
  - Matrix contains a homogeneous and clear fluid.
- **Matrix**
  - It is the ground material or space inside the inner membrane of mitochondria.
  - It consists of 60–70 per cent proteins and 25–30 per cent lipids, many enzymes, vitamin B, etc.
  - The matrix possess a **circular double stranded DNA** molecule and many **70S ribosome** granules.
  - It is the site for many metabolic activities and energy production.
- **Elementary Particles**
  - The stalked bodies present in the cristae of mitochondria are called elementary particles.
  - They are also known as **oxisomes** or R, particles or Fernandez-Moran unit or ETP (Electron Transport particle).
  - Each elementary particle is divided into three parts — **head, stalk** and **base piece.**
  - Oxisome consists of the enzymes ATPase and ATP synthetase which are concerned with ATP formation.
  - The membrane apart from oxisomes, contains electron carriers such as cytochrome, flavoproteins, etc.
  - The head of oxisome is about 70Å to 80Å in diameter.
  - The F subunit is an integral protein. The F_1 subunit is an integral protein. The F_0 – F_1 combination functions as **ATP synthase** that catalyses ATP synthesis.

Gray Matter Alert!!!

'Bioplast' was the term originally used for a mitochondrion by Altman in 1890.

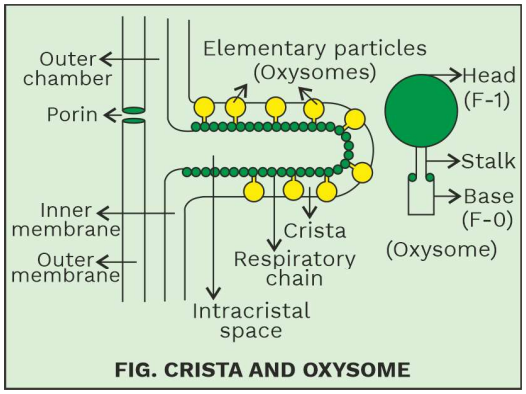


FIG. CRISTA AND OXYSOME

- These are also involved in **oxidative phosphorylation.**

Biogenesis of Mitochondria

- *De Novo* synthesis, i.e., mitochondria arise new from precursors in cytoplasm.
- They may arise from plasma membrane, ER, golgi body or nuclear envelope.
- Mitochondria arise by replication (fission) from pre-existing mitochondria.

Functions of Mitochondria

- Site for enzymatic reactions.
- Site for aerobic respiration and ATP synthesis.
- Involved in oxidative phosphorylation.
- Acts as power house of cell or storage batteries of cell.

Oxidative Phosphorylation

- The enzymatic phosphorylation of ADP to ATP coupled to electron transfer from a substrate to molecular oxygen is called oxidative phosphorylation.

$$ADP + Pi \longrightarrow ATP$$

PLASTIDS

- The term plastid was given by **Haeckel** (1866).
- **Plastids** are present mostly in plants and in **euglenoides.**
- These are easily observed under the microscope as they are large. They bear some specific pigments, thus imparting specific colours to the plants.
- They are bimenbranous organelles.

Types of Plastids

- Chloroplast (green plastids)
- Chromoplast (coloured plastids)
- Leucoplast (colourless plastids)

Rack Your Brain

Oxysomes are found in which cell organelle?

Previous Year's Question

Mitochondrial cristae are sites of
(1) Breakdown of macromolecules
(2) Protein synthesis
(3) Phosphoration of flavoproteins
(4) Oxidation-reduction reactions

Rack Your Brain

From a cell endoplasmic recticulum, chloroplasts and ribosomes are separated.
Which of the separated components is likely to survive *in vitro*?

CHLOROPLAST

- Majority of the chloroplasts of the green plants are found in the mesophyll cells of the leaves.
- These are lens-shaped, oval, spherical, discoid or even ribbon-like organelles having variable length (5μm-10μm) and width (2μm-4μm).
- Their number varies from 1 per cell of the *Chlamydomonas*, a green alga to 20–40 per cell in the mesophyll layer of leaves.
- **Semi-autonomous** organelle.

Previous Year's Question

The organelle regarded as the sugar factory in an autotrophic eukaryotic cell is
(1) Mitochondrion
(2) Endoplasmic reticulum
(3) Chloroplast
(4) Ribosome

ULTRASTRUCTURE OF CHLOROPLAST

Each eukaryotic chloroplast consists of the following components:

- **Membranes**
  - These are two membranes, each is about 90Å-100Å in thickness.
  - Each membrane is made up of lipoproteins.
  - Two membranes are separated from each other by a space of 25Å to 75Å wide.

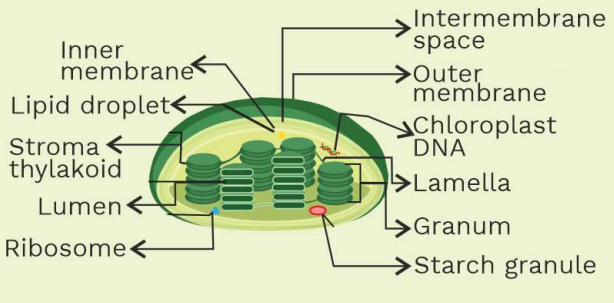


FIG. ULTRASTRUCTURE OF CHLOROPLAST

Gray Matter Alert!!!

The term thylakoid was coined by Menke in 1962.

- **Grana and Thylakoids**
  - Grana or the intergranal thylakoids are denser green bodies embedded in the matrix (stroma).
  - They are semi permeable in nature but outer membrane is more permeable and the inner membrane is relatively less permeable.
  - They are arranged into a series and connected to each other by flat membranous tubules called stroma lamellae.

Previous Year's Question

Solar energy is trapped by
(1) Grana
(2) Lamellae
(3) Stroma
(4) DNA

- Each granum consists of 2–100 coin like thylakoids.
- In some plant cells such as spinach there may be 40-60 grana per chloroplast.
- The membrane of the thylakoids enclose a space called a lumen.
- Each thylakoid consists of small spherical bodies on their inner membrane called 'quantasomes'.
- Grana contain chlorophyll pigments and carotenoid pigments which are responsible for trapping light energy essential for photosynthesis.
- They are light trapping devices carrying out photochemical reactions in the chloroplast.
- Grana are the sites for **light reaction** of photosynthesis.

- **Stroma or Matrix (Ground Matter)**
  - It is watery; transparent and proteinaceous granular part consisting enzymes and dissolved salts required for the synthesis of carbohydrates and proteins
  - It also contains small, double stranded circular DNA molecules and ribosomes. The ribosomes of the chloroplasts are smaller (70S) than the cytoplasmic ribosomes (80S).
  - The matrix also consists of starch granules known as osmophilic granules.
  - It provides the site for dark reaction of Photosynthesis.

Gray Matter Alert!!!

Agranal chloroplasts: These chloroplasts lack grana and are found in the bundle sheath cells of vascular bundles in monocot leaves.

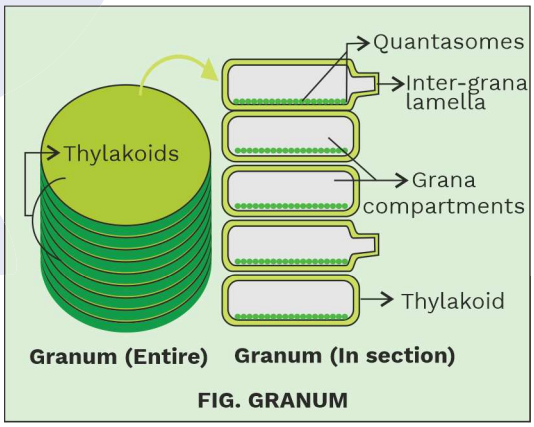


FIG. GRANUM

Functions of Chloroplasts

- Site for photosynthesis (light and dark reaction).
- Site for photophosphorylation (process of formation of ATP by linking ADP and Pi in chloroplast in the present of light).

$$ADP + Pi \xrightarrow[\text{chloroplast}]{\text{Light}} ATP$$

- Hereditary carrier.
- Store fat, protein and starch.

Previous Year's Question

Membrane covering is absent around
(1) Lysosome
(2) Nucleolus
(3) Mitochondrion
(4) Chloroplast

SHAPES OF CHLOROPLASTS IN FEW GREEN ALGAE

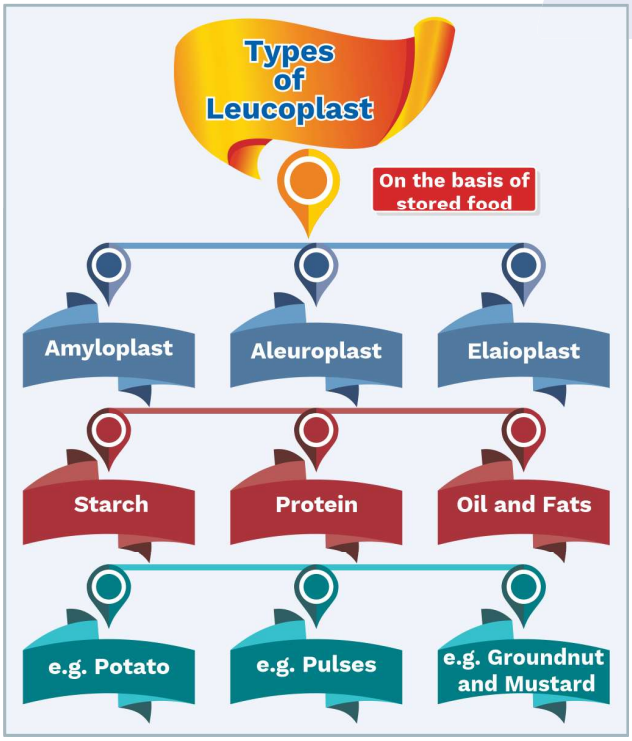
- Cup shaped - *Chlamydomonas*
- Ribbon shaped - *Spirogyra*
- Plate like - *Ulothrix*

CHROMOPLASTS

- These are coloured plastids.
- They contain fat soluble pigments.
- These are yellow, orange and red pigments mainly carotenoids like carotene, xanthophylls and others are present.
- These give the part of the plant a yellow, orange or red colour, mainly in flowers and fruits.

LEUCOPLASTS

- These are colourless plastids.
- These are spherical, oval, rod shaped or filamentous.
- These are mainly found in the cells of fruits seeds, tubers and rhizomes. These store nutrients.



Previous Year's Question

Solar energy is trapped by
(1) Oxysomes
(2) Lamellae
(3) Stroma
(4) DNA

Rack Your Brain

Anthocyanin occurs in
(1) Chloroplasts (2) Leucoplasts
(3) Chromoplasts (4) Vacuoles

Previous Year's Question

Starch grains in potato tuber are stored in
(1) Ribosomes
(2) Nucleus
(3) Leucoplasts
(4) Golgi bodies

RIBOSOMES

- Ribosomes were first discovered by **George Palade** (1953) in animal cells and **Robison and Brown** (1953) in plant cells.
- They are also called as '**engine of cells**' or '**protein factories**'.
- They are ribonucleic acid and protein structures.
- Ribosomes are membrane-less organelle.
- Their number is more in active cells and excess in cancer more in active cells.
- They are spherical bodies which are about 150Å to 250Å in diameter.
- Each ribosome consists of two sub-units of unequal sizes, the larger dome shaped and smaller oval shaped. Both sub-units are bound with the help of magnesium ions (Mg++).
- Ribosome may be 'bound' or 'free'.

Types of Ribosomes:

70S ribosomes and 80S ribosomes (as per sedimentation rate).

70S Ribosomes

- These ribosomes consist of 50S and 30S sub-units.
- These are found in prokaryotes, chloroplasts and mitochondria of eukaryotic cells
- (in chloroplasts the ribosomes are of 55S type).
- Each sub-unit is a complex nucleoprotein consisting equal amount of proteins and RNA in the ratio of 1:2, 50S sub-unit, has 28S and 55S rRNAs. 30S sub-unit has 18S rRNA.

80S Ribosome

- These ribosomes consist of large 60S sub-unit and small 40S sub-unit. 60S sub-unit has 28S and 5S rRNA and 40S sub-unit has 18S rRNA.

Gray Matter Alert!!!

Cell organelles without membrane covering are–

- Ribosome
- Centrosome
- Centriole
- Nucleolus (inside the nucleus)
- Cytoskeletal structures

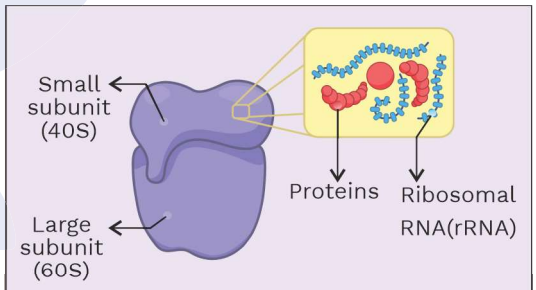


FIG. RIBOSOME (80S)

80S Ribosome

Ribosome	Subunit	rRNAs	r-proteins
80S	60S	28S (4718 nt)	49
		5.8S (160 nt)	
		5S (120 nt)	
	40S	18S (1874 nt)	33

*** nt-Nucleotides**

- The enzyme peptidyl transferase that brings about the actual formation of a peptide bond consists of two large sub-units, 60S and 40S.

BIOGENESIS

- 70S ribosomes (prokaryotic) are synthesised in cytoplasm.
- 80S ribosomes (eukaryotic) are synthesised in nucleus.

SVEDBERG UNIT 'S'

- 'S' is Svedberg unit to measure the sedimentation coefficient during separation of organelle.

POLYRIBOSOMES OR POLYSOMES

- Collections of ribosomes in a group during active protein synthesis are collectively called as polysomes or polyribosomes. Those polyribosomes are attached by a strand of mRNA which is about 10 nm to 20 nm thick.

Functions of Ribosomes

- Synthesis of protein
- Synthesis of enzymatic proteins as well as structural proteins.

MICROBODIES:

They are uni-membranous spherical or oval vesicles filled with a fluid matrix. For example:

- Lysosome
- Peroxisome
- Spherosome
- Glyoxisome

CYTOSKELETON

- In the cytoplasm of cell an elaborate network of filamentous proteinaceous structures consisting of microtubules, microfilaments and intermediate filaments is present which is collectively referred to as the cytoskeleton.

Previous Year's Question

Protein synthesis in animal cell occurs in the
(1) Cytoplasm
(2) Cytoplasm and mitochondria
(3) Ribosomes attached to nuclear envelop
(4) Nucleolus and cytoplasm

Rack Your Brain

Which of the following are not present in a prokaryotic cell?
(1) DNA
(2) Ribosome
(3) Mesosome
(4) Microfilaments

Gray Matter Alert!!!

Ergasome is another term for a polyribosome.

- The cytoskeleton in a cell are involved in many functions such as **mechanical support, motility,** maintenance of the shape of the cell

Microfilaments

- They are found as an extensive network in cytoplasm and are associated with plasma membrane.
- They are mostly found in muscle cells and are associated with myosin to form myofilaments.
- They extend into microvilli and help in quick absorption of food in the small intestine. They mainly consist of **actin** (but **myosin** may be present).
- They are not found in prokaryotes.

Functions of Microfilaments

- They help in locomotion.
- Responsible for muscle contraction.
- Supporting the cell.
- Allow intracellular movement.
- They cause streaming movement.
- Help in cleavage during cell division in animal cells

Microtubules

- These are composed of glycoprotein **tubulin,** Mg and GTP.
- They are generally found in cytoplasmic matrix and occur in cilia and flagella, centrioles and basal bodies, etc.

Functions of microtubules

- In the formation of mitotic spindle.
- Distribution of pigments.
- Cell differentiation after mitosis cell division.
- Support and movement.
- These are the components of centrioles and basal bodies.

Gray Matter Alert!!!

Tubulin proteins make a microtubule which are arranged to form a hollow, straw-like tube, and each tubulin protein consists of two subunits, α-tubulin and β-tubulin. Microtubules are 25 nm in diameter.
Actin protein forms microfilaments which are fine, thread-like protein fibers. Microfilaments are 6 to 10 nm in diameter.

Previous Year's Question

Organelle covered by a single unit membrane is
(1) Peroxisome
(2) Glyoxysome
(3) Lysosome
(4) All of these

Previous Year's Questions

The filaments present in cilia and flagella are composed of
(1) Microtubules
(2) Microfilaments
(3) Microfibrils
(4) Microvilli

Cilia and Flagella:

- Cilia (singular: cilium) and flagella (sing.: flagellum) are hair-like outgrowths of the cell membrane.
- Cilia and flagella are fine vibratile cytoplasmic processes arising from basal bodies.
- They remain embedded in cytoplasm and help in locomotion.
- Cilia are small structures which work like oars, causing the movement of either the cell or the surrounding fluid.
- Flagella are comparatively longer and responsible for cell movement.
- Flagellary motion is slow in comparison to cillary motion.
- The cilium and the flagellum both are covered with plasma membrane.
- Their core called the axoneme, possesses a number of microtubules running parallel to the long axis.
- The axoneme has nine doublets of radially arranged peripheral microtubules, and a pair of centrally located microtubules.
- This arrangement of axonemal microtubules is referred to as the 9+2 array.
- The central tubules are connected by bridges and is also enclosed by a central sheath, which is connected to one of the tubules of each peripheral doublets by a radial spoke. Thus, there are nine radial spokes.
- The peripheral doublets are also interconnected by linkers. Both the cilium and flagellum emerge from centriole-like structure called the basal bodies.
- The prokaryotic bacteria also possess flagella but these are structurally different from that of the eukaryotic flagella.
- In flame cells of platyhelminthes, they eliminate the particles or drive food or produce water waves.

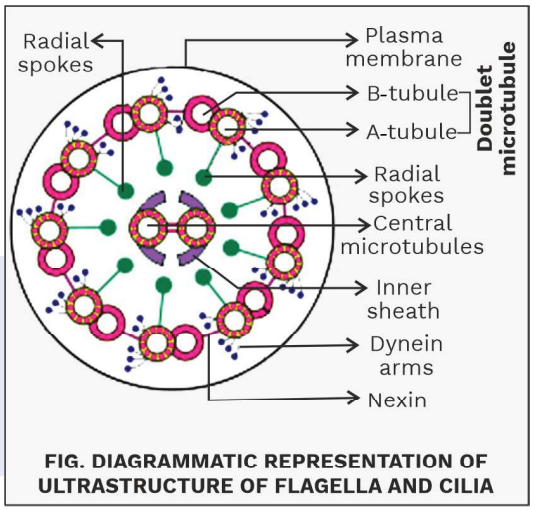


FIG. DIAGRAMMATIC REPRESENTATION OF ULTRASTRUCTURE OF FLAGELLA AND CILIA

Gray Matter Alert!!!

The prokaryotic flagella do not have microtubules or dynein in their structure like the flagella in eukaryotic cells. Each flagellum has helical filaments, with a rotary motor at its base.

Table. Difference between Cilia and Flagella

Cilia	Flagella
I5–10 μ in length.	About 150 μ in length.
Hair like projection.	Whip like structure.
More in number (up to 1400)	One or two in number each cell.
They show metachronous or synchronous movement.	Flagella move independently.
They move in running manner.	They show wave like movement (undulating).

Basal Body: It is the structure found in the cells in which centriole forms cilia and flagella. These structures are also known as 'basal granules' or 'blepharoplast' or 'kinetosome'.

CENTROSOME AND CENTRIOLE

Centrosome is an organelle usually containing two cylindrical structures called centrioles. (Pair of centrioles is surrounded by a **amorphous pericentriolar materials,** i.e, PCM, which makes a structure called a centrosome.

- Both the centrioles in a centrosome lie perpendicular to each other in which each has an organisation like the **cartwheel.**
- Centrioles appear as a pair of granular bodies which are present in all eukaryotic cells except in red algae, pines, flowering plants and *Amoeba*.
- They are cylindrical in structure and are located close to the golgi body.
- They are about 0.3 μm – 0.5 μm in length.

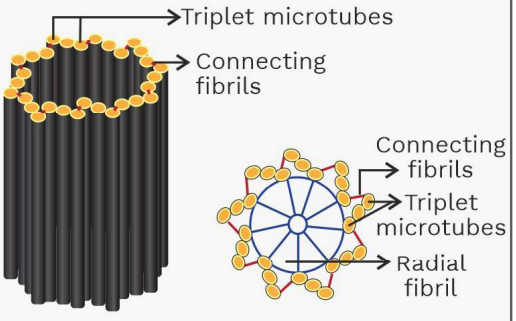


FIG. THE STRUCTURE OF CENTRIOLES

- Under electron microscope each centriole is made up of nine sets of tubular structures which are equally spaced and arranged in circular fashion.
- Each of nine sets, is a triplet which is composed of three microtubules. The diameter of each microtubule is about 250 nm.
- The triples are embedded in matrix. Microtubules of centriole are composed of protein '**tubulin**' having a high concentration of ATPase.
- The adjacent triplets are also linked by linker proteins. The central part of the proximal region of the centriole is also proteinaceous and called the hub, which is connected with tubules of the peripheral triplets by radial spokes made of protein.
- This arrangement of microtubules, nine peripheral triplets attached with the central hub is called **9+0 arrangement**.
- Centrosome duplicates itself when DNA replication starts (during G-2 phase of interphase).

Note: No centriole is found in ferns except in their sperms.

Rack Your Brain

What do you understand by 9+0 arrangement of microtubules?

Functions of Centriole

- Involved in spindle formation during cell division in animal cells.
- Formation of basal bodies which give rise to cilia and flagella.
- They are capable of forming new centrioles.
- Distal centriole in the spermatid, forms the axial filament of the flagellum of sperm for locomotion.

Previous Year's Questions

Microtubules take part in
(1) Muscle constriction
(2) Membrane architecture
(3) DNA recognition
(4) Cell division

CILIOGENESIS

The process of formation of cilia and flagella by the centriole is called ciliogensis and during this process the centriole is called basal body.

Cilium vs Centriole

- Pattern of organisation of cilium (and flagellum) is 9 + 2, while that of centriole is 9 + 0.
- Centrioles are present within the cytoplasm and without any membrane, whereas cilium is bound by a membrane.
- In centriole, the peripheral tubules, are triplets while in cilium these tubules are doublets.

Tubulin and Dynein

- Tubulin is a protein in the peripheral microtubules of cilia and flagella. The tubulin is similar to **actin** of muscle fibre.
- Dynein is protein present in the central tubules and areas of peripheral tubules. Dynein is similar to ATPase which splits the phosphate bond of ATP to release energy.

CELL INCLUSIONS:

Both organic and inorganic crystals are collectively called cell inclusions. Following are some of the cell inclusions found in the cells.

- **Crystals:** Calcium oxalate, calcium sulphate, calcium carbonate and silica are found in the plant cells in the form of crystals.
- **Fat Droplets:** They are found in the cells of endosperm of castor and coconut, cotyledons of groundnut and mustard seeds. They are also found in adipose cells.
- **Starch Grains:** They are found in the cells of tuber (potato), rhizomes (ginger), etc. These grains may be oval, spherical, elliptical or polyhedral bodies. Each grain may have concentric or eccentric rings of starch around a hilum made up of protein.
- **Glycogen Granules:** They are found near the SER in liver and muscle cells. Glucose is converted into glycogen and stored in the cells. They are small spherical or large rosette shaped particles.
- **Aleurone Grains:** These are found mainly in the outermost cells of endosperm in the cereal

Rack Your Brain

Select the odd one out.
(1) Centriole (2) Basal body
(3) Flagella (4) Lysosomes

Gray Matter Alert!!!

Centrioles are non-membranous, cylindrical or rod shaped microtubular structures which have the ability to form their own duplicates, astral poles and basal bodies without having DNA.

grains such as maize, wheat and barley. They store protein in plant cells.

Peroxisomes

- These microbodies were first observed in rodent kidney and liver.
- They are about 0.6 µm to 0.7 µm in diameter and bound by a single membrane with a granular matrix. They have a central core called 'nucleoid'.
- They contain some peroxide producing enzymes like D-amino acid oxidase, urate oxidase, B-Hydroxyacid oxidase and catalase.
- Catalase is involved in decomposing peroxide and has a protective effect on the cell.
- Urate oxidase and other enzymes help in purine metabolism.

Major Functions of Peroxisomes

- Photorespiration in plant cell.
- Lipid metabolism in animal cell.

Spherosomes

- They were discovered by **Perner** (1958).
- They are also unimembranous microbodies.
- They originate from ER as buds.
- They contain lipid and protein.
- They are easily visible by staining with Sudan dyes and Osmium Tetra oxide.
- Due to specific lipid nature, the spherosomes may be grouped morphologically and functionally as different from lysosome.

Functions of Spherosome: They are involved in the synthesis of oils and fats (lipid metabolism).

Glyoxisomes

- These microbodies are involved with glyoxylate cycle, which is similar to TCA cycle.
- They are found in the cells of germinating fatty seeds such as ground nut, *Brassica*, castor, etc.

Previous Year's Questions

Photorespiration occurs in plant cells in
(1) Dictyosomes
(2) Glyoxisomes
(3) Peroxisomes
(4) Endoplasmic reticulum

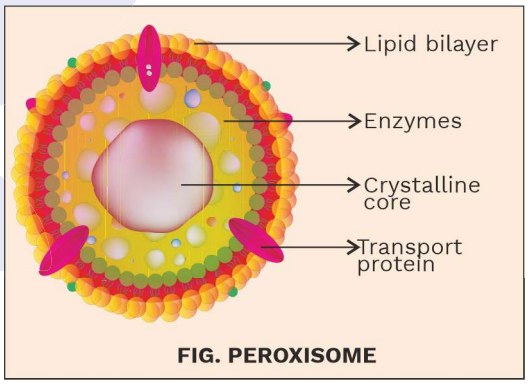


FIG. PEROXISOME

Previous Year's Questions

In which one of the following would you expect to find glyoxysomes?
(1) Endosperm of wheat
(2) Endosperm of castor
(c) Palisade cells in leaf
(d) Root hairs

Function of Glyoxisomes: They are involved in the breakdown of fats.

PHOTORESPIRATION

The process of evolution of CO_2 by the green plants in the presence of light is called photorespiration. The side for photorespiration in the cells are chloroplasts and peroxisomes.

NUCLEUS

- Nucleus was discovered by **Robert Brown** in 1831. It is the 'main organelle' or 'director' of the cell.
- The term '**chromatin**' was given by **Flemming** for the material of the nucleus which was stained by the basic dyes.

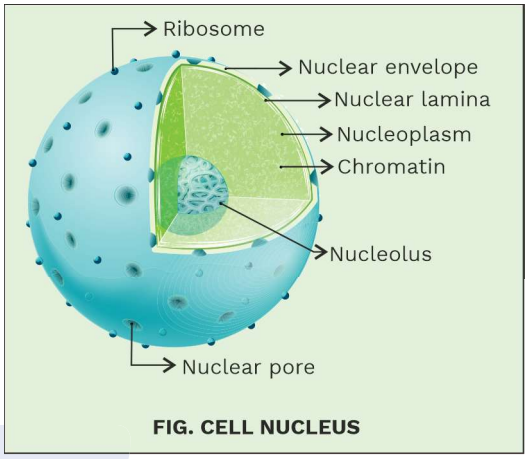


FIG. CELL NUCLEUS

Main components of nucleus during interphase stage

- Nuclear envelope
- Chromatin material
- Nucleolus
- Nucleoplasm or Nuclear matrix

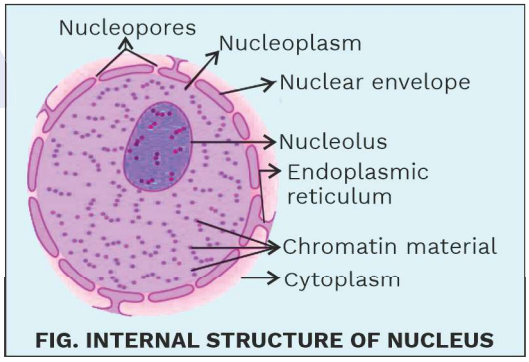


FIG. INTERNAL STRUCTURE OF NUCLEUS

Nuclear Envelope (Karyotheca)

- It is the outermost, double layered (double membranes that are parallel to each other) structure containing a large number of nuclear pores.
- The pores are circular or polygonal in shape and about 500 Å in diameter which are formed by the fusion of the two membranes.
- These nuclear pores are the passages through which movement of RNA and protein molecules takes place in both directions between the nucleus and the cytoplasm.
- There is a space between two nuclear membranes. This space is called perinuclear space which measures 10 nm – 50 nm, perinuclear space, forms a barrier between the materials present inside the nucleus and that of the cytoplasm.

Gray Matter Alert!!!

Nucleoplasm does not show cyclosis (streaming movement).

- The membrane is lipoproteins in nature and each membrane is about 60Å – 90Å thick.
- The outer membrane is often connected to the endoplasmic reticulum. Inner membrane is smooth.

Chromatin Material: Chromatin fibers are thin filaments, coiled and threads like structure. They are stained by basic fuchsin (basic dyes/stain).

- Chromatin contains **DNA** and some basic proteins called **histones,** some **non-histone** proteins and also **RNA**.
- During cell division the condensing and coiling of chromatin occurs that gives rise to thread like distinct structures which later on become thick rod-like structures called chromosomes.
- A single human cell has approximately two metre long thread of DNA distributed among its forty six (twenty-three pairs) chromosomes.
- Every chromosome which is visible only in dividing cells has a **primary constriction** or the **centromere** on the sides of which disc shaped structures called **kinetochores** are present.
- Centromere holds two **chromatids** of a chromosome.

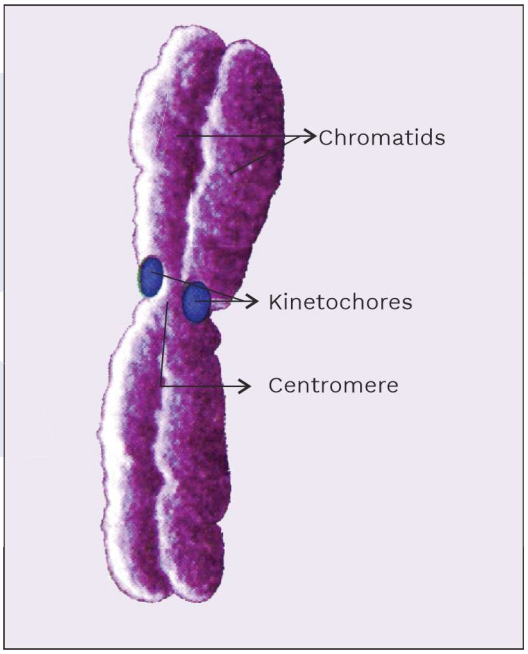
CHROMATIN IS OF TWO TYPES IN A EUKARYOTIC CELL

Heterochromatin and euchromatin

- **Heterochromatin**
  - It is the **darkly stained** part (on staining with DNA specific stains) of chromatin. It is metabolically inert and genetically less active.
  - It does not take part in the process of protein synthesis.
  - It has small amount of DNA but large amount of RNA.
  - Heterochromatin is densely packed which carries genetically inactive DNA sequences or genes.

Definition

Chromatin: Chromatin is made up of DNA, protein and RNA observed in non-dividing eukaryotic cells

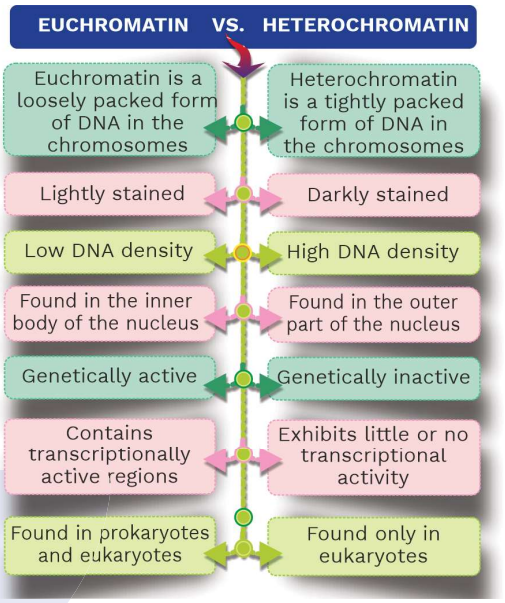


Previous Year's Questions

Physical basis of life is
(1) Protoplasm
(2) Food
(3) Cell
(4) Nucleus

- It is located towards the peripheral region of the nucleus and is present only in eukaryotic cells.
- For example, in humans Y chromosome in men contains larger quantities of this heterochromatin.

- **Types of Heterochromatin—**
  Constructive heterochromatin and facultative heterochromatin.
  - Constructive heterochromatin packages same DNA sequences in all the cells of a species.
  - Facultative heterochromatin packages different DNA sequences in the cells of a species.
- **Euchromatin (True chromatin)**
  - It is **less deeply stained** part of chromatin fibers on staining with DNA specific stains. It is metabolically and genetically more active, i.e., carries active genes. It takes part in the process of protein synthesis.
  - It consists of more amount of DNA. It is uncoiled state of chromatin and is loosely packed.
  - It is present in the deeper regions of the nucleus and is found in both prokaryotic and eukaryotic cells.
  - In entire, euchromatin is constructive in nature.
  - During cell division, chromatin fibers are condensed and form short rod-like bodies called chromosomes.



Nucleolus

- It was observed by **Bowman and Wagner** (1840) but was discovered by **Fontana** (1781) in eel skin.
- It is a round, dense, dark staining organelle without any membrane so the content of nucleolus is continuous with the rest of the nucleoplasm .
- Larger and more numerous nucleoli are present in cells actively carrying out protein synthesis.

Rack Your Brain

Observe the relationship and fill in the blank space.
ER: Electron Microscope : :
Nucleus: .....

Definition

The nucleolus is the largest structure in the nucleus of eukaryotic cells which can be observed during interphase. It is best known as the site of ribosome biogenesis.

- Nucleoli disappear during cell division and reappear by the activity of Nucleolar Organiser Region (NOR) of nucleolar chromosomes.
- Normally it is eccentric in position, it contains DNA, RNA and Protein and also its enzymes for RNA synthesis as well as synthesis of co-enzymes NAD.
- Nucleolus is differentiated into 4 regions:
  - **Granular zone:** It is composed of dense granules about 150Å-200Å in diameter which are made up of ribonucleic proteins.
  - **Fibrillar zone:** It has thread like network made up of RNA and non-histone proteins. This zone is also known as nucleolonema.
  - **Amorphous or Pars morpha**
  - **Nucleolar chromatin**

Functions of Nucleolus

- It provides machinery for protein synthesis.
- It stores and synthesises rRNA and ribosomes (It is a site for active ribosomal RNA synthesis).
- It stores ribosomal proteins.

Nuclear Matrix (Nucleoplasm)

- It is the ground material, irregular shaped particles or granules.
- The nuclear matrix or the **nucleoplasm** contains nucleolus and chromatin.
- Interphase nucleus has a loose and indistinct network of nucleoprotein fibres called chromatin. In the matrix chromatin is embedded.
- Matrix contains hydrolytic enzymes, such as peptidase ribonuclease, etc.
- It also consists of RNA. It is proteinaceous in nature.
- The matrix provides transparency to the nucleus as well as site for various metabolic activities.

Rack Your Brain

Ribosomal RNA is synthesized in which part of the cell?

Previous Year's Questions

In eukaryotes, basic structural unit made up of histone and DNA is

(1) Nucleosome
(2) Nucleolusc
(3) Chromosome
(4) Lysosome

TYPES OF CHROMSOME

Based on the position of the centromere, the chromosomes can be classified into four types

- The **metacentric** chromosome has middle centromere forming two equal arms of the chromosome.
- The **sub-metacentric** chromosome has centromere slightly away from the middle of the chromosome resulting into one shorter arm and one longer arm.

Rack Your Brain

Select the odd one out

(1) Chromatid (2) Satellite

(3) DNA (4) Nucleoid

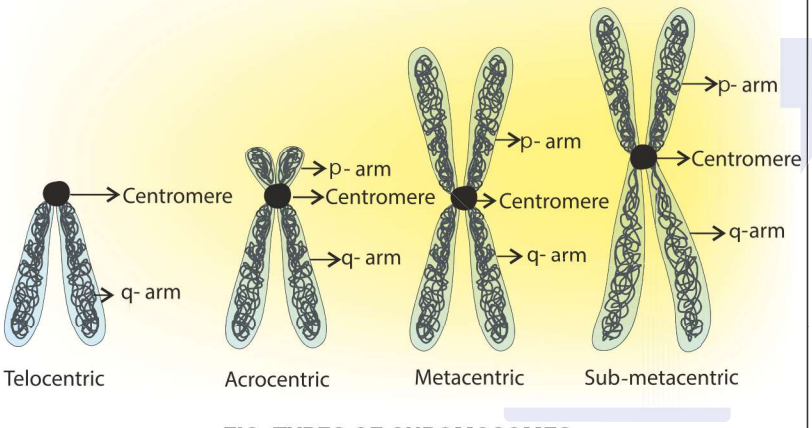


FIG. TYPES OF CHROMOSOMES

- In the **acrocentric** chromosome, the centromere is situated close to its end forming one extremely short and one very long arm.
- In the **telocentric** chromosome, centromere is terminal in position.

Satellite chromosome or SAT chromosome: Sometimes a few chromosomes have non-staining secondary constrictions at a constant location. This gives the appearance of a small fragment called the satellite. For example chromosome number **13, 14, 15, 21 and 22 in humans are SAT chromosomes.**

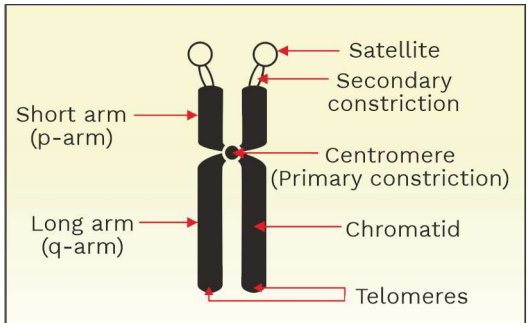


FIG. CHROMOSOME SHOWING SATELLITE REGION

Functions of Nucleus

- To control metabolism of the cell.

- To control hereditary information.
- To help in the formation of structures and functional proteins.
- To co-ordinate the nuclear and cytoplasmic activities.

KARYOTYPE

- The complete set of chromosomes of an organism is referred as karyotype.
- Pictomicrographs of chromosomes are clicked from a cell (stained by a suitable dye, such as Giemsa) arrested at metaphase of mitosis as they are shortest in their length in this phase of cell division.
- These photographs are then arranged according to their length (in increasing or in decreasing order), position of centromere, banding pattern, etc., in a standard format which is known karyogram or idiogram.
- The typical human karyotype contain 22 pairs of autosomal chromosomes and one pair of sex chromosomes (allosomes).
- Karyotypes are used to study evolutionary relationships, to diagnose chromosomal aberrations, etc.
- The process of taking pictomicrographs of chromosomes is called karyotyping.

Note: Cell division can be arrested by using colchicine)

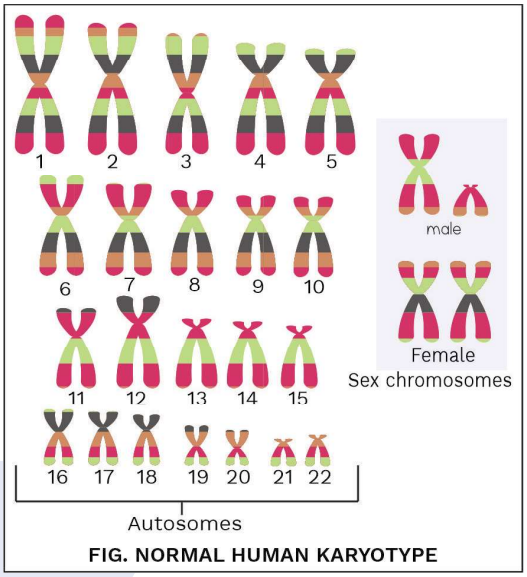


FIG. NORMAL HUMAN KARYOTYPE

Gray Matter Alert!!!

lampbrush (Gaint) chromosomes are transcriptionally active chromsomes found in the germinal vesicle of large oocytes of many vertebrates and invertebrates, first described by Walther Flemming (1882).

Rack Your Brain

Assertion: Nucleus controls metabolism as well as heredity
Reason: There is usually a single nucleus in a cell.

(1) Both statements are true and Reason is the correct explanation of the Assertion.
(2) Both statements are true but Reason is not the correct explanation of the Assertion.
(3) Assertion is true but Reason is a false statement .
(4) Both Assertion and Reason are false statements.

POLYTENE CHROMOSOME

- Polytene chromosomes (many stranded) were first reported by E.G. Balbiani in 1881. Polytene chromosomes are found in dipteran flies for e.g., *Drosophila*, *Chironomus*, etc. In insects, they are commonly found in the salivary glands when the cells are not dividing.
- Polytene chromosomes are formed when multiple rounds of replication produce many sister chromatids which stay fused together without cell division to form giant chromosomes. This type of division is called endomitosis.
- The large size of the chromosome is due to the presence of many longitudinal strands called chromonemata. They are about 0.5 mm in length and 20 µm in diameter.
- The polytene chromosome contains two types of bands, dark bands and interbands. The dark bands are darkly stained and the inter bands are lightly stained with nuclear stains. The dark bands contain more DNA and less RNA. The interbands contain more RNA and less DNA.
- The bands of polytene chromosomes become enlarged at certain times to form swellings called puffs. The puffs indicate the site of active genes where mRNA synthesis takes place.

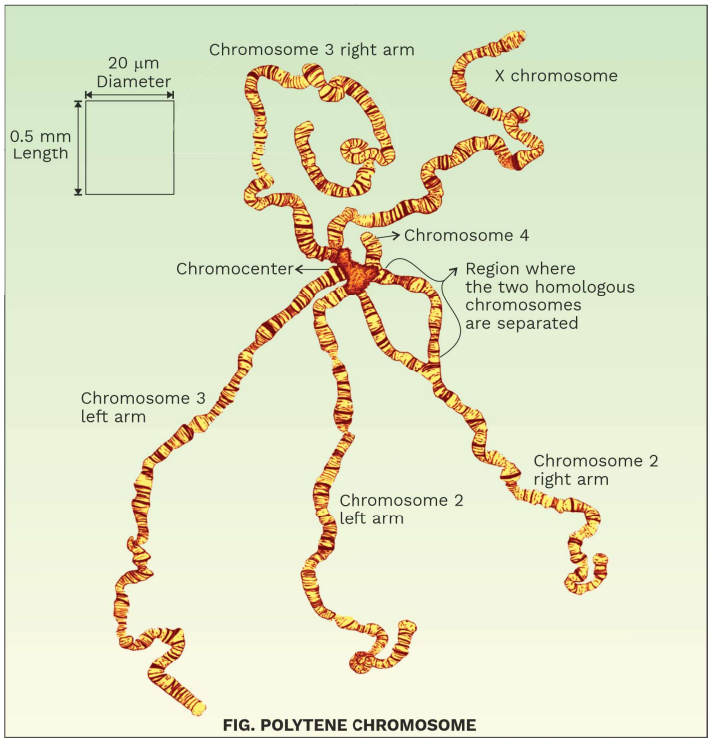
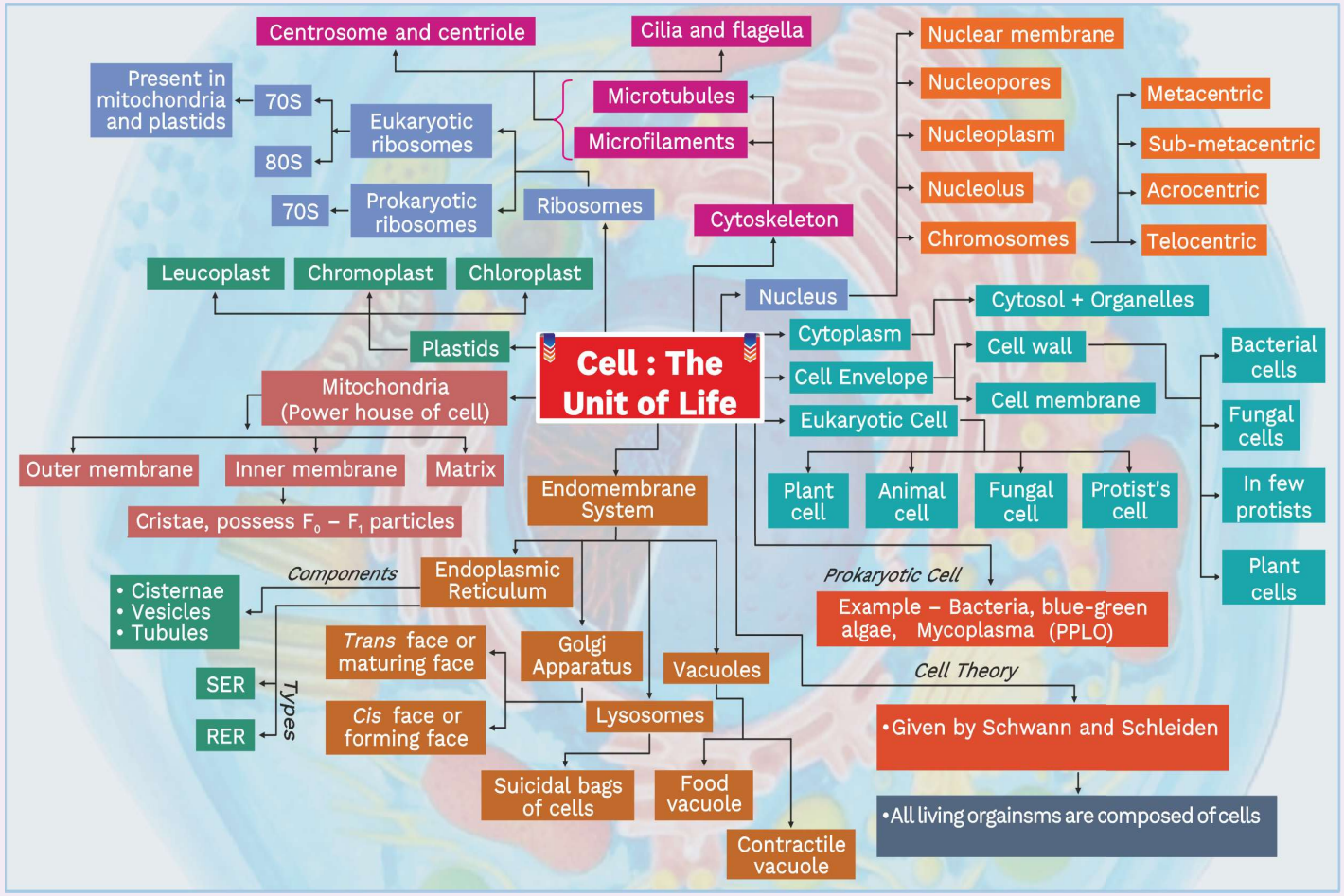


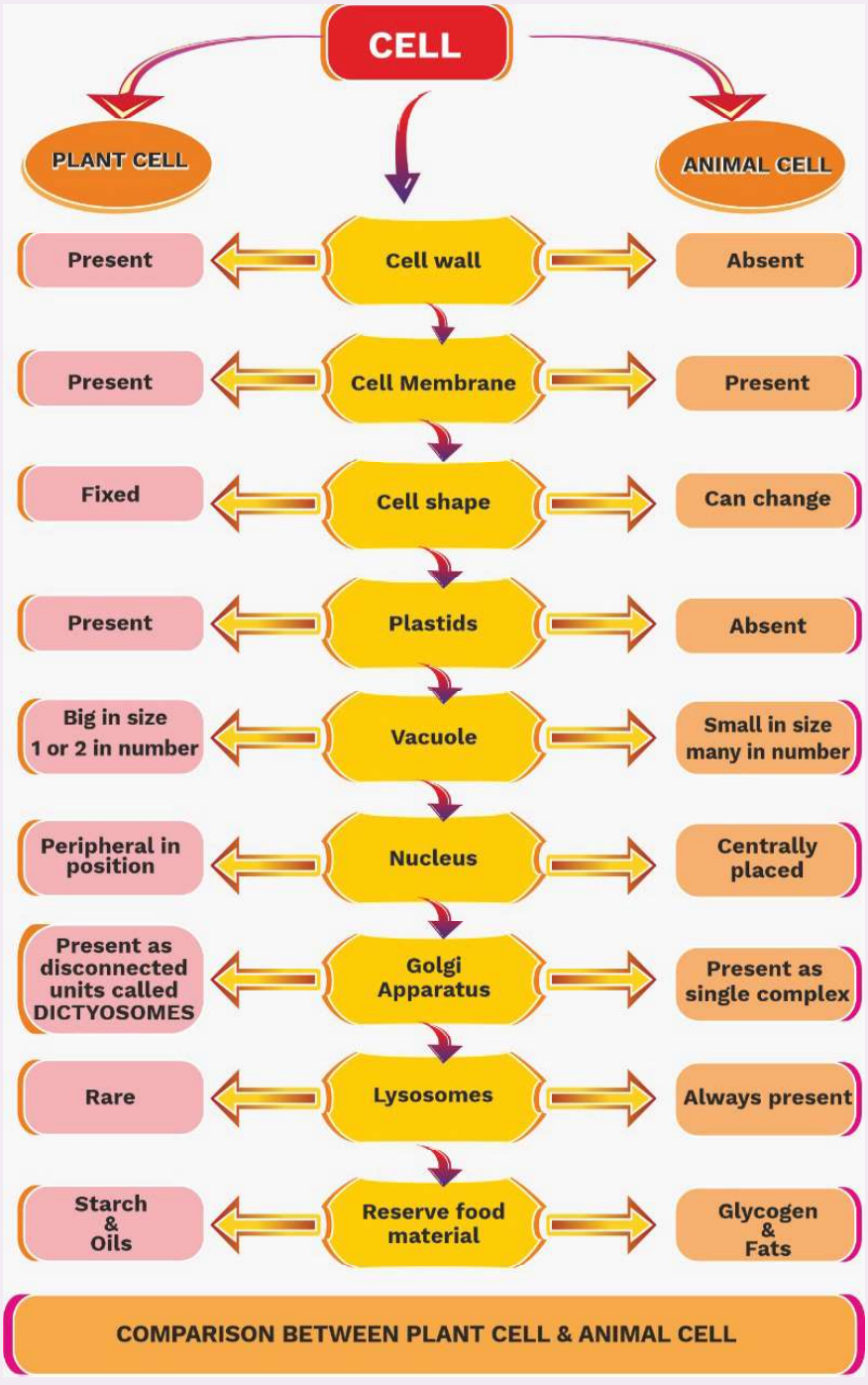
FIG. POLYTENE CHROMOSOME

Summary



Cell: The Unit of Life

Summary


CELL
PLANT CELL
ANIMAL CELL
Present
Cell wall
Absent
Present
Cell Membrane
Present
Fixed
Cell shape
Can change
Present
Plastids
Absent
Big in size
1 or 2 in number
Vacuole
Small in size
many in number
Peripheral in
position
Nucleus
Centrally
placed
Present as
disconnected
units called
DICTYOSOMES
Golgi
Apparatus
Present as
single complex
Rare
Lysosomes
Always present
Starch
&
Oils
Reserve food
material
Glycogen
&
Fats
COMPARISON BETWEEN PLANT CELL & ANIMAL CELL

Summary

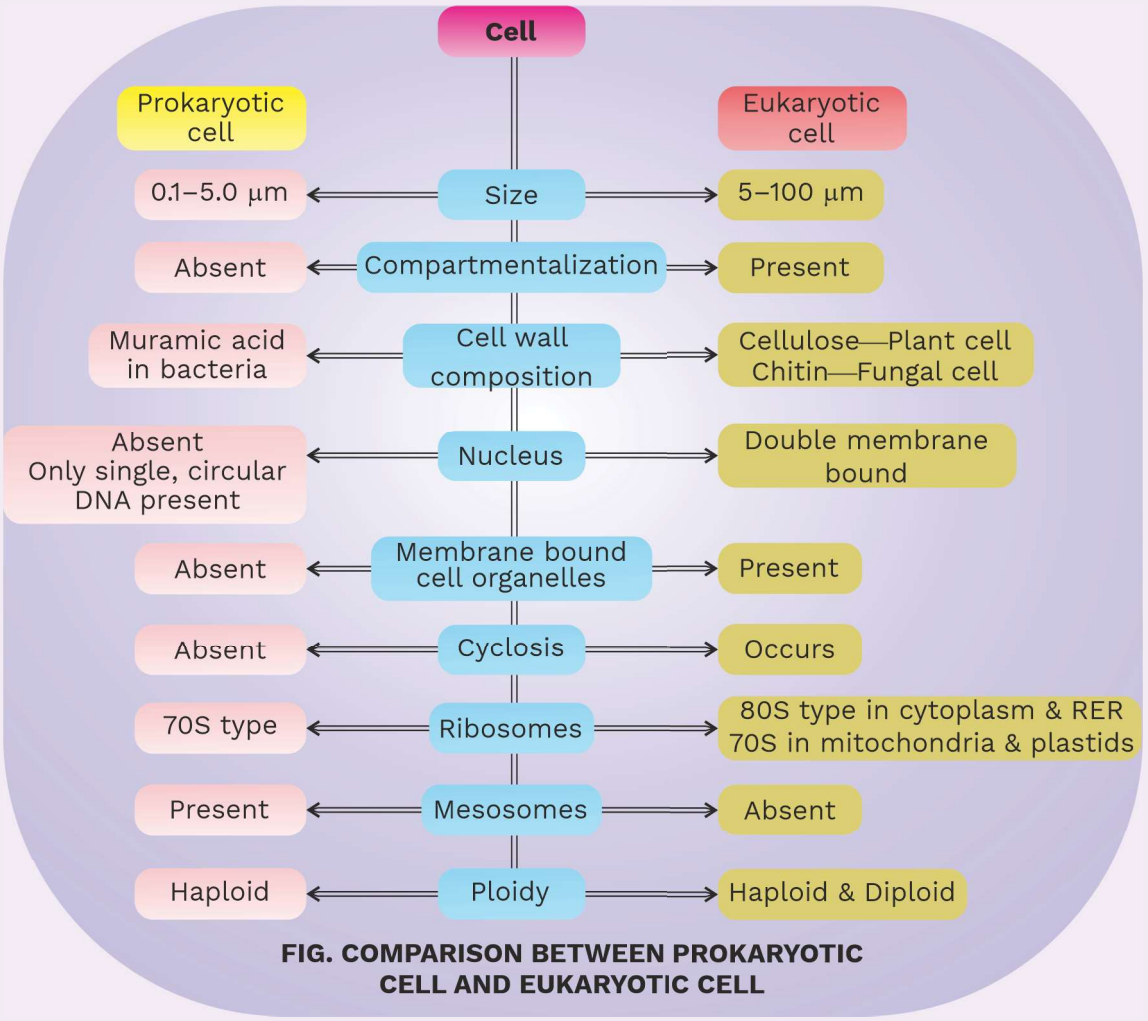


FIG. COMPARISON BETWEEN PROKARYOTIC CELL AND EUKARYOTIC CELL

Solved Exercise

Q1 **The scientist who was the first to explain that cells divide and that all new cells must come from pre-existing cells was—**
(1) Robert Brown
(2) Schleiden and Schwann
(3) Flemming
(4) Rudolf Virchow

A1 **(4)**
Rudolf Virchow was the first person to explain that cells arise from the pre-existing cells which was not explained in cell theory by Schleiden and Schwann.

Q2 **Many intracellular structures enclosed by membranes in the cells of plants, animals, fungi, etc., are called—**
(1) Cell inclusions
(2) Cell organelles
(3) Membrane bound organelles
(4) Non-membranous organelle

A2 **(3)**
Inside the eukaryotic cells, numerous membrane structures are called membrane bound cell organelles like mitochondria, golgi complex, etc.

Q3 **Cell theory was propounded by**
(1) Schleiden and Schwann
(2) Robert Hooke
(3) Robert Koch
(4) Darwin

A3 **(1)**
Schleiden and Schwann together propounded cell theory.

Q4 **Osmoregulatory organelle in the plant cell is**
(1) Lysosome
(2) Peroxisome
(3) Ribosome
(4) Vacuole

A4 **(4)**
Osmoregulatory organelle helps in maintaining water and ionic balance in the cell and the said function is fulfilled by vacuole.

Q5 **Nucleoid is found in**
(1) *Nostoc*
(2) *Mycoplasma*
(3) *Chlamydomonas*
(4) *Rhizopus*

A5 **(2)**
Mycoplasma is a prokaryote and nucleoid is present only in prokaryotes.

Q6 **The plasma membrane is made up of**
(1) Proteins and carbohydrates
(2) Carbohydrates and fats
(3) Lipids and proteins
(4) Phospholipids and proteins

A6 **(4)**
Plasma membrane has a quasi fluid (partly liquid and partly solid) nature and is composed of phospholipids and proteins which makes it flexible in nature.

Q7 **Smooth endoplasmic reticulum synthesises—**
(1) Proteins
(2) Steroids and lipids
(3) Fats
(4) Carbohydrates

A7 **(2)**
SER is associated primarily with the synthesis of lipids and steroids.

Q8 **Which of the following structures are present in mitochondria?**
(1) Circular DNA
(2) RNA
(3) Ribosomes
(4) All of these

A8 **(4)**
Mitochondria are semi-autonomous cell organelle which can duplicate themselves. For this duplication, these have their own DNA, 70S ribosomes and RNA.

Q9 **Basal bodies are associated with**
(1) Animal cell
(2) Plant cell
(3) Flagella and cilia
(4) Chromosomes

A9 **(3)**
Basal bodies give rise to flagella and cilia.

Q10 **Which of the following is not a part of endomembrane system?**
(1) Endoplasmic reticulum
(2) Golgi complex
(3) Mitochondria
(4) Lysosomes

A10 **(3)**
Mitochondria function individually and need no coordination with other organelle, so it is not the part of endomembrane system. While ER, golgi complex and lysosomes work in coordination and are the part of endomembrane system.