**CC4 – CELL AND MOLEULAR BIOLOGY**

**Subject Code: 18K3Z04**

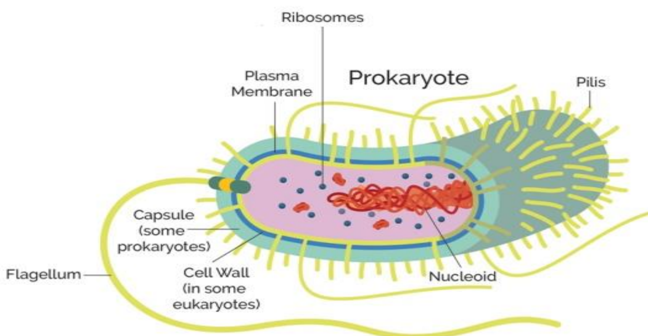
# Unit I

## PROKARYOTIC AND EUKARYOTIC CELL

Every living organism falls into one of two groups: **eukaryotes or prokaryotes**. Cellular structure determines which group an organism belongs to.

**Prokaryote definition**

Prokaryotes are **unicellular organisms** that lack membrane-bound structures, the most noteworthy of which is the nucleus. Prokaryotic cells tend to be small, simple cells, measuring around 0.1-5 μm in diameter.




While prokaryotic cells do not have membrane-bound structures, they do have distinct cellular regions. In prokaryotic cells, DNA bundles together in a region called the nucleoid.

**Prokaryotic cell features**

Here is a breakdown of what you might find in a prokaryotic bacterial cell.

- **Nucleoid:** A central region of the cell that contains its DNA.
- **Ribosome:** Ribosomes are responsible for protein synthesis.
- **Cell wall:** The cell wall provides structure and protection from the outside environment. Most bacteria have a rigid cell wall made from carbohydrates and proteins called peptidoglycans.
- **Cell membrane:** Every prokaryote has a cell membrane, also known as the plasma membrane, that separates the cell from the outside environment.
- **Capsule:** Some bacteria have a layer of carbohydrates that surrounds the cell wall called the capsule. The capsule helps the bacterium attach to surfaces.
- **Fimbriae:** Fimbriae are thin, hair-like structures that help with cellular attachment.
- **Pili:** Pili are rod-shaped structures involved in multiple roles, including attachment and DNA transfer.

- **Flagella:** Flagella are thin, tail-like structures that assist in movement.

  **Examples of prokaryotes**

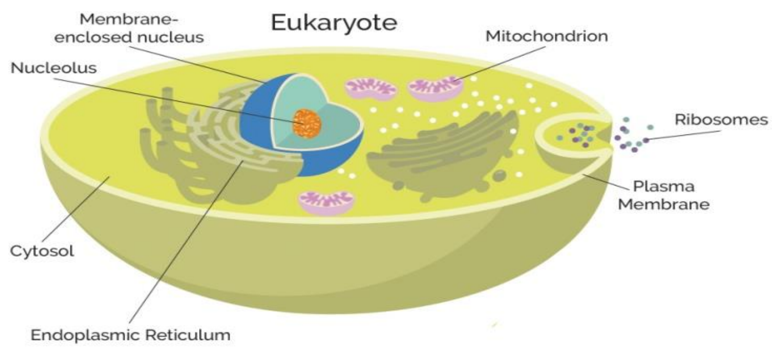
  Bacteria and archaea are the two types of prokaryotes.

  **Do prokaryotes have mitochondria?**

  No, prokaryotes do not have mitochondria. Mitochondria are only found in eukaryotic cells.

**Eukaryote definition**

Eukaryotes are organisms whose cells have a nucleus and other organelles enclosed by a plasma membrane. Organelles are internal structures responsible for a variety of functions, such as energy production and protein synthesis




Eukaryotic cells are large (around 10-100 μm) and complex. While most eukaryotes are multicellular organisms, there are some single-cell eukaryotes.

**Eukaryotic cell features**

Within a eukaryotic cell, each membrane-bound structure carries out specific cellular functions. Here is an overview of many of the primary components of eukaryotic cells.

- **Nucleus:** The nucleus stores the genetic information in chromatin form.
- **Nucleolus:** Found inside of the nucleus, the nucleolus is the part of eukaryotic cells where ribosomal RNA is produced.
- **Plasma membrane:** The plasma membrane is a phospholipid bilayer that surrounds the entire cell and encompasses the organelles within.
- **Cytoskeleton or cell wall:** The cytoskeleton or cell wall provides structure, allows for cell movement, and plays a role in cell division.
- **Ribosomes:** Ribosomes are responsible for protein synthesis.
- **Mitochondria:** Mitochondria, also known as the powerhouses of the cell, are responsible for energy production.
- **Cytoplasm:** The cytoplasm is the region of the cell between the nuclear envelope and plasma membrane.

- **Cytosol:** Cytosol is a gel-like substance within the cell that contains the organelles.
- **Endoplasmic reticulum:** The endoplasmic reticulum is an organelle dedicated to protein maturation and transportation.
- **Vesicles and vacuoles:** Vesicles and vacuoles are membrane-bound sacs involved in transportation and storage.

  Other common organelles found in many, but not all, eukaryotes include the Golgi apparatus, chloroplasts and lysosomes.

  **Examples of eukaryotes**

  Animals, plants, fungi, algae and protozoans are all eukaryotes.

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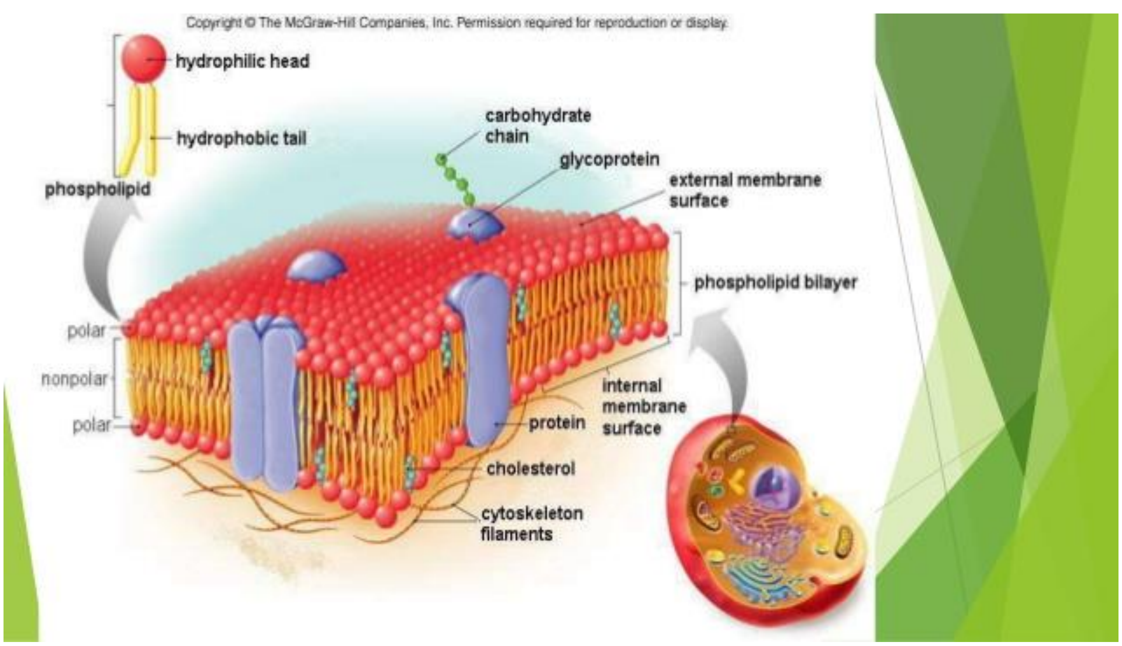
## PLASMA MEMBRANE - ULTRA STRUCTURE

### Introduction

The plasma membrane (also known as the cell membrane or cytoplasmic membrane) is a biological membrane that separates the interior of a cell from its outside environment.

Plasma membrane composed of a phospholipid bilayer with embedded proteins, the plasma membrane is selectively permeable to ions and organic molecules and regulates the movement of substances in and out of cells. Plasma membranes must be very flexible in order to allow certain cells, such as red blood cells and white blood cells, to change shape as they pass through narrow capillaries.

The plasma membrane also plays a role in anchoring the cytoskeleton to provide shape to the cell, and in attaching to the extracellular matrix and other cells to help group cells together to form tissues. The membrane also maintains the cell potential.



## UNIT MEMBRANE MODEL

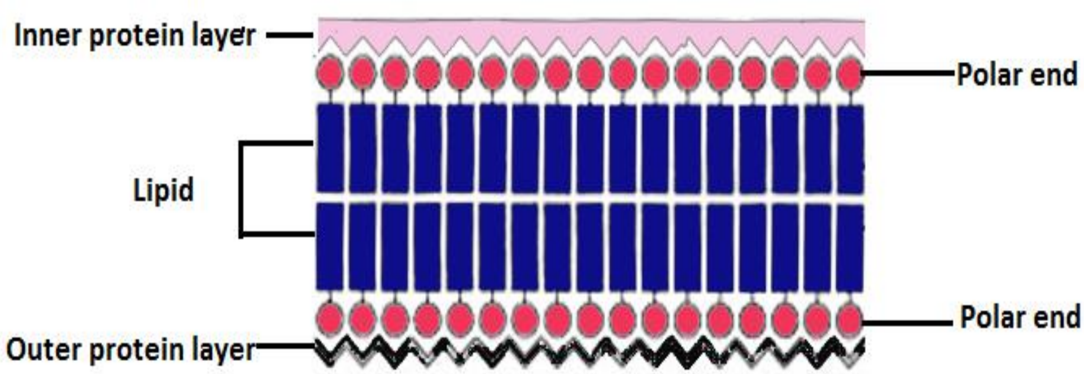
The structure of the fatty acid tails of the phospholipids is important in determining the properties of the membrane, and in particular, how fluid it is.

**Saturated** fatty acids have no double bonds (are saturated with hydrogens), so they are relatively straight. **Unsaturated** fatty acids, on the other hand, contain one or more double bonds, often resulting in a bend or kink. The saturated and unsaturated fatty acid tails of phospholipids behave differently as temperature drops:

- At cooler temperatures, the straight tails of saturated fatty acids can pack tightly together, making a dense and fairly rigid membrane.
- Phospholipids with unsaturated fatty acid tails cannot pack together as tightly because of the bent structure of the tails. Because of this, a membrane containing unsaturated phospholipids will stay fluid at lower temperatures than a membrane made of saturated ones.

Most cell membranes contain a mixture of phospholipids, some with two saturated (straight) tails and others with one saturated and one unsaturated (bent) tail. Many organisms—fish are one example—can adjust physiologically to cold environments by changing the proportion of unsaturated fatty acids in their membranes. For more information about saturated and unsaturated fatty acids, see the article on lipids.

In addition to phospholipids, animals have an additional membrane component that helps to maintain fluidity. **Cholesterol**, another type of lipid that is embedded among the phospholipids of the membrane, helps to minimize the effects of temperature on fluidity.

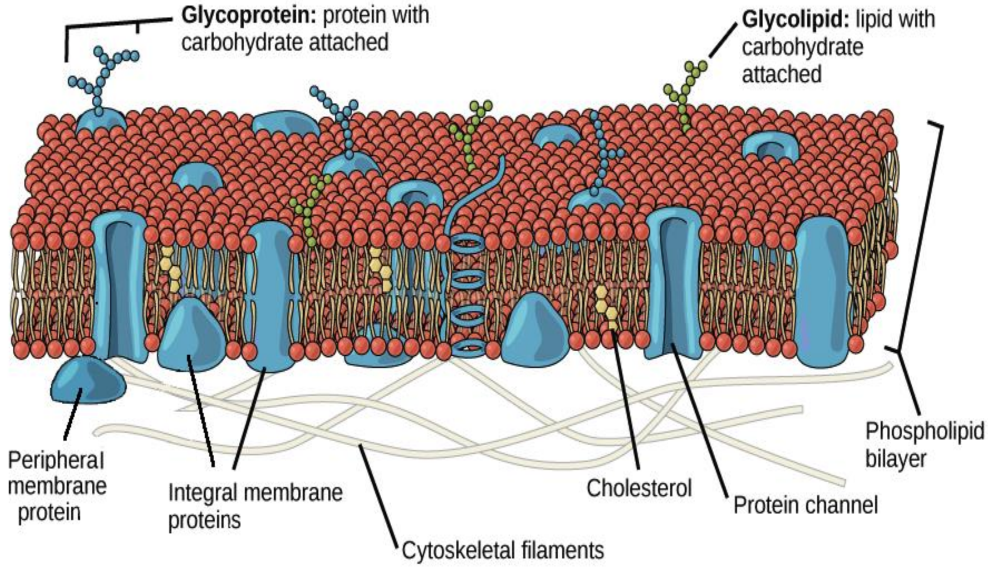



At low temperatures, cholesterol increases fluidity by keeping phospholipids from packing tightly together, while at high temperatures, it actually reduces fluidity^{3,4}3,4start superscript, 3, comma, 4, end superscript. In this way, cholesterol expands the range of temperatures at which a membrane maintains a functional, healthy fluidity.

## FLUID MOSAIC MODEL

The currently accepted model for the structure of the plasma membrane, called the **fluid mosaic model**, was first proposed in 1972. This model has evolved over time, but it still provides a good basic description of the structure and behavior of membranes in many cells.

According to the fluid mosaic model, the plasma membrane is a mosaic of components—primarily, phospholipids, cholesterol, and proteins—that move freely and fluidly in the plane of the membrane.




***Source: Open Stax Biology.***

Image of the plasma membrane, showing the phospholipid bilayer with peripheral and integral membrane proteins, glycoproteins (proteins with a carbohydrate attached), glycolipids (lipids with a carbohydrate attached), and cholesterol molecules.

The principal components of the plasma membrane are lipids (phospholipids and cholesterol), proteins, and carbohydrate groups that are attached to some of the lipids and proteins.

- A **phospholipid** is a lipid made of glycerol, two fatty acid tails, and a phosphate-linked head group. Biological membranes usually involve two layers of phospholipids with their tails pointing inward, an arrangement called a **phospholipid bilayer**.
- **Cholesterol**, another lipid composed of four fused carbon rings, is found alongside phospholipids in the core of the membrane.
- Membrane proteins may extend partway into the plasma membrane, cross the membrane entirely, or be loosely attached to its inside or outside face.
- Carbohydrate groups are present only on the outer surface of the plasma membrane and are attached to proteins, forming **glycoproteins**, or lipids, forming **glycolipids**.

The proportions of proteins, lipids, and carbohydrates in the plasma membrane vary between different types of cells. For a typical human cell, however, proteins account for about 50 percent of the composition by mass, lipids (of all types) account for about 40 percent, and the remaining 10 percent comes from carbohydrates.

# FUNCTIONS OF THE PLASMA MEMBRANE

**A Physical Barrier**

The plasma membrane surrounds all cells and physically separates the cytoplasm, which is the material that makes up the cell, from the extracellular fluid outside the cell. This protects all the components of the cell from the outside environment and allows separate activities to occur inside and outside the cell.

The plasma membrane provides structural support to the cell. It tethers the cytoskeleton, which is a network of protein filaments inside the cell that hold all the parts of the cell in place. The cell wall is composed of molecules such as cellulose. It provides additional support to the cell, and it is why plant cells do not burst like animal cells do if too much water diffuses into them.

**Selective Permeability**

Plasma membranes are selectively permeable (or semi-permeable), meaning that only certain molecules can pass through them. Water, oxygen, and carbon dioxide can easily travel through the membrane. Generally, ions (e.g. sodium, potassium) and polar molecules cannot pass through the membrane; they must go through specific channels or pores in the membrane instead of freely diffusing through.

**Endocytosis and Exocytosis**

Endocytosis is when a cell ingests relatively larger contents than the single ions or molecules that pass through channels. Through endocytosis, a cell can take in large quantities of molecules or even whole bacteria from the extracellular fluid. Exocytosis is when the cell releases these materials. The cell membrane plays an important role in both of these processes. The shape of the membrane itself changes to allow molecules to enter or exit the cell.

**Cell Signaling**

Another important function of the membrane is to facilitate communication and signaling between cells. It does so through the use of various proteins and carbohydrates in the membrane. Proteins on the cell "mark" that cell so that other cells can identify it. The membrane also has receptors that allow it to carry out certain tasks when molecules such as hormones bind to those receptors.

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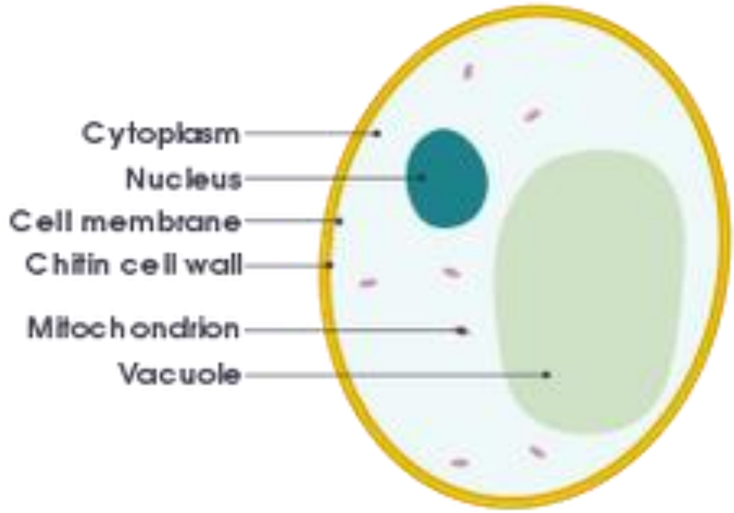
# CYTOPLASM- PHYSICAL AND BIOLOGICAL PROPERTIES

**Definitions**

The cytoplasm is a highly viscous (gel-like) substance enclosed within the cell membrane. It is composed of water (about 85 percent), proteins (10 to 15 percent), lipids (2 to 4 percent), nucleic acids, inorganic salts and polysaccharides in smaller amounts.

Depending on the cell, cytoplasm may also contain occasional granules of inclusions (e.g. stored nutrients and pigments, etc). Apart from the cell membrane, which encloses all cell components, a majority of cell organelles (ribosome, Golgi apparatus, Endoplasmic Reticulum, etc) are located in the cytoplasm. For this reason, most of the metabolic activities occur within the cytoplasm.




**1. Physical properties:**

The colloidal nature of cytoplasm is responsible for the various physical properties a colloidal system may be defined as a system of liquid medium containing suspends particles varying in diameter from 1/1,000,000 to 1/10,000 nm. Some of the physical properties are follows.

Cytoplasm may be differentiated into a sol state and gel state. Sol state is the liquid state and the gel state is the semi solid state. These two phases are interchangeable. This capacity is known as phase reversal.

**Elasticity:**

Depending on the circumstances, the cytoplasm can extend or contract subject to a certain limit. This is known as elasticity.

**Cohesiveness:**

The suspended particles in cytoplasm have mutual attraction, thus exhibiting cohesiveness.

**Contractility:**

It is the capacity of peripheral cytoplasm to absorb or remove water from cell to the exterior. This is manifested very well by guard cells.

**Viscosity:**

The suspended particles of cytoplasm are responsible for its viscous nature.

**Brownian movement:**

The suspended particles of cytoplasm are in a state of to and fro movement called Brownian movement.

In addition to this, cytoplasm also exhibits movements (seen in the Plasmodium of slime molds) and ‘cyclosis or streaming movements (seen in the leaf cells of Elodea).

**2. Biological properties:**

**Irritability:**

The irritability is the fundamental and inheritant property of the matrix.

**Conductivity:**

The conductivity is the process of conduction or transmission of excitation from the place of its origin to the region of its reaction.

**Movement:**

The cytoplasmic matrix can perform movement due to cyclosis.

**Growth:**

Due to secretory or anabolic activities of the cell, new protoplasm continuously increases in its volume.

**Reproduction:**

The cytoplasm has the property of asexual and sexual reproduction.

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Unit II

# 12 Endoplasmic Reticulum

Endoplasmic reticulum is a network of ***membrane bound cavities, vesicles*** and ***tubules,*** distributed throughout the cytoplasm. It is concerned with the biosynthesis of proteins and lipids. It is more concentrated in the ***endoplasm*** than in the ***ectoplasm***. Hence the name.

- It is the ***cytoskeleton*** of the cell.
- It is a cytoplasmic ***vesicular system***.
- It is the ***transportation*** system of the cell.
- It functions as the ***packaging*** system.
- The term ***endoplasmic reticulum*** (ER) was introduced by ***Porter 1948.***
- According to ***Porter,*** the endoplasmic reticulum is a complex, finely divided ***vacuolar system*** extending from the nucleus throughout the cytoplasm to the margin of the cell.
- Since this network is more concentrated in the endoplasm of the cytoplasm, the name ***endoplasmic reticulum*** was proposed.
- ***De Robertis, Nowinski*** and ***Saez*** have coined another term, the ***cytoplasmic vacuolar system*** for these membrane bound cavities present in the cytoplasm.
- It is a ***cell organelle.***

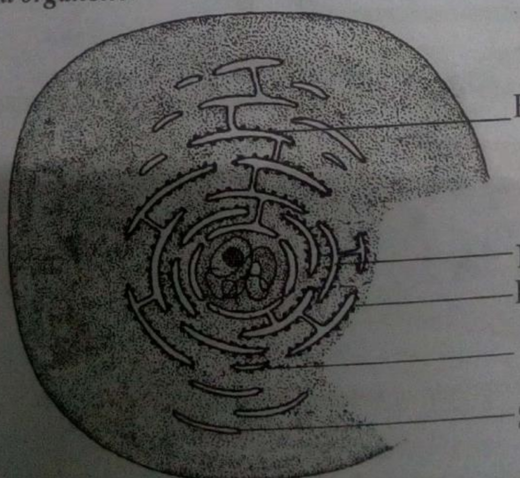



*Fig.12.1 : A cell showing endoplasmic reticulum.*

## Structure

Endoplasmic reticulum consists of three components. They are *cisternae*, ve... *tubules.*

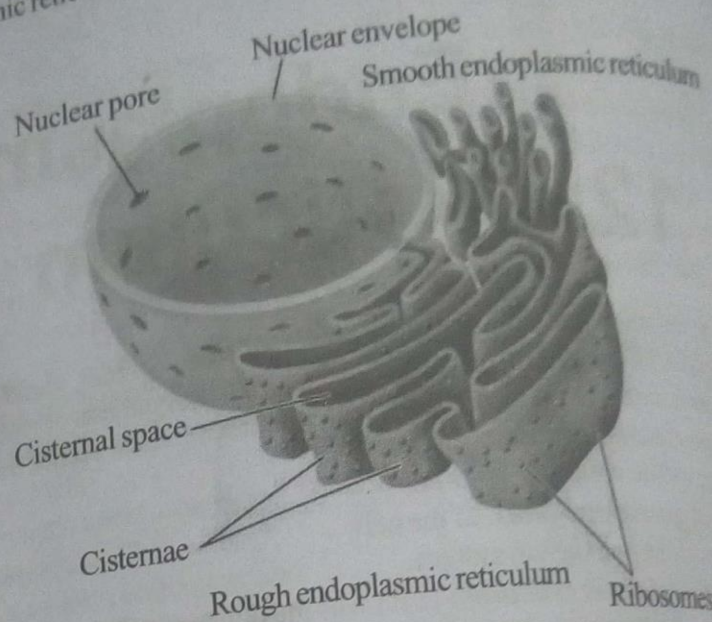



*Fig.12.2 : Endoplasmic reticulum.*

### 1. Cisternae

These are long flattened, unbranched ***sac-like*** structures. They are arranged in bundles. Their diameter is 40-50 m.micron. They have ribosomes on their surface... normally found in secretory cells.

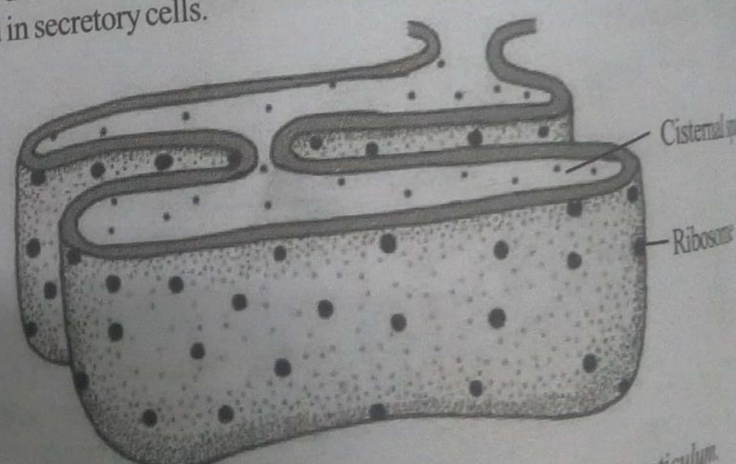



*Fig.12.3: Cisternae of rough endoplasmic reticulum.*

### 2. Vesicles

These are rounded or ovoidal structures having the diameter of 25-500 m...

are found in abundance in ***pancreatic cells.*** They are found at the end of cisternae and tubules. Many vesicles are left free in the cytoplasm.

Vesicles are surrounded by coating proteins called COPI and COPII.

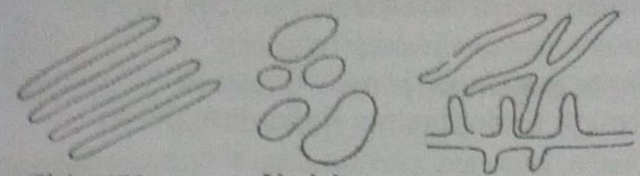



*Fig.12.4 : Components of endoplasmic reticulum.*

COPI makes the vesicle to move to Golgi apparatus. COPII directes vesicles back to the ER.

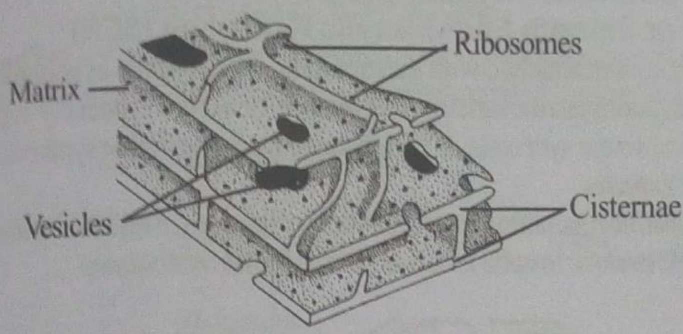



*Fig.12.5: 3D-View of endoplasmic reticulum.*

### 3. Tubules

These are ***smooth*** walled and highly branched tubular spaces having ***diverse*** forms. They have the diameter of 50-100 m. microns. They normally occur in ***non-secretory cells*** like striated muscle cells. They arise from the cisternae.

- The membrane of endoplasmic reticulum is made up of ***phospholipids*** and ***proteins.*** It has a ***fluid-mosaic*** structure. It is 50-60Å in thickness. The membranes of endoplasmic reticulum constitute more than half of the total membranes of an animal cell.
- The membrane of endoplasmic reticulum is ***continuous*** with the plasma membrane, Golgi membrane and nuclear membrane.

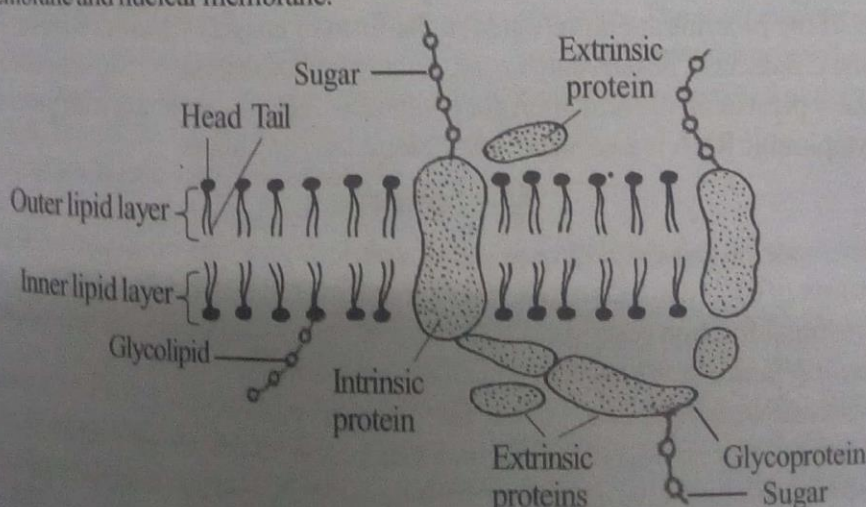



*Fig.12.6: Fluid mosaic model.*

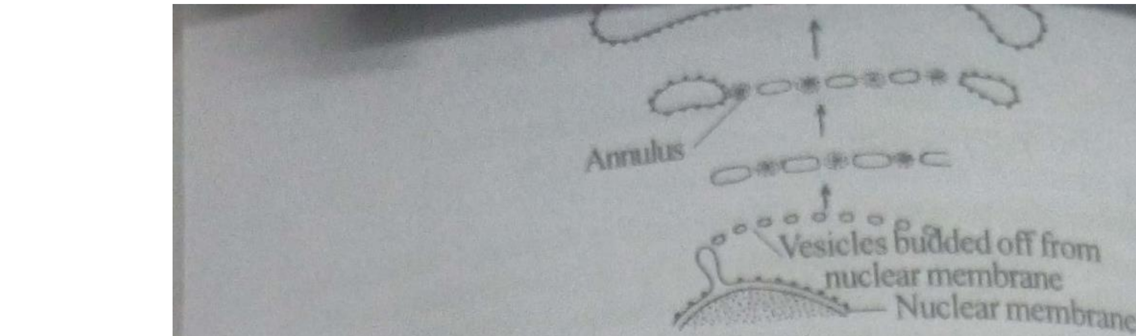



*Fig.12.10: Origin of endoplasmic reticulum from annulate lamellae*

2. It may originate as the infoldings of plasma membrane (***Palade***).

3. Endoplasmic reticulum may be formed from the evagination of nuclear membrane (... 1955, ***Rebhun*** 1956) through the formation of ***annulate lamellae.***

## Functions of Endoplasmic Reticulum

Endoplasmic reticulum performs the following functions:

### 1. Mechanical support

The endoplasmic reticulum divides the fluid content of the cell into different compartments by which it gives ***mechanical support*** to the cell. Hence it is known as the cytoskeleton of the cell.

### 2. Transport

Endoplasmic reticulum acts as a kind of ***circulatory system***, involved in the inter and intracellular circulation of various substances. By this process, proteins, lipids, etc. are transported to the various parts of the cell.

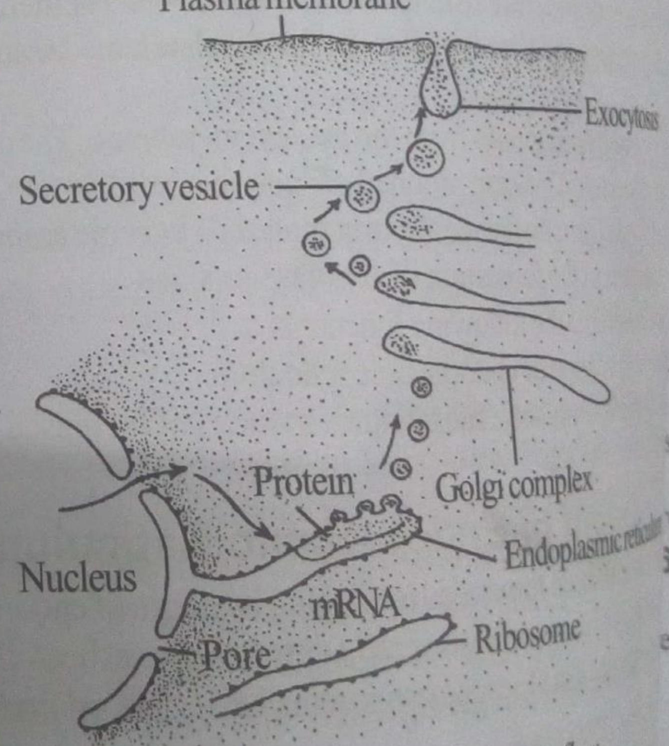



*Fig.12.11 : Transport and membrane flow.*

# 13 Ribosomes

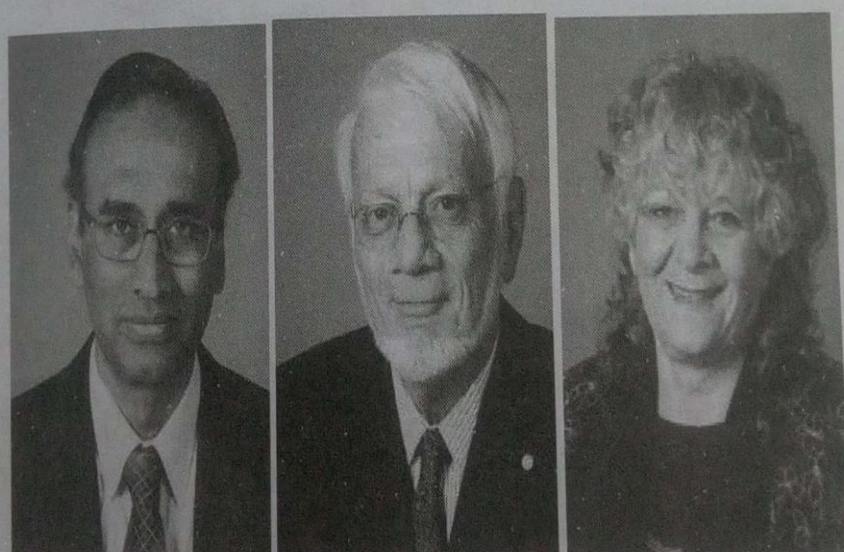
***Ribosomes*** are *ribonucleo-protein particles found in all cells.*

Ribosomes are ***assembly shops*** for protein synthesis. They are also described as ***protein factories.*** They are found in the cytoplasm or attached to the endoplasmic reticulum.

Ribosomes were first observed by ***Claude*** in 1941 and named them as ***microsomes.***

***Palade*** in 1955 named them as ***ribosomes.***

***Ramakrishnan, Steitz*** and ***Ada E.Yonath*** described the structure and functions of ribosomes and for their work they were given Nobel Prize in 2009.



Venkatraman Ramakrishnan    Thomas A. Steitz    Ada E.Yonath

*Fig.13.1 : Nobel prize winners in 2009 for the discovery of the structure and functions of ribosomes.*

Ribosomes are found in all the living cells which synthesize protein. They are usually located on the membranes of the endoplasmic reticulum. Some ribosomes remain scattered in the cytoplasm. They are also present inside the cell organelles like mitochondria and chloroplasts.

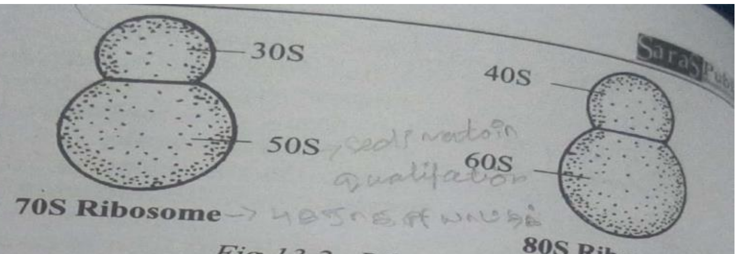



*Fig.13.2 : Ribosomes.*

Bacterial ribosomes are ***70S*** type and eukaryotic ribosomes are ***80 S type.***

The number of ribosomes are directly related to the RNA content of the cell. ... reticulocytes, their number is found to be 1 x $10^5$ per cell. One mm of liver con... 2 x $10^{13}$ ribosomes. In *E.coli,* there are about 20,000 - 30,000 ribosomes per cell.

## Structure of Ribosomes

Ribosomes are ***protein factories.***

Ribosomes are ***spherical*** in shape. The ribosomes of prokaryotes are smaller ... those of eukaryotes are larger in size.

In prokaryotes, they are 150A° and in eukaryotes, they are 250A° in diameter.

Each ribosome consists of two sub-units, namely a ***large sub-unit*** and a ***small***

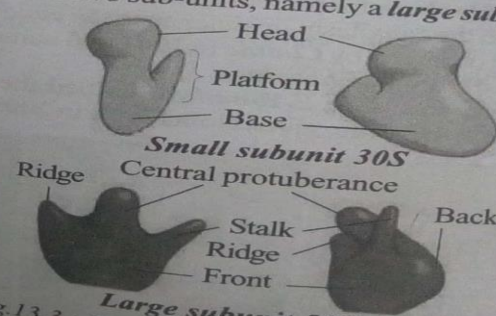



*Fig.13.3 : Prokaryotic ribosomes (70S).*

The sub-units occur separately in the cytoplasm. They join together to form rib... only at the time of protein synthesis.

Generally 5 or more ribosomes line up and join an mRNA chain. Such a string of rib... is called ***polyribosome*** or ***polysome.***

The small sub-unit holds the mRNA during protein synthesis.

The ribosome has 3 binding sites, namely ***A-site, P-site*** and ***E site.*** The A-site c... tRNA containing activated amino acid. The P-site carries a tRNA containing ***polypeptide***... The E site is the ***exit site*** from where the deacylated tRNA is released into the cytosol.

The eukaryotic ribosome has only two sites, namely ***A site*** a... absent. The binding sites are contributed by both the ribos...

## Functions of Ribosomes

*...bosomes are ribonucleo protein particles found in all cells.*

...hey are ***protein factories.***

...hey are ***assembly shops*** for protein synthesis.

...hey are the ***sites*** of protein synthesis.

...hey ***move*** along the mRNA to read the codes.

...hey ***read*** and ***translate*** the code present in the mRNA.

...***recruits*** the ***correct tRNA*** carrying amino acids.

...ibosomes ***link*** the amino acids by ***peptide bonds.***

...hey protect the ***mRNA*** and newly synthesized ***proteins*** from ***nuclea...***
***...roteases.***

# 14 Golgi Complex

***Golgi complex*** is a *stack of membranous flattened sacs and vesicles concerned with cell secretion.*

It was first described by ***Camillo Golgi*** (1898) in the nerve cells of barn owl.

The Golgi complex has been variously named as ***Golgi body, dictyosome, lipochondrion, internal reticular apparatus, canalicular system*** and ***tropho-spongium*** by various workers.

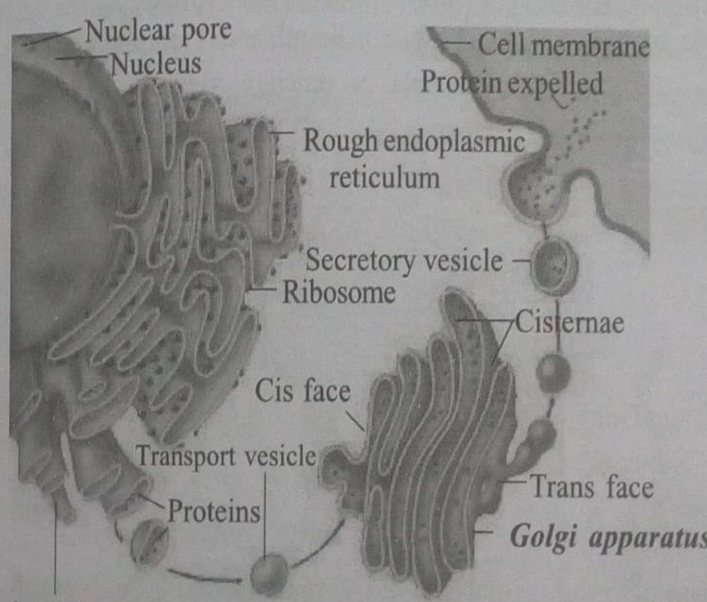



*Fig.14.1 : Golgi complex.*

Generally, the term ***dictyosome*** is used for the Golgi body of invertebrates and plants.

The Golgi is located in the ***cytoplasm***.

It is a cell membrane bound ***organelle.***

Most animal cells contain only one Golgi complex. But developing contain many Golgi bodies. Similarly, nerve cells and liver cells contain usually contain hundreds of Golgi bodies.

The Golgi complex is absent from ***prokaryotic cells***, *certain* ***bryophytes*** and ***pteridophytes*** and ***RBC.***

## Structure of Golgi complex

***Golgi complex*** is a ***stack of membranous flattened sacs*** and ve by tubules.

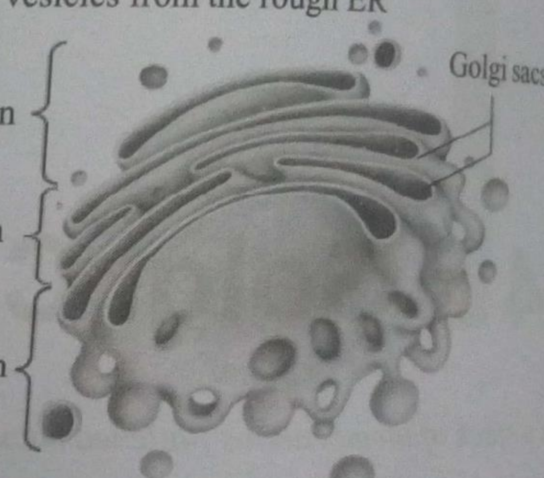
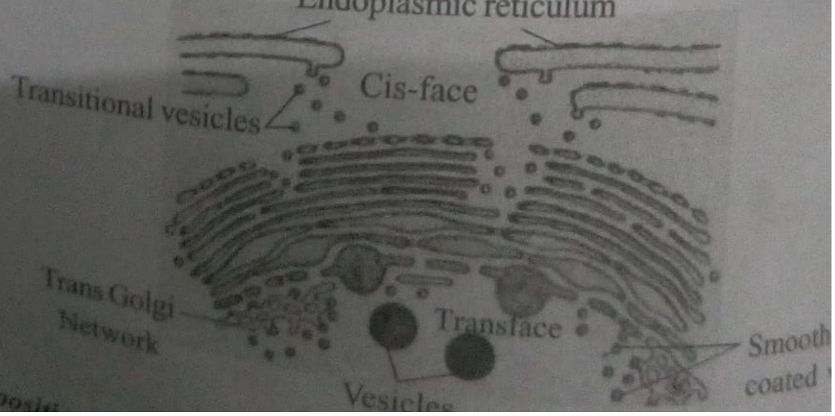



*Fig.14.2: Golgi apparatus.*

The ***size*** of the Golgi complex is variable. It is larger and well develo gland cells and nerve cells and poorly developed in muscle cells. As the c Golgi tends to decrease in size. It is 1-3mm in length and 0.5mm in thickn




The *positi* nucleu

## Functions of Golgi Complex

*Golgi complex is a stack off flattened sacs and vesicles. It is a cell* **organelle**.

- They are the ***post office*** of the cell.
- They function as the **'*Receiving*, *Sorting*** and ***Shipping*** Departments' of the cell.
- They do the following functions:
  - Cell secretion
  - Produce ***lysosomes***.
  - Golgi of plant cells produce ***pectin*** and ***cell wall***.
  - ***Plasma membrane*** formation.
  - Secretion of ***mucous***.
  - Secretion of ***saliva***.
  - Secretion of ***sweat*** by sweat glands.
  - Secretion of ***oil*** by oil glands.
  - Secretion of ***tear*** by tear glands
  - Secretion of ***enzymes*** by exocrine glands.
  - Secretion of ***hormones*** by endocrine glands.
  - Secretion of ***antibodies*** by plasma cells.

# 15 Lysosomes

*Lysosomes* are *membrane bound tiny bags filled with digestive enzymes. They are concerned with intracellular digestion.* They were discovered by ***de Duve*** in 1955.

- A lysosome is a ***lytic body.*** It is capable of lysis.
- *Lyso* means ***digestive,*** *soma* means ***body.***
- It can destroy a cell in which it releases its enzymes. Hence, it is often called ***suicidal bag.***
- As the lysosome digests the components of the cells, it is often referred to as the ***digestive tract of the cell*** (**de Duve,** 1963).
- It is a ***cell organelle.***
- Lysosomes were first named as ***pericanalicular bodies*** because of their location. They are renamed as ***lysosomes*** by ***de Duve*** in 1955.
- Lysosomes occur in most animal cells and in a few plant cells. They are most abundant in cells which are related with ***enzymatic reactions*** such as liver cells, pancreatic cells, kidney cells, spleen cells, leucocytes, etc.

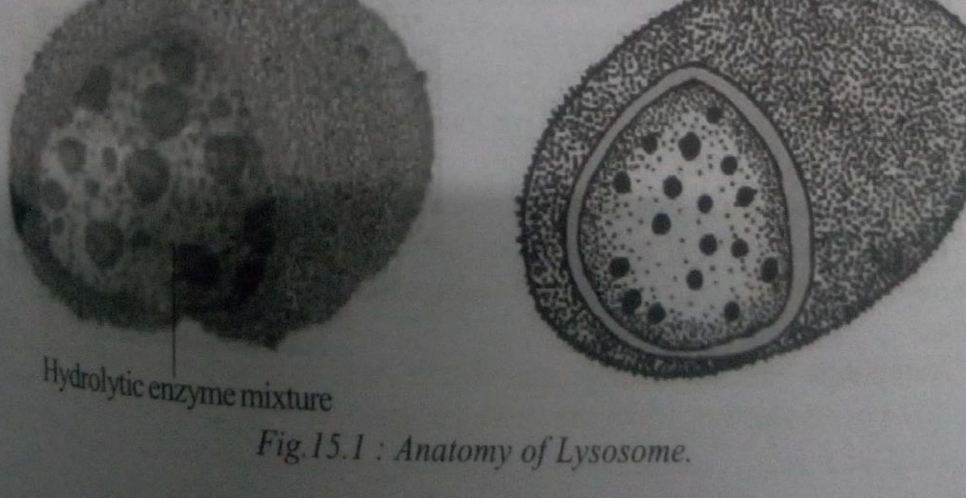



*Fig.15.1 : Anatomy of Lysosome.*

- Lysosomes are usually ***spherical*** in shape; but they are irregular in certain m... cells of roots.
- The size of the lysosomes usually ranges from 0.2 micron to 0.8 micron in dia... may be exceptionally large as 8 microns in mammalian kidney cells and leucocytes.
- Lysosomes are spherical dense bodies filled with large number of dense granules ... ***hydrolytic enzymes*** and ***acid phosphatases***.
- The lysosomes are bounded by a ***single layered membrane*** in contrast to the d... layered membranes of other organelles. It is a ***membrane*** like that of plasma membrane made up of ***proteins*** and ***lipids.*** Proteins in the lysosome membrane are glycosylated wi... residues.
- The interior of some lysosomes are uniformly solid while others have very dense ... zone and a less dense inner zone.
- The interior of the lysosome is ***acidic*** with a ***pH*** of ***4.8***, but the pH of the surro... cytosol is 7.2.

The low pH is maintained by pumping ***protons*** ($H^+$) from the cytosol.

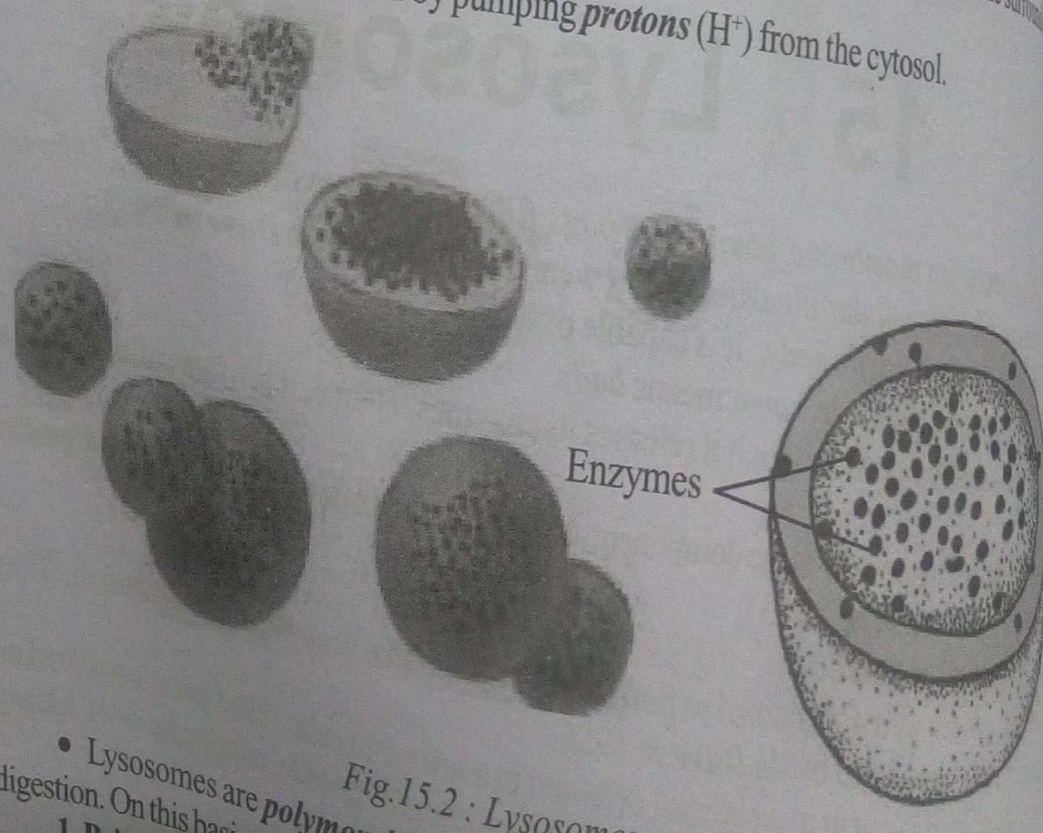



*Fig.15.2 : Lysosomes.*

- Lysosomes are ***polymorphic structures*** because thei... digestion. On this basis, the lysosomes can ...

**1. Primary Lysosomes:** ... by the Golgi body ... stora...

# Functions of Lysosomes

*Lysosomes are membrane bound tiny bags filled with digestive enzymes.*

- They are cell ***organelles***.
- They are the ***'suicide bag'*** or ***'suicide sac'***.
- They are the ***'stomach'*** of the cells.
- They are the ***'digestive tract'*** of the cell
- They are the ***'digester'*** of the cells.
- They form the ***'garbage disposal system'*** of the cell.
- They do the following functions:

1. They supply ***hydrolytic enzymes*** for the ***digestion***.
2. They carry out ***intracellular*** and ***extracellular*** digestion.
3. They digest worn out cell components by ***autolysis***.
4. They digest food materials present in the ***phagosomes*** and ***pinosomes***.
5. They cause ***programmed cell death*** in ***metamorphosis***.
6. Lysosomes of sperm release ***hyaluronidase*** to penetrate the egg membranes during ***fertilization***.
7. ***Bleeding*** during ***menstruation*** is due to the breaking of the cells of uterine epithelium by the lysosomal enzymes.
8. ***Resorption*** of ***tail*** of ***tadpole*** is due to the digestion of cells by lysosomal enzymes.
9. ***Silicosis*** is caused by the rupture of lysosomes of lung cells by the inhaled ***silica.***

# 16 Mitochondria

The ***mitochondria*** are *thread-like or granular cytoplasmic organelles* (Gr.***mito*** = thread, ***chondrion*** = granule). They contain many enzymes and coenzymes which are responsible for energy metabolism.

They are described as the ***power plants*** or ***power houses*** of cells. The mitochondria play main roles in ***cellular respiration*** and ***energy production.***

The mitochondria were first observed by ***Flemming*** and ***Kolliker*** in 1882. These organelles were first called ***bioblasts*** by ***Altmann.*** Later, the term ***mitochondria*** was introduced by ***Benda*** in 1898.

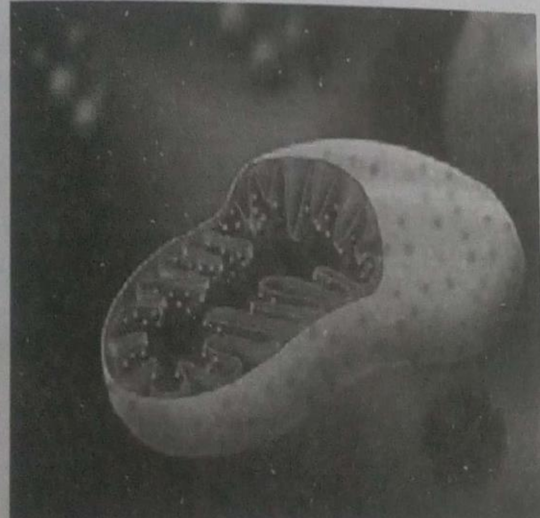


*Fig.16.1 : Mitochondria.*

Mitochondria are found both in plant and animal cells. But they are absent from ***prokaryotes.***

The mitochondria may be ***filamentous*** or ***granular*** in shape. The shape of mitochondria may change from one cell to another depending upon the physiological conditions of the cell. They may be rod-shaped, club-shaped, ring-shaped, rounded or vesicular.

The size of the mitochondria is highly variable. In most cells, their length varies from 3 to 10

... the region ...

The mitochondria ... an *outer* and an ***inner mitochondrial membranes***, each measuring about 60Å in thickness. The two membranes are separated by a space of 80 to 100Å. The space between the outer and inner mitochondrial membranes is called ***outer chamber*** or ***perimitochondrial space.*** This chamber is filled with a fluid of low viscosity and density.

The central space of the mitochondria is called the ***inner chamber.*** The inner chamber is filled with ***mitochondrial matrix***. The matrix contains ***70S ribosomes*** and mitochondrial DNA. The inner mitochondrial membrane produces ***finger-like*** projections known as ***cristae*** into the inner chamber.

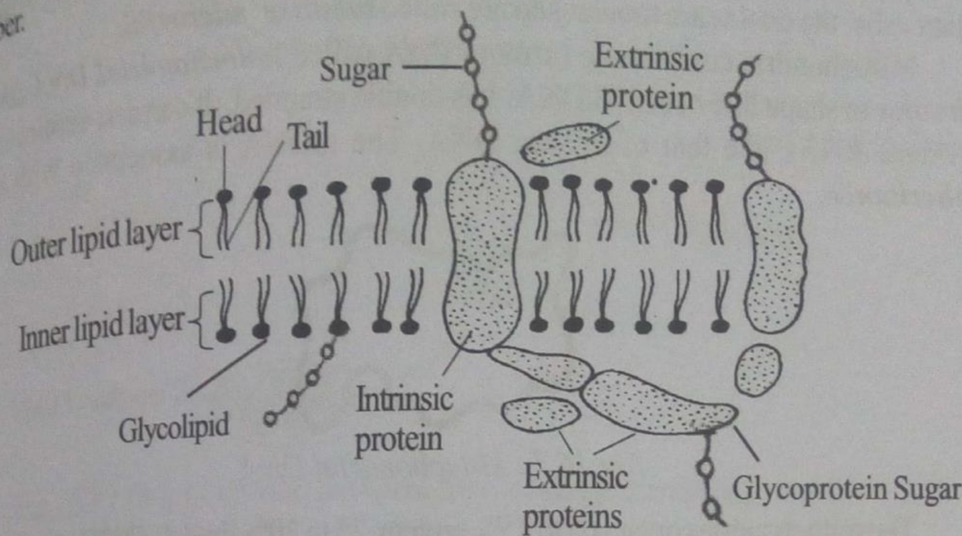



*Fig.16.5: Fluid mosaic model.*

The mitochondrial membrane contains small particles called ***elementary particles*** or ***$F_1$***

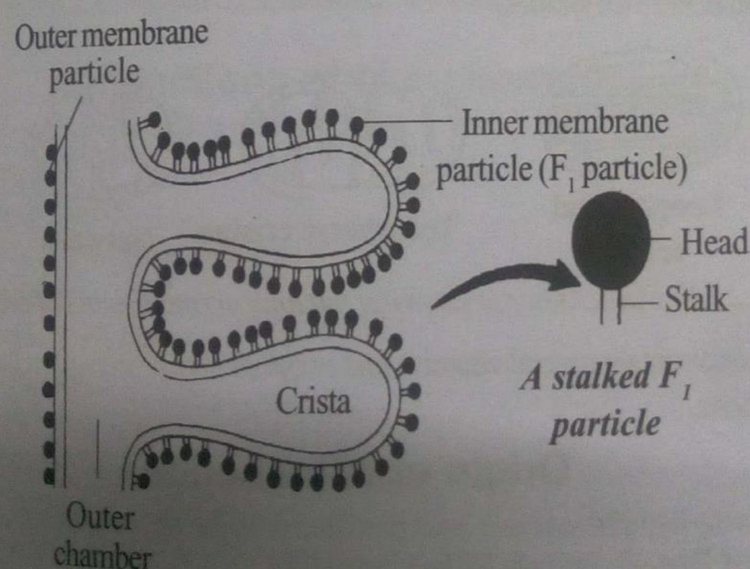


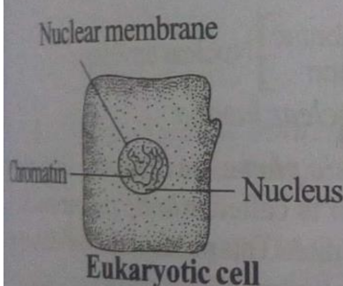

*Fig.16.6 : Cristae showing $F_1$ particles.*

# 23 Nucleus

*Nucleus is a membrane bound organelle containing chromosomes and nucleolus.* It controls all the cellular activities. So it is referred to as the ***controlling centre*** of the cell. It functions as the ***heart*** of a cell. The nucleus acts as the ***brain*** of a cell. It is the ***administrative*** office of the cell.

It was first discovered by ***Robert Brown*** (1831) in plant cells. The study of nucleus is termed ***karyology.***

Nucleus is the ***largest organelle*** of the cell.



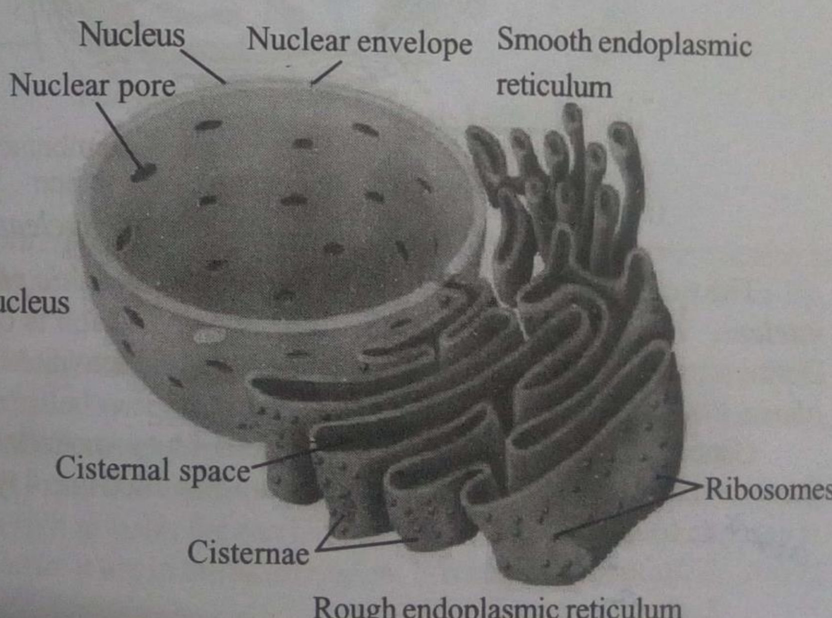




*Fig.23.1 : A cell with nucleus.*

*Fig.23.2 : Nucleus with endoplasmic reticulum.*

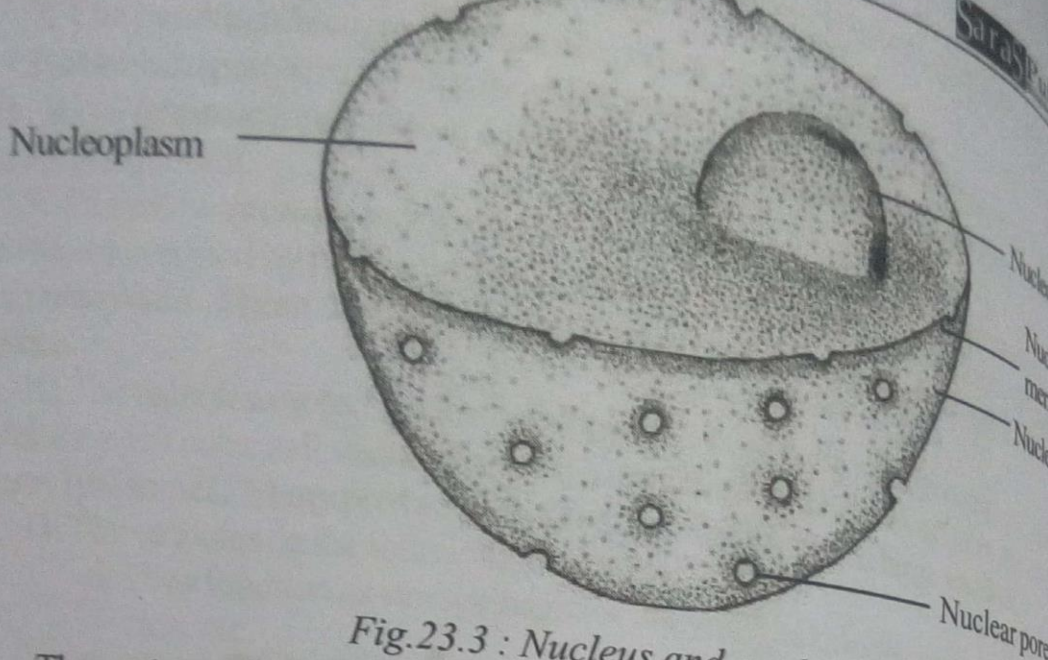



*Fig.23.3 : Nucleus and nucleolus.*

The nucleus is present in all ***eukaryotic cells***. However, it is absent from *RBC* of ... some ***lens cells*** of eye. The ***sieve tubes*** of plants also lack nucleus.

In eukaryotes, the nucleus is surrounded by a ***nuclear membrane***. But in prok... the nucleus is not surrounded by a nuclear membrane. Such a nucleus without a nuclear m... is called a ***nucleoid*** or ***incipient nucleus.***

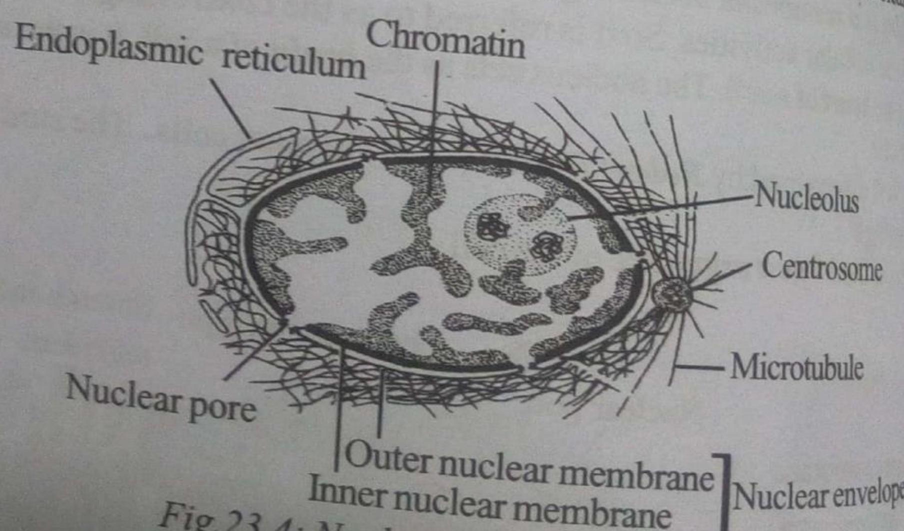



*Fig.23.4: Nucleus showing nuclear lamina.*

The nucleus occurs in two phases. They are ***mitotic phase*** nucleus and ***interp...*** ***nucleus.*** *The nucleus which is involved in cell division* is called ***mitotic phase n...*** During interphase, the nucleus is involved in metabolic activities. This phase is also called ... ***phase.***

Generally, a cell contains only one nucleus. But sometimes two or more nuclei are pr... Based on the number of nucleus, the cells are classified into 4 types. They are :

absent 1. *Anucleate cell*
2. *Mononucleate cell*
3. *Binucleate cell*
4. *Multinucleate c...*

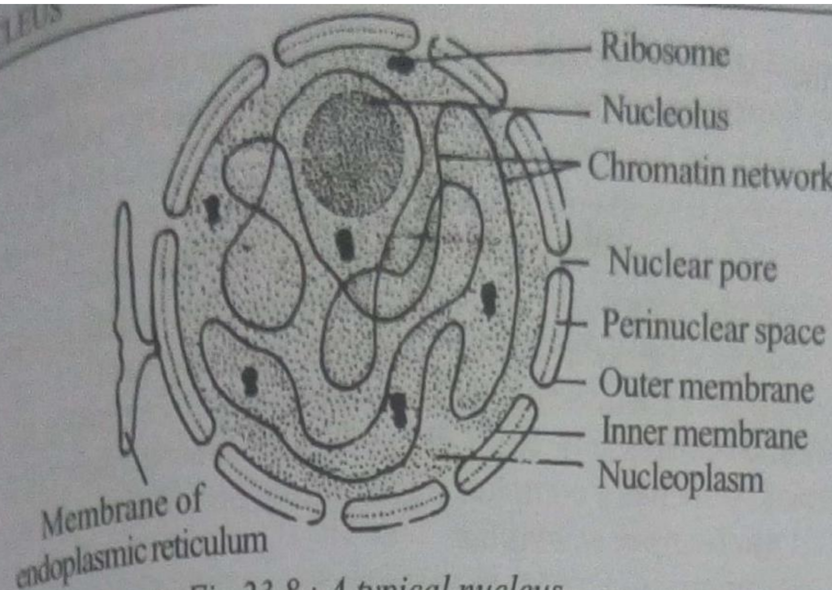



*Fig.23.8 : A typical nucleus.*

led *ecto karyotheca* and the inner layer is called ***endo karyotheca.*** They are separated by *rinuclear space* which is about 150 to 300 Å. Each layer is about 70 to 80 Å thick.

The nuclear membrane has a ***fluid mosaic*** structure similar to plasma membrane.

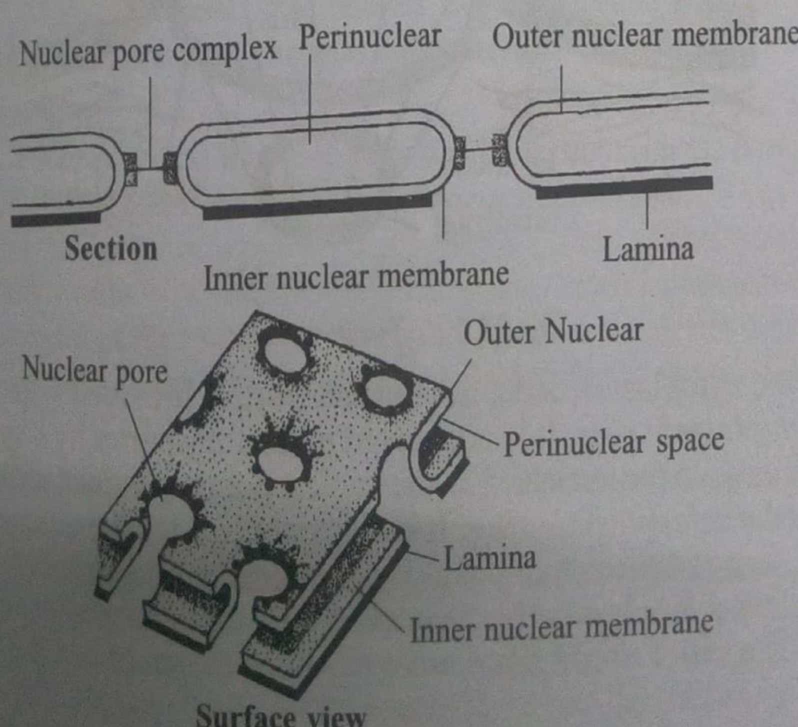
The inner nuclear membrane is lined by a fibrous material called ***nuclear lamina***. It is posed of a filament protein called ***lamin***.

The outer membrane is also surrounded by lamin, but they are not well organised like the lear lamina.

The outer nuclear membrane is beset with ***ribosomes***. The outer membrane communicates th endoplasmic reticulum at several points.

The outer membrane is often continuous with membranes of the Golgi, endoplasmic reticulum, tochondrion and plasma membrane. The outer membrane is ***rough*** owing to the presence of osomes, while the inner membrane is smooth.

*The nuclear membrane contains many pores* called ***nuclear pores***. These pores are



## Nucleolus

***Nucleolus** is the deeply staining spherical body concerned with rRNA synth...* *inside the nucleus.*

It was first discovered by ***Fontana*** in 1874.

Nucleolus is absent from lower organisms like ***bacteria, yeasts, some algae,*** ***cells, mammalian RBC, reticulocytes, spermatozoa***, etc. In all other cells, nucleolus...

The number of nucleoli depends upon the number of sets of chromosomes... nucleolus is present for each chromosome set. A diploid cell contains two nucleoli... cell contains only one nucleolus. Thus the sperm and ovum contain only one nucleolus... the amphibian oocyte contains 600 to 1200 nucleoli.

The nucleolus is located on the ***nucleolar organizer region (secondary con...*** of the nucleolar chromosome.

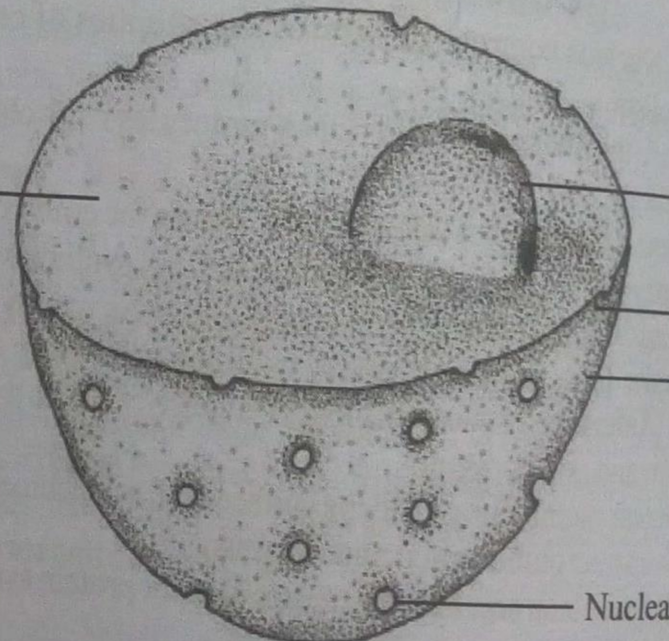



*Fig.23.11: Nucleus and nucleolus.*

Frequently the nucleolus is attached with the nuclear membrane.

The size of the nucleolus depends upon the metabolic activity of the cell. The nuc... small or absent in cells exhibiting little protein synthesis. They are very large in cells where... synthesis is going on actively as in oocytes, neurons, secretory cells, etc.

The nucleolus is surrounded by a thick covering called ***perinucleolar chromati...***

Here and there, the perinucleolar chromatin projects into the nucleolus... ***intranucleolar chromatin.***

The perinucleolar chromatin and the intranucleolar chromatin are rich in DNA.

Nucleolus is composed of RNA, DNA, proteins and enzymes. The RNA is si... rRNA. The enzymes include ***acid phosphatase, nucleoside phosphorylase, RNA me...*** and enzymes for the synthesis of NAD.

The nucleoli are classified into three types based on the distribution of granules. T... the following:

- In plant cells, the ...
- Nucleolus is a ***genetically determ...***

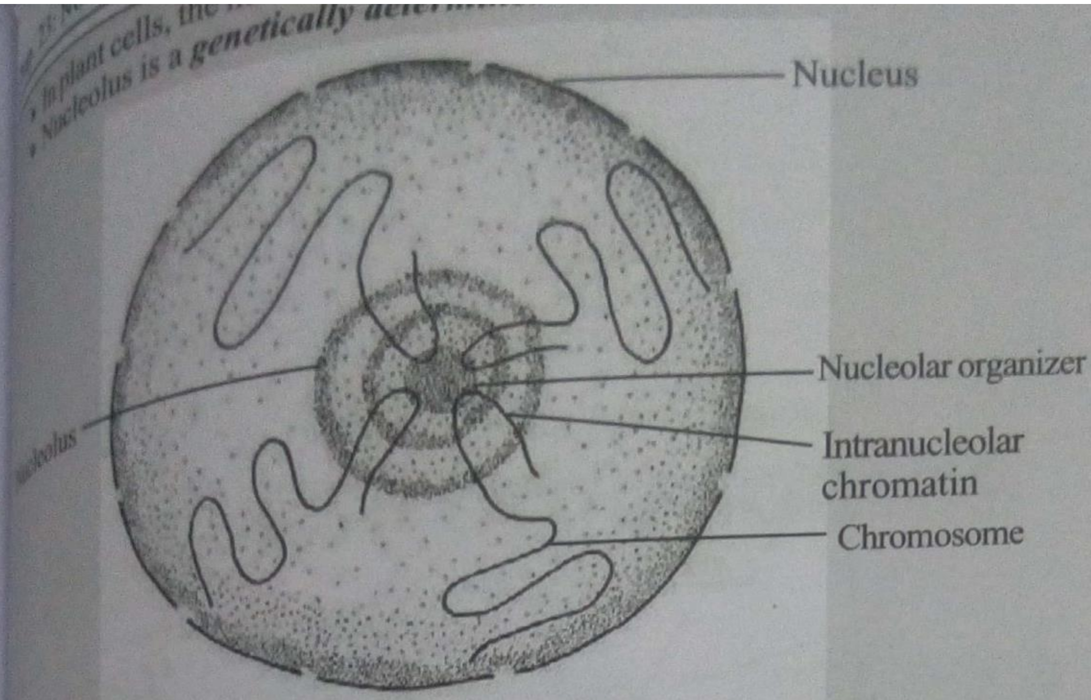



*Fig.23.14: Human nucleolus - To avoid confusion only 4 chromosomes are shown.*

- It is controlled by the genes present in the ***nucleolar organizer*** of the nucleolar chromosome.
- It is the largest ***organelle present*** inside the nucleus.
- Nucleolus contains enzymes like ***acid phosphatase, nucleoside phosphorylase, RNA methylase***, etc.
- Nucleolus contains ***rRNA, DNA*** and ***proteins*** .
- The DNA is contributed by the nucleolar organizer .
- RNA is synthesized by the DNA of nucleolar organizer.
- The proteins are imported from the cytoplasm.
- Nucleolus contains the ***genes 45 S-rDNA*** producing ***45S rRNA***.

**Function**

1. Nucleolus synthesizes rRNA .
2. It assembles small and large ***sub units of ribosomes*** by combining ***rRNA*** and ***proteins***.
3. It exports sub units of ribosomes to the cytoplasm for assembling ribosomes.

## Functions of Nucleolus

The nucleolus has the following functions:

1. **RNA Synthesis:** The nucleolus is the active site for RNA synthesis. The nucleolus synthesizes 70-90% of rRNA in the cell.