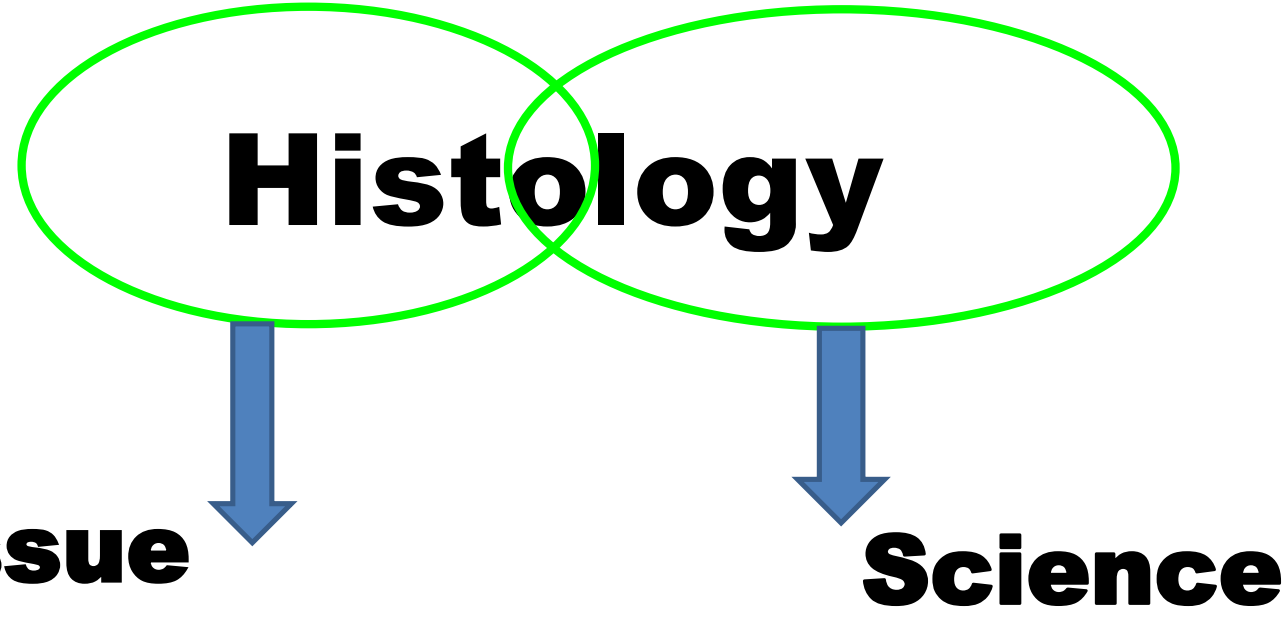


Macroscopic anatomy

Gross anatomy – the study of large, easily observable structures (by naked eye)

Microscopic anatomy

Cytology = histology – the study of very small structures, where a magnifying lens or microscope is needed.

Histology: study of normal tissues

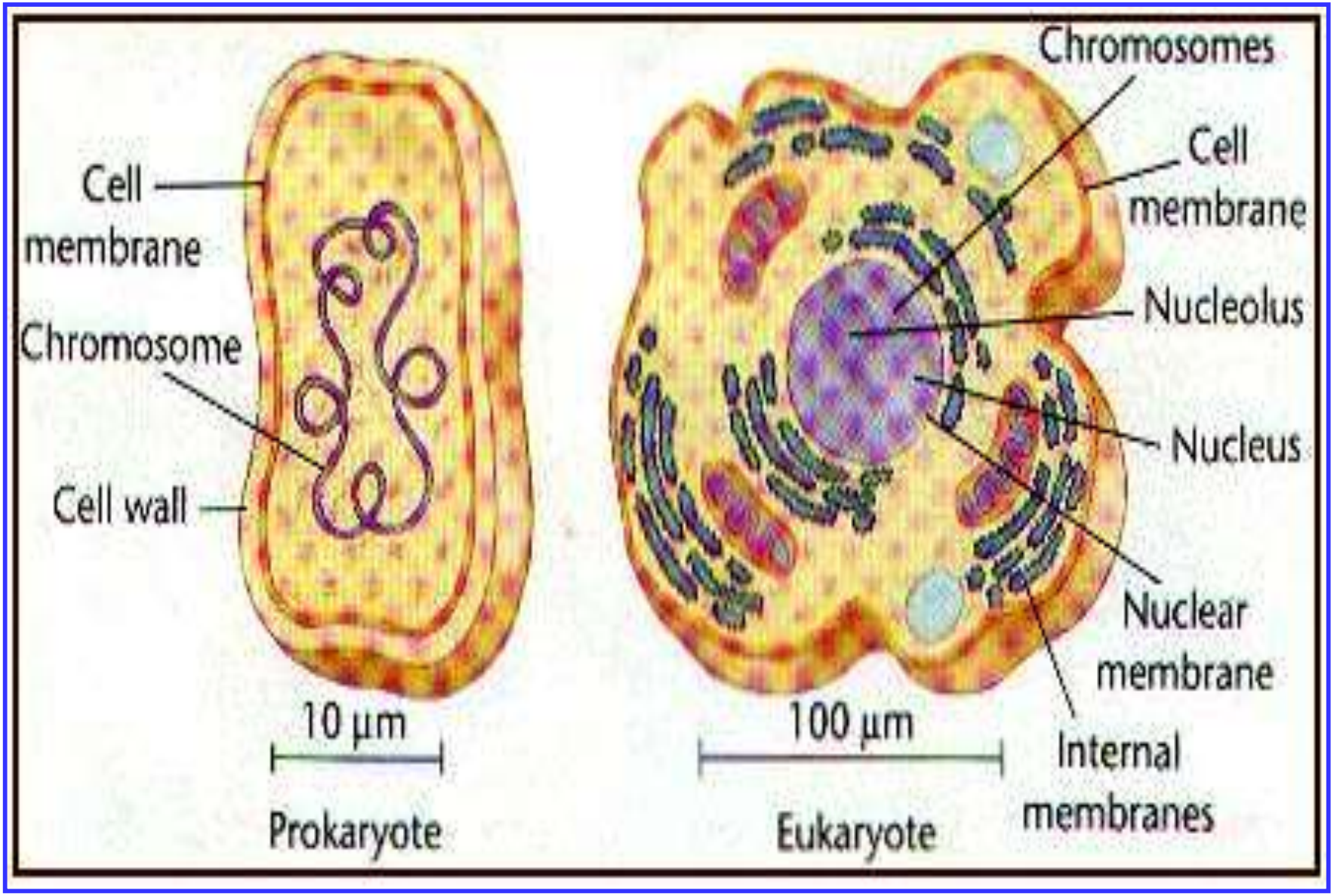
Pathology: study of diseased tissues

Introduction to Histology and Cell Structure

- All organisms are made of cells
- The cell is the simplest collection of matter that can live

Two types of cells make up every organism

- Prokaryotic No true nucleus
- Eukaryotic with true nucleus


Cell membrane
Chromosome
Cell wall
10 µm
Prokaryote
Chromosomes
Cell membrane
Nucleolus
Nucleus
Nuclear membrane
Internal membranes
100 µm
Eukaryote

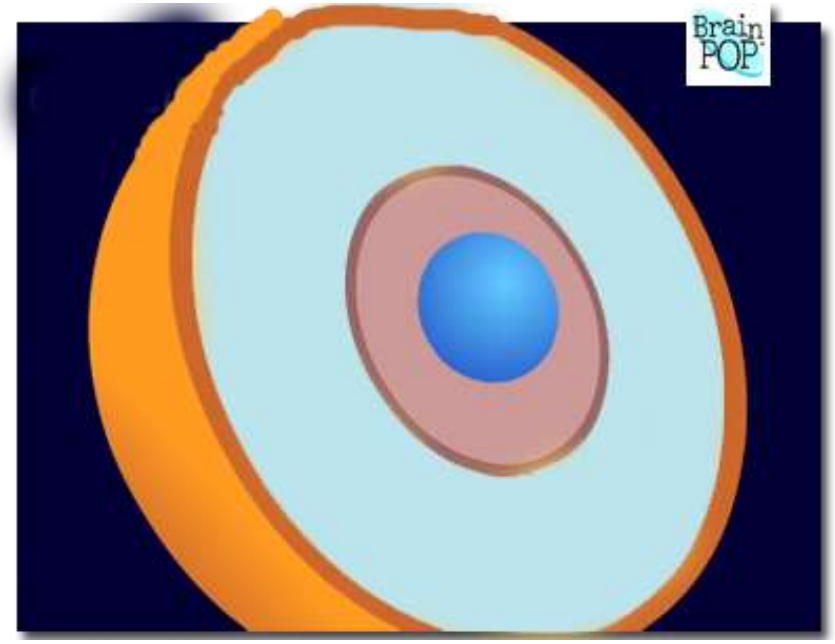
Eukaryotic cells

have **three** major components

- **Cell membranes** separate a cell from its environment also form distinct functional compartments e.g nucleus, organelles. The outer cell membrane is called **plasma membrane** (**plasmalemma**)

- **Nucleus**: contains DNA (genetic material)

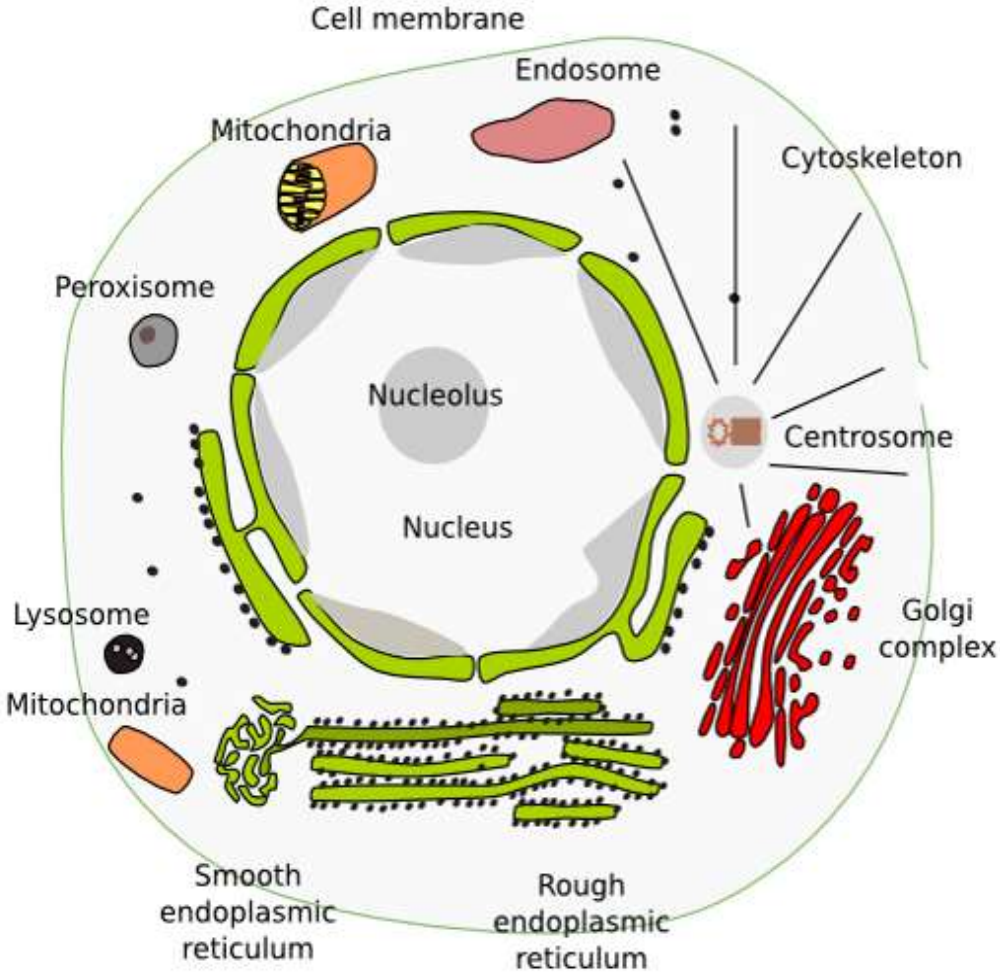
- **Cytoplasm**



The cytoplasm

Composed of:

- **Cytosol:**
  jelly like fluid matrix, its primary component is water
- **Organelles**
- **Inclusion**
- **Cytoskeleton**



The Cell Membrane
Plasma membrane = Plasmalemma

Definition

- It is a vital, dynamic , stable , semipermeable structure

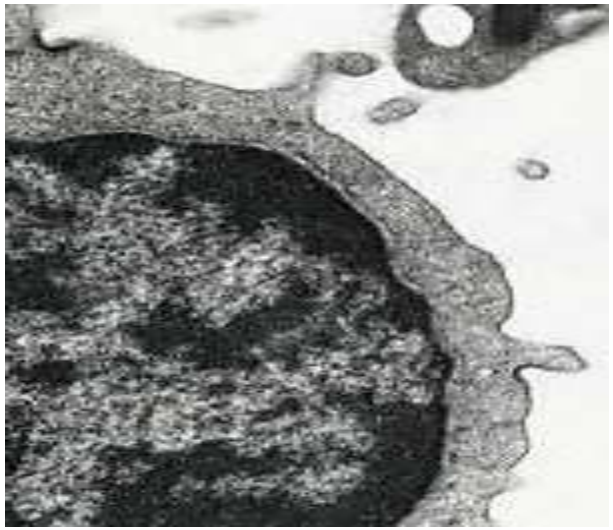
-Acting as a barrier that surrounds the boundary of the cell and separates its internal contents from the environment

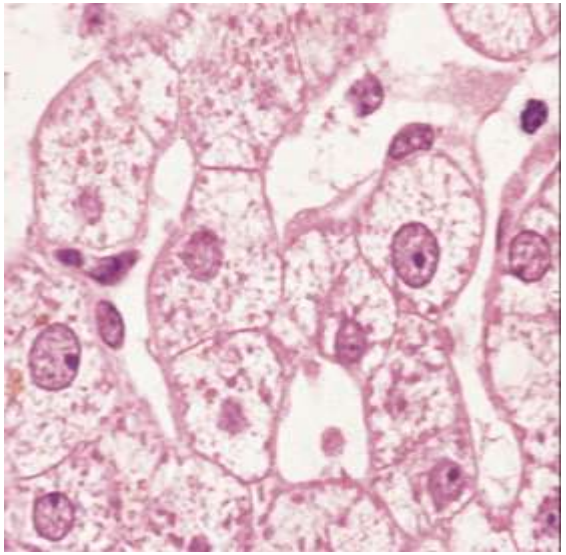
Structure:

- **LM :** 8.5-10 nm not seen (too thin)
- **EM :**

Low magnification:

Single electron dense line (black)





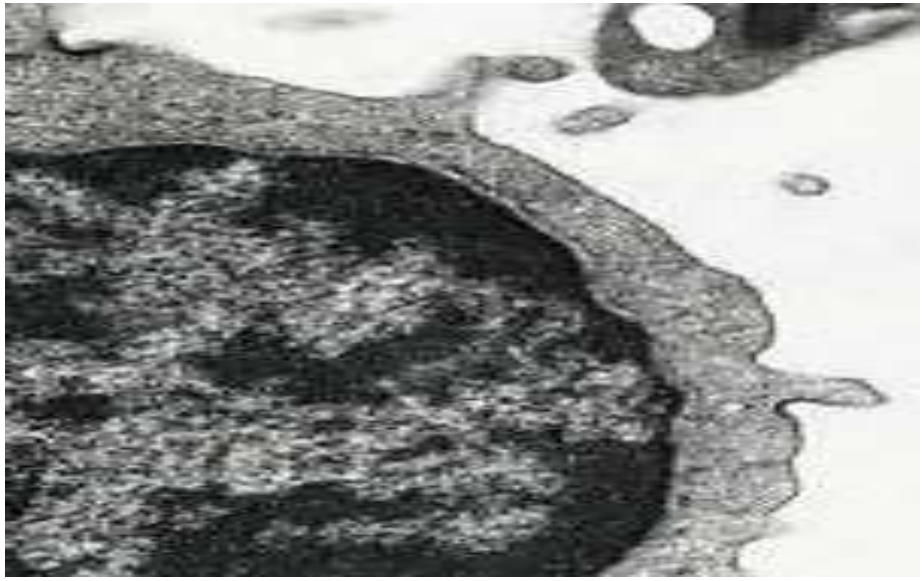
Higher magnification:

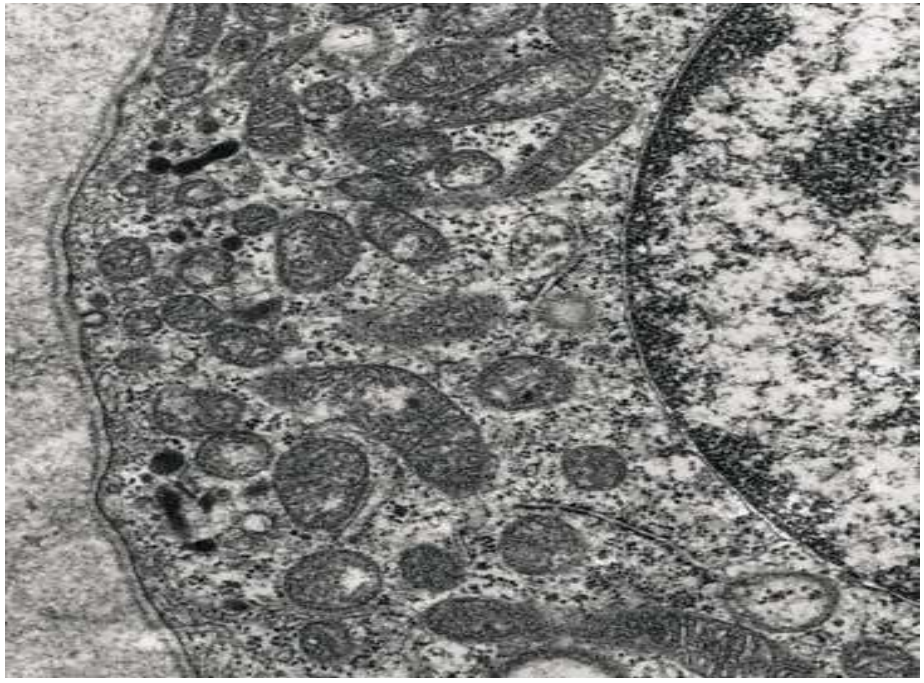
Trilaminar =

Trilamellar =

3 layers?????

- Outer dense (black)
- Middle lucent (white)
- Inner dense (black)





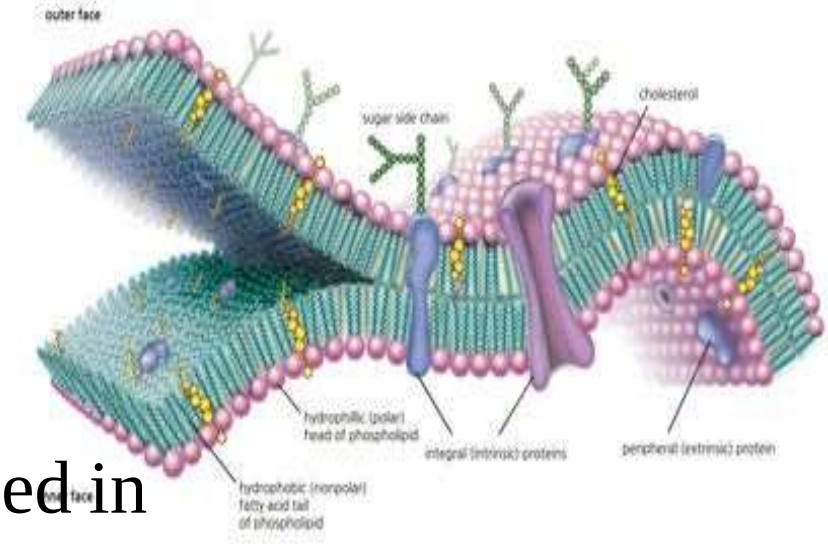
Molecular structure of the Cell membrane

The membrane chemically composed of

3 components:

1-Lipid molecules:

- **phospholipids**
- **cholesterol**



phospholipid molecules are arranged in **2 layers (phospholipid bilayer)**

2- Protein molecules

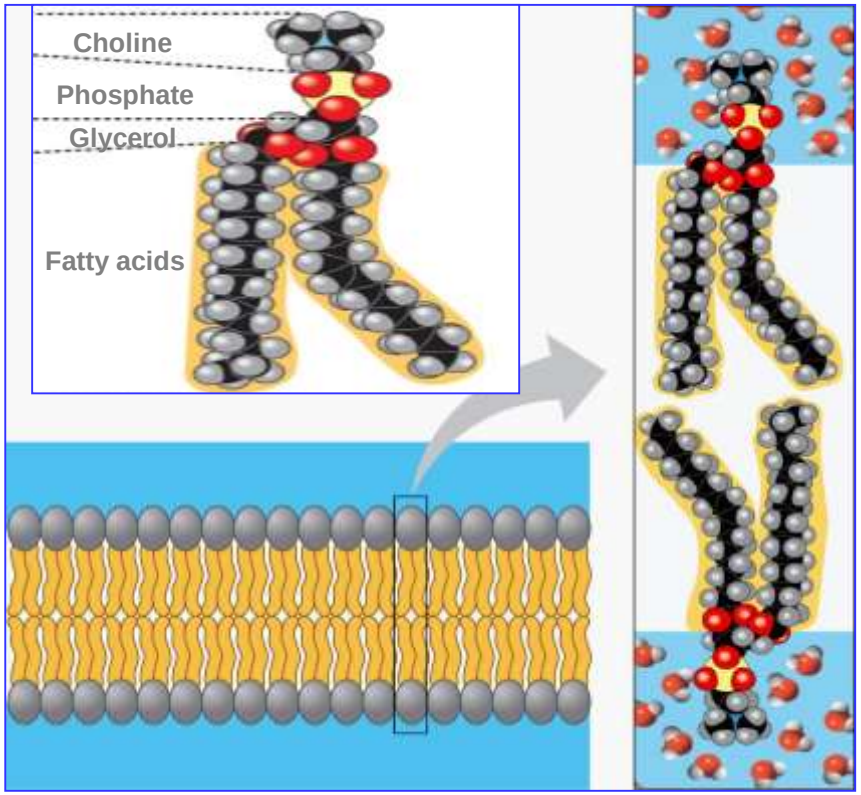
3- Carbohydrate molecules

Lipids

Phospholipids

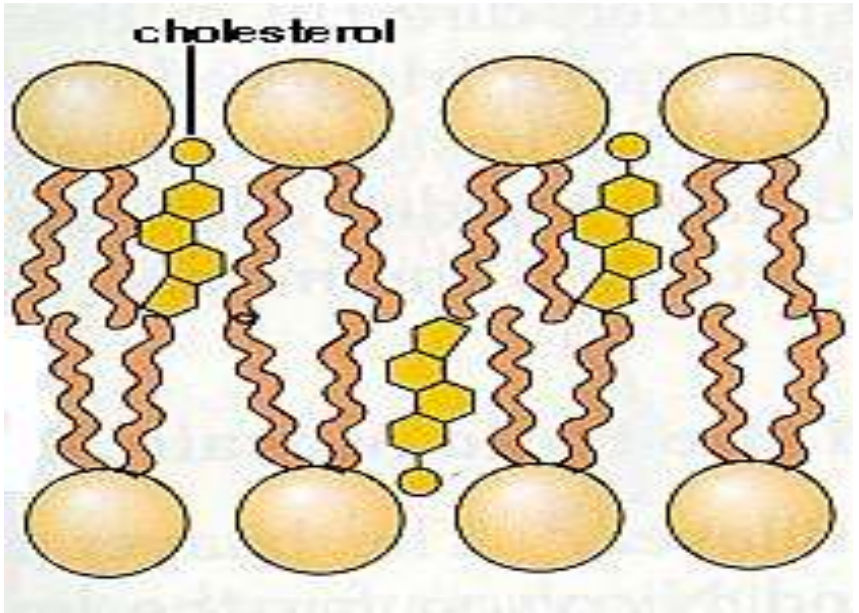
1. Phospholipids form the bilayer
2. The basic structural composition
3. act as barrier to most water soluble substances

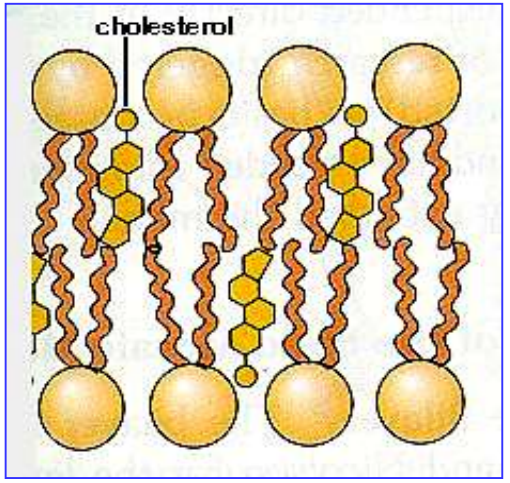
- **HYDROPHILIC** (**polar heads**/ water liking) **.**
  - polar heads are on the surface.
- Phospholipids have **HYDROPHOBIC** (**non-polar**/ water fearing) **tails**
  - non-polar tails point inward



Cholesterol

Wedged between phospholipid molecules with the same orientation as the phospholipid molecules (the polar head of the cholesterol is aligned with the polar head of the phospholipids).





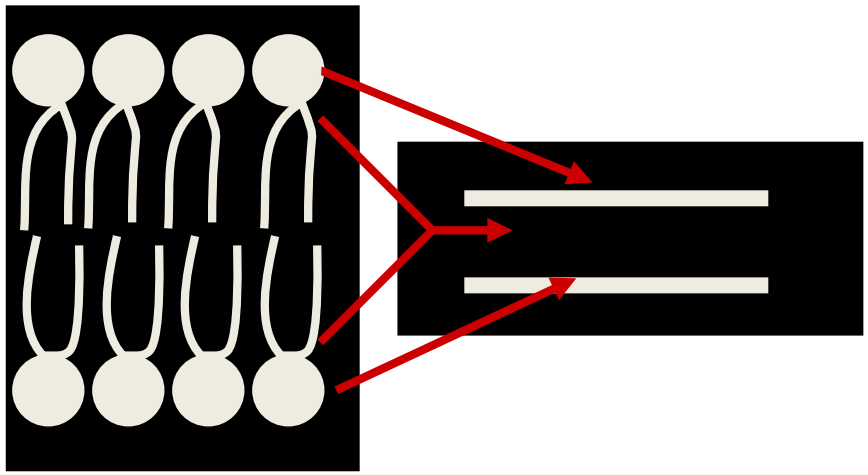
Function

Control membrane ; Fluidity, stability , permeability

- Cholesterol regulates the fluidity of the membrane
- mechanical stability and help to prevent ions from passing through the membrane.
- At warm temperatures (such as 37°C), cholesterol restrains the movement of phospholipids and reduces fluidity.
- At cool temperatures, it maintains fluidity by preventing tight packing.
- Thus, cholesterol acts as a “temperature buffer” for the membrane, resisting changes in membrane fluidity as temperature changes

Trilaminar membrane

Deposition of osmium in the polar heads



Protein molecules

According to membrane proteins' location

2 Types:

- Integral proteins
- peripheral proteins

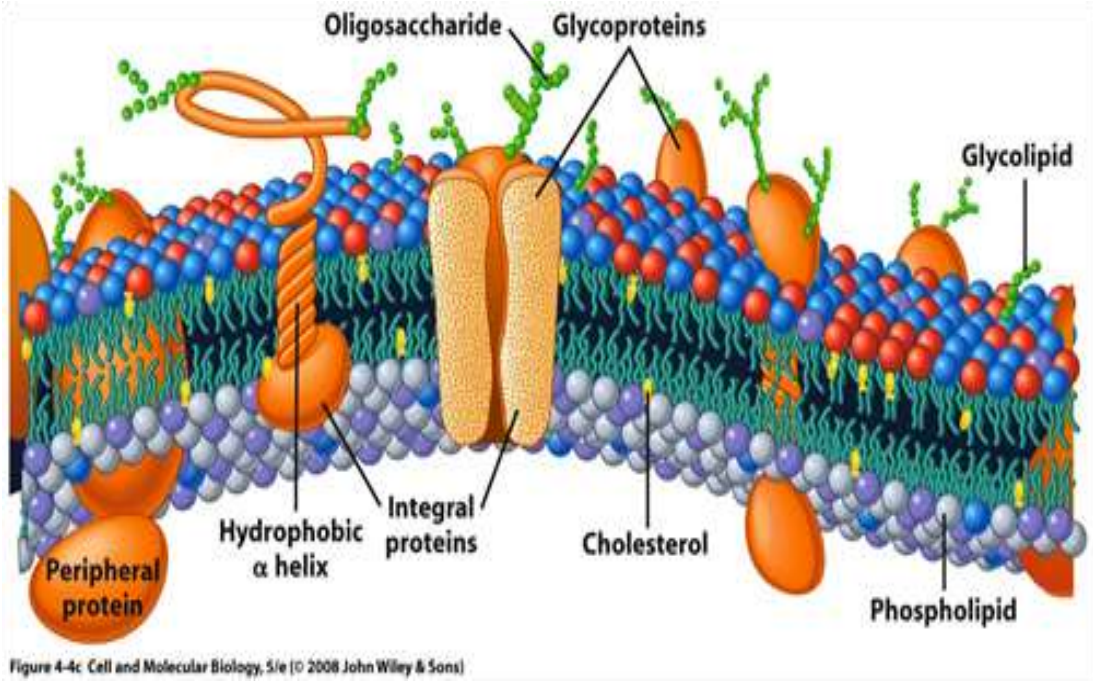
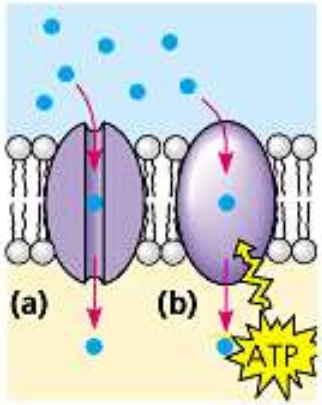


Figure 4-4c Cell and Molecular Biology, 5/e (© 2008 John Wiley & Sons)

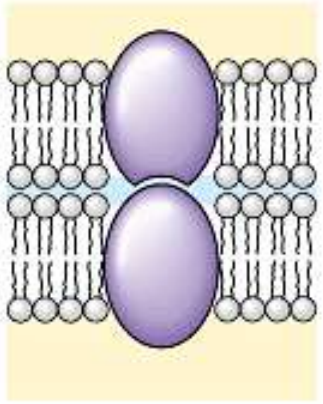
Functions of integral protein



Transport

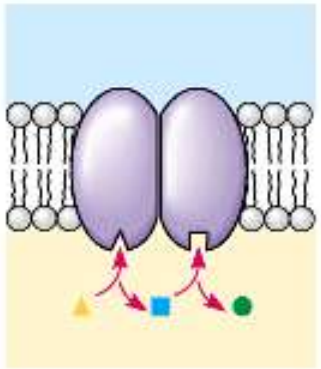
-Passive // Channel Proteins

-Active // Protein Pumps



Intercellular joining

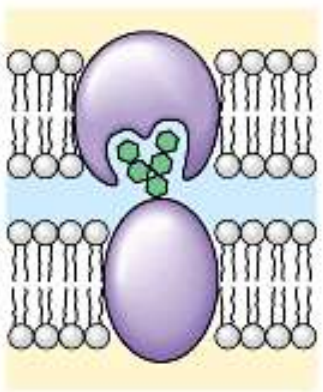
Intercellular junctions



Enzymatic activity

Membrane enzymes produce a variety of substances

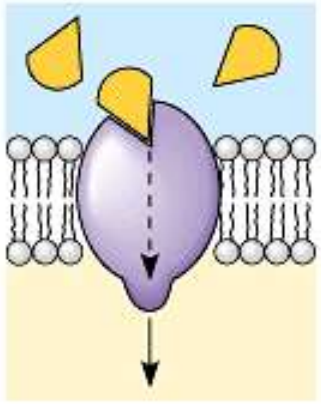
essential for cell function



Cell-cell recognition

(Cell surface identity Marker)

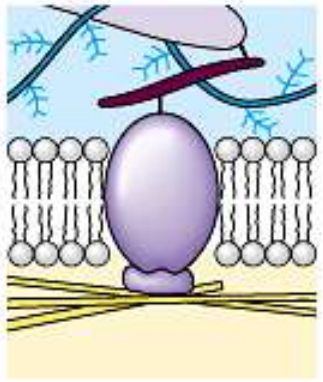
Some glycoproteins serve as identification tags that are specifically recognized by other cells



Signal transduction (Cell surface Receptor)

Extracellular signaling molecule activates a membrane receptor

creating intracellular response

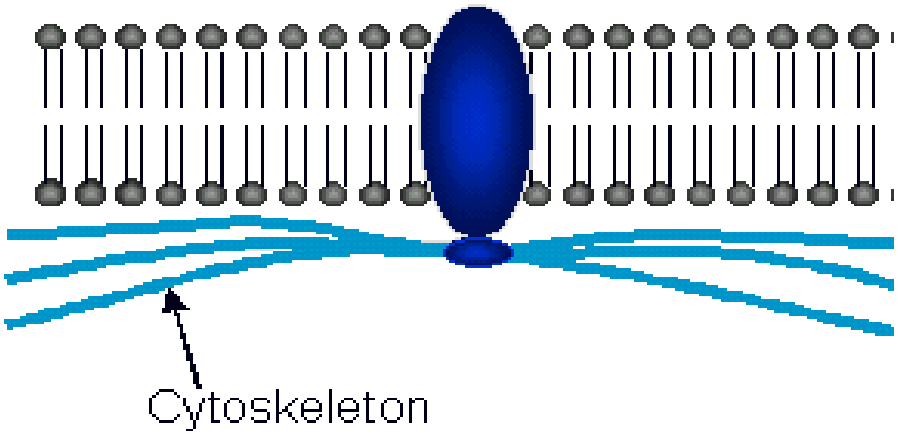


Attachment to the cytoskeleton and extracellular matrix

Microfilaments or other elements bonded to membrane proteins, maintain cell shape and stabilizes the location of certain membrane proteins

Peripheral proteins

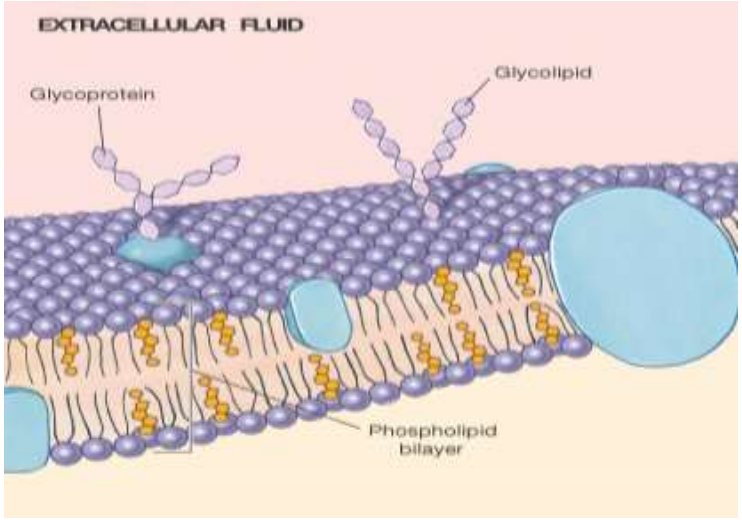
- They are not embedded into lipid bilayer



- They are usually located on the cytoplasmic surface and occasionally on the extracellular surface of the membrane.
- loose association with membrane surface
- Easy to be extracted without chemical substances
- Functionally, They are associated with the cytoskeletal apparatus.

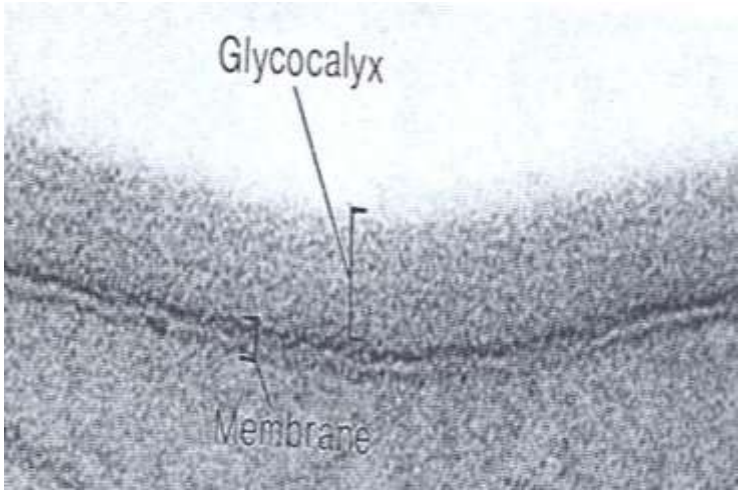
Carbohydrate molecules
The cell coat = Glycocalyx

- Only at the outer surface of the membrane.
- Attached to lipid molecules to form glycolipids
- Attached to integral proteins to form glycoproteins



Function:

- ❑ Protection
- ❑ Identification markers **(Recognition)**
- ❑ Adhesion
- ❑ Receptors



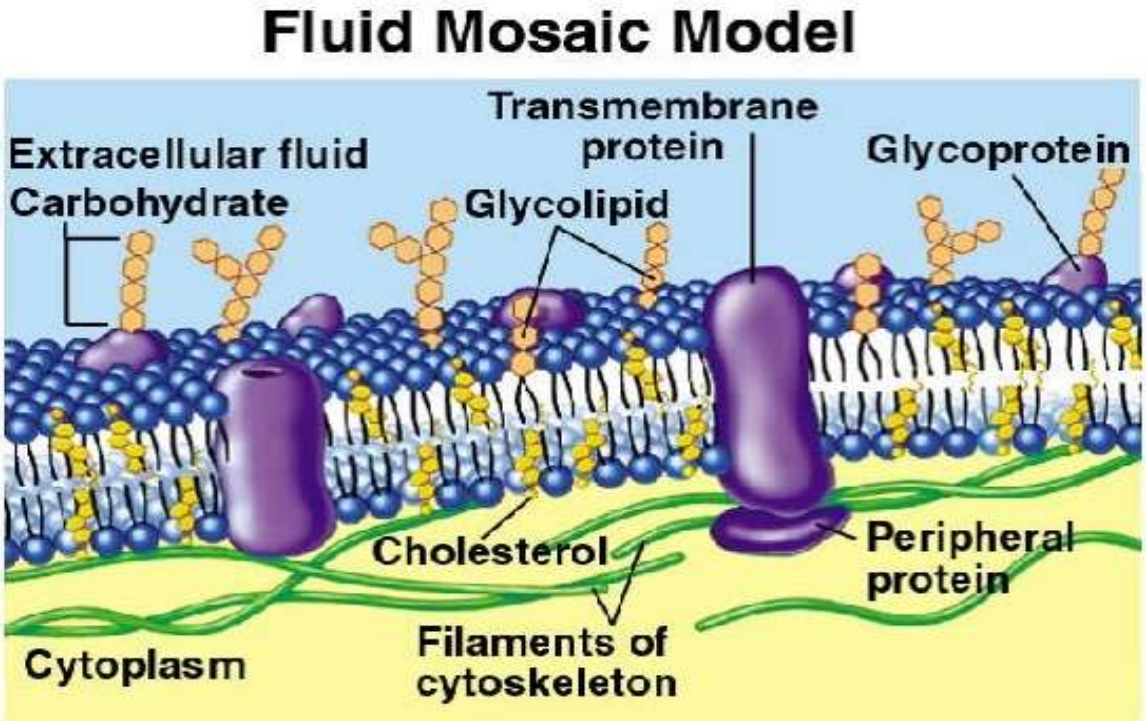
Biochemical components of plasma membrane

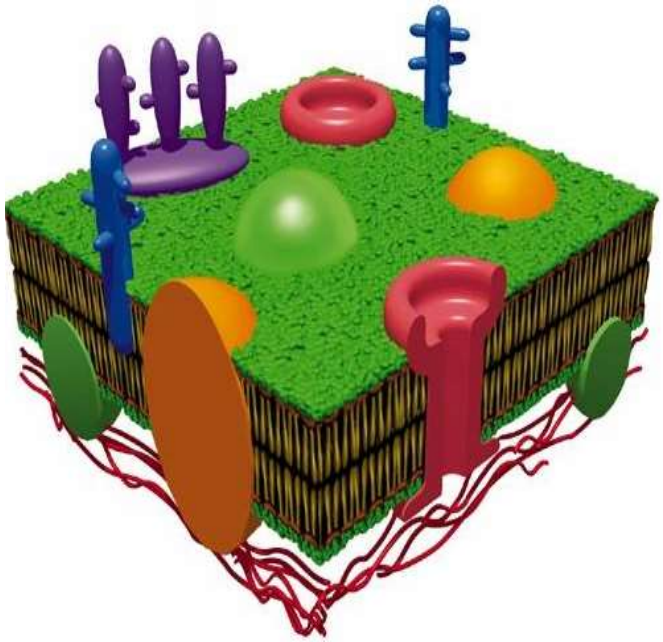
Fluid mosaic model of the cell membrane

The membrane is composed of a sea of lipids (fluid) in which proteins (mosiac) are moving and floating like icebergs.

FLUID- because individual phospholipids and proteins can move around freely within the layer, like it's a liquid.

MOSAIC- because of the pattern produced by the scattered protein molecules when the membrane is viewed from above.





Membranes are dynamic

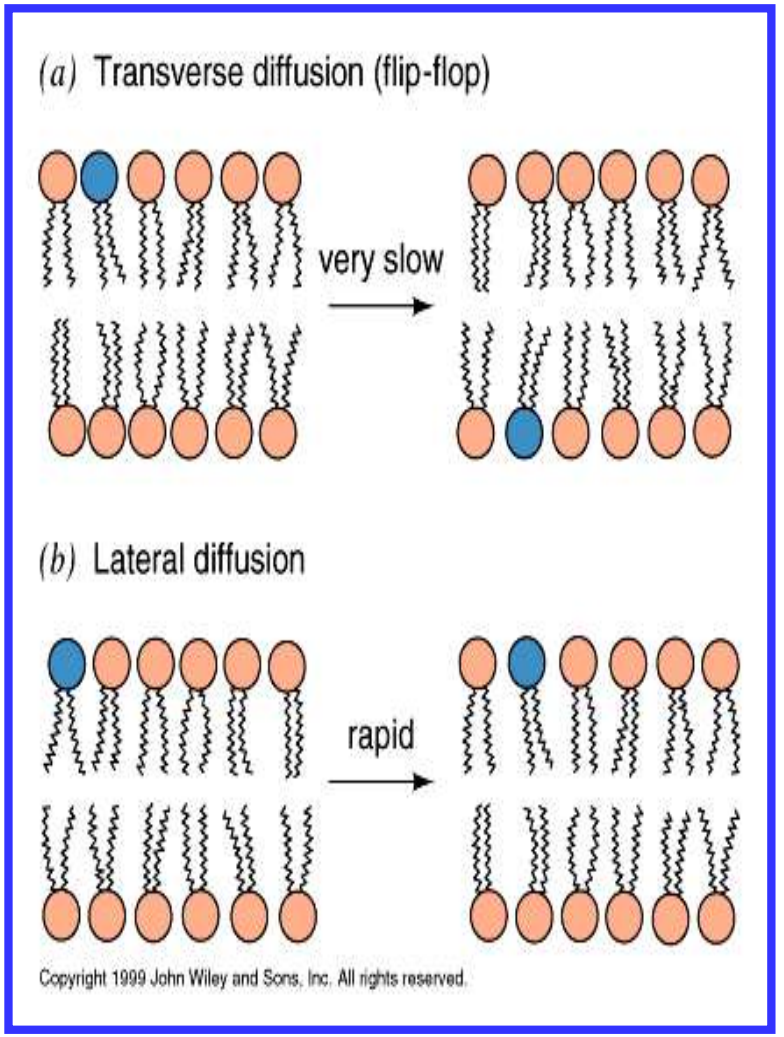
•They can **move**.

•Their components are **continuously** synthesized and degraded.

•damage to the cell membrane leads to **cell death**

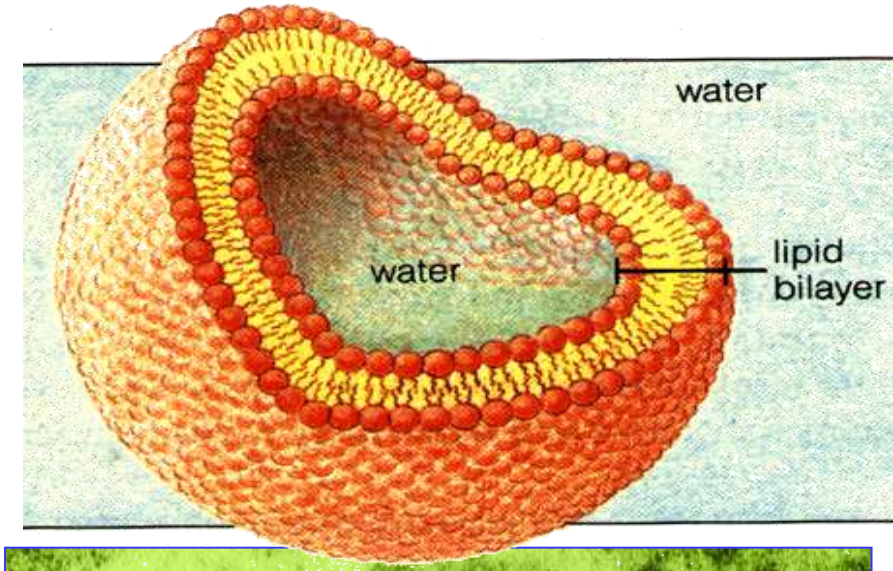
- **Lateral diffusion** refers to the **lateral** movement of **lipids** and **proteins** found in the membrane. Membrane lipids and proteins are generally free to move laterally if they are not restricted by certain interactions. Lateral diffusion is a fairly **quick** and **spontaneous** process.

- **Transverse diffusion** or **flip-flop** involves the movement of a **lipid** or **protein** from one membrane surface to the other. Unlike lateral diffusion, transverse diffusion is a fairly **slow** process due to the fact that a relatively significant amount of **energy** is required for flip-flopping to occur.



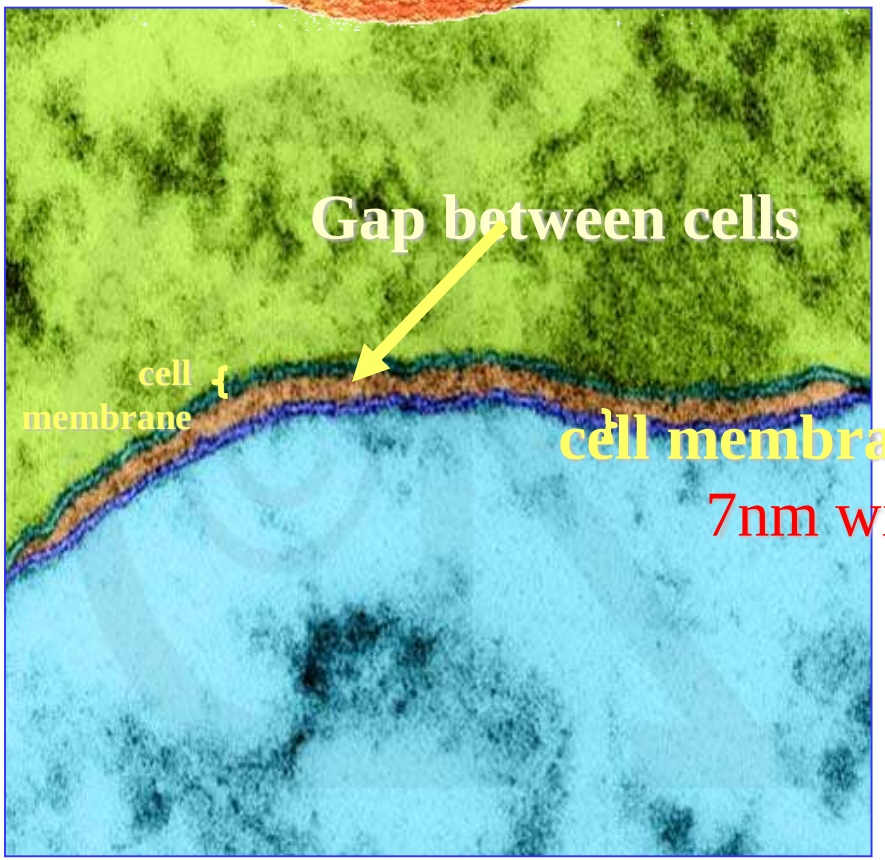
Cell membrane or plasma membrane

(Gateway to the cell) **thin barrier**



Cell membrane functions:

- Physically separate a cell from its environment, provides protection and support for the cell
- Anchor cells to the extracellular matrix
- Maintain an internal balance called **homeostasis**
- Control what goes in and out of the cell (semi-permeable)
- Detect chemical messengers arriving at the surface
- Provide anchoring sites for filaments of cytoskeleton
- Link adjacent cells together by membrane junctions



Functions of the cell membrane

Vital exchange of materials (semipermeable)

Small molecules

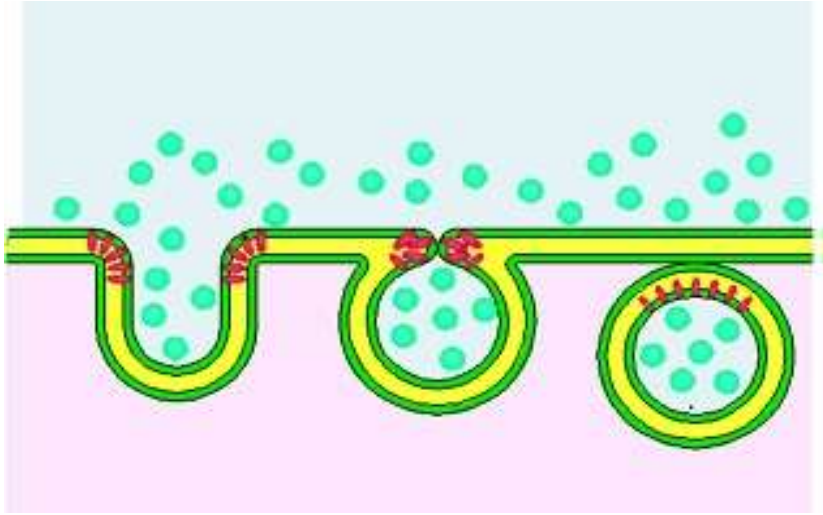
- ❑ Passive diffusion
- ❑ Osmosis
- ❑ Facilitated diffusion
- ❑ Active transport

Large molecules (macromolecules)

- ❑ Endocytosis
- ❑ Exocytosis

Endocytosis

- **Inside = internal**
- Intake of molecules to the inside of cell.

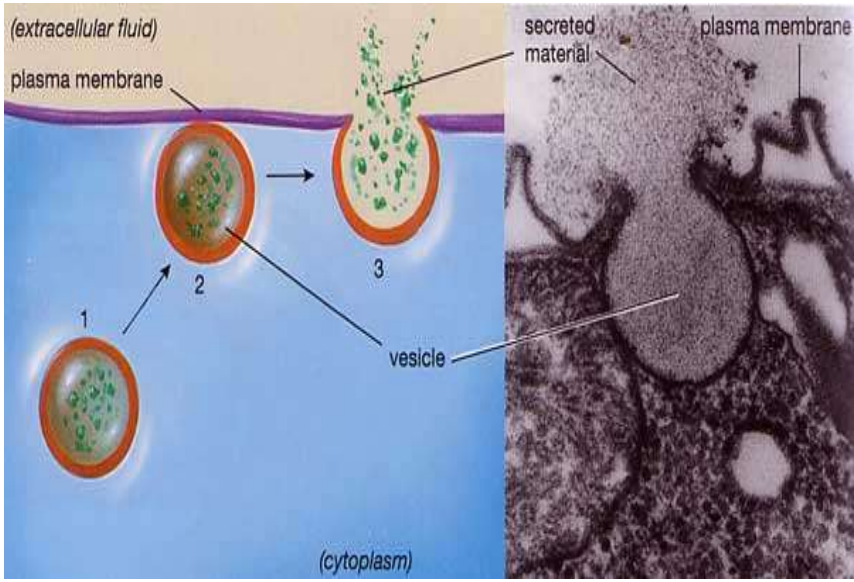


3 mechanisms:

- ❑ Pinocytosis (cell drinking)
- ❑ Phagocytosis (cell eating)
- ❑ Receptor–mediated endocytosis

Exocytosis

- External = outside
- Release of cell products into the extracellular environment.



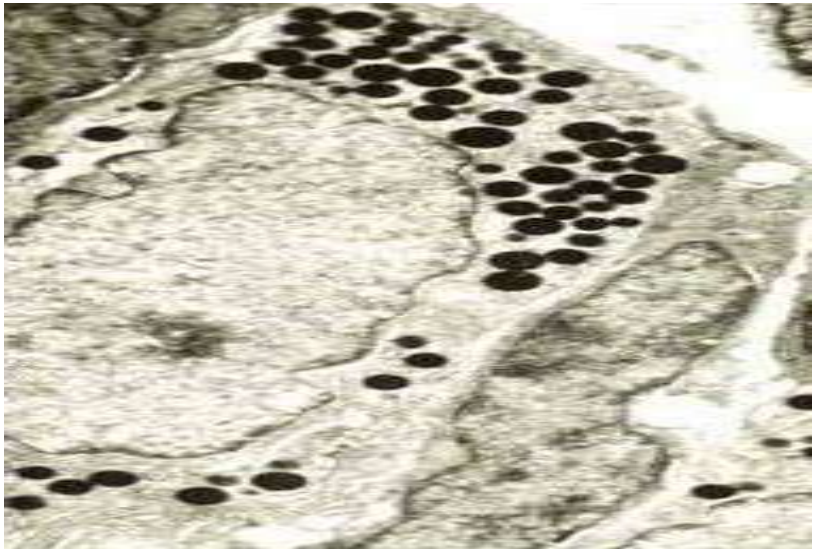
Types of exocytosis

❑ Constitutive secretion:

- continuous
- without a stimulus
- transport vesicles

❑ Regulated secretion:

- stimulus-dependent
- secretory granules



Small molecules

1. Passive diffusion

e.g. gases , Na ions passes from high to low concentration

2. Osmosis

- Passive process
- In isotonic solution e.g. 0.9% Na Cl
- Hypotonic solution---swell
- Hypertonic solution—shrink

3. Facilitated diffusion

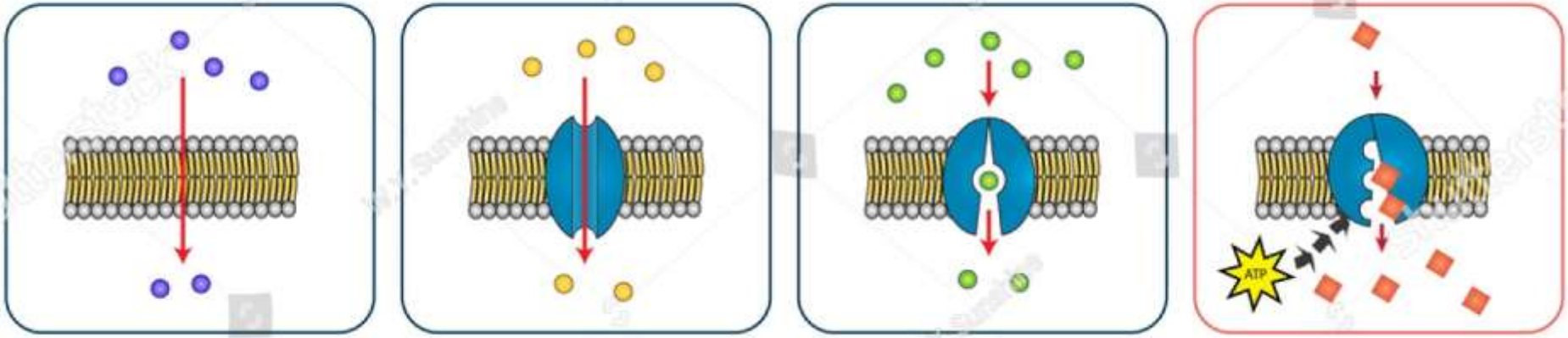
Not fat soluble it need carrier

e.g. sugar

4. Active transport

- From low to high
- Need energy
- e.g. sodium – potassium pump

MEMBRANE TRANSPORTER



Membrane permeability

The plasma membrane is **selectively permeable**, it allows some substances to cross it more easily than others

Types of Cellular Transport

Passive Transport

cell **does not** use energy

molecules move randomly, molecules spread out from an area of **high** concentration to an area of **low** concentration

- Diffusion
- Facilitated Diffusion
- Osmosis

Active Transport

cell does **use energy**

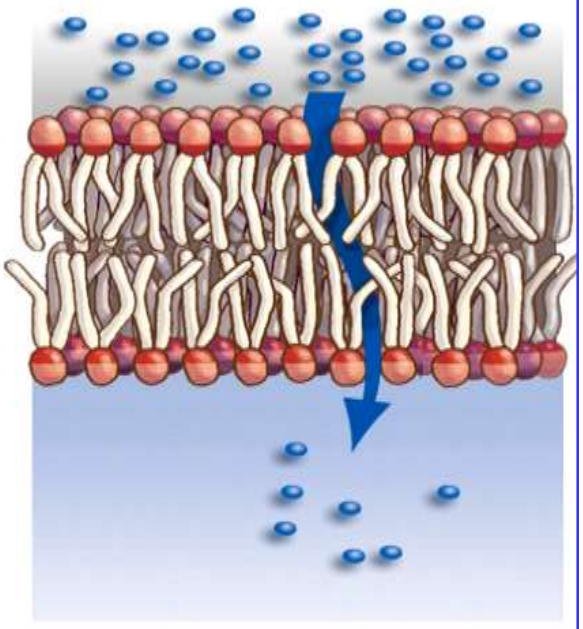
- Protein Pumps
- Endocytosis
- Exocytosis

Passive Transport

Diffusion: random passive movement of particles from an area of high concentration to an area of low concentration until equilibrium is reached.
(High to Low)

diffusion of nonpolar, hydrophobic molecules

Example: lipid and gases, oxygen diffusing into a cell and carbon dioxide diffusing out.



Materials move down their concentration gradient through the phospholipid bilayer.

Facilitative Diffusion

diffusion of specific particles (**high** to **low** concentration)

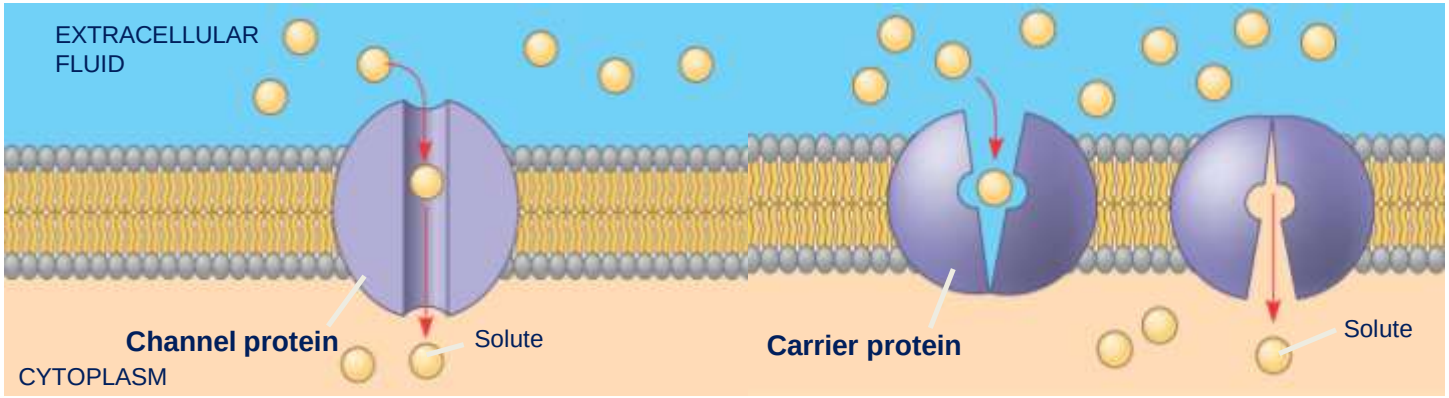
- **Diffusion through protein channels**
- **no energy** needed

diffusion of polar, hydrophilic molecules

Two types of transport proteins can help ions and large polar molecules diffuse through cell membranes:

- **Channel proteins** – provide a narrow channel for the substance to pass through.
- **Carrier proteins** – physically bind to the substance on one side of membrane and release it on the other.

Examples: **Glucose** or **amino acids** moving from blood into a cell.



Osmosis

Osmosis is the diffusion of water across a semi-permeable membrane from a hypotonic solution to a hypertonic solution

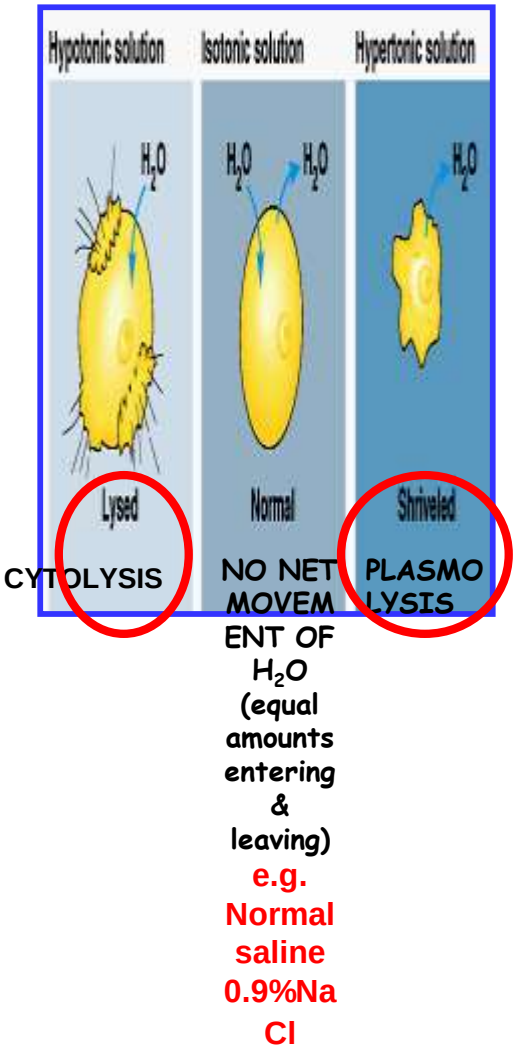
Direction of osmosis is determined by comparing total solute concentrations (Tonicity)

- Hypertonic (low water potential) - more solute, less water
- Hypotonic (high water potential)- less solute, more water
- Isotonic - equal solute, equal water

Water can diffuse across plasma membrane--- Moves from HIGH water potential (low solute concentration) to LOW water potential (high solute concentration)

Aquaporins (water channels) are proteins embedded in the cell membrane that regulate the flow of water only.

Homeostasis (equilibrium)



Active Transport

Protein Pumps -transport proteins that require **energy** to do work (**low to high** concentration) **AGAINST concentration gradient**

2 types:

- **Primary active transport (** directly uses metabolic energy/ energy is derived directly from the breakdown of ATP)**: Membrane pump** (protein-mediated active transport) example **Na+/K+ Pump**

- **Secondary active transport**: (electrochemical potential difference created by pumping/ energy is derived secondarily from energy that has been stored in the form of ionic concentration differences between the two sides of a membrane.)

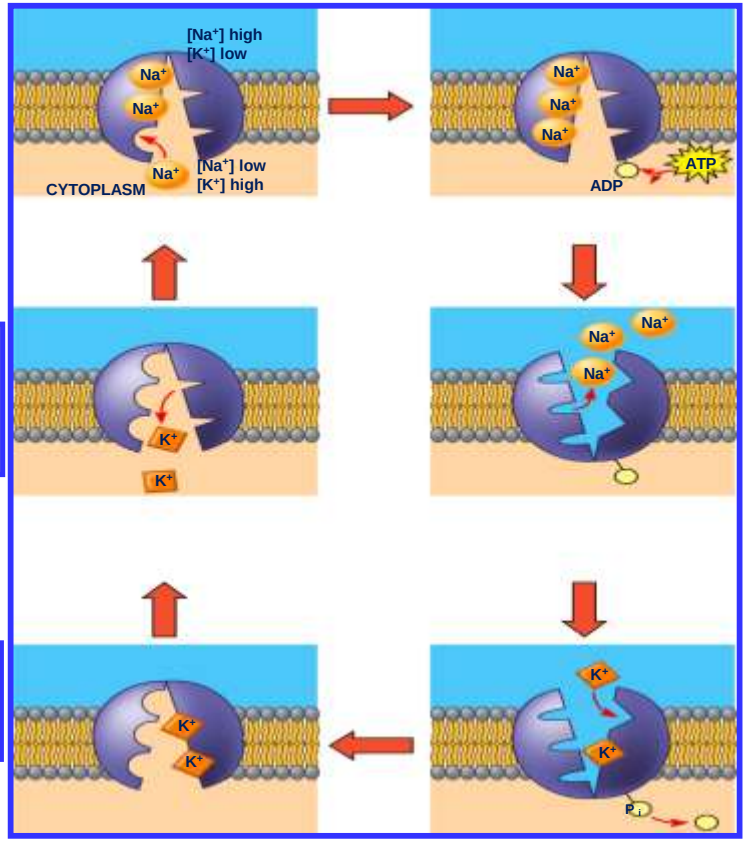
Coupled transport (cotransport)

symport transport two substances simultaneously in the same direction example **glucose symporter** (glucose and sodium)

-antiport transport two substances in opposite directions example **sodium-calcium exchanger** or **antiporter**

The Sodium-potassium Pump

1. Cytoplasmic Na^+ binds to the sodium-potassium pump.



2. Na+ binding stimulates phosphorylation by ATP.

3. Phosphorylation causes the protein to change its conformation, expelling Na^+ to the outside.

4. Extracellular K^+ binds to the protein, triggering release of the Phosphate group.

5. Loss of the phosphate restores the protein's original conformation.

6. K^+ is released and Na^+ sites are receptive again;
the cycle repeats.

The cytoplasm

Composed of:

1- Cytosol:

jelly like fluid matrix, its primary component is water

2- Organelles

They are specialized structures, **Essential** for vital processes of the cell

3- Inclusion

They are **Not essential** for vitality of cells. may be present or absent. Examples are lipids, glycogen and pigments like melanin & lipofuscin

4- Cytoskeleton

Network of filaments and microtubules responsible for cell motility, cell shape , and mvement

Organelles

Little organs:

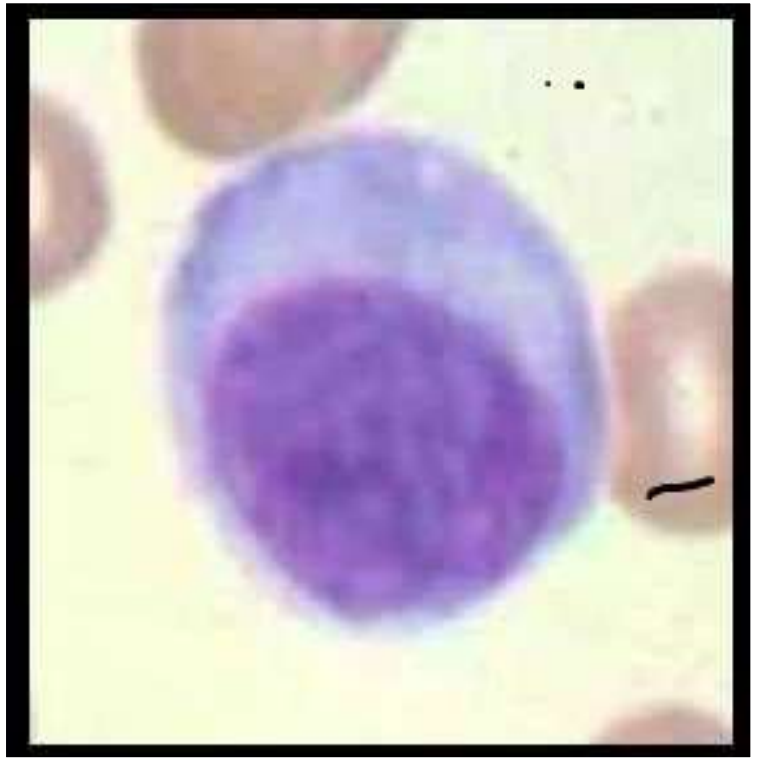
- Living structures
- Metabolically active
- Perform certain functions
- Always present in all cell types

Types:

- Membranous organelles (All organelles **Except**)
- Non-membranous organelles (Ribosomes, Centrosome)

Ribosomes

- Non-membranous organelles
- Chemical nature: nucleoproteins consist of proteins conjugated with ribosomal RNA (rRNA)



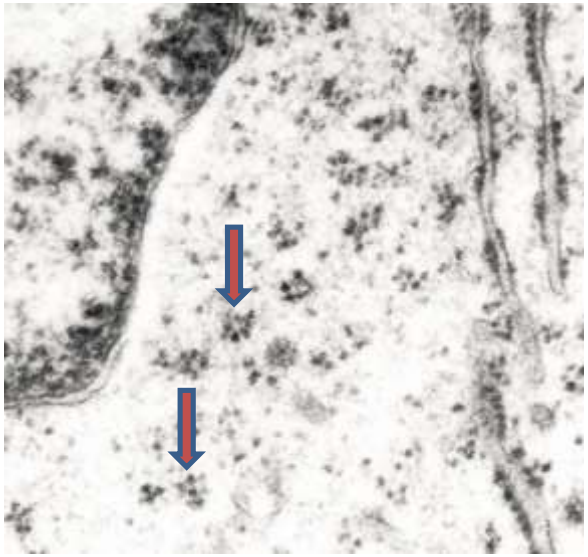
Structure:

LM:

- By H&E stain: can not be seen
- if large in number they impart
- Cytoplasmic basophilia

EM :

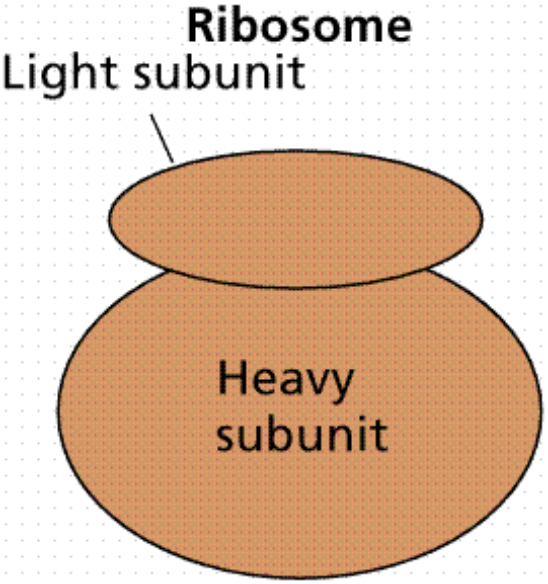
Electron dense granules

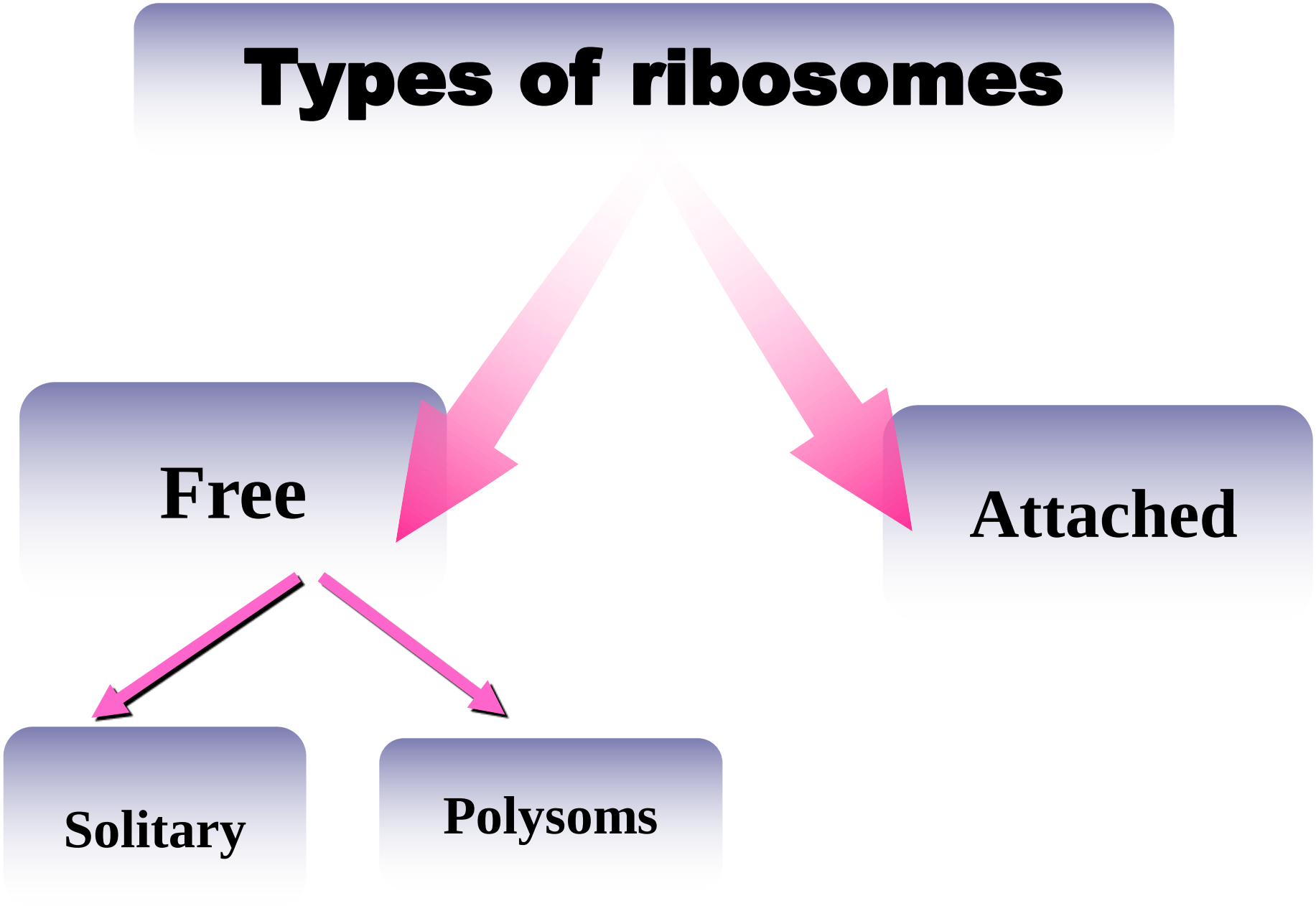


2 subunits:

Small subunit (RNA+**30** P)

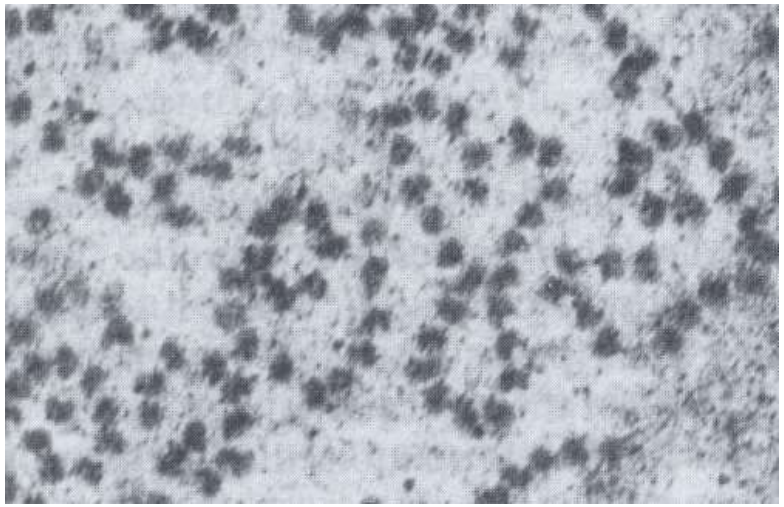
large subunit (2RNA+**40** P)

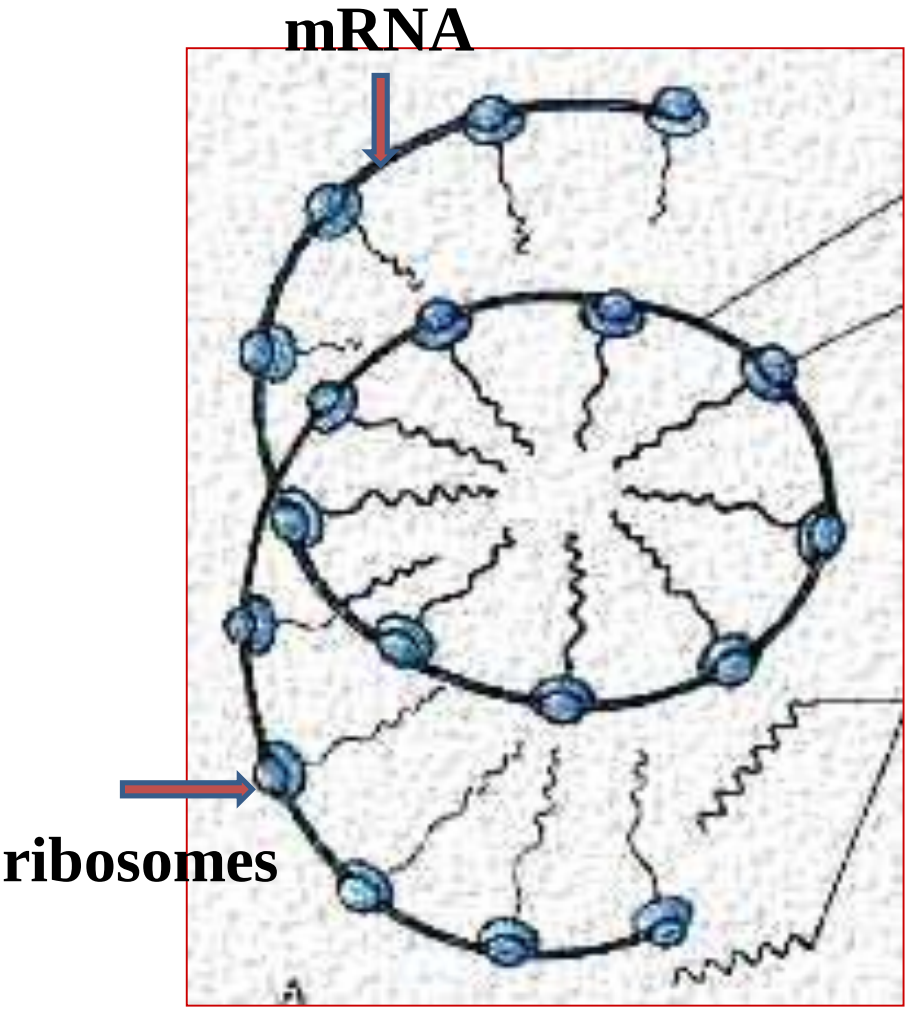



Types of ribosomes
Free
Attached
Solitary
Polysoms

Polysoms

- Clusters of ribosomes connected by mRNA thread & producing identical proteins





Function of ribosomes

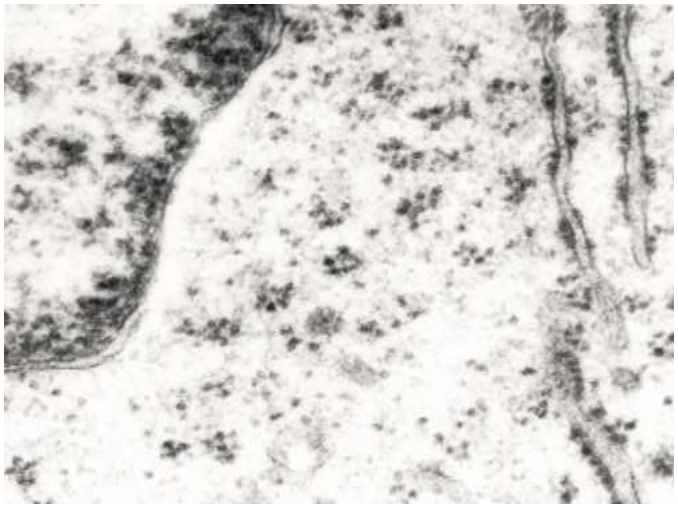
Ribosomes are the sites of protein synthesis:

Solitary: reserve

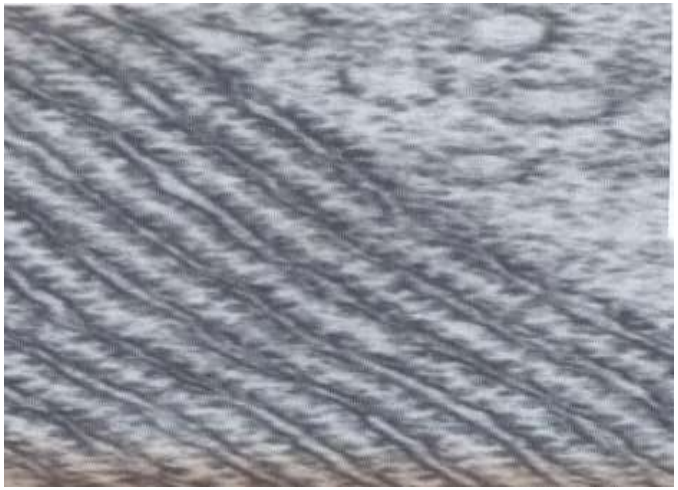
Polysoms: proteins used by the cell

Attached: proteins for secretion outside the cell

EM of free ribosome



EM of attached ribosome



Endoplasmic reticulum

- Membranous organelle
- Network of interconnecting tubules and cisternae

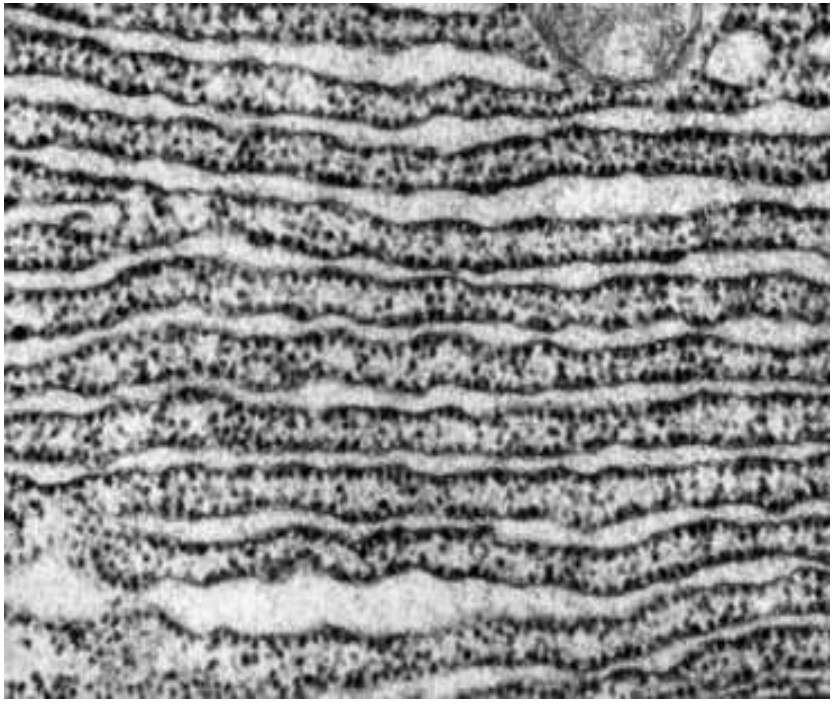
Endoplasmic reticulum

Rough (rER)

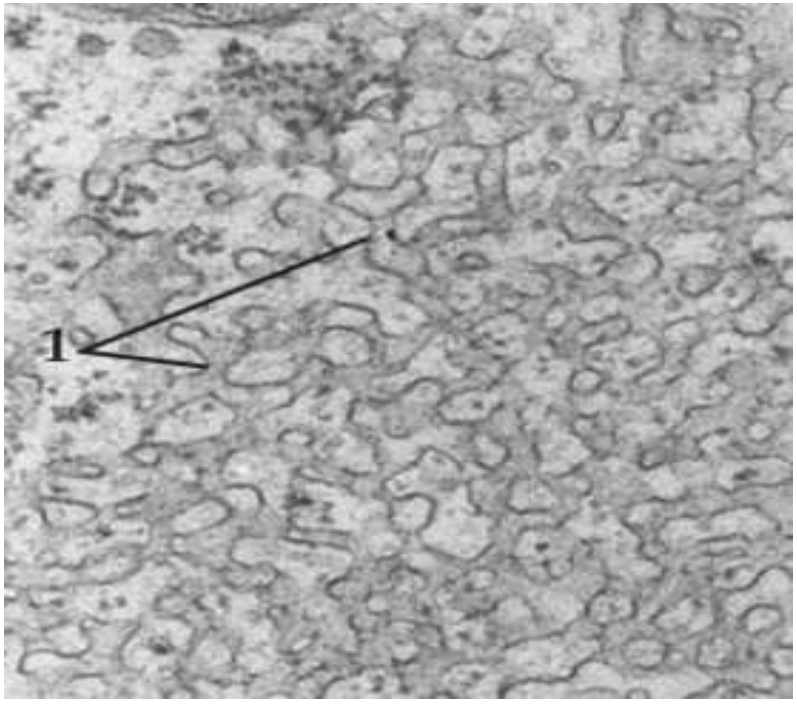
- Interconnected cisternae
- Has attached ribosomes

Smooth (sER)

- Interconnected tubule
- Lacks ribosomes



EM



Function

rER

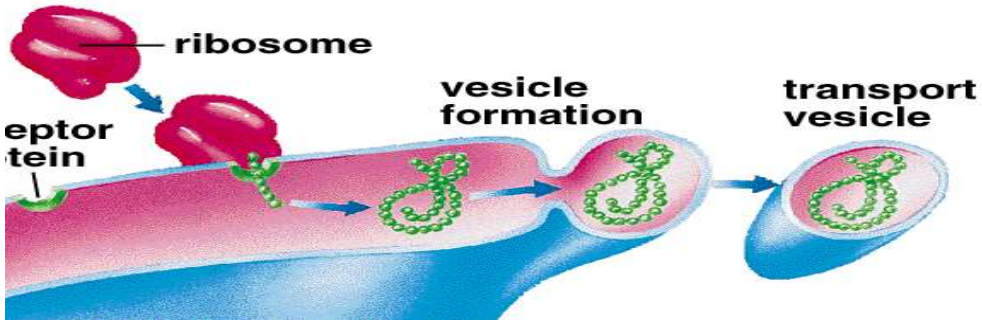
- Participates in protein synthesis.

Role of rER in protein synthesis

1- receiving of polypeptide chains in ER lumen

2- storage

3- protein transport



sER

- ❑ Lipid synthesis (fatty acids ,cholestrol & steroid hormones)
- ❑ Detoxification of toxic substance
- ❑ Muscle contraction
- ❑ control calcium ions (sarcoplasmic reticulum)
- ❑ Glycogen synthesis

Golgi apparatus

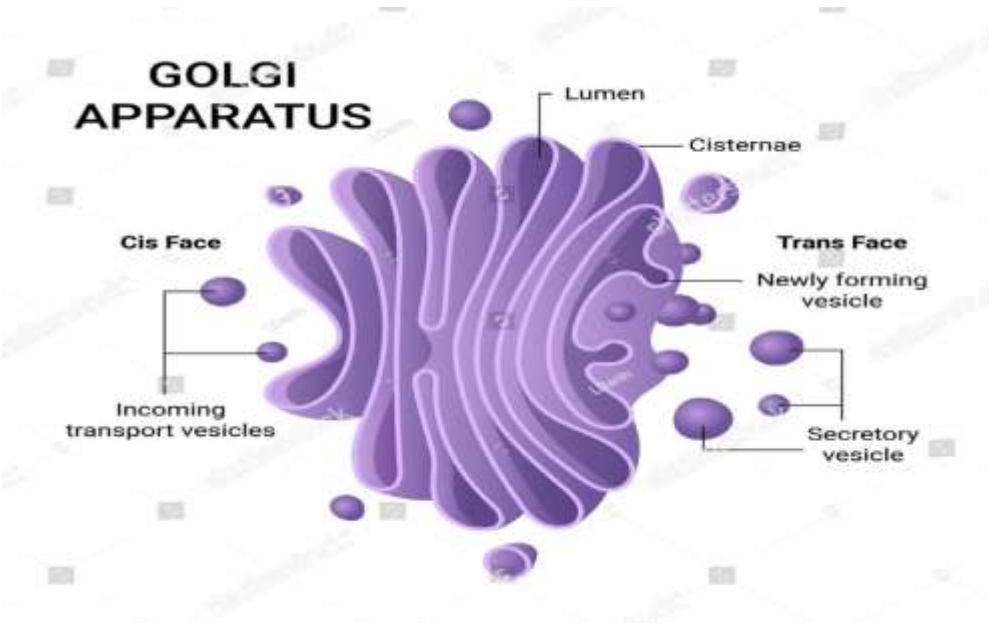
Membranous organelle

LM:

- H&E stain: not apparent
- Special stain: silver stain

E.M.

- Transport vesicles
- Cisternae
- Secretory vesicles



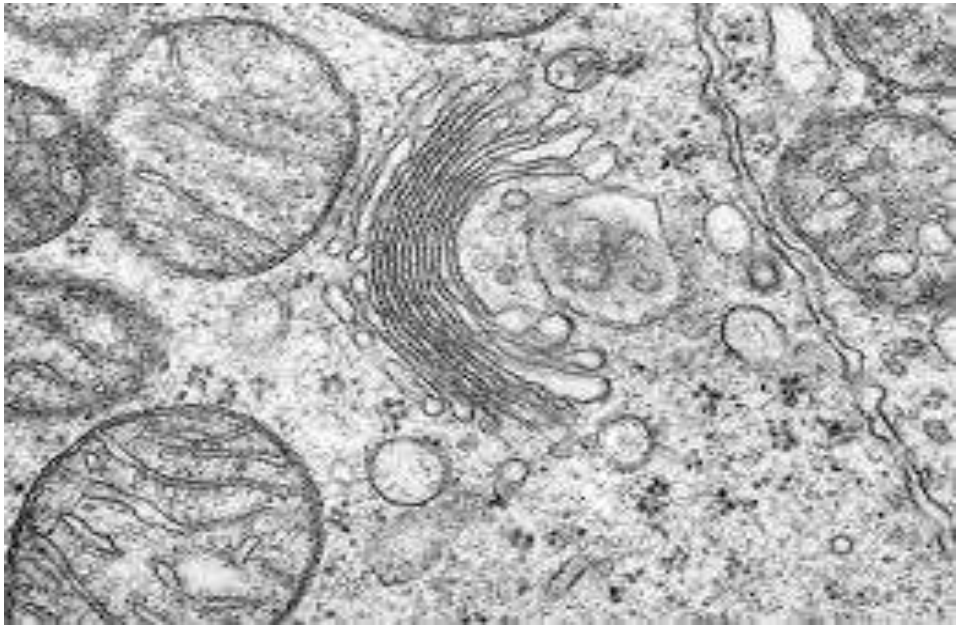
Functions of Golgi apparatus

1- modification of proteins

2- Formation of primary lysosomes

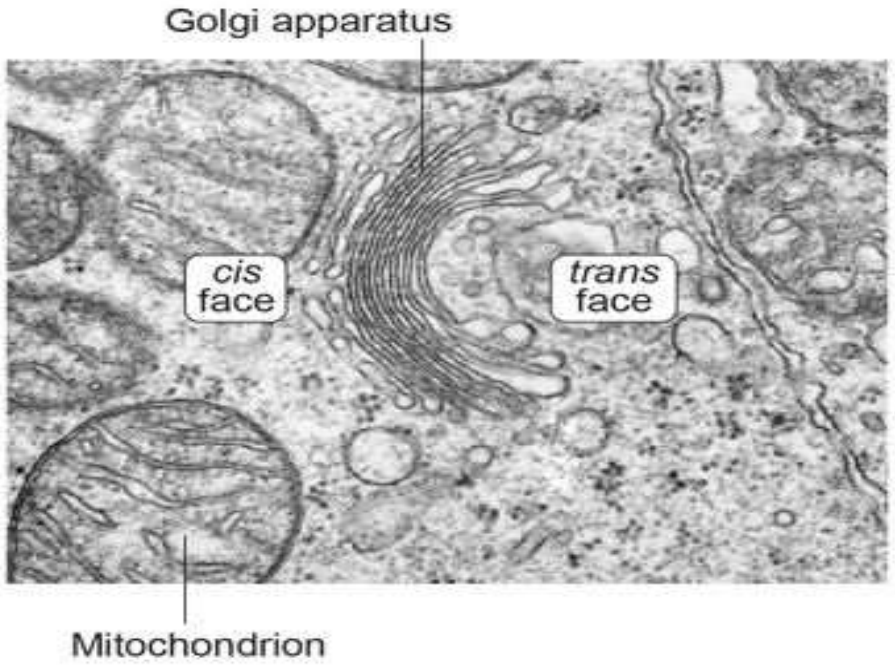
3- Secretion of cell products

4- Renewal of the cell membrane

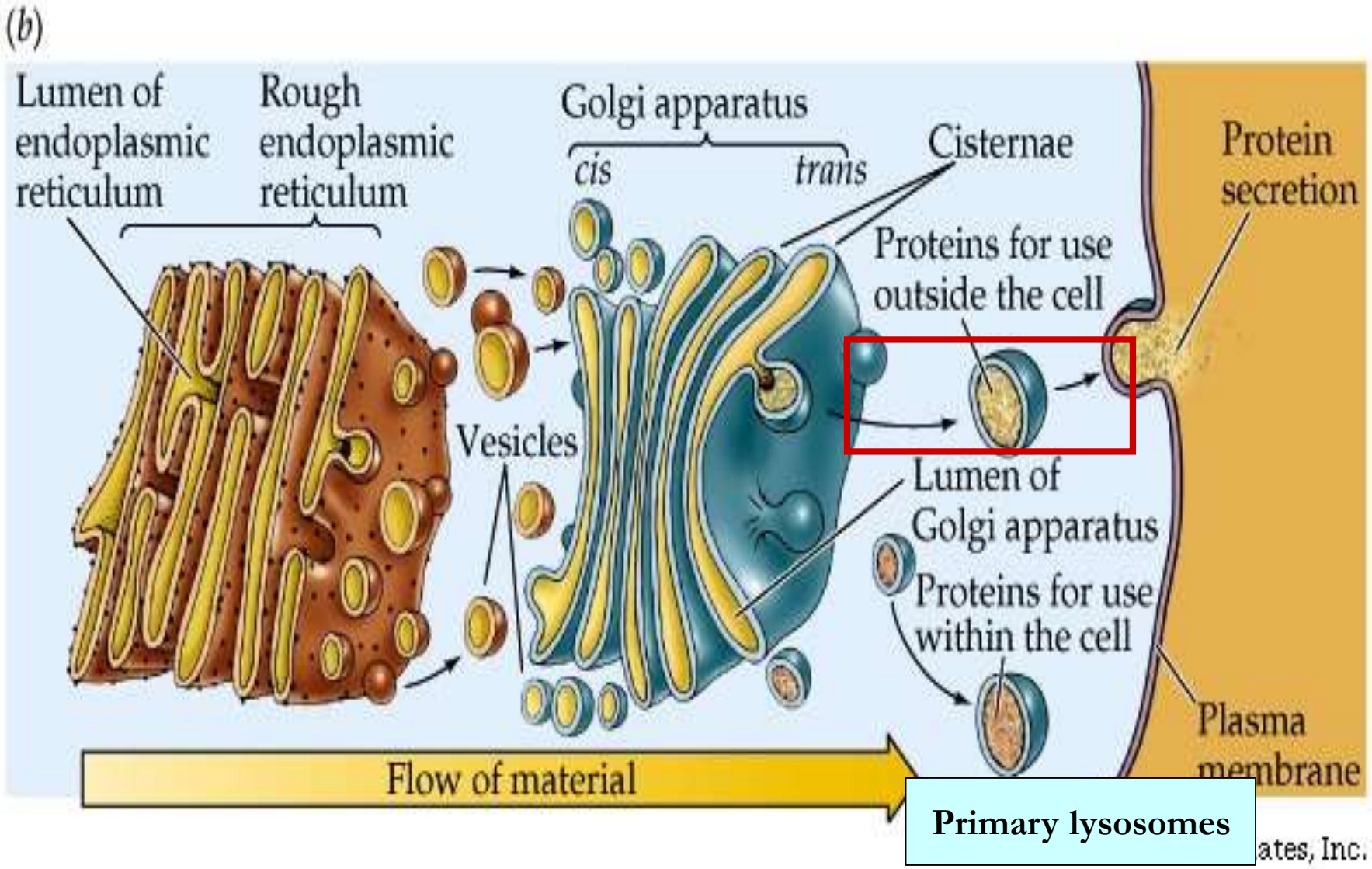


Organelles that participate in protein synthesis

- Ribosomes (factories)
- Rough endoplasmic reticulum (storage & transport)
- Golgi apparatus (chemical modification & secretion)



Fate of protein transported by rER



Mitochondria

Mitos= thread **chondros= granule**

Membranous organelles

LM:

- H&E stain: not apparent
- Special stain: silver stain

EM

Double membranes:

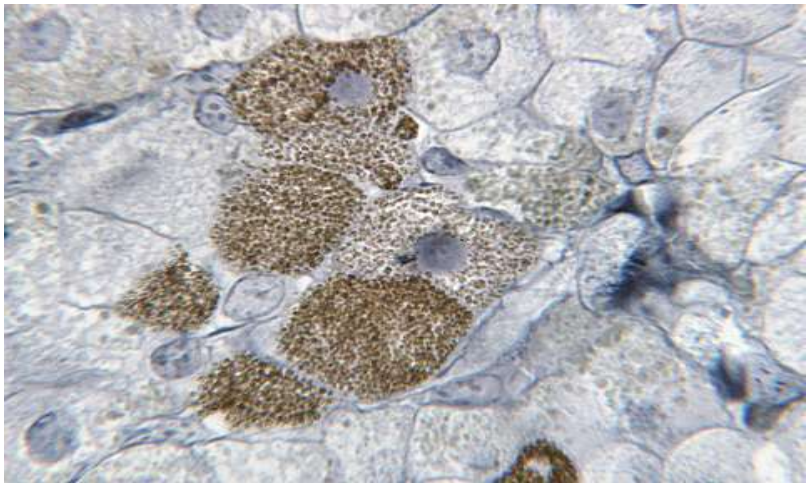
-Outer smooth

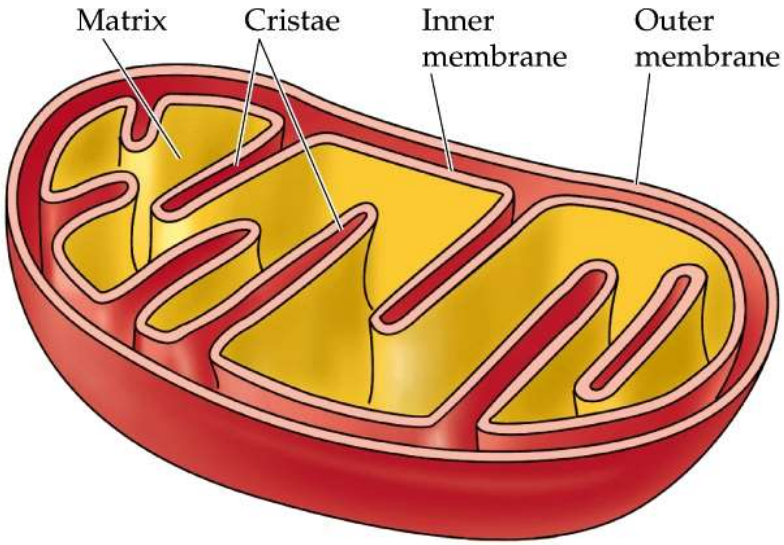
-Inner folded forming cristae

Double spaces:

-intermembranous space

- intercristal space (matrix sp*ace)*



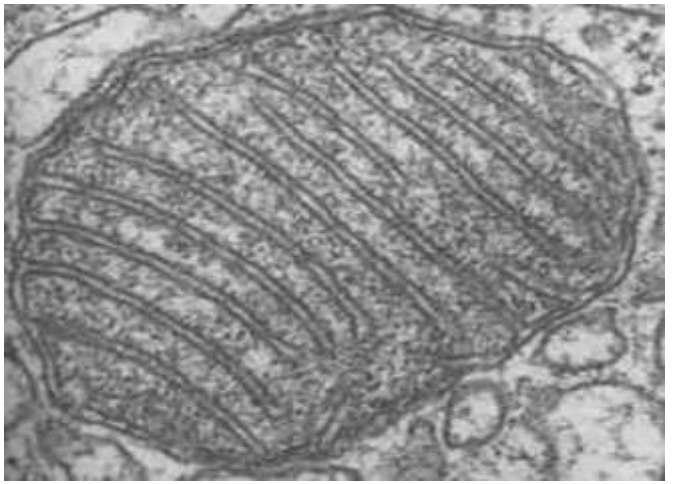


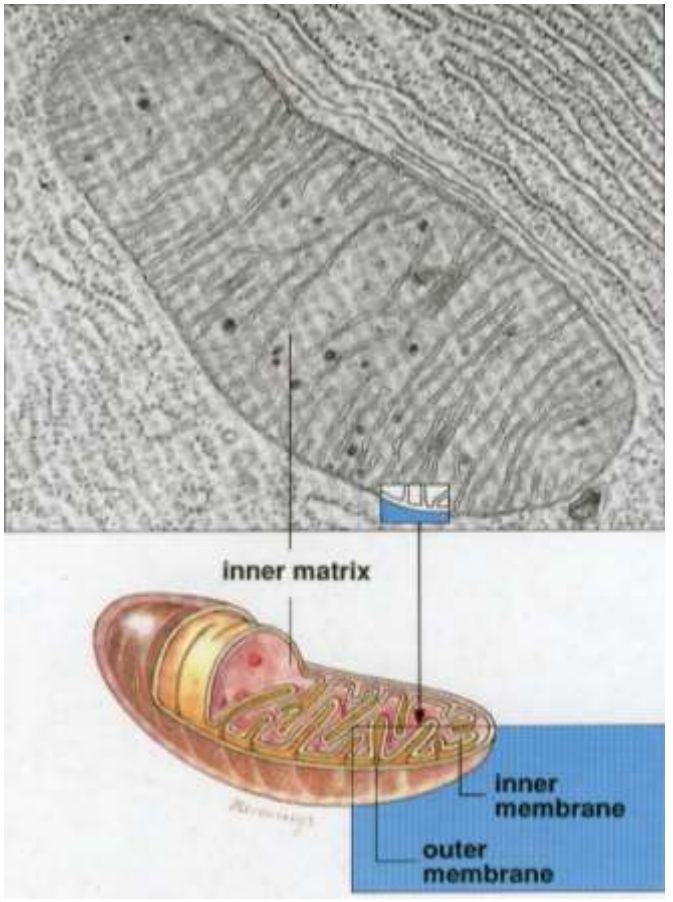
- Each mitochondrion is rod-shaped .
- The wall is composed of 2 membranes.
- The outer is smooth, the inner is folded to form cristae.
- The cavity is filled with mitochondrial matrix, which contains enzymes. Also contains its own DNA.

Functions:

1- Generation of ATP which is the source of energy for the cell. They are called the power-house of the cell.

2- They can form their own proteins and undergo self replication.





	Mitochondria	Peroxisome
E.M	Variable shape & surrounded by 2 membrane	Spherical surrounded by a single membrane
Function	Responsible for ATP synthesis	➢ No ATP synthesis so unable to store energy ➢ Contain enzyme for B oxidation of fatty acid , energy released as heat for maintenance of body temperature ➢ Contain enzymes for regulation of hydrogen peroxide ➢ Synthesis of cholesterol & bile acid ➢ Detoxification of alcohol
Abundant in	All tissues particularly cardiac muscle	Particularly in the liver

Lysosomes

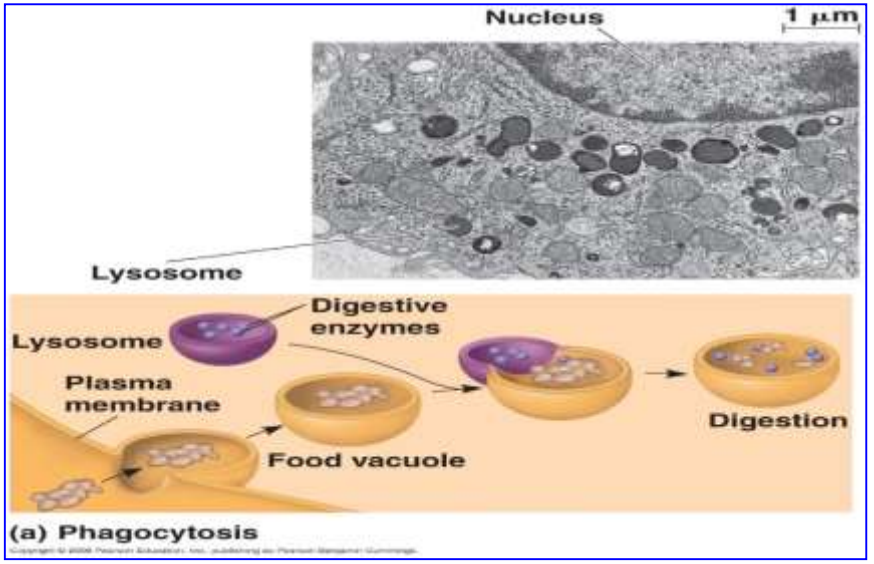
Structure:

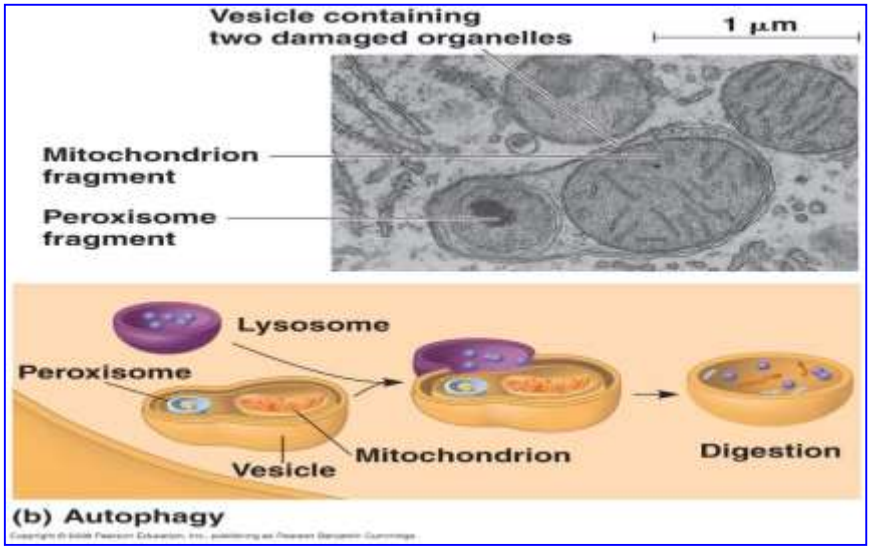
Small membrane-bound organelles , but **bigger** than ribosomes

packets of 40 hydrolytic enzymes that break down materials in a cell

Function:

- Breaks down (**digests**) food, bacteria and waste
- **Autophagy –** Breaks down damaged organelles
- **Programmed for cell death** break down the cell when it dies, called **"suicidal bags"** of the cell

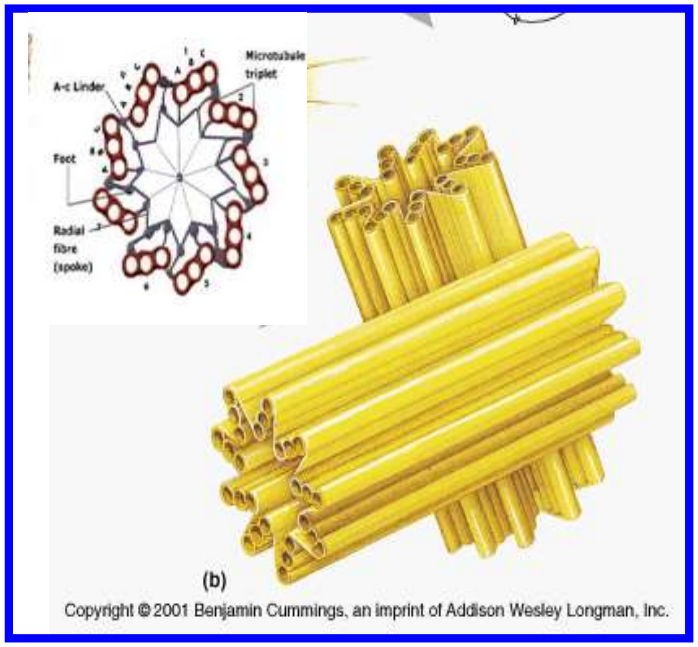




Centrosome

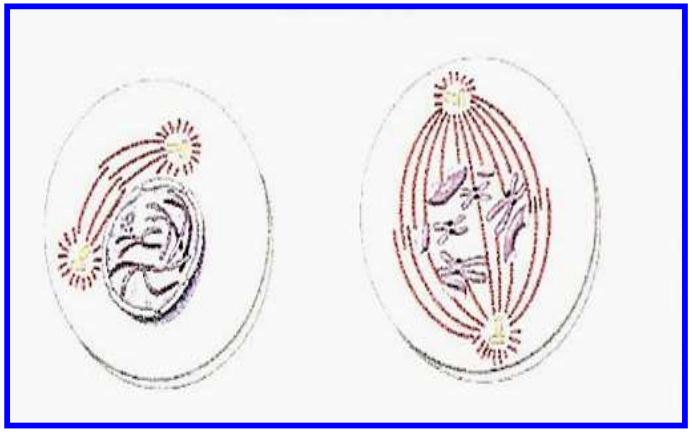
Structure:

An associated **pair** of centrioles, arranged **perpendicularly** to each other each composed of sets of **microtubules** arranges to form a cylinder. The walls of each centriole are usually composed of **nine triplets** of microtubules



Function:

Microtubules that help divide the cell during cell division via **mitotic spindle ,**it is called microtubules organizing center



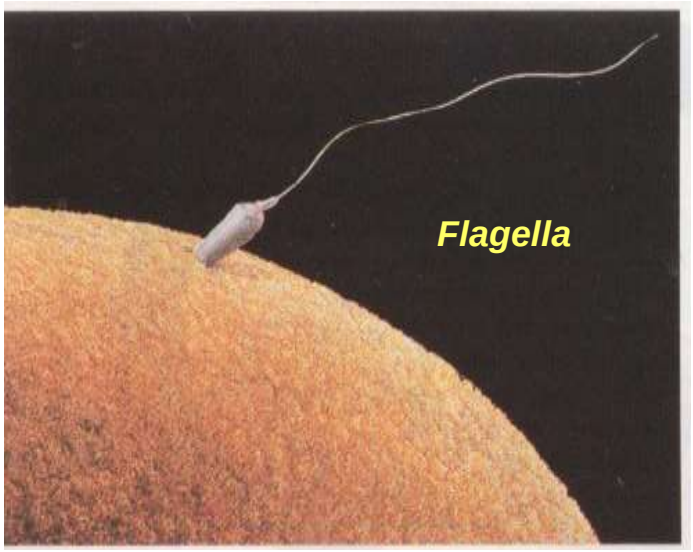
Cilia & Flagella

Cilia (cilium) :

project from cell surface, cylindrical in shape & enclosed by membrane.

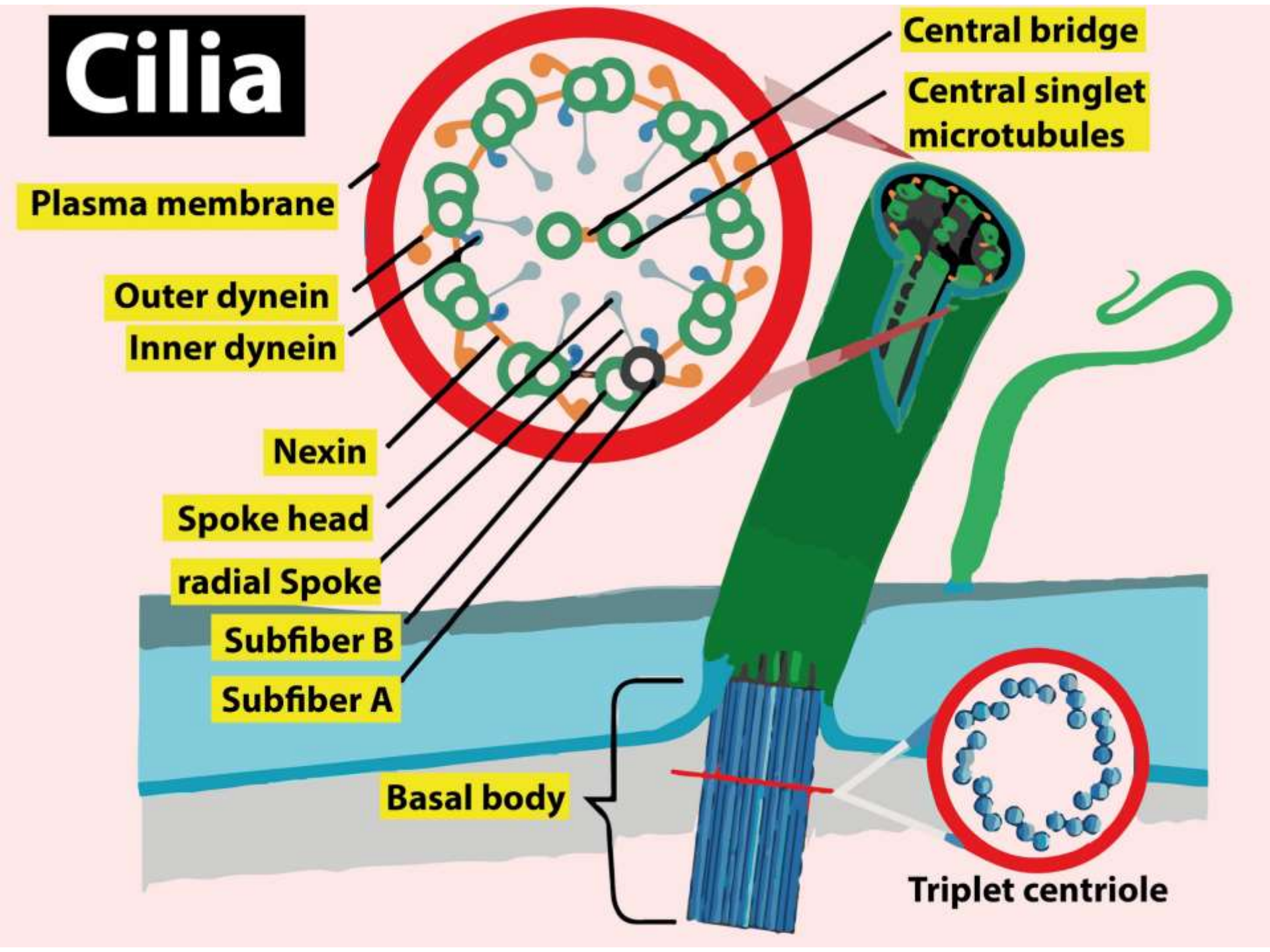
Contain microtubules. **Numerous** in certain cells e.g. cells that line **respiratory tract**

Flagella (flagellum) : structure similar to cilia but longer (whip-like). Usually **one-three** in certain cells e.g. **sperm**



Microtubules wrapped in an extension of the plasma membrane (**9 + 2 double** arrangement of microtubules) **(axoneme)**

Function: provides **movement** for the **cell** or **objects** moving by the cell

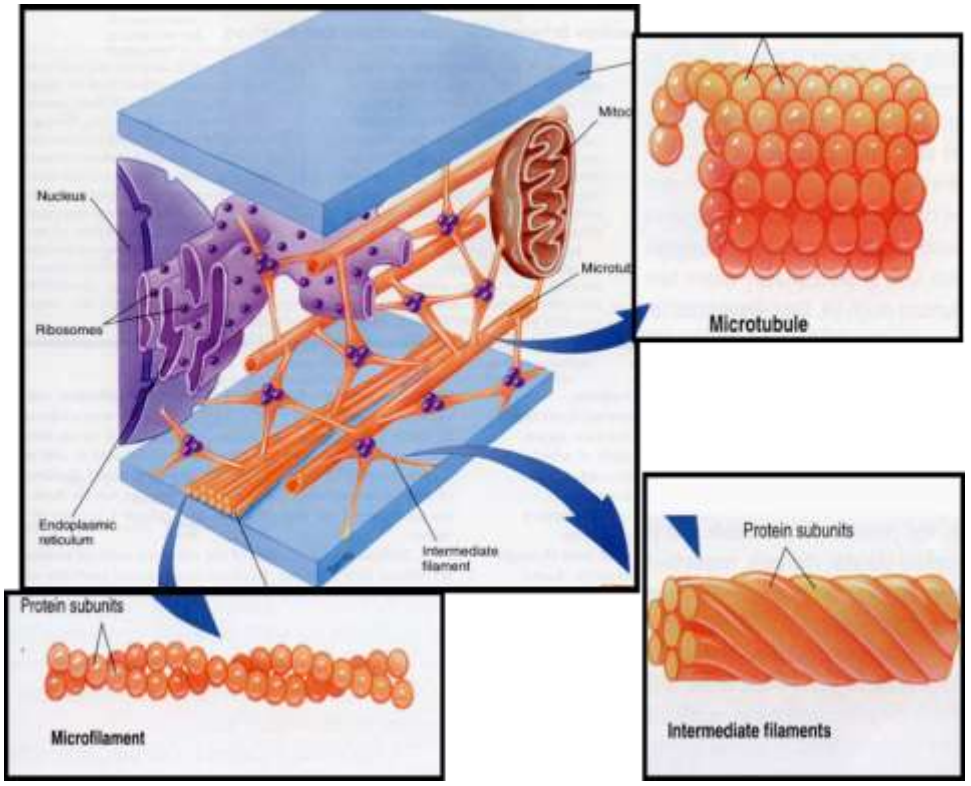

Cilia
Central bridge
Central singlet microtubules
Plasma membrane
Outer dynein
Inner dynein
Nexin
Spoke head
radial Spoke
Subfiber B
Subfiber A
Basal body
Triplet centriole

Cytoskeleton

Proteins that **support** the cell, **hold** organelles in place, enable cell to **change shape**

Types according to the size

- ❑ Microfilaments
- ❑ Microtubules
- ❑ Intermediate Filaments



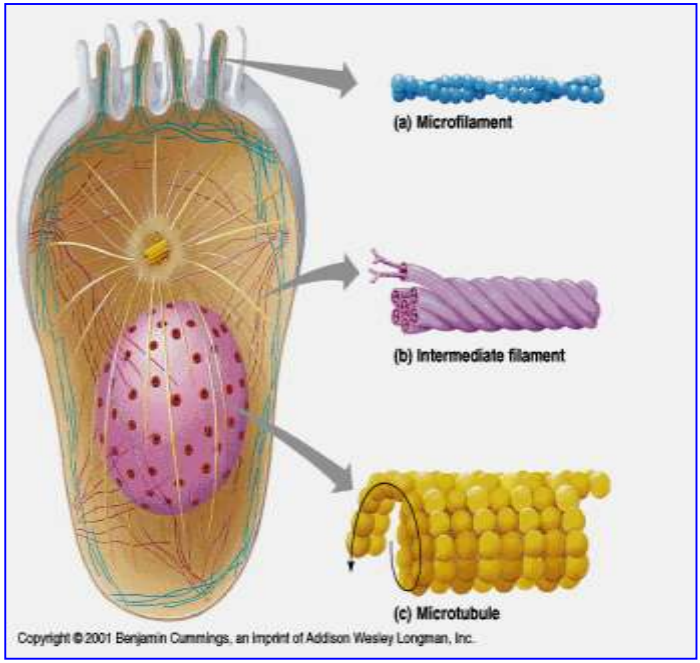
Function

- Support
- Motility
- Regulation of internal structure

The cytoskeleton of eukaryotic cells is **not stable**, but is always being **assembled** & **disassembled**

Microfilaments: are **threadlike** composed of the proteins **actin //myosin**. Provide for structural **support**. Involved in **cell movement muscle cell contraction**, **changes** in cell membrane **shape**- amoeba; Movement of cilia & flagella

Microtubules: are **tube-like &** made of **TUBULIN** i.e. hollow structures helps provide **support** to cytoplasm. **Forms** organelles such as **cilia & flagella** & **centrioles**.



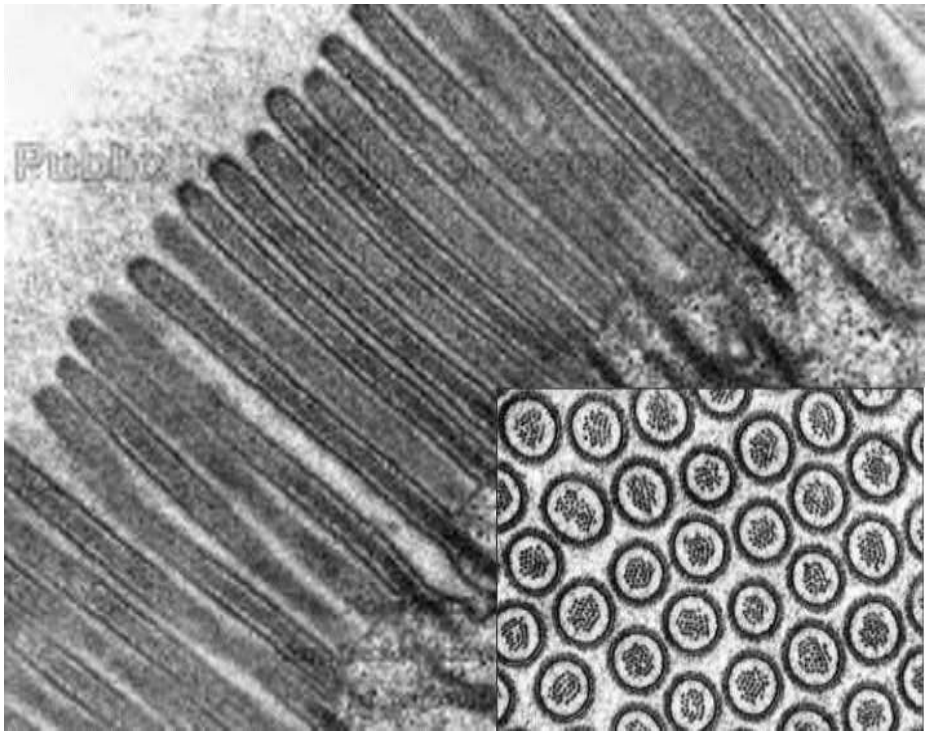
Intermediate Filaments: Bigger than microfilaments but smaller than microtubules, provides **tension bearing Permanent fixtures** of cells (**do not move**) Present only in **animal cells** of certain tissues

Microvilli :

- ❖ specialized extensions of cell membrane
- ❖ contain microfilaments
- ❖ Do not move.

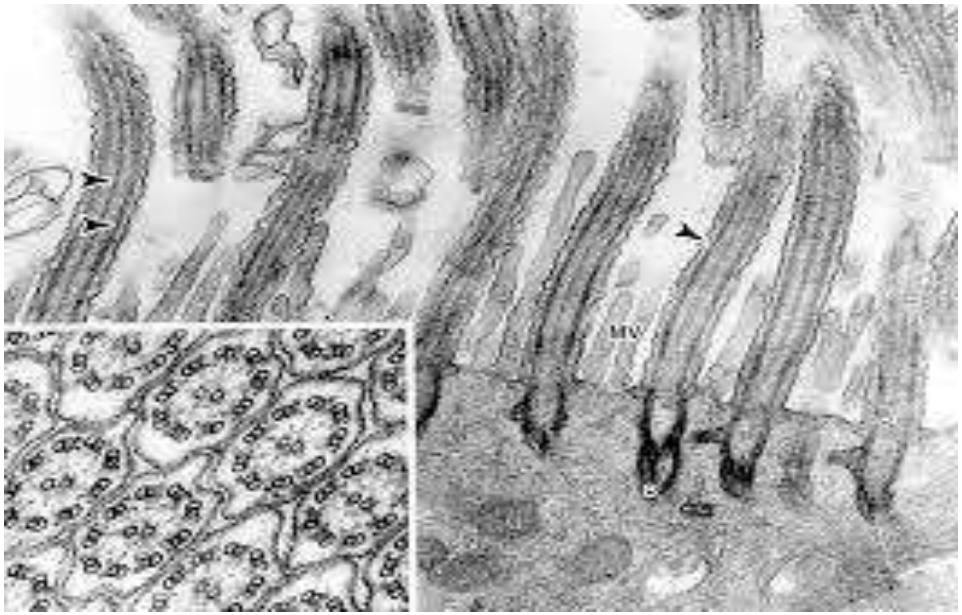
Function :

is to **increase surface area** esp. in cells that are used to **absorb**
e.g. **intestines, kidney**

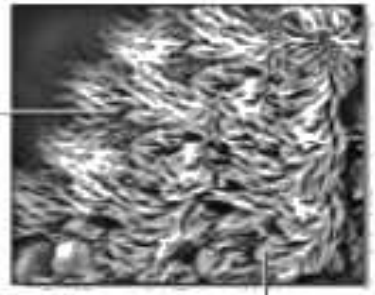
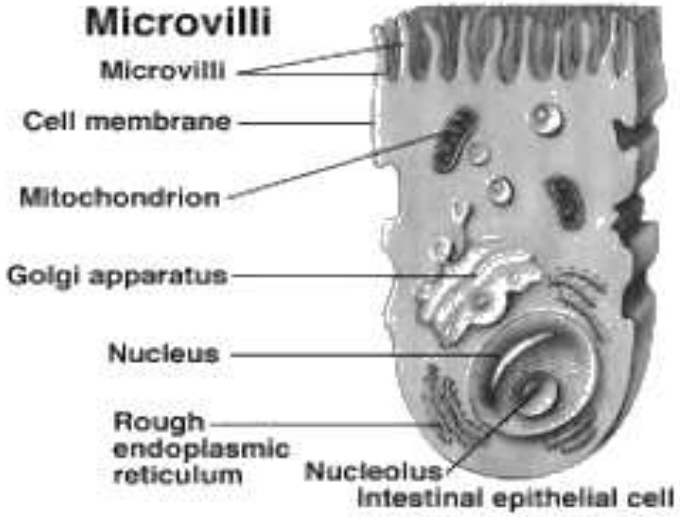


Sterocilia

- ➢ Long
- ➢ Non motile
- ➢ Contain actin filaments
- ➢ In male genital ducts



Cilia vs Microvilli

Cilia	Microvilli
 Hair-like projections called cilia line the primary bronchus to remove microbes and debris from the interior of the lungs 	
Occur in cells of respiratory and reproductive tracts.	Found in intenstine; where absorption an secretions are the major activities
Arise from the basal granules	Basal granules are absent
Motile	Non motile
Cilia has 9+2 ultra structure	9+2 ultra structure absent
They taper distally	They are extremely thin and short structu

Cytoplasmic inclusions

1. Stored food:

- Glycogen
- Lipids
- Protein

2. Pigments:

- **Endogenous:**

e.g. Hemoglobin, Melanin, Lipofuscin

- **Exogenous :**

e.g. Carotene, carbon particles