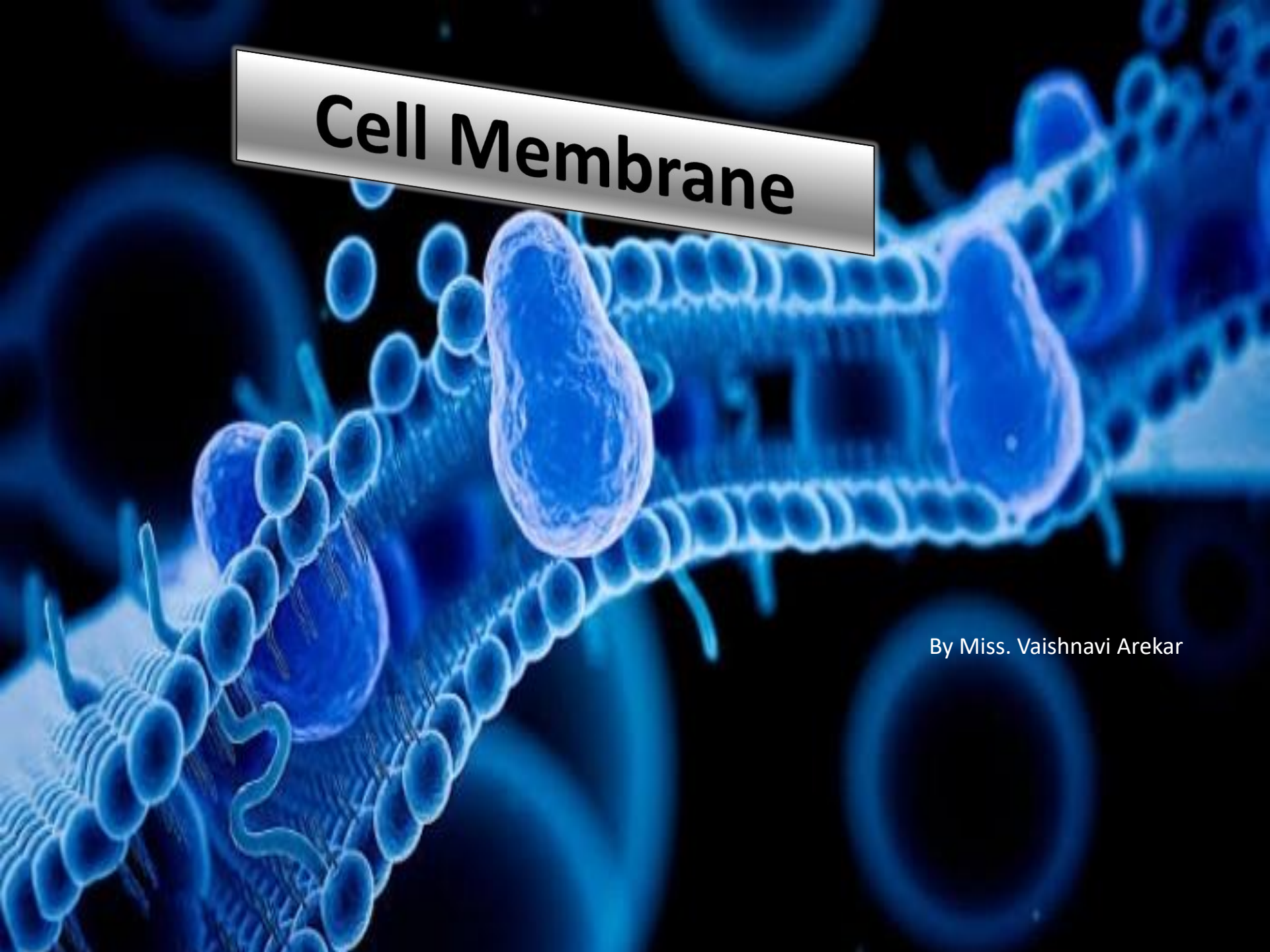
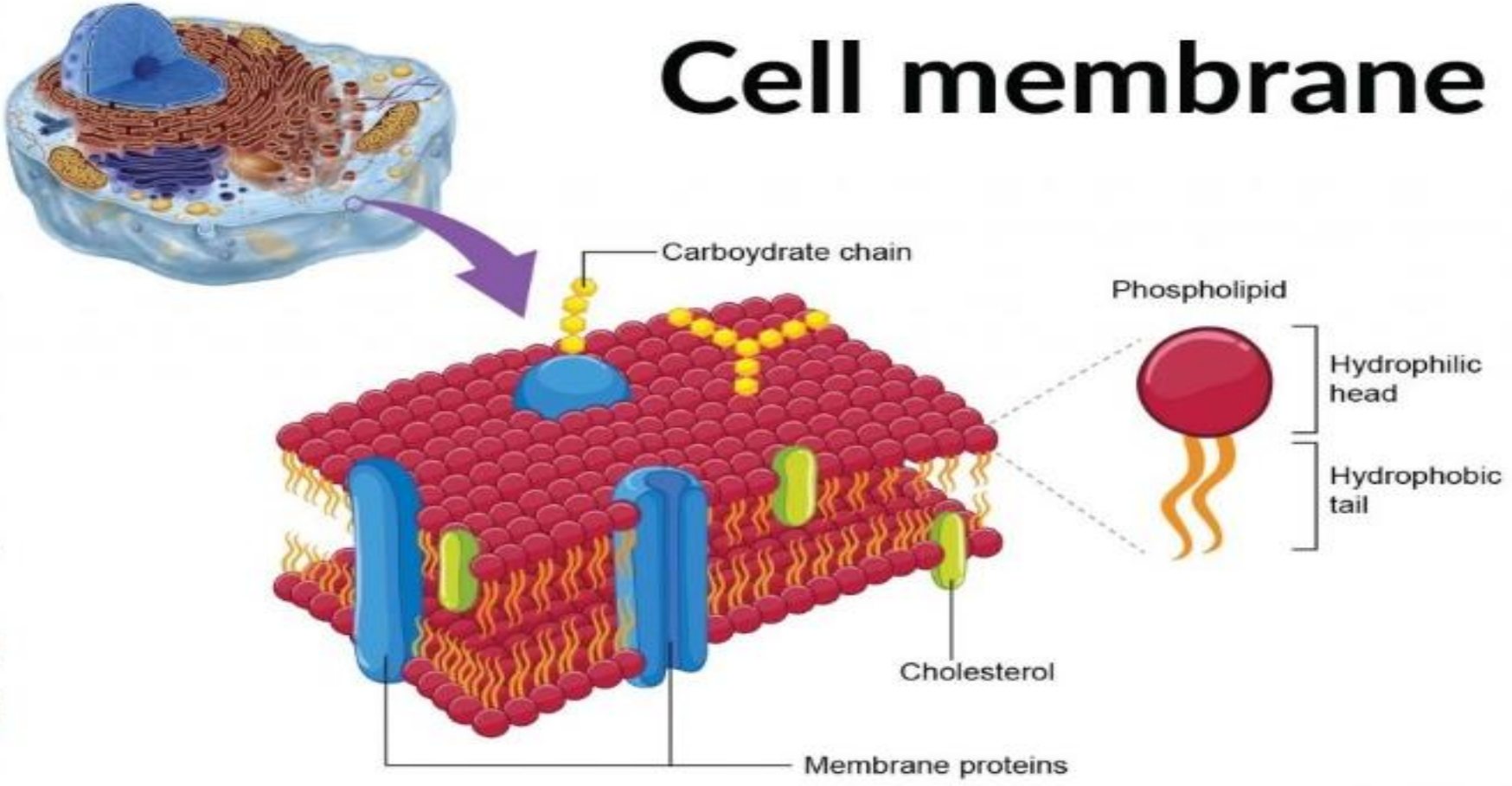
Cell Membrane



By Miss. Vaishnavi Arekar

Cell membrane

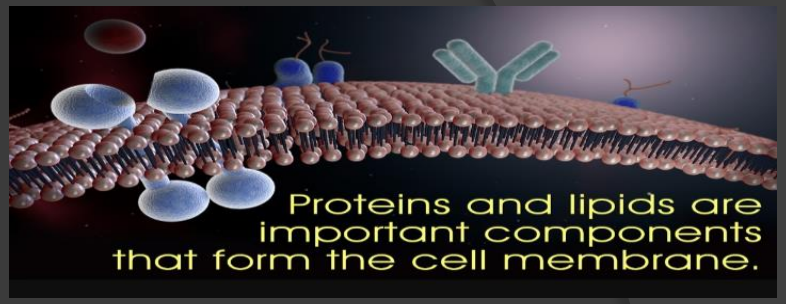


• **Cell membrane or plasma membrane or plasmalemma** is a thin, elastic **semipermeable** living membrane that serves as **a boundary for the cytoplasm**.

• The term plasma membrane was coined by **Nageli in 1855**

• It is outer limiting membrane in all animal cells while in plant cells & bacterial cells it is present inner to the cell wall

Chemical Components of Cell Membrane



Cell membrane
Formed mainly of

Lipids

Proteins

Ratio of these two components varies with the cell type

Small proportions of

Carbohydrates

Nucleic acids (e.g plasma membrane of Arbacia egg)

Salts

Water

Structure of plasma membrane
Chemical Components of Cell Membrane

1. Lipids:

- Cell membrane contains lipid bilayer as a basic structural unit where tails are orineted inwards and head facing outwards
- They are **amphipathic** in nature i.e they have hydrophilic (water loving or polar) head & hydrophobic (water hating or non-polar) tail (Two tails made up of fatty acids).
- Lipids are insoluble in water but dissolves in organic solvents
- Major types of lipids are –

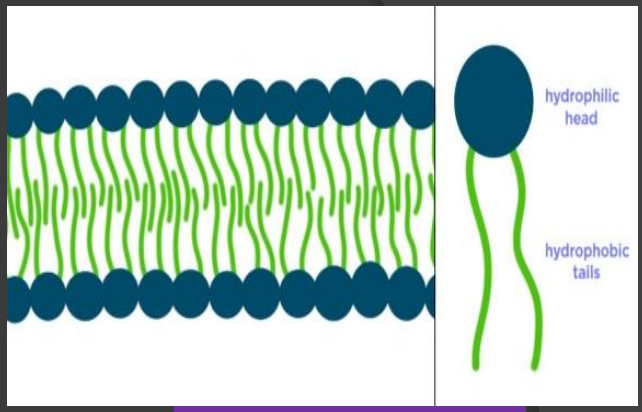


Fig: Lipid bilayer

Phospholipids	• These lipids contain phosphate moiety in the hydrophilic head • Can be distinguished into **glycerophospholipids** with a glycerol backbone & **sphingophospholipids** based on sphingosine
Glycolipids	• These lipids contain one or more carbohydrate residues • If it is a simple sugar (monosaccharide) the glycolipid is called **Cerebrocide** • And if it is an oligosaccharide, the glycolipid is called a **ganglioside**
Cholesterol	• It is a sterol which is most abundant in animal tissue • It regulates the fluidity of the membrane & enhances its mechanical stability

Chemical Components of Cell Membrane

2. Proteins : They have **high molecular weight**

- The proteins in the plasma membrane play various functions – that forms backbone of cell membrane, some proteins that are involved in active transport, some proteins act as a enzymes (esterase, hexokinase etc)
- Membrane proteins can be divided into three groups **based on their relationship to the lipid bilayer**

Peripheral or extrinsic proteins

- They are located entirely outer side of the lipid bilayer (extracellular as well as on cytoplasmic surface)
- They forms a fibrillar network on the inner surface to provide mechanical support
- Best studied peripheral proteins are **Spectrin & ankyrin**

Integral or intrinsic proteins

- They pass entirely through lipid bilayer (penetrate into the lipid bilayer)
- Their domains protrude out on both the extracellular and intracellular sides of membrane
- Therefore, they are called transmembrane proteins
- They are amphipathic having both hydrophilic and hydrophobic portions
- Contains higher percentage of non-polar amino acids

Lipid anchored proteins

- They are located outside the lipid bilayer and are linked to a lipid molecule that is situated within the bilayer

3. Carbohydrates : Carbohydrates are present only in the plasma membrane

- They are in the form of glycoproteins (proteins with attached sugars) & glycolipids (lipids with attached chains of sugars)
- Glycoproteins are present in the form of branched oligosaccharide chain with sialic acid terminals

Molecular models of cell membrane

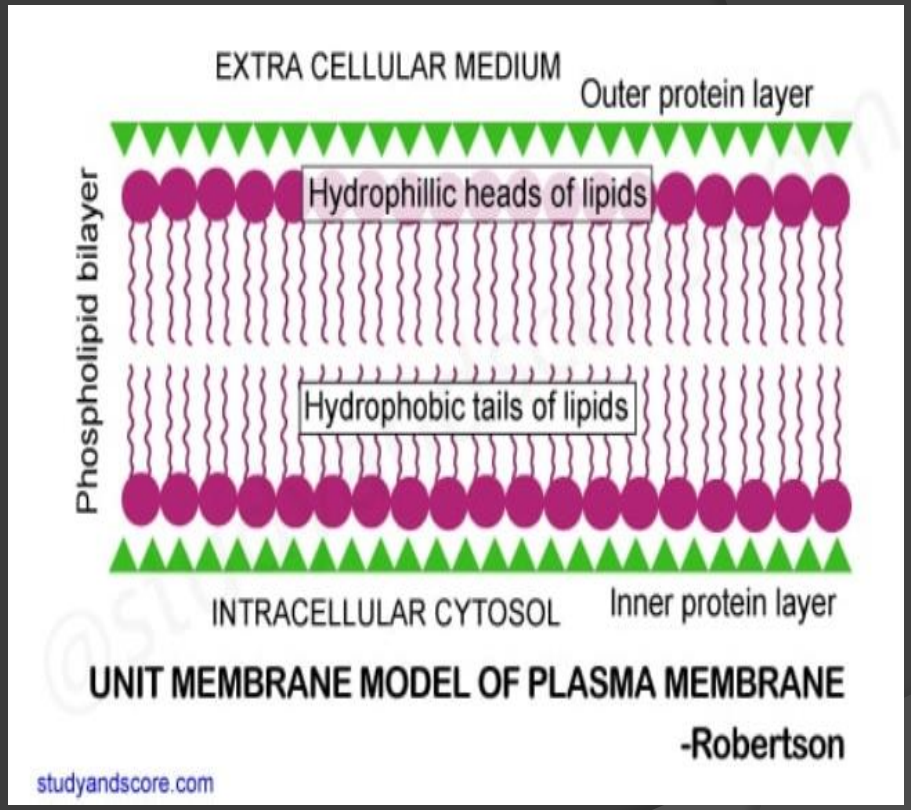
Unit membrane model

- This model was proposed by Robertson in 1950 with the help of electron micrograph
- According to this model, the plasma membrane is made up of three layers (Trilaminar Membrane)

1. Outer protein layer – 20A°
2. Middle lipid layer – 35A°
3. Inner protein layer – 20A°

} Trilaminar membrane

- This trilaminar form shows unity in structure of all biological membranes (e.g membrane of bacteria, plants, animals, organelles etc) – so called UNIT membrane & this concept is called UNIT membrane concept or UNIT membrane hypothesis
- This unit membrane concept was proposed by Robertson in 1959
- This model explains lipid content, electrical resistance & permeability of membrane



Fluid Mosaic Model

- Fluid mosaic model of plasma membrane was proposed by **Singer & Nicolson in 1972**
- Most accepted model of plasma membrane
- According to this model, plasma membrane is semi-fluid in nature which is consists of lipids (hydrophilic head & hydrophobic tail) & proteins
- Why fluid mosaic?

Lipid is in the form of fluid & proteins are embedded within this lipid bilayer gives mosaic pattern, so membranes were described as the protein icebergs in the sea of lipids

- The lipids are arranged in the form of two layers -
- outer and inner lipid layer where hydrophilic head face outwards (because the intercellular fluid and cytoplasm are watery in nature)& hydrophobic tails of two layers face each other

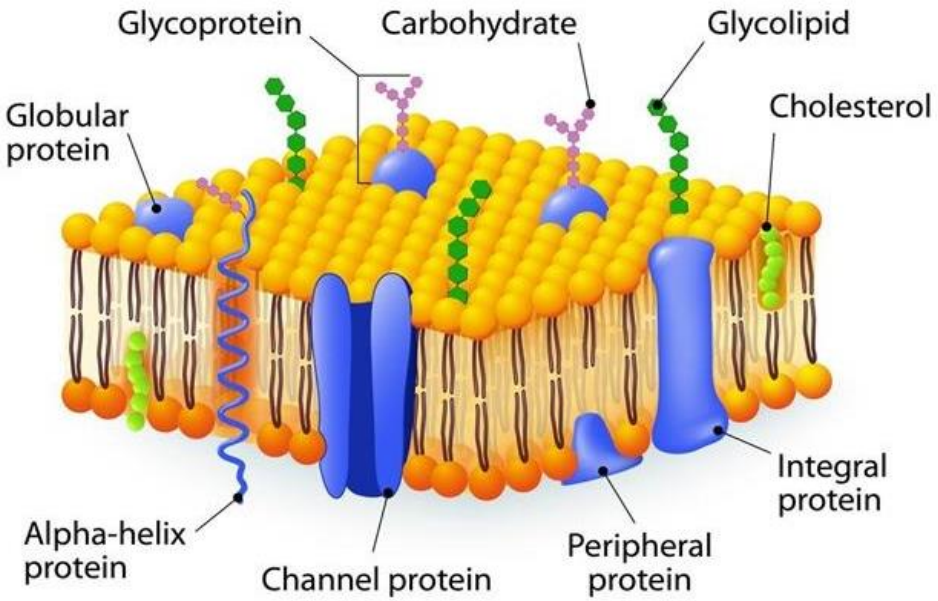


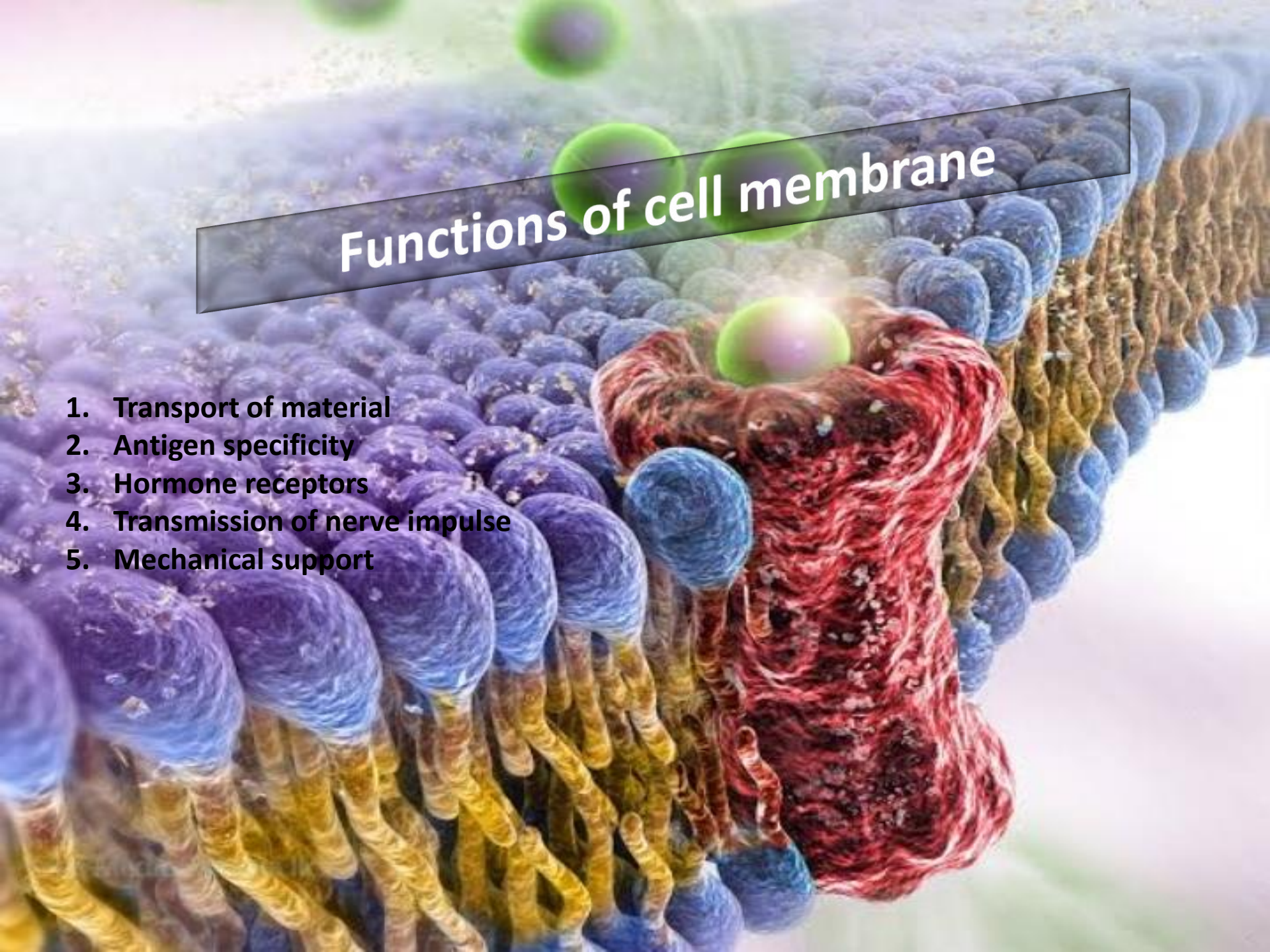
Fig : Fluid mosaic model

- Proteins are globular having two types such as peripheral proteins and integral proteins
- Peripheral proteins are arranged on the outer surface and loosely bound to the lipid molecules whereas integral proteins are deeply embedded & are tightly bound to the lipid molecules
- The peripheral proteins & the outer surface of the integral proteins are studded with sugars
- Such proteins with attached sugars are called glycoproteins
- The sugars are attached to the outer surface of some lipids, such lipids with attached sugars are called glycolipids

Glycoproteins } forms sugary covering
Glycolipids } called glycocalyx

- The lipid and integral proteins move freely within the lipid bilayer

Functions of cell membrane



1. Transport of material
2. Antigen specificity
3. Hormone receptors
4. Transmission of nerve impulse
5. Mechanical support

Transport of material across plasma membrane

- The internal composition of the cell is maintained because the plasma membrane is selectively permeable
- It acts as a barrier that blocks the free exchange of molecules between the cytoplasm & the external environment of the cell
- Membrane transport may be passive or active

Passive transport

1. The molecules moves across the plasma membrane from the region of higher concentration to a region of lower concentration, called passive transport or diffusion
2. . Called down-hill movement (With the concentration gradient)
3. This process doesn't consume energy
4. Types – Simple diffusion, facilitated diffusion, osmosis

Active transport

1. The molecules moves across the plasma membrane from the region of lower concentration to a region of higher concentration, called active transport
2. Called uphill movement (Against concentration gradient)
3. This process requires energy (ATP)
4. Types – Primary & secondary active transport

Passive transport

- The molecules moves across the plasma membrane from the region of higher concentration to a region of lower concentration till equillibrium, called passive transport or diffusion
- Passive transport is consists into osmosis, simple diffusion & facilitated diffusion

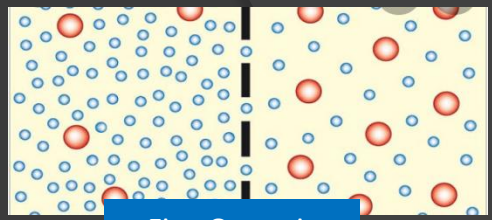


Fig : Osmosis

1. Osmosis :

- The plasma membrane is permeable to water molecules
- The process of movement of water molecules from the region of higher water concentration (low solute conc.) to the region of lower water concentration (high solute conc.) through semipermeable membrane till equillibrium, is called **osmosis**
- Endosmosis – The osmotic process in which the water molecules enter the cell
- The exact reverse process of endosmosis is called Exosmosis
- Due to endosmosis, the pressure inside the cell increases (hydrostatic pressure), this pressure is caused by osmosis so it is termed as osmotic pressure
- The plasma membrane maintains a balance between the osmotic pressures of the inter & intracellular fluids
- Tonicity – Determines the direction of water movement due to osmosis
- There are three types of solutions:
- A. **Hypotonic solution** has less solute & high water concentration than the cell, a cell placed in this solution, will take up water & swell (plasmotysis)
- B. **Isotonic solution** has just right amount of solute and water for the cell, a cell placed in this solution will stay the same
- C. **Hypertonic solution** has more solute & less water concentration than the cell, a cell placed in this solution will losses water & shrink (plasmolysis)

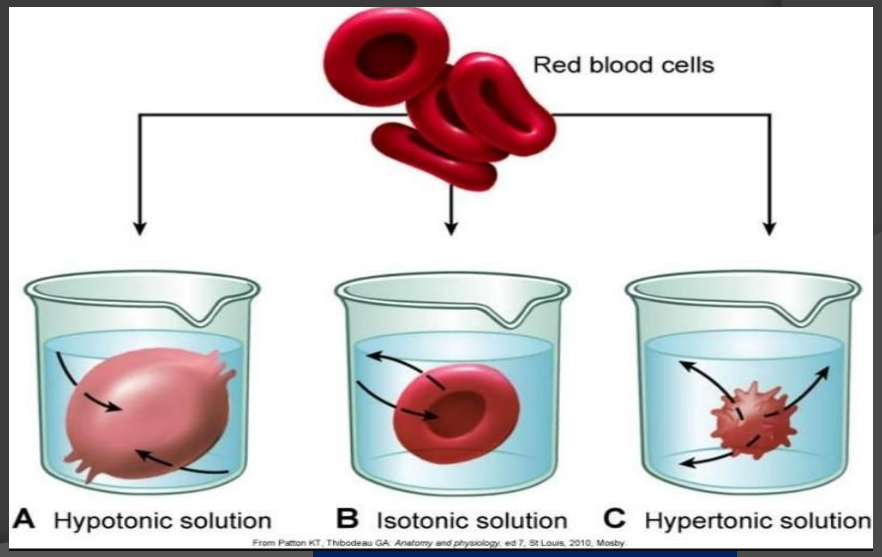


Fig: Tonicity effect on cell

Passive transport

2. Simple diffusion :

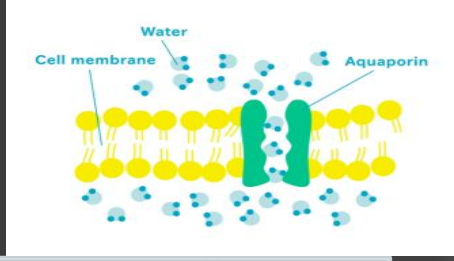
- Simple diffusion is non- selective process by which any molecule able to dissolve in the phospholipid bilayer is able to cross the plasma membrane & equillibrate between inside and outside of the cell
- Gases (O_2, CO_2), small polar but uncharged molecules (water, ethanol etc) will diffuse across membrane
- No transport proteins (permease) are involved in transportation of molecules
- The relative rate of diffusion of the molecule across the phospholipid bilayer will be proportional to the concentration gradient across the membrane

3. Facilitated diffusion :

- This is special type of passive transport, in which ions or molecules cross the membrane rapidly because specific transport protein (permease) in the membrane facilitate their crossing
- This process is specific means a single species of ion or molecule is transported
- Like simple diffusion, facilitated diffusion does not require energy & it occurs only in the direction of a concentration gradient
- The rate of transport of the molecule across the membrane is greater than simple diffusion
- Carrier proteins & channel proteins are involved in facilitated diffusion

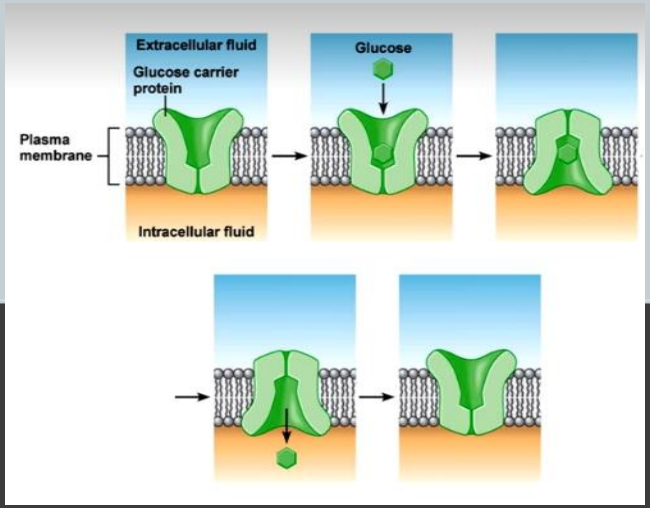
Passive transport

3. Facilitated diffusion :



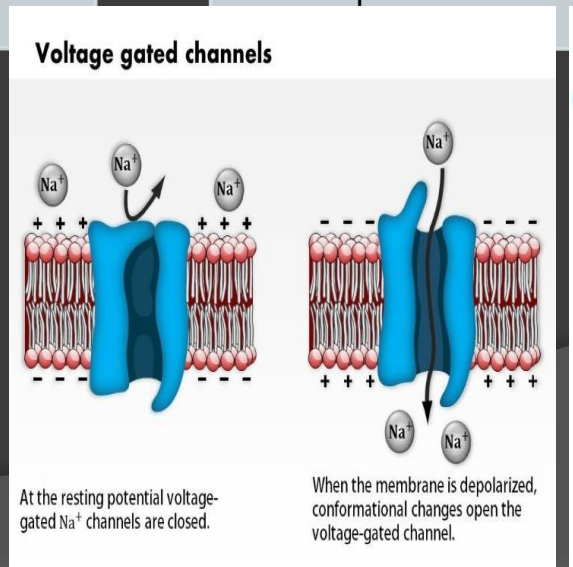
Carrier protein

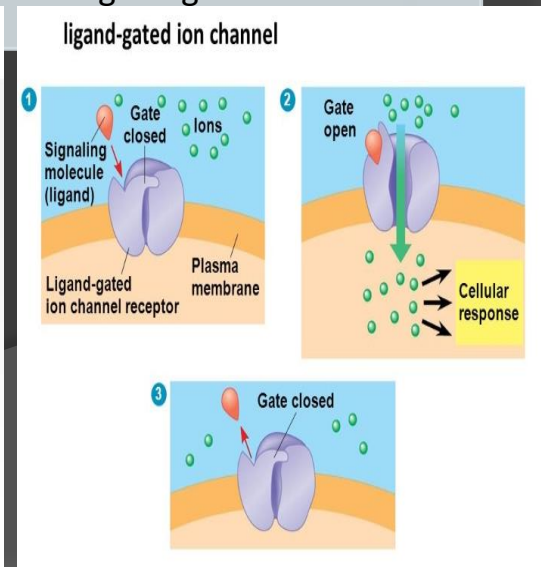
- When target molecule bind to the carrier protein, they change their shape to move target molecule across the membrane
- Like channel proteins, carrier proteins are typically selective for one or a few substances
- Carrier proteins are also involved in active transport of material
- e.g Movement of glucose by glucose transporter



Channel protein

- Channel proteins form pore like structure that transport only a single species of ion or molecule
- e.g **Aquaporin** channel protein allows water to cross the membrane in plant cells, RBC's (animal cells) etc
- Channel proteins concerned specifically with inorganic ions transport, called ion channels
- Most of the ion channels are not permanently open so they may be classified by the nature of their gating as:
- a) Voltage gated channel- Some channel open in response to change in electrical potential
- b) Ligand gated channel- Some channel open in the response to the binding of ligands



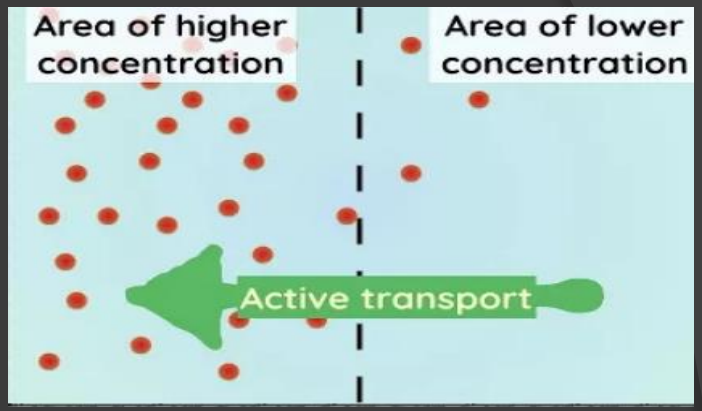


Active transport

- It is the movement of molecules or ions against the concentration gradient that means from the region of low concentration to the region of high concentration
- It requires carrier molecules & energy also
- Active transport is different from carrier proteins mediated facilitated diffusion
- It has two types –

A) primary active transport

B) secondary active transport



A) Primary (direct) active transport-

- They uses the energy directly from the hydrolysis of ATP for transportation of molecules
- It is an endergonic (uphill transport) process

Types of ATPases(ion transporting ATPases)

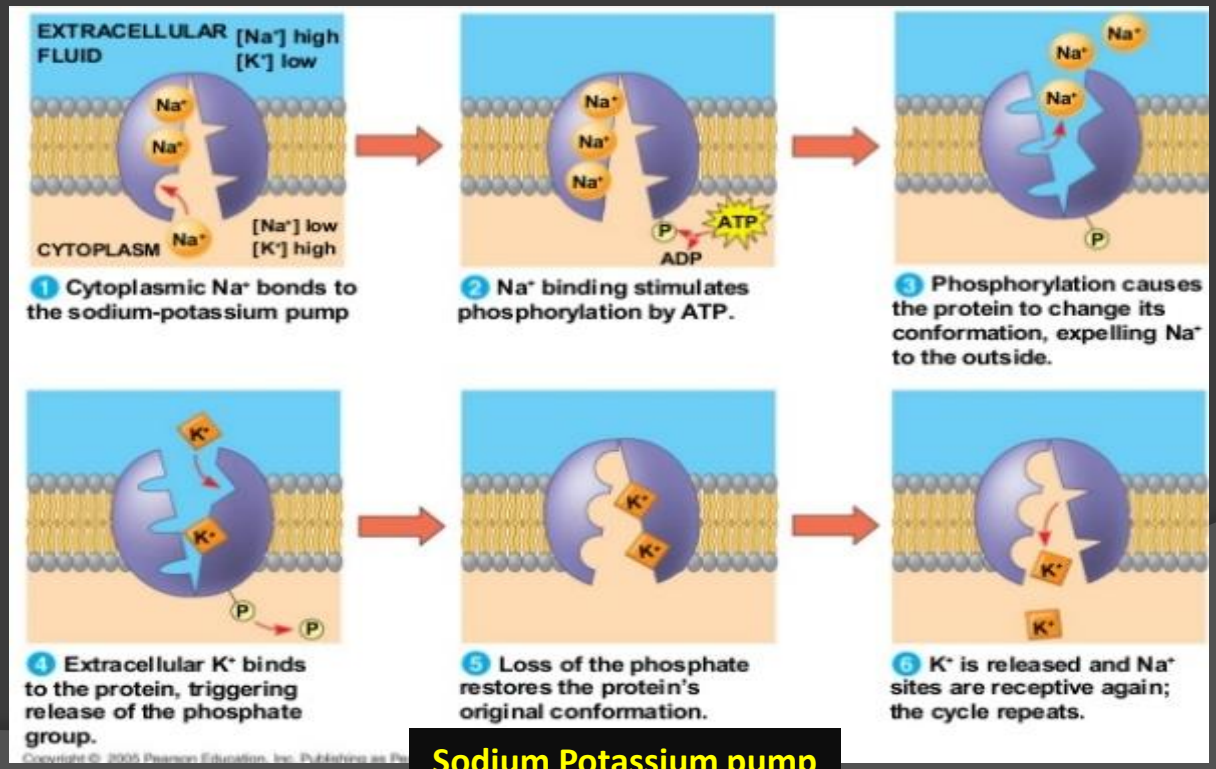
Types	Example	Location in cell
P- type	Na^+- K^+ ATPase	Plasma membrane
	Ca^{++} ATPase	Sarcoplasmic reticulum
V- type	H^+-K^+ ATPase	Plasma membrane
	H^+ ATPase	Lysosomal membrane
F- type	Mitochondrial ATP synthase	Inner mitochondrial membrane

Active transport

A) Primary (direct) active transport-

Na^+- K^+ ATPase (Sodium- Potassium pump): It is an antiporter

- This is one of the best example of primary active transport in animal cells
- The cells have a high intracellular K concentration & a low Na concentration, where **Na^+- K^+** pump is responsible for the maintenance of this concentration
- This is brought about by an integral plasma membrane protein, namely the enzyme **Na^+- K^+ ATPase** (it is heterodimer having alpha subunit that is responsible for ATP hydrolysis, ion pumping & beta subunit)
- **Na^+- K^+ ATPase pumps 3 Na^+ ions from inside the cell to outside & brings 2 K^+ ions from outside to the inside with a concomitant hydrolysis of intracellular ATP**
- **Inhibitors** of this pump are **Ouabain, Digitalis** both are steroids

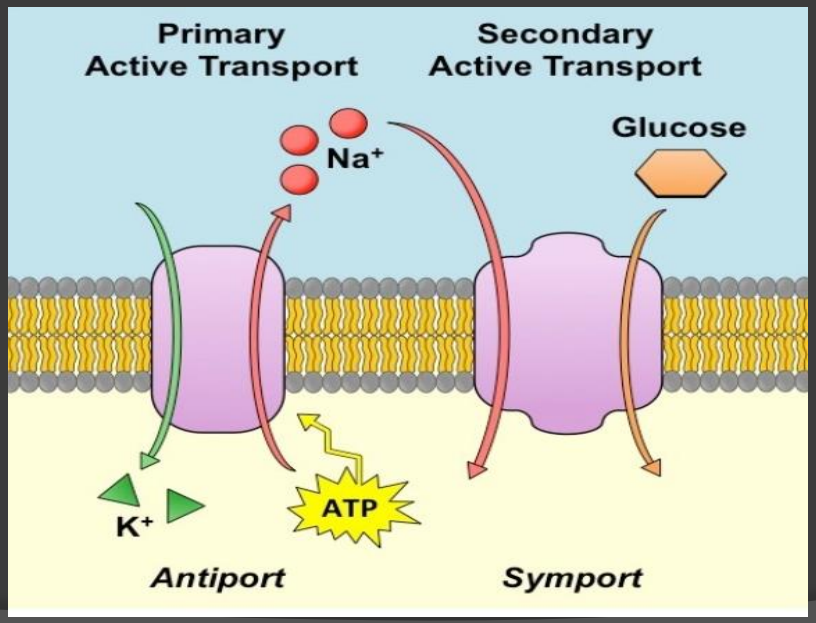


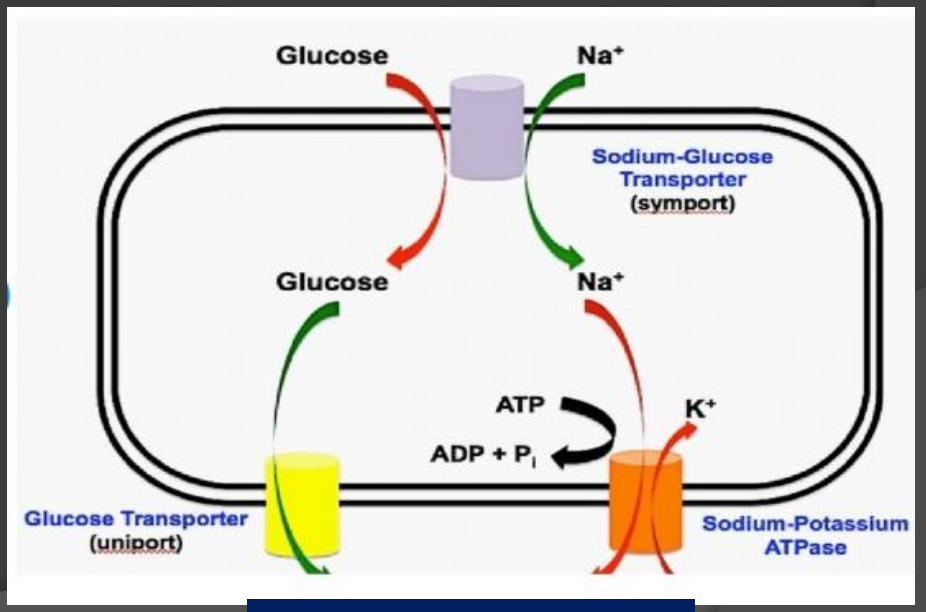
Sodium Potassium pump

Active transport

- **B) Secondary (indirect) active transport-**
- Energy utilized in the transport of one substance helps in the movement of the other substance
- Secondary active transport occure when endergonic (uphill) transport of one molecule is coupled to the exergonic (downhill) flow of a different molecule that was originally pumped uphill by primary active transport

- E.g Glucose transport into intestinal cells or kidney cells
- The transmembrane protein Na^+ glucose transporter, acts as carrier that allows sodium ions & glucose to enter the cell together
- The sodium ions flow down their concentration gradient while the glucose molecules are transported against their concentration gradient into the cell
- Later the sodium is pumped back out of the cell by Na^+ K^+ ATPase





Na^+ Glucose transporter

Bulk transport

- The molecules are too large to move through a channel protein or carrier protein, vesicles are used to move bulk molecule
- It has two ways i.e exocytosis & endocytosis
- Both requires energy

Endocytosis

Endocytosis is the engulfing of food or foreign particles through the plasma membrane.

Endocytosis carried out by two ways - 1. Phagocytosis, 2.Pinocytosis, 3. Receptor mediated endocytosis

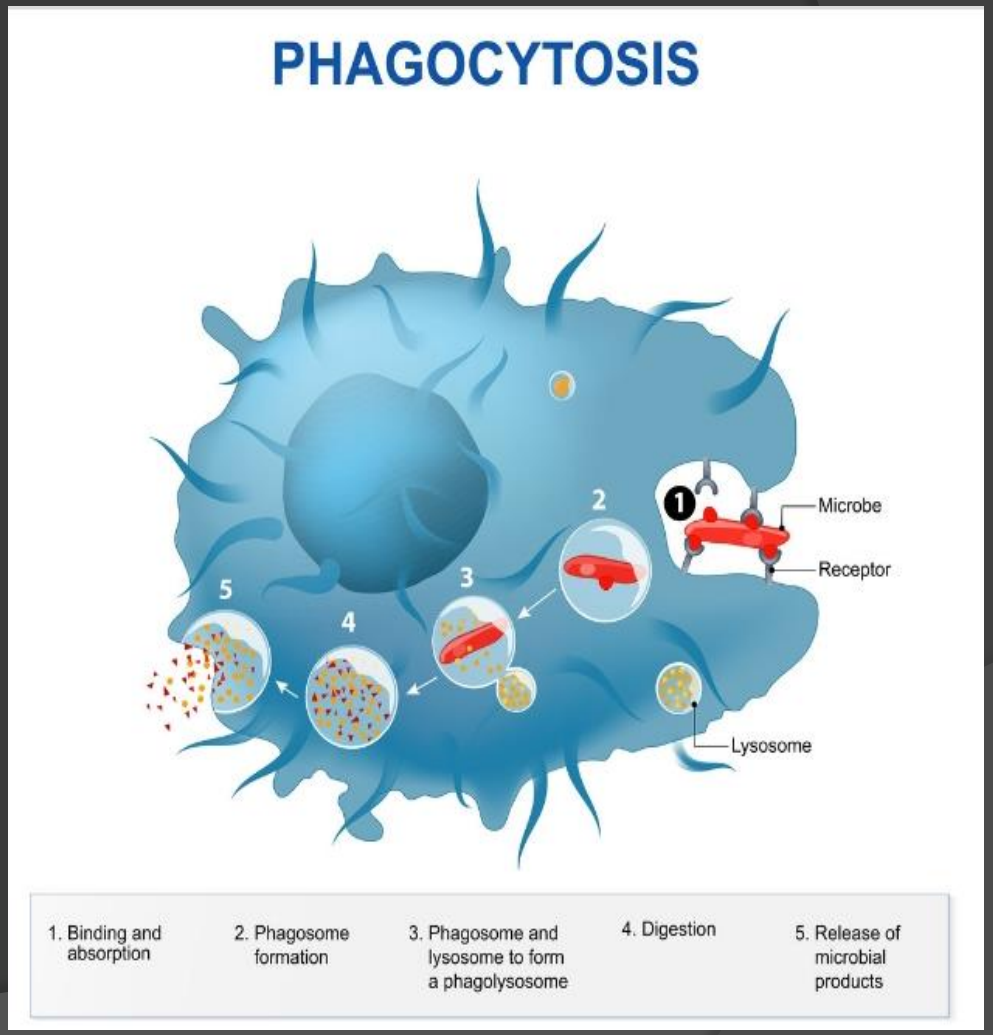
1. Phagocytosis or cell eating:

- It is the process of engulfing of solid particles (foreign particles e.g bacterial cells) through plasma membrane
- The cells which performs phagocytosis, are known as phagocytic cells
- The term 'Phagocytosis' was coined by **Metchnikoff in 1885**

- **Process:**

1. The food or foreign particles are adsorbed at plasma membrane surface which are taken into the cytoplasm by membrane infoldings
2. Then food or foreign particles are completely enclosed in the vacuoles, called phagosomes
3. Phagosome soon fuses with lysosome of the phagocytic cell, called phagolysosome (secondary lysosome)
4. The food or foreign particles are digested by different enzymes of lysosome
5. The digested food or foreign cell (nutrients) absorbed in the cytoplasm of phagocyte & residual undigested part is thrown out of the cell

- E.g Macrophages, Amoeba etc.



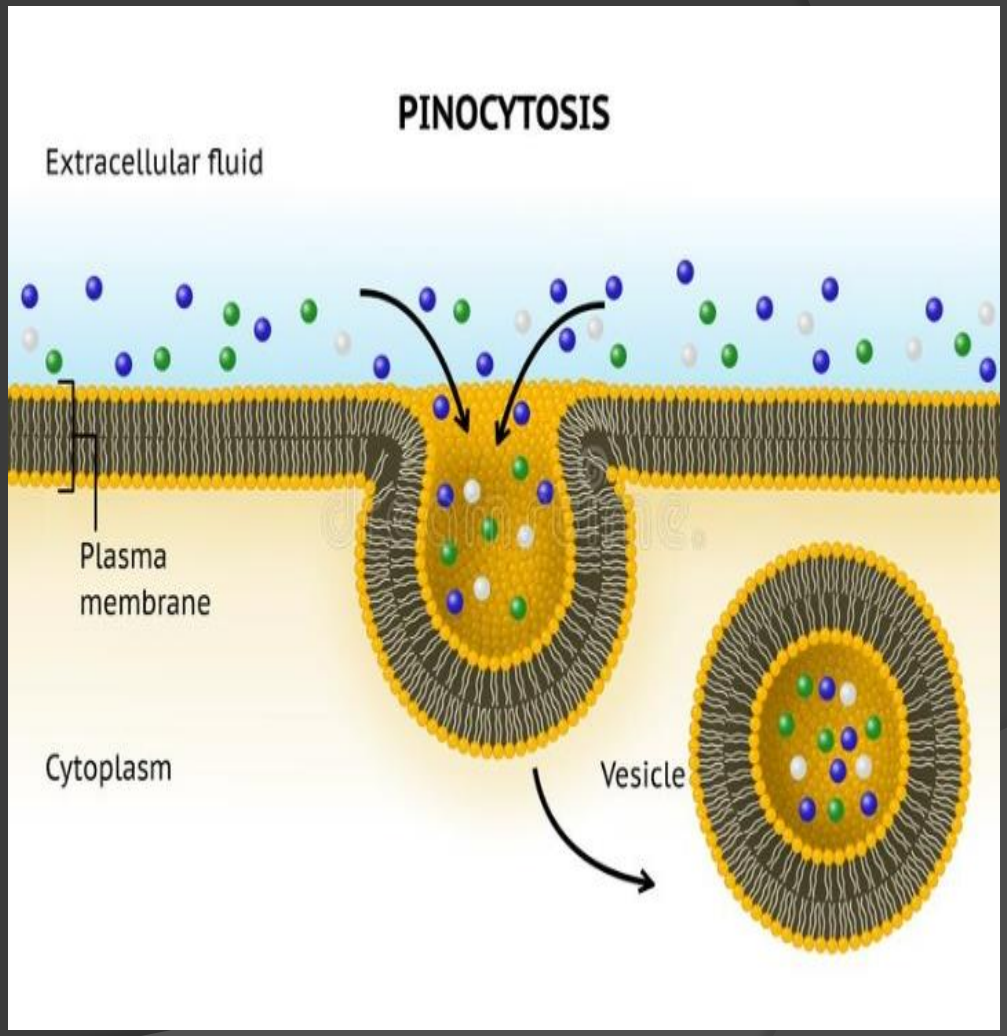
Endocytosis

2. Pinocytosis or Cell drinking :

It is the process of engulfing of fluid through the plasma membrane
First time observed by **Warren Lewis**

Process :

1. The plasma membrane is invaginated to form sac like structure and fluid food or solutes are drawn into the sac
2. The vesicle called pinosome is formed due to the sac is pinched off from the plasma membrane
3. Then pinosome fuses with lysosome
4. The food is digested by the different enzymes of lysosome
5. The digested food absorbed in the cytoplasm of phagocyte & residual undigested part is thrown out of the cell
6. E.g Intestinal epithelial cells absorbs fat droplets



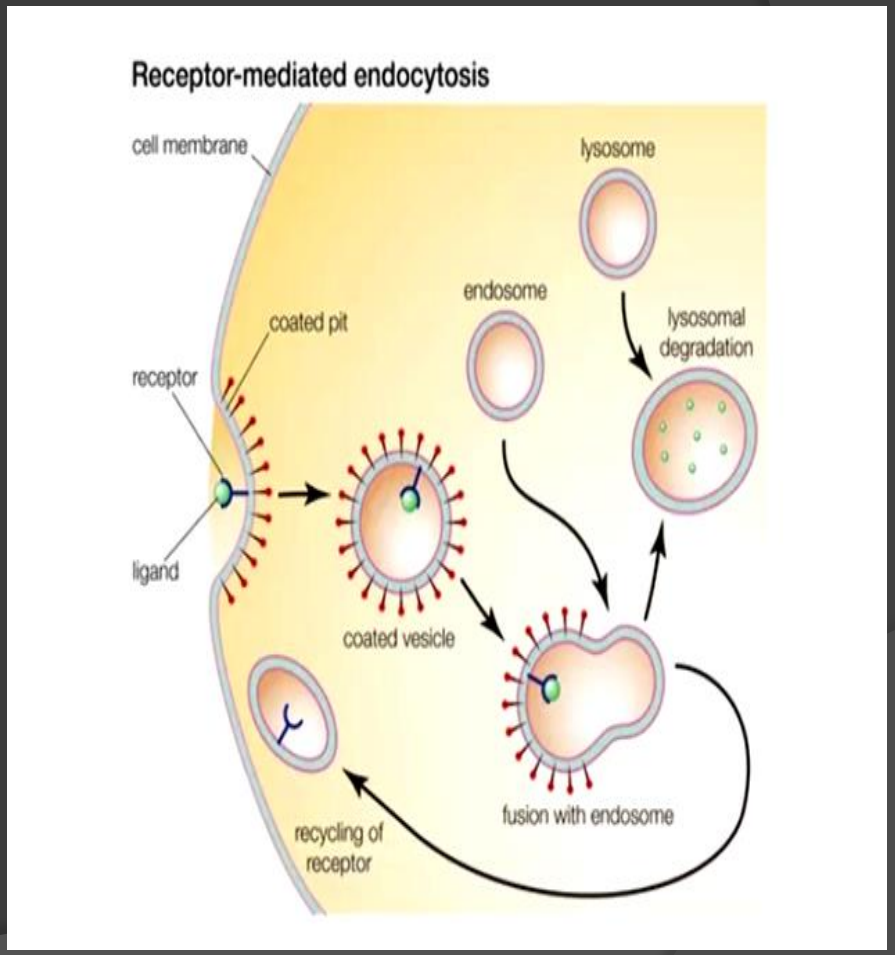
Endocytosis

3. Receptor mediated endocytosis : Also called as clathrin mediated endocytosis

It is a form of endocytosis in which receptor proteins on the cell surface are used to capture a specific target molecule (proteins, hormones, in some cases viruses etc.)

Process :

1. The specified molecule binds to a receptor on the plasma membrane
2. The molecule bound receptor migrates along the membrane coated with the protein clathrin known as a clathrin coated pit
3. The molecule- receptor complexes accumulate in the clathrin coated pit & the pit region is internalized that forms clathrin coated vesicle by endocytosis
4. The clathrin coated vesicle fuses with an endosome in the cytoplasm & the clathrin coating is removed
5. The receptor can be enclosed in a lipid membrane & recycled back to the plasma membrane
6. Then the specified molecule remains in the endosome & the endosome fuses with a lysosome
7. Lysosomal enzymes degrade the specified molecule & deliver the desired contents to the cytoplasm



Exocytosis or Cell Vomiting

- This is also known as **emeiocytosis** or **reverse endocytosis (opposite of endocytosis)**
- This mechanism has been used in the removal of waste materials from cell, transport hormones, proteins etc
- E.g The pancreatic cells expels the enzymatic secretions through plasma membrane by exocytosis
- The vesicles involved in exocytosis are formed by the golgi bodies, endosomes

Process:

1. The transportation of the cell vesicle (contains cellular content) to the cell membrane
2. The vesicle then attaches to the cell membrane
3. Then vesicle fuses with the cell membrane that allows to release contents of vesicle to the outside of cell

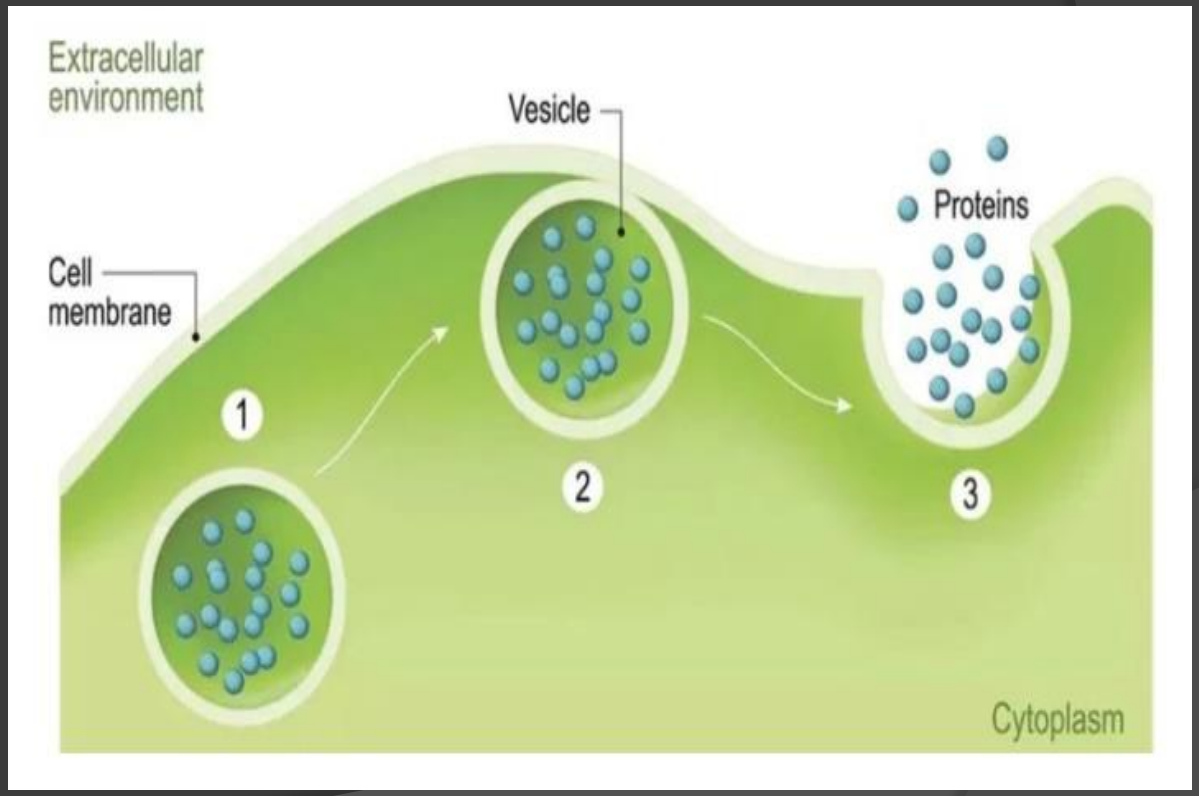


Fig : Exocytosis process