GENERAL PHYSIOLOGY
(LECTURE 3)
PASSIVE TRANSPORT ACROSS CELL MEMBRANE

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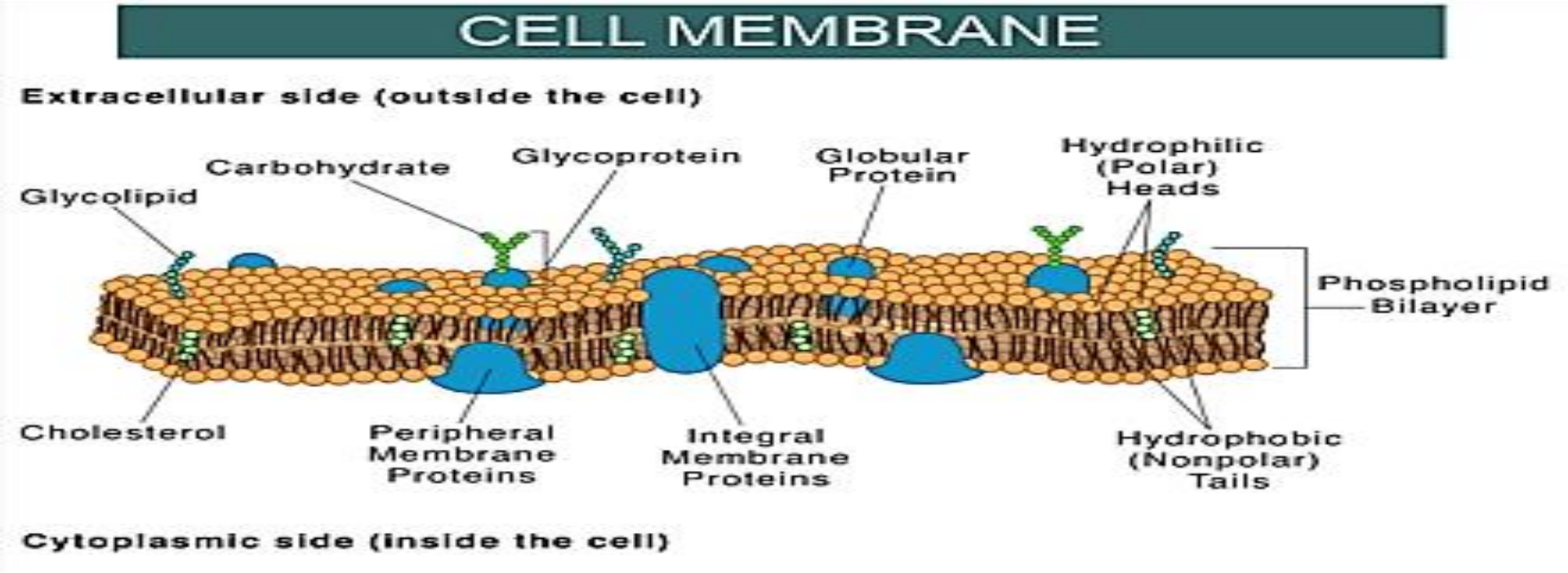
2023-2024



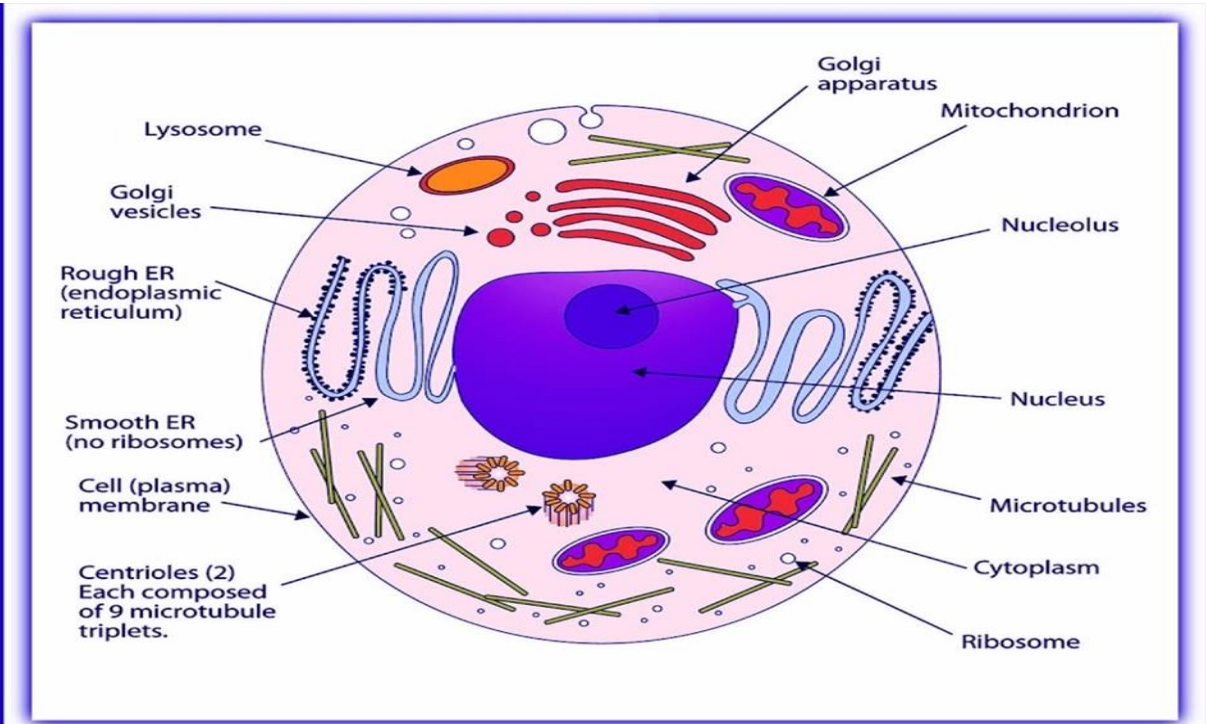
The cell:

It is the structural unit of the human body.

Components of human cell:

1. **The cell membrane (also called plasma membrane).**
2. **The nucleus.**
3. **The cytoplasm ……. Organelles.**

Human Cell Composition



THE CELL MEMBRANE

It is a very thin elastic structure which envelopes the cell separating and keeping intracellular fluid (ICF) completely different from extracellular fluid (ECF).

Functions:

1. It forms the outer boundary surrounding the cell to protect it from the external environment.
2. Selective permeability; as it permits the passage of certain substances and prevents others.
3. Detect chemical messengers arriving at the cell surface.
4. Link adjacent cells together by membrane junctions.

Characters:

- Very thin; 75-100 A^o (A^o= angstrom= 0.1nm; 10^{-10} m); 7.5-10 nm.
- Elastic.
- Semipermeable.
- Dynamic.

Composition:

- **Proteins:** 55%
- **Lipids:** 42%

Phospholipids: 25% & Cholesterol 13 % and other lipids (4%)

- **Carbohydrates:** 3%

STRUCTURE OF THE CELL MEMBRANE

Chemical Structure:

1. Lipids:

A. Phospholipids:

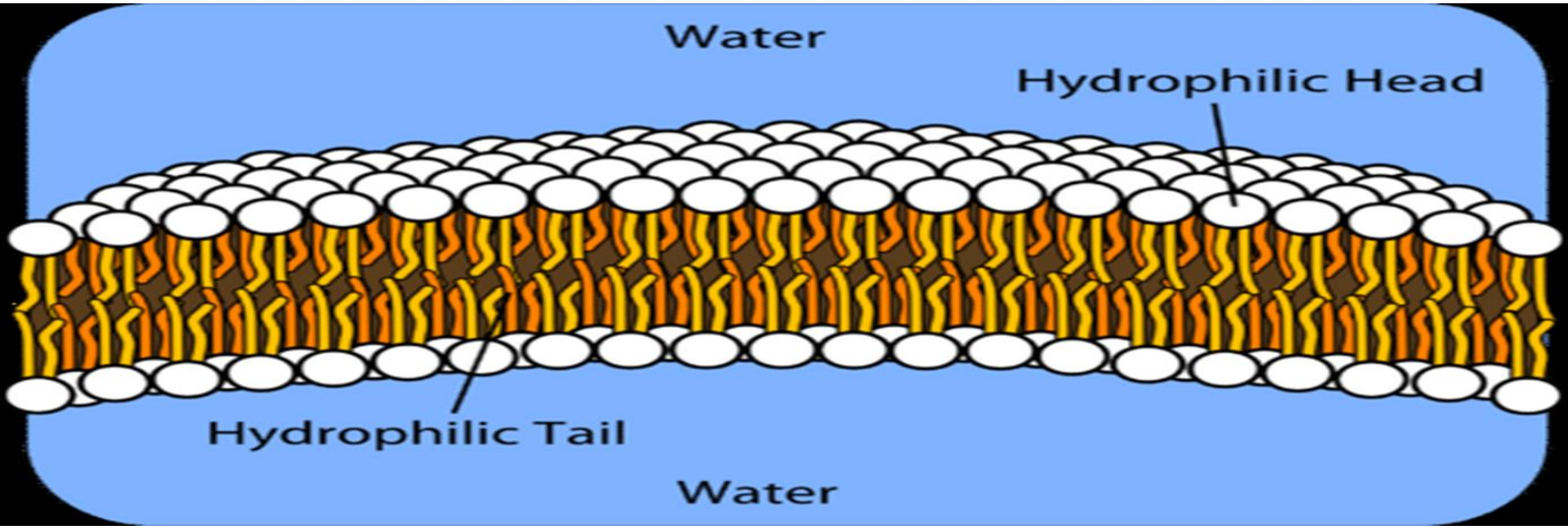
- Each **phospholipid** molecule in the cell membrane is formed of:

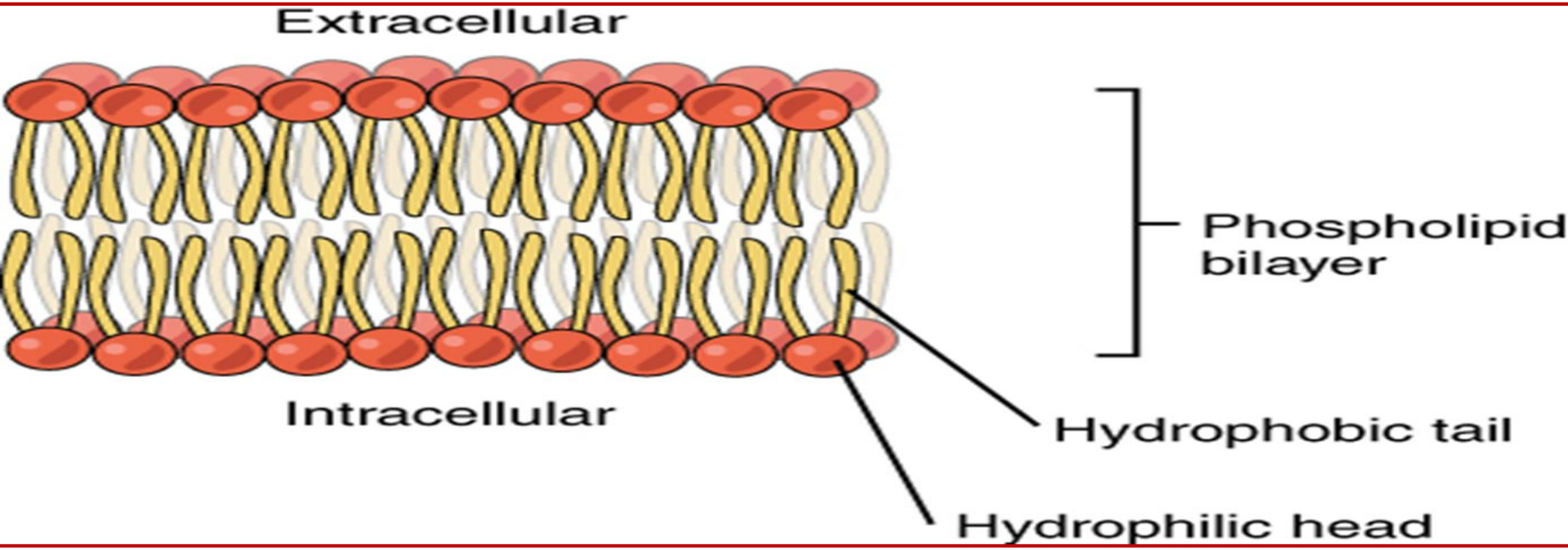
1. Water soluble (**hydrophilic**) phosphate part.
2. Fat soluble (**hydrophobic**) lipid part containing **cholesterol**.

- The cell membrane is formed of **two layers (bilayer)** of phospholipid molecules with their **hydrophilic phosphate heads** directed **outwards and inwards** and their **hydrophobic lipid tails** directed to the **interior** of the membrane.

B. Cholesterol:

Controls the fluidity of the membrane.


Water
Hydrophilic Head
Hydrophilic Tail
Water


Extracellular
Phospholipid bilayer
Intracellular
Hydrophobic tail
Hydrophilic head

B. Proteins:

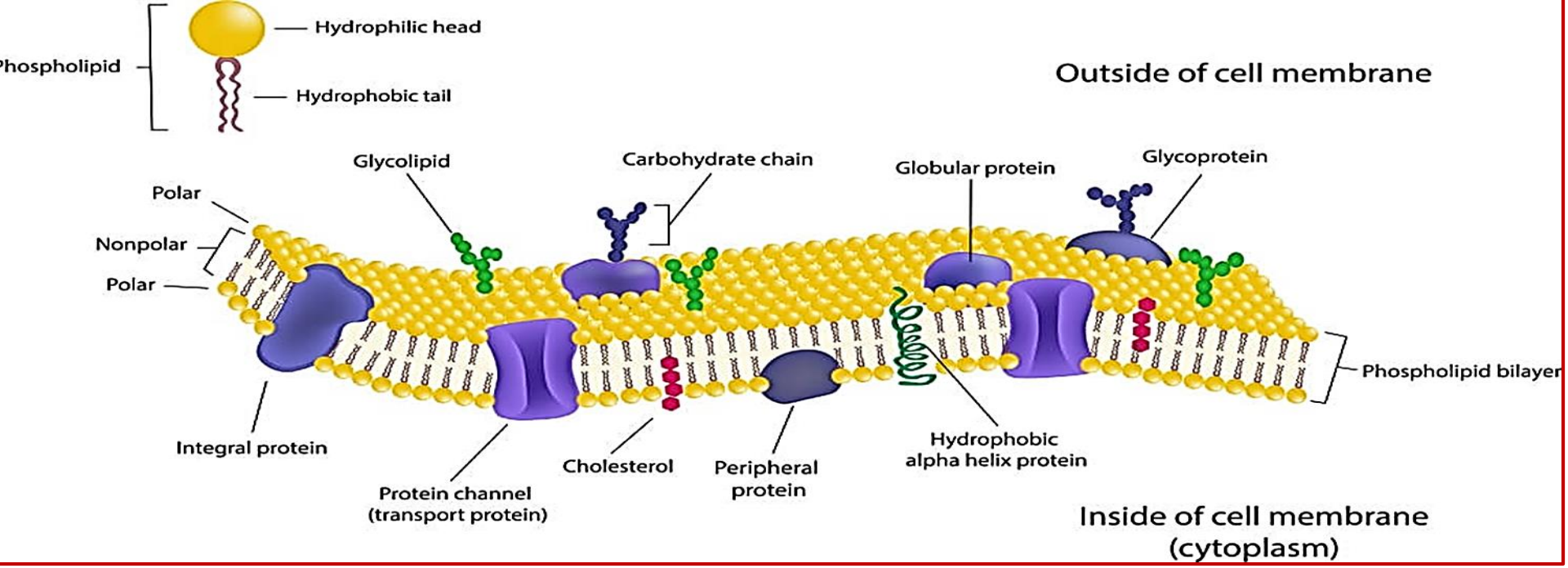
✓ **Chemically, they are either;**

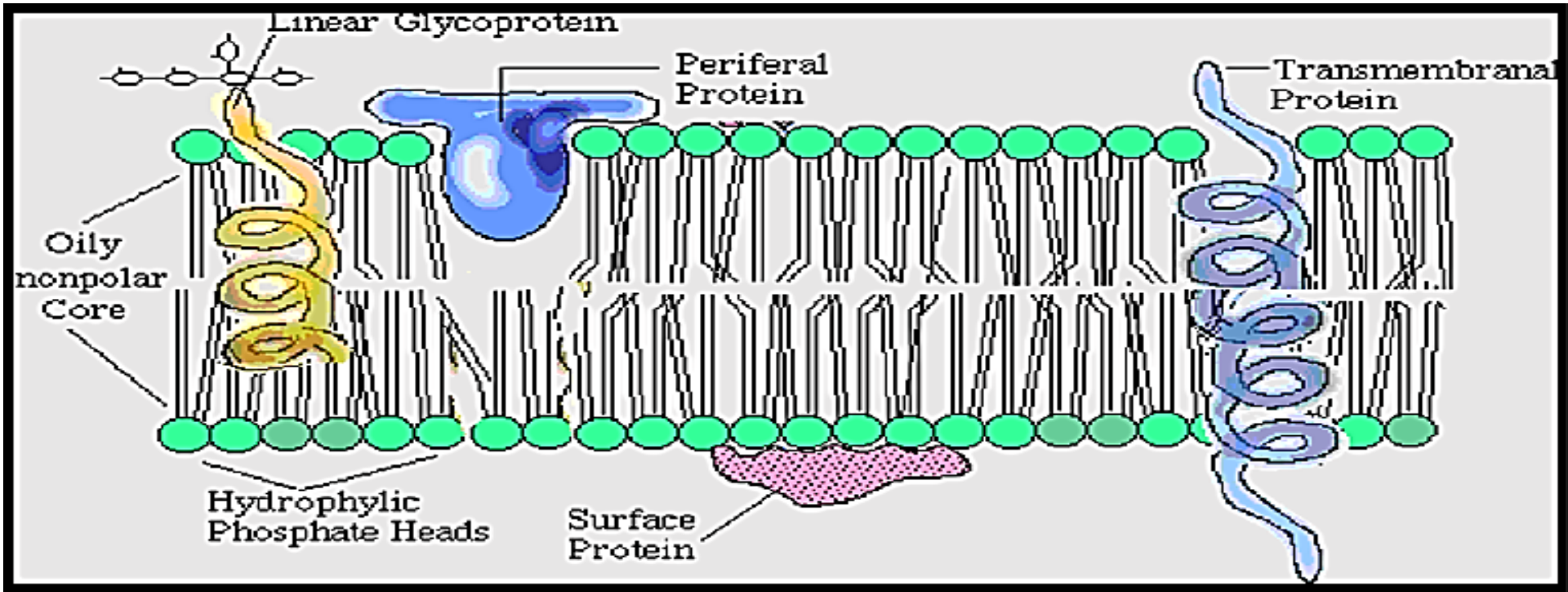
1. Pure proteins. or
2. Conjugated proteins with carbohydrates (glycoproteins) or with lipids (lipoproteins).

✓ **According to their site;**

Proteins are either:

1. Peripheral (surface) proteins on the outer or inner surfaces (do not penetrate it).
2. Integral (Transmembrane or through & through proteins) ---- extend all the way through the cell membrane.


Phospholipid
Hydrophilic head
Hydrophobic tail
Outside of cell membrane
Glycolipid
Carbohydrate chain
Globular protein
Glycoprotein
Polar
Nonpolar
Polar
Phospholipid bilayer
Integral protein
Protein channel
(transport protein)
Cholesterol
Peripheral
protein
Hydrophobic
alpha helix protein
Inside of cell membrane
(cytoplasm)


Linear Glycoprotein
Periferal
Protein
Transmembranal
Protein
Oily
nonpolar
Core
Hydrophylic
Phosphate Heads
Surface
Protein

Functions of Cell Membrane Proteins

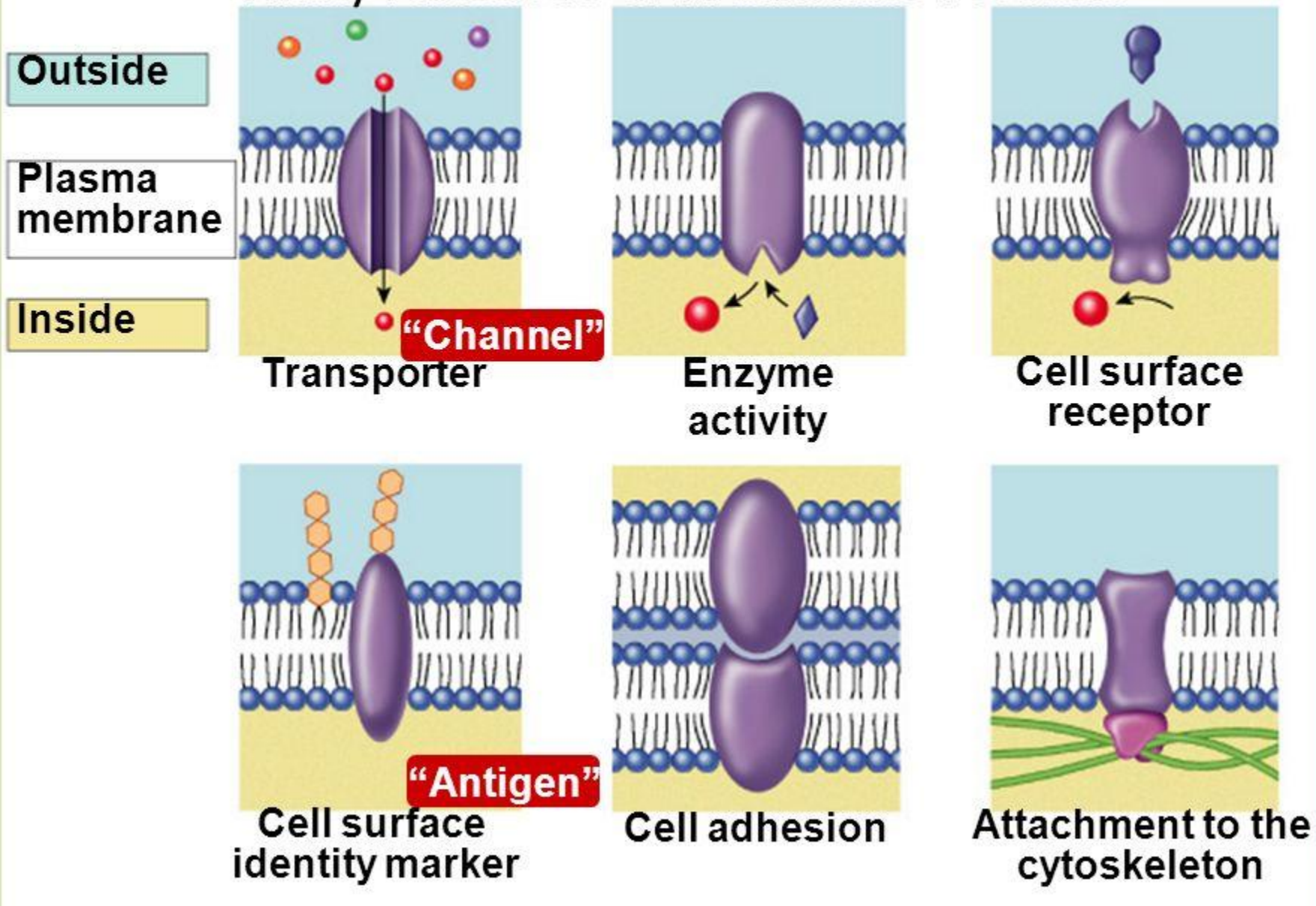
1. Structural proteins: Some of these contain lipids (lipoproteins) while others contain carbohydrates (glycoproteins)
2. Act as **Receptors** for;

a. Hormones.

b. Chemical transmitters.

3. Act as **Pumps;** actively transport ions across the cell membrane **e.g. Na^+-K^+ pump**.
4. Act as **Enzymes;** they catalyze chemical reactions at the surface of the cell membrane e.g. adenylate cyclase enzyme ------ which catalyzes the formation of cyclic AMP (cyclic AMP) from ATP.
5. Antibody processing by specific glycoproteins (**surface recognition sites; self-antigens)** ----- very important for immune system to differentiate between what is self and non-self (foreign) ------ thus preventing the body from attacking itself (i.e. autoimmune diseases).
6. Act as **Carriers**; helping transport of substances through the cell membrane.
7. Act as **Channels**: through which water soluble substances can pass through the cell membrane.
8. Intercellular connections & Cell adhesion molecules.

Many Functions of Membrane Proteins



C. Membrane Carbohydrates (The Cell Glycocalyx):

A loose carbohydrate coat that protrude to the outside surface of the cell.

Chemically:

Glycoproteins.

Glycolipids.

Functionally:

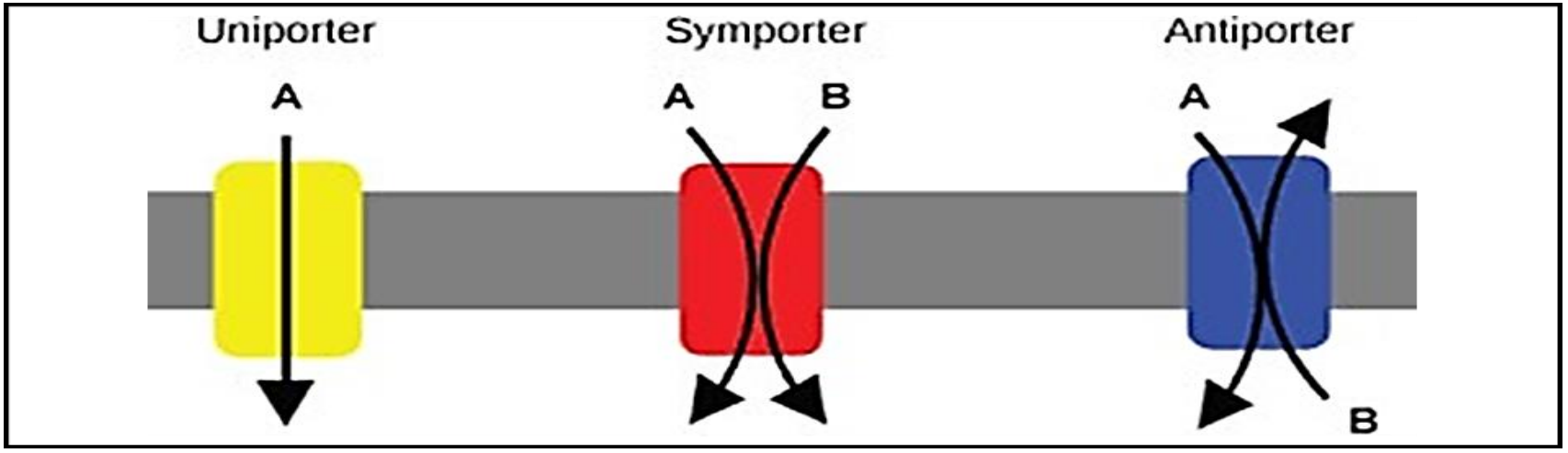
1. Recognition site.
2. Cell adhesion: the glycocalyx of some cells attaches to the glycocalyx of other cells, thus attaching cells to one another.

TYPES OF CARRIERS

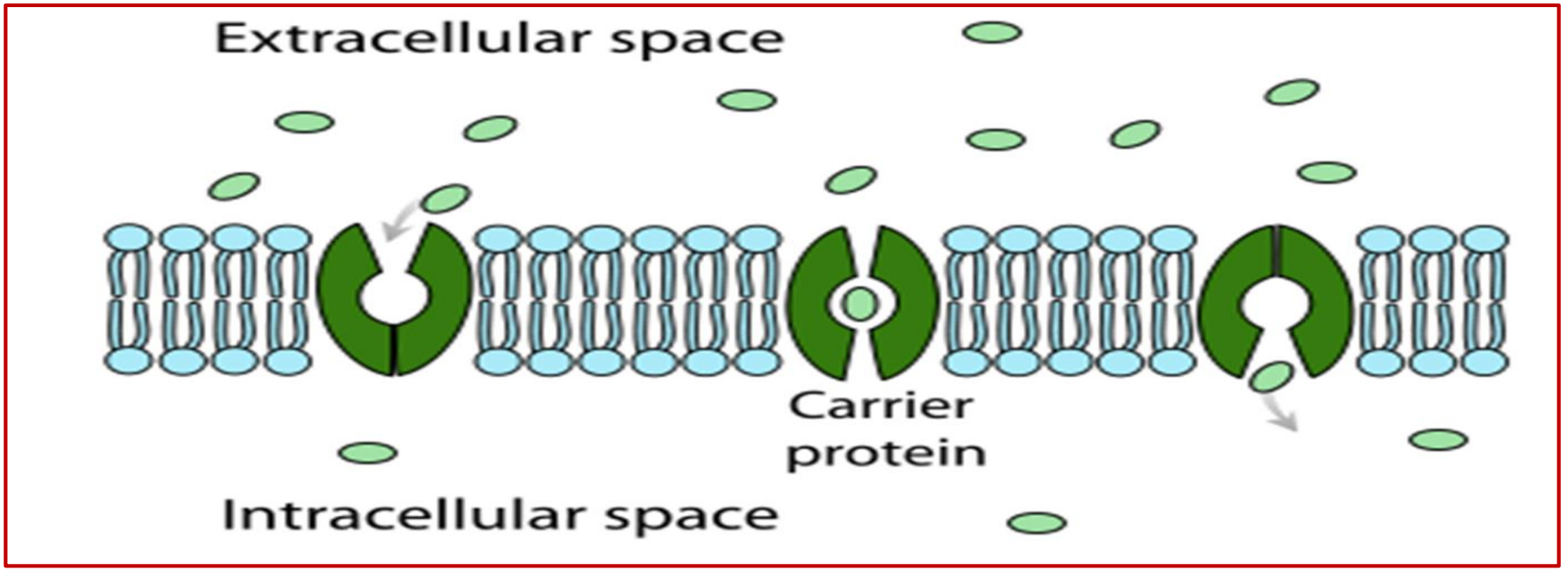
1. Uniport: transport one substance in one direction as Ca^{2+} pump.

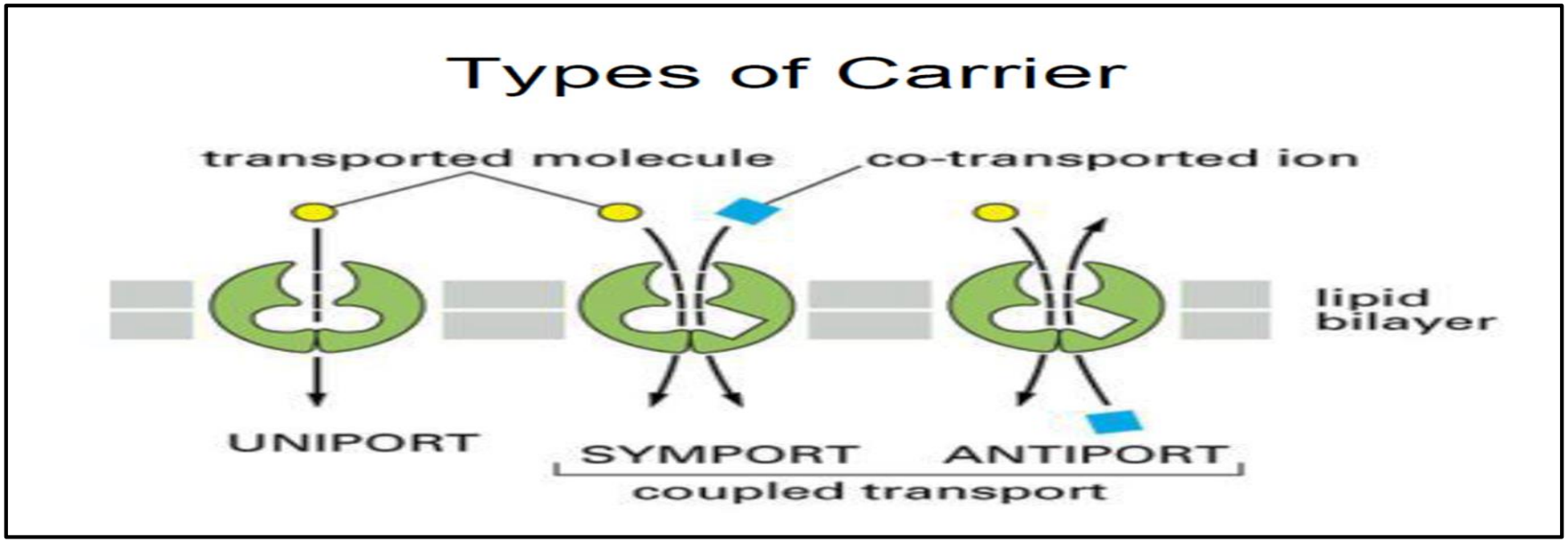
2. Symport : transport two substances simultaneously in the same direction. = (Co-transport) e.g. Na^+ and glucose carrier.

3. Antiport: transport two substances simultaneously in opposite direction. = (Counter-transport). e.g. Na^+-K^+ pump → it transports 3 Na^+ out of the cell **in exchange** with 2 K^+ into the cell.



CELL MEMBRANE CARRIER PROTEINS





CELL MEMBRANE CHANNELS

1. **Non gated channels:**

- They are channels that are **open all the time** allowing passage of ions all the time.
- Sometimes they are called "**leak channels**" as Na^+ leak channels and K^+ leak channels.

2. **Gated channels: Have gates that open or close.**

- They are specific allowing passage of only one type of molecule or ion.
- The gated channels are closed during rest by protein acts as a gate that can change their shape to open or close the channels in response to various signals.

Gated channels are classified into:

A. Voltage gated channels: they open or close in response to changes in membrane potential as voltage gated Na^+, K^+ and Ca^{++}.

- **Voltage-gated Na^+ channel:** has two voltage-sensitive gates; outer faster gate called activation gate and an inner slower gate called the inactivation gate.
- **Voltage-gated K^+ channel:** has only one gate at the inner side of the channel and are closed during rest.

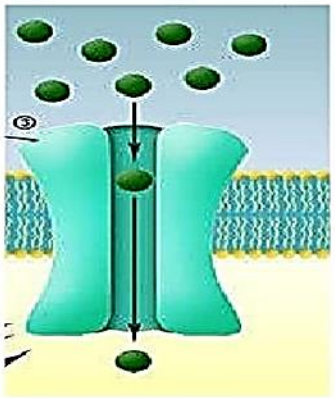
B. Ligand gated channels: they open or close in response to binding to a chemical substance called (ligand), which may be either:

- **External ligands;** binds to the outer surface of the cell membrane as neurotransmitters and hormones. e.g. **Ligand-gated Na^+ channels in the motor end plate**.
- **Internal ligands;** binds to the inner surface of the cell membrane as **Ca^{2+} and cyclic AMP**.

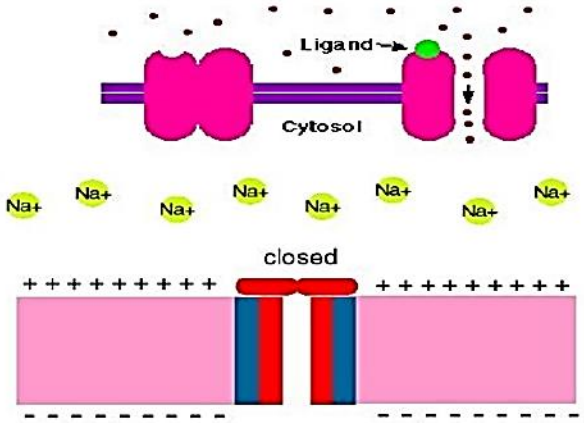
C. Mechanical gated channels: they open or close in response to mechanical stretch or pressure.

Types of channels

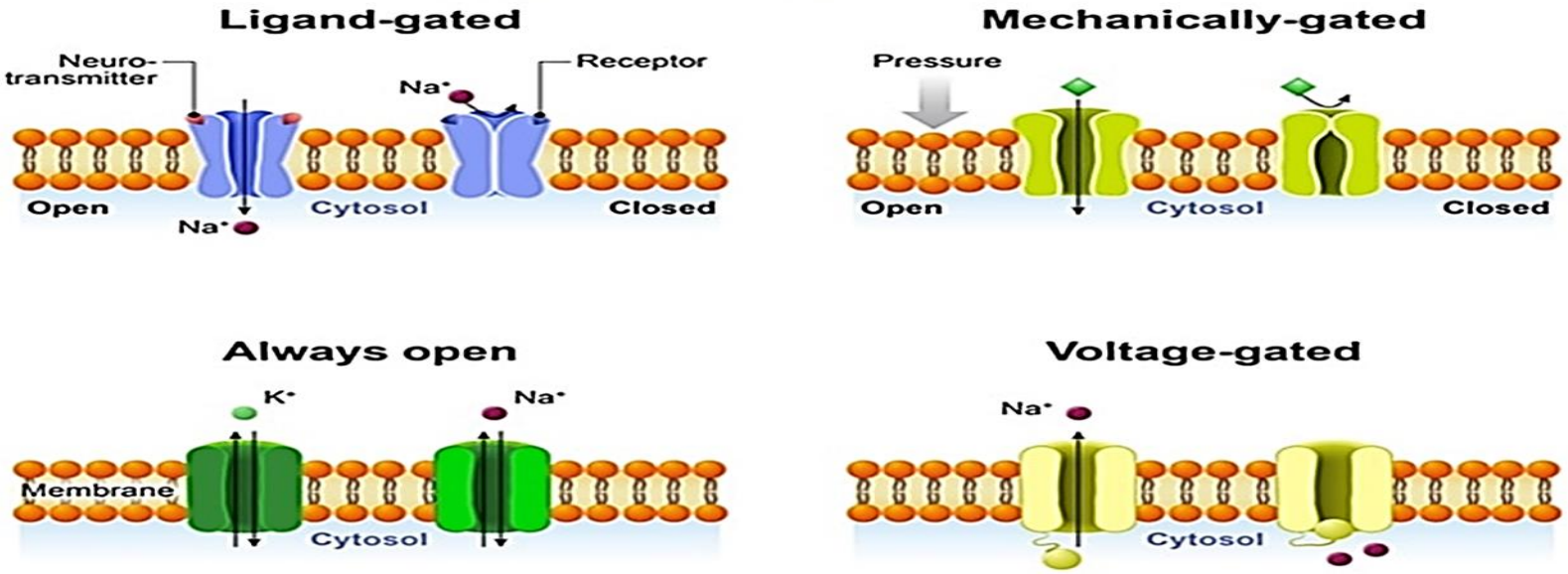
❑ Non-gated channels



❑ Gated channels



ION CHANNEL



TRANSPORT MECHANISMS THROUGH CELL MEMBRANE

The transport mechanisms of the cell membrane try to keep the composition of the fluids in various body compartments constant at optimal cellular activities. In the same time, it tries to supply the cells with the needed materials and to remove the waste products.

Substances can pass through the cell membrane in different ways .

Transport either:

1. Passive:

i.e. No need for energy as substances **move with gradient**.

2. Active:

i.e. Need energy **(ATP)** as substances **move against gradient**.

TRANSPORT

Passive	Active
- Doesn't need energy	- Needs energy
- Needs gradient (difference)	- Doesn't need gradient
- Examples: 1. Diffusion: - Simple diffusion - Facilitated diffusion 2. Filtration 3. Osmosis	- Examples: 1. Active transport: a. Primary active transport b. Secondary active transport 2. Vesicular transport: a. Exocytosis b. Endocytosis

1. FILTRATION

Definition

- It is a process by means of which a **fluid (with its dissolved molecules)** is forced to pass through a **semipermeable** membrane due to a **difference of pressure** (Pressure gradient) on the two sides of the membrane.
- It is a **Passive** mechanism (**no** energy needed).

- **The amount of filtered fluid/unit time is directly proportional to:**

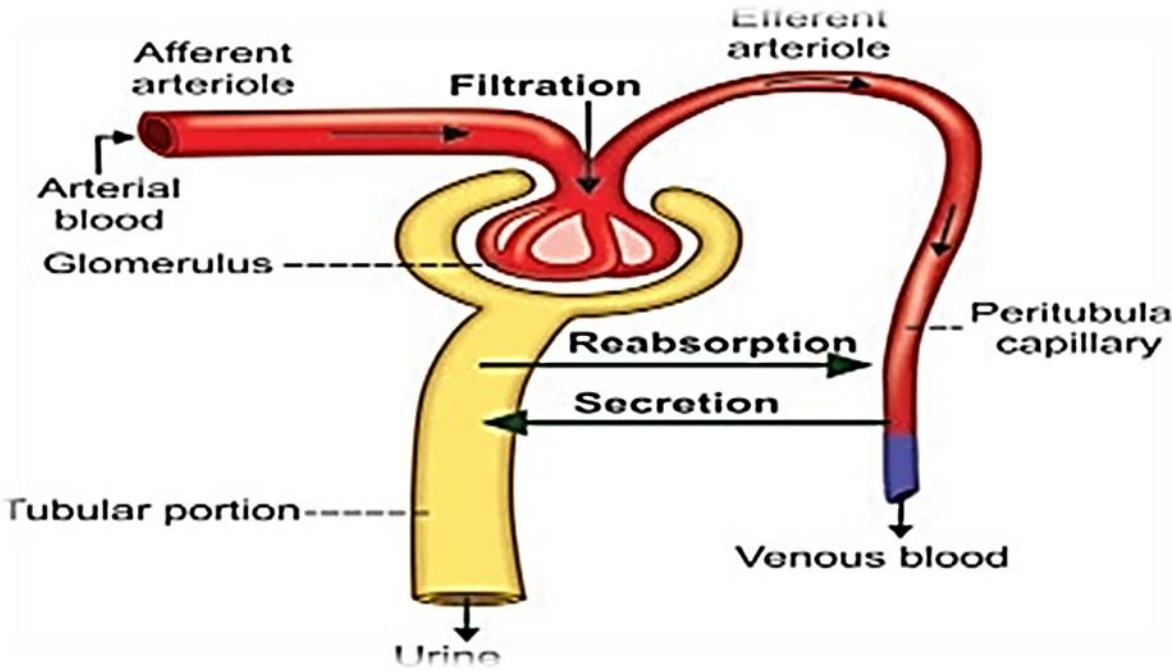
1. The pressure gradient.
2. The surface area of the membrane.
3. The permeability of the membrane.

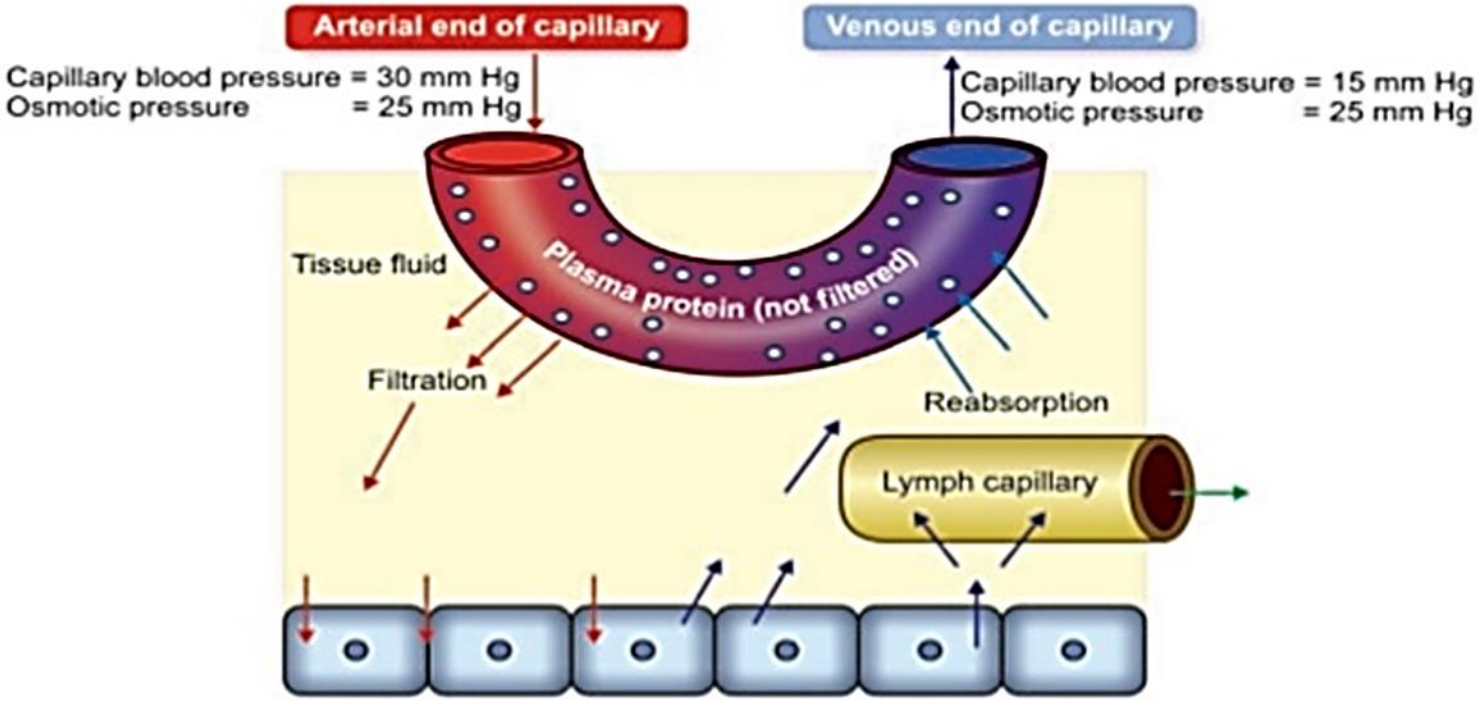
Importance:

1. Filtration of plasma to form **tissue (interstitial) fluid**.
2. Filtration of plasma in the kidney → **urine formation.**

FILTRATION:

Movement of water and solutes from an area of high hydrostatic pressure to an area of low hydrostatic pressure is called Filtration.

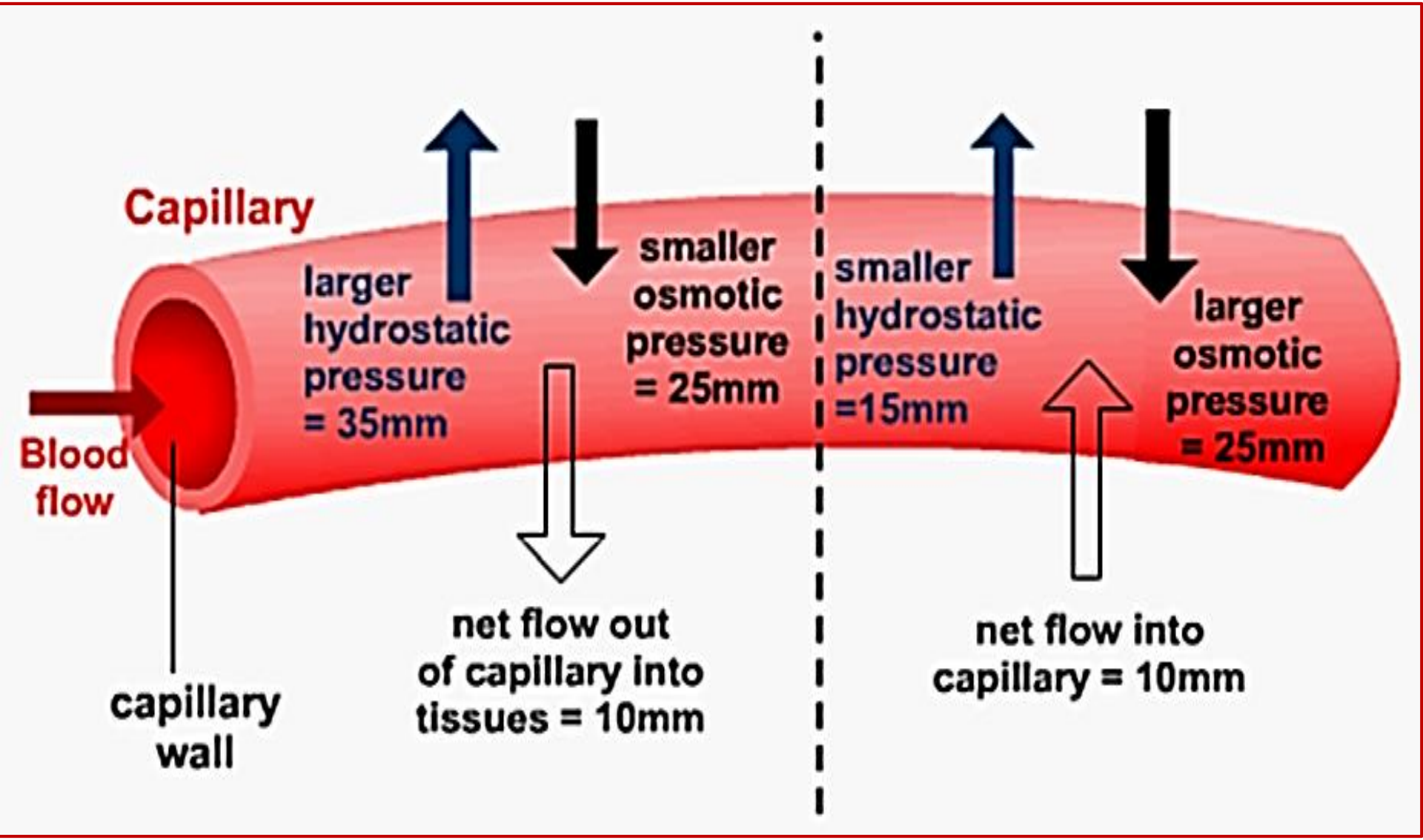




- Inside the body, the exchange of fluids and materials occurs at the level of capillaries where, there is nearly a balance between filtration force (Hydrostatic capillary pressure) and the absorbing force (Plasma osmotic pressure), i.e. the amount of fluid filtered at the arterial end of the capillary = the amount absorbed at the venous end of the capillary.

- So, the volume of different water compartments (ECF and ICF; extra- and intra cellular fluids) is kept constant.

Fluid exchange through the blood capillary




THANK
YOU