Chapter 8

Membrane Structure & Function

1. Membrane Structure

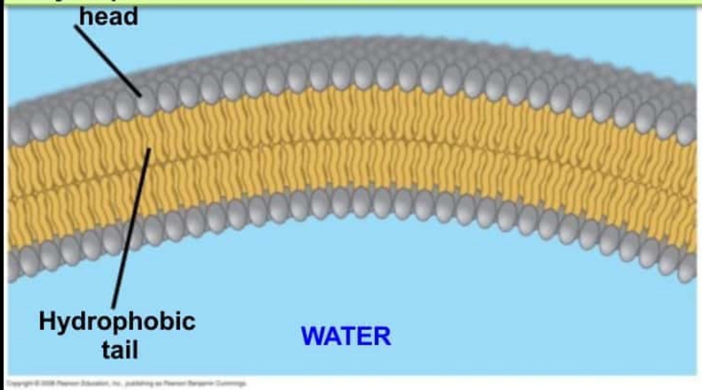
2. Transport Across Membranes

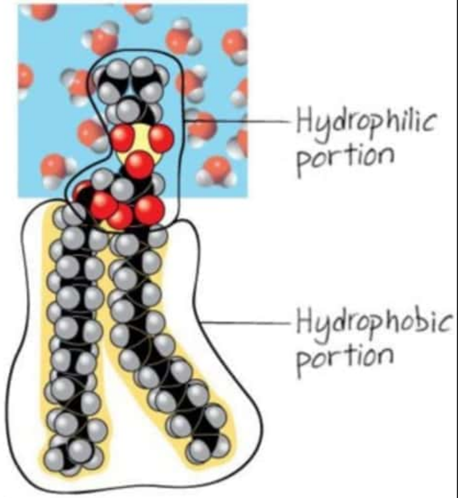
Prof. Dr. Samih Tamimi

Please carefully read the pages covering these topics in your text book

What are Biological Membranes?

They're basically a 2-layered sheet of phospholipids with some proteins & cholesterol.



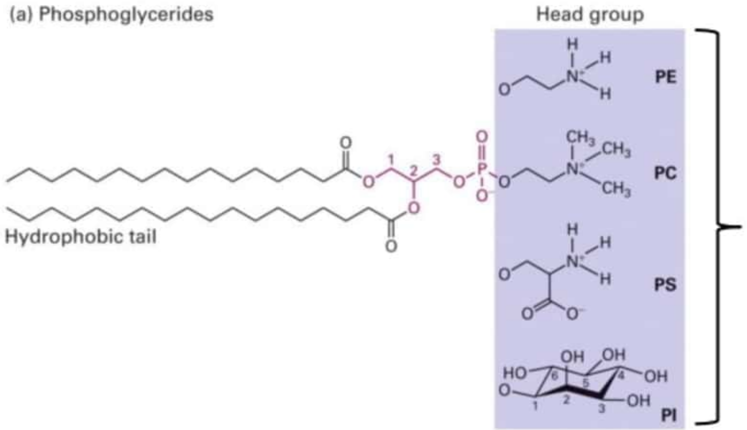


Why phospholipids?

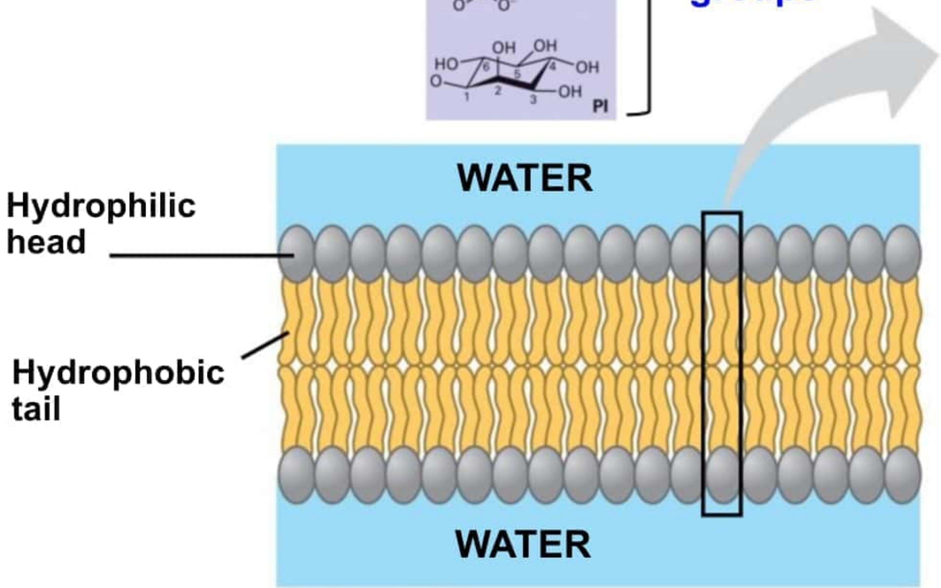
Because they are amphipathic - i.e., part is hydrophilic and part is hydrophobic.

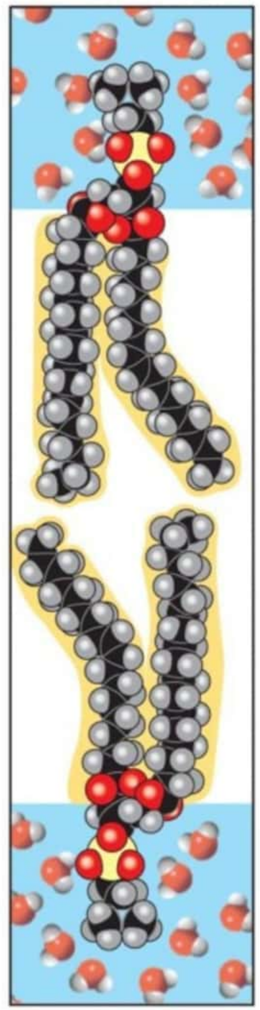
They self-assemble spontaneously into a variety of organized structures, one of which is a lipid bilayer.

Phospholipids



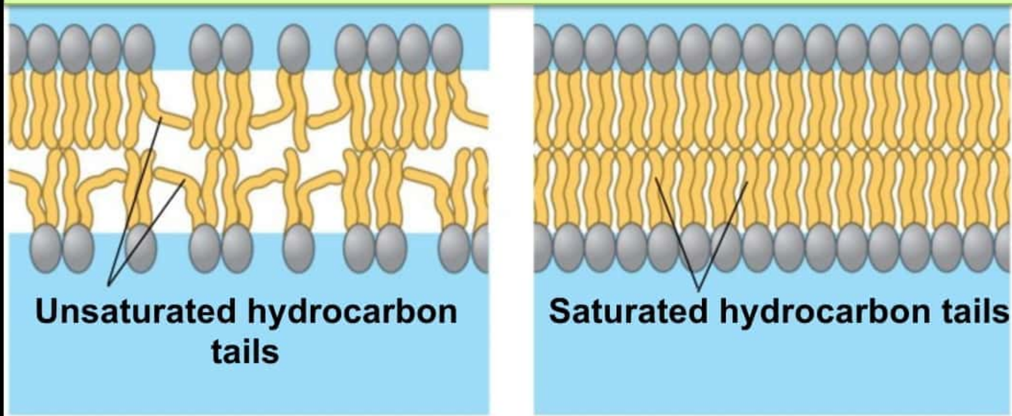
phospholipids have a variety of polar head groups





Membrane Viscosity

Fluid Viscous



(a) Unsaturated versus saturated hydrocarbon tails

TEMPERATURE

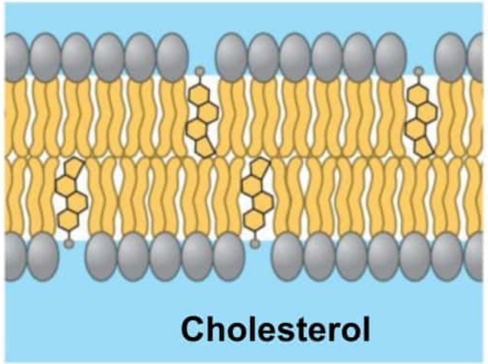
higher temp = lower viscosity

SATURATION

more saturation of HC tails = more viscosity

(b) Cholesterol within the animal cell membrane

Act as fluidity buffer



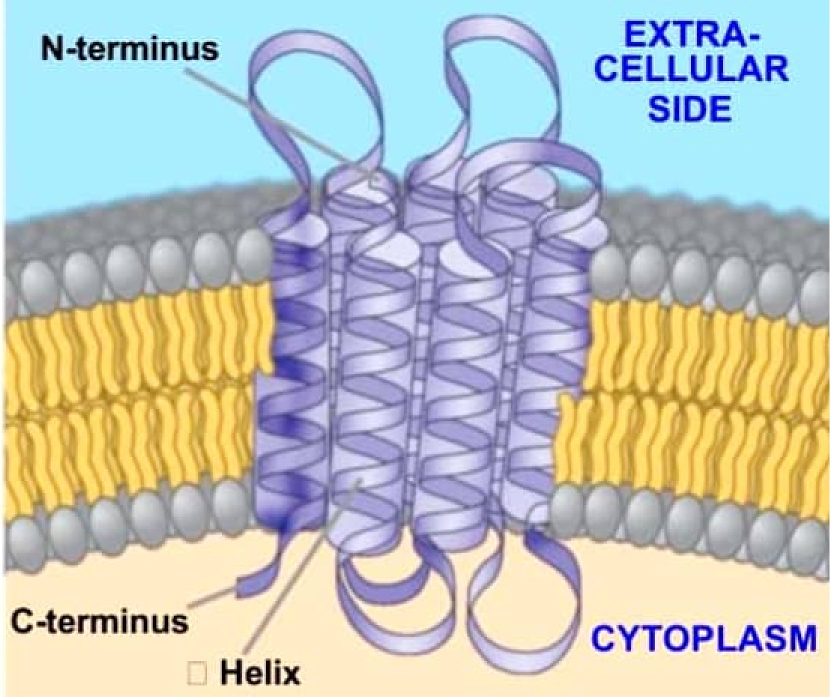
CHOLESTEROL

increases viscosity at higher temp, prevents hardening at lower temp

Membrane Proteins

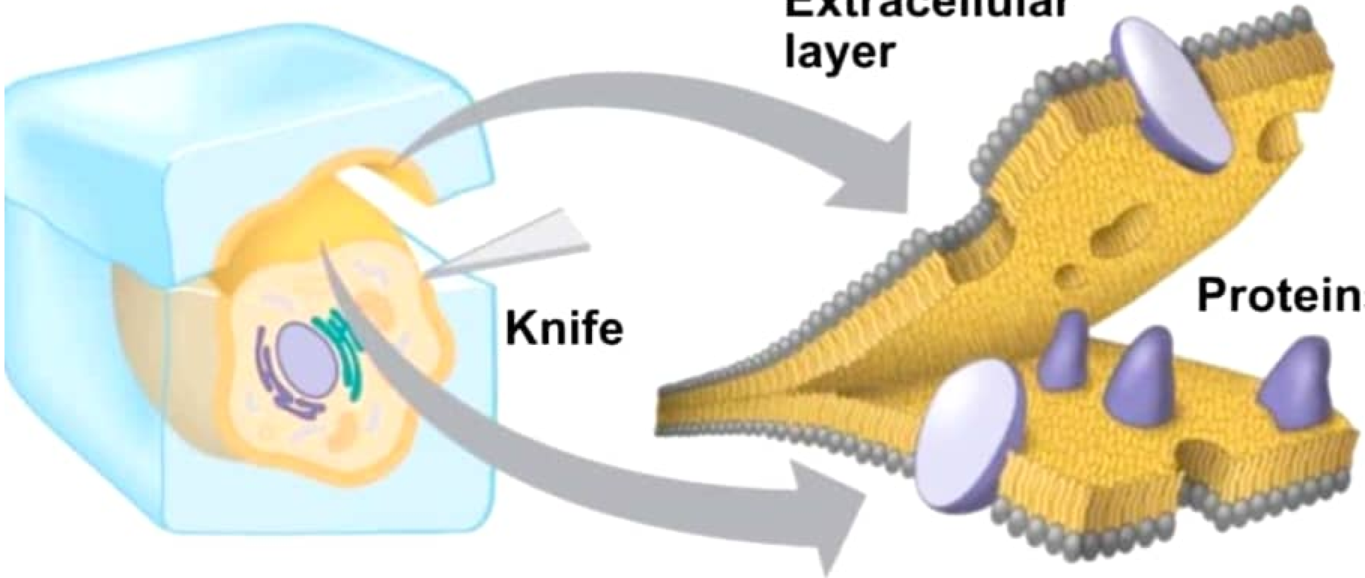
Membrane proteins may penetrate the interior of the membrane (integral) or interact with it externally (peripheral).

- **the portions of a membrane protein that interact with the hydrophobic interior contain non-polar R groups**



FREEZE FRACTURE

TECHNIQUE



RESULTS

Inside of extracellular layer

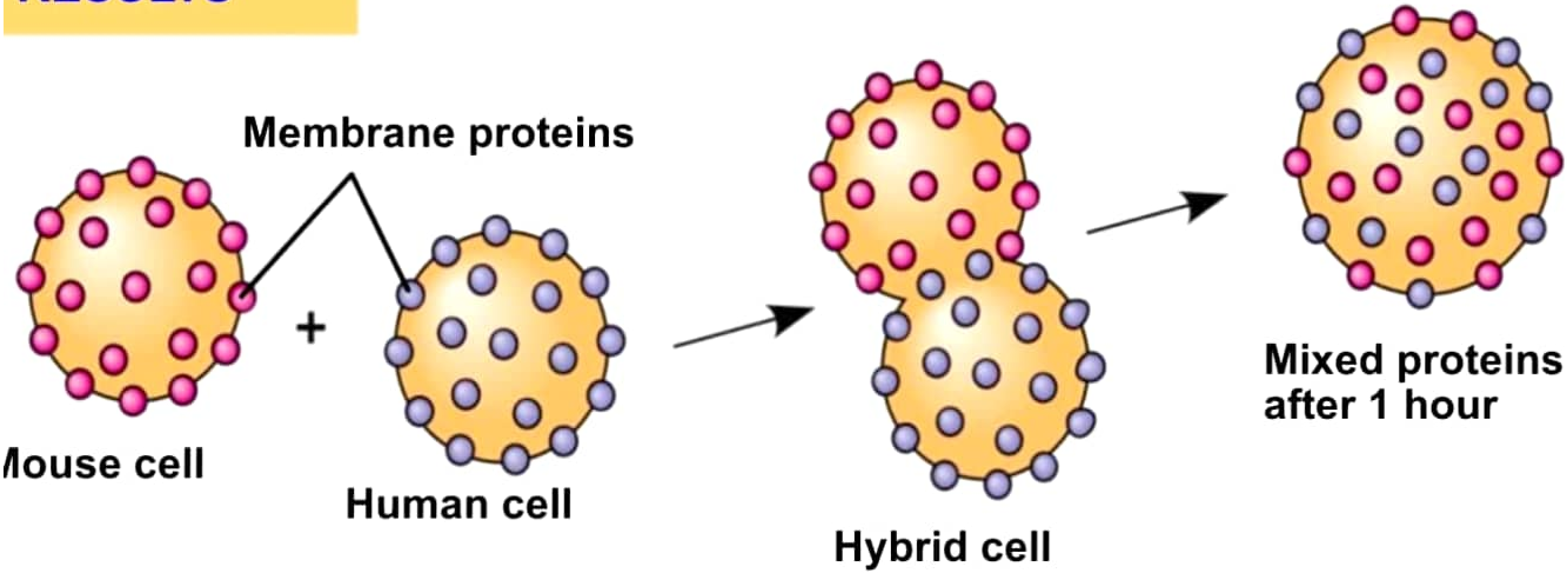
Inside of cytoplasmic layer

The Fluid Mosaic Model

This model (hypothesis) proposes that proteins are scattered within a membrane and can move freely within the plane of the membrane.

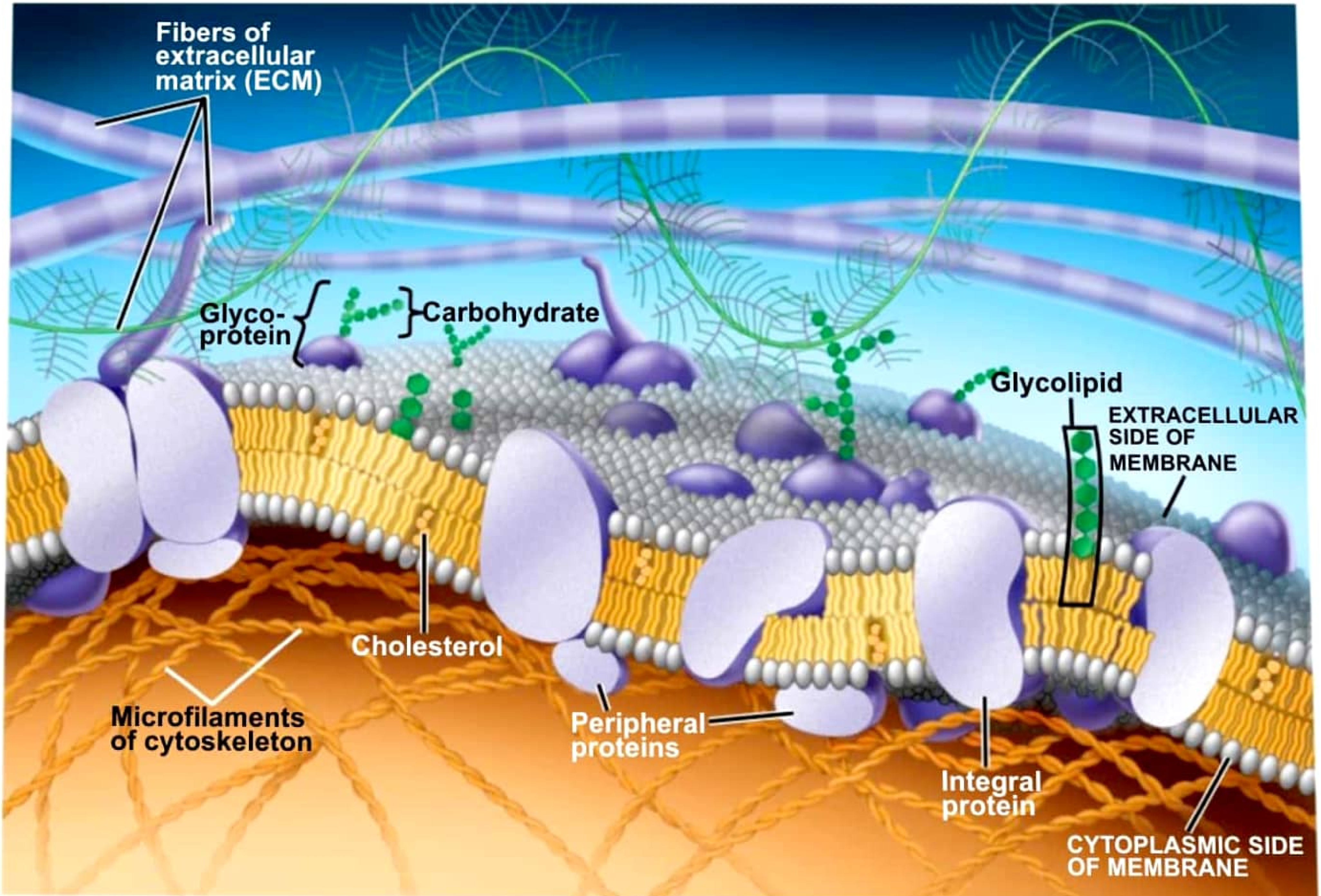
- **supported by the experiment shown below**

RESULTS

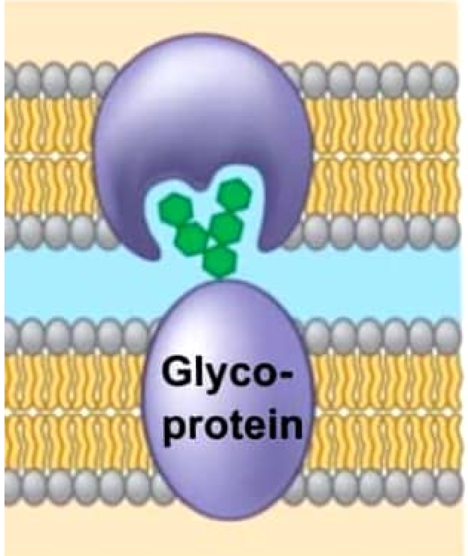


*****some proteins are "fixed" by attachment to cytoskeleton or ECM*****

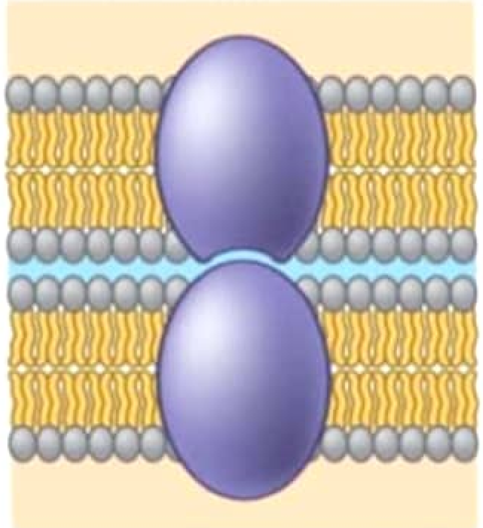
Model of Membrane Structure



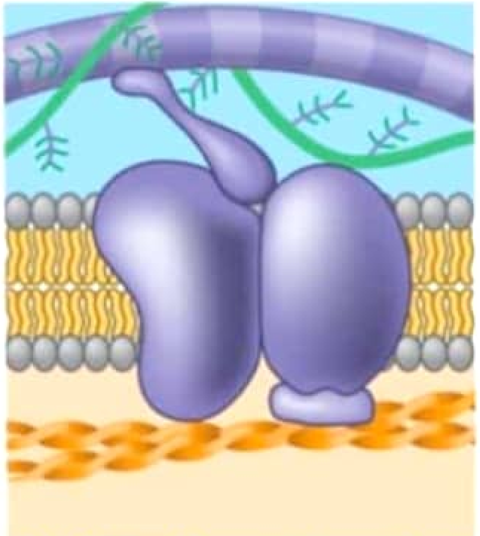
Main Roles of Membrane Proteins



(a) Cell-cell recognition

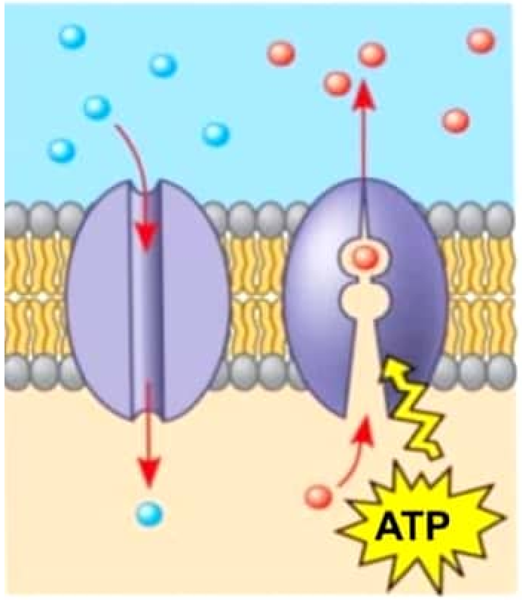


(b) Intercellular joining

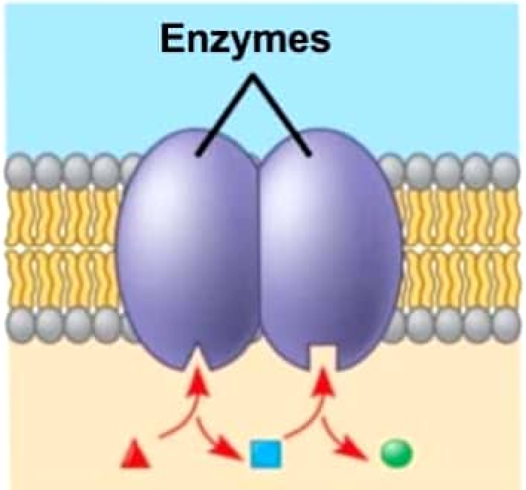


(c) Attachment to the cytoskeleton & ECM (extracellular matrix)

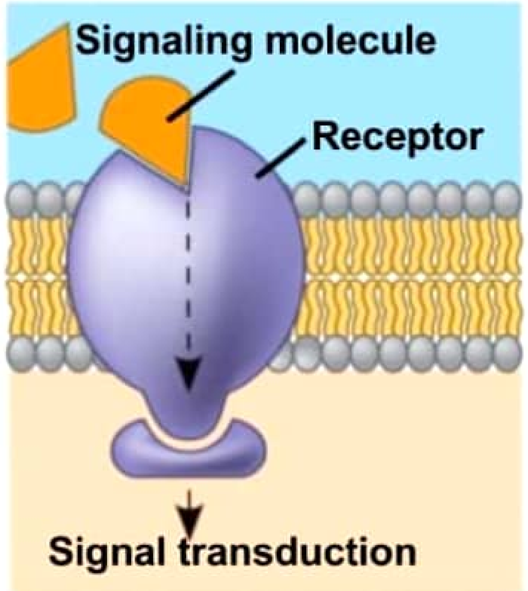
These are the most common, though there are many other functions for membrane proteins.



(d) Transport

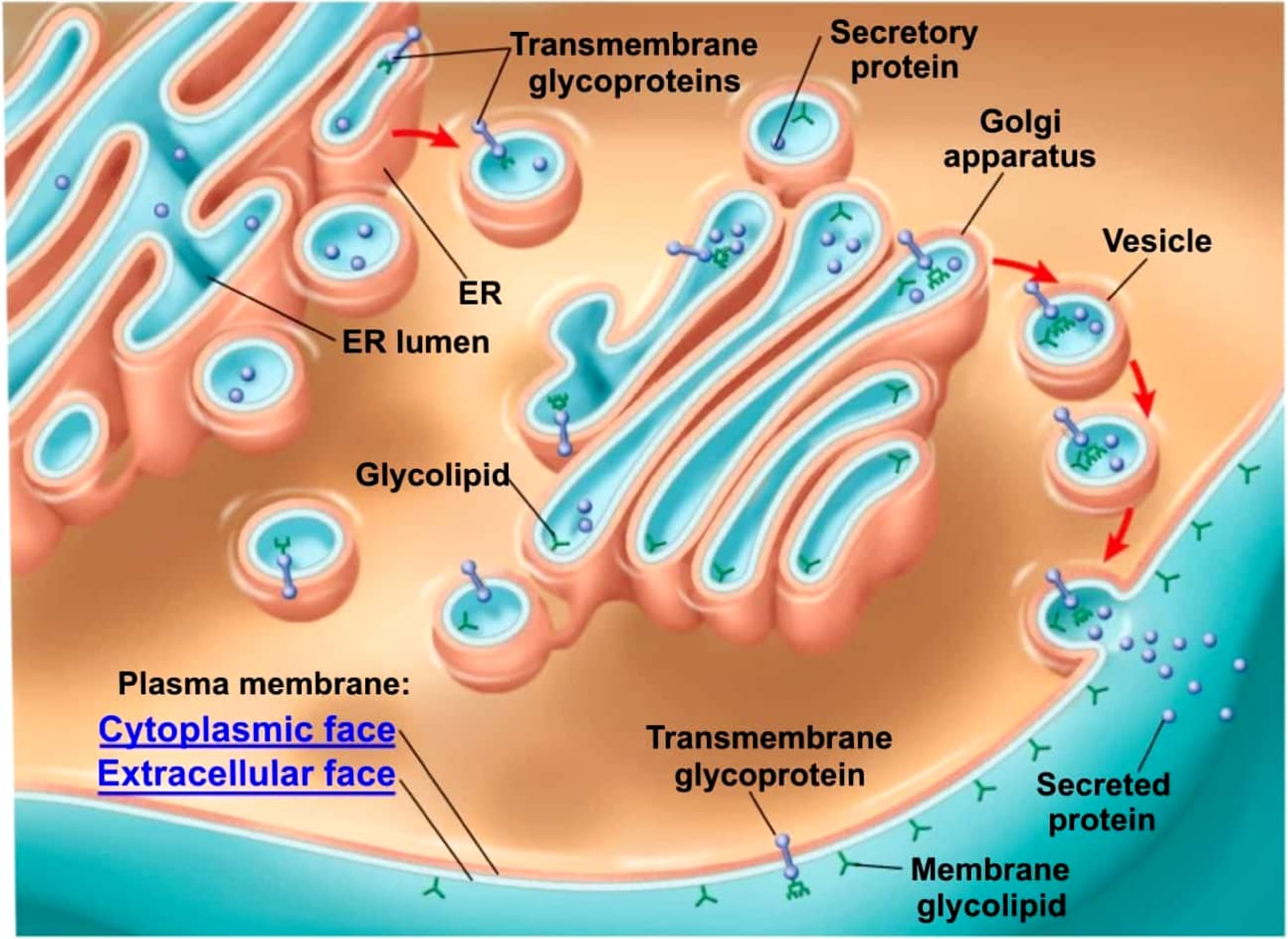


(e) Enzymatic activity



(f) Signal transduction

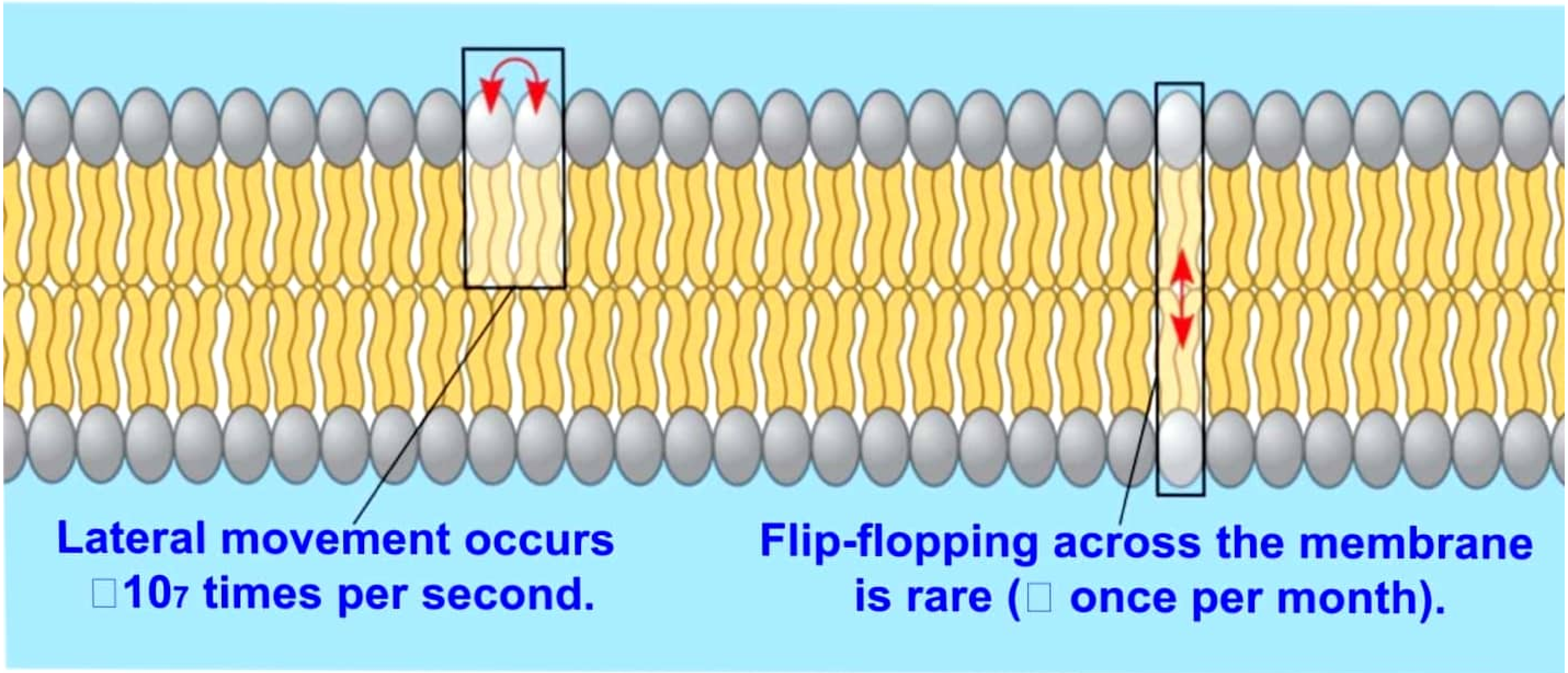
Membrane Orientation



Membrane “Faces” are Different

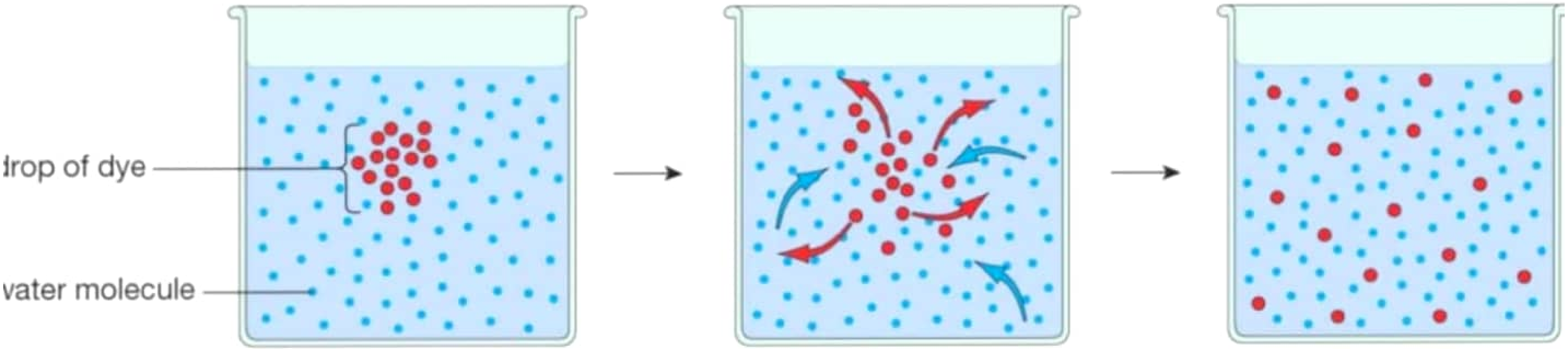
While phospholipids move freely and rapidly within a given layer or “face”, they rarely switch layers.

- **phospholipid composition of cytoplasmic vs extracellular face is different & is set up in the ER**



2. Transport Across Membranes

Diffusion

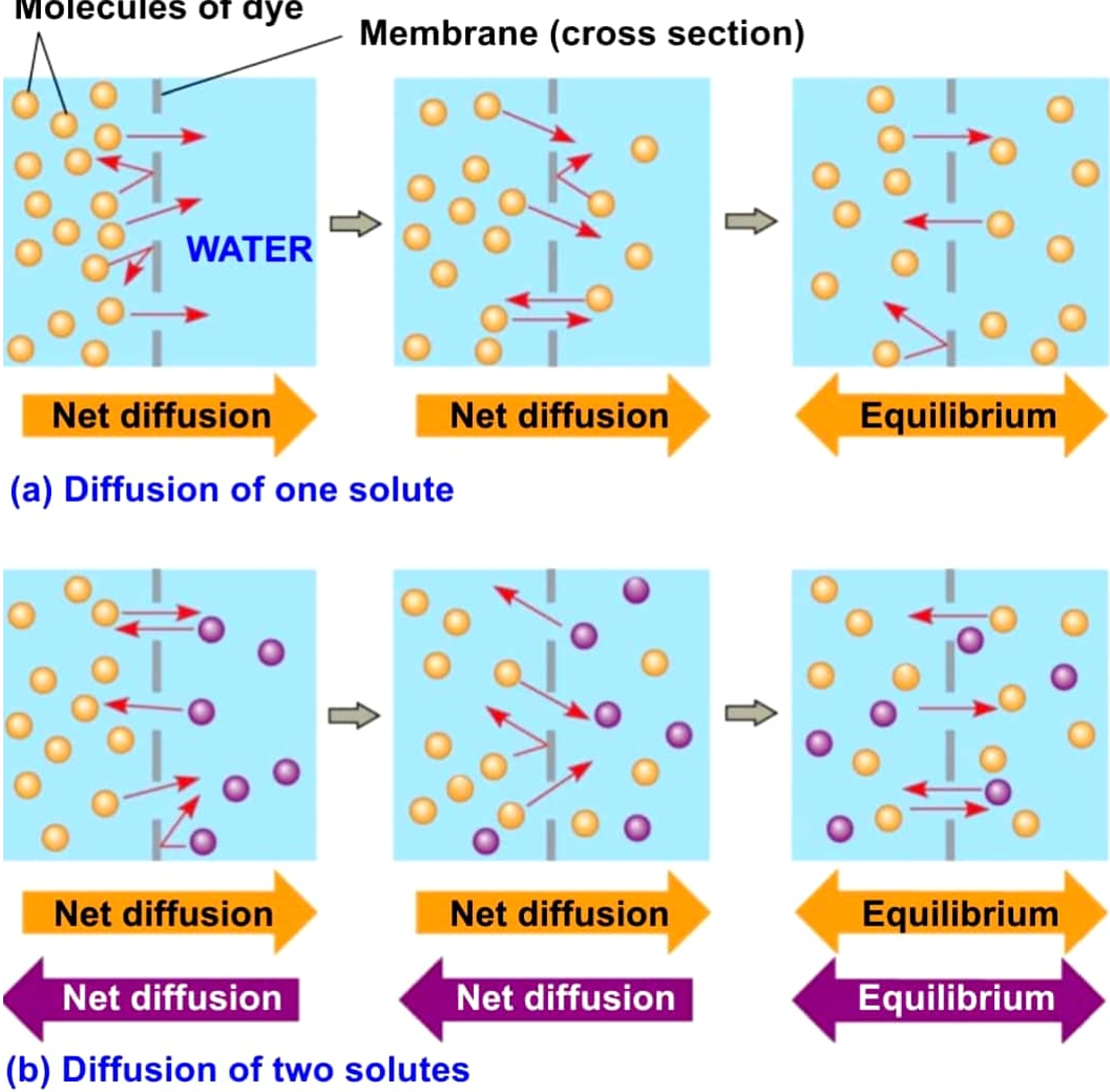


Diffusion is the net or overall movement of a substance from <u>higher</u> to <u>lower</u> concentration

- **molecules dissolved in liquid move randomly**
- **over time the net effect is equal dispersion of the molecules (provided there is no barrier)**

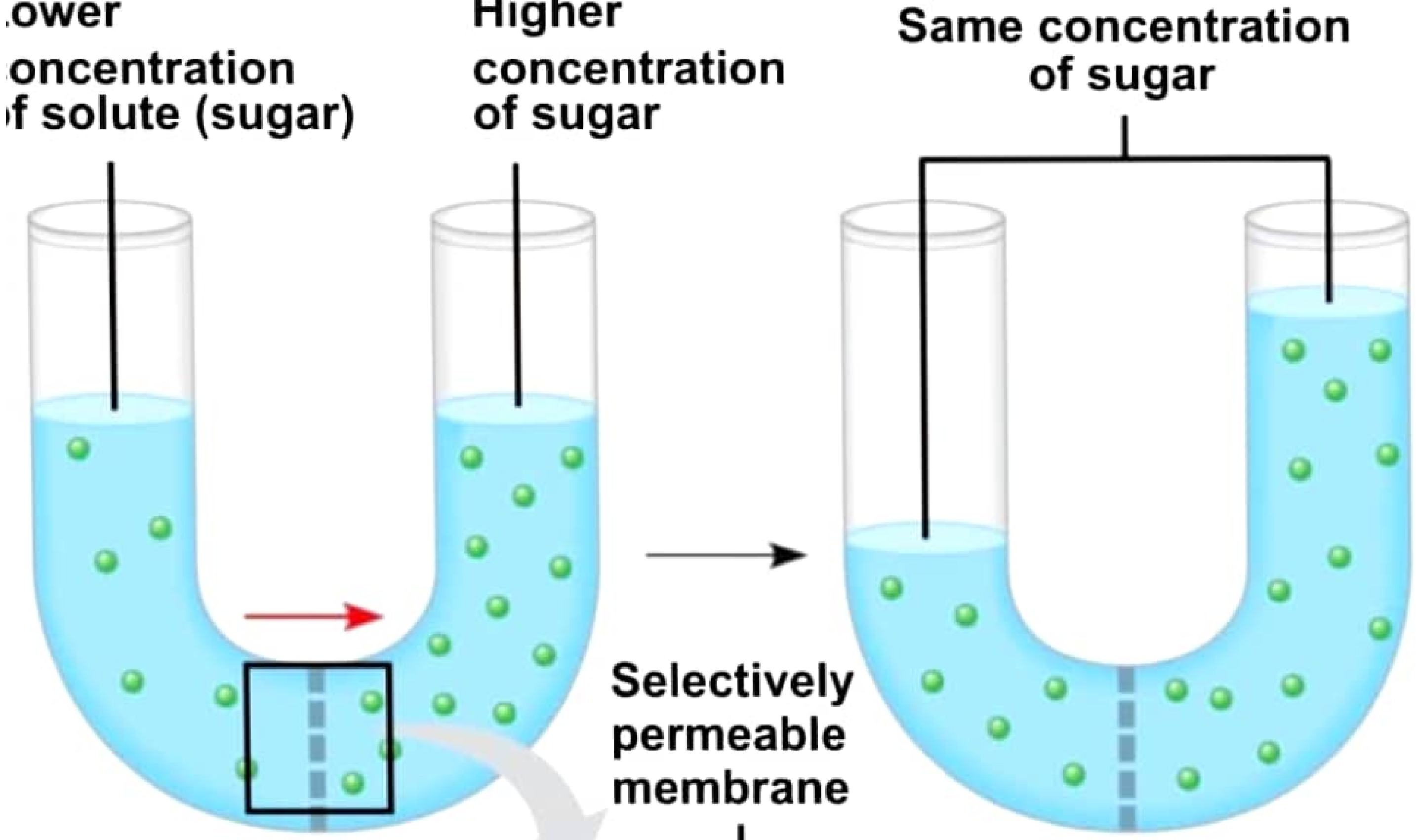
- **aka "moving <u>down</u> concentration gradient"**

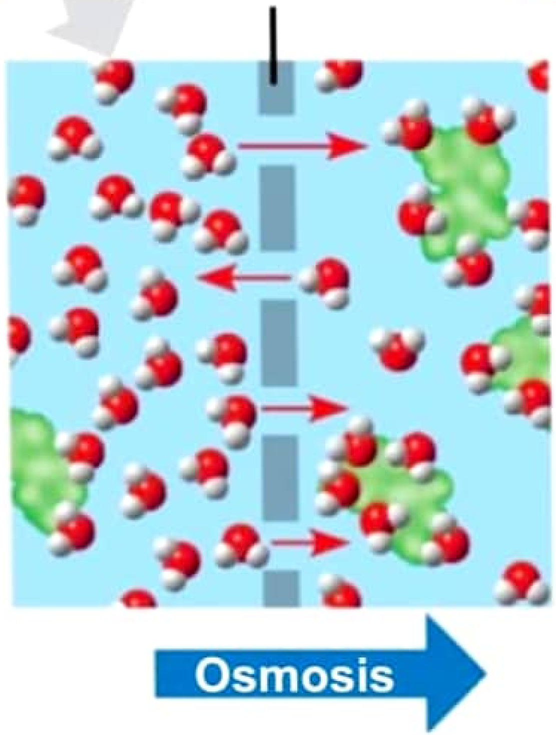
Diffusion across a permeable barrier



As long as there is nothing to block the passage of solutes, the 2 compartments will reach equilibrium

Diffusion across a selectively permeable barrier



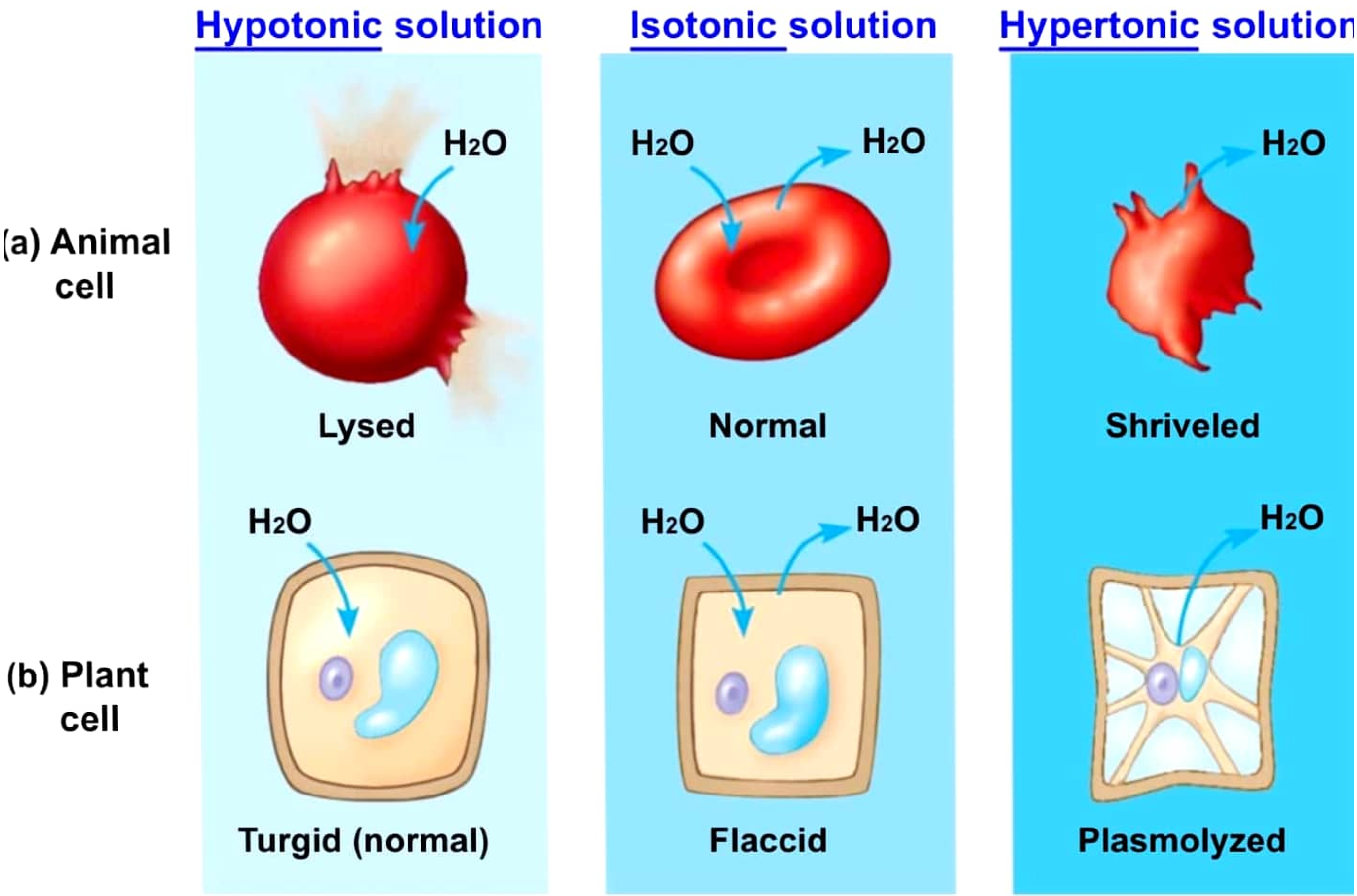


OSMOSIS is the diffusion of water across a selectively permeable membrane

The barrier allows water (solvent) to pass freely while the sugar (solute) cannot pass

- the net flow of water from [high] to [low] creates osmotic pressure on one side of the barrier

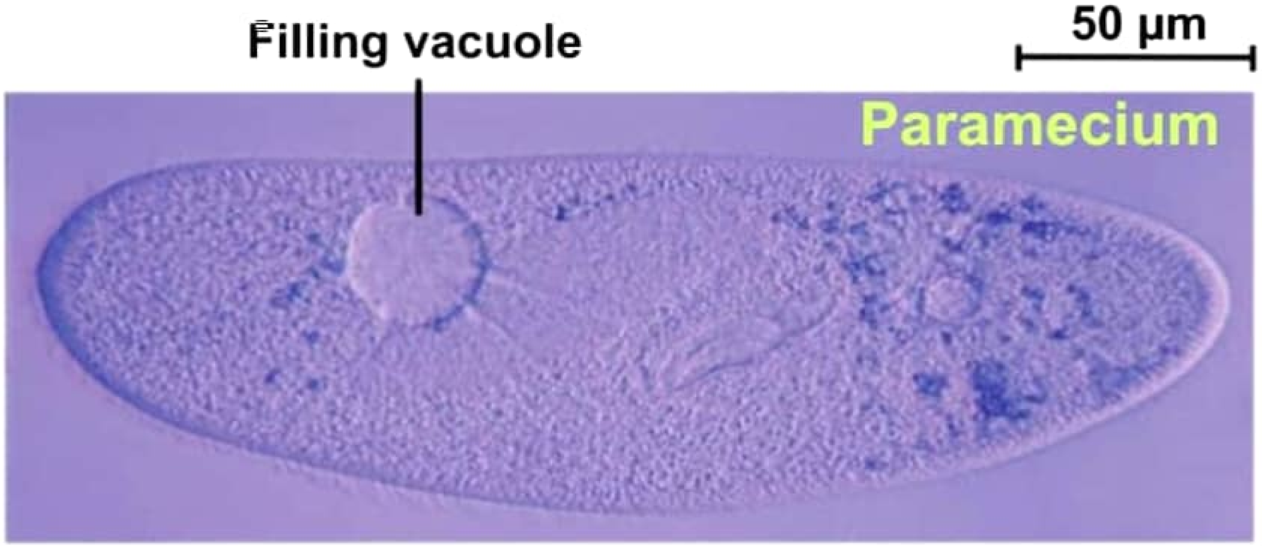
Osmosis and Cells



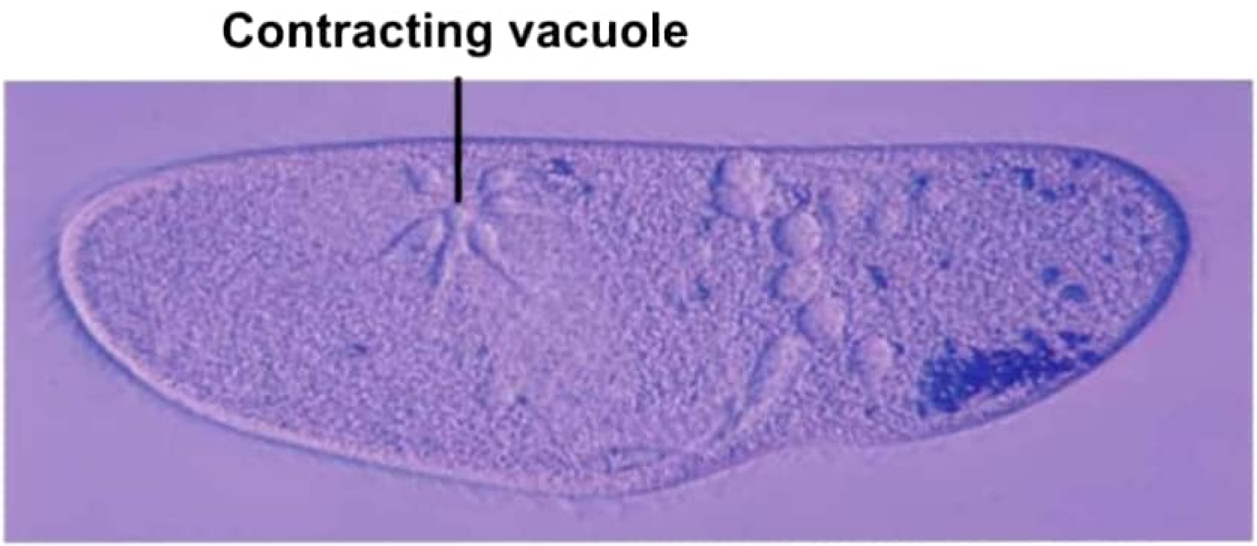
Combating Osmotic Pressure

Unicellular freshwater organisms that lack cell walls (such as many protozoa) are vulnerable to <u>osmotic lysis</u> (<u>osmolysis</u>).

<u>Contractile</u> <u>vacuoles</u> provide protection by taking on excess water and releasing it externally by exocytosis.



(a) A contractile vacuole fills with fluid that enters from a system of canals radiating throughout the cytoplasm.



(b) When full, the vacuole and canals contract, expelling fluid from the cell.

"Small-scale" Transport

Cells accomplish membrane transport on a "small scale" (molecule by molecule) in 3 basic ways:

1) passive transport (simple diffusion)

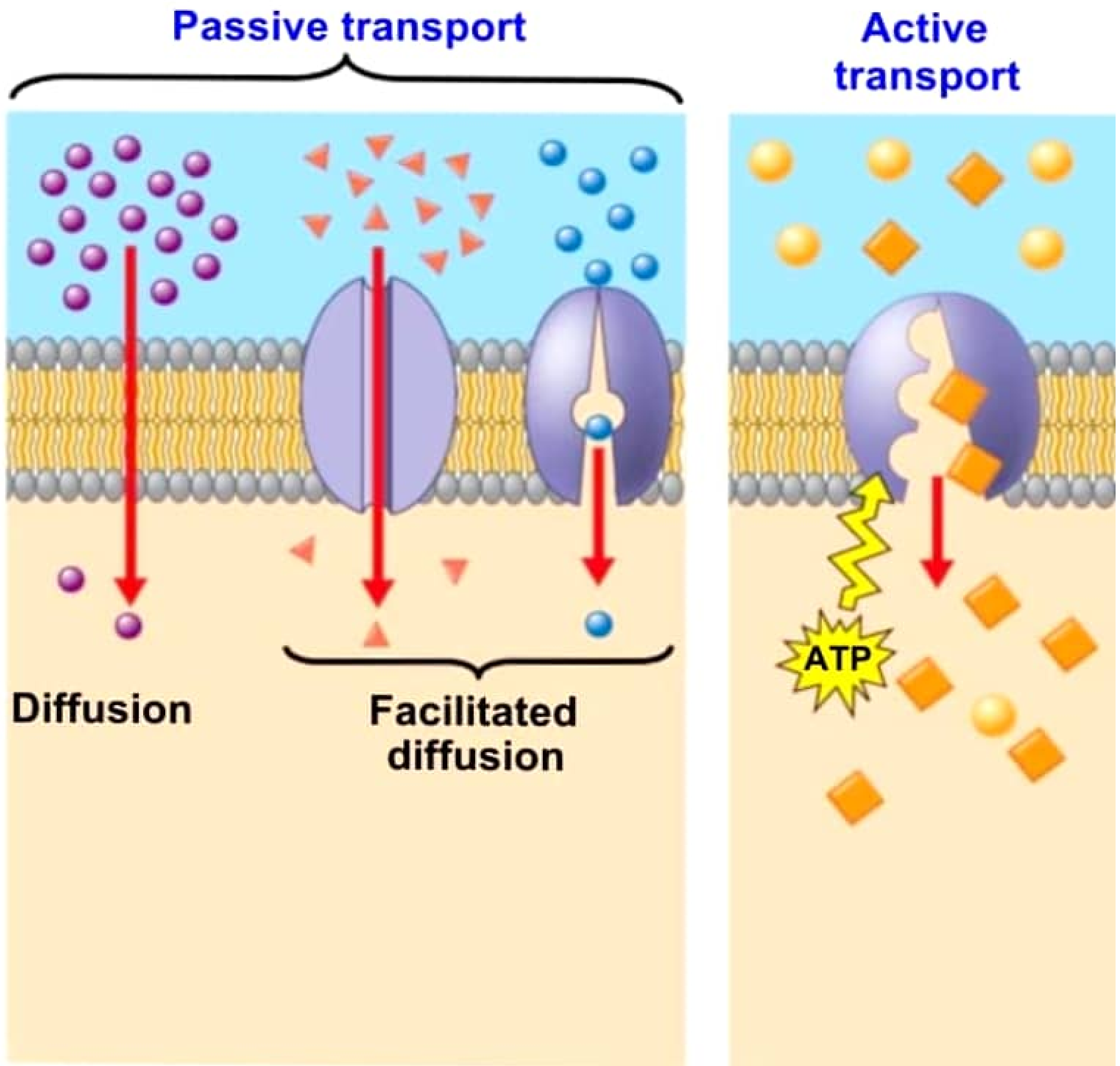
- diffusion directly through the membrane bilayer

2) facilitated diffusion

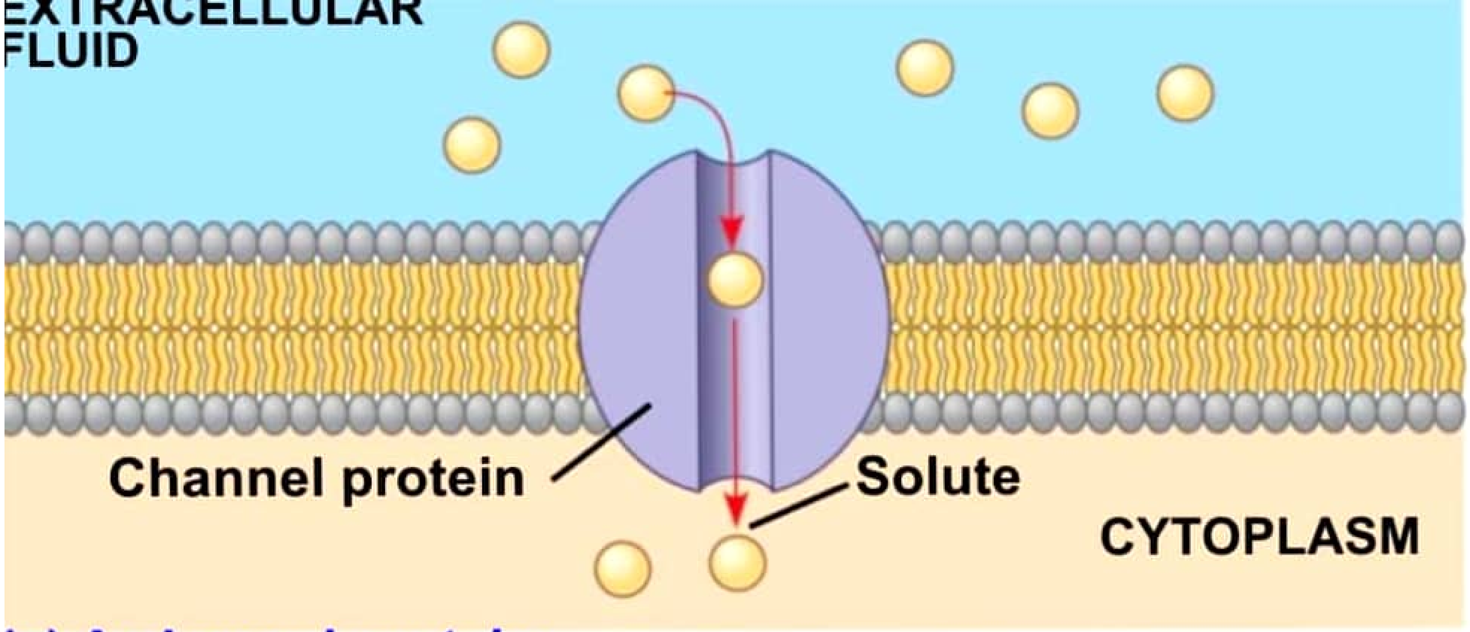
- diffusion with the help of specific membrane proteins

3) active transport

- movement from low to high concentration
- requires special membrane proteins and <u>energy</u>

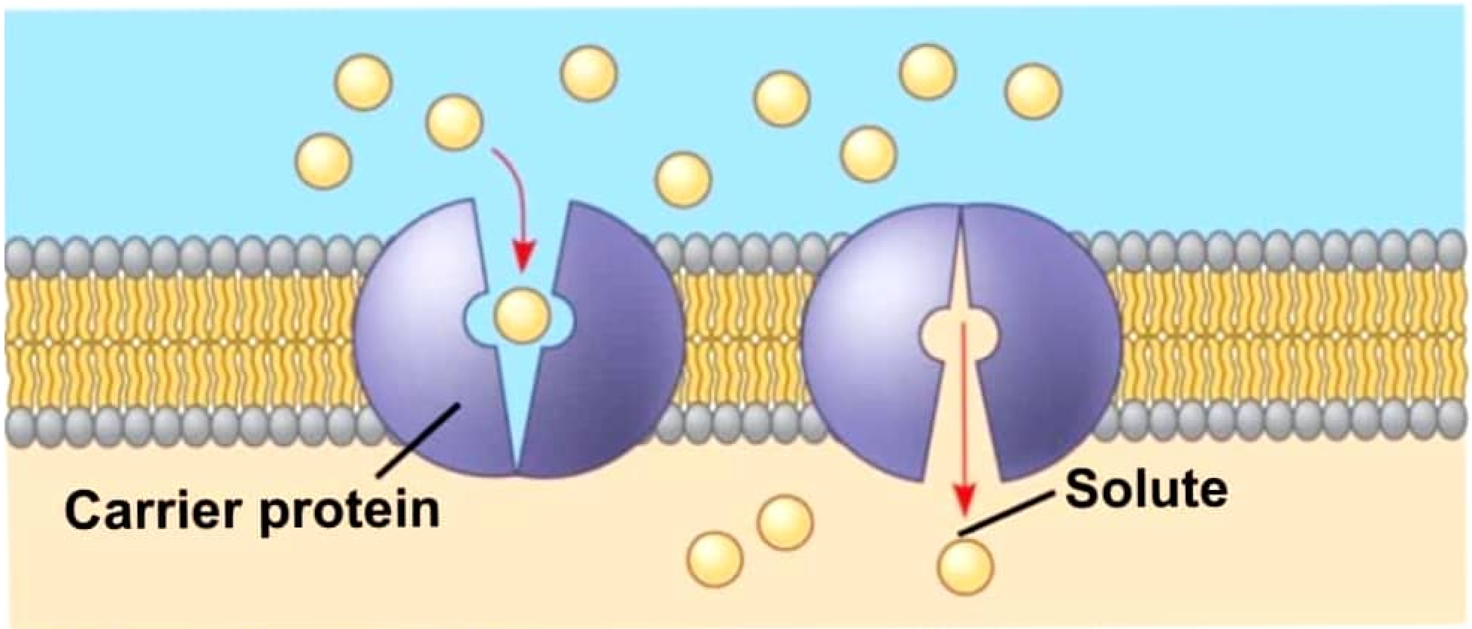


Facilitated Diffusion



(a) A channel protein

CHANNEL PROTEINS, some of which are gated, allow the passive transport of small molecules such as ions

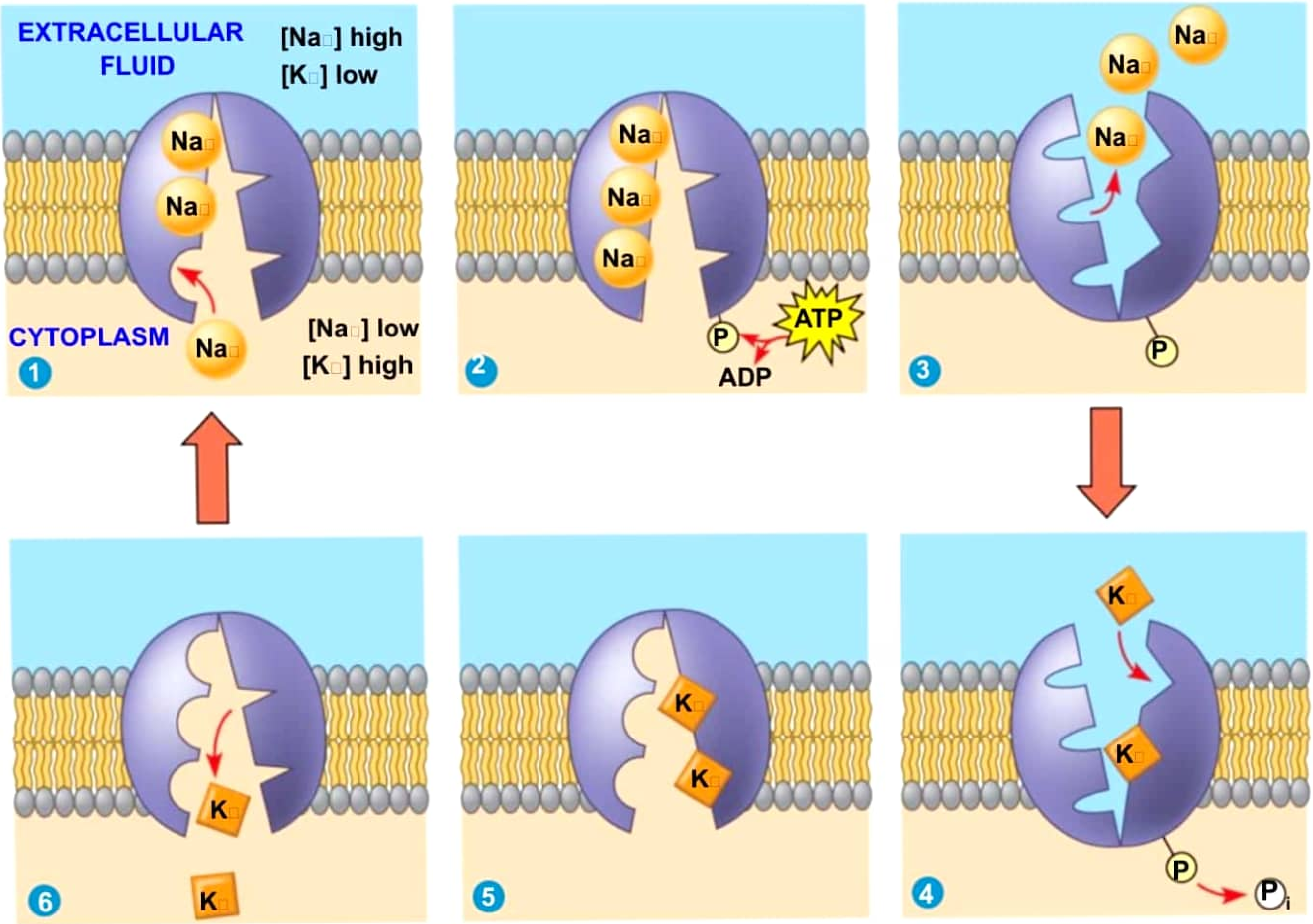


(b) A carrier protein

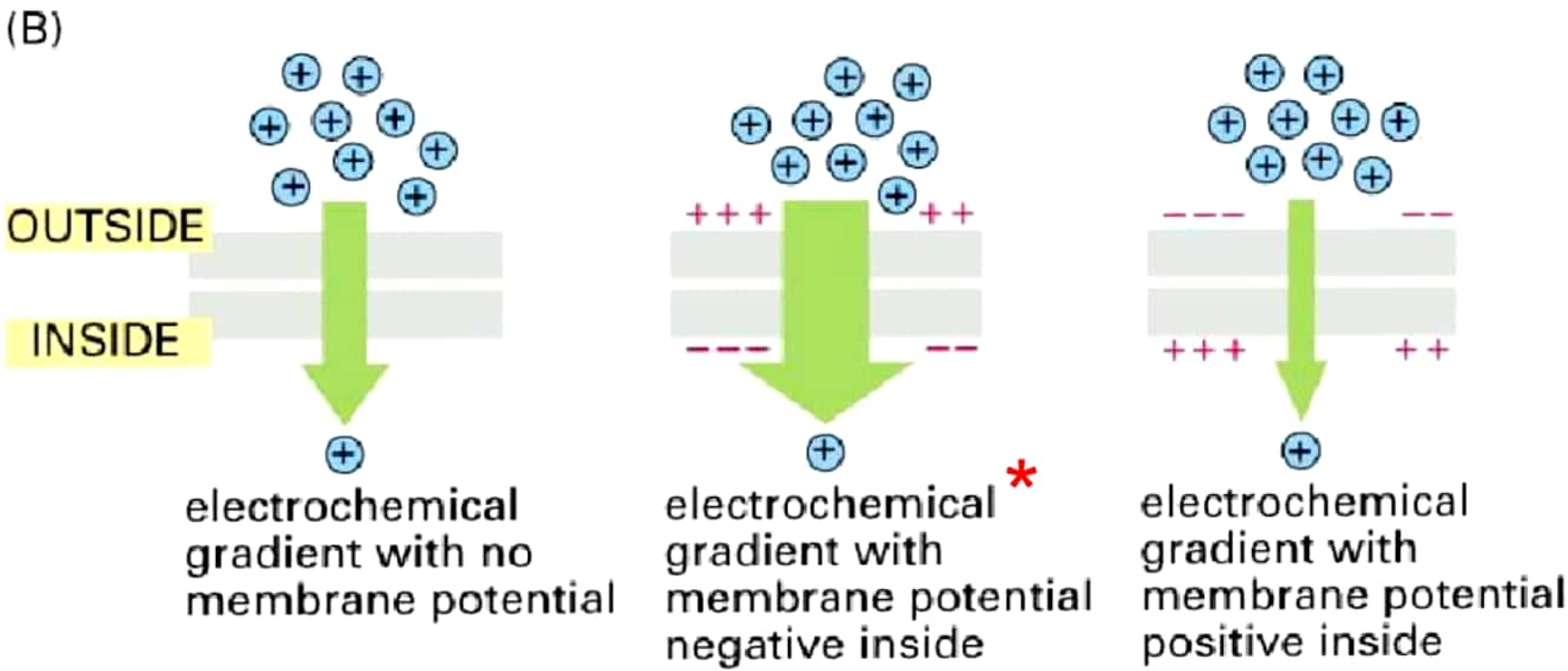
CARRIER PROTEINS bind to specific solutes and change conformation to release the solute on the opposite side

- works both directions with overall movement from [high] to [low]

The Sodium-Potassium Pump



Ion Transport & Membrane Potential



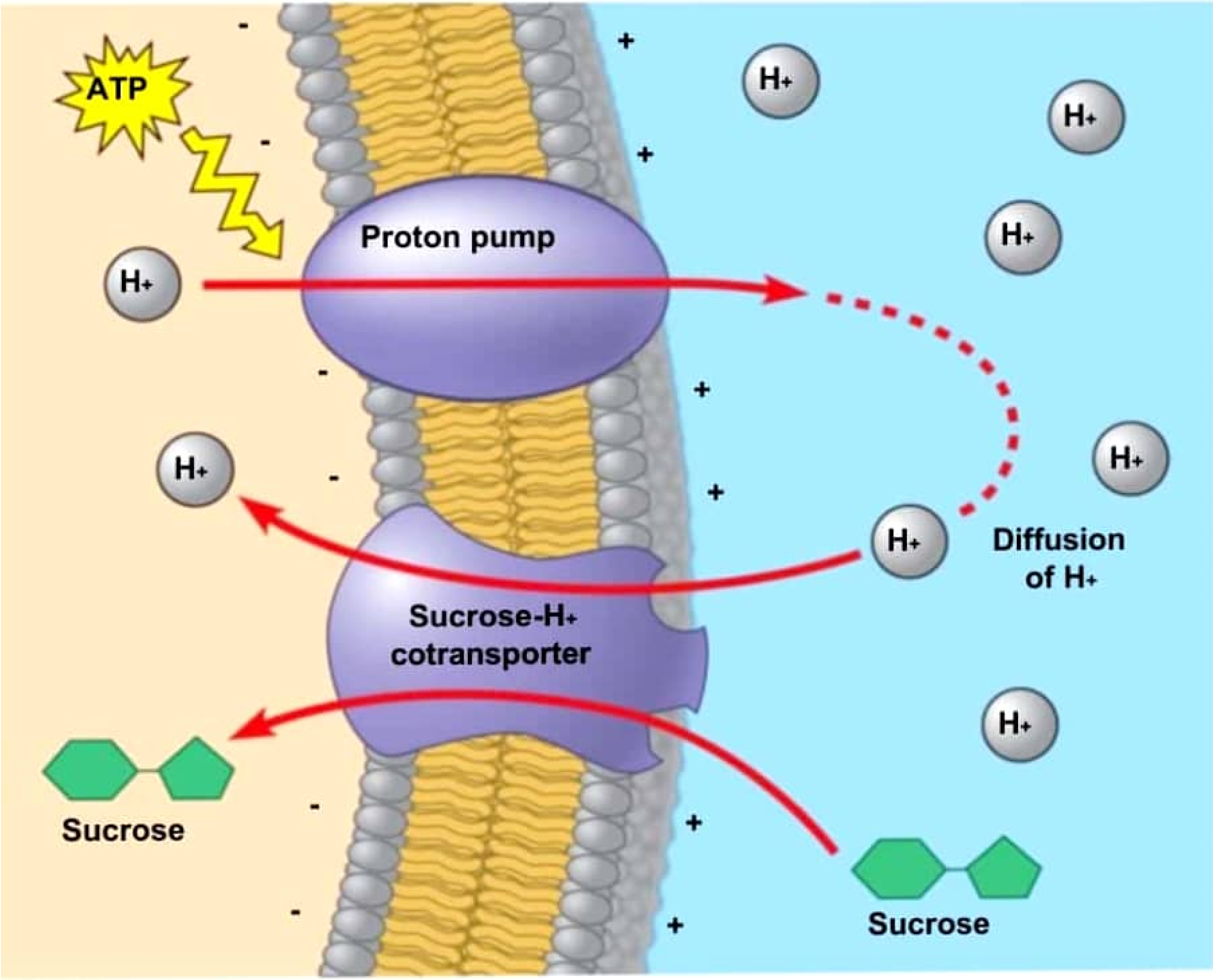
*cells normally have a negative membrane potential

Ion diffusion is driven by differences in concentration & charge across a membrane (electrochemical gradient)

- **i.e., electrochemical gradient**

Cotransport

Active Transport can be fueled by ATP or other energy-rich molecules, OR by the <u>cotransport</u> of another molecule down its concentration gradient



- this example shows how plants carry out the active transport of sucrose into vascular cells for distribution to the rest of the plant

- ATP is still required for this process since it is used to set up the proton gradient sucrose transport depends on

“Large-scale” Transport

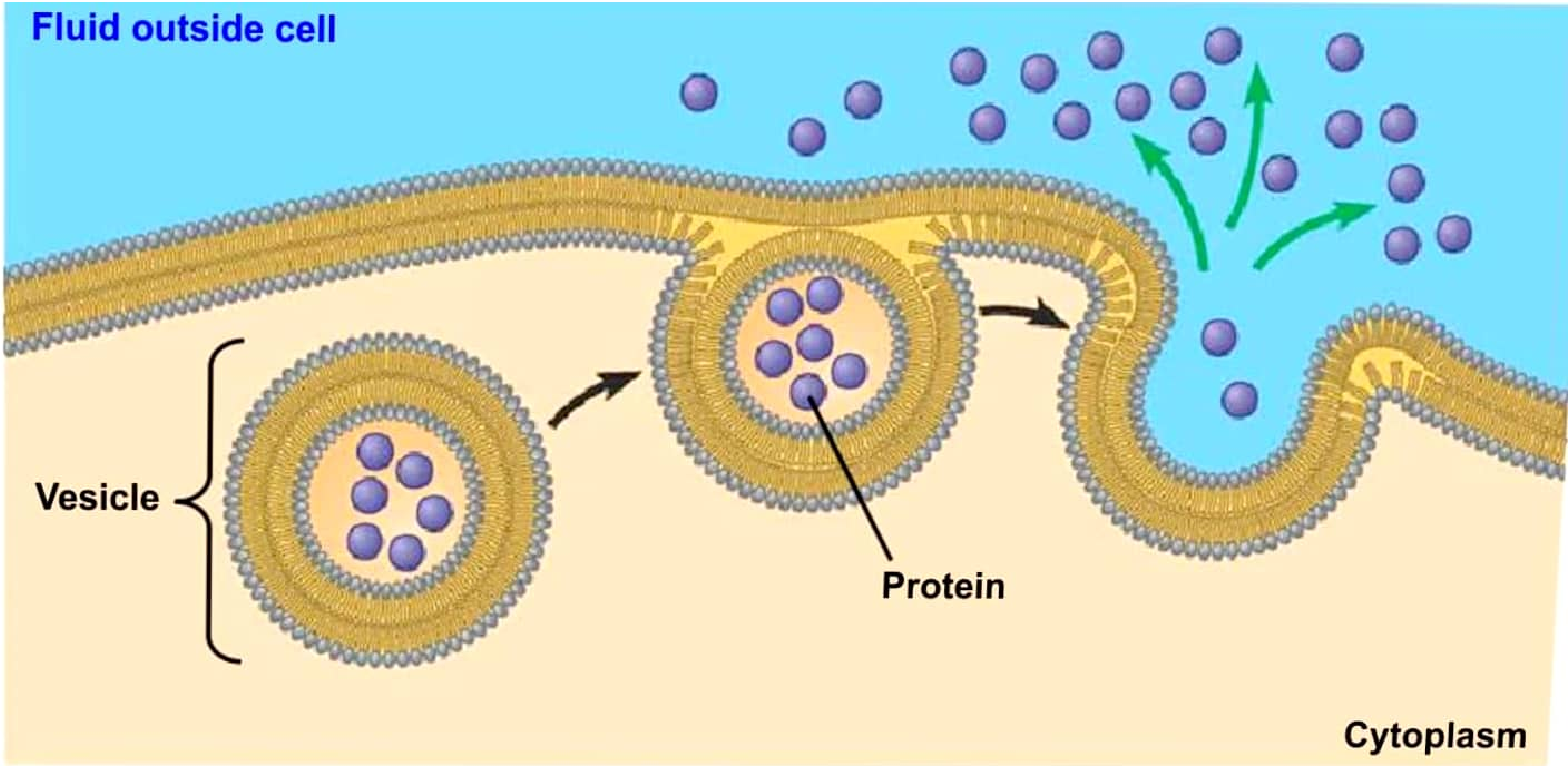
Cells accomplish membrane transport on a “large scale” (in bulk) in 2 basic ways:

1) exocytosis

- **release of material packaged in membrane vesicles to the outside of a cell**

2) endocytosis

- **ingestion of large objects or large amounts of material by enclosing within a membrane vesicle:**
  - **PINOCYTOSIS**
  - **PHAGOCYTOSIS**
  - **RECEPTOR-MEDIATED ENDOCYTOSIS**



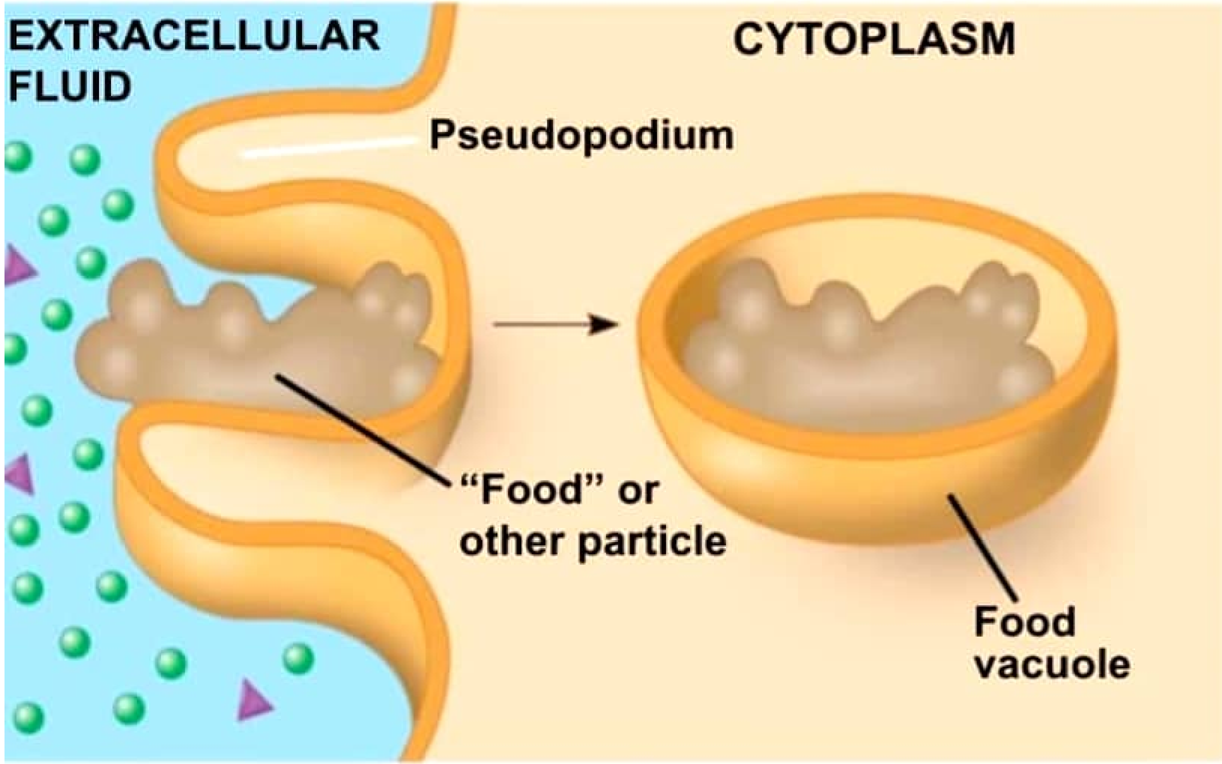
A general process for releasing material from a cell.

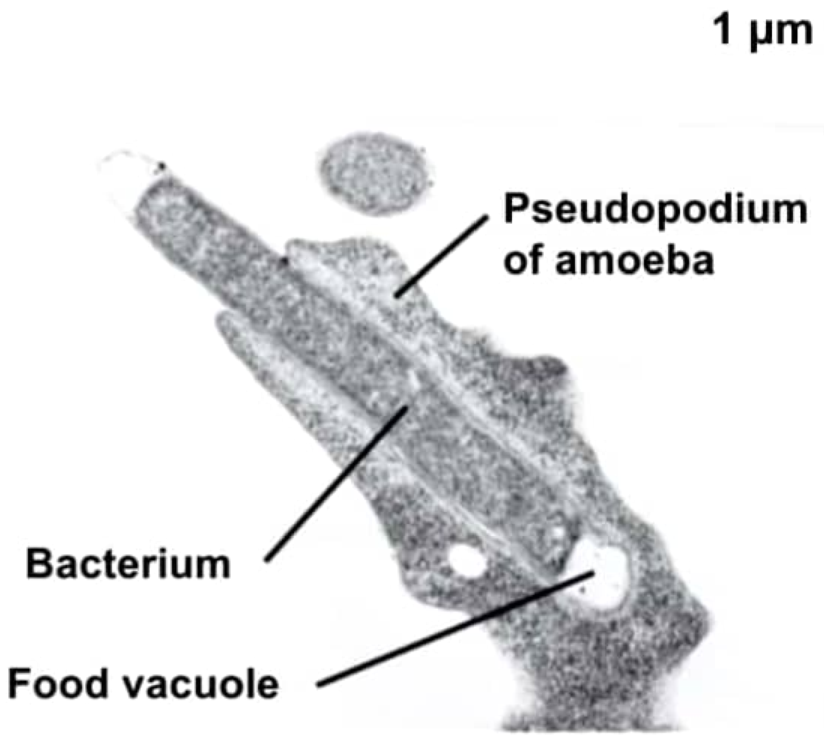
- e.g., neurotransmitters into a synapse, water from a contractile vacuole, antibodies from a B cell

Phagocytosis ("cell eating")

Capture of large extracellular particles in vesicles.

PHAGOCYTOSIS



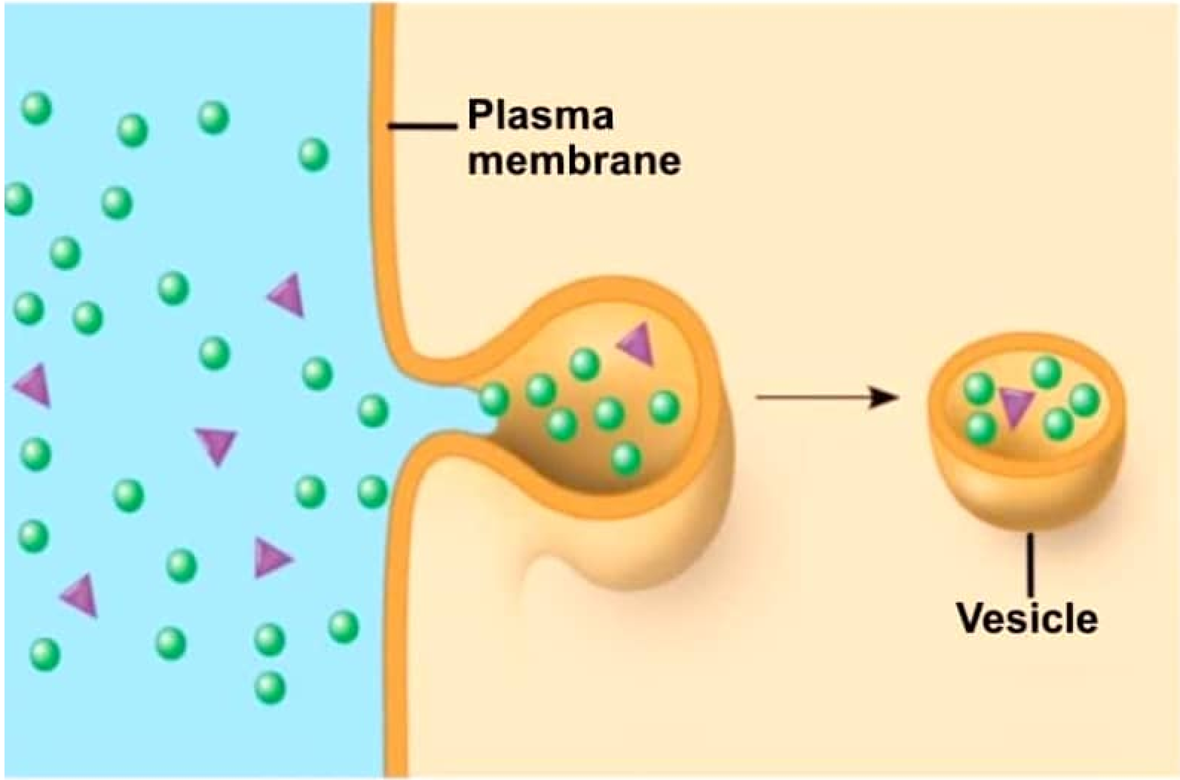


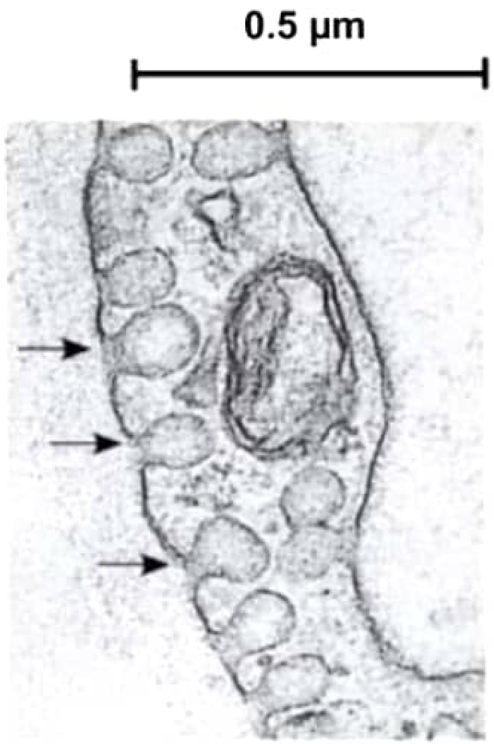
An amoeba engulfing a bacterium
via phagocytosis (TEM)

- how many single-celled organisms feed (e.g., amoeba)
- how cells of the immune system destroy invaders

Pinocytosis (“cell drinking”)

PINOCYTOSIS



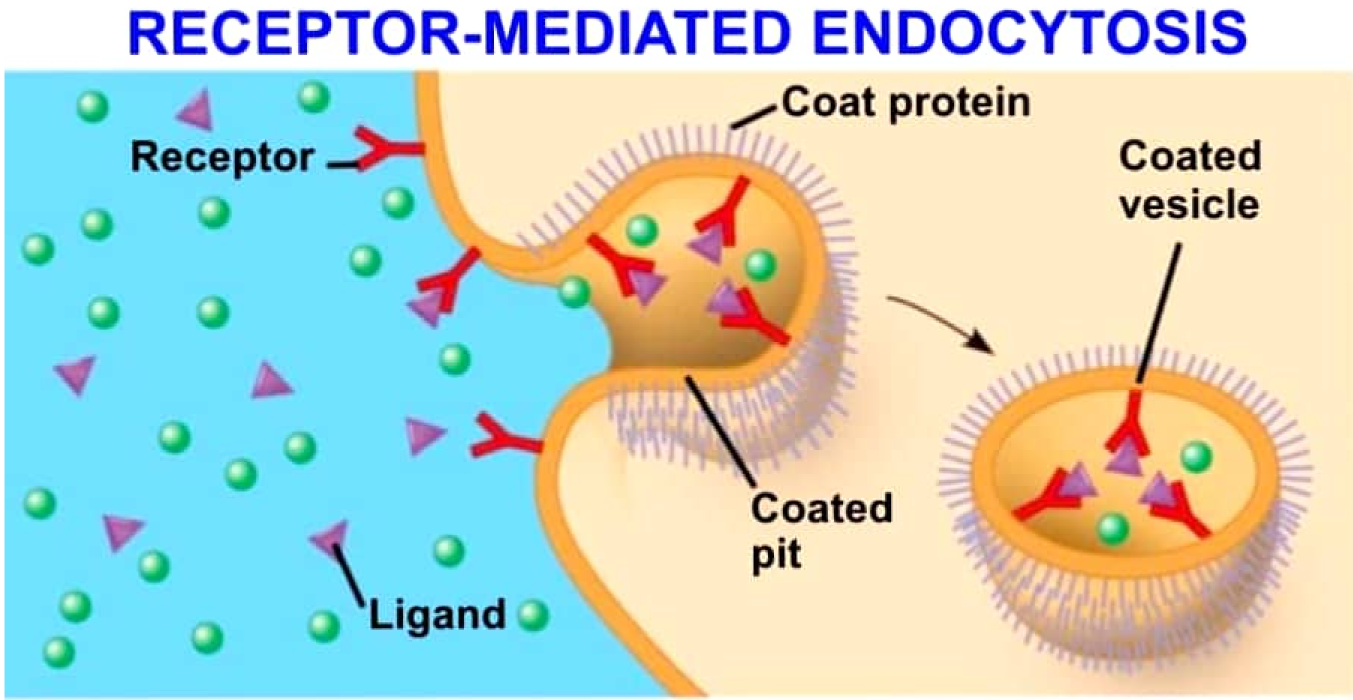


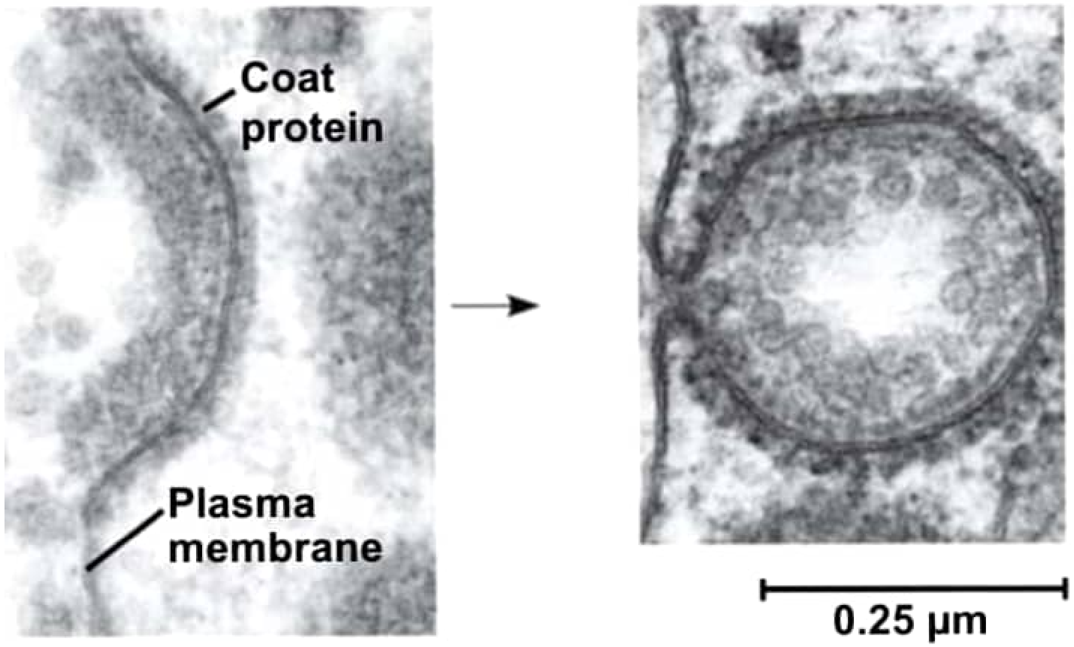
Pinocytosis vesicles forming (arrows) in a cell lining a small blood vessel (TEM)

Capture of extracellular fluid in vesicles.

- a non-specific process of capturing solutes in the fluid immediately surrounding a cell

Receptor-mediated Endocytosis





A coated pit and a coated vesicle formed during receptor-mediated endocytosis (TEMs)

A highly specific process of capturing substances in vesicles.

- receptors on the cell surface bind specific substances (receptor ligand)
- this triggers the formation of a coated pit which ultimately forms a vesicle transporting the receptor-ligand complex inside the cell

Key Terms for Chapter 7

- integral vs peripheral proteins, freeze fracture
- amphipathic, fluid mosaic model
- cytoplasmic & exoplasmic faces of membranes
- diffusion, osmosis, isotonic, hypertonic, hypotonic
- osmotic pressure, osmolysis, contractile vacuole
- passive transport, active transport, cotransport
- facilitated diffusion, electrochemical gradient
- carrier proteins, protein channels, pumps
- exocytosis, endocytosis, receptor-mediated end.
- vesicle, pinocytosis, phagocytosis