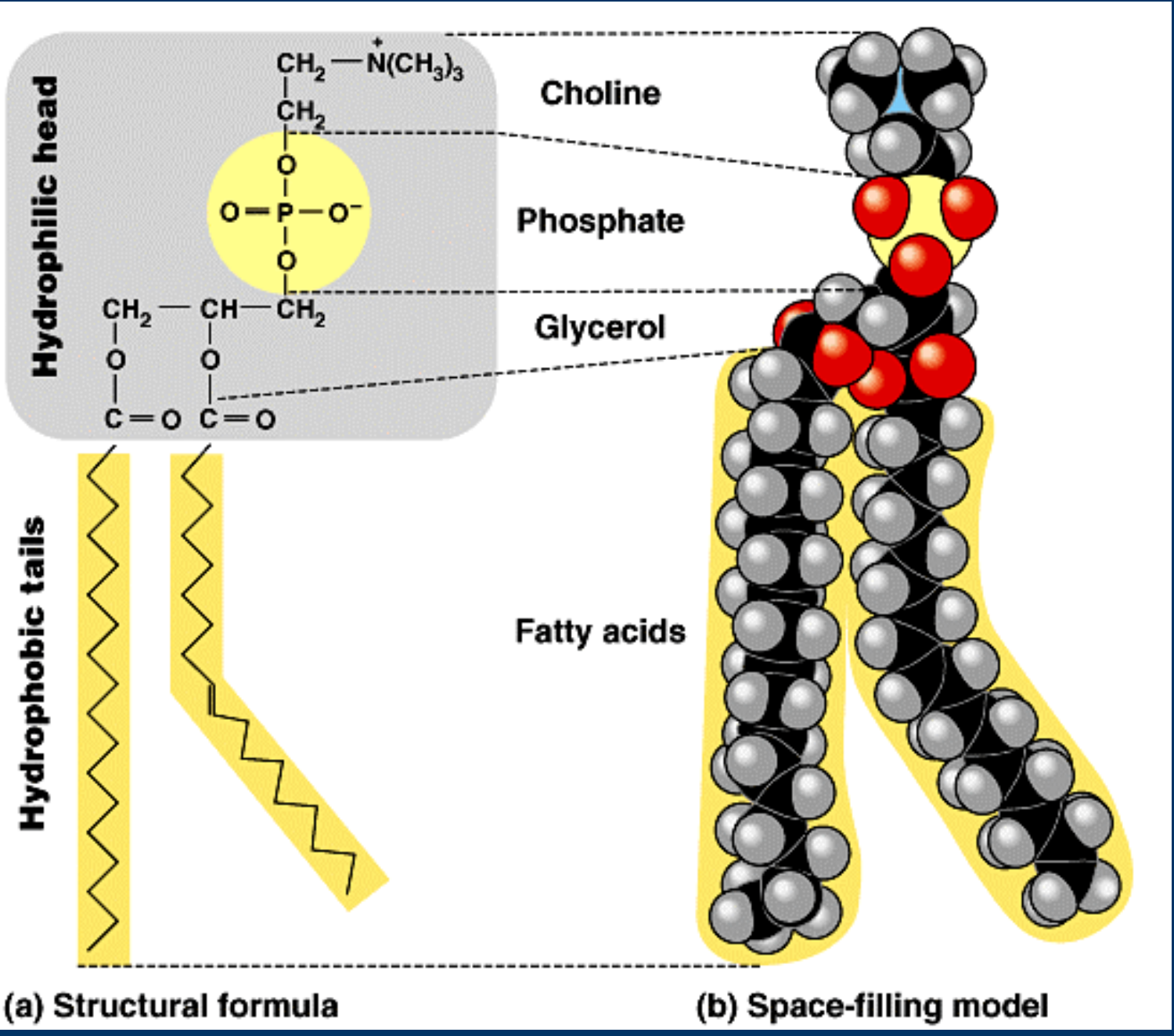


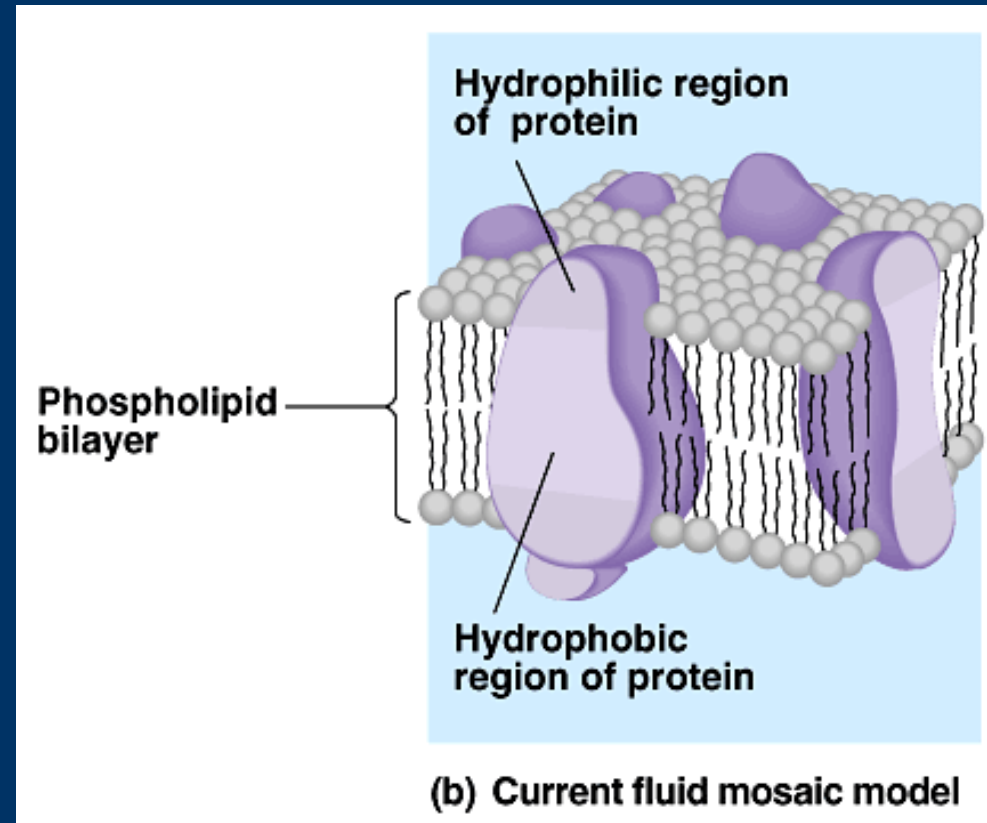
Membrane Structure and Function

- plasma membrane acts as a barrier between cells and the surrounding.
- plasma membrane is selective permeable
- consist of lipids, proteins and carbohydrates
- major lipids are phospholipid which is amphipathic
= contain both hydrophobic and hydrophilic region



The Fluid Mosaic Model :current model of membrane

1972, S.J.Singer and G. Nicolson proposed this model: the membrane is a mosaic of protein molecules bobbing in a fluid bilayer of phospholipid.

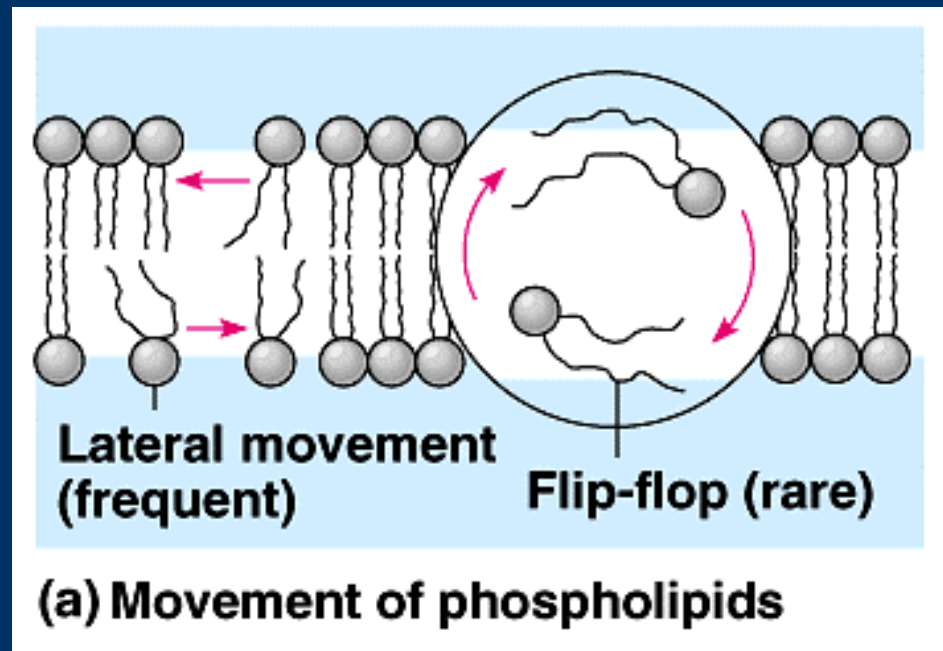


- membrane is held together by hydrophobic interaction
- some membrane proteins move along cytoskeletal fibers by motors proteins
- some membrane proteins are immobile by attachment to the cytoskelton

Membranes are fluid

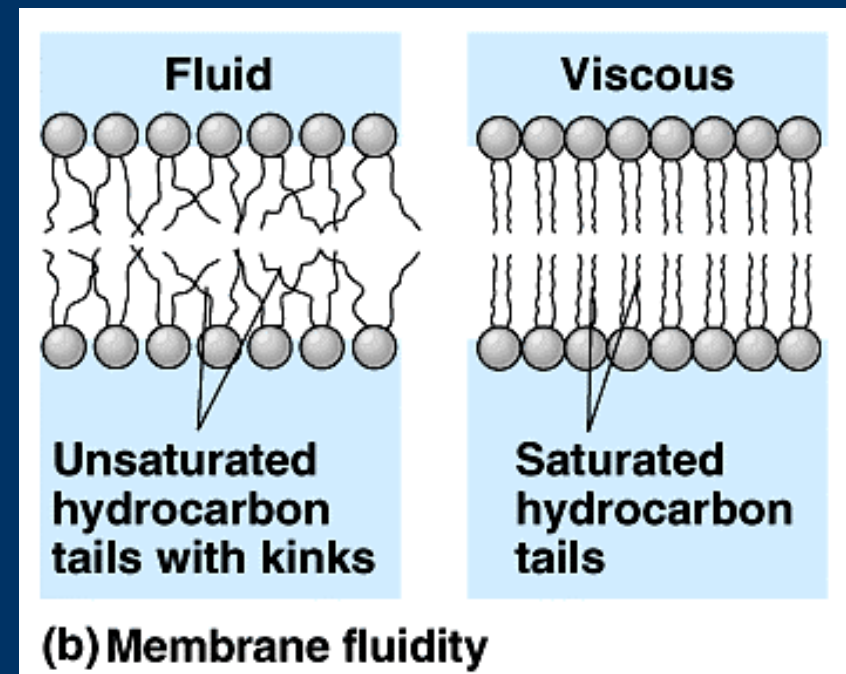
-phospholipids can drift laterally in the plane of the membrane (an average lipid molecule can diffuse the length of a large bacterial cells ($\sim 2 \mu\text{m}$) in about 1 second) = lateral movement (frequently)

-also, phospholipids can migrate from the monolayer on one side to that on the other = flip-flop (rarely)



- Temperature and lipid composition determine fluidity of the membrane
- At low temperature, membrane is less fluid and because the phospholipids are more closely packed.

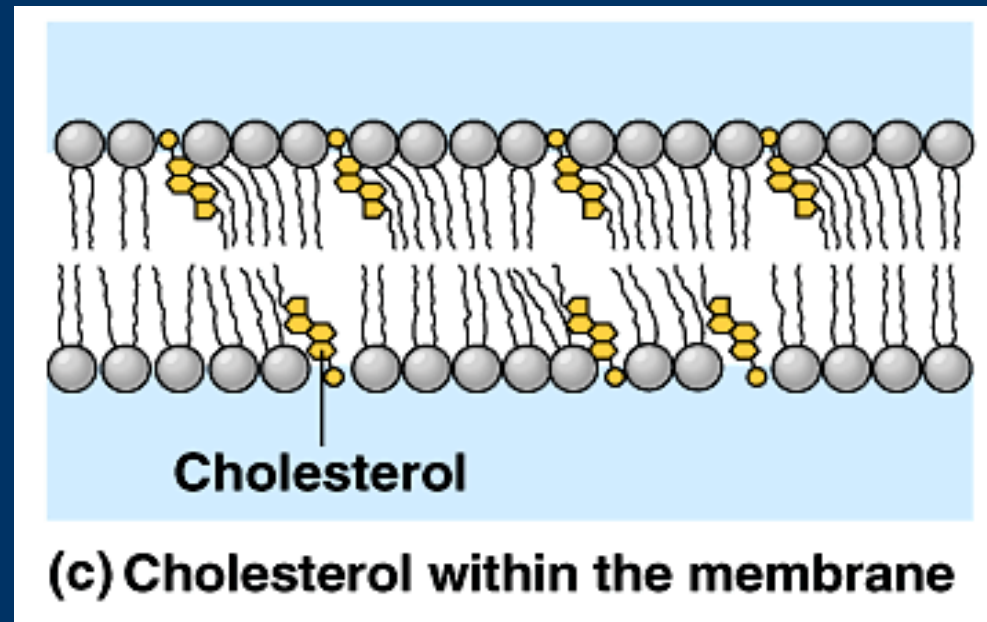
- Membranes rich in unsaturated fatty acids are more fluid than those dominated by saturated fatty acids because the kinks in the unsaturated fatty acid tails prevent tight packing.



-Steroid cholesterol which is wedged between phospholipids also effects membrane fluidity.

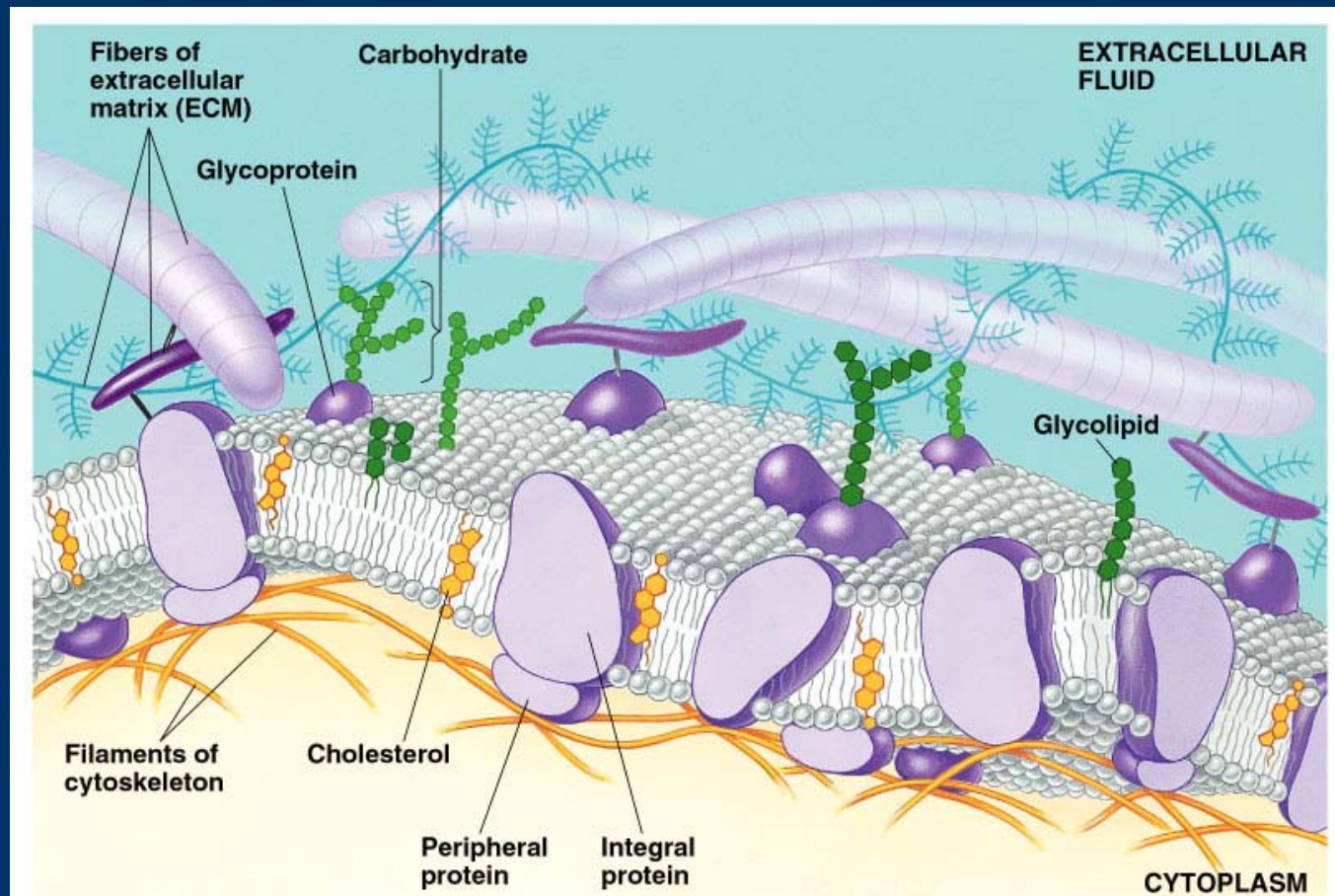
-At warm temperature, it makes membrane less fluid by restraining the movement of phospholipid.

-At low temperature, the membrane remains fluid because cholesterol hinders the close packing of the phospholipids.



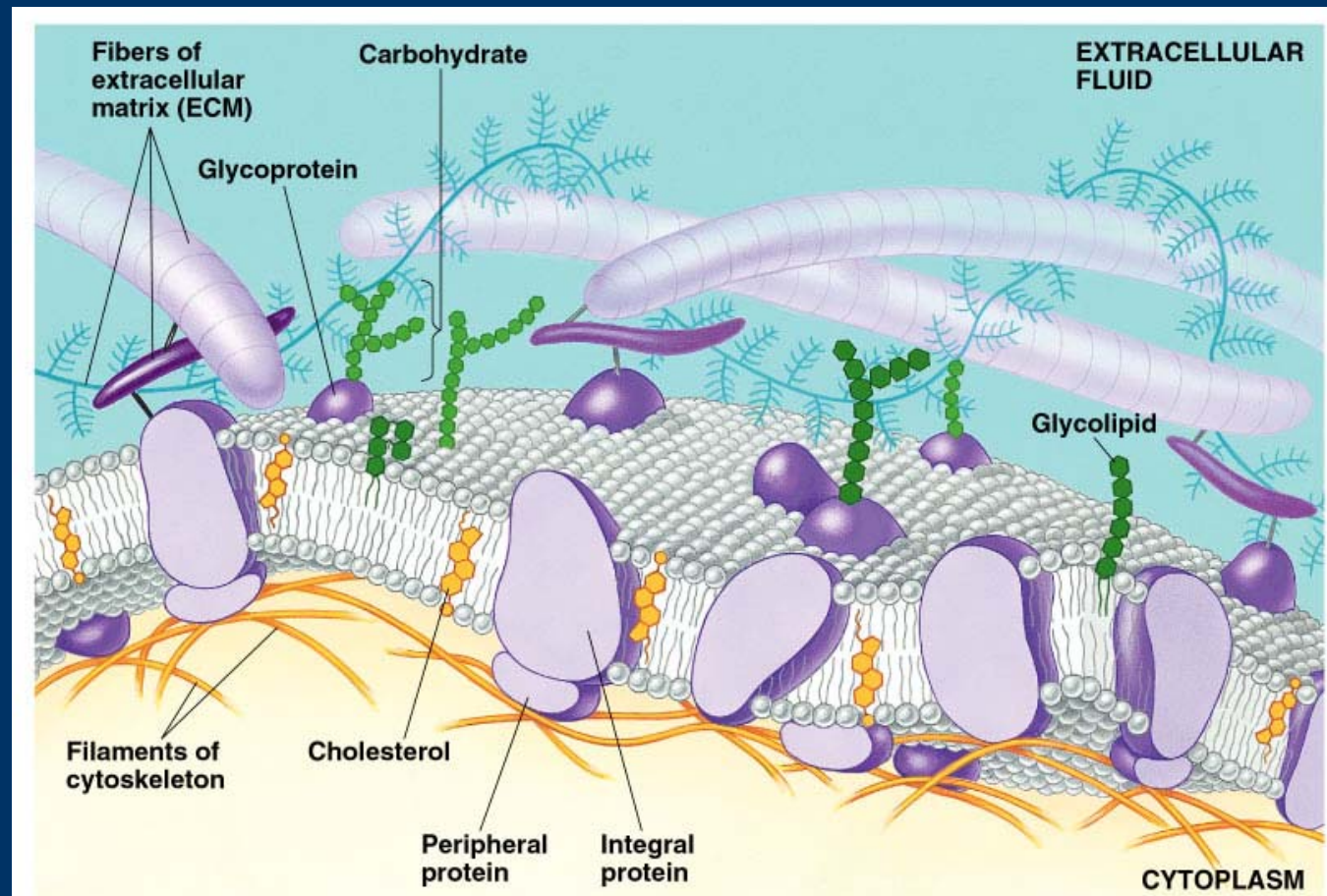
Membranes are **mosaic** of structure and function

A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer



2 major populations of membrane proteins:

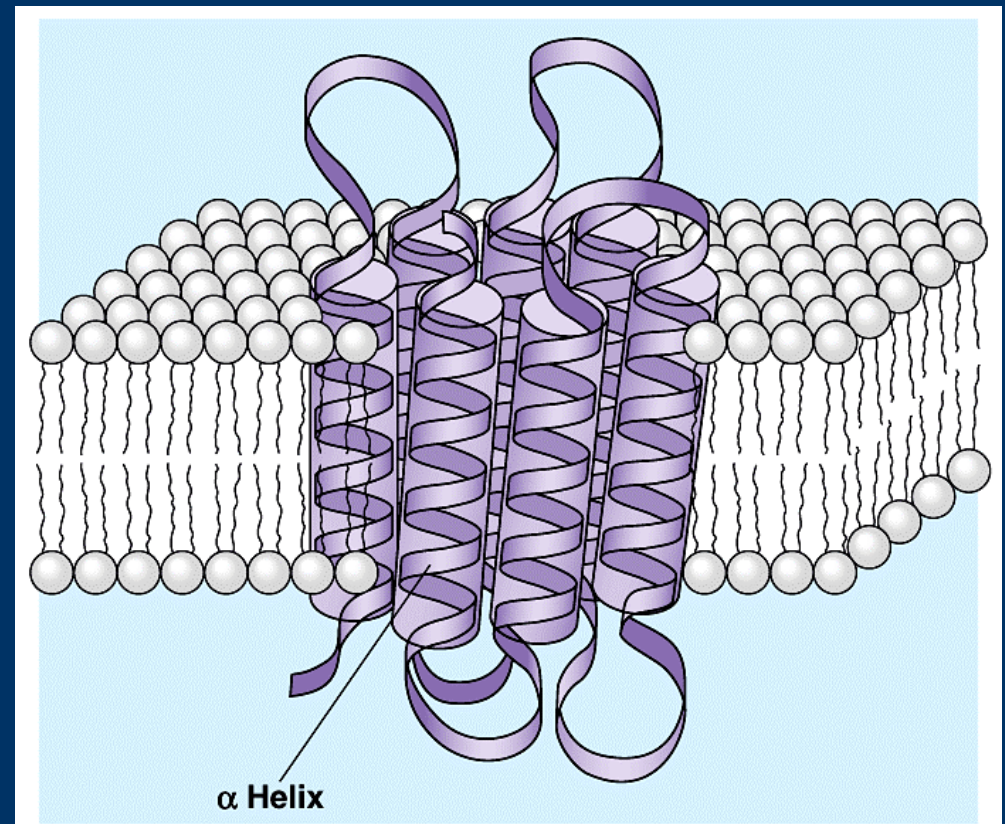
- integral proteins
- peripheral proteins



Integral proteins penetrate the hydrophobic core of the lipid bilayer.

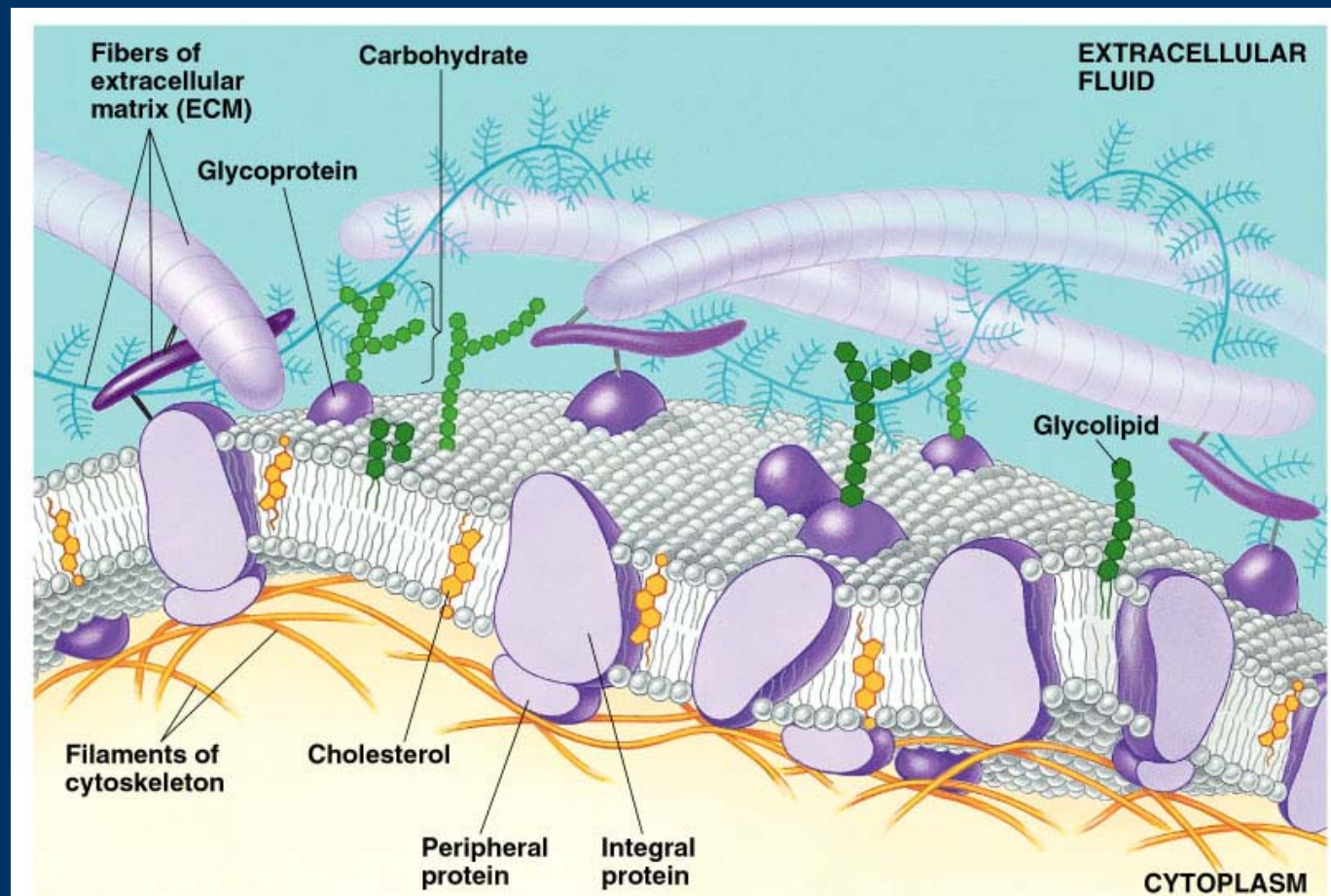
Many of the integral proteins are **transmembrane** proteins which completely span the membrane.

- The hydrophobic region of an integral protein consist of one or more stretches of nonpolar amino acids, usually coiled into α -helices.
- The hydrophilic parts are exposed to the aqueous solutions on either side of the membrane.



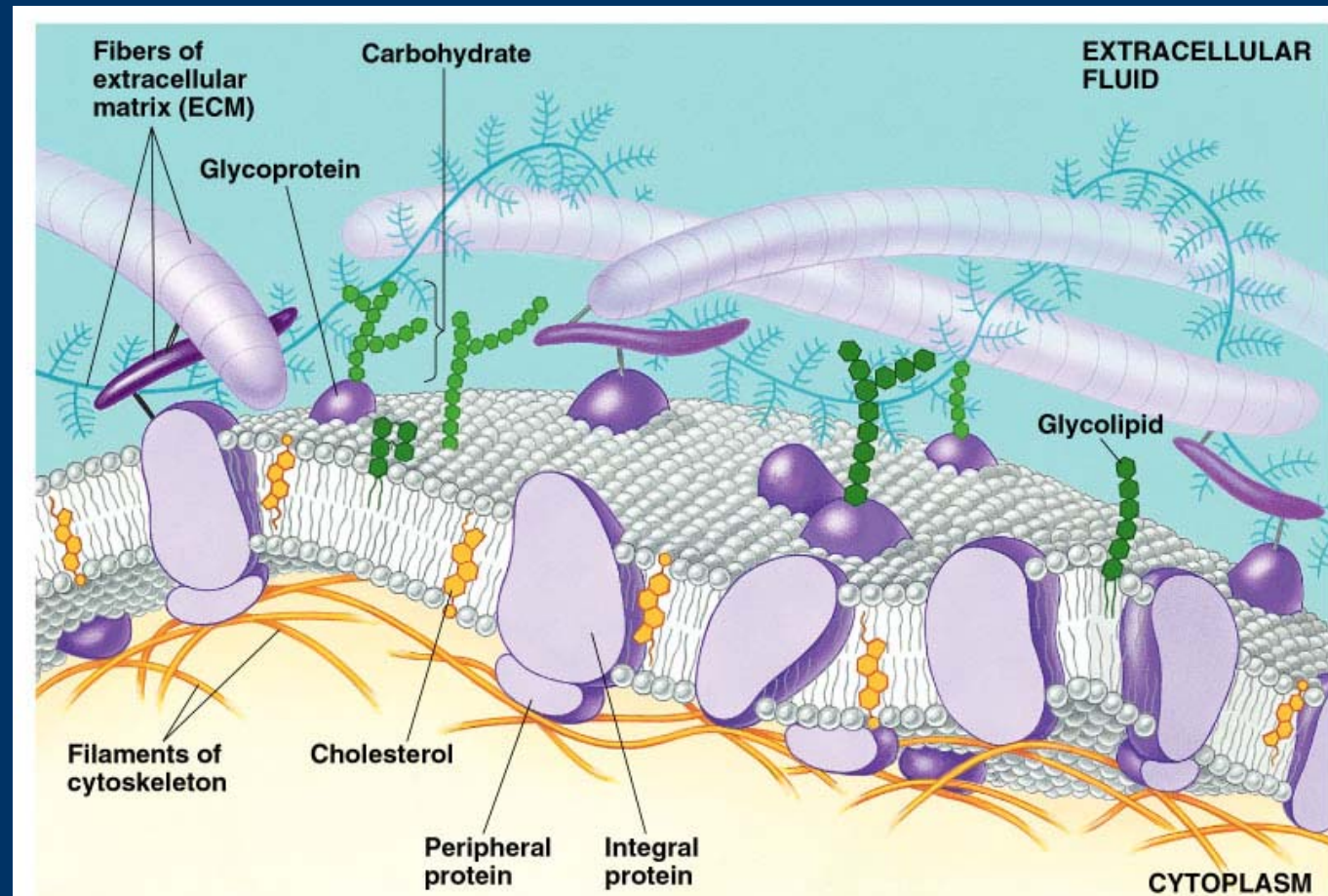
Peripheral proteins are not embedded in the lipid bilayer at all.

They are appendage loosely bound to the surface of the membrane, often to the exposed parts of integral proteins.



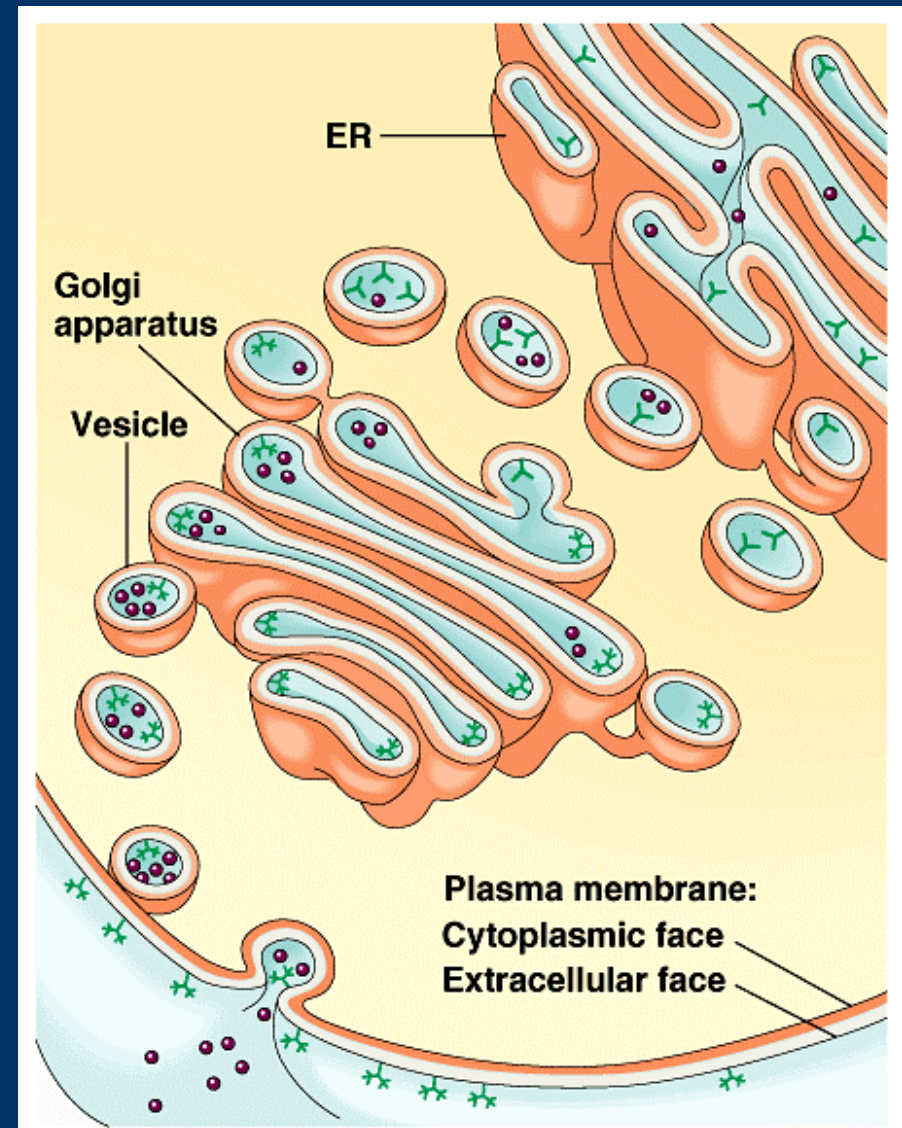
-The lipid and proteins of plasma membrane also covalently bound to carbohydrates (~15 sugar units) = glycolipid and glycoprotein which are restricted to the exterior surface and are important for cell-cell recognition.

-e.g.variation of oligosaccharides on the RBC determines human blood group A,B,AB and O.

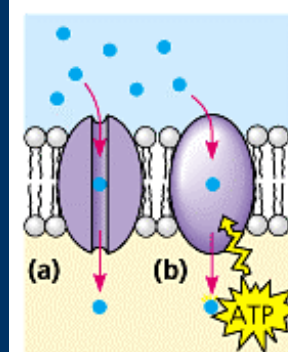


-Membrane has distinct inside and outside faces.

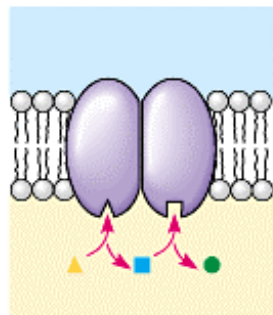
-This asymmetrical orientation begins during synthesis of new membrane in the endoplasmic reticulum



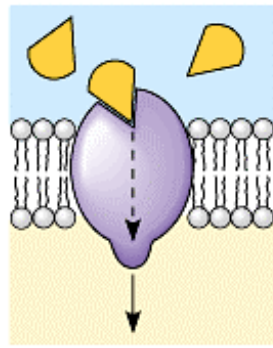
Some Functions of Membrane Proteins



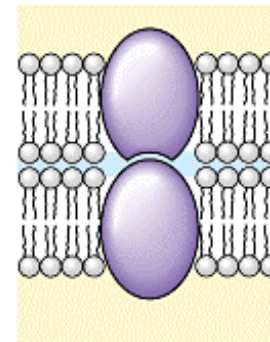
Transport



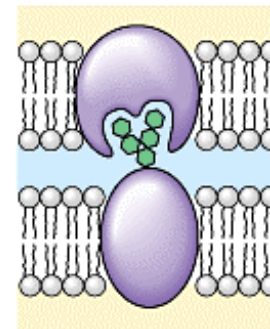
Enzymatic activity



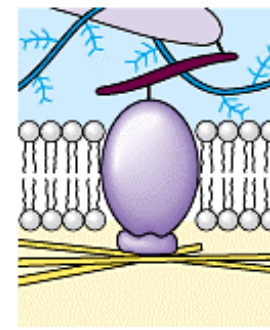
Signal transduction



Intercellular joining



Cell-cell recognition



Attachment to the cytoskeleton and extracellular matrix (ECM)

Traffic across Membranes

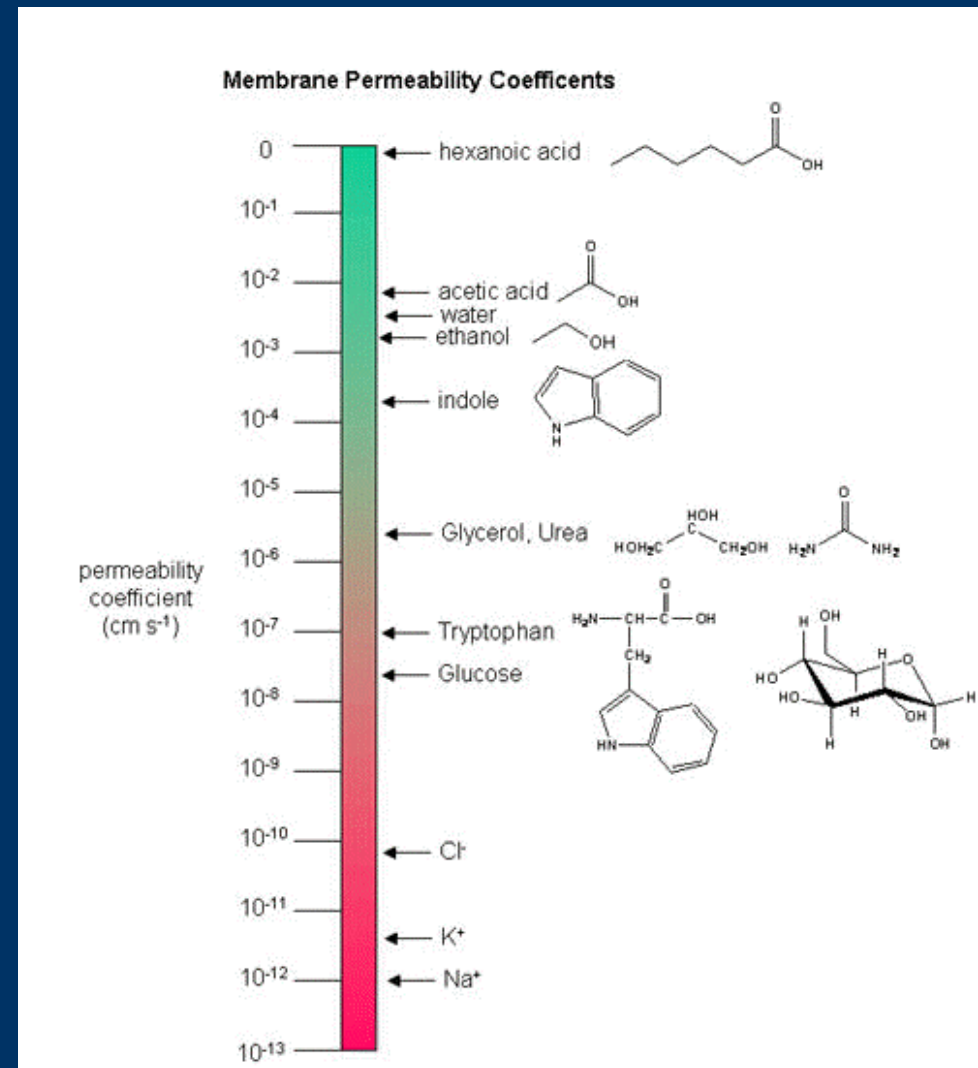
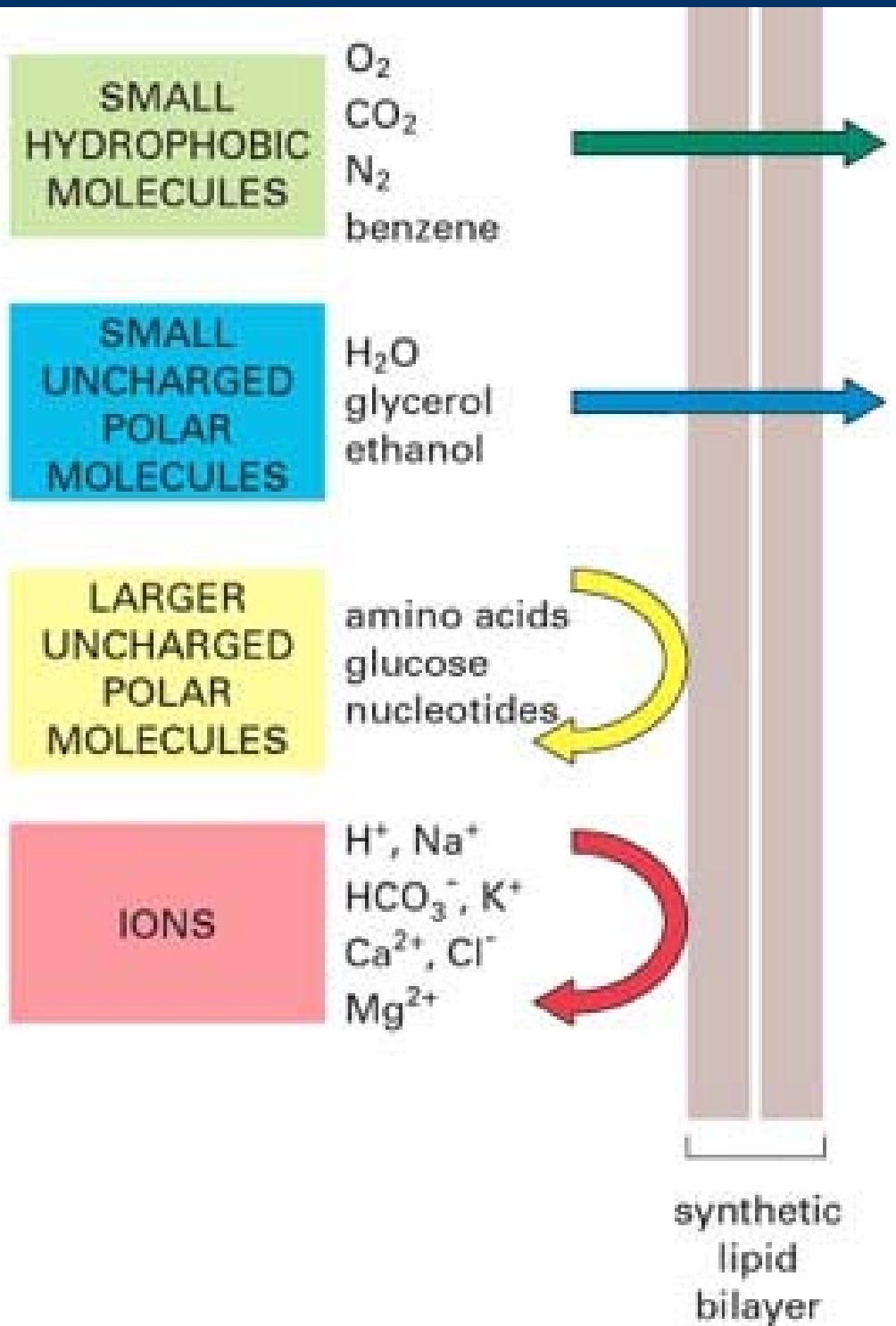
Biological membrane is a supramolecular structure = many molecules ordered into a higher level of organization with emergent properties beyond those of the individual molecules.

The supramolecular structure of the membrane results in selective permeability.

Permeability of the membrane

- lipid bilayer is permeable to small nonpolar molecules: CO_2 and O_2
- but it is impermeable to ions and polar molecules: glucose, sucrose, Na^+ , H^+ , Cl^-
- transport proteins enable cell membranes permeable to specific ions and polar molecules including H_2O

Thus, the selective permeability of a membrane depends on **both** the discriminating barrier of the lipid bilayer and the specific transport proteins.



Transport Across Membrane

- **passive transport** = diffusion across a membrane **down the concentration gradient**
 - osmosis = passive transport of water
 - facilitated diffusion = specific proteins facilitate the passive transport of water and selected solutes
- **active transport** = pumping of solutes against their concentration gradients
- **cotransport** = membrane protein couples the transport of one solute to another
- **exocytosis and endocytosis** transport large molecules

Passive transport is diffusion across a membrane

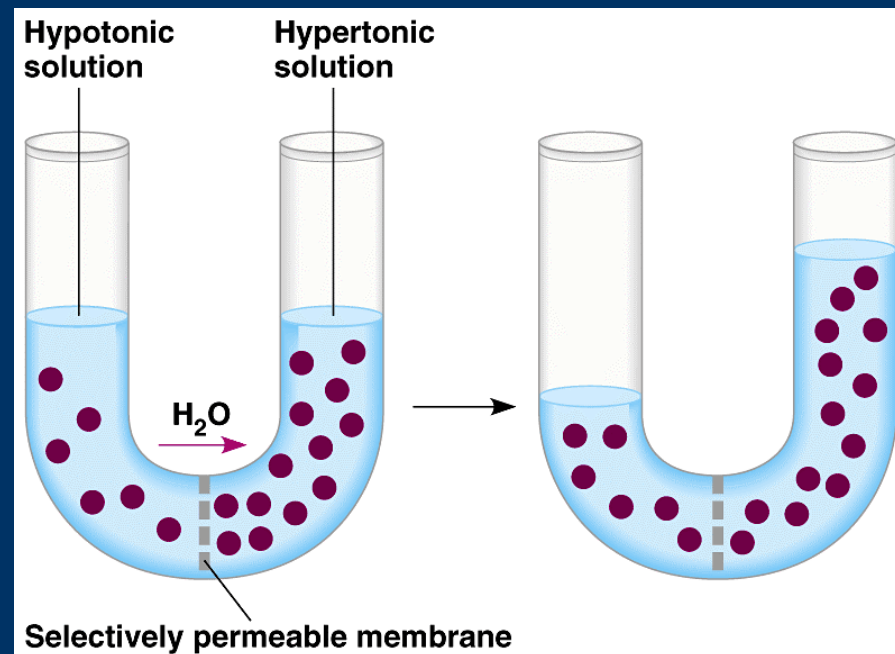
- diffusion of a substance across a biological membrane is called passive transport
- molecules diffuse across membrane down its concentration gradient
- spontaneous process: does not need energy

Osmosis is the passive transport of water

Hypertonic solution = solution with higher concentration of solute

Hypotonic solution = solution with lower solute concentration

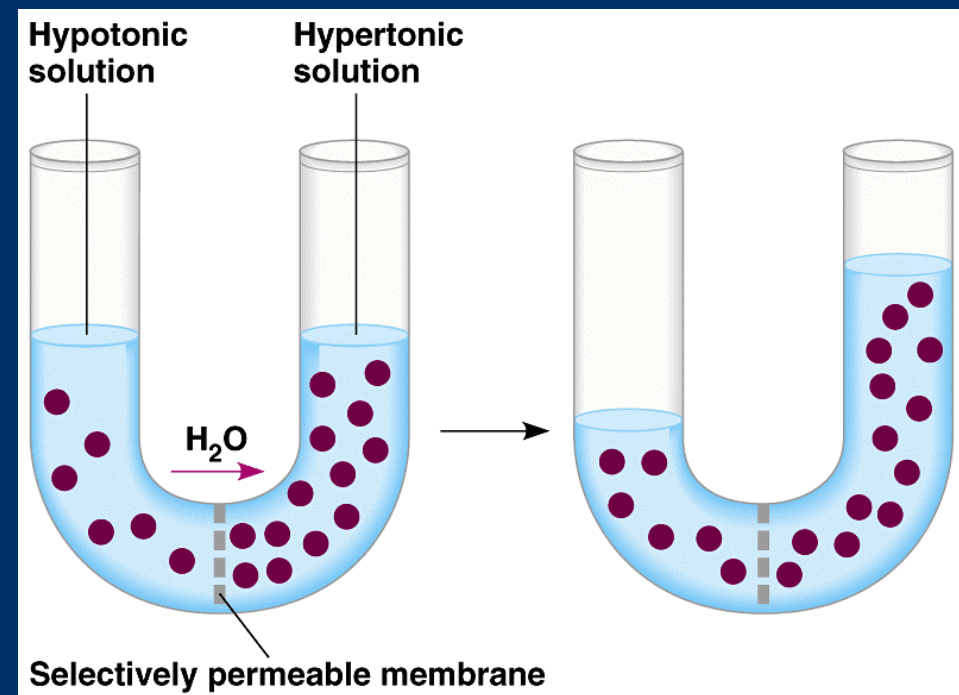
Isotonic solution = solution of equal solute concentration



U-shaped vessel with a selectively permeable membrane separating 2 sugar solution of different concentration.

The membrane pores are too small for sugar molecule to pass but large enough for water

Water diffuses across membrane from hypotonic solution to the hypertonic solution.
This diffusion of water = osmosis



Direction of osmosis is determined only by a difference in **total solute concentration**.

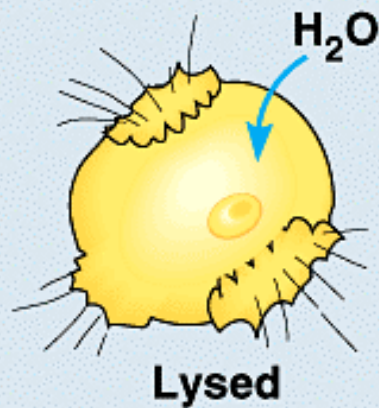
Water diffuses from hypotonic to a hypertonic even if the hypotonic solution has more kinds of solutes.

(Water from seawater (containing a great variety of solutes) will diffuse to a very concentrated sugar solution)

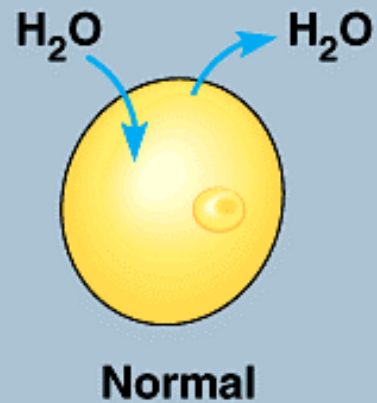
For isotonic solutions, water moves across membrane in both directions at an equal rate.

Water balance of cells

Hypotonic solution



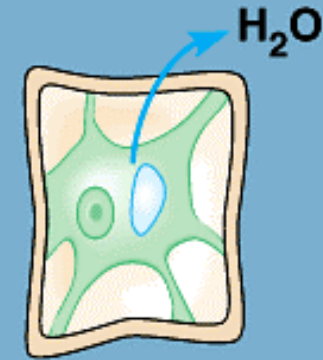
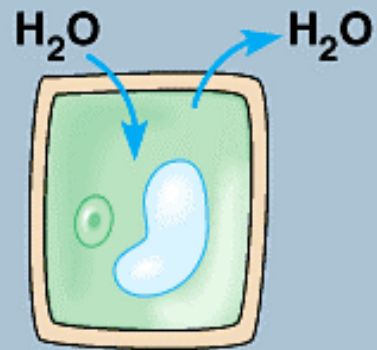
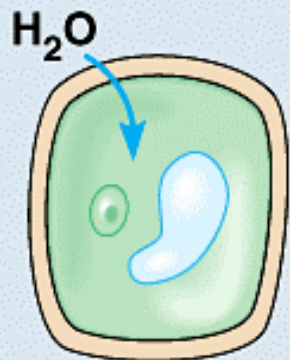
Isotonic solution



Hypertonic solution



Animal cell

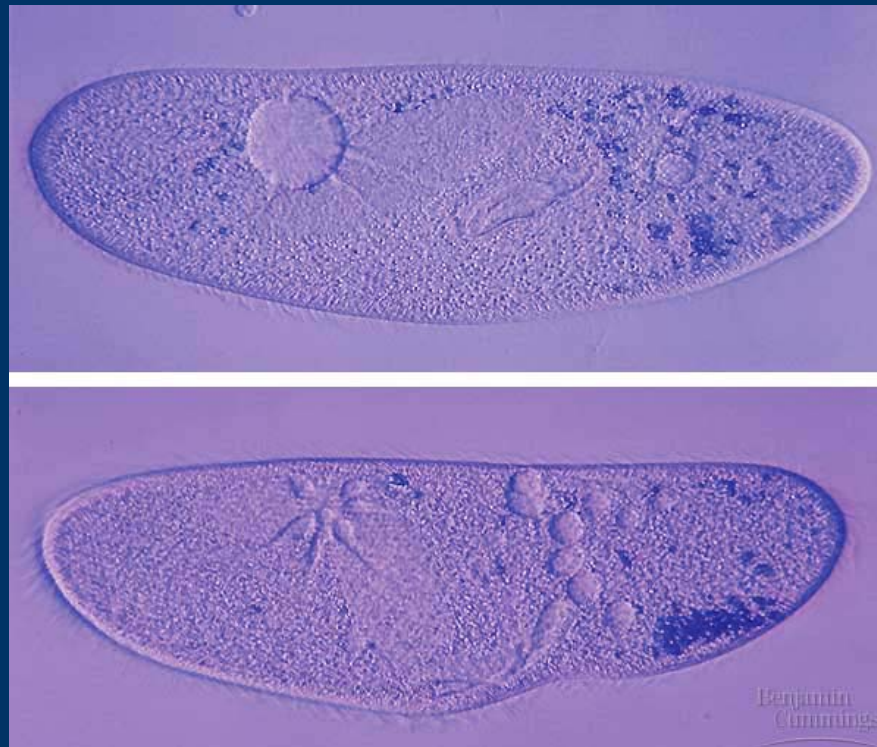


Plant cell

Osmoregulation: the control of water balance

The protist *Paramecium* lives in pond water which is hypotonic to the cell.

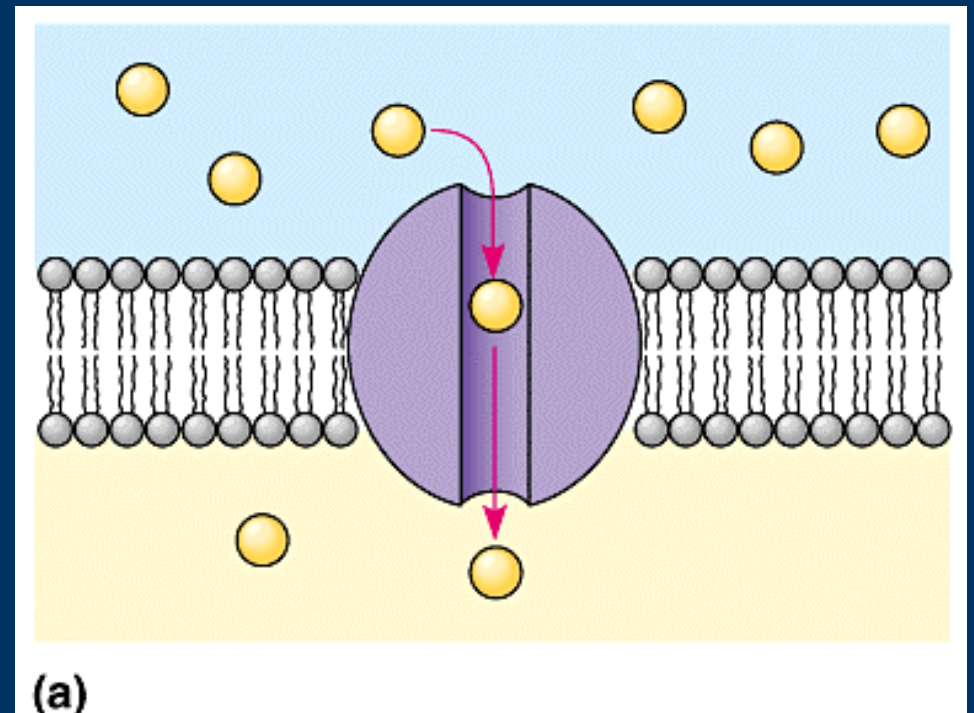
Its contractile vacuole forces water out of the cell as fast as it enters by osmosis.



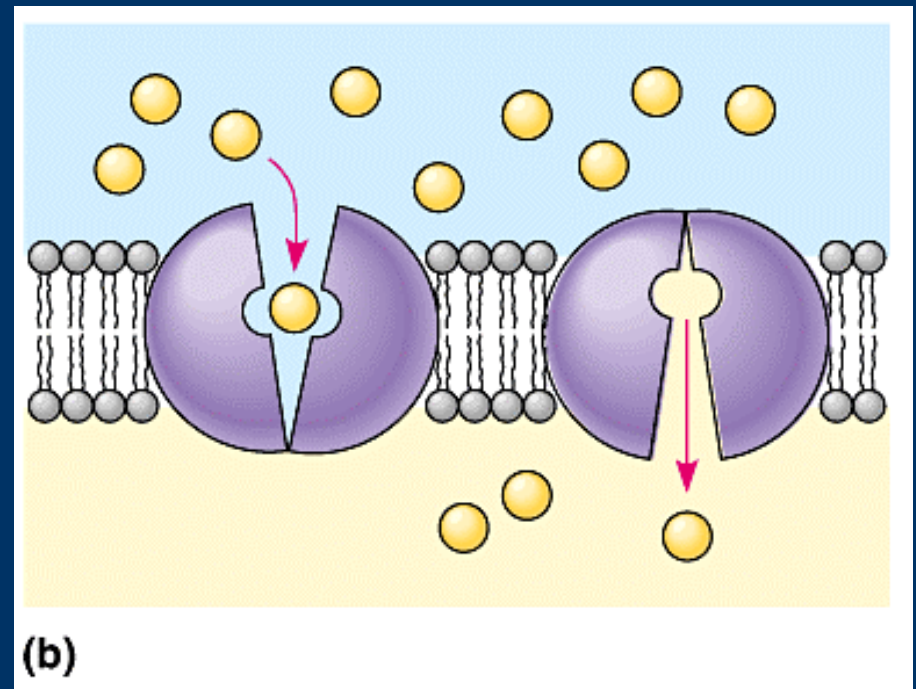
Specific proteins facilitate the passive transport of water and selected solutes

Facilitate diffusion = diffusion of polar molecules (including H₂O) and ions with the help of transport proteins spanning the membrane

Model # 1: The purple transport protein forms a channel through which water molecules or a specific solute can pass.



Model # 2: Transport protein alternates between 2 conformations, moving a solute across the membrane as the shape of the protein changes.

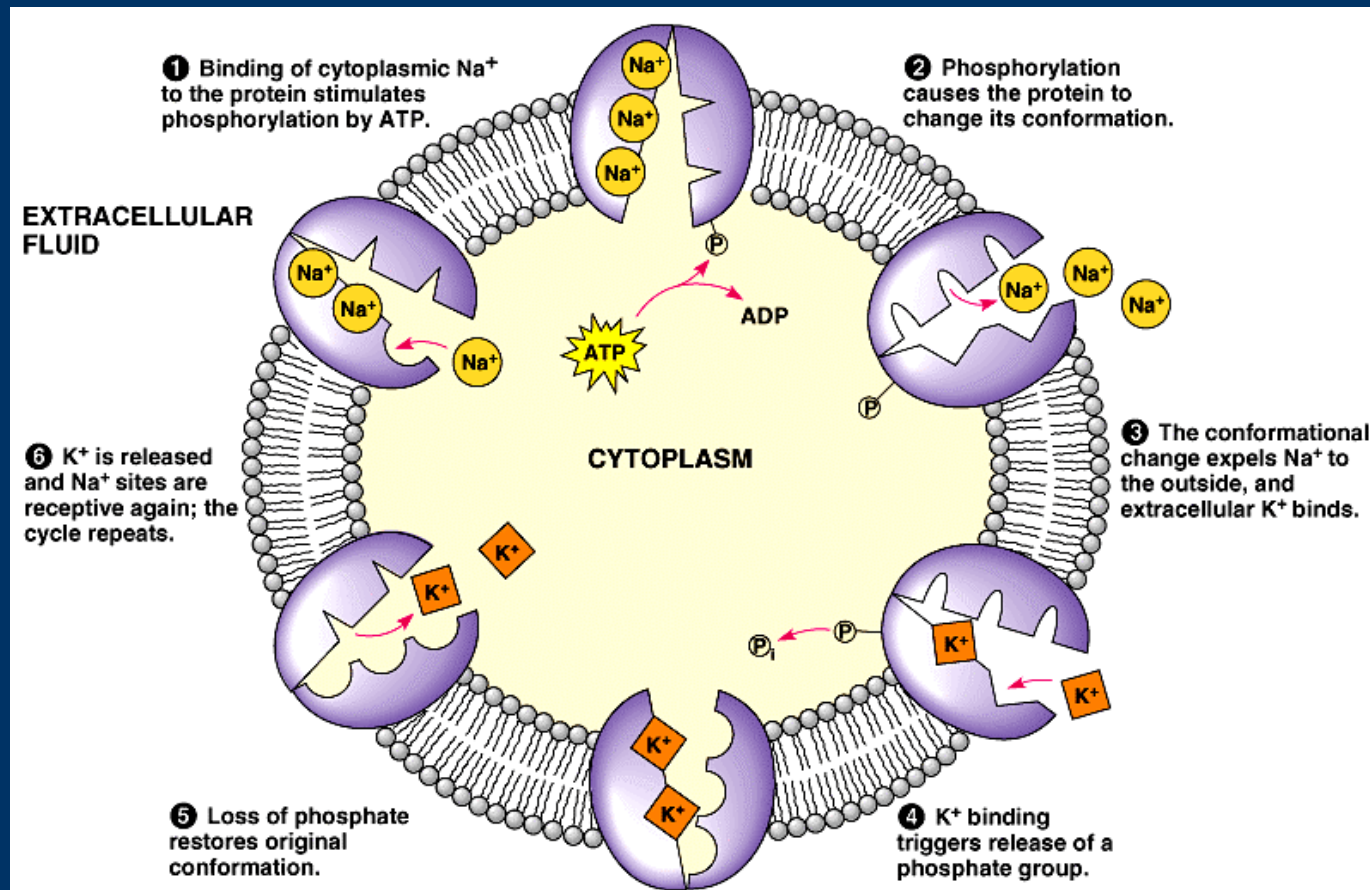


The proteins can transport the solute in **either** direction, with the **net movement being down the concentration gradient of the solute.**

Active transport:

-pumping of solutes against their concentration gradient

-require energy in the form of ATP



1 Binding of cytoplasmic Na^+ to the protein stimulates phosphorylation by ATP.

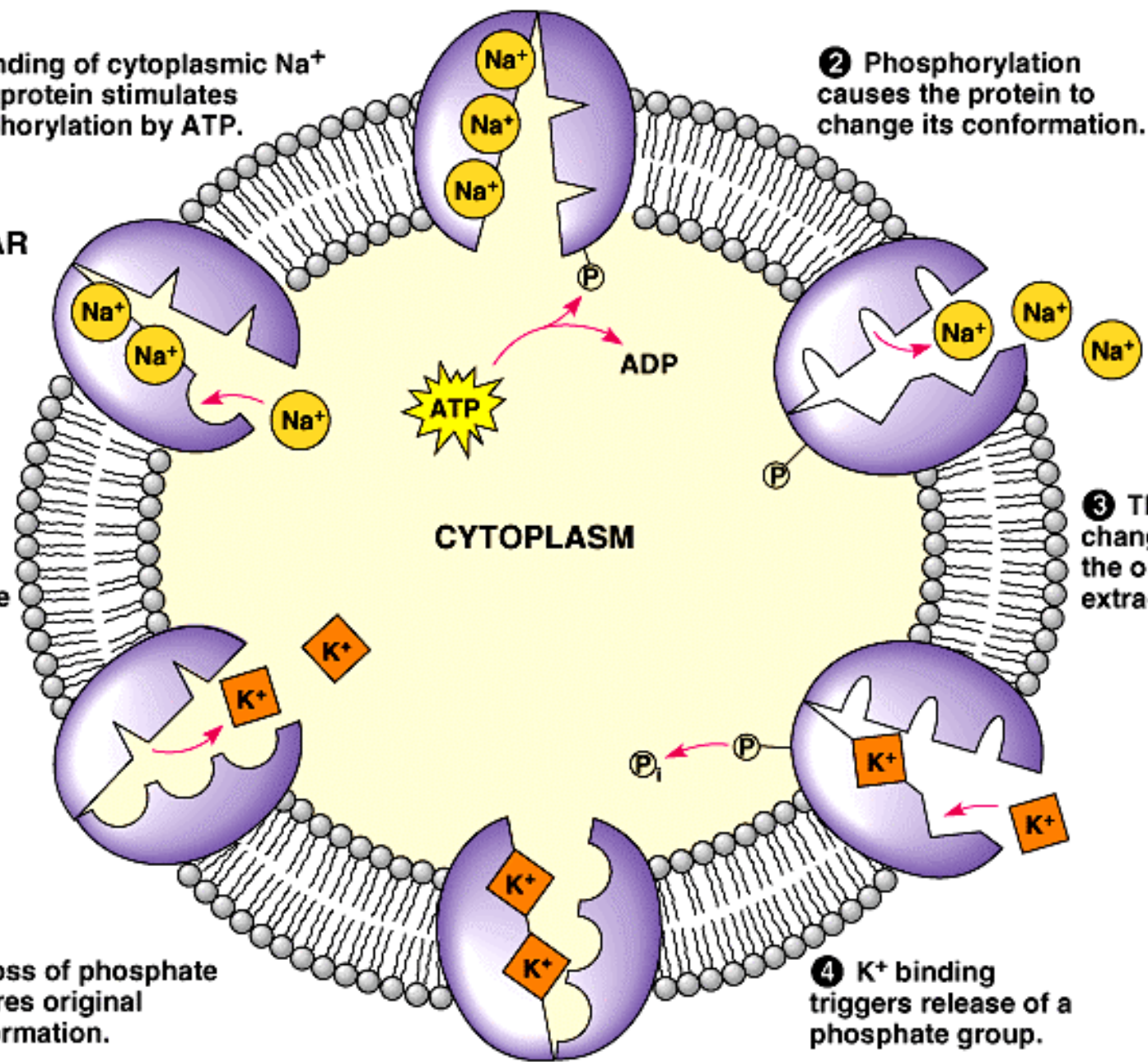
2 Phosphorylation causes the protein to change its conformation.

3 The conformational change expels Na^+ to the outside, and extracellular K^+ binds.

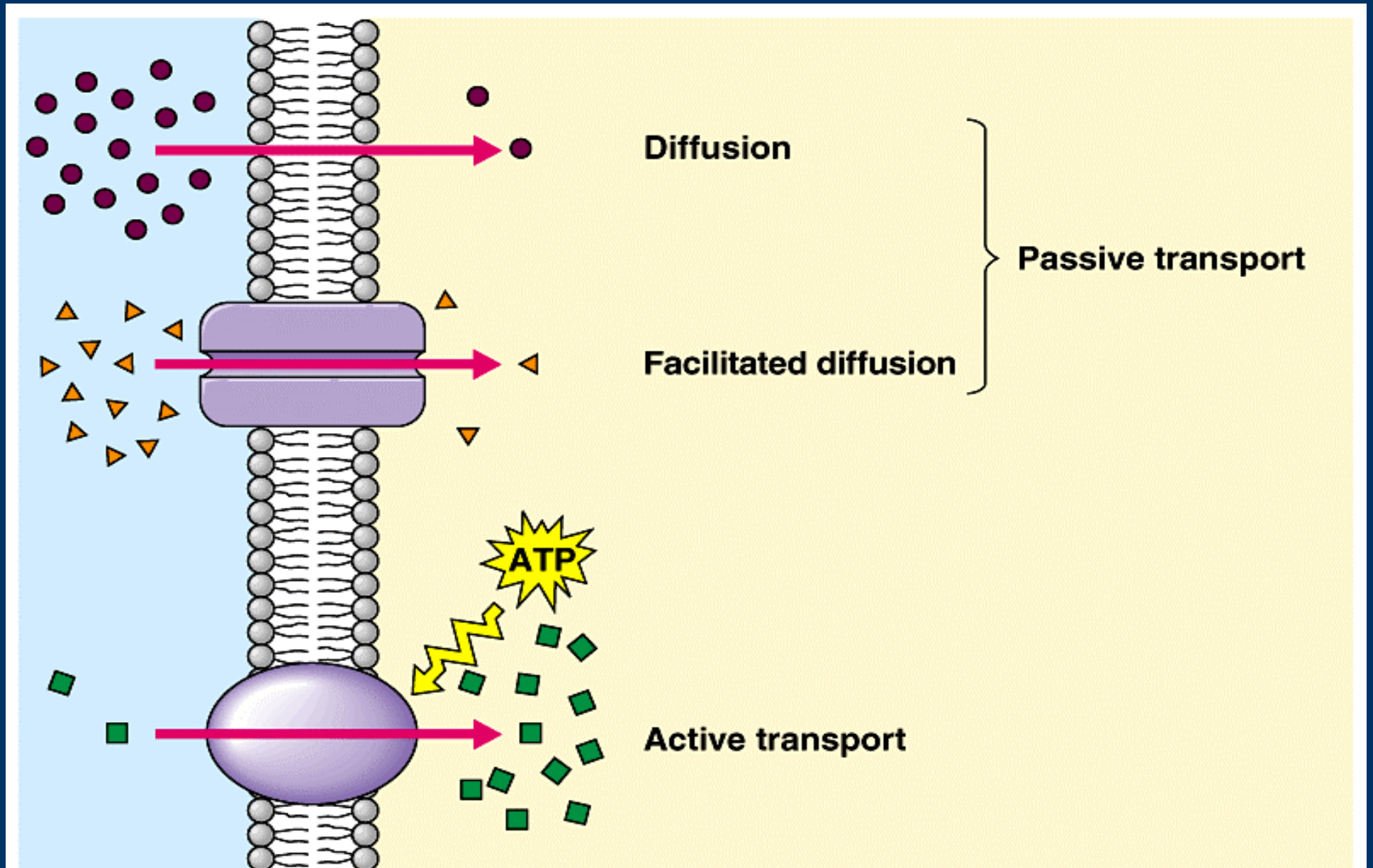
4 K^+ binding triggers release of a phosphate group.

5 Loss of phosphate restores original conformation.

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



The sodium-potassium pump

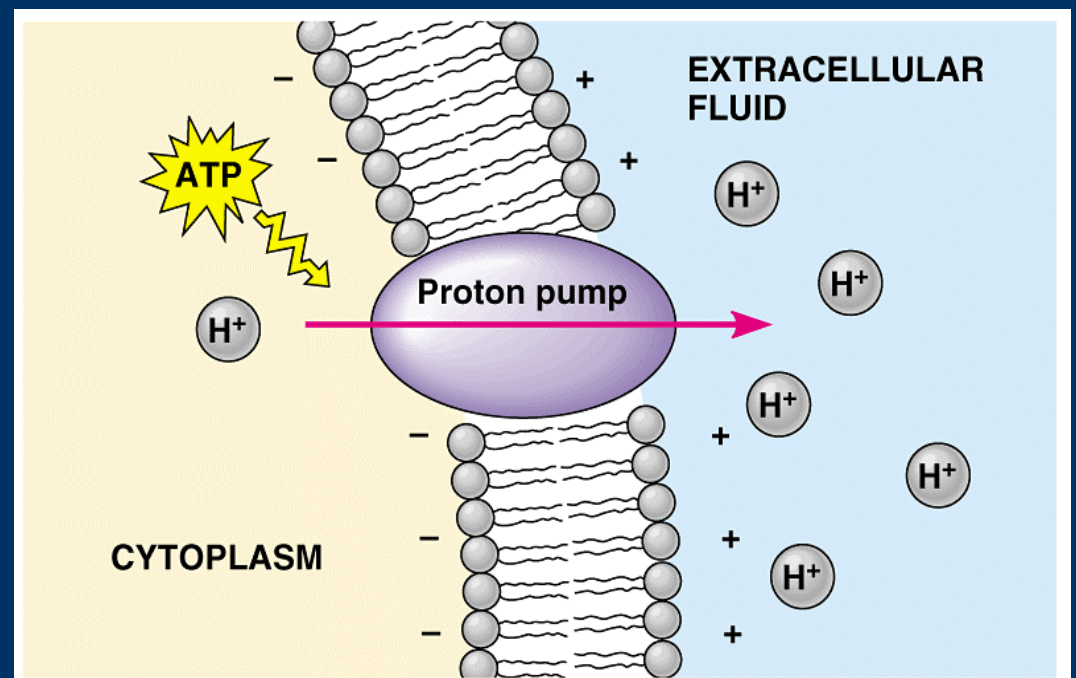


Comparison between passive and active transport

An electrogenic pump = a transport protein that generates voltage across a membrane

- sodium-potassium pump
- proton pump transport positive charge in the form of hydrogen ions

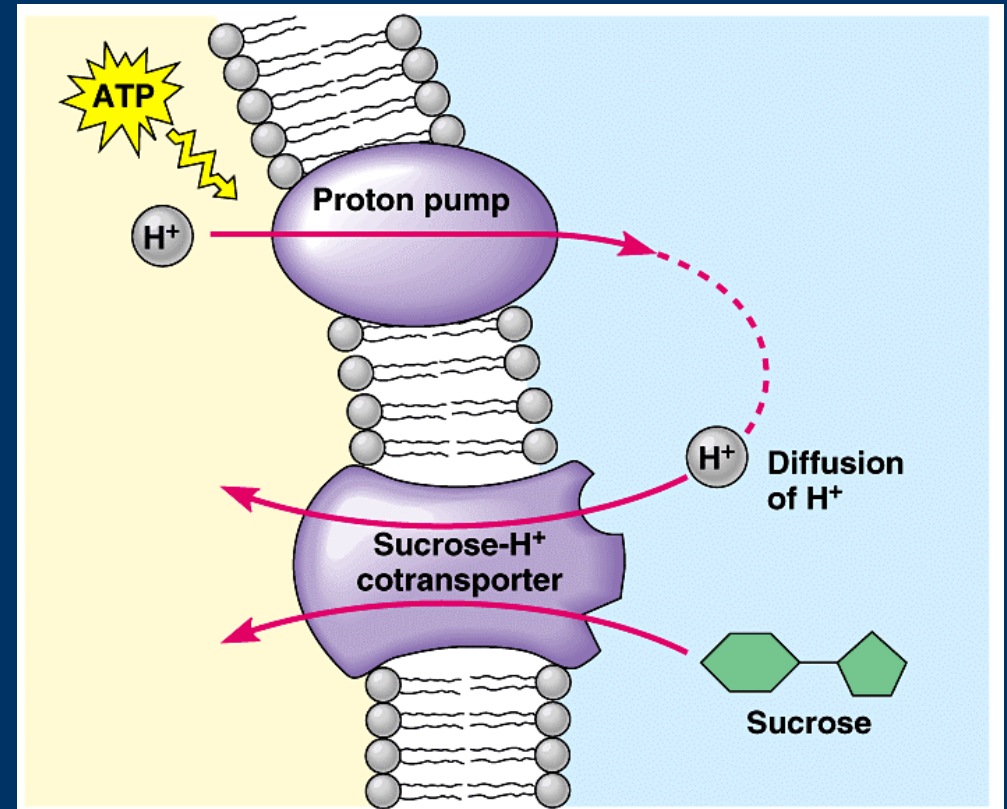
Voltage generated across membranes can be trapped for cellular work such as in cotransport.



Cotransport: a membrane protein couples the transport of 2 solutes

A substance that has been pumped across a membrane can do work as it leaks back by diffusion.

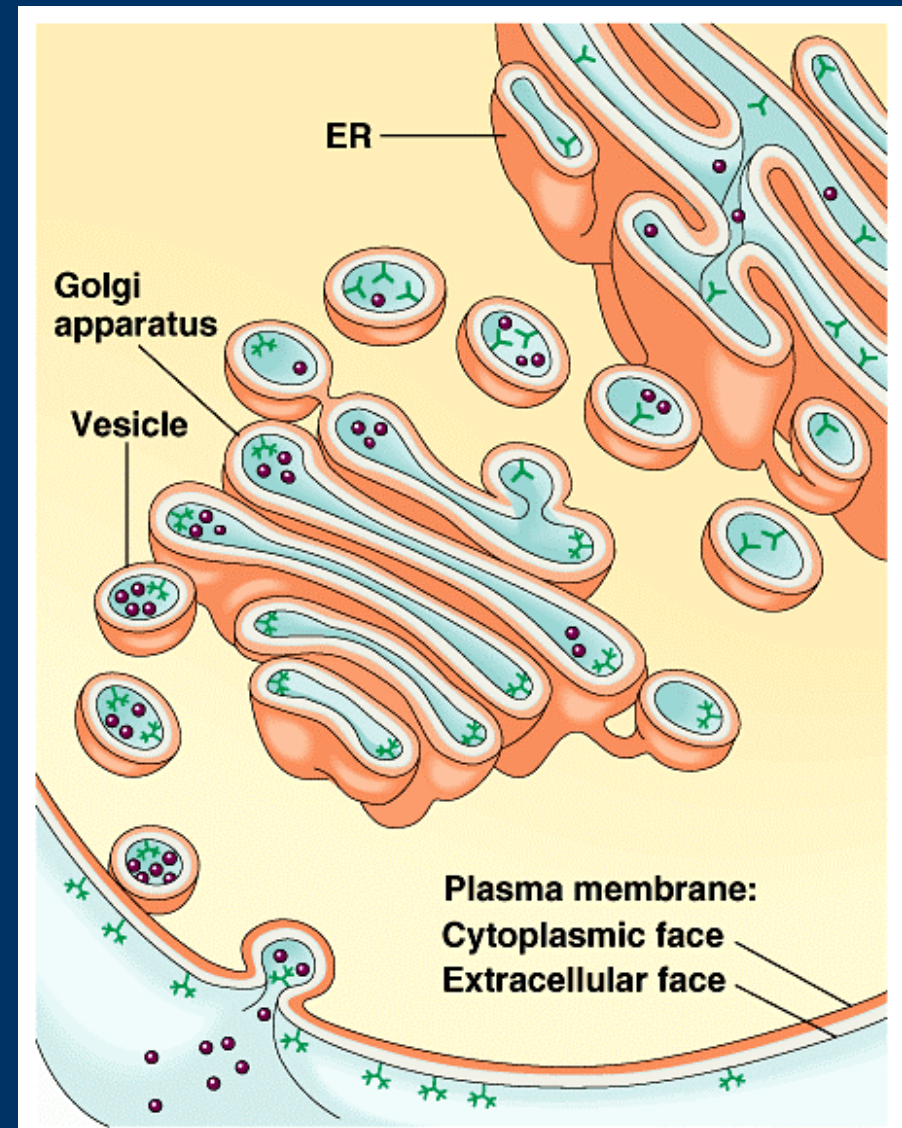
Plant cells uses



hydrogen gradient generated by proton pumps to drive active transport of amino acids, sugar and other nutrients

Exocytosis and endocytosis: transport of large molecules (proteins, polysaccharides)

Exocytosis = secretion of macromolecules from cells by the fusion of vesicles with the plasma membrane.



Endocytosis = the process which cell takes in macromolecules and particulate matter by forming new vesicles from the plasma membrane.

3 types of endocytosis:

phagocytosis = cellular eating

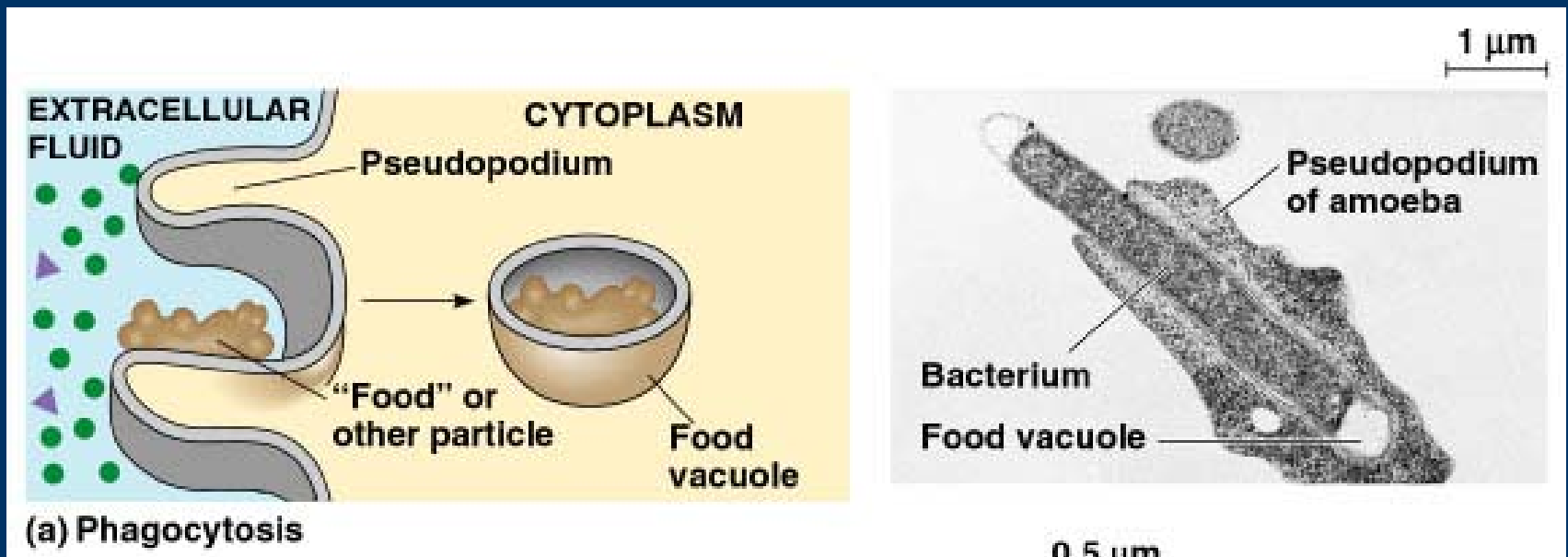
pinocytosis = cellular drinking

receptor-mediated endocytosis

Phagocytosis

The cell engulfs a particle by wrapping pseudopodia around it and packaging it within a vacuole: food vacuole.

Food vacuole fuses with lysosome to be digested.

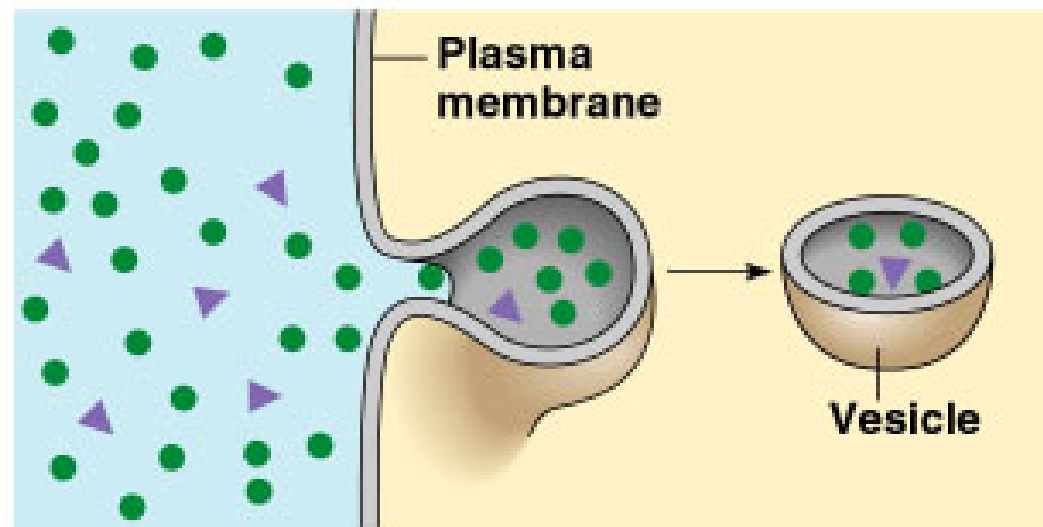


Pinocytosis

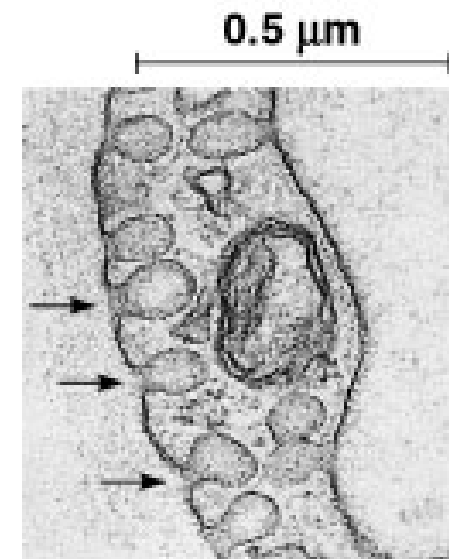
The cell gulps droplets of extracellular fluid into tiny vesicles.

Pinocytosis is unspecific in the substances it transports.

(a) Pinocytosis



(b) Pinocytosis



Receptor-mediated endocytosis

Specific receptor proteins embedded in the membrane bind to the **ligands**.
e.g. transport of cholesterol into the cells.

