

Homeostasis and Membrane Transport

Unit 2 Homeostasis

What determines whether a substance can pass through a membrane or not?

- ▶ Chemical properties of the molecule attempting to cross the membrane



Movement of molecules

- ▶ What substances can cross by themselves?
- ▶ Small, polar molecules (H_2O)
- ▶ Small non-polar molecules (N_2 , O_2 , CO_2)



Movement of molecules

- ▶ What types of molecules need assistance?
- ▶ Ions (Na^+ , H^+ , K^+ ...)
- ▶ Large polar molecules (Glucose)

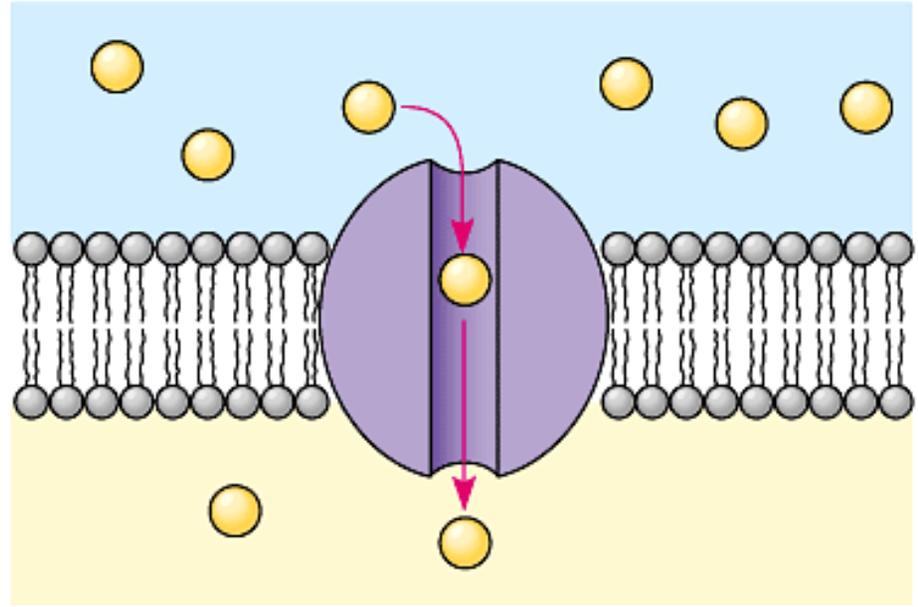


Movement of molecules

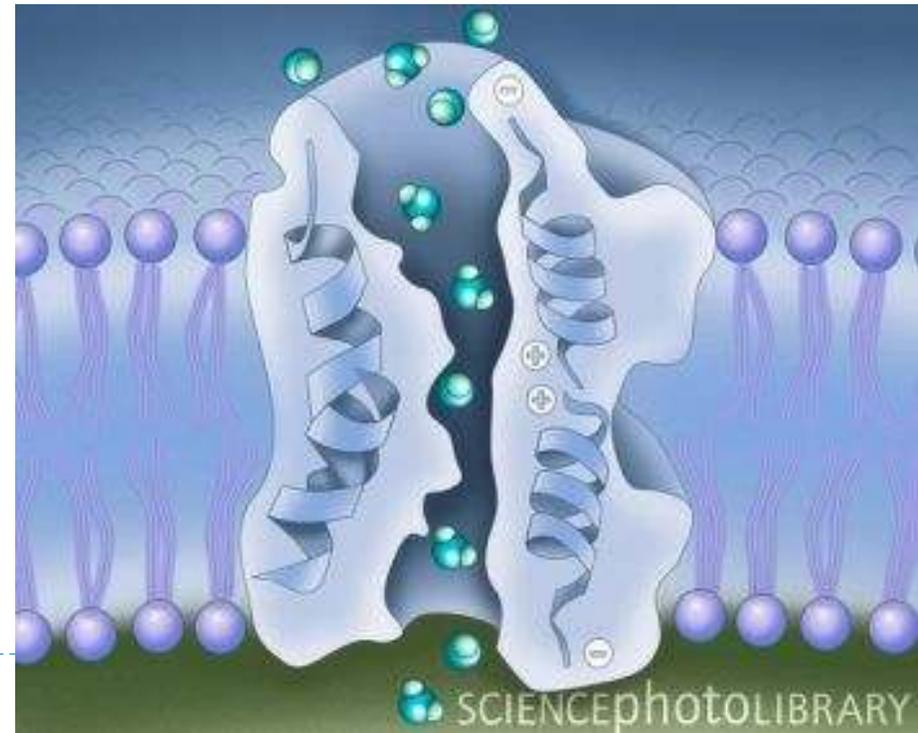
- ▶ How does the membrane provide the assistance?
- ▶ Membrane proteins act as the transporters
 - ▶ Channel and carrier proteins- like secret passageways!
- ▶ Cells can even transport mass amounts of water when needed
 - ▶ Aquaporins- water transporting proteins



▶ Channel proteins



▶ Aquaporins



More membranes

- ▶ We know what membranes are now, so lets talk about how they do their most important function

Maintain homeostasis

- ▶ Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.



Homeostasis?

- ▶ What is it?
- ▶ Basically it's the idea that living things can maintain a constant internal environment even when the external environment changes
- ▶ Living things respond to change
- ▶ Things that are regulated by homeostasis:
 - ▶ Temperature
 - ▶ pH
 - ▶ Solutes: sugar, etc
 - ▶ Hormones
 - ▶ And more!



Why is homeostasis important?

- ▶ Discuss and write



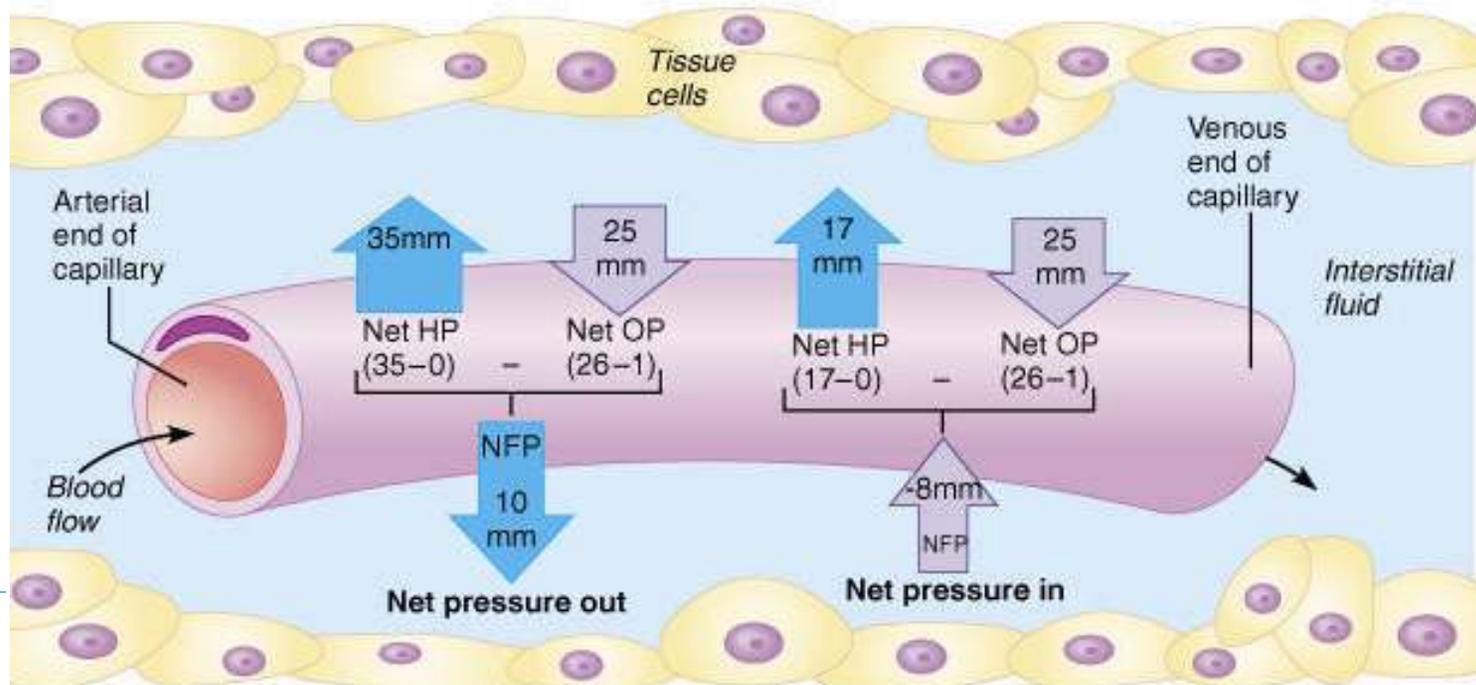
Membranes, homeostasis and growth

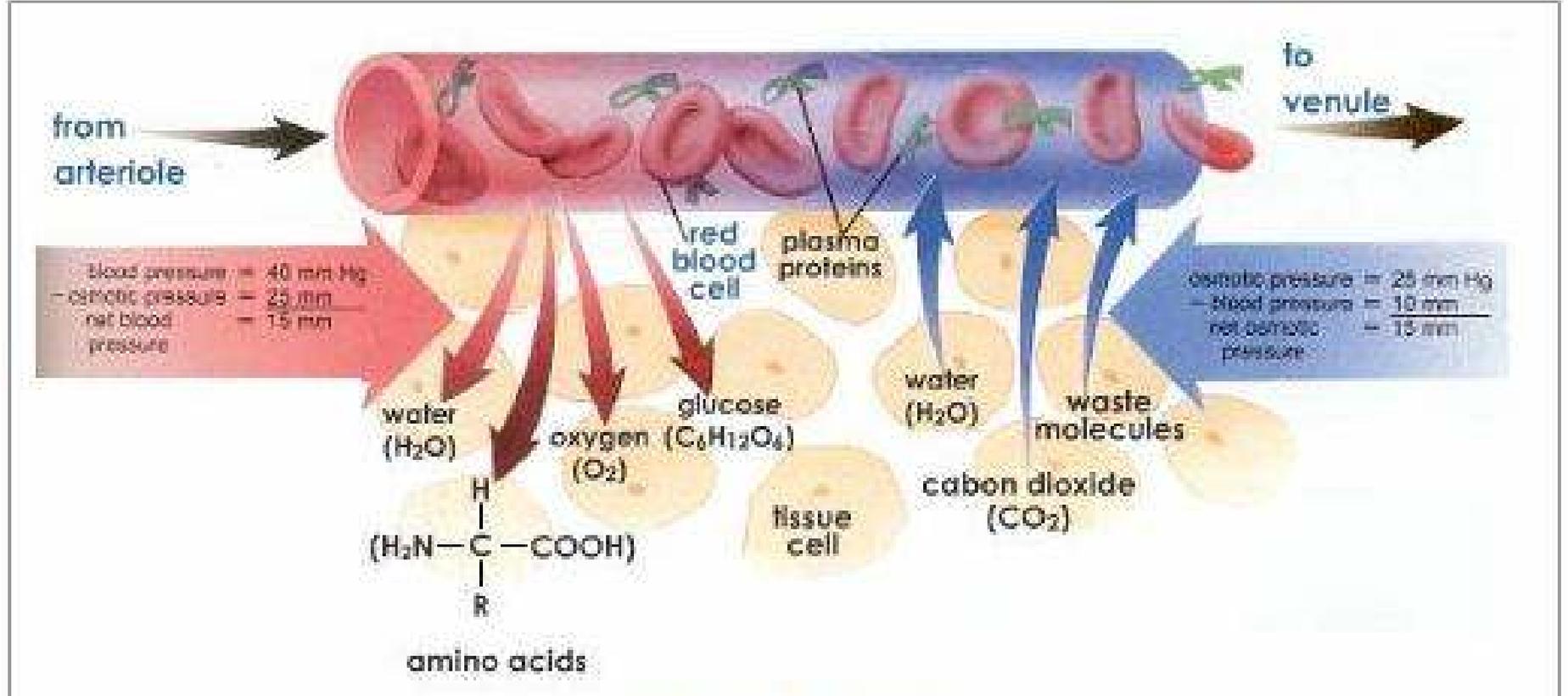
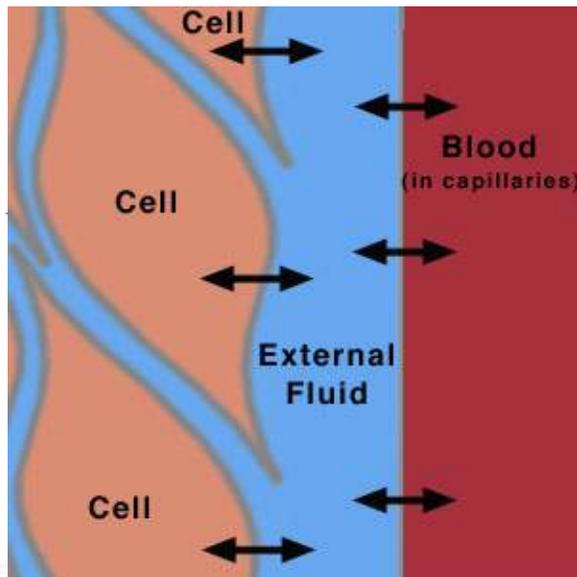
- ▶ Membranes are critical for homeostasis and growth because membranes transport needed substances (H_2O , O_2 , Na^+ , glucose etc) in and out of the cell
- ▶ Types of transport
 - ▶ Passive transport
 - ▶ Active transport
 - ▶ Bulk transport



How does this affect my cells?

- ▶ Many of your cells live in an aquatic environment
- ▶ Between each cell and the next cell is space which is filled with fluid
 - ▶ Interstitial fluid
 - ▶ Site of nutrient and waste exchange





Passive transport

- ▶ **Passive transport**

- ▶ Does not use metabolic energy
- ▶ (What form is metabolic energy found in?)

- ▶ **Molecules naturally move from areas of high concentration to areas of low concentration**

Vocab

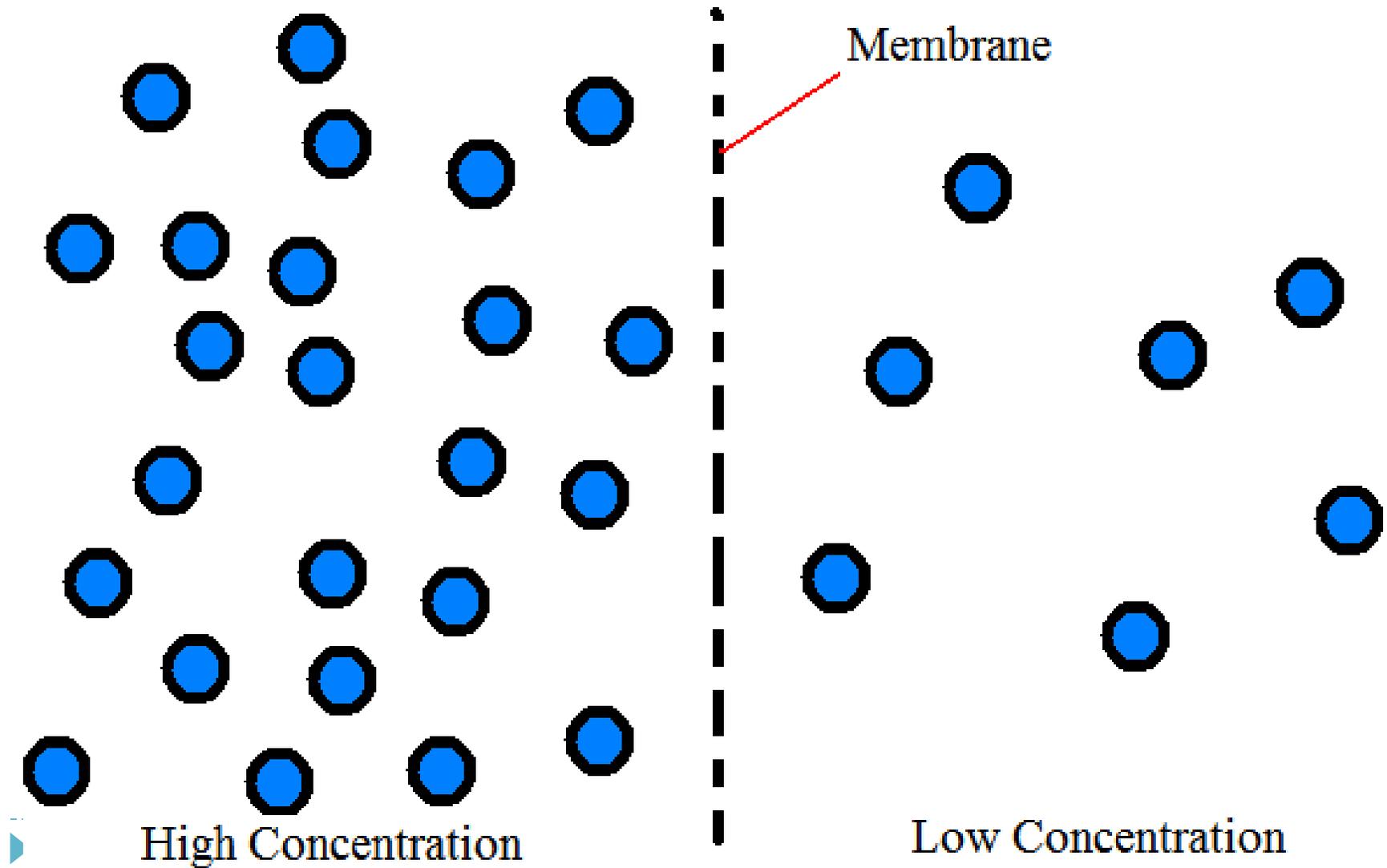
- ▶ Concentration gradient
- ▶ Diffusion



Diffusion



Concentration gradients



Concentration gradients



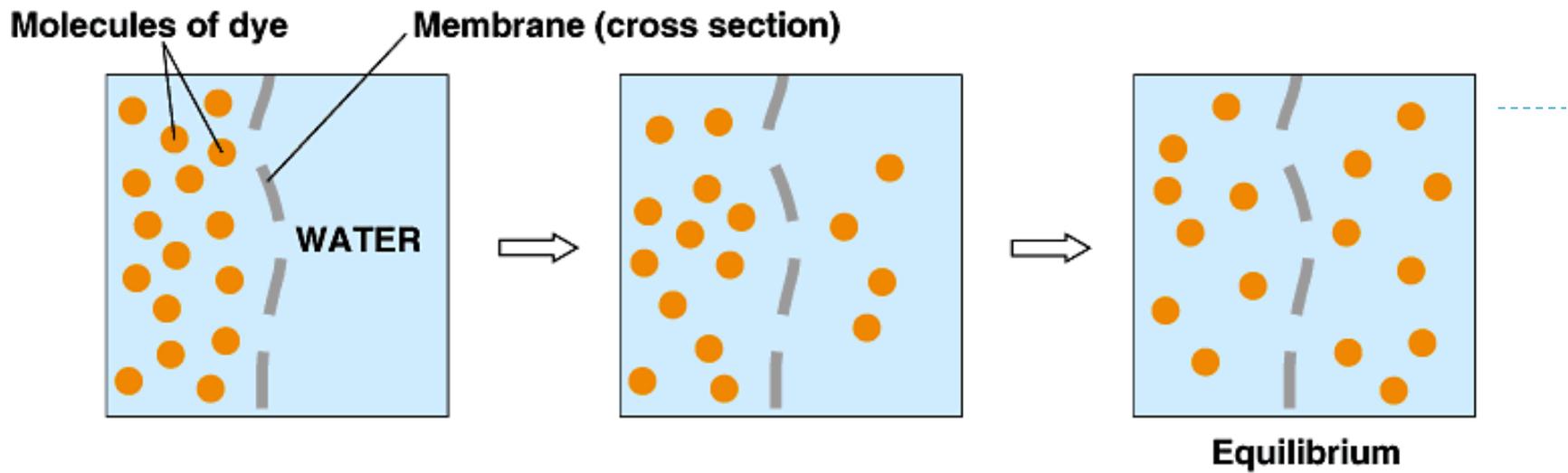
High Concentration



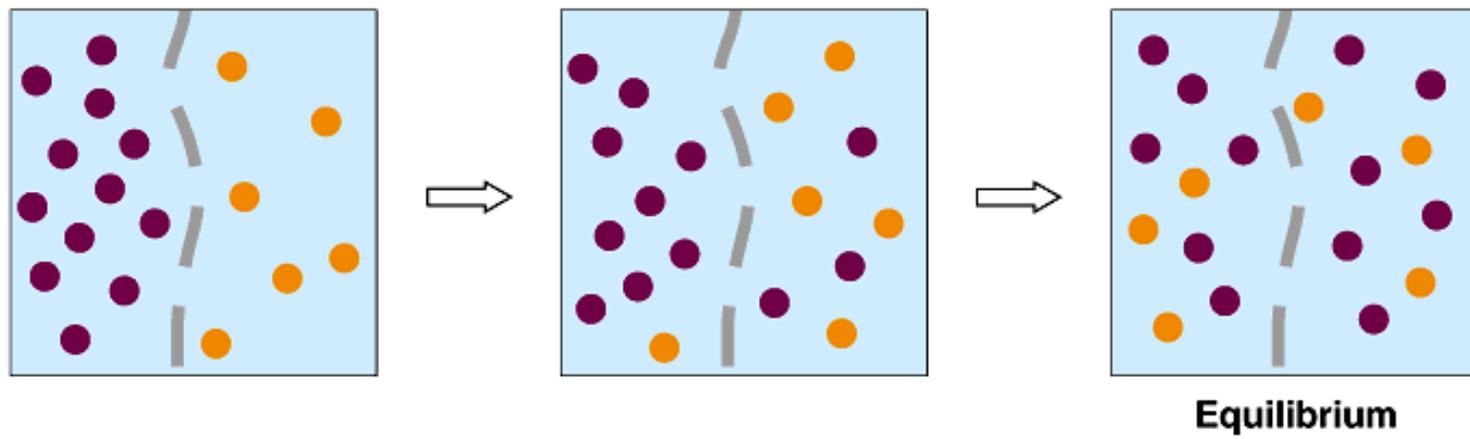
Membrane

Low Concentration





(a) Diffusion of one solute



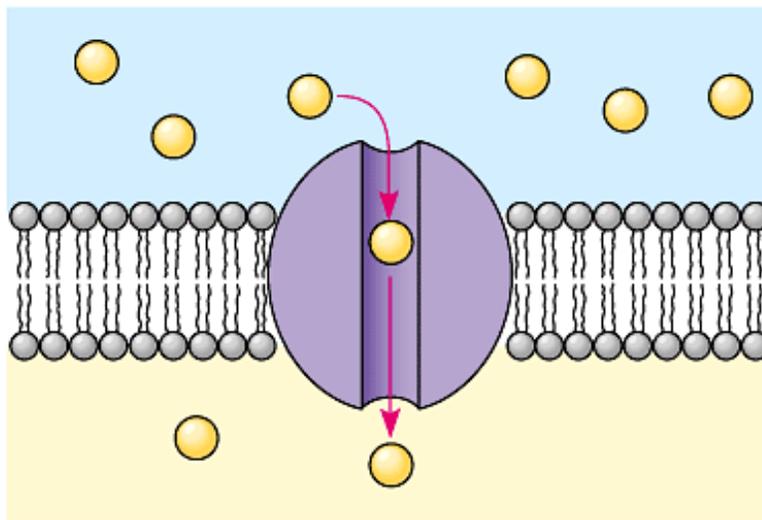
(b) Diffusion of two solutes



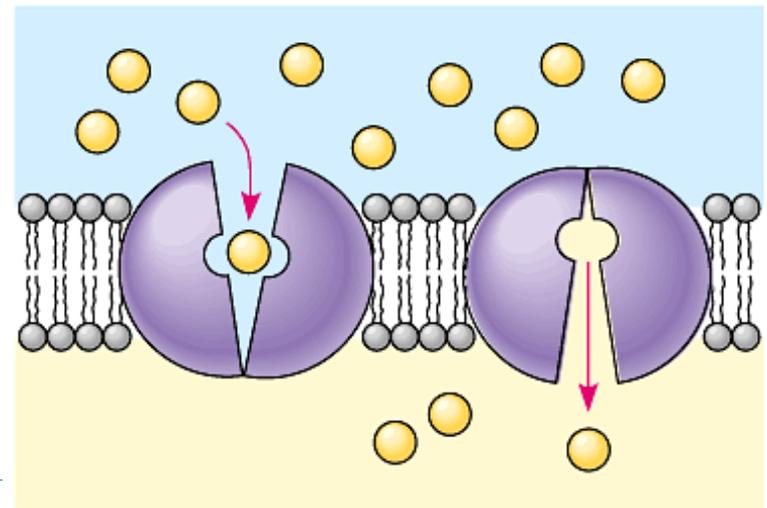


Passive Transport – Facilitated Diffusion

- ▶ Used for removing wastes and importing resources
- ▶ Proteins can assist the movement of polar molecules and charged molecules across the membrane
 - ▶ Facilitated diffusion
 - ▶ Channel and carrier proteins
 - ▶ Gated

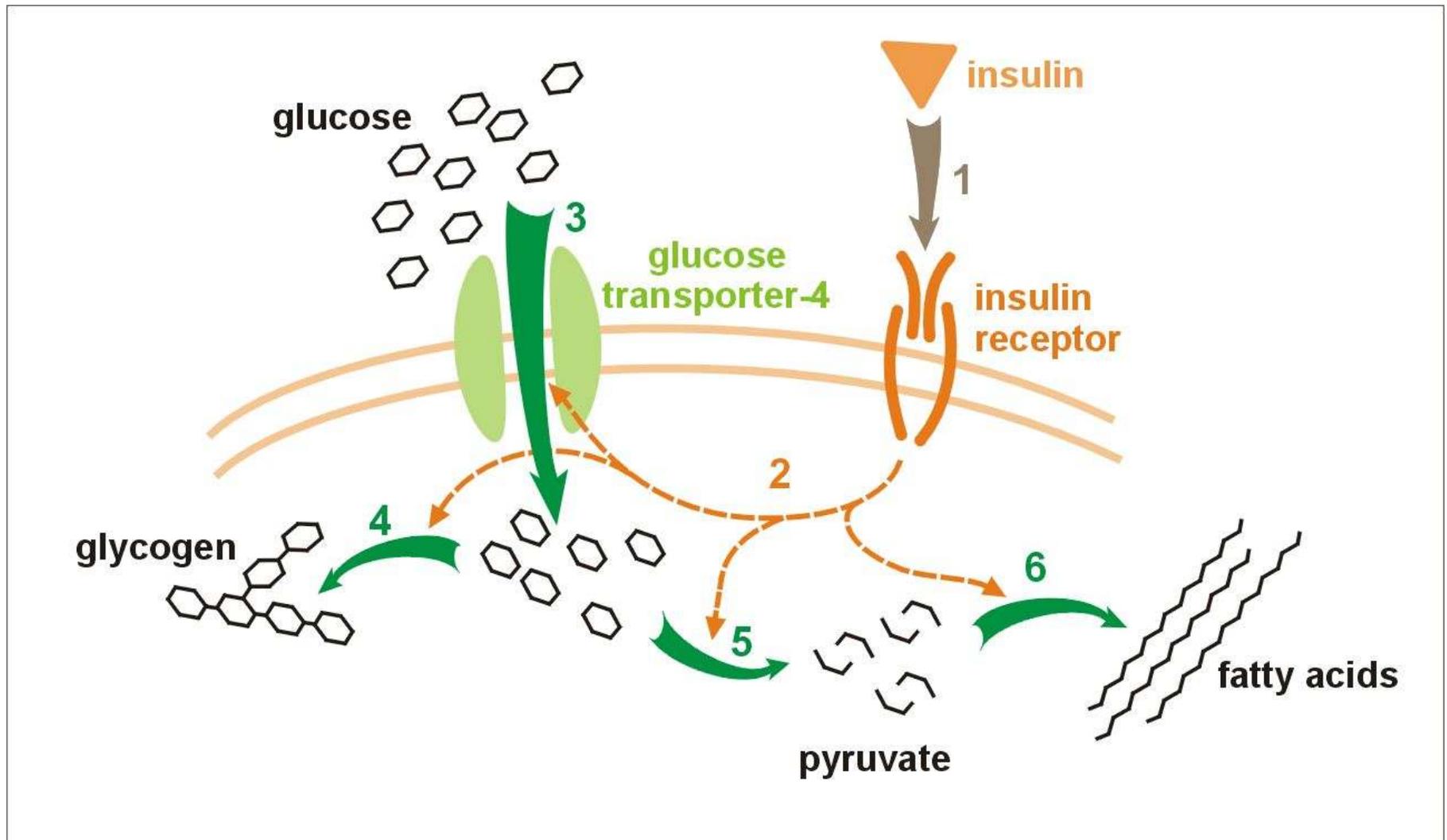


(a)



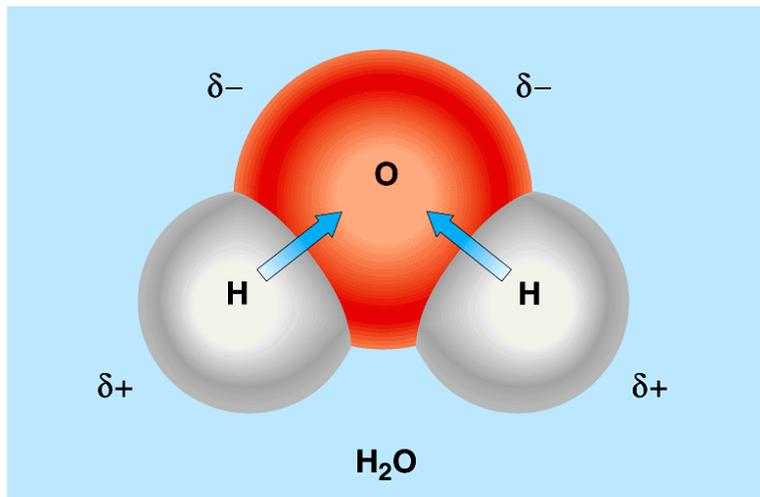
(b)

Example: Glucose Transport

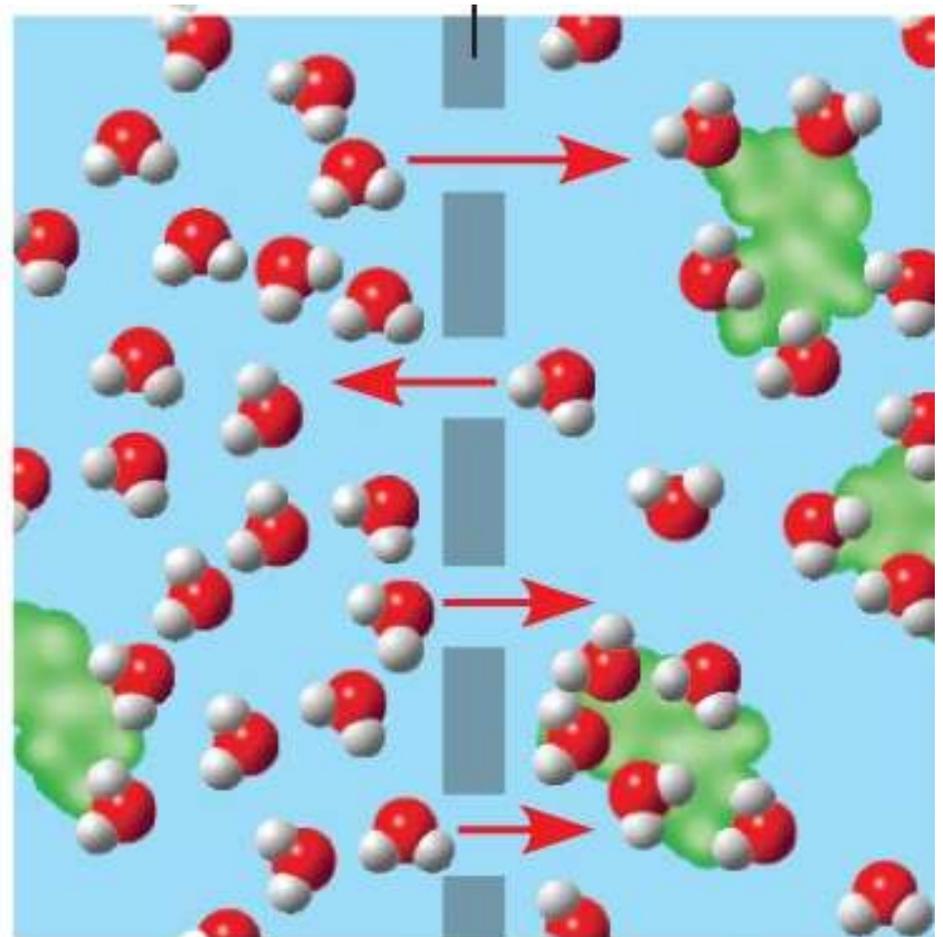


Osmosis: the diffusion of water

- ▶ When water is passively diffusing, we call it osmosis
- ▶ What makes water move?
 - ▶ The concentration gradient
 - ▶ Free water



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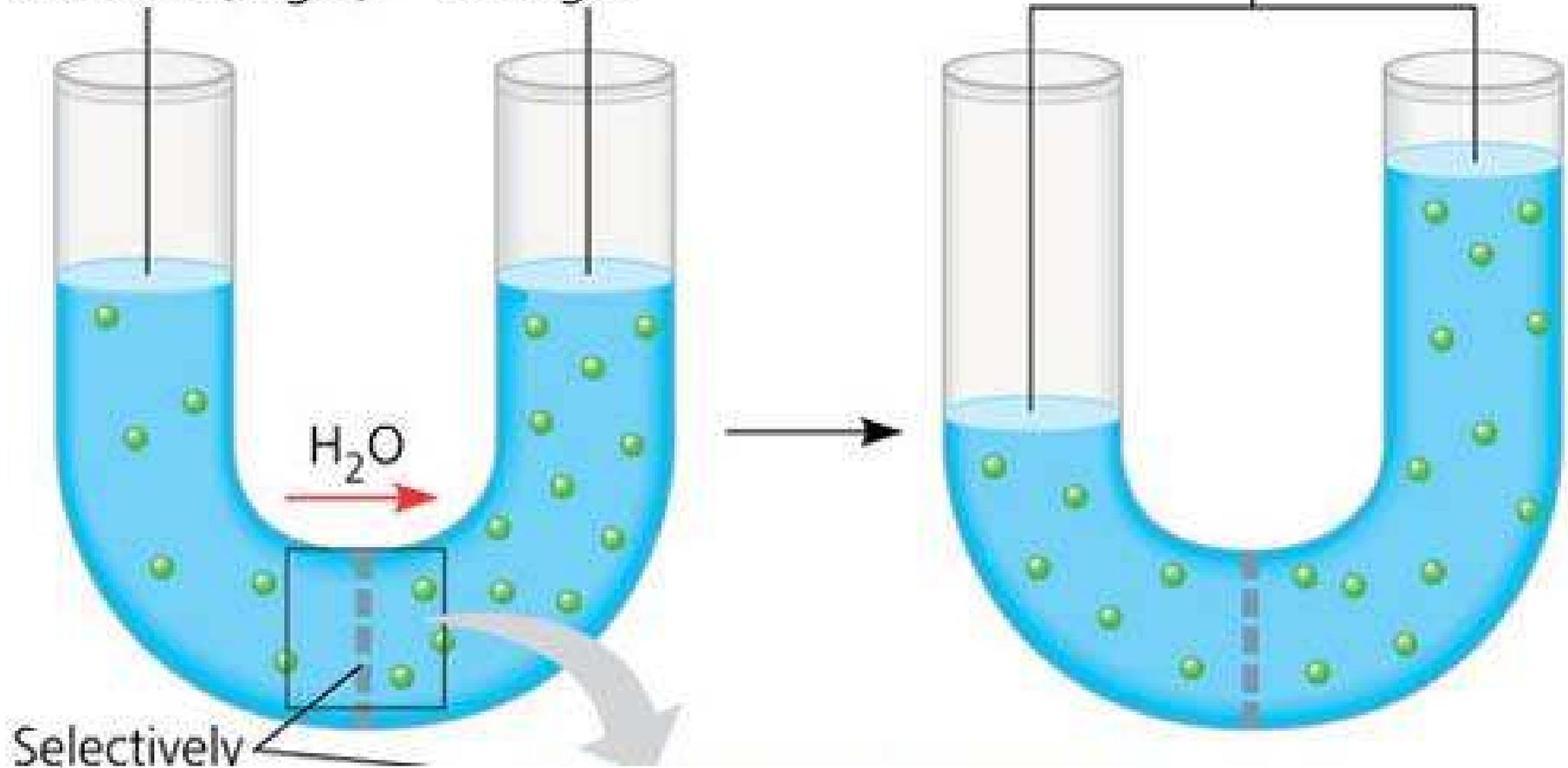


Osmosis

Lower concentration of solute (sugar)

Higher concentration of sugar

Same concentration of sugar



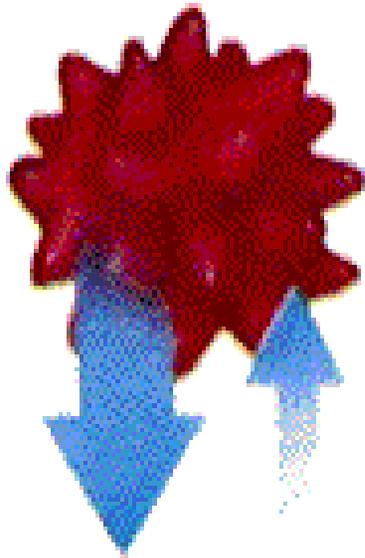
Tonicity

- ▶ The tonicity of the solution affects the movement of water molecules
 - ▶ Vocab review
 - ▶ Solute
 - ▶ Solvent
 - ▶ Solution
- ▶ Real life application
 - ▶ External environments
 - ▶ Interstitial fluid

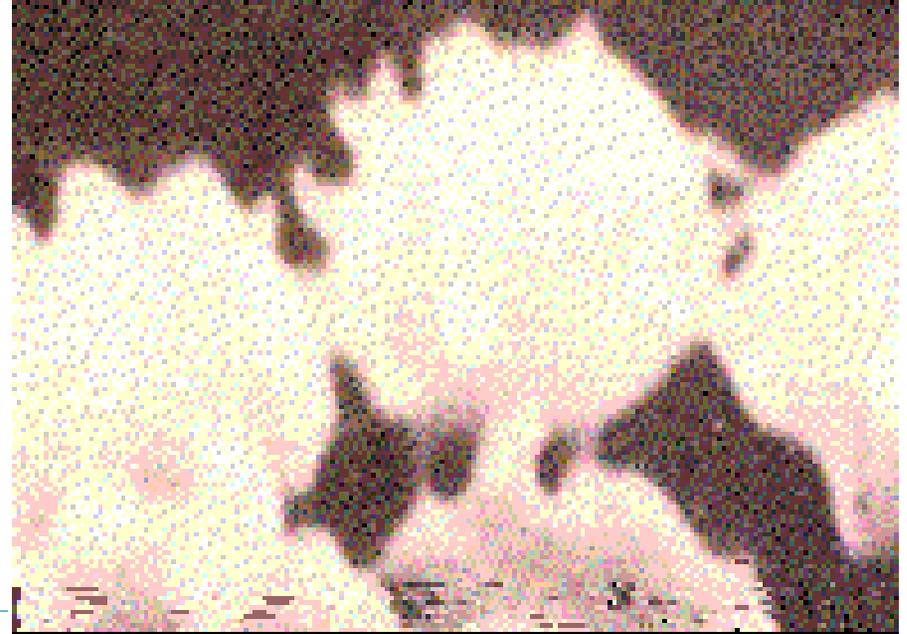


Hypertonic

- ▶ Hypertonic solutions have a higher concentration of solutes outside of the cell compared to the concentration of solutes inside of the cell

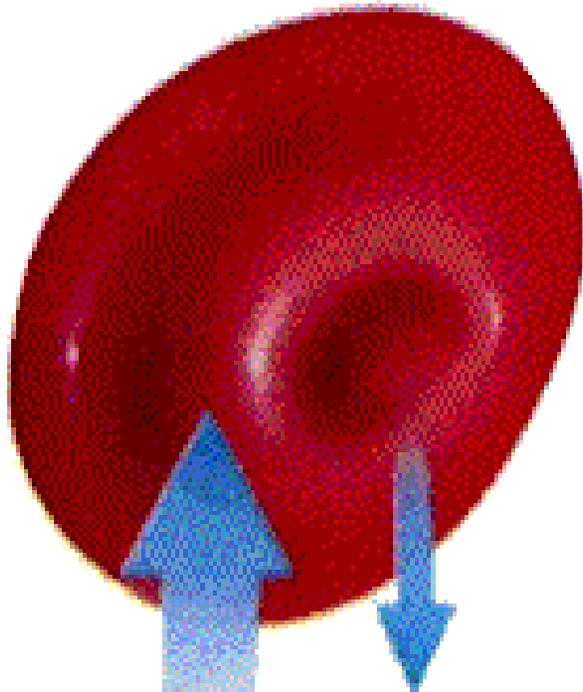


**net water movement
out of cells**

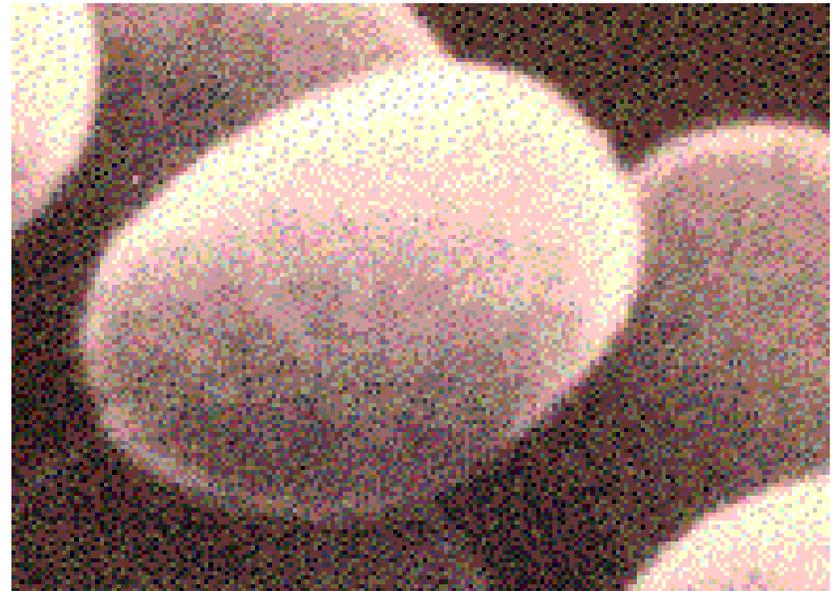


Hypotonic

- ▶ Hypotonic solutions have a lower concentration of solutes outside of the cell compared to the concentration of solutes inside of the cell

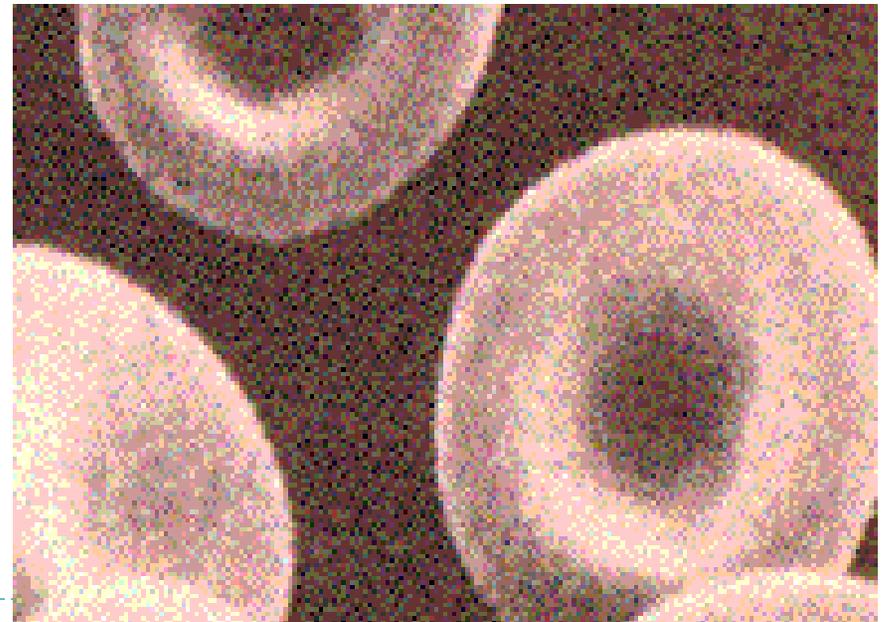
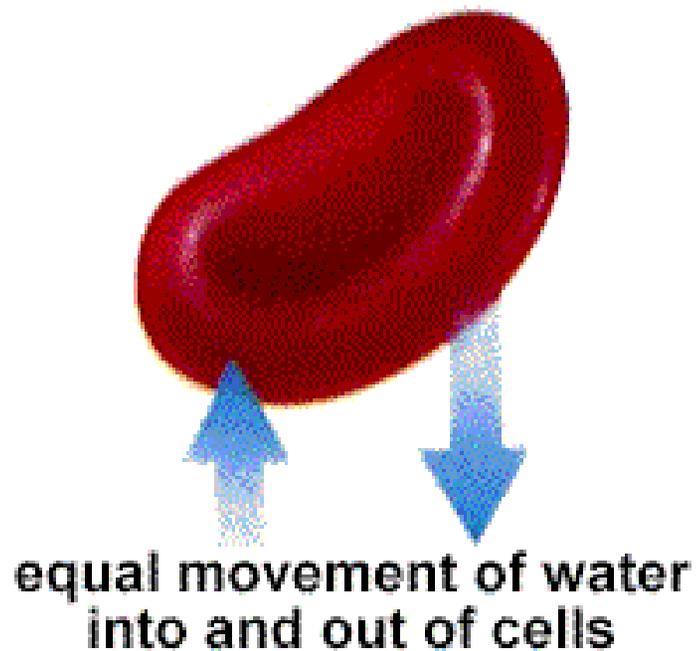


▶ **net water movement
into cells**



Isotonic

- ▶ Isotonic solutions have an equal concentration of solutes outside of the cell compared to the concentration of solutes inside of the cell



How does this affect living cells?

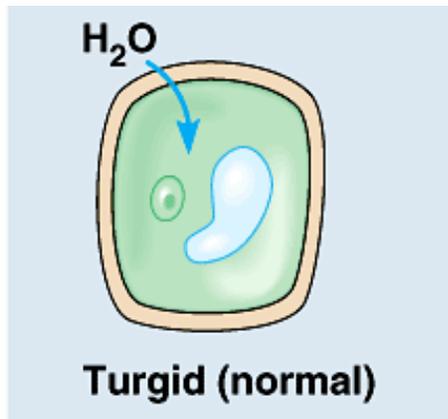
- ▶ Your cells are in an aquatic environment
- ▶ Concentration gradients need to be maintained



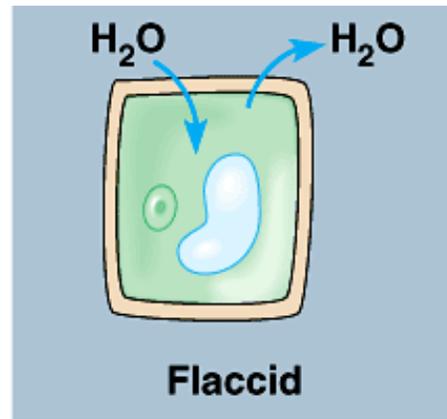
Different story for cells with walls

- ▶ Plants, fungi, prokaryotes and some protists
- ▶ Hypotonic is good= turgid
- ▶ Hypertonic is bad= flaccid and plasmolysis

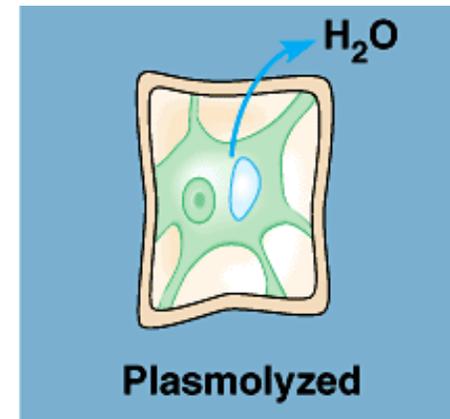
Hypotonic



Isotonic



Hypertonic



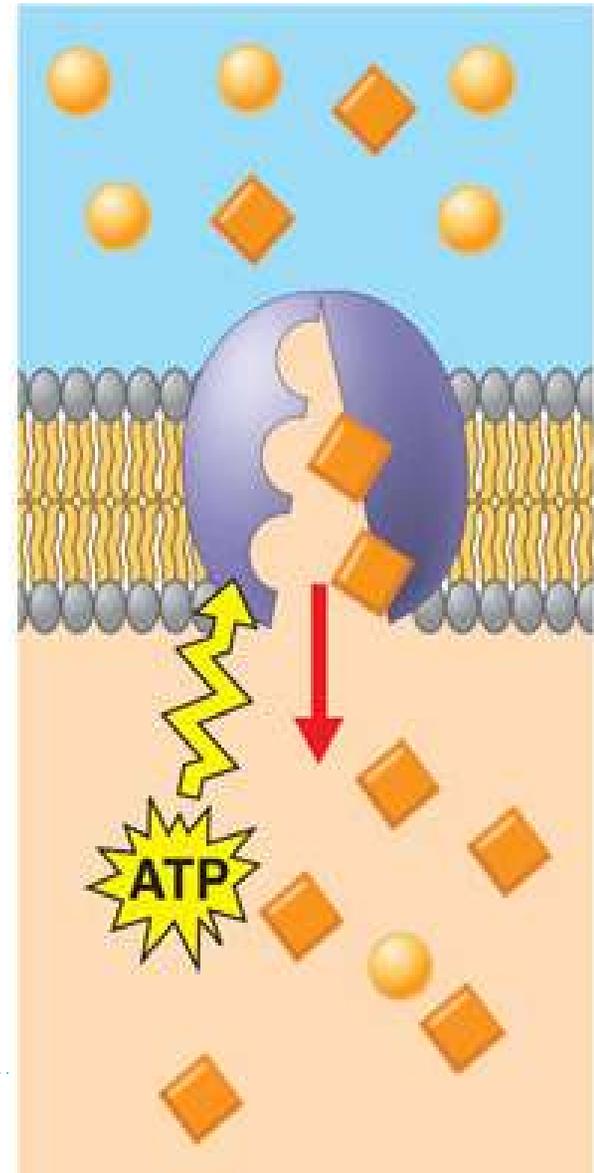
Plant cell





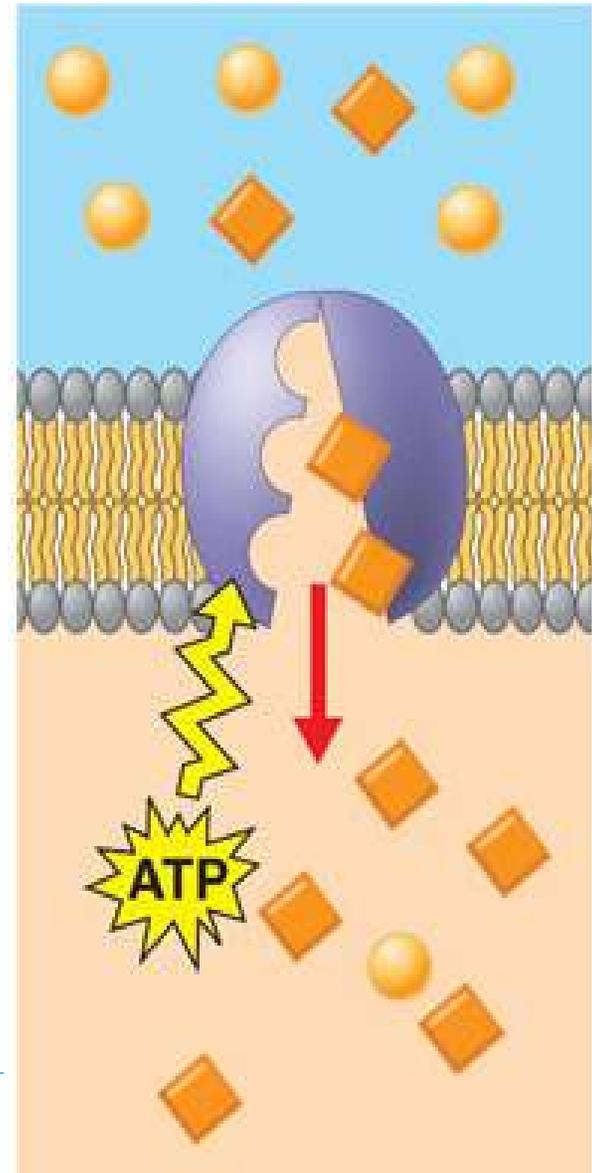
Active transport

- ▶ Requires the use of free energy
- ▶ ATP is used by membrane proteins to move molecules/ions across the membrane
- ▶ Moves from areas of low concentration to areas of high concentration
- ▶ Against the concentration gradient



How does active transport work?

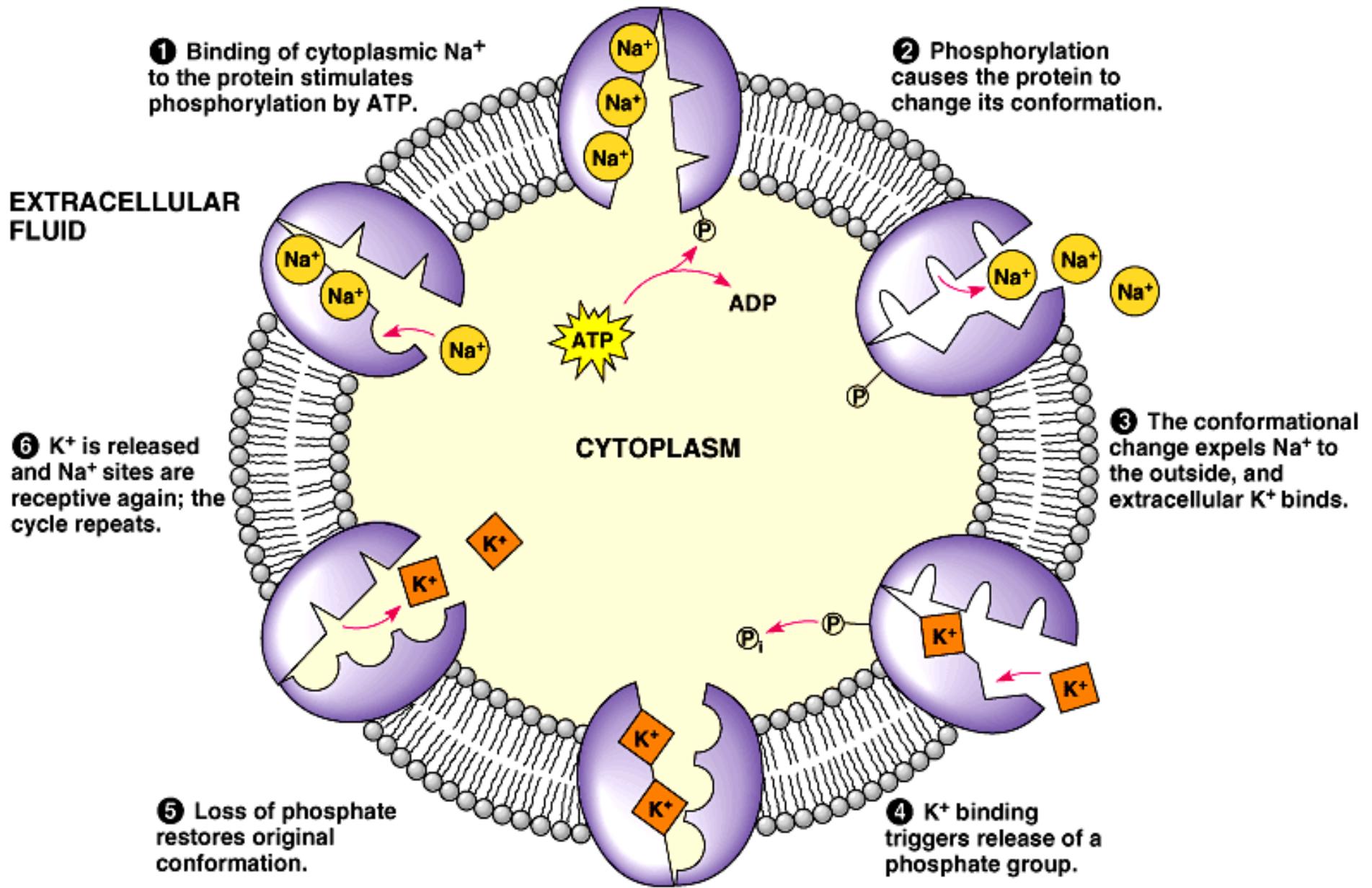
- ▶ Phosphorylation
- ▶ Physical change of the protein



Active transport example

- ▶ **The Sodium-Potassium pump**
 - ▶ Exchanges sodium (Na^+) for potassium (K^+)
- ▶ **Maintains the concentration gradient**
 - ▶ Cytoplasm: High K^+ /low Na^+
 - ▶ Outside the cell: High Na^+ /low K^+
 - ▶ Pumps against steep gradient. Three Na^+ out and two K^+ in
- ▶ **Important in nerve cells**





Why do we need active transport?

- ▶ Maintains concentration gradients and prevents the arrival of the equilibrium state
- ▶ Maintains membrane potential
 - ▶ What is that?



Membrane Potential

- ▶ Potential energy that is “stored” across a membrane
- ▶ The physical movement of ions is kinetic energy.
- ▶ If they are held outside the cell and waiting to diffuse, its potential energy



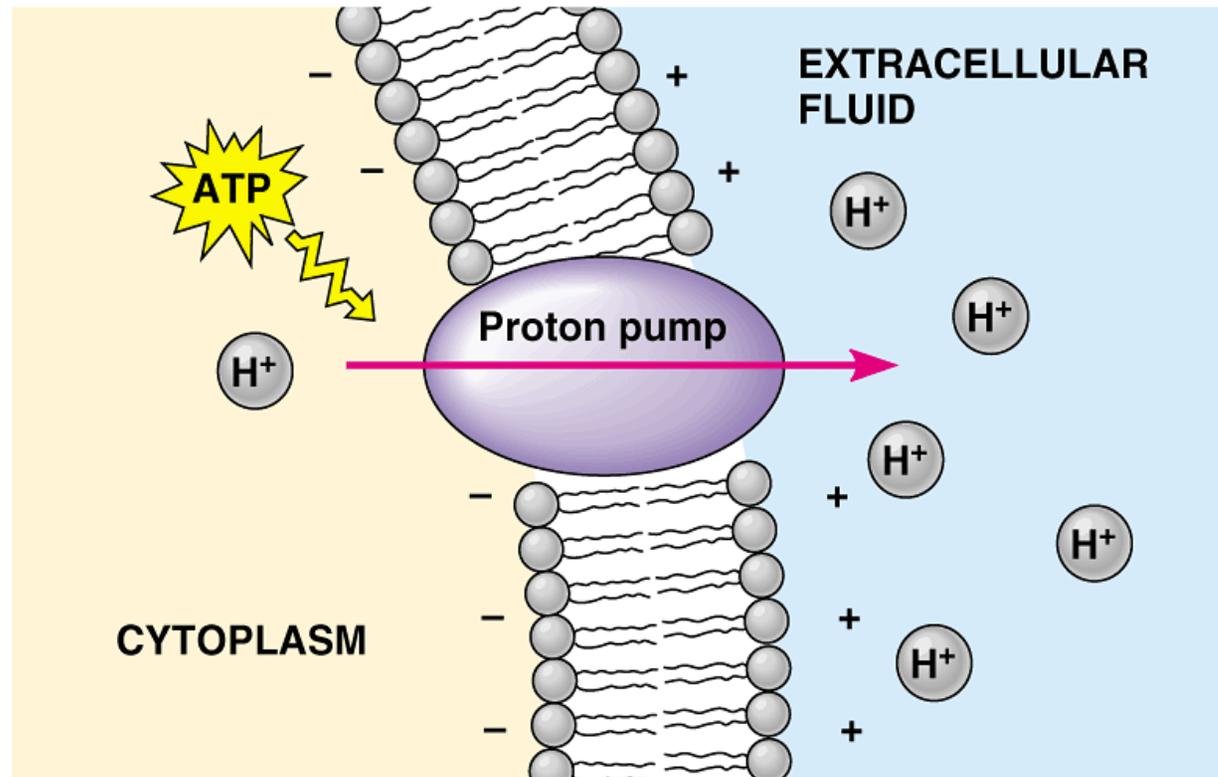
Membrane Potential

- ▶ **Measured in voltage**
 - ▶ Opposite charges are separated
 - ▶ Cytoplasm is negative
 - ▶ Outside the cell is positive
 - ▶ Favors the rush of + ions into the cell
- ▶ **Electrochemical gradient**
 - ▶ Concentration and the attraction of charges
- ▶ **Sodium-potassium pump maintains the electrochemical gradient by increasing the + charge on the outside of the cell**



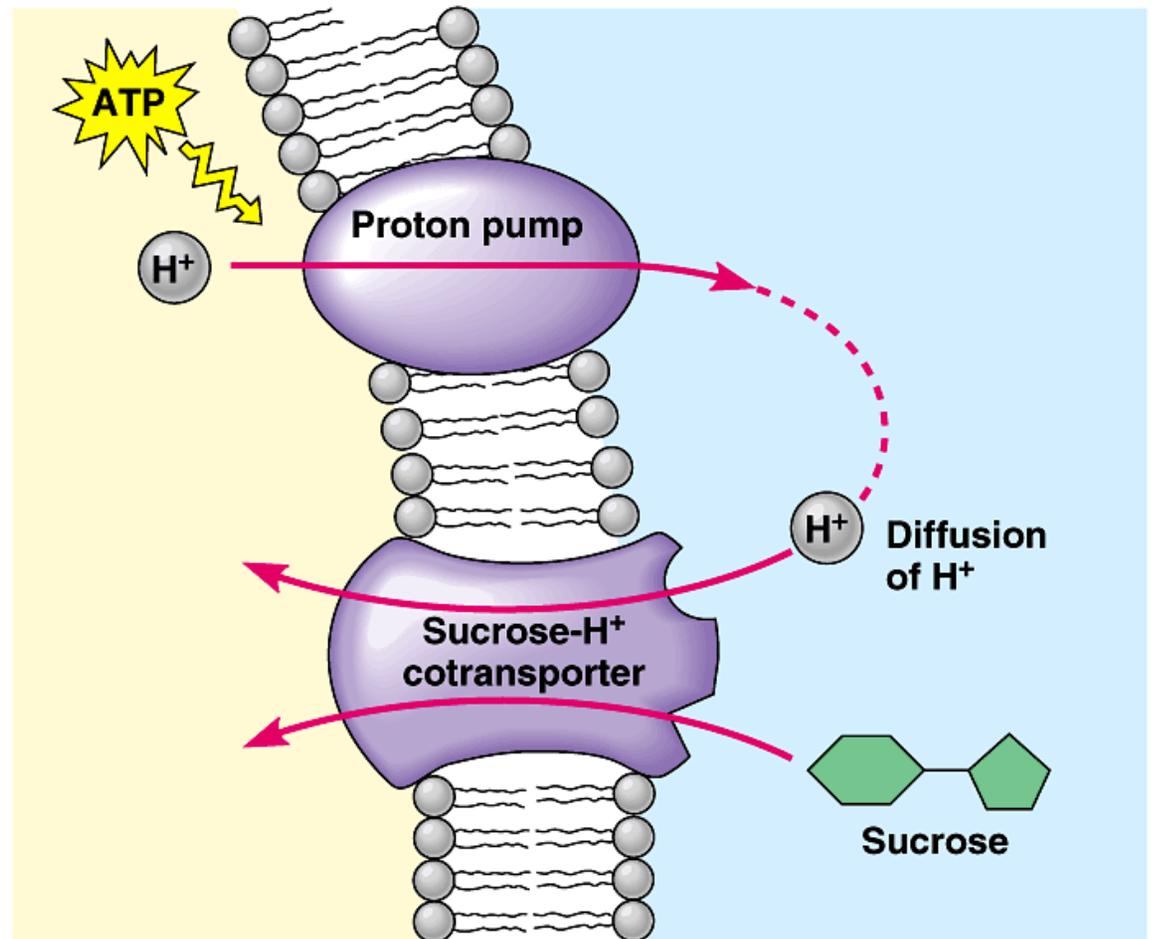
Proton Pumps

- ▶ Active transport that removes protons from the cell
- ▶ Establishes gradient
 - ▶ Potential energy that can later be used for work

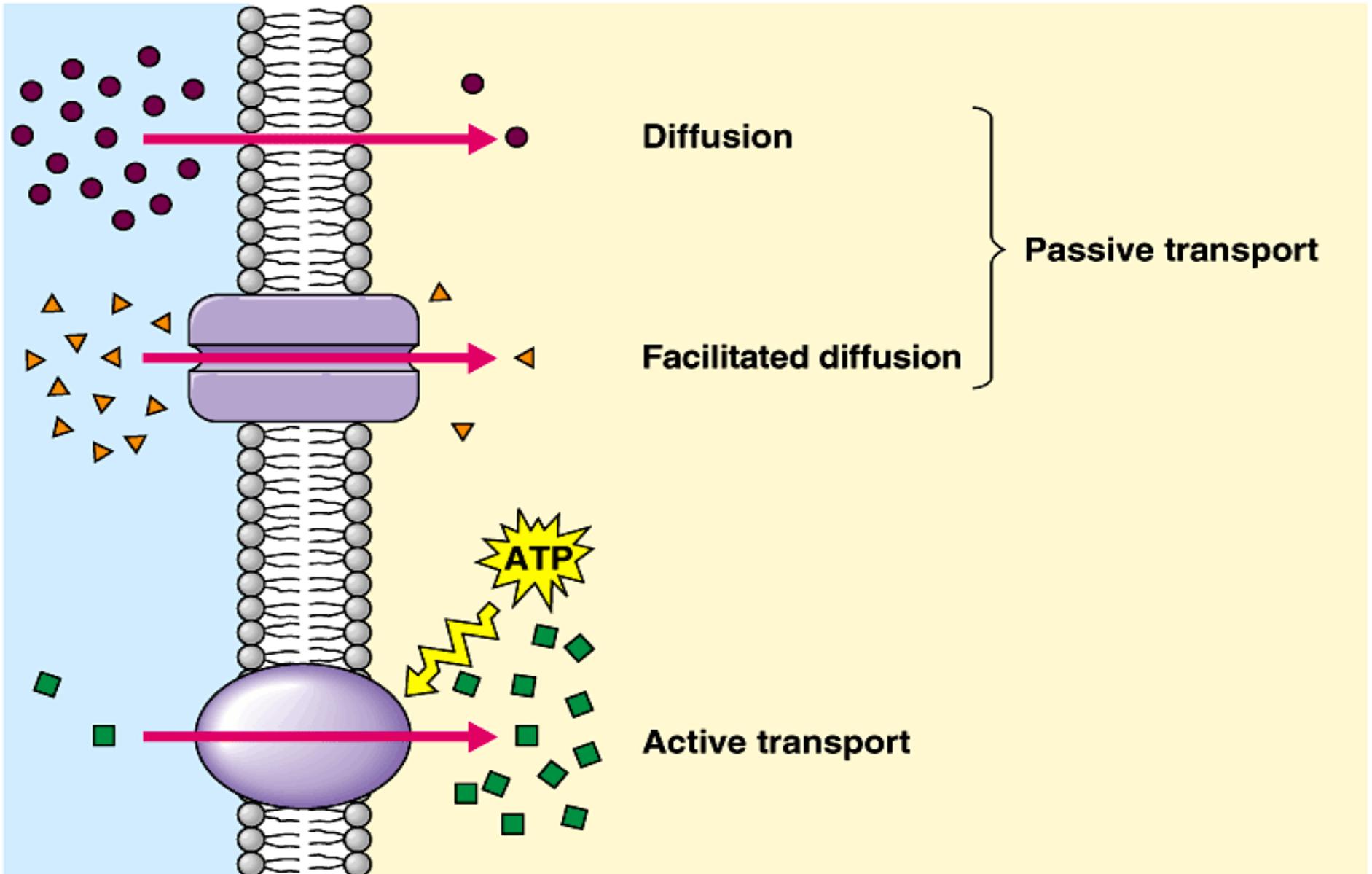


Cotransport

- ▶ Active transport coupled with passive transport
 - ▶ Molecule triggers passive transport
 - ▶ Gatorade

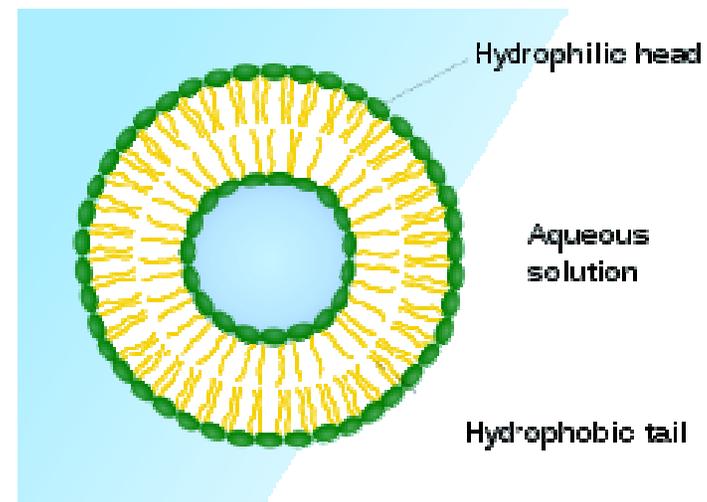


Transport Review



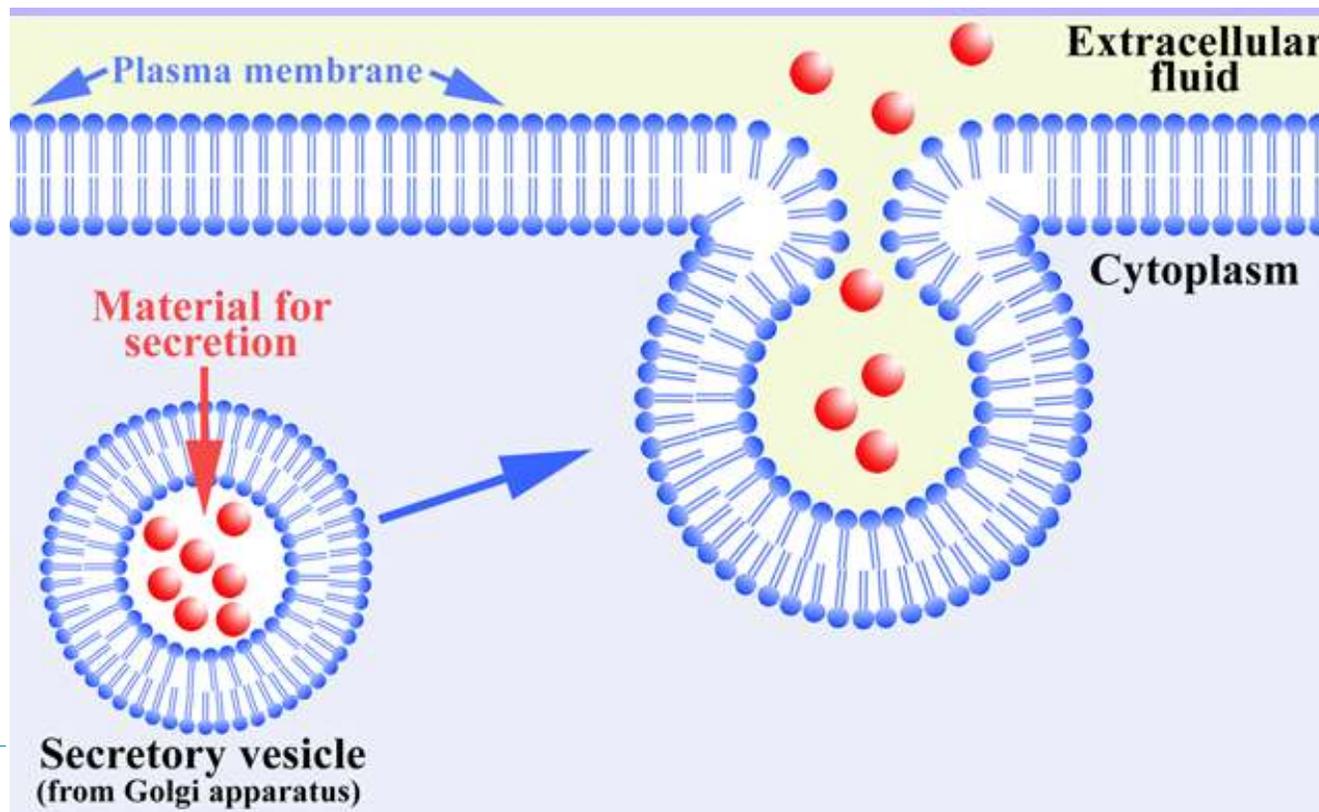
Bulk transport

- ▶ Exocytosis and endocytosis
- ▶ Vesicles are used to move large molecules in or out of a cell
 - ▶ Macromolecules
- ▶ What is a vesicle?



Exocytosis

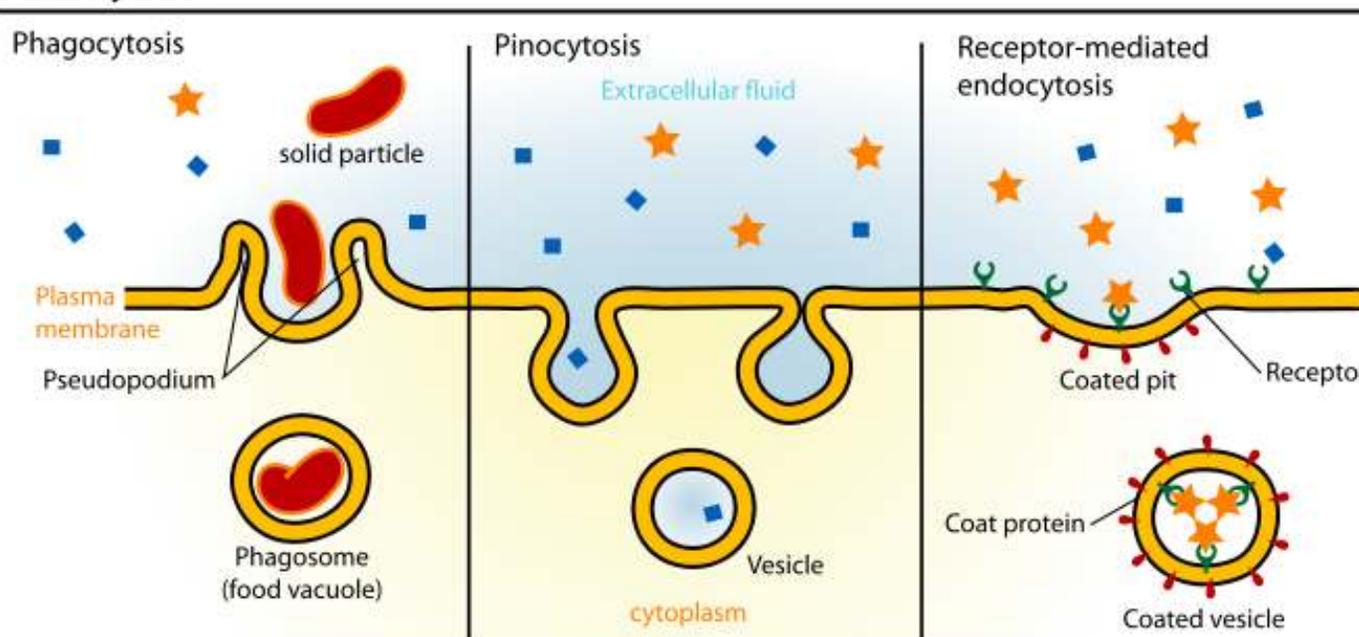
- ▶ Vesicles fuse with plasma membrane
- ▶ EX: Insulin from the pancreas, Neuron and neurotransmitters, Plant cell walls

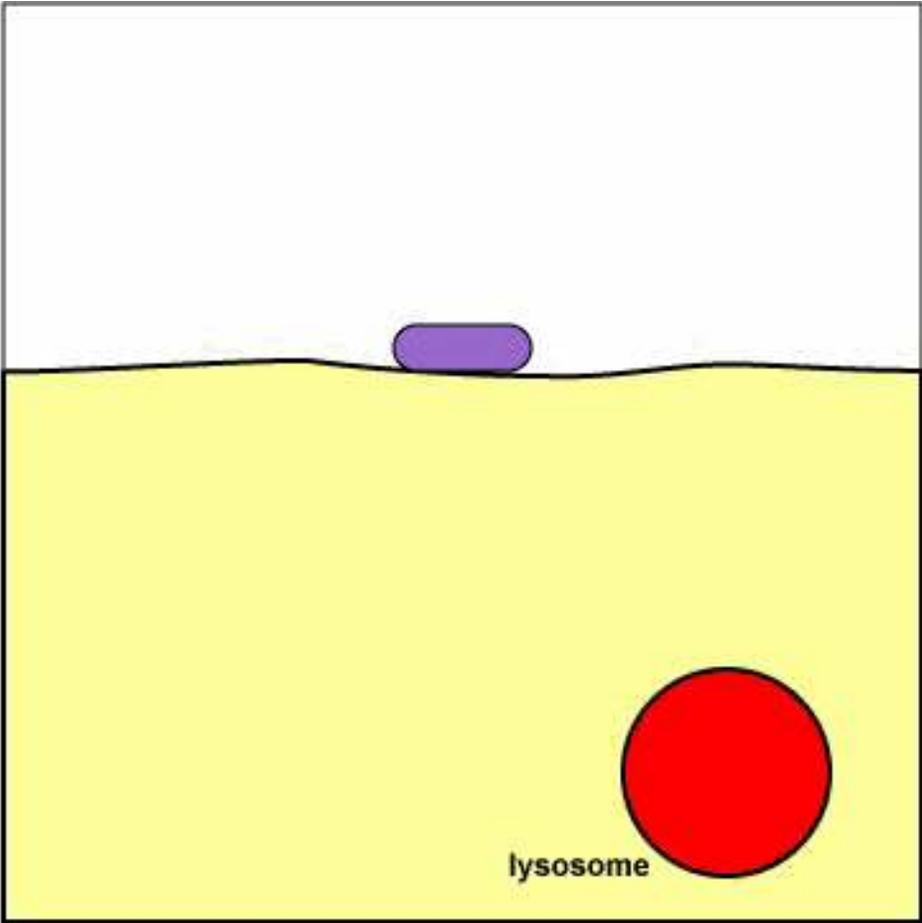


Endocytosis

- ▶ New vesicles are formed from the plasma membrane capturing macromolecules and particles
 - ▶ Phagocytosis
 - ▶ Pinocytosis
 - ▶ Receptor-mediated endocytosis

Endocytosis





Receptor mediated endocytosis

