Introduction to Celluar Physiology

Course: Destistry
Hashemite University

Lecture No. 1

1. **Levels of organization in the body**
2. **Levels of Homeostasis and body fluids**

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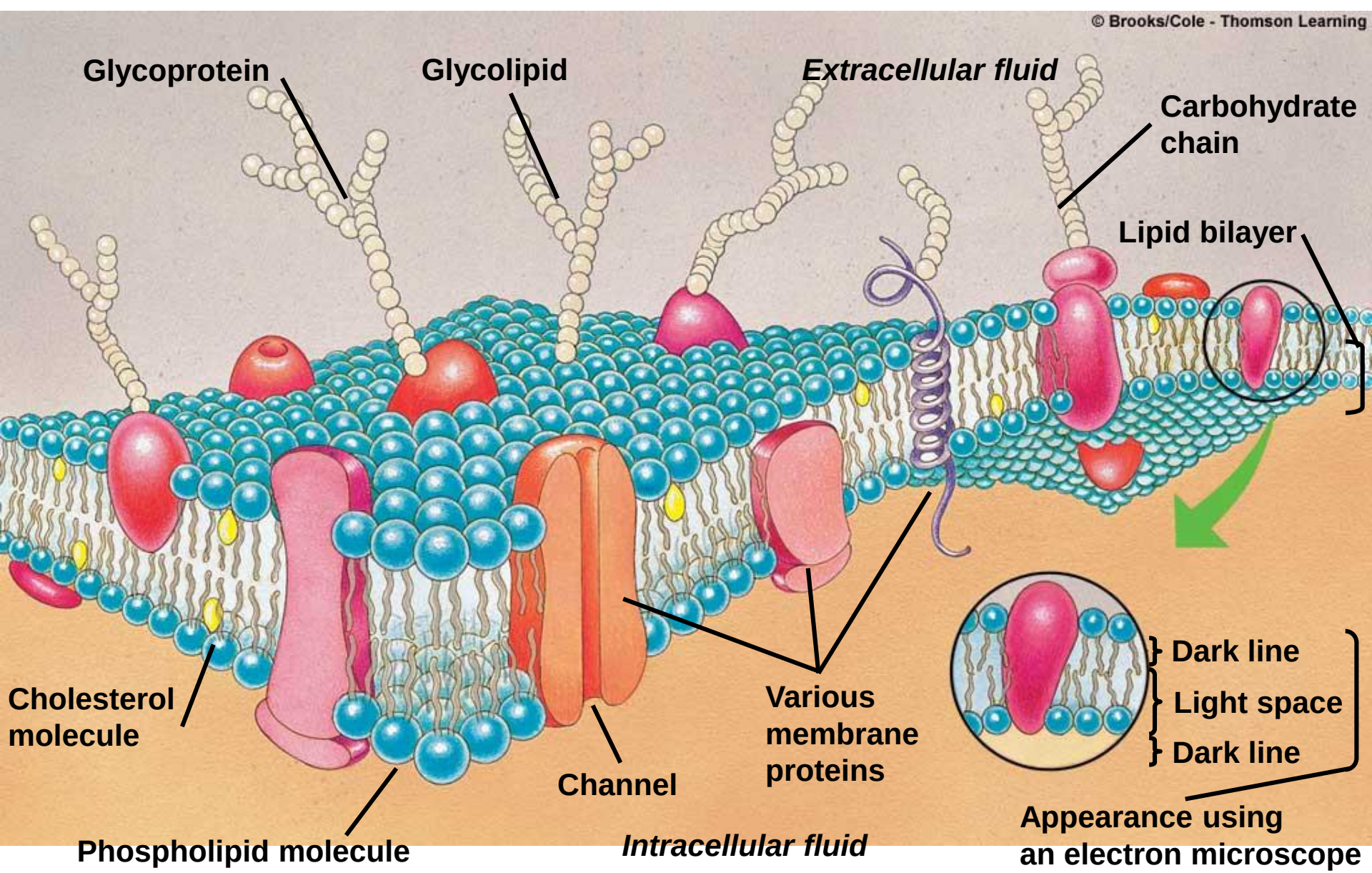


- Composition
  - Proteins 55%
  - Lipids 42%
  - carbohydrates 3%

Fig. 3-3, p. 45

Cont. cell membrane composition →

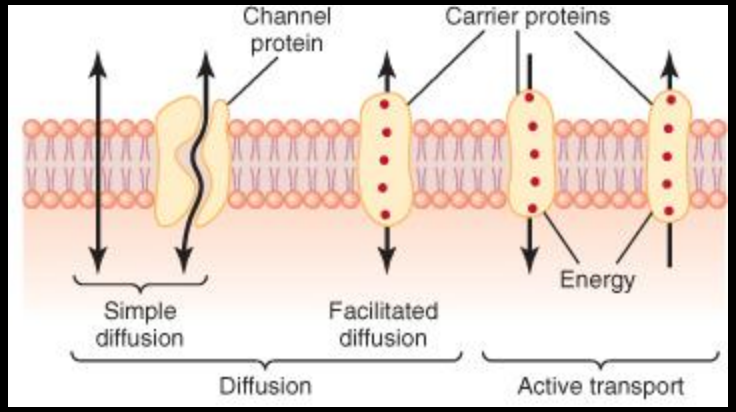
- Proteins

Integral; penetrate cell membrane.

peripheral; attached to integral protein, don't penetrate the cell M.

Actions:

a) Forming channels (pores)
b) Carrier proteins.
c) enzymes.



- Carbohydrates

Actions:

With proteins (glycoproteins)

With lipids (glycolipids)

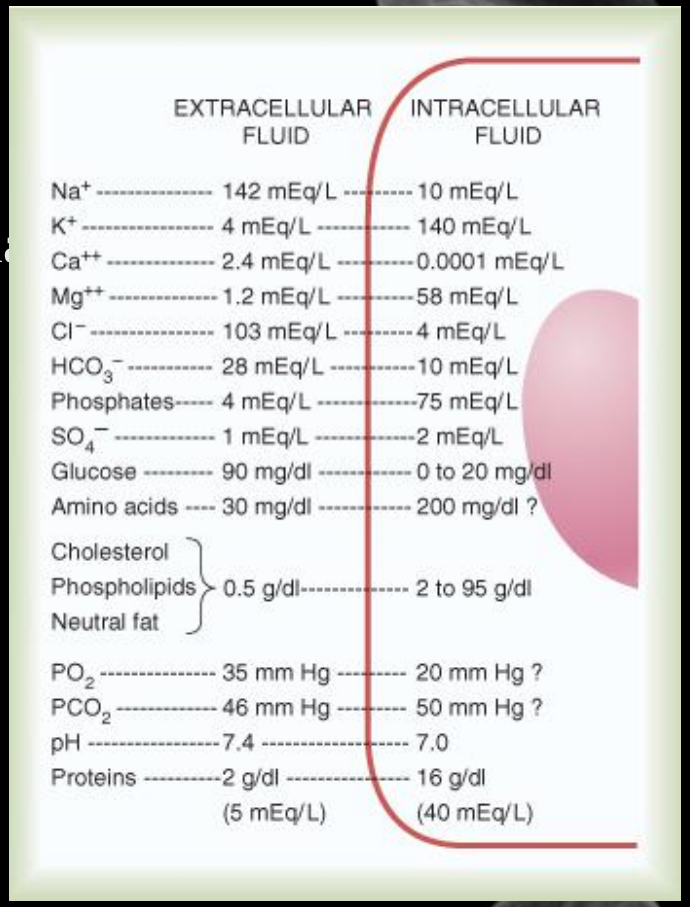
Glycocalyx

a) receptors.
b) Share in immune reaction.
c) Help in attachment of one cell to another.
d) Provide negative charge to the cell.

Responsible for antigenic properties of the cells

Why do we care about cell membranes?

- If the cell membrane breaks, the cell dies.!
- Cell membrane creates and maintains concentration differences between the intracellular and extracellular solutions.
- Contrast concentration and conditions



Inside and outside the cell..:

1- much higher K+ conc. Inside than outside.

2- much higher Na+ conc. outside than Inside.

3- much higher Cl- conc. outside than Inside.

4- much higher Ca++ conc. outside than inside.

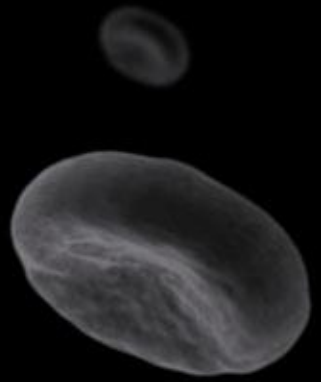
5- higher protein conc. inside than outside.

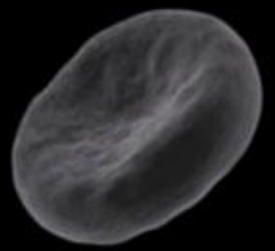
6- outside is slightly alkaline (PH=7.4) while inside is neutral (PH=7).

7- osmolarity of solutions inside and outside is similar

How do substances (particles) cross cell membranes?

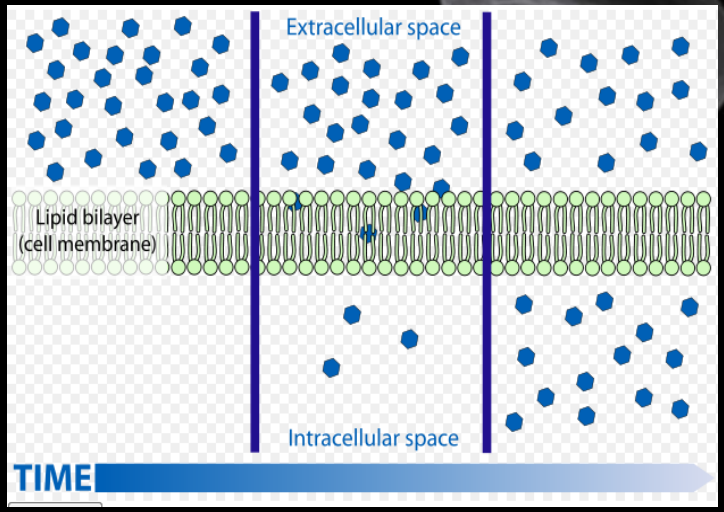
1. Diffusion
   - Simple
   - Facilitated
2. Osmosis
3. Active transport
   - Primary
   - Secondary
4. In vesicles
   - Endocytosis
   - Exocytosis.





Diffusion

- Is the random movement of particles in a solution. This movement depends on the temperature.
- The process of diffusion causes particles to move from an area of high concentration to an are of low concentration. Finally the concentration of particles becomes equal through out the solution.
- The net diffusion is always from high Conc. to low.



Diffusion tries to reach equilibrium Where the conc. are the same everywhere. No energy source is needed, the random movement of the particles is all what is needed.

Cont. simple diffusion →

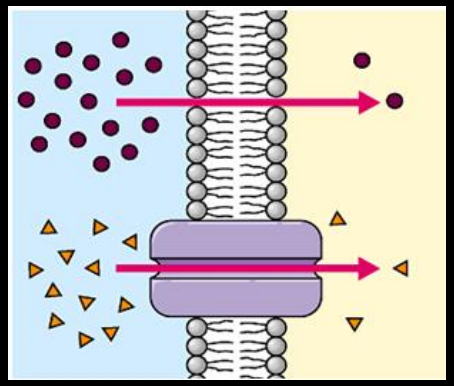
- Two types of simple diffusion

a) Through intermolecular spaces of the membrane

"lipid soluble substances"

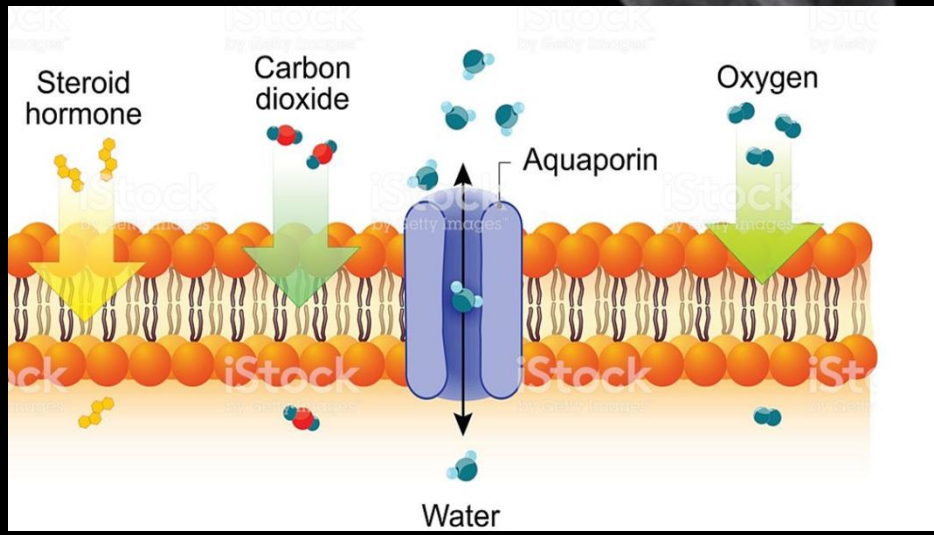
b) Through membrane channels

"water and lipid insoluble molecules"



Simple diffusion (Cont.)

- **Lipid-soluble molecules like oxygen and CO2 cross the cell membrane by simple diffusion. The degree of diffusion of these substances is determined mostly by their lipid solubility.**

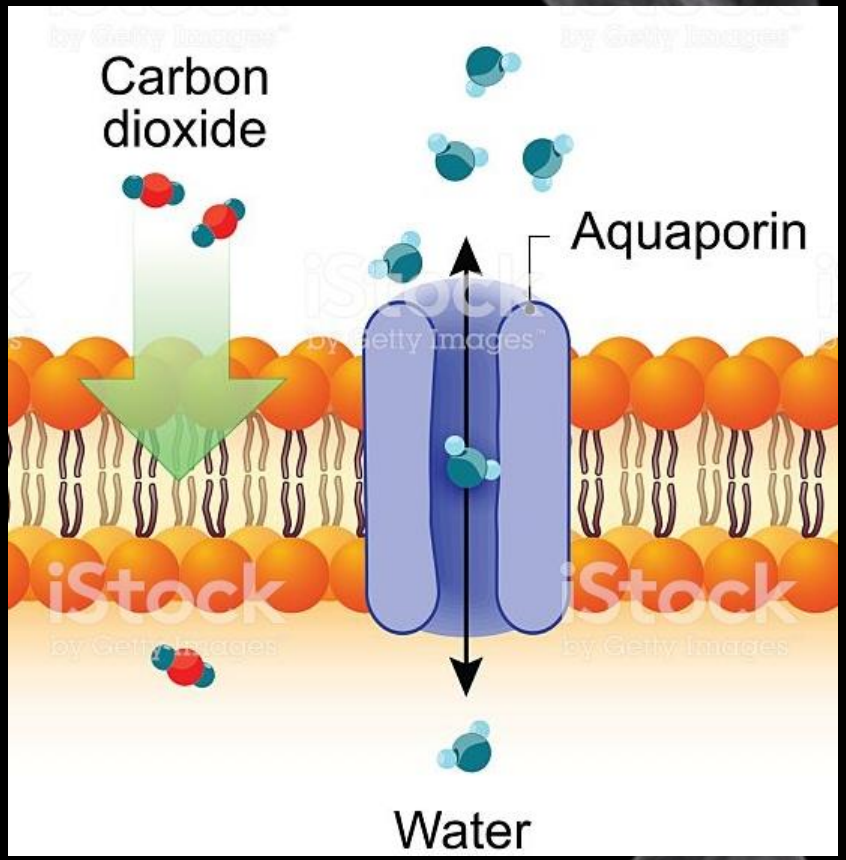


- **Hydrophobic, lipophilic substances like fatty acids, fat-soluble vitamins and drugs can dissolve in the lipid bilayer of the cell membrane and diffuse across the membrane.**

Simple diffusion (Cont.)

- **Diffusion of water is through membrane channels. Water penetrates very rapidly the cell membrane through protein channels (aquaporins).**

- **Urea can cross the cell membrane by simple diffusion through protein channels. Urea molecule is 20% larger than water molecule and thus → its rate of diffusion is less than water.**



Simple diffusion (Cont.)

- **Transport of ions (Na+ and K+) is by simple diffusion through protein channels.**

>> these channels are:

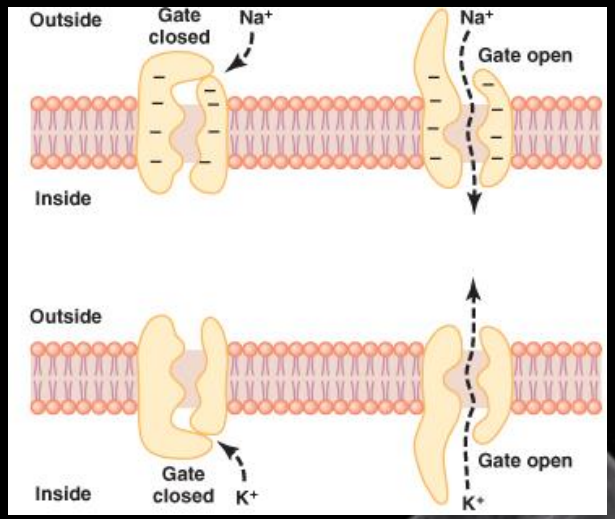
a) **Selectively permeable to certain substance.**

b) **Opened or closed by gates.**

- **The presence of gates in these channels controls the movement of ions through these channels.**
- **The opening and closing of these gates are controlled by:**

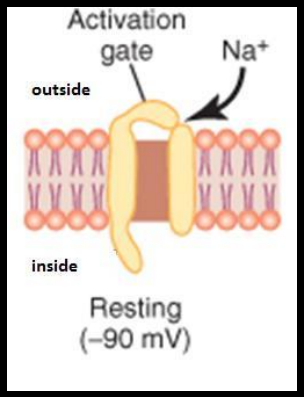
a. Changing the potential of the cell "voltage gating".

b. Binding chemical substances To the gate "chemical or ligand gating".

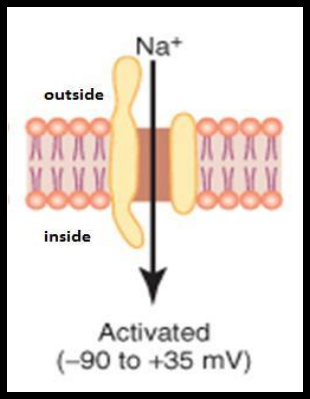


Voltage-gated channels

Closed Na+ channel



open Na+ channel

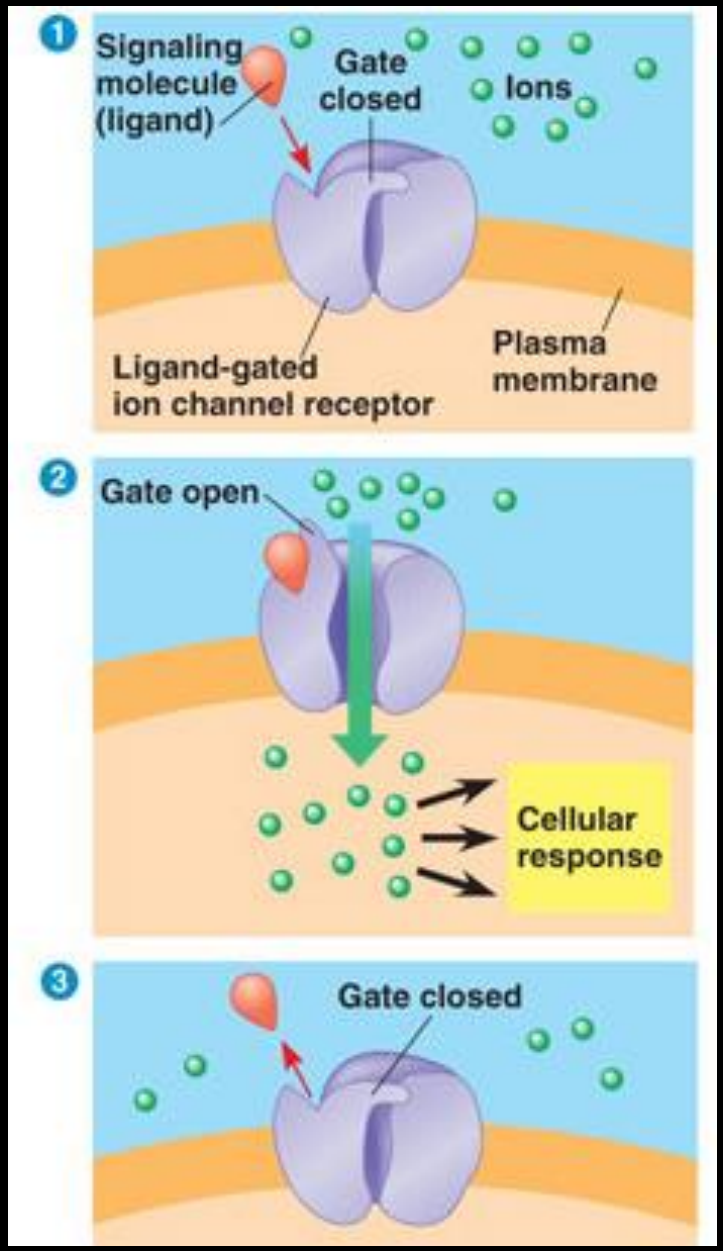


Less negative

- Na+ voltage gated channels are open when the inside of the membrane becomes less negative, allowing Na+ to pass from outside to inside the cells.
- Conversely, these Na+ channels are closed when inside of the membrane is highly negative

- K+ voltage gated channels are open when inside the membrane becomes positively charged.

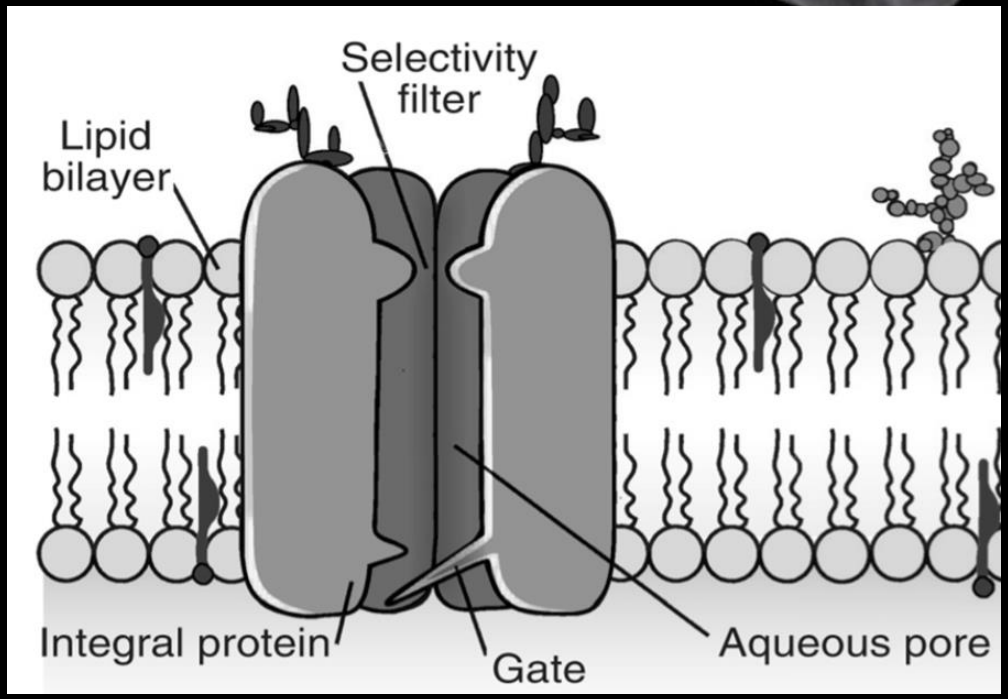
Ligand (chemical) gated



- Example:
- Acetylcholine chanels (they open when Ach binds with its receptor. These channels are 0.65 nm in diameter and negatively charged.)

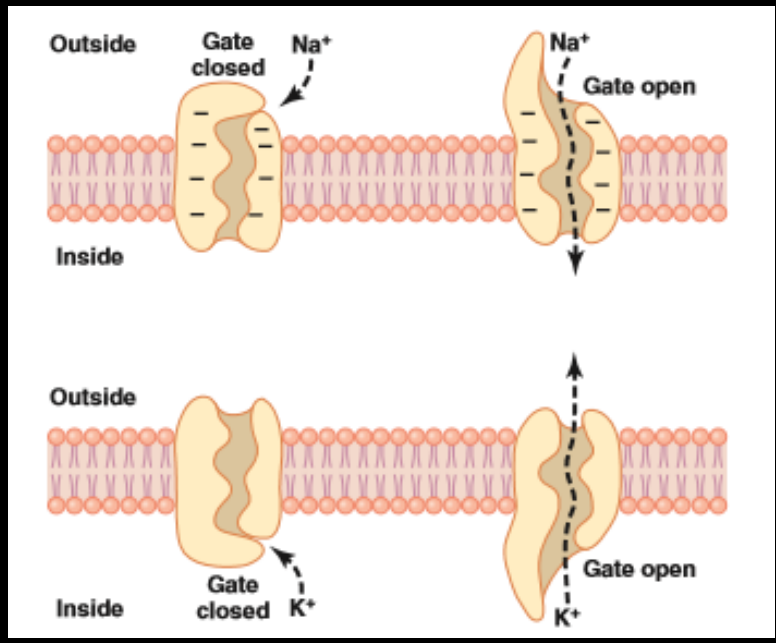
Selectivity of protein channels

- These channels are selective for transport of one or more specific ions.
- The selectivity depends on:
  1) Shape of the channel.
  2) Size of the channel.
  3) Nature of the electrical charges of the channel.



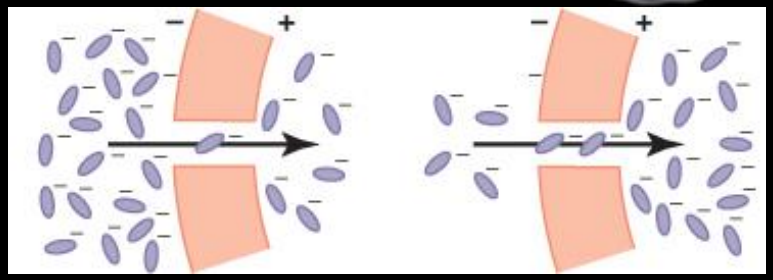
Gated sodium and potassium channels

- Sodium channels:
- Negatively charged → pull sodium ion from its water.
- Diameter 0.3 X 0.5 nm.
- Gate is found at the extracellular end of the channel.
- Potassium channels:
- Smaller than sodium channels (0.3 X 0.3 nm).
- Are not charged.
- Gate is found at intracellular end of the channel.

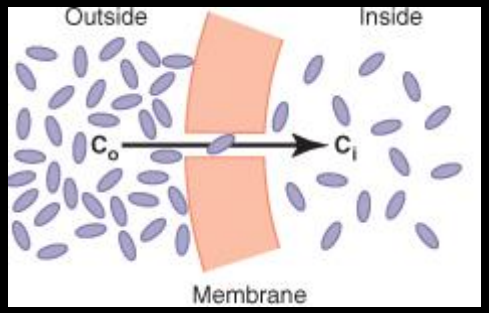


Other Factors affecting the net rate of diffusion:

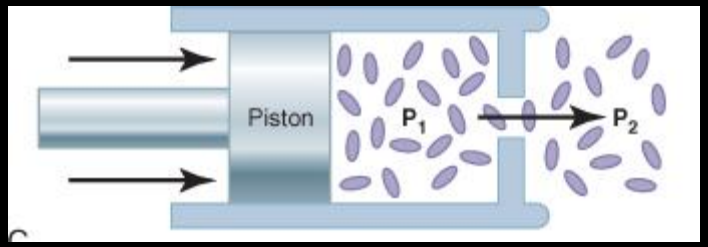
a) **Effect of concentration difference.**
b) **Effect of electrical difference.**
c) **Effect of pressure difference.**



Effect of electrical difference



Effect of concentration difference

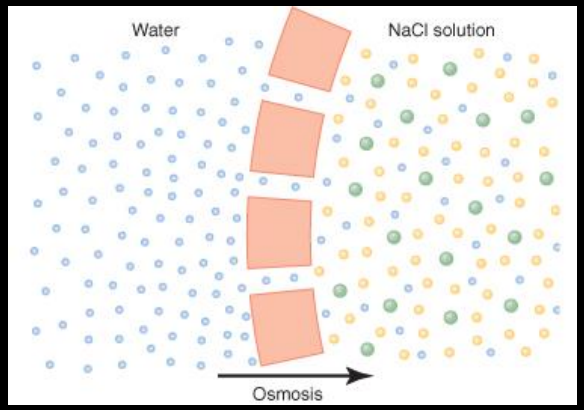


Effect of pressure difference.

Osmosis

- Osmosis is the flow of water across a semipermeable membrane cased by a difference in the concentration of the solutions on either side of the membrane.

  - **Water flows from the solution containing a low concentration of solute to the solution containing a high concentration of solute.**



Water conc. on this side is higher.

Water conc. on this side is lower

  - **The water is forced through the membrane by an osmotic pressure difference between the two compartments.**

Water conc. water in this side is lower in is higher. this side.

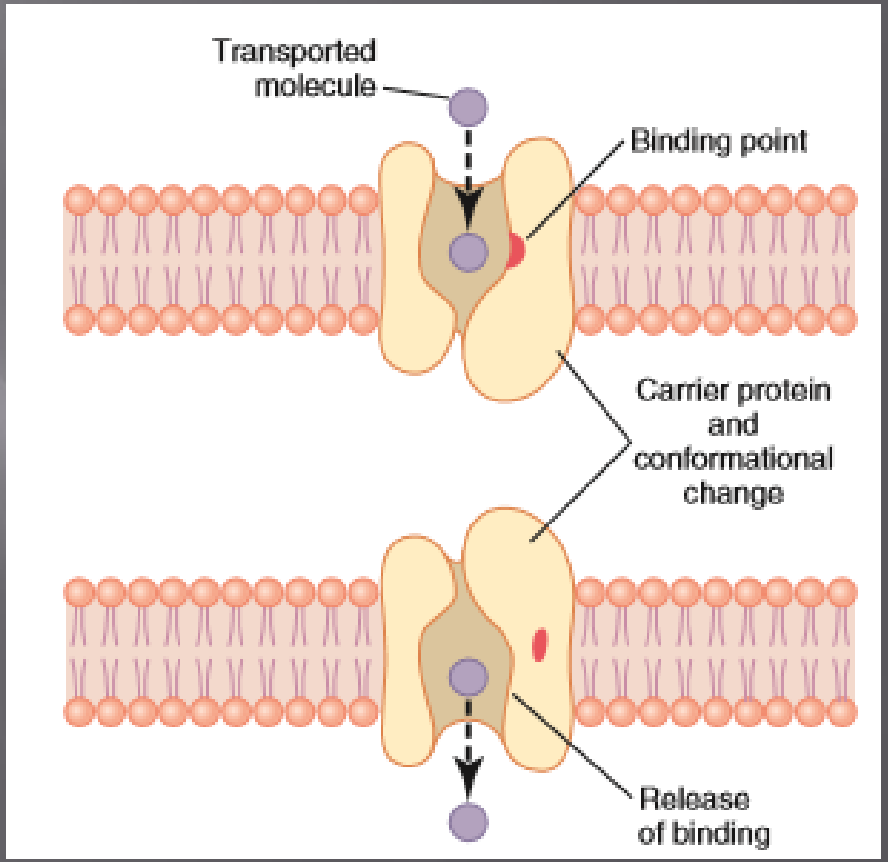
Measurements of solute concentraion

- Concentration of particles (molecules/ions) is measured in miliosmoles/Litre.
  - 1 molecular weight of undissociated solute like glucose = 1 osmol.
  - 1 molecular weight of dissociated solute:
    - into two ions like NaCl = 2 osmoles.
    - Into three ions like CaCl2 = 3 osmoles.

Facilitated diffusion

** It is passive transport which does not require energy to move the large molecules.

** Used carrier protein to move molecules across the membrane.
Example: transport of glucose and amino acids
into muscle or fat cells.
The hormone “insulin” can increase facilitated diffusion of glucose by 10-20 times.

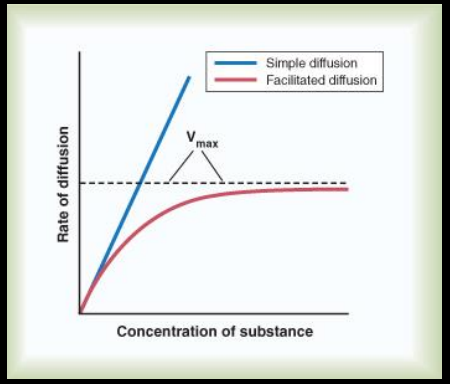


Facilitated Diffusion (carrier mediated diffusion)

- Only one solute is involved by specific carrier. (i.e. it shows specificity)
- The direction of transport is downhill (i.e from high concentration to low concentration).
- The carrier can be saturated.

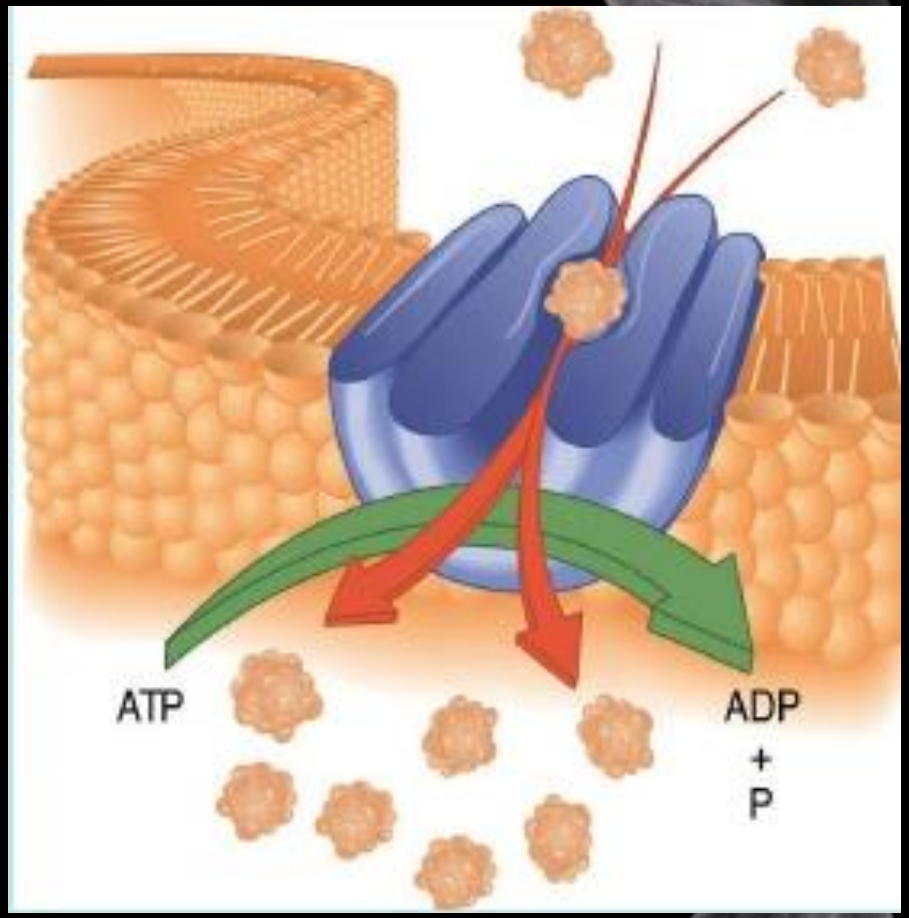
(saturated means: has a capacity, can hold just A fixed amount of molecules)

- ATP energy is not required.
- They are specific each specific molecule has a certain carrier.



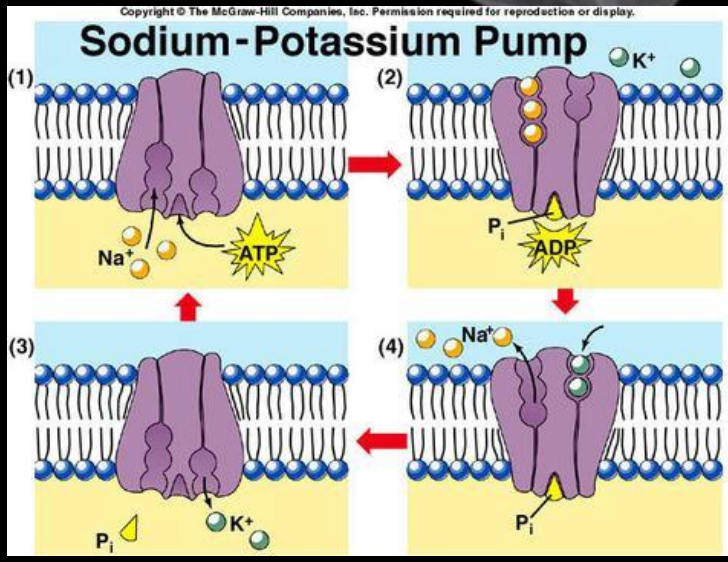
Active transport

- Transport of ions or molecules **against** their concentration gradient.
- It is **carrier-mediated** (needs carrier).
- Uses energy.
- Examples: transport of; **Na+ , K+, Ca++, H+, Cl-, I- Glucose, amino acids.**



Sodium/Potassium Pump

****Are proteins which can transport Na+ and K+ from low conc to high conc area, it needs ATP. Transport reaches maximum when all transporters are being used (saturated). Very specific..!**



- **3 Na+ ions are removed from the cell as 2 K+ ions brought into cell, with 1 ATP molecule is used. (it is electrogenic pump).**
- **Na/K pump uses large amount of ATP produced by the cell (cells lining renal tubules use 90% of ATP for this pump).**

-Importance of Na+ /K+ pump

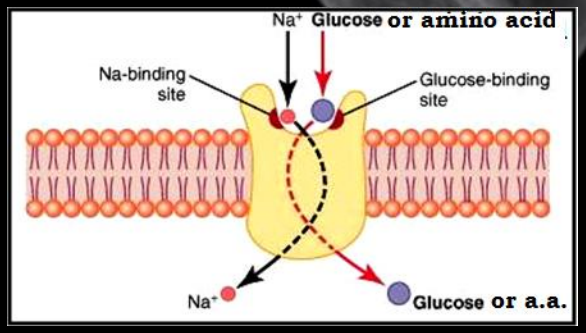
1. Responsible for creating and maintaining the high K+ and low Na+ in the cytoplasm. These concentrations make cell resting membrane potential and generation of action potential possible.

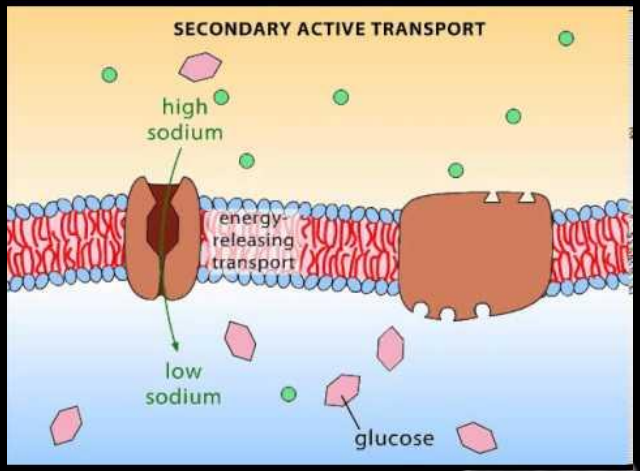
2. The low Na+ conc. inside the cell provides the energy needed for secondary active transport (discussed later).

3. Prevents cell swelling “i.e. keeps cell volume constant”.

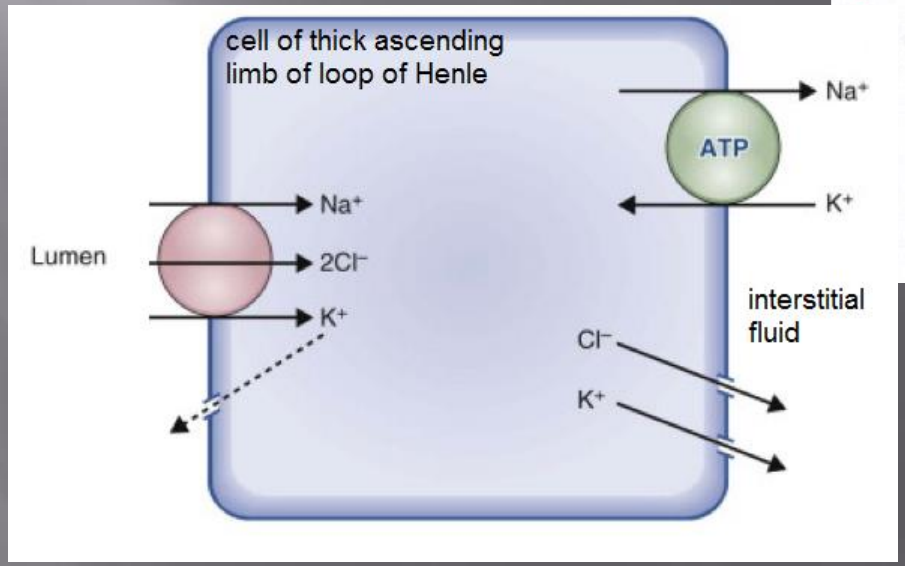
Secondary active co-transport

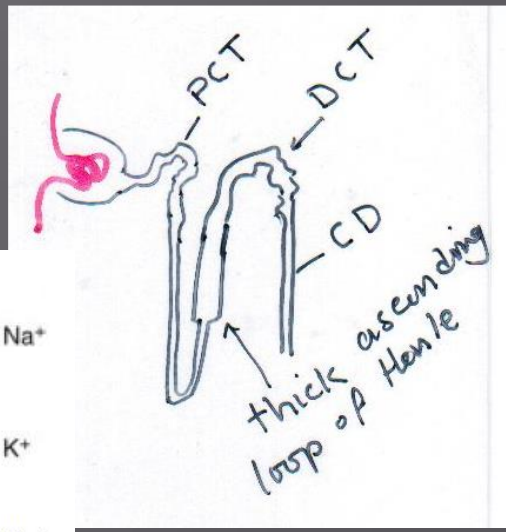
- Na Co-transport of glucose or amino acid:
- **Sometimes called symport.**
- **Both Na+ and Glucose (or amino acid) have to be present.**
- **The energy available from Na+ gradient is used as an energy source.**
- **Found in the epithelial cells of the intestine.**





** A co-transporter can carry more than 2 ions. For example, a co-transporter in cells of the ascending loop of Henle can carry 1 Na+, 2 Cl- and 1 K+.

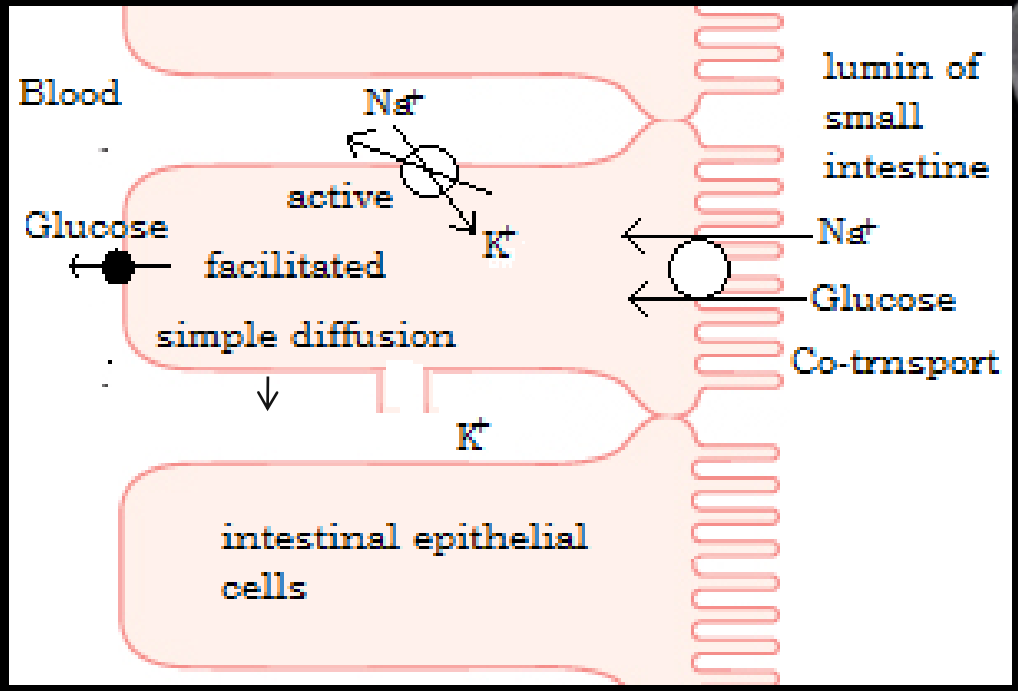




Comparison of simple diffusion, facilitated diffusion and active transport

Active transport	Facilitated diffusion	Simple diffusion	Property
yes	Yes	No	Requires special membrane protein
yes	yes	No	Highly selective
yes	yes	no	Transport saturation
yes	yes	no	Hormonal regulation
yes	no	no	Uphill transport “against concentration gradient”
yes	no	no	Requires ATP energy

Absorption of Glucose from small intestine needs all types of transportation

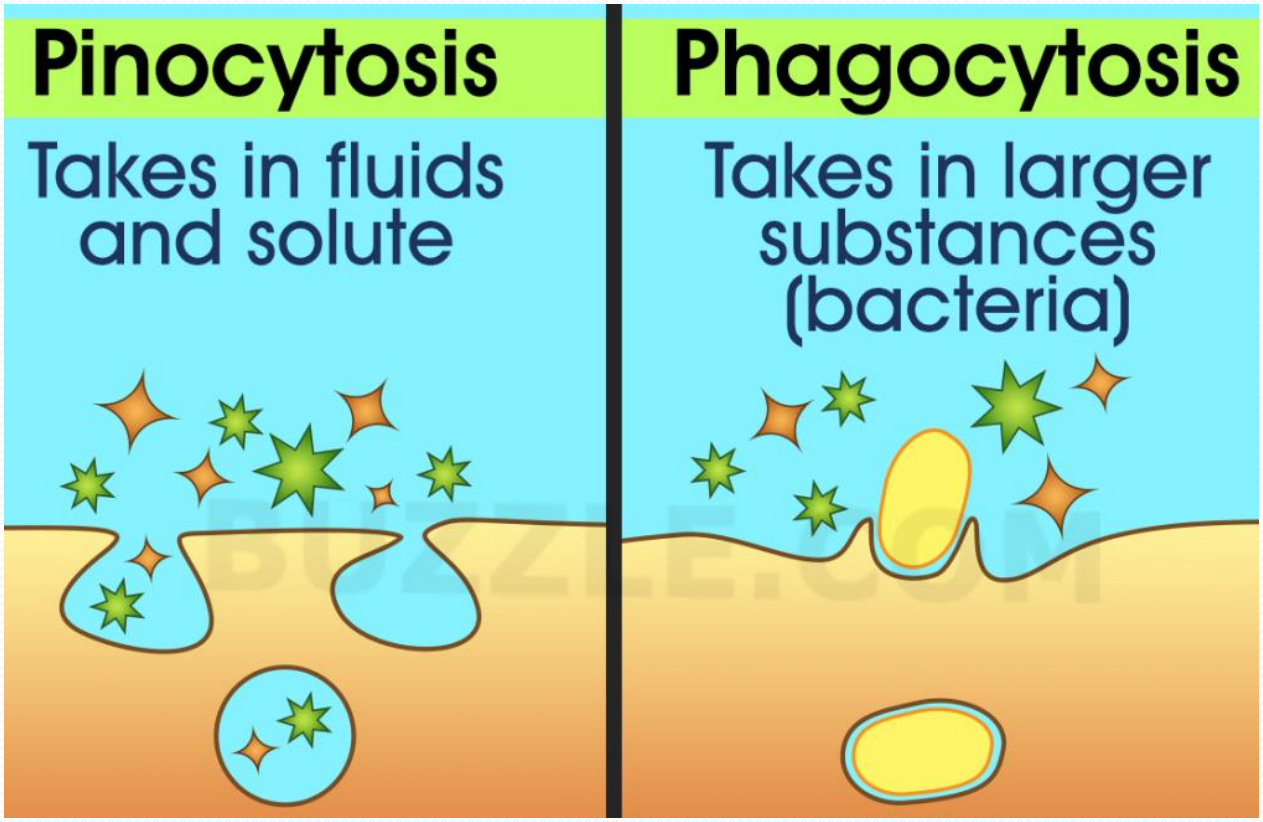


- Glucose transporters:

1- Sodium-Glucose transporter (SGLT) → found in the small intestine and renal tubules.

2- Facilitated diffusion glucose transporter (GLUT)

a. **GLUT 1 Found in RBCs.**
b. **GLUT 2 : transports glucose of intestinal cells.**
c. **GLUT 4 found in muscle and adipose tissue << insulin stimulates this type of transporters.**



Main transport system for immunoglobulins in infants since their immunity system is suppressed when born

Phagocytosis

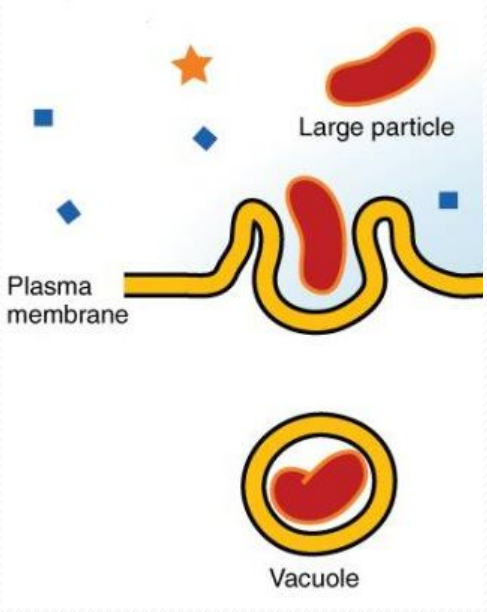
Phagocytosis involves large particles (bacteria, dead cells, or tissue debris) rather than molecules.

Tissue macrophages and some white blood cells have this ability

Bacterium is usually already attached to a specific antibody

Antibody attached to bacteria binds to the phagocyte receptors

The point of attachment invaginates inward forming vesicle inside the cell that contains the engulfed surround the bacteria.



End of lecture