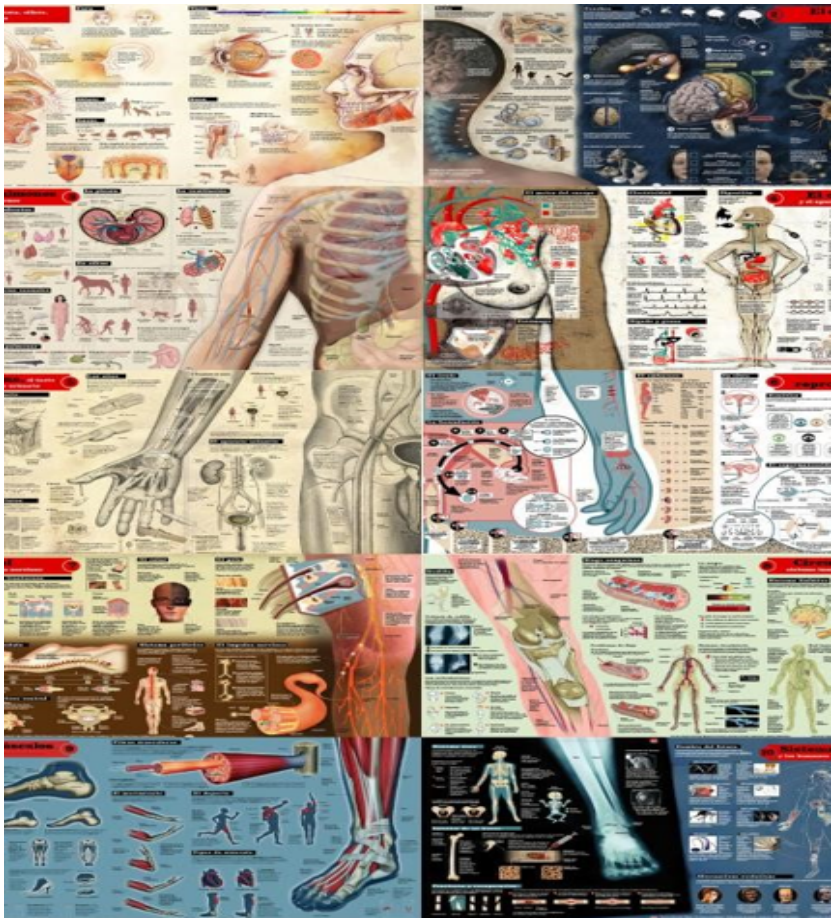
The University of Jordan

Dentin 2020

Dentistry 020

Physiology



Title: Third sheet / Introduction to Physiology (3)

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✶ Membrane Permeability

- The cell is either *permeable* or *impermeable* to certain substances.
- The lipid bilayer is **permeable** to lipid-soluble substances like: **oxygen**, **carbon dioxide**, **water** and **steroids**, but **impermeable** to **glucose, ions** ($Na^{+,}$ k^{+}).
- Transmembrane proteins act as channels and transporters to assist the entrance of **certain** substances, for example, glucose and ions.

✶ Passive vs. Active Processes

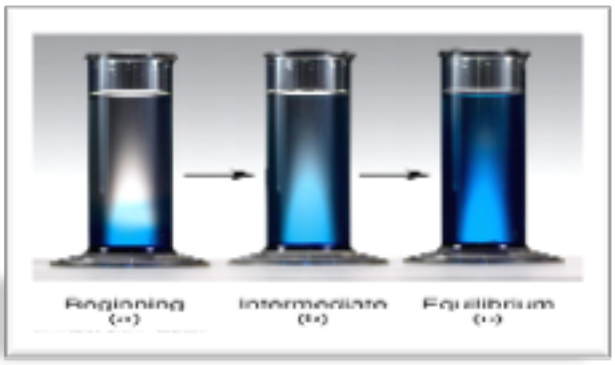
- **Passive processes**
- substances move across cell membranes without energy inputs.
- They cross the membrane using the kinetic energy of individual molecules or ions
- Substances move from higher concentrations to lower concentrations, with their concentration gradient(**downhill**).
- **Active processes**
- a cell consumes energy, primarily from the breakdown of ATP to move a substance across the membrane.
- Substances move from lower to higher concentrations, against their concentration gradient (**uphill**).

Passive process	Active process
From higher to lower concentration	From lower to higher concentration
Substances move Downhill	Substances move uphill

✶ Diffusion

Simple diffusion

- Lipid-soluble substances can easily penetrate the lipid bilayer.
- Hydrophilic substances enter the cell through channels and transporters.
- moving from **higher** to **lower** concentration.
- Without energy input.



Factors affecting the rate of the diffusion:

1. **concentration gradient**: (from **higher** to **lower** concentration)
2. **Temperature:** (because of the kinetic energy the substances move faster)
3. **Mass of diffusing substances**
4. **Surface area**: (the **higher** the surface area, the **faster** the diffusion)
5. **Diffusion distance**: depends on the thickness of the membrane

   Thicker membrane = Slowest diffusion

Examples: ink in the water and perfume in the room

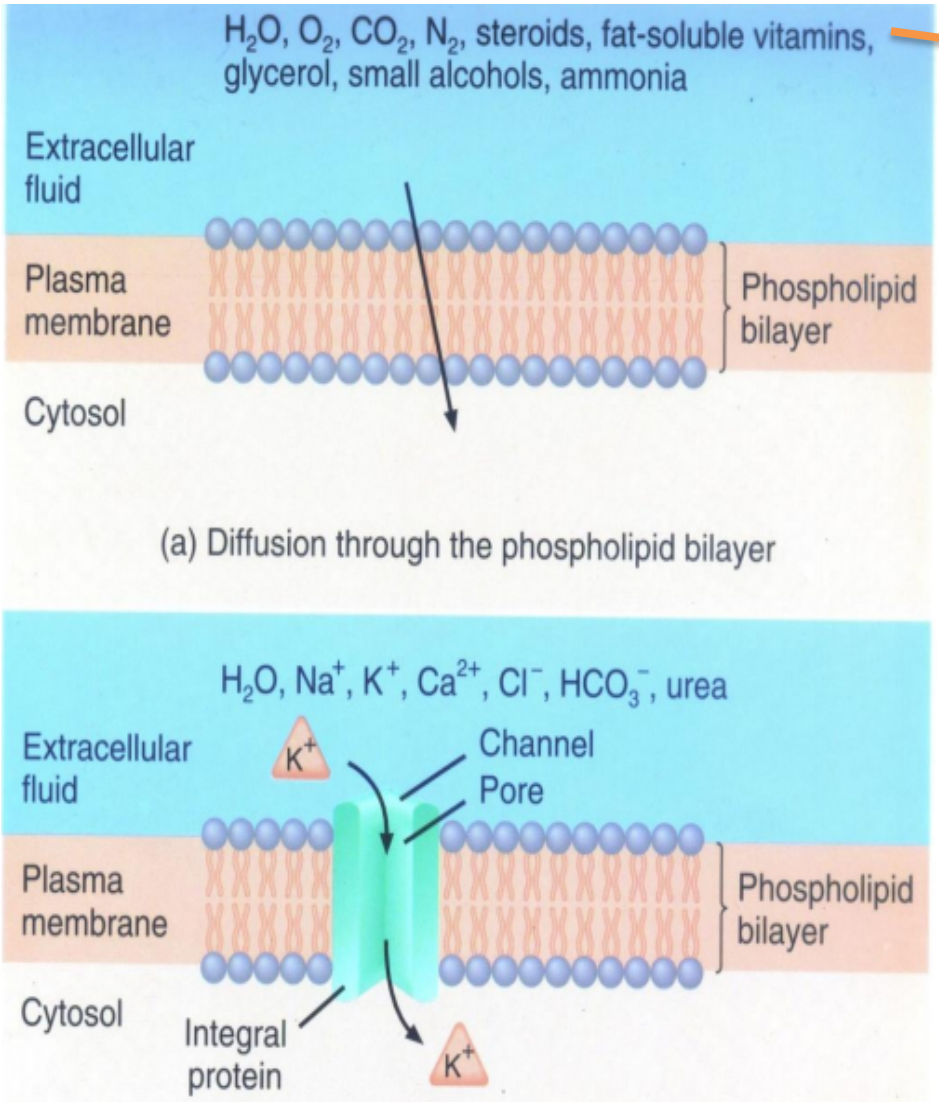
So, diffusion is **directly** proportional to:

a) **concentration gradient**
b) **Temperature**
c) **Surface area**

And **inversely** proportional to:

a) **thickness of the membrane**
b) **Square root of the molecular weight (MWT)**
c) **Mass**

✶Simple diffusion through the membrane of lipid soluble substances



Vitamin(A,D,E,K)

✶Simple diffusion

Diffusion rate (J) is directly proportional to the concentration gradients and solubility in lipids.

It is inversely proportional to the square root of the molecular weight and thickness of the membrane.

CO2 is 24 times soluble than O2.

	Lungs		veins
240ml/m =	PO_2 100	concentration gradient =60	$PO_2$40
240ml/m =	$PCO_2$40	concentration gradient =5	$PCO_2$45

So we need less CO2 gradient to pass the same amount of O2.

Fick's law of diffusion

$$J = P\,(C2 - C1)*S$$

Where

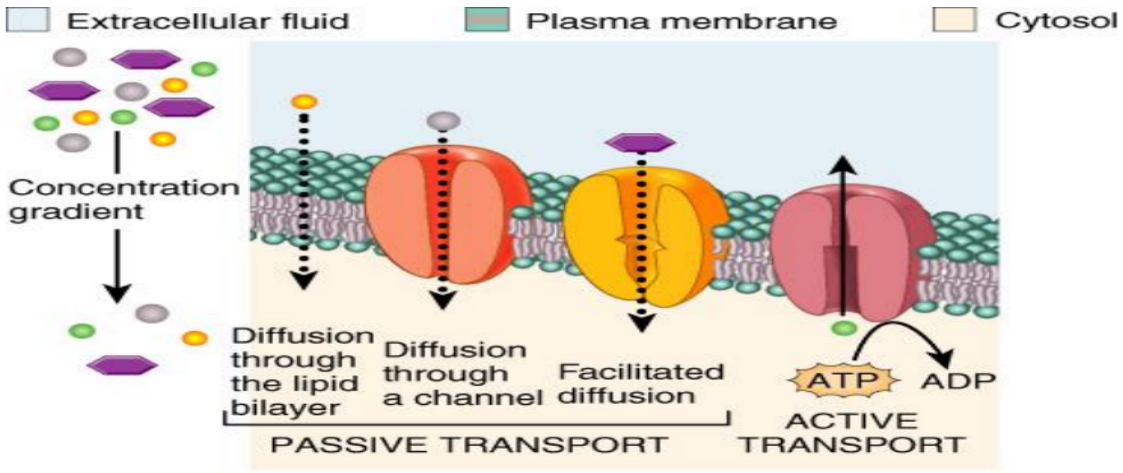
- P: permeability in lipid
- (C2 -C1): concentration gradient
- S: surface area

OR

$$J = DA*(\Delta C/\Delta X)$$

Where

- ΔC: concentration gradient (C1-C2)
- ΔX: Thickness of the membrane
- A: Area
- D: diffusion coefficient (depends on the solubility in lipids, molecular weight).



✶ Simple Diffusion, Channel-mediated Facilitated Diffusion, and Carrier-mediated Facilitated Diffusion

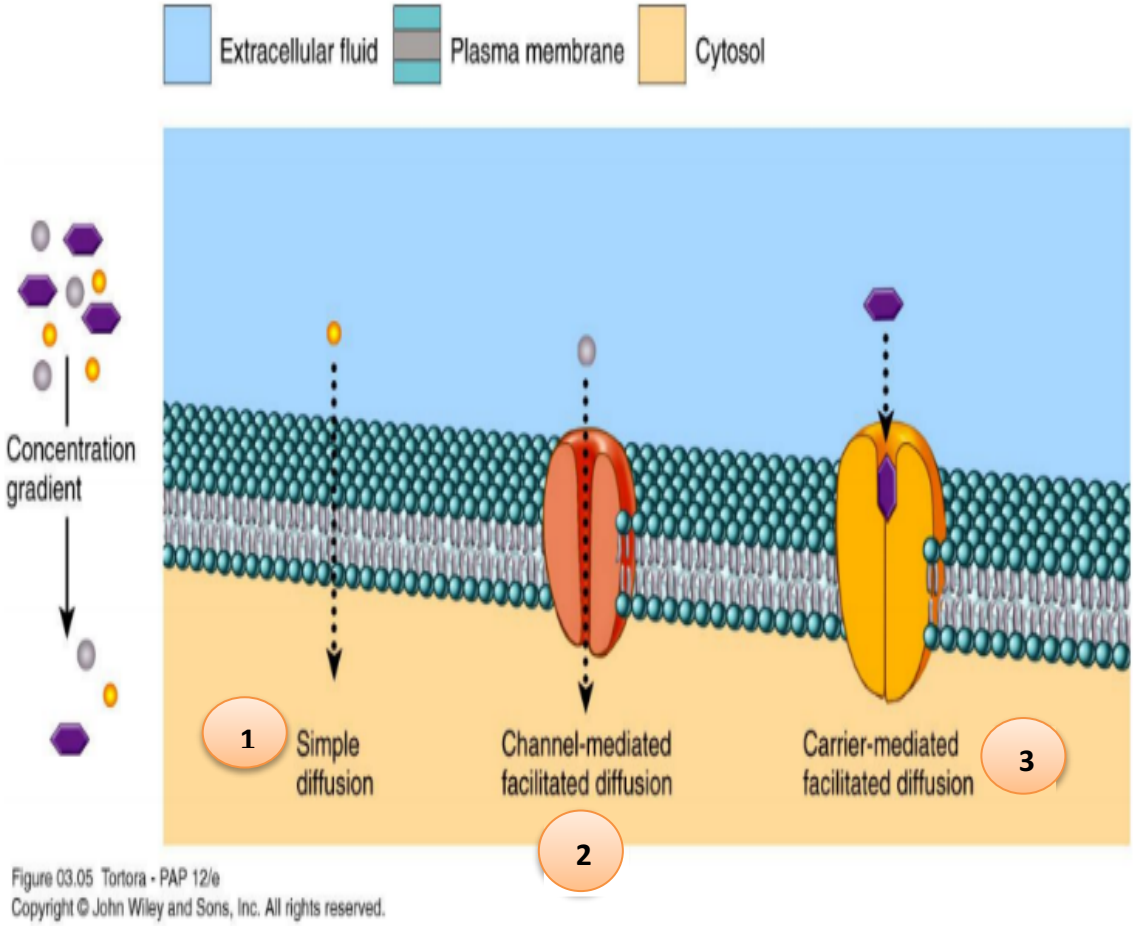


Figure 03.05 Tortora - PAP 12/e

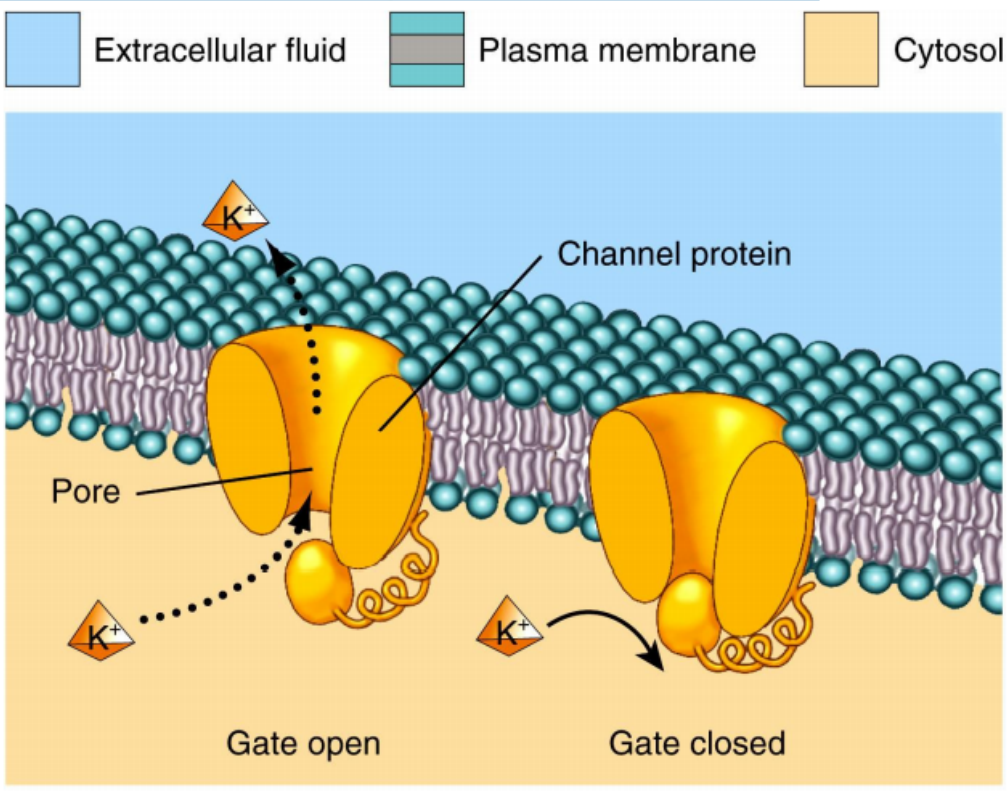
Remember:

Facilitated diffusion does not need energy because it goes from higher to lower concentration.

Although we call it facilitated diffusion, it's still simple diffusion.

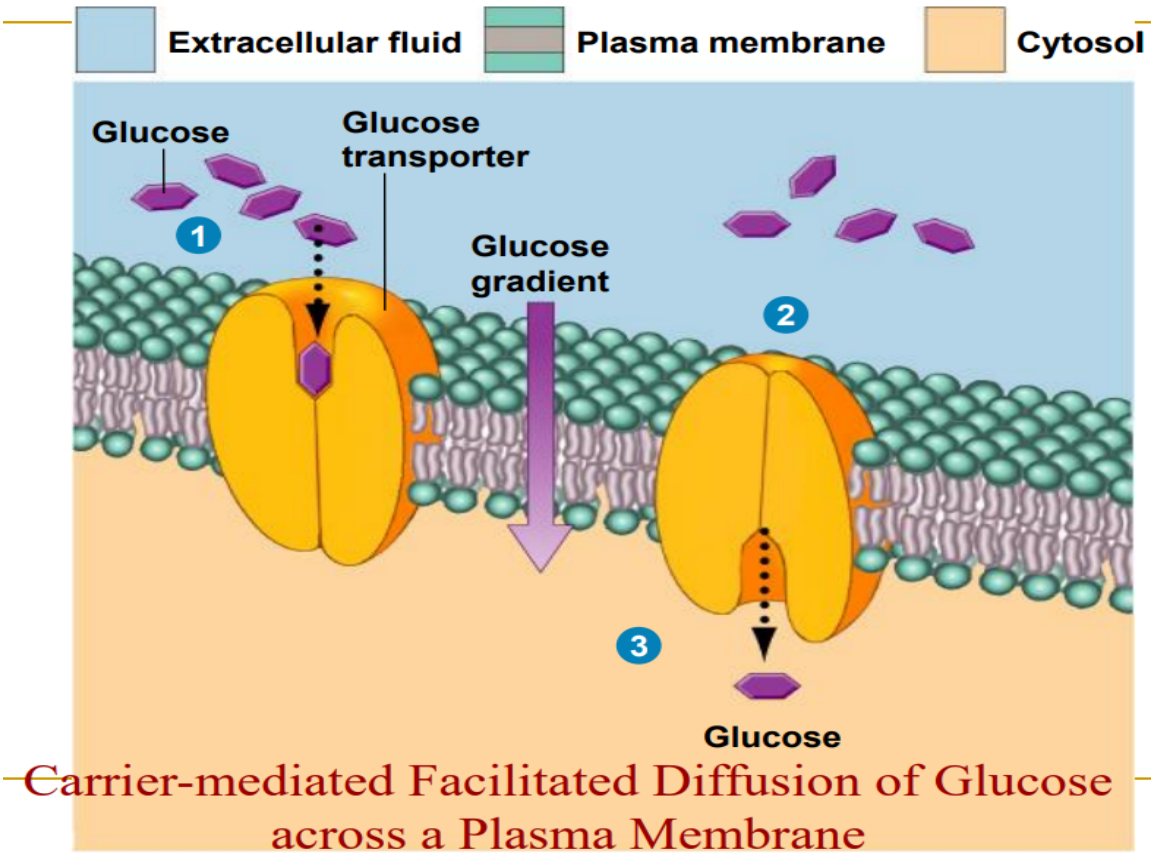
(Dr. Faisal mentioned this point many times)

Channel-mediated Facilitated Diffusion of Potassium ions through a Gated K + Channel



Details of the K^+ channel

- It's considered simple diffusion.
- As long as the channel is open, substances will pass from higher to lower concentration(Down their concentration gradient)

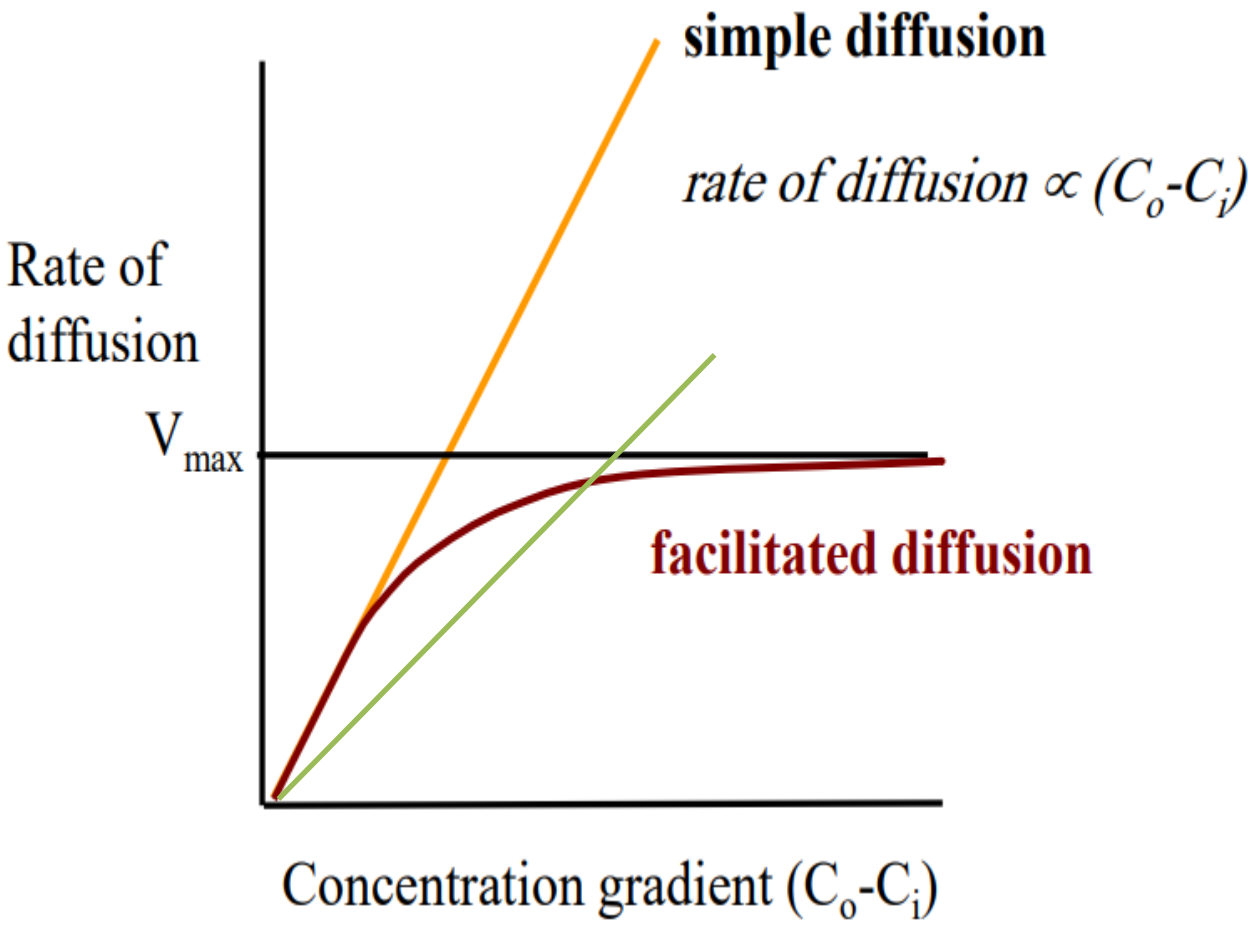


Carrier-mediated Facilitated Diffusion of Glucose across a Plasma Membrane

- The membrane is impermeable to glucose.
- The channel has a limit called transport maximum (T-max) or velocity maximum (V-max)
- Example: If there are 500 carriers in the membrane and 1000 glucose molecules, the carriers allow for 500 molecules to pass. **(Specific number of molecules)**

Simple diffusion

- **Facilitated diffusion** is saturable because the binding sites are limited and has transport maximum (velocity MAX).
- **Simple diffusion** we mentioned it earlier.



- What exceeds the T-max (V-max) won't pass.

What limits maximum rate of facilitated diffusion?

Number of binding sites.

Osmosis

The net movement of **water** through a selectively permeable membrane from an area of **high** concentration of water (lower concentration of solutes) to one of **lower** concentration of water (higher concentration of solutes).

◂ Water can pass through plasma membranes in **2 ways**:

1. through lipid bilayer by **simple diffusion**.
2. through aquaporins (water channels), integral membrane proteins **facilitated diffusion.**

- **Osmolality:** No. of molecules (osmoles) per kilogram of H_2O (Osml/Kg)
- **Osmolarity:** No. of molecules per liter of solution (Osml/L)

39 grams of K^+ = 1 mole = Avogadro's number (6.0×10^{23})
23 grams of Na^+ = 1 mole = Avogadro's number (6.0×10^{23})

1 mole of NaCl = 2 Osmole
1 mole of $CaCl_2$ = 3 Osmole

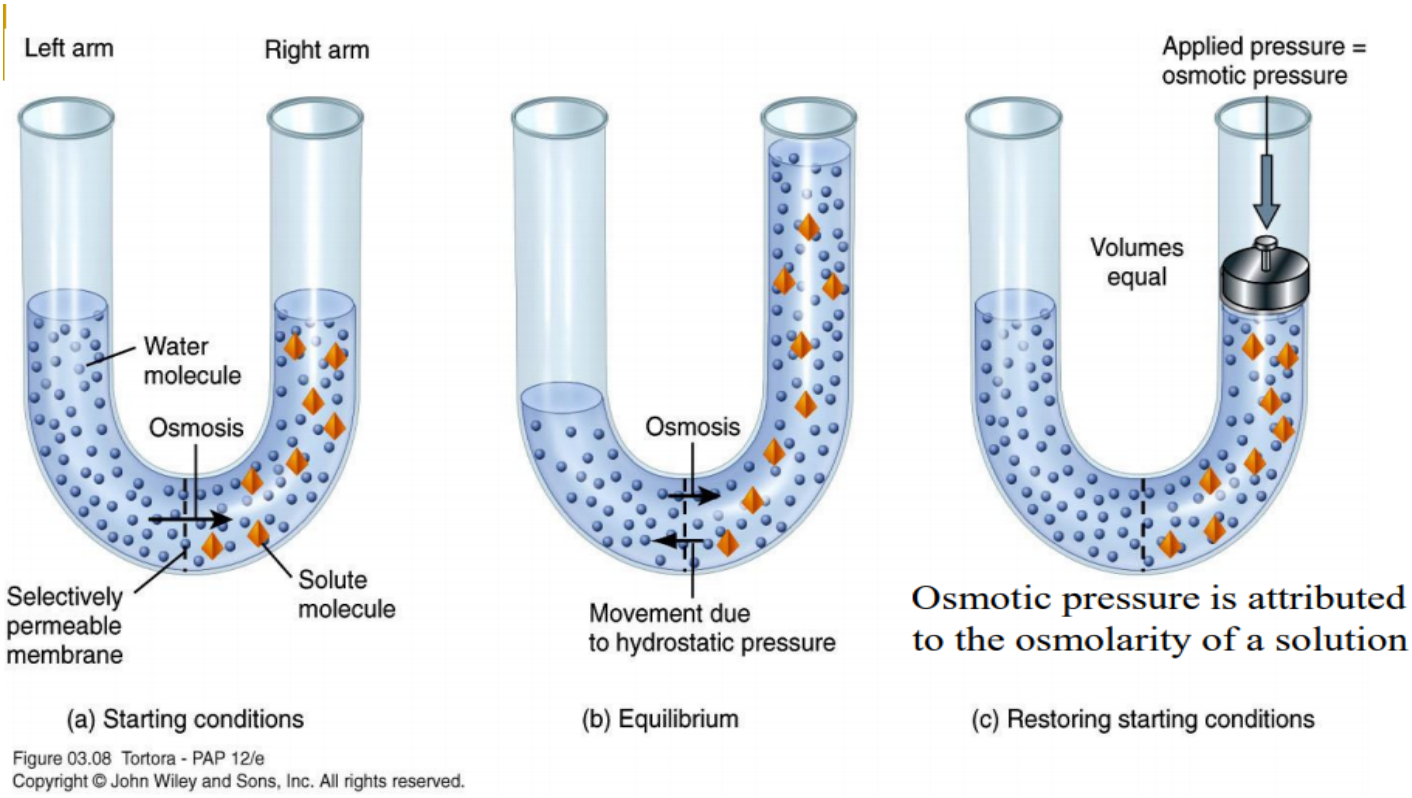


Figure 03.08 Tortora - PAP 12/e

a) The concentration of solute in the right side is **higher** than the left side. So, water will move from left to right arm across the selectively permeable membrane.
b) Water keeps moving until the pressure of solute molecules prevent the water from moving to the right arm.
c) Or by applying pressure on the right arm called **Osmotic pressure.**

That's what we will talk about in the next lecture;)

Your only limit is you ;)

Good luck

THE END