Physiology
Sheet No. 2

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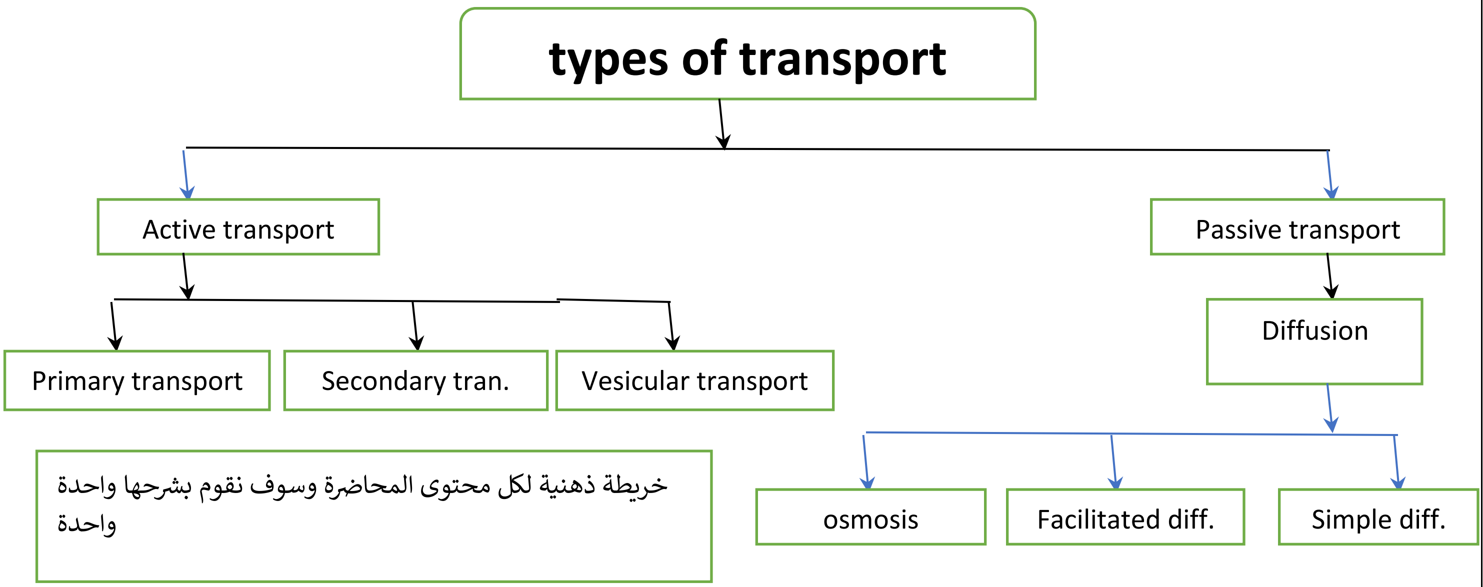
Membrane Permeability

-The cell is either permeable or impermeable to certain substances.{Selective}

-Since the membrane is phospholipids bilayer this membrane will be amenable to lipid soluble substances. → Ex: oxygen, carbon dioxide, water and steroids.

-Transmembrane proteins act as channels and transporters to assist the entrance of certain substances, for example, glucose and ions.



A-passive transport:

-substances move across cell membranes without the input of any energy; use the kinetic energy of individual molecules or ions.{from higher concentration to lower concentration , we call it downhill}

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➢ -Diffusion rate {J}:

-there are 5 factor on which diffusion depends :

Directly proportional

1-conc. Gradient

2-sarface area

5-solubility in lipid

inversely proportional

3-square root of molar mass

4-thickness of membrane

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

NOTE : CO_2 is 24 more soluble than O_2

Conceptual Example : In the respiratory system , we can have a diffusion rate of O_2 250ml/min , diffusion rate of CO_2 250 ml/min such that the gradient of O_2 is 40-100 and the gradient of CO_2 is 40-45 . Although the gradient of CO_2 is much smaller than that of O_2 , the fact that CO_2 is far more soluble than O_2 makes it diffuse at the same rate as O_2 .

1-Simple diffusion: through the membrane of lipid soluble substances

Examples : 1-H_2O 2- Gasses (O_2 ,CO_2 ,N_2) 3-Steroids 4-Fat-soluble vitamins

(Vitamin A , D, E ,K) 5-glycerol , Small alcohols 6- Ammonia

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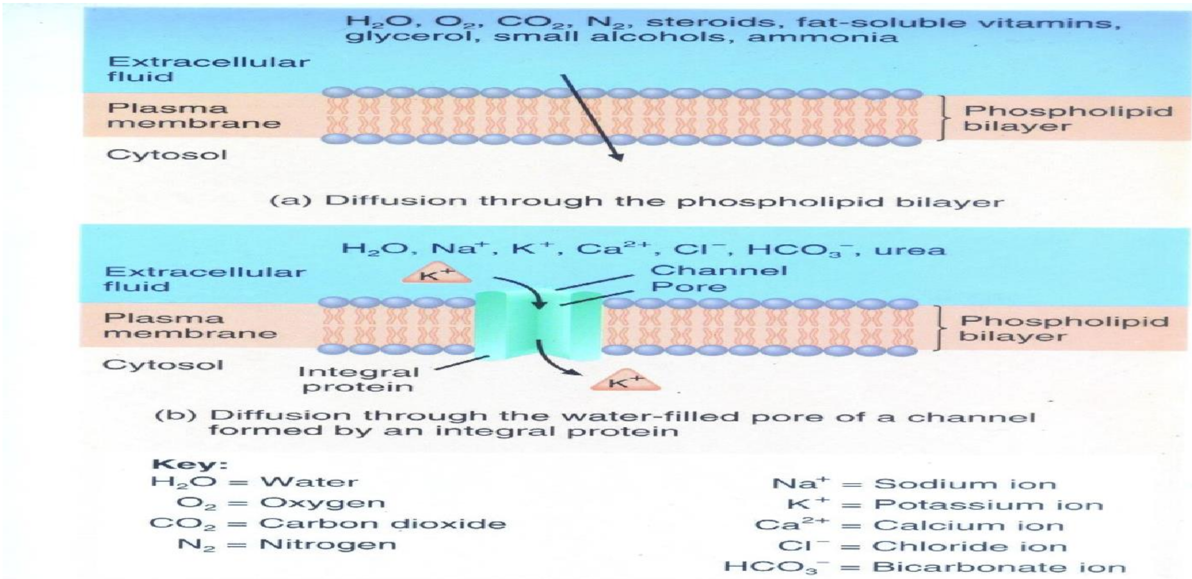
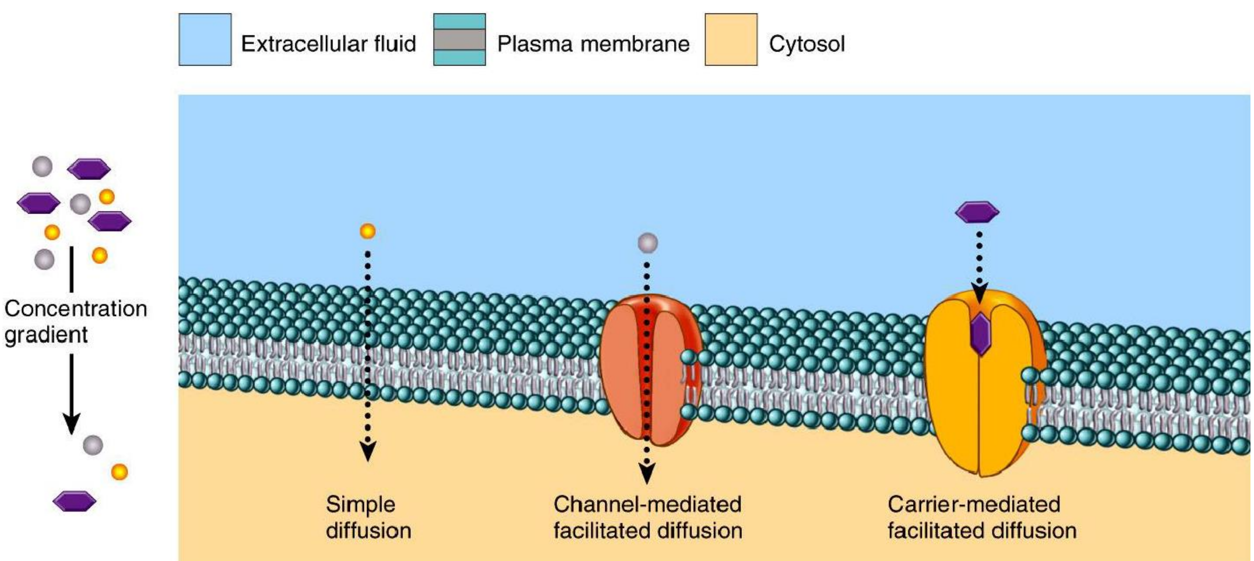


Diffusion Through the Plasma Membrane, Fig# 3.6a-b

2-facilitated diffusion: is the movement of insoluble-lipid substances through Channel-mediated Facilitated Diffusion (Ions like K+, Na+) Or Carrier-mediated Facilitated Diffusion (glucose)



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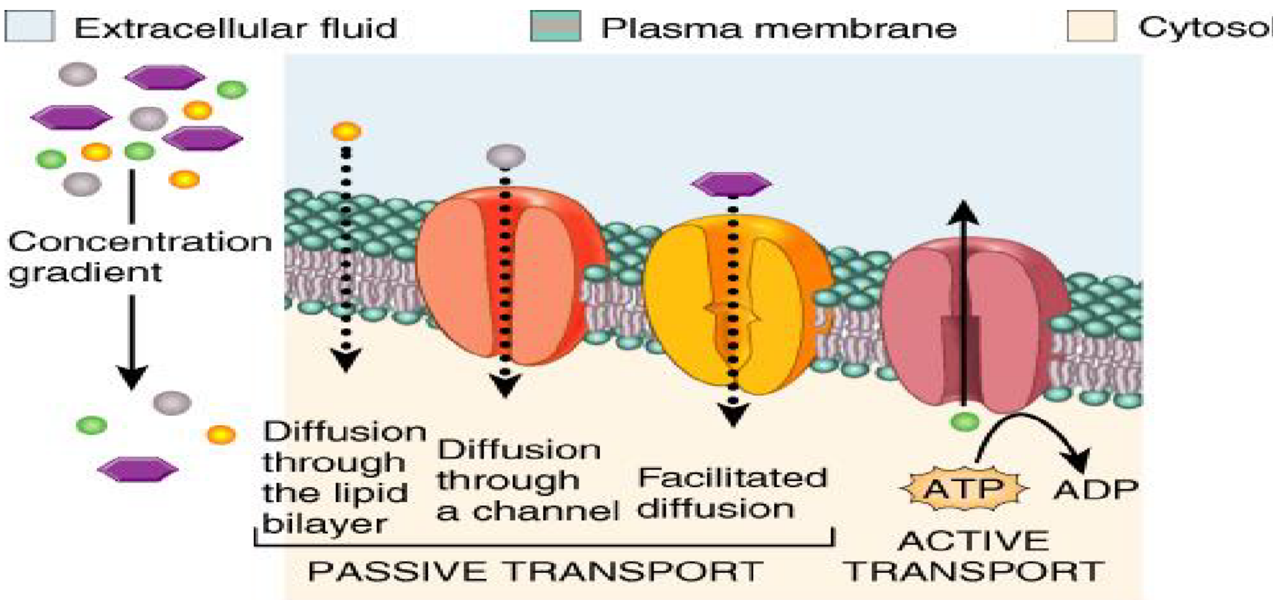

-Facilitated Diffusion has a limit {**T max}{V max** } because it depends on the **number of carriers** available .

Facilitated diffusion is said to be **saturable** because the binding sites are limited and has transport maximum.

- There are type of channels that have a gate {بوابة}.We may call it facilitated diffusion by channel or simple diffusion by channel.

- The gates open and close due to :

1- Change in voltage (Voltage-gated)

2- Change in the concentration of a particular Substance (Chemically-gated)

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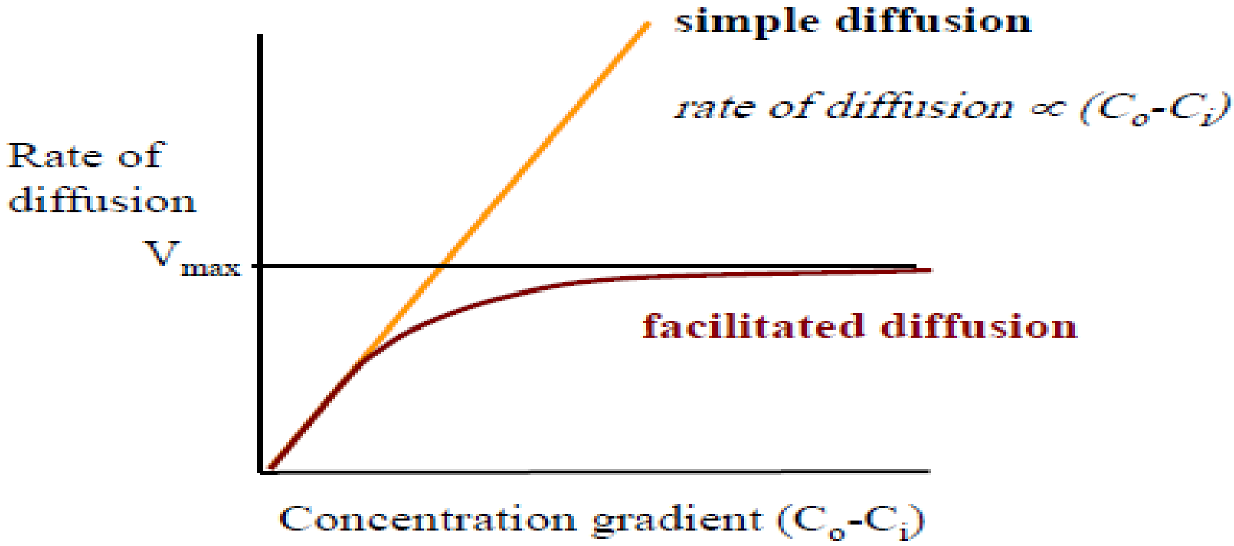

-What limits maximum rate of facilitated diffusion? **The number of Carriers**

3-Osmosis

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

Water can pass through plasma membrane in 2 ways:

1.through lipid bilayer by (**simple diffusion) .**

2.through aquaporins, integral membrane proteins **(Facilitated diffusion)**

- osmolarity → no. of molecule / liter$_{H2O}$

-osmolality → no. of molecule / kg$_{H2O}$

-Because the one mole of the substances has the same number of molecules the osmolality and osmolarity are equals.

- **Osmotic pressure**: Is the pressure needed to be applied to prevent movement of water molecules = applied pressure.

-osmotic pressure is attributed to the osmolarity of a solution .

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Osmotic pressure is higher when molar concentration is higher .

$$\pi = inRT$$

Where : n= Molarity of the solution (Molar concentration)

R= the universal gas constant

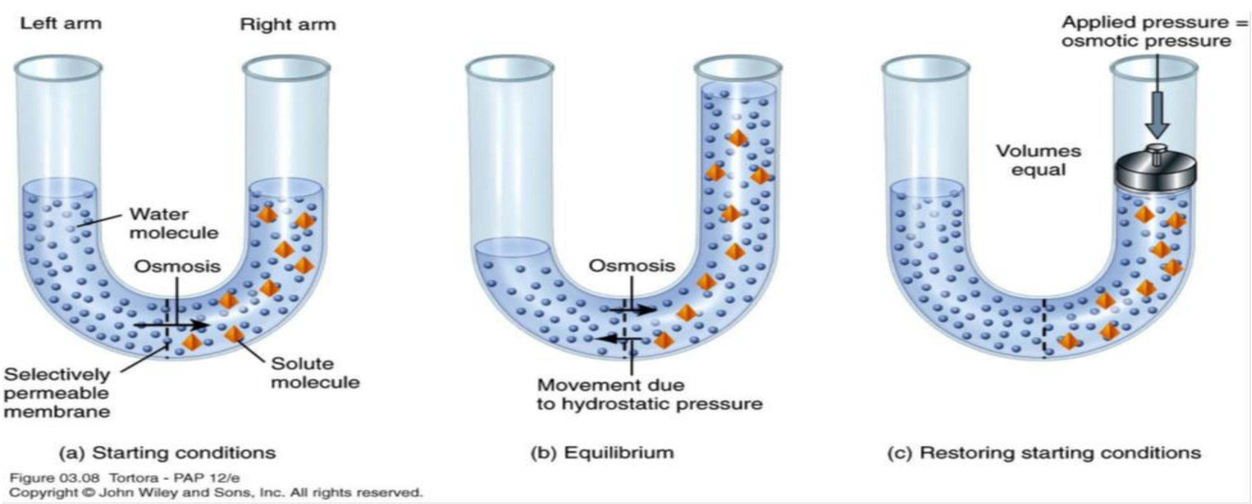
T= Temperature in Kelvin

π= Osmotic Pressure

i= number of ions

The greater the number of osmotically active ions/molecules ,the greater the osmotic pressure is .

Conceptual Example : if we have 23 g of Na , 39 g Of K .Although different masses but both samples contain one Mole (I.E Both samples contain the same number of molecules) and so , if we are to dissolve them in separate tubes of water containing one liter of water , we will have the same osmolarity in both tubes despite using different masses of different substances .



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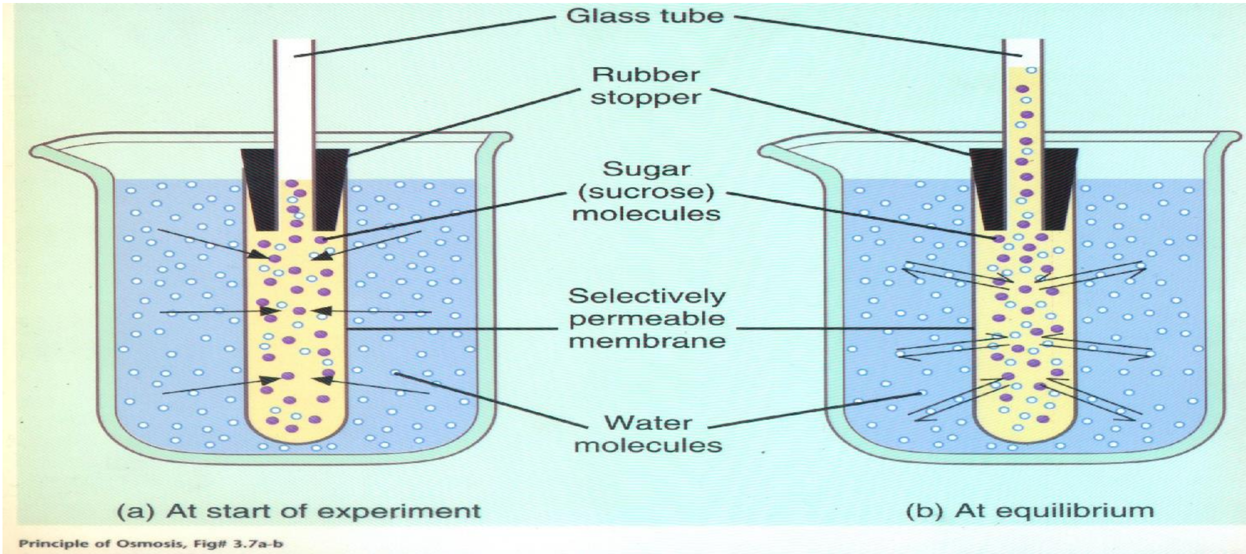

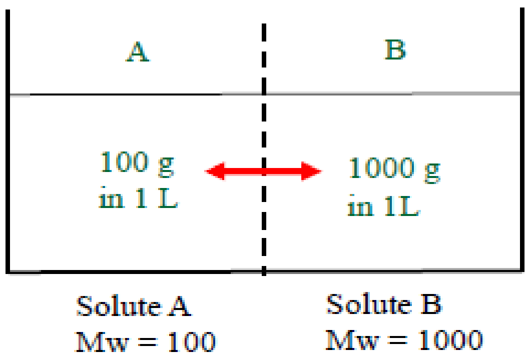

هنا لان عدد المولات في المحلول الاول هو 1

وفي المحلول الثاني هو 1 فان

في كلا المحلولين Molarity=1/1=1

لذا لن يكون هنالك حركة لان المحلولين نفس التركيز

Movement of water goes from where to where? Since we have 100 g in 1L in A the molarity =1 and the molarity in B =1 so no net movement of water because molarity the same

Which solution has the greatest osmolarity? the same

Which has the greatest molar concn.? the same

Which has the greatest number of molecules? the same

$(6.02^{*} \cdot 10^{23}$ particles)

للسهولة أعتبر ان عدد الاوزمولات هو عدد الذرات التي تتاين في المحلول

- Relation between osmolarity and molarity

Osmolarity or mOsm/L = index of the concentration of particles per liter solution

Molarity or mM/L = index of concentration of molecules per liter solution

150 mM NaCl = 300 mOsm

Osmol :osmlarity caused by a Mole of osmotically active substances

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300 mM glucose = 300 mOSM

100 mM $CaCl_2$=300 mOSM

Explanation : In the case of **NaCl , $CaCl_2$** , both of which dissociate into water solution and form freely-moving ions (**Osmotically active particles**) .Whereas in the case of glucose , **glucose** remains intact (i.e **it doesn't dissociate**) and thus the molarity is the same as the osmolarity .

-ECF and I **ICF** have the same osmolarity in normal body because water move from lower osmolarity to higher osmolarity to reach equilibrium .

NOTE: the Osmolarity of Body-fluids (Plasma of blood) is approximately **300 mOsm** (**isotonic-Isosmolar**)

Anything Larger than 300 mOsm : **(Hyperosmolar)**

Anything smaller than 300 mOsm : **(Hyposmolar)**

في غيره لكن هو الاكثر وجودا

-**In ECF** :

Plasma :

The main cation is **sodium**

and the main anion is **chloride**

interstitial:

The main cation is **sodium**

and the main anion is **chloride**

- That means that the osmolarity of the plasma and interstitial mainly depends on the concentration of sodium and chloride.

- The difference between plasma and interstitial is the fact that proteins anions are present in the plasma more than the interstitial fluid .This is due to the fact : **that the capillary isn't permeable to the Protein anions** and as such , the protein anions stay in the Plasma of the blood .

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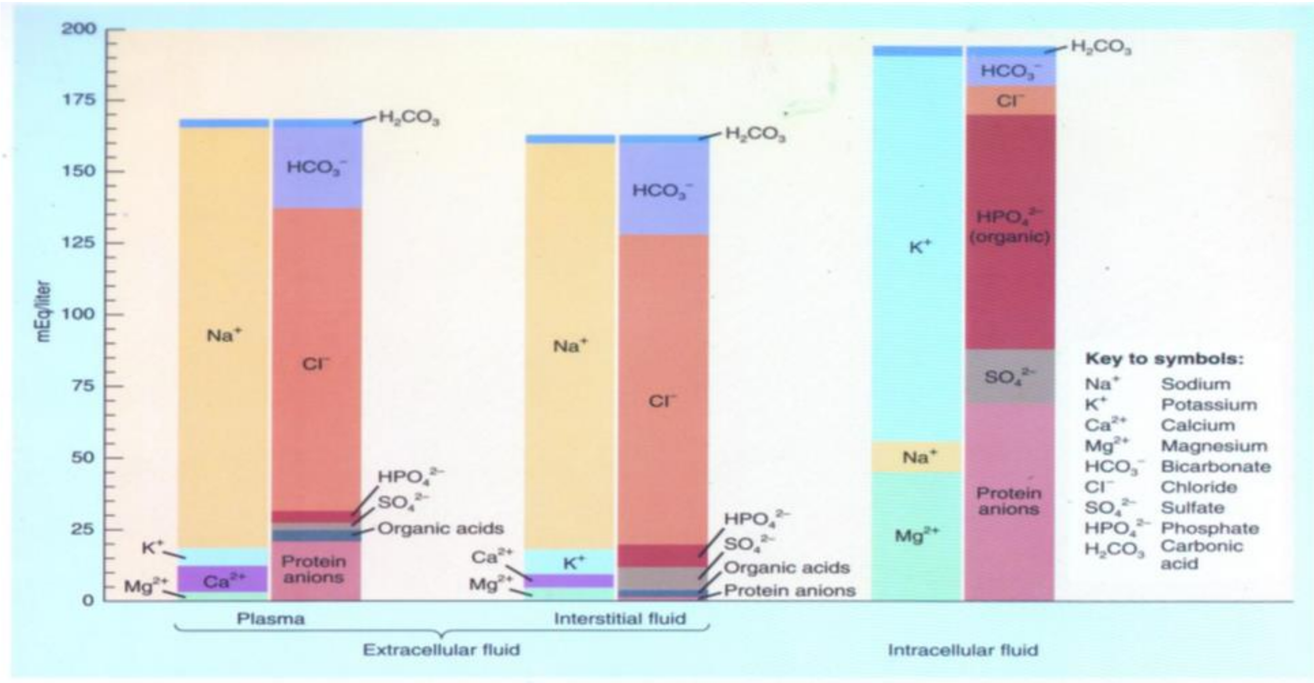
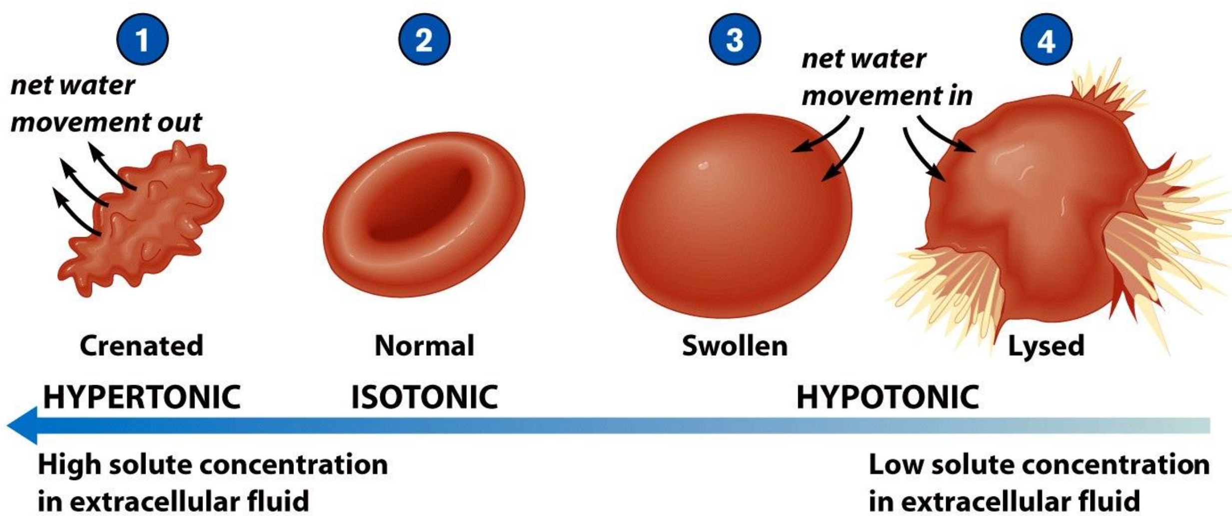
-In ICF: The main cation is **potassium** and magnesium and the main anions are protein anions and HPO_4 .



Comparison of Electrolyte and Protein Anion Concentrations in the Body Fluid Compartments, Fig# 27.4



-if a red blood cell is put in an isotonic solution, the net water movement is zero.

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-if a red blood cell is put in a hypotonic solution, water will move towards the higher osmolarity . **In other words** , it will enter the cells, causing ***hemolysis,***

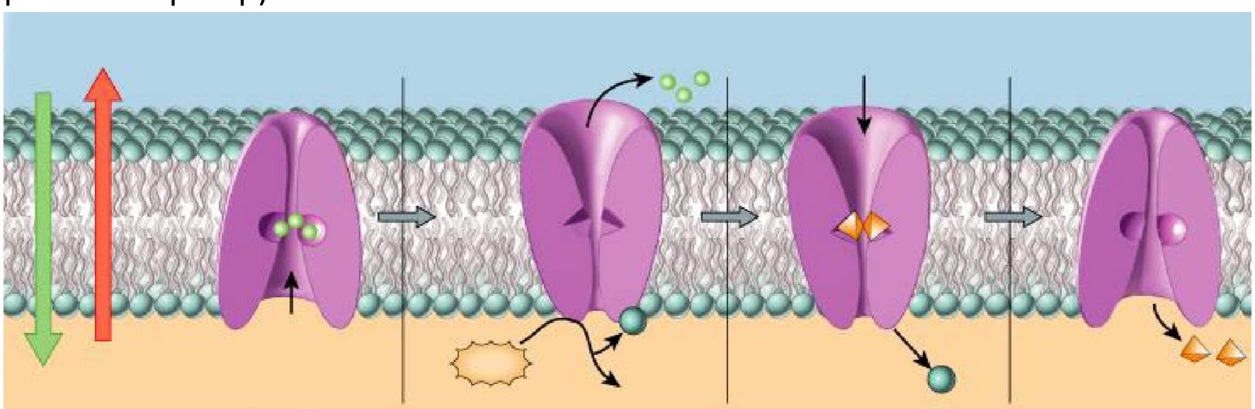
Hemolysis causes **death**

-if a red blood cell is put in a hypertonic solution the water will leave the cell, causing **crenation. (shrinking)**

-water move from low concentration of **solute** to high concentration of **solute** .

-Water molecules move from lower osmolarity to higher osmolarity. **.Recall that lower osmolarity means higher concentration of water and vice-versa .** Since Osmolarity depends on the number of **SOLUTE** molecules .

B-Active transport : Solutes are transported across plasma membranes **against their concentration gradient** with the use of energy, from an area of lower concentration to an area of higher Concentration (Example :Sodium-potassium pump) .



The **Sodium-Potassium pump** is called an **electrogenic pump** because it causes a separation of charges (Difference in charges inside and outside the cell) .

1-Primary Active Transport:

• Molecules are "pumped" against a concentration

gradient at the expense of energy (ATP)

– **direct use of energy**

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-driven by pumps such : Potassium sodium pumps /calcium pumps/ hydrogen pumps

2-Secondary Active Transport:

• Transport is driven by the energy stored in the

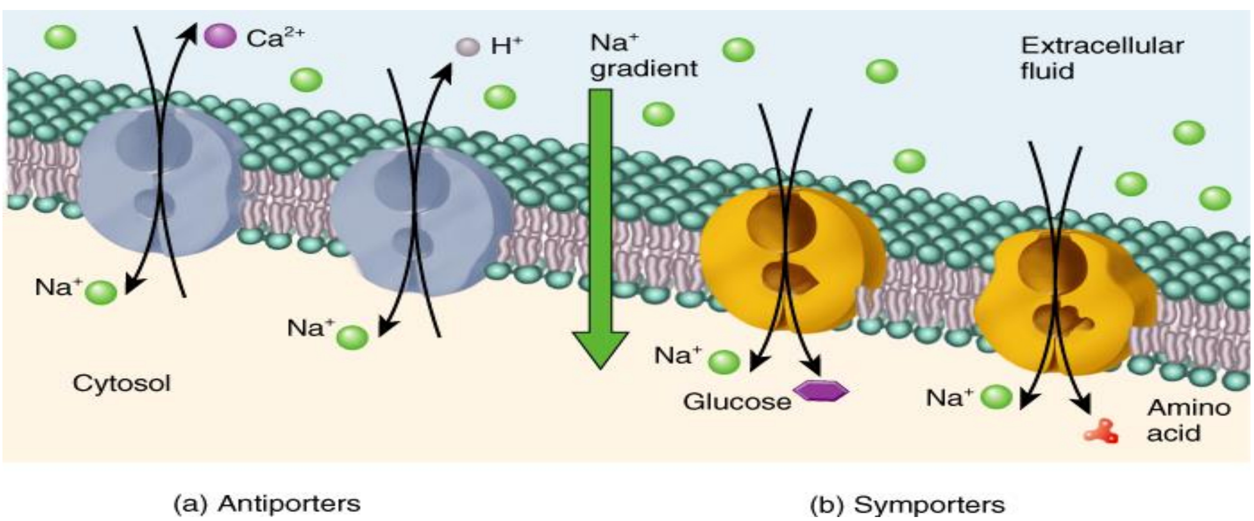
concentration gradient of another molecule (Na+)

– **indirect use of energy**

Saturation

• Similar to facilitated diffusion

• Rate limited by Vmax of the transporters



Antiporters: transport two substances in two directions (2×2)

Symporters: transport two substances in one direction (2×1)

3- Transport in Vesicles:

-Vesicle - a small spherical sac formed by budding off from a membrane.

Endocytosis

materials move into a cell in a vesicle formed from the plasma membrane.

phagocytosis

The substance is captured by pseudopods Then the vesicle is punched in and will fuse with lysosomes for digestion via lysosomal enzymes

receptor-mediated endocytosis

The substances are attached to the receptors (it might be attached by pseudopods), Then the vesicle is punched in then the vesicle fuses with the lysosomes and the lysosome will degrade these substances.

pinocytosis

It is mainly for fluids , there is some kind of pseudopods, then its digested.

Exocytosis

vesicles fuse with the plasma membrane, releasing their contents into the extracellular fluid

Transcytosis

a combination of endocytosis and exocytosis

هذه العمليات موضحة في الصور في الاسفل

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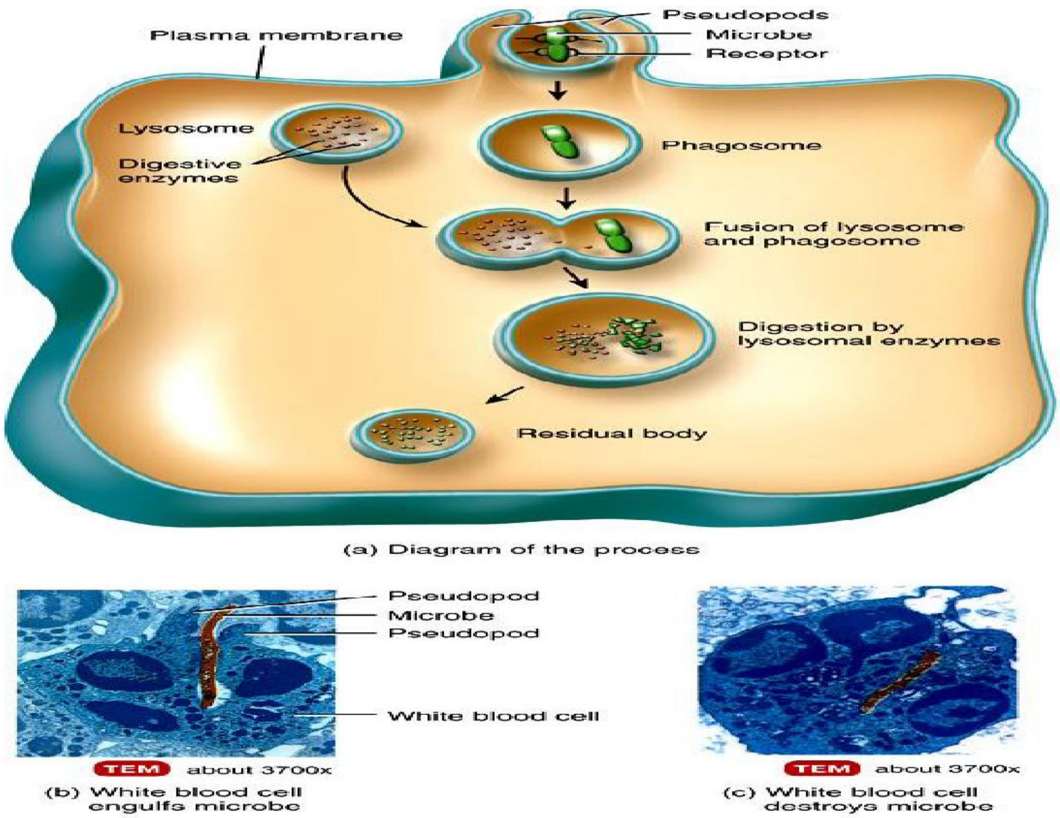
Phagocytosis



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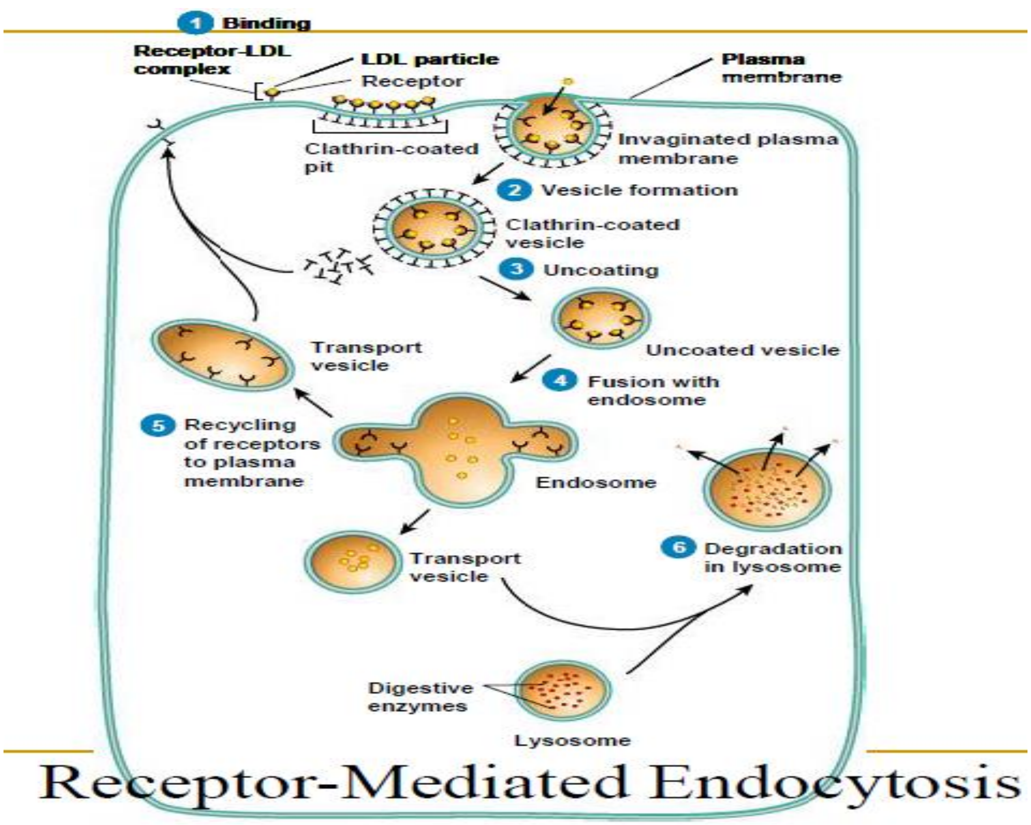


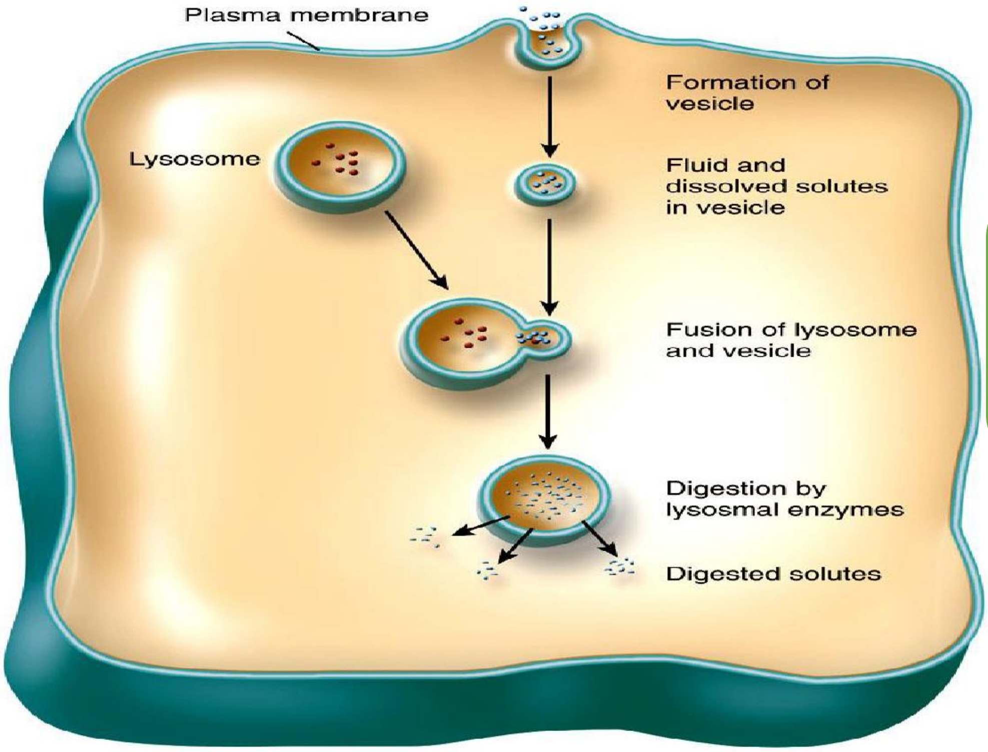
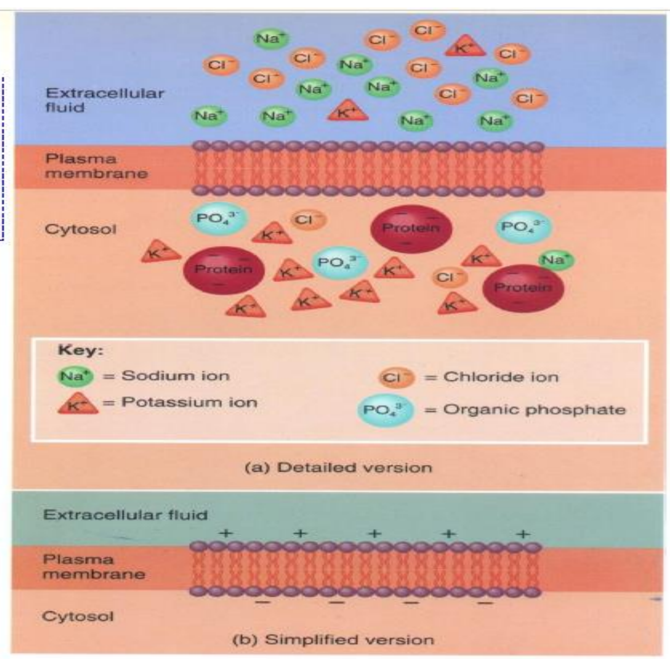


Figure 03.14 Tortora - PAP 12/e

Bulk-phase Endocytosis

Resting Membrane Potential and polarization of cell membranes



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السلايدات الاضافية :

■ **All non penetrable solutes in a solution exert osmotic pressure .**

#Osmotic pressure is higher when molar concentration is higher or temperature is higher and the molecular weight is lower

■ Osmotic pressure depends mainly on the molar concentration (n) or molarity of a solution .

■ Osmotic pressure is a colligative property, meaning that the property depends on the concentration of the solute but not on its identity

■ **According to Van't Hoff, osmotic pressure (π) depends on the molar concentration (n) of the solution and the temperature T in kelvin. π = nRT where R is the gas constant :**

$$\pi = i\, nRT$$

where "i" is the number of ions formed by

dissociation per molecule

■ The greater the no of ion/molecule when

Dissolved ,the greater the osmotic pressure .

■ To describe the total number of osmotically active

particles per liter of solution . The term osmolarity is used

■ The total number of osmotically active particles per

kilogram of water is known as osmolality .

■ Two solutions can have the same molarity but may

have different osmolarities. E.g

osmotically active particles: are particles that cannot penetrate the semi-permeable membrane .

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-Pressures of a solution:

■ **Osmotic pressure (the pulling pressure) :** of a solution is the measure of tendency of a solution to pull water into it by osmosis because of the relative concentration of non penetrating solute and water.

■ **Hydrostatic pressure of a solution** : is the pressure exerted by a stationary fluidic part of the solution on an object (semi permeable membrane in case of osmosis) i.e **(It is due to the column of water**)

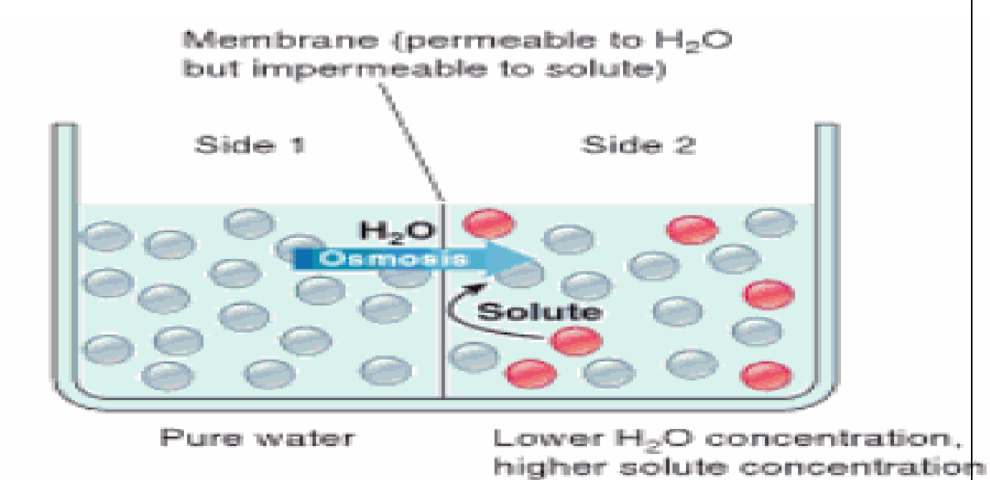
■ Net hydrostatic pressure of a solution = hydrostatic pressure – osmotic pressure =zero at equilibrium

Example:

■ Separate pure water from a sugar solution with semi permeable membrane

■ Both have same hydrostatic pressure

■ Osmosis take water from side 1 to side 2 because solution on side 2 has a greater pulling tendency



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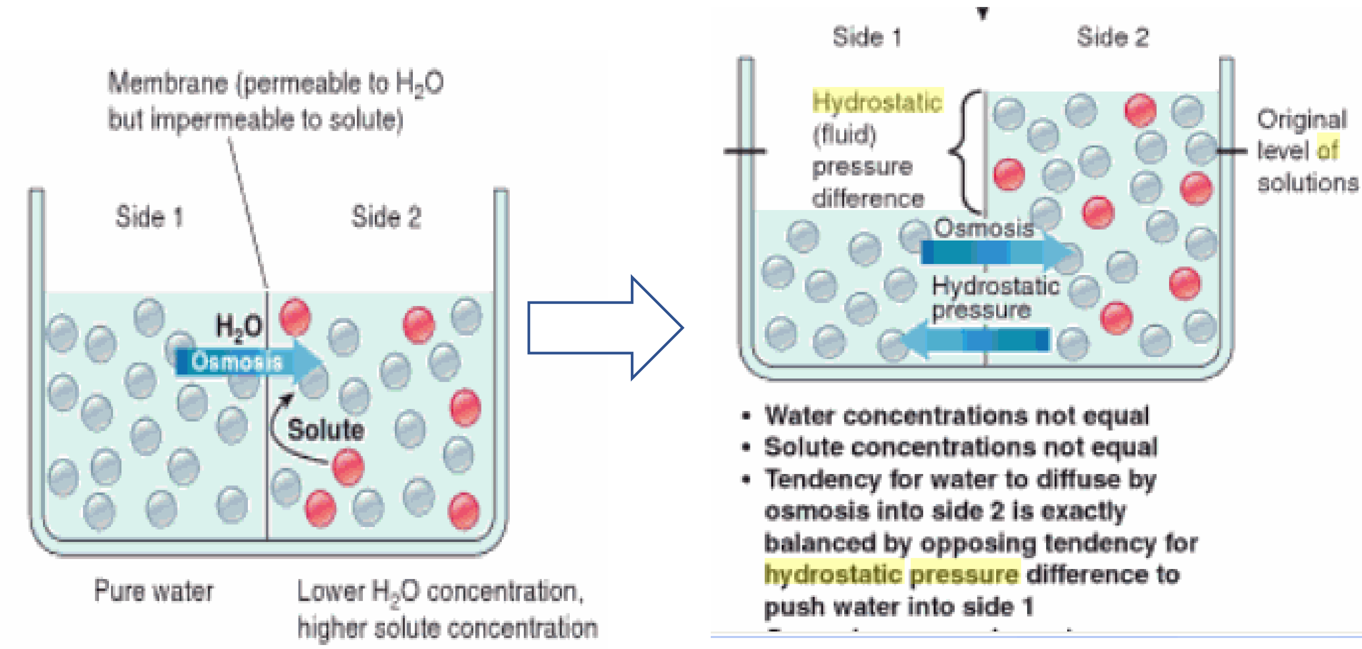
■ Will all water go to side 2?

■ No it stops after some time. This is the equilibrium state



Equilibrium state:

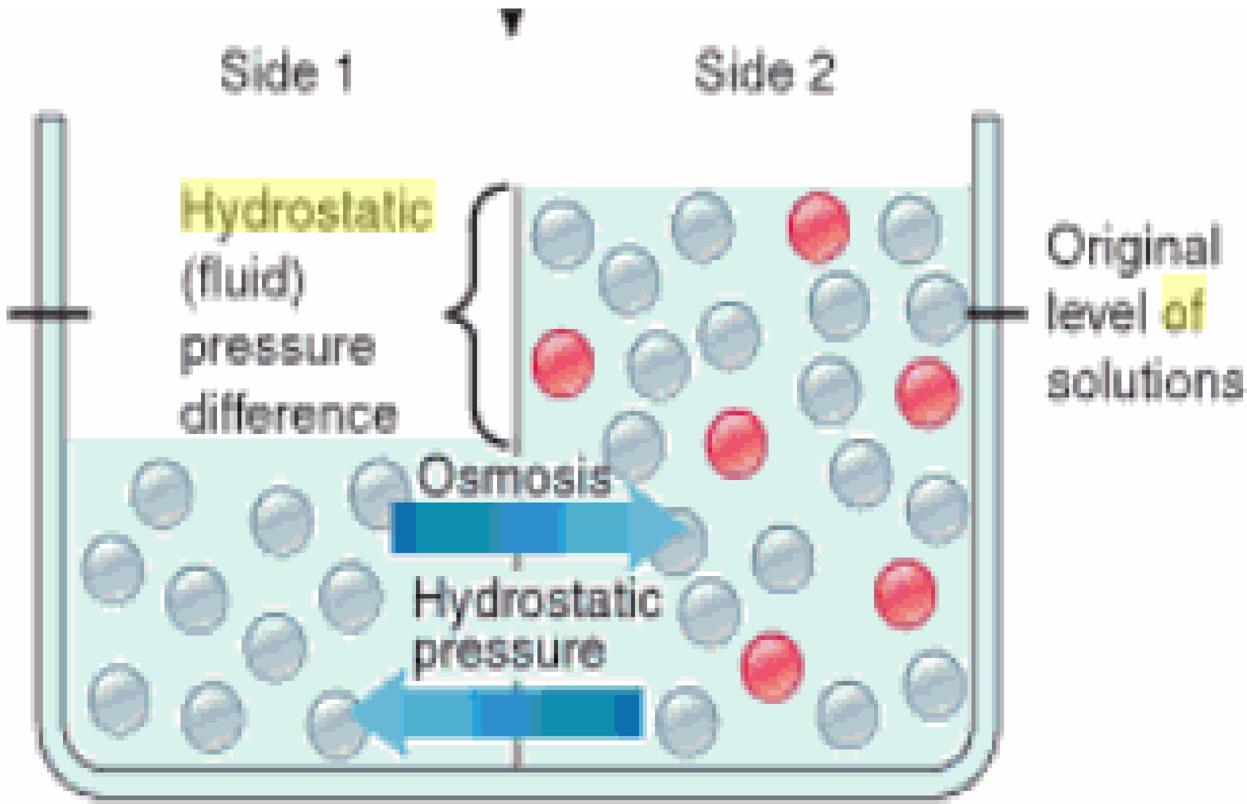
#As water moves by osmosis to side 2.

■ Solution on side 2 has two tendencies now

■ Tendency to push water back to side 1 due to greater hydrostatic pressure

■ Tendency to pull water by osmosis back to side 2

■ Equilibrium is achieved when tendency to pull water to side 1 and to push water into side 2 balances out



- Water concentrations not equal
- Solute concentrations not equal
- Tendency for water to diffuse by osmosis into side 2 is exactly balanced by opposing tendency for hydrostatic pressure difference to push water into side 1