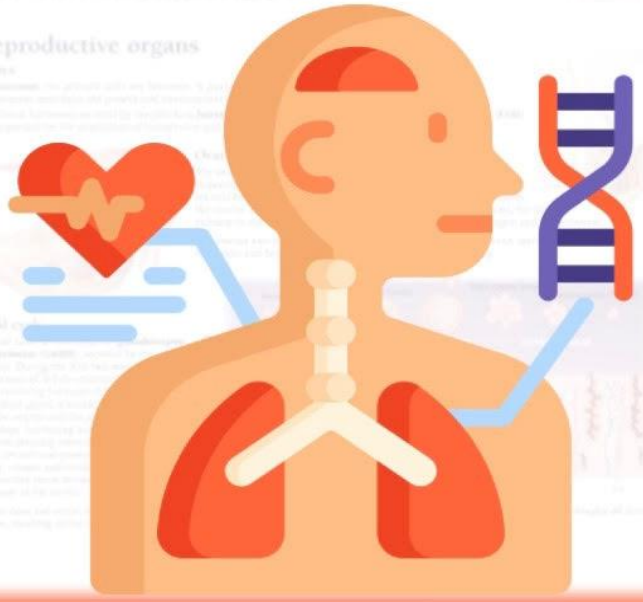
Doctor 022

Physiology

Sheet no. 03



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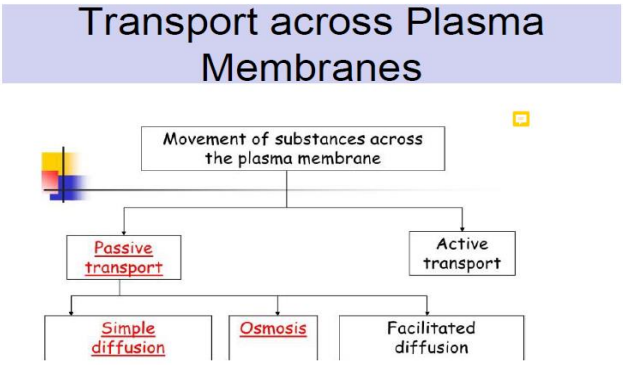
-TRANSPORT ACROSS PLASMA MEMBRANES:

-There are two types of transport modalities across the plasma membrane: Passive transport and active transport. The difference is that passive transport does not need macro energetic molecules and it has three types:

1.simple diffusion
2.osmosis
3.facilitated diffusion



-Active transport modalities on the other hand need to consume macro energetic molecules like ATP to Phosphorylate the transport protein and transport particles

-PASSIVE TRANSPORT

-In passive modalities you transport a particle from the high concentration to the low concentration without the use of macro energetic molecules.

-Particles can move across membranes in three ways:(3rd type in page 5)

a-Diffusion through the lipid bilayer:

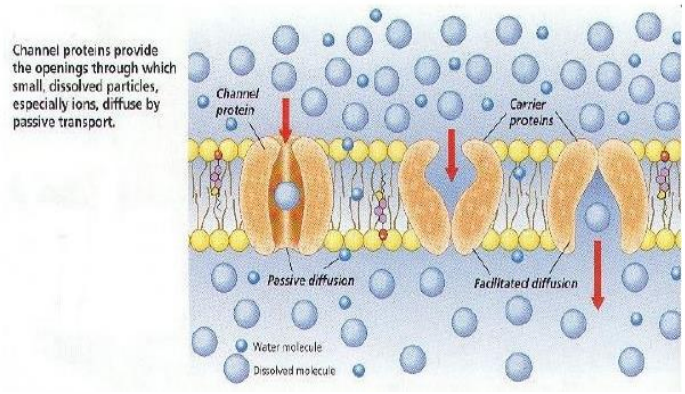
Particles that diffuse through the lipid bilayer have to be highly liposoluble (Soluble in lipids) like

1.carbon dioxide CO2
2.oxygen O2
3.nitrogen oxide NO
4.Steroid hormones (steroids are lipids so they can dissolve in the lipid bilayer)
5.Monoglyceride,etc.

-Also, some liposoluble (not water soluble) vitamins can be transported across the membrane through simple diffusion.

b-Diffusion through channels:

-Other structures like ions cannot move straight through the lipid bilayer because they have electrical properties... So, to move from the high concentration into the low concentration these particles need channels.

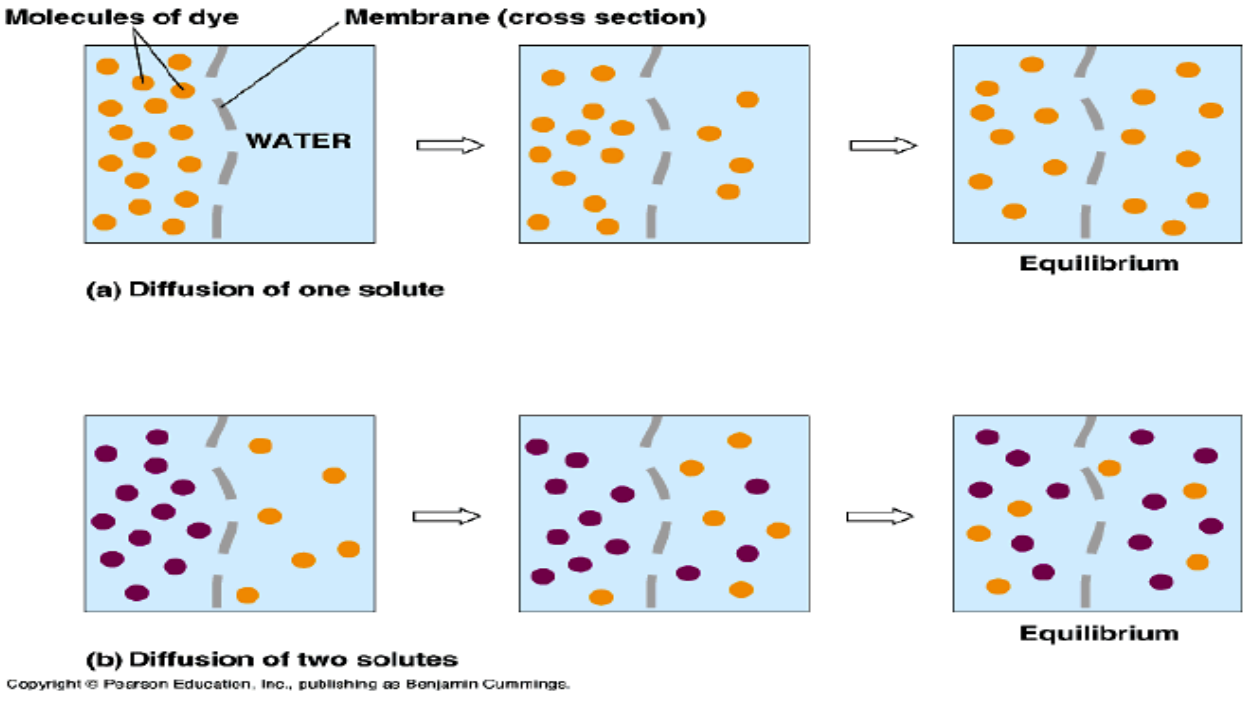


-Those channels are Specific and selective, for example: sodium channels only transport sodium and they differ from calcium channels.

-types of passive diffusion:

1-SIMPLE DIFFUSION:

-To understand simple diffusion, we assume that we have a semi permeable membrane separating 2 compartments:



(a)in one compartment we have a high concentration of particles and the membrane is semi permeable to these particles... some of these particles will pass from the first to the second compartment until it reaches equilibrium and the two compartments have the same concentration.

-As long as there is a concentration gradient there will be a net rate of diffusion from the first to the second compartment.

-When you reach equilibrium there will still be diffusion but the net rate of diffusion will be zero (meaning that the number of particles that cross from 1st compartment to the 2nd is equal to those that across from the 2nd to the 1st).

(b)if the membrane is permeable to 2 solutes each one diffuses separately down its own gradient until equilibrium.

-As we said… simple diffusion does not consume macro energetic molecules... rather it uses another form of energy: kinetic energy.

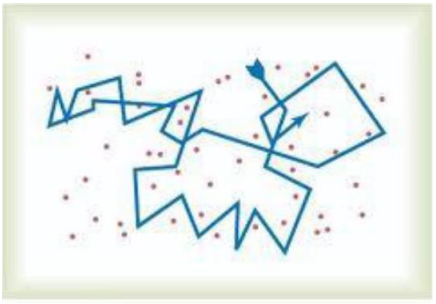


Figure 4–3
Diffusion of a fluid molecule during a thousandth of a second.

-When particles are moving haphazardly in a solution the sum of kinetic energy in that solution depends on the concentration (if you have more particles, you have more kinetic energy in the compartment).

-So, the difference in concentration results in a difference in kinetic energy (so the concentration gradient is the driving force of diffusion).

-fick's law:

Rate of diffusion: is the number of diffused particles per unit time and according to **Fick's law:** the net rate of diffusion(J) is equal to the permeability(P) multiplied by the concentration gradient(ΔC) (J=P.ΔC).

Fick's Law

- $J = P.\Delta C$
- $P = D.A/\Delta X$
- $J = D.A.\Delta C/\Delta X$

J = Flux (Rate of diffusion)
P = Permeability
D = Diffusion Coefficient
A = Surface area
C = Concentration
X = Membrane thickness

-Permeability itself depends on many factors like the size of the transported particles & the size of the pores that they move through and those factors can be expressed with the **diffusion coefficient(D)** which differs from one type of particle to another.

-other factors are:

surface area(A): The higher the surface area of the membrane is the more permeability and diffusion it provides.

membrane thickness(ΔX): A bigger thickness means less permeability because particles face more resistance.

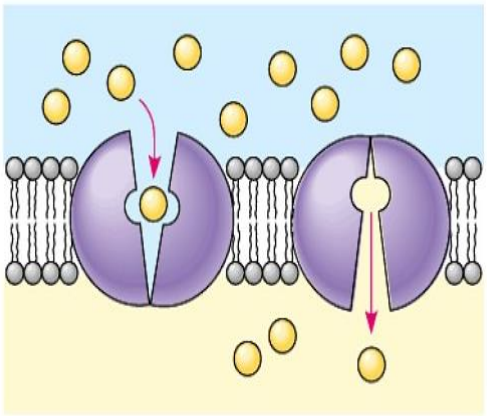
-So overall P=D.A/ΔX and J=D.A.ΔC/ΔX.

2-FACILITATED DIFFUSION:

c-Diffusion through carriers: *plz refer to the last page (1) *

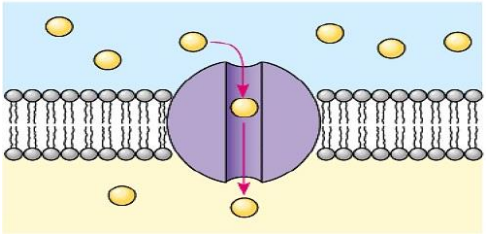
-this type is considered as facilitated diffusion.

-Some bigger particles like amino acids, glucose, galactose, and fructose cannot pass through channels so transporting them from the high concentration to the low concentration needs carriers.



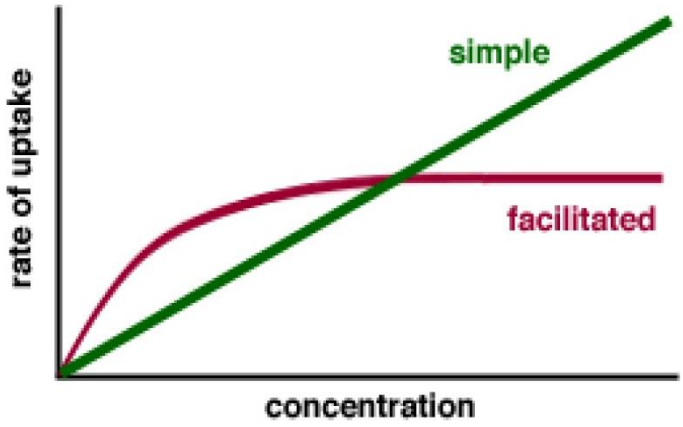
-Those particles bind to specific sites on the carriers which results in changes in the structure of that carrier and moves them from one side to the other (still with no consumption of macro energetic molecules).

-now the question is: Is diffusion through channels considered simple diffusion or facilitated??



-To answer this question, we must observe the relation between the concentration and the rate of diffusion.

-In **simple diffusion** at any time that you have an increase in concentration the rate of uptake or diffusion also increases (linear relation) (العلاقة خطية).



-With regard to **facilitated diffusion**… Initially rate of diffusion increases with concentration, however it reaches a point where there is no more increase that is called *maximum velocity of transport* Because the number of carriers is limited and once all those carriers are busy you get no more increase in the net rate of diffusion even if you increase concentration.

-Now to answer our previous question: as long as the transport channels are open, they follow the kinetics of simple diffusion where there is a linear relationship between concentration and the rate of diffusion. for that reason, some scientists consider it simple diffusion others however can consider it facilitated diffusion because of the use of channels to help with and facilitate the transport of particles through the membrane

-So, the answer is just really up to you and the way you think about it!

3-OSMOSIS:

-If we assume that the membrane is not permeable to the particles but it's permeable to the media (water)...In this case water will move from the low concentration of particles to the high concentration of particles **or in other words** from the high concentration of water to the low concentration of water.

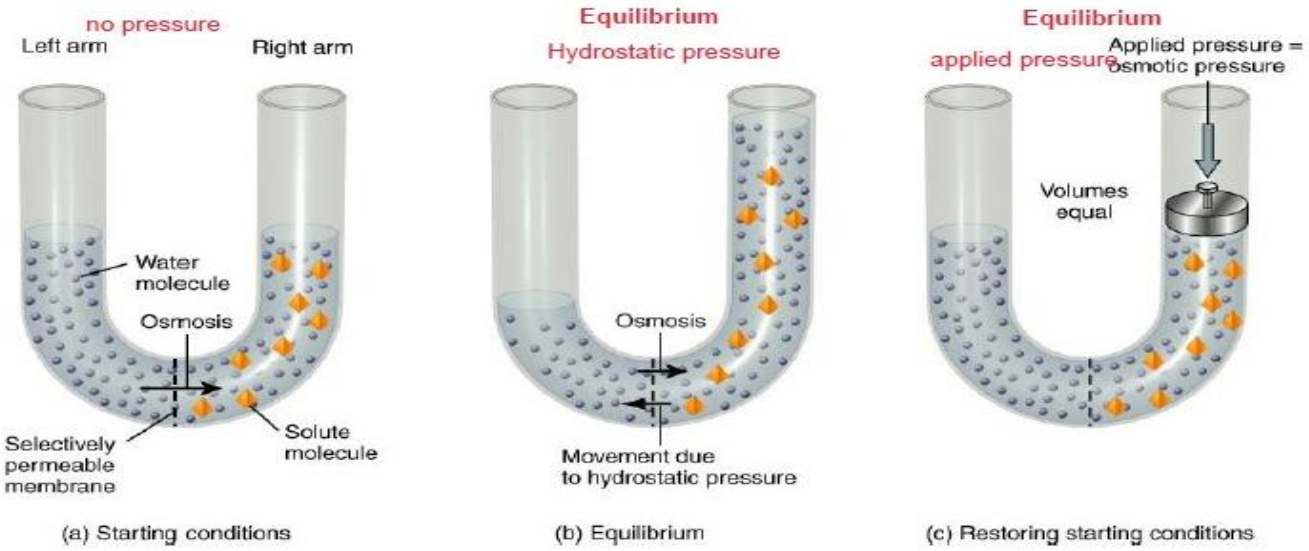
-This movement will continue until we reach equilibrium, where the hydrostatic pressure that has been created opposes any more movement of water, and the net movement of osmosis is 0.

-This hydrostatic pressure equals the osmotic pressure of that soluble

-Now to understand osmotic pressure more: -

-if you, instead, apply a pressure that is equal to the pressure created by the column of water (due to movement by osmosis ="osmotic pressure") this applied pressure will oppose movement of water.

-If the applied pressure is higher than osmotic pressure water will move in the opposite direction, from the low concentration of water to the high concentration of water. And this process is called **filtration.**



Van't Hoff's law:

We can calculate osmotic pressure(π) with Van's Hoff's law: π= RTC

-If temperature is raised osmotic pressure increases.

-if concentration is raised osmotic pressure also increases.

Van't Hoff's Law

$$\pi = RTC$$

π: osmotic Pressure
R = Gas constant
T = Absolute Temprature
C = Concentration

-TONICITY OF SOLUTION:

-Our cells are bathed in a solution (the extracellular fluid), and have a certain osmolarity inside it.

-**Molarity** (M): is the number of moles of solute dissolved in one liter of solution.

-**Osmolarity**: refers to the number of moles of solute *particles* per 1 **L (volume)** of solvent.

-**Osmolality**: is the number of solute particles in 1 **kg (mass)** of solvent.

EXAMPLES:

1.If we have a solution of sodium chloride with the concentration of 1 molar the osmolarity is 2, because sodium chloride NaCl disassociates in

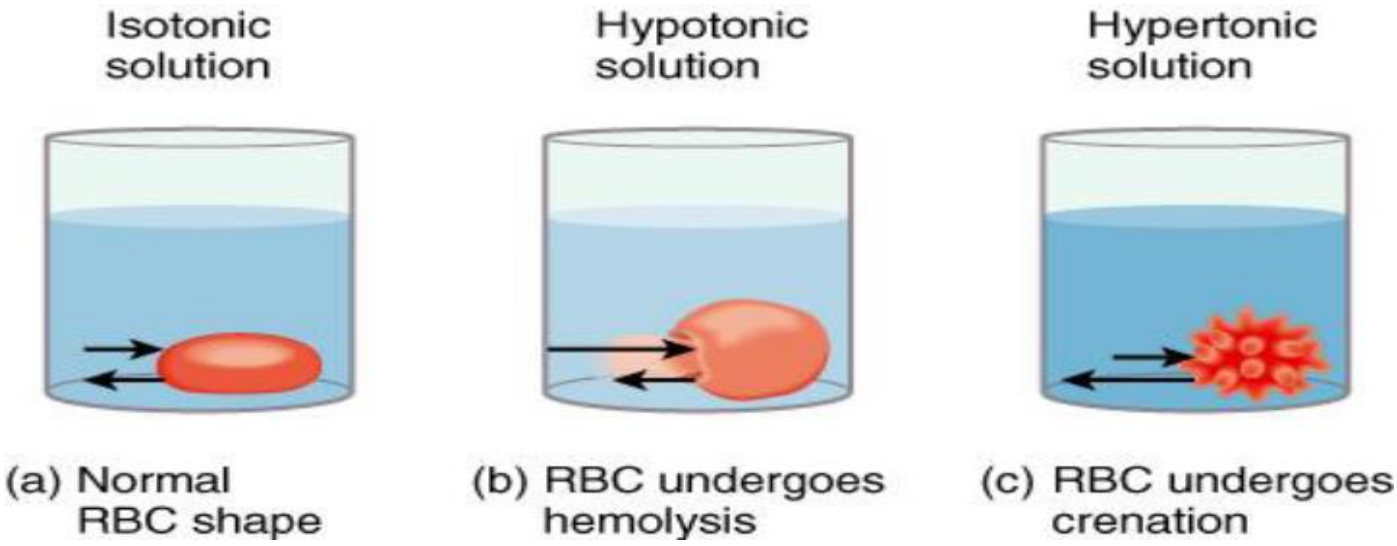
water into Na+ ions and Cl- ions (So in total there is 2 moles of particles: one mole of Na and one mole of Cl)

2.One mole of calcium chloride $CaCl_2$ is dissolved in one-liter Osmolarity=3 (the inside of the toilet it dissociates in water into one mole of Ca and two moles of Cl)

-In our body fluids the intracellular fluid has a totally different composition from the extra cellular fluid but they both have the same osmolarity.

-If, however the osmolarities were different water will move from the low osmolarity to the high osmolarity and close disturbance to the cell

*plz refer to the last page (2) *



(a) If you place a red blood cell in a solution with the same osmolarity **(Isotonic solution)**: it remains intact and nothing happens.

(b) If you place the RBC in a solution with a lower osmolarity **(Hypotonic solution)**: water will move to the inside the cell and cause it to rupture.

(c) If you place the RBC in a solution with higher osmolarity **(Hypertonic solution)**: water will move from the inside to the outside and the cell will shrink. *plz refer to the last page (3) *

MORE EXAMPLES:

1. In emergency rooms a solution of sodium chloride called saline is prepared with concentration of 0.9% : this means that there is 0.9g of (NaCl) per 100 ml of solution, or 9 G per liter, What is the osmolarity of that solution and is it isotonic, hypertonic. or hypotonic ?

First, it is important for IV solutions to be isotonic to your blood. so it is isotonic.

Second, to calculate osmolarity we

1) calculate the number of moles in 9 grams of an NaCl

Number of moles (n) = Mass of substance / Molecular weight

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n=9/58.44 =0.153996807475071

2) Molarity= 0.153996807475071 mol/L

3) Osmolarity= 0.153996807475071 x2= 0.307993614950142 Osm/L =308 mOsm/L

(this is close to osmolarity in our bodies which is around 280-300 mOsm/L)

2.a solution of glucose has a concentration of 5% calculate it's osmolarity:-
5% means that it has 5g of glucose in 100 mL or 50g in 1 L

n=50/180.156= 0.277537430363085 mol

M= 277.5 mMol/L

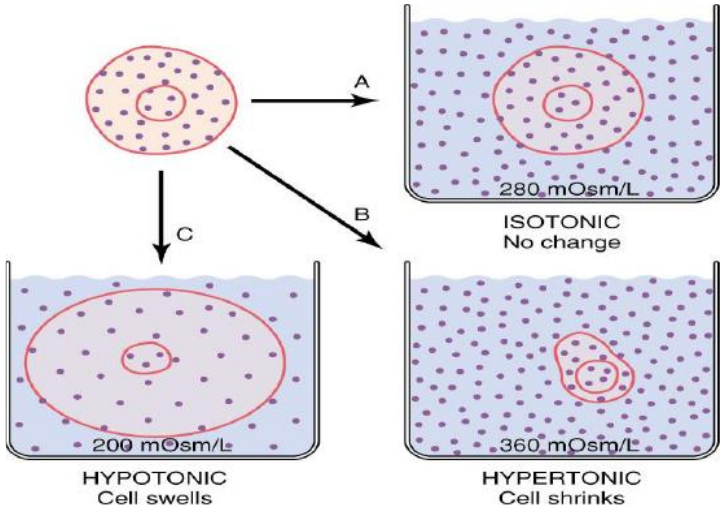
(Glucose molecules do not dissociate in water so the total number of particles is still 1 so molarity =osmolarity)

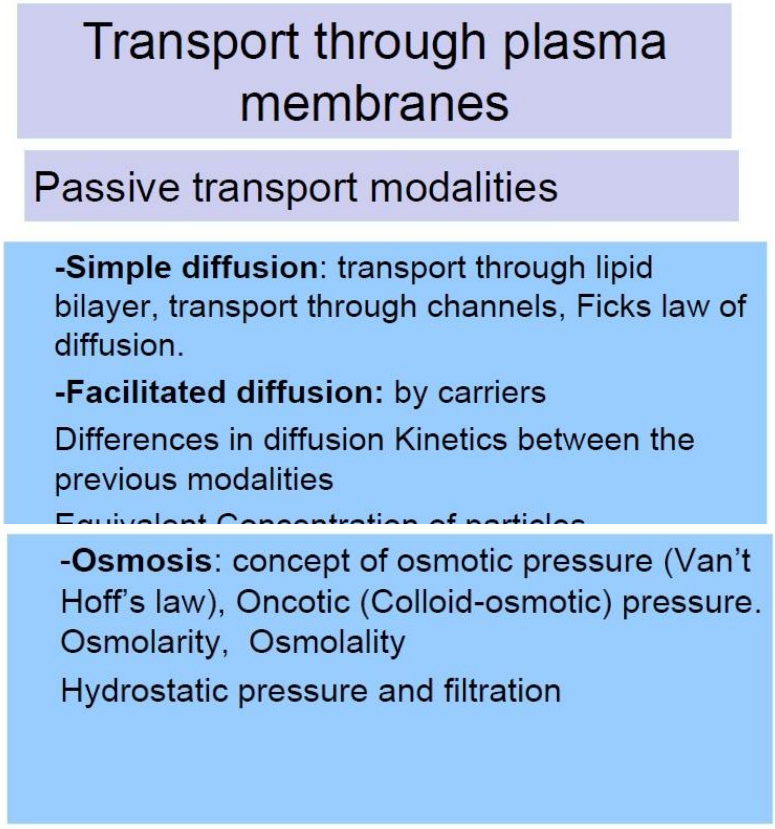
Osmolarity =277.5 mOsm/L

-The volume of the cell can increase if it's placed in a hypotonic solution or it can decrease if it's placed in a hypertonic solution.

hypertonic: the tonicity of the solution is higher than 300.

hypotonic: tonicity of the solution is lower than 280.





V2

(1) 3rd type for the movement of particles across membranes is Diffusion through (carriers) instead of (Channels)

(2) Hyper & hypo were switched, plz correct them as follows:

(a) If you place a red blood cell in a solution with the same osmolarity (**Isotonic solution**): it remains intact and nothing happens.
(b) If you place the RBC in a solution with a lower osmolarity (**Hypotonic solution**): water will move to the inside the cell and cause it to burst/rupture.
(from low osmolarity to high osmolarity)
(c) If you place the RBC in a solution with higher osmolarity (**Hypertonic solution**): water will move from the inside to the outside and the cell will shrink.

(3) Correction:
If, however the osmolarities were different water will move from the low osmolarity to the high osmolarity and cause disturbance to the cell (not the opposite)