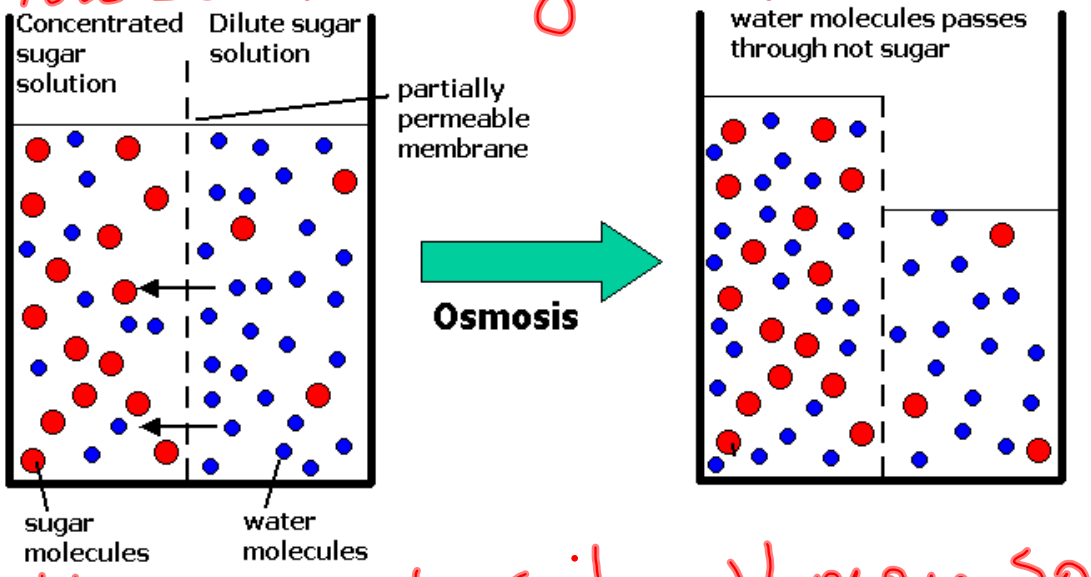
Osmotic Pressure:

osmosis is always net movement of a solvent from an area of low solute concentration (high solvent conc.) to an area of high solute concentration (low solvent conc.).

solvent moves through a semipermeable membrane

low solute → high solute



H_2O goes to side w/ more solute molecules/particles

osmotic pressure (π):

pressure required to prevent osmosis

ideal gas law:

$PV = nRT$

$\pi V = nRT$

$\pi = \frac{nRT}{V}$

$\pi = iMRT$

π = osmotic pressure

n = moles

V = volume

R = ideal gas constant

0.08206 Latm/molK

T = kelvin temp.

M = Molarity

i = # moles of ions

$\frac{n}{V}$ = Molarity

Ex. 1
Find the molar mass of a protein if 1.00 x 10^3 g of it was dissolved into enough solution to make 1.00 mL of solution. The osmotic pressure was 1.12 torr at 25°C.

$\pi = MRT$

$1.12\ \text{torr}\left(\frac{1\ \text{atm}}{760\ \text{torr}}\right) = 0.00147\ \text{atm}$

$1.47 \times 10^{-3}\ \text{atm} = \left(\frac{x}{0.001\ \text{L}}\right)\left(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)(298\ \text{K})$

$1.47 \times 10^{-3}\ \text{atm} = 2.45 \times 10^{4}\ \frac{\text{atm}}{\text{mol}}\ x$

$x = 6.01 \times 10^{-8}\ \text{moles}$

$\text{molar mass} = \frac{g}{\text{moles}}$

$= \frac{1.00 \times 10^{3}\ g}{6.01 \times 10^{-8}\ \text{mol}}$

$= 1.63 \times 10^{10}\ g/\text{mol}$

Types of solutions:

Isotonic solutions have the same osmotic pressure
Hypotonic solution has lower osmotic pressure--relative to concentrated solution
Hypertonic solution has higher osmotic pressure-- realtive to dilute solution

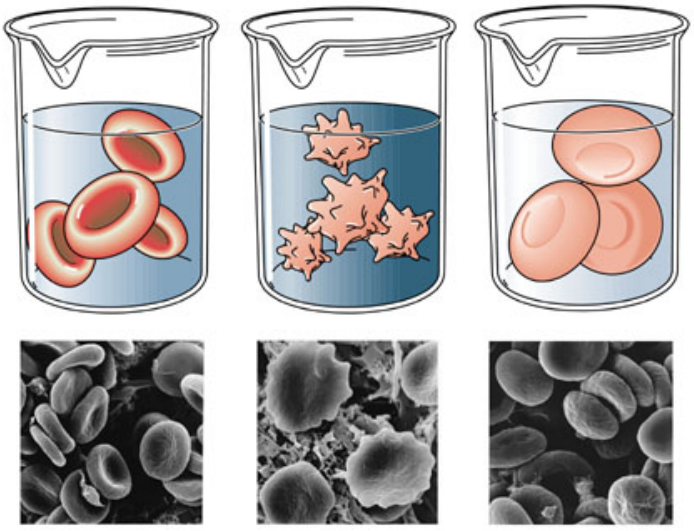
Red Blood Cells (RBC):

membrane is semipermeable
if placed in a hypertonic solution (relative to their intracellular solution) there is lower solute conc. in cell than in surrounding tissue, water moves out of cell and cell shrivels up (process is crenation)
plants wilting

if placed in hypotonic solution then there is a higher solute concentration inside cell than outside, water moves into the cell and causes it to swell and burst (process is hemolysis or lysis)

to prevent crenation or hemolysis I.V. solutions must be isotonic relative to intracellular fluids.

Tobin/Dusheck, Asking About Life, 2/e
Figure 4.20



A.
Isotonic solution (equal concentration of ions in solution and cell)

B.
Hypertonic solution (higher concentration of ions in solution than in cell)

C.
Hypotonic solution (lower concentration of ions in solution than in cell)

Everyday examples: Explain what happens when...

1. cucumber in NaCl solution-- hypertonic

shrivels up → pickle

2. limp carrot is placed in water-- hypotonic

swells → firmer

3. you eat a lot of salty food--

swell tissues

4. add salt to meat as a preservative--

bacteria

Practice problems:

1. The average osmotic pressure of blood is 7.7 atm at 25^{o}C. What concentration of glucose ($C_6H_{12}O_6$) will be isotonic with blood?

2. What is the osmotic pressure at 20°C of a 0.0020 M sucrose ($C_{12}H_{22}O_{11}$) solution?

3. A solution of an unknown nonvolatile nonelectrolyte was prepared by dissolving 0.250 g of the substance in 40.0 g of CCl_4. The boiling point of the resultant solution was 0.357°C higher than that of the pure solvent. Calculate the molar mass of the solute.

4. Camphor ($C_{10}H_{16}O$) melts at 179.8°C, and it has a particularly large freezing point depression constant, K_f = 40.0°C/m. When 0.186 g of an organic substance of unknown molar mass is dissolved in 22.01 g of liquid camphor, the freezing point of the mixture is found to be 176.7°C. What is the molar mass of the solute?

5. The osmotic pressure of an aqueous solution of a certain protein was measured in order to determine its molar mass. The solution contained 3.50 mg of protein dissolved in sufficient water to form 5.00 mL of solution. The osmotic pressure of the solution at 25^{o}C was found to be 1.54 torr. Calculate the molar mass of the protein.

6. A sample of 2.05 g of the plastic polystyrene was dissolved in enough toluene to form 0.100 L of solution. The osmotic pressure of this solution was found to be 1.21 kPa at 25°C. Calculate the molar mass of the polystyrene.