Class: First Year MBBS

- Subject: Biochemistry
- Module: Foundation
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- DEMONSTRATOR

OSMOSIS AND FACTORS AFFECTING OSMOSIS

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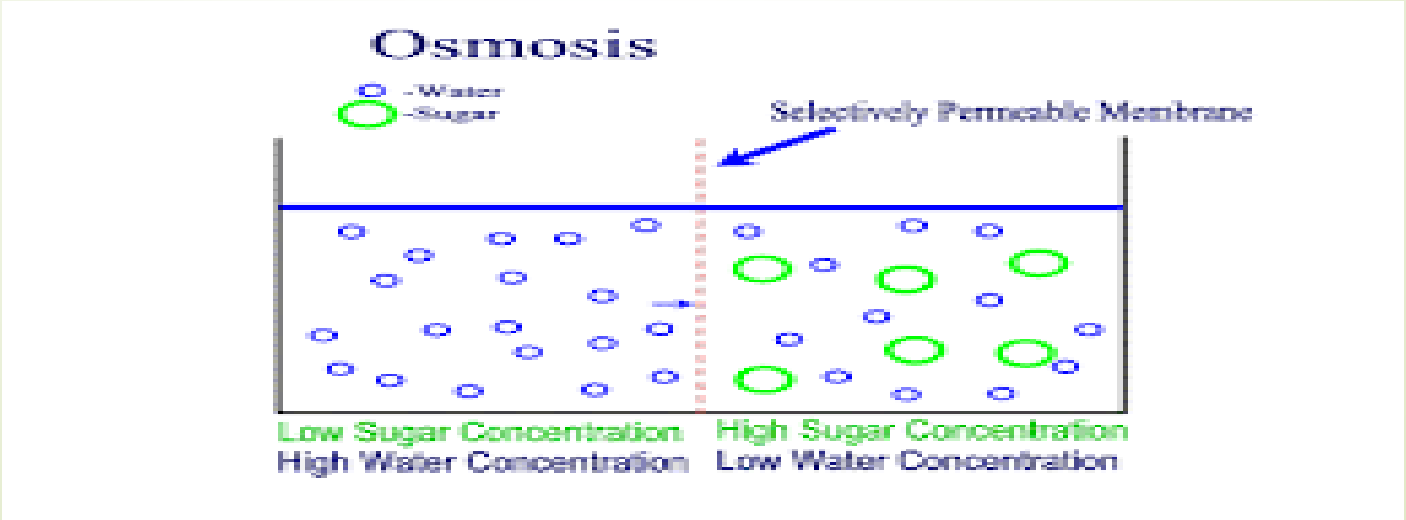
LEARNING OBJECTIVES

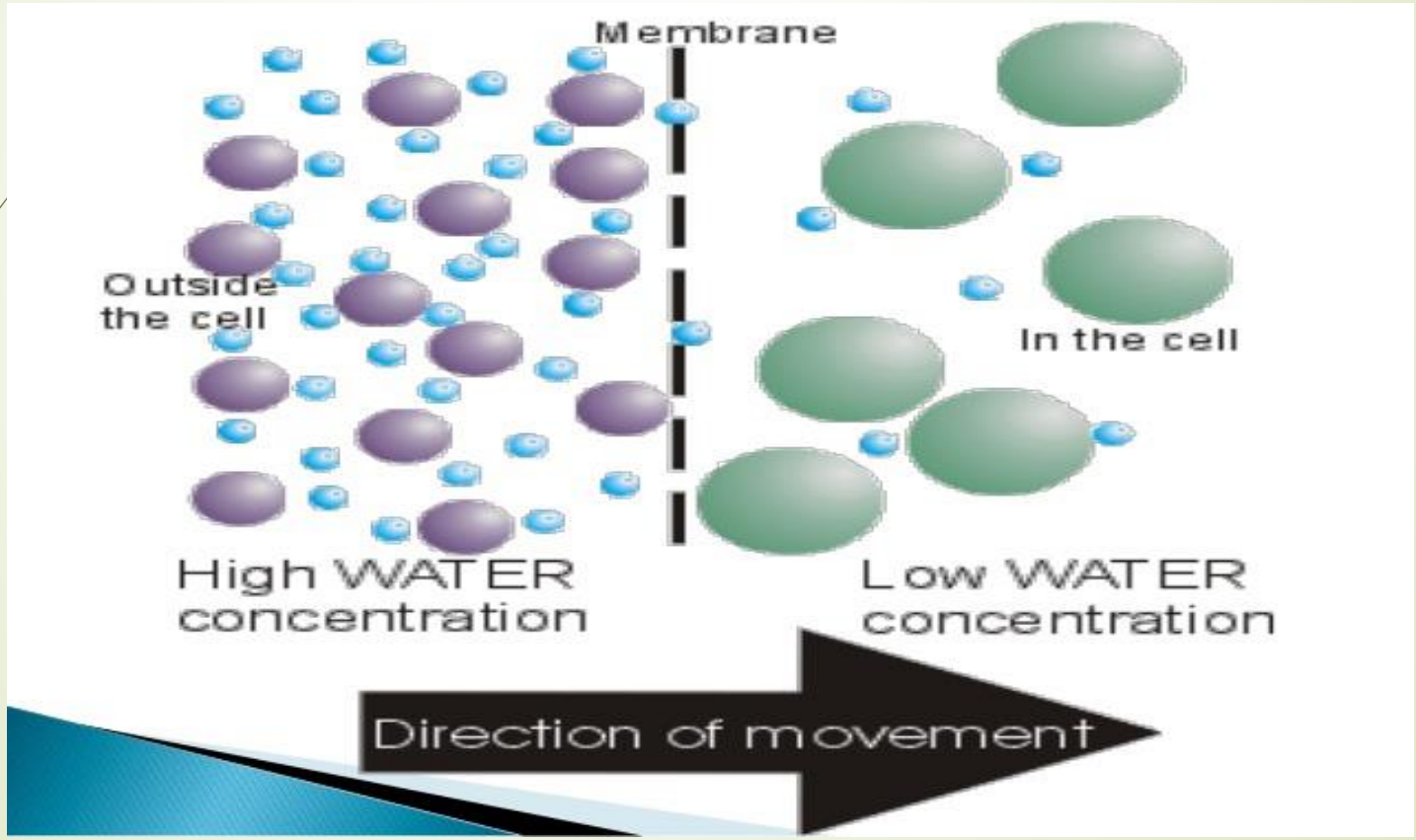
- Definition
- Types of osmosis
- Osmosis in living cells
- Osmotic pressure

OSMOSIS

- Osmosis is a type of a process where a fluid passes through a semipermeable membrane and moves from an area where a solute is present in low concentrations to an area where a solute is present in a higher concentration.
- Selective passage of solvent in response to concentration gradient through a semi permeable membrane.



- Osmosis is a type of a process where a fluid passes through a semi-permeable membrane, from a higher concentration of water to a lower concentration of water.



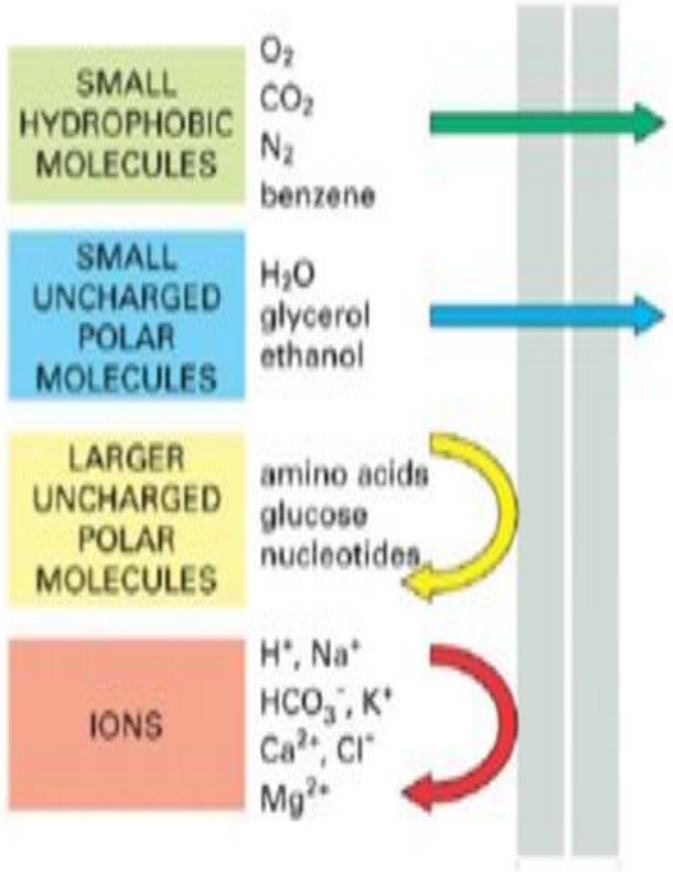
Osmosis – A Special kind of Diffusion

- Diffusion of water across a selectively permeable membrane (a barrier that allows some substances to pass but not others). The cell membrane is such a barrier.
- Small molecules pass through – ex: water
- Large molecules can't pass through – ex: proteins and complex carbohydrates.

Cell Membrane

Transport In & Out of the Cell

Cell membrane is semi-permeable, meaning it is a barrier to most, but not all molecules



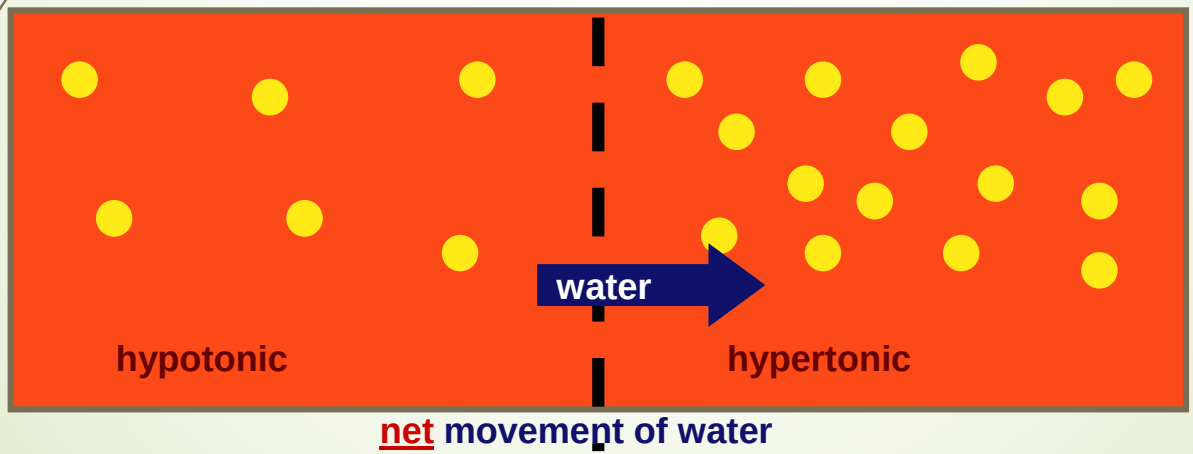
- osmosis does not require input of energy, it does use kinetic energy.
- Osmosis provides the primary means by which water is transported into and out of cells.
- It differs from diffusion in that the flow is in one direction only.

Osmosis types

- Osmosis may be divided into following types,
- **ExoOsmosis-:** The outward osmotic flow of water from a cell containing an aqueous solution through a semi-permeable membrane is called as Exo-osmosis. For example, egg (after removing hard shell) placed in conc. NaCl solutions, will shrink due to exo-osmosis.
- **Endo-osmosis:** The inward flow of water into the cell containing an aqueous solution through a semi-permeable membrane is called as endo-osmosis. e.g., an egg placed in water swells up due to endo-osmosis.
- **Reverse osmosis:** If a pressure higher than osmotic pressure is applied on the solution, the solvent will flow from the solution into the pure solvent through the semi-permeable membrane. Since here the flow of solvent is in the reverse direction to that observed in the usual osmosis, the process is called reverse osmosis. This process is used in water purification.

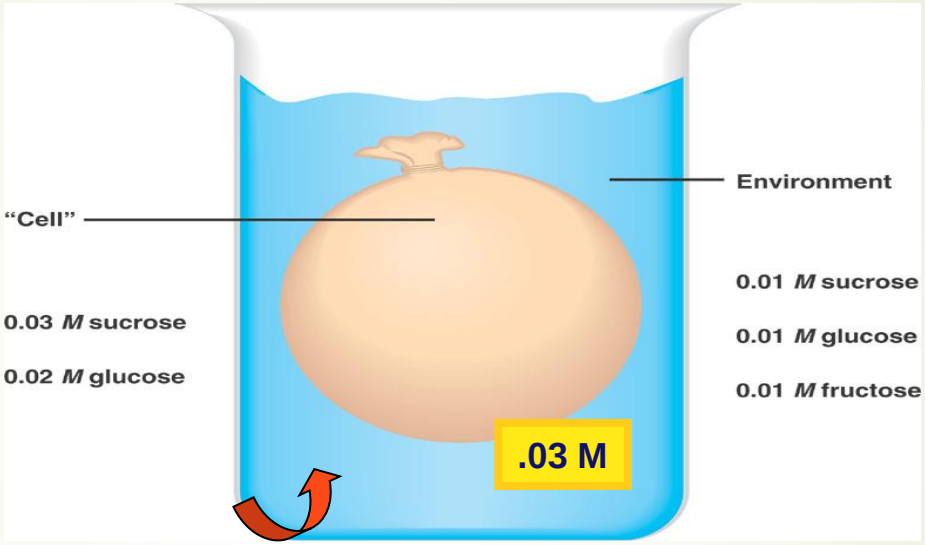
Osmotic solutions

- There are three types of osmotic solutions:
  - Hypertonic - more solute, less water
  - Hypotonic - less solute, more water
  - Isotonic - equal solute, equal water



Osmosis…

.05 M

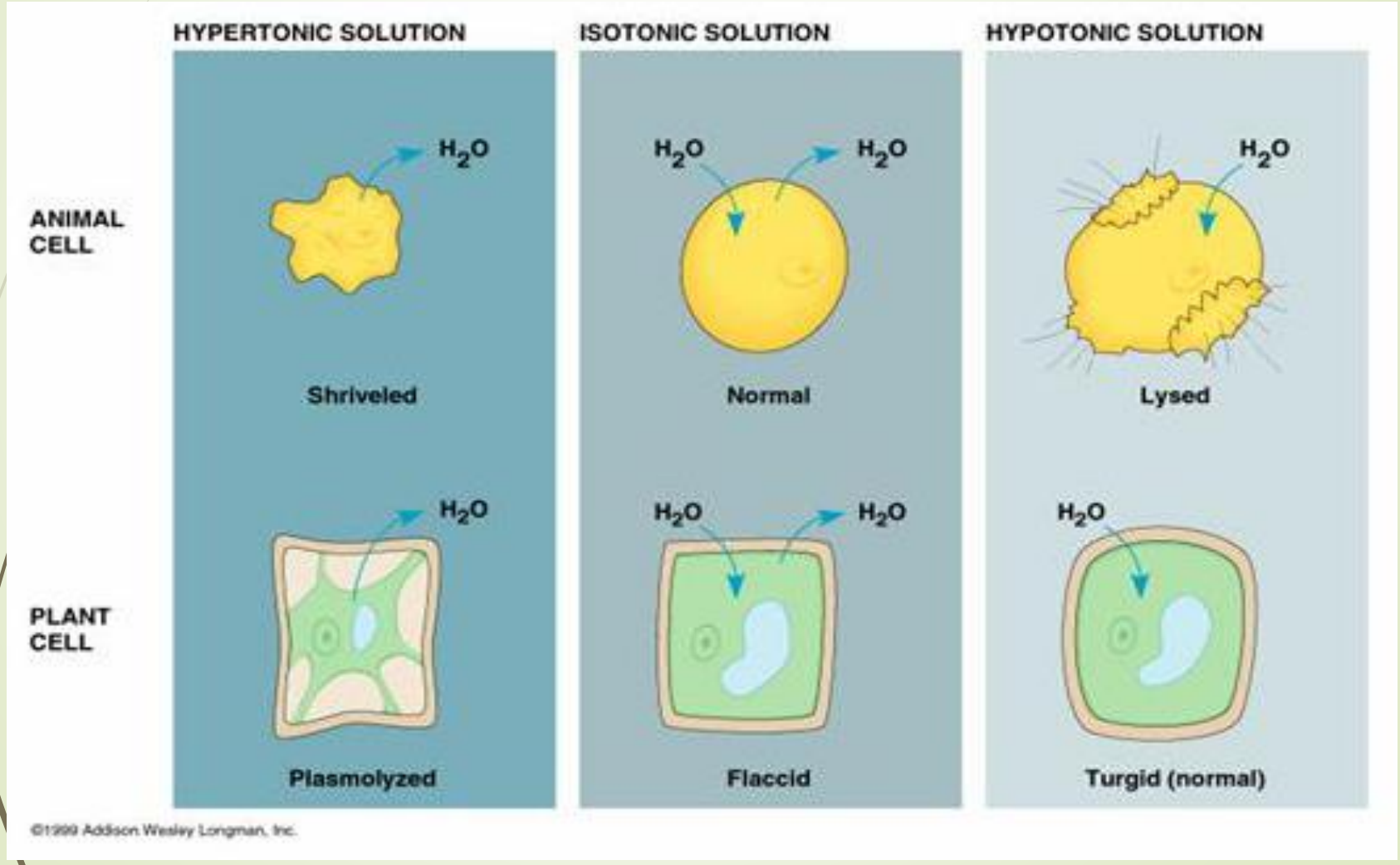


Cell (compared to beaker) → hypertonic or hypotonic

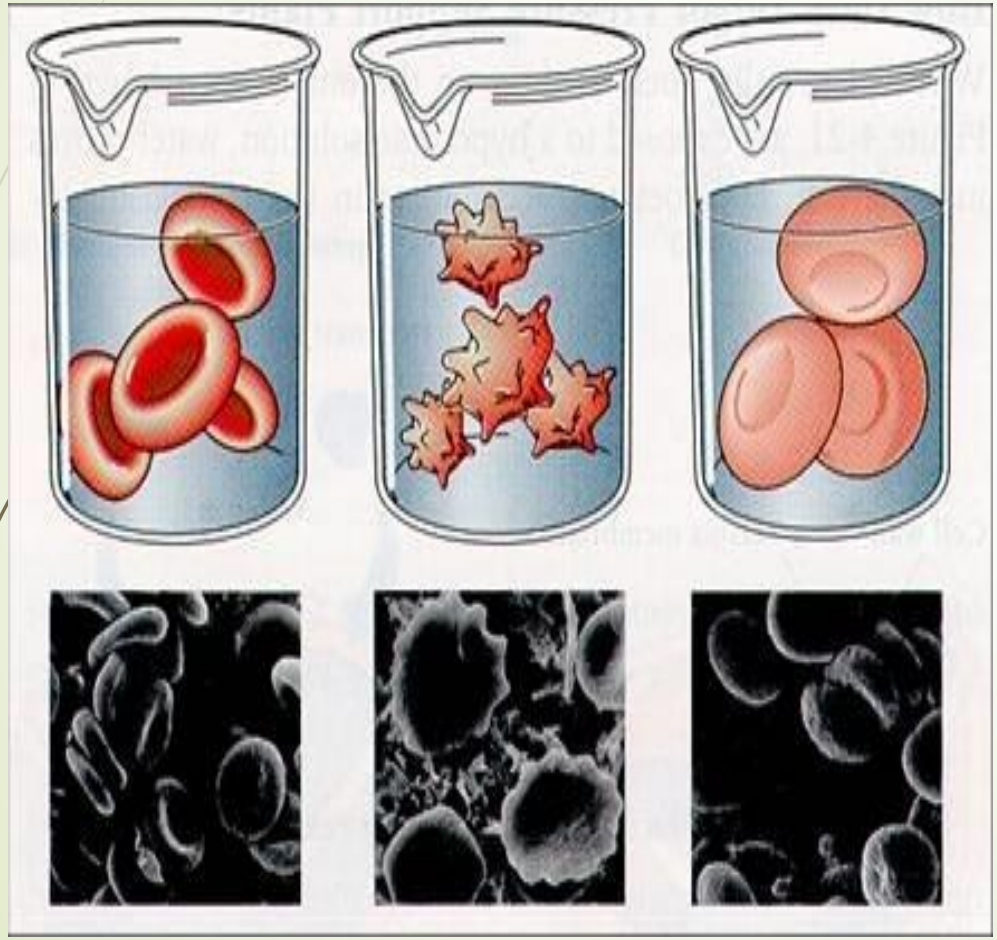
Beaker (compared to cell) → hypertonic or hypotonic

Which way does the water flow? → in or out of cell

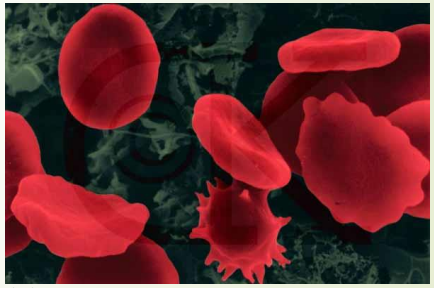
Osmosis in Living Cells



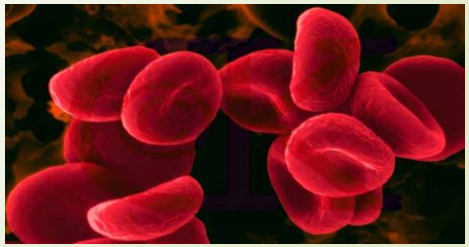
Osmosis in Red Blood Cells



Isotonic

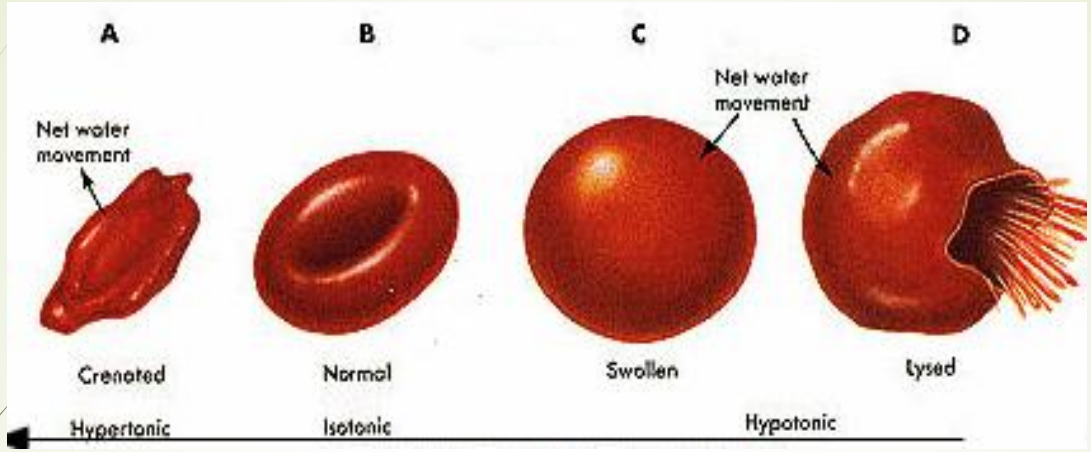


Hypertonic



Hypotonic

Effect of Water on RBC



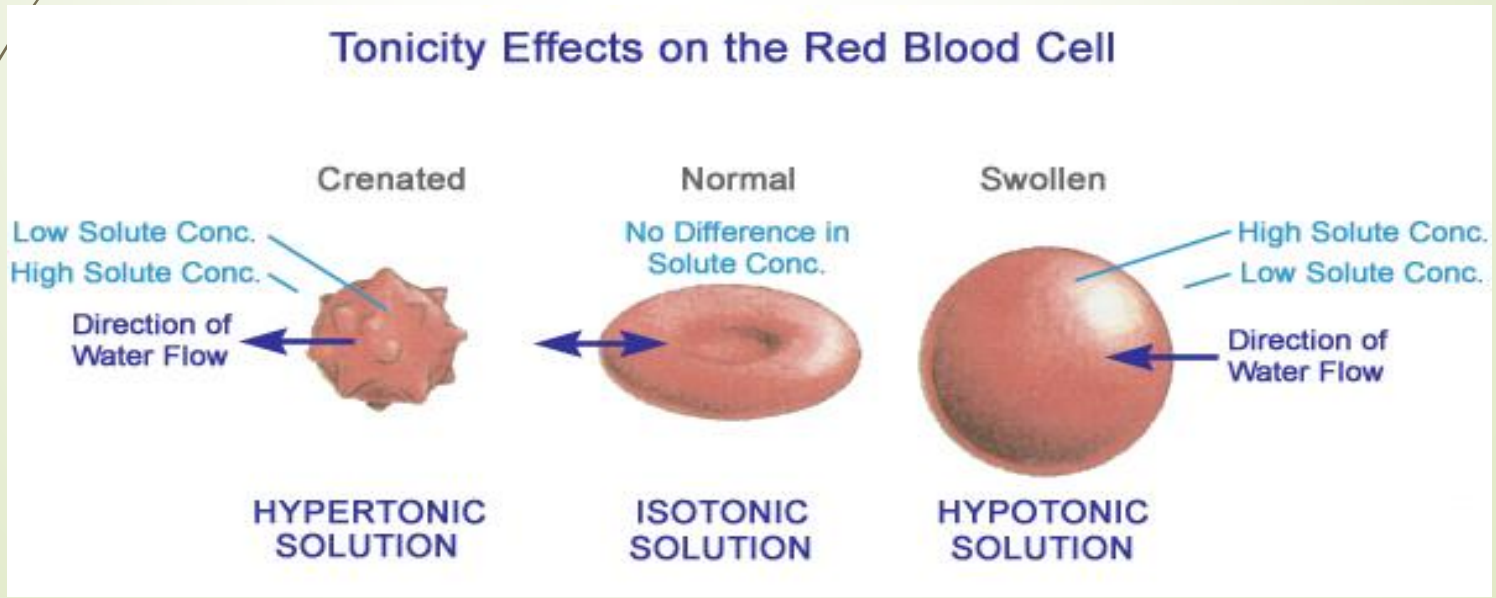
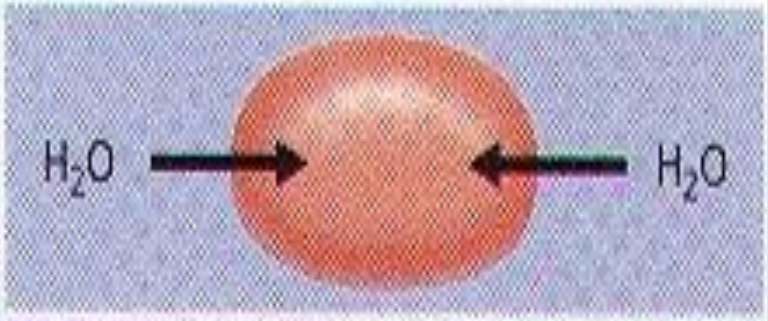
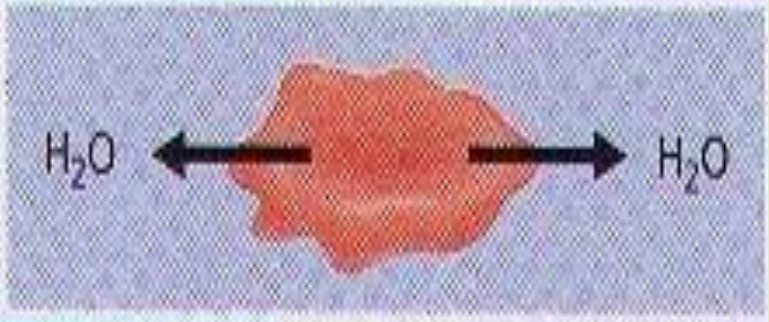
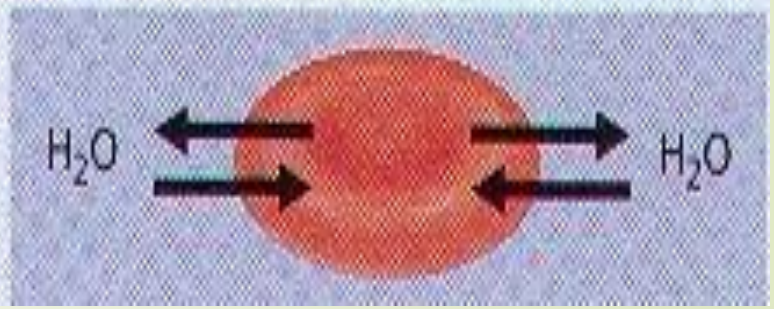


TABLE 5-1 Direction of Osmosis

Condition	Net movement of water	
External solution is hypotonic to cytosol	into the cell	
External solution is hypertonic to cytosol	out of the cell	
External solution is isotonic to cytosol	none	

Is osmosis a reason for cholera

- Osmosis allows for terrible things to happen. Cholera would not be possible without osmosis. The choleric bacteria populate in our intestines and begin to reverse the intestinal cells' ionic orientation.
- when our ions' orientations are changed, the intestinal cells are no longer able to absorb water into the body. Now osmosis happens in the other direction and water moves from our intestinal cells into our intestines. This is what causes cholera's infamously deadly watery diarrhea. Not only can you not absorb water, you are literally being drained dry. This is why cholera can kill you so quickly because it does not rely on how much water you consume.

OSMOTIC PRESSURE

- Osmotic pressure may be defined as the pressure which must be applied to the solution in order to prevent the passage of the solvent through a semi-permeable membrane separating the two i.e. the solution and the pure solvent.
- Pressure which must be applied to solution in order to stop osmosis.
- Osmotic pressure is a colligative property, meaning that the property that depends only on the no. of the molecules present.

Osmotic Pressure formula

- van't Hoff equation
- "The external pressure which must be applied to the solution to keep the solution and the solvent (separated by a semi,, permeable membrane) in equilibrium"

Π(pi) = *MRT*

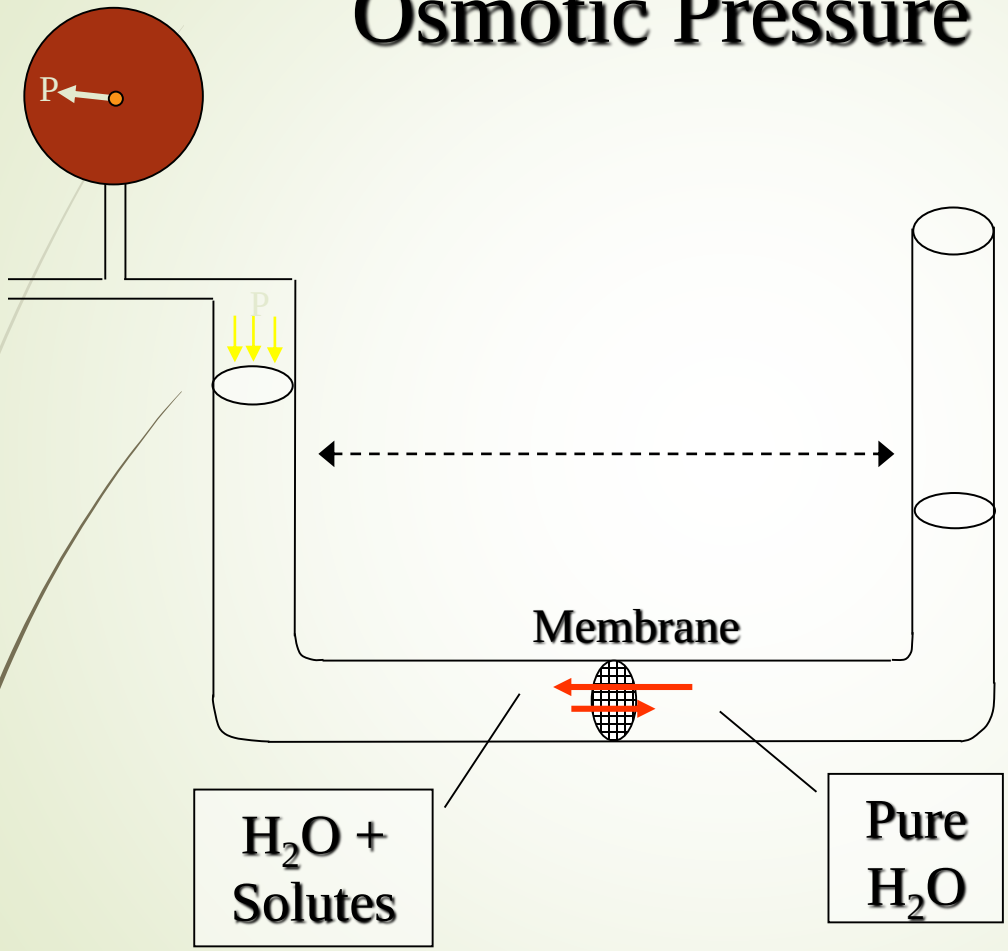
M is the molar concentration

R is the gas constant

T is the absolute temperature

- Unit is Osmoles per liter
- 1 osmole = 22.4 atm = 17024 mmHg
- 1 m osm = 1 / 1000 osmole = 17 mmHg

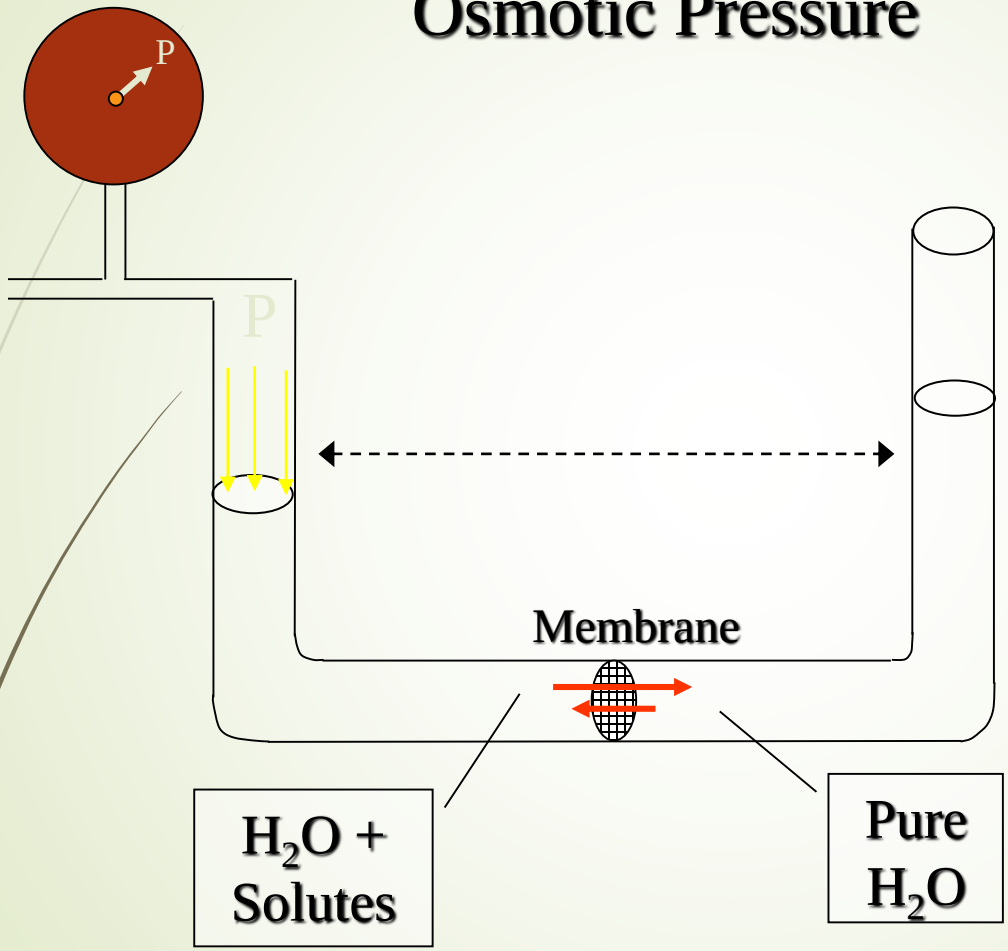
Osmotic Pressure



If applied pressure is too low, H_2O flows into the region of higher ***solute*** concentration…

"Down the concentration gradient" for H_2O.

Osmotic Pressure

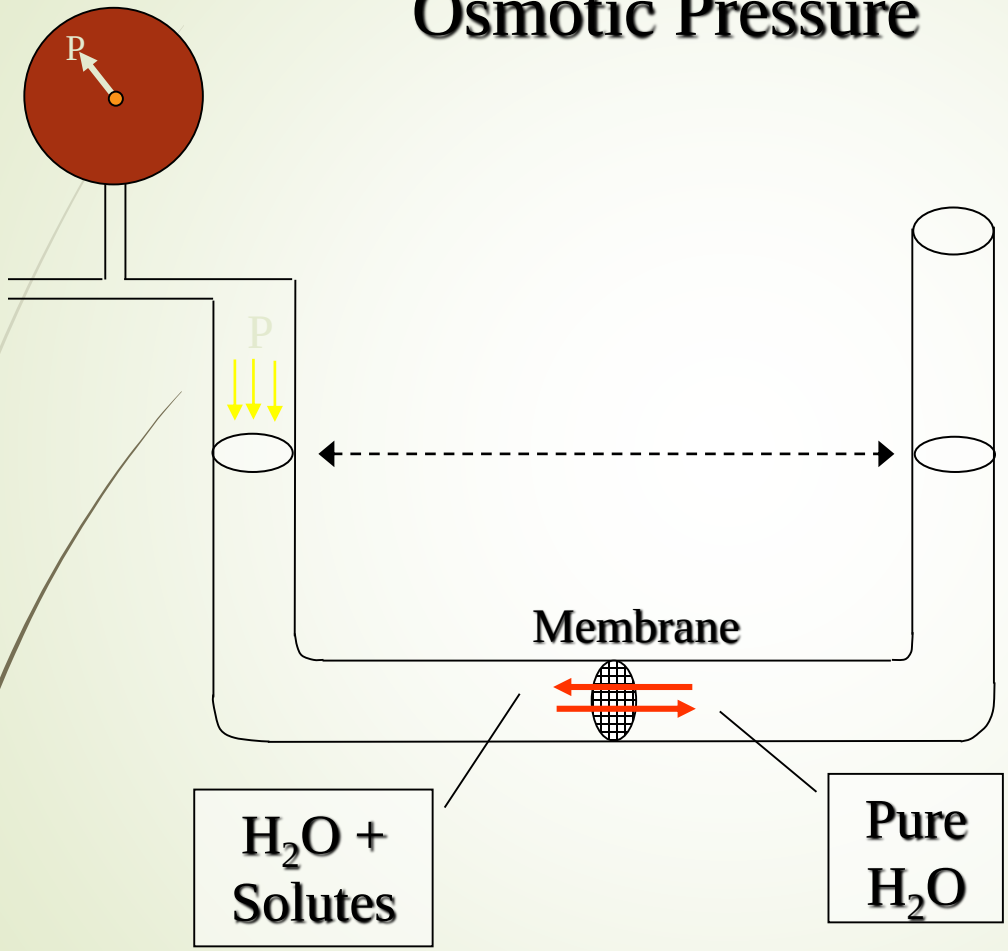


If applied pressure is too high, H_2O flows into the region of lower ***solute*** concentration...

Against the natural concentration gradient for H_2O.

--Reverse Osmosis

Osmotic Pressure



Minimum pressure required to maintain equal flow rates.

Proportional to solute concentration differences across membrane.

BlOOD OSMOTIC PRESSURE

Plasma proteins are chief colloid of plasma and the osmotic pressure due to it is called **oncotic pressure** and is 25-30mmHg. It is the main force which tends to keep the plasma water within the vessels.

Dialysis

- The main function of the kidneys is to filter the blood to remove wastes and extra water, which are then expelled from the body as urine. Some diseases deprive the kidneys of their ability to perform this function, causing a buildup of waste materials in the bloodstream. If a kidney transplant is not available or desirable, a procedure called dialysis can be used to remove waste materials and excess water from the blood.
- In *dialysis*, a patient's blood is passed though a length of tubing that travels through an *artificial kidney machine* (also called a *dialysis machine*). A section of tubing composed of a semipermeable membrane is immersed in a solution of sterile water, glucose, amino acids, and certain electrolytes. The osmotic pressure of the blood forces waste molecules and excess water through the membrane into the sterile solution. Red and white blood cells are too large to pass through the membrane, so they remain in the blood. After being cleansed in this way, the blood is returned to the body. ***Hemodialysis depends on osmosis to cleanse the blood of waste products that the kidneys are incapable of removing due to disease.***

Normal saline solution to prevent osmotic disruption of cells

- The interiors of cells contain salts and other solutes that dilute the intracellular water. If the cell membrane is permeable to water, placing the cell in contact with pure water will draw water into the cell, tending to rupture it. This is easily and dramatically seen if red blood cells are placed in a drop of water and observed through a microscope as they burst. This is the reason that "normal saline solution", rather than pure water, is administered in order to maintain blood volume or to infuse therapeutic agents during medical procedures. It contains 0.91% w/v of sodium chloride, corresponding to 0.154 M, making its osmotic pressure close to that of blood.

- Two ways of expressing the concentration of moles with regard to osmotic pressure.
- Osmolarity: The no. of moles or mmoles per liter of solution.
- Osmolality: The no. of moles or mmoles per kg of solvent.


thanks!