

# Osmosis & Tonicity

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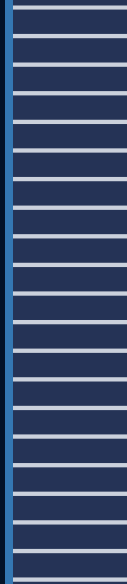
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# Osmosis

# Osmosis

- ❖ Osmosis = net diffusion of water down its own concentration gradient.
- ❖ Water moves: from high water concentration to low water concentration (i.e., toward higher solute concentration).
- ❖ Occurs across a selectively permeable membrane.



# Osmosis

## ❖ Water Permeability:

### • Water crosses membranes by:

1. Direct diffusion (slow)

2. **Aquaporins** (rapid, specialized water channels)

❖ Different cells vary in aquaporin density → variable water permeability.



# Osmosis

- ❖ Relationship Between Solute & Water Concentration:
- ❖ Adding solute:
  - ❖ ↓ Water concentration
  - ❖ ↑ Solute concentration
- ❖ Water always diffuses toward:
  - Area of higher nonpenetrating solute concentration.

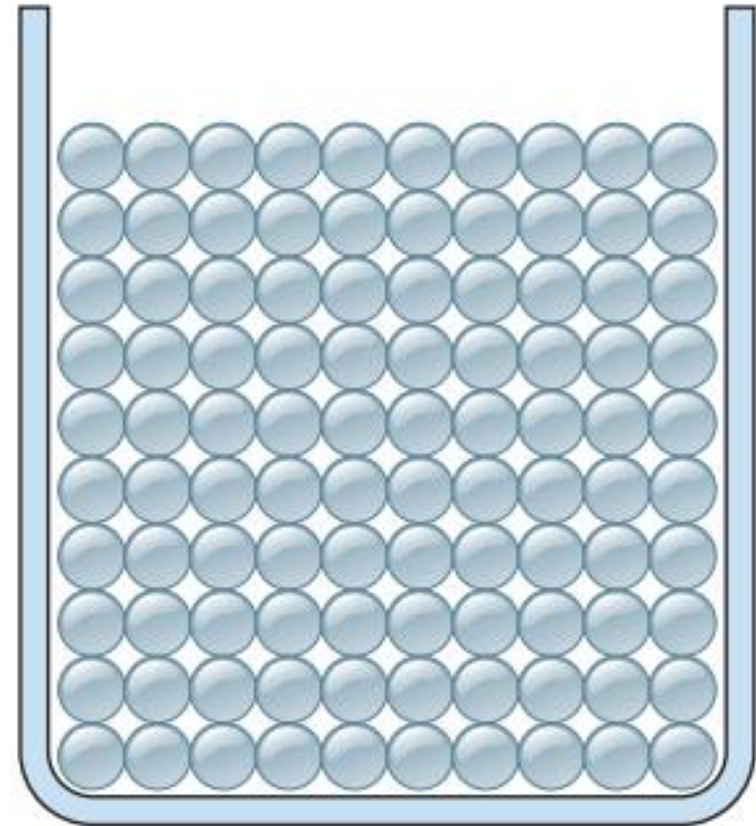
## KEY



= Water molecule



= Solute molecule



**100% water concentration**  
**0% solute concentration**

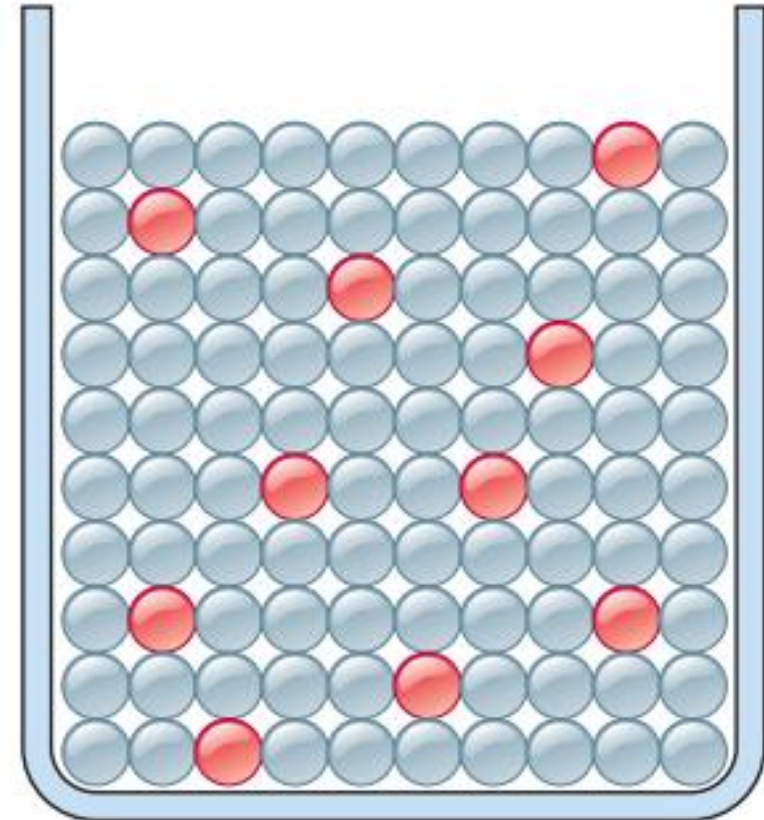
**(a)** Pure water

# Osmosis

- ❖ Relationship Between Solute & Water Concentration:
- ❖ Adding solute:
- ❖ ↓ Water concentration
- ❖ ↑ Solute concentration

## KEY

● = Water molecule    ● = Solute molecule

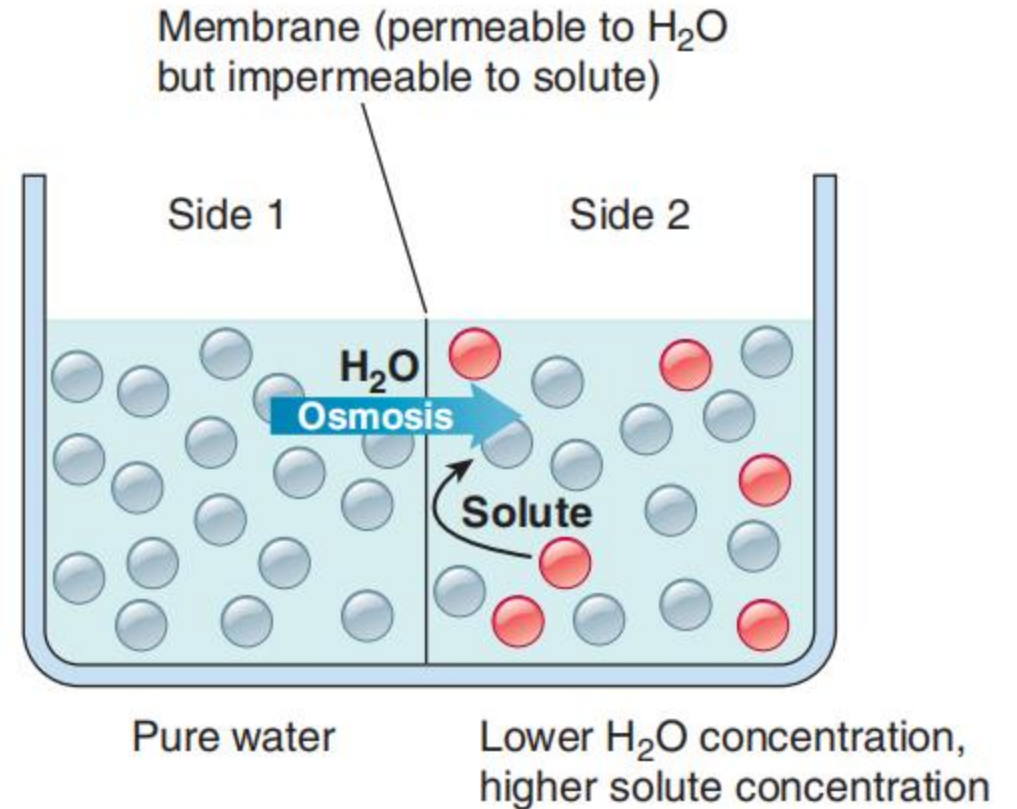


**90% water concentration**  
**10% solute concentration**

**(b) Solution**

# Osmosis

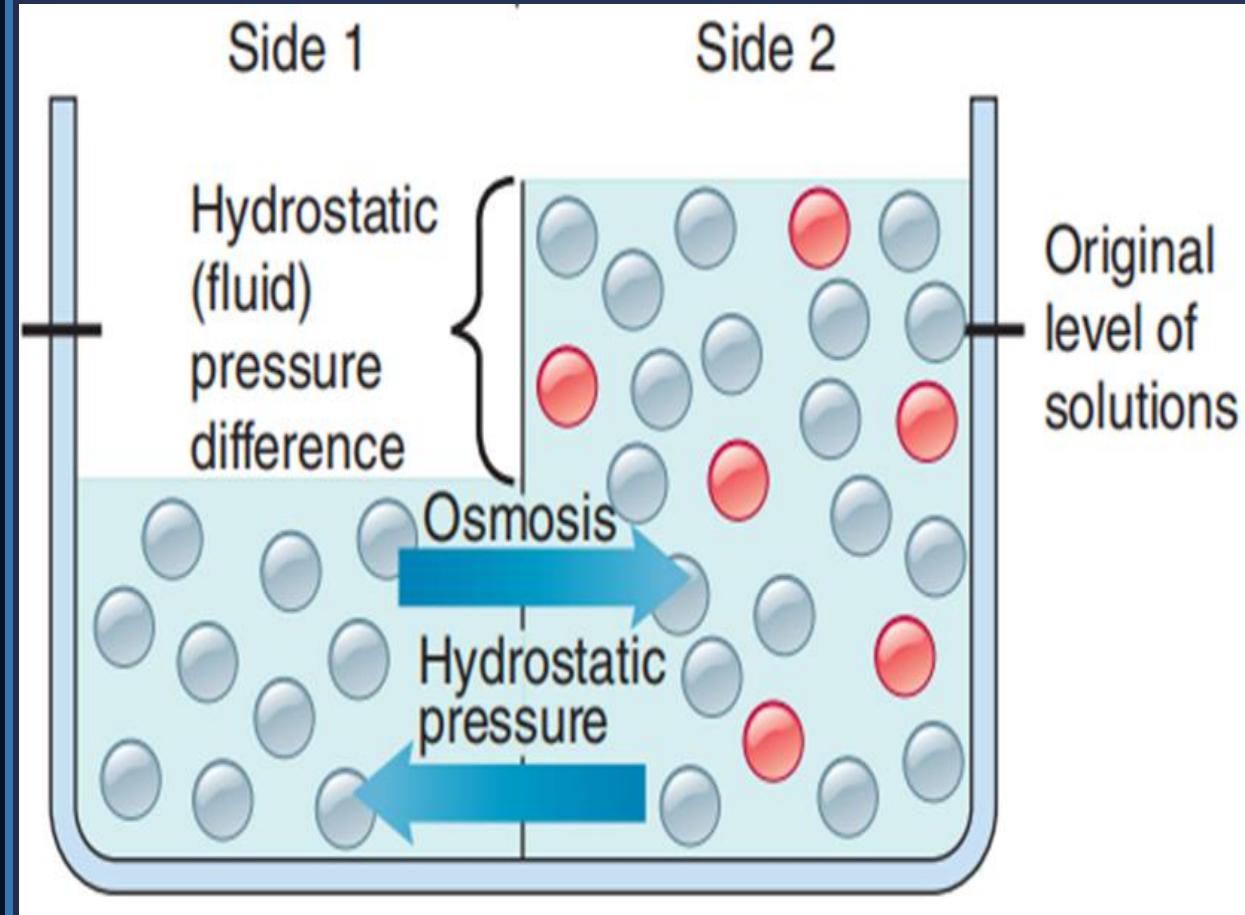
- ❖ The net diffusion of water down its concentration gradient through a selectively permeable membrane is known as **osmosis**.
- Because solutions are always referred to in terms of concentration of solute, water moves by osmosis to the area of higher solute concentration.



H<sub>2</sub>O moves from side 1 to side 2  
down its concentration gradient = osmosis

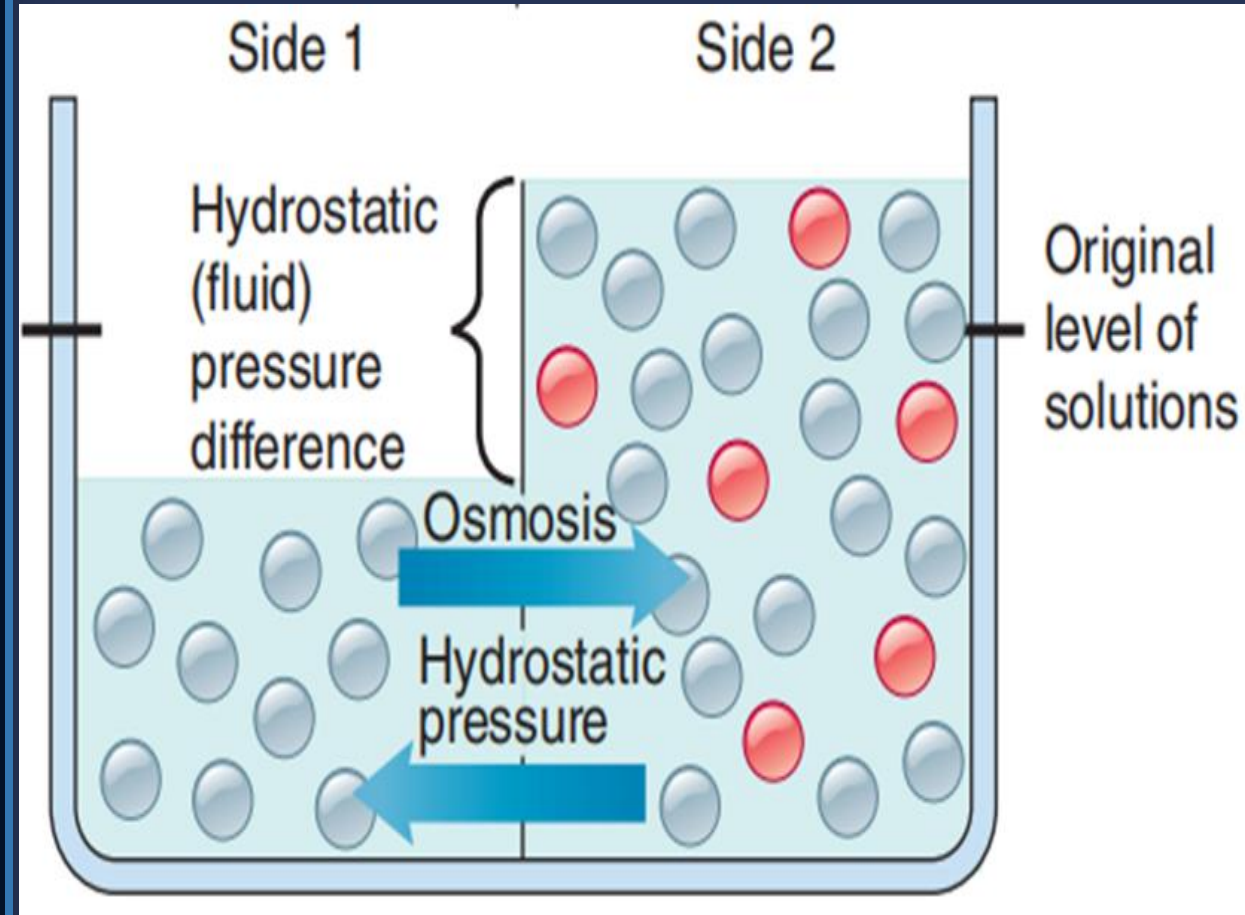
# Osmosis

- ❖ **Osmotic Pressure:**
- ❖ Osmotic pressure = “pulling force” drawing water into a solution.
- ❖ **(The osmotic pressure of a solution:** is a measure of the tendency for osmotic flow of water into that solution because of its relative concentration of nonpenetrating solutes and water.
- ❖ Opposed by hydrostatic pressure = “pushing force”.



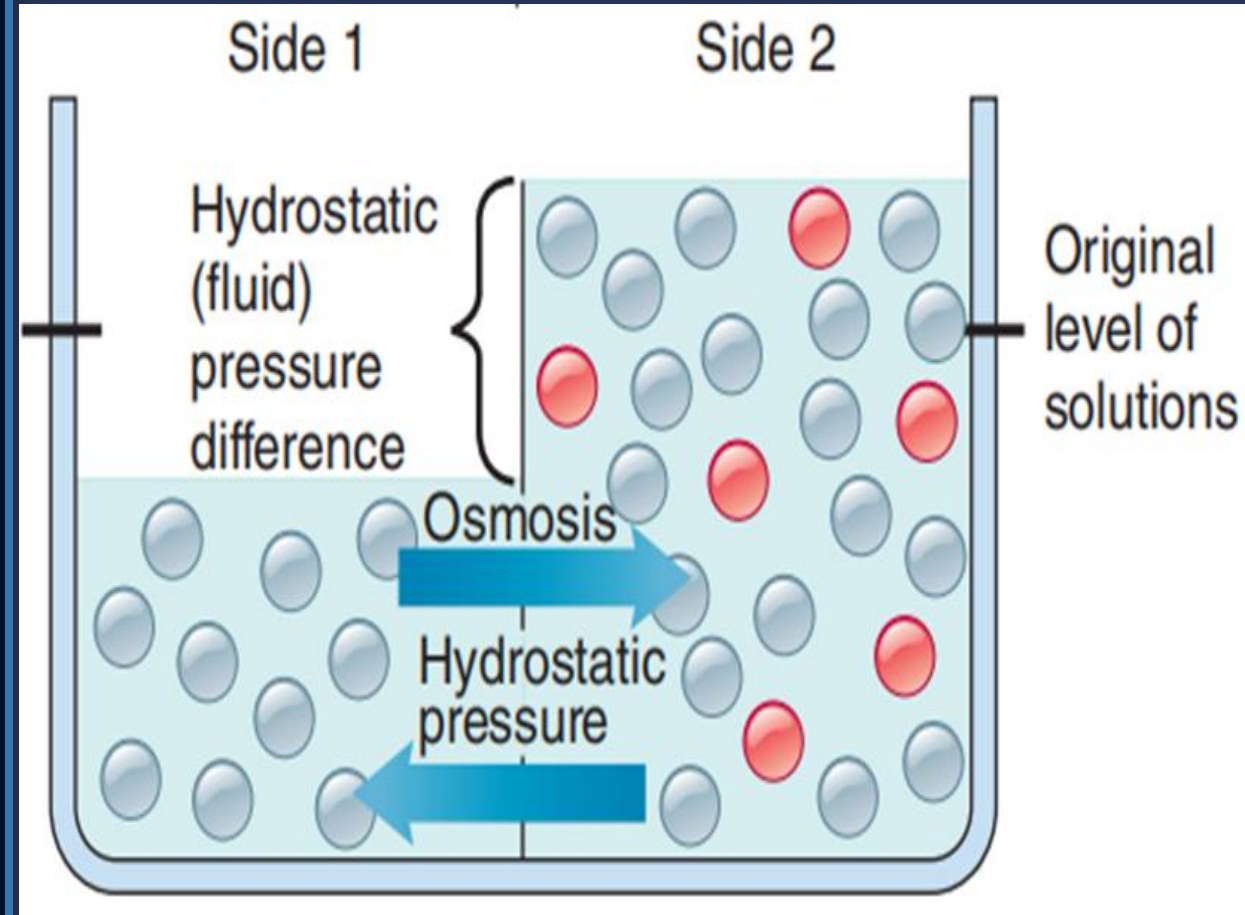
# Osmosis

- ❖ Osmosis **stops** when:
- ❖ Hydrostatic pressure = Osmotic pressure
- ❖ Dynamic equilibrium is reached
  
- ❖ Greater nonpenetrating solute concentration → Greater osmotic pressure



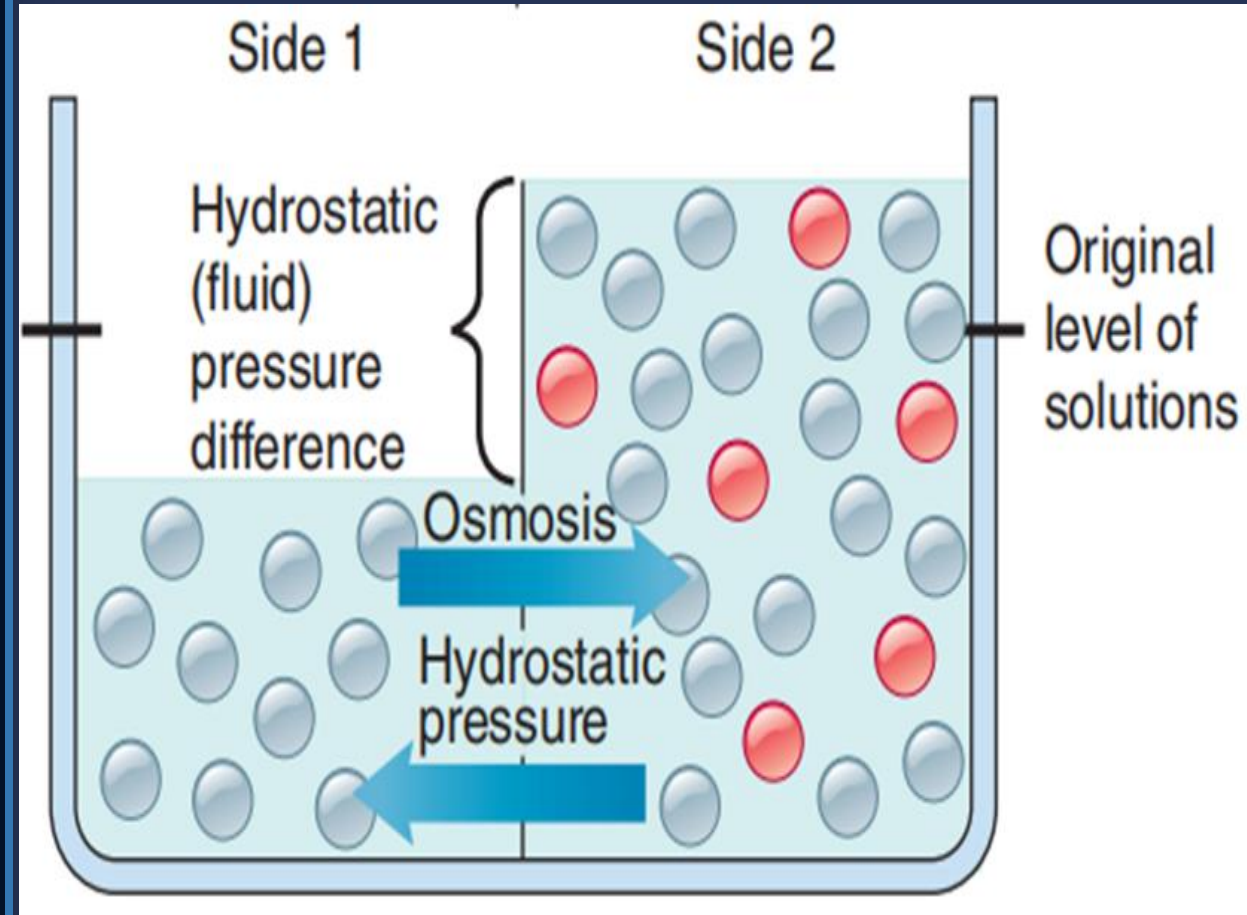
# Osmosis

- ❖ Osmotic pressure is an **indirect measure of solute concentration**, expressed in units of pressure.
- ❖ A more direct means of expressing solute concentration is the **osmolarity** of a solution, which is a measure of its **total solute concentration given in terms of the number of particles (molecules or ions)**.
- ❖ Osmolarity is expressed in osmoles per liter (or **Osm/L**), the number of moles of solute particles in 1 liter of solution.

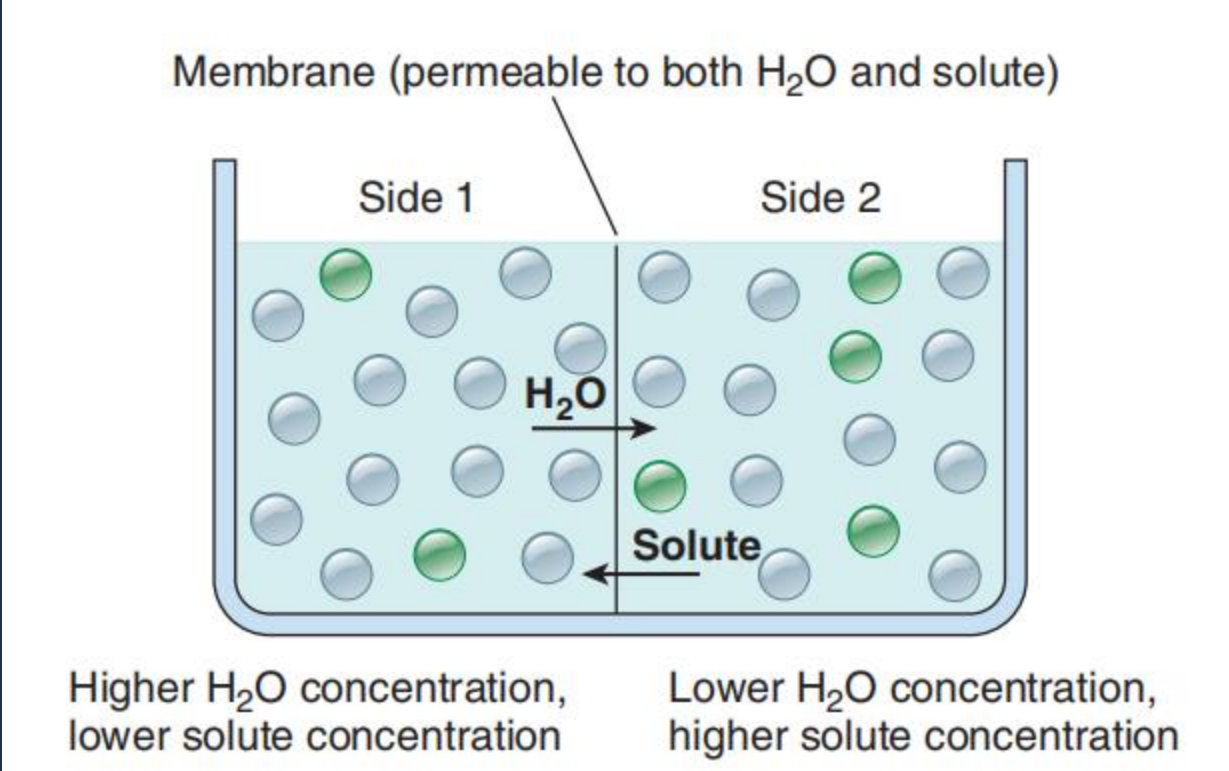


# Osmosis

- ❖ Osmolarity : Depends on number of particles, not type.
- ❖ Normal body fluid osmolarity  $\approx$  **300 mOsm/L**.
- ❖ Osmolarity includes all solutes.



# Movement of Water and Solute When a Membrane Separates Unequal Solutions of a Penetrating Solute

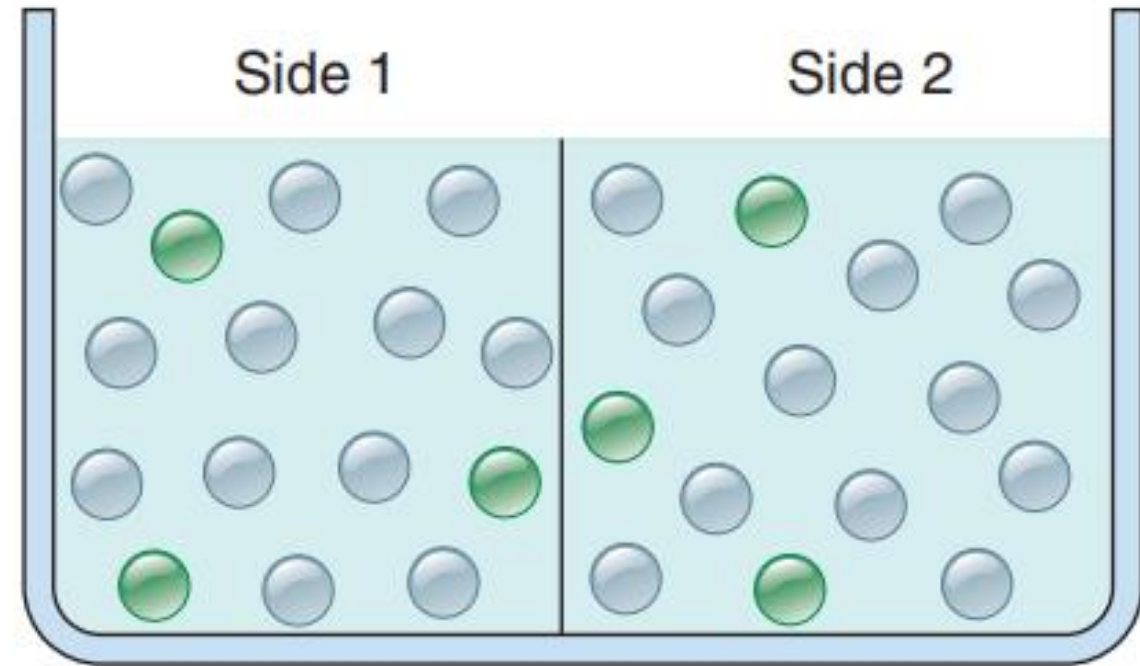


**H<sub>2</sub>O moves from side 1 to side 2  
down its concentration gradient**

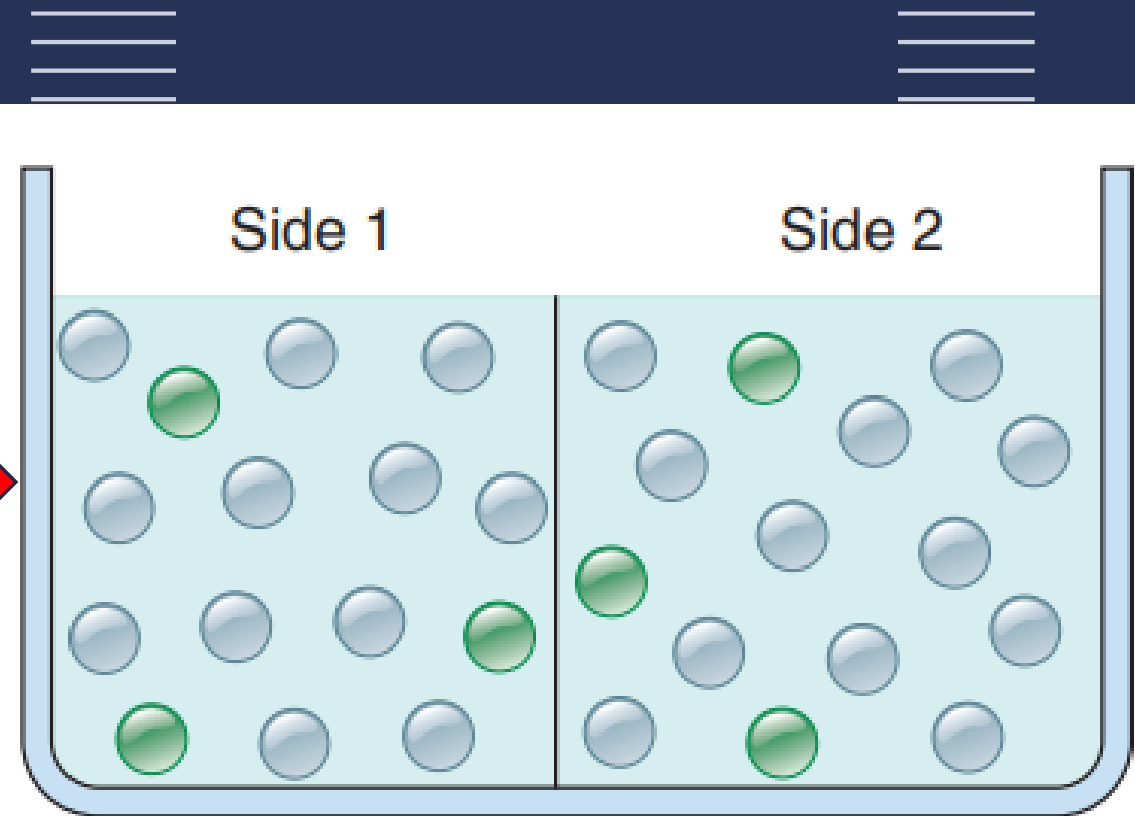
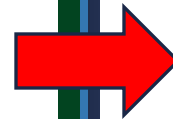
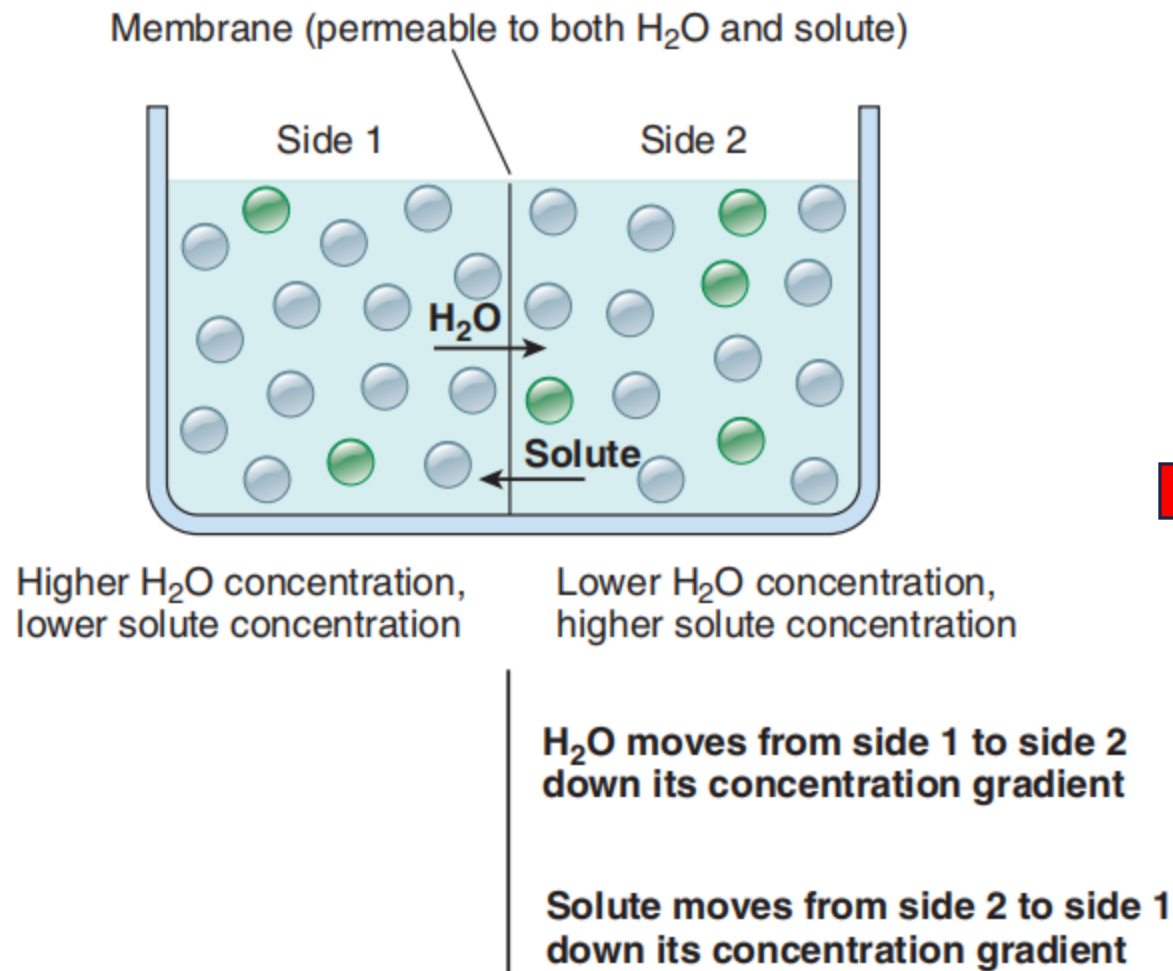
**Solute moves from side 2 to side 1  
down its concentration gradient**

# Movement of Water and Solute When a Membrane Separates Unequal Solutions of a Penetrating Solute

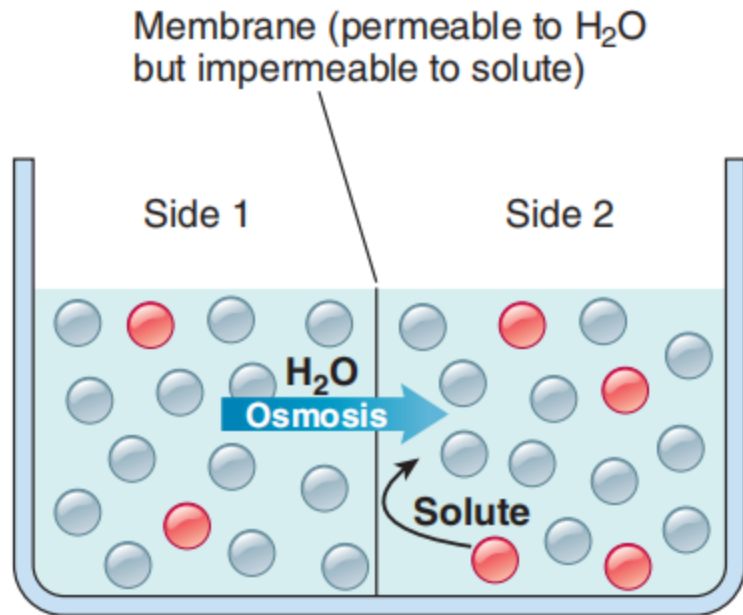
- ❖ Solutes that can penetrate the plasma membrane do **not contribute** to osmotic differences between the ICF and the ECF and **do not affect** cell volume.
- ❖ Only nonpenetrating solutes affect tonicity and cell volume.



# Movement of Water When a Membrane Separates Equal or Unequal Solutions of a **penetrating** Solute



# Movement of Water When a Membrane Separates Equal or Unequal Solutions of a Nonpenetrating Solute

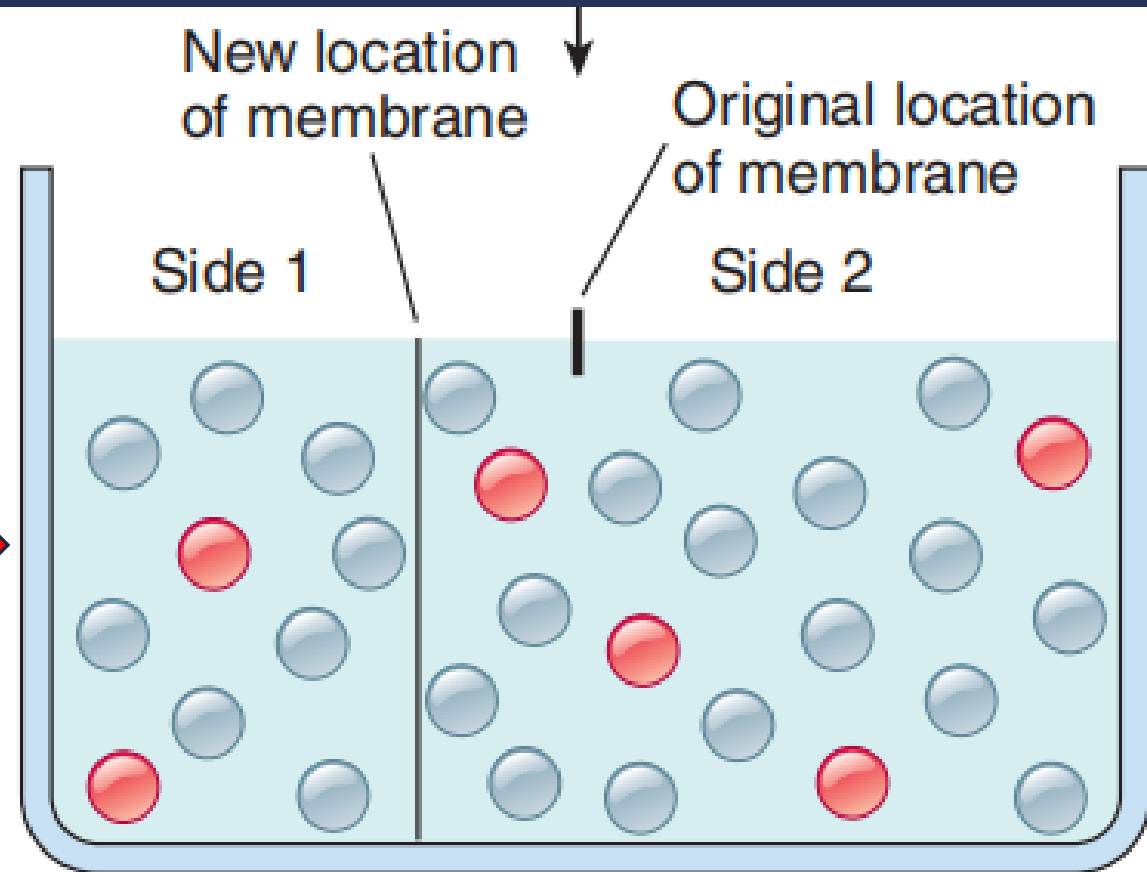
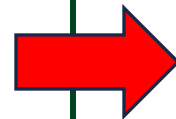


Higher H<sub>2</sub>O concentration,  
lower solute concentration

Lower H<sub>2</sub>O concentration,  
higher solute concentration

H<sub>2</sub>O moves from side 1 to side 2  
down its concentration gradient

Solute unable to move from side 2 to  
side 1 down its concentration gradient



# Movement of Water When a Membrane Separates Equal or Unequal Solutions of a Nonpenetrating Solute

- ❖ Within the slight range of changes in ECF osmolarity that occur physiologically, if water moves by osmosis into the cells, their plasma membranes normally accommodate the increase in cell volume with no significant change in hydrostatic pressure inside the cells.



# Movement of Water When a Membrane Separates Equal or Unequal Solutions of a Nonpenetrating Solute

- ❖ Osmotic movement of water across the plasma membrane always results in a **change in cell volume**, and cells, especially brain cells, do not function properly when they swell or shrink.



# Tonicity

# Tonicity

- ❖ Tonicity: refers to the effect the **concentration** of **nonpenetrating** solutes in a solution has on **cell volume**.
- ❖ whether the cell:
  1. Remains the same size
  2. Swells
  3. Shrinks





Normal cell volume  
Intracellular fluid: 300 mOsm/L  
nonpenetrating solutes

# Tonicity

- ❖ An **isotonic solution** (iso means “equal”) has the **same** concentration of nonpenetrating solutes as normal body cells do.
- ❖ When a cell is bathed in an isotonic solution, no water enters or leaves the cell by osmosis, so cell volume **remains constant**.
- ❖ **ECF is normally maintained isotonic.**



No net movement of water; no change in cell volume.

**(a) Isotonic conditions**

## Tonicity

- ❖ If red blood cells are placed in a dilute or **hypotonic solution** (hypo means “below”), a solution with a **below-normal** concentration of nonpenetrating solutes (and therefore a higher concentration of water), water enters the cells by osmosis.

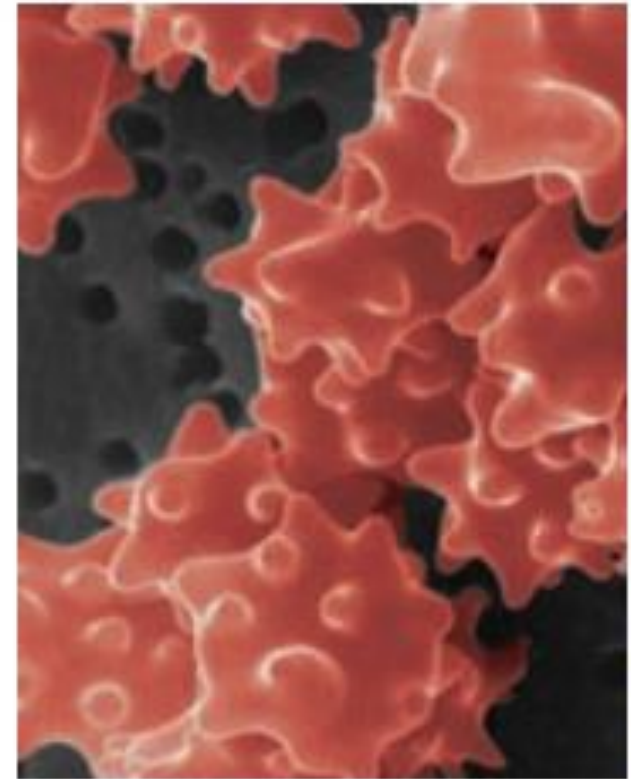


Water diffuses into cells; cells swell.

**(b) Hypotonic conditions**

## Tonicity

- ❖ If red blood cells are placed in a concentrated or **hypertonic solution** (hyper means “above”), a solution with an **above-normal concentration** of nonpenetrating solutes (and therefore a lower concentration of water), the cells **shrink** as they lose water by osmosis



Water diffuses out of cells; cells shrink.

**(c) Hypertonic conditions**

**Thank You**