MEDICAL CHEMISTRY
GENERAL CHEMISTRY

University Of Fallujah

College Of Medicine

Lecture : Medical Chemistry (4) (Solutions)

Stage : 1st Stage

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Department: Chemistry and Biochemistry department

Date: 4 / 12 / 2025

Learning Objective :

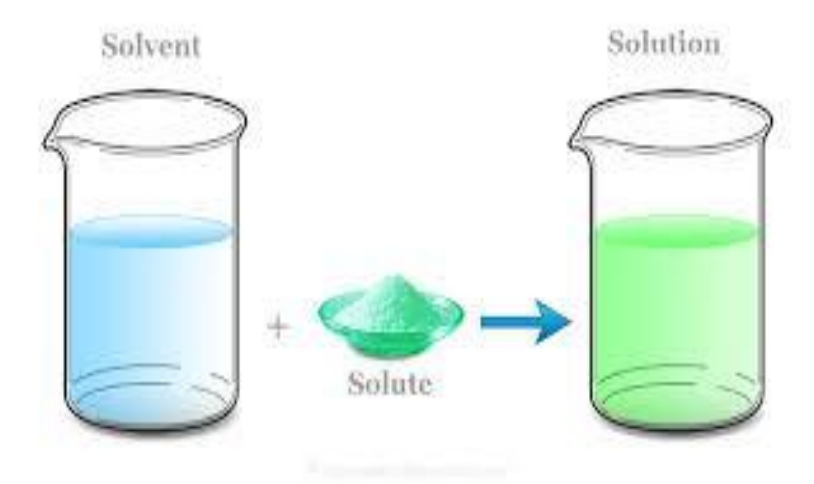
- Define and understand aqueous solutions and their significance in biological and chemical contexts.
- Explain the concept of solubility and identify the factors affecting solubility, such as temperature, pressure, and solvent-solute interactions.
- Distinguish between different solution concentrations (e.g., molarity, molality) and calculate them accurately.
- Differentiate between electrolytes and non-electrolytes and describe their roles in conducting electricity and biological processes.
- Describe osmosis and osmotic pressure, including their mechanisms and real-life applications.
- Identify the types of osmotic solutions (isotonic, hypertonic, hypotonic) and their effects on cells and tissues.

SOLUTIONS

- What Are Aqueous Solutions ?

- Solutions where water is the solvent.

- Common in biological and chemical processes.

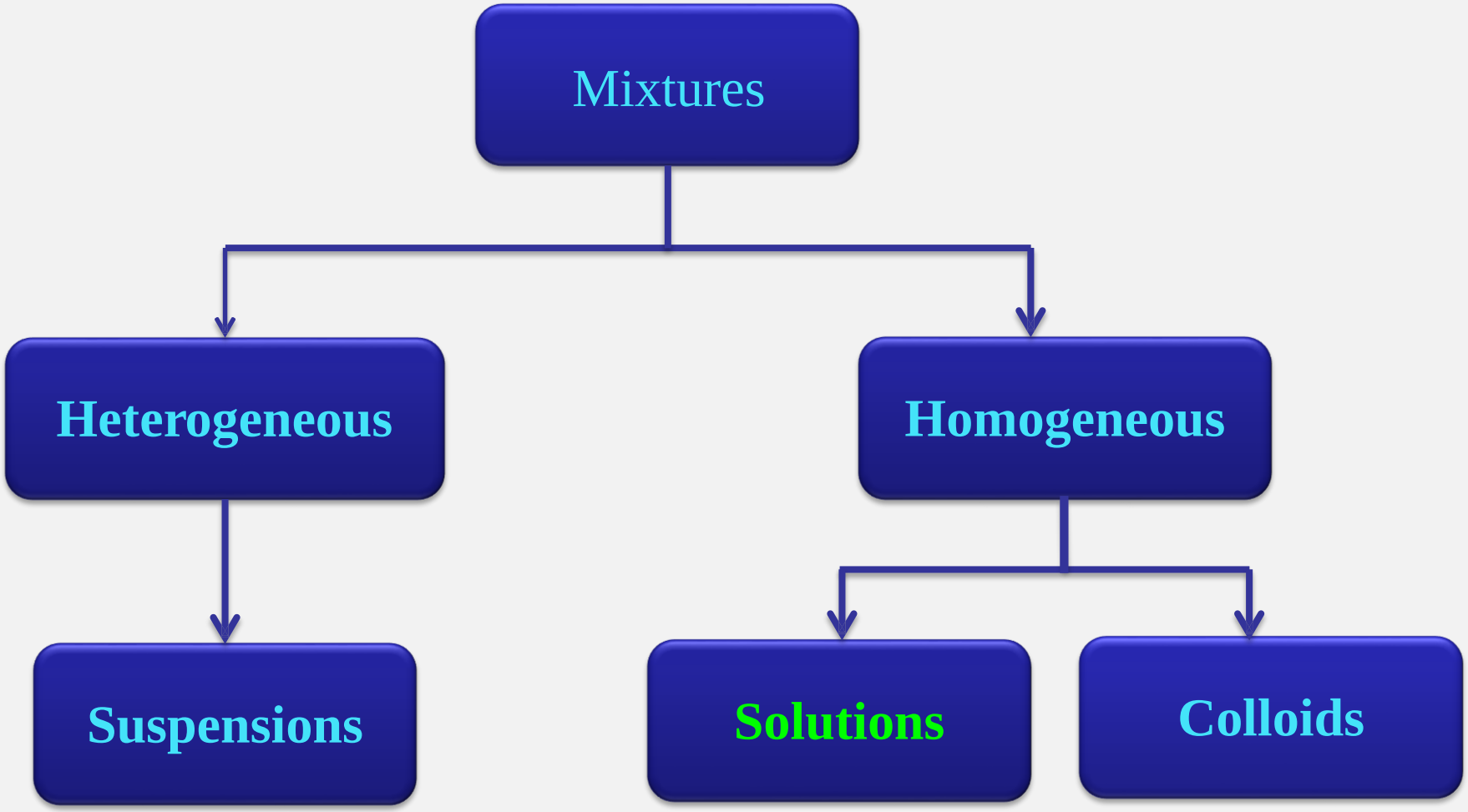


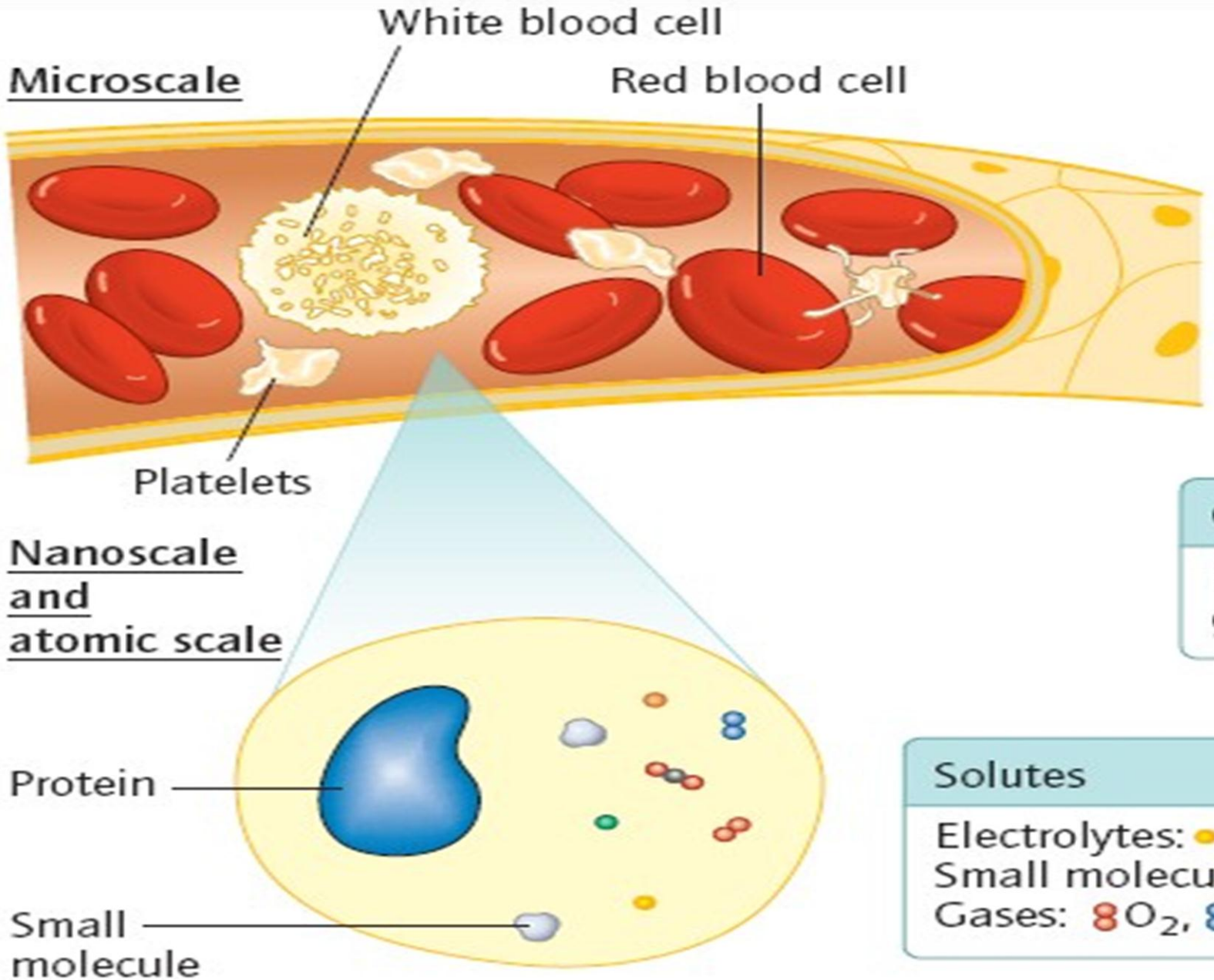
SOLUTE + SOLVENT = SOLUTION

- SOLUTE – the part of a solution that is being dissolved (usually the lesser amount)
- SOLVENT – the part of a solution that dissolves the solute (usually the greater amount)

Solute	*Solvent*	*Example*
solid	solid	Alloys (brass, steel)
solid	liquid	Salt water
gas	solid	Air bubbles in ice cubes
liquid	liquid	mixed drinks
gas	liquid	Soft drinks
gas	gas	Air

TYPES OF MIXTURES





Suspended particles

Blood cells: red, white, and platelets

Colloidal particles

Plasma proteins: albumin, globulin, and fibrinogen

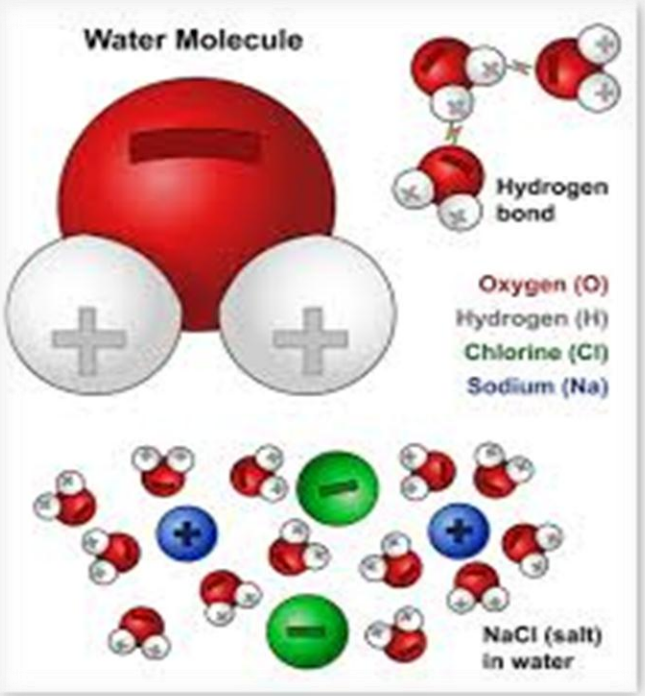
Solutes

Electrolytes: Na^+, K^+, Cl^-, HPO_4^{2-}
Small molecules: glucose, creatinine
Gases: O_2, N_2, and CO_2

SOLUTIONS

- Properties of Aqueous Solutions: Depend on the number of particles in solution, not their identity.

1. Boiling Point Elevation
2. Freezing Point Depression
3. Vapor Pressure Lowering
4. Osmotic Pressure



SOLUTIONS

- **Types of Aqueous Solutions:**

1. **Saturated Solution:** Contains the maximum solute that can dissolve at a given temperature.
2. **Unsaturated Solution:** Less solute than can dissolve.

3. **Supersaturated Solution:** More solute than can typically dissolve under normal conditions.

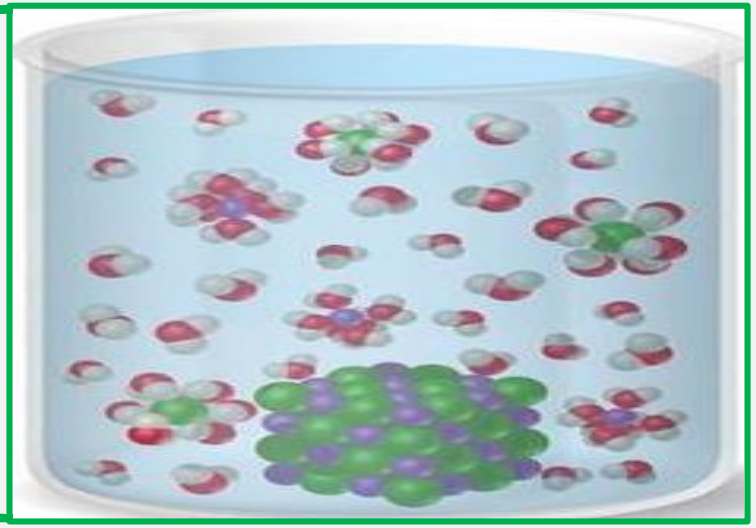
TYPES OF SOLUTIONS

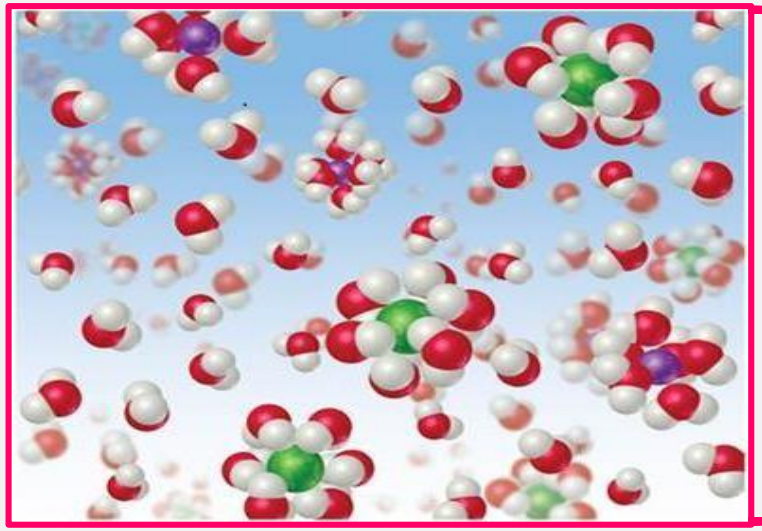
- Solutions can be classified as saturated or unsaturated.
- A saturated solution contains the maximum quantity of solute that dissolves at that temperature.
- An unsaturated solution contains less than the maximum amount of solute that can dissolve at a particular temperature

DEGREE OF SATURATION

- Saturated Solution

1. Solvent holds as much solute as it possible at that temperature.
2. Undissolved solid remains in flask.
3. Dissolved solute is in dynamic equilibrium with solid solute particles



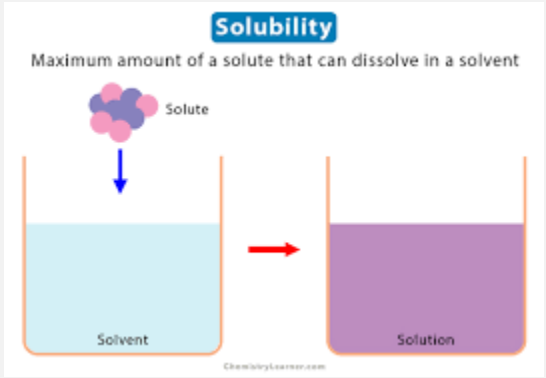


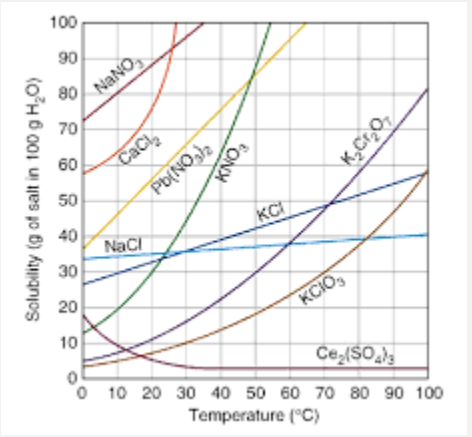
- Unsaturated Solution

1. Less than the maximum amount of solute for that temperature is dissolved in the solvent.
2. No solid remains in flask.

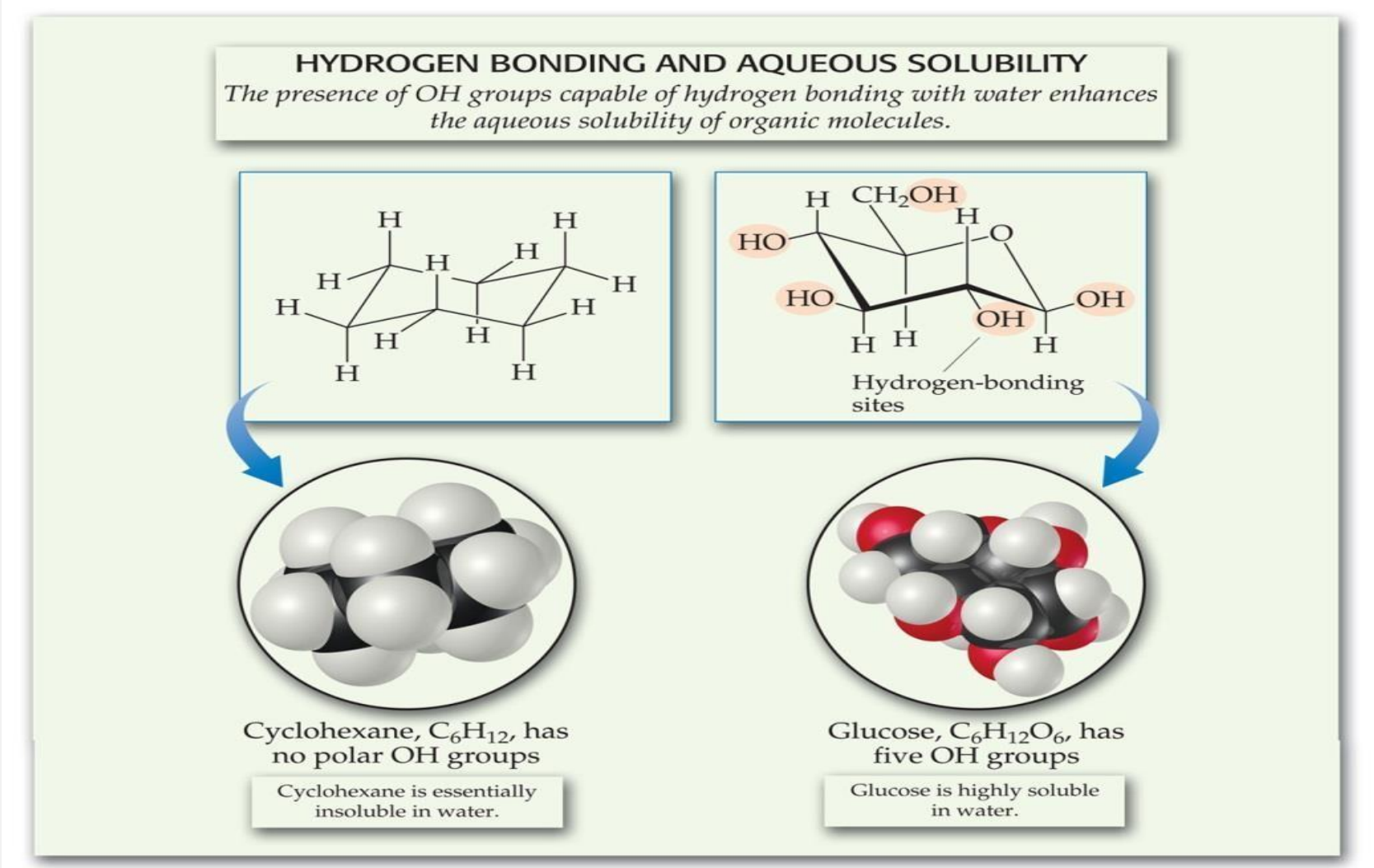
What Are Solubility ?

- The ability of a solute to dissolve in a solvent.
- **Factors Influencing Solubility**:
- Temperature :Solubility increases with temperature for solids and liquids but decreases for gases.
- Pressure (for gases) :Solubility of gases increases with pressure (Henry's Law).
- Nature of solute and solvent:Polar solvents dissolve polar solutes; non-polar dissolves non-polar. ("like dissolves like").

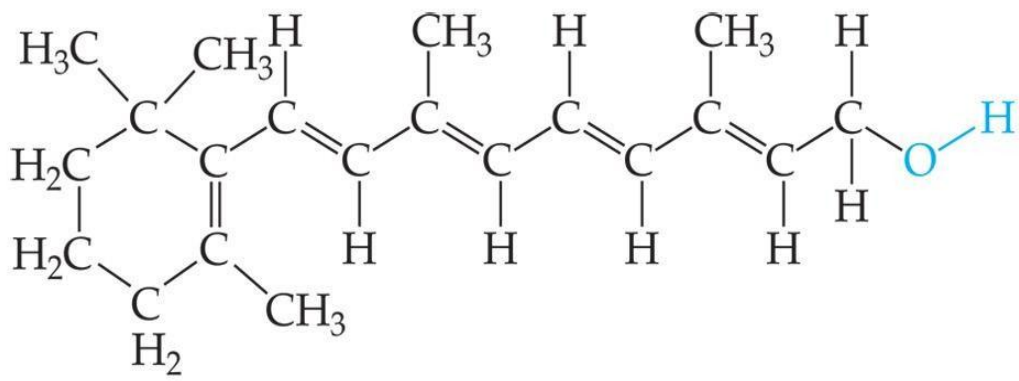


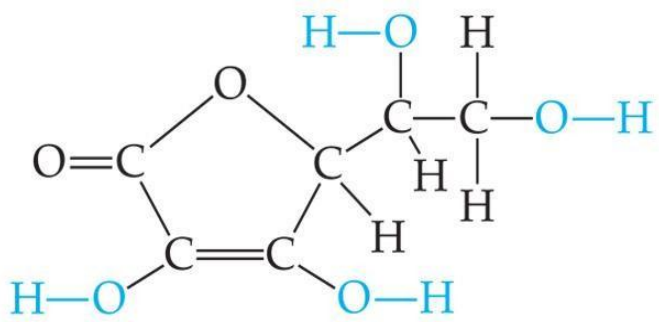


- The stronger the intermolecular attractions (H-bonds; ion-dipole forces) between solute and solvent, the more likely the solute will dissolve

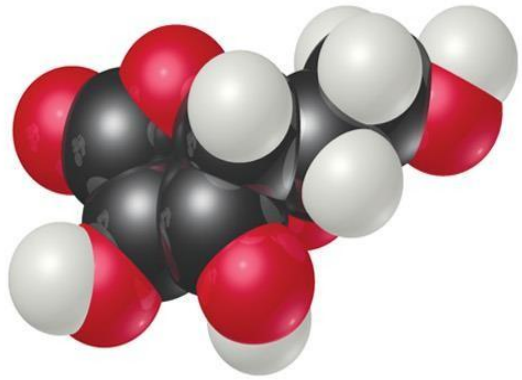


Vitamin A is soluble in nonpolar compounds (like fats). While Vitamin C is soluble in water. **Why?**





Vitamin A



Vitamin C

- Applications of Solubility :

- Pharmaceuticals: Drug formulations rely on solubility for effectiveness.
- Environmental Science: Water treatment and pollutant removal.
- Food Industry: Solubility of flavors and preservatives.

SOLUTIONS

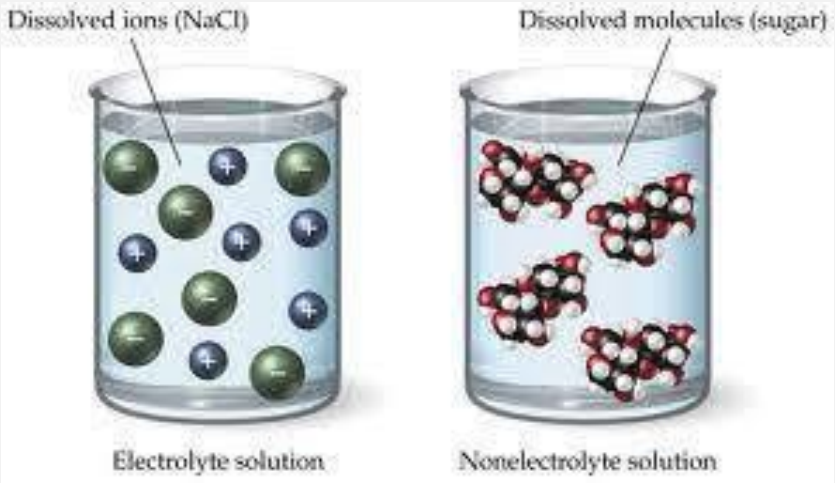
- What Are Concentrations of Solutions ?

- Types of Concentrations:
- Molarity (M): Moles of solute per liter of solution.
- Molality (m): Moles of solute per kilogram of solvent.
- Percent solutions (weight/volume or volume/volume).

SOLUTIONS

- What Are Electrolytes and Non-Electrolytes ?

- Electrolytes: Substances that dissociate into ions in water (e.g., NaCl, KCl). Conduct electricity
- Non-Electrolytes: Substances that dissolve in water but do not produce ions (e.g., sugar, urea,Ethanol). Do not conduct electricity.



SOLUTIONS

- What Are Electrolytes and Non-Electrolytes ?

- Electrolytes: Substances that dissociate into ions in water (e.g., NaCl, KCl). Conduct electricity
- Major Electrolytes: Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), Calcium (Ca^{2+}).
- Functions:

1. Nerve transmission.
2. Muscle contraction.
3. Regulation of pH and fluid balance.

- Imbalance Effects: Dehydration, cramping, arrhythmias.

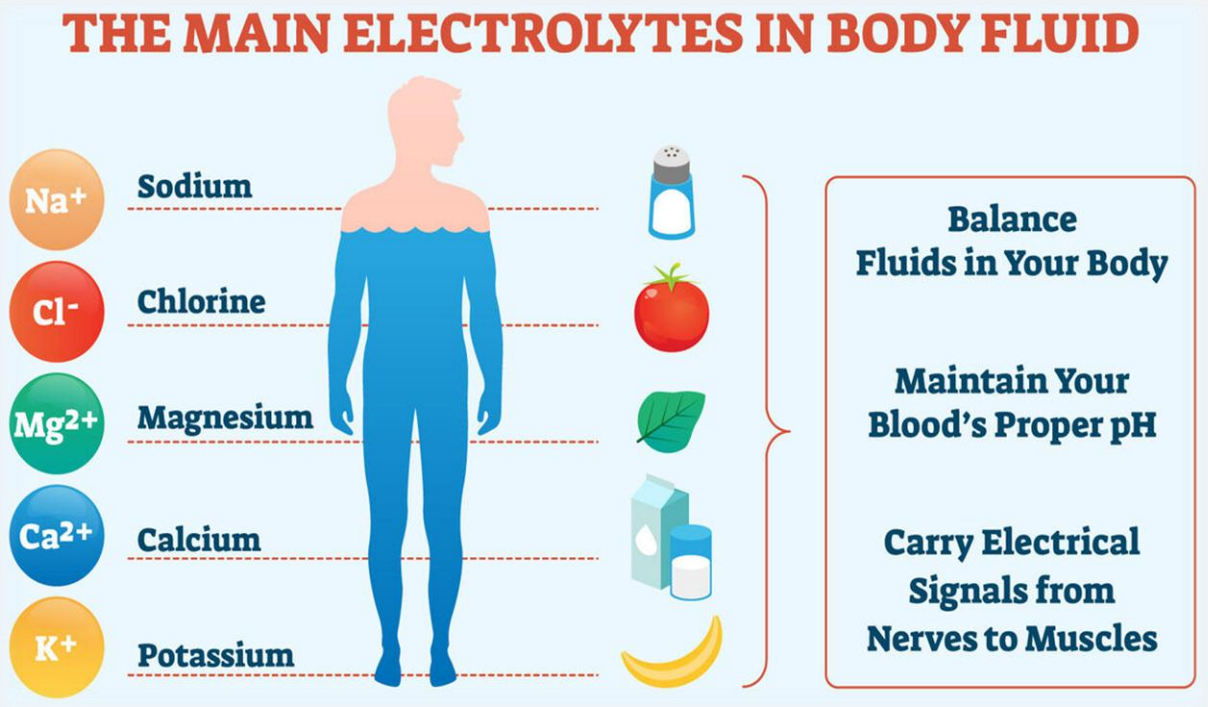
SOLUTIONS

- What Are Electrolytes in the Body ?

- Examples: Sodium, potassium, calcium, chloride ions.

- Importance:

1. Maintain fluid balance.
2. Conduct nerve impulses.
3. Muscle contraction.



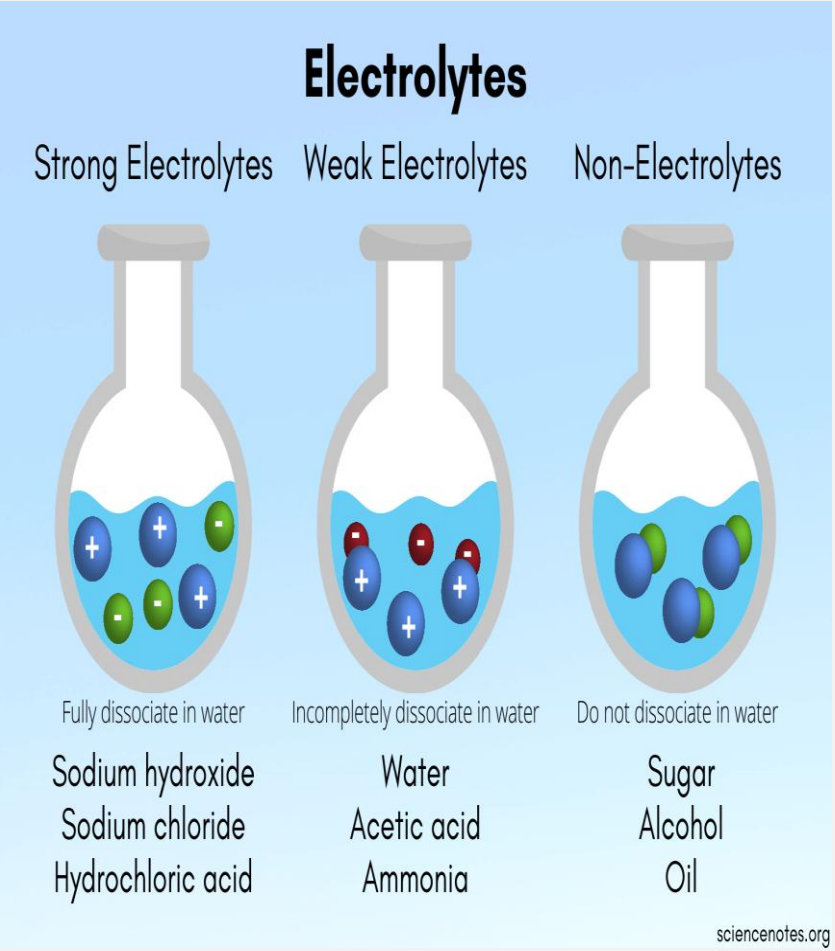
SOLUTIONS

- What Are Properties of Electrolytes ?

- Strong Electrolytes: Completely dissociate in water (e.g., HCl, NaOH).

- Weak Electrolytes: Partially dissociate (e.g., CH3COOH).

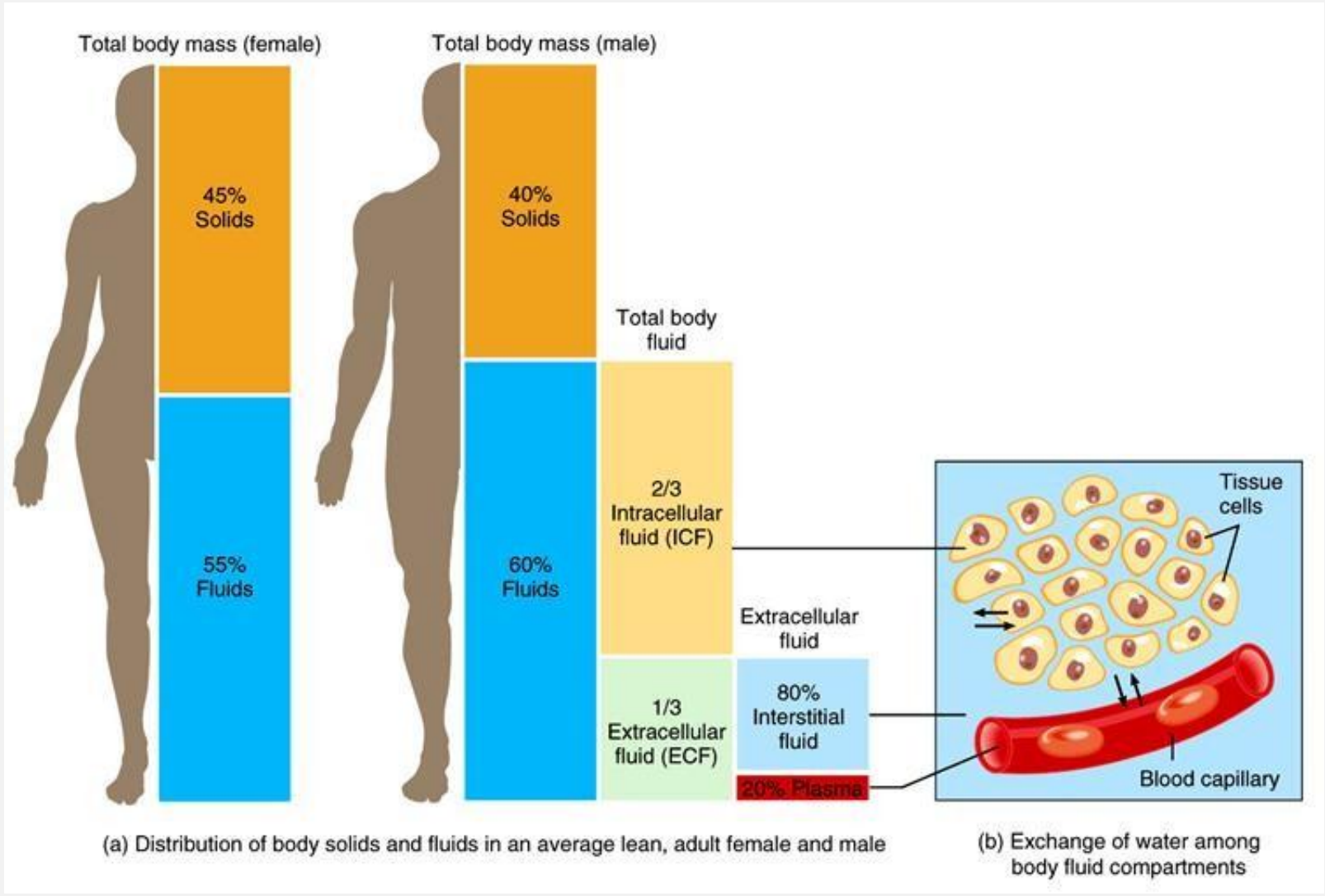
- Non-Electrolytes: Do not ionize (e.g., glucose).



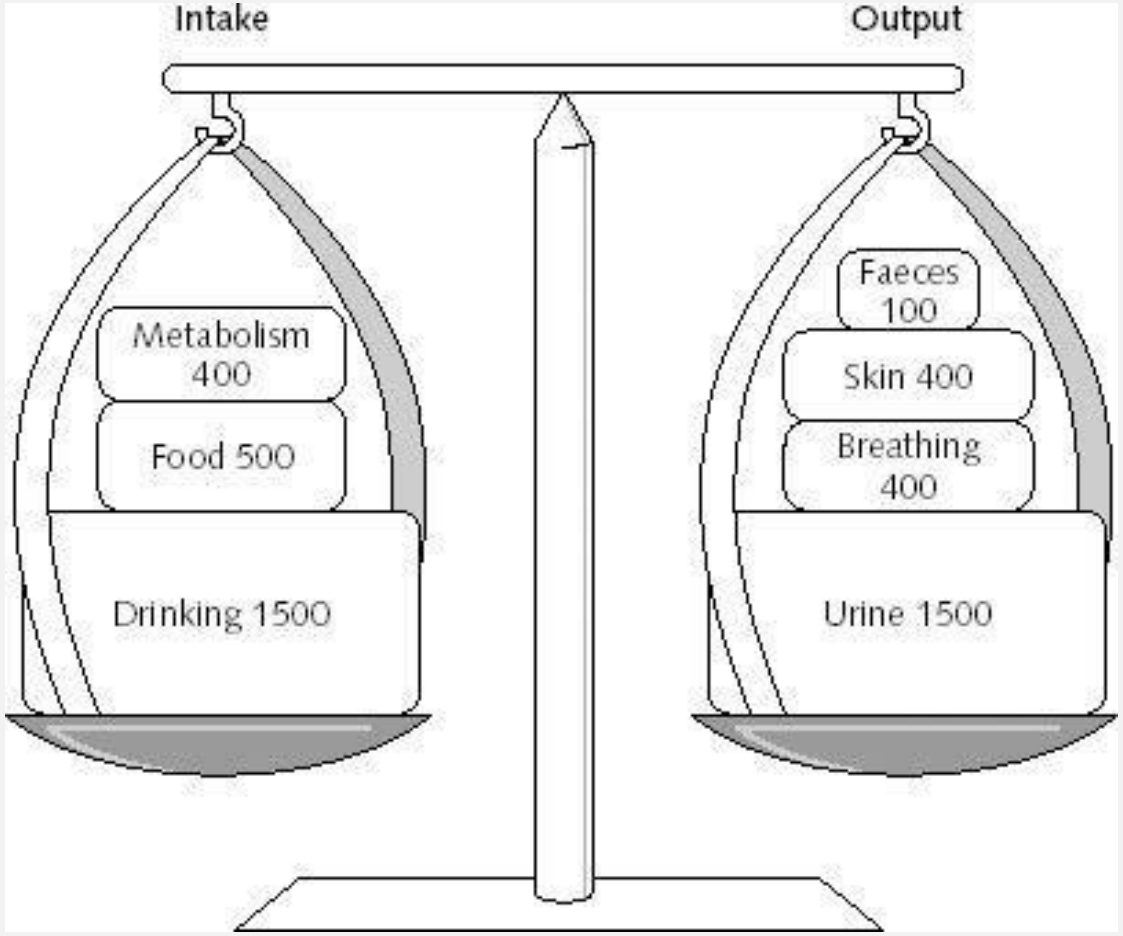
The ECF and the ICF are two distinct fluid compartment

1. Intracellular Fluids(ICF): All fluids inside cells.
   The cytosol of cells Makes up about two-thirds of the total body water. (2/3 ≈ 66%)
2. Extracellular Fluids (ECF) : All fluids outside cells.
   √ Major components include the interstitial fluid. (between, ≈ 25%).
   √ Plasma (Intravascular fluids= inside). (≈ 5-8%)
   √ Minor components include all other extracellular fluids, respiratory, urinary tracts. 1-2%

Body Fluid Compartments



In adults, body, fluids constitute 55% of female and 60% of male total body mass



Balance between typical fluid intake and output in a 70 kg adult.
(Values are ml per 24 hours.)

SOLUTIONS

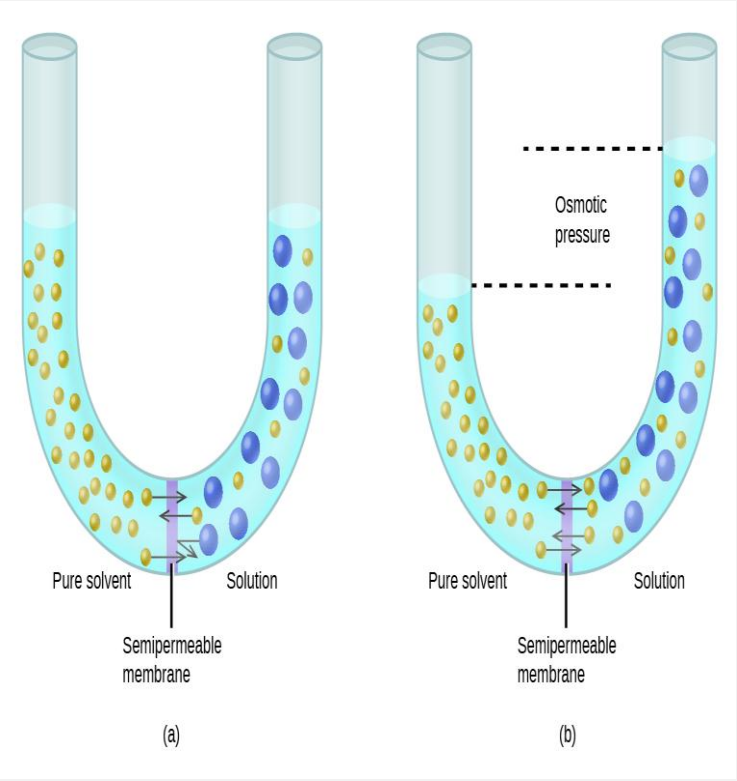
- What Are **Osmosis** ?

- **Osmosis :** Movement of water through a semi-permeable membrane from low solute concentration to high solute concentration.

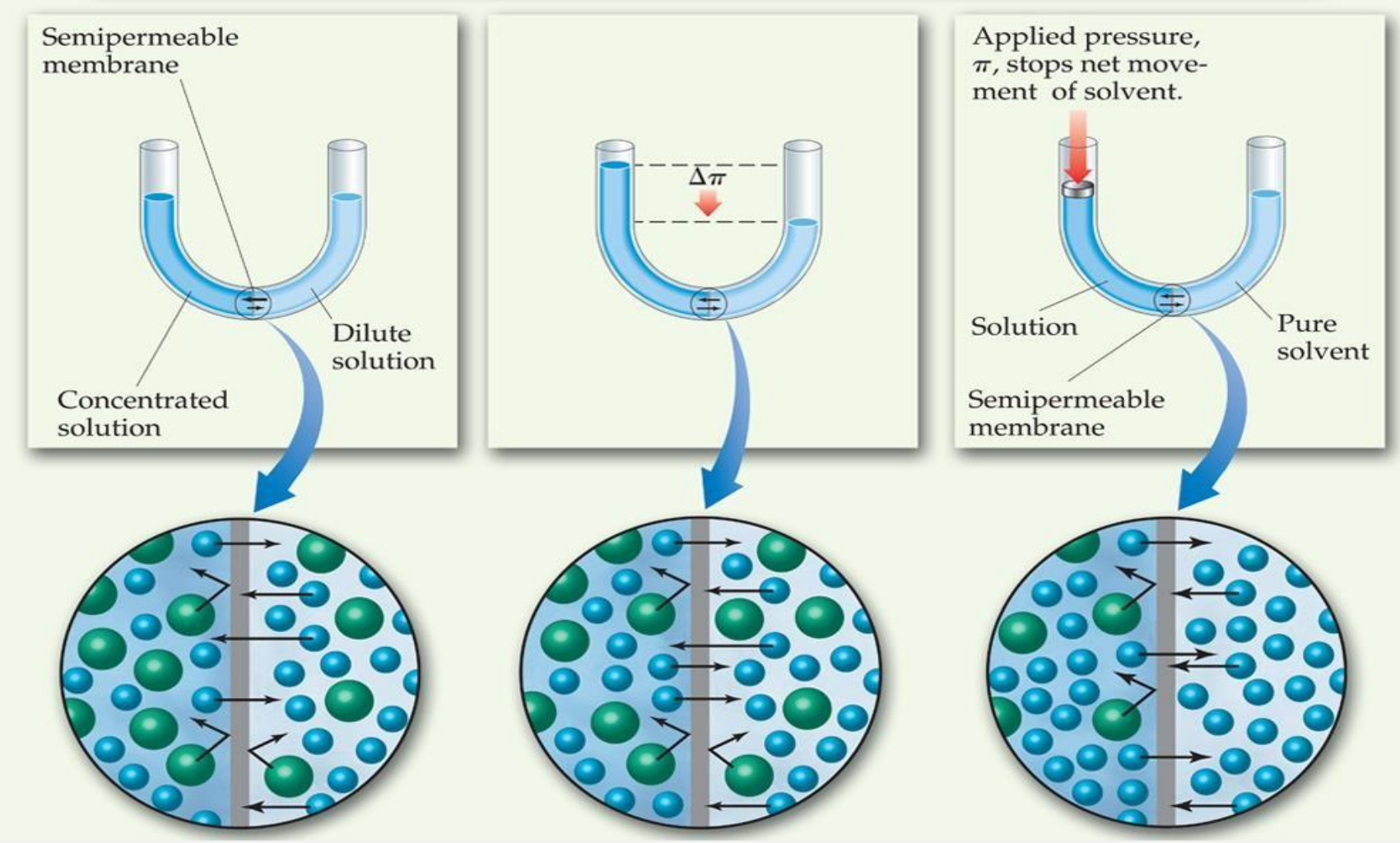
- **Importance:**

-Biological processes (e.g., nutrient absorption)
-Role in maintaining cell turgor.
-Osmoregulation in organisms.
-Effects of dehydration and overhydration.

- **Examples:**
- -Swelling of raisins in water.
- -Water absorption by plant roots.



Osmosis



Water tries to equalize the concentration on both sides until pressure is too high.

SOLUTIONS

• What Are Osmotic Pressure ?

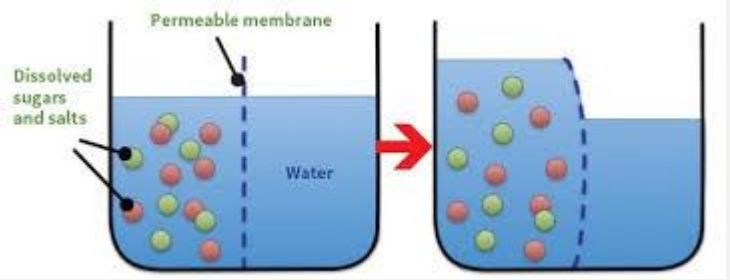
- **Osmotic Pressure :** The pressure required to stop osmosis.

- **Equation: $\Pi = MRT$**

-Where Π = osmotic pressure, M = molarity, R = gas constant, T = temperature.

-**Applications:**

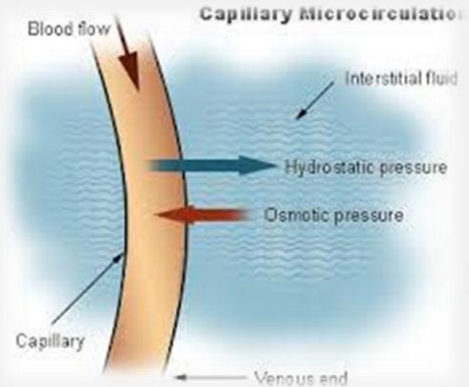
- In Medicine: IV fluids, dialysis.
- In Food Industry: Preservation using osmotic principles.
- In Nature: Plant water uptake.



SOLUTIONS

• Osmotic Pressure in Medicine

- IV Fluids : Must be isotonic to prevent damage to red blood cells.
- Dialysis : Removes waste by osmotic principles.
- Edema Treatment : Hypertonic solutions to reduce swelling.

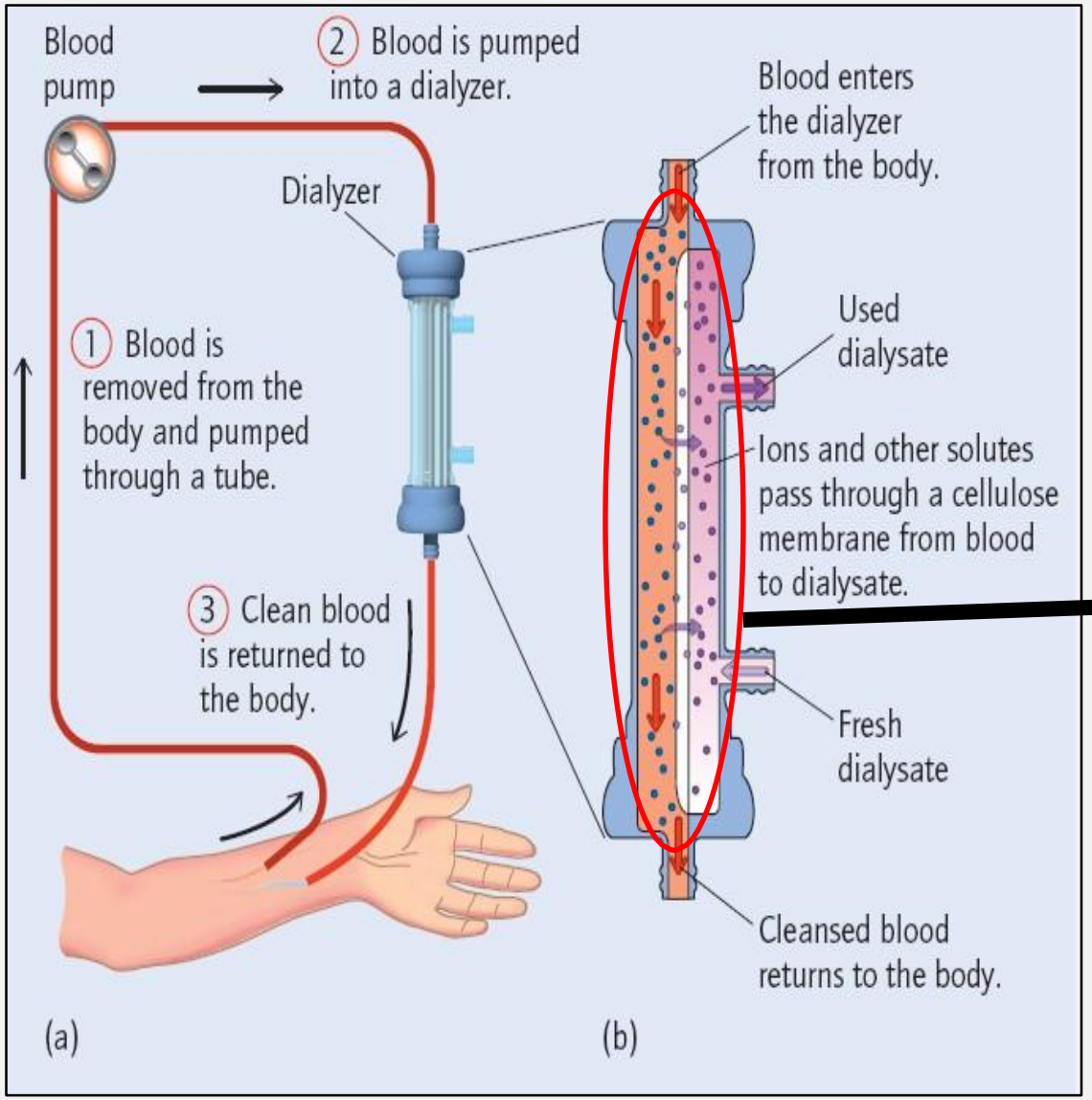


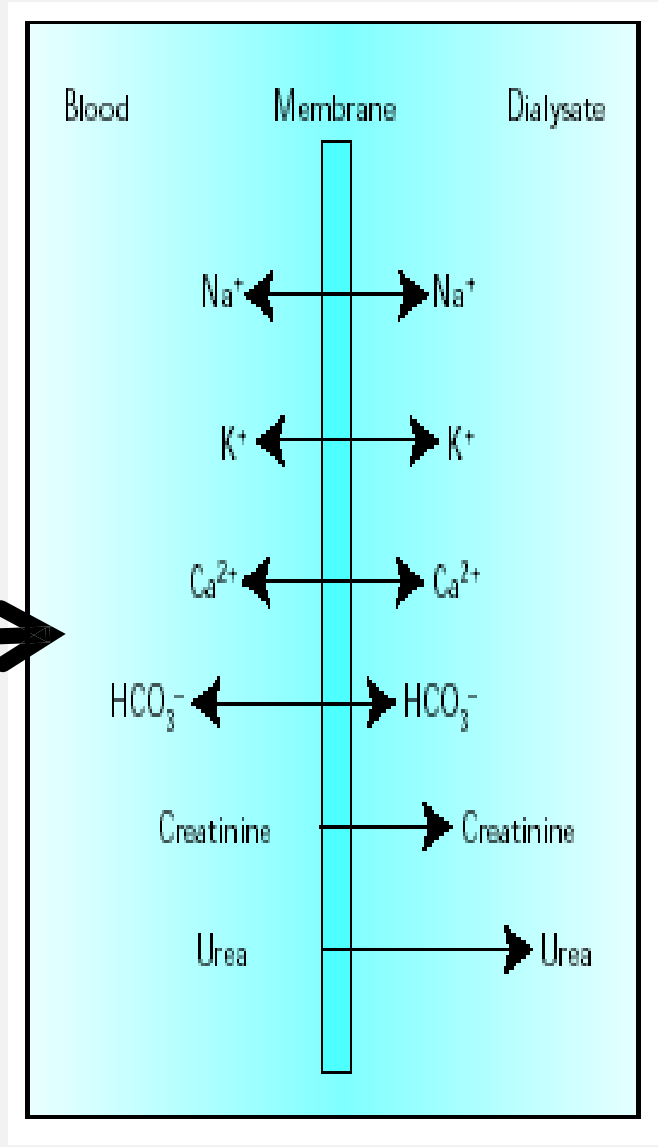
DIALYSIS

- **Occurs when solvent and small solute particles pass through a semipermeable membrane**

- Large particles retained inside
- Hemodialysis is used medically (artificial kidney) to remove waste particles such as urea, creatinine and uric acid from blood.
- This is the process for repletion of the bicarbonate deficit of the metabolic acidosis associated with renal failure in humans

DIALYSIS

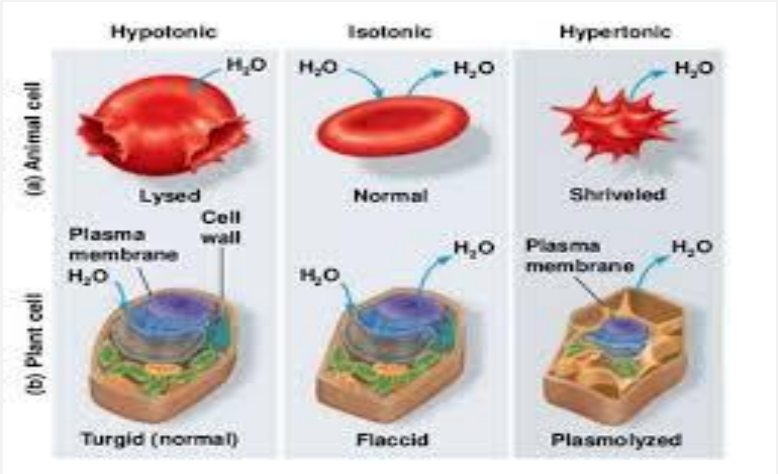

Blood pump
2 Blood is pumped into a dialyzer.
Dialyzer
1 Blood is removed from the body and pumped through a tube.
3 Clean blood is returned to the body.
(a)
Blood enters the dialyzer from the body.
Used dialysate
Ions and other solutes pass through a cellulose membrane from blood to dialysate.
Fresh dialysate
Cleansed blood returns to the body.
(b)

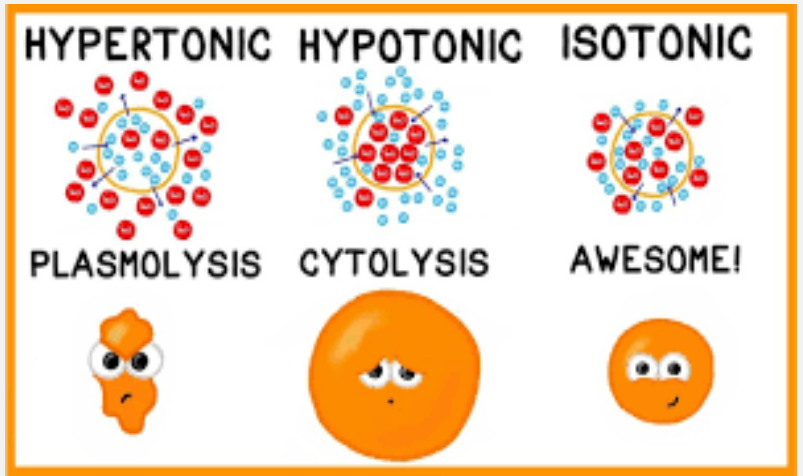

Blood
Membrane
Dialysate
Na^+
Na^+
K^+
K^+
Ca^{2+}
Ca^{2+}
HCO_3^-
HCO_3^-
Creatinine
Creatinine
Urea
Urea

SOLUTIONS

- What Are Isotonic, Hypertonic, and Hypotonic Solutions?

- Isotonic: Equal solute concentration inside and outside the cell (0.9% of salt) (e.g., saline solution).
- Hypertonic: Higher solute concentration outside the cell; water leaves the cell. (3% or 3.5% or 7% of salt)
- Hypotonic: Higher solute concentration inside the cell; water enters the cell. (0.5% of salt)

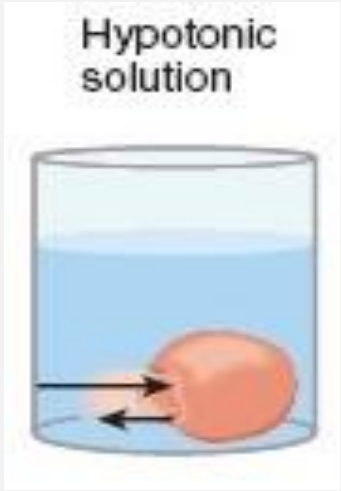




OSMOSIS IN BLOOD CELLS

- If the solute concentration outside the cell is greater than that inside the cell, the solution is hypertonic. Water will flow out of the cell, and crenation results.

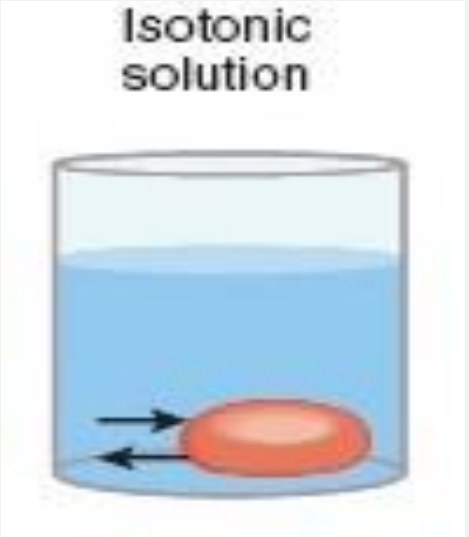
- If the solute concentration outside the cell is less than that inside the cell, the solution is hypotonic.
- Water will flow into the cell, and hemolysis results.

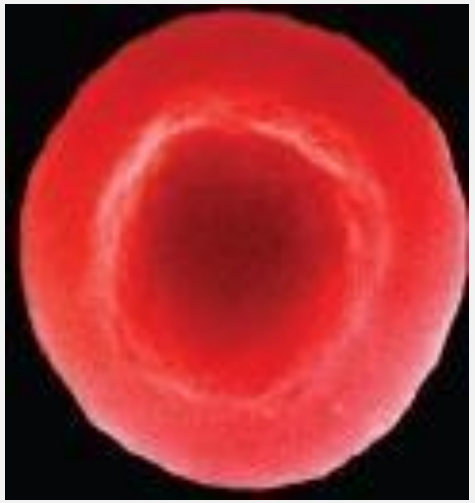


ISOTONIC SOLUTIONS

An isotonic solution

- exerts the same osmotic pressure as red blood cells.
- is known as a "physiological solution".
- of 5.0% glucose or 0.90% NaCl is used medically because each has a solute concentration equal to the osmotic pressure equal to red blood cells.






THANK YOU
FOR YOUR
ATTENTION