9.1 Mixtures and Solutions

Heterogeneous mixture: A nonuniform mixture that has regions of different composition.

Homogeneous mixture: A uniform mixture that has the same composition throughout.

Solution: A homogeneous mixture that contains particles the size of a typical ion or small molecule.

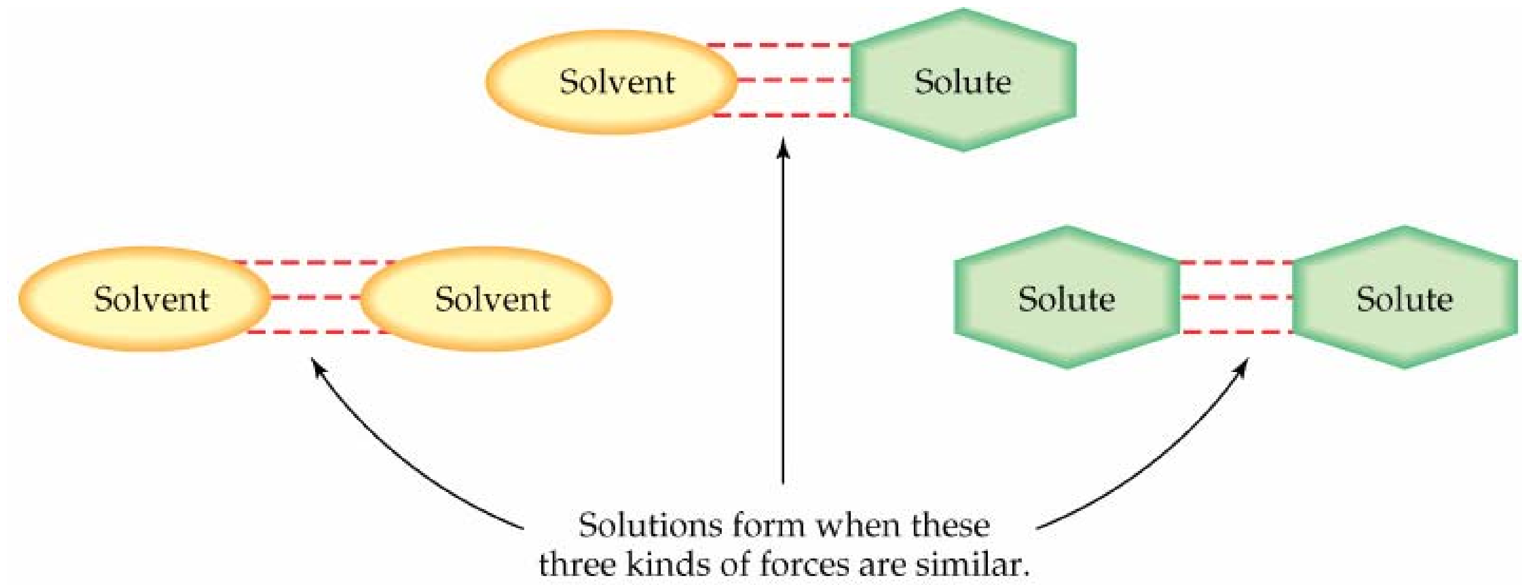
Colloid: A homogeneous mixture that contains particles in the range of 2-500 nm diameter.

Solute: A substance dissolved in a liquid.

Solvent: The liquid in which another substance is dissolved.

9.2 The Solution Process

Solubility depends primarily on the strength of the attractions between solute and solvent particles relative to the strengths of the attractions within the pure substances.



Ethyl alcohol is soluble in water because hydrogen bonding between ethyl alcohol and water is nearly as strong as hydrogen bonding between the water or ethyl alcohol molecules.

A good rule of thumb for predicting solubility is "*like dissolves like*" that is polar solvents dissolve polar and ionic solutes; nonpolar solvents dissolve nonpolar solutes; and hydrogen bonding solvents dissolve hydrogen bonding solutes.

Solvation: The clustering of solvent molecules around a dissolved solute molecule or ion. When $Na^{+}Cl^{-}$ is dissolved in water, Na+ and Cl- ions are completely surrounded by solvent molecules, Fig 9.1.

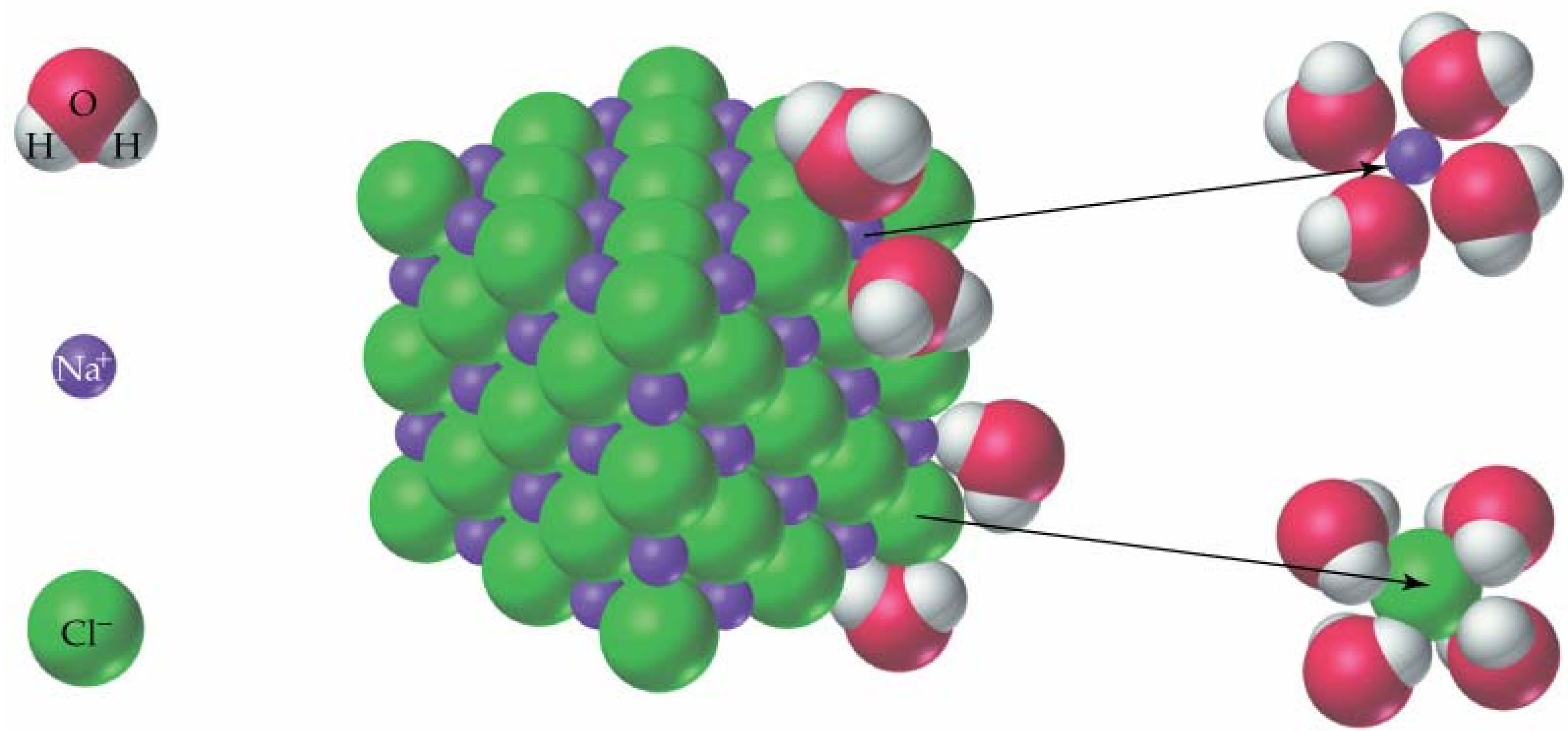


Fig 9.1 Dissolution of NaCl in water

9.4 Solubility

Miscible: Mutually soluble in all proportions.

Not all substance continue to dissolve regardless of amount added. For example, if we want to make a saline solution by adding NaCl to water, dissolution of NaCl will occur rapidly at first but will then slow down as more NaCl is added. Eventually the dissolution stops because an equilibrium is reached when the numbers of Na^+ and Cl^- ions leaving the crystal and going into the solution and the numbers of Na^+ and Cl^- ions leaving the solution and going into the crystals are equal. At this point the solution is said to be *saturated.*

9.7 Units of Concentration

Mole/Volume concentration, Molarity (M): The most useful unit for concentration is molarity (M). Molarity is defined as '*the number of moles of solute dissolved per liter of solution*'.

$$\text{Molarity (M)} = \frac{\text{Moles of solute}}{\text{Liters of solution}}$$

Weight/Volume Percent Concentration [(w/v)%]

Mathematically, (w/v)% concentration is found by taking the number of grams of solute per milliliters of solution and multiplying by 100.

$$(w/v)\%\ \text{concentration} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$$

9.8 Dilution

Dilution: Lowering concentration by adding additional solvent. In the dilution process, the amount of solute remains constant only the volume is increased by adding more solvent.

Dilution factor: The ratio of the initial and final solution volumes (v_1/v_2).

The following equation is very useful in calculating final concentration of a solution after dilution.

$$M_1V_1 = M_2V_2$$

where M_1 and V_1 refers to the initial concentration and volume of the solution and M_2 and V_2 refers to the final concentration and volume of the solution.

9.9 Ions in Solution: Electrolytes

Electrolyte: A substance that produces ions and therefore conducts electricity when dissolved in water.

Ionic compounds in aqueous solution can conduct electricity – thus ionic compounds are called electrolytes.

Strong electrolyte: A substance that ionizes completely when dissolved in water, such as NaCl.

Weak electrolyte: A substance that is partly ionized in water, such as CH_3CO_2OH.

Nonelectrolyte: A substance that does not produce ions when dissolved in water, such as sucrose.

9.10 Electrolytes in Body Fluids: Equivalents and Milliequivalents

In blood and other body fluids contain many different cations and anions. To discuss such mixtures, equivalent of ions is used to address concentration of specific ion and nonionic compound present in this type of solutions.

$$\text{One equivalent of ion} = \frac{\text{Molar mass of ion (g)}}{\text{Number of charges on ion}}$$

1 milliequivalent (mEq) = 0.001 equivalent (Eq)

1 Eq = 1000 mEq

9.11 Properties of Solutions

The properties of solutions are similar in many respects to those of pure solvents, but there are some important differences.

The properties of a solution that depends on the concentration of a dissolved solute but not on its chemical identity is known as ***colligative properties***.

The colligative properties are:

- Vapor pressure is lower for a solution than for a pure solvent.
- Boiling point is higher for a solution than for a pure solvent.
- Freezing point is lower for a solution than for a pure solvent.
- Osmosis occurs when a solution is separated from a pure solvent by a semipermeable membrane.

9.12 Osmosis and Osmotic Pressure

***Osmosis*:** The passage of solvent through a semipermeable membrane separating two solutions of different concentrations.

Osmotic pressure: The amount of external pressure applied to the more concentrated solution to halt the passage of solvent molecules across a semipermeable membrane.

Osmolarity: The sum of the molarities of all dissolved particles in a solution.

Osmosis is important in living organisms because membranes around cells are semipermeable. The fluids both inside and outside cells must therefore have the same osmolarity to prevent buildup of osmotic pressure and consequently rupture the cell membrane.

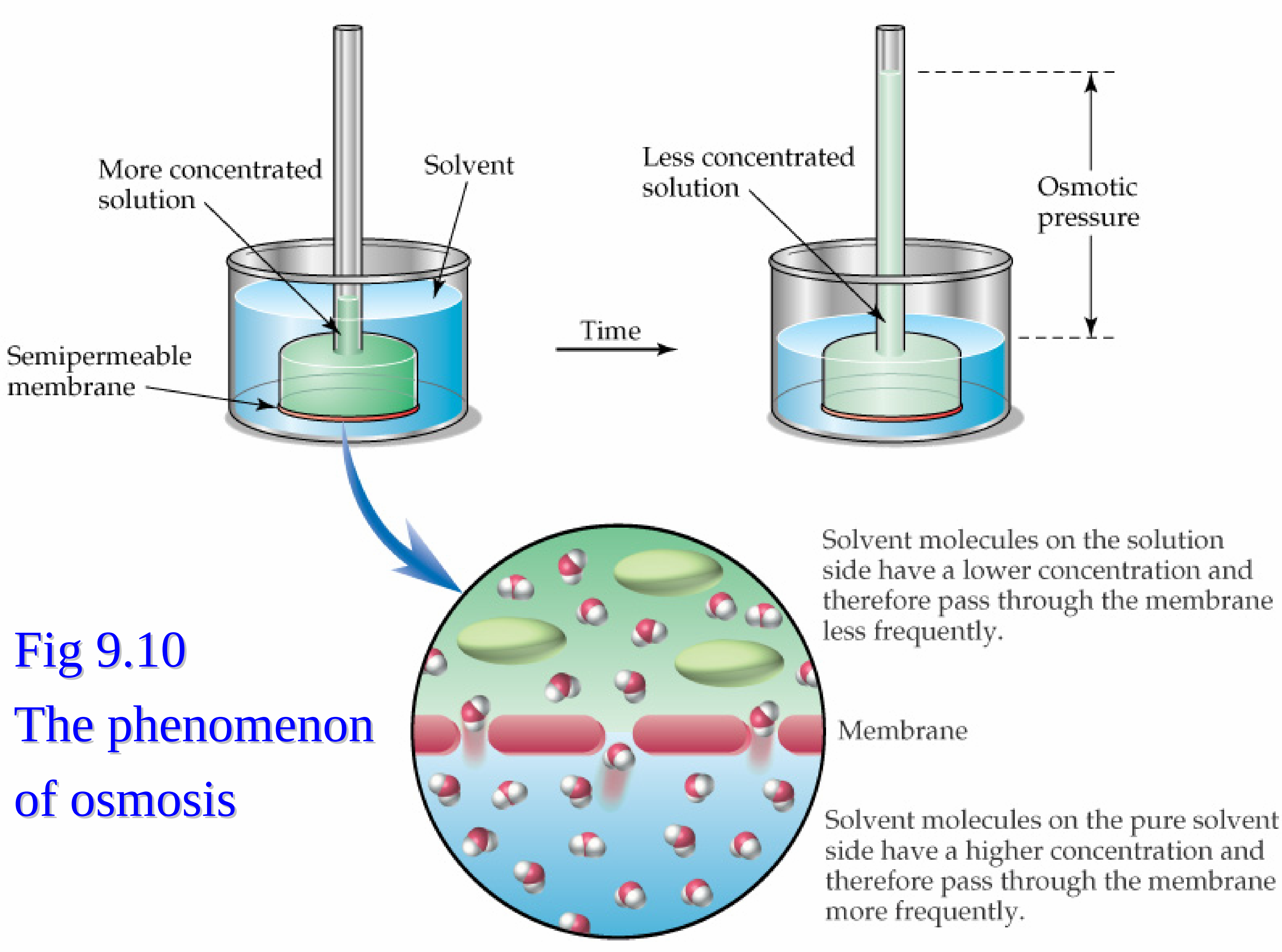
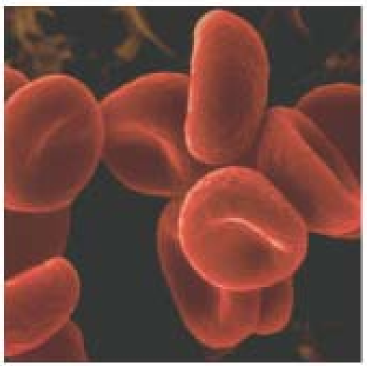


Fig 9.10 The phenomenon of osmosis

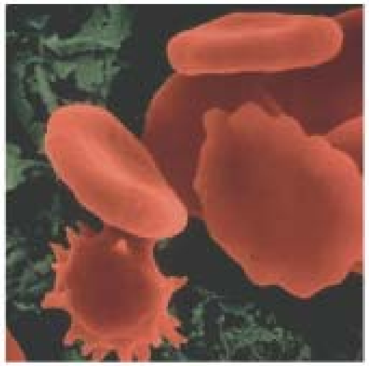
- In blood, plasma surrounding blood cells has an approximately osmolarity 0.3 osmol and is said to be *isotonic* (has the same osmolarity) as the cell contents.
- If the cells are removed from the plasma and placed in a 0.15M NaCl (physiological saline solution), they are unharmed since the osmolarity of this saline solution is also approximately 0.30 osmol.

- If the, however, the cells are placed in pure water or any other solution that has much lower osmolarity than 0.30, water will pass through the membrane into the cells, causing the cells to swell up and burst, a process called *hemolysis*.
- If red blood cells are placed in a solution that has much higher osmolarity (*hypertonic* solution) than the cell content, water will pass out of the cells into the surrounding solution, causing the cells to shrivel, a process called *crenation*.

(a)



(b)



(c)

Red blood cells in

(a) an isotonic solution are normal in appearance, while the cells in

(b) (b) a hypotonic solution are swollen because of water gain, and those in

(c) (c) a hypertonic solution are shriveled because of water loss.