Chap. 2 Biomolecules and Cells

2.4 Building a Human Cell

2.4.3 Cell Membrane

- A cell is encased in a semipermeable bilayer, called a plasma membrane which separates chemical reactions inside the cell from those outside the cell. Membranes regulate traffic of ions and molecules in and out of the cell.

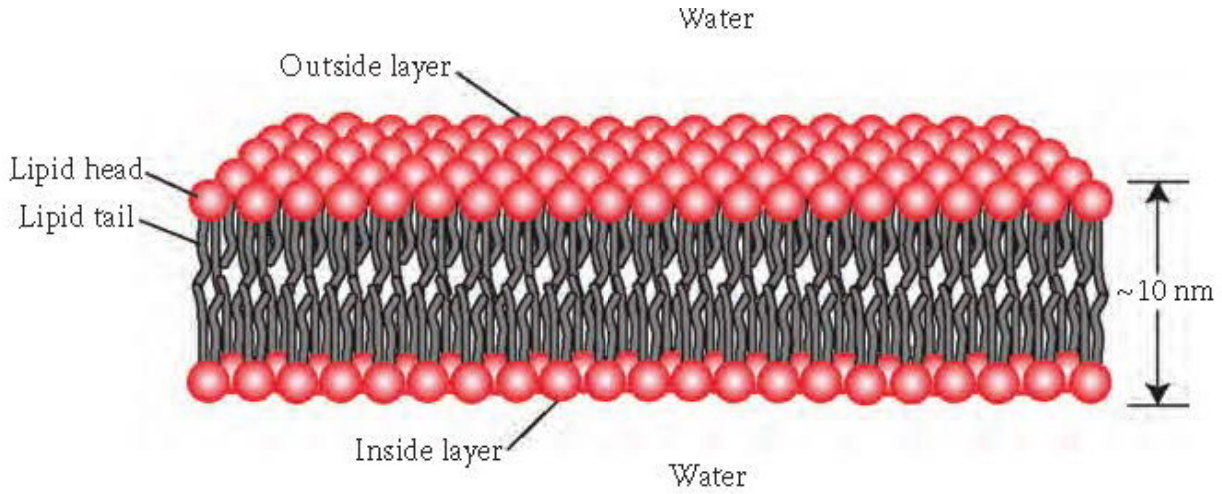

Figure 2.13 Cross section illustration of simplified bilayer cell membrane in aqueous solutions inside and outside cell membrane. [Courtesy of Mariana Ruiz Villarreal, Lady of Hats.]

- In the cell membrane (phospholipid bilayer), each layer consists of a lipid head and a lipid tail, and the bilayer is mirror reflection of each layer.

- Molecules and ions are entering and exiting the cell by diffusion through pore channels. Calcium ions (Ca^{2+}) and potassium ions (K^{+}) diffuse through the protein channels in the cell membrane. Some proteins in the cell membrane can act as receptor sites for signaling molecules to bind.

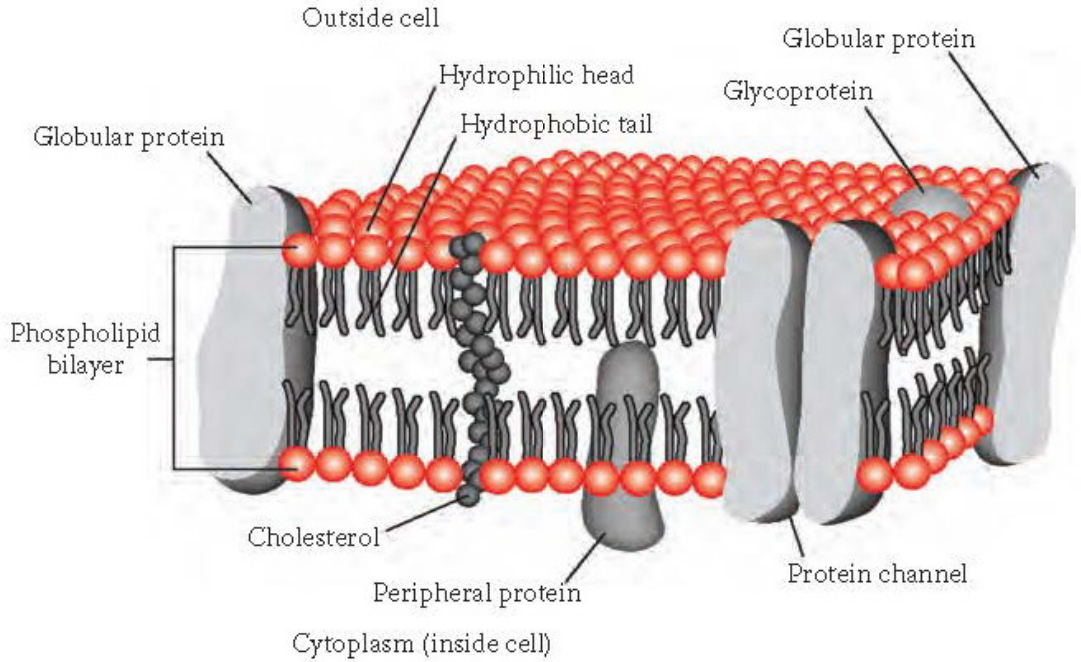

Figure 2.14 Cross-sectional illustration of a cell membrane cross section, where the outer and inner surfaces are hydrophilic. [From Siegfried, D.R.: *Biology for Dummies*. p. 29. 2001. Copyright Wiley-VCH Verlag GmbH & Co.

Chap. 3 Molecular Chemistry

3.2 Periodic Table

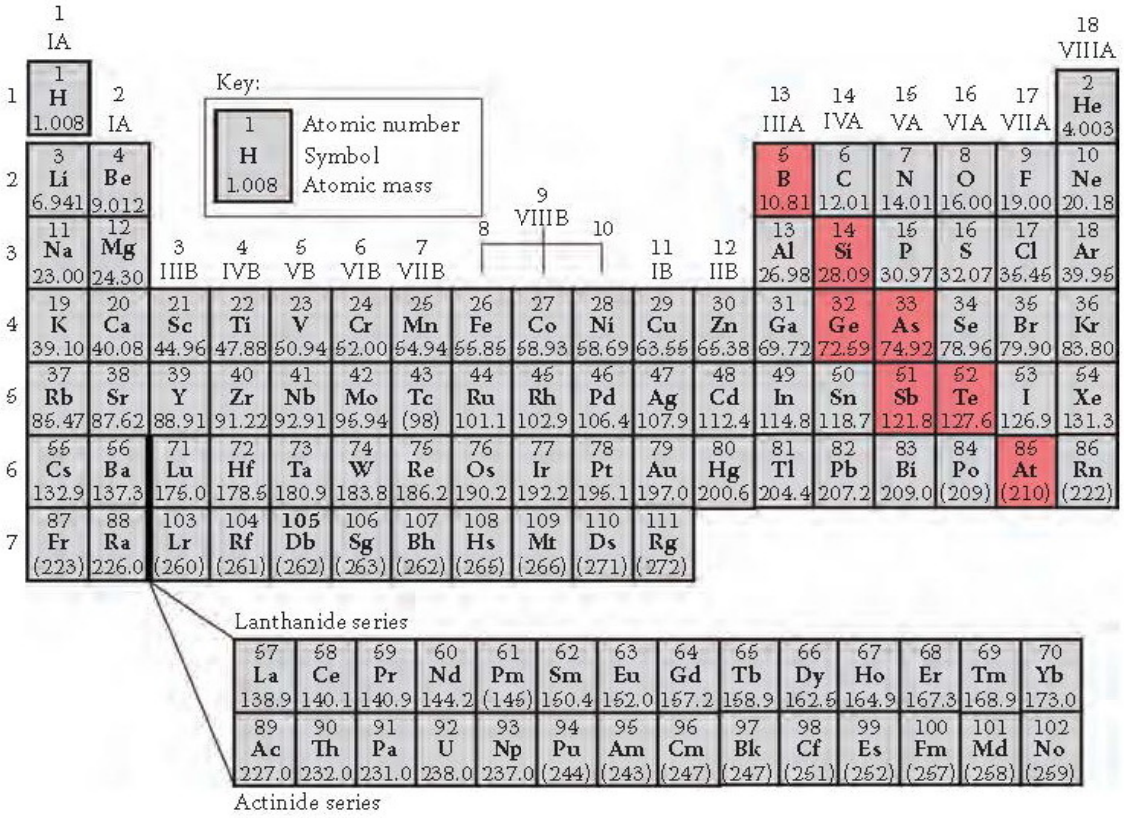

Figure 3.2 Periodic Table of elements. [Courtesy of Educational Innovations, Inc., Bethel, CT.]

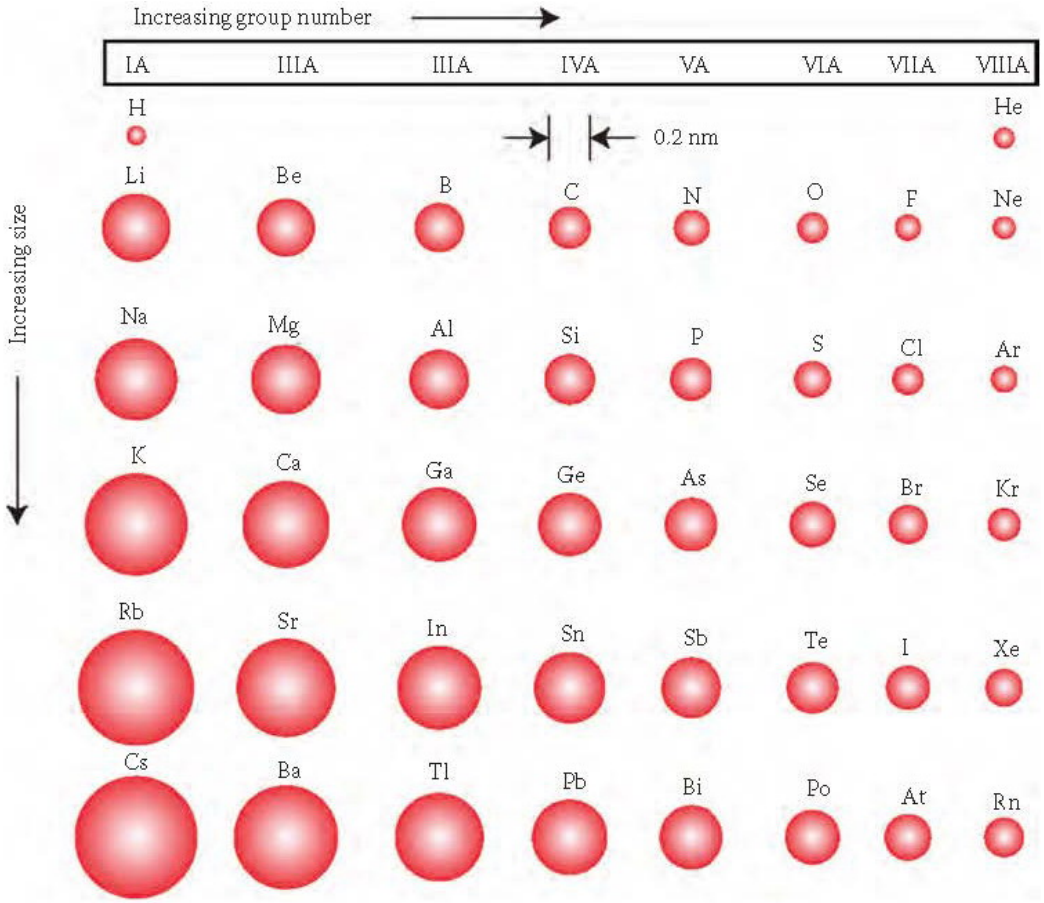

Figure 3.5 Relative size (diameter) of different atoms in the Periodic Table, starting with H and ending at Rn (atomic number 86). Atoms are organized according to their group number (IA–VIIIA). [Adapted from Masterton,

3.4 Chemical Bonding

3.4.1 Primary Bonding

1) Covalent bonding

TABLE 3.3 Electron Configuration and Number of Covalent Bonds for C, H, N, O, P, and S

Element	Electron Configuration	No. of Covalent Bonds	Example
Carbon (C)	[He] $2s^2 2p^2$, or $2s^1 2p^3$, or $2sp^2 2p^1$	4	O=C=O
Hydrogen (H)	$1s^1$	1	H–H
Nitrogen (N)	[He] $2s^2 2p^3$	3	H–N–H,
Oxygen (O)	[He] $2s^2 2p^4$	2	O=C
Phosphorous (P)	[Ne] $3s^2 3p^3$	5	PO_4^{3-}
Sulfur (S)	[Ne] $3s^2 3p^4$	4	SO_4^{2-}

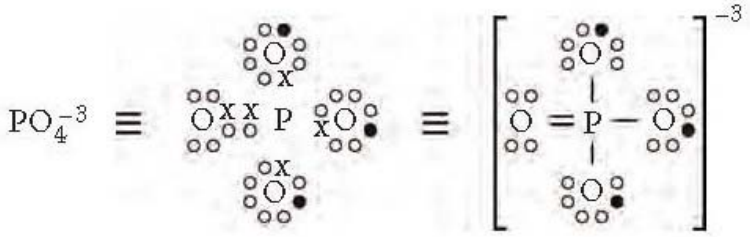

Figure 3.9 Illustration of Lewis structure for phosphate molecule—its bonding and chemical formula.

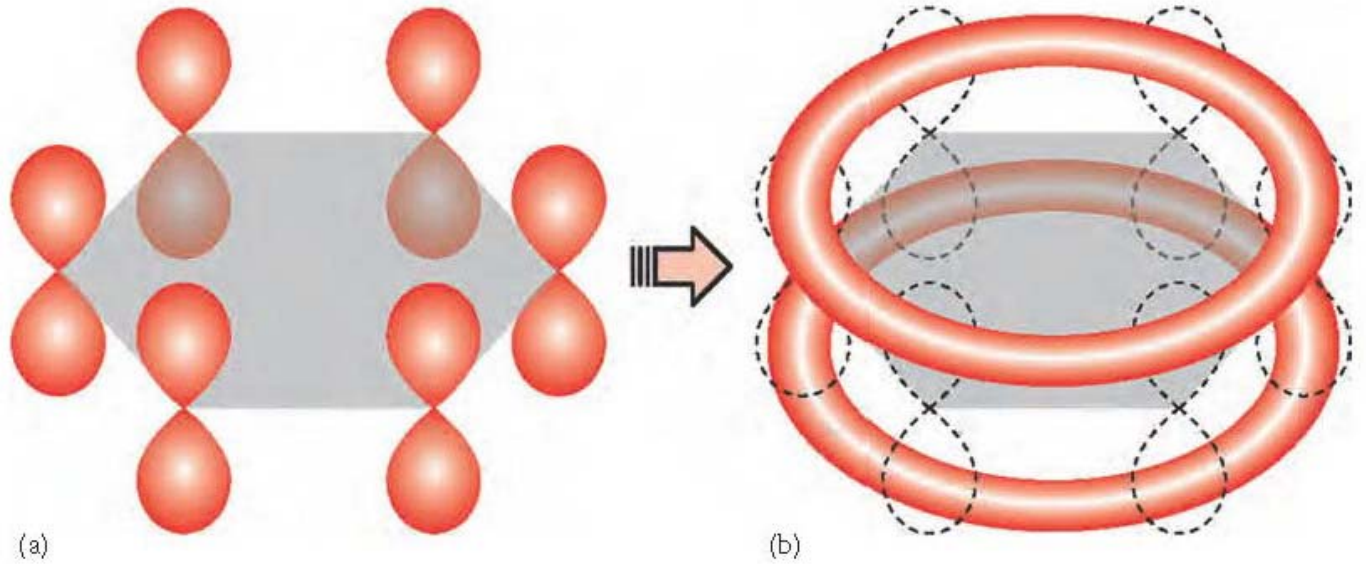

Figure 3.10 Illustration of π-bonding where (a) shows the p_z orbitals of the C atoms in the hexagonal layer. (b) Illustration of π nonlocalized bonding electrons.

2) Ionic bonding: cations (+ ions) and anions (- ions); NaCl, MgO, SiO_2, ZnO, TiO_2, Fe_3O_4

3) Metallic bonding: pur metals, metal alloys; the orbitals overlap as bands

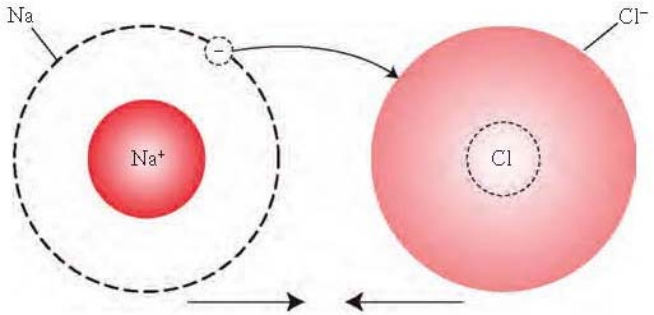

Figure 3.11 Illustration of ionic bonding and attraction (arrows) between Na^+ and Cl^- ions after electron exchange.

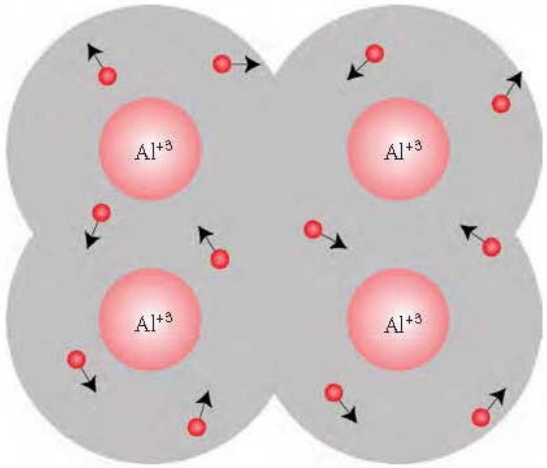

Figure 3.12 Illustration of metallic bonding: sea of electrons (•) moving in various directions around fixed Al^{+3} ions.

3.4.2 Secondary Bonding: Intermolecular Bonding

1) Ion-dipole bonding
2) Dipole-dipole interactions
3) Electrostatic effects
4) Hydrogen bonding: between the hydrogen atom and strongly electronegative atoms (O, N,)
5) Hydrophobic Effect: between polar and nonpolar molecules

TABLE 3.4 Type of Forces, Binding Energies, and Examples of Intermolecular Binding

Secondary Bonding	Bonding Energy (kJ/mol)[a]	Energy Dependence on Distance (R)[b]	Example
Ion–dipole	~40	$1/R^2$	K^+ in H_2O
Dipole–dipole	4–30	$1/R^6$–$1/R^3$	H_2O–H_2O
Dispersion forces (dipole-induced dipole)	<4	~$1/R^6$	CCl_4–CH_4
Electrostatic effect	4–24	$1/R$	$-O^-–{}^+H_3N-$
Hydrogen bonding	4–30	~$1/R$	$-N^{(-)}–H^{(+)}-$ between DNA bases
Hydrophobic effect	8–12		$-CH_3$ groups in H_2O

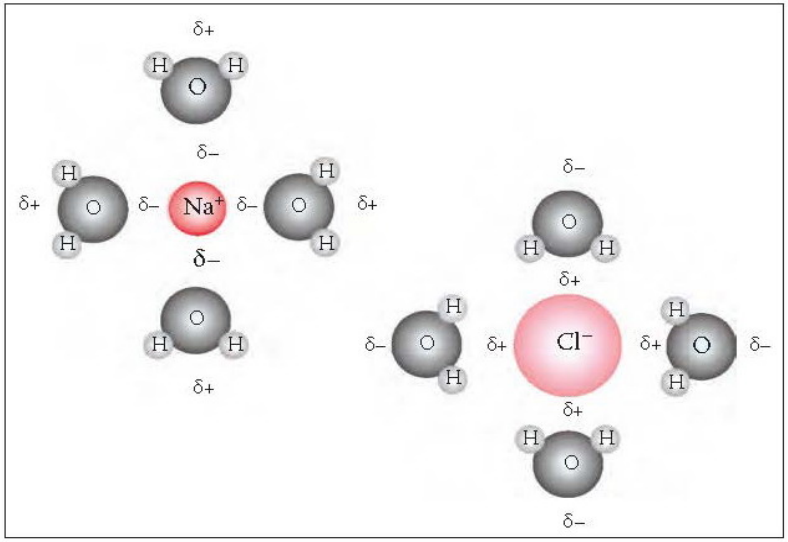

Figure 3.13 Illustration of ion–dipole bonding for Na^+ and Cl^- ions dissolved in water. The charged ions surround themselves with the polarized water molecules that have δ+, δ– dipoles. [Adapted from Solomons, T.W.G. and Fryble,

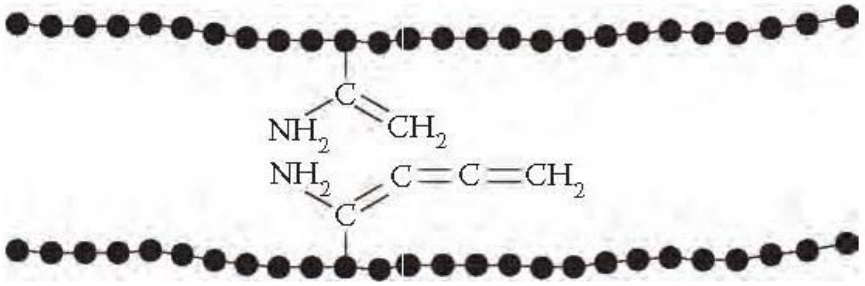

Figure 3.15 Illustration of dipole–dipole and dipole-induced dipole interactions.

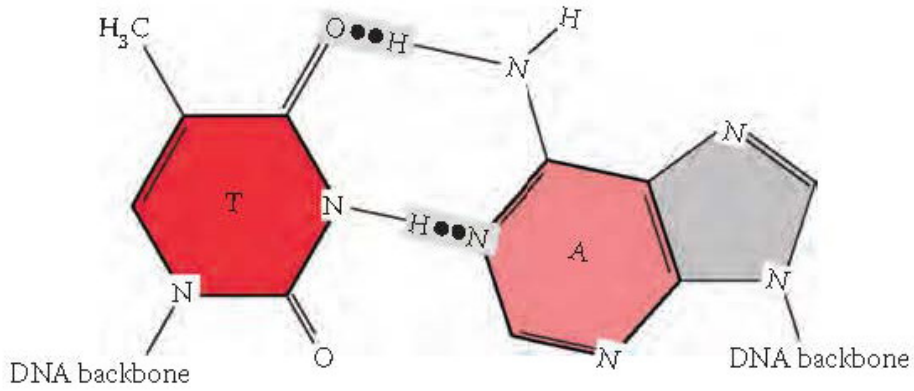

Figure 3.17 Illustration of hydrogen bonding (••) between thymine (T) and adenine (A) bases in DNA.

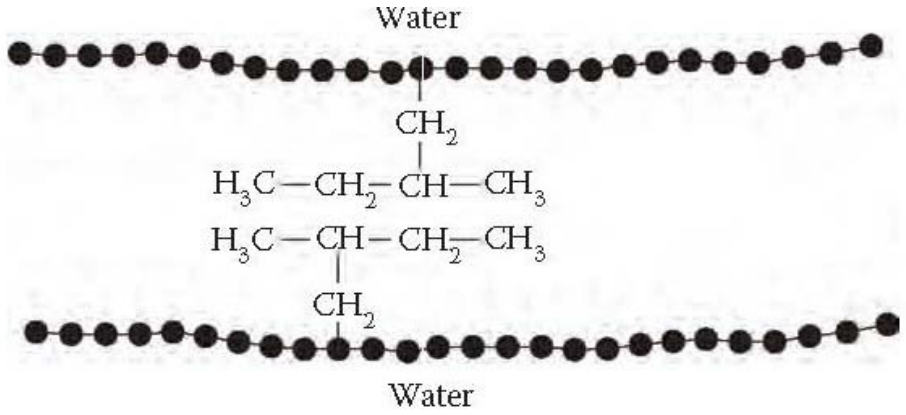

Figure 3.18 Illustration of nonpolar hydrocarbon molecules inside polymer chains with water on the outside.

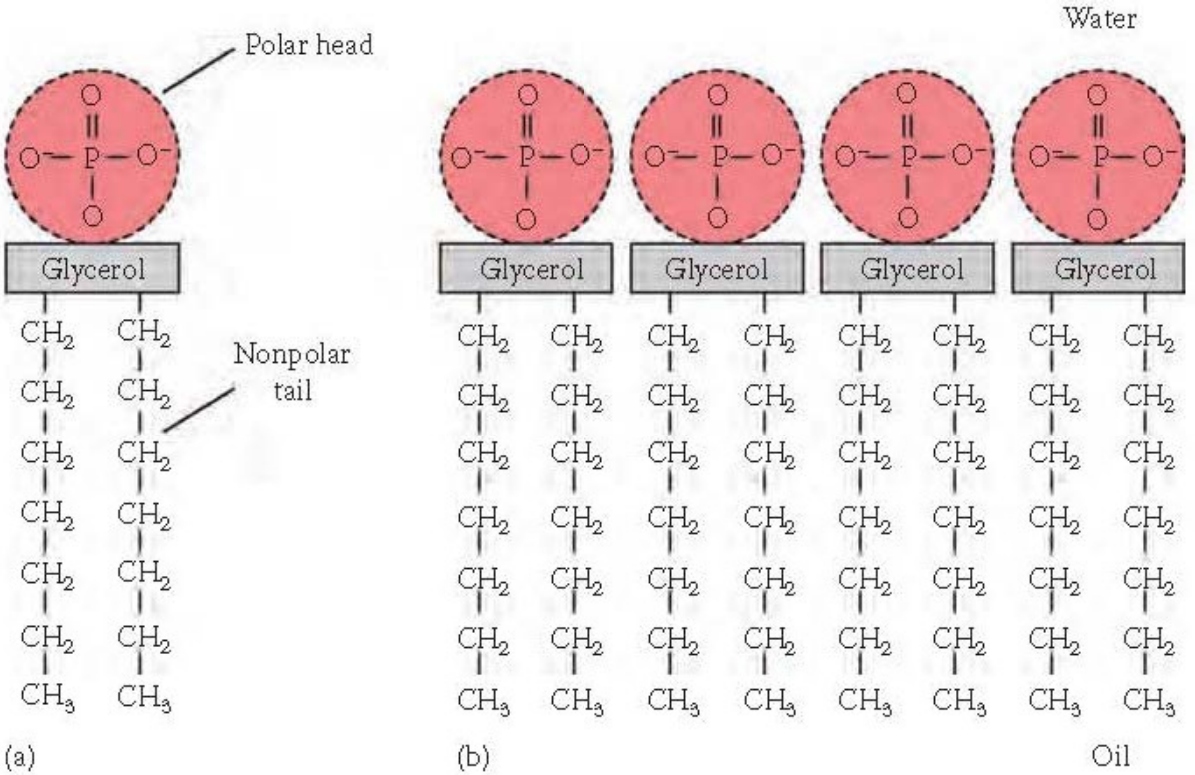

Figure 3.21 Illustration of (a) amphiphilic molecule with a polar head and nonpolar hydrocarbon tail, and (b) micelle.