Hole's Essentials of Human Anatomy & Physiology

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Chapter 2

Lecture Outlines*

***See PowerPoint image slides for all figures and tables pre-inserted into PowerPoint without notes.**

Chapter 2

Chemical Basis of Life

Introduction:

A. Chemistry deals with the composition of substances and how they change.

B. A knowledge of chemistry is necessary for the understanding of physiology because of the importance of chemicals in body processes.

Structure of Matter:

A. Elements and Atoms:

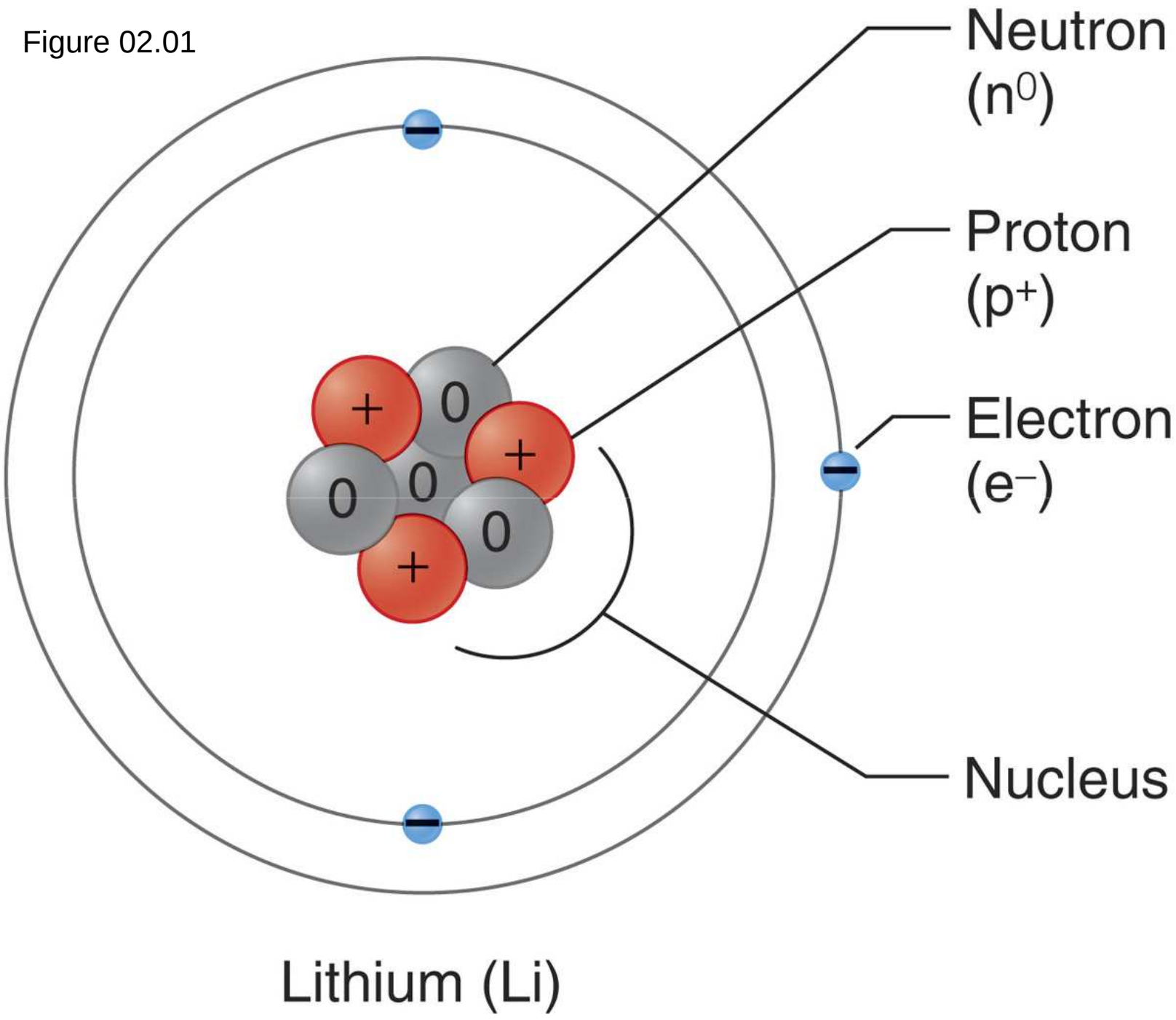
1. Matter is anything that has mass and takes up space.

2. All matter is composed of elements, 90 of which occur naturally.

3. Living organisms require about 20 elements, of which *oxygen, carbon, hydrogen,* and *nitrogen* are most abundant.

4. Elements are composed of atoms; atoms of different elements vary in size, weight, and interaction with other atoms.

Figure 02.01



B. Atomic Structure:

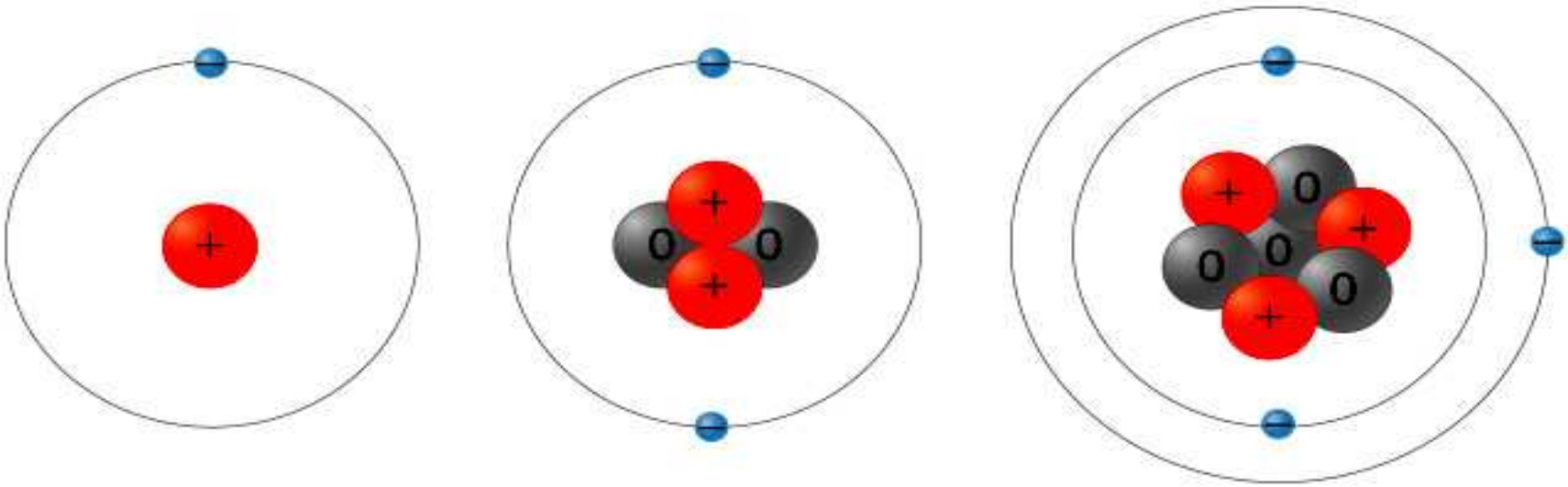
1. An atom consists of a nucleus containing protons and neutrons, with electrons in orbit around the nucleus in shells.

2. Protons, with a positive charge, are about equal in size to neutrons, which have no charge. Mass = 1

3. Electrons are much smaller and bear a negative charge. (1/1840th the size of protons)

4. An electrically neutral atom has equal numbers of protons and electrons.

5. The number of protons denotes the atomic number of an element; the number of protons plus the number of neutrons equals the atomic weight. (also called mass #)



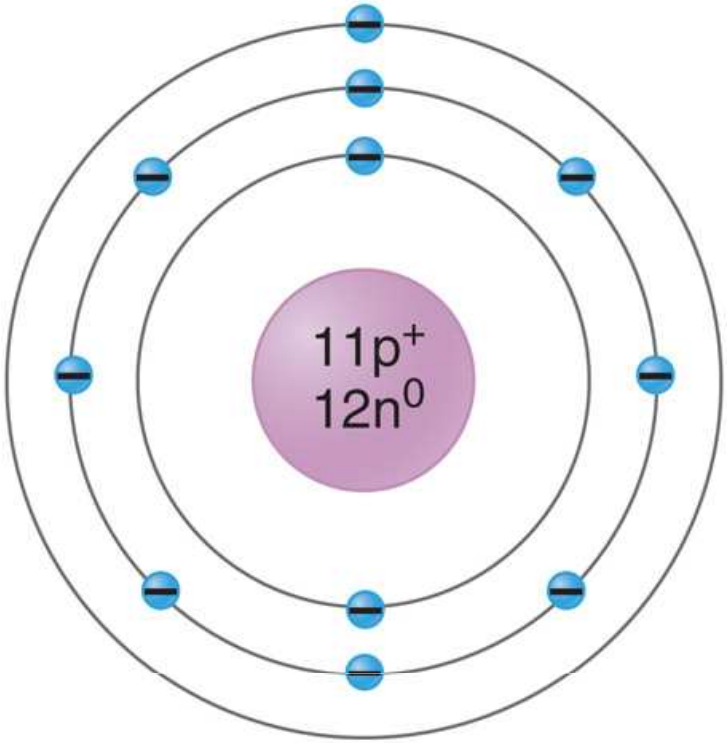
Hydrogen (H) **Helium (He)** **Lithium (Li)**

C. Bonding of Atoms:

1. Atoms form bonds by gaining, losing, or sharing electrons.

2. Electrons are found in shells around the nucleus.

   a. The first energy shell holds a maximum of *two* electrons; the other energy shells each hold a maximum of *eight* electrons when on the outside.



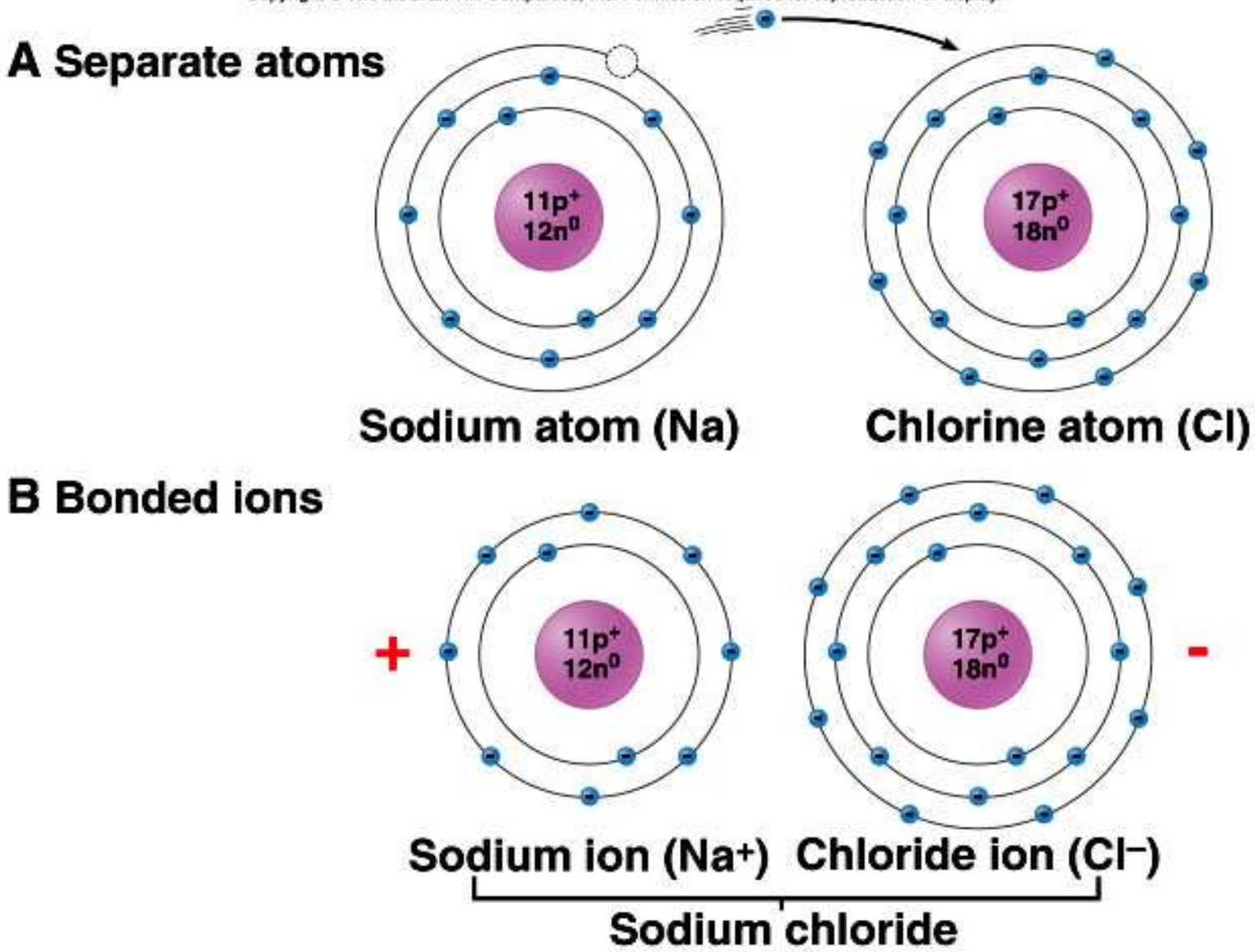
Sodium atom contains
11 electrons (e^-)
11 protons (p^+)
12 neutrons (n^0)

Atomic number = 11
Atomic weight = 23

3. Atoms with incompletely filled outer shells tend to be reactive to form stable outer shells of 8.

4. When atoms gain or lose electrons, they become ions with a charge. Whether they gain or lose will depend on how many electrons they have in the outer shell to start with.

5. Oppositely-charged ions attract each other and form an ionic bond.



6. Covalent bonds are formed when atoms share electrons to become stable with filled outer shells.

    a. Two pairs of electrons shared between atoms form a *double covalent bond*.

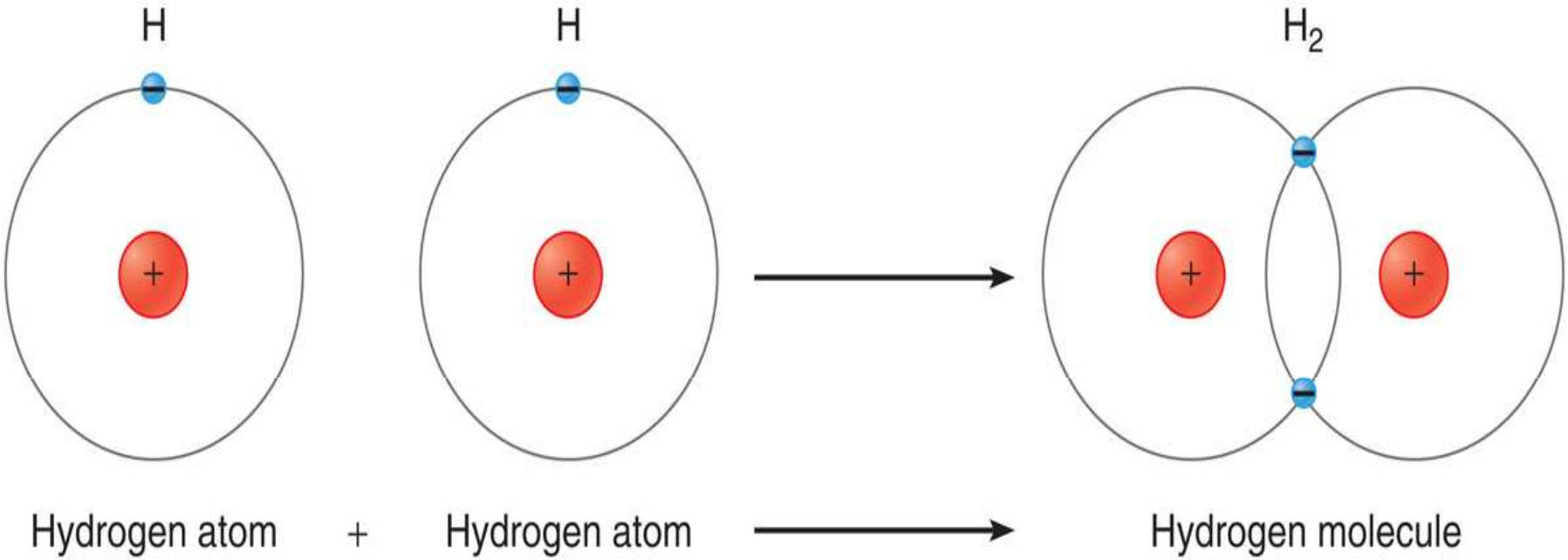


Figure 02.07

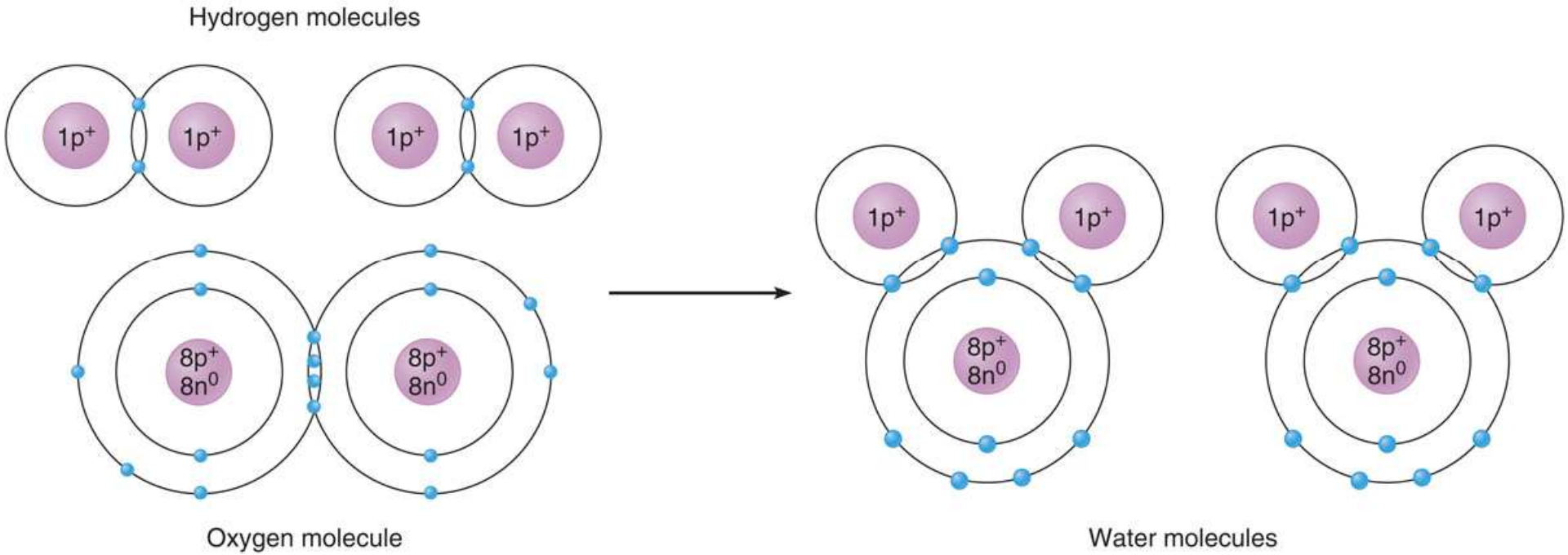
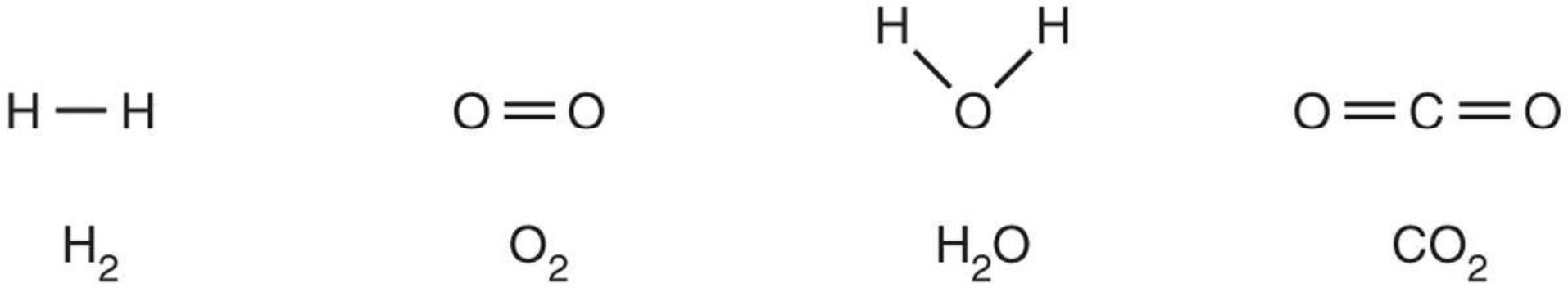


Figure 02.08



D. Molecules and Compounds:

1. A molecule is formed when two or more atoms combine.

2. If atoms of different elements combine, the molecule can also be called a compound.

   a. Compounds always have a definite kind and number of atoms.

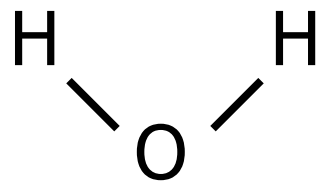
E. Formulas:

1. A molecular formula represents the numbers and types of atoms in a molecule.

Ex: Glucose = $C_6H_{12}O_6$

2. Various representations, called structural formulas, can be used to illustrate molecules.

Ex: Water =



F. Chemical Reactions:

1. A *chemical reaction* occurs as bonds are formed or broken between atoms, ions, or molecules.

2. Those changed by the reaction are the *reactants;* those formed are the *products*.

3. Two or more atoms or molecules can be joined during synthesis.

$$A + B \longrightarrow AB$$

4. Larger molecules can be broken into smaller ones in decomposition reactions.

$$AB \longrightarrow A + B$$

5. Exchange reactions occur as parts of molecules trade places.

$$AB + CD \longrightarrow AD + CB$$

6. Reversible reactions are symbolized by using two arrows.

7. Catalysts influence the speed of chemical reactions.

G. Acids and Bases:

1. Substances that release ions in water are called electrolytes.

2. Electrolytes that release hydrogen ions (H^+) in water are called acids.

3. Electrolytes that release ions that combine with hydrogen ions in water are called bases.

    Hydroxide ions (OH^-)

4. The concentrations of H^+ and OH^- in the body is very important to physiology.

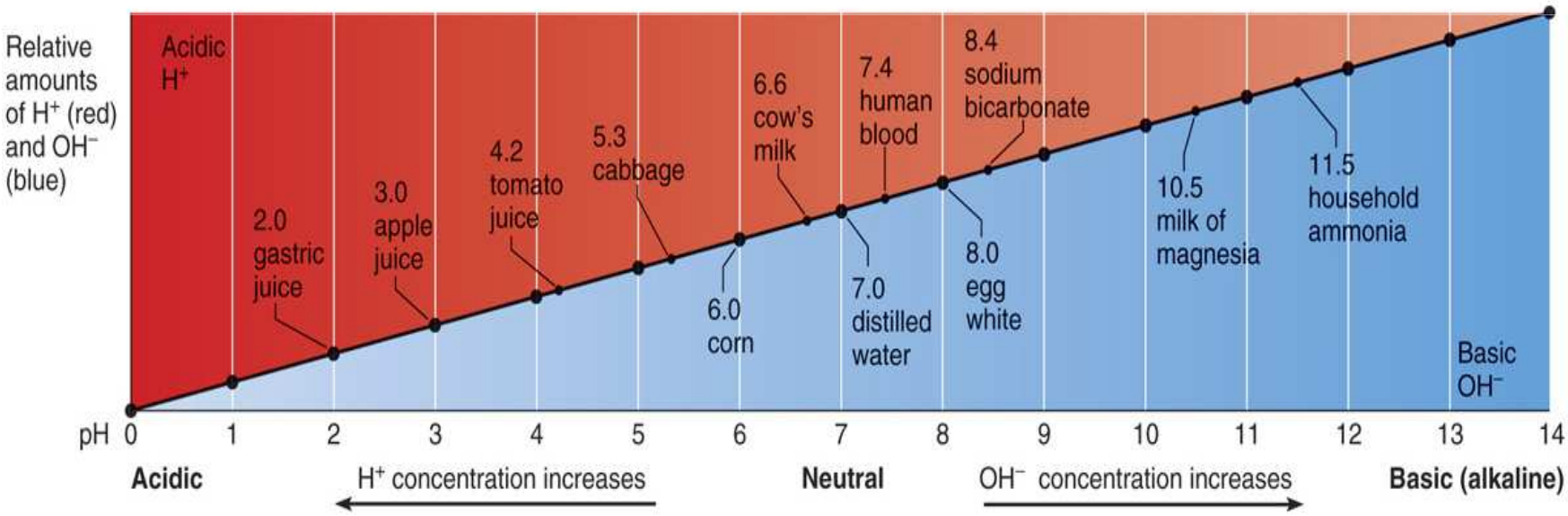
5. pH represents the concentration of hydrogen ions [H^+] in solution.

6. A *pH of 7* indicates a *neutral solution* with equal numbers of hydrogen ions and hydroxyl (OH^-) ions.

a. A pH of *zero to less than 7* indicates the presence of more hydrogen ions, and thus the solution is more *acidic;* a pH *greater than 7 to 14* indicates more hydroxyl ions, or a *basic* solution.

b. Between each whole number of the pH scale there is a tenfold difference in hydrogen ion concentration.

7. Buffers are chemicals that combine with excess acids or bases to help minimize pH changes in body fluids.



Chemical Constituents of Cells:

A. Organic compounds contain both hydrogen and carbon.

B. All other compounds are considered inorganic.

1. Water

a. Water is the most abundant compound in living things and makes up two-thirds of the weight of adults.

b. Water is an important *solvent* so most metabolic reactions occur in water.

c. Water is important in transporting materials in the body since it is a major component of blood.

d. Water carries waste materials and can absorb and transport heat.

2. Oxygen

   a. Oxygen is needed to release energy from nutrients and is used to drive the cell's metabolism.

3. Carbon Dioxide

   a. Carbon dioxide is released as a waste product during energy-releasing metabolic reactions.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_2O + 6CO_2 + ATP$$

4. Inorganic Salts

a. Inorganic salts provide necessary ions including sodium, chloride, potassium, calcium, magnesium, phosphate, carbonate, bicarbonate, and sulfate.

b. These electrolytes play important roles in many of the body's metabolic processes.

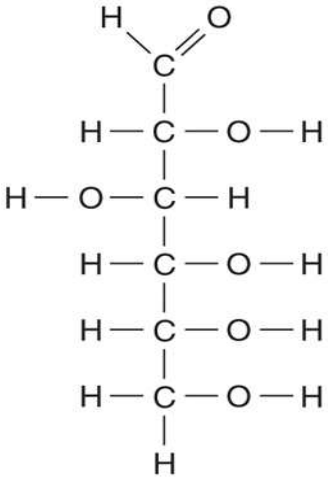
C. Organic Substances:

1. Carbohydrates

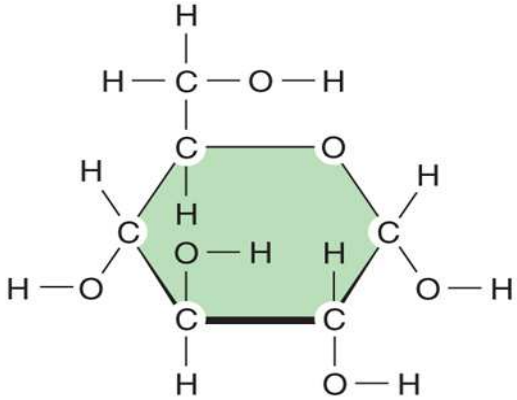
a. Carbohydrates provide energy for cellular activities and are composed of carbon, hydrogen, and oxygen.

b. Carbohydrates are made from monosaccharides (simple sugars); disaccharides are two monosaccharides joined together; complex carbohydrates (polysaccharides), such as starch, are built of many sugars.

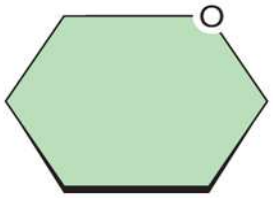
c. Humans synthesize the polysaccharide *glycogen*.



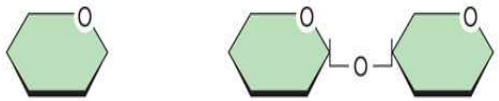
(a) Some glucose molecules ($C_6H_{12}O_6$) have a straight chain of carbon atoms.



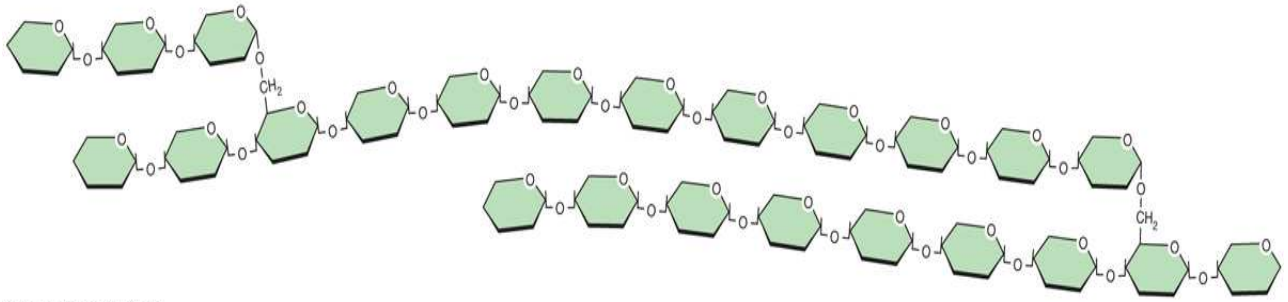
(b) More commonly, glucose molecules form a ring structure.



(c) This shape symbolizes the ring structure of a glucose molecule.



(a) Monosaccharide **(b)** Disaccharide



(c) Polysaccharide

2. Lipids:

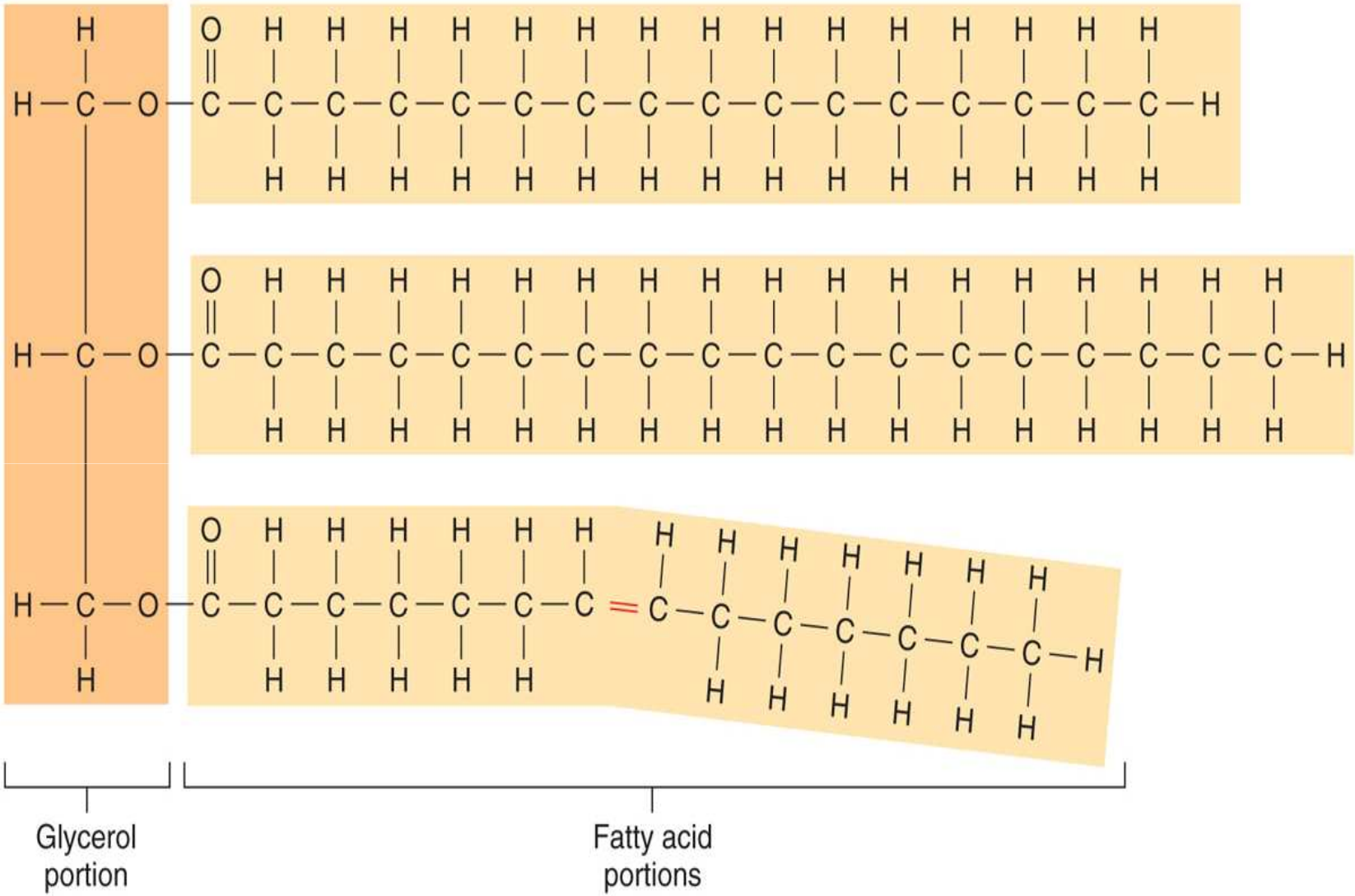
a. Lipids are organic substances that are insoluble in water and include *fats, phospholipids,* and *steroids.*

b. Fats supply energy for cellular function, and are built from glycerol and three fatty acids. Fats have a smaller proportion of oxygen atoms than carbohydrates.

i. Fatty acids with hydrogen at every position along the carbon chain are *saturated;* those with one or more double bonds are called *unsaturated* fats.

c. Phospholipids contain glycerol, two fatty acids, and a phosphate group, and are important in cell structures.

d. Steroids are complex ring structures, and include cholesterol, which is used to synthesize the sex hormones.



3. Proteins:

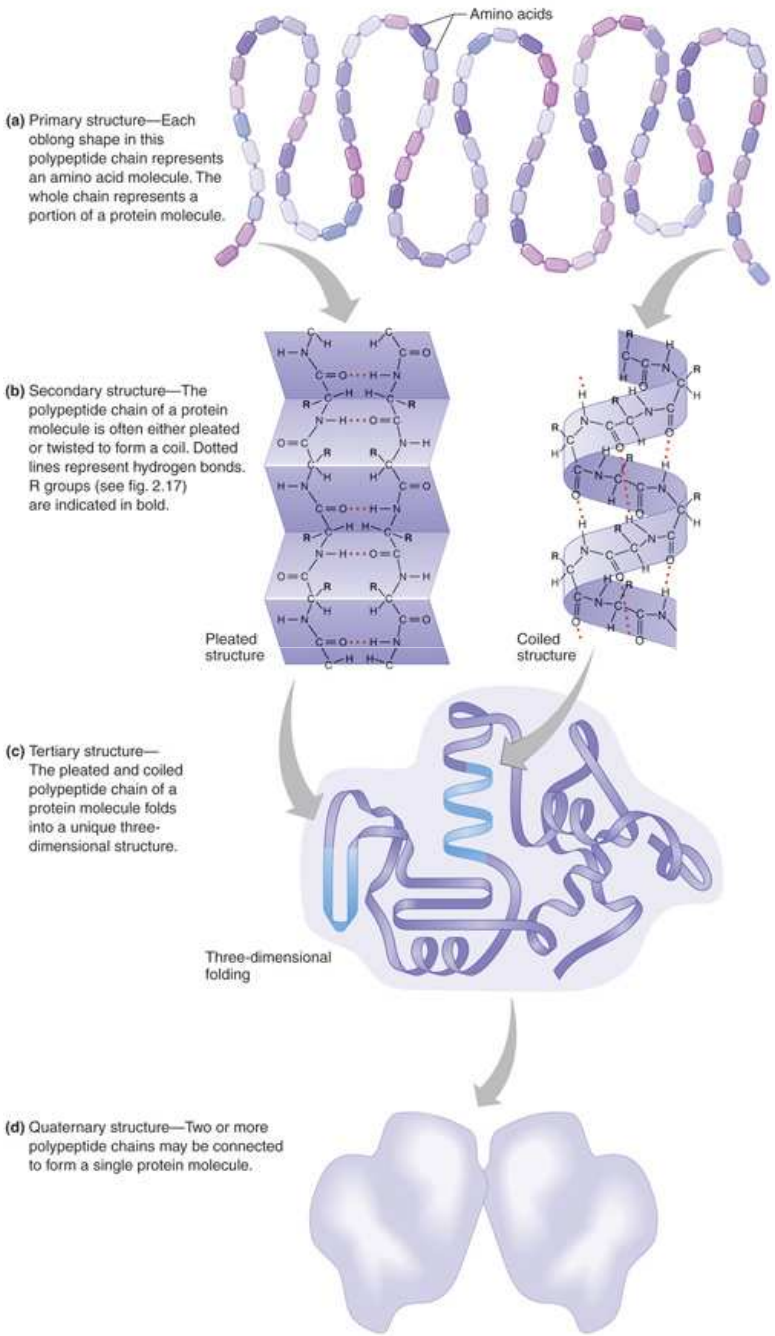
   a. Proteins have a great variety of functions in the body--as structural materials, as energy sources, as certain hormones, as receptors on cell membranes, as antibodies, and as enzymes to catalyze metabolic reactions.

b. Proteins contain C, O, H, and *nitrogen* atoms; some also contain sulfur.

c. Building blocks of proteins are the amino acids, each of which has a carboxyl group, an amino group and a side chain called the R group.

d. Proteins have complex shapes held together by hydrogen bonds.

e. Protein shapes, which determine how proteins function, can be altered (denatured) by pH, temperature, radiation, or chemicals.



4. Nucleic Acids:

a. Nucleic acids form genes and take part in protein synthesis.

b. They contain carbon, hydrogen, oxygen, nitrogen, and phosphorus, which are bound into building blocks called nucleotides.

c. Nucleic acids are of two major types: DNA (with deoxyribose) and RNA (with ribose).

d. RNA (ribonucleic acid) functions in protein synthesis; DNA (deoxyribonucleic acid) stores the molecular code in genes.