CHAPTER
2 Chemistry Comes Alive

Objectives

Part 1: Basic Chemistry

Definition of Concepts: Matter and Energy

1. Differentiate between matter and energy and between potential energy and kinetic energy.
2. Describe the major energy forms.

Composition of Matter: Atoms and Elements

3. Define chemical element and list the four elements that form the bulk of body matter.
4. Define atom. List the subatomic particles, and describe their relative masses, charges, and positions in the atom.
5. Define atomic number, atomic mass, atomic weight, isotope, and radioisotope.

How Matter Is Combined: Molecules and Mixtures

6. Define molecule, and distinguish between a compound and a mixture.
7. Compare solutions, colloids, and suspensions.

Chemical Bonds

8. Explain the role of electrons in chemical bonding and in relation to the octet rule.
9. Differentiate among ionic, covalent, and hydrogen bonds.
10. Compare and contrast polar and nonpolar compounds.

Chemical Reactions

11. Define the three major types of chemical reactions: synthesis, decomposition, and exchange. Comment on the nature of oxidation-reduction reactions and their importance.
12. Explain why chemical reactions in the body are often irreversible.
13. Describe factors that affect chemical reaction rates.

Part 2: Biochemistry

Inorganic Compounds

14. Explain the importance of water and salts to body homeostasis.
15. Define acid and base, and explain the concept of pH.

Organic Compounds

16. Describe and compare the building blocks, general structures, and biological functions of carbohydrates and lipids.

17. Explain the role of dehydration synthesis and hydrolysis in forming and breaking down organic molecules.

18. Describe the four levels of protein structure.

19. Indicate the function of molecular chaperones.

20. Describe enzyme action.

21. Compare and contrast DNA and RNA.

22. Explain the role of ATP in cell metabolism.

Suggested Lecture Outline

Part 1: Basic Chemistry

I. Definition of Concepts: Matter and Energy (pp. 23–25)

A. Matter is anything that occupies space and has mass (p. 24).

- **1.** Mass is equal to the amount of matter in the object.
- **2.** Mass remains constant regardless of gravity.

B. States of Matter (p. 24)

- **1.** Matter exists in one of three states: solid, liquid, or gas.

C. Energy (pp. 24–25)

- **1.** Energy is the capacity to do work, and it exists in two forms.
  - **a.** Kinetic energy is the energy of motion.
  - **b.** Potential energy is stored energy.
- **2.** Forms of Energy
  - **a.** Chemical energy is energy stored in chemical bonds.
  - **b.** Electrical energy results from the movement of charged particles.
  - **c.** Mechanical energy is energy directly involved with moving matter.
  - **d.** Radiant energy is energy that travels in waves.
- **3.** Energy is easily converted from one form to another.

II. Composition of Matter: Atoms and Elements (pp. 25–28; Figs. 2.1–2.3; Table 2.1)

A. Basic Terms (p. 25; Table 2.1)

- **1.** Elements are unique substances that cannot be broken down into simpler substances by ordinary chemical means.
- **2.** Four elements—carbon, hydrogen, oxygen, and nitrogen—make up roughly 96% of body weight.
- **3.** Atoms are the smallest particles of an element that retain the characteristics of that element.
- **4.** Elements are designated by a one- or two-letter abbreviation called the atomic symbol.

B. Atomic Structure (pp. 25–27; Figs. 2.1–2.2)

1. Each atom has a central nucleus with tightly packed protons and neutrons.

a. Protons have a positive charge and weigh 1 atomic mass unit (amu).

b. Neutrons do not have a charge and weigh 1amu.

2. Electrons are found moving around the nucleus, have a negative charge, and are weightless (0 amu).

3. Atoms are electrically neutral and the number of electrons is equal to the number of protons.

4. The planetary model is a simplified, two-dimensional model of atomic structure.

5. The orbital model is a more accurate three-dimensional model talking about orbital regions instead of set orbital patterns.

C. Identifying Elements (pp. 27–28; Fig. 2.3)

1. Elements are identified based on their number of protons, neutrons, and electrons.

2. The atomic number of an element is equal to the number of protons of an element.

a. Because the number of protons is equal to the number of electrons, the atomic number indirectly tells us the number of electrons.

3. The mass number of an element is equal to the number of protons plus the number of neutrons.

a. The electron is weightless, and is ignored in calculating the mass number.

4. Isotopes are structural variations of an atom that have the same number of protons, but differ in the number of neutrons.

5. The atomic weight is an average of the relative weights of all known isotopes of an element, taking into account their relative abundance in nature.

6. Radioisotopes are heavier, unstable isotopes of an element that spontaneously decompose into more stable forms.

a. The time for a radioisotope to lose one-half of its radioactivity is called the half-life.

III. How Matter Is Combined: Molecules and Mixtures (pp. 28–30; Fig. 2.4)

A. Molecules and Compounds (pp. 28–29)

1. A combination of two or more atoms is called a molecule.

2. If two or more atoms of the same element combine it is called a molecule of that element.

3. If two or more atoms of different elements combine it is called a molecule of a compound.

B. Mixtures (pp. 29–30; Fig. 2.4)

1. Mixtures are substances made of two or more components mixed physically.

2. Solutions are homogeneous mixtures of compounds that may be gases, liquids, or solids.

a. The substance present in the greatest amount is called the solvent.

b. Substances present in smaller amounts are called solutes.

c. Solutions may be described by their concentrations. These may be expressed as a percent or in terms of molarity.

3. Colloids or emulsions are heterogeneous mixtures that often appear milky, and have larger solute particles that do not settle out of solution.

4. Suspensions are heterogeneous mixtures with large, often visible solutes that tend to settle out.

C. Distinguishing Mixtures from Compounds (p. 30)

1. The main difference between mixtures and compounds is that no chemical bonding occurs between molecules of a mixture.
2. Mixtures can be separated into their chemical components by physical means; separation of compounds is done by chemical means.
3. Some mixtures are homogeneous, while others are heterogeneous.

IV. Chemical Bonds (pp. 30–35; Figs. 2.5–2.10)

A. A chemical bond is an energy relationship between the electrons of the reacting atoms (p. 30; Fig. 2.5).

1. The Role of Electrons in Chemical Bonding (p. 31)
   - **a.** Electrons occupy regions of space called electron shells that surround the nucleus in layers.
   - **b.** Each electron shell represents a different energy level.
   - **c.** Each electron shell holds a specific number of electrons, and shells tend to fill consecutively from the closest to the nucleus to the furthest away.
   - **d.** The octet rule, or rule of eights, states that except for the first energy shell (stable with two electrons), atoms are stable with eight electrons in their outermost (valence) shell.

B. Types of Chemical Bonds (pp. 31–35; Figs. 2.6–2.10)

1. Ionic bonds are chemical bonds that form between two atoms that transfer one or more electrons from one atom to the other.
   - **a.** Ions are charged particles.
   - **b.** An anion is an electron acceptor carrying a net negative charge due to the extra electron.
   - **c.** A cation is an electron donor carrying a net positive charge due to the loss of an electron.
   - **d.** Crystals are large structures of cations and anions held together by ionic bonds.
2. Covalent bonds form when electrons are shared between two atoms.
   - **a.** Some atoms are capable of sharing two or three electrons between them, resulting in double covalent or triple covalent bonds.
   - **b.** Nonpolar molecules share their electrons evenly between two atoms.
   - **c.** In polar molecules, electrons spend more time around one atom thus providing that atom with a partial negative charge, while the other atom takes on a partial positive charge.
   - **d.** A polar molecule is often referred to as a dipole due to the two poles of charges contained in the molecule.
3. Hydrogen bonds are weak attractions that form between partially charged atoms found in polar molecules.
   - **a.** Surface tension is due to hydrogen bonds between water molecules.
   - **b.** Intramolecular bonds may form between partially charged atoms in a large molecule and are important in maintaining the shape of that molecule.

V. Chemical Reactions (pp. 35–38; Fig. 2.11)

A. Chemical Equations (pp. 35–36)

1. Chemical reactions occur whenever bonds are formed, rearranged, or broken.

2. Chemical Equations

a. A chemical equation describes what happens in a reaction.

b. Chemical reactions denote the kinds and number of reacting substances, called reactants; the chemical composition of the products; and the relative proportion of each reactant and product, if balanced.

B. Patterns of Chemical Reactions (pp. 36–37; Fig. 2.11)

1. In a synthesis (combination) reaction, larger molecules are formed from smaller molecules.

2. In a decomposition reaction a molecule is broken down into smaller molecules.

3. Exchange (displacement) reactions involve both synthesis and decomposition reactions.

4. Oxidation-reduction reactions are special exchange reactions in which electrons are exchanged between reactants.

C. Energy Flow in Chemical Reactions (p. 37)

1. Exergonic reactions release energy as a product, while endergonic reactions absorb energy.

D. Reversibility of Chemical Reactions (p. 37)

1. All chemical reactions are theoretically reversible.

2. When the rate of the forward reaction equals the rate of the reverse reaction, the reactions have reached a chemical equilibrium.

E. Factors Influencing the Rate of Chemical Reactions (pp. 37–38)

1. Chemicals react when they collide with enough force to overcome the repulsion by their electrons.

2. An increase in temperature increases the rate of a chemical reaction.

3. Smaller particle size results in a faster rate of reaction.

4. Higher concentration of reactants results in a faster rate of reaction.

5. Catalysts increase the rate of a chemical reaction without taking part in the reaction.

Part 2: Biochemistry

VI. Inorganic Compounds (pp. 38–41; Figs. 2.12–2.13)

A. Water (pp. 38–39)

1. Water is the most important inorganic molecule, and makes up 60–80% of the volume of most living cells.

2. Water has a high heat capacity, meaning that it absorbs and releases a great deal of heat before it changes temperature.

3. Water has a high heat of vaporization, meaning that it takes a great deal of energy (heat) to break the bonds between water molecules.

4. Water is a polar molecule and is called the universal solvent.

5. Water is an important reactant in many chemical reactions.

6. Water forms a protective cushion around organs of the body.

B. Salts (p. 39; Fig. 2.12)

1. Salts are ionic compounds containing cations other than H^+ and anions other than the hydroxyl (OH^-) ion.

2. When salts are dissolved in water they dissociate into their component ions.

C. Acids and Bases (pp. 39–41; Fig. 2.13)

1. Acids are also known as proton donors and dissociate in water to yield hydrogen ions and anions.

2. Bases are also called proton acceptors and absorb hydrogen ions.

3. The relative concentration of hydrogen ions is measured in concentration units called pH units.

a. The greater the concentration of hydrogen ions in a solution, the more acidic the solution is.

b. The greater the concentration of hydroxyl ions, the more basic, or alkaline, the solution is.

c. The pH scale extends from 0–14. A pH of 7 is neutral; a pH below 7 is acidic; a pH above 7 is basic or alkaline.

4. Neutralization occurs when an acid and a base are mixed together. They react with each other in displacement reactions to form a salt and water.

5. Buffers resist large fluctuations in pH that would be damaging to living tissues.

VII. Organic Compounds (pp. 41–56; Figs. 2.14–2.24; Tables 2.2–2.4)

A. Carbohydrates, lipids, proteins, and nucleic acids are molecules unique to living systems, and all contain carbon, making them organic compounds (pp. 41–43).

B. Carbohydrates (p. 43; Fig. 2.15)

1. Carbohydrates are a group of molecules including sugars and starches.

2. Carbohydrates contain carbon, hydrogen, and oxygen.

3. The major function of carbohydrates in the body is to provide cellular fuel.

4. Monosaccharides are simple sugars that are single-chain or single-ring structures.

5. Disaccharides are formed when two monosaccharides are joined by dehydration synthesis.

6. Polysaccharides are long chains of monosaccharides linked together by dehydration synthesis.

C. Lipids (pp. 43–47; Fig. 2.16; Table 2.2)

1. Lipids are insoluble in water, but dissolve readily in nonpolar solvents.

2. Triglycerides (neutral fats) are commonly known as fats when solid and oils when liquid.

3. Phospholipids are diglycerides with a phosphorus-containing group and two fatty acid chains.

4. Steroids are flat molecules made up of four interlocking hydrocarbon rings.

5. Eicosanoids are a group of diverse lipids derived from arachidonic acid.

D. Proteins (pp. 47–53; Figs. 2.17–2.21; Table 2.3)

1. Proteins compose 10–30% of cell mass.

a. They are the basic structural material of the body.

b. They also play vital roles in cell function.

2. Proteins are long chains of amino acids connected by peptide bonds.
3. Proteins can be described in terms of four structural levels.
   a. The linear sequence of amino acids is the primary structure.
   b. Proteins twist and turn on themselves to form a more complex secondary structure.
   c. A more complex structure is tertiary structure, resulting from protein folding upon itself to form a ball-like structure.
   d. Quaternary structure results from two or more polypeptide chains grouped together to form a complex protein.
4. Fibrous and Globular Proteins
   a. Fibrous proteins are extended and strandlike. They are known as structural proteins and most have only secondary structure.
   b. Globular proteins are compact, spherical structures. They are water-soluble, chemically active molecules and play an important role in vital body functions.
   c. Fibrous proteins are stable, but globular proteins are susceptible to denaturing, losing their shape due to breaking of their hydrogen bonds.
5. Protein denaturation is a loss of the specific three-dimensional structure of a protein. It may occur when globular proteins are subjected to a variety of chemical and physical changes in their environment.
6. Molecular chaperones, or chaperonins, are a type of globular protein that help proteins achieve their three-dimensional shape.
7. Enzymes and Enzyme Activity
   a. Enzymes are globular proteins that act as biological catalysts.
   b. Enzymes may be purely protein or may consist of two parts that are collectively called a holoenzyme.
   c. Each enzyme is chemically specific.
   d. Enzymes work by lowering the activation energy of a reaction.

E. Nucleic Acids (DNA and RNA) (pp. 53–55; Fig. 2.22; Table 2.4)

1. Nucleic acids composed of carbon, oxygen, hydrogen, nitrogen, and phosphorus are the largest molecules in the body.
2. Nucleotides are the structural units of nucleic acids.
3. Each nucleotide consists of three components: a pentose sugar, a phosphate group, and a nitrogen-containing base.
4. There are five nitrogenous bases used in nucleic acids: Adenine (A), Guanine (G), Cytosine (C), Uracil (U), and Thymine (T).
5. DNA, or Deoxyribonucleic Acid
   a. DNA is the genetic material of the cell and is found within the nucleus.
   b. DNA replicates itself before cell division and provides instructions for making all of the proteins found in the body.
   c. The structure of DNA is a double-stranded polymer containing the nitrogenous bases A, T, G, and C, and the sugar deoxyribose.
   d. Bonding of the nitrogenous bases in DNA is very specific; A bonds to T, and G bonds to C.
   e. The bases that always bind together are known as complementary bases.

6. RNA, or Ribonucleic Acid
   a. RNA is located outside the nucleus and is used to make proteins using the instructions provided by the DNA.
   b. The structure of RNA is a single-stranded polymer containing the nitrogenous bases A, G, C, and U, and the sugar ribose.
   c. In RNA, G bonds with C, and A bonds with U.

F. Adenosine Triphosphate (ATP) (pp. 55–56; Figs. 2.23–2.24)
   1. ATP is the energy currency used by the cell.
   2. ATP is an adenine-containing RNA nucleotide that has two additional phosphate groups attached.
   3. The additional phosphate groups are connected by high-energy bonds.
   4. Breaking the high-energy bonds releases energy the cell can use to do work.

Cross References

Additional information on topics covered in Chapter 2 can be found in the chapters listed below.

1. Chapter 3: Phospholipids in the composition and construction of membranes; DNA replication and roles of DNA and RNA in protein synthesis; cellular ions; enzymes and proteins in cellular structure and function; hydrogen bonding
2. Chapter 9: Function of ATP in muscle contraction; role of ions in generating muscle cell contraction
3. Chapter 11: ATP, ions, and enzymes in the nervous impulse
4. Chapter 16: Steroid- and amino acid–based hormones
5. Chapter 22: Acid-base balance
6. Chapter 23: Digestive enzyme function; acid function of the digestive system; digestion of proteins, carbohydrates, and lipids
7. Chapter 24: Oxidation-reduction reaction; importance of ions (minerals) in life processes; metabolism of carbohydrates, lipids, and proteins; basic chemistry of life examples
8. Chapter 25: Renal control of electrolytes
9. Chapter 26: Acid-base balance, electrolytes, and buffers; sodium and sodium-potassium pump
10. Appendix E: Periodic Table of the Elements

Lecture Hints

1. *Introduction to Chemistry for Biology Students*, Ninth Edition, by George Sackheim, is an excellent aid for students who need a quick brushup in chemistry or for those who need extra help. The book is designed as a self-paced learning guide. Most students should be able to finish a review of the essentials for Marieb Chapter 2 in about two to six hours.
2. As an alternative to presenting the chemistry in Chapter 2 as a distinct block of material, you could provide the absolute minimum coverage of the topics at this time and expand upon topics later as areas of application are discussed.
3. Students often find the concept of isotopes confusing. A clear distinction between atomic mass and atomic weight will help clarify the topic.
4. In discussing radioisotopes it might be helpful to refer the students back to the discussion of PET scans in *A Closer Look* in Chapter 1 (p. 16).
5. Oxidation-reduction reactions involve the loss and gain of electrons. The reactant oxidized will lose electrons while the reactant reduced will gain electrons. One easy way to remember this is by using the phrase "Leo the lion goes ger." Leo stands for "loss of electrons is oxidation," and ger for "gain of electrons is reduction."
6. In biological oxidation-reduction reactions the loss and gain of electrons is often associated with the loss and gain of hydrogen atoms. Electrons are still being transferred since the hydrogen atom contains an electron.
7. The relationship between the terms catalyst and enzyme can be clarified by asking the students if all enzymes are catalysts and if all catalysts are enzymes.
8. Table 2.4 is an excellent summary of the differences between DNA and RNA. This information will be important when discussing protein synthesis.
9. The notion that ATP is the "energy currency" of the cell should be emphasized. Students should realize that without ATP, molecules cannot be synthesized or degraded, cells cannot maintain boundaries, and life processes cease.
10. The cycling back and forth between ATP and ADP is a simple but important concept often overlooked by students.

Activities/Demonstrations

1. Audiovisual materials are listed in the Multimedia in the Classroom and Lab section of this Instructor Guide (p. 387).
2. Obtain and/or construct 3-D models of various types of biological molecules such as glucose, DNA, protein, and lipids.
3. Bring in materials or objects that are composed of common elements, e.g., a gold chain, coal, copper pipe, cast iron. Also provide examples of common compounds such as water, table salt, vinegar, and sodium bicarbonate. Solicit definitions of *atom*, *element*, and *compound* and an explanation of how an atom and a molecule of a compound differ.
4. Ask students to name all the foods containing saturated fats and all those containing unsaturated fats that they have eaten in the past 24 hours.

5. Obtain a two-foot-long piece of thick string or cord. Slowly twist to exhibit primary, secondary, and tertiary levels of protein organization.
6. Obtain a Thompson-style vacuum tube with an internal frosted plate (to exhibit electrons), a direct current generator (Tesla coil), and bar magnet. Turn off room lights and charge one end of the tube to start an electron beam. Use a magnet to move the electron beam up and down. This experiment helps to illustrate electrons as particles.
7. Obtain an electrolyte testing system (lightbulb setup connected to electrodes) and prepare a series of solutions such as salt, acid, base, glucose, etc. Place the electrodes into the solutions to illustrate the concept of electrolytes.
8. Prepare two true solutions (1% sodium chloride; 1% glucose) and two colloidal solutions (1% boiled starch, sol state; Jell-O®, gel state). Turn off the room lights and pass a beam of light through each to demonstrate the Tyndall effect of colloids.
9. Obtain two strings of dissimilar “pop-it” beads. Put the beads together to demonstrate a synthesis reaction, and take them apart to demonstrate a decomposition reaction. Take a bead from each different chain and put them together to illustrate an exchange reaction.
10. Use a metal or plastic “coil” toy to demonstrate denaturation of an enzyme. Tie colored yarn on the coil at two sites that are widely separated, and then twist the coil upon itself to bring the two pieces of yarn next to each other. Identify the site where the yarn pieces are as the active site. Then remind students that when the hydrogen bonds holding the enzyme (or structural protein) in its specific 3-D structure are broken, the active site (or structural framework) is destroyed. Untwist the coil to illustrate this point.

Critical Thinking/Discussion Topics

1. Discuss how two polysaccharides, starch and cellulose, each having the same subunit (glucose), have completely different properties. Why can we digest starch but not cellulose?
2. How and why can virtually all organisms—plant, animal, and bacteria—use the exact same energy molecule, ATP?
3. How could a substance such as alcohol be a solvent under one condition and a solute under another? Provide examples of solid, liquid, and gaseous solutions.
4. Describe how weak bonds can hold large macromolecules together.
5. Why can we state that most of the volume of matter, such as the tabletop you are writing on, is actually empty space?
6. When you drive up your driveway at night you see the light from the headlights on the garage door, but not in the air between the car and the door. Why? What would be observed if the night were foggy?
7. Why are water molecules at the surface of a drop of water closer together than those in the interior?

Library Research Topics

1. Explore the use of radioisotopes in the treatment of cancers.
2. Study the mechanisms by which DNA can repair itself.

3. Locate the studies of Niels Bohr concerning the structure of atoms and the location of electrons. Determine why his work with hydrogen gas provided the foundation of our knowledge about matter.
4. How can a doughnut provide us with so much "energy"? Find out exactly where this energy is coming from.
5. Phospholipids have been used for cell membrane construction by all members of the "cellular" world. What special properties do these molecules have to explain this phenomenon?
6. What are the problems associated with trans fatty acids in the diet? How has awareness of these effects changed our food practices?
7. Virtually every time an amino acid chain consisting of all 20 amino acids is formed in the cell, it twists into an alpha helix, then folds upon itself into a glob. Why?
8. What advances in science have come out of the sequencing of the human gemone (the Human Genome Project)?
9. What is DNA fingerprinting? Explore the applications of this technology.

List of Figures and Tables

All of the figures in the main text are available in JPEG format, PPT, and labeled & unlabeled format on the Instructor Resource DVD. All of the figures and tables will also be available in Transparency Acetate format. For more information, go to www.pearsonhighered.com/educator.

Answers to End-of-Chapter Questions

Multiple-Choice and Matching Question answers appear in Appendix H of the main text.

Short Answer Essay Questions

23. Energy is defined as the capacity to do work, or to put matter into motion. Energy has no mass, takes up no space, and can be measured only by its effects on matter. Potential energy is the energy an object has because of its position in relation to other objects. Kinetic energy is energy associated with a moving object. (p. 24)

24. Energy may be released in another form such as heat or light, which may be partly unusable. In this instance, energy is not “lost,” but simply converted to another form. (p. 24)

25. **a.** Ca, **b.** C, **c.** H, **d.** Fe, **e.** N, **f.** O, **g.** K, **h.** Na (Appendix E)

26. **a.** All three are carbon with six protons. (p. 27)
b. All possess different numbers of neutrons and therefore have different atomic masses. (p. 27)
c. Isotopes. (p. 28)
d. See Figure 2.1, which provides a drawing of a planetary model. (p. 25)

27. **a.** Add molecular weight of all atoms: 9 x 12 (C) + 8 x 1 (H) + 4 x 16 (O) = 180 g.
b. Total molecular weight equals the number of grams in one mole, in this case 180.
c. Divide the number of grams in the bottle by the number of grams in one mole of aspirin. This equals the total number of moles in the bottle.
d. Answer = 2.5 moles (p. 30)

28. **a.** Covalent. **b.** Covalent **c.** Ionic (pp. 32–33)

29. Hydrogen bonds are weak bonds that form when a hydrogen atom, already covalently linked to an electronegative atom, is attracted by another electronegative atom. Hydrogen bonding is common between water molecules, and in binding large molecules such as DNA and protein into specific three-dimensional shapes. (pp. 34–35)

30. **a.** The reversibility of the reaction can be indicated by double reaction arrows pointed in opposing directions.
b. When arrows are of equal length the reaction is at equilibrium.
c. Chemical equilibrium is reached when, for each molecule of product formed, one product molecule breaks down, releasing the same reactants. (p. 37)

31. Primary structure—linear sequence of amino acids in a polypeptide chain; second structure—coiling of primary structure into alpha helix or ß-pleated sheet; tertiary structure—folding of alpha helices or beta-pleated sheets into a ball-like, or globular, molecule.
(pp. 48–50)

32. Dehydration refers to the joining together of two molecules by the removal of water. Monosaccharides are joined to form disaccharides and amino acids are joined to form dipeptides (and proteins) by this process. Hydrolysis refers to the breakdown of a larger molecule such as a disaccharide into small molecules or monosaccharides by the addition of water at the bond that joins them. (p. 36)

33. Enzymes decrease activation energy and decrease the randomness of reactions by binding reversibly to the reacting molecules and holding them in the proper position(s) to interact. (p. 52)

34. Molecular chaperones are proteins that aid the folding of other proteins into their functional three-dimensional structures. They also inhibit incorrect folding. They are produced in great amounts when cells are damaged and proteins are denatured and must be replaced. (pp. 50–51)

35. The surface tension of water tends to pull water molecules into a spherical shape, and since the glass does not completely overcome this attractive force, water can elevate slightly above the rim of the glass. (pp. 34–35)

Critical Thinking and Clinical Application Questions

1. In a freshwater lake, there are comparatively few electrolytes (salts) to carry a current away from a swimmer's body. Hence, the body would be a better conductor of the current and the chance of a severe electrical shock if lightning hit the water is real. (p. 39)

2. **a.** Some antibiotics compete with the substrate at the active site of the enzyme. This would tend to reduce the effectiveness of the reaction.
   b. Because the bacteria would be unable to catalyze the essential chemical reactions normally brought about by the "blocked" enzymes, the anticipated effect would be the inhibition of its metabolic activities. This would allow white blood cells to remove them from the system. However, some human cells would also be affected and this could cause them to cease their functions, hopefully only temporarily. (p. 52)

3. **a.** pH is defined as the measurement of the hydrogen ion concentration in a solution. The normal blood pH is 7.4.
   b. Severe acidosis is critical because it can adversely affect cell membranes, the function of the kidneys, muscle contraction, and neural activity. (pp. 39–40)

4. The blood pH is rising, thus becoming more basic or alkaline. This is due to changes in the carbonic acid-bicarbonate buffer system in the blood. Hyperventilation will cause an increase in blood pH by reducing the amount of carbonic acid in the blood. (p. 39)

5. The proteins in the energy bar must undergo catabolic decomposition reactions in which they are enzymatically broken down to individual amino acids. The resulting amino acids can then be reassembled using anabolic synthesis reactions into either structural or functional proteins. (p. 36)

Suggested Readings

Gorman, Jessica. "Getting Out the Thorn: Biomaterials Become Friendlier to the Body." *Science News* 161 (1) (Jan. 2002): 13–14.

Russo, S., and M. Silver. *Introductory Chemistry: A Conceptual Focus*. San Francisco: Benjamin Cummings, 2000.

Ruvkun, Gary. "Glimpses of a Tiny RNA World." *Science* 294 (5543) (Oct. 2001): 797–799.