STUDENT STUDY GUIDE FOR

BIOLOGY

CAMPBELL • REECE

Sixth Edition

MARTHA R. TAYLOR

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Benjamin Cummings

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Benjamin Cummings

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PREFACE

Another name for the *Student Study Guide* for Campbell/Reece, *Biology,* Sixth Edition, could be "A Student Structuring Guide." The purpose of this guide is to help you to structure and organize your developing knowledge of biology and to create your own personal understanding of the topics covered in the text.

Biology is a visual science, and this *Student Study Guide* includes many diagrams and pictures taken from *Biology,* Sixth Edition, to help you see and understand the relationships among the parts of structures and processes. Interactive Questions, which are interspersed throughout each chapter's narrative, are designed to help you develop an active learning approach to your study of biology. The numerous multiple choice questions in each chapter will help you test your growing understanding of biological facts and concepts. (See the end of this Preface for tips on taking objective tests.) New to this sixth edition is a Word Roots section in most of the chapters, intended to help you learn the large new vocabulary that is a necessary part of a biology course.

The five divisions of each study guide chapter are as follows:

- The ***Framework*** identifies the overall picture; it provides a conceptual framework into which the chapter information fits.
- The ***Chapter Review*** is a condensation of each textbook chapter, with page references given for each concept heading within the chapter. All text bold terms are also shown in boldface in this section. Interspersed in this summary are **Interactive Questions** that help you stop and synthesize the material just covered. You are asked to complete tables, label diagrams, respond to short answer or essay questions, and complete or construct concept maps.
- The ***Word Roots*** section presents the derivation of key biological prefixes, suffixes, and word roots. Examples of bold-faced terms from the chapter are then defined. Breaking a complicated term down to identifiable components will help you to recognize and learn many new biological terms.
- The ***Structure Your Knowledge*** section directs you to organize and relate the main concepts of the chapter. It helps you to piece together the key ideas into a bigger picture.
- In the ***Test Your Knowledge*** section, you are provided with objective questions to test your understanding. The multiple choice questions presented in each chapter ask you to choose the best answer. Some answers may be partly correct; almost all choices have been written to test your ability to think and discriminate among alternatives. Make sure you understand why the other choices are incorrect as well as why the correct answer is correct.
- Suggested answers to the Interactive Questions, the Structure Your Knowledge sections, and the Test Your Knowledge questions are provided in the ***Answer Section*** at the end of the book.

Using Concept Maps: What are the ***concept maps*** that appear throughout this study guide? A concept map is a diagram that shows how ideas are organized and related. The *structure* of a concept map is a hierarchically organized cluster of concepts, enclosed in boxes and connected with labeled lines, that explicitly shows the relationships among the concepts. The *function* of a concept map is to help you structure your understanding of a topic and create meaning. The *value* of a concept map is in the thinking and organizing required to create a map.

Developing a concept map for a group of concepts requires you to evaluate the relative importance of the concepts (Which are most inclusive and important? Which are less important and subordinate to other concepts?), arrange the concepts in a meaningful cluster, and draw connections between them that help you make their meanings explicit.

This book uses concept maps in several ways. A map of a chapter may be presented in the Framework section to show the organization of the key concepts in that chapter. An Interactive Question may provide a skeleton concept map, with some concepts provided and boxes for you to complete. This technique is intended to help you become more familiar with concept maps and to illustrate one possible approach to organizing the concepts of a particular section.

You will also be asked to develop your own concept maps on certain subsets of ideas. In these cases, the Answer Section will present a suggested concept map. A concept map is an individual picture of your understanding at the time you make the map. As your understanding of an area develops, your concept map will evolve—sometimes becoming more complex and interrelated, sometimes becoming simplified and streamlined. Do not look to the Answer Section for the "right" concept map. After you have organized your own thoughts, look at the answer map to make sure you have included the key concepts (although you may have added more), to check that the connections you have made are reasonable, and perhaps to see another way to organize the information.

Tips for Using this Study Guide: This guide certainly is not a replacement for your textbook or biology class. But it should help support and even streamline your learning process. Some students read the assigned text chapters before lecture and then the study guide chapters after class to reinforce and review. Others reverse that order, skimming the study guide chapter before lecture and then carefully dissecting the text after listening to the professor's presentation. This study guide is especially helpful in preparation for tests. With the text open beside it so you can refer to the essential textbook diagrams, reread the relevant study guide chapters for a quick review. Return to the text for a more complete description of any sections that you don't fully understand.

Because this book is intended to help you learn, most incorrect choices given for multiple choice questions are written to be educational: to review other concepts covered in the chapter, to help you distinguish between closely related ideas, to point out common misconceptions of a particular concept. Get your money's worth out of this book. Even when you can quickly identify the correct answer to a question, take the time to read the other choices to see what they can teach you. Page back through the Chapter Summary section and the textbook to review material that you have not yet fully understood. Take your time with the Test Your Knowledge section—don't rush through it right before an exam. Treat it as an important learning opportunity. And use it to practice good test-taking skills.

Tips for Taking Multiple Choice Tests: Don't do all of your thinking in your head. Write in the margins and blank spaces of your test. Interact with each question. Read the stem of the question carefully, underlining or even using a highlighter to identify the key concept. Read each answer slowly. Cross out the ones you know are wrong. Circle the key idea that you think identifies the correct answer. Now read the question and the answer you chose together, making sure your choice really does answer what is asked. If you aren't sure about a question, try rereading the question and each choice individually. Draw yourself diagrams and pictures. Write down what you do know, and it may jog your memory. If you still are not sure, mark the question to come back to later. As you work through related questions, you may find information that helps you figure out that question. And remember, there is no substitute for good preparation, proper rest and nutrition, and a positive attitude.

Biology is a fascinating, broad, and exciting subject. Campbell/Reece, *Biology* is filled with terminology and facts organized in a manner that will help you build a conceptual framework of the major themes of modern biology. This *Student Study Guide* is intended to help you learn and recall information and, most importantly, to encourage and guide you as you develop your own understanding of and appreciation for biology.

Martha R. Taylor

CONTENTS

CHAPTER 1

INTRODUCTION: TEN THEMES IN THE STUDY OF LIFE

FRAMEWORK

This chapter outlines broad themes that unify the study of biology and describe the scientific construction of biological knowledge. A course in biology is neither a vocabulary course nor a classification exercise for the diverse forms of life. Biology is a collection of facts and concepts structured within theories and organizing principles. Recognizing the common themes within biology will help you to structure your knowledge of this fascinating and challenging study of life.

CHAPTER REVIEW

Biology, the scientific study of life, is an extension of our innate interest in life in its diverse forms. The scope of biology is immense, spanning the submicroscopic level to the complex web of ecosystems from the present back through nearly 4 billion years of evolutionary history. Recent advances in research methods have aided the efforts of a large number of contemporary biologists working throughout the many subfields of biology to achieve an explosion of information. A beginning student can make sense of this expanding body of knowledge by focusing on a few enduring themes that unify the study of biology.

Exploring Life on Its Many Levels

Each level of biological organization has emergent properties (2–4)

A Hierarchy of Organization The hierarchy of biological structure includes atoms, biological molecules, organelles, cells, tissues, organs, organ systems, organisms, populations, communities, and ecosystems. The study of biology encompasses these various levels of structure and the interactions among them.

Emergent Properties Interactions among components at each level of biological organization lead to the emergence of novel properties at the next level: The whole is greater than the sum of its parts. Structural arrangement is central to these emergent properties.

The properties of life include order, reproduction, growth and development directed by heritable programs, energy utilization, responsiveness to the environment, homeostasis, and evolutionary adaptation.

Reductionism in Biology Biology combines the powerful and pragmatic reductionist strategy, which breaks down complex systems to simpler components, with the study of higher organizational levels of life.

Cells are an organism's basic units of structure and function (4–6)

The cell is the simplest structural level capable of performing all the activities of life.

The Cell Theory Hooke first described and named cells in 1665 when he observed a slice of cork with a simple microscope. Leeuwenhoek, a contemporary, developed lenses that permitted him to view the world of microscopic organisms. In 1839, Schleiden and Schwann concluded that all living things consist of cells. This cell theory now includes the idea that all cells come from other cells.

The Two Main Cell Types Two major types of cells are recognized. The simpler prokaryotic cell, unique to bacteria and archaea, lacks both a nucleus to enclose its DNA and most cytoplasmic organelles. The eukaryotic cell, with its nucleus, DNA organized into chromosomes, and numerous membrane-bound compartments, is typical of all other living organisms.

The continuity of life is based on heritable information in the form of DNA (6–7)

The biological instructions for the development and functioning of organisms are coded in the arrangement of the four kinds of nucleotides in DNA molecules. A precise mechanism for replicating the DNA double helix is essential for cell division and for the transmission from parent to offspring of the units of inheritance called genes. All forms of life use essentially the same genetic code.

The first sequencing of the human genome, or complete set of genetic instructions, was published in 2001.

Structure and function are correlated at all levels of biological organization (7–8)

The form of a biological structure gives information about its function, and a study of function provides insight into structural organization. The principle that form fits function is illustrated at all levels of biological organization.

Organisms are open systems that interact continuously with their environments (8)

An organism exchanges materials and energy with its surroundings. Organisms affect and are affected by the physical and biological environments with which they interact.

Ecosystem Dynamics Within an ecosystem, nutrients cycle between the abiotic and biotic components, and energy flows from sunlight to photosynthetic organisms (producers) to consumers and exits in the form of heat.

Energy Conversion Photosynthetic plants convert solar energy to chemical energy. The work of cells relies on chemical energy, which may be converted to kinetic energy and which eventually dissipates as heat.

Regulatory mechanisms ensure a dynamic balance in living systems (8–9)

Enzymes are organic catalysts produced by a cell that speed up its chemical reactions. Precise regulation of its enzymes allows a cell to respond to changing conditions or needs. Organisms maintain an internal balance (homeostasis) through positive or negative feedback systems that either speed up or slow down body processes.

Evolution, Unity, and Diversity

Diversity and unity are the dual faces of life on Earth (9–12)

About 1.5 million species, out of an estimated total of 5–30 million, have been identified and named.

Grouping Species: The Basic Concept Taxonomy is the branch of biology that names organisms and classifies species into hierarchical groups.

The Three Domains of Life Traditionally, life forms have been organized into five kingdoms, although schemes of six, eight, or more kingdoms have recently been proposed. These varying numbers of kingdoms can be grouped into three domains. The prokaryotes are split into the domains Archaea and Bacteria, and the eukaryotes are placed in the domain Eukarya. Within the Eukarya, the traditional kingdom Protista contains mostly unicellular or simple multicellular forms. The other three kingdoms contain multicellular organisms characterized to a large extent by their mode of nutrition. Plants are photosynthetic, fungi absorb their nutrients from decomposing organic material, and animals ingest other organisms.

Unity in the Diversity of Life Within this diversity, living forms share a universal genetic language of DNA and similarities in cell structure.

Evolution is the core theme of biology (12–15)

Evolution connects all of life by common ancestry. The history of living forms extends back over 3.5 billion years to the ancient prokaryotes, and the incredible diversity of life is the result of evolution.

Darwin and Natural Selection In *The Origin of Species*, published in 1859, Charles Darwin presented his case for evolution, or "descent with modification," that present forms evolved from a succession of ancestral forms. Darwin synthesized the theory of natural selection as the mechanism of evolution by drawing an inference from two observations: Individuals vary in many heritable traits, and the overproduction of offspring sets up a struggle for existence. Individuals with traits best suited for an environment leave a larger proportion of offspring than do less fit individuals. This natural selection, or differential reproductive success within a population, results in the gradual accumulation of favorable adaptations to the challenges of an environment.

Natural Selection and the Diversity of Life According to Darwin, new species originate when isolated populations diversify over time in response to different environmental selective pressures. Evolution makes sense of both the unity and diversity of life.

The Process of Science

Science is a process of inquiry that includes repeatable observations and testable hypotheses (16–20)

Science is a way of knowing that involves asking and endeavoring to answer questions about nature.

Discovery Science and Induction Careful and verifiable observation and description are the basis of discovery science. Using inductive reasoning, a generalized conclusion can often be drawn from collections of observations.

Hypothetico-Deductive Science The scientific process is based on hypothetico-deductive reasoning. A hypothesis is a tentative explanation for an observation or question. Using "if . . . then" logic, deductive reasoning proceeds from the general to the specific, from a general hypothesis to specific predictions of results if the general premise is true. A hypothesis is usually tested by performing experiments or making observations to see whether predicted results occur.

The field and laboratory experiments of Reznick and Endler illustrate the hypothetico-deductive approach. By maintaining control populations and following generations of guppies transplanted from sites with pike-cichlids to sites with killifish for 11 years, they were able to conclude that natural selection due to differential predation was the most likely explanation for differences in life history characteristics between guppy populations.

The Reznick and Endler experimental design also illustrates the scientific use of controlled experiments in which subjects are divided into an experimental group and a control group. Both groups are treated alike except for the one variable that the experiment is trying to test.

Theories in Science Facts, in the form of observations and experimental results, are prerequisites of science, but it is the new ways of organizing and relating those facts that advance science. A theory is broader in scope than a hypothesis and is supported by a large body of evidence.

Science as a Social Process Most scientists work in teams and share their results with a broader research community in journal articles. Science is characterized as progressive and self-correcting. Scientists build on the work done by others, refining or refuting their ideas, both cooperating and competing with each other.

The Cultural Context of Science The political and cultural environment influences the ways in which scientists approach their work. But the adherence to the criteria of hypothesis testing and verifiable observations sets science apart from other ways of "knowing nature."

Science and technology are functions of society (21)

Science and technology are interwoven as the information generated by science is used in the development of goods and services, and as technological advances are used to extend scientific knowledge. The fields of molecular biology and genetic engineering illustrate this relationship. Technology contributes to our standard of living and has made it possible for the human population to expand rapidly but at a price of severe environmental consequences. Solutions to environmental problems and future uses of scientific knowledge and technologies will involve politics, economics, and cultural values as well as science and technology.

Review: Using Themes to Connect the Concepts of Biology

Biology is a demanding science—partly because living systems are so complex and partly because biology incorporates concepts from chemistry, physics, and math. This book presents a wealth of information. The basic themes of biology will help you understand, appreciate, and structure your growing knowledge of biology.

STRUCTURE YOUR KNOWLEDGE

1. This chapter presents ten unifying themes of biology. Briefly describe each of these in your own words:
   - **a.** emergent properties
   - **b.** the cell
   - **c.** heritable information
   - **d.** correlation of structure and function
   - **e.** interaction with the environment
   - **f.** regulation
   - **g.** unity and diversity
   - **h.** evolution
   - **i.** scientific inquiry
   - **j.** science, technology, and society

UNIT ONE

THE CHEMISTRY OF LIFE

CHAPTER 2

THE CHEMICAL CONTEXT OF LIFE

FRAMEWORK

This chapter considers the basic principles of chemistry that explain the behavior of atoms and molecules and that form the basis for our modern understanding of biology. Emergent properties are associated with each new level of structural organization as the subatomic particles—protons, neutrons, and electrons—are organized into atoms and atoms are combined by covalent or ionic bonds into molecules.

INTERACTIVE QUESTION 2.1

On Earth, mass and weight may be considered synonymous.

a. Define mass.

b. Define weight.

CHAPTER REVIEW

Chemical Elements and Compounds

Matter consists of chemical elements in pure form and in combinations called compounds (26–28)

Matter is anything that takes up space and has mass. The basic forms of matter are **elements**, substances that cannot be chemically broken down to other types of matter. A **compound** is made up of two or more elements combined in a fixed ratio. A compound usually has characteristics quite different from its constituent elements, an example of the emergence of novel properties in higher levels of organization.

Life requires about 25 chemical elements (27–28)

Carbon (C), oxygen (O), hydrogen (H), and nitrogen (N) make up 96% of living matter. The remaining 4% is composed of the seven elements listed on the following page. Some elements, like iron (Fe) and iodine (I), may be required in very minute quantities and are called **trace elements.**

Atoms and Molecules

Atomic structure determines the behavior of an element (28–33)

An **atom** is the smallest unit of an element retaining the physical and chemical properties of that element. Each element has its own unique type of atom.

INTERACTIVE QUESTION 2.2

Fill in the names beside the symbols of the following elements commonly found in living matter.

Symbol	Element
Ca	
P	
K	
S	
Na	
Cl	
Mg	

Subatomic Particles Three stable subatomic particles are important to our understanding of atoms. Uncharged **neutrons** and positively charged **protons** are packed tightly together to form the **atomic nucleus** of an atom. Negatively charged **electrons** orbit rapidly about the nucleus.

Protons and neutrons have a similar mass of about 1.7×10^{-24} g or 1 **dalton** each. A dalton is the measurement unit for atomic mass. Electrons have negligible mass.

Atomic Number and Atomic Weight Each element has a characteristic **atomic number,** or number of protons in the nucleus of its atom. Unless otherwise indicated, the number of protons in an atom is equal to the number of electrons, and the atom has a neutral electrical charge. A subscript to the left of the symbol for an element indicates its atomic number; a superscript indicates mass number. The **mass number** is equal to the number of protons and neutrons in the nucleus and approximates the mass of an atom of that element in daltons. The term **atomic weight** is often used to refer to the mass of an atom.

INTERACTIVE QUESTION 2.3

The difference between the mass number and the atomic number of an atom is equal to the number of __________. An atom of phosphorus, $^{31}_{15}P$, contains _____ protons, _____ electrons, and _____ neutrons. The atomic weight of phosphorus is __________.

Isotopes Although the number of protons is constant, the number of neutrons can vary among the atoms of an element, creating different **isotopes** that have slighlty different masses but the same chemical behavior. Some isotopes are unstable, or radioactive; their nuclei spontaneously decay, giving off particles and energy.

Radioactive isotopes are important tools in biological research and medicine. Techniques using scintillation counters or autoradiography can determine the quantity and location of radioactively labeled molecules within a cell or tissue. Chemical processes can be located and monitored within an organism using radioactive tracers and PET (positron-emission tomography). Too great an exposure to radiation from decaying isotopes poses a significant health hazard.

The Energy Levels of Electrons **Energy** is defined as the ability to do work. **Potential energy** is energy stored in matter as a consequence of the relative position of masses. Matter naturally tends to move toward a more stable lower level of potential energy and requires the input of energy to return to a higher potential energy.

The potential energy of electrons increases as their distance from the positively charged nucleus increases. Electrons can orbit in several different potential energy states, called **energy levels** or **electron shells,** surrounding the nucleus.

INTERACTIVE QUESTION 2.4

To move to a shell farther from the nucleus, an electron must (absorb/release) energy; energy is (absorbed/released) when an electron moves to a closer shell. (Circle correct terms.)

Electron Configuration and Chemical Properties The chemical behavior of an atom is a function of its electron configuration—in particular, the number of **valence electrons** in its outermost electron shell, or **valence shell.** A valence shell of eight electrons is complete, resulting in an unreactive or inert atom. Atoms with incomplete valence shells are chemically reactive because of their unpaired electrons. The periodic table of elements is arranged in order of the sequential addition of electrons to orbitals in the electron shells.

Electron Orbitals An **orbital** is the three-dimensional space or volume within which an electron is most likely to be found. No more than two electrons can occupy the same orbital. The first electron shell can contain two electrons in a single spherical orbital, called the 1*s* orbital. The second electron shell can hold a maximum of eight electrons in its four orbitals, which are a 2*s* spherical orbital and three dumbbell-shaped *p* orbitals located along the *x*, *y*, and *z* axes.

INTERACTIVE QUESTION 2.5

Draw the electron configuration for these atoms.

a. $_{7}N$

c. $_{12}Mg$

b. $_{8}O$

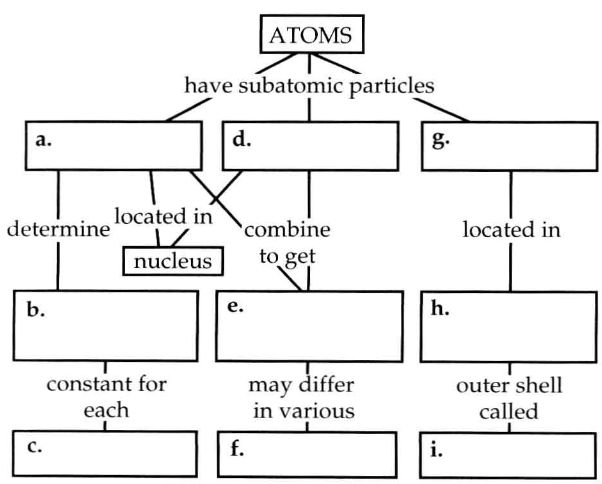
d. $_{17}Cl$

Atoms combine by chemical bonding to form molecules (33–36)

Atoms with incomplete valence shells can either share electrons with or completely transfer electrons to or from other atoms such that each atom is able to complete its valence shell. These interactions usually result in attractions, called **chemical bonds,** that hold the atoms together.

INTERACTIVE QUESTION 2.6

Fill in the blanks in the following concept map to help you review the atomic structure of atoms.



Covalent Bonds When two atoms share a pair of valence electrons, a **covalent bond** is formed. A **molecule** consists of two or more atoms held together by covalent bonds. A **structural formula,** such as H—H, indicates both the number and type of atoms and also the bonding within a molecule. A **molecular formula,** such as O_2, indicates only the kinds and numbers of atoms in a molecule. In an oxygen molecule, two pairs of valence electrons are shared between oxygen atoms, forming a **double covalent bond.**

The **valence,** or bonding capacity, of an atom equals the number of unpaired electrons in its valence shell.

INTERACTIVE QUESTION 2.7

What are the valences of the four most common elements of living matter?

a. hydrogen ____

c. nitrogen ____

b. oxygen ____

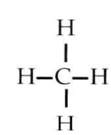
d. carbon ____

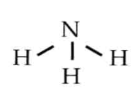
Electronegativity is the attraction of an atom for shared electrons. If the atoms in a molecule have similar electronegativities, the electrons remain equally shared between the two nuclei, and the covalent bond is said to be **nonpolar.** If one element is more electronegative, it pulls the shared electrons closer to itself, creating a **polar covalent bond.** This unequal sharing of electrons results in a slight negative charge associated with the more electronegative atom and a slight positive charge associated with the atom from which the electrons are pulled.

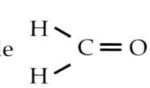
INTERACTIVE QUESTION 2.8

Explain whether the following molecules contain nonpolar or polar covalent bonds. (Hint: N and O both have high electronegativities.)

a. nitrogen molecule N≡N

b. methane 

c. ammonia 

d. formaldehyde 

Ionic Bonds If two atoms are very different in their attraction for the shared electrons, the more electronegative atom may completely transfer an electron from another atom, resulting in the formation of charged atoms called **ions.** The atom that lost the electron is a positively charged **cation.** The negatively charged atom that gained the electron is called an **anion.** An **ionic bond** may hold these atoms together because of the attraction of their opposite charges. **Ionic compounds,** called **salts,** often exist as three-dimensional crystalline lattice arrangements held together by electrical attraction. The number of ions present in a salt crystal is not fixed, but the atoms are present in specific ratios. Salts have strong ionic bonds when dry, but the crystal dissolves in water.

Ion also refers to entire covalent molecules that are electrically charged. Ammonium (NH_4^+) is a cation; this covalently bonded molecule is missing one electron.

INTERACTIVE QUESTION 2.9

Calcium ($_{20}Ca$) and chlorine ($_{17}Cl$) can combine to form the salt calcium chloride. Based on the number of electrons in their valence shells and their bonding capacities, what would the molecular formula for this salt be? **a.** ____________________ Which atom becomes the cation? **b.** ____________________

Weak chemical bonds play important roles in the chemistry of life (36–37)

Weak bonds, such as ionic bonds in water, form temporary interactions between molecules and are involved in many biological signals and processes. Weak bonds within large molecules such as proteins help to create the three-dimensional shape and resulting activity of these molecules.

Hydrogen Bonds When a hydrogen atom is covalently bonded with an electronegative atom and thus has a partial positive charge, it can be attracted to another electronegative atom and form a **hydrogen bond.**

Van der Waals Interactions All atoms and molecules are attracted to each other when in close contact by **van der Waals interactions.** Momentary uneven electron distributions produce changing positive and negative regions that create these weak attractions.

INTERACTIVE QUESTION 2.10

Sketch a water molecule, showing oxygen's electron shells and the covalently shared electrons. Indicate the areas with slight negative and positive charges that enable a water molecule to form hydrogen bonds with other polar molecules.

A molecule's biological function is related to its shape (37–38)

A molecule's characteristic size and shape affect how it interacts with other molecules. When atoms form covalent bonds, their *s* and three *p* orbitals hybridize to form four teardrop-shaped orbitals in a tetrahedral arrangement. These hybrid orbitals dictate the specific shapes of different molecules.

Chemical reactions make and break chemical bonds (38–39)

Chemical reactions involve the making or breaking of chemical bonds in the transformation of matter into different forms. Matter is conserved in chemical reactions; the same number and kinds of atoms are present in both **reactants** and **products,** although the rearrangement of electrons and atoms causes the properties of these molecules to be different.

INTERACTIVE QUESTION 2.11

Fill in the missing coefficients for respiration, the conversion of glucose and oxygen to carbon dioxide and water, so that all atoms are conserved in the chemical reaction.

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

Most reactions are reversible—the products of the forward reaction can become reactants in the reverse reaction. Increasing the concentrations of reactants can speed up the rate of a reaction. **Chemical equilibrium** may be reached when the forward and reverse reactions proceed at the same rate, and the relative concentrations of reactants and products no longer change.

WORD ROOTS

an- = not (*anion:* a negatively charged ion)
co- = together; **-valent** = strength (*covalent bond:* an attraction between atoms that share one or more pairs of outer-shell electrons)
electro- = electricity (*electronegativity:* the tendency for an atom to pull electrons towards itself)
iso- = equal (*isotope:* an element having the same number of protons and electrons but a different number of neutrons)
neutr- = neither (*neutron:* a subatomic particle with a neutral electrical charge)
pro- = before (*proton:* a subatomic particle with a single positive electrical charge)

STRUCTURE YOUR KNOWLEDGE

Take the time to write out or discuss your answers to the following questions. Then refer to the suggested answers at the end of the book.

1. Fill in the following chart for the major subatomic particles of an atom.

Particle	Charge	Mass	Location

2. Atoms can have various numbers associated with them.
   a. Define the following and show where each of them is placed relative to the symbol of an element such as C: atomic number, mass number, atomic weight.
   b. Define valence.
   c. Which of these four numbers is most related to the chemical behavior of an atom? Explain.
3. Explain what is meant by saying that the sharing of electrons between atoms falls on a continuum from covalent bonds to ionic bonds.

TEST YOUR KNOWLEDGE

MULTIPLE CHOICE: *Choose the one best answer.*

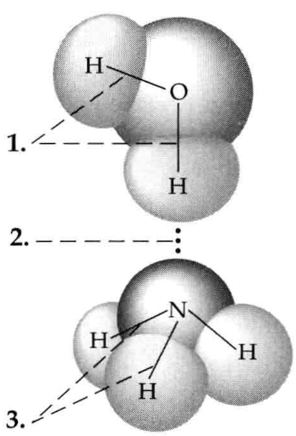
1. Each element has its own characteristic atom in which
   a. the atomic weight is constant.
   b. the atomic number is constant.
   c. the mass number is constant.
   d. two of the above are correct.
   e. all of the above are correct.
2. Radioactive isotopes can be used in studies of metabolic pathways because
   a. their half-life allows a researcher to time an experiment.
   b. they are more reactive.
   c. the cell does not recognize the extra protons in the nucleus, so isotopes are readily used in metabolism.
   d. their location or quantity can be experimentally determined because of their radioactivity.
   e. their extra neutrons produce different colors that can be traced through the body.
3. In a reaction in chemical equilibrium,
   a. the forward and reverse reactions are occurring at the same rate.
   b. the reactants and products are in equal concentration.
   c. the forward reaction has gone further than the reverse reaction.
   d. there are equal numbers of atoms on both sides of the equation.
   e. a, b, and d are correct.
4. Oxygen has eight electrons. You would expect the arrangement of these electrons to be:
   a. eight in the second energy shell, creating an inert element.
   b. two in the first energy shell and six in the second, creating a valence of six.
   c. two in the 1*s* orbital and two each in the three 2*p* orbitals, creating a valence of zero.
   d. two in the 1*s* orbital, one each in the 2*s* and three 2*p* orbitals, and two in the 3*s* orbital, creating a valence of two.
   e. two in the 1*s* orbital, two in both the 2*s* and 2*px* orbitals, and one each in the 2*py* and 2*pz* orbitals, creating a valence of two.

5. A covalent bond between two atoms is likely to be polar if
a. one of the atoms is much more electronegative than the other.
b. the two atoms are equally electronegative.
c. the two atoms are of the same element.
d. the bond is part of a tetrahedrally shaped molecule.
e. one atom is an anion.

6. A triple covalent bond would
a. be very polar.
b. involve the bonding of three atoms.
c. involve the bonding of six atoms.
d. produce a triangularly shaped molecule.
e. involve the sharing of six electrons.

7. A cation
a. has gained an electron.
b. can easily form hydrogen bonds.
c. is more likely to form from an atom with six or seven electrons in its valence shell.
d. has a positive charge.
e. Both c and d are correct.

8. What types of bonds are identified in the following illustration of a water molecule interacting with an ammonia molecule?



a. Bonds 1 are polar covalent bonds, bond 2 is a hydrogen bond, and bonds 3 are nonpolar covalent bonds.
b. Bonds 1 and 3 are polar covalent bonds and bond 2 is a hydrogen bond.
c. Bonds 1 and 3 are polar covalent bonds and bond 2 is an ionic bond.
d. Bonds 1 and 3 are nonpolar covalent bonds and bond 2 is a hydrogen bond.
e. Bonds 1 and 3 are polar covalent bonds and bond 2 is a nonpolar covalent bond.

9. Which of the following weak bonds may form between any closely aligned molecules?
a. nonpolar covalent
b. polar covalent
c. ionic
d. hydrogen
e. van der Waals interactions

10. The ability of morphine to mimic the effects of the body's endorphins is due to
a. a chemical equilibrium developing between morphine and endorphins.
b. the one-way conversion of morphine into endorphin.
c. molecular shape similarities that allow morphine to bind to endorphin receptors.
d. the similarities between morphine and heroin.
e. hydrogen bonding and other weak bonds forming between morphine and endorphins.

The six elements most common in living organisms are:

$^{12}_{6}C$ $^{16}_{8}O$ $^{1}_{1}H$ $^{14}_{7}N$ $^{32}_{16}S$ $^{31}_{15}P$

Use this information to answer questions 11 through 16.

11. How many electrons does phosphorus have in its valence shell?
a. 5
b. 7
c. 8
d. 15
e. 16

12. What is the atomic weight of phosphorus?
a. 15
b. 16
c. 31
d. 46
e. 62

13. A radioactive isotope of carbon has the mass number 14. How many neutrons does this isotope have?
a. 6
b. 7
c. 8
d. 12
e. 14

14. How many covalent bonds is a sulfur atom most likely to form?
a. 1
b. 2
c. 3
d. 4
e. 5