Study Guide

Biology

By

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About the Author

Wendy O'Neal has a Master of Science degree in biology from McNeese State University in Lake Charles, Louisiana. While pursuing her degree, she was the lead graduate assistant and acted as instructor in the zoology and human anatomy and physiology laboratories. She went on to become the senior lab technician in the water division of the City of Lake Charles. Currently, she's continuing her education with coursework in technology.

Contents

INTRODUCTION

Welcome to the wonderful world of biology! Few subjects can teach as much about the world around you. During this course, you'll gain insight into the origin of life, the relationships among all living organisms, and even how your own body works.

The textbook for this course is *Essentials of Biology* by Sylvia S. Mader.

The course consists of five lessons. Each lesson covers information from several chapters of the textbook. This study guide gives you your reading assignments for each chapter of your textbook. It also highlights and clarifies important information in each chapter.

At the end of each lesson, you must submit an examination covering information from all of the chapters in that lesson.

OBJECTIVES

When you complete this course, you'll be able to

- Describe the characteristics of living things
- Identify the structure and function of eukaryotic cells
- Explain the process of photosynthesis
- Describe the characteristics of ionic and covalent bonds
- List the steps involved in cellular respiration
- Explain the processes of mitosis and meiosis
- Discuss the basic principles of genetics
- Describe the structure and function of DNA and RNA
- List the domains and kingdoms of living organisms
- Discuss Darwin's theory of natural selection
- Name the major plant groups and outline the characteristics of each

- List the characteristics of the major classes of invertebrates
- Name and describe eight classes of vertebrates
- Discuss the functions of four types of animal tissues
- Identify the components and functions of major human organ systems
- Explain the factors that influence population growth
- Describe how communities are organized and how they develop
- Explain the effects modern agriculture has had on many of the world's ecosystems

COURSE MATERIALS

This course includes the following materials:

1. This study guide, which includes an introduction to your course, plus
    - A lesson assignments page with a schedule of study assignments
    - Introductions to lessons and assignments, which emphasize the main points in the textbook
    - Self-checks and answers designed to measure your understanding of the course material as you proceed through the course
    - An exam for each lesson that you'll submit as you progress through the course
2. Your course textbook, *Essentials of Biology*, by Sylvia S. Mader, which contains your assigned readings

KNOW YOUR TEXTBOOK

Your textbook, *Essentials of Biology*, contains most of the detailed information upon which your examinations are based. You should read your assignments carefully and thoroughly. Your textbook material is divided into chapters. The pages for each chapter are clearly indicated in this study guide.

Listed below are some of the features of your textbook:

- Key concepts to help you focus on what you should learn in each chapter
- Short questions that test your knowledge about what you've read
- Exercises that teach you to think critically
- Suggested readings
- A glossary of key terms
- An index for fast, easy reference of topics

At the end of every chapter in your textbook is a "Summary." Please read this material carefully as a check to your understanding. Following the "Summary" are a number of tools you can use to review the material you've just studied. We highly recommend that you complete "Thinking Scientifically," "Testing Yourself," "Bioethical Issue," and "Understanding the Terms." The answers to these questions and problems (except for the "Bioethical Issue") are included in Appendix A, beginning on page 597.

A STUDY PLAN

This study guide is intended to help you achieve the maximum benefit from the time you spend on this course. It doesn't replace the textbook in any way. It serves as an introduction to the material that you'll read in the book and as an aid to assist you in understanding this material.

This study guide divides your course into five lessons. Each lesson contains several assignments, with a self-check for each assignment. A comprehensive examination covers the material for each of the five lessons. Be sure to complete all work related to a lesson before moving on to the next lesson.

Below is a suggested format for using this study guide. Remember that this is only a suggested plan. If you feel that another method would help you learn more effectively, by all means use that method.

1. Note the pages for each assignment.
2. Scan the assigned pages in the textbook. Make a note of the headings and illustrations. Write down questions to yourself in the margin of the textbook or on a separate sheet of paper.
3. Keep your textbook open to the chapter assignment and read the assignment text in this study guide. When the study guide makes references to passages or figures in the textbook, refer to the text to complete your understanding. It may answer your questions or inspire more.
4. Read the assigned pages in the textbook. This time, pay more attention to details. Concentrate on gaining an understanding of the concepts being presented.
5. Read the text in this study guide again. Check on anything that's still not clear, and reexamine the pages and illustrations to which the study guide refers. Then complete the self-check. Don't submit your answers for the self-checks to the school for grading. You can check your own answers using the answers at the back of this study guide. If you have problems completing any self-check question, reread the sections of the textbook that pertain to the problem area. If you still need assistance, contact your instructor.
6. When you've completed all of the assignments for the first lesson and you feel confident that you understand the material covered in these assignments, take the lesson examination. Follow the directions for submitting your exams.

7. When you receive the results of your examination, don't dwell on the mistakes you made. Simply note which questions you answered wrong, go back to the textbook to locate the right answer, and move on. A successful learner isn't someone who never makes mistakes; a successful learner is someone who learns to benefit from correcting mistakes. After all, once you've corrected a mistake, you know the right answer and shouldn't make the same mistake again.

Repeat these steps for each lesson in this course.

You're now ready to begin Lesson 1. Good luck and have fun!

NOTES

Lesson 1: The Cell

For:	Read in the study guide:	Read in the textbook:
Assignment 1	Pages 9–12	Pages 1–14
Assignment 2	Pages 14–16	Pages 15–28
Assignment 3	Pages 19–22	Pages 29–46
Assignment 4	Pages 24–26	Pages 47–68
Assignment 5	Pages 29–31	Pages 69–82
Assignment 6	Pages 33–35	Pages 83–96
Assignment 7	Pages 37–39	Pages 97–110
	Examination 00764600	Material in Lesson 1

Lesson 2: Genetics

For:	Read in the study guide:	Read in the textbook:
Assignment 8	Pages 45–48	Pages 111–126
Assignment 9	Pages 51–53	Pages 127–140
Assignment 10	Pages 55–57	Pages 141–158
Assignment 11	Pages 60–62	Pages 159–178
Assignment 12	Pages 64–66	Pages 179–194
Assignment 13	Pages 68–71	Pages 195–214
	Examination 00764700	Material in Lesson 2

Lesson 3: Evolution and the Diversity of Life

For:	Read in the study guide:	Read in the textbook:
Assignment 14	Pages 80–83	Pages 215–230
Assignment 15	Pages 85–87	Pages 231–244
Assignment 16	Pages 89–92	Pages 245–264
Assignment 17	Pages 94–97	Pages 265–282
Assignment 18	Pages 99–101	Pages 283–304
Assignment 19	Pages 103–109	Pages 305–336
	Examination 00764800	Material in Lesson 3

Lesson 4: Structure and Function in Plants and Animals

For:	Read in the study guide:	Read in the textbook:
Assignment 20	Pages 118–121	Pages 337–354
Assignment 21	Pages 123–126	Pages 355–376
Assignment 22	Pages 128–131	Pages 377–394
Assignment 23	Pages 133–135	Pages 395–412
Assignment 24	Pages 137–142	Pages 413–434
Assignment 25	Pages 145–146	Pages 435–454
Assignment 26	Pages 148–151	Pages 455–470
Assignment 27	Pages 153–157	Pages 471–492
Assignment 28	Pages 159–163	Pages 493–510
Assignment 29	Pages 165–168	Pages 511–532
	Examination 00764900	Material in Lesson 4

Lesson 5: Ecology

For:	Read in the study guide:	Read in the textbook:
Assignment 30	Pages 175–178	Pages 533–550
Assignment 31	Pages 180–184	Pages 551–574
Assignment 32	Pages 186–187	Pages 575–595
	Examination 00765000	Material in Lesson 5

Lesson 1

The Cell

Your first lesson consists of seven assignments that cover Chapters 1–7 of your textbook, pages 1–110. Chapter 1 introduces the science of biology. Chapters 2–7 cover the cell.

When you complete this lesson, you'll be able to

- Describe the characteristics of living things
- Discuss the levels of biological organization and how organisms are classified
- Explain the atomic structure of matter and the different kinds of chemical bonds
- Explain why water is vital to life on Earth
- Summarize the properties of organic compounds based on carbon
- Describe and explain the structural organization of cells
- Explain how cells make adenosine triphosphate (ATP)
- Identify the basic processes of photosynthesis
- Discuss the nature of cellular respiration

ASSIGNMENT 1: A VIEW OF LIFE

Refer to the following information as you read Chapter 1, "A View of Life," pages 1–14 in your textbook.

The Unity and Diversity of Life

Biology is the scientific study of life. Several characteristics help to define the term *life:*

1. All living things are composed of cells, which inherit DNA from a parent organism through reproduction.
2. All living things obtain energy from their surroundings and use it to grow, develop, and maintain specific internal conditions.
3. Living organisms can sense changes in their environment and adjust their activities in response to those changes.

Review and study the illustrations on page 1 of your textbook. As you examine these illustrations, think about life's diversity. Review Figure 1.1 on page 2 to consider the chain of biological organization from molecules to cells and onward to tissues, organs, organ systems, and complex organisms that live and breath. The *cell,* which you'll be studying throughout this lesson, is the smallest unit of biological organization that displays all of the characteristics of life. Multicelled organisms are made up of specialized cells that have been organized into tissues and organs.

How the Biosphere Is Organized

Many organisms of the same kind that live in close proximity to one another make up a *population*. All populations (of different types of organisms) that live in a certain area form a *community*. A community together with its physical environment forms the next level of organization—the *ecosystem*.

Within an ecosystem are producers, consumers, and decomposers. Review Figure 1.4 on page 5 of your textbook for an illustration of the three members that make up a grassland, which is one kind of terrestrial ecosystem. The highest level of organization is the *biosphere*. Looked at from space, the biosphere is a thin, fragile layer over Earth's surface. It includes the areas of the lower atmosphere, the oceans, and various land surfaces that are able to support life.

How Organisms Are Classified

Biologists use the science of *taxonomy* to classify organisms into groups, according to the way in which they're related to one another. Classification categories range from the most specific (a *species*) to the very general (a *domain*).

The standard system of classification separates all living organisms into three domains (domain Archaea, domain Bacteria, and domain Eukarya). Domain Eukarya is further categorized into four kingdoms. Here's an explanation of each:

1. *Domain Archaea* is made up of prokaryotic, unicellular organisms that live in extreme habitats, such as deep ocean steam vents. (The term *prokaryotic* is used to describe an organism that lacks the membrane-bounded nucleus and membranous organelles typical of eukaryotes.)
2. *Domain Bacteria* consists of prokaryotic, unicellular, bacteria. They inhabit a wide variety of environments and display a remarkable range of adaptations.
3. *Domain Eukarya* consists of four kingdoms:
    a. *Kingdom Protista* are organisms that may be unicellular, multicelled, or *colonial* (living in colonies). They have more internal complexity than prokaryotes.

    b. *Kingdom Fungi* are eukaryotic, multicelled organisms that display extracellular digestion. That is, they break down organic debris as a source of sustenance.

    c. *Kingdom Plantae* are multicelled, eukaryotic, photosynthetic producers with vascular tissues.

    d. *Kingdom Animalia* are eukaryotic, multicelled, consumers that are usually mobile.

Review the excellent photographs and accompanying text in Figures 1.5–1.10 on pages 6 and 7 to get a feel for the nature of the biological domains and kingdoms.

Science As a Way of Knowing

The scientific approach to studying biology should always include the following steps:

1. Develop a question you would like to answer based on observations you've made.
2. Based on your observations and on what others have found in the past, develop a hypothesis, which is your best guess of possible answers to the questions you've posed.

3. Based on your hypothesis, predict what you think will occur.
4. Find ways to test your predictions by conducting experiments or by making further observations.
5. Develop conclusions by analyzing and reporting your test results.

Figure 1.12 on page 9 presents a flow diagram describing the scientific method. Study this figure and then read the example of a controlled study on pages 10–11.

Science and Society

Technologies developed from the biological sciences have often provided mixed blessings. For example, the use of fertilizers produced spectacular increases in agricultural efficiency and productivity. On the other hand, fertilizer runoff from farmlands has also contaminated groundwater and caused other kinds of ecological damage. In a nutshell, human needs must be evaluated in terms of the ecological pros and cons of new technologies.

Self-Check 1

At the end of each section of *Introduction to Biology,* you'll be asked to pause and check your understanding of what you've just read by completing a "Self-Check" exercise. Answering these questions will help you review what you've studied so far. Please complete Self-Check 1 now.

1. _______ are the smallest units of life.

   a. Protons
   b. Cells
   c. Molecules
   d. Proteins

2. Which one of the following lists shows the *correct* order of biological organization?

   a. Ecosystem, population, community, biosphere
   b. Community, population, biosphere, ecosystem
   c. Population, community, ecosystem, biosphere
   d. Biosphere, community, population, ecosystem

3. Organisms that depend on food energy stored in other living organisms are called

   a. protists.
   b. producers.
   c. composers
   d. consumers.

4. The processes in organisms by which internal conditions—like temperature and acidity—are kept about the same is called

   a. homeostasis.
   b. photosynthesis.
   c. metabolism.
   d. nutrition.

5. The life-domain whose members live in very harsh environments, such as salt lakes and hot springs, is called

   a. Fungi.
   b. Eubacteria.
   c. Archaea.
   d. Protista.

6. During a scientific experiment, the control group is

   a. identical to the experimental group.
   b. not aware of the experiment taking place.
   c. different from the experimental group in all respects.
   d. identical to the experimental group in all areas except the variable being tested.

Check your answers with those on page 193.

ASSIGNMENT 2: THE CHEMICAL BASIS OF LIFE

Refer to the following information as you read Chapter 2, "The Chemical Basis of Life," pages 15–28 in your textbook.

The Nature of Matter

Atomic Structure

The *nucleus,* or center, of an atom is composed of *protons* (positively charged particles) and *neutrons* (uncharged particles). Under most conditions, *electrons* (very light negatively charged particles) balance the positive charges of nuclear protons.

The number of protons in the nucleus of an atom represents its unique *atomic number*. For example, oxygen contains eight protons in its nucleus and has an atomic number of eight. Hydrogen contains only one nuclear proton and has an atomic number of one. On page 17 of your textbook, the diagram in Figure 2.2 illustrates the protons, neutrons, and electrons in an atom of helium. Study this illustration carefully.

The Periodic Table

The *periodic table* is a tabular arrangement of the chemical elements according to atomic number. As shown on page 17, the number that appears above the atomic symbol represents the atomic number, or the number of protons in the nucleus, of the element. Figure 2.3 illustrates a portion of the periodic table of the elements.

Atoms of a particular element can vary in the number of neutrons they contain. Atoms that vary in neutron number are called *isotopes.* Some unstable isotopes—like carbon 14—are radioactive.

Electrons occupy cloudlike orbits around atomic nuclei. Figure 2.6 on page 19 of your textbook illustrates the atoms of the six elements that are important to life—CHNOPS, or carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. You should be able to recognize and draw the shell models for these elements.

Types of Chemical Bonds

Based on how their electrons interact, two or more atoms can join to form a *molecule*. For this course, you should understand the following two types of atomic bonding:

1. *Ionic bonding* occurs when atoms either donate or accept electrons from another atom. For example, ionic bonding may occur when one atom has a vacancy in its outer shell and another has only one electron in its outer orbital that can be easily removed. The atom that donates an electron becomes positively charged, while the atom that gains an electron becomes negatively charged. The two atoms are now attracted to each other and can join to form a molecule. Review Figure 2.7 on page 20 to visualize the way chlorine and sodium join to form molecules of sodium chloride—common table salt.

2. *Covalent bonding* occurs when each of two atoms has an unpaired electron in its outer electron shell. Each atom exerts a force on the unpaired electron of the other, pulling them together. The unpaired electrons are then shared between the two atoms. This sharing of electrons may be equal between the two atoms, producing what's called a *nonpolar bond.* It may also be unequal, causing one end of the molecule to have a slight positive charge and the other end to have a slight negative charge. Unequal electron sharing produces a polar covalent bond. Covalent bonding is illustrated in your textbook on pages 20–21.

Water's Importance to Life

Water is the most important substance on Earth. Life couldn't occur without it, because it has several important properties:

1. *Water is a solvent.* Water molecules attract other polar molecules and can separate them. In a water solution, for example, sodium chloride is dissociated into negative (Cl) and positive (Na) ions.

2. *Water is cohesive and adhesive.* The *cohesive* quality of water causes its molecules to cling to each other; the *adhesive* quality of water causes water to stick to polar surfaces. Both of these qualities make water an excellent transport system.

3. *Water has a high surface tension.* Because of the hydrogen bonding in water, it has a high surface tension. That is, the molecules on the surface of the liquid are attracted to each other, thereby creating a barrier between the air and the liquid.

4. *Water has a high heat capacity.* Because of this quality, water helps to stabilize temperature by absorbing large amounts of heat energy.

5. *Water is less dense as ice.* That is, as water freezes, it becomes less dense. Therefore, ice floats and forms on top of bodies of water. If ice sank, bodies of water might freeze completely, thus preventing life from existing in the water.

If water molecules dissociate, they must yield an equal quantity of hydrogen ions (H^+) and hydroxide ions (OH^-). But, for example, when vinegar is in a water solution, the result is a higher concentration of H^+ ions. Thus, a vinegar solution is *acidic.* By contrast, if ammonia is in a water solution, hydroxide ions (OH^-) are more prevalent, and the solution becomes an *alkali base.* Review the information about acids, bases, and pH levels in Figure 2.17 on page 26.

Before proceeding to the next assignment, take a moment to complete *Self-Check 2.*

Self-Check 2

1. The subatomic particle that carries a positive electrical charge is the

    a. electron.
    b. proton.
    c. isotope.
    d. neutron.

2. When an atom has two or more outer electron shells, the outer shell will be *most* stable if it contains eight electrons. This concept is called the

    a. valence rule.
    b. rule of eight.
    c. octet rule.
    d. isotope rule.

3. When two oxygen atoms join together, a _______ is formed.

    a. mixture
    b. shell model
    c. compound
    d. molecule

4. The type of bond in which atoms share electrons to produce a stable outer shell is a/an _______ bond.

    a. ionic
    b. covalent
    c. colloquial
    d. isotonic

5. The polarity of water molecules causes them to be attracted to one another in what's called a _______ bond.

    a. covalent
    b. polarized
    c. hydrogen
    d. hydrophilic

6. As the number of hydrogen ions in a solution increases, the pH of the solution

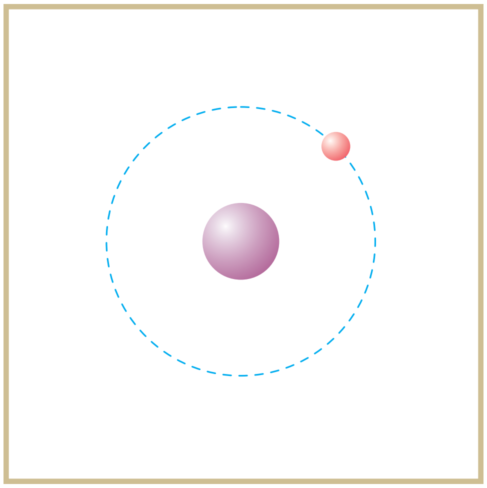
    a. decreases.
    b. stabilizes.
    c. increases.
    d. neutralizes.

(Continued)

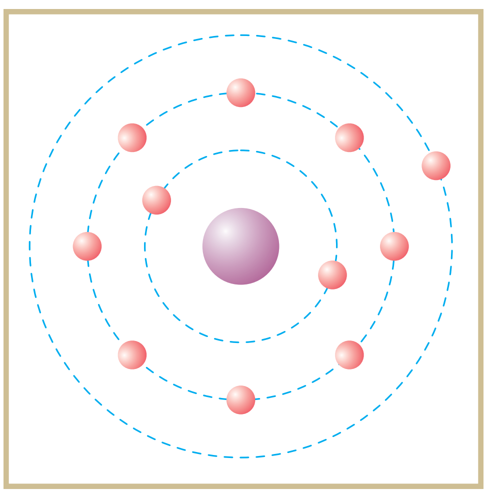
Self-Check 2

7. If you're looking for an atomic number of 8, which one of the following figures represents the shell model for oxygen?

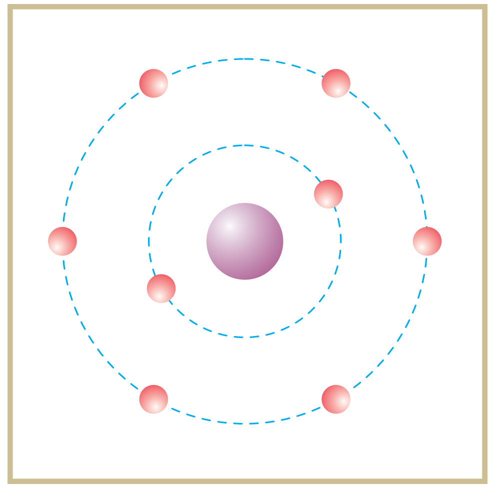
a.



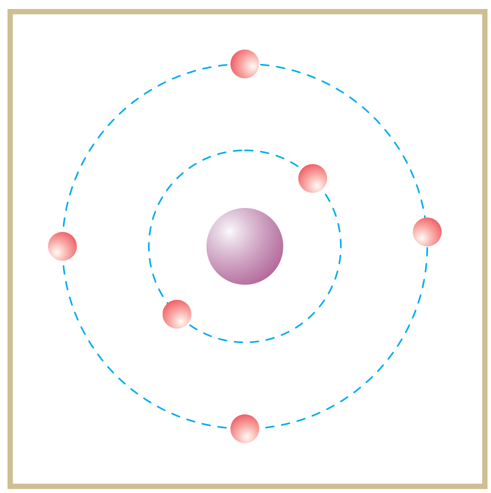
b.



c.



d.



Check your answers with those on page 193.

ASSIGNMENT 3: THE ORGANIC MOLECULES OF LIFE

Refer to the following information as you read Chapter 3, "The Organic Molecules of Life," pages 29–46 in your textbook.

Organic Molecules

Organic chemistry is the study of the chemical compounds in living things. Since living things are mainly composed of water, water can be considered the medium of life. But the organic compounds that depend on that medium are based on the chemical properties of carbon and hydrogen. Carbon is the key to life on earth because of its peculiar bonding properties. With four electrons in its outer shell, carbon is more than happy to make a home for four additional electrons to complete its outer shell. Carbon-hydrogen compounds range from simple methane (CH_4) to incredibly complex compounds comprised of long chains, or rings, of carbon atoms. Review Figure 3.2 on page 31 to consider the versatility of *hydrocarbons* (carbons that are chains of carbon atoms bonded only to hydrogen atoms).

Organic chemists identify two basic parts of a hydrocarbon skeleton—a *functional group* and a wide range of *carbon-based molecular arrangements* that can be simply denoted as *R*. Study Figure 3.3 on page 31 to see an illustration of a variety of functional groups. And note yet again that most of the weight of living things is made up of the CHNOPS elements referred to earlier on page 16.

The Organic Molecules of Cells

Carbohydrates, *lipids*, *proteins*, and *nucleic acids* are large molecules based on carbon atoms. As the basic organic compounds of life, each carbon atom can share electrons with up to four other atoms, forming stable covalent bonds. Carbon atoms tend to link together into chains, forming a functional group backbone to which R elements can become attached.

Carbohydrates

Carbohydrates consist of carbon, hydrogen, and oxygen in a 1:2:1 ratio. Cells use them for energy as well as structural materials. There are three main classes of carbohydrates:

1. *Monosaccharides* are simple sugars composed that have only one sugar molecule. Their carbon backbone is composed of five or six carbon atoms that form a ring. Examples are glucose, fructose, and ribose. As you've already learned, glucose is the most basic source of energy for living things. On page 33, study Figure 3.8 to review the nature of glucose.

2. *Disaccharides* contain two monosaccharides (sugars) bonded together. Examples of disaccharides are *lactose* (milk sugar), *sucrose* (table sugar), and *maltose.* Figure 3.9 on page 33 illustrates the breakdown of the disaccharide maltose.

3. *Polysaccharides* are complex carbohydrates with many monosaccharide molecules that form chains or branches. Examples are glycogen, starch, and cellulose. Polysaccharides can serve as structural components of cells. *Cellulose*, abundant in plants, is the most common structural polysaccharide on our planet. Another polysaccharide, *chitin,* forms the shells of crabs and lobsters as well as the exoskeletons of insects. Figure 3.10 on page 34 shows the structure and function of starch and cellulose.

Lipids

Lipids are fats and other oily organic substances. Cells use lipids for energy storage, for structural support, and as signaling molecules. Lipids are nonpolar hydrocarbons that don't dissolve in water. (Recall that hydrocarbons are compounds made only of hydrogen and carbon atoms.) Lipids are composed of fatty acids attached to glycerol. Fatty acids may be saturated on unsaturated. *Saturated fatty acids,* which are associated with cardiovascular disease, should be avoided in foods. By contrast, *unsaturated fats* protect against fat buildup in arteries.

Forms of fat (called *triglycerides*) are the most abundant lipids in the body. When broken down, they provide more than twice the energy of complex carbohydrates. Study Figure 3.13 on page 36 to visualize saturated and unsaturated fatty acids. Note the carboxyl functional group.

Phospholipids are structurally important lipids found in the plasma membranes that surround cells. Among these lipids are *steroids*, which serve regulating functions in humans. Cholesterol is a steroid in the plasma membranes of animals. It's also a precursor of the male sex hormone *testosterone* and the female sex hormone *estrogen.* Study Figure 3.15 on page 37 to view the fused hydrocarbon rings of steroids.

Proteins

Proteins are the vital infrastructure of life. Proteins like *keratin* (which makes up hair and fingernails) and *collagen* (which supports skin and tendons) provide structural support. Proteins called *enzymes* act as *catalysts,* which speed the basic chemical reactions of life and sustain the life-energy economy called *metabolism.* Proteins that make up *hemoglobin* in red blood cells transport oxygen to cells throughout the body. Proteins called *antibodies* help protect us from disease. Proteins called *hormones* coordinate chemical communications among cells and regulate levels of vital nutrients like glucose. *Actin* and *myosin* are proteins that allow animals to walk, run, and fly. Working together, these proteins permit muscle cells to contract and relax in the rhythms of motion.

Proteins are composed of chains of amino acids joined by peptide bonds. A *peptide bond* is formed when an amino group bonds covalently to a carboxyl group. Study Figure 3.17 on page 39 to learn the basic structure of the 20 kinds of amino acids. (The sequence of amino acids in each type of protein is highly specific, giving a protein its primary structure.) Also on page 39, carefully study Figure 3.18, which illustrates the hydrolysis and dehydration reactions that characterize peptide bonds.

While all proteins have a primary structure, different kinds of proteins take on characteristic shapes. *Fibrous proteins*, like keratin and collagen, perform their support roles precisely because they have a distinctive, *secondary* helical structure.

Globular proteins have a *tertiary* structure. Very complex proteins—like hemoglobin—have more than one polypeptide bond. Therefore, they have a *quaternary* structure. The best way to make sense of all this is by visualization. Carefully study Figure 3.19 on page 40.

Nucleic Acids

Small organic compounds that contain one or more than one phosphate group and a five-carbon sugar attached to a nitrogenous base are called *nucleotides. Adenosine triphosphate (ATP)* is an important nucleotide, produced in the body during cellular respiration. ATP is used for energy storage. *Cellular respiration* is a biological process used by eukaryotes to produce energy. Nucleic acids are either single (as in RNA) or double (as in DNA) strands of covalently bonded nucleotides. Adenine, guanine, cytosine, and thymine are the bases that occur in DNA. RNA is composed of the bases adenine, guanine, cytosine, and uracil. Study Figure 3.20 on page 41 to review the structure of nucleotides in general and DNA and RNA specifically.

Before proceeding to the next assignment, take a moment to complete *Self-Check 3*. Don't forget to use the summaries and quizzes at the end of each chapter to check your progress.

Self-Check 3

1. Among living things, the *most* common among the polysaccharide structural carbohydrates is

   a. starch.
   b. glycogen.
   c. keratin.
   d. cellulose.

2. Which one of the following functional groups is associated with fatty acids?

   a. Phosphate
   b. Amino
   c. Carboxyl
   d. Hydroxyl

3. The hard body parts of insects and crabs are composed of a polysaccharide called

   a. cellulose.
   b. chitin.
   c. glycogen.
   d. glucose.

4. Cell membranes are composed *mainly* of which type of lipids?

   a. Phospholipids
   b. Waxes
   c. Steroids
   d. Glycerides

5. Proteins whose polypeptide chains are folded into rounded compact shapes are

   a. fibrous.
   b. pleated.
   c. helical.
   d. globular.

6. When joined by a dehydration reaction, the covalent bond between the carboxyl groups of two amino acids is called a ________ bond.

   a. peptide
   b. carboxyl
   c. hydrogen
   d. hydroxyl

7. The sugar in RNA is

   a. deoxyribose.
   b. ribose.
   c. glucose.
   d. sucrose.

Check your answers with those on page 193.

ASSIGNMENT 4: INSIDE THE CELL

Refer to the following information as you read Chapter 4, "Inside the Cell," on pages 47–68 in your textbook.

Cells Under the Microscope

With very few exceptions, cells are too small to be seen without a microscope. Why are cells so small? The answer has to do with surface-area-to-volume ratios. A small cell has a greater surface-area-to-volume ratio than a larger cell. Review this topic on page 49 to make sure you understand this principle. Because of this greater ratio, smaller cells are better adapted to exchanging gases and nutrients with their fluid environments. Carefully study Figure 4.2, which illustrates the relative sizes of living things and their components.

The Two Main Types of Cells

The cell is the smallest unit that has the potential to live on its own. There are two fundamentally different types of cells. *Eukaryotic* cells have a nucleus as well as other membrane-bound organelles. *Prokaryotic* cells, represented in your text by bacteria, have no nucleus or other organelles. Figure 4.3 on page 50 compares these two types of cells. Figure 4.4 on page 51 presents a detailed diagram of a prokaryotic cell.

The Plasma Membrane

The boundary between the inside and the outside of any cell is the *plasma membrane*. In all cells, this cell boundary is composed of a lipid bilayer whose *hydrophobic* (water-fearing) tails are sandwiched between the *hydrophilic* (water-loving) heads. Proteins embedded within or attached to the lipid bilayer allow the movement of water-soluble substances into and out of the cell. (Figure 4.5 on page 52 beautifully illustrates the general features of a plasma membrane.)

The functions of the plasma membrane proteins include channeling, transporting, cell recognition, receptor functions, enzymatic processes, and junctions for cell-to-cell communication. These functions are explained on page 53. Study Figure 4.6 on page 53 to master your understanding of the membrane proteins.

Eukaryotic Cells

The vast majority of cells in nature are eukaryotic; therefore, you should make sure you're quite clear on the structures and functions of this type of cell. You should be able to label drawings of plant and animal cells after studying Figures 4.7 on page 54 (for animal cells) and Figure 4.8 on page 55 (for plant cells).

The *nuclear envelope* (double membrane surrounding the nucleus of eukaryotic cells) protects the DNA within it. The nucleus separates the DNA molecules from the cytoplasm, thus making it easier for the cell to replicate its DNA before cell division occurs. The presence of a double nuclear membrane also allows for strict control of the passage of substances to and from the cytoplasm.

The *endoplasmic reticulum (ER)* is continuous with the nuclear envelope and extends into the cytoplasm. ER with *ribosomes* attached is known as *rough ER*. ER without ribosomes is called *smooth ER*. Ribosomes are responsible for synthesizing polypeptide chains. Smooth ER curves through the cytoplasm and functions in lipid synthesis. Figure 4.12 on page 59 illustrates the organelles of the endomembrane system.

Golgi apparatus bodies modify polypeptide chains into mature proteins before shipping them out to specific locations within the cell. They're composed of flattened, membrane-bound sacs that resemble a stack of pancakes.

The *mitochondria* (Figure 4.15) are often called the "powerhouses" of a cell. *Adenosine triphosphate (ATP)* for energy is formed from the breakdown of organic compounds within a mitochondrion. Each mitochondrion has a double membrane system. The inner membrane is folded to create compartments within the organelle itself.

Chloroplasts are specialized organelles in photosynthetic plant cells. The first stage of photosynthesis begins in a special area of the chloroplast called the *thylakoid membrane,* where energy from sunlight is used to form ATP molecules. Review and study Figure 4.14 on page 60 to visualize chloroplast structures.

The *cytoskeleton* of a eukaryotic cell extends from the nucleus to the plasma membrane. Comprised of different kinds of protein filaments and *microtubules*, it serves as a sort of framework or internal scaffolding for the cell. Study Figure 4.16 on page 62 to learn the nature and functions of microtubules. Figure 4.17 on the same page will help you understand how actin protein filaments help maintain the shape of a cell.

Outside the Eukaryotic Cell

All plant cells have cell walls that are connected by *plasmodesmata,* which contain numerous tiny channels that allow direct exchange among grouped cells. Animal cells, on the other hand, don't have cell walls. Instead, they have an *extracellular matrix* of polysaccharides and proteins. Remember that many cell types are grouped as tissues by three different types of junctions. *Adhesive* (stretchy) *junctions* form between the cells of heart and bladder tissues. *Tight junctions* make for tight cell connections as cell wall proteins actually attached to each other. *Gap junctions*—as in muscle tissues—consist of channels that allow direct communication by way of flowing ions.

Before proceeding to the next assignment, take a moment to complete *Self-Check 4.*

Self-Check 4

1. Within cells, the synthesis of proteins occurs in

    a. the nuclear envelope.
    b. ribosomes.
    c. chromatin.
    d. nucleolus.

2. What is the *main* function of the mitochondria?

    a. Assembling polypeptide chains
    b. Digesting substances
    c. Producing ATP
    d. Moving internal structures

3. The ________ keep(s) the cytoplasm of eukaryotic cells separate from the DNA.

    a. Golgi body
    b. ribosomes
    c. chromosomes
    d. nuclear envelope.

4. Vesicles that participate in cell apoptosis—programmed cell death—are called

    a. peroxisomes.
    b. lysosomes.
    c. ribosomes.
    d. vacuoles.

5. The ________ are sometimes called the “powerhouses” of the cell.

    a. ER
    b. mitochondria
    c. chloroplasts
    d. nuclei

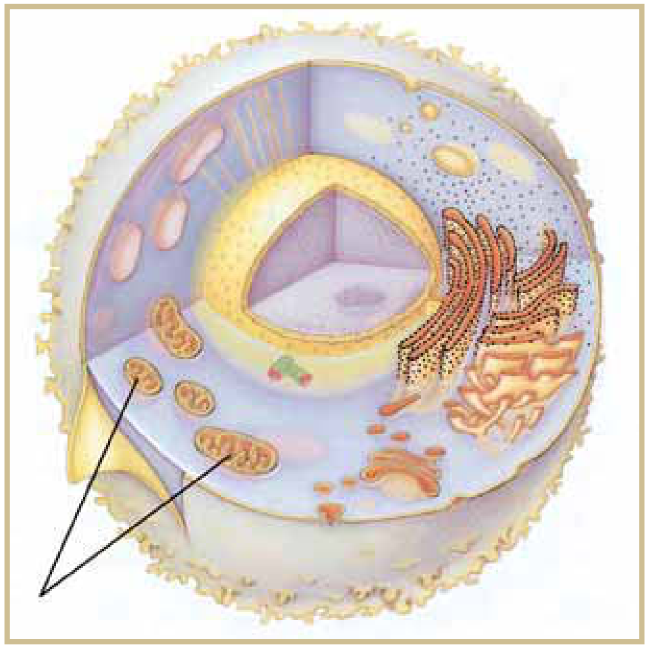
6. The cell-to-cell junctions that allow cells to communicate are called ________ junctions.

    a. gap
    b. adhesion
    c. matrix
    d. tight

(Continued)

Self-Check 4

7. The drawing on the right illustrates a eukaryotic cell. Which one of the following parts is labeled in that drawing?
   a. Golgi body
   b. Mitochondria
   c. Vesicle
   d. Nucleus



8. The drawing on the right illustrates a eukaryotic cell. Which one of the following parts is labeled in the drawing?
   a. Vacuole
   b. Rough ER
   c. DNA
   d. Ribosome

Check your answers with those on page 194.

ASSIGNMENT 5: THE DYNAMIC CELL

Refer to the following information as you read Chapter 5, "The Dynamic Cell," pages 69–82 in your textbook.

What Is Energy?

All organisms must secure energy from their environment to be used for metabolic processes in cells. The *first law of thermodynamics* states that the total amount of energy in the universe remains constant. That is, energy can't be created, and it can't vanish. It can only be converted from one form to another. For example, when a plant absorbs energy from the sun and converts it into chemical energy, the cells of an organism that eats the plant may convert that energy into mechanical energy for movement, or perhaps use it for chemical energy to build or break apart substances within its cells. But every time this energy is converted to another form, some of it's lost to the environment as *heat*. The energy that's lost can't be recaptured, which illustrates the *second law of thermodynamics*. The second law states that the total amount of energy in the universe is spontaneously flowing from usable to nonusable forms.

Note: Make sure you understand the difference between *potential* and *kinetic energy.*

ATP: Energy for Cells

ATP is the main molecule of stored energy used by cells. ATP is a *nucleotide,* the kind of molecule that serves as a monomer in DNA and RNA. ATP contains the sugar ribose, along with a nitrogen-containing base adenine, and three phosphate groups. (See Figure 5.3 on page 72.)

Figure 5.4 on page 72 illustrates the ATP cycle. The cycle is driven by *coupled reactions* that occur in the process of cellular respiration. Coupled reactions take place when an energy-releasing reaction occurs along with an energy-requiring reaction. See Figure 5.5 on page 73. In that figure, note how coupled reactions occur during muscle contraction. The world of living things is sustained in renewable cycles—illustrated by the ATP cycle. Review and study Figure 5.6 on page 74, and think about the energy flow from plants to animals and back again.

Metabolic Pathways and Enzymes

A *metabolic pathway* is a chain or series of linked reactions—like those related to the ATP cycle. They start with a particular chemical reaction and end with a product of a chain of reactions. In an enzymatic reaction, the reactants are called *substrates.* Metabolic reactions inside cells wouldn't occur fast enough to keep an organism alive without enzymes.

Enzymes are proteins that speed up the rate of a metabolic reaction. They don't cause reactions to occur—they just make them occur many times faster than they would otherwise. Enzymes aren't used up once they jump-start a reaction; rather, they may be used over and over again. Each type of enzyme recognizes certain substrates and binds to them in specific ways. As soon as the enzyme binds to an active site on a substrate, it *catalyzes,* or sets into motion, a reaction. Cells have control mechanisms to adjust how quickly enzymes are produced and to stop an enzyme's action when reactions are no longer necessary. Figure 5.8 on page 75 illustrates the idea of *energy of activation,* which is the amount of energy needed to begin a chain of reactions in the first place. The figure helps you visualize how catalytic enzymes add to the energy available for a series of reactions.

Figure 5.9 on page 76 helps you visualize the way an enzyme does its job. Figure 5.10, on the same page, helps you visualize how, through feedback, the products of a reaction can serve to regulate a metabolic pathway—stopping it when enough is enough.

Cell Transport

Substances (nutrients, enzymes, and so on) must get into cells if the cells are to function properly. These substances enter cells in one of three ways:

1. *Passive transport,* including *osmosis,* requires no energy on the part of the cell. The energy of moving molecules in a fluid does the trick. One type of passive transport is *simple diffusion.* To see how this works, lay out a paper towel. Drip some water onto one end of the sheet and notice how the water spreads outward all of its own accord. Another example of simple diffusion is illustrated for you in Figure 5.11 on page 77. *Osmosis,* another type of passive transport, is illustrated in Figure 5.12 on the same page and in Figure 5.13 on page 78. In osmosis, water molecules diffuse across a membrane from an area of greater concentration to an area of weaker concentration.
2. *Active transport* through a cell's plasma membrane requires energy from the cell. Figure 5.14 on page 78 illustrates the fact that transport proteins in a plasma membrane require energy to move a solute across the membrane. Proteins that do this kind of work are often called *pumps.*
3. *Bulk transport* is illustrated in Figure 5.15 on page 79. In this process, cell membranes form *vesicles* (pockets) to capture groups of macromolecules for *exocytosis* (export) or *endocytosis* (import).

Before proceeding to the next assignment, take a moment to complete *Self-Check 5.*

Self-Check 5

1. In a/an _______ reaction, one reaction releases energy and the second uses energy.
   a. paired
   b. energetic
   c. coupled
   d. diverted

2. Which of the following is *not* a feature of enzymes?
   a. They drive reactions only in a forward direction.
   b. They can bind to many substrates.
   c. Metabolic reactions destroy the enzyme molecules.
   d. They speed up reaction time.

3. The term *entropy* refers to
   a. the absorption of heat.
   b. the relative amount of disorganization in a system.
   c. an open system.
   d. the first law of thermodynamics.

4 The term *phagocytosis* refers to a type of
   a. vesicle.
   b. exocytosis.
   c. endocytosis.
   d. passive transport.

5. The movement of water across a semipermeable membrane from an area of higher concentration of water molecules to an area of lesser concentration is
   a. active transport.
   b. osmosis.
   c. endocytosis.
   d. diffusion.

6. _______ energy is the ability or capacity to do work.
   a. Kinetic
   b. Chemical
   c. Thermal
   d. Potential

Check your answers with those on page 194.

ASSIGNMENT 6: ENERGY FOR LIFE

Refer to the following information as you read Chapter 6, "Energy for Life," pages 83–96 in your textbook.

Overview of Photosynthesis

Plants, including algae, some protists, and all *cyanobacteria* (bacteria that contain chlorophyll), use sunlight, carbon dioxide, and water to make glucose by the process of *photosynthesis.* As they do, they create most of the carbohydrates used by living organisms. Review Figure 6.1 on page 84 for an overview of the photosynthesizing organisms. When activated by sunlight, the general chemical equation for photosynthesis is

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

This formula isn't given as such in your text, but you can use it as a shorthand notation for thinking about what you've studied in this assignment.

Among flowering plants, the photosynthesis reaction takes place in the *chloroplasts* of cells. The first stage occurs in the thylakoid membranes. Light energy is trapped and converted to ATP during these light-dependent reactions. *Stroma* (a fluid in the chloroplast) is where *dark reactions,* or second-stage reactions, of photosynthesis occur. The stroma reactions don't require light, but they do require the energy produced by light during the first-stage reactions. Study Figure 6.2 on page 85 to review the role of plant leaves in photosynthesis. Keep mind that there are two kinds of reactions in flowering-plant photosynthesis—light reactions and second-stage Calvin cycle reactions.

Light Reactions

Pigments, such as *chlorophyll,* are molecules that absorb certain wavelengths of light and reflect the rest. In fact, the main photosynthetic pigments are the chlorophylls, which are located in the thylakoid membranes. They absorb all wavelengths of light and reflect only the green ones.

Therefore, plants appear green to us. *Carotenoids* are plant pigments that absorb blue-violet and blue-green wavelengths and reflect red, orange, and yellow. Carotenoid pigments give fall leaves their dramatic color.

Flowering plant pigments capture the energy of the sun to split water into hydrogen, oxygen, and electrons. Electron transport systems then move these electrons step by step through a pathway containing enzymes and coenzymes that help to move the reactions along. Energy that escapes at each step drives the formation of ATP and NADPH (nicotinamide adenine dinucleotide phosphate).

An electron pathway is necessary for the production of ATP and NADPH. This pathway uses two *photosystems* for electron flow: PS II splits water, and PS I produces NADPH. Figure 6.6 on page 88 presents a summary of an electron pathway. Figure 6.7 provides a graphic explanation of the organization of a thylakoid, including the electron transport chain and the processes that lead to the Calvin cycle reactions.

Calvin Cycle Reactions

Calvin cycle reactions use carbon dioxide from the atmosphere to produce a carbohydrate. The reactions require energy from ATP and NADPH formed during the light reactions. The first step of the cycle is *carbon dioxide fixation.* During this step, CO_2 is attached to *RuBP,* a five-carbon molecule that acts as a substrate for the enzyme *RuBP carboxylase (rubisco).* Rubisco drives a reaction that ends up with three carbon molecules.

The next step, reduction of CO_2, uses NADPH and some ATP to produce a carbohydrate, which is usually *glyceraldhyde-3-phosphate (G3P).* G3P can be broken down to produce glucose. However, G3P is versatile stuff. Plants can use it to produce all the hydrocarbon molecules they need to be healthy—from glucose to fatty acids.

The final step in the Calvin cycle is the regeneration of RuBP. This step is necessary to proceed to another turn of the cycle. (It takes three turns of the Calvin cycle to produce one G3P molecule.) Study Figure 6.8 to better understand the Calvin cycle reactions.

Other Types of Photosynthesis

The three other types of photosynthesis discussed in your textbook are C_3 photosynthesis, C_4 photosynthesis, and CAM photosynthesis.

Some plants, including most of the familiar flowering plants, are adapted to areas of moderate rainfall. These plants are said to utilize a *C_3 photosynthesis system,* because the first detectable molecule after CO_2 fixation is a C_3 molecule.

C_4 photosynthesis occurs in plants that have adapted to arid conditions and/or environments with high levels of light intensity. These plants, called *C_4 plants,* include corn and sugarcane.

CAM photosynthesis occurs in flowering succulents like pineapple and cactuses, which thrive in warm, arid environments. The CAM system is unique because it divides different stages of photosynthesis into nighttime and daylight phases. Figures 6.11 and 6.12 on page 93 compare carbon dioxide fixation in C_4 and CAM plants.

Before proceeding to the next assignment, take a moment to complete *Self-Check 6.*

Self-Check 6

1. In the electron pathway for light reactions in photosynthesis, PS II involves
   a. splitting water.
   b. the production of NADPH.
   c. producing coenzymes.
   d. the production of ATP.

2. In plants that absorb blue-violet-green wavelengths of light, what color do they reflect?
   a. White-yellow
   b. Blue
   c. Yellow-orange
   d. Green

3. _______ is an example of a CAM plant.
   a. Corn
   b. Pineapple
   c. Sugarcane
   d. Crabgrass

4. The final step of the Calvin cycle is the regeneration of
   a. ATP.
   b. electrons.
   c. RuBP.
   d. G3P.

5. Atmospheric carbon dioxide enters leaves through
   a. stroma.
   b. grana.
   c. thylakoids.
   d. stomata.

Check your answers with those on page 194.

ASSIGNMENT 7: ENERGY FOR CELLS

Refer to the following information as you read Chapter 7, "Energy for Cells," pages 97–110 of your textbook.

Cellular Respiration

Cellular respiration produces ATP—the energy source absolutely basic to organic processes. In cellular respiration, oxidation of substrates is crucial. However, unlike the case of burning wood, where oxygen is (rapidly) added, oxidation in cellular respiration amounts to removing hydrogen atoms from glucose. Glucose, in turn, is broken down to release energy.

Outside the Mitochondria: Glycolysis

The four phases in the complete breakdown of glucose are summarized in Figure 7.2 on page 99. Review it when in doubt.

Glycolysis, the first phase in the breakdown of glucose takes place in the cytoplasm outside the mitochondria. In glycolysis, a molecule of glucose, a 6-carbon molecule, is broken down into *two* 3-carbon pyruvate molecules. Glycolysis has two steps. In the *energy-investment steps,* two ATP molecules are broken down to release energy used in subsequent reactions. In the *energy-harvesting steps,* oxidation produces substrates with energized phosphate groups. The end result of a chain of reactions is a yield of two pyruvate molecules for each glucose molecule. If oxygen is present in the cytoplasm, the pyruvates then enter mitochondria for further processing. To follow the glycolysis reactions, study Figure 7.3 on page 100.

Inside the Mitochondria

As you just learned, glycolysis, the first phase of cellular respiration, takes place outside the mitochondria. The next three phases happen inside the mitochondria.

The second phase, *preparatory reaction,* occurs in the matrix of the mitochondria. During this phase, pyruvate is oxidized, releasing the carbon dioxide we exhale when we breathe. NAD^+ gains a hydrogen atom to become NADH. A C_2 acetyl group is attached to a coenzyme A (CoA), forming *acetyl CoA*. All of this activity is preparation for the citric acid cycle.

The third phase of cellular respiration is the *citric acid cycle,* also called the *Krebs cycle.* During this phase, the acetyl group is oxidized, releasing more carbon dioxide. NAD^+ and FAD accept hydrogen atoms to produce NADH and $FADH_2$. Substrate-level ATP synthesis now occurs, producing ATP. Carefully study Figure 7.6 on page 103. Make sure you completely understand the citric acid cycle.

The final phase of cellular respiration is the *electron transport chain,* which is located in the *cristae* of mitochondria. High-energy electrons enter the chain; low-energy electrons leave the chain. In the process, the energy released is used to make ATP. More specifically, electrons are transferred through a system that causes the unbound hydrogen ions to be pushed into the inner compartment of the mitochondrion. Electric gradients then cause the hydrogen ions to be pumped back out of the mitochondrion through a series of reactions that drive the formation of an additional 28 ATP.

From start to finish, the process of aerobic respiration produces a net yield of 36 ATP molecules for every molecule of glucose! Review Figure 7.7 on page 104 to master ideas about the electron transport chain. Study Figure 7.8 on page 105 to see how the organization of mitochondrial cristae allows for the production of ATP by using the enzyme ATP synthase.

Fermentation

Anaerobic means "in the absence of oxygen."

Fermentation is the *anaerobic* breakdown of glucose to produce ATP and a toxic end product of some kind. In effect, 1 molecule of glucose yields 2 ATP and an end product. Bacteria and yeasts use fermentation to get their needed energy. The end products in the case of bacteria may be lactate or alcohol. For yeasts, used in baking breads, the end product is ethyl alcohol and carbon dioxide.

After you complete *Self-Check 7,* review the material you've learned in this study guide as well as in the assigned pages in your textbook for Assignments 1–7. A good way to review the chapters is to reread the summaries at the end of each one. If you find you don't understand something in the summary, go back to the textbook pages and review the material. When you're sure that you completely understand the information in Assignments 1–7, complete your examination for Lesson 1.

Self-Check 7

1. The *largest* energy yield during aerobic respiration occurs after which stage?

   a. Pyruvate cycle
   b. Electron transport chain cycle
   c. Krebs cycle
   d. Glycolysis

2. A molecule of glucose contains

   a. 12 carbon atoms, 6 oxygen atoms, and 6 hydrogen atoms.
   b. 6 carbon atoms, 6 hydrogen atoms, and 12 oxygen atoms.
   c. 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.
   d. 8 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.

3. What process results in 2 ATP and a toxic end product?

   a. Fermentation
   b. Citric acid cycle
   c. Preparatory reaction
   d. Energy harvesting

4. Besides carbon dioxide, the other end product of cellular respiration is

   a. oxygen.
   b. water.
   c. lactate.
   d. nitrogen.

5. In cellular respiration, the number of ATP molecules produced is as many as 38, which is about 40% of the energy available from a glucose molecule. The remainder of the energy is lost as

   a. water.
   b. pyruvate
   c. heat.
   d. carbon dioxide.

Check your answers with those on page 195.

Lesson 1
The Cell

EXAMINATION NUMBER

00764600

Whichever method you use in submitting your exam answers to the school, you must use the number above.

For the quickest test results, go to http://www.takeexamsonline.com

When you feel confident that you have mastered the material in Lesson 1, go to http://www.takeexamsonline.com and submit your answers online. If you don't have access to the Internet, you can phone in or mail in your exam. Submit your answers for this examination as soon as you complete it. *Do not wait until another examination is ready.*

Questions 1–20: Select the one best answer to each question.

1. An element that speeds up chemical reactions is called a/an

   A. enzyme.
   B. calorie.
   C. substrate.
   D. solvent.

2. A substance that's attracted to water molecules is called

   A. hydrophobic.
   B. cohesive.
   C. hydrophilic.
   D. adhesive.

3. Short, hairlike projections called ________ enable the motion of some eukaryotic cells.

   A. cilia
   B. actinites
   C. centrioles
   D. microtubules

4. Biology is the study of

   A. animals.
   B. the physical world.
   C. plants.
   D. life.

Examination

5. Plants and algae are remarkable in that they can make all the organic compounds they need from the end product of the Calvin cycle, which is

A. carbon dioxide.
B. $NADH^+$.
C. G3P molecules.
D. RuBP carboxylase.

6. Which one of the following events occurs during Calvin cycle reactions?

A. Chlorophyll energizes electrons.
B. Carbohydrates are produced.
C. ATP is produced.
D. An enzyme helper becomes NADPH.

7. The monomers of nucleic acids, such as DNA and RNA, are known as

A. nucleotides.
B. proteins.
C. nuclei.
D. polypeptides.

8. What happens during glycolysis?

A. Hydrogen ions combine to form water.
B. Oxidation takes place in the matrix of mitochondria.
C. The oxidation of pyruvate forms NADH and CO_2.
D. Glucose breaks down into two molecules of pyruvate.

9. The process by which a biologist uses creative thought to find a pattern among isolated facts is called

A. inductive reasoning.
B. proving a theory.
C. simple reasoning.
D. proving a hypothesis.

10. In a eukaryotic cell, a network of protein filaments called ________ help maintain the shape of the cell.

A. organelles
B. the cytoskeleton
C. ribosomes
D. the nucleolus

11. Glycerol is a subunit molecule of a

A. carbohydrate.
B. lipid.
C. protein.
D. nucleic acid.

12. In the electron transport chain, the main purpose of the ________ we breathe is to keep electrons moving along from the first to the last chemical carrier.

A. carbon dioxide
B. nitrogen
C. atoms
D. oxygen

13. The tiny particles that comprise an element are called

A. ions.
B. protons.
C. atoms.
D. nuclei.

14. In cells, a form of active transport is

A. osmosis.
B. a sodium-potassium pump.
C. simple diffusion.
D. facilitated diffusion.

15. In the leaves of flowering plants, where does the process of photosynthesis occur?

A. In chloroplasts
B. In stomata
C. In glucose
D. Between chlorophylls

16. According to the octet rule, an atom with two electron shells is *most* stable when it contains eight

A. protons.
B. isotopes.
C. electrons.
D. neutrons.

17. The *least* usable form of energy is

A. a calorie.
B. ATP.
C. food.
D. heat.

18. The energy used by living organisms on Earth comes from

A. the sun.
B. fossil fuels.
C. the oceans.
D. volcanoes.

19. A carbon molecule that has a different arrangement of atoms is known as a/an

A. monomer.
B. peptide.
C. isomer.
D. nucleotide.

20. Single-celled organisms that do *not* have a membrane-bound nucleus are called

A. prokaryotes.
B. organelles.
C. Golgi bodies.
D. eukaryotes.

NOTES

Lesson 2

Genetics

Your second lesson consists of six assignments. It covers Part II of your textbook, "Genetics," which includes Chapters 8–13.

When you complete this lesson, you'll be able to

- Explain the basics of cellular reproduction
- Outline the stages in the cell cycle
- Describe the phases of mitosis
- Describe the cell cycle control system
- Describe and explain the basics of meiosis with respect to sexual reproduction
- Compare the phases of meiosis and mitosis
- Identify some effects of abnormal chromosome inheritance
- Outline and explain Mendel's laws of inheritance
- Relate the basic concepts of sex-linked inheritance
- Describe and explain the structures and functions of DNA and RNA
- Explain the control of gene expression and some results of control failures
- Discuss issues related to counseling of chromosomal and genetic disorders

ASSIGNMENT 8: CELLULAR REPRODUCTION

Refer to the following information as you read Chapter 8, "Cellular Reproduction," pages 111–126 in your textbook.

The Basics of Cellular Reproduction

Multicellular organisms have two types of cells: *somatic cells* (all the body cells of an organism) and *reproductive cells* (gamete-producing cells). New cells arise from the division of these existing cells. Somatic cells divide by a process called *mitosis,* and reproductive cells divide by *meiosis.* Mitosis aids in the growth and development of an organism, as well as in the replacement of old and injured cells. Mitosis results in two genetically identical *daughter cells,* which are identical to the parent. Meiosis, on the other hand, produces gametes for sexual reproduction. The gametes have a reduced number of chromosomes from the parent cell.

The process of cellular reproduction involves two basic processes: growth and cell division. During the growth phase, a cell duplicates the contents of its cytoplasm and its DNA. During cell division, the cytoplasm and DNA of a parent cell are distributed to two daughter cells. During the growth phase, nuclear DNA appears as *chromatin*. During cellular reproduction, the DNA sorts itself into *chromosomes*. Figure 8.2 on page 113 illustrates the levels of chromosome organization.

The Cell Cycle

The *cell cycle* consists of two stages: *interphase* and the *mitotic (M) stage.* Both of these stages are further divided into smaller phases. The time necessary to complete one cell cycle varies greatly depending on the type of organism and the type of conditions. For example, in bacteria, it may take as little as 20 minutes; in higher plants and animals, it may occur over 12–24 hours.

Figure 8.3 on page 114 gives a nice summary of the eukaryotic cell cycle. You'll notice in this figure that interphase is the part of the cell cycle in which the cell increases in mass and duplicates its DNA. It's the longest portion of the cell cycle and is broken down into three parts:

1. During G_1, a cell grows and builds proteins, carbohydrates, and lipids.
2. During S, the chromosomal DNA is replicated in preparation for nuclear division.
3. During G_2, a cell produces proteins necessary for mitosis and then prepares to divide.

During the mitotic stage, both the nucleus and the cytoplasm of a cell divide. The result is a pair of daughter cells that are identical to each other and to the parent cell.

Mitosis and Cytokinesis

After a cell completes interphase, it's then ready to begin the mitotic (M) phase. As you can see in Figure 8.3 (page 114), the process of mitosis involves five phases. These phases are clearly explained and diagrammed in Figure 8.5 (plant cells) and Figure 8.6 (animal cells). Carefully study these illustrations and review the accompanying material until you understand how a cell duplicates itself.

> *Mitosis* involves the division of the nucleus of a cell. *Cytokinesis* involves the division of the cytoplasm. Cytokinesis begins at the end of mitosis, during telephase.

The process of cytokinesis occurs differently in plant and animal cells. In plant cells, a cell plate forms between the two daughter cells (Figure 8.8 on page 118). In animal cells, the cytoplasm is basically pinched in two after an indentation called a *cleavage furrow* forms in the plasma membrane (Figure 8.7 on page 118).

The Cell Cycle Control System

The cell cycle has a series of checkpoints to make sure that everything is proceeding properly. These checkpoints delay development from one phase of the cycle to the next until everything that should happen in a particular phase has happened. The *G_1 checkpoint* is important because once it's crossed the cell is committed to division. In the G_1 phase, if all isn't as it should be, a remedial phase—*G_0*—kicks in to make adjustments. If the cell's DNA is fatally damaged, the cell doesn't proceed toward division. At the *G_2 checkpoint,* cell mechanisms check to assure that the cell's DNA has replicated. Figure 8.9 on page 119 illustrates some cell cycle checkpoints.

Both internal and external signals control the cell cycle checkpoints. Internal cell signals are conveyed by enzymes called *kinases*. Figure 8.10 illustrates the internal signals of the cell cycle. External signals include growth factors and hormones that stimulate cells to go through the cell cycle.

In a multicelled organism, cells are constantly dying and being replaced. The programmed chemical process that manages this is called *apoptosis*. Apoptosis and cellular division are opposite processes. Basically, apoptosis serves the purpose of keeping the cell level in the body roughly constant.

The Cell Cycle and Cancer

The essential challenge in this section is mastering a few ideas about the nature of cancer. *Carcinogenesis* is the development of cancer. It often occurs over many months or years. Cancer cells are nonspecialized and undifferentiated; they serve no bodily function. The nuclei and the chromosomes of cancer cells are abnormal. As cancer cells multiply, they cluster together as tumors. In the context of learning a bit about the treatments of cancers, review Figure 8.14 on page 123 to consider how diet can help to prevent cancer.

Before proceeding to the next assignment, take a moment to complete *Self-Check 8.* Don't forget to use the summaries and quizzes at the end of each chapter to check your progress.

Self-Check 8

1. Eukaryotic cells generally rely on a cytoskeletal structure called a ________ to pull chromatids apart.

   a. controsome
   b. centromere
   c. spindle
   d. aster

2. The process of nuclear division called ________ keeps the chromosome number constant from one cell generation to the next.

   a. meiosis
   b. mitosis
   c. eukaryotic fission
   d. prokaryotic splitting

3. In the cell cycle, DNA replication occurs during the ________ interval of interphase.

   a. G_1
   b. G_2
   c. S
   d. cytoplasmic division

4. Which of the following lists the *correct* order of the stages of mitosis?

   a. Metaphase, anaphase, telophase, prophase
   b. Prophase, telophase, metaphase, anaphase
   c. Metaphase, prophase, anaphase, telophase
   d. Prophase, metaphase, anaphase, telophase

5. During which stage of mitosis does the nuclear envelope start to break down?

   a. Prophase
   b. Metaphase
   c. Anaphase
   d. Telophase

6. During ________, the two copies of each chromosome separate from each other and begin to move to opposite poles.

   a. prophase
   b. metaphase
   c. anaphase
   d. telophase

7. Angiogenesis is

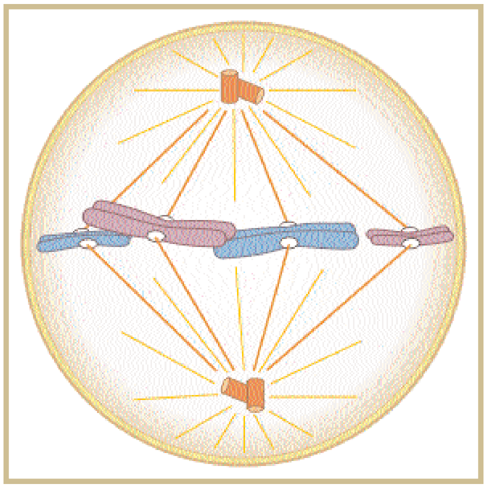
   a. the formation of new blood vessels.
   b. programmed cell death.
   c. the formation of somatic cells.
   d. the process of contact inhibition.

(Continued)

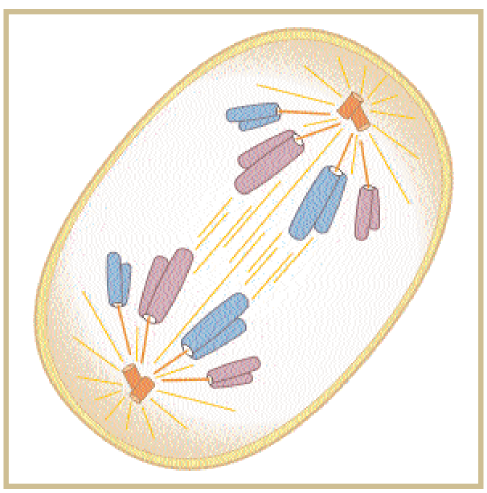
Self-Check 8

8. Which one of the following illustrations represents an animal cell at the anaphase stage of mitosis?

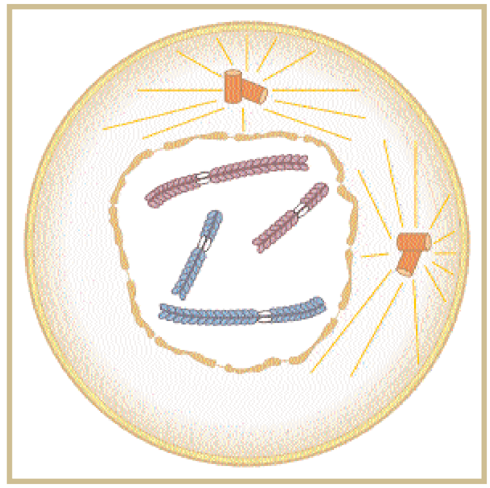
a.



b.



c.



d.

Check your answers with those on page 195.

ASSIGNMENT 9: SEXUAL REPRODUCTION

Refer to the following information as you read Chapter 9, "Sexual Reproduction," pages 127–140 in your textbook.

In *asexual reproduction,* one parent organism produces offspring. Each offspring inherits the same genes that are present in the parent. Therefore, asexual reproduction can produce only exact clones of the parent organism. In *sexual reproduction,* offspring inherit a copy of each gene from both a female and a male parent organism. These genes may have slightly different molecular forms, called *alleles,* which produce different traits in the offspring. Therefore, offspring produced sexually aren't exactly like their parents. Most eukaryotic organisms reproduce sexually. The basic events that occur during sexual reproduction are meiosis, gamete formation, and fertilization.

The Basics of Meiosis

Meiosis is a type of cell division in which the number of chromosomes is reduced from the *diploid* number (2n) to the *haploid* number (n). The result of meiosis is four *gametes* (eggs in females and sperm in males). During meiosis the chromosomes divide once, but the nucleus (and sometimes the cytoplasm) divides twice. In this way, four haploid daughter cells are produced from one diploid mother cell. Later, when fertilization occurs, two haploid gametes combine to form a diploid *zygote* (fertilized egg). This combination restores the diploid condition necessary for the life cycle to continue. As the zygote develops, each diploid somatic cell produced has a pair of each type of chromosome, one inherited from the mother and one from the father. We call these *homologous chromosomes*. Figure 9.1 on page 128 illustrates the homologous chromosomes of a male.

The Phases of Meiosis

Meiosis occurs in two stages—*meiosis I and meiosis II.* Each stage has its own prophase, metaphase, anaphase, and telophase. Figures 9.5 and 9.6 on pages 132–133 illustrate meiosis in an animal cell. As you read the material on the phases of meiosis, refer to these two figures. Keep in mind what you learned in your study of mitosis. You'll be comparing these two processes next.

Meiosis Compared to Mitosis

As you've already learned, both mitosis and meiosis are processes that cause cells to divide. Mitosis results in two cells that are genetically identical to the parent cell. Meiosis results in four cells that have half the number of chromosomes as the parent cell.

Meiosis I is what makes the two processes different. Meiosis II is really the same as mitosis, except the process is occurring with haploid cells. Pages 134–135 in your textbook clearly explain the similarities and differences between these two processes. The text provides tables, figures, and words to illustrate this concept.

Also, notice that the two processes differ in occurrence. That is, meiosis occurs only at certain times during the life of sexually reproducing organisms. Mitosis occurs more consistently during the life cycle.

Abnormal Chromosome Inheritance

The normal number of human chromosomes is 46. Therefore, a normal gamete (egg or sperm) contains half that number, or 23 chromosomes. But errors may occur during meiosis. For example, an egg or a sperm may end up with 22 or 24 chromosomes. When one of these abnormal gametes is involved in fertilization, the result is a fertilized egg with either an extra chromosome *(trisomy)* or one chromosome too few *(monosomy).* Down syndrome, described in your text on page 136, is an example of *trisomy 21* because chromosome 21 has three instead of two copies of the chromosome.

Other genetic abnormalities involve the sex hormones. For example, in Klinefelter syndrome, the sex chromosome group is XXY. In Turner syndrome, a female has only one sex chromosome (X). Figure 9.10 on page 137 illustrates the effects of Klinefelter and Turner syndrome.

Before proceeding to the next assignment, take a moment to complete *Self-Check 9.*

Self-Check 9

1. How many chromosomes are located in a single human somatic cell?
   a. 21
   b. 23
   c. 42
   d. 46

2. _______ occurs in cells especially set aside for reproduction, but not in somatic cells.
   a. Mitosis
   b. Meiosis
   c. Metaphase
   d. Formation of sister chromatids

3. In meiosis, the exchange of genetic material between nonsister chromatids occurs during
   a. interphase.
   b. prophase I.
   c. metaphase I.
   d. anaphase II.

4. The first cell formed when two gametes come together at fertilization is the
   a. zygote.
   b. sporophyte.
   c. gametophyte.
   d. homologue.

5. How many daughter cells result when a cell undergoes the process of meiosis?
   a. One
   b. Two
   c. Four
   d. Eight

Check your answers with those on page 195.

ASSIGNMENT 10: PATTERNS OF INHERITANCE

Refer to the following information as you read Chapter 10, "Patterns of Inheritance," pages 141–158 in your textbook.

Mendel's Laws

Heredity is the transmission of characteristics from one generation to the next. Variations in heredity are the visible differences between parents and offspring, or between two offspring of the same parents. During the second half of the nineteenth century, a monk named Gregor Mendel conducted experiments with pea plants to try to determine just how parent genes are transmitted to offspring. His experiments tested his idea that the plants inherited two units of information (now called *genes*) for a trait, one from each parent. Mendel conducted his pea plant experiments in three stages:

1. Mendel identified parent plants that he knew to be *true-breeding* for a particular trait. That is, when the plants self-pollinated, the offspring were just like the parent plants and like each other. For example, true-breeding tall plants always produced tall plants; true-breeding short plants produced short plants.

2. Mendel selected a true-breeding plant from each group (for example, one that produced tall plants and one that produced short plants) and performed a cross between the selected parents. That is, pollen from the male parts of one plant was dusted on the female stigma of the other. The true-breeding plants were the first generation in his experiments. He called them the *P generation.* The hybrid offspring resulting from such a cross Mendel called the F_1 *generation.* This generation inherited a trait for tallness from each parent. Mendel found that all of the F_1 hybrids resembled only one parent; the other trait wasn't seen. He called the trait seen in the F_1 generation *dominant,* and he named the other unseen trait *recessive*.

3. Mendel allowed each F_1 hybrid to self-pollinate and produce the next generation, known as F_2. The resulting F_2 offspring showed the characteristics of *both* parental forms in the ratio of 3 dominants to 1 recessive. Figure 10.6 on page 144 illustrates the results of a one-trait (monohybrid) cross.

Mendel's pea plant experiments led to the development of two important genetic principles:

1. *The law of segregation.* The four elements of this law are listed on page 145.
2. *The law of independent assortment.* The two elements of this law are listed on page 146. Figure 10.6 illustrates a two-trait cross and its associated ratio. Review and study this figure and Figure 10.3 to understand the logic of a Punnett square.

Also review Figure 10.8 on page 148 to understand how Mendel's laws are expressed in meiosis.

Beyond Mendel's Laws

Mendel's laws are correct, but they're insufficient in explaining the nature of genetic inheritance. In fact, as we now understand, the *genotype* (the pattern of genes at fertilization) has to be considered as an integration of all the genes. Thus, some patterns of inheritance involve incomplete dominance, multiple alleles, and polygenes.

Incomplete dominance occurs when the heterozygote has an intermediate phenotype between that of either homozygote. Figure 10.9 on page 149 illustrates degrees of dominance in a particular flowering plant.

When more than two alleles control a trait, that trait is called a *multiple-allele trait.* Figure 10.10 on page 149 shows how multiple alleles work with blood types.

Polygenic inheritance is illustrated in Figure 11.11 on page 150, as the result of the influence of three pairs of alleles. Review the figure carefully to understand the concept of polygenic inheritance.

Environmental conditions can also influence gene expression. Figure 10.12 on page 150 illustrates different coloration in Himalayan rabbits. This variation is thought to result from differing ambient temperatures—and thus differing body temperatures.

When a single gene has multiple effects, one mutation can affect many parts of the organism, causing a syndrome. Such a pattern is called *pleiotropy*. Review Figure 10.13 on page 151 for an example of pleiotropy called *Marfan syndrome,* which can impact bones, the heart, blood vessels, eyes, lungs, and skin.

Sex-Linked Inheritance

Some traits unrelated to gender are controlled by genes on the X chromosome. Therefore, a gene on the X chromosome can produce a pattern of inheritance that differs from what one may expect from the genes on the 22 pairs of *autosomes* (matched chromosomes). Your text discussion of this topic relies heavily on the study of *Drosophila,* the common fruit fly. These insects are ideal subjects because they breed rapidly and they carry the same kind of XY sex chromosome pattern as humans. Figure 10.15 on page 153 illustrates X-linked inheritance in fruit flies.

Inheritance of Linked Genes

Each gene has a specific location on a chromosome. Genes at different locations on the same chromosome are linked together in groups—that is, they don't sort independently of one another during meiosis. These linkage groups can be disrupted by crossing-over. This factor is the basis for genetic recombination in offspring, which produces *recombinant gametes*. The farther apart two genes are on a chromosome, the greater the chance of crossing-over. Figure 10.18 on page 155 illustrates complete versus incomplete gene linkage in the context of estimating the occurrence of recombinant phenotypes.

Before proceeding to the next assignment, take a moment to complete *Self-Check 10.*

Self-Check 10

1. If an individual's alleles for a certain trait aren't identical, the individual is said to be

    a. true-breeding.
    b. homozygous.
    c. heterozygous.
    d. recessive.

2. Assume that the allele for curly hair dominates the allele for straight hair. If a homozygous man with straight hair marries a homozygous curly-haired woman, we would expect their children to display which phenotypes?

    a. All would have straight hair.
    b. All would have curly hair.
    c. Three out of four would have straight hair.
    d. One out of four would have straight hair.

***Use the Punnett-Square method to answer Questions 3–5*. Assume that the allele for brown hair (B) dominates the allele for red hair (b) and that the allele for curly hair (C) dominates the allele for straight hair (c).**

BBCC	BBCc	BbCC	BbCc
BBCc	BBcc	BbCc	Bbcc
BbCC	BbCc	bbCC	bbCc
BbCc	Bbcc	bbCc	bbcc

3. If two terriers are heterozygous for these alleles, what is the expected phenotypic outcome for their offspring?

    a. 9/16 red curly, 3/16 brown straight, 3/16 red straight, 1/16 red curly
    b. 9/16 brown curly, 3/16 brown straight, 3/16 red curly, 1/16 red straight
    c. 1/4 brown curly, 1/4 brown straight, 1/4 red curly, 1/4 red straight
    d. All will have brown, curly hair.

4. What will result if two terriers are homozygous dominant for these alleles?

    a. All offspring will be brown with curly hair.
    b. All offspring will be red with straight hair.
    c. One half of the offspring will be brown with curly hair.
    d. One fourth of the offspring will be red with straight hair.

(Continued)

Self-Check 10

5. If the two terriers produced pups that were reddish-brown with curly hair, then
   a. brown displays incomplete dominance over red.
   b. red displays partial dominance over brown.
   c. curly hair displays incomplete dominance over straight hair.
   d. a mutation must have occurred.

6. What outcome would you expect if you cross a homozygous red tulip with a homozygous yellow tulip if red is incompletely dominant over yellow?
   a. All offspring will be red.
   b. One-half of the offspring will be yellow.
   c. One-fourth of the offspring will be orange.
   d. All of the offspring will be orange.

7. The ability of primroses with the same genotype to express different phenotypes for flower color is an example of
   a. a dihybrid cross.
   b. codominance.
   c. an environmental effect on gene expression.
   d. pleiotropy.

Use the following information to answer questions 8 and 9: **In pea plants, tall (T) is dominant to short (t), a smooth pod (S) is dominant to a wrinkled pod (s), and a yellow pea color (Y) is dominant to green (y).**

8. a. Consider the gene for height. If we have two plants, one being heterozygous for the trait and the other is homozygous recessive, what are the genotypes of the two plants?
   b. Perform a monohybrid cross between these two plants. (*Hint:* You'll need to construct a Punnett square.)
   c. What percentage will be tall? What percentage will be short?

9. a. What are the genotypes of two plants if one is homozygous for yellow, heterozygous tall and the other is heterozygous for both traits. What would be the possible genotypes of the gametes?
   b. Perform a dihybrid cross between these two plants.
   c. What percentage will be yellow and tall, yellow and short, green and tall, and green and short?

Check your answers with those on page 195.

ASSIGNMENT 11: DNA BIOLOGY AND TECHNOLOGY

Refer to the following information as you read Chapter 11, "DNA: Biology and Technology," pages 159–178 in your textbook.

DNA and RNA Structure and Function

Structure of DNA

Deoxyribonucleic acid (DNA) is a long chain of repeating units called *nucleotides*. Each nucleotide contains a five-carbon sugar, a phosphate group, and one of four nitrogen-containing bases—*adenine* (A), *guanine* (G), *cytosine* (C), and *thymine* (T). Adenine and guanine are two-ringed structures called *purines;* cytosine and thymine are single-ringed structures known as *pyrimidines*.

DNA consists of two strands that spiral around each other in a pattern known as a *double helix*. The two strands are held together by hydrogen bonds and complement each other with regard to the arrangement of the bases. For example, where adenine occurs in one strand, thymine is present in the corresponding position in the opposite strand. Wherever guanine is present, the opposite strand will contain cytosine. As a result, if the base sequence of one strand of a DNA molecule is known, you can easily figure out the base sequence of the other. Figure 11.5 on page 163 offers you a beautiful illustration of DNA structure and complementary base structure.

Replication of DNA

At the time of replication, the two strands of DNA are separated by the enzyme *helicase*. Complementary nucleotides in the nucleus pair up with the bases. The nucleotides joint to form new strands with the help of an enzyme called *DNA polymerase*. In each new DNA molecule, one strand is old and one is newly formed. Figure 11.6 on page 164 illustrates DNA replication.

RNA Structure and Function

Ribonucleic acid (RNA) is a single-stranded molecule that consists of nucleotides arranged in a long chain. It contains a five-carbon sugar called ribose, a phosphate group, and four nitrogen-containing bases—*adenine*, *guanine*, *cytosine*, and *uracil*. Figure 11.8 on page 165 illustrates the structure of RNA.

There are three types of RNA:

1. *Messenger RNA (mRNA)* carries information for protein synthesis from the DNA to the ribosomes of the cell.
2. *Transfer RNA (tRNA)* carries the required amino acids from the cytoplasm to the ribosome for protein synthesis. In the ribosome, tRNA helps to arrange the amino acids into the proper sequence for the synthesis of a protein.
3. *Ribosomal RNA (rRNA)* makes up about 80 percent of the total RNA. Molecules of rRNA bind with certain proteins to form a complex called a *ribosome*. A ribosome is a complex that reads the mRNA to link amino acids into the specified proteins.

Gene Expression

From DNA to RNA to Protein

Gene expression occurs as amino acid codons are translated and organized to produce the very wide range of proteins used in multicelled organisms. Figure 11.12 on page 168 illustrates mRNA processing from DNA. Figure 11.13 on page 169 illustrates tRNA structure and function.

DNA translation has three phases: *initiation,* the *elongation cycle,* and *termination*. After studying this material in your textbook, review Figures 11.15 and 11.16 on page 170. Fig. 11.15 illustrates how initiation involves the organization of a ribosome. Fig. 11.16 illustrates the elongation cycle, which also relates to ribosome configuration. Termination occurs at a codon that means “stop,” because it’s not a codon for an amino acid. Study Figure 11.17 on page 171 for an excellent summary illustration of gene expression in eykaryotes.

Genes and Gene Mutations

Gene mutations are caused by an error in replication, by a *transposon*, or by environmental influences like radiation and pesticides. A transposon is a specific kind of DNA sequence that's able to move about within or between chromosomes. These so-called "jumping genes" are found in a number of species, including humans. Environmental influences, called *mutagens,* may also cause mutations. Radiation, chemicals, and cigarette smoke are recognized as mutagens. We know a mutagen has had an influence when we detect genetic disorders and cancers.

Point mutations involve a change in a single DNA nucleotide. Just which nucleotide determines what effects may result. *Frameshift mutation* happens when a codon triplet sequence doesn't "spell" a functional protein. A protein produced from a frameshift will be entirely nonfunctional.

DNA Technology

Humans are purposefully bringing about genetic changes by isolating gene sections, cutting them, and then splicing them together with genes from other species. The genes that interest scientists can be amplified in number in the laboratory to be used for research and practical applications. Figure 11.19 on page 173 illustrates *recombinant DNA technology* used to produce insulin. Figure 11.20 on page 174 illustrates the uses of a *polymerase chain reaction,* which may be used to produce millions of copies of a DNA segment in a short period of time.

Applications of DNA technology include DNA fingerprinting and the creation of transgenic organisms. *Transgenic organisms* are naturally occurring organisms, which have been genetically modified for various purposes. Currently, transgenic organisms include bacteria, plants, and animals. The latter applications of *biotechnology* have included the successful cloning of a few different animals—most famously a sheep named Dolly.

Before proceeding to you next assignment, take time to respond to *Self-Check 11.*

Self-Check 11

1. Which type of RNA carries the instructions for building proteins?

   a. mRNA
   b. tRNA
   c. rRNA
   d. xRNA

2. Which one of the following bases occurs *only* in RNA?

   a. Thymine
   b. Cytosine
   c. Uracil
   d. Adenine

3. In DNA replication, one of the two old strands of DNA remains as it was. Therefore, DNA replication is called

   a. semiconservative.
   b. unwinding.
   c. templative.
   d. template redundant.

4. The Watson and Crick model of DNA led to the discovery of

   a. messenger RNA.
   b. complementary base paring.
   c. X-ray diffraction.
   d. consequential pairing.

5. Which one of the following examples is the *correct* base pairing for DNA?

   a. A-C, G-T
   b. A-T, G-C
   c. A-G, C-T
   d. A-A, C-C, G-G, T-T

6. During DNA replication, enzymes called DNA ________ helps fill in the gaps between the portions of replicated DNA to form a continuous strand.

   a. polymerase
   b. replicase
   c. ligase
   d. lactase

7. Which of the following strands of DNA is a complement to T-A-G-G-T-C-A?

   a. G-C-T-T-G-A-C
   b. C-G-A-A-C-T-G
   c. A-T-C-C-A-G-T
   d. A-T-G-G-A-G-T

8. In the context of gene mutations, if a codon triplet makes no sense in respect to any protein used by the organism, it's called a

   a. transposon mutation.
   b. point mutation.
   c. transgenic mutation.
   d. frameshift mutation.

Check your answers with those on page 197.

ASSIGNMENT 12: GENE REGULATION AND CANCER

Refer to the following information as you read Chapter 12, “DNA: Gene Regulation and Cancer,” on pages 179–194 in your textbook.

Control of Gene Expression

Reproductive and Therapeutic Cloning

With a few exceptions, like red blood cells, every cell in your body has a nucleus that contains the full DNA menu for your entire body. With this understanding, biotechnology has undertaken practical research into two kinds of cloning. *Reproductive cloning* is undertaken to produce a genetically exact clone of an organism. Figure 12.1 on page 180 illustrates the cloning of carrots from its root cells. *Therapeutic cloning* is aimed at producing mature cells of different kinds. Beyond research interests, possible objectives include producing tissues for medical treatments of spinal cord injuries and conditions like diabetes. The two types of cloning are illustrated in Figure 12.1 on page 181.

Levels of Gene Expression Control

Gene expression is controlled within cells. But there are different levels and types of gene expression control depending on the specialized functions of, say, muscle cells, skin cells, or neurons. In effect, this means that most of the genes in a specialized cell are “switched off.” Figure 12.4 on page 182 illustrates gene expression in specialized cells.

The simplest of organisms, the prokaryotes (such as bacteria), use only one level of control over gene expression. Specifically a gene sequence, called an *operon,* controls gene expression. To review the details of how this works, study Figure 12.5 on page 182. Note that the process involves a regulator gene located outside the operon which codes for a *repressor,* a protein that keeps the operon inactive. It takes the presence of lactose to switch on the gene needed to produce the enzymes necessary to metabolize lactose.

By contrast, eukaryotes have several different levels of gene expression. These include *DNA unpacking, DNA transcription, mRNA processing, mRNA translation,* and *protein activity*. These mechanisms are summarized for you in Figure 12.6 on page 183 and explained on pages 184–186.

All of these activities depend on signaling between cells. In eukaryotic cells, a *cell-signaling pathway* is initiated when a receptor protein is activated in the cell membrane. The receptor protein then initiates a series of chemical reactions within a *signal-transduction pathway*. The end product of this pathway—not the chemical signal—directly affects the metabolism of a cell. The chemical signal simply serves as a cue for cellular response. Figure 12.13 on page 187 illustrates what's involved in a cell-signaling pathway.

Cancer: A Failure of Genetic Control

In a sense, cancer has a mind of its own. Cancer cells release a growth factor that causes nearby blood vessels to branch into the cancerous clump of cells—a process called *angiogenesis*. Refer to Figure 12.14 on page 188 for an illustration of how cancer develops. Also note the table at the bottom of this page to compare normal and cancerous cells. *Apoptosis,* cell death, isn't present in cancer cells.

Mutations in *proto-oncogenes* and tumor suppressor genes bring about the onset of cancer tumor growth. Proto-oncogenes are proteins that code for the cell cycle and inhibit apoptosis. Two factors are central to cancer growth. First, proto-oncogenes mutate to become *oncogenes,* and second, *tumor suppressor genes* mutate. Oncogenes are cancer-causing genes. Tumor suppressor genes are proteins that inhibit the cell cycle and promote apoptosis. When they mutate, these functions may be deleted. With both of these factors present as a result of mutation, the result is uncontrolled growth and the deletion of cell death. Figures 12.15 and 12.16 on page 189 help you compare normal cells and cancer cells.

Other genetic changes that lead to cancer are discussed on page 190. These include the *absence of telomere shortening, angiogenesis,* and *metastasis*. Telomeres act like DNA caps at the ends of chromosomes. They serve to keep chromosomes from fusing to each other. In that context, some undifferentiated cells, like embryonic stem cells, contain an enzyme called *telomerase,* which serves to build or regenerate the telomere caps. The genes that code for telomerase are switched on in cancer cells, allowing them to divide over and over again—especially when apoptosis is deleted. *Angiogensis,* as you've already learned, is the formation of new blood vessels diverted to feed a cancer tumor. *Metastasis* occurs when *malignant* (evil-doing) tumors spread to other parts of the body from the original tumor.

In some rare cases, mutated proto-oncogenes and tumor suppressor genes may be inherited. That doesn't mean that the inheritor will necessarily develop cancer, but it does mean that the occurrence of a cancer is more likely. Increasingly, genetic tests for detecting the likelihood for developing cancer are being researched and developed.

Before proceeding to your next assignment, take time to complete *Self-Check 12.*

Self-Check 12

1. A DNA sequence that controls transcription in a prokaryote is called
   a. a repressor.
   b. polymerase.
   c. an operon.
   d. a cloning factor.

2. Loosely packed chromatin in eukaryotic cells is called
   a. a nucleosome.
   b. euchromatin.
   c. an operon.
   d. heterochromatin.

3. In eukaryotes, transcription ________ are DNA-binding proteins that assist RNA polymerase to bind to a promoter.
   a. activators
   b. factors
   c. enhancers
   d. translators

4. Reproductive cloning refers to growing an organism; ________ cloning refers to producing cells that might be used to repair spinal tissue injuries.
   a. nuclear
   b. specific
   c. specialized
   d. therapeutic

5. In general, a cell-signaling pathway begins when
   a. a chemical signal is emitted from a transmitter protein.
   b. an end product activates reactions within a cell's cytoplasm.
   c. a chemical signal binds to a receptor protein.
   d. a transcription activator reacts to the chemical signal.

6. A mutation that activates cancer-causing genes is called a "gain-of-function" mutation because it causes the gene to
   a. overexpress some function.
   b. become a proto-oncogene.
   c. to stop the cell cycle.
   d. promote apoptosis.

7. ________ occurs when new tumors are established distant from the original tumor.
   a. Oncogeneis
   b. Angiogenesis
   c. Vascularization
   d. Metastasis

Check your answers with those on page 197.

ASSIGNMENT 13: GENETIC COUNSELING

Refer to the following information as you read Chapter 13, "Genetic Counseling," on pages 195–214 in your textbook.

Counseling for Chromosomal Disorders

Autosomes are the pair of chromosomes that are the same in males and females of any given species. Humans have a total of 23 pairs of chromosomes; 22 of these pairs are autosomes. The final pair of chromosomes determines whether an individual is male or female. These are the sex chromosomes. Each somatic cell of a human male contains one X and one Y chromosome; each somatic cell of a human female contains two X chromosomes.

Today, genetic counseling helps parents deal with concerns about the likelihood that a fetus will be impacted by a genetic disorder. A basic tool of genetic counseling is the *karyotype,* a visual display of a person's autosomes and sex chromosomes arranged as pairs. An adult person's white blood cells are normally used to create a karyotype. Different procedures apply for a fetus. They include *amniocentesis* and *chorionic villi sampling.* In amniocentesis, fluid is drawn from a pregnant woman's amniotic sac—the membrane that contains the fetus. Fetal cells that form the amniotic fluid can be used to create a karyotype. *Chorionic villi sampling (CVS)* involves drawing tissue samples from the region where the placenta will develop. Cells from the tissue can be used to produce a karyotype. Both of these procedures come with the relatively slight risk of spontaneous abortion.

Chromosomal mutations may produce a change in chromosome number. In this regard, there are four types of structural changes that may occur spontaneously in nature:

1. *Deletions* may occur when a segment of a chromosome is lost due to some environmental factor such as a viral attack or the impact of some kind of chemical—such as one derived from a pesticide. (See Figure 13.3 on page 198.)

2. *Duplications* occur when a gene segment is repeated on a chromosome. The result is that the person has more than one allele for a trait. (See Figure 13.4 on page 198.)
3. *Translocations* occur when a broken piece of a chromosome attaches to a nonhomologous chromosome. (See Figure 13.5 on page 199.)
4. *Inversions* occur when a stretch of DNA on the chromosome becomes reversed in direction. Inversions are known to occur in chromosome 15. (See Figure 13.6 on page 199.)

Counseling for Genetic Disorders: The Present

A genetic *pedigree* may be constructed to show the genetic inheritance pattern for an individual in the context of a family history. The pedigree can be used to predict the likelihood that a genetic disorder will be passed on to offspring.

An *autosomal disorder* is one that involves any chromosomes except those that determine a person's gender. *Autosomal recessive disorder* occurs when an offspring inherits two recessive alleles from either heterozygous or homozygous recessive parents (Figure 13.7). *Autosomal dominant disorder* occurs when an offspring inherits either two dominant alleles or one dominant and one recessive allele from its parents (Figure 13.8).

X-linked recessive disorders occur when a recessive allele on an X chromosome is inherited from a parent. This recessive allele is expressed more often in male offspring than in females, since males have only one X chromosome. A dominant allele on the other X chromosome in female offspring often masks the recessive allele. Common examples of X-linked recessive disorders are color blindness and hemophilia A. Figure 13.9 on page 201 illustrates an X-linked recessive pedigree for color blindness.

On pages 202–204 of your textbook are capsule summaries of several autosomal disorders, such as cystic fibrosis, sickle cell disease, and Huntington disease. On page 204, several X-linked recessive disorders are explained, including color blindness and hemophilia. Be sure to read these carefully so you understand how they result.

Tests for genetic disorders employ several different strategies. For example, in search of the risk for Tay-Sachs disease, tests may determine whether or not a single protein—a vital enzyme (PKU)—is present or missing. DNA testing may also seek *genetic markers* like those characteristic of Huntington disease. Figure 13.16 on page 205 illustrates the use of a genetic marker to test for a genetic mutation. Another test involves the use of a *DNA probe,* a single-stranded piece of DNA that will bind to complimentary DNA. In a new technology called a *DNA chip,* several rows of probes are laid out on a very small glass square. Figure 13.17 on page 205 illustrates and explains the use of a DNA chip. The procedure can be used to test for many genetic disorders at one time.

Beyond these noted strategies are procedures for testing a fetus, an embryo, and an egg. A common and popular test of the fetus employs *ultrasound* (Figure 13.18), which produces an image of a fetus. Fetal cells can also be tested for genetic defects. Testing an embryo involves removing a cell one the embryo has six to eight cells (Figure 13.19). Testing an egg is usually carried out in the context of *in vitro fertilization (IVF).* The polar-body product of female meiosis is removed for testing in IVF—a procedure that doesn't impact the later development of the egg.

Counseling for Genetic Disorders: The Future

The human genome project has revealed the sequence of all of the base pairs in the human genome. From this has emerged the new science of *genomics*—the study of genomes. Figure 13.21 on page 208 illustrates the comparative study of human and chimpanzee genomes to discover that the genes for speech, hearing, and smell may have influenced human evolution.

DNA chips (DNA microarrays) can be used to display the entire genome of a person, thereby producing a *genetic profile* for an individual. Thus, full-spectrum genetic counseling is now—or soon will be—a viable option in genetic counseling. In this context, the field of *proteomics* deals with the development of new drugs for the treatment of genetic disorders.

Proteomics explores the structure, function, and interactions of cellular proteins. Meanwhile, the new field of *bioinformatics* allows the application of computer technology to the study of the genome.

Gene Therapy

Gene therapy is a method of treating a genetic disorder. *Ex vivo* techniques in gene therapy involve the genetic engineering of a person's cells outside the body. Review Figure 13.23 on page 210 to help you understand ex vivo therapy applied to bone marrow.

In vivo gene therapy techniques attempt to alter cells without removing them from the body. This type of treatment is increasingly used in cancer therapy. Figure 13.25 on page 211 show you sites where ex vivo and in vivo somatic techniques may be applied.

After you complete *Self-Check 13,* review the material you've learned in this study guide as well as in the assigned pages in your textbook for Assignments 8–13. A good way to review the chapters is to reread the summaries at the end of each one. If you find you don't understand something in the summary, go back to the textbook pages and review the material. When you're sure that you completely understand the information in Assignments 8–13, complete your examination for Lesson 2.

Self-Check 13

1. The scientific study of genomes is called

   a. genomics.
   b. proteomics.
   c. bioinformatics.
   d. genetics.

2. Chorionic villi sampling (CVS) involves drawing tissue samples from the region where the ________ will develop.

   a. fetus
   b. placenta
   c. egg
   d. X chromosome

3. The process of transferring normal or modified genes into an individual in an attempt to correct some type of genetic defect is called

   a. DNA fingerprinting.
   b. gene mutation.
   c. cloning.
   d. gene therapy.

4. The international attempt to map out the entire human genome is known as the

   a. Eugenic Engineering Project.
   b. Human Genome Project.
   c. Genetic Engineering Consortium.
   d. DNA Blueprint System.

5. By testing, I've identified an autosomal recessive disorder in which the red blood cells are misshapen and irregular. This person probably suffers from

   a. Huntington disease.
   b. hemophilia.
   c. sickle cell disease.
   d. Marfan syndrome.

6. To get an overall sense of the anatomy of a fetus, I should use ________ for my examination.

   a. embryonic testing
   b. genetic markers
   c. amniocentesis
   d. ultrasound

7. In a pedigree chart, female offspring are represented by

   a. squares.
   b. vertical lines.
   c. triangles.
   d. circles.

8. I've produced a karyotype of a fetus to find that there are three number 21 chromosomes. I now know that his child will be afflicted with

   a. Down syndrome.
   b. Tay-Sachs disease.
   c. chromosomal deletion.
   d. cystic fibrosis.

9. Williams syndrome results when a ________ occurs in chromosome 7.

   a. translocation
   b. inversion
   c. deletion
   d. duplication

Check your answers with those on page 197.

Lesson 2
Genetics

EXAMINATION NUMBER

00764700

Whichever method you use in submitting your exam answers to the school, you must use the number above.

For the quickest test results, go to http://www.takeexamsonline.com

When you feel confident that you have mastered the material in Lesson 2, go to http://www.takeexamsonline.com and submit your answers online. If you don't have access to the Internet, you can phone in or mail in your exam. Submit your answers for this examination as soon as you complete it. *Do not wait until another examination is ready.*

Questions 1–20: Select the one best answer to each question.

1. Which one of the following statements would *most* clearly refer to a person's genotype?

   A. Susan has blue eyes.
   B. Bill is recessive for height and dominant for hair color.
   C. Karen has broad shoulders, long legs, and green eyes.
   D. Harold inherited high cheekbones.

2. In one kind of abnormal chromosome inheritance called Down syndrome, a child has three copies of

   A. chromosome X.
   B. chromosome 23.
   C. chromosome Y.
   D. chromosome 21.

3. The process of reproductive cloning begins by

   A. genetically modifying an embryo.
   B. genetically modifying a stem cell.
   C. placing an adult nucleus in a cell without a nucleus.
   D. isolating cells to learn more about how they specialize.

4. In humans, blood type inheritance is an example of

   A. complete dominance.
   B. codominance.
   C. incomplete dominance.
   D. predominance.

5. During division in cellular reproduction, the DNA and cytoplasm of the parent cell is distributed to two

   A. clones.
   B. chromosomes.
   C. daughter cells.
   D. simplified cells.

6. Suppose you're looking through a microscope and you see an exchange of chromosome segments between chromosome pair 7 and chromosome pair 15. This condition is an example of

   A. translocation.
   B. duplication.
   C. inversion.
   D. relocation.

7. A DNA molecule has a unique design that resembles a spiral staircase. Scientists call this design a

   A. spiral purine.
   B. double helix.
   C. double nucleotide.
   D. spiral structure.

8. During meiosis, the “shuffling” exchange of genetic material is called

   A. synapsis.
   B. crossing-over.
   C. tetrad formation.
   D. allele distribution.

9. The scientific field devoted to developing new drugs for treating genetic disorders is

   A. bioinformatics.
   B. proteomics.
   C. genetic profiling.
   D. genomics.

10. Animal cells actively replicate their genetic material during

   A. interphase.
   B. the mitotic stage.
   C. metaphase.
   D. cytokinesis.

11. Proteins are synthesized in

   A. messenger RNA.
   B. the cell nucleus.
   C. transfer RNA.
   D. ribosomes.

12. What cell parts have been compared to the protective caps on the ends of shoe laces?

   A. Oncogenes
   B. BRCA1
   C. Angiogenes
   D. Telomeres

13. The human chromosomes that are responsible for the gender of a child are the

   A. homologues.
   B. autosomes.
   C. X and Y chromosomes.
   D. alleles.

14. A visual display of the chromosomes of a person, arranged by size, shape, and patterns of banding is called

A. a karyotype.
B. a genetic profile.
C. a gene map.
D. bioinformatics.

15. In the development of a cancer cell, the formation of new blood vessels is called

A. metastasis.
B. angiogenesis.
C. carcinogenesis.
D. differentiation.

16. Transgenic bacteria can be used to produce

A. food.
B. proteins.
C. medicines.
D. antibodies.

17. Let *T* mean tall and *t* mean short. If Clara's mother is *Tt* and her father is *Tt,* what is the chance that she'll be tall?

A. 1 in 4
B. 2 in 4
C. 3 in 4
D. Zero

18. Which statement about Chargaff's rules is *correct?*

A. In each species, the amount of adenine equals the amount of guanine.
B. In each species, the amount of adenine equals the amount of thymine.
C. In each species, the amount of adenine equals the amount of cytosine.
D. The amount of adenine, guanine, thymine, and cytosine is the same in every species.

19. Once the _______ checkpoint is passed in the cell cycles, the cell is committed to division.

A. M
B. G_2
C. S
D. G_1

20. A change in a single DNA nucleotide is called a

A. point mutation.
B. mutagen.
C. transposon.
D. ligase.

NOTES

Evolution and the Diversity of Life

Lesson 3

Your third lesson consists of six assignments covering Part III, "Evolution," and Part IV, "Diversity of Life," Chapters 14–19 of your textbook.

When you complete this lesson, you'll be able to

- Explain Darwin's theory of natural selection and cite the evidence for his theory
- Discuss and explain the genetic processes of microevolution
- Describe the differences between directional, stabilizing, and disruptive selection
- Discuss the concepts of adaptive radiation in different environments
- Explain the gradualistic and punctuated equilibrium models of speciation
- Discuss the principles of taxonomy and classification in differentiating species
- Discuss the first forms of life, including viruses, prokaryotes, and protists
- Describe and explain the origins of land plants and describe their diversity
- Discuss the nature of fungi as distinct from both plants and animals
- Outline an overview of the evolution of animals
- Discuss and describe the invertebrates
- Compare and differentiate between protostomes and deuterostomes
- Discuss and differentiate molluscs, annelids, and the arthropods
- Discuss and differentiate echinoderms and chordates
- Explain selected basic understandings about the evolutions of humans

ASSIGNMENT 14: DARWIN AND EVOLUTION

Refer to the following information as you read Chapter 14, "Darwin and Evolution," on pages 215–230 in your textbook.

Darwin's Theory of Evolution

> The theory of evolution states that life forms have changed throughout geologic time. This theory, however, is only one way to characterize the life forms in our world. One other theory, *intelligent design,* holds that certain features of the universe and of living things are best explained by an intelligent cause, not an undirected process such as natural selection. Highly respected scientists support both of these proposed explanations.

The influence of Darwin's ideas about evolution radically transformed the science of life, but his concepts of evolution, especially the *theory of natural selection*, were also a catalyst for changing educated peoples' views about the nature of our world. Table 14.1 on page 218 compares pre-Darwinian and post-Darwinian worldviews.

Simply put, *evolution* is genetic change in a line of descent over time. The primary importance of this theory is that it presumes present-day organisms have arisen from simpler ancestral organisms. In general, changes in the genetic composition of a population take place through the inheritance of slight variations that occur generation after generation. This results in the development of new characteristics within a species, and the eventual formation of new species.

Darwin's Conclusions

In 1831, Charles Darwin was hired as a naturalist aboard a ship called the *H.M.S. Beagle.* His five-year voyage took him around the world and gave him the opportunity to study species in a great variety of habitats. After returning to England, he studied his extensive notes and came up with many ideas about how evolution occurs. These ideas led to the development of his theory of natural selection.

Natural Selection and Adaptation

Here are some key elements that Darwin used to develop his theory:

1. If there were no environmental checks on reproduction, populations would show a rapid increase in number. However, Darwin found that the number of individuals in a population remains relatively constant over time, which suggests a struggle for existence.
2. Competition exists between organisms for food, water, nesting sites, shelter, and other factors necessary for survival and reproduction. This struggle affects both plants and animals.
3. Genetic variations arise from changes that occur in DNA. These variations are passed to offspring from the parent organisms. Individuals with favorable variations have a better chance of survival and reproduction. The advantageous traits are passed from generation to generation, and these organisms become better suited for survival. Darwin stated that nature itself selects these organisms—hence the term *natural selection.*
4. The physical environment is always changing. Therefore, organisms are continually tested by these changes. New advantageous mutations will occur and be selected in response to the environment. After a period of time, the resulting organisms may appear so different from the original species that a new species evolves.

Study Figure 14.6 on page 220 for an illustration of beak variations in finches. These variations are related to the different species' feeding habits. Also study Figure 14.8 on page 222 for an illustration of the mechanism of evolution.

Evidence for Evolution

Several bodies of data support the idea that species have evolved from very simple to increasingly complex organisms over many millions of years. In particular, four bodies of evidence support this view: fossil evidence, biogeographical evidence, anatomical evidence, and biochemical evidence.

Fossil Evidence

Proponents of intelligent design point to gaps in the fossil record as one of the main problems with the theory. The fossil record doesn't show any transitions, or intermediate forms, proposed by Darwin.

For the most part, fossils are impressions, or casts, in sedimentary rocks of long-deceased organisms—or fragments of organisms. Sedimentary rocks include shale, limestone, and sandstone. See Figure 14.3 on page 218 to see how sedimentary strata are formed. With a few very early exceptions, the fossil record begins to be nearly continuous beginning some 600 million years ago. From that distant time onward, we're able to trace a progression of plant and animal species that evolved from earlier ancestors. Modern birds, for example, have physiological features that relate them to dinosaurs. The fossil record is a rich source of information about ancient species now long been extinct. Figure 14.11 on page 224 illustrates a re-creation of Archaeopteryx, an extinct species with feature of both modern birds and ancient reptiles. Figure 14.12 illustrates the interesting fact that whales evolved from ancient land mammals.

Biogeographical Evidence

Biogeography is the study of the distribution of plant and animal species. A primary finding derived from studying the global distribution of plant and animal species is that land regions separated from each other have led to different paths of evolution. Australia, for example, long separated from other landmasses, permitted the domination of ecological niches and habitats by marsupials—as opposed to the placental mammals found elsewhere on the planet. Figure 14.13 on page 225 illustrates a few of the marsupials of Australia.

Anatomical Evidence

Anatomical evidence takes three general forms.

1. *Vestigial structures* found in some species indicate evolutionary adaptation from earlier ancestors. Some species of snakes, for example, have vestigial (nonfunctional) structures that once were pelvises and legs.
2. *Homologous structures* are very common across many animal species. The upper arm bone (humerus) of birds, cats, humans, whales, and horses are homologous, as illustrated in Figure 14.14 on page 226. Homologous structures imply common ancestors.
3. *Analogous structures* may serve the same function but be constructed differently. The wings of birds and insects are analogous as to function but their distinct anatomy and construction imply different evolutionary paths. Figure 14.15 illustrates the fact that the embryos of species with common ancestors follow fascinatingly similar paths of development. The human embryo, for example, has vestigial gills at one phase of development.

Biochemical Evidence

Nearly all organisms on Earth use the same common elements. All contain DNA, and all use the same 20 amino acids that "spell" proteins—using the same triplet code. Nearly all use ATP as well as many of the same enzymes. Figure 14.16 on page 227 illustrates the significance of biochemical differences. Specifically, it focuses on cytochrome *c,* a molecule used in the electron transport chain. Comparing interspecies data on the sequence of amino acids used in producing cytochrome *c,* one finds degrees of genome relatedness. Thus, humans differ from monkeys by only one amino acid. They differ from ducks by 11 amino acids and from *Candida* (a yeast), by 51 amino acids.

Before going on to your next assignment, take a few minutes to respond to *Self-Check 14.* Also, read the "Summary" on page 228 and complete the questions on pages 228–230. The answers to these questions are in Appendix A in the back of your textbook.

Self-Check 14

1. The study of the distribution of organisms around the world is known as
   a. biodiversity.
   b. biogeography.
   c. comparative morphology.
   d. evolutionary biology.

2. How can you tell a population is evolving?
   a. Variations in traits are affecting an individual's survival.
   b. Individuals are reproducing only in particular environments.
   c. Forms of heritable traits are changing over generations.
   d. Population size is growing rapidly.

3. Humans have a tailbone but no tail. This fact illustrates a/an _______ structure.
   a. vestigial
   b. analogous
   c. elusive
   d. analogous

4. From the Darwinian point of view, when humans breed cattle for certain traits, they're engaged in _______ selection.
   a. fitness
   b. artificial
   c. commercial
   d. population

5. As a result of reading Thomas Malthus on the topic of human population increase, Wallace came up with the concept of
   a. selective reproduction.
   b. natural selectivity.
   c. speciation.
   d. survival of the fittest.

6. Evidence suggests that life's diversity has come about as the result of very slight differences in certain genes. This sort of observation is *most* likely to have arisen through examining _______ evidence.
   a. biochemical
   b. fossil
   c. biogeographical
   d. anatomical

Check your answers with those on page 198.

ASSIGNMENT 15: EVOLUTION ON A SMALL SCALE

Refer to the following information as you read Chapter 15, "Evolution on a Small Scale," on pages 231–244 in your textbook.

Microevolution

For the science of biology, a *population* is all of the members of a species living and reproducing within a particular area. *Microevolution* refers to evolutionary changes within a population. In terms of genetics, all of the alleles and various gene locations within a population make up its *gene pool*.

Evolution in a Genetic Context

Individual sexual reproduction by itself can't change allele frequencies. Put simply, a Punnett square for individual breeding couples doesn't give the proportions (percentages) of alleles in a breeding population over time. Study the explanation for this fact on page 233 of your text.

To work out the relative percentages of dominant versus recessive alleles in the genotypes of a reproducing population, we can apply a version of the binomial equation, $p^2 + 2pq + q^2$. Review Figure 15.3 on page 234 to see how the calculations work out for a selected set of two alleles.

The proportions of alleles in a population will remain the same as long as there are no mutations, gene flow, random mating, genetic drift, and mating selection factors. Be sure you have a good understanding of each of these factors before you go on.

Causes of Microevolution

Your textbook covers the following causes of microevolution:

1. Mutations create the raw material for evolution. Mutations are the cause of variations within a breeding population. While many mutations are either neutral or destructive, some may favor an adaptive advantage in the phenotype of some individuals in a population.
2. *Gene flow* occurs when alleles are exchanged between migrating populations of the same species. Basically, the interbreeding of two adjacent animal populations tends to work in favor of stable allele combinations and may actually prevent speciation. Figure 15.6 on page 236 illustrates examples of gene flow related to several subspecies of one species of snake.
3. *Random mating* occurs when males and females mate by chance according to the laws of probability. It's *nonrandom mating,* or inbreeding, that can lead to microevolution. Thus, in *assortative mating,* people tend to mate with people who have the same genotype. Tall people tend to marry tall people, for example. In *sexual selection,* particular phenotypic traits may increase the likelihood of mating and reproduction. For example, more assertive males in a population may mate more often than less assertive males.
4. *Genetic drift* refers to the tendency of allele ratios to change simply by chance, especially given a sufficiently long period of time. For example, the genotypes of members of species that live in separated habitats tend to gradually drift apart—although usually in only minor ways. Figure 15.7 illustrates genetic drift.
   - A *bottleneck effect* may occur when some kind of natural catastrophe greatly reduces the size of a species population. The genotypes of the survivors will become dominant; the genotypes of nonsurvivors will be erased. Figure 15.8 on page 237 cleverly illustrates a bottleneck effect.
   - A *founder effect* may occur when populations are separated to interbreed more or less exclusively over time. Figure 15.9 on page 238 illustrates a founder effect related to the Amish people of Lancaster, Pennsylvania.

Natural Selection

As particular phenotypic traits favor adaptation, survival, and reproduction, allele frequencies within breeding population change from generation to generation. This is the essence of ongoing natural selection. However, there are types of selection.

Directional selection occurs when an extreme phenotype is favored. The increase in the size of the horse over time is an example of directional change related to environmental changes that favored larger size. Figure 15.10 on page 239 illustrates directional selection among horses. Another example discussed in your text is selection for genetic traits that protect people against the malaria *Plasmodium.*

Stabilizing selection takes place when extreme phenotypes are selected against, thus resulting in average or intermediate phenotypes. See Figure 15.11 on page 240.

Disruptive selection occurs when two or more extreme phenotypes are favored over intermediate types. See Figure 15.12 on page 240.

Before going on to your next assignment, take a few minutes to respond to *Self-Check 15.*

Self-Check 15

1. The mechanism that creates new alleles is

   a. independent assortment.
   b. random mating.
   c. industrial melanism.
   d. mutation.

2. If we observe small changes in the frequency of an allele's appearance in a population's offspring due to mutation, natural selection, and genetic drift, we're observing

   a. microevolution.
   b. mutation rate.
   c. genetic equilibrium.
   d. polymorphism.

3. Gene flow is the movement of alleles into and out of a population as a result of

   a. fertilization.
   b. migration.
   c. mutation.
   d. stabilizing selection.

4. A group of individuals of the same species occupying a given area is a

   a. gene pool.
   b. phenotype.
   c. generation.
   d. population.

5. The genes shared by an entire group and their offspring constitutes a/an

   a. gene pool.
   b. population.
   c. allele frequency.
   d. phenotypic variation.

6. If we're looking for the proportions of recessive to dominant alleles *A* and *a* under the Hardy-Weinberg equation $p^2 + 2pq + q^2$, and p^2 is the frequency of homozygous dominant (*A*) individuals, then q^2 must represent the frequency of

   a. heterozygous individuals.
   b. random mating.
   c. homozygous recessive individuals.
   d. homozygous genetic drift.

7. When we see that two or more extreme phenotypes of field mice are favored over any intermediate phenotype for this species, we're detecting _______ selection.

   a. maintenance
   b. disruptive
   c. stabilizing
   d. directional

Check your answers with those on page 198.

ASSIGNMENT 16: EVOLUTION ON A LARGE SCALE

Refer to the following information as you read Chapter 16, "Evolution on a Large Scale," on pages 245–264 in your textbook.

Macroevolution

Defining Species

A *species* is considered to be the smallest, most basic unit of classification among organisms. Individuals of a species are capable of breeding with each other under natural conditions, but are unable to breed successfully with members of another species. Simply stated, a species is a group of fertile organisms that can interbreed and produce fertile offspring only among themselves. Figure 16.2 on page 247 shows three species of flycatchers. Though similar in appearance, they're separate species because each reproduces only within their phenotype.

Certain reproductive barriers exist that prevent reproduction attempts and fertilization. For example, *prezygotic isolating mechanisms* (those occurring before the formation of a zygote) include habitat isolation, temporal isolation related to the time of year individuals mate, behavioral isolation as in the case of different courtship patterns, mechanical isolation, and gamete isolation.

Postzygotic isolating mechanisms (those occurring after a zygote is formed) include such things as the death of nonviable hybrid zygotes and hybrid sterility, in which the adult is reproductively sterile. Mules, the hybrid offspring of donkeys and horses, are an example illustrated in Figure 16.6 on page 249. Figure 16.4 on page 248 presents an overview of both prezygotic and postzygotic reproductive barriers.

Models of Speciation

Speciation is the process by which a daughter species forms from a population of a parent species. This is caused by mutation, natural selection, and genetic drift. There are three ways speciation can occur:

1. In *allopatric speciation,* some type of physical barrier prevents gene flow between subpopulations of the same species. Reproductive isolating mechanisms begin to evolve as changes occur in the separated populations. Eventually, the changes are so great that the populations can no longer successfully interbreed. Figure 16.7 on page 250 illustrates allopatric speciation of salamanders.
2. In *sympatric speciation,* a daughter species arises within an existing population with no physical barrier present. This type of speciation has been important in the evolution of flowering plants that engage in self-fertilization. Mutations in gene number sometimes cause no harmful effects, but they keep the plants from being able to breed with others of the same species, and a new species is formed. See Figure 16.8 for an illustration with respect to modern bread wheat.
3. *Speciation through adaptive radiation* occurs when neighboring populations become separate species even though their territories overlap in a certain area. It's sometimes difficult to determine whether these populations are actually separate species, or merely subspecies (geographically distinct populations of the same species) since they sometimes produce hybrid offspring where the territories overlap. Figure 16.9 on page 251 illustrates adaptive radiation in the case of Darwin's famous Galapagos finches.

The History of Species

Table 16.1 on page 252 should get your serious and repeated attention. It presents the geological time scale, major divisions of geological time, and a summary of major evolutionary events that occurred from Precambrian time to the present.

The information from Table 16.1 is explained further in "The Geological Timescale" and "The Pace of Speciation" on pages 253–254. Today, there are two basically opposed ideas about the pace of speciation. In the *gradualisitc model,* illustrated in part (a.) of Figure 16.11, evolution over time has been steady and orderly. In the *punctuated equilibrium model,* illustrated in part (b) of Figure 16.11, new species appear suddenly and then remain largely unchanged until they go extinct.

As you read the information in "Mass Extinctions of Species," pages 254–255, refer to Table 16.1 to see where these extinctions occurred. These mass extinctions resulted from radical changes due to such things as volcanism, plate tectonics (as illustrated in Figures 16.12 and 16.13), as well as radically fluctuating atmospheric and climate conditions.

Classification of Species

Taxonomy is a branch of biology concerned with identifying, naming, and classifying organisms. The taxonomic hierarchy begins with the species. A species, in turn, belongs to a *genus,* a *family,* an *order,* a *class,* a *phylum,* and a *kingdom.* More recently, as you may recall, a higher taxonomic category, the *domain,* has been added. Figure 16.14 on page 256 gives you the taxonomic hierarchy for a species of orchid.

Classification and Phylogeny

Taxonomy and classification are included a in a broader field of biology called *systematics*. The objective of systematics is the study of the diversity of organisms at all levels of organization. Part of the field of systematics involves the tracing of evolutionary relationships between species, known as *phylogeny.* Scientists rely on both the fossil record and on molecular data to analyze various kinds of clues. Figure 16.15 illustrates the classification of a phylogenetic tree showing the evolution of sheep, cattle, deer, and reindeer from common ancestors. Figure 16.16 on page 258 illustrates the use of molecular data (like DNA base sequences) to discover the relative evolutionary "distance" between the galago and modern humans.

The goal of *cladistic systematics* is determining testable hypotheses about the evolutionary relationship between organisms. A *cladogram* is a diagram that illustrates phylogenetic relationships. The logic and procedures for creating a cladogram are illustrated for you in Figure 16.17.

Study Figure 16.18 on page 260, which illustrates the differences between traditional and cladistic approaches to phylogeny. The differences derive from different assumption about how to determine traits derived from common ancestors. All of this should remind you that science is an ongoing process.

Classification Systems

You've already seen that there are different approaches to taxonomic schemes for classifying species and phyla. Be sure to become familiar with the differences between the traditional five-kingdom system and the newer approach based on systematics. Figure 16.19 on page 261 allows you to visualize the three-domain system that includes Bacteria and Archaea as Prokaryotes, differentiating these organisms from the kingdoms that comprise the Eukaryotes.

Before going on to your next assignment, take a few minutes to respond to *Self-Check 16*. Are you remembering to read the chapter summaries and complete the exercises at the end of each chapter? You can check your work with the answers given in Appendix A of the textbook.

Self-Check 16

1. The evolution of many new species from a single lineage is likely to involve
   - a. adaptive radiation.
   - b. anagenesis.
   - c. gametic mortality.
   - d. mass extinction.

2. In _______ evolution, two species acquire traits similar to those of very distantly related evolutionary ancestors.
   - a. homologous
   - b. parallel
   - c. phylogenetic
   - d. convergent

3. Which of the following is a postzygotic isolating mechanism?
   - a. Habitat isolation
   - b. Behavioral isolation
   - c. Hybrid sterility
   - d. Gamete isolation

4. The courtship rituals performed by some male birds to attract females of the same species are an example of _______ isolation.
   - a. temporal
   - b. ecological
   - c. behavioral
   - d. mechanical

5. Speciation due to geographic barrier separating populations is called _______ speciation.
   - a. allopatric
   - b. archipelago
   - c. parapatric
   - d. sympatric

6. All of the following factors have been implicated in mass extinctions, *except*
   - a. continental drift.
   - b. punctuated equilibrium.
   - c. meteorite impact.
   - d. loss of habitat.

7. Sympatric speciation may occur in plants due to
   - a. geographic isolation.
   - b. mechanical isolation.
   - c. polyploidy.
   - d. gametic mortality.

Check your answers with those on page 198.

ASSIGNMENT 17: THE FIRST FORMS OF LIFE

Refer to the following information as you read Chapter 17, "The First Forms of Life," on pages 265–282 in your textbook.

The Viruses

Viruses are organic systems that have some properties of living things, yet aren't classified as organisms. First discovered in the late 1800s, viruses are the causative agents of many dreaded diseases of both plants and animals. Common human viral diseases include mumps, measles, chicken pox, and the common cold. A virus consists of a protein coat, or *capsid*, wrapped around a chromosome of genetic material (either DNA or RNA). Viruses can reproduce only by commandeering the metabolic machinery of a host cell. Once they infect host cells, viral cycles proceed through five phases called the *lytic cycle*. Figure 17.3 on page 267 summarizes the lytic cycle as it relates to the *lysogenic cycle,* in which the virus is integrated into the DNA of the host cell.

Viruses are adapted to plants and animals in distinct ways. Viruses tend to enter plants through damaged tissues and to move about in the *plasmodesmata,* the cytoplasmic strands that extend between plant cell walls. In animals, viruses tend to behave like the *bacteriophages* that invade bacteria, except they're invading eukaryotic cells. On page 268, Figure 17.4 illustrates infected tobacco plants. On the same page, Figure 17.5 illustrates the reproduction of the HIV retrovirus in an animal cell. A retrovirus has an RNA genome although it goes through a DNA stage. Figure 17.6 on page 269 illustrates the rather appalling incidence of emerging diseases around the globe—reminding us that viruses tend to evolve as they utilize the nuclear material of host cells.

Viroids and Prions

Unlike viruses, *viroids* are naked strands of DNA that have been implicated in serious crop diseases. Meanwhile, recently discovered *prions* are protein-like particles that act as agents of disease by altering the nature of proteins in host organisms in a destructive direction.

The Prokaryotes

The *prokaryotes* are sorted into two domains, Bacteria and Archaea. Both are simple unicellular creatures that lack a nucleus.

Bacteria

Domain Bacteria is comprised of 400 known genera that are found in practically every environment on Earth. Some bacteria are *photoautotrophs* (often called *autotrophs*), which are capable of oxygen-based photosynthesis. Most bacteria, however, are *chemoheterotrophs (heterotrophs),* which aren't capable of using solar energy directly. The heterotrophic varieties are mostly decomposers that are beneficial to humans. They're used to produce food items such as yogurt and pickles, as well as antibiotics. Other heterotrophs are pathogenic, causing a variety of illnesses including botulism, tetanus, and Lyme disease. Figure 17.8 on page 271 shows you different shapes taken by bacteria.

Bacteria (as well as Archaea) reproduce through *binary fission,* the splitting of a parent cell into two daughter cells. Bacteria may also reproduce by three means of *genetic recombination*. In *conjugation* (which occurs only in closely related species), DNA goes from a donor cell to a recipient cell through tiny tubes called *sex pili*. In *transformation,* fragments of DNA are picked up from surrounding living or dead bacteria. In *transduction,* bacteriophages carry portions of bacterial DNA from one cell to another. On page 272, Figure 17.10 illustrates concepts about bacterial reproduction and survival; Figure 17.11 illustrates cyanobacteria, which are capable of photosynthesis, and chemoautotrophic bacteria that live inside tubeworms.

Archaea

Domain Archaea consists of ancient prokaryotes sometimes referred to as "living fossils." They're adapted to extreme habitats like those that were found on the early Earth. Today, they thrive in oxygen-free environments such as sewage, swamps, and animal guts; salty environments such as salt lakes; and hot environments such as hot springs; and highly acidic soils. Types of archaea include *methanogens,* which release methane into the air, and *halophiles,* which depend on environments rich in salts. Figures 17.15–17.17, all on page 275, illustrate three typical archaea habitats.

The Protists

The Protists include all the eukaryotic unicellular organisms that may resemble either animals or plants. They're primarily aquatic and are widely distributed all over the world in lakes and ponds. Because some protests live in very inhospitable environments—like deep ocean steam vents—they're considered to be among them most ancient life forms on our planet. Figure 17.18 on page 276 illustrates the evolution of the eukaryotic cell.

There are three major groups of protests: algae, protozoans, and slime and water molds.

Algae are plantlike protists, which are generally photosynthetic. They may be single-celled, or they may cluster in colonies as in the case of red, brown, and green types of algae. Algal diversity is illustrated for you in Figure 17.20 on page 227. On the same page, Figure 17.19 presents an inside view of a *Chlamydomonas,* an autotrophic green alga.

Protozoans are categorized by the types of locomotion they employ. *Ciliates* have hairlike cilia for swimming about to capture food such as bacteria, algae, or other protozoans. *Amoeboids* use *pseudopods* (false feet) for moving around and capturing prey. *Radiolarians* and *foraminiferans* are marine amoeboids that form calcium carbonate shells. The accumulation of these shells in sediments leads to the formation of limestone. The *zooflagellates* move about by means of long slender extensions called *flagella.* Under a microscope, flagella look bit like whips. They flail about to propel the creature from place to place. *Sporozoans* aren't *motile* (capable of self-propulsion) They complete part of their life cycle inside specific host cells, and are the cause of many human diseases, including malaria.

Slime molds and *water molds* resemble fungi in many respects. They're heterotrophic and form spore-bearing structures. Unlike fungi, however, they produce motile cells during their life cycle. The life cycle of plasmodium slime molds is illustrated in Figure 17.23 on page 279. Slime molds feed on (and thus help recycle) dead plant matter. They also feed on bacteria, providing checks on bacterial populations. Water molds decompose remains, but they're also parasitic on plants and animals.

Before going on to your next assignment, take a few minutes to respond to *Self-Check 17.*

Self-Check 17

1. Infectious, disease-causing agents are
   a. bacteria.
   b. pathogens.
   c. microorganisms.
   d. protistans.

2. Self-feeders that depend on sunlight to split water and for the reduction of carbon dioxide are called
   a. chemoautotrophs.
   b. photoheterotrophs.
   c. chemoheterotrophs.
   d. photoautotrophs.

3. A rod-shaped prokaryotic cell is a
   a. bacillus.
   b. coccus.
   c. spirillum.
   d. flagellum.

4. Methanogens, extreme halophiles, and extreme thermoacidophiles are all classified as
   a. photoautotrophs.
   b. eubacteria.
   c. archaea.
   d. protists.

5. In which of these phases of the lyctic cycle do we observe the assembly of viral components within a host cell?
   a. Penetration
   b. Attachment
   c. Maturation
   d. Biosynthesis

6. Complete this analogy: Among protozoans, ciliates are to cilia as ________ are to pseudopods.
   a. amoebas
   b. trypanosomes
   c. radiolarians
   d. sporozoans

7. Slime molds differ from water molds in that
   a. water molds are actually amoebas while slime molds are parasitic.
   b. water molds are unique in their capacity to consume plant remains.
   c. slime molds are unique in their capacity to consume plant remains.
   d. water molds may be parasitic to both plants and animals.

Check your answers with those on page 199.

ASSIGNMENT 18: LAND ENVIRONMENT: PLANTS AND FUNGI

Refer to the following information as you read Chapter 18, "Land Environment: Plants and Fungi," on pages 283–304 in your textbook.

Onto Land

Plants (kingdom Plantae) are multicelled eukaryotes that are photosynthetic autotrophs. Most plants are *vascular.* That is, they have internal tissues that conduct water and solutes through roots, stems, and leaves. Green plants are the major producers for land ecosystems.

To track the evolution of land plants, we can begin with *green algae*—a water-dwelling plant that appears to be the common ancestor of land plants. Major evolutionary changes then began with the development of *vascular tissues,* the development of *seeds*, and the arrival of the *flowering plants* (angiosperms) during the age of dinosaurs. The evolution of the different kinds of plants is illustrated in Figure 18.2 on page 285.

The life cycle of all plants is different from that of animals. As illustrated in Figure 18.3 on page 286, plants reproduce in *alternating generations*. Study the illustration to better understand how the diploid *sporophyte* alternates with the haploid *gametophyte*.

Diversity of Plants

The four major divisions in the plant kingdom are illustrated in Figure 18.1 on page 284.

1. The *nonvascular plants* include *mosses* (bryophytes). These plants are well adapted for growth in moist habitats. As noted, a moss's leaflike, stemlike, and rootlike parts have no xylem or phloem (vascular tissues). Instead, they have threadlike structures called *rhizoids* for absorbing water and solutes. Bryophytes include mosses, liverworts, and hornworts. Mosses are illustrated in Figure 18.5 on page 287.

2. *Seedless vascular plants* include club mosses, horsetails, and ferns. All of these kinds of plants reached heroic proportions during the Carboniferous period (286 to 360 million years ago). They eventually formed the sediments we now mine as coal. Today, seedless vascular plants include maidenhair, royal, and hart's tongue ferns—illustrated for you in Figure 18.8 on page 289. Ferns have true roots, and their vascular tissue include xylem and phloem. Most ferns are found in wet, humid environments since they require a dependable water supply for metabolism and reproduction. Figure 18.9 on page 289 illustrates the fern life cycle.

3. *Seed-bearing vascular plants, gymnosperms,* and *angiosperms* have adapted tissue structures for life in dry climates. They produce seeds that encase their embryonic sporophytes inside a protective coat. They also produce pollen grains as a means for sperm dispersal in the absence of water. Figure 18.11 on page 290 illustrates what's involved in the production of a seed.

   a. Gymnosperms produce "naked seeds," seeds with no fruit wall covering. In fact, gymnosperm pollination occurs mostly by the wind. This group includes conifers, cycads, and the ginkgo. On page 291, Figure 18.12 illustrates the ancient cycads. Figure 18.13 illustrates different conifers.

   b. Angiosperms are flowering plants in which the seed is enclosed in a fruit wall. The flowering angiosperms are the most highly evolved and diverse in the plant kingdom. Most *coevolved* with pollinators, such as bees and other insects, allowing the plants to "ship" pollen grains to the female reproductive parts of other plants. There are at least 240,000 species of angiosperms thriving all over the world. Study Figure 18.15 on page 292 to learn the general parts of a flower, including the petals, the parts of the *stamens,* and those of the *carpel.* Figure 18.6 on page 293 portrays the life cycle of a flowering *eudicot,* illustrating the reproductive mechanisms involved in alternating generations.

A *eudicot* is a flowering plant that has two cotyledons. You'll study more about eudicots later in this course.

The Fungi

Fungi are distinct from both plants and animals. Review Table 18.1 on page 296 for an overview of the ways fungi differ from plants and animals. In general, fungi are non-green, somewhat plantlike heterotrophic organisms that grow in dark, moist habitats. Fungi include mushrooms, molds, and yeasts. Figure 18.20 on page 296 illustrates several types of fungi. Figure 18.23 on page 298 illustrates the sexual reproductive cycle of mushrooms.

Most fungi are *saprotrophs,* which decompose dead organic matter. Some fungi, however, like the *fungal pathogens* noted below, are parasitic. Fungi may have *mutualistic relationships* with other organisms. *Lichens,* for example, involve a mutualistic relationship between a fungus and photosynthetic organism. Varieties of lichens are illustrated in Figure 18.25 on page 299. *Mycorrhizal* fungi sustain mutualistic, symbiotic associations between a fungus and the roots of a young plant.

A *mutualistic relationship* is a relationship in which both species benefit in terms of growth and reproduction.

The main body of a fungus is called a *mycelium*. The chains of cells (filaments) that compose the mycelium are called *hyphae*. Fungal hyphae greatly expand the surface areas of plant root systems, allowing them greater efficiency in extracting water and nutrients from soils.

Some fungi—like mushrooms—are a popular source of food for humans and other animals. *Fungal pathogens,* however, are another matter. Plant fungal diseases are illustrated for you in Figure 18.28 on page 300. *Mycoses*—diseases caused by fungi—include several that can plague humans. *Candida albicans* produces the widest variety of fungal diseases. *Candida* infections are generally called “yeast infections” when they infect women, but *Candida* infestations can also cause what’s called *oral thrush* (common in newborns and AIDS patients). In people with suppressed immune systems, *Candida* can attack other tissues, including those of the heart and brain. *Ringworm,* a cause of so-called athlete’s foot, is a *cutaneous* (skin-surface) infection that may appear in other skin areas besides one’s feet. Figure 18.29 on page 301 illustrates oral thrush and ringworm infections.

Before going on to your next assignment take a few minutes to respond to *Self-Check 18.*

Self-Check 18

1. If you observe a fungus intertwined with one or more photosynthetic organisms, you're looking at a
   a. mycorrhiza.
   b. heterotrophic decomposer.
   c. fungal pathogen.
   d. lichen.
2. The main body of a fungus is composed of a mass of hyphae called a
   a. hypha.
   b. chitin.
   c. mycelium.
   d. filament.
3. The pollen sacs in the flower of an angiosperm are located in the
   a. ovary.
   b. stamens.
   c. anther.
   d. style.
4. The two halves within a peanut shell are actually
   a. sporophytes.
   b. cotyledons.
   c. pollen grains.
   d. stigmas.
5. Drought-resistant male gametophytes are called
   a. ovules.
   b. conifers.
   c. pollen grains.
   d. seeds.
6. In vascular plants, ________ conducts water and minerals, while ________ conducts organic nutrients.
   a. lignin, phloem
   b. xylem, phloem
   c. phloem, lignin
   d. phloem, xylem.
7. The *most* common bryophytes include
   a. common mosses and club mosses.
   b. liverworts and Irish moss.
   c. mosses and ferns.
   d. liverworts and mosses.
8. Where does germination take place in a flowering plant?
   a. Stigma
   b. Anther
   c. Ovary
   d. Stamen
9. In terms of numbers and diversity, ________ are the *most* successful plants.
   a. gymnosperms
   b. angiosperms
   c. ferns
   d. bryophytes

Check your answers with those on page 199.

ASSIGNMENT 19: BOTH WATER AND LAND: ANIMALS

Refer to the following information as you read Chapter 19, "Both Water and Land: Animals," on pages 305–336 in your textbook.

Evolution of Animals

Domain Eukarya, Kingdom Animalia contains multicelled organisms with cells arranged into tissues and organs. The more complex animals have their organs arranged into organ systems. All animals are heterotrophic and require oxygen for aerobic respiration. Most are motile at some point during their life cycle, which includes stages of embryonic development. Study Figure 19.1 on page 306 and think about how a frog develops from a single fertilized egg.

Some scientists believe that ancient ancestors of all of the animals now living on Earth appeared all at once at the outset of the so-called *Cambrian explosion.* Figure 19.2 on page 307 illustrates the sea life of the Cambrian period. Turn then to Figure 19.3 for an overall view of the theory behind the evolution of animals. Note the basic characteristics developed along the 600-million-year path to the animals we know today. They include *true tissues,* which are specialized cells organized for specific functions; *radial symmetry,* in which the animal is organized circularly; and *bilateral symmetry,* in which the animal has definite right and left halves. Use Figure 19.6 on page 309 to review the proposed evolutionary tree of animals in terms of molecular data.

Introducing the Invertebrates

Invertebrates are animals that don't have a backbone. They're separated into different phyla with respect to symmetry, type of gut, type of body cavity, and segmentation. The invertebrates include sponges, cnidarians, flatworms, and roundworms.

Sponges

Sponges, which belong in phylum Porifera, don't display any type of symmetry, tissues, or organs. There are 800 species ranging in size from less than one inch to several feet. Water flows into a sponge's body through microscopic openings and out through larger openings. *Collar cells* that line the inside of the sponge trap small food particles. Sponges reproduce sexually by releasing sperm into the water. After the eggs are fertilized, a swimming larval stage is formed that will later develop into an adult sponge. Figure 19.7 on page 310 illustrates the anatomy of a sponge.

Cnidarians

Phylum Cnidaria display true tissues. The phylum includes jellyfishes, the hydra, sea anemones, and corals. The cnidaria have radial symmetry. They're also famous for tentacles with stinging cells called *nematocysts*. Two common body forms among these creatures are the bell-shaped *medusa* and the tube-like *polyp*. Cnidarians are organized to allow their tissues (specialized cells) to cooperate. They feature a saclike gut for food processing. Figure 19.8 on page 310 illustrates the hydra and the sea anemone. Figure 19.9 on page 311 gives you great illustrations of the Portuguese man of war, corals that form and live in a calcium carbonate shell (thus producing coral reefs), and one of the many kinds of jellyfish.

Flatworms

Phylum Platyhelminthes includes a group of animals called *flatworms*. Flatworms were the first animals to display bilateral symmetry and actual organ systems. Often these organisms are *hermaphrodites*. That is, they have both male and female reproductive parts. They reproduce sexually by exchanging sperm with another individual. Classes of flatworms include *planarians,* which are free-living organisms. As shown in Figure 19.10, planarians have many of the features found in animals higher up the evolutionary ladder. Rather unpleasant parasitic flatworms, the tapeworm and the blood fluke, are illustrated in Figure 19.11 on page 312.

Roundworms

Phylum Nematoda classifies the *roundworms*. Roundworms display bilateral symmetry, and the body is usually tapered at both ends. A protective covering called a *cuticle* surrounds the body. Roundworms are the simplest animals to have a complete digestive system. Most are free-living, but some are parasitic species that do great harm to humans, cats, dogs, cattle, and sheep. Roundworms are male or female, not both as in the case of flatworms. Their anatomy is illustrated for you in Figure 19.12 on page 312.

Protostomes and Deuterostomes Compared

Protostomes can be distinguished from *deuterostomes* on the basis of their embryonic development. The differences are illustrated in Figure 19.13 on page 313. (Notice the reversed position for the mouth and the anus.) Protosomes include mollusks, *annelids* (segmented worms), and the enormous family of arthropods (which includes insects, crustaceans, and spiders). Deuterotomes include *echinoderms* (starfish and seas urchins) and *chordates* (creatures with backbone structures).

Molluscs, Annelids, and Arthropods

Molluscs

Phylum Mollusca includes organisms that are bilaterally symmetrical, with a fleshy, soft body. Most have a calcium carbonate shell called the *mantle* that drapes over the body. There are three major classes of molluscs:

1. *Gastropods* include some 90,000 species of snails and slugs. Most have a spirally coiled shell, although some species have a reduced shell or no shell at all.

2. *Cephalopods* include squids, octopuses, cuttlefish, and the chambered nautilus. This class contains the fastest-swimming invertebrates (squids) and the smartest (octopuses). These are the only molluscs to display a closed circulatory system for advanced oxygen uptake.
3. *Bivalves* include oysters, clams, and scallops. They're called bivalves because their shells have two halves.

Figure 19.14 on page 314 illustrates the body plan of molluscs. The three main classes of mollusks are illustrated in Figure 19.15 on the same page.

Annelids: Segmented Worms

Phylum Annelida, the segmented worms, are organisms with highly pronounced segmentation as well as bilateral symmetry. Their body plans permit complex internal organs and systems. The phylum contains earthworms and leeches. Earthworms are valuable aids to soil formation; leeches are parasitic fluid (blood) feeders. Figure 19.16 on page 315 illustrates the anatomy of an earthworm.

Arthropods: Jointed Appendages

Phylum Arthropoda includes an enormous diversity of species and, in that respect, may be considered the most successful animal phylum. The term *arthropod* means joint-footed. Extant (living) arthropods include *crustaceans* (crabs and lobsters), *arachnids* (spiders, ticks, and scorpions), and the more than one million species of insects.

Six characteristics are considered to have contributed to the success of the arthropods. Carefully study all six of these adaptive-success features on page 316 of your text.

Figure 19.18 illustrates an exoskeleton and jointed appendage in a lobster. Figure 19.19 illustrates the metamorphosis of a monarch butterfly. Figures 19.20 and 19.21 on page 317 give you a look at crustacean diversity as well as assorted arthropods—from the black widow spider to the "living fossil" known as the horseshoe crab. Figure 19.22 on page 318 offers you a short visual tour of the amazing world of insects.

Echinoderms and Chordates

Echinoderms

Phylum Echinodermata includes sea stars, sea lilies, sea cucumbers, brittle stars, sea urchins, and sand dollars—all of which are illustrated for you in Figure 19.23 on page 319. The echinoderm body wall contains a number of spines that are used for defense. Most have a well-developed inner skeleton and most often display radial symmetry with some bilateral features during larval stages. In spite of having no brain, they have a well-developed decentralized nervous system.

Chordates

Phylum Chordata (the chordates) is divided into invertebrates and vertebrates. Compared to the vertebrate group, the invertebrate group is rather small. It includes *tunicates* and *lancelets* (Figure 19.25 on page 320). Review Figure 19.26 on page 321 to get a good overview of the chordates.

In general, chordates include bilaterally symmetrical animals that have a backbone composed of either cartilage or bone. There are four distinct features present at some stage of development:

1. A *notochord,* a long rod of stiff tissue, supports the body
2. A *nerve cord* running parallel to the notochord and gut, providing the framework from which the nervous system develops
3. *Pharyngeal pouches,* openings in the wall of the muscular tube, which serve functions related to feeding or respiration
4. A *tail* formed in embryos and extending past the anus

Phylum Chordata is further classified into classes. These classes are shown in Figure 19.26 on page 321 and explained on pages 322–327.

- *Class Agnatha* (jawless fish) includes the hagfish and lamprey.
- *Class Chondrichthyes* includes cartilaginous fishes like sharks, skates, and rays.

- *Class Osteichthyes* (bony fishes) is the most diverse and abundant vertebrate class. Illustrations on page 322 offer you some visual clues about these creatures.
- *Class Amphibia* includes frogs, toads, and salamanders. Figure 19.29 offers some striking illustrations of the evolution of amphibians.
- *Class Reptilia* includes turtles, snakes, alligators, and crocodiles. Reptiles are the first vertebrate class to escape dependency on water in their habitat due to development of internal fertilization, tough skin, and *amniotic eggs,* which have internal membranes that conserve water and protect the embryo. Figure 19.31 on page 324 illustrates reptile reproduction on land.
- *Class Aves* includes birds. These are the only animals with feathers that are derived from skin and used for flight and insulation. Like mammals, birds rely on metabolic heat and a four-chambered heart to maintain body temperature.
- *Class Mammalia* includes the mammals—the only organisms with hair and mammary glands that produce milk for their young. Humans are included in this class.

Most mammals care for their young for extended periods of time, with adults actively teaching certain behaviors. Almost all female mammals develop a *placenta,* a spongy tissue that delivers oxygen and nutrients to the developing embryo and disposes of its wastes. However, *marsupials* and *monotremes* are mammals that don't have a placenta. Monotremes lay eggs; marsupials give birth to underdeveloped young that mature in the mother's pouch. Monotremes and marsupials are illustrated in Figure 19.34 on page 326. Placental mammals are illustrated on page 327 in Figure 19.35.

Human Evolution

Those propounding the theory of evolution believe that human evolution begins with *prosimians,* like the ring-tailed lemur, and proceeds across the spectrum of anthropoids onward to the hominids. *Anthropoids* include all kinds of New World and Old World monkeys, apes, and humans. *Hominids* are mammals that have an anatomy suitable for standing erect and walking on two feet. Figure 19.6 on page 328 presents the suggested evolutionary tree of primates. Note that the common ancestor of the whole group is closest in appearance to modern lemurs.

The evolution of hominids remains clouded in degrees of mystery, largely because the fossil record is thin and new discoveries keep rattling the proposed family tree. Basically, however, what you see in Figure 19.37 is what evolutionists propose as the progress of our species through basic stages, including the *australopithecines, Homo habilis*, and *Homo erectus*. Virtually all of the early fossil evidence is out of Africa. Homo erectus, however, immigrated out of Africa into Asia and Europe.

The final pages of Chapter 19 present one possible theory of how humans evolved.

After you complete *Self-Check 19,* review the material you've learned in this study guide as well as in the assigned pages in your textbook for Assignments 14–19. A good way to review the chapters is to reread the summaries at the end of each one. If you find you don't understand something in the summary, go back to the textbook pages and review the material. When you're sure that you completely understand the information in Assignments 14–19, complete your examination for Lesson 3.

Self-Check 19

1. A sand dollar or a brittle star displays ________ symmetry.
   a. radial
   b. cephalized
   c. bilateral
   d. segmented
2. The most diverse and numerous of the vertebrates are the
   a. lobe-finned fishes.
   b. reptiles.
   c. birds.
   d. bony fishes.
3. Sponges belong to Phylum
   a. Cnidaria.
   b. Platyhelminthes.
   c. Porifera.
   d. Mollusca.
4. Among cephalopods, the ________ has been found to be highly intelligent.
   a. snail
   b. nautilus
   c. squid
   d. octopus
5. Jellyfish are examples of the ________ body form of cnidarians.
   a. polyp
   b. medusa
   c. nematocystic
   d. planula
6. Among mammals, the spiny anteater is distinctive in that it's a/an
   a. egg layer.
   b. prosimian.
   c. placental mammal.
   d. marsupial.
7. The first hominid group known to use fire is now called
   a. Cro-Magnon.
   b. Neanderthals.
   c. *Homo Erectus.*
   d. *Australopithicines.*
8. Free-living (nonparasitic) flatworms are called
   a. planarians.
   b. nematodes.
   c. tapeworms.
   d. flukes.

(Continued)

Self-Check 19

9. Animals with repeating segments that exhibit bilateral symmetry are the
   a. chitins.
   b. annelids.
   c. mollusks.
   d. deuterostomes.

10. Sea cucumbers, brittle stars, and sea urchins belong to the phylum of
    a. arthropods.
    b. echinoderms.
    c. crustaceans.
    d. mollusks.

11. Sharks and skates are classified as ________ fishes.
    a. bony
    b. ray-finned
    c. cartilaginous
    d. amphibioius

Check your answers with those on page 199.

NOTES

Lesson 3
Evolution and the Diversity of Life

EXAMINATION NUMBER

00764800

Whichever method you use in submitting your exam answers to the school, you must use the number above.

For the quickest test results, go to http://www.takeexamsonline.com

When you feel confident that you have mastered the material in Lesson 3, go to http://www.takeexamsonline.com and submit your answers online. If you don't have access to the Internet, you can phone in or mail in your exam. Submit your answers for this examination as soon as you complete it. *Do not wait until another examination is ready.*

Questions 1–20: Select the one best answer to each question.

1. Scientists believe that modern humans appeared during the ________ epoch.

   A. Pleistocene
   B. Pliocene
   C. Miocene
   D. Paleocene

2. In a population of horses, an extreme phenotype is favored and the distribution of genes in that population shifts toward that phenotype. This process is called ________ selection

   A. random
   B. stabilizing
   C. disruptive
   D. directional

3. Which of these creatures are annelids?

   A. Gastropods
   B. Earthworms
   C. Planarians
   D. Sponges

4. Which of the following is a type of archaea?

   A. Algae
   B. Mold
   C. Halophiles
   D. Spirilum

5. What is the process by which a species becomes better suited to its environment?

A. Variation
B. Adaptation
C. Selection
D. Adjustment

6. Of the four plant groups, which one probably evolved *first?*

A. Angiosperms
B. Ferns
C. Mosses
D. Gymnosperms

7. Which one of the following is an example of a postzygotic reproductive barrier?

A. Hybrid sterility
B. Habitat isolation
C. Incompatible anatomy
D. Gamete isolation

8. Most fungi live by decomposing the remains of plants, animals, and microbes found in soil. That is why *most* fungi are called

A. mushrooms.
B. saprotrophs.
C. lichens.
D. mycelium.

9. Scientists who argue that modern humans evolved from a single population believe that humans came from the continent of

A. Europe.
B. Africa.
C. Asia.
D. South America.

10. Any trace of a dead organism, such as an imprint in a rock, is called a

A. homologous structure.
B. transitional form.
C. strata.
D. fossil.

11. Most scientists now believe that birds evolved directly from bipedal

A. amphibians.
B. lizards.
C. dinosaurs.
D. marsupials.

12. The similarity of the characteristics of sheep and reindeer is due to their having a common ancestor. This sort of phenomenon is called

A. homology.
B. convergent evolution.
C. taxonomy.
D. parallel evolution.

13. What do biologists call the process when allele frequencies in a population of a species change over time due to chance?

A. Gene flow
B. Nonrandom mating
C. Genetic drift
D. Bottleneck effect

14. In vascular plants, which of these parts conducts water and minerals upward from the roots?

A. Xylem
B. Lignin
C. Phloem
D. Fronds

15. Amoebas move by using extensions of their cytoplasm called

A. cilia.
B. pseudopods.
C. vacuoles.
D. sporozoa.

16. The structure of the forelimb of a bird is similar in structure to that of the forelimb of a mammal, suggesting that both descended from a common ancestor. This similarity is an example of ________ evidence that supports the theory of evolution.

A. biochemical
B. vestigial
C. anatomical
D. biogeographical

17. The varieties of beak structures among Galapagos finches is a good example of

A. adaptive radiation.
B. allopathic speciation.
C. random radiation.
D. sympatric evolution.

18. Which one of these creatures is an echinoderm?

A. Grasshopper
B. Spider
C. Crab
D. Sea star

19. In biology, the members of a single species occupying the same area and reproducing with one another is called a

A. herd.
B. gene pool.
C. group.
D. population.

20. A virus that reproduces in a bacterium is called a

A. lysogene.
B. retrovirus.
C. phage.
D. viroid.

NOTES

Structure and Function in Plants and Animals

Lesson 4

Your fourth lesson consists of 10 assignments. Part V, "Plant Structure and Function," covers plant anatomy and growth; Part VI, "Animal Structure and Function," covers anatomy, body transport and maintenance systems, nutrition, defenses against disease, and the control systems—as these topics relate to the human body.

When you complete this lesson, you'll be able to

- Identify types of plant tissues
- Explain how water is transported through plants
- Discuss plant reproduction and development
- Describe the process of homeostasis
- Describe human the nervous system and explain the importance of neurons
- Identify the hormones that make up the endocrine system
- Explain the human senses and the nature of motor functions
- Discuss the structure and function of skeletal muscle
- Describe the circulatory system and the characteristics of blood
- Identify the roles of antibodies in the body's defenses against disease
- Describe and explain basic principles of human nutrition
- Describe the functions of the digestive, respiratory, and urinary systems
- Discuss male and female reproductive systems

ASSIGNMENT 20: PLANT ANATOMY AND GROWTH

Refer to the following information as you read Chapter 20, "Plant Anatomy and Growth," on pages 337–354 in your textbook.

Plant Organs

The above-ground parts of vascular plants include the *shoots*—stems, leaves, and flowers—while the underground portion is composed of the *root system,* or roots. *Roots* are specialized structures for the absorption of minerals and water from the soil. Roots also support and anchor the aboveground portion of the plant.

Perennial plants are those that can outlast winter because their roots can survive to produce new shoots in the spring. *Annual plants* survive for only one season. Figure 20.1 on page 338 gives you a good overall representation of the body of a plant.

Flowering plants are divided into two types, based on the nature of their embryonic leaves, called *cotyledons*. *Monocots* have a single cotyledon in their seeds. *Eudicots* (dicots) have two cotyledons in their seeds. Figure 20.4 on page 340 illustrates the differences between monocots and eudicots.

Plant Tissues and Cells

Plants have three types of specialized tissues:

1. The outside of a plant is made up of a single layer of cells called the *epidermis,* which consists of closely packed epidermal cells. Epidermal cells exposed to air are covered with a waxy *cuticle*. The cuticle restricts water loss and resists attacks by microorganisms. Specialized guard cells present in the epidermis allow for the opening and closing of the *stomata*. Stomata are like pores. They control the movement of water vapor, oxygen, and carbon dioxide across the epidermis. (A *periderm* replaces epidermis in plants with secondary growth; periderm is what forms the outer bark of woody plants.)

2. The *ground tissue* makes up the bulk of the plant body. It includes three types of simple tissues. *Parenchyma cells,* which have thin walls, are active in photosynthesis and storage. *Collenchyma cells* provide support for primary tissues. *Sclerenchyma cells* are fibrous cells that give stalks their gravity-resisting strength. Figure 20.6 on page 341 illustrates these three kinds of ground tissue cells.

3. The *vascular tissue* of a plant is composed of two types of tissues. *Xylem* conducts water and dissolved minerals through the plant body. It also functions as a mechanical support for the plant. The cells of this tissue are actually dead at maturity, and the cell walls interconnect to form pipelines for water flow. *Phloem* conducts sugars and other solutes throughout the plant. The cells are alive at maturity. Sugars traveling through the phloem pipelines are unloaded where there's cell growth or where food storage is needed. Figure 20.7 on page 342 illustrates vascular tissue.

Organization of Leaves

The interior of a leaf is composed of *mesophyll,* the tissue that carries out the work of photosynthesis. *Leaf veins* are transport highways to and from the mesophyll cells. They carry water and minerals in and transport sugar out. There are two distinct regions among mesophyll cells. The *palisade mesophyll* has elongated cells. The *spongy mesophyll* contains irregularly shaped cells surrounded by air spaces. The latter arrangement facilitates a maximum exposure of cell surface areas for gas exchange and water loss. Stomata on the leaves allow carbon dioxide to enter and oxygen (a byproduct of photosynthesis) to leave. Figure 20.8 and Figure 20.9 on page 343 illustrates different kinds of leaf arrangements and details of leaf structures.

Organization of Stems

Read pages 344 and 345 carefully to make sure you have a clear sense of the differences between *nonwoody stems* and *woody stems*. Nonwoody stems, like those on daisies, are illustrated in Figure 20.11 on page 344.

Woody stems include bark, which is composed of cork, cork-cambium, cortex, and phloem. Wood like that used for lumber is *secondary xylem,* which builds up year after year in a tree trunk or branch. Since this buildup follows the seasons, we can estimate the age of a tree by counting the annual rings on a cross section of its trunk. Figure 20.12 on page 345 illustrates the organization of a woody stem.

Organization of Roots

Eudicot roots have five different types of specialized tissues. These tissues are listed and explained on page 347 and illustrated in Figure 20.13. Monocot roots are very similar to eudicot roots, but they don't produce the secondary growth that forms wood. Also, the tissues of monocots are arranged differently to include a central ground tissue called the *pith*.

Plant Nutrition

Nutrients are elements essential for a given organism because they're necessary for growth and survival. Essential plant elements include oxygen and hydrogen (from water) and carbon (from carbon dioxide). Plants also rely on the uptake of a wide range of different elements dissolved in soil water. Those required in greater amounts are called *macronutrients*. The others, called *micronutrients,* make up only traces of a plant's dry weight. You'll find a display in your text on page 348 that specifies essential macro and micro plant nutrients.

Plants have special adaptations that aid in the uptake of water and nutrients from the soil:

1. *Root hairs* (Figure 20.1 on page 338) are slender extensions of epidermal cells specialized for absorption. A plant may develop millions or even billions of these to increase absorptive surface area during primary growth.
2. *Root nodules* have a mutualistic relationship with certain bacteria. The bacteria convert nitrogen to usable forms for the plant, while the plant supplies bacteria with organic compounds produced during photosynthesis. Another mutualistic relationship, called *mycorrihizal association,* exists between roots and fungi. Basically, certain fungi attached to root cells and break down inorganic matter to release minerals for the plant's use.

Soil is any plant's vital partner. Soil is composed of mineral particles and decaying organic matter called *humus.* Water and oxygen fill in the spaces between these substances. Mineral particles come in three sizes—sand, silt, and clay. How suitable a particular soil is for plant growth depends on the proportions of each of these minerals. Plants grow best in *loams,* which are soils containing equal amounts of sand, silt, and clay.

Transport of Nutrients

In plants, water and mineral in solutes are taken up in roots hairs and then transported upward in xylem. The mechanism by which water and minerals travel in xylem is called the *cohesion-tension model,* illustrated in Figure 20.17 on page 349. Another concept involved in the transport of nutrients is a phenomenon called *transpiration*. Transpiration occurs by way of the stomata of leaves. As dry air crosses a leaf surface, water in the plant evaporates into the air. The evaporation creates a tension that's sufficient to draw water upward from the root hairs, through the xylem and onward into the atmosphere. At least 90% of the water taken up by roots hairs evaporates from leaves.

Before proceeding to the next assignment, take a moment to complete *Self-Check 20.*

Self-Check 20

1. The centrally located ground tissue of a monocot is the

   a. pith.
   b. endodermis.
   c. cortex.
   d. pericycle.

2. Of the types of simple plant tissues, ________ has a number of commercial uses.

   a. eudicot
   b. collenchyma
   c. sclerenchyma
   d. phloem

3. The plant tissue in which photosynthesis occurs is called

   a. sieve tubes.
   b. xylem.
   c. mesophyll.
   d. phloem.

4. The ground tissue that has thick secondary walls full of lignin is called

   a. parenchyma.
   b. sclerenchyma.
   c. the epidermis.
   d. the cuticle.

5. In the process of ________, the evaporation of water creates a tension that draws water upward from the root hairs.

   a. cohesion
   b. adhesion
   c. transpiration
   d. mycorrhizal association

6. What is the function of the root cap?

   a. Growth
   b. Absorption
   c. Reproduction
   d. Protection

7. A secondary form of xylem that builds up year after year is called

   a. wood.
   b. bark.
   c. cork.
   d. cork cambium

8. ________, which help plants "fix" needed nitrogen, are located in root nodules.

   a. Fungi
   b. Bacteria
   c. Stems
   d. Cotyledons

Check your answers with those on page 200.

ASSIGNMENT 21: PLANT RESPONSES AND REPRODUCTION

Refer to the following information as you read Chapter 21, "Plant Responses and Reproduction," on pages 355–376 in your textbook.

Responses in Flowering Plants

Plant Hormones

In flowering plants, different classes of small molecular hormones are associated with specific responses. There are five currently recognized groups of plant hormones.

Auxins are produced in the shoot apical meristem (located in the terminal bud of the shoot system as well as in the root tip). Auxins are found in young leaves as well as in flowers and fruits. Auxins inhibit lateral bud growth in the vicinity of the root tip. This process is called *apical dominance*. (Clipping a shoot tip on purpose aims at encouraging further bud growth.) When a plant is exposed to light from only one side, auxin moves to the shady side causing the leaves on the shady side to elongate and therefore bend toward the light source. Figure 21.1 on page 356 illustrates this phenomenon. Apical dominance is illustrated in Figure 21.2.

Gibberellins were originally thought to originate with a fungus—in the context of a plant disease. In 1956 it was discovered that gibberellins are also produced by plants. Gibberellins are growth-promoting hormones. Applied externally, they encourage dwarf plants to grow by elongating leaves and stems. The effect of gibberellins is illustrated in Figure 21.3.

Cytokinins are hormones that promote cell division. (Recall that cytoplasm division is called cytokinesis.) Cytokinins applied to plants can restore aging leaves and also encourage new leaf growth. In overall plant metabolism, cytokinins work interactively with auxins, given the relative acidity of the plant environment, to promote or retard plant growth. A correct ratio of the two hormones is best.

Abscisic acid (ABA) is produced by any plant tissue with chloroplasts as well as in monocot endosperm and roots. ABA is sometimes called the plant "stress hormone" because it maintains the dormancy of seeds and buds and closes off stomata. In general, you can assume, that "stress" means cold or adverse weather. In fact, the closing of stomata is a specific response to "water stress" under drought conditions. Effects of abscisic acid are illustrated in Figure 21.4 on page 358.

Ethylene is a gas that moves freely in the air. It works with other plant hormones to produce varying effects. One of these effects is the speeding up of fruit ripening. Ripening bananas and other fruits give off ethylene. Study Figure 21.5 to learn about the effects of ethylene. Note that one of them is *abscission*—the falling off of leaves.

For an overall review of these five main plant hormones, consult Table 21.1 on page 359.

Environmental Stimuli and Plant Responses

Plants respond to their changing environment. For example, stomata open quickly in the presence of light. Also, a plant turns toward a primary source of light through growth mechanisms. Differential growth in a plant is called a *tropism*. *Phototropism* causes plants to turn toward light; *gravitropism* causes plant stems to curve away from gravity.

Photoperiodism

In some plants, flowering occurs in response to the ratio of light to darkness over a 24-hour period. In a given plant, this ratio is its *photoperiod.* To the extent that plant responses are controlled by the photoperiod, they rely on *phytochrome*—a blue-green leaf pigment. Figure 21.8 on page 361 contrasts length of darkness photoperiods in cocklebur (a short-day plant) and clover (a long-day plant).

Sexual Reproduction in Flowering Plants

Most plants reproduce sexually by alternating the production of *sporophytes* (spore-producing bodies) with the production of *gametophytes* (gamete-producing bodies). A sporophyte forms in the vegetative body composed of roots, stems, leaves, and flowers. The gametophytes form in the male and female floral parts. Figure 21.10 summarizes the alternation of generations in flowering plants (*angiosperms*).

As flowers form, they differentiate into *nonfertile* parts (sepals and petals) and *fertile* parts (stamens and carpels). *Stamens* are the male reproductive parts made up of *anthers* on a long stalk *(filament).* The anthers contain pollen sacs. Haploid spores form in the anthers and give rise to the *male gametophytes,* which are the *pollen grains*. The female reproductive structures are the *carpels* (formerly called *pistils*). A carpel is composed of a *stigma,* a *style,* and an *ovary* (the location of egg development).

Pollination is the transfer of pollen grains from an anther to a stigma. The pollen grain then germinates and develops into a *pollen tube* that grows down into the ovary, carrying the sperm nuclei with it. Double fertilization occurs, and a *diploid zygote* forms along with the *nutritive tissue* needed to sustain it. These two structures form a *seed*. While the seeds are forming, the ovaries begin to develop into fruits, which help to protect and disperse the seeds. Figure 21.14 on page 364 illustrates the life cycle of flowering plants. Figure 21.16 on page 366 illustrates the development of a seed in a eudicot. To get a basic sense of the differences between monocots and eudicots, review Figures 21.19 and 21.20 on page 368. The figures contrast the two patterns of seed germination.

Asexual Reproduction in Flowering Plants

Asexual reproduction in flowering plants can be thought of as an alternative or default option. Plants contain nondifferentiated meristem tissue. The cells of this tissue routinely reproduce asexually. For example, white (Irish) potatoes are actually stem extensions. Each eye of the potatoes is a bud that can generate a new potato. Indeed, potato fields are seeded by planting buds. Sweet potatoes are modified roots, and sections of the root can be planted to produce sweet potatoes. Review Figure 21.21 for two examples of *vegetative reproduction*.

Plant cells are *totipotent*. That is, each plant cell can, in principle, become an entire plant. Thus, plant cells can be *cultured,* or developed, as illustrated in Figure 21.22 on page 369. Today, tissue cultures are widely used in the genetic engineering of plants.

Genetically modified plants (GMPs) are also called *transgenic plants*. Today, the modification of plants to encompass desirable genetic traits is a very big global business. And since the commercial potential of genetically modified plants is very large, there are also very large concerns among many people about what's sometimes called "Frankenfood." The concerns mainly have to do with unintended consequences of genetically modified corn, wheat, tomatoes, and so on. However, the long-term effects of GMPs aren't presently crystal clear.

Before proceeding to the next assignment, take a moment to complete *Self-Check 21.* Also, don't forget to review this assignment by studying the chapter summary on page 373 and completing the exercises on pages 374–376. The answers to these exercises are in Appendix A in your textbook.

Self-Check 21

1. ________ is the so-called stress hormone in plants.
   a. Abscisic acid
   b. Cytokin
   c. Ethylene
   d. Auxin

2. The most leaflike part of a flower is called the
   a. petal.
   b. sepal.
   c. stigma.
   d. anther.

3. Initially, a pollen grain is an immature male gametophyte made up of two cells. One of these cells will become a pollen tube, and the other will become
   a. an embryo sac.
   b. an ovule.
   c. sperm.
   d. a pollinator.

4. Which of the following groups represents the female parts of a flower?
   a. Pollen grains, anther, style
   b. Ovary, style, stigma
   c. Stigma, ovary, filament
   d. Anther, filament, stamen

5. If you needed to make spaghetti sauce for dinner but your tomatoes aren't yet ripe, you need to treat them with
   a. cytokinins.
   b. ethylene.
   c. auxins.
   d. gibberellins.

6. Plants growing upward along a trellis are exhibiting a type of
   a. thigmotropism.
   b. phototropism.
   c. gravitropism.
   d. mechanical stress.

7. To say that plant cells are totipotent is to say that
   a. they're composed of nondifferentiated meristem.
   b. each plant cell is devoted to vegetative propagation.
   c. they're capable of phototropism.
   d. each plant cell can become an entire plant.

Check your answers with those on page 200.

ASSIGNMENT 22: BEING ORGANIZED AND STEADY

Refer to the following information as you read Chapter 22, "Being Organized and Steady," on pages 377–394 in your textbook.

The Body's Organization

The cells of most animals interact at three levels of organization. Namely, tissues are combined into organs, which are components of organ systems. Review Figure 22.1 on page 378 to visualize this idea. *Tissues* are groups of similar cells performing particular functions—like motility or respiration. There are four major types of tissues: epithelial, connective, muscular, and nervous. The types of vertebrate tissues, as well as their relationships to organs and organ systems, are beautifully illustrated in Figure 22.2 on page 379.

Epithelial Tissue Protects

Epithelial tissue covers all the outer surfaces of the body and also lines the body cavities. Although the primary function of epithelial tissue is protection, it also performs other functions. Based on these functions, the cells differ in shape. Use Figure 22.3 on page 380 and 22.4 on page 381 to help you differentiate among the different shapes and functions of epithelial tissue cells.

Connective Tissue Connects and Supports

Connective tissue is the most abundant and widely distributed type of animal tissue. There many varieties of connective tissue depending on the bodily functions with which they're associated. In general, connective tissues are connected in a noncellular material called a *matrix*. The matrix may be fluid, semifluid, or solid (as in bones).

Loose connective tissue, like that which lies under the skin to provide elasticity, contains fibers that are loosely arranged in a semifluid substance. *Adipose tissue,* a type of loose connective tissue, is composed of large, tightly packed fat cells. It's commonly found under the skin and around the heart and kidneys where it stores energy storage as well as insulation.

Dense fibrous connective tissue is found in tendons and ligaments. *Cartilage* is a pliable intercellular material that's very strong. It's found in the nose, ears, and parts of the respiratory system. *Bone* is composed of collagen fibers that are strengthened by calcium salts. Bones form the animal skeleton, which supports the body and helps allow for movement. Figure 22.5 on page 382 illustrates some of these types of connective tissue.

In spite of its other functions, *blood* is also classified as connective tissue because it's derived from connective tissue. Blood, of course, serves to transport oxygen and nutrients. As tissue, blood contains two kinds of cells. *Red blood cells* are tiny, disc-shaped cells that lack a nucleus. They're red because they contain the complex iron-based molecule *hemoglobin,* which serves to transport oxygen to all the cells of the body. *White blood cells* are nucleated and specialized for different purposes, mainly related to defense against pathogens. *Platelets* are actually fragments of large cells that are present only in bone marrow. They serve to assist the clotting process in the event of injury. Figure 22.6 on page 383 illustrates the three main types of blood cells as they move about in blood's protein fluid called *plasma.*

Muscle Tissue Moves the Body

Muscle tissue is composed of cells arranged in parallel arrays. Layers of muscles *contract* (shorten) and then relax in a coordinated fashion. This pattern of contraction and relaxation helps to move the body and specific body parts. There are three types of muscle tissue:

1. *Skeletal muscle,* which is attached to bones, functions in moving the body and its parts. This type of tissue is under voluntary control by way of the nervous system.
2. *Cardiac muscle* is present only in the heart. It allows for the contraction and relaxation of heart tissue, which provides for the flow of blood throughout the body.
3. *Smooth muscle* is present in the walls of the stomach, bladder, lungs, and other internal organs. The contractions of smooth muscles are slower than those in skeletal muscle. Smooth muscles normally function involuntarily in gut motility, bladder emptying, and other organ functions.

Figure 22.7 on page 384 illustrates the types of muscular tissue.

Nervous Tissue Communicates

Nervous tissue conducts impulses throughout the body, coordinating body movements and organ functions. The workhorse of all nervous tissue is the *neuron,* which is illustrated in Figure 22.8. Neurons, in turn, are supported by *neuroglia* cells—in a ratio of about 9 to 1. About half the volume of the brain is made up of neuroglia cells. You'll be learning quite a bit more about neurons and the nervous system in Assignment 27.

Organs and Organ Systems

Organs and organ systems are explored in more detail in later assignments. On pages 386–387, your textbook offers an overview that can help you organize what you'll learn later. The *transport systems* include the *circulatory* and *lymphatic* systems. *Maintenance system* functions include *digestion*, *respiration*, and *urinary* manufacture and disposal. *Control systems* include the *nervous* and *endocrine* (hormone) systems. *Sensory input* and *motor output* functions are served by the *skeletal* and *muscular* systems. *Reproduction* is served by the reproduction system. Figures 22.9–22.13, on pages 386–387, illustrate these five basic systems.

Homeostasis

The term *homeostasis* can be illustrated by a household thermostat. Let's say the thermostat is set at 72 degrees. If the outside temperature drops below 72 degrees, the thermostat turns on the heat. Once the temperature reaches 72 degrees, the thermostat turn off the heat. See Figure 22.16 on page 389 for a visual representation of this idea.

From the thermostat analogy, it's easy to understand that homeostasis in biology refers to keeping internal body conditions roughly constant. It's also pretty easy to grasp the idea that homeostatic body processes regulate all kinds of things—temperature, fluid level, sodium level, and so—by *negative feedback.* Figure 22.14 on page 388 provides a diagram of homeostasis with respect to blood and fluid levels. Figure 22.15 on page 389 illustrates the general principles of negative feedback mechanisms.

Before proceeding to the next assignment, take a moment to complete *Self-Check 22.*

Self-Check 22

1. ________ connective tissue found in ligaments features large numbers of collagen fibers packed closely together.

   a. Adipose
   b. Loose fibrous
   c. Dense fibrous
   d. Fibroblast

2. Complete this analogy: Cells are to tissues as organs are to

   a. epithelium.
   b. an organism.
   c. a specific function.
   d. an organ system.

3. Blood is considered what type of tissue?

   a. Epithelial
   b. Connective
   c. Muscle
   d. Nerve

4. The type of epithelial tissue that secretes mucous is

   a. pseudostratified.
   b. columnar.
   c. squamous.
   d. cuboidal.

5. ________ feedback mechanisms are predominant in maintaining homeostasis in the body.

   a. Primary
   b. Positive
   c. Localized
   d. Negative

6. Which type of muscular tissues is striated due to the presence of actin and myosim filaments?

   a. Skeletal
   b. Connective
   c. Smooth
   d. Cardiac

7. In neurons, Schwann cells are a type of neuroglia that surround nerve fibers with a/an ________ sheath.

   a. neuron
   b. axon
   c. myelin
   d. dendrite

Check your answers with those on page 200.

ASSIGNMENT 23: THE TRANSPORT SYSTEMS

Refer to the following information as you read Chapter 23, "The Transport Systems," on pages 395–412 in your textbook.

Open and Closed Circulatory Systems

In some simple animals, such as hydras and planarians, no circulatory system is necessary. See Figure 23.1 on page 396. Other more complex animals have an *open circulatory system* like that of the grasshopper (Figure 23.2a). All vertebrates and some invertebrates, however, have *closed circulatory systems*—properly called *cardiovascular systems* (Figure 23.2b). *Cardio* means "heart"; *vascular* refers to vessels like veins and arteries. In Figure 23.3 on page 398, you can compare the cardiovascular systems of fishes, amphibians, birds, and mammals.

Transport in Humans

In the human cardiovascular system, a muscular heart pumps the blood into large vessels called *arteries*. The blood then flows into smaller *arterioles,* which branch into even smaller vessels called *capillaries*. Blood flows from the capillaries into small *venules.* From there, large-diameter *veins* return it to the heart. The "heart" of the human circulatory system is the heart. Study Figure 23.4 on page 399 to identify the basic anatomical features of this remarkable organ. In particular, note the locations and functions of the left and right *atria,* the left and right *ventricles,* and the *tricuspid* and *bicuspid* valves.

To understand the characteristics of the heartbeat, review Figures 23.5 and 23.6 on page 400. Trace the circuit from the *atrial systole* to the *ventricular systole,* to the *atrial and ventricular diastole.*

A partition (the *septum*) separates the heart into two cardiovascular circuits:

1. The *pulmonary circuit* consists of a short loop that oxygenates the blood. It leads from the right side of the heart to capillary beds in both lungs, where the blood picks up oxygen. The loop then returns to the left side of the heart.

2. The *systemic circuit* is a longer loop that begins at the left half of the heart. Its main artery, the *aorta,* picks up oxygenated blood that flows through arterioles to capillary beds in all regions of the body. Veins then deliver the oxygen-depleted blood back to the right half of the heart.

Review Figure 23.9 on page 402 to master the path of the blood through these circuits. Be aware that the whole process begins and ends with the lungs.

The *lymphatic system* consists of an extensive system of lymphatic vessels that complement the blood-circulatory system. Lymphatic fluid—called *lymph*—picks up excess tissues fluids to return them to the cardiovascular veins. The lymphatic system plays a vital role in maintaining the body's immune system, which you'll study later in this course. Study Figure 23.10 for a sense of the lymphatic-vessel network. Note the location of ducts in the shoulders and thorax where lymph is deposited into the cardiovascular system.

Blood: A Transport Medium

As you've already learned, blood is a type of connective tissue that carries out many functions. It transports oxygen and nutrients to all of the cells in the body. It carries away metabolic wastes and secretions such as hormones. It transports cells that fight infections and remove debris from tissues. It also stabilizes body temperature by moving excess heat from muscles to the skin for dissipation.

Blood components consist of *plasma* plus a number of *formed elements*. The formed elements include red blood cells, white blood cells, and platelets. You can get an overall view of the components of blood by reviewing Figure 23.13 on page 405.

Plasma is mostly water, but it also contains certain ions and proteins. It serves as a transport medium for blood cells and platelets. It supplies water, oxygen, and metabolites to cells and removes nitrogen wastes and carbon dioxide.

Red blood cells, or *erythrocytes,* transport oxygen for aerobic respiration and carry away some of the carbon dioxide wastes. As previously noted, mature red blood cells don't have nuclei. (Immature red blood cells, formed in bone marrow, do have nuclei.) As red blood cells mature, they begin to synthesize *hemoglobin*—the complex iron-based molecule that can bind with oxygen. Red blood cells live only about 120 days before being "recycled"—mainly in the liver and spleen.

White blood cells, or *leukocytes,* function in daily housekeeping by patrolling tissues and engulfing damaged or dead cells and anything recognized as foreign to the body. Many leukocytes are located in lymph nodes and the spleen, where they divide to produce armies of defense cells when the body is threatened.

Figure 23.15 on page 406 summarizes the formed elements of blood. Take some time to study the different kinds of leukocytes and think about their specific functions. Doing this will give you a head start in understanding the body's defenses against disease discussed later in this course.

Platelets, or *thrombocytes,* are tiny oval discs formed by the fragmentation of large cells that are provided in bone marrow. Their function is to initiate blood clotting when necessary. Blood contains at lest 12 clotting factors. Among these, proteins called *prothrombin* and *fibrinogen* are deposited into the blood by the liver. In the event of an injury that damages tissues and blood vessels, platelets hasten to plug the gap, forming a temporary seal. Then, by way of complex reactions, platelets in conjunction with injured tissues, release a clotting factor called *prothrombin activator* that creates *thrombin.* Thrombin, in turn, acts as an enzyme to catalyze further chemical reactions to produce a proper clot made sturdy by fibrin threads. Study Figure 23.16 on page 407 for a graphic illustration of the stages of blood clotting.

Before proceeding to the next assignment, take a moment to complete *Self-Check 23.*

Self-Check 23

1. Which one of the following organisms has an open circulatory system?
   a. Hydra
   b. Grasshopper
   c. Common field mouse
   d. Planarian

2. The heart of a vertebrate is in contraction during
   a. diastole.
   b. pulse.
   c. systole.
   d. heartbeat.

3. All of the following are formed elements of blood, *except*
   a. platelets
   b. red blood cells.
   c. white blood cells.
   d. plasma.

4. Venous blood from the superior vena cava enters the human heart at the
   a. left ventricle.
   b. right atrium.
   c. right ventricle.
   d. left atrium.

5. Which one of the following statements is *accurate* for an antigen?
   a. It doesn't belong to the body.
   b. It's produced by an antibody.
   c. It's a form of platelet.
   d. It releases white blood cells.

Check your answers with those on page 201.

ASSIGNMENT 24: THE MAINTENANCE SYSTEMS

Refer to the following information as you read Chapter 24, “The Maintenance Systems,” on pages 413–434 in your textbook.

Digestive System

Tube-Within-a-Tube Body Plan

Some animals, like the jellyfish, have a *sac body plan*. One “mouth” is both the entryway for food and the exit for wastes. Most of the other animals, including humans, feature the *tube-within-a-tube* body plan, which has both an entrance and an exit. Figure 24.2 on page 415 presents an anatomical breakdown of the digestive systems of earthworms and humans. Basically, the one-way tube plan includes a *gut* (the *alimentary canal*) with a mouth at one end and an anus at the other. In this system, the wall of the gut is separated from the outer body wall by a *coelom*. In Figure 24.2a, you can see that the coelom is simply “packing space” for accessory digestive organs.

Animals of all kinds can be sorted by their typical diet. Animals are *herbivores* if they eat vegetable matter, *carnivores* if they depend on meat, and *omnivores* if they’ll eat anything that strikes their fancy. (*Omni* is a Latin prefix meaning “all.”) Humans are omnivores. The mouths and dentition of the different kinds of feeders are illustrated in Figure 24.3 on page 415.

The physiology of the human digestive system includes a number of components:

- The *mouth* is the entrance to the system where food is moistened and chewed. Digestion begins when the teeth break down food into smaller particles and salivary glands secrete saliva containing digestive enzymes.
- The *pharynx* is a short but wide space that serves as a common passageway for both food and air; it moves food forward through the system by muscle contraction.

- The *esophagus* extends from the pharynx to the stomach. As food reaches the esophagus, it's moved along by involuntary, rhythmic contractions called *peristalsis.*

- The *stomach* is a J-shaped sac that expands to a capacity of about one liter. Its epithelial lining, the *mucosa,* imbeds millions of *gastric glands,* which secrete *hydrochloric acid (HCl).* The high acidity of the stomach is also ideal for a digestive enzyme called *pepsin*. Together, HCl and pepsin kill all kinds of potential pathogens while breaking down proteins into *peptides*. (The thick mucus in the stomach and in the intestines protects these organs from acidity and the actions of digestive enzymes.) The churning action of the stomach resolves *boluses* of food into *chyme.* Figure 24.5 on page 417 displays the anatomy of the human stomach. Figure 24.6 allows you to contrast the human stomach with the chambered stomach of *ruminants,* such as cows and camels.

Boluses are rounded masses of food formed by swallowing.

- The *small intestine,* a tube approximately seven meters long, receives the chyme from the stomach. The small intestine is separated into three regions. The *duodenum,* a C-shaped structure, receives bile from the liver and digestive enzymes from the pancreas. The *jejunum* section is where most nutrients are digested and absorbed by way of fingerlike projections called *villi*. In the *ileum,* some nutrients are absorbed while unabsorbed material is passed onward to the *large intestine.*

- The *large intestine* absorbs water, salts, and some vitamins. It then stores indigestible material in the form of *feces,* which eventually leave the body through the anus.

Review Figures 24.2–24.10 and pages 415–420 for complete information on the main parts of the digestive system.

Accessory Organs

Two accessory organs involved in digestion are the pancreas and the liver. In digestion, the *pancreas* secretes *pancreatic juice* directly into the duodenum, as shown in Figure 24.7. The *liver*, a large organ, has multiple functions, including *blood detoxification* (that is, the removal of poisonous substances from the blood), the production of plasma proteins, bile production for digesting fats, and the production of *urea* as a contribution to the urinary system. Figure 24.11 presents an illustration of the *hepatic portal system*. By way of that system, products of digestion are absorbed from the small intestine, processed, and passed onward to the bloodstream through *hepatic veins*. (Anything "hepatic" is related to the liver, including the varieties of hepatitis.)

Respiratory System

Respiration is the process by which animals move oxygen into blood for the processes of aerobic respiration, which includes ridding the body of the accumulated carbon dioxide wastes.

The Human Respiratory Tract

The function of the human respiratory system is to conduct air to and from the lungs. The system is composed of upper and lower respiratory tracts.

The *upper respiratory tract* includes the *nasal cavities,* which are narrow canals separated by a *septum* of bone and cartilage. The nasal cavities are in communication with air-filled spaces called *sinuses,* which reduce the mass and weight of the skull and act as resonating chambers for speaking and singing. Inhaled air passes from the *pharynx* through the *glottis,* an opening into the *larynx*. The larynx, or voice box, along with the vocal cords, allows us to vocalize.

The *lower respiratory tract* begins with the *trachea,* also called the *windpipe.* The trachea is a four-inch tube that runs from the larynx. It's lined with *cilia* that beat upward to drive out dust particles. The trachea divides into two branches called *bronchi,* which enter the lungs. The *lungs* are a pair of respiratory organs situated on each side of the heart. They're separated from the abdomen by a muscular partition called the *diaphragm*. The lungs are smooth, spongy, and, when healthy, pink in color. The right lung is divided into three lobes. The left lung, which is smaller to accommodate the space taken up by the heart, is divided into two lobes. After entering the lungs, the bronchi divide into smaller *bronchioles,* like a tree branching into thinner branches and then twigs.

The smallest branches end in clusters of *alveolar sacs,* each of which contain bunches of *alveoli* that resemble clusters of grapes. The alveoli are lined with flat *epithelial cells* that facilitate the exchange of gases from the networks of blood capillaries that surround every alveolus.

Figure 24.12 on page 422 illustrates the gas exchange functions of the respiratory system, as these are aimed at maintaining bodily temperature homeostasis. Figure 24.13 on the same page illustrates the *ciliated cells* of the respiratory passages. For an overview of the human respiratory tract, study Figure 24.14 on page 423. On the same page, Figure 24.15 contrasts the tracheae of insects with those of humans.

Breathing

Breathing involves inhalation and exhalation. *Inhalation (inspiration)* is an active process in which air enters the lungs. In the lungs, the exchange of gases between the inhaled air and the bloodstream capillaries takes place through the internal lining of alveoli due to different gas concentration gradients. As oxygen is removed from inhaled air, the air in the lungs quickly becomes saturated with carbon dioxide.

Exhalation (expiration) is a passive process during normal activity; that is, it's automatic. During exhalation, air moves out of the lungs. The ribs fall, the sternum sinks, and the diaphragm arches upward. This reduces the volume capacity of the thorax, and air is expelled from the lungs as a result.

Review Figure 24.16 on page 424 for an overview of inspiration versus expiration. Compare our pulmonary system to that of birds in Figure 24.17 on the same page. Figure 24.18 on page 425 will help you understand the processes of gas exchange in human lungs. Compare that with the gill system of bony fishes illustrated in Figure 24.19.

Transport and Internal Exchange of Gases

On page 426, Figure 24.20 illustrates the structure of *hemoglobin* molecules. Note how oxygen bonds to the central iron atom of a *heme* (polypeptide group). Figure 24.21 on the same page illustrates the neural control of breathing rate. The chemical reactions given in the text on this page should help you understand how carbon dioxide is carried in the bloodstream and how it diffuses into the alveoli during internal gas exchange.

Urinary System and Excretion

In complex vertebrates like humans, organs called *kidneys* are designed to excrete nitrogenous wastes, like urea and uric acid, and help maintain the body's water-salt balance. Also, in mammals, the kidneys regulate the acidity (pH) of blood. In all mammals, the two kidneys are compact, reddish-brown, bean-shaped structures located on the *dorsal* (back) wall of the abdominal cavity. The kidneys constantly filter water and solutes (except proteins) from the blood. They reclaim the amount of water and solutes that the body requires, and the rest is excreted as urine. Each kidney is attached to a *ureter,* a tube that takes urine from the kidney to a muscular sac called the *urinary bladder*. A single *urethra* conveys urine from the body during urination. Figure 24.22 on page 417 illustrates the functions of the kidneys.

Each kidney has three major parts. The outer region of the kidney, the *renal cortex,* has a granular texture. The *renal medulla* is made up of the cone-shaped *renal pyramids* that lie inside the renal cortex. The innermost part of the kidney is the hollow *renal pelvis*. There, urine is collected for transport via the ureters to the urinary bladder.

Under the microscope, we discover that each kidney is composed of about one million *nephrons*—the bodies that produce urine. Figure 24.23 on page 427 displays the anatomy of the urinary system. Figure 24.24 on page 428 illustrates the process of urine formation in the nephron. In this illustration, locate the *nephron capsule,* the *proximal tubule,* the *nephron loop,* the *distal tubule,* and the *collecting duct*. The location and function of these parts are shown in that illustration.

Urine formation includes three steps. First, *filtration* moves small molecules (water, nutrients, salts, and urea) from a blood capillary to the inside of the *nephron capsule*. Next, during *reabsorption,* substances from the proximal tubule move into the bloodstream. This is the kidney's blood filtration system at work. Finally, *secretion* is the transport of substances into the nephron by means other than filtration. Secreted substances include uric acid, hydrogen ions, ammonia, and drugs like penicillin that are harmful to the body.

The final sections of this assignment discuss the manner in which animals maintain water salt balance and pH. Figure 24.26 illustrates the way kidney tubules help maintain the water-salt balance in mammals. The final topic presents problems in kidney functioning and explains the process of dialysis by means of an artificial kidney machine.

Before proceeding to the next assignment, take a moment to complete *Self-Check 24.*

Self-Check 24

1. ________ breaks up fats through a process of emulsification.

   a. Bile
   b. Trypsin
   c. Pancreatic amylase
   d. Chyme

2. The coelom separates the ________ from the ________.

   a. pharynx, mouth
   b. alimentary canal, mouth
   c. pharynx, esophagus
   d. alimentary canal, body wall

3. What modification to the respiratory system allows birds to support higher rates of respiration?

   a. Larger lungs
   b. More surface area in trachea
   c. Spiracles
   d. Air sacs

4. In the context of gas exchange, the epithelium of an alveolus is snugly adjacent to the epithelium of a/an ____________, forming a respiratory membrane.

   a. hemoglobin molecule
   b. capillary
   c. bronchiole
   d. pulmonary artery

5. The structure that allows you to speak is the

   a. alveolar sac.
   b. pharynx.
   c. larynx.
   d. nasal cavity.

6. Complete this analogy: The villi are to small-molecule nutrient absorption as the large intestine is to the

   a. absorption of water and salts.
   b. formation of chyme.
   c. production of a bolus.
   d. secretion of intestinal enzymes.

7. The ________ stores bile secreted by the liver.

   a. pancreas
   b. gallbladder
   c. small intestine
   d. colon

(Continued)

Self-Check 24

8. Urea is formed in the

   a. urethra.
   b. kidneys.
   c. liver.
   d. bladder.

9. As a participant in the ________ system, the pancreas is a ductless gland that produces insulin.

   a. digestive
   b. endocrine
   c. respiratory
   d. urinary

10. In the process of urine formation, the movement of small molecules from a capillary to the inside of a nephron capsule is called

    a. secretion.
    b. absorption.
    c. reabsorption.
    d. filtration.

Check your answers with those on page 201.

ASSIGNMENT 25: HUMAN NUTRITION

Refer to the following information as you read Chapter 25, "Human Nutrition," on pages 435–454 in your textbook.

Nutrition

Nutrition is the process by which food is obtained, prepared, absorbed, and converted into body substances such as carbohydrates, lipids, proteins, and nucleic acids. Nutritive processes provide the raw materials necessary for the maintenance of life and the maintenance of homeostasis. *Macronutrients* include carbohydrates, proteins, and lipids. They're called "macro" because the body needs to consume them in fairly large quantities on a regular basis. *Micronutrients,* which include vitamins and minerals, are required in only small amounts. Table 25.1 on page 438 summarizes the classes of nutrients.

The Classes of Nutrients

Macronutrients: Carbohydrates, Lipids, and Proteins

All of the macronutrients are sources of energy. However, each provides energy in somewhat different ways, and each also has other specific functions.

- *Carbohydrates* are present in foods as sugars, starches, and fiber. Sugars provide more or less immediate sources of energy, but they can present problems if they're consumed in excess. Starches metabolize differently than sugars. Any excess starches can be stored in the body as glycogen. Fiber isn't digestible, but it's important for stimulating effective passage of food through the gut.
- Some *lipids* (fats and oils) can be stored in the body for use as energy when needed. Other lipids serve as structural components of cells.
- *Proteins* are digested (broken down) into amino acids that can be reconfigured to produce the thousands of proteins manufactured in the cells.

Micronutrients: Minerals, Vitamins, and Water

Although the body needs only small amounts of micronutrients, they're still vital components for a healthy body. Micronutrients help to process the macronutrients, and they're essential for growth and good health.

- *Minerals* are required for a wide variety of physiological functions, including the regulation of biochemical reactions. Table 25.4 on page 441 summarizes the functions and food sources of vital minerals. This table also includes conditions that can be caused by either an excess or a deficiency of a given mineral. In this table, notice that the mineral iron is listed as a trace element, which means the body needs less than 5 grams of this mineral each day. Even so, iron is crucial to the formation of hemoglobin and therefore a very important part of good nutrition.

- *Vitamins* have a wide variety of functions, as summarized in Tables 25.6 and 25.7 on page 443.

- *Water* is a basic requirement for all carbon-based life forms. About 60% of the human body is water and, as you may guess, lack of water in a body can lead to serious problems.

The remainder of Chapter 25 presents a simple, practical guide to understanding relationships between diet and health, as well as what it takes to plan a nutritious meal. As you read and study this material, think about your own diet. Are you eating properly? Is your body getting the right kinds and amounts of the nutrients it needs?

Also, pay particular attention to the topic of eating disorders discussed on page 448. Finally, examine Figure 25.14 on page 449. Even though you may have seen this good guide pyramid before, carefully consider it in light of your own diet.

Before proceeding to the next assignment, take a moment to complete *Self-Check 25.* Be sure to read the chapter summary and complete the exercises on pages 452–454.

Self-Check 25

1. The body mass index (BMI) is the ratio between a person's height and
   a. energy intake.
   b. weight.
   c. age.
   d. energy output.

2. A deficiency of vitamin D can lead to bone decalcification and a disorder called
   a. scurvy.
   b. beriberi.
   c. rickets.
   d. pellagra.

3. Complete this analogy: Triglycerides are to ________ as starches are to carbohydrates.
   a. proteins
   b. cholesterol
   c. obesity
   d. lipids

4. If the body can't produce a certain nutrient, it must be supplied by diet. Such a nutrient is called
   a. essential.
   b. a macronutrient.
   c. healthful.
   d. a micronutrient.

5. Which one of the following vitamins is essential for strong bones and teeth?
   a. Thiamine
   b. Vitamin D
   c. Riboflavin
   d. Vitamin E

Check your answers with those on page 201.

ASSIGNMENT 26: DEFENSES AGAINST DISEASE

Refer to the following information as you read Chapter 26, "Defenses Against Disease," on pages 455–470 in your textbook.

The human body is continuously exposed to pathogens such as viruses and bacteria. Fortunately, vertebrate systems have developed various organic features that sustain what's called the body's *immune system,* which helps the body repel foreign substances, cancers, and pathogens.

Organs, Tissues, and Cells of the Immune System

The organs of the immune system are called *lymphatic organs.* They include red bone marrow, the thymus gland, and lymph nodes, and the spleen.

- *Red bone marrow* produces all kinds of blood cells. With respect to the immune system, it specifically produces B lymphocytes (B cells) and T lymphocytes (T cells). B cells provide an antibody response to a pathogen, and T cells destroy antigen-bearing cells.
- The *thymus gland* is where T cells mature. It produces thymic hormones that are believed to aid the maturing of T cells. Note that T cells have to pass a test before they're released into the bloodstream. They must demonstrate that they aren't inclined to ingesting their own kind—only hostile strangers.
- The *lymph nodes* filter lymph of impurities such as pathogens and antigens. *Sinuses* (open spaces) in the lymph nodes are lined with *macrophages*. Macrophages are large cells that can engulf and consume as many as 100 pathogens.

- The *spleen,* which is about the size of one's fist, is where red blood cells go to be "recycled". The spongy tissue of this organ is also adapted to filtering out all kinds of impurities from the blood, including debris and pathogens.
- The *tonsils* and the *appendix* are also areas of lymphatic tissue that contribute the immune system.

Review Figure 26.1 on page 456 for a graphic glance at the nature of the lymphatic organs and the locations of lymph nodes. Study Table 26.1 on page 457 for an overview of the types and functions of immunocells.

Nonspecific Defenses

The human body has four strategies for nonspecific defense against disease.

1. The skin and mucous membranes serve as body surface barriers. Generally, pathogens can't get past the linings of these surfaces. The flushing effects of tears, saliva, urination, and diarrhea also help rid the body of invaders. Figure 26.2 on page 458 illustrates a cross section of skin. The outer cells of the dermis form the pathogen barrier.
2. The *inflammatory response* kicks in when a pathogen invades body tissues. Three kinds of white blood cells react swiftly to any tissue injury. *Neutrophils,* the most abundant type, ingest, kill, and digest bacterial cells. *Mast cells* release neutralizing chemicals, like *histamine*, which cause capillaries to dilate. This dilation causes the redness and swelling around a cut or abrasion. *Macrophages* also participate in the inflammatory response, releasing hordes of leukocytes into an affected area. Figure 26.3 on page 458 illustrates the inflammatory response.
3. The *complement system* is made up of a number of blood plasma proteins that complement certain kinds of immune response actions.
4. *Natural killer cells (NK cells)* are large granular lymphocytes that kill cancer cells and cells infected by viruses. Figure 26.4 on page 459 illustrates the actions of macrophages and the manner in which complement proteins form a membrane attack in the face of pathogens.

Specific Defenses

Specific defenses require the presence of an *antigen*—a molecule that stimulates the immune system because it's alien to the body. Here's a quick overview of specific immunity mechanisms.

B cells and T cells of the immune system have four outstanding features:

1. The B cells and T cells ignore the body's own cells.
2. Only a specific antigen triggers a B cell or T cell response.
3. The capacity of B cells and T cells to form receptors specific to particular antigens is enormous. Many millions of specific antigen threats can be recognized and neutralized.
4. B cells and T cells have a biochemical memory. That is, after a B cell or T cell responds to an antigen, a portion of the cell is set aside for future battles with the same pathogen.

To better understand the functions of B cells and T cells, study Figures 26.5 and 26.7 and Tables 26.2 and 26.4 on pages 460 and 462. Then study Figure 26.8 on page 463 to review the ways helper (cytoxic) T cells regulate immunity by secreting *cytokines*.

Immunizations

Make sure you understand the difference between *active* and *passive immunity.* In response to vaccine, active immunity is a measurable response in terms of antibody production largely by memory B cells. Passive immunity is temporary in that antibodies aren't produced in the body but may, as in the case of a newborn infant, be received through the placenta.

Immune System Problems

Immune systems don't always work the way they should. For example, *allergies* are specific responses to particular antigens, such as plant pollens, which are identified as *allergens.* Also, severe autoimmune disorders, including *myasthenia gravis* and *lupus,* are examples of malfunctioning immune systems.

AIDS results from an HIV retrovirus infection. Full-blown AIDS amounts to a general assault on the body's immune system—making the body vulnerable to a wide range of pathogens and cancers.

Before proceeding to the next assignment, take a moment to complete *Self-Check 26.*

Self-Check 26

1. Of the types of T cells, which kind regulates immunity by secreting signaling chemicals called cytokines?
   a. Receptor T cells
   b. Helper T cells
   c. Granzyme T cells
   d. Cytoxic T cells

2. A/An _______ is a molecule that stimulates the immune system.
   a. complement
   b. antigen
   c. histamine
   d. antibody

3. Which blood type contains plasma antibodies that are both anti-A and anti-B?
   a. A
   b. B
   c. AB
   d. O

4. In the inflammatory response, _______ release chemical mediators that cause capillaries to dilate and become more permeable.
   a. macrophages
   b. killer NK cells
   c. mast cells
   d. neutrophils

5. T lymphocytes mature in the
   a. red bone marrow.
   b. spleen.
   c. lymph nodes.
   d. thymus gland.

Check your answers with those on page 202.

ASSIGNMENT 27: THE CONTROL SYSTEMS

Refer to the following information as you read Chapter 27, "The Control Systems," on pages 471–492 in your textbook.

Nervous System

The Human Nervous System

The *central nervous system (CNS)* of vertebrates, including humans, is composed of the brain and the spinal cord. The *peripheral nervous system (PNS),* which consists of nerves, carries signals from the brain and spinal cord to the rest of the body. Figure 27.1 on page 472 illustrates the ways in which the nervous and endocrine systems work together. Figure 27.2 compares the nervous systems in earthworms, planarians, and humans.

Neurons, the Nerve Impulse, and the Synapse

Neurons, or nerve cells, respond to changes in voltages across their plasma membranes. The cell body and slender extensions called *dendrites* are the input zones for incoming signals. The signals, or *nerve impulses,* flow to the *axon,* a longer extension that serves as a conducting zone. Axon endings are the output zones for signals to be sent on to the dendrites of other cells. When neurons are triggered by an abrupt change in voltage (called an *action potential*), they're able to send this signal to the next neuron by way of signaling molecules called *neurotransmitters.* These chemical signals diffuse across a chemical *synapse,* the narrow space between a neuron's output zone and the input zone of a neighboring cell. This system allows messages traveling through the nervous system to either be reinforced or suppressed, depending on the intensity of the signal.

Vertebrates have their neurons connected in cable-like bundles called *nerves* that allow communication between the brain, the spinal cord, and the rest of the body. Figure 27.3

on page 474 illustrates three types of neurons. Reviewing Figure 27.4 on page 475 and comparing it with Figure 27.5 on the same page will help you understand the role of myelin in speeding a nerve impulse propagation through *saltatory conduction*. Figure 27.6 on page 476 will help you distinguish the synapse from the synaptic cleft and visualize the way chemical signals called *neurotransmitters* travel across that that cleft.

The Central Nervous System

As already mentioned, the central nervous system consists of the brain and the spinal cord. The *brain* is the master control system of the body. It receives, integrates, stores, and retrieves sensory information. The brain is protected by the cranium as well as by membranes and the fluid contained by these protective membranes. In effect, the surrounding fluids cushion brain tissues. The *spinal cord* is the expressway for signals between the brain and the peripheral nervous system. Signals travel swiftly up and down the cord.

The brain includes the following functional divisions:

- The *cerebrum,* the largest part of the brain, is divided into two halves, each of which has a number of divisions called *lobes*. The convoluted outer layer of the cerebrum, called the *cerebral cortex,* manages responses to sensations, voluntary movement, and higher thought processes such as reasoning. Each lobe in the cerebrum has specialized functions, as shown in Figure 27.10 on page 479.
- The *diencephalon* (Figure 27.9) lies beneath the cerebrum. In the diencephalon are the *hypothalamus,* which helps maintain homeostasis, and the *thalamus,* which receives sensory information and sends it to the appropriate area of the cerebrum.
- The *cerebellum* receives and processes information from the various senses, both external and internal. It then fine-tunes motor responses. (Because the cerebellum in cats is highly developed, their movements are graceful and fluid.)

- The *brain stem* contains the midbrain, the pons, and the *medulla oblongata*. The medulla oblongata contains reflex centers for managing heartbeat, breathing, and blood pressure. It's also responsible for reflexes like sneezing, coughing, swallowing, and vomiting.

The *limbic system* can be thought of as a cooperative complex involving different parts of the CNS, including the cerebrum and the diencephalon. The limbic system blends higher cognitive (thought) functions with basic human emotions like fear and pleasure. In the limbic system, the *hippocampus* acts to create associations between sensory experiences and memories. Hearing the song that was playing when you were on your first date, for example, can evoke certain memories. This reaction is controlled by the hippocampus. Another part of the limbic system is the *amygdala,* an almond-like structure under the cerebrum. The amygdala is especially implicated in giving remembered experiences emotional fearful, exciting, or arousing overtones. Figure 27.11 shows the location of the thalamus, hippocampus, hypothalamus, and amygdala.

The Peripheral Nervous System

The peripheral nervous system consists of two subdivisions:

1. The *somatic system* carries signals about moving the head, trunk, and limbs. First, its sensory axons deliver information from receptors in the skin, skeletal muscles, and tendons to the central nervous system. Then, its motor axons deliver the commands from the brain and spinal cord to the skeletal muscles.
2. The *autonomic system* carries signals to and from smooth muscle, cardiac muscle, and glands. Figure 27.14 on page 482 illustrates the two divisions of the autonomic system: the *parasympathetic division* and the *sympathetic division*. Think of the parasympathetic system as associated with happy feelings and the sympathetic system as related to stress and perceived threats.

Endocrine System

All animals contain chemical components known as *hormones,* which are produced by *endocrine glands* that release these secretions into the bloodstream. These hormones are carried to other parts of the body where they act on target cells to alter their activities. Collectively, the body's sources of hormones make up the *endocrine system*. The organs of the endocrine system are illustrated in Figure 27.15 on page 483.

The Action of Hormones

There are two main categories of hormones:

1. *Steroid hormones,* which are soluble in lipids, can diffuse across the lipid bilayer of a cell membrane. Once inside the cell, they move into the nucleus, where they bind with a receptor. This complex then interacts with the cell's DNA to call for the production of enzymes and other proteins to carry out a response to the hormonal signal. Steroid hormones are secreted by the *adrenal glands* and the *gonads*. Testosterone and estrogen are examples.

2. *Peptide hormones* are soluble in water. When they bind to receptors at the cell membrane, specific enzyme systems become activated and lead to a cellular response; the hormone itself doesn't enter the cell. Examples of peptide hormones include peptides, proteins, glycoproteins and modified amino acids.

Review Figure 27.16 on page 483 to compare cell interactions between steroid and peptide hormones.

Hypothalamus and Pituitary Gland

Two major components of the endocrine system are the *hypothalamus* and the *pituitary gland*. Figure 27.18 on page 485 illustrates the relationship of these two glands and their functions. Figure 27.17 provides some visual insight into how the hypothalamus and the *anterior lobe* of the pituitary gland interact with the thyroid gland, the adrenal cortex, and the gonads. Note the great variety of bodily functions related to hormones produced and/or regulated by these powerhouse glands of the endocrine system.

Other Endocrine Glands

The thyroid, parathyroid, adrenal, and pancreas glands are also part of the endocrine system. Their functions and possible dysfunctions are provided on pages 486–488.

Before proceeding to the next assignment, take a moment to complete *Self-Check 27.*

Self-Check 27

1. Two important functions of the ________ system are learning and memory.

   a. somatic
   b. limbic
   c. cerebellum
   d. medulla

2. Signals are carried across a synaptic cleft by

   a. neurotransmitters.
   b. neurons.
   c. dendrites.
   d. axons.

3. Complete this analogy: Steroid hormones are to ________ as peptide hormones are to proteins.

   a. synthesis
   b. glands
   c. reflexes
   d. lipids

4. Hormones produced by the anterior pituitary gland don't always affect other endocrine glands. Which one of these hormones is produced during pregnancy?

   a. Thyroid hormone
   b. Oxytocin
   c. Prolactin
   d. Antodiuretic hormone

5. Which one of the following elements is part of the PNS?

   a. Brain stem
   b. Ganglia
   c. Spinal cord
   d. Cerebellum

6. In the CNS, the hypothalamus and the thalamus are located in the

   a. diencephalon.
   b. cerebrum.
   c. cerebellum.
   d. primary motor area.

7. Involuntary responses to stimuli, which occur in the ________ system of the peripheral nervous system, are called

   a. somatic, sympathetic.
   b. autonomic, sympathetic.
   c. somatic, reflexes.
   d. autonomic, reflexes.

Check your answers with those on page 202.

ASSIGNMENT 28: SENSORY INPUT AND MOTOR OUTPUT

Refer to the following information as you read Chapter 28, "Sensory Input and Motor Output," on pages 493–510 in your textbook.

The Senses

The *inputs* of the senses are correlated with motor *outputs* enacted by bodily movements, mainly associated with different kinds of muscles. Figure 28.1 on page 494 illustrates the basic scheme of sensory inputs and motor outputs.

Chemical Senses

In the chemical senses, *chemoreceptors* detect chemical energy. For example, *taste buds,* found mainly on our tongues, are stimulated by food molecules. As that happens, we experience different tastes, such as sweet, sour, bitter, and salty. The many combinations of these four tastes account for the variety of tastes we can detect. In addition, chemoreceptors for the sense of smell detect odors from very tiny proportions of odor-producing molecules in the air, such as those offered by a rose or a skunk. Figure 28.2 on page 495 illustrates chemoreceptors within the animal kingdom.

Hearing and Balance

Most vertebrates have a sense of hearing that involves structures that collect and amplify sound waves from the environment. In addition, vertebrate ears function in the sense of balance. Figure 28.5 illustrates *rotational equilibrium* (related to the rotating of the head) and *gravitational equilibrium* (related to the bending of the head).

The human ear is divided into three parts (see Figure 28.3 on page 496):

1. The *inner ear* includes fluid-filled sacs that detect motions of the head and send information about balance to the brain. The inner ear also contains the *cochlea,* which houses the receptors for hearing.
2. The *middle ear* sends sound waves to the inner ear. An air-filled cavity and three small bones transmit vibrations.
3. The *outer ear* collects sound waves from the environment through skin-covered flaps of cartilage called the *pinna.* The outer ear sends these waves to the middle ear.

Vision

Photoreceptors are sensory receptors that are sensitive to light. Two common types of eyes are *compound eyes,* found in many insects, and *camera-type eyes,* found in vertebrates. Figure 28.7 on page 499 illustrates these two kinds of eyes.

Most vertebrate eyes have three layers (Figure 28.8):

1. The outer layer has a *sclera* of dense fibers that protect the eyeball and a transparent *cornea* that covers and protects the front of the eye. The cornea, along with the *lens,* helps us focus light images.
2. The middle layer contains an *iris,* a *pupil,* and *ciliary muscles* for eyeball movement. The iris is a pigmented ring behind the cornea. It's the iris that determines eye color. The pupil is an opening at the center of the iris that widens or narrows according to the amount of light present.
3. The inner layer includes the *retina* at the back of the eye, where photoreception occurs in the human eye. A sensory pathway from the retina to the brain detects and transmits raw visual information. (See Figures 28.9 and 28.10 on page 500.)

Cutaneous Receptors and Proprioreceptors

Sensory inputs begin with the energy input of some environmental stimulus, such as light, sound, heat, and pressure. Any such stimulus is registered by a specialized sensory neuron acting as a stimulus receptor. *Cutaneous receptors,* which are located in the skin, register temperature and pressure. *Proprioceptors,* which are located in the muscles and joints, help the body maintain equilibrium and balanced posture. Working together, the two kinds of receptors "read" acceleration or deceleration like that experienced in an elevator ride. In doing so, they help us stay oriented to a position in space, helping us differentiate "up" from "down." Figure 28.11 on page 501 illustrates both kinds of sensory input to primary sensory areas of the brain.

The Motor Systems

The motor systems of humans are the muscles and bones, which together make up the *musculoskeletal system* shown in Figure 28.13. Muscles and bones work together to support the body, making movements possible; protect internal organs; and help in the functioning of other systems such as those involving breathing and ingesting water and food. Muscles and bones also have individual functions, as explained on page 502.

The Human Skeleton

Humans, like all vertebrates, have internal skeletons, called *endoskeletons* (Figure 28.13). By contrast, some parts of the animal kingdom have *exoskeletons* (external skeletons) and *hydrostatic skeletons* (fluid-filled cavities that aid in support and movement), as shown in Figure 28.14 on page 503.

The human skeleton has 206 bones. Some of the important human bones are identified in red in Figure 28.13. The human bone system is arranged into an *axial skeleton* and an *appendicular skeleton.* The bones of the axial skeleton, like the skull, vertebral column, sternum, and parts of the rib cage, protect vital organs and provide flexibility for functions like breathing. The bones of the *appendicular skeleton* are devoted to all kinds of bodily movements.

The structure of bone is illustrated in Figure 28.15. Refer to this illustration as you read the material on osteocytes, osteoblasts, spongy bone, and red bone marrow on page 504.

Skeletal Muscle and Physiology

The human body has almost 700 skeletal muscles. These muscles fall into three categories—smooth, cardiac, and skeletal. Carefully read the first paragraph on page 505 so you understand the composition of each of these muscle types.

The contractile fiber of muscle cells is made up of threadlike *myofibrils*. The myofibrils in turn are made up of protein filaments called *sarcomeres,* which cause muscle cells to appear striated. Sarcomeres contain thick filaments made of a protein called *myosin,* along with thin filaments of a protein called *actin*. See Figure 28.16 on page 504 to study skeletal muscle structure and function.

Muscle contractions arise from the joint interaction of myosin and actin in what's called the *sliding filament model*. During the sliding process, the sarcomere shortens, even though the filaments themselves remain the same length. How all this works is illustrated in terms of chemical reactions in Figure 28.17 on page 505. To visualize how this works, lace your fingers and slide them together. The distance between your two wrists shortens (contracts) while your fingers (the "filaments") remain the same length.

Skeletal muscles work in teams—almost as antagonists. Figure 28.19 on page 506 illustrates this idea. As the biceps contracts, the triceps has to relax to permit that contraction to be effective. Similarly, contractions of the triceps require complementary relaxation on the part of the biceps. Overall, movements, like those of an athlete or dancer require a lot of teamwork from the roughly 700 muscles that allow someone to run for a touchdown or leap gracefully across a stage.

Joints are areas of contact between bones that are bridged by connective tissue. Your textbook covers three different types of synovial joints (Figure 28.20):

1. *Generalized synovial joints* are freely movable and are connected by long straps of dense connective tissue called *ligaments.*

2. *Ball-and-socket joints,* such as those in the hips and shoulders, allow movement in different directions.

3. *Hinge joints,* like those in elbows and knees, bend or move in one direction only.

Before proceeding to the next assignment, take a moment to complete *Self-Check 28.*

Self-Check 28

1. What kind of skeleton does an earthworm have?
   a. Endoskeleton
   b. Hydrostatic skeleton
   c. Exoskeleton.
   d. None. Earthworms don't have skeletons.
2. The skull, the ribs, the vertebrae, and the sacrum are parts of the ________ skeleton.
   a. axial
   b. distal
   c. appendicular
   d. proximal
3. The basic units of muscular contraction, containing all the components of the sliding filament model, are threadlike
   a. actins.
   b. myosins.
   c. myofibrils.
   d. sarcomeres.
4. Chemical receptors for salt, bitter, and sweet are located in the
   a. olfactory cilia.
   b. nasal cavity.
   c. olfactory cell.
   d. tongue.
5. If I want to focus on an image in a photo or a line of print, what part or parts of my eye will I depend on?
   a. Cornea and iris
   b. Lens and cornea
   c. Fovea
   d. Iris and pupil
6. The synovial joint of the shoulder and hips are examples of a ________ joint.
   a. hinge
   b. cartilage
   c. ball-and-socket
   d. generalized
7. The sensory receptors for hearing are located in the
   a. spiral organ.
   b. ossicles.
   c. tympanic membrane.
   d. auditory canal.
8. In a humerus, red bone marrow is located in
   a. compact bone.
   b. osteoclasts.
   c. the spongy ends.
   d. the long section of the bone.
9. Among cutaneous receptors, cold and warm receptors are found in the
   a. muscle spindles.
   b. dermis.
   c. spinal cord.
   d. epidermis

Check your answers with those on page 202.

ASSIGNMENT 29: REPRODUCTION AND DEVELOPMENT

Refer to the following information as you read Chapter 29, "Reproduction and Development," on pages 511–532 in your textbook.

How Animals Reproduce

Animals lower down on the phylogenetic scale may reproduce *asexually,* sometimes—as in the case of the flatworm and the hydra—from fragments of their previous intact bodies. *Parthogenesis* is a modification of sexual reproduction in which an unfertilized egg develops into a complete individual organism. Among honeybees, for example, the queen can fertilize eggs to become diploid females or leave them unfertilized to develop into haploid males called *drones. Sexual reproduction,* by contrast, involves the uniting of eggs and sperm to form a *zygote*. Figure 29.1 illustrates asexual reproduction in the hydra. Figures 29.2 and 29.3 on page 513 illustrate reproduction in the water and on land, respectively.

Human Reproduction

Male Reproductive System

The human male reproductive system (Figure 29.4) is made up of a pair of *testes,* the *epididymis,* the *vas deferens,* and the *urethra*. (In males, the urethra is part of both the reproductive and the urinary systems.) In an adult male, the testes produce *sperm* and *sex hormones* that control both reproductive functions and secondary sexual traits. After sperm are produced, they travel from each testis through a duct called the epididymis, where they completely mature. Sperm are stored in the epididymis until they're ejaculated from the body. The *seminal vesicles* and *prostate gland* secrete the substances that form the *semen (seminal fluid),* and the *bulbourethral gland* produce lubricating mucus. As sperm travel to the urethra, they're mixed with these glandular secretions before ejaculation. When a male is sexually aroused, muscles propel the sperm into a pair of tubes of the *vas deferens*. From there they travel to the ejaculatory duct and on through the urethra.

The testes are made up of compartments called *lobules.* In each of these lobules are one to three *seminiferous tubules*. *Spermatogenesis* (sperm creation) occurs within these tubules. As that process is completed, the chromosome count for each sperm is now haploid. Figure 29.5 on page 515 illustrates the seminiferous tubules. Note that the haploid nucleus is in the head of the sperm.

The hypothalamus secretes *gonadotropin-releasing hormone (GnRH),* which controls the functioning of the testes. Both males and females have two *gonadotropic hormones*—the *follicle-stimulating hormone (FSH)* and the *luteinizing hormone (LH).* FSH stimulates spermatogenesis in the male seminiferous tubules. LH is responsible for producing testosterone. Testosterone is the trigger for male secondary characteristics—like musculature and facial hair—that develop at puberty.

The Female Reproductive System

The female's primary reproductive organs are a pair of *ovaries* that produce eggs and secrete sex hormones. Immature eggs are called *oocytes*. An oocyte that's released from an ovary moves into one of two *oviducts,* which are the channels into the uterus, a pear-shaped organ in which embryos develop and grow. The inner lining of the uterine wall is composed of specialized tissue called *endometrium*. This tissue, which is made of connective tissue, glands, and blood vessels, is the site of implantation of the *blastocyst* (early embryo) during pregnancy. The narrowed-down portion of the uterus is the *cervix*. The *vagina* is a muscular tube that extends from the cervix to the body surface. The vagina, the organ of sexual intercourse, also serves as the birth canal. Figure 29.6 on page 516 illustrates the female reproductive system.

In the ovaries, a body called an *oogonium* gives rise to an *oocyte* surrounded by epithelium. This body is called a primary *follicle.* When a female child is born, each of her ovaries contains as many as 2 million follicles. Over the course of a woman's life, only about 400 follicles will ripen into a *secondary oocyte*. The release of a secondary oocyte from a nature follicle is called *ovulation,* and ovulation follows the *menstrual cycle*. A follicle that has lost it oocyte is transformed into a *corpus luteum*. If pregnancy doesn't occur, this body falls apart after about 10 days. In any case, oogenesis is completed only if a secondary oocyte is fertilized by a sperm.

The ovarian cycle is controlled by the gonadotropic hormones FSH and LH. Figure 29.7 on page 517 illustrates the ovarian cycle. Figure 29.8 on page 518 illustrates both the ovarian the menstrual cycles. Refer to these figures as your read and study the text.

Estrogen and *progesterone* are the two primary female sex hormones. Estrogen in particular is responsible for female secondary characteristics like breast development and the more rounded curves of the typical female anatomy.

Human Development

Pages 523–529 describe and illustrate the events that occur from the time of *fertilization* (the union of a sperm and an egg) until birth. The material is clearly explained and includes many diagrams and photographs to help you understand the process. Read and study the material carefully. As you read, refer to the illustrations to identify each part discussed.

Because this chapter covers a lot of information and includes many new terms, be sure to read the chapter summary and complete the exercises on pages 530–532. The answers to the exercises are in Appendix A at the back of your textbook.

After you complete *Self-Check 29,* review the material you've learned in this study guide as well as in the assigned pages in your textbook for Assignments 20–29. A good way to review the chapters is to reread the summaries at the end of each one. If you find you don't understand something in the summary, go back to the textbook pages and review the material. When you're sure that you completely understand the information in Assignments 20–29, complete your examination for Lesson 4.

Self-Check 29

1. In the testes, seminiferous tubules carry out the processes of
   a. ejaculation.
   b. insemination.
   c. prostration.
   d. spermatogenesis.
2. What hormone is responsible for the development of female secondary characteristics?
   a. Estrogen
   b. Progesterone
   c. FSH
   d. Luteum
3. In the female reproductive system, fimbriae are finger-like projections attached to the
   a. uterus.
   b. cervix.
   c. oviducts.
   d. endometrium.
4. In early embryonic development, cleavage results in a clump of cells called a/an
   a. endometrium.
   b. morula.
   c. amnion.
   d. blastocyst.
5. The reproductive behavior of the queen bee in a honeybee hive is an example of
   a. hermaphroditic fertilization.
   b. parthenogenesis.
   c. extraembryonic fertilization.
   d. regeneration.
6. Over the lifecycle of a female, primary follicles produce about ________ secondary oocytes.
   a. 9
   b. 400
   c. 1,000
   d. 1,000,000
7. The glands involved in the production of seminal fluid include all the following *except*
   a. the prostate gland.
   b. bulbourethral glands.
   c. seminal vesicles.
   d. the vas deferens.
8. Which of the following STDs results from a bacterial infestation?
   a. Syphilis
   b. Hepatitis
   c. Genital herpes
   d. Genital warts
9. In embryonic development, a process called ________ gives rise to what will become the central nervous system.
   a. induction
   b. gastrulation
   c. neurulation
   d. fertilization.

Check your answers with those on page 203.

NOTES

Lesson 4
Structure and Function in Plants and Animals

EXAMINATION NUMBER

00764900

Whichever method you use in submitting your exam answers to the school, you must use the number above.

For the quickest test results, go to http://www.takeexamsonline.com

When you feel confident that you have mastered the material in Lesson 4, go to http://www.takeexamsonline.com and submit your answers online. If you don't have access to the Internet, you can phone in or mail in your exam. Submit your answers for this examination as soon as you complete it. *Do not wait until another examination is ready.*

Questions 1–20: Select the one best answer to each question.

1. In the human body, the ________ is a muscular membrane that separates the thoracic cavity from the abdominal cavity.

   A. epiglottis
   B. esophagus
   C. diaphragm
   D. bolus

2. In kidneys, the tiny tubules that produce urine are called

   A. nephrons.
   B. the ureters.
   C. the renal cortex.
   D. the renal medulla.

3. Which of these plant hormones hastens the ripening of fruit and helps to cause the fall of leaves, flowers, and fruit?

   A. Cytokinins
   B. Auxins
   C. Ethylene
   D. Gibberellins

4. In the central nervous system, the ________ communicates with and coordinates what happens in other parts of the brain.

   A. cerebrum
   B. cerebellum
   C. brain stem
   D. hypothalamus

5. In the body of a human or other complex organism, a group of similar cells performing similar functions is called a/an

A. organ.
B. tissue.
C. organ system.
D. cell.

6. In the human body, which of the following is part of the axial skeleton?

A. Clavicle
B. Femur
C. Sternum
D. Ulna

7. The purpose of the cuticle in plants is to

A. minimize water loss.
B. provide support.
C. transport water.
D. support plant functions.

8. The colored part of the human eye is the

A. pupil.
B. retina.
C. cornea.
D. iris.

9. Which of these is a white blood cell?

A. Neutrophil
B. Erythrocyte
C. Thrombocyte
D. Hemoglobin

10. Which one of these eating disorders is *more* likely to affect men than women?

A. Bulimia nervosa
B. Chronic dieting
C. Anorexia nervosa
D. Muscle dysmorphia

11. The wood in the trunk and limbs of a tree is made up of

A. cork cambium.
B. pith.
C. secondary xylem.
D. phloem.

12. Which blood type has neither anti-A nor anti-B antibodies?

A. A
B. B
C. O
D. AB

13. What part of the lower respiratory tract is made up of tiny air sacs where oxygen and carbon dioxide are exchanged?

A. Bronchioles
B. Alveoli
C. Trachea
D. Larynx

14. All the systems of the body work together to keep the internal environment of the body constant within certain limits. This process is called

A. homoeostasis.
B. positive feedback.
C. neuroglia.
D. homeopathy.

15. What divides the human heart into a left and right side?

A. Aaorta
B. Septum
C. Ventricles
D. Atria

16. The *main* sex hormone in males is

A. estrogen.
B. progesterone.
C. testosterone.
D. luteum.

17. A plant sits on a window sill. Over time, the stems of the plant curve toward the light coming in the window. This process is called

A. phototropism.
B. photoperiodism.
C. gravitropism.
D. phytochromism.

18. Which of these parts receive nerve impulses from the central nervous system, causing muscle fibers to contract?

A. Interneurons
B. Motor neurons
C. Sensory neurons
D. Myelin sheaths

19. In the human immune system, the *main* function of the ________ is filtering blood.

A. thymus gland
B. spleen
C. tonsils
D. appendix

20. In flowering plants, which of these becomes the female gametophyte?

A. Microspore
B. Pollen grains
C. Pollen sacs
D. Megaspores

NOTES

Lesson 5

Ecology

When you complete this lesson, you'll be able to

- Discuss and explain concepts about Earth's human population
- Describe the characteristics and patterns of creature populations
- Discuss the life history patterns of opportunistic and equilibrium populations
- Explain concepts related to the ecology of communities
- Discuss and describe the ways in which energy flows through ecosystems
- Describe the impacts of humans on Earth's biosphere
- Discuss the scope of biodiversity and threats to biodiversity
- Discuss approaches toward a sustainable society

ASSIGNMENT 30: ECOLOGY OF POPULATIONS

Refer to the following information as you read Chapter 30, "Ecology of Populations," on pages 533–550 in your textbook.

The Human Population

Today, human populations are growing at an unprecedented rate, and most of this growth is taking place in less-developed countries (LDCs). Figure 30.1 on page 534 will help you visualize human population growth trends from the year 1200 to 2000 and beyond. Put simply, human population growth is now so great that it threatens Earth's *carrying capacity*—the number of people our planet can sustain over an indefinite period. You can better understand the global distributions for population growth by reviewing Figure 30.2 on page 535.

Comparing age structures helps us predict future population growth trends. Data from 1998 (Figure 30.4) show that in less-developed countries the proportions of young people (age 19 and below) are much greater than they are in the more-developed countries (MDCs). Therefore, these populations will continue to expand.

Populations can also be assessed in terms of environmental impact. The more-developed countries have a much greater impact on the environment than do the less-developed countries. Figure 30.5 on page 537 compares LDCs with MDCs in a number of different indices (like creation of wastes).

Characteristics of Populations

Distribution and Density

As you've already learned, a population is a group of individuals of the same species that occupies a given area. Population *size* is the number of individuals that contribute to a population's gene pool. Population *density* is the number of individuals in some specified area of habitat. Population *distribution* is the general pattern of dispersal of individuals in a specified area. Populations may display three distributional patterns: *clumped, nearly uniform,* and *random.* In general, the highest *density* of human populations is found along seacoasts.

Patterns of Population Growth

Exponential growth occurs when the reproduction base of a population increases and its size keeps expanding by ever-increasing increments. Figure 30.10 on page 540 illustrates exponential growth. *Logistic growth* occurs when a population low in density slowly increases in size, goes through a rapid growth phase, and then levels off in size when its carrying capacity is reached. Figure 30.11 on page 541 illustrates a logistic growth curve.

Factors That Regulate Population Growth

Two kinds of factors regulate population growth:

1. *Density-independent factors* include natural disasters such as flash floods and volcanic eruptions. Such events may radically reduce a population. But the density of a population isn't a factor because the proportion of a population killed may be roughly the same in a dense or a dispersed population. Figure 30.13 on page 542 can help you understand this idea.
2. *Density-dependent factors* include *competition, predation,* and *predator-prey population cycles*. Here are a few examples of these factors:
   - Interspecies competition for a finite food supply grows more intense as population density increases.
   - Where population densities are low, the mortality rate due to predation is also low. By contrast, when densities are high, the instances of predation are greater and the mortality rate is much higher.
   - Predator and prey populations tend to vary in cycles. For example, as a rodent population increases, the population of its predators—such as hawks—increases. As the rodent population decreases due to predation, the cycle reverses and the population of predators declines.

Figures 30.14–30.16 illustrate these three factors.

Life History Patterns and Extinction

Ecologists have identified two fundamental types of populations. First, *opportunistic populations* tend to exhibit exponential growth. Species of this type tend to have short life spans, while providing only minimal care for large numbers of offspring. Insects are a paramount example of an opportunistic population. High population densities of, say, cockroaches, may check the growth of opportunistic populations simply due to limits of available food. However, creatures like insects tend to be widely dispersed, thus favoring species survival.

Equilibrium populations tend toward logistic population growth. Populations remain near or at the carrying capacity for a habitat. Species of this type, like the mountain gorilla illustrated in Figure 30.17, tend to have longer life spans, no doubt related in important ways to extended time and energy devoted to caring for offspring.

Extinction occurs with the complete disappearance of a species. Within equilibrium populations, the extent of geographic range, the degree of habitat tolerance, and the size of the local population are related to the likelihood of extinction. Figure 30.18, on page 545 illustrates factors that make seven species vulnerable to extinction.

The Scope of Ecology

Ecology is the scientific study of organisms as they interact with each other and with their physical environment. In general, the study of ecology can be broken down into five levels of focus:

1. Particular species or organisms
2. Populations of species or organisms
3. Communities, which may include all species living and interacting within a locale
4. Ecosystems, which are communities understood in relation to their natural environment
5. The entirety of Earth's biosphere

Figure 30.19 on page 546 presents a summary of these levels of organization.

Modern ecology arose from the study of *natural history,* the observing of organisms in their environment. Today, ecology goes beyond merely observing to studying the factors that allow species to thrive. Having identified those factors, ecologists seek ways to foster those factors in favor of biodiversity. This new ecological focus is called *conservation biology.* It reminds us of the first law of ecology: "Everything is connected to everything else."

Before proceeding to the next assignment, take a moment to complete *Self-Check 30.* Also, use the chapter summary and exercises (pages 548–550) to review the material in Chapter 30.

Self-Check 30

1. Which one of the following factors is considered part of a population's demographics?
   a. Available resources
   b. Climate
   c. Age
   d. Population density

2. With respect to the regulation of population growth, which one of the follow factors is a density-independent factors?
   a. A tsunami
   b. Competition
   c. Predation
   d. Predator-prey cycles

3. A coral reef with its various species is a good example of a
   a. niche.
   b. population.
   c. biosphere.
   d. community.

4. As an ecologist, I would most probably be studying patterns of _______ if I'm concerned about how average age at death influences the size of a population.
   a. clumped resources
   b. survivorship
   c. uniform distribution
   d. speciation

5. Demographic factors, such as the typical number of offspring per reproduction and the age at which reproduction begins, are considered to be factors impacting _______ potential.
   a. exponent
   b. phase
   c. pattern
   d. biotic

6. The number of species individuals the environment can sustain indefinitely is referred to as
   a. carrying capacity.
   b. the rate of growth per square mile.
   c. demand capacity.
   d. the rate of reproduction per unit time.

Check your answers with those on page 203.

ASSIGNMENT 31: COMMUNITIES AND ECOSYSTEMS

Refer to the following information as you read Chapter 31, "Communities and Ecosystems," on pages 551–574 in your textbook.

Ecology of Communities

As you've already learned, a *community* is an ensemble (assembly) of populations of species interacting in a common environment. Across the broad multimillion year panorama of species adaptation and evolution, species in communities have interacted in relationships of mutual benefit called *coevolution*. The interplay of adaptive features developed in flowering plants and their insect pollinators (bees, wasps, and so on) offers a striking example. Figure 31.1 on page 552 illustrates coevolution.

At the same time, species in a community acquire adaptations suitable for a particular environment. An *ecosystem* is a group of species interacting with each other *and* with the features of their physical environment. Following from this definition of an ecosystem, we can understand that rapid changes in a physical environment, say due to climate change, can disrupt a community and even bring about the extinction of species.

Community Composition and Diversity

The concepts of *species composition* and *species diversity* help to classify communities. Carefully read the definitions and explanations of these two concepts on page 553. The two images in Figure 31.2 on page 553 illustrate community species composition in a coniferous forest and tropical rain forest.

Ecological Succession

Ecological succession occurs when community character changes from one type to another type in a more or less orderly manner. Disturbances that bring about ecological succession may be natural or manmade. According to the *climax-pattern model,* the climate of an area generally tends toward a particular balance of species and physical resources in a *climax community*. For example, a conifer forest will gradually return to the same sort of ecosystem after a massive fire or following destruction due to a volcanic eruption. Figure 31.3 on page 554 illustrates forest and desert types of climax communities, pointing out that climax community types may vary due to the random migration of species.

Ecologists recognize two kinds of succession. *Primary succession* occurs where soil hasn't yet formed. For example, a new island formed by a lava extrusion will gradually develop soils and acquire species habitats due to weathering, seed migration in atmospheric or ocean currents, and so on. An example of *secondary succession* is the gradual drift of a previously cultivated farmland toward the type of climax community that was there before cultivation. The basic differences between primary and secondary succession are illustrated in Figure 31.4 on page 554. Secondary succession is also illustrated in Figure 31.5 on page 555.

Interactions in Communities

Like different kinds of shops and residences in a city neighborhood, communities are divided into *habitats*. The community role a species plays in its habitat defines its *ecological niche*. The ecological niche of a backswimmer is illustrated in Figure 31.6. Figure 31.7 illustrates feeding niches for wading birds. With the concept of ecological niches in mind, review Table 31.1 on page 556 for a summary of the five basic kinds of *species interaction* within and between community habitats.

In *competition,* the interaction of two species brings about a decrease in the populations of both species. Thus, according to the *competitive exclusion principle,* no two species can occupy the same niche at the same time. Figure 31.8 on page 557 graphically illustrates the competitive exclusion principle as it applies to *Paramecium.*

On the other hand, multiple species can coexist in a community through *resource partitioning,* exemplified by *niche specialization*. For example, the varied feeding adaptations of Darwin's finches led to niche specialization through resource partitioning, as illustrated in Figure 31.9 on page 557. The variations in beaks among the finches reflected different diets and, therefore, the *character displacement* that permitted niche specialization.

Mutualism and competition are the two most important interaction types in a community. Fundamentally, *mutualism* amounts to complex cooperative relationships among species. The relationship between angiosperms and insect pollinators is once again an example. A subtle and complex example is offered in Figure 31.10 on page 558.

Community Stability

Community stability can be fragile, but there are instances when one species—a *keystone species*—acts to hold the web of interactions together, thus stabilizing the community. The example of the sea otter is offered in your text (page 559).

On the other hand, the introduction of *exotic* (non-native) species into a community can be intensely disruptive. In our globalizing world, the examples are legion. Your textbook provides a number of examples on page 559.

Ecology of Ecosystems

Autotrophs and Heterotrophs

Autotrophs are called *producers* because they produce food for the global food chain. Two autotrophs are illustrated in Figure 31.13 on page 560. *Heterotrophs,* on the other hand, which feed on producers, are called *consumers. Decomposers,* which include bacteria and fungi, are included with heterotrophs. Consumers are illustrated in Figure 31.14, which points out that consumers may be herbivores or carnivores. Omnivores, such as humans, are also, of course, consumers on a grand scale.

Energy Flow and Chemical Cycling

Energy flow and chemical cycling are basic mechanisms of Earth's biosphere. The fascinating complexity of energy flow is illustrated in Figures 31.16 and 31.17, both on page 561.

Figure 31.16 offers the basic concept of energy flow in a single image—from producer to consumers to decomposers to an inorganic nutrient pool and then back to producers. Figure 31.17 points out that only about 10% of nutrient energy taken in by herbivores goes to carnivores. The rest goes to detritus feeders (decomposers) and the processes of cellular respiration.

The biosphere's food web is made up of *grazing* and *detrital food webs*. In grazing food webs, energy goes from photoautotrophs to herbivores and then onward to carnivores. In detrital food webs, energy flows from photoautotrophs through detritivores to decomposers. In the context of a temperate deciduous food web, the interactions of these two parts of the food web are displayed in Figure 31.18 on page 562. Studying this illustration will help you better understand related concepts.

The *food chain* concept states that organisms are related to one another in a straight line with respect to the question "who eats whom?" Within a food chain, the *trophic level* is a level of nourishment (consumed energy) within a web or chain composed of producers, herbivores, and carnivores. Assessing (measuring) the flow of energy between trophic levels permits us to create an *ecological pyramid*. Figure 31.19 on page 563 illustrates a food chain, and Figure 31.20 on the same page illustrates an ecological pyramid. In Figure 31.20, the so-called 10% rule of thumb shows why only a very few top carnivores like lions, eagles, and humans can be supported by all of the other organisms in the pyramid.

Chemical Cycling

Chemical cycling within ecosystems involves the combined interactions of living producers, consumes, and decomposers, as well as rock, soils, and the atmosphere. All of these together are known as *biogeochemical cycles*. A model for chemical cycling in general is illustrated in Figure 31.21 on page 564. Note that the figure includes human activities. As you study the figure, identify *reservoirs* of fossil fuels, sediments, and minerals; *exchange pools* (water, soil, and atmosphere), and the producers and consumers of the *biotic community*.

Carefully read and study the three basic chemical cycles on pages 565–567. As you do, take account of the disruption of all of these cycles by human activities, as described in your text.

- The *phosphorous cycle* (Figure 31.22) is a *sedimentary biogeochemical* cycle. Phosphorus and other solid nutrients move from land to the sea floor and return to dry land by geographic uplifting.

- The *nitrogen cycle* (Figure 31.24) is called a *gaseous biogeochemical cycle.* It relies mainly on the activities of bacteria found in soils.

- The *carbon cycle* (Figure 31.26) is another gaseous biogeochemical cycle. Producers take in carbon dioxide from the atmosphere in the process of photosynthesis. Living and dead organisms serve as a basic reservoir for carbon and the carbon cycle. Decomposed organisms return carbon to the atmosphere and to soils. Long-dead organisms pressed into sediments are the basis of fossil fuels—coal, petroleum, and natural gas.

Ecology of Major Ecosystems

Aquatic ecosystems are divided into *fresh water* and *saltwater* types, which are also called *marine ecosystems.* As shown in Figure 31.27 on page 568, coral reefs and marshes, which generally provide very bio-rich habitats along coast lines, are also included among aquatic ecosystems.

Terrestrial ecosystems, called *biomes,* are defined by their temperatures and levels of rain. Figure 31.28 illustrates the major terrestrial ecosystems.

Before proceeding to the next assignment, take a moment to complete *Self-Check 31.*

Self-Check 31

1. Which of the following biogeochemical cycles involves the weathering of sedimentary rock?
   a. Carbon
   b. Phosphorous
   c. Biotic
   d. Nitrogen

2. Most of the organic nutrients for Earth's biosphere are produced by
   a. photoautotrophs.
   b. chemoautotrophs.
   c. heteroautotrophs.
   d. omnivores.

3. A detrital food web begins with
   a. invertebrates.
   b. herbivores.
   c. bacteria and fungi.
   d. photosynthesizers.

4. All of the following are terrestrial biomes *except*
   a. coral reefs.
   b. tundra.
   c. tropical rain forest.
   d. temperate forest.

5. Hummingbirds and certain kinds of red flowers acquire adaptive features that allow them to interact for mutual benefit. What do ecologists call this process?
   a. Species diversity
   b. Coevolution
   c. Primary succession
   d. Niche specialization

6. Two protozoan species are introduced into a pond habitat niche. After a few weeks pass, only one of the species is still there. This occurrence is an example of
   a. resource partitioning.
   b. niche displacement.
   c. character displacement.
   d. the competitive exclusion principle.

7. The *main* difference between primary and secondary succession is the
   a. presence or absence of moisture.
   b. passage of time.
   c. presence or absence of soil.
   d. influence of a dominant species.

Check your answers with those on page 203.

ASSIGNMENT 32: HUMAN IMPACT ON THE BIOSPHERE

Refer to the following information as you read Chapter 32, "Human Impact on the Biosphere," on pages 575–595 in your textbook.

Resources and Pollution

Human biological needs are met by using land, water, food, energy sources, and minerals. Some of these resources are *renewable*—that is, they aren't limited in supply. Water and some kinds of energy sources (solar, wind) can be used indefinitely for growing food, animal husbandry, manufacturing commodities, and so on. *Nonrenewable* resources, such as fossil fuels, are finite sources of energy. Mineral resources, like copper, zinc, or silver, are also nonrenewable—although, through recycling, they can be conserved. Figure 32.1 on page 576 illustrates the five basic resources.

Pages 577–586 of your textbook focus on these five main resources. The material is mainly aimed at making you aware of the real or potential ecological threats posed by each resource concern, as well as possible remedies. Read this material carefully. As you do, ask yourself what you can do to help conserve some or all of these resources.

Biodiversity

Ecologists have identified patterns of *biodiversity* based on variables such as sunlight intensity, moisture levels, average seasonal temperatures, and latitude. In this context, mainland marine patterns reveal that species diversity is much richer toward the equator. Diversity is less in the northern or southern temperate zones and even less as one approaches the Arctic or Antarctic regions. This is partly the case because tropical communities have been evolving for longer periods of time. Tropical areas, especially tropical rain forests, harbor an astonishing richness of species diversity.

Direct Values of Biodiversity

Direct values of biodiversity include medical, agricultural, and consumptive use values. Most of the prescription drugs now in use were discovered in plants. Penicillin was first identified in bread mold. All of our main agricultural crops—like rice, wheat, and corn—were cultivated from wild forms of these grain plants. Keeping wild forms of crop plants around provide a reservoir of genetic diversity in case highly cultivated food plants should suffer misfortune from blight or infestation. Also, insects that pollinate flowering plants need protection—even if people occasionally get stung. Finally, many popular modern products are derived directly from wild species, including beeswax, shampoos and body lotions, and a wide variety of herbs increasingly popular among people seeking natural cures and a healthy lifestyle.

Indirect Values of Biodiversity

Indirect values of biodiversity are considerable. Biogeochemical cycles, like the carbon and nitrogen cycles, are sustained by undisturbed ecosystems. In that context, biodiversity is crucial to the health of ecosystems and, therefore, human health and well-being. On pages 590–591, your textbook outlines and explains a number of indirect values that result from biodiversity.

Working Toward a Sustainable Society

Figure 32.20 on page 592 graphically contrasts resource use patterns for present-day human society with resource uses in a possible sustainable society of the future. Your textbook lists six pieces of evidence indicating that present-day human society is unsustainable. Read them carefully. Do you agree?

After you complete *Self-Check 32,* review the material you've learned in this study guide as well as in the assigned pages in your textbook for Assignments 30–32. A good way to review the chapters is to reread the summaries at the end of each one. If you find you don't understand something in the summary, go back to the textbook pages and review the material. When you're sure that you completely understand the information in Assignments 30–32, complete your examination for Lesson 5.

Self-Check 32

1. It's estimated that about 25% to 35% of western croplands in the United States have undergone salinization due to
   a. saltwater intrusion.
   b. excessive use of fertilizers.
   c. soil degradation.
   d. evaporation of excessive irrigation water.

2. Radioactive decay of elements like uranium and thorium can provide geothermal energy due to the intense heating of subsurface
   a. strata.
   b. water.
   c. hydrocarbons.
   d. hydrogen.

3. _______ hold about 1,000 times the volume of water precipitation that occurs over a land area in a year.
   a. Subsidence faults
   b. Dams
   c. Aquifers
   d. Saltwater intrusions

4. One direct value of biodiversity is
   a. prevention of soil erosion.
   b. waste disposal.
   c. agricultural value.
   d. climate regulation.

5. According to computer models, because of the accumulation of greenhouse gases in the atmosphere, it's predicted that _______ region temperatures will rise fastest.
   a. polar
   b. desert
   c. tropical forest
   d. coastal

Check your answers with those on page 204.

Lesson 5
Ecology

EXAMINATION NUMBER

00765000

Whichever method you use in submitting your exam answers to the school, you must use the number above.

For the quickest test results, go to http://www.takeexamsonline.com

When you feel confident that you have mastered the material in Lesson 5, go to http://www.takeexamsonline.com and submit your answers online. If you don't have access to the Internet, you can phone in or mail in your exam. Submit your answers for this examination as soon as you complete it. *Do not wait until another examination is ready.*

Questions 1–20: Select the one best answer to each question.

1. What is the term for an evolutionary change in one species that results in the evolutionary change of another species?

   A. Binary evolution
   B. Competitive evolution
   C. Coevolution
   D. Interactive evolution

2. All the interconnected paths of energy flowing from species to species in an ecosystem is called a

   A. detrital food web.
   B. trophic level.
   C. food chain.
   D. food web.

3. The number of individuals an environment can sustain for an indefinite period of time is called its

   A. limit of growth.
   B. rate of growth.
   C. carrying capacity.
   D. ideal birth rate.

4. The *main* reason for land subsidence is

   A. the removal of water from aquifers.
   B. the destruction of plant life.
   C. desertification.
   D. land exploitation.

5. Which statement *best* describes the competitive exclusion principle?

   A. Decreased competition between two species leads to increased niche specialization.
   B. Character displacement is evidence of competition and resource partitioning.
   C. No two species can occupy the same ecological niche at the same time.
   D. Adjacent ecological niches lead to the elimination of one of the niches.

6. Which one of the following statements expresses a characteristic of MDCs?

   A. The population of MDCs is larger than that of LDCs.
   B. MDCs produce most of the world's hazardous wastes.
   C. People in MDCs use less water than those in LDCs.
   D. The age structure of MDCs is less stable than that of LDCs.

7. An example of a renewable energy source is

   A. coal.
   B. water.
   C. land.
   D. minerals.

8. A species that takes in *only* inorganic nutrients is called a/an

   A. decomposer.
   B. consumer.
   C. heterotrophy.
   D. autotroph.

9. What kind of ecological succession occurs when soil has not yet formed?

   A. Secondary
   B. Primary
   C. Mutual
   D. Climatic

10. If, over a period of 10 years, a population has a logistic growth rate, you would expect to see

   A. a death rate much higher than the birth rate.
   B. an S-shaped curve followed by a J-shaped curve.
   C. accelerating population growth over the entire period.
   D. a stable equilibrium phase.

11. Which of these is an indirect value of biodiversity?

   A. Prevention of soil erosion
   B. Agricultural value
   C. Medicinal value
   D. Provision of consumable resources

12. What occurs when members of one species try to use necessary resources that are in limited supply?

A. Predation
B. Natural disasters
C. Predator-prey cycles
D. Competition

13. When decomposers are unable to break down industrial wastes, they become more concentrated as they move through the food chain. This process is called biological

A. pollution.
B. synthesis.
C. magnification.
D. concentration.

14. What is described by the following sentence? The members of a population are small in size, the young mature early, they get little care from their parents, and they have a short life span.

A. Equilibrium population
B. Population of mountain gorillas
C. Opportunistic population
D. Species of birds approaching extinction

15. In an ecosystem, a large number of species are dependent on one particular species of bird. The species of bird is an example of a/an ________ species.

A. keystone
B. native
C. capstone
D. exotic

16. The science of ecology developed from the study of

A. natural history.
B. biology.
C. chemistry.
D. human populations.

17. Following deforestation of tropical forests, the remaining soil is nutrient-poor because

A. it's located over bedrock.
B. it's mostly sand.
C. there are no remaining nitrogen-fixing bacteria.
D. most nutrients have been absorbed by the vegetation.

18. Which biochemical cycle aids plants through bacterial nodules in soil?

A. Carbon
B. Nitrogen
C. Phosphorus
D. Oxygen

19. All of the different species living in a particular location are called a/an

A. community.
B. ecosystem.
C. biosphere.
D. population.

20. The process in which two species interact in ways that benefit both of them is called

A. commensalism.
B. parasitism.
C. mutualism.
D. predation.

Answers

Self-Check 1

1. b
2. c
3. d
4. a
5. c
6. d

Self-Check 2

1. b
2. c
3. d
4. b
5. c
6. a
7. c

Self-Check 3

1. d
2. c
3. b
4. a
5. d
6. a
7. b

Self-Check 4

1. b
2. c
3. d
4. b
5. b
6. a
7. b
8. c

Self-Check 5

1. c
2. c
3. b
4. c
5. b
6. d

Self-Check 6

1. a
2. c
3. b
4. c
5. d

Self-Check 7

1. b
2. c
3. a
4. b
5. c

Self-Check 8

1. c
2. b
3. c
4. d
5. a
6. c
7. a
8. b

Self-Check 9

1. d
2. b
3. b
4. a
5. c

Self-Check 10

1. c
2. b
3. b
4. a

5. a
6. d
7. c
8. a. Tt, tt

   b.

	T	**t**
t	Tt	tt
t	Tt	tt

   Note: You can get the same results by omitting the second (t) from the Punnett square. The ratio in the square below is the same as that in the square above.

	T	**t**
t	Tt	tt

   c. 50% tall, 50% short

9. a. The genotypes of the plant that's homozygous for yellow and heterozygous for tall (YYTt) are YT and Yt. The genotypes of the plant that's heterozygous for both traits (YyTt) are YT, Yt, yT, and yt.

   b.

	YT	**Yt**	**yT**	**yt**
YT	YYTT	YYTt	YyTT	YyTt
Yt	YYTt	YYtt	YyTt	Yytt

   c. 75% yellow and tall ($^6/_8$ or $^3/_4$)
   25% yellow and short ($^2/_8$ or $^1/_4$)
   0% green and tall
   0% green and short

Self-Check 11

1. a
2. c
3. a
4. b
5. b
6. c
7. c
8. d

Self-Check 12

1. c
2. b
3. b
4. d
5. c
6. a
7. d

Self-Check 13

1. a
2. b
3. d
4. b
5. c
6. d
7. d
8. a
9. c

Self-Check 14

1. b
2. c
3. a
4. b
5. d
6. a

Self-Check 15

1. d
2. a
3. b
4. d
5. a
6. c
7. b

Self-Check 16

1. a
2. d
3. c
4. c
5. a
6. b
7. c

Self-Check 17

1. b
2. d
3. a
4. c
5. c
6. a
7. d

Self-Check 18

1. d
2. c
3. c
4. b
5. c
6. b
7. d
8. a
9. b

Self-Check 19

1. a
2. d
3. c
4. d
5. b
6. a

7. c
8. a
9. b
10. b
11. c

Self-Check 20

1. a
2. c
3. c
4. b
5. c
6. d
7. a
8. b

Self-Check 21

1. a
2. b
3. c
4. b
5. b
6. c
7. d

Self-Check 22

1. c
2. d
3. b

4. a
5. d
6. b
7. c

Self-Check 23

1. b
2. c
3. d
4. b
5. a

Self-Check 24

1. a
2. d
3. d
4. b
5. c
6. a
7. b
8. c
9. b
10. d

Self-Check 25

1. b
2. c
3. d
4. a
5. b

Self-Check 26

1. b
2. b
3. d
4. c
5. d

Self-Check 27

1. b
2. a
3. d
4. c
5. b
6. a
7. c

Self-Check 28

1. b
2. a
3. c
4. d
5. b
6. c
7. a
8. c
9. d

Self-Check 29

1. d
2. a
3. c
4. b
5. b
6. b
7. d
8. a
9. c

Self-Check 30

1. c
2. a
3. d
4. b
5. d
6. a

Self-Check 31

1. b
2. a
3. c
4. a
5. b
6. d
7. c

Self-Check 32

1. d
2. b
3. c
4. c
5. a