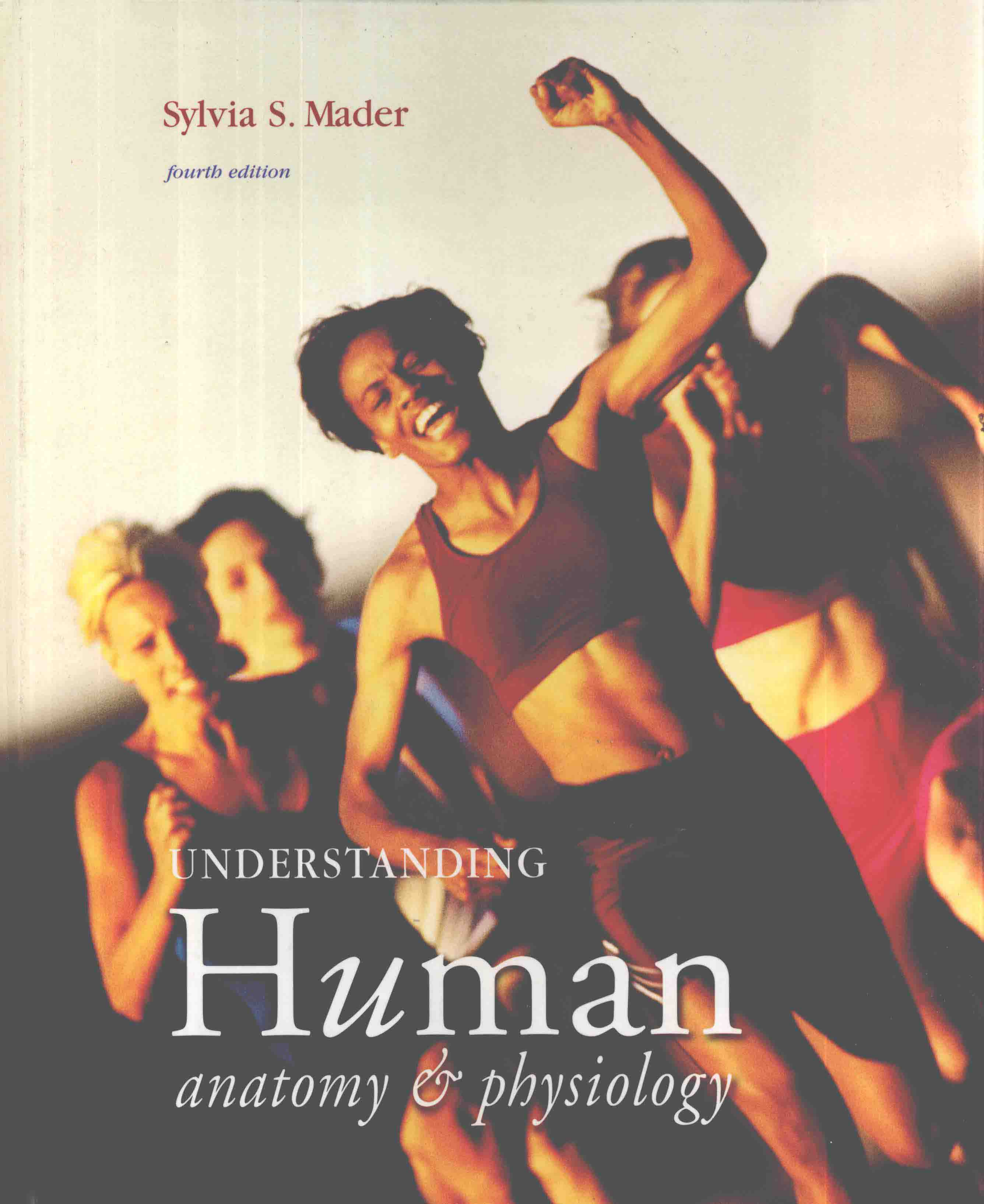
Sylvia S. Mader

fourth edition



UNDERSTANDING *Human* *anatomy & physiology*

Sylvia S. Mader

with contributions by

Patrick L. Galliart

North Iowa Area Community College

fourth edition

UNDERSTANDING Human

anatomy & physiology

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Preface

Understanding Human Anatomy and Physiology is written for students who are taking a one-semester course in anatomy and physiology. It covers all the basic information necessary for a general understanding of the structure and function of the human body.

The writing style and depth of presentation are appropriate for students who have little background in science and who are just beginning to pursue a career in an allied health field. Each chapter presents the topic clearly, simply, and distinctly so that students will feel capable of mastering the chapter learning objectives.

Understanding Human Anatomy and Physiology excels in pedagogical features which are described in the Guided Tour.

The Fourth Edition Changes

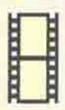
New and vibrant illustrations are a part of an art program that will motivate students because of its appeal. The Visual Focus illustrations and the Working Together illustrations have also been redone to increase their vitality. The illustrations in certain chapters, such as the cell chapter and the skeletal system chapter, have icons which will help students relate the part to the whole.

All chapters have been revised in this edition to update where necessary and to increase student learning of difficult concepts. The end of chapter and the end of text material have also been expanded. There are more objective questions in most chapters and 50 additional Further Readings have been added to Appendix D.

This edition uses three different icons at the end of figure legends, or the titles of sections, to alert students to technology resources. The icons are:


Indicates The Dynamic Human: the 3D Visual Guide to Anatomy and Physiology, a CD-ROM.


Indicates the WCB Life Science Animations, a videotape series that covers key physiological processes.


Indicates animations in the Essential Study Partner CD-ROM, an interactive student study tool.

The Correlation section of the Preface, p. xxii, correlates these resources to the text.

The New Technology

Many technology aids are available for use with *Understanding Human Anatomy and Physiology*

New to this edition, the Mader home page contains an Online Learning Center with instructor and student resources such as Web links, Quizzes, Study Guide, Case Studies, Clinical Applications and Matching Activities provides additional resources student will enjoy and appreciate. Each chapter in the text ends with Website Link, a section that gives the Mader home page internet address.

The Essential Study Partner, free with each text, is an interactive student study tool which contains more than 100 animations and more than 800 learning activities. This powerful CD-ROM contains a text guide correlated to the material presented in *Understanding Human Anatomy and Physiology.* A film icon placed in the text beside topics and concepts that are animated on this resource.

The Organization of the Text

This edition of *Understanding Human Anatomy and Physiology.* has a renewed emphasis on homeostasis. A significant portion of chapter 1 is devoted to explaining the concept of homeostasis and outlining the role the systems of the body play in to maintaining homeostasis. The Working Together illustrations that appear throughout the text describe how each organ system works with other systems to achieve homeostasis.

Part I: Human Organization

Chapter 1 explains the organization of the human body and the terms used to describe the location of body parts. It introduces the various organ systems and the concept of homeostasis, an equilibrium that is maintained by these systems.

Chapters 2 through 4 describe the chemistry of cell, cell structure and function, body tissues and membranes. Chapter 5 reviews the structure, functions, and disorders of the skin. This chapter has a Working Together illustration.

Part II: Support and Movement

The two chapters in this section concern the skeletal system and the muscular system, which support and protect the body and allow its parts to move. Both chapters have a Working Together illustration.

Chapter 6 considers the functions of the skeletal system before taking up the axial skeleton, the appendicular skeleton and the joints. Lists, tables, and oversize illustrations facilitate student learning. Chapter 7 considers the functions of the muscular system and the contraction of muscle fibers before reviewing the skeletal muscles of the body. The sliding filament theory is explained in an easy-to-understand manner.

Part III: Integration and Coordination

Separate chapters are devoted to the nervous system, the senses, and the endocrine system. The nervous and endocrine systems are vitally important to the coordination of body systems and therefore to homeostasis.

The first part of chapter 8 describes the structure and function of a neuron, a description of the central nervous system precedes that of the peripheral nervous system. In this chapter, illustrations coordinate closely with the discussion of brain structure and function. Chapter 9 is divided into general receptors (skin, visceral and proprioceptors); chemoreceptors (taste and smell); photoreceptors (those of the eye); mechanoreceptors (hearing and balance). The explanations of how we taste, smell, see and hear in this chapter are well presented. Chapter 10 considers the cellular mechanism of hormonal action before taking up the endocrine glands in turn. A table of the principal endocrine gland and their hormones is central to this chapter. Human hormonal disorders, such as diabetes mellitus, are emphasized.

Part IV: Maintenance of the Body

In this part chapter 11 reviews the composition of blood and functions of blood before taking up blood groups and typing. Chapter 12 first considers the anatomy of the heart before the vascular system and disorders of the circulatory system. Chapter 13 includes a description of the lymphatic system as well as a modern discussion of the defense mechanisms. In chapter 14, a description of the anatomy of the respiratory system precedes mechanisms of breathing and gas exchange. Chapter 15 describes the organs of the digestive system, mechanical and chemical digestion, and nutrition. Chapter 16 reviews the organs of the urinary system before explaining urine formation and the regulatory functions of the kidneys. Working Together illustrations appear before each chapter summary except for chapter 11. The functions of blood are included in the Working Together illustration for the circulatory system.

Part V: Reproduction and Development

This part includes chapters on the reproductive system, human development and genetics.

In chapter 17, the male reproductive system is discussed before the female reproductive system. There is also a discussion of birth control measure and infertility. This chapter has a Working Together illustration. Chapter 18 begins with a description of fertilization, the extraembryonic membranes and the functions of the placenta before the events of development and birth are outlined. Chapter 19 gives a simplified view of the human inheritance and biochemical genetics. It also includes a look at biotechnology, a technique that is now utilized to produce medications and carry out gene therapy.

About the Author

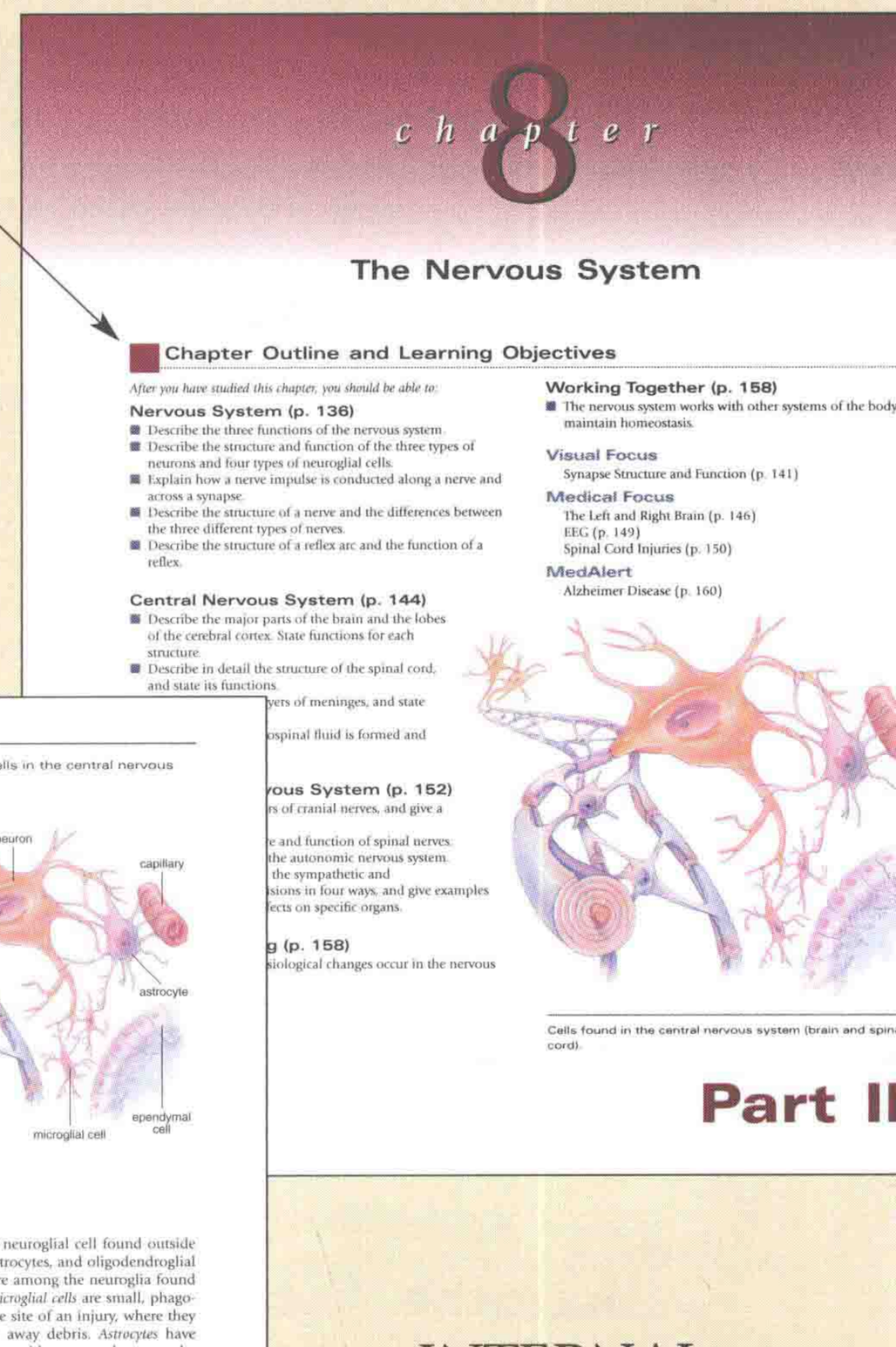
Dr. Sylvia Mader has successfully helped students learn the structure and function of the human body for more than 20 years. A brilliant and prolific writer, Dr. Mader was a respected and well-loved instructor before she began her writing career. Her descriptive writing style, carefully constructed pedagogy, and emphasis on concepts as well as terminology provides students with a firm grasp of anatomy and physiology. In her 20 year career with McGraw-Hill, she has written an impressive collection of textbooks including Human Biology, Sixth Edition, Inquiry into Life, Ninth Edition, and Biology, Seventh Edition, in addition to this text. Throughout the years, her goal remains the same—"to give students what they need to best understand and learn the basics."

GUIDED TOUR

Before you begin your study of anatomy and physiology, spend a little time looking over the next few pages. They provide a quick guide to the learning tools found throughout the text that have been designed to enhance your understanding of human anatomy and physiology.

CHAPTER OUTLINE

Each chapter begins with a chapter outline that lists the learning objectives appropriate to each major section of the chapter. Page referencing of the major sections makes it easier for students to coordinate the learning objectives with the text material.



chapter 8

The Nervous System

Chapter Outline and Learning Objectives

After you have studied this chapter, you should be able to:

Nervous System (p. 136)
- Describe the three functions of the nervous system.
- Describe the structure and function of the three types of neurons and four types of neuroglial cells.
- Explain how a nerve impulse is conducted along a nerve and across a synapse.
- Describe the structure of a nerve and the differences between the three different types of nerves.
- Describe the structure of a reflex arc and the function of a reflex.

Central Nervous System (p. 144)
- Describe the major parts of the brain and the lobes of the cerebral cortex. State functions for each structure.
- Describe in detail the structure of the spinal cord, and state its functions.

yers of meninges, and state

ospinal fluid is formed and

ous System (p. 152)
rs of cranial nerves, and give a

e and function of spinal nerves.
the autonomic nervous system.
the sympathetic and
sions in four ways, and give examples
fects on specific organs.

g (p. 158)
siological changes occur in the nervous

Working Together (p. 158)
- The nervous system works with other systems of the body maintain homeostasis.

Visual Focus
Synapse Structure and Function (p. 141)

Medical Focus
The Left and Right Brain (p. 146)
EEG (p. 149)
Spinal Cord Injuries (p. 150)

MedAlert
Alzheimer Disease (p. 160)

Cells found in the central nervous system (brain and spin cord).

Part II

ICONS

Following various figures icons direct you to media that further explain the concept.

figure 8.3 Myelin and neurilemmal sheaths. The myelin sheath forms when Schwann cells wrap themselves around a nerve fiber in the manner shown. The neurilemmal sheath contains the cytoplasm, nucleus, and outer plasma membrane of the Schwann cell.

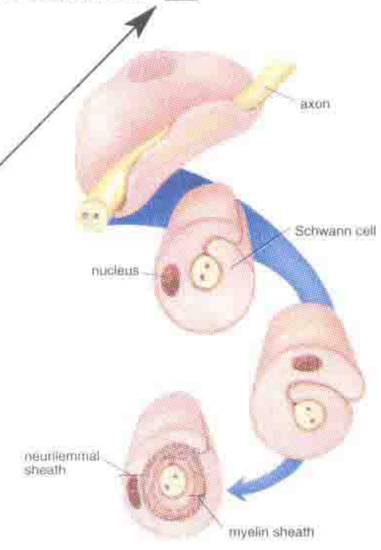
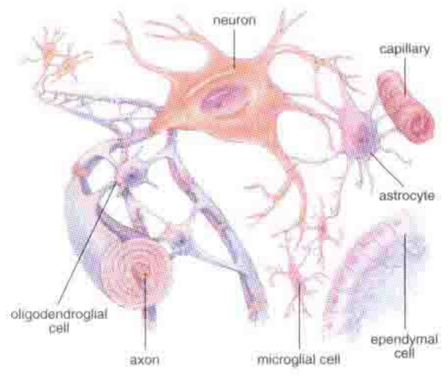


figure 8.4 Neuroglial cells in the central nervous system.



The dendrites and axons of neurons are sometimes called processes or neuron **fibers**. Outside the CNS, long fibers are covered by a white **myelin sheath** formed by **Schwann cells**, which wrap themselves tightly around these fibers. The portions of the Schwann cells that contain cytoplasm and nuclei form a **neurilemmal sheath** (fig. 8.3). The neurilemmal sheath promotes regeneration of a nerve fiber if it is injured. Gaps between Schwann cells form the nodes of Ranvier and are important in nerve cell conduction (see fig. 8.2).

Multiple sclerosis (MS) is a disease of the myelin sheath. Lesions develop that soon become hardened scleroses, or scars, that interfere with normal conduction of nerve impulses. The effects are widespread because of the number of fibers covered by a myelin sheath. The disease is chronic and tends to worsen with time.

Neuroglial Cells

Schwann cells are a type of neuroglial cell found outside the CNS. Microglial cells, astrocytes, and oligodendroglial cells and ependymal cells are among the neuroglia found inside the CNS (fig. 8.4). *Microglial cells* are small, phagocytic cells that migrate to the site of an injury, where they engulf microbes and clean away debris. *Astrocytes* have cytoplasmic processes that provide structural support by forming bridges between neurons and capillaries. They may have a nutritive function involving the transport of molecules between capillaries and neurons. *Oligodendroglial cells* produce the myelin sheath that envelops neurons in the CNS. *Ependymal cells* line cavities in the CNS and assist in the production and circulation of the cerebrospinal fluid that fills the cavities of the CNS.

Nervous tissue contains neurons and neuroglial cells. Each type of neuron has three parts (dendrite[s], cell body, and axon) but is specific as to function. Neuroglial cells support, protect, and nourish the neurons.

INTERNAL SUMMARY STATEMENTS

Summary statements are strategically placed throughout the chapter to immediately reinforce the concepts just discussed. These internal summary statements will aid your retention of the chapter's central concepts.

BOLDFACED TERMS

Basic Key Terms and Clinical Key Terms appear in boldface print as they are introduced in the text. Phonetic pronunciations follow the more challenging boldfaced terms. The terms are immediately defined in context. Key terms are listed with their pronunciations and page referenced at the end of the chapter. All boldfaced terms are defined in the glossary at the end of the book.

VISUAL FOCUS ILLUSTRATIONS

Visual Focus illustrations describe complex processes and use boxed statements to help you follow the events being depicted.

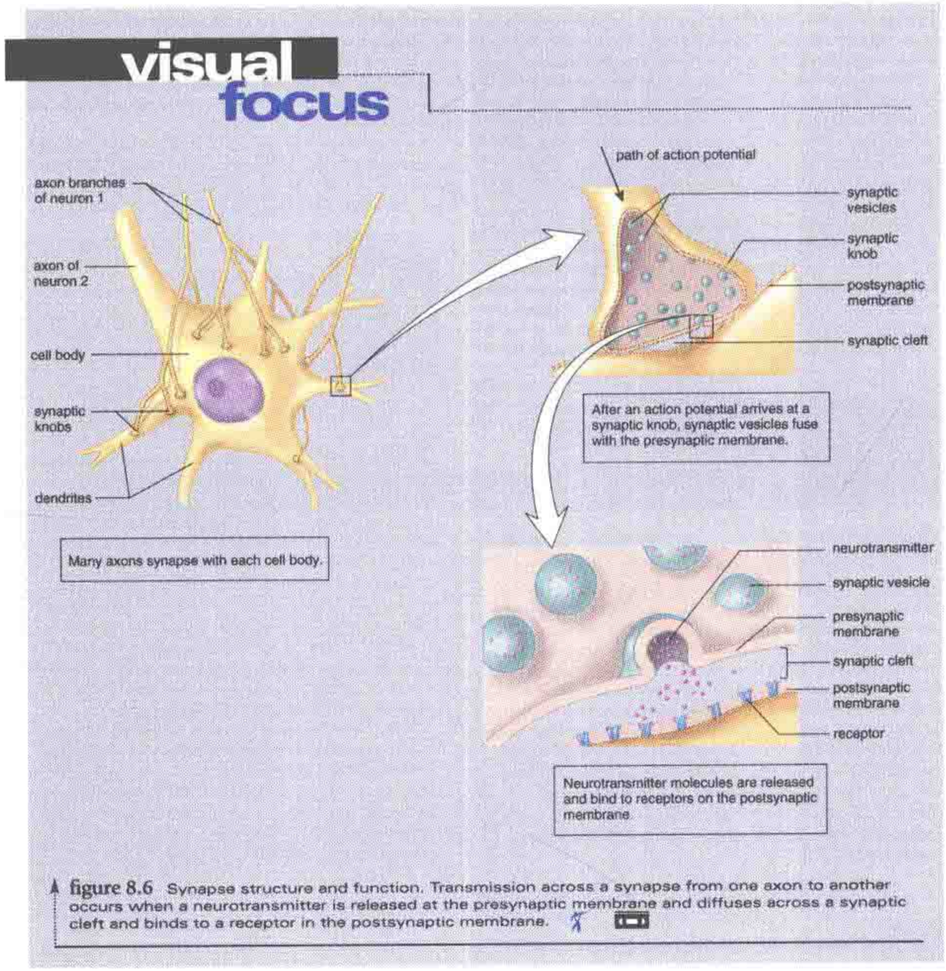
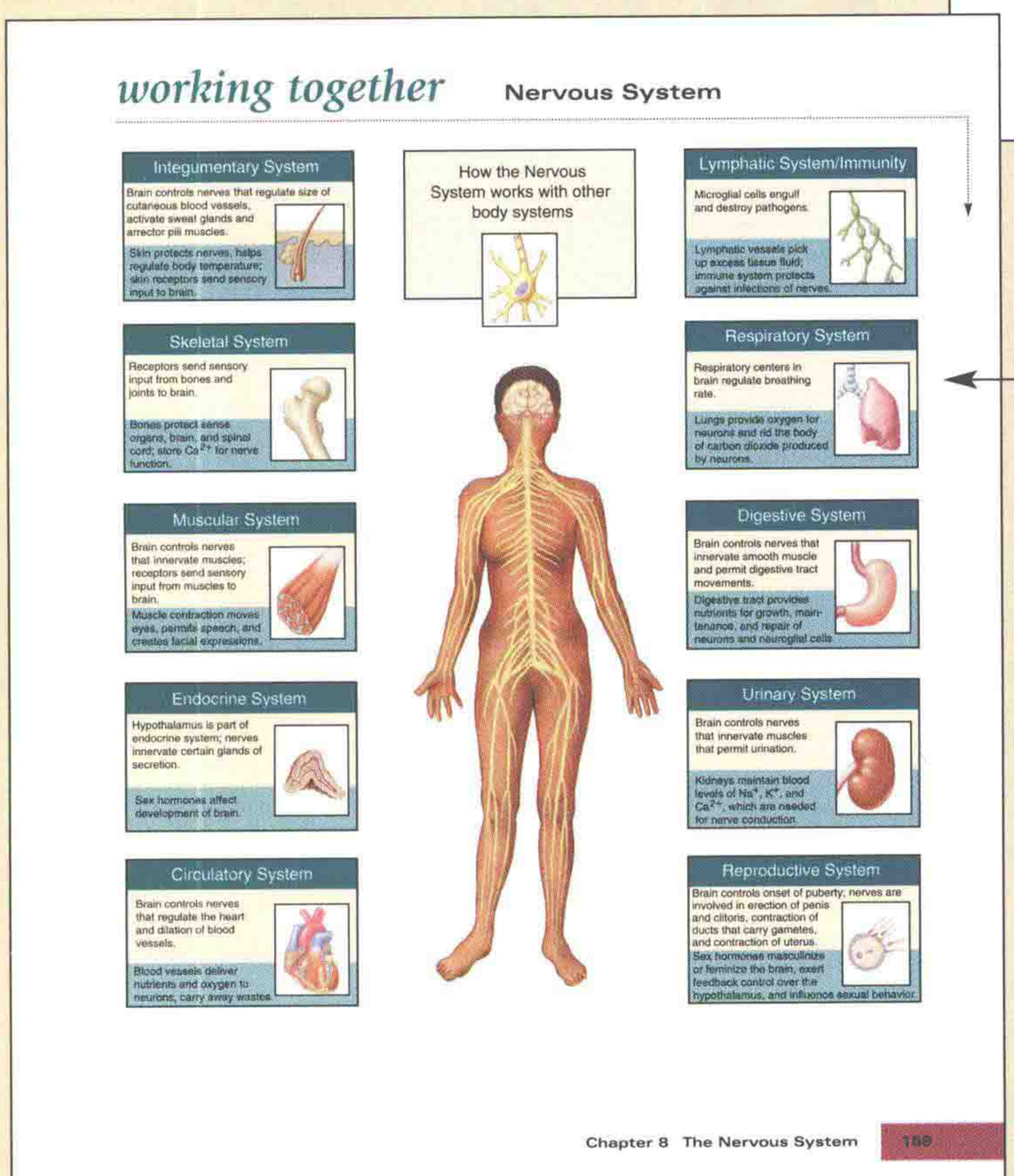


figure 8.6 Synapse structure and function. Transmission across a synapse from one axon to another occurs when a neurotransmitter is released at the presynaptic membrane and diffuses across a synaptic cleft and binds to a receptor in the postsynaptic membrane.

Neurotransmitters and Neurological Disorders

Several neurological illnesses, such as **Parkinson disease** and **Huntington disease**, are due to an imbalance in neurotransmitters within the brain. Parkinson disease is characterized by a wide-eyed, unblinking expression, an involuntary tremor of the fingers and thumbs, muscular rigidity, and a shuffling gait. All of these symptoms are due to a deficiency of dopamine. Huntington disease is characterized by a progressive deterioration of the individual's nervous system, which eventually leads to constant thrashing and writhing movements, and finally, to insanity and death. The problem is believed to be due to a malfunction of GABA, another neurotransmitter of the brain. As



WORKING TOGETHER ILLUSTRATIONS

Working Together illustrations describe how each organ system works with the other systems to achieve homeostasis. These illustrations help you see the body as a working whole.

The **pons** is a "bridge;" it contains bundles of axons traveling between the cerebellum and the rest of the CNS. In addition, the pons functions with the medulla to regulate breathing rate and has reflex centers concerned with head movements in response to visual and auditory stimuli.

The **midbrain** encloses the cerebral aqueduct. Aside from acting as a relay station for tracts passing between the cerebrum and the spinal cord or cerebellum, the midbrain has reflex centers for visual, auditory, and tactile responses.

Diencephalon

The hypothalamus and thalamus are in a portion of the brain known as the **diencephalon** (di"en-sef'ah-lon), where the third ventricle is located. The **hypothalamus** (hi"po-thal'ah-mus), which forms the floor of the third ventricle, maintains homeostasis, or the constancy of the internal environment, and contains centers for regulating hunger, sleep, thirst, body temperature, water balance, and blood pressure. The hypothalamus controls the pituitary gland and thereby serves as a link between the nervous and endocrine systems.

The **thalamus,** in the lateral walls of the third ventricle, is the last portion of the brain for sensory input before the cerebrum. It serves as a central relay station for sensory impulses traveling upward from other parts of the body and brain to the cerebrum. It receives all sensory impulses (except those associated with the sense of smell) and channels them to appropriate regions of the cortex for interpretation.

The brain stem and the diencephalon contain reflex centers that are involved in controlling internal organs, and tracts that channel impulses into the brain or between brain regions. The hypothalamus maintains homeostasis and controls the secretions of the pituitary gland.

Cerebellum

The **cerebellum** (ser"ĕ-bel'um), which lies below the posterior portion of the cerebrum, is separated from the brain stem by the fourth ventricle. The cerebellum has two parts called hemispheres that are joined by a constricted median portion. The surface of the cerebellum is gray matter, and the interior is largely white matter. The cerebellum functions in muscle coordination, integrating impulses received from higher centers to ensure that all of the skeletal muscles work together to produce smooth and graceful motion. The cerebellum is also responsible for maintaining normal muscle tone and transmitting impulses that maintain posture. It receives information about body position from the inner ear and then sends impulses to the muscles, whose contraction maintains or restores balance.

The cerebellum controls balance and complex muscular movements.

Cerebrum

The **cerebrum** (ser'ĕ-brum) is the largest and most superior part of the brain. It is the only area of the brain responsible for consciousness. The cerebrum is divided into halves known as the right and left **cerebral hemispheres,** each hemisphere contains a lateral ventricle.

The outer layer of the cerebrum, called the *cortex,* is gray and contains cell bodies and short fibers. The cortex has convolutions known as **gyri,** which are separated by shallow grooves called *sulci* and deep grooves called *fissures.* The cerebrum is almost divided by a deep, longitudinal fissure. At the base of this fissure lies the **corpus callosum,** a bridge of myelinated fibers that joins the two hemispheres. Left-brain and right-brain abilities are examined in the Medical Focus reading on this page.

Each cerebral hemisphere has four lobes: **frontal, parietal** (pah-ri'ĕ-tal), **temporal,** and **occipital** (ok-sip'i-tal) (fig. 8.11), which are named for the bones that cover them. Each lobe has particular functions (table 8.3).

Medical Focus

The Left and Right Brain

Some years ago, Roger W. Sperry and Michael Gazzaniga severed the corpus callosum in some of their patients who suffered from epilepsy. The corpus callosum connects the left and right sides of the brain. From these procedures and further experimentation, they learned that the left brain and right brain have different abilities.

Sperry and Gazzaniga found that the left brain contains centers for speech and is responsible for language ability. Therefore, patients could report what was seen by the left half of each eye but not what was seen by the right half of each eye. In contrast, patients were unable to report verbally on left-hand activities because the left hand is controlled by the right half of the brain.

Sperry and Gazzaniga also determined that the right brain is far superior to the left brain in dealing with spatial relationships. For example, the left hand, not the right hand, is better able to recognize and remember objects by their shape. In addition to spatial relationships, the right brain also appears to be involved with musical and artistic activities and the expression of emotions.

THE *ESSENTIAL STUDY PARTNER* CD-ROM

The filmstrip icon next to various topics encourage you to use the interactive CD-ROM that accompanies your textbook. *The Essential Study Partner* is packed with hundreds of animations and learning activities. The animations will bring to life those concepts that are difficult to envision. The quizzing will help you grasp difficult topics.

BOXED READINGS

Most chapters have a MedAlert reading, which examines a particular medical condition in some detail. These end with critical thinking questions for you to answer. (Answers to these questions are included in Appendix C.)

Also, Medical Focus readings appear in each chapter. The clinical terms used in the boxed readings appear as Clinical Key Terms at the end of the chapter and are defined in the glossary at the end of the book.

MedAlert

Alzheimer Disease

Alzheimer disease (AD) is a disorder characterized by a gradual loss of reason that begins with memory lapses and ends with an inability to perform any type of daily activity. Personality changes signal the onset of AD. A normal 50- to 60-year-old adult might forget the name of a friend not seen for years. People with AD, however, forget the name of a neighbor who visits daily. With time, they have trouble traveling and cannot perform simple errands. People afflicted with AD become confused and tend to repeat the same question. Signs of mental disturbances eventually appear, and patients gradually become bedridden and die of a complication, such as pneumonia.

A normal neuron (nerve cell), and a neuron damaged by Alzheimer disease (AD), are shown in figure 8A. The AD neuron has two abnormalities not seen in the normal neuron: (1) Bundles of fibrous protein, called neurofibrillary tangles, surround the nucleus in the cell, and (2) protein-rich accumulations, called amyloid plaques, envelop the axon branches. These abnormal neurons are especially seen in the portions of the brain that are involved in reason and memory (frontal lobe and limbic system). To see the abnormal brain neurons, brain tissue must be examined microscopically after the patient dies.

A chemical test can be used to check brain tissue for the presence of a protein called Alzheimer disease associated protein (ADAP), which is believed to be the protein contained in the neurofibrillary tangles. If ADAP is proven to be the protein involved in AD, individuals could be tested for this protein by obtaining a spinal tap of cerebrospinal fluid.

Over a life span of 100 years, the likelihood of developing AD is 16% for people with no family history of AD, and 24% for those having first-degree relatives with AD. This difference in susceptibility suggests that AD might have a genetic basis. Researchers have discovered that in some families whose members have a 50% chance of AD, a genetic defect exists on chromosome 21. This is of extreme interest because Down syndrome (p. 381) results from the inheritance of three copies of chromosome 21, and people with Down syndrome tend to develop AD. Further, the genetic defect affects the normal production of amyloid precursor protein (APP), which may be the cause of the amyloid plaques.

Acetylcholine is a chemical that stimulates neurons to carry nerve impulses, and it appears that this chemical may be in short supply in the brains of patients with AD. Drugs that enhance acetylcholine production are currently being tested in AD patients. Experimental drugs that prevent neuron degeneration are also being tested. For example, it is possible that nerve growth factor, a substance that is made by the body and that promotes the growth of neurons, will one day be available to AD patients.

Questions

1. Why are drugs that enhance acetylcholine production being tested in AD patients?
2. What evidence suggests that AD might have a genetic basis?
3. How does the AD neuron differ from a normal neuron?

NEW TERMS LIST

The Selected New Terms list at the end of each chapter is divided into two parts. The first part lists many of the Basic Key Terms that appear in boldface in the chapter, and the second part lists Clinical Key Terms that appear in boldface in the chapter. All terms are defined in the glossary at the end of the book.

Selected New Terms

Basic Key Terms

acetylcholine (ACh) (as″ē-til-ko′lēn), p. 140
acetylcholinesterase (AChE) (as″ē-til-ko″lin-es′ter-ās), p. 140
arachnoid membrane (ah-rak′noid mem′brān), p. 150
autonomic nervous system (aw″to-nom′ik ner′vus sis′tem), p. 152
axon (ak′son), p. 137
cell body (sel bod′ē), p. 137
central nervous system (sen′tral ner′vus sis′tem), p. 136
cerebellum (ser″ē-bel′um), p. 146
cerebral hemisphere (ser′ē-bral hem′ī-sfēr), p. 146
cerebrospinal fluid (ser″e-bro-spi′nal floo′id), p. 151
cerebrum (ser′ē-brum), p. 146
cranial nerve (kra′ne-al nerv), p. 152
dendrite (den′drīt), p. 137
diencephalon (dī″en-sef′ah-lon), p. 146
dorsal-root ganglion (dor′sal root gang′gle-on), p. 142
dura mater (du′rah ma′ter), p. 150
hypothalamus (hi″po-thal′ah-mus), p. 146
limbic system (lim′bik sis′tem), p. 149
medulla oblongata (mē-dul′ah ob″long-ga′tah), p. 144
meninges (mē-nin′jēz), p. 150
midbrain (mid′brān), p. 146
neurilemmal sheath (nu″rī-lem′al shēth), p. 139
neuron (nu′ron), p. 137
neurotransmitter (nu″ro-trans′mit-er), p. 140
parasympathetic division (par″ah-sim″pah-thet′ik di-vizh′un), p. 158
peripheral nervous system (pē-rif′er-al ner′vus sis′tem), p. 136
pia mater (pī′ah ma′ter), p. 150
pons (ponz), p. 146
reflex (re′fleks), p. 142
Schwann cell (schwon sel), p. 139
sensory receptor (ri-sep′ter), p. 142
somatic nervous system (so-mat′ik ner′vus sis′tem), p. 152
spinal nerve (spī′nal nerv), p. 152
sympathetic division (sim″pah-thet′ik dī-vizh′un), p. 155
synapse (sin′aps), p. 140
ventricle (ven′trī-k'l), p. 144

Clinical Key Terms

Alzheimer disease (altz′hi-mer dī-zēz′), pp. 142, 160
ankle-jerk reflex (an′kl-jerk re′fleks), p. 143
cerebral palsy (ser′ē-bral pal′ze), p. 148
dermatome (der′mah-tōm), p. 152
electroencephalogram (e-lek″tro-in-sef′lah-gram), p. 149
epidural hematoma (ep″ī-du′ral he″mah-to′mah), p. 150
Huntington disease (hun′ting-tun dī-zēz′), p. 141
hydrocephalus (hi″dro-sĕ′fah-lus), p. 151
knee-jerk reflex (ne-jerk re′fleks), p. 143
multiple sclerosis (mul′tī-pul skler-o′sis), p. 139
paraplegia (par-ah-ple′je-ah), p. 150
Parkinson disease (par′kin-sun dī-zēz′), p. 141
quadriplegia (kwah-drah-ple′je-ah), p. 150
stroke (strōk), p. 149
subdural hematoma (sub″du′ral he″mah-to′mah), p. 150

Summary

I. Nervous System
- A. Divisions of the nervous system. The nervous system is divided into the central nervous system (brain and spinal cord) and the peripheral nervous system (somatic and autonomic nervous systems). The CNS lies in the midline of the body, and the PNS is located peripherally to the CNS.
- B. Functions of the nervous system. The nervous system permits sensory input, performs integration, and stimulates motor output.
- C. Cells of nervous tissue. Nervous tissue contains neurons and neuroglial cells. Each type of neuron has three parts (dendrites, cell body, and axon) but is specific as to function. Neuroglial cells support, protect, and nourish the neurons.
- D. Nerve impulses. All neurons transmit the same type of nerve impulse: a change in polarity that flows along the membrane of a nerve fiber.
- E. Synapse. Transmission of a nerve impulse across a synapse is dependent on the release of a neurotransmitter into a synaptic cleft.
- F. Nerves. A nerve contains bundles of long fibers covered by fibrous, connective tissue layers. In the CNS, bundles of long fibers are found in tracts. White matter is composed of myelinated fibers, and gray matter is composed of cell bodies and unmyelinated fibers.
- G. Reflexes and the reflex arc. Reflexes (automatic reactions to internal and external stimuli) depend on the reflex arc. Some reflexes are important for avoiding injury, and others are necessary for normal physiological functions.

II. Central Nervous System
- A. Ventricles of the brain. The brain has four ventricles. The lateral ventricles are found in the left and right cerebral hemispheres. The third ventricle is found in the diencephalon. The fourth ventricle is found in the brain stem.
- B. Brain stem. The brain stem contains the medulla oblongata, pons, and midbrain. The medulla oblongata contains vital centers for regulating heartbeat, breathing, and blood pressure. The pons assists the medulla oblongata in regulating the breathing rate. The midbrain contains tracts that conduct impulses to and from the higher parts of the brain.
- C. Diencephalon. The hypothalamus helps control the functioning of most internal organs and controls the secretions of the pituitary gland. The thalamus receives sensory impulses from all parts of the body and channels them to the cerebrum.
- D. Cerebellum. The cerebellum controls balance and complex muscular movements.
- E. Cerebrum. Consciousness is under the control of the cerebrum, the most highly developed portion of the brain. It is responsible for higher mental processes, including the interpretation of sensory input and the initiation of voluntary muscular movements.
- F. Limbic system. The limbic system includes portions of the cerebrum, the thalamus, and the hypothalamus. It is involved in learning and memory and in causing the emotions that guide behavior.
- G. Spinal cord. The spinal cord is located in the vertebral column in cross sections composed of white matter and gray matter. White matter contains bundles of nerve fibers, called tracts, that conduct nerve impulses to and from the higher centers of the brain. Gray matter is mainly made up of short fibers and cell bodies. The spinal cord is a center for reflex action and allows communication between the brain and the peripheral nerves leaving the spinal cord.
- H. Meninges and cerebrospinal fluid. The CNS is protected by the meninges and the cerebrospinal fluid.

III. Peripheral Nervous System
- A. Somatic nervous system. Cranial nerves take impulses to and/or from the brain. Spinal nerves take impulses to and from the spinal cord.
- B. Autonomic nervous system. The ANS controls the functioning of internal organs without need of conscious control.
  1. The divisions of the autonomic nervous system: (1) function automatically and usually subconsciously in an involuntary manner, (2) innervate all internal organs, and (3) utilize two motor neurons and one ganglion for each impulse.
  2. The sympathetic division brings about the responses associated with the "fight-or-flight" response.
  3. The parasympathetic division brings about the responses associated with normally restful activities.

CHAPTER SUMMARY

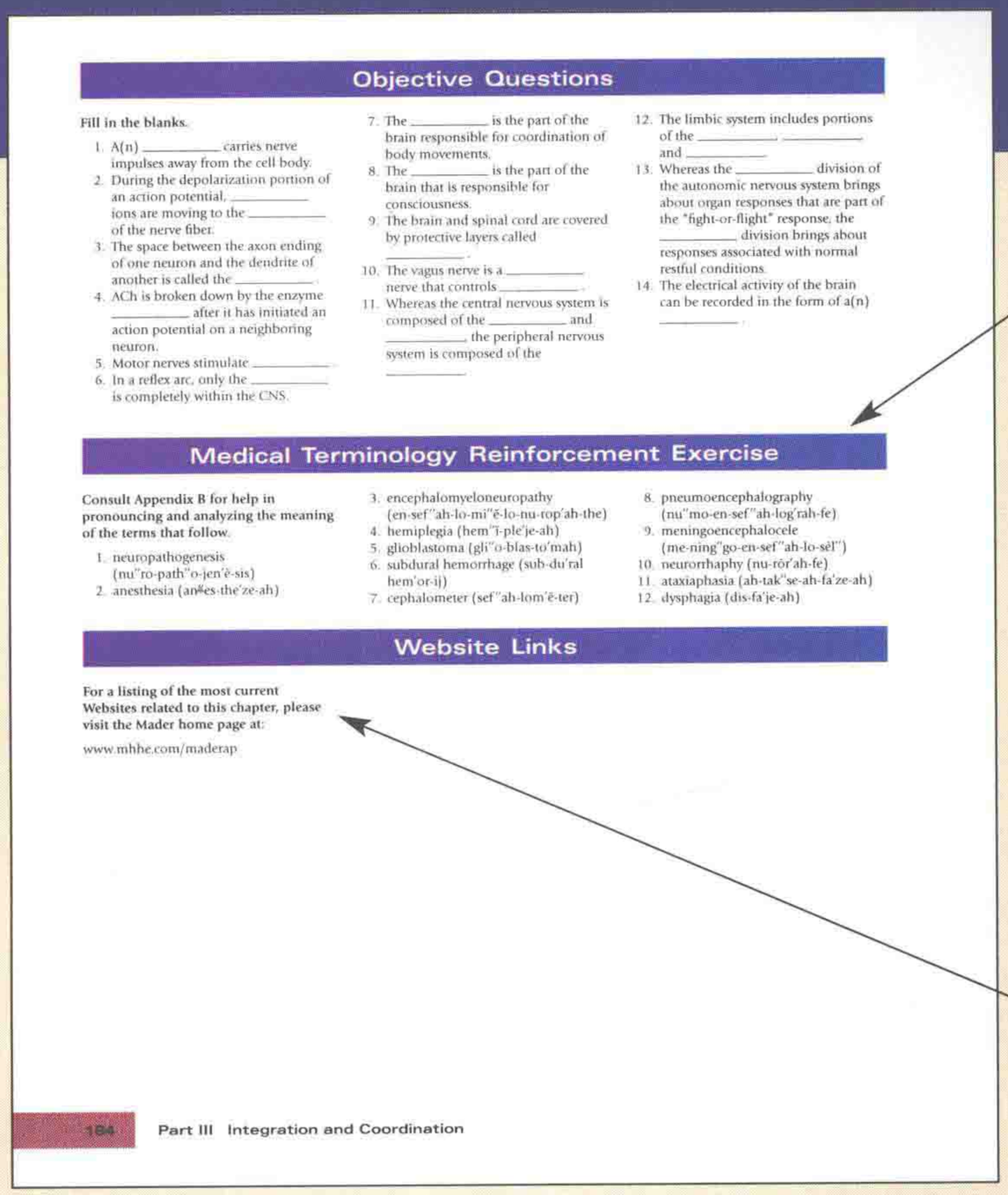
A summary at the end of each chapter offers a concise review of chapter material. You may read the Summary before beginning the chapter to preview the topics of importance, and you may also use it to refresh their memory after you have a firm grasp of the chapter's concepts.

Study Questions

1. What are the two main divisions of the nervous system? How are these divisions subdivided? (pp. 136–37)
2. What are the types of neurons and neuroglial cells? How are they similar, and how are they different? (pp. 137–39)
3. What does the term *nerve impulse* mean, and how is a nerve impulse brought about? (p. 140)
4. What is a neurotransmitter? Where is it stored, and how does it function? How is it destroyed? Name several well-known neurotransmitters. (pp. 140–41)
5. Describe the structure of a nerve, and state the location of nerves and tracts. (p. 142)
6. What is the path of a spinal reflex that involves three neurons? What is the function of reflexes? (pp. 142–43)
7. Where are the ventricles of the brain located? (p. 144)
8. Name the various parts of the brain, state where the parts are located, and give their functions. (pp. 144–48)
9. What does it mean to say that the cerebral cortex can be mapped? Discuss this in relation to the primary motor areas and the primary sensory areas. (pp. 146–49)
10. Describe the anatomy of the spinal cord. What are the functions of the gray and white matter in the spinal cord? (p. 150)
11. What are the three different meninges, and what is their function? (pp. 150–51)
12. What is cerebrospinal fluid? Where is it made, and how does it circulate? (p. 151)
13. What are the different cranial nerves, and what is the function of each? (pp. 152–53)
14. What are the structure and function of the spinal nerves? (p. 152)
15. What is the autonomic nervous system, and what are its two major divisions? Describe several similarities and differences between these divisions. (pp. 155–58)

CHAPTER QUESTIONS

Two types of questions—Study Questions and Objective Questions—appear at the close of each chapter. Answering the Study Questions results in a sequential review of chapter material. The Objective Questions allow you to quiz yourself with fill-in-the-blank and matching questions. The Objective Questions are answered in the *Instructor's Manual.*



Objective Questions

Fill in the blanks.

1. A(n) _____ carries nerve impulses away from the cell body.
2. During the depolarization portion of an action potential, _____ ions are moving to the _____ of the nerve fiber.
3. The space between the axon ending of one neuron and the dendrite of another is called the _____.
4. ACh is broken down by the enzyme _____ after it has initiated an action potential on a neighboring neuron.
5. Motor nerves stimulate _____.
6. In a reflex arc, only the _____ is completely within the CNS.
7. The _____ is the part of the brain responsible for coordination of body movements.
8. The _____ is the part of the brain that is responsible for consciousness.
9. The brain and spinal cord are covered by protective layers called _____.
10. The vagus nerve is a _____ nerve that controls _____.
11. Whereas the central nervous system is composed of the _____ and _____, the peripheral nervous system is composed of the _____.
12. The limbic system includes portions of the _____, _____, and _____.
13. Whereas the _____ division of the autonomic nervous system brings about organ responses that are part of the "fight-or-flight" response, the _____ division brings about responses associated with normal restful conditions.
14. The electrical activity of the brain can be recorded in the form of a(n) _____.

Medical Terminology Reinforcement Exercise

Consult Appendix B for help in pronouncing and analyzing the meaning of the terms that follow.

1. neuropathogenesis (nu"ro-path"o-jen'ĕ-sis)
2. anesthesia (an#es-the'ze-ah)
3. encephalomyeloneuropathy (en-sef"ah-lo-mi"ĕ-lo-nu-rop'ah-the)
4. hemiplegia (hem"ĭ-ple'je-ah)
5. glioblastoma (gli"o-blas-to'mah)
6. subdural hemorrhage (sub-du'ral hem'or-ij)
7. cephalometer (sef"ah-lom'ĕ-ter)
8. pneumoencephalography (nu"mo-en-sef"ah-log'rah-fe)
9. meningoencephalocele (me-ning"go-en-sef"ah-lo-sēl")
10. neurorrhaphy (nu-ror'ah-fe)
11. ataxiaphasia (ah-tak"se-ah-fa'ze-ah)
12. dysphagia (dis-fa'je-ah)

Website Links

For a listing of the most current Websites related to this chapter, please visit the Mader home page at:

www.mhhe.com/maderap

MEDICAL TERMINOLOGY REINFORCEMENT EXERCISE

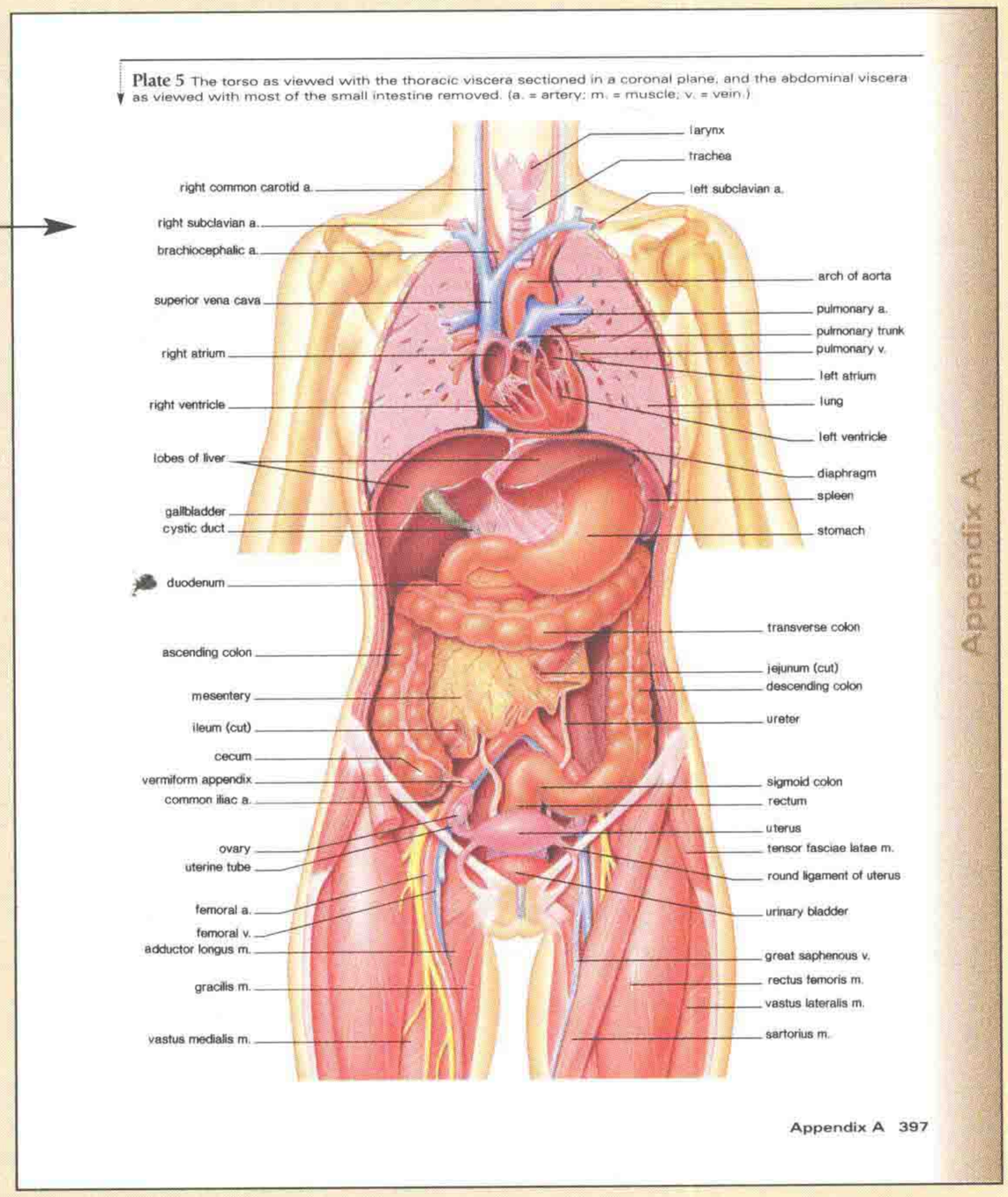
An understanding of medical terminology is critical to students of anatomy and physiology. A medical terminology reinforcement exercise at the end of each chapter reinforces the principles covered in Appendix B, "Understanding Medical Terminology." Answers to these exercises are included in the *Instructor's Manual.*

WEBSITE LINK

The web address located at the end of the chapter is a reminder to you that additional study questions and links to anatomy- and physiology-related topics appear on the Mader home page.

APPENDICES

Appendix A: Reference Figures: The Human Organism. The reference figures show the major organs of the human torso. The first plate illustrates the anterior surface and reveals the superficial muscles on one side. Each subsequent plate exposes deeper organs, including those of the thoracic, abdominal, and pelvic cavities. As you read the systems chapters of the text, you can refer to these plates to help visualize the locations of various organs.



Understanding Medical Terminology

Learning Objectives

Upon completion of this section, you should be able to:

1. Discuss the importance of medical terminology and how it can be incorporated into the study of the human body.
2. Differentiate between a prefix, suffix, root word, and compound word.
3. Link word parts to form medical terms.
4. Differentiate between singular and plural endings of medical terms.
5. Practice pronunciation of medical words.
6. Dissect (cut apart) compound medical words into parts to analyze the meaning.
7. Recognize the more commonly used prefixes, suffixes, and root words used in medical terminology.

Introduction to Medical Terminology

As students of medical science, we are the inheritors of a vast fortune of knowledge. This fortune, amassed by giants of eighteenth- and nineteenth-century scholarship, was nurtured largely in the atmospheres of universities in which Latin and Greek were the languages of lecture and writing. Scientists then strove to define a universal language in which to communicate their findings. Latin and Greek, studied throughout Europe, became the languages of choice for scholars whose native tongue was English, German, French, Spanish, and so on, because they all read Latin and Greek. So, many seminal works in medicine were first penned in Latin, and their vocabularies remain to this day.

Anatomy and physiology were born in the eighteenth century in the midst of a glut of quacks, frauds, charlatans, myths, and superstitions. Honest scholars sought proofs to banish practices that should have been questioned by reason and proved wrong by experience. These scholars were among the first to connect disease with the failure of function or structure of body tissue; thus, the race to name and define all anatomical structures began.

Problems arose, inevitably, with the discovery of heretofore unknown tissue. Names were virtually created from parts or existing words by combining parts until they approximated an acceptable description. Medical terminology is simply a catalog of parts that allows us to take apart and reassemble the special language of medicine. The study of medical terminology is easier than it first seems.

Medical words have three basic parts: prefix, root word, and suffix. A prefix comes before a root word and alters the meaning. For example, the prefix *hyper-* means over or above. Hyper/kinetic means overactive, hyper/esthesia is overly sensitive, hyper/tension is high blood pressure, and hyper/trophy is overdevelopment.

A suffix is attached to the end of a root word and changes the meaning of the word. For example, the suffix *-itis* means inflammation. Inflammation can occur at almost any part of the body, so *-itis* can be added to root words to make hundreds of words. Dermat/itis is inflammation of the skin, rhin/itis is inflammation of the nose, gastr/itis is inflammation of the stomach, and so on.

A root word is the main part of the word. Once the root word is known for each part of the anatomy, the prefixes and suffixes can be used to analyze and/or build many medical words. The root word for heart is *cardi*. A few terms in which *cardi* appears are: cardi/algia means pain in the heart, cardio/omegaly means enlarged heart, brady/cardia means slow heart, and peri/cardio/centesis means puncture to aspirate fluid from around the heart.

Many medical words have, in addition to a prefix and/or a suffix, more than one word part. These are called compound words and can be analyzed by breaking them into parts. For example, hysterosalpingo-oophorectomy is made up of three root words and a suffix. *Hyster* is the root word for uterus, *salping* is the root word for tube, *oophor* is the root word for ovary, and *-ectomy* is the suffix for cut out. Now we know that hysterosalpingo-oophorectomy means the surgical excision of the uterus, tube, and ovary.

To facilitate pronunciation, word parts need to be linked together. The linkage for word parts is *o* and may be referred to as a combining form. For example, linking the root *cardi* with the suffix *-pathy* would produce a word that would be difficult to pronounce; therefore, an *o* is used to link the root word with the suffix. The complete word is written cardiopathy and pronounced kar"dēop'ah-thē, and the combining form is cardi/o.

When a word is only a root or ends with a root, the word ending depends on whether the word is a noun or an

Appendix B: Understanding Medical Terminology
This appendix gives an overview of the basics of medical terminology and introduces you to the correct pronunciation of medical terms.

Appendix C: Answers to MedAlert Questions
This appendix gives answers to the questions that appear at the end of each MedAlert reading.

Answers to MedAlert Questions

Chapter 3

Cell Structure and Function

1. The longer we live, the more time there is to acquire "promoters" of cancer.
2. Smokers take carcinogens into the respiratory tract.
3. Certain foods are known to inhibit cancer, while others are known to promote cancer.

Chapter 6

The Skeletal System

1. It takes time for a joint to be "overworked."
2. Artificial hips do not have the flexibility of natural ones.

Chapter 7

The Muscular System

1. Exercise promotes regular bowel movements because it encourages movement of intestinal contents.
2. Exercise requires energy; therefore, it uses up body fat.
3. It would improve longevity because the heart does not work as hard.

Chapter 8

The Nervous System

1. Neurons that release this neurotransmitter are damaged in AD.
2. AD runs in families.
3. The AD neuron has neurofibrillary tangles and amyloid plaques.

Chapter 9

The Senses

1. and 2. If the macula lutea degenerates, a person cannot see detail or color.
3. Vision in dim light is dependent on the rods, which are found outside the macula.

Chapter 12

The Circulatory System

1. Such a diet reduces blood cholesterol levels. High blood cholesterol levels cause plaque, particularly in coronary arteries.
2. During a myocardial infarction, a thromboembolism, or clot, lodges in a coronary artery that has already been narrowed by plaque. The portion of the heart deprived of blood dies, and surrounding tissue may be damaged.

Chapter 13

The Lymphatic System and Immunity

1. An HIV blood test is used to detect the presence of antibodies in the blood that are directed against HIV. A positive HIV test indicates prior exposure to the virus. A T4 cell count examines the number of T4 cells in the blood. AIDS is characterized by a T4 cell count below 200 per cubic millimeter.
2. Individuals with AIDS have a drastically weakened immune system and are unable to fend off infections that are normally nonfatal.

Appendix D: Further Readings
This appendix lists articles and books to give you more information about a particular topic or if you need references for a research paper.

Further Readings

Achord, J. L. March/April 1995. Alcohol and the liver. *Scientific American Science & Medicine* 2(2):16.

Alcamo, I. E. 1997. *AIDS: The biological basis. 2nd ed.* Dubuque, Iowa: The McGraw-Hill Companies, Inc.

American Chemical Society. 2000. *Chemistry in context. Applying chemistry to society.* 3rd ed. The McGraw-Hill Companies, Inc.

Applegate, E. J. 1995. *The anatomy and physiology learning system.* Philadelphia: W. B. Saunders.

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Bayley, H. September 1997. Building doors into cells. *Scientific American* 277(3):62. Protein engineers are designing artificial pores for drug delivery.

Beardsley, T. January 1994. A war [on cancer] not won. *Scientific American* 270(1):130.

Beardsley, T. March 1996. Vital data. *Scientific American* 274(3):100. DNA tests for a wide array of conditions are becoming available.

Beardsley, T. August 1997. The machinery of thought. *Scientific American* 277(2):78. Researchers have identified the area of the brain responsible for memory.

Becker, W. M., and D. W. Deamer. 1995. *The world of the cell.* 3d ed. Redwood City, Calif.: Benjamin/Cummings Publishing.

Berns, M. W. April 1998. Laser scissors and tweezers. *Scientific American* 278(62):4. New laser techniques allow manipulation of chromosomes and other structures inside cells.

Bikle, D. D. March/April 1995. A bright future for the sunshine hormone. *Scientific American Science & Medicine* 2(2):58.

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Boon, T. March 1993. Teaching the immune system to fight cancer. *Scientific American* 268(3):82.

Botek, C. November/December 1997. Antioxidants and cancer. *Scientific American Science & Medicine* 4(6):52. The importance of supplemental antioxidant vitamins depends on factors such as diet and lifestyle.

Borén, T., and P. Falk. September/October 1994. *Helicobacter pylori* binds to blood group antigens. *Scientific American Science & Medicine* 1(4):28.

Brown, J. L., and E. Pollitt. February 1996. Malnutrition, poverty and intellectual development. *Scientific American* 274(2):38. Article discusses the complex role of essential nutrients in a child's mental development.

Carey, R. L., et al. 1997. *Principles and applications of organic and biological chemistry.* 2d ed. Dubuque, Iowa: The McGraw-Hill Companies, Inc. This text emphasizes material unique to health-related studies.

Cavanee, W. K., and R. L. White. March 1995. The genetic basis of cancer. *Scientific American* 272(3):72.

Chiu, R. C. J. November/December 1994. Using skeletal muscle for cardiac assistance. *Scientific American Science & Medicine* 1(5):68.

Clemente, C. D. 1996. *Anatomy: A regional atlas of the human body.* 4th ed. Philadelphia: Lea and Febiger.

Cooper, G. 1993. *The cancer book.* Boston: Jones and Bartlett Publishers.

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Crowley, L. 1997. *Introduction to human disease.* Boston: Jones & Bartlett Publishers. This well-illustrated text for study in the allied health fields describes diseases and their symptoms, diagnoses, and treatments.

Curiel, T. September/October 1997. Gene therapy: AIDS-related malignancies. *Scientific American Science & Medicine* 4(5):4. The field of AIDS-related gene therapies is advancing.

Defeating AIDS: What will it take? July 1998. *Scientific American* 279(1):81. Nine separate articles address AIDS problems and issues.

Dickman, S. July 1997. Mysteries of the heart. *Discover* 18(7):117. Article discusses why coronary arteries may still become blocked after treatment for atherosclerosis.

Duan, L., and R. I. Pomerantz. May/June 1996. Intracellular antibodies for HIV-1 gene therapy. *Scientific American Science & Medicine* 3(3):24. Article discusses the cloning of synthetic antibody fragments that can inhibit the function of viral proteins.

Eisenbarth, G. S., and D. Bellgrau. May/June 1994. Autoimmunity. *Scientific American Science & Medicine* 1(2):38.

Emini, E. A. May/June 1995. Hurdles in the path to an HIV-1 vaccine. *Scientific American Science & Medicine* 2(3):38.

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Frank, J. September/October 1998. How the ribosome works. *American Scientist* 86(5):428. New imaging techniques using cryo-electron microscopy allows researchers to study a three-dimensional map of the ribosome.

Frenzy, A. C. F., and R. M. Mahoney. 1998. *Understanding medical terminology.* 10th ed. Dubuque, Iowa: The McGraw-Hill Companies Inc.

Garnick, M. B. April 1994. The dilemmas of prostate cancer. *Scientific American* 270(4):72.

Garnick, M. B., and W. R. Fair. December 1998. Combating prostate cancer. *Scientific American* 279(6):74. Article details the recent developments in diagnosis and treatment of prostate cancer.

Gibbs, W. W. August 1996. Gaining on fat. *Scientific American* 275(2):88. Some weight problems are genetic or physiological in origin. New treatments might help.

Glausiusz, J. October 1997. The good bugs on our tongues. *Discover* 18(10):32. Without the friendly bacteria that live on our tongues, we would be vulnerable to bacteria such as *Salmonella*.

Glausiusz, J. September 1998. Infected hearts. *Discover* 19(9):30. Infectious bacteria may play a role in heart disease; antibiotics could prevent the need for heart surgery.

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Glover, D. M. et al. June 1993. The centrosome. *Scientific American* 268(6):62.

Goldberg, I. April 1998. A head full of hope. *Discover* 19(4):70. A new gene therapy for killing brain cancer cells is presented.

Golde, D. W. December 1991. The stem cell. *Scientific American* 265(6):86.

Golub, E. S., and D. R. Green. 1992. *Immunology: A synthesis.* 2d ed. Sunderland, Mass.: Sinauer Associates.

Green, H. November 1991. Cultured cells for the treatment of disease. *Scientific American* 265(5):96.

Griffner, S. January 1996. Neural networks for vertebrate locomotion. *Scientific American* 274(1):64. Discoveries about how the brain coordinates muscle movement raise hopes for restoration of mobility for some accident victims.

Gunstream, S. E. 2000. *Anatomy and physiology.* 2d ed. Dubuque, Iowa: Wm. C. Brown Publishers.

Guyton, A. C. 1992. *Human physiology and mechanisms of disease.* 5th ed. Philadelphia: Saunders College Publishing.

Hales, C. N. July/August 1994. Fetal nutrition and adult diabetes. *Scientific American Science & Medicine* 1(3):54.

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Halstead, L. S. April 1998. Post-polio syndrome. *Scientific American* 278(4):42. Recovered polio victims are experiencing fatigue, pain, and weakness, resulting from degeneration of motor neurons.

Hanson, L. A. November/December 1997. Breast feeding stimulates the infant immune system. *Scientific American Science & Medicine* 4(6):12. Long-lasting protection against some infectious diseases has been reported in breast-fed infants.

Harken, A. H. July 1993. Surgical treatment of cardiac arrhythmias. *Scientific American* 269(1):68.

Harvard Health Letter. April 1998. A special report: Parkinson's disease. This overview presents the symptoms and diagnosis of Parkinson disease, and discusses medications and surgical methods of treatment.

Hirshhorn, N., and W. B. Greenbough, III. May 1991. Progress in oral rehydration therapy. *Scientific American* 264(5):50.

Hole, J. W., Jr. 1995. *Essentials of human anatomy and physiology.* 5th ed. Dubuque, Iowa: Wm. C. Brown Publishers.

Holloway, M. March 1991. Rx for addiction. *Scientific American* 264(3):94.

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Julien, R. M. 1992. *A primer of drug action.* 6th ed. New York: W. H. Freeman.

Kempermann, G., and F. Gage. May 1999. New nerve cells for the adult brain. *Scientific American* 280(5):48. The knowledge that the human brain can produce new nerve cells in adulthood could lead to better treatments for neurological diseases.

Kher, U. January 1998. A manmade chromosome. *Discover* 18(1):40. Researchers announce a promising new gene carrier, a human artificial chromosome, for use in gene therapy.

Klatsky, A. L. March/April 1995. Cardiovascular effects of alcohol. *Scientific American Science & Medicine* 2(2):28.

Koff, R. S. March/April 1994. Solving the mysteries of viral hepatitis. *Scientific American Science & Medicine* 1(1):24.

Koprowski, J. May/June 1995. Visit to an ancient curse [rabies]. *Scientific American Science & Medicine* 2(3):48.

Krauskopf, S. January 1999. Doing the meiosis shuffle. *American Biology Teacher* 61(1):60. A playing card demonstration walks students through the stages of meiosis.

Kunzig, R. February 1999. What's a pinna for? *Discover* 20(2):24. Article examines the function of the folds of the outer ear.

Lacy, P. E. July 1995. Treating diabetes with transplanted cells. *Scientific American* 273(1):50.

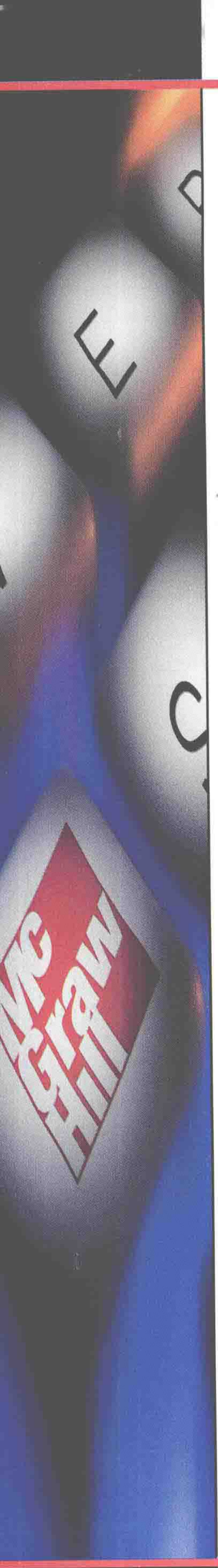
Lang, F., and Waldegger, S. September/October 1997. Regulating cell volume. *American Scientist* 85(5):456. Changes in cell volume may threaten organ or tissue function.

INDEX

A thorough and complete index at the end of the book directs you to the page or pages on which various topics are discussed.

GLOSSARY

The end-of-book glossary defines all the boldfaced terms, including the Basic Key Terms and the Clinical Key Terms that appear at the end of each chapter. The glossary is page-referenced.



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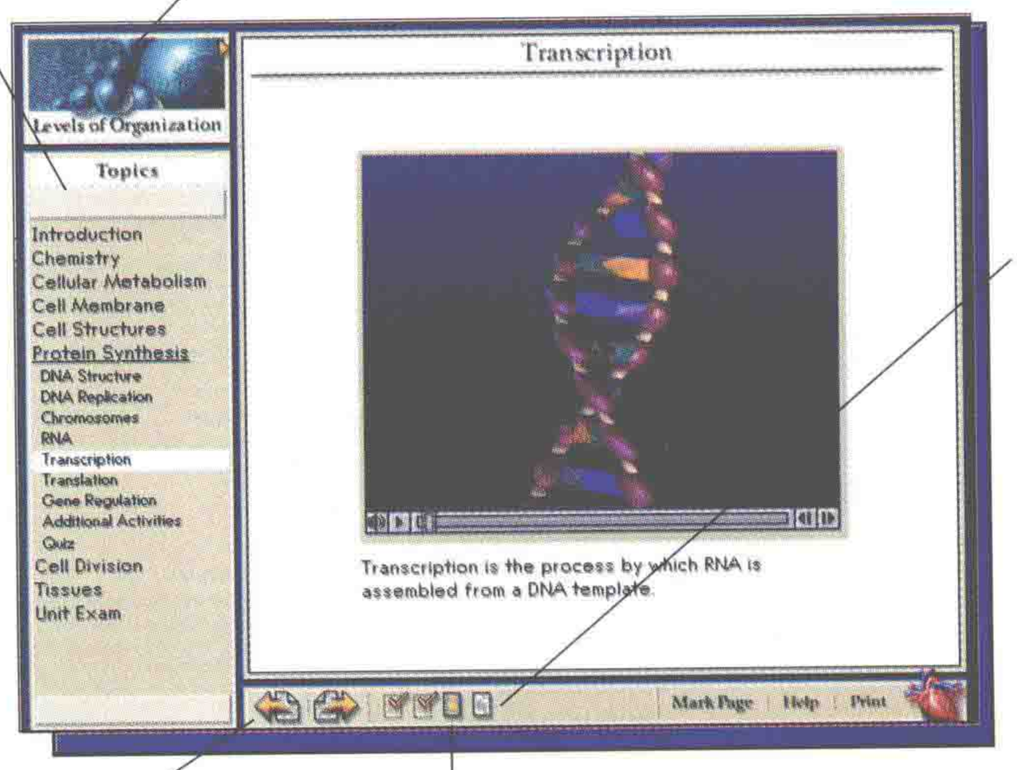

To the right of the arrows is a row of icons that represent the number of screens in a concept. There are three different icons, each representing different functions that a screen in that section will serve. The screen that is currently displayed will highlight yellow and visited ones will be checked.

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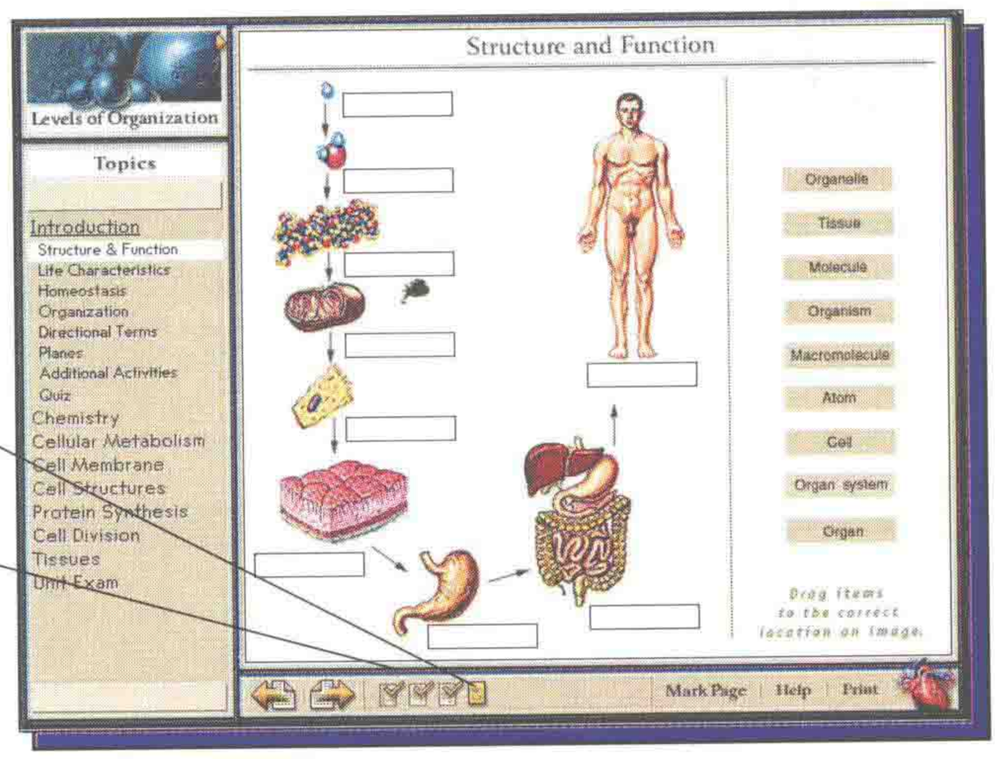
Along the bottom of the screen you will find various navigational aids. At the left are arrows that allow you to page forward and backward through text screens or interactive exercise screens. You can also use the LEFT and RIGHT arrows on your keyboard to perform the same function.



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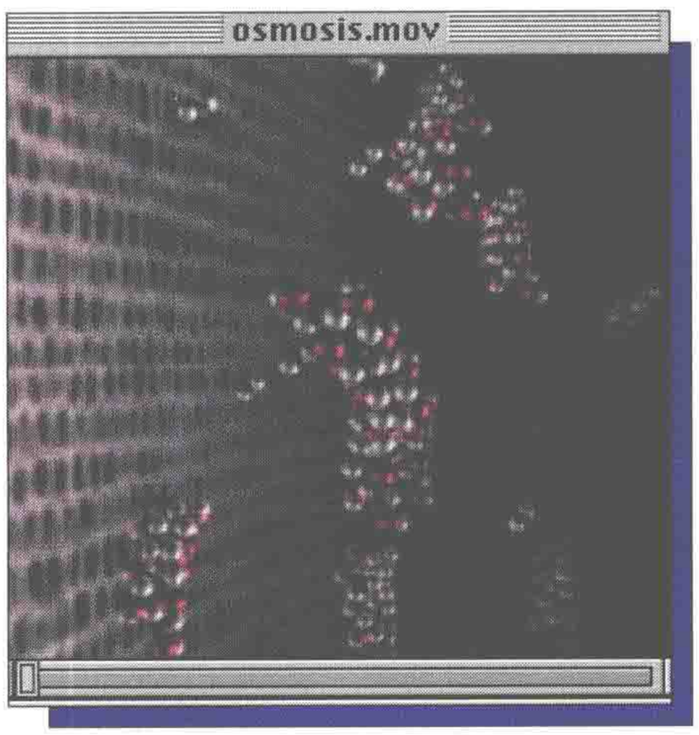

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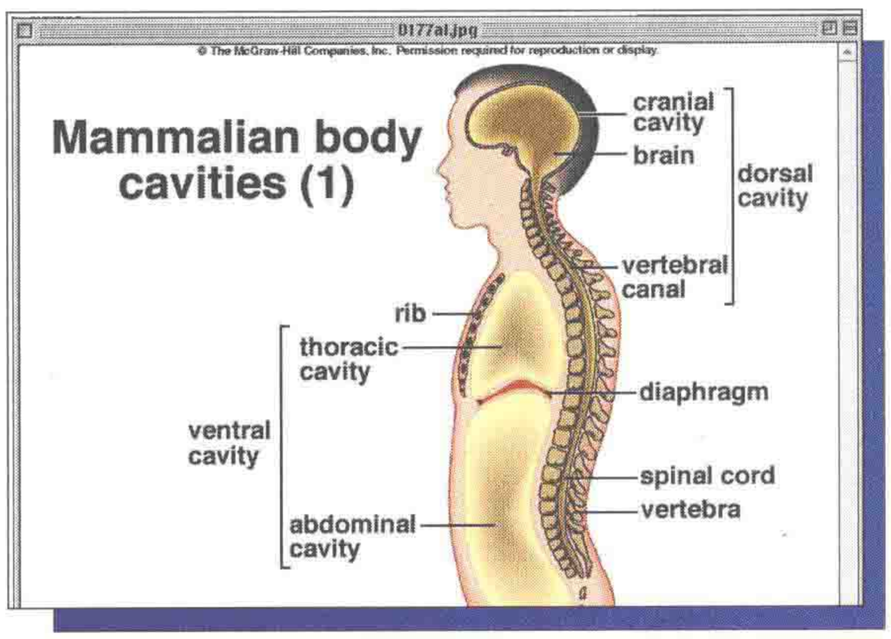

Inquiry and Human Biology Visual Resource Library CD-ROM

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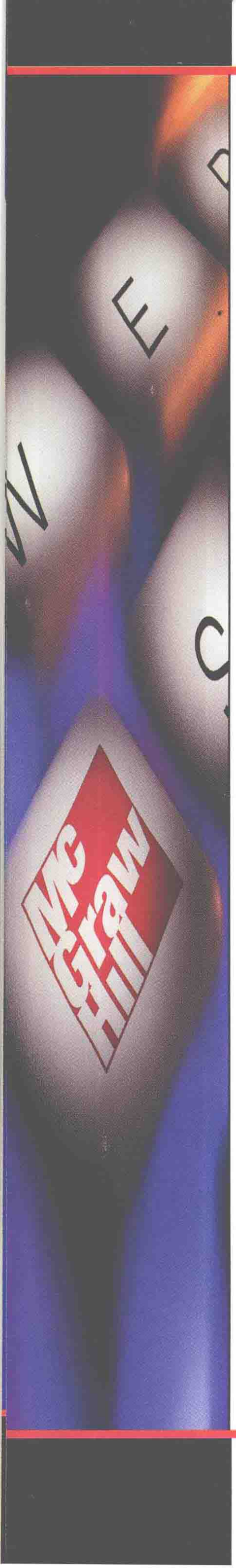

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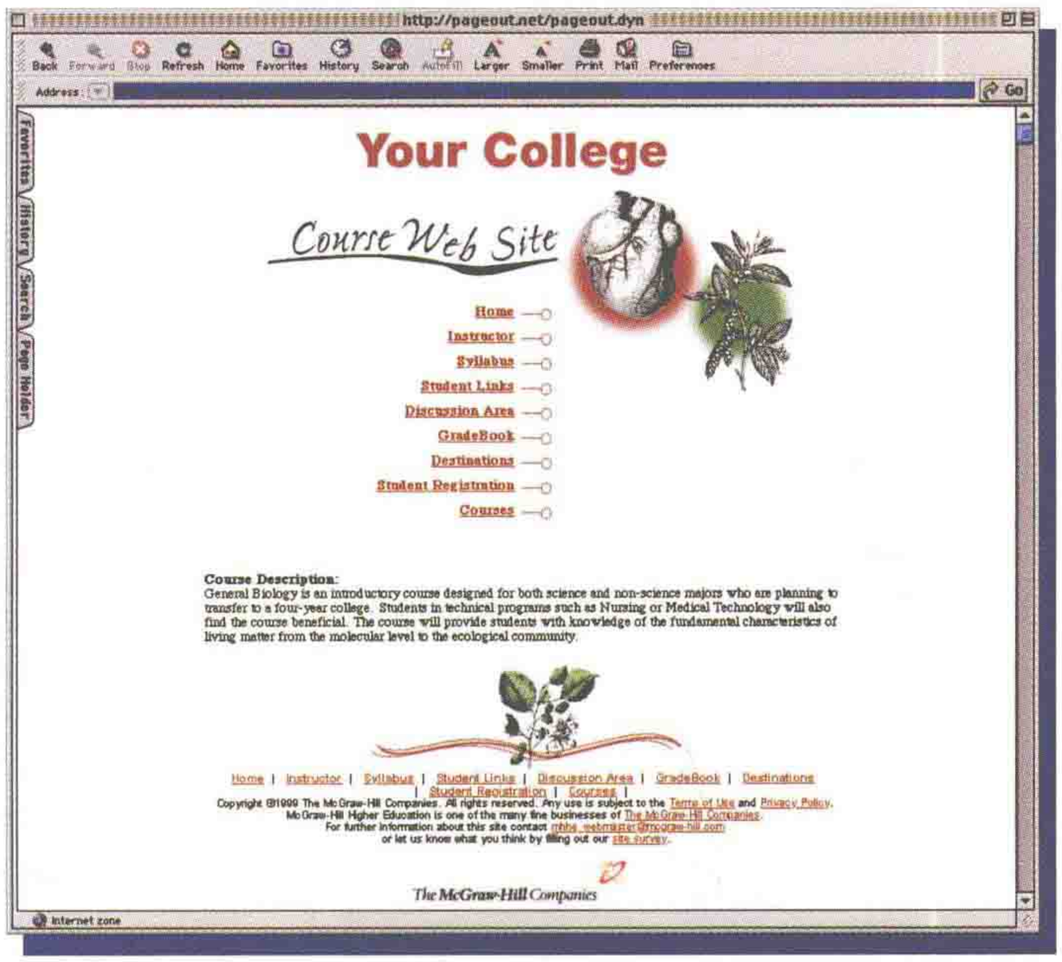

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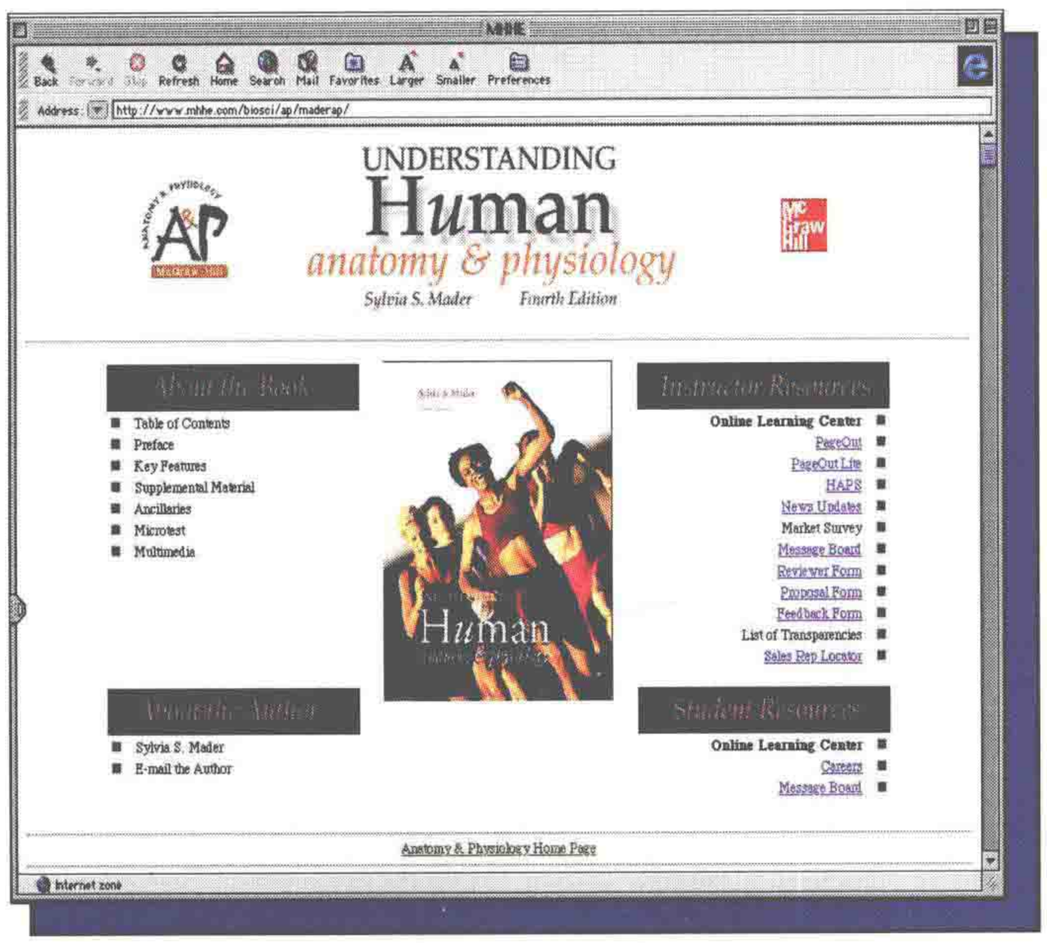

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