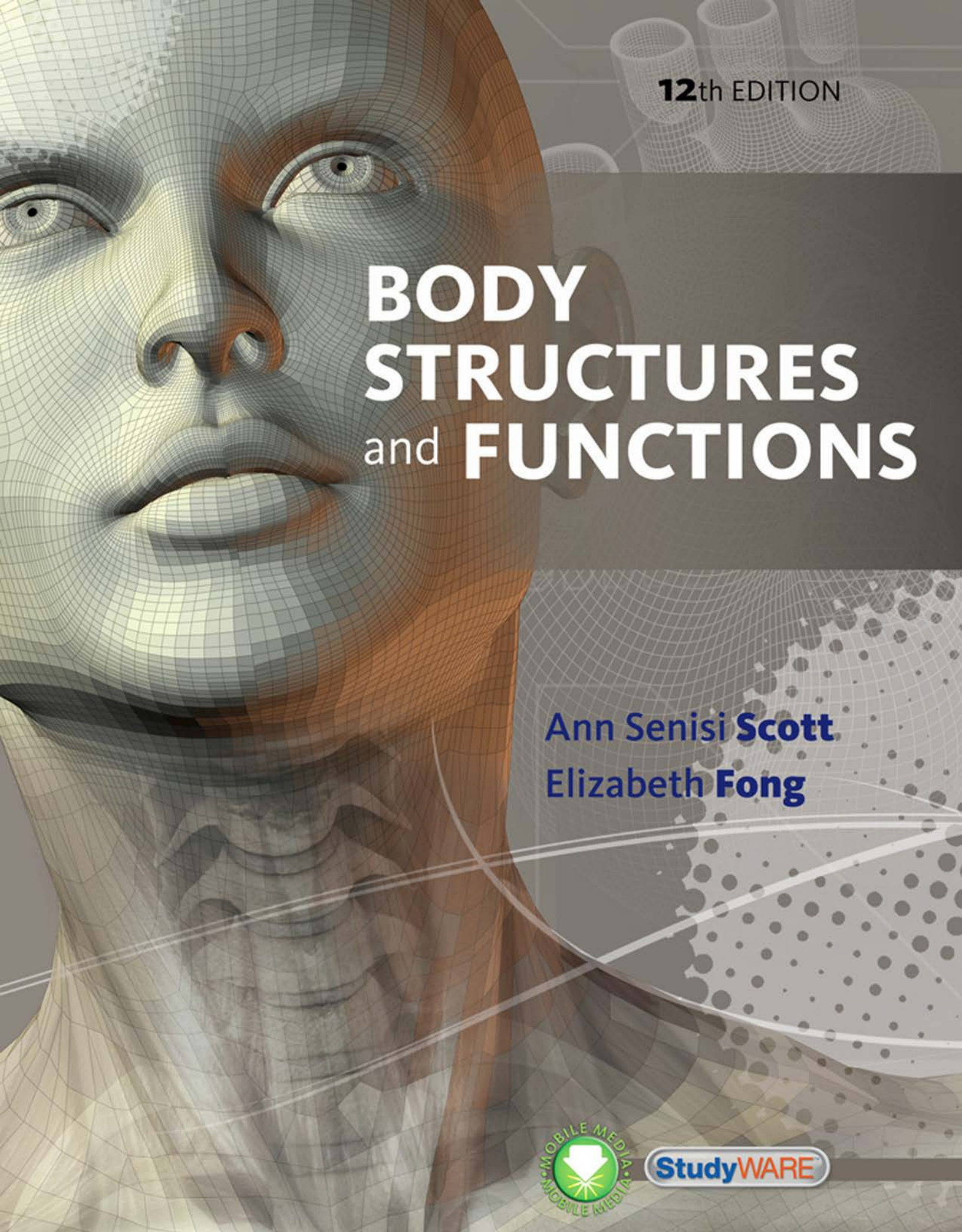
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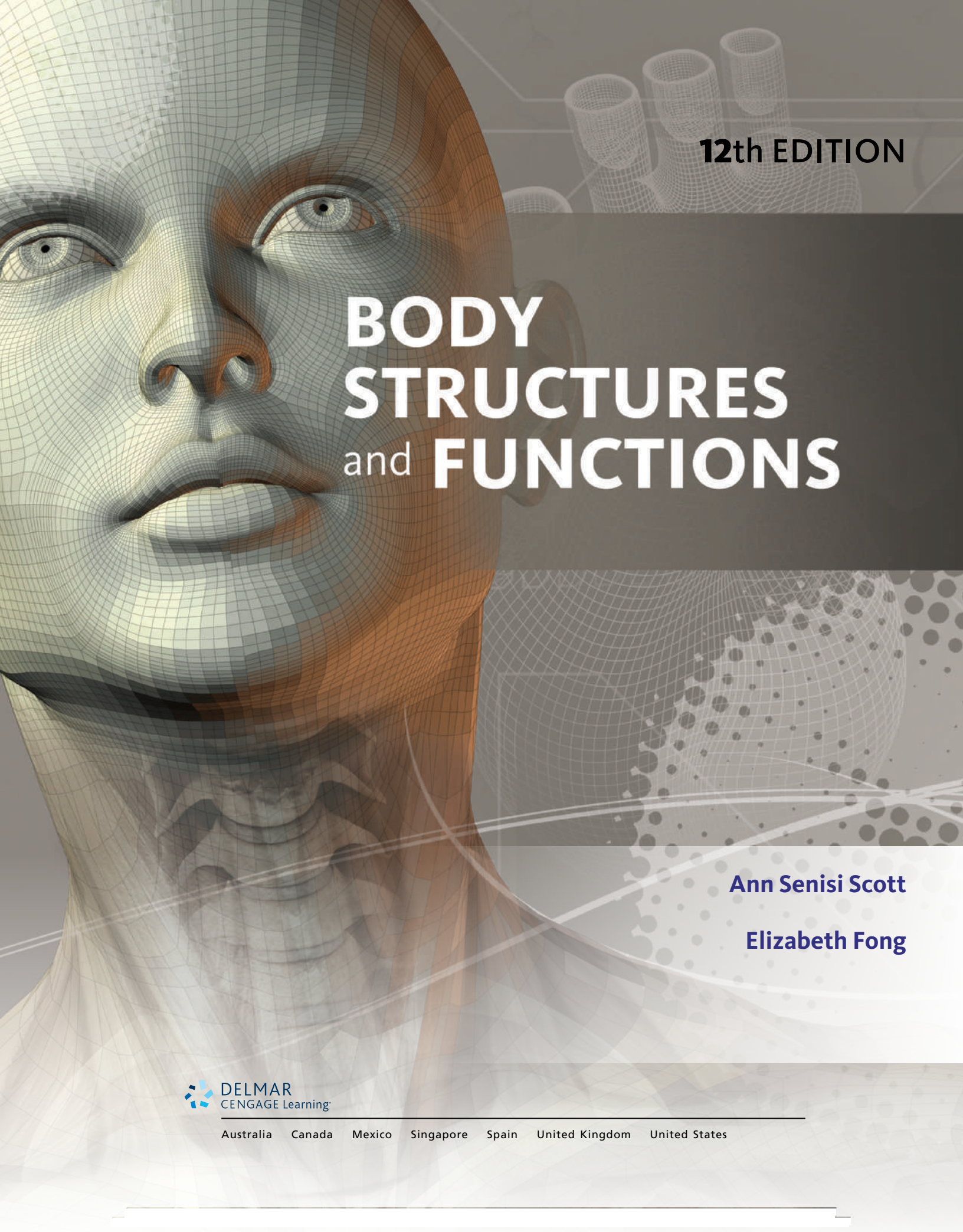

12th EDITION

BODY STRUCTURES and FUNCTIONS

Ann Senisi Scott

Elizabeth Fong

DELMAR CENGAGE Learning

Australia Canada Mexico Singapore Spain United Kingdom United States

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Body Structures and Functions, Twelfth Edition
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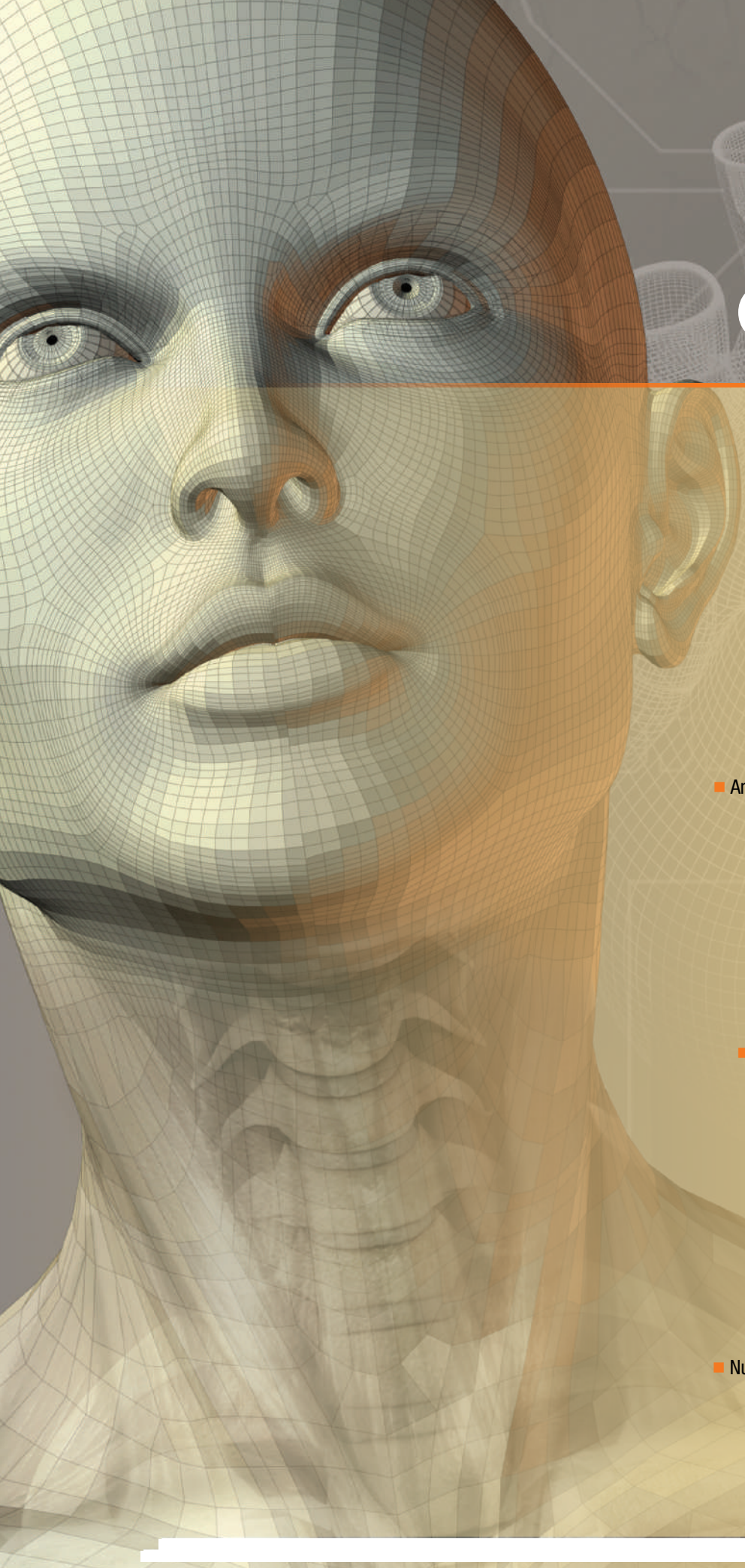
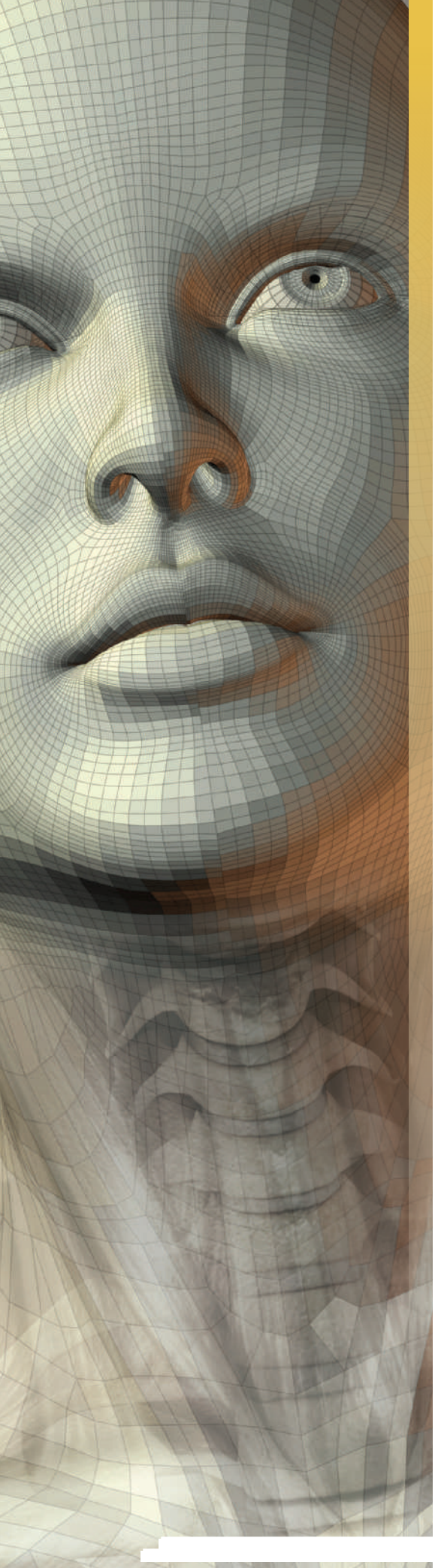


CONTENTS



PREFACE

Introduction

The twelfth edition of *Body Structures & Functions* has been revised to reflect the many changes that are occurring in today's health science and medical fields. The multiskilled health practitioner (MSHP) of today must know the structure and function of each body system as well as the common diseases. All diseases and disorders content is integrated within each chapter as appropriate.

This book and the accompanying teaching materials are designed to facilitate learning. Review the introductory sections, including "How to Study Using *Body Structures and Functions*."

Major Changes to the Twelfth Edition

- Phonetic pronunciations of key words are included in each chapter.
- The new feature **One Body** outlines how each body system interacts with other body systems.
- The new feature **Study Tools** directs learners to additional resources to enhance learning and assess mastery of the material.
- Chapter 1: Introduction to the Structural Units—includes new information on abdominal quadrants and expanded information on homeostasis.
- Chapter 2: Chemistry of Living Things—provides expanded information on chemical bonds and a new table on essential and nonessential amino acids.
- Chapter 3: Cells—provides an expanded discussion on protoplasm.
- Chapter 5: Integumentary System—has a new table on skin color changes and disease conditions.
- Chapter 6: Skeletal System—provides an expanded discussion on bones of the pelvic girdle.
- Chapter 7: Muscular System—expands on the discussion of muscular disorders, including dystonia, heel spurs, and plantar fasciitis.
- Chapter 8: Central Nervous System—provides an expanded discussion on brain injuries.
- Chapter 9: Peripheral and Autonomic Nervous System—includes a new lab activity on cranial nerves.

- Chapter 10: Special Senses—adds new material on taste: *umami*.
- Chapter 11: Endocrine System—expands the discussion on classification of hormones.
- Chapter 13: Heart—presents new guidelines for cardiopulmonary resuscitation.
- Chapter 15: The Lymphatic and Immune Systems—updates the schedule for immunizations for children 0 to 18 years old, and provides new immunization schedules for adults by age group and medical condition. The normal defense mechanisms section has been moved from Chapter 16 to this chapter.
- Chapter 16: Infection Control and Standard Precautions—expands the discussion on the superbugs MRSA and *C. diff*. The normal defense mechanisms section has been moved from this chapter to Chapter 15.
- Chapter 18: Digestive System—provides an expanded discussion on the liver and pancreas.
- Chapter 19: Nutrition—includes updated and revised content from the United States Department of Agriculture dietary recommendations, in which the Food Pyramid has been replaced by MyPlate.
- Chapter 20: Urinary System—provides new material on the urethra and urination.
- Chapter 21: Reproductive System—presents an expanded discussion on external female genitalia and the structure of breasts. Also includes a new table on the function of testosterone and an added career profile on medical assistants.

Phonetic Pronunciations of Key Words

Phonetic pronunciations of key words are included in each chapter in parentheses following the key word. Pronounce the word by saying each syllable, placing more emphasis on the syllable in boldface capital letters. In the example below, the syllable *NAT* would receive more emphasis than the rest of the syllables.

anatomy (ah-**NAT**-oh-mee)

Most key word pronunciations will contain only one syllable in boldface however there are some key words that contain more than one. When a pronunciation contains more than one syllable in boldface, place *some* emphasis on the syllable in boldface *lowercase* letters and the *most* emphasis on the syllable in boldface *capital* letters. In the example below, the syllable *em* would receive some emphasis and the syllable *OL* would receive the most emphasis.

embryology (**em**-bree-**OL**-oh-jee)

Medical Highlights

- Biotechnology and Nanotechnology (Chapter 1)
- Medical Imaging (Chapter 2)
- Stem Cells (Chapter 3)
- Tissue and Organ Transplant (Chapter 4)
- Hazards of the Sun (Chapter 5)
- RICE Treatment (Chapter 6)
- Surgical Joint Procedures (Chapter 6)
- Massage Therapy and Health (Chapter 7)
- Specialized Brain Cells: Mirror Neurons (Chapter 8)
- Headaches (Chapter 8)
- Parkinson's Disease and Deep Brain Stimulation (Chapter 8)
- Types of Anesthesia (Chapter 9)
- Lasers (Chapter 10)
- Eye Surgery (Chapter 10)
- Hearing Aids (Chapter 10)
- Taste: Umami (Chapter 10)
- Hormone Imbalance: Mental Health (Chapter 11)
- Bone Marrow Transplant (Chapter 12)
- Diagnostic Tests for the Heart (Chapter 13)
- Pacemakers, Defibrillators, and Heart Pumps (Chapter 13)
- How the Brain Heals after a Stroke (Chapter 14)
- Mucosa-Associated Lymphoid Tissue (MALT) (Chapter 15)
- Changes Occurring in Infectious Diseases (Chapter 16)
- Sleep Apnea (Chapter 17)
- Pulmonary Function Tests (Chapter 17)
- Minimally Invasive Surgery: Laparoscopy (Chapter 18)
- Foods That Heal (Chapter 19)
- Kidney Stone Removal (Chapter 20)
- Treatment for Benign Prostatic Hypertrophy and Prostate Cancer (Chapter 21)
- Human Papillomavirus Vaccine (Chapter 21)

Career Profiles

- Audiologists (Chapter 10)
- Cardiovascular Technologists and Technicians/EKG Technicians (Chapter 13)
- Chiropractors (Chapter 7)
- Clinical Laboratory Technicians/Medical Laboratory Technicians and Clinical Laboratory Technologists/Medical Technologists (Chapter 12)
- Dental Hygienists, Dental Assistants, and Dental Laboratory Technicians (Chapter 18)
- Dentists (Chapter 18)
- Dietitians and Nutritionists (Chapter 19)
- Doctor of Osteopathic Medicine (Chapter 6)
- Electroneuro Diagnostic Technicians/EEG Technicians (Chapter 8)
- Emergency Medical Technicians and Paramedics (Chapter 13)
- Home Health Aides (Chapter 15)
- Licensed Practical Nurses (Chapter 14)
- Massage Therapists (Chapter 7)
- Medical Assistants (Chapter 21)
- Nursing Aides and Psychiatric Aides (Chapter 15)
- Optometrists and Dispensing Opticians (Chapter 10)
- Orthotists and Prosthetics (Chapter 6)
- Physical Therapists and Physical Therapy Assistants (Chapter 6)
- Physicians (Chapter 5)
- Radiologic Technologists (Chapter 2)
- Registered Nurses and Nurse Practitioners (Chapter 14)
- Respiratory Therapists (Chapter 17)
- Sports Medicine/Athletic Training (Chapter 7)

Student Workbook

The student workbook includes activities that focus on applied academics through a variety of practical application exercises including multiple choice, fill-in-the-blank, matching, labeling, and word puzzles, basic skill problems, application of theory to practice, plus a Surf-the-Net feature.

Online Resources

Online resources are available to accompany a new textbook that includes slide presentations in PowerPoint® and 3D animations.

How to Access the Online Resources:

1. GO TO: http://www.CengageBrain.com
2. REGISTER as a new user or Log In as an existing user if you already have an account with Cengage Learning or CengageBrain.com

About the Author

Ann Senisi Scott, RN, BS, MA, is the author of the twelfth edition of *Body Structures & Functions.* Ann was previously the Coordinator of Health Occupations and Practical Nursing at Nassau Tech Board of Cooperative Education Services, Westbury, New York. As the Health Occupations Coordinator, she worked to establish a career ladder program from health care worker to practical nurse. Before becoming the administrator of these programs, she taught practical nursing for more than 12 years.

Acknowledgments

To complete this revision of the textbook, I have had the assistance of many people at Delmar Cengage Learning. I want to extend my thanks to Matt Seeley and all the personnel in the Health Science area. To Debra Myette-Flis: You have generated so much encouragement and enthusiasm as you guided me through this revision and other revisions—a very heartfelt thank you. Thanks to the reviewers who highlighted areas that needed additional information and corrections; your comments were invaluable. Thanks to Margaret Valdini, RN, who assisted with some valuable insight into disease conditions.

Special thanks to Wayne Scott, my personal reviewer and mentor, and to my family cheering section: Vincent, Margaret, Carolyn, Daniel, Michael, Kenneth, Leslie, Scotty, and their spouses.

To my grandchildren and future students: Have a love for learning since it will bring much knowledge and rewards as you journey through life.

To the health care professionals of tomorrow: Your knowledge will be an asset in the art of caring for the people entrusted to your care.

Reviewers

We are particularly grateful to the reviewers who continue to be a valuable resource in guiding this book as it evolves. Their insights, comments, suggestions, and attention to detail were very important in guiding the development of this textbook.

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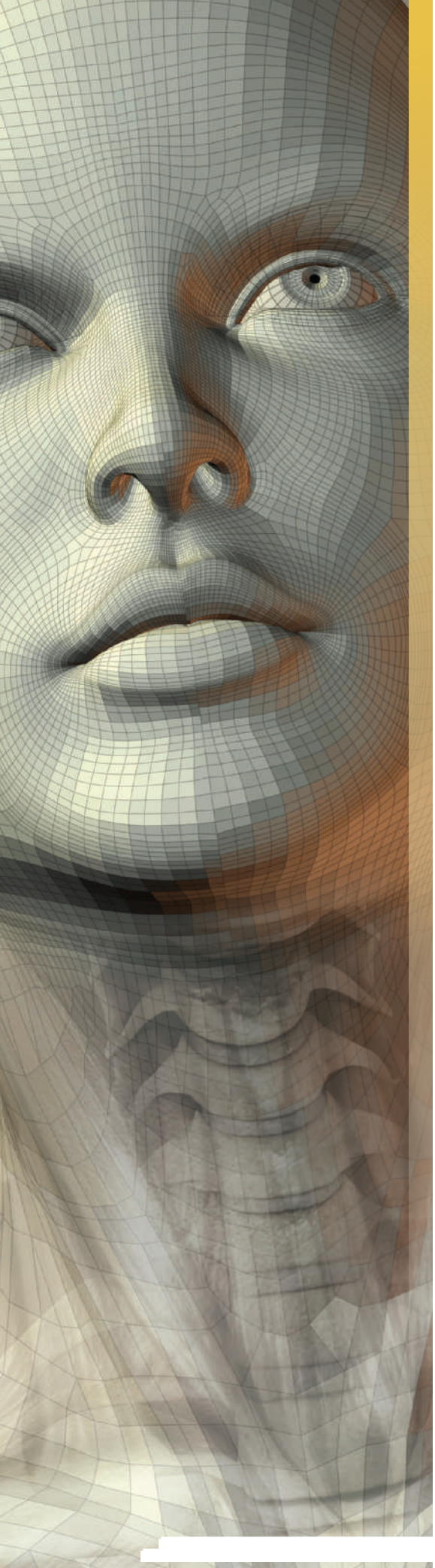


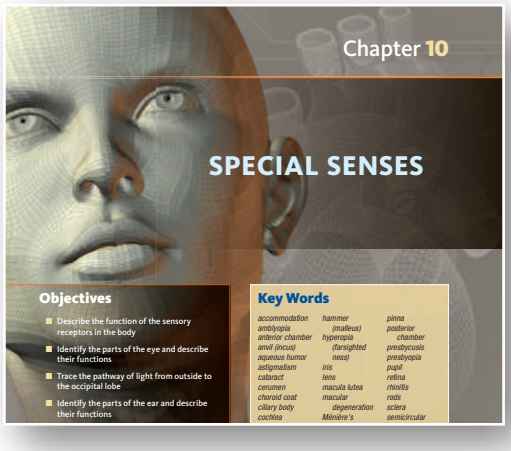
How to Study Using BODY STRUCTURES & FUNCTIONS

Preview the text before attempting to study the material covered in the individual chapters. By reviewing each section of this textbook, you will better understand its organization and purpose. Reading comprehension and long-term memory levels improve dramatically when you take the time to review the text and learn how it can help you learn.

To get the most from this course, take an active role in your learning by integrating your senses to increase your retention. You may want to:

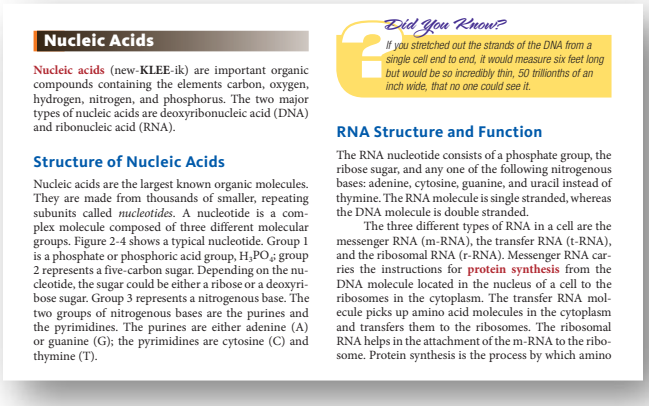
- *Visually* highlight important material.
- *Read* critically—turn headings, subheadings, and sentences into questions.
- *Recite* important material aloud to stimulate your auditory memory.
- *Draw* your own illustrations of anatomy or function processes and check them for accuracy.
- *Answer* (in writing or verbally) the review questions at the end of the chapter.

Each time you encounter a new chapter, preview it first to understand its overall structure. Review the **Objectives** presented at the beginning of each chapter to easily identify the key facts *before* you read the chapter. These objectives are also useful to review *after* you have completed a chapter. After reading a chapter, test yourself to see whether you can answer each objective. If you cannot, you will know exactly which areas to study again. The **Key Words** are listed at the beginning of each chapter, are highlighted in **red** (at first usage) within the chapter, and are also defined in the glossary.



Read the **main headings, subheadings,** and first sentence of each paragraph—these elements serve as the outline for the whole chapter. Be careful not to overlook the **illustrations, photographs,** and **tables,** which can help you comprehend difficult material.

Did You Know? boxes feature fun, interesting, trivia-like facts to engage the learner.



Nucleic Acids

Nucleic acids (new-**KLEE**-ik) are important organic compounds containing the elements carbon, oxygen, hydrogen, nitrogen, and phosphorus. The two major types of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

Structure of Nucleic Acids

Nucleic acids are the largest known organic molecules. They are made from thousands of smaller, repeating subunits called *nucleotides*. A nucleotide is a complex molecule composed of three different molecular groups. Figure 2-4 shows a typical nucleotide. Group 1 is a phosphate or phosphoric acid group, H_3PO_4; group 2 represents a five-carbon sugar. Depending on the nucleotide, the sugar could be either a ribose or a deoxyribose sugar. Group 3 represents a nitrogenous base. The two groups of nitrogenous bases are the purines and the pyrimidines. The purines are either adenine (A) or guanine (G); the pyrimidines are cytosine (C) and thymine (T).

Did You Know?

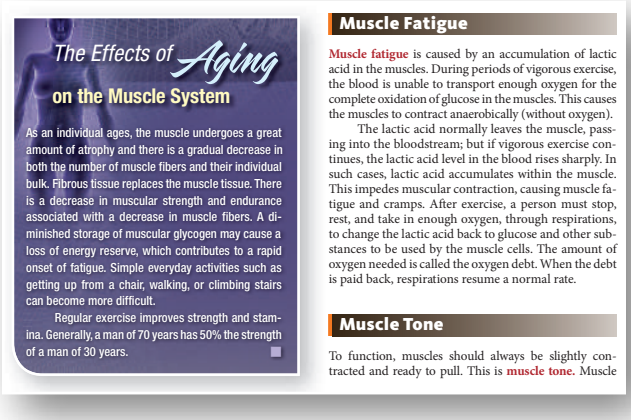
If you stretched out the strands of the DNA from a single cell end to end, it would measure six feet long but would be so incredibly thin, 50 trillionths of an inch wide, that no one could see it.

RNA Structure and Function

The RNA nucleotide consists of a phosphate group, the ribose sugar, and any one of the following nitrogenous bases: adenine, cytosine, guanine, and uracil instead of thymine. The RNA molecule is single stranded, whereas the DNA molecule is double stranded.

The three different types of RNA in a cell are the messenger RNA (m-RNA), the transfer RNA (t-RNA), and the ribosomal RNA (r-RNA). Messenger RNA carries the instructions for **protein synthesis** from the DNA molecule located in the nucleus of a cell to the ribosomes in the cytoplasm. The transfer RNA molecule picks up amino acid molecules in the cytoplasm and transfers them to the ribosomes. The ribosomal RNA helps in the attachment of the m-RNA to the ribosome. Protein synthesis is the process by which amino

Effects of Aging boxes are integrated within the chapters to highlight the changes that are associated with the body systems as we age.



The Effects of ***Aging***

on the Muscle System

As an individual ages, the muscle undergoes a great amount of atrophy and there is a gradual decrease in both the number of muscle fibers and their individual bulk. Fibrous tissue replaces the muscle tissue. There is a decrease in muscular strength and endurance associated with a decrease in muscle fibers. A diminished storage of muscular glycogen may cause a loss of energy reserve, which contributes to a rapid onset of fatigue. Simple everyday activities such as getting up from a chair, walking, or climbing stairs can become more difficult.

Regular exercise improves strength and stamina. Generally, a man of 70 years has 50% the strength of a man of 30 years.

Muscle Fatigue

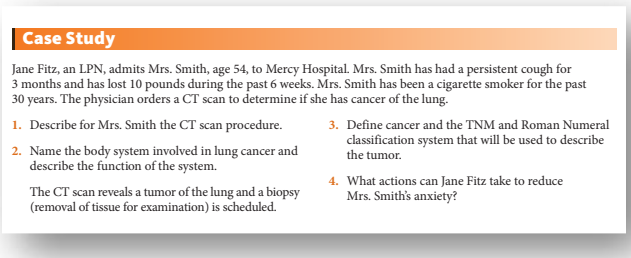
Muscle fatigue is caused by an accumulation of lactic acid in the muscles. During periods of vigorous exercise, the blood is unable to transport enough oxygen for the complete oxidation of glucose in the muscles. This causes the muscles to contract anaerobically (without oxygen).

The lactic acid normally leaves the muscle, passing into the bloodstream; but if vigorous exercise continues, the lactic acid level in the blood rises sharply. In such cases, lactic acid accumulates within the muscle. This impedes muscular contraction, causing muscle fatigue and cramps. After exercise, a person must stop, rest, and take in enough oxygen, through respirations, to change the lactic acid back to glucose and other substances to be used by the muscle cells. The amount of oxygen needed is called the oxygen debt. When the debt is paid back, respirations resume a normal rate.

Muscle Tone

To function, muscles should always be slightly contracted and ready to pull. This is **muscle tone.** Muscle

Case Studies promote a real-world view of medical careers and encourage critical thinking.



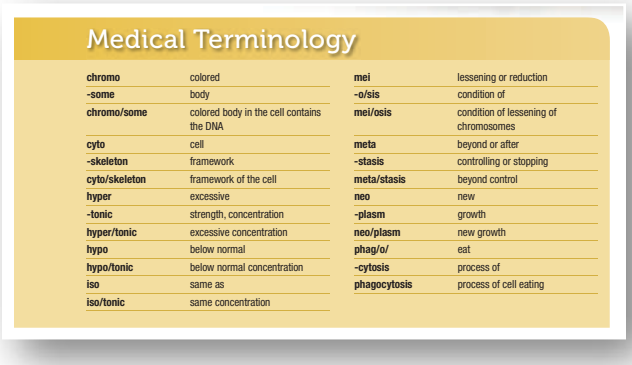
Case Study

Jane Fitz, an LPN, admits Mrs. Smith, age 54, to Mercy Hospital. Mrs. Smith has had a persistent cough for 3 months and has lost 10 pounds during the past 6 weeks. Mrs. Smith has been a cigarette smoker for the past 30 years. The physician orders a CT scan to determine if she has cancer of the lung.

1. Describe for Mrs. Smith the CT scan procedure.
2. Name the body system involved in lung cancer and describe the function of the system.

   The CT scan reveals a tumor of the lung and a biopsy (removal of tissue for examination) is scheduled.
3. Define cancer and the TNM and Roman Numeral classification system that will be used to describe the tumor.
4. What actions can Jane Fitz take to reduce Mrs. Smith's anxiety?

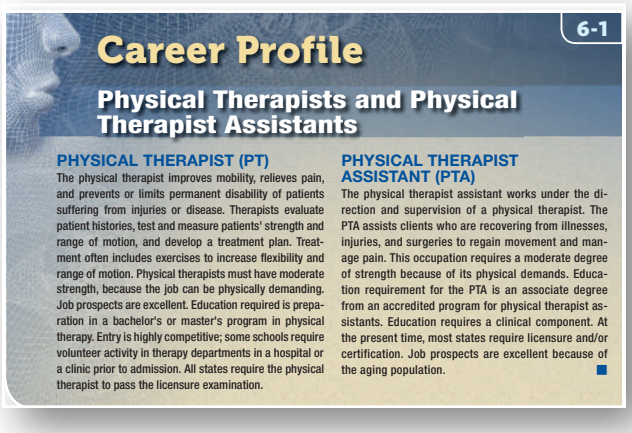
Medical Terminology Review introduces you to common medical prefixes and suffixes and how they work to form medical terms.



Medical Terminology

chromo	colored	**mei**	lessening or reduction
-some	body	**-o/sis**	condition of
chromo/some	colored body in the cell contains the DNA	**mei/osis**	condition of lessening of chromosomes
cyto	cell	**meta**	beyond or after
-skeleton	framework	**-stasis**	controlling or stopping
cyto/skeleton	framework of the cell	**meta/stasis**	beyond control
hyper	excessive	**neo**	new
-tonic	strength, concentration	**-plasm**	growth
hyper/tonic	excessive concentration	**neo/plasm**	new growth
hypo	below normal	**phag/o/**	eat
hypo/tonic	below normal concentration	**-cytosis**	process of
iso	same as	**phagocytosis**	process of cell eating
iso/tonic	same concentration		

Career Profiles provide descriptions of many health professions in today's dynamic health and medical environment. These profiles describe the role of each professional, and may even provide you with insight into possible future career paths.



6-1

Career Profile

Physical Therapists and Physical Therapist Assistants

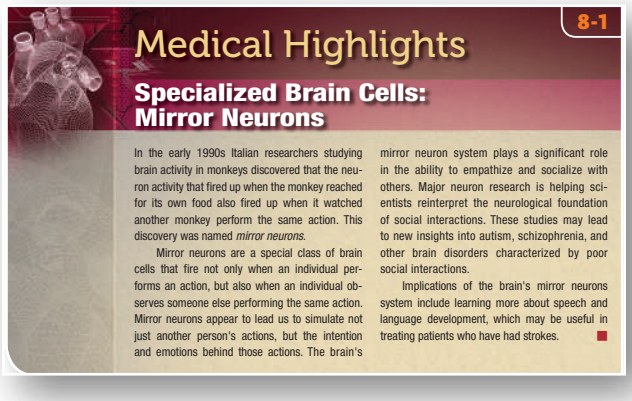
PHYSICAL THERAPIST (PT)

The physical therapist improves mobility, relieves pain, and prevents or limits permanent disability of patients suffering from injuries or disease. Therapists evaluate patient histories, test and measure patients' strength and range of motion, and develop a treatment plan. Treatment often includes exercises to increase flexibility and range of motion. Physical therapists must have moderate strength, because the job can be physically demanding. Job prospects are excellent. Education required is preparation in a bachelor's or master's program in physical therapy. Entry is highly competitive; some schools require volunteer activity in therapy departments in a hospital or a clinic prior to admission. All states require the physical therapist to pass the licensure examination.

PHYSICAL THERAPIST ASSISTANT (PTA)

The physical therapist assistant works under the direction and supervision of a physical therapist. The PTA assists clients who are recovering from illnesses, injuries, and surgeries to regain movement and manage pain. This occupation requires a moderate degree of strength because of its physical demands. Education requirement for the PTA is an associate degree from an accredited program for physical therapist assistants. Education requires a clinical component. At the present time, most states require licensure and/or certification. Job prospects are excellent because of the aging population.

Medical Highlights provide information on technology, innovations, discoveries, and bioethical issues in research and medicine. These topics are based on current information obtained from research on various medical Websites.



8-1

Medical Highlights

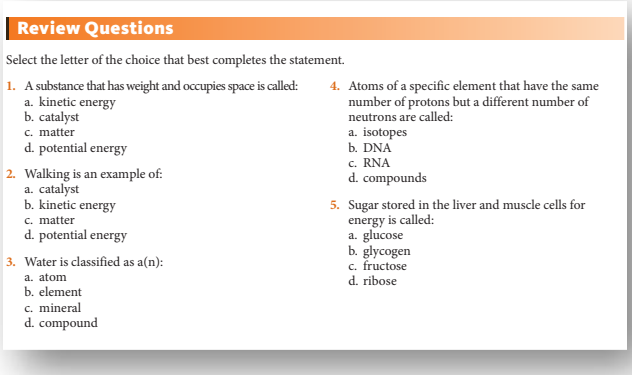
Specialized Brain Cells: Mirror Neurons

In the early 1990s Italian researchers studying brain activity in monkeys discovered that the neuron activity that fired up when the monkey reached for its own food also fired up when it watched another monkey perform the same action. This discovery was named *mirror neurons.*

Mirror neurons are a special class of brain cells that fire not only when an individual performs an action, but also when an individual observes someone else performing the same action. Mirror neurons appear to lead us to simulate not just another person's actions, but the intention and emotions behind those actions. The brain's mirror neuron system plays a significant role in the ability to empathize and socialize with others. Major neuron research is helping scientists reinterpret the neurological foundation of social interactions. These studies may lead to new insights into autism, schizophrenia, and other brain disorders characterized by poor social interactions.

Implications of the brain's mirror neurons system include learning more about speech and language development, which may be useful in treating patients who have had strokes.

Review Questions will help you measure whether you have mastered the material that you have covered. Questions in a variety of formats are presented to reinforce important information within each chapter. Also integrated here and in the workbook are applied academic activities for math, spelling, communication, and legal-ethical issues.

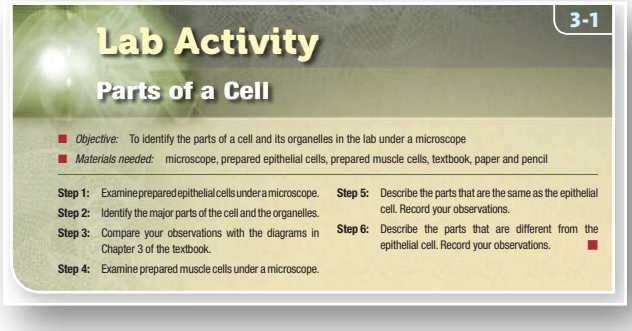


Review Questions

Select the letter of the choice that best completes the statement.

1. A substance that has weight and occupies space is called:
   a. kinetic energy
   b. catalyst
   c. matter
   d. potential energy
2. Walking is an example of:
   a. catalyst
   b. kinetic energy
   c. matter
   d. potential energy
3. Water is classified as a(n):
   a. atom
   b. element
   c. mineral
   d. compound
4. Atoms of a specific element that have the same number of protons but a different number of neutrons are called:
   a. isotopes
   b. DNA
   c. RNA
   d. compounds
5. Sugar stored in the liver and muscle cells for energy is called:
   a. glucose
   b. glycogen
   c. fructose
   d. ribose

Lab Activities incorporate an element of interactivity to the content, further enhancing comprehension.



3-1

Lab Activity

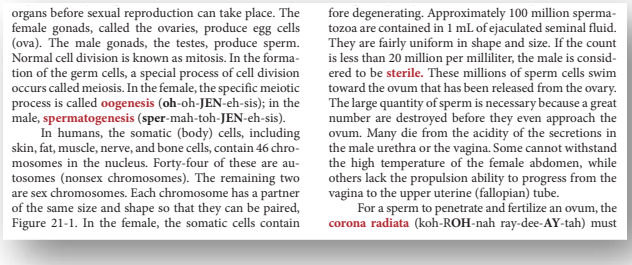
Parts of a Cell

- *Objective:* To identify the parts of a cell and its organelles in the lab under a microscope
- *Materials needed:* microscope, prepared epithelial cells, prepared muscle cells, textbook, paper and pencil

Step 1: Examine prepared epithelial cells under a microscope.
Step 2: Identify the major parts of the cell and the organelles.
Step 3: Compare your observations with the diagrams in Chapter 3 of the textbook.
Step 4: Examine prepared muscle cells under a microscope.
Step 5: Describe the parts that are the same as the epithelial cell. Record your observations.
Step 6: Describe the parts that are different from the epithelial cell. Record your observations.

NEW Phonetic Pronunciations of Key Words

Phonetic pronunciations of key words in each chapter are in parentheses following the key word. Pronounce the word by saying each syllable, placing more emphasis on the syllable in boldface capital letters.

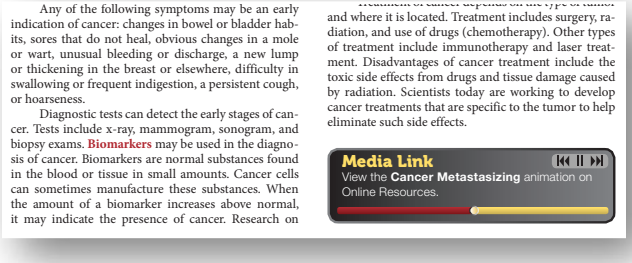


organs before sexual reproduction can take place. The female gonads, called the ovaries, produce egg cells (ova). The male gonads, the testes, produce sperm. Normal cell division is known as mitosis. In the formation of the germ cells, a special process of cell division occurs called meiosis. In the female, the specific meiotic process is called **oogenesis** (**oh**-oh-**JEN**-eh-sis); in the male, **spermatogenesis** (**sper**-mah-toh-**JEN**-eh-sis).

In humans, the somatic (body) cells, including skin, fat, muscle, nerve, and bone cells, contain 46 chromosomes in the nucleus. Forty-four of these are autosomes (nonsex chromosomes). The remaining two are sex chromosomes. Each chromosome has a partner of the same size and shape so that they can be paired, Figure 21-1. In the female, the somatic cells contain fore degenerating. Approximately 100 million spermatozoa are contained in 1 mL of ejaculated seminal fluid. They are fairly uniform in shape and size. If the count is less than 20 million per milliliter, the male is considered to be **sterile**. These millions of sperm cells swim toward the ovum that has been released from the ovary. The large quantity of sperm is necessary because a great number are destroyed before they even approach the ovum. Many die from the acidity of the secretions in the male urethra or the vagina. Some cannot withstand the high temperature of the female abdomen, while others lack the propulsion ability to progress from the vagina to the upper uterine (fallopian) tube.

For a sperm to penetrate and fertilize an ovum, the **corona radiata** (koh-R**OH**-nah ray-dee-**AY**-tah) must

NEW Media Links direct you to Online Resources that includes PowerPoint® presentations and 3D animations.



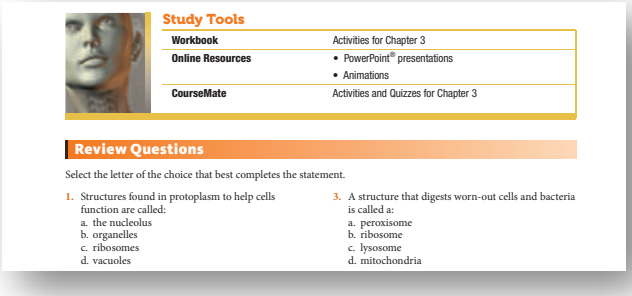
Any of the following symptoms may be an early indication of cancer: changes in bowel or bladder habits, sores that do not heal, obvious changes in a mole or wart, unusual bleeding or discharge, a new lump or thickening in the breast or elsewhere, difficulty in swallowing or frequent indigestion, a persistent cough, or hoarseness.

Diagnostic tests can detect the early stages of cancer. Tests include x-ray, mammogram, sonogram, and biopsy exams. **Biomarkers** may be used in the diagnosis of cancer. Biomarkers are normal substances found in the blood or tissue in small amounts. Cancer cells can sometimes manufacture these substances. When the amount of a biomarker increases above normal, it may indicate the presence of cancer. Research on

Treatment of cancer depends on the type of tumor and where it is located. Treatment includes surgery, radiation, and use of drugs (chemotherapy). Other types of treatment include immunotherapy and laser treatment. Disadvantages of cancer treatment include the toxic side effects from drugs and tissue damage caused by radiation. Scientists today are working to develop cancer treatments that are specific to the tumor to help eliminate such side effects.

Media Link
View the **Cancer Metastasizing** animation on Online Resources.

NEW Study Tools alert you to additional resources to help you understand the material.



Study Tools

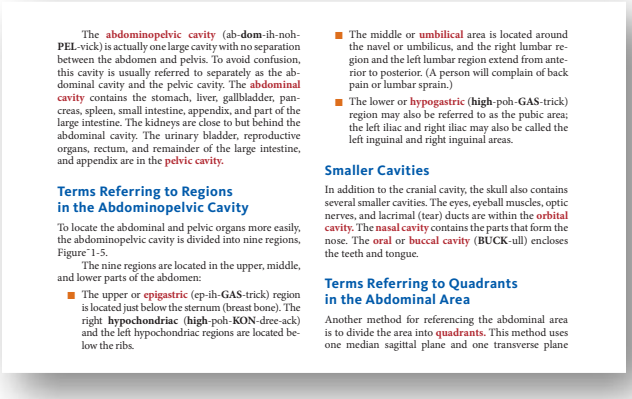
Workbook	Activities for Chapter 3
Online Resources	• PowerPoint® presentations • Animations
CourseMate	Activities and Quizzes for Chapter 3

Review Questions

Select the letter of the choice that best completes the statement.

1. Structures found in protoplasm to help cells function are called:
   a. the nucleolus
   b. organelles
   c. ribosomes
   d. vacuoles
3. A structure that digests worn-out cells and bacteria is called a:
   a. peroxisome
   b. ribosome
   c. lysosome
   d. mitochondria

The **Glossary of Terms** provides you with a concise definition for all the *key words* in the textbook. The **Index** serves as an alphabetical listing of topics, terms, concepts, and important names for easy reference. Note that figure page numbers are listed in **boldface** in the index.



The **abdominopelvic cavity** (ab-**dom**-ih-noh-**PEL**-vick) is actually one large cavity with no separation between the abdomen and pelvis. To avoid confusion, this cavity is usually referred to separately as the abdominal cavity and the pelvic cavity. The **abdominal cavity** contains the stomach, liver, gallbladder, pancreas, spleen, small intestine, appendix, and part of the large intestine. The kidneys are close to but behind the abdominal cavity. The urinary bladder, reproductive organs, rectum, and remainder of the large intestine, and appendix are in the **pelvic cavity.**

Terms Referring to Regions in the Abdominopelvic Cavity

To locate the abdominal and pelvic organs more easily, the abdominopelvic cavity is divided into nine regions, Figure 1-5.

The nine regions are located in the upper, middle, and lower parts of the abdomen:

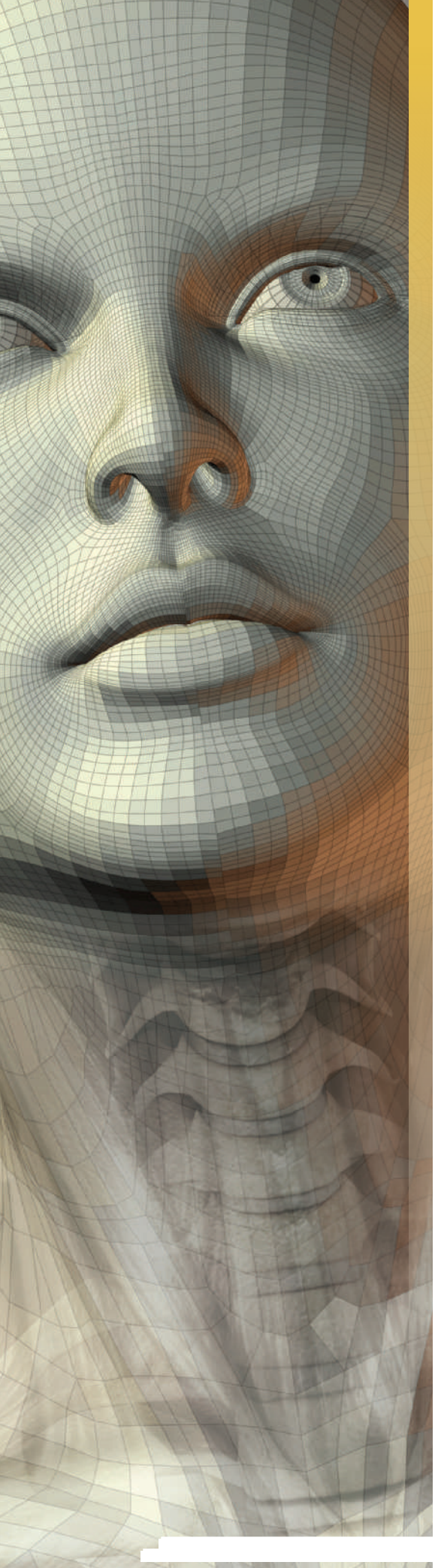
- The upper or **epigastric** (ep-ih-**GAS**-trick) region is located just below the sternum (breast bone). The right **hypochondriac** (**high**-poh-**KON**-dree-ack) and the left hypochondriac regions are located below the ribs.
- The middle or **umbilical** area is located around the navel or umbilicus, and the right lumbar region and the left lumbar region extend from anterior to posterior. (A person will complain of back pain or lumbar sprain.)
- The lower or **hypogastric** (**high**-poh-**GAS**-trick) region may also be referred to as the pubic area; the left iliac and right iliac may also be called the left inguinal and right inguinal areas.

Smaller Cavities

In addition to the cranial cavity, the skull also contains several smaller cavities. The eyes, eyeball muscles, optic nerves, and lacrimal (tear) ducts are within the **orbital cavity.** The **nasal cavity** contains the parts that form the nose. The **oral** or **buccal cavity** (**BUCK**-ull) encloses the teeth and tongue.

Terms Referring to Quadrants in the Abdominal Area

Another method for referencing the abdominal area is to divide the area into **quadrants.** This method uses one median sagittal plane and one transverse plane



PROLOGUE

The History of Anatomical Science and Scientists

Much of the early study of gross anatomy and physiology comes from Aristotle, a Greek philosopher. Aristotle believed that every organ had a specific function and that function is based on the organ's structure. Most of Aristotle's ideas were based on the dissection of plants and animals. He never dissected a human body.

In the third century bc, Herophilus founded the first school of anatomy and encouraged the dissection of the human body. He is credited with demonstrating that the brain is the center of the nervous system. It was a Greek physician, Galen, however, who is credited with the creation of the first standard medical text expanding on Aristotle's ideas. Galen was the first to discover many muscles and the first to find the value in monitoring an individual's pulse. Galen never performed human dissections and many of his theories were later proven wrong.

The first medical schools were founded in the Middle Ages; however, instructors at this time were hesitant to question the theories and beliefs founded by the early Greeks such as Aristotle and Galen. As a result, very few ideas or discoveries were made in the medical field in the Middle Ages.

During the Renaissance, however, interest in anatomy was renewed due in part to the work of artist Leonardo da Vinci who studied the form and function of the human body. It was during this period in history that the first systematic study of the structure of the human body was made. Many of these early scientists were hindered in their pursuit of knowledge of the human body because it was believed by many that human dissections were immoral and illegal. For example, Andreas Vesalius, a founder of modern anatomy, was sentenced to death because of his anatomical dissections of humans.

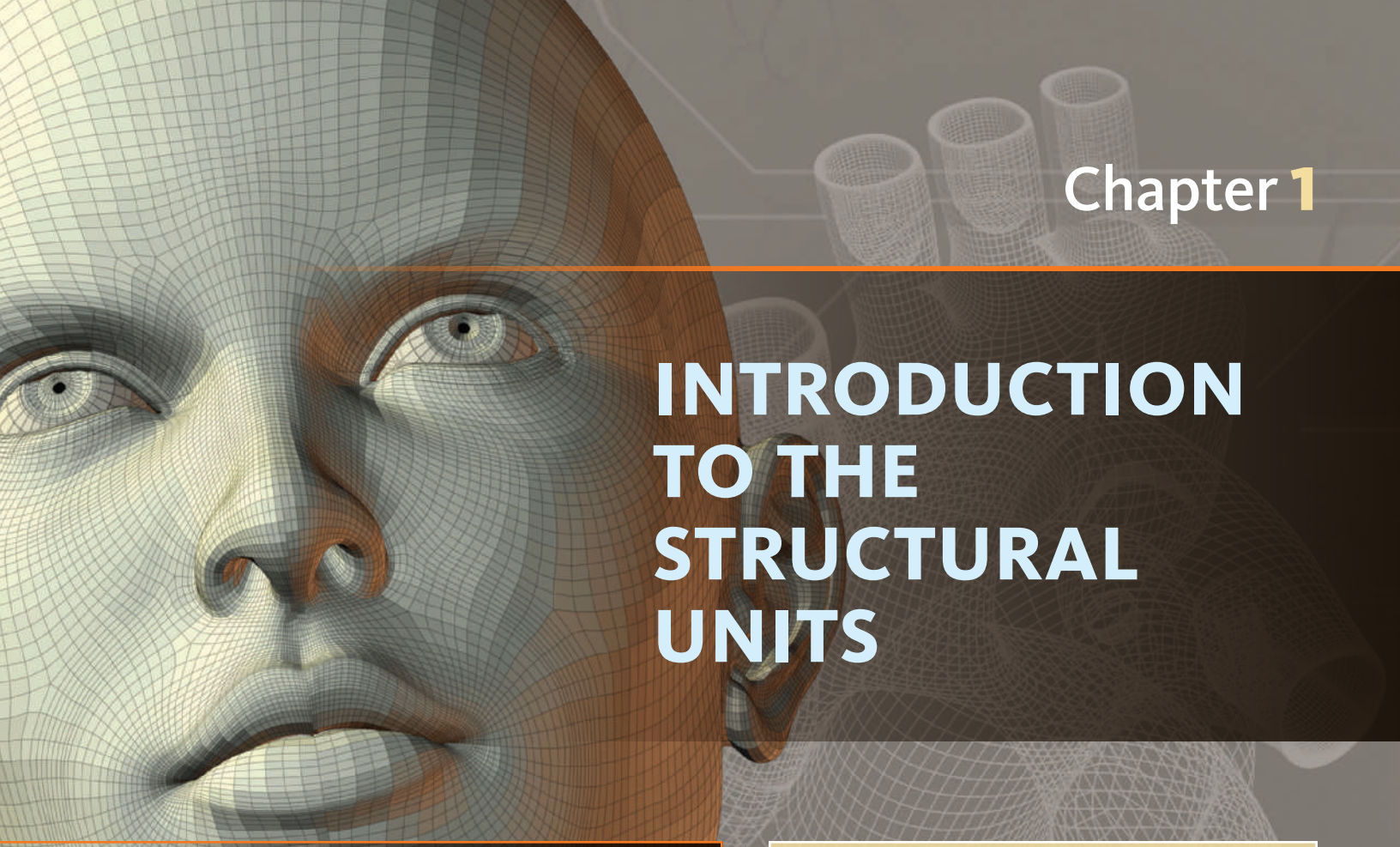
In the seventeenth century, the invention of the microscope aided in new anatomical discoveries and research. Scientists could now see structures that were invisible to the naked eye. Robert Hooke's investigation of cork under the microscope was the foundation of the theory that the cell is the basic unit of life. This theory was later proved and expanded on by other scientists in the eighteenth century as technological advances continued to improve.

Advances in technology have continued into today and new anatomical and physiological discoveries are still being made. With the mapping of the human genome, completed in 2003, the complete genetic code has been documented. It is hoped that this knowledge will enable discoveries

into disease processes and the development of cures for many of the diseases that continue to plague our society.

The use of new types of medical imaging, such as computerized scanning and digitalized photography, has helped researchers make new discoveries about the body.

Use key words to search the Internet for new discoveries related to a particular body system and the scientists who made those discoveries.



Chapter 1

INTRODUCTION TO THE STRUCTURAL UNITS

Objectives

- Identify and discuss the different branches of anatomy
- Identify terms referring to location, direction, planes, and sections of the body
- Identify the body cavities and the organs they contain
- Identify and discuss body processes
- Identify the units of measure used in health care
- Define the key words that relate to this chapter

Key Words

abdominal cavity
abdominopelvic cavity
anabolism
anatomical position
anatomy
anterior
biology
buccal cavity
catabolism
caudal
cell
cephalic
coronal (frontal) plane
cranial cavity
cytology
deep
dermatology
disease
distal
dorsal
dorsal cavity
embryology
endocrinology
epigastric
external
histology
homeostasis
hypogastric
inferior
internal
lateral
medial
metabolism
metric system
midsagittal plane
nasal cavity
neurology
oral cavity
orbital cavity
organ system
organs
pelvic cavity
physiology
planes
posterior
proximal
quadrants
sagittal plane
section
spinal cavity
superficial
superior
thoracic cavity
tissues
transverse
umbilical
umbilicus
ventral

Anatomy and Physiology

Anatomy and physiology are branches of a much larger science called **biology** (bye-**OL**-oh-jee). Biology is the study of all forms of life. Biology studies microscopic one-celled organisms, multi-celled organisms, plants, animals, and humans.

Anatomy (ah-**NAT**-oh-mee) studies the shape and structure of an organism's body and the relationship of one body part to another. The word *anatomy* comes from the Greek *ana,* meaning "apart," and *temuein,* "to cut"; thus, the acquisition of knowledge on human anatomy comes basically from dissection. However, one cannot fully appreciate and understand anatomy without the study of its sister science, **physiology** (fiz-ee-**OL**-oh-jee). Physiology studies the function of each body part and how the functions of the various body parts coordinate to form a complete living organism. Any abnormal change in a structure or function that produces symptoms is considered a **disease.**

Branches of Anatomy

Anatomy is subdivided into many branches based on the investigative techniques used, the type of knowledge desired, or the parts of the body under study.

1. **Gross anatomy.** Gross anatomy is the study of large and easily observable structures on an organism. This is done through dissection and visible inspection with the naked eye. In gross anatomy, the different body parts and regions are studied with regard to their general shape, external features, and main divisions.
2. **Microscopic anatomy.** Microscopic anatomy refers to the use of microscopes to enable one to see the minute details of organ parts. The ultrawave and electron microscopes provide greater magnification and resolution than optical microscopes. Microscopic anatomy is subdivided into two branches. One branch is **cytology** (sigh-**TOL**-oh-jee), which is the study of the structure, function, and development of cells that comprise the different body parts. The other subdivision is **histology** (hiss-**TOL**-oh-jee), which studies the tissues and organs that make up the entire body of an organism.
3. **Developmental anatomy.** Developmental anatomy studies the growth and development of an organism during its lifetime. More specifically, **embryology** (**em**-bree-**OL**-oh-jee) studies the formation of an organism from the fertilized egg to birth.
4. **Comparative anatomy.** Humans are one of many animals found in the animal kingdom. The different body parts and organs of humans can be studied with regard to similarities and differences with other animals in the animal kingdom.
5. **Systematic anatomy.** Systematic anatomy is the study of the structure of various organs or parts that comprise a particular organ system. Depending on the particular organ system under study, a specific term is applied, for example:
   a. **Dermatology** (der-mah-**TOL**-oh-jee)—study of the integumentary system (skin, hair, and nails)
   b. **Endocrinology** (**en**-doh-krin-**OL**-oh-jee)— study of the endocrine or hormonal system
   c. **Neurology** (**new**-**ROL**-oh-jee)—study of the nervous system.

Anatomical Terminology

In the study of anatomy and physiology, special words are used to describe the specific location of a structure or organ, or the relative position or direction of one body part to another. The initial reference point used is the anatomical position. In the **anatomical position,** a human being is standing erect, with face forward, arms at the side, and palms forward, Figure 1-1.

Terms Referring to Location or Position and Direction

See Figures 1-1 and 1-2.

- **Anterior** or **ventral** means "front" or "in front of." For example, the knees are located on the anterior surface of the human body. A ventral hernia may protrude from the front or belly of the abdomen.
- **Posterior** or **dorsal** means "back" or "in back of." For example, human shoulder blades are found on the posterior surface of the body. The dorsal aspect of the foot is the top of the foot.
- **Cephalic** (seh-**FAL**-ick) and **caudal** (**KAWD**-al) refer to direction: Cephalic means "skull" or "head end" of the body; caudal means "tail end." For example, a blow to the skull may increase cranial pressure and cause headaches. Caudal anesthesia is injected in the lower spine.
- **Superior** means "upper" or "above another" and **inferior** refers to "lower" or "below another." For

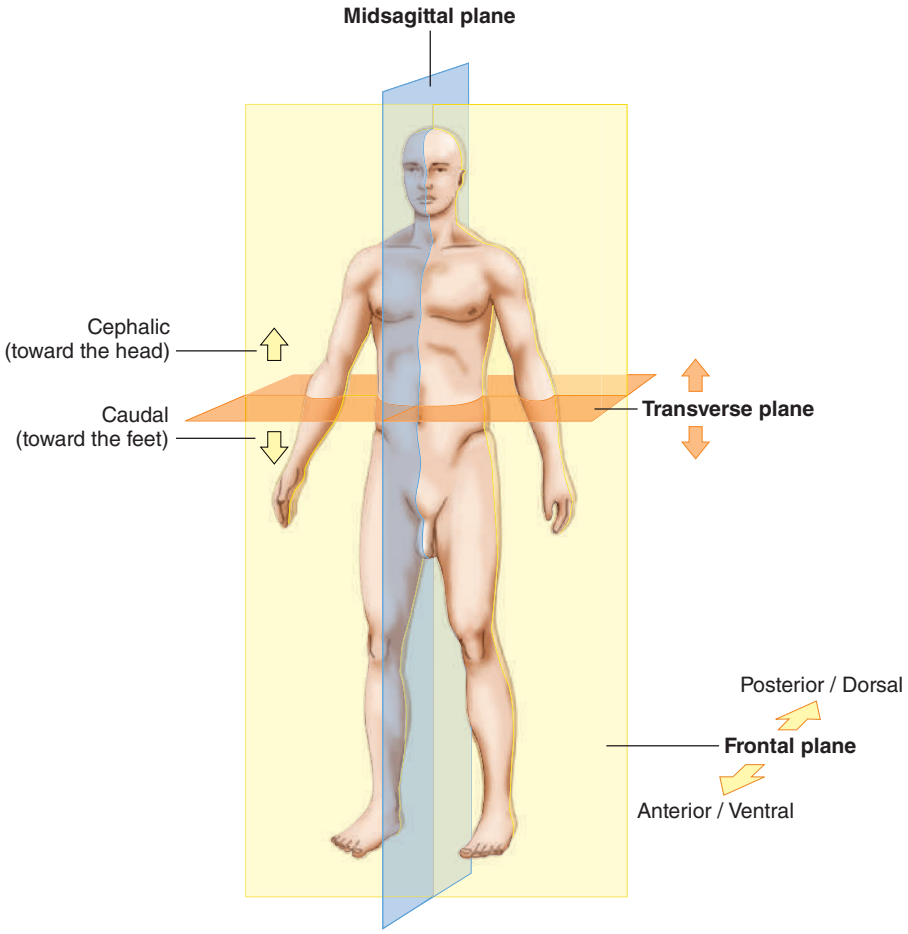


Figure 1-1 *Body directions: Cephalic refers to the skull or head end of the body, and caudal refers to the tail end. Anterior (or ventral) means "front" or "in front of." Posterior (or dorsal) means "back" or "in back of."*

example, the heart and lungs are situated superior to the diaphragm, while the intestines are inferior to it.

- **Medial** signifies "toward the midline or median plane of the body," while **lateral** means "away" or "toward the side of the body." For example, the nose is medial to the eyes and the ears are lateral to the nose.
- **Proximal** means "toward the point of attachment to the body" or "toward the trunk of the body; **distal** means "away from the point of attachment or origin" or "farthest from the trunk." For example, the wrist is proximal to the hand; the elbow is distal to the shoulder. *Note:* These two words are used primarily to describe the appendages or extremities.
- **Superficial** or **external** and **deep** or **internal**—superficial implies "on or near the surface of the body." For example, a superficial wound involves an injury to the outer skin. A deep injury involves damage to an internal organ such as the stomach. The terms *external* and *internal* are specifically used to refer to body cavities and hollow organs.

Terms Referring to Body Planes and Sections

Planes are imaginary anatomical dividing lines that are useful in separating body structures, Figure 1-3. A **section** is a cut made through the body in the direction of a certain plane.

The **sagittal plane** (**SAJ**-ih-tal) divides the body into right and left parts. If the plane started in the middle of the skull and proceeded down, bisecting the sternum and the vertebral column, the body would be divided equally into right and left halves. This would be known as the **midsagittal plane.**

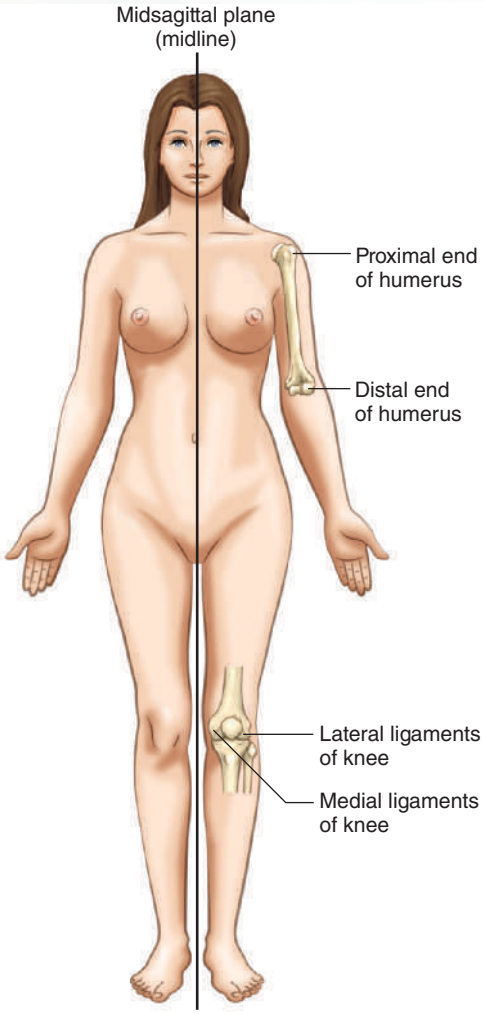


Figure 1-2 *Body directions: Proximal means "toward the point of attachment to the body" or "toward the trunk of the body." Distal means "away from the point of attachment or origin" or "farthest from the trunk." Medial means "toward the midline or median plane of the body," and lateral means "away or toward the side of the body."*

A **coronal (frontal) plane** is a vertical cut at right angles to the sagittal plane, dividing the body into anterior and posterior portions. The term *coronal* comes from the coronal suture, which runs perpendicular (at a right angle) to the sagittal suture. A **transverse** or cross section is a horizontal cut that divides the body into upper and lower portions.

Media Link
View the **Body Planes** animation on CourseMate.

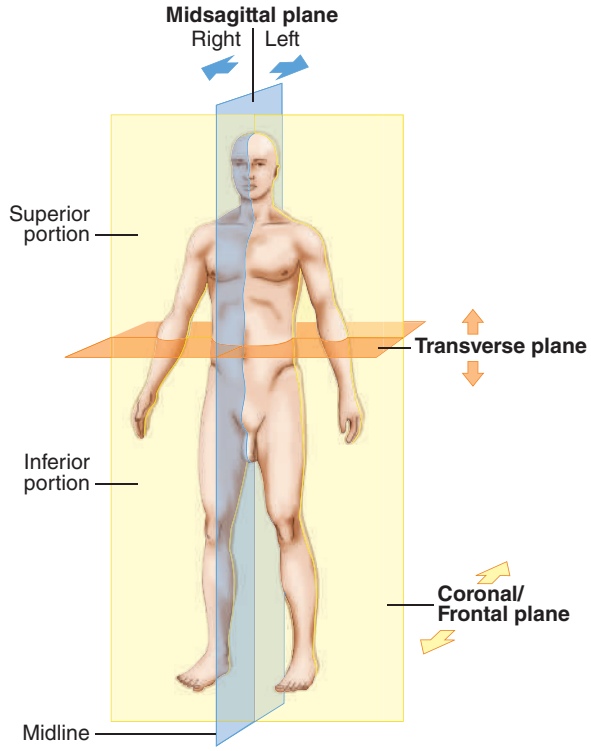


Figure 1-3 *Body planes: The midsagittal plane divides the body equally into right and left halves. The transverse plane divides the body into upper and lower portions. The coronal (or frontal) plane divides the body into anterior and posterior portions.*

Terms Referring to Cavities of the Body

The organs that comprise most of the body systems are located in four major cavities: cranial, spinal, thoracic, and abdominopelvic, Figure 1-4. The cranial and spinal cavities are within a larger region known as the posterior (dorsal) cavity. The thoracic and abdominopelvic cavities are found in the anterior (ventral) cavity.

The **dorsal cavity** contains the brain and spinal cord: The brain is in the **cranial cavity** and the spinal cord is in the **spinal cavity,** Figure 1-4. The diaphragm divides the ventral cavity into two parts: the upper thoracic and lower abdominopelvic cavities.

The central area of the **thoracic cavity** (tho-**RASS**-ik) is called the mediastinum. It lies between the lungs and extends from the sternum (breast bone) to the vertebrae of the back. The esophagus, bronchi, lungs, trachea, thymus gland, and heart are located in the thoracic cavity. The heart itself is contained within a smaller cavity, called the pericardial cavity.

The thoracic cavity is further subdivided into two pleural cavities. The left lung is in the left cavity, the right lung is in the right cavity. Each lung is covered with a thin membrane called the pleura.

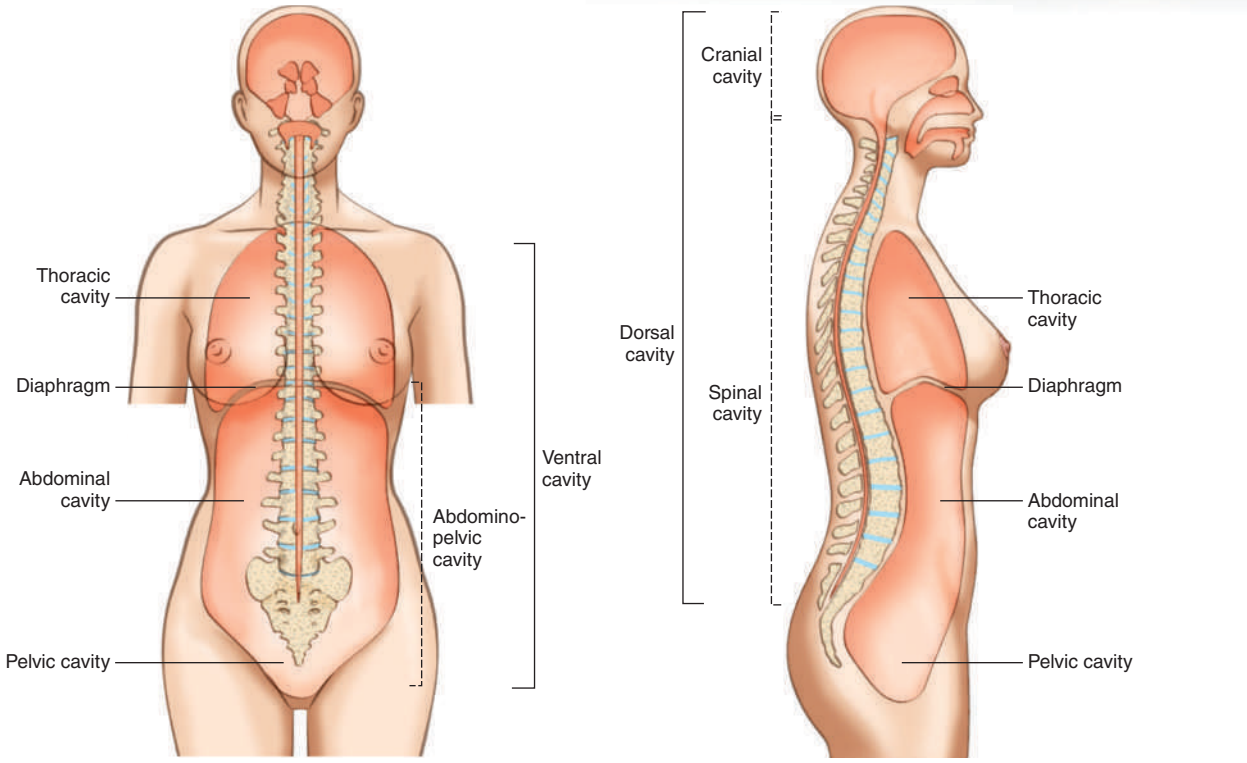


Figure 1-4 *The major body cavities*

The **abdominopelvic cavity** (ab-**dom**-ih-noh-**PEL**-vick) is actually one large cavity with no separation between the abdomen and pelvis. To avoid confusion, this cavity is usually referred to separately as the abdominal cavity and the pelvic cavity. The **abdominal cavity** contains the stomach, liver, gallbladder, pancreas, spleen, small intestine, appendix, and part of the large intestine. The kidneys are close to but behind the abdominal cavity. The urinary bladder, reproductive organs, rectum, and remainder of the large intestine, and appendix are in the **pelvic cavity.**

Terms Referring to Regions in the Abdominopelvic Cavity

To locate the abdominal and pelvic organs more easily, the abdominopelvic cavity is divided into nine regions, Figure 1-5.

The nine regions are located in the upper, middle, and lower parts of the abdomen:

- The upper or **epigastric** (ep-ih-**GAS**-trick) region is located just below the sternum (breast bone). The right **hypochondriac** (**high**-poh-**KON**-dree-ack) and the left hypochondriac regions are located below the ribs.
- The middle or **umbilical** area is located around the navel or umbilicus, and the right lumbar region and the left lumbar region extend from anterior to posterior. (A person will complain of back pain or lumbar sprain.)
- The lower or **hypogastric** (**high**-poh-**GAS**-trick) region may also be referred to as the pubic area; the left iliac and right iliac may also be called the left inguinal and right inguinal areas.

Smaller Cavities

In addition to the cranial cavity, the skull also contains several smaller cavities. The eyes, eyeball muscles, optic nerves, and lacrimal (tear) ducts are within the **orbital cavity.** The **nasal cavity** contains the parts that form the nose. The **oral** or **buccal cavity** (**BUCK**-ull) encloses the teeth and tongue.

Terms Referring to Quadrants in the Abdominal Area

Another method for referencing the abdominal area is to divide the area into **quadrants.** This method uses one median sagittal plane and one transverse plane

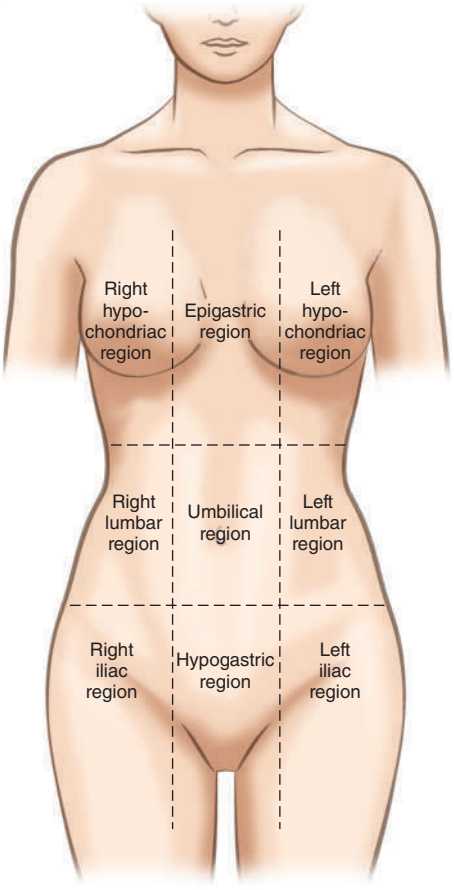


Figure 1–5 *Regions of the thorax and abdomen*

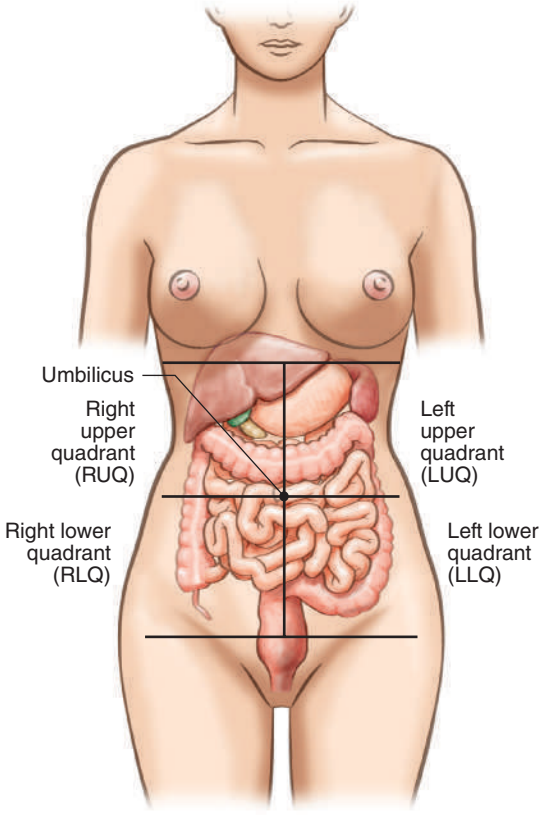


Figure 1-6 *Division of the abdomen into quadrants*

that passes through the **umbilicus** (um-**BILL**-ih-kus) at right angles. The four resulting quadrants are named according to their positions: right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ), and left lower quadrant (LLQ), Figure 1-6.

Did You Know?

McBurney's point is not at the top of a mountain but midway between the umbilicus and the iliac crest (the prominent area on the hip bone) and the right lower quadrant or right inguinal area. This area is painful when a person has appendicitis.

Life Functions

When we examine humans, plants, one-celled organisms, or multicelled organisms, we recognize that all of them have one thing in common: They are alive.

All living organisms are capable of carrying on life functions. **Life functions** are a series of highly organized and related activities that allow living organisms to live, grow, and maintain themselves.

These vital life functions include movement, ingestion, digestion, transport, respiration, synthesis, assimilation, growth, secretion, excretion, regulation (sensitivity), and reproduction, Table 1-1.

Human Development

During our lifetime, the body carries on numerous life functions that keep us alive and active. Living depends on the constant release of energy in every cell of the body. Powered by the energy that is released from food, the cells are able to maintain their own living condition and, thus, the life of a human being.

A complex life-form like a human being consists of over 50 trillion cells. The **cell** is the basic unit of structure and function of all living things. Early in human development, certain groups of cells become highly specialized for specific functions, such as movement or growth.

Special cells—grouped according to function, shape, size, and structure—are called **tissues.** Tissues, in turn, form larger functional and structural units known as **organs.** For example, human skin is an organ of epithelial, connective, muscular, and nervous tissue. In

Table 1-1 *Review of the Life Functions and Body Systems*

LIFE FUNCTIONS/BODY SYSTEMS	*DEFINITION*
Movement / Muscle System	The ability of the whole organism—or a part of it—to move
Ingestion / Assimilation / Digestive System	The process by which an organism takes in food The breakdown of complex food molecules into simpler food molecules The transformation of digested food molecules into living tissue for growth and self-repair
Transport / Circulatory System	The movement of necessary substances to, into, and around cells, and of cellular products and wastes out of and away from cells
Respiration / Respiratory System	The burning or oxidation of food molecules in a cell to release energy, water, and carbon dioxide
Immune System of Body / Lymphatic System	Filters out harmful bacteria and produces the white blood cells; lymphocytes
Protection / Integumentary System	Waterproof covering of body
Growth / Skeletal System	The enlargement of an organism due to synthesis and assimilation, resulting in an increase in the number and size of its cells
Secretion / Endocrine System	The formation and release of hormones from a cell or structure
Excretion / Urinary System	The removal of metabolic waste products from an organism
Regulation (Sensitivity) / Nervous System	The ability of an organism to respond to its environment so as to maintain a balanced state (homeostasis)
Reproduction / Reproductive System	The ability of an organism to produce offspring with similar characteristics (This is *essential* for species survival as opposed to individual survival.)

much the same way, kidneys consist of highly specialized connective and epithelial tissue.

The organs of the human body do not operate independently. They function interdependently with one another to form a live, functioning organism. Some organs are grouped together because more than one is needed to perform a function. Such a grouping is called an **organ system.** One example is the digestive system composed of the teeth, esophagus, stomach, small intestine, and large intestine. In this textbook you will study the various body systems and the organs that comprise them.

Body Processes

Homeostasis

Homeostasis (**hoe**-mee-oh-**STAY**-sis) is the ability of the body to regulate its internal environment within narrow limits. Maintaining homeostasis is essential to survival; imbalance results in **disease** (**DIZ-ease**). All organ systems contribute to homeostasis. Examples of homeostasis controls are blood sugar levels, body temperature, heart rate, and the fluid environment of the cells.

Most of homeostasis control works on a **negative feedback loop.** Feedback responses reverse disturbances to our body's condition. An example of how a negative feedback loop operates is seen in maintaining our body temperature. Our normal body temperature is 37°C (98.6°F). Outside, on a very hot summer day, our body temperature rises. The hypothalamus in the brain detects this and sends signals to various organs and we start to sweat (sweating is a cooling process). As water is excreted by the sweat glands on the skin, it evaporates (evaporation is a cooling mechanism). In addition, our blood vessels dilate to bring blood near the skin's surface to dissipate body heat. If we go outside on a cold day and our body temperature falls below 37°C (98.6°F), the hypothalamus of the brain detects this and sends signals to the muscles, causing us to shiver, which raises the body temperature (increased muscle activity produces heat). In addition, the hypothalamus sends signals to the blood vessels, causing them to constrict, which reduces blood flow near the surface, which conserves body heat.

Metabolism

The functional activities of cells that result in growth, repair, energy release, use of food, and secretions are combined under the heading of **metabolism** (meh-**TAB**-oh-lizm). Metabolism consists of two processes that are opposite to each other: anabolism and catabolism. **Anabolism** (ah-**NAB**-oh-lizm) is the building up of complex materials from simpler ones such as food and oxygen and requires energy. **Catabolism** (kah-**TAB**-oh-lizm) is the breaking down and changing of complex substances into simpler ones, with a release of energy and carbon dioxide. The sum of all the chemical reactions within a cell is therefore called metabolism.

Metric System

To understand the language used in *Body Structure and Function*, you must be familiar with the metric system. The medical community measures length, determines weight, and measures volume using this system. The **metric system** is a decimal system based on the power of 10. Just as there are 100 cents in a dollar, there are 100 centimeters in a meter (see Appendix A).

Some of the prefixes used in the metric system are:

centi = 1/100 (one/one-hundredth)
milli = 1/1000 (one/one-thousandth)
micro = 1/1,000,000 (one/one-millionth)

Lengths are measured using meters instead of inches and feet.

1 centimeter (cm) = 0.4 inch
2.5 cm = 1 inch

Weights are measured using grams instead of ounces and pounds.

1 gram (g) = 1 ounce
1 kilogram (kg) = 2.2 pounds
1000 g = 1 kg

In drug dosages, the most familiar unit used is the gram or milligram (mg)

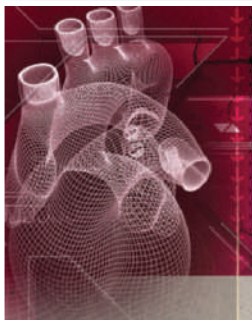
500 mg = 0.5 g

Volumes are measured using liters or milliliters instead of quarts, pints, ounces, teaspoon, and tablespoon.

1 liter (L) = 1.06 quarts (a liter is slightly larger than a quart)
1 L = 1000 milliliters (mL)

For liquid drug dosage milliliters are used.

5 mL = 1 teaspoon
15 mL = 1 tablespoon
30 mL = 1 ounce



1-1

Medical Highlights

Biotechnology and Nanotechnology

In the future we will see advances in the treatment and diagnosis of disease using techniques such as *biotechnology* and *nanotechnology*.

Biotechnology refers to any technological application that uses biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific uses. One field of biotechnology, genetic engineering, has introduced techniques such as gene therapy, recombinant DNA technology, and the polymerase chain reaction. These techniques make use of genes and DNA molecules to diagnose disease and insert new and healthy genes into the body to replace damaged cells. Using the techniques of biotechnology, biopharmaceutical drugs have been developed. Scientists are trying to develop biopharmaceutical drugs to treat diseases such as hepatitis, cancer, and heart disease.

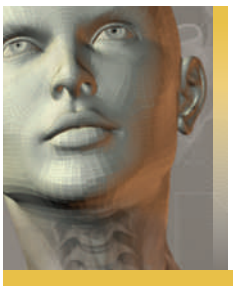
Nanotechnology is a relatively new science that manipulates atoms and molecules to form new materials. Nanotechnology deals with materials a billion times smaller than a soccer ball. We cannot even visualize such minute dimensions. At this size, matter exhibits unusual properties that can be engineered to perform tasks not otherwise possible.

At present the signs of disease first appear at a cellular level. To date, instruments used within medicine have only been able to detect abnormalities at the macro level. Being able to diagnose and treat disease at the molecular level will enable physicians to reach the root origins of disease and assist—or even replace—the healing process.

The development of nanotechnology for nanomedical applications is a priority of the National Institutes of Health (NIH). Among the long-term goals of the NIH is to be able to use nanoparticles to seek out cancer cells before tumors grow and to remove and/or replace "broken" parts of cells or cell mechanisms with miniature, molecular sized biological "machines" and use these "machines" as pumps or robots to deliver medicines when and where needed in the body. ■

Medical Terminology

ana	apart
-tom	cutting
-y	process of
ana/tom/y	process of cutting apart; study of body parts by dissection
-ology	study of
bio	life
bio/logy	study of life
physio	nature
physi/ology	study of nature or natural function of body
ante	in front of
anter/ior	in the front
poster	behind
poster/ior	in back of
super	above
super/ior	above a part
infer	below
infer/ior	below a part
-al	pertaining to
caud	tail
caud/al	pertaining to the tail
crani	skull
crani/al	pertaining to the skull
dist	distant
dist/al	pertaining to a distant part
dors	back
dors/al	pertaining to the back
later	side
later/al	pertaining to the side
medi	middle
medi/al	pertaining to the middle
proxim	near
proxim/al	pertaining to nearness or close
ventr	belly, front side
ventr/al	pertaining to the belly or front side



Study Tools

Workbook	Activities for Chapter 1
Online Resources	• PowerPoint® presentations
CourseMate	Activities and Quizzes for Chapter 1 Animations

Review Questions

Select the letter of the choice that best completes the statement.

1. The study of the size and shape of the heart is called:
   a. physiology
   b. anatomy
   c. histology
   d. embryology

2. Physiology is the study of:
   a. the size of the cell
   b. the shape of the kidney
   c. the function of the lungs
   d. the size and shape of the liver