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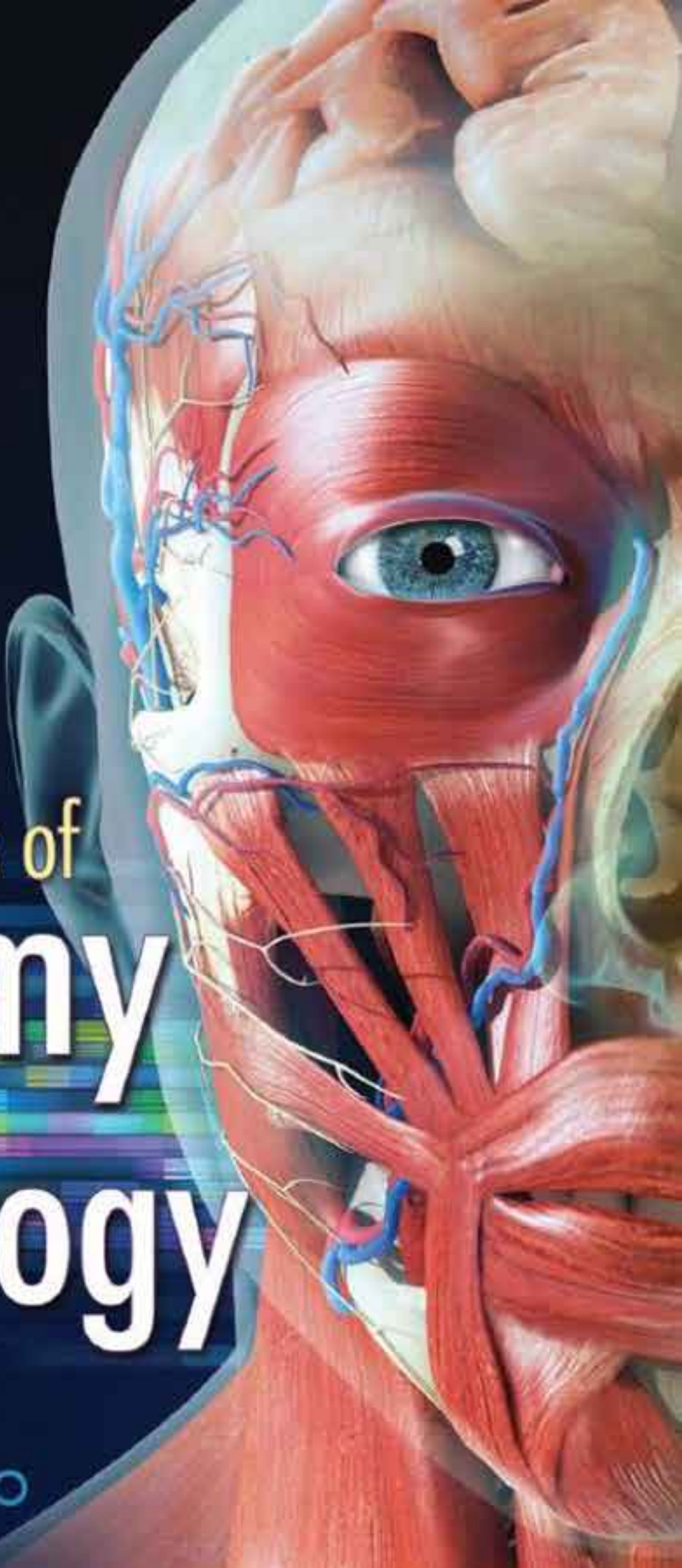
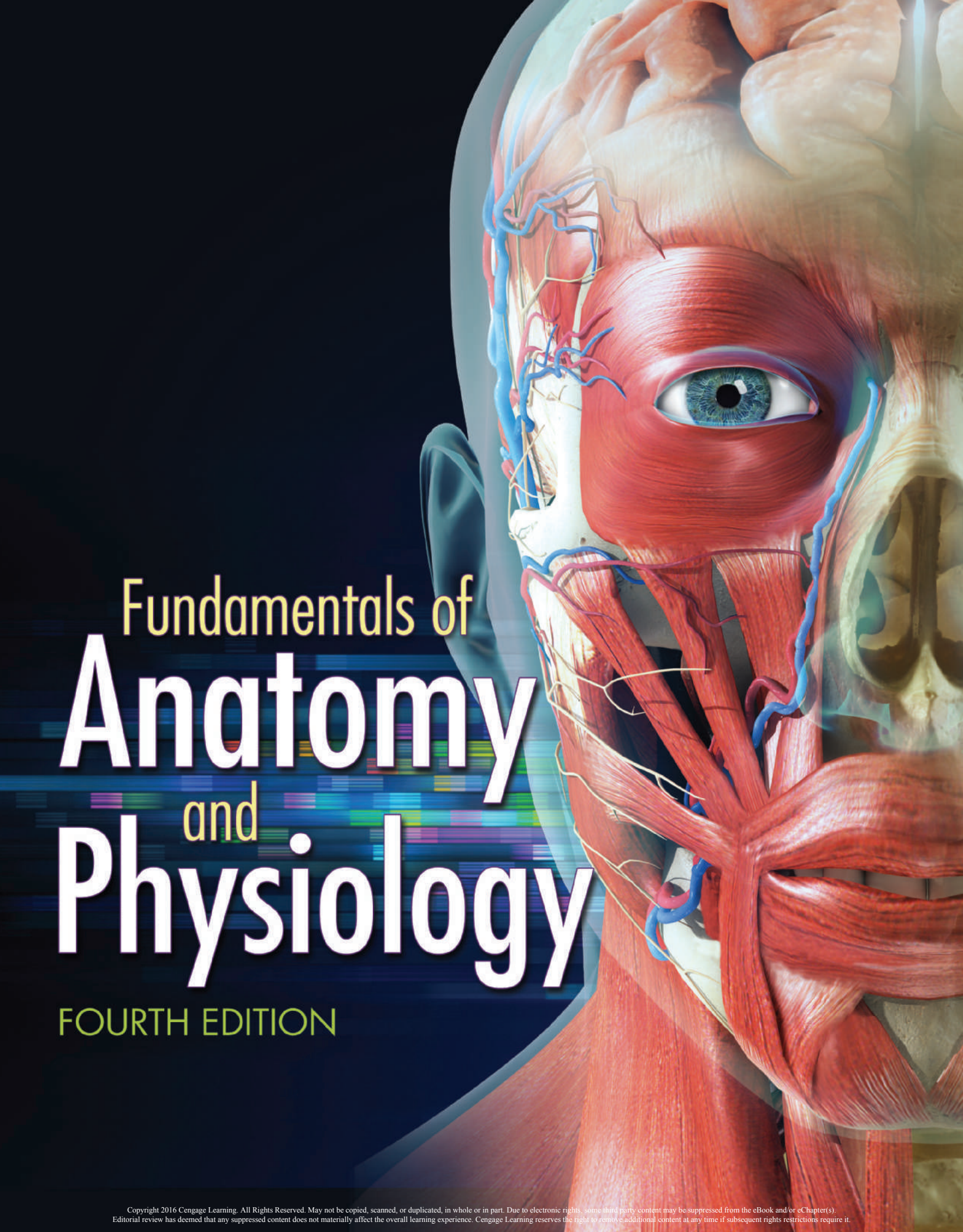


# Fundamentals of Anatomy and Physiology

FOURTH EDITION

Donald C. Rizzo



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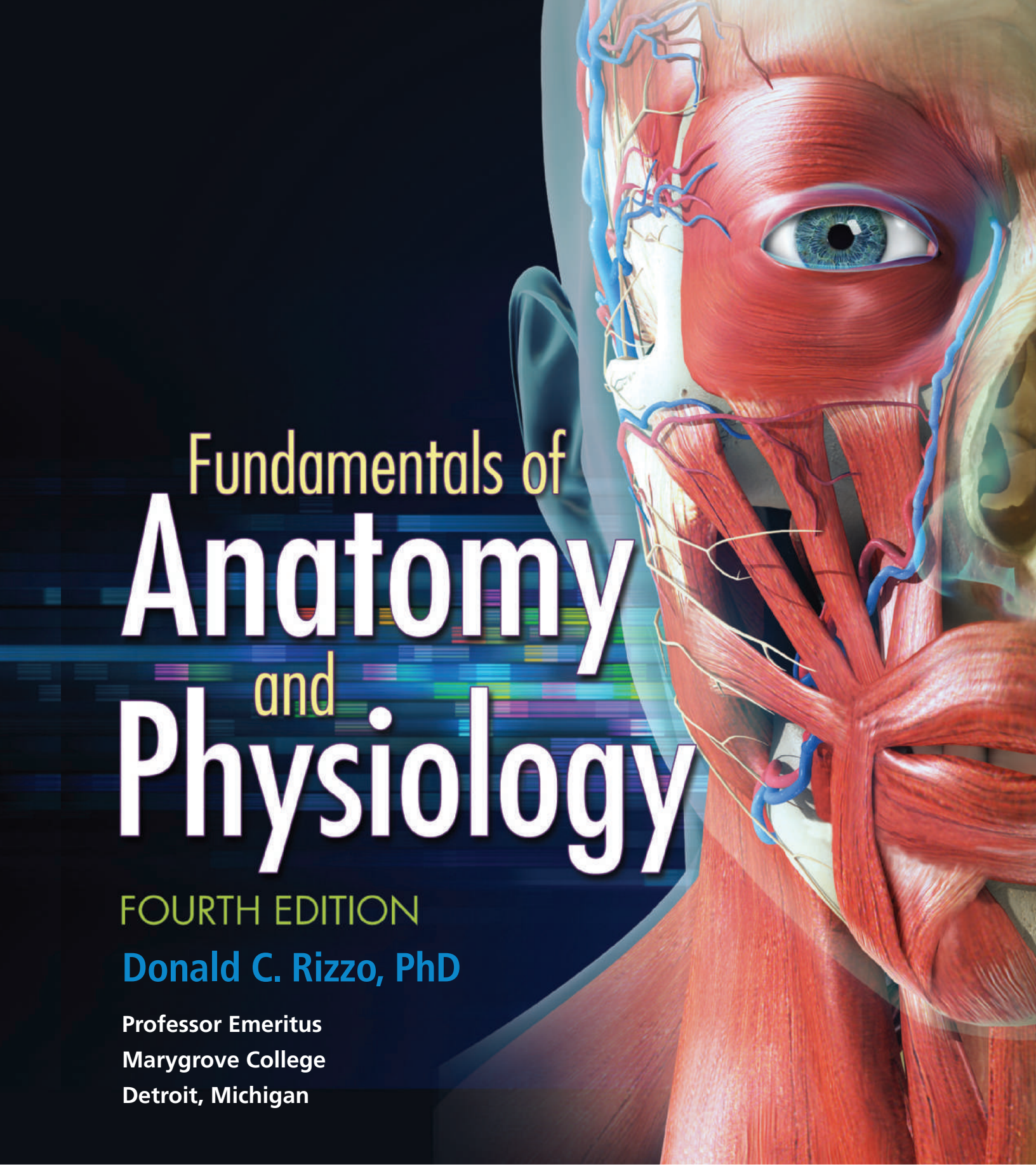

# Fundamentals of Anatomy and Physiology

FOURTH EDITION


**Donald C. Rizzo, PhD**

**Professor Emeritus**
**Marygrove College**
**Detroit, Michigan**



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**Fundamentals of Anatomy and Physiology, Fourth Edition**
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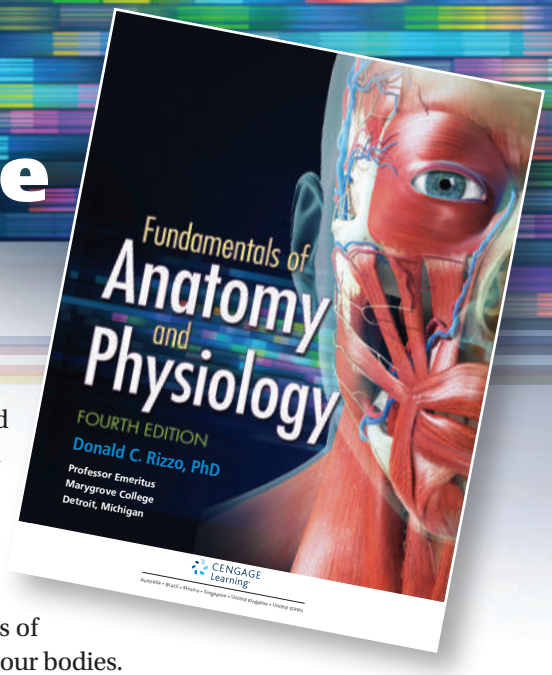
# Preface




## TO THE LEARNER

*Fundamentals of Anatomy & Physiology*, Fourth Edition, was written and designed for learners pursuing careers in the allied health fields. It is written in clear, concise, and easily understandable scientific language and presupposes no previous biology exposure. This text will guide you along a journey of understanding how the human body operates on a daily basis from birth to death. The writing style and presentation will assist introductory learners with limited backgrounds in the sciences to comprehend the basic concepts of human anatomy and physiology, and the fascinating working mechanisms of our bodies.

Several features are incorporated into each chapter to help you master the content. Review the "How to Use This Book" section on page xxiii for a detailed description and benefit of each feature.

## Organization of the Text

### Introductory Chapters

The text begins with an introduction to the human body, explaining anatomic terms and the organization of the body from the cellular to the tissue level, how tissues form organs and how organs comprise the various systems of the body. The chemical basis of life is covered in Chapter 2, explaining how elements bond to form molecules like carbohydrates, proteins, fats, and nucleic acids, which are the building blocks of cellular structures. After a discussion of the structure and functions of cells in Chapter 3, Chapter 4 explains how cells convert the foods we eat, via metabolism, into a new form of cellular chemical energy, ATP. This chapter also discusses how cells divide by mitosis, how we pass on our genetic characteristics by meiosis, and the structure of the DNA molecule. After this thorough yet understandable explanation of how cells operate, Chapter 5 describes the anatomy and function of body tissues.

### Body System Chapters

Having laid the groundwork for understanding the cellular and tissue levels of organization of the body, the text takes the student on a journey through the various systems of the body. Each system chapter has an introduction to set the stage for explaining in general terms what the system does and the organs it contains. Each organ is discussed in terms of its anatomy and physiology, beginning with the first organ and concluding with the final organ of that system. Beginning on the outside, the first system discussed is the integumentary system in Chapter 6. The skeletal (Chapter 7), articular (Chapter 8), and muscular (Chapter 9) systems are discussed next. These systems operate closely together to allow us to move and respond to changes in our external environment.

The nervous system (Chapters 10 and 11) controls and integrates all other body systems. Chapter 12 discusses the endocrine system, which operates very closely with the nervous system in the chemical control of the body through hormones, helping to maintain the body's internal environment, or homeostasis.

Chapter 13 focuses on the blood and begins the discussion of systems that transport materials through the body. Chapter 14 covers the cardiovascular circulatory system, which transports the blood that carries oxygen and nutrients to the body cells, as well as eliminates waste from the body cells. The lymphatic circulatory system (Chapter 15) transports fats from the digestive tract to the blood and develops immunities to protect the body from disease. Chapter 16 covers nutrition and the digestive system, which converts the food we eat into a usable form for use by body cells. The respiratory system, which brings in oxygen gas to the body and eliminates carbon dioxide gas, a waste product of cellular metabolism, is discussed in Chapter 17. The urinary system, which filters our blood 60 times a day of the many wastes and excesses that the body does not need, is covered in Chapter 18.

The final chapter of the text is the reproductive system. This system allows us to propagate our species and to pass on our genetic characteristics to our offspring.

## Key Features

Key features retained in the Fourth Edition include:

- Photomicrographs paired with illustrations in Chapter 5 present complete anatomical detail of tissues in the body.
- Concept Maps section illustrates the connections between anatomy and physiology of the organs of each body system.
- Body Systems Working Together section illustrates each body system's role in maintaining homeostasis and emphasizes the integration of separate systems into one body.
- Overviews of common diseases, disorders, or conditions specific to each body system.
- Laboratory exercises provide hands-on experience in the lab to observe structures.
- As the Body Ages section considers physiological changes and effects aging has on body systems.
- Career Focus section explores potential careers related to body systems.
- Search and Explore section expands learning beyond the text with Internet or human interest assignments.
- Case Studies encourage synthesis of key concepts learned in the chapter.

## Changes to the Fourth Edition

- New full-color illustrations and photos to visually reinforce anatomical structures and physiology.
- New photos of actual human bones in Chapters 7 and 8 are paired side-by-side with illustrations. Students observe details of bone structure in the illustrations and are then able to compare with photos of actual bones.
- Online Resources section directs students to study tools such as PowerPoint® slides and anatomy and physiology animations on the Student Companion Website.

### Chapter-Specific Changes

#### CHAPTER 1: THE HUMAN BODY

- New illustration on negative feedback and body temperature was added.

#### CHAPTER 4: CELLULAR METABOLISM AND REPRODUCTION: MITOSIS AND MEIOSIS

- A discussion on the disease Progeria was added.

#### CHAPTER 5: TISSUES

- All new photomicrographs were paired with illustrations to present complete anatomical details of tissues.

### CHAPTER 6: THE INTEGUMENTARY SYSTEM

- Expanded discussion on sebaceous glands was added.
- Expanded discussion on thermoregulation was added.
- New illustration showing cross section of a hair and hair follicle was added.

### CHAPTER 7: THE SKELETAL SYSTEM

- New photos of actual human bones, paired side-by-side with illustrations, were added.
- New illustration showing osteoblast cells producing ossification in cartilage was added.
- New illustration showing intramembranous ossification was added.
- New illustration showing the inferior view of skull bones was added.

### CHAPTER 8: THE ARTICULAR SYSTEM

- New illustration showing a syndesmosis joint between the radius and ulna bones was added.
- New illustration showing examples of synchondroses joints, a pelvic bone and the sternum and sternocostal cartilages, was added.

### CHAPTER 9: THE MUSCULAR SYSTEM

- Expanded discussion on the naming and actions of skeletal muscles was added.
- Expanded discussion on the muscles of facial expression was added.

### CHAPTER 10: THE NERVOUS SYSTEM: INTRODUCTION, SPINAL CORD, AND SPINAL NERVES

- New illustration of a bipolar neuron producing a fatty myelin sheath outside of the central nervous system was added.
- New illustration of a Schwann cell was added.
- New illustration of an oligodendrocyte producing a fatty myelin sheath on axons in the central nervous system was added.

### CHAPTER 11: THE NERVOUS SYSTEM: THE BRAIN, CRANIAL NERVES, AUTONOMIC NERVOUS SYSTEM, AND THE SPECIAL SENSES

- Expanded discussion on anatomy of the eye was added.
- New discussion on the disorder vertigo was added.

### CHAPTER 14: THE CARDIOVASCULAR CIRCULATORY SYSTEM

- New illustration illustrating a cardiac cycle was added.
- New discussion on cerebral circulation was added.

### CHAPTER 15: THE LYMPHATIC CIRCULATORY SYSTEM

- New discussion on the vermiform appendix was added.

### CHAPTER 16: NUTRITION AND THE DIGESTIVE SYSTEM

- New illustration of the MyPlate icon was added.
- New discussion on the MyPlate dietary guidelines was added.
- New health alert on the importance of vitamins in our diets was added.

### CHAPTER 17: THE RESPIRATORY SYSTEM

- Expanded discussion on the anatomy and function of the lungs was added.

### CHAPTER 19: THE REPRODUCTIVE SYSTEM

- New labels were added to the organs and ducts of the male reproductive system.

# LEARNING SUPPLEMENTS

## Study Guide

The study guide offers additional practice with exercises corresponding to each chapter in the text, including completion, matching, key terms, art labeling, coloring exercises, critical thinking questions, case studies, crossword puzzles, and chapter quizzes. A section on study tips and test-taking strategies is also included. **ISBN 978-1-2851-7416-7**

## Anatomy & Physiology Illustrated Flashcards

Review and learn anatomy and physiology key concepts and terminology with just under 200 full-color flashcards. Anatomy & Physiology Illustrated Flashcards provide mastery of terms and body structures through a series of image labeling and key concept cards. Start by reviewing the anatomy image to study the body structures. Turn the card over to review key concepts or terms related to the body system or individual structures. Next, test yourself with the image labeling cards. Color-coded to keep *like* cards together after separation; the flashcards are organized by introductory and body systems and correlate to chapters in the text where you can access additional information. **ISBN 978-1-4283-7657-1**

# Online Resources

A Student Companion Website is available to accompany the text that includes slide presentations created in PowerPoint® and anatomy and physiology animations.

How to access the Online Resources:

1. GO TO: 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

# TO THE INSTRUCTOR

## Rationale and Intended Market

There are many human anatomy and physiology textbooks that instructors can choose for their learners. Most are designed for those with a background in biology and are so extensive in content and coverage that it would take at least a full year to teach all the in-depth subject matter. These texts are designed for biology majors and pre-med learners. There was a need for a textbook that was written for the introductory learner choosing a career in allied health, a book that covers the fundamentals of human anatomy and physiology at a reasonable depth to satisfy the needs of these learners in a one-semester course.

### Teaching Support Materials

A number of resource materials are available to accompany this text.

### Instructor Companion Website

Powerful resources for instructors are available to assist you with teaching anatomy and physiology and assessing your students' mastery of the material.

The Instructor's Manual is Designed to Help You with Lesson Preparation and Performance Assessment. It Includes:

- syllabus for a one-semester course
- lecture outlines with classroom demonstrations/activities incorporated
- critical thinking classroom discussion questions
- answers to review questions in the text
- answers to exercises and chapter quizzes in the study guide

Cognero online Testbank contains over 1000 questions organized by chapter content, including matching, fill in the blank, multiple choice, and true/false, to assist you in creating chapter, midterm, and final exams.

PowerPoint® slides, including animations, are designed to aid you in planning your class presentations.

## THE LEARNING LAB

Learning Lab is an online homework solution that maps to learning objectives in *Fundamentals of Anatomy & Physiology*, Fourth Edition. Interactive, scenario-based activities build students' understanding of anatomy and physiology. The Learning Lab includes a pre-assessment, learning activities, and a post-assessment organized around the chapters in this text. The post-assessment scores can be posted to the instructor grade book in any learning management system. The amount of time the student spends within the Learning Lab can also be tracked.

IAC Learning Lab to Accompany Fundamentals of Anatomy and Physiology, 4th Edition, **ISBN 978-1-2854-3565-7**

## MindTap

MindTap is a fully online, interactive learning experience built upon authoritative Cengage Learning content. By combining readings, multimedia, activities, and assessments into a singular learning path, MindTap elevates learning by providing real-world application to better engage students. Instructors customize the learning path by selecting Cengage Learning resources and adding their own content via apps that integrate into the MindTap framework seamlessly with many learning management systems.

The guided learning path demonstrates the relevance of anatomy and physiology to health care professions through engagement activities and interactive exercises. Learners apply an understanding of anatomy and physiology through scenarios. These simulations elevate the study of anatomy and physiology by challenging students to apply concepts to practice.

To learn more, visit www.cengage.com/mindtap

## Delmar Learning's Anatomy & Physiology Image Library CD-ROM, Third Edition

This CD-ROM includes over 1,050 graphic files. These files can be incorporated into a Power Point®, Microsoft® Word presentation, used directly from the CD-ROM in a classroom presentation, or used to make color transparencies. The Image Library is organized around body systems and medical specialties. The library includes various anatomy, physiology, and pathology graphics of different levels of complexity. Instructors can search and select the graphics that best apply to their teaching situation. This is an ideal resource to enhance your teaching presentation of medical terminology or anatomy and physiology. **ISBN: 978-1-4180-3928-8**

## ABOUT THE AUTHOR

Donald C. Rizzo, PhD, is currently professor emeritus of biology and was head of the biology department at Marygrove College in Detroit, Michigan, where he taught human anatomy and physiology and medical terminology. He was also responsible for teaching biology II: the unity and diversity of life, principles of biology, parasitology, zoology, and botany. He began his teaching career at Marygrove College in 1974. He was chairperson of the Science and Mathematics Department from 1975 to 2006 in addition to full-time teaching.

Dr. Rizzo received his B.A. in biology and education in 1968 from Boston State College (now the University of Massachusetts at Boston), MS in 1970, and PhD in 1973 from Cornell University in Ithaca, New York. He has been a long-term member of the American Association of University Professors and is a member of the American Institute of Biological Sciences and was a past member of the National Association of Science Teachers.

Dr. Rizzo has published in the *Journal of Invertebrate Pathology* and coauthored a computerized test bank for medical terminology. He has developed many teaching aids for his biology classes, including a laboratory manual for parasitology and student study guides for all other classes.

Dr. Rizzo's awards include the Sears Roebuck Foundation Teaching Excellence and Campus Leadership Award in 1990 and the Marygrove College Teacher Scholar Award in 1992. Nominated by his students, he became a member of Who's Who Among American Teachers in 1996, 2000, and 2004. In 2006, he received the Marygrove College Presidential Award for Teaching. In 1990–1996, he was a summer session visiting professor at the University of Michigan Medical School, where he taught the biology component of the post-baccalaureate Pre-Medical Scholarship Program for minority students. He presented at national and international conferences on an interdisciplinary service learning course on "HIV/AIDS: Its Biological and Social Impact" with his two friends and colleagues Professor James Karagon in social work and Dr. Loretta Woodard in literature who, with him, developed and taught this course.

He has conducted biological field work around the globe and participated with students on Study Abroad trips to places such as the Galapagos Islands, South Africa, China, Russia, Europe, and South and Central America. His hobbies include world travel, American art pottery, and American glass. In 2009, he was awarded the Marygrove College Presidential Award for Scholarship. In 2010, he was awarded the Marygrove College Presidential Award for Service. He incoporated Service Learning into all the courses he taught.

## ACKNOWLEDGMENTS

I would like to acknowledge the technical assistance of my friend and colleague, Ms. Teri Miller, administrative assistant. A very special thank you is also extended to Debra Myette-Flis, my Senior Content Developer, who began working with me on the first edition many years ago and has remained with me as a patient and competent link to Cengage Learning. She is always available with assistance and answers to my numerous technical questions, providing me with consistent words of encouragement. A special thank you is extended to Dr. Jesse Baker for his invaluable assistance with the technical editing of this fourth edition.

A heartfelt thank you goes to my family, friends, administrators, staff, students, and colleagues at Marygrove College who supported me in this endeavor. To my friends Rico and Jess, thank you for making my life easier by taking care of the dogs and cats when I needed periods of quiet time and solitude to write and edit.

Many thanks are also extended to the instructors from other colleges who reviewed the manuscript. Their constructive suggestions brought new perspectives to topics and their ideas and comments helped make this fourth edition the product it is. They each had a new and different perspective that was invaluable to the final editing of this edition.

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# How to Use This Book

*Fundamentals of Anatomy & Physiology*, Fourth Edition, helps you understand how the human body is structured, the functions it performs on a daily basis, and how the body systems work together to maintain homeostasis. The following features are integrated throughout the text to assist you in learning and mastering anatomy and physiology core concepts and terms.

The Fourth Edition retained all the successful features of the third edition.

## Chapter Objectives

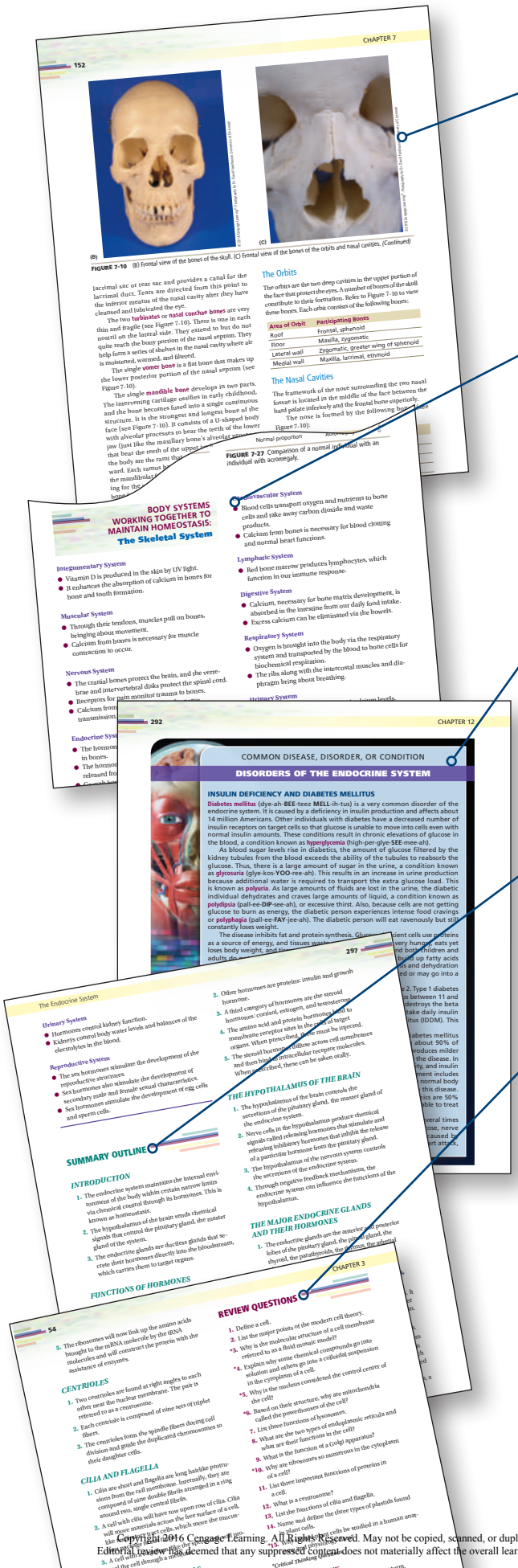
The chapter objectives alert you to concepts you should understand after reading the chapter and completing the review questions.

## Key Terms

The list of key terms at the beginning of each chapter references the page number where each term can be found within the text, locating specific terms for quick and easy review.

## Concept Map

Each body system chapter includes a concept map that introduces you to the relationship between various structures of the system and how these structures enable the system to perform its functions. The concept maps help you see the connections between anatomy and physiology of the organs of each body system.



## Full-Color Illustrations & Photos

Full-color illustrations and photos provide visual reinforcement of the major concepts covered in each chapter. Color can help you keep a mental picture of the various systems and help reinforce the material you learn in each chapter. New photos of actual human bones allow students to compare structures outlined in illustrations.

## Body Systems

This section at the end of each chapter illustrates how each body system works together to maintain the body's internal environment within certain narrow ranges. Seeing each body system's role in maintaining homeostasis helps you see the integration of separate systems into one body.

## Special Condition Boxes

Health Alert or Common Disease, Disorder, or Condition boxes provide short descriptions of a significant health alert, common disease, disorder, or condition that can occur in the body system being covered. This information enables you to relate concepts presented in the chapter to real-life situations.

## Summary Outline

The summary outline, listing the major topics covered in the chapter, provides a valuable study tool by summarizing the chapter contents.

## Review Questions

A variety of exercises provide self-assessment of comprehension of the chapter material. Critical thinking questions allow you to apply concepts learned and encourage further discussion.

## Laboratory Exercises

Essential laboratory exercises at the end of most chapters allow you hands-on experience in the laboratory to observe structures or apply the knowledge learned in the chapter.

## As the Body Ages

As the Body Ages feature in all body system chapters discusses physiological changes and effects that aging has on each specific body system.

## Career Focus

Career Focus feature introduces learners to health professions related to the chapter content and illustrates how anatomy and physiology content is used in a real-world career.

## Search and Explore

The Search and Explore feature takes you beyond the textbook to expand your learning experience with key word Internet searches, suggested websites to visit with related activities, and brief *human interest* projects designed to add a personal element to your assignments.

## Case Study

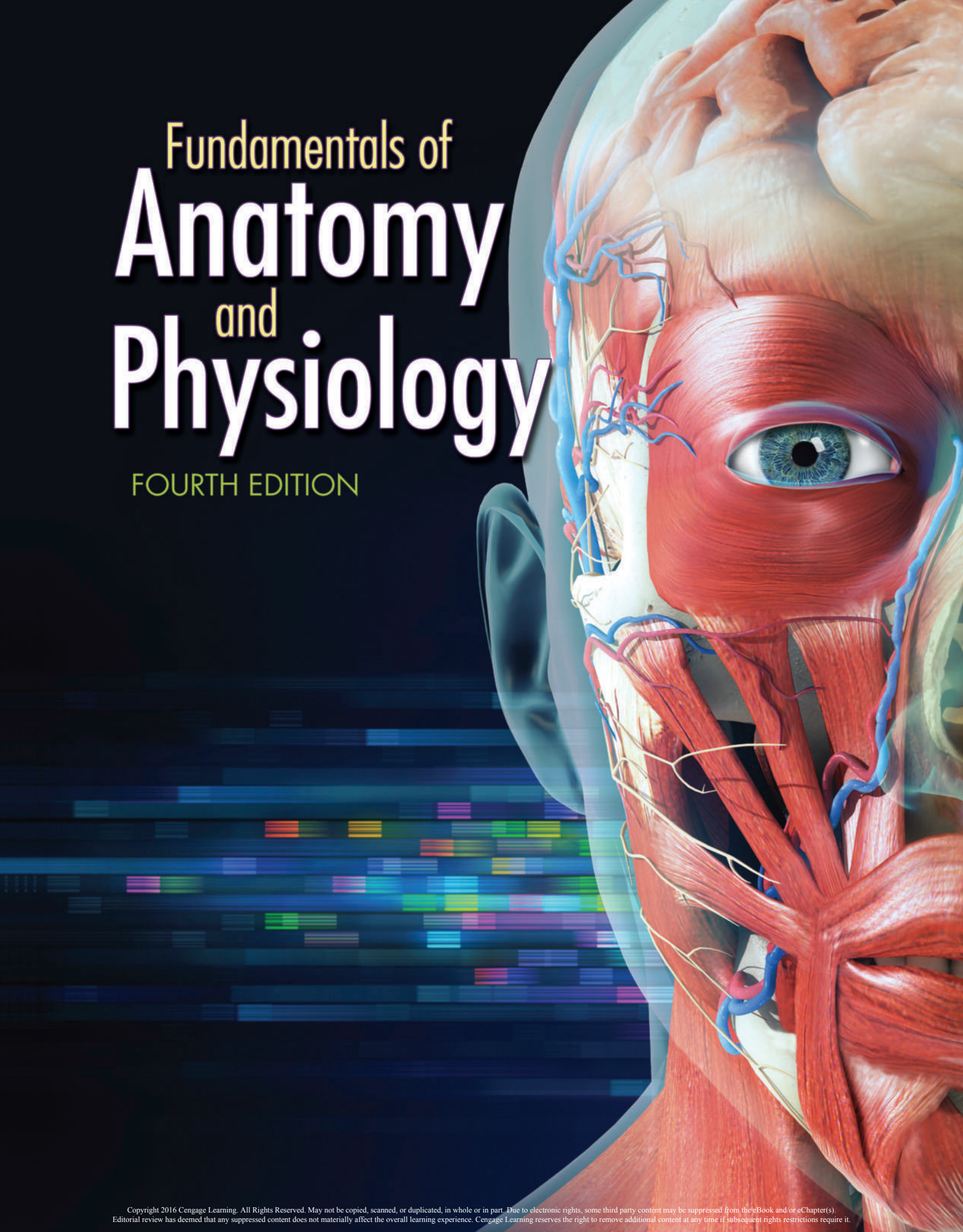
A Case Study is included in each body system chapter to encourage you to synthesize material you have learned apply it as you answer each question that follows.

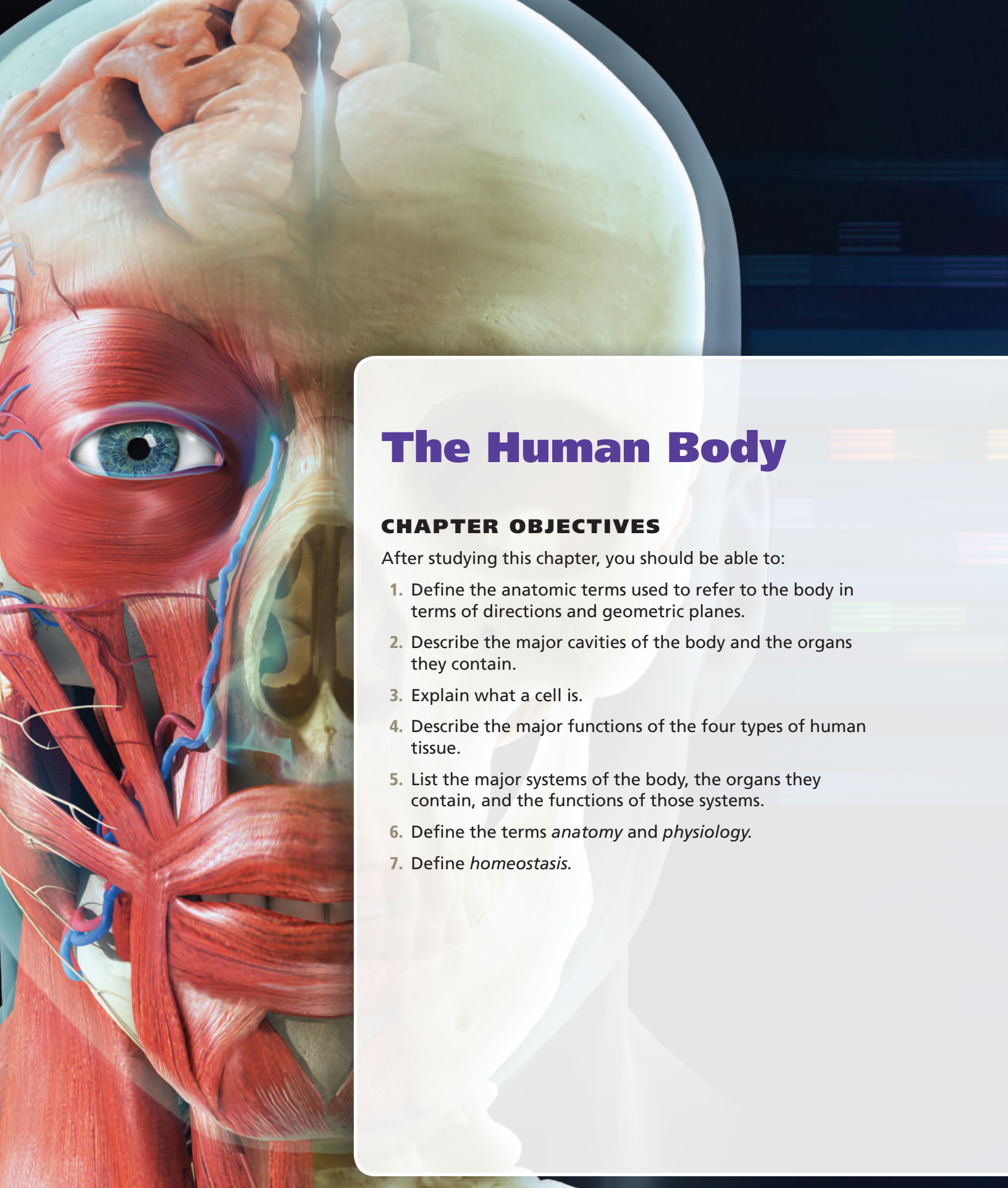
## Study Tools

This section reminds you of additional tools for review and to enhance your study of anatomy and physiology, including Online Resources with PowerPoint slides and anatomy and physiology animations on the Student Companion Website, and the Study Guide with practice questions, image labeling and coloring exercises, and crossword puzzles.

# Fundamentals of Anatomy and Physiology

FOURTH EDITION





# The Human Body

## CHAPTER OBJECTIVES

After studying this chapter, you should be able to:

1. Define the anatomic terms used to refer to the body in terms of directions and geometric planes.
2. Describe the major cavities of the body and the organs they contain.
3. Explain what a cell is.
4. Describe the major functions of the four types of human tissue.
5. List the major systems of the body, the organs they contain, and the functions of those systems.
6. Define the terms *anatomy* and *physiology.*
7. Define *homeostasis.*

CHAPTER

# 1

## KEY TERMS



## INTRODUCTION

Interest in the human body and how it functions probably developed when our ancestors began to think about the reasons why people became ill and died. All earlier cultures had someone designated as a healer who was responsible for finding plants and herbs that cured body disorders. This healer also was responsible for praying or invoking the assistance of past ancestors to help in the healing process.

As cultures developed and science began to evolve, interest in and knowledge about the human body advanced. Leonardo da Vinci (1452–1519), an Italian, was the first to correctly illustrate the human skeleton with all of its bones. The Flemish anatomist Andreas Vesalius (1514–1564) wrote a book on the human body, and the English anatomist William Harvey (1578–1657) discovered how blood circulates through the body. These are just a few of the many contributors who added to our understanding of the human body and how it functions.

**Anatomy** is the study of the structure or morphology of the body and how the body parts are organized. **Physiology** is the study of the functions of body parts, what they do, and how they do it. These two areas of the organization of the body are so closely associated that it is difficult to separate them. For example, our mouth has teeth to break down food mechanically, a tongue that tastes the food and

manipulates it, and salivary glands that produce saliva containing enzymes that break down complex carbohydrates into simple sugars, thus beginning the process of digestion. **Pathology** is the study of the diseases of the body.

We still do not know everything about how the human body functions. Research is still going on today to discover the mysteries of this complex unit we call ourselves.

To facilitate uniformity of terms, scientists have adopted four basic reference systems of bodily organization. These systems are directions, planes, cavities, and structural units. When referring to terms of direction, planes, and cavities, the human body is erect and facing forward. The arms are at the sides and the palms of the hand and feet are positioned toward the front (Figure 1-1). All descriptions of location or position assume the body to be in this posture.

## TERMS OF DIRECTION

When an anatomist (one who studies the human body's structures) is describing parts of the body, it is necessary to make reference to their positions in regard to the body as a whole. The following directional terms have been established to facilitate these references. Use Figure 1-2 as your guide as these terms are defined.

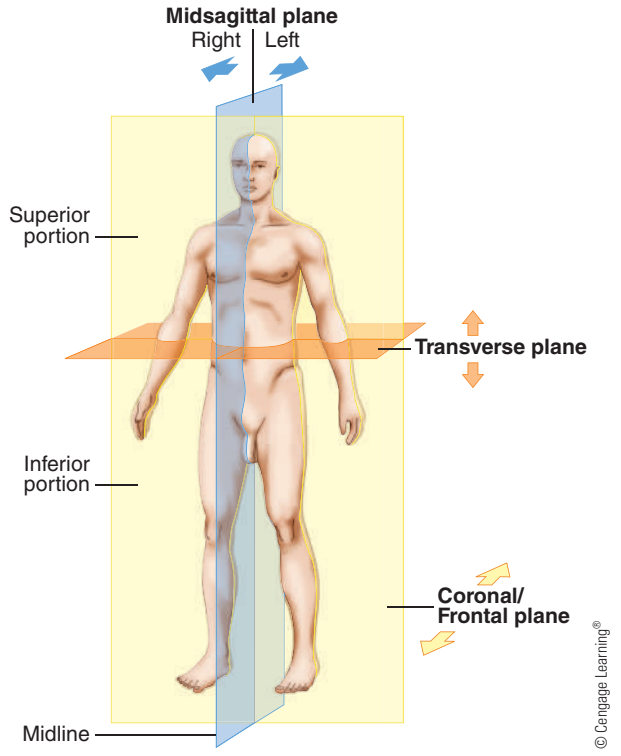



**FIGURE 1-1** The human body in correct anatomic position illustrating the planes of the body.

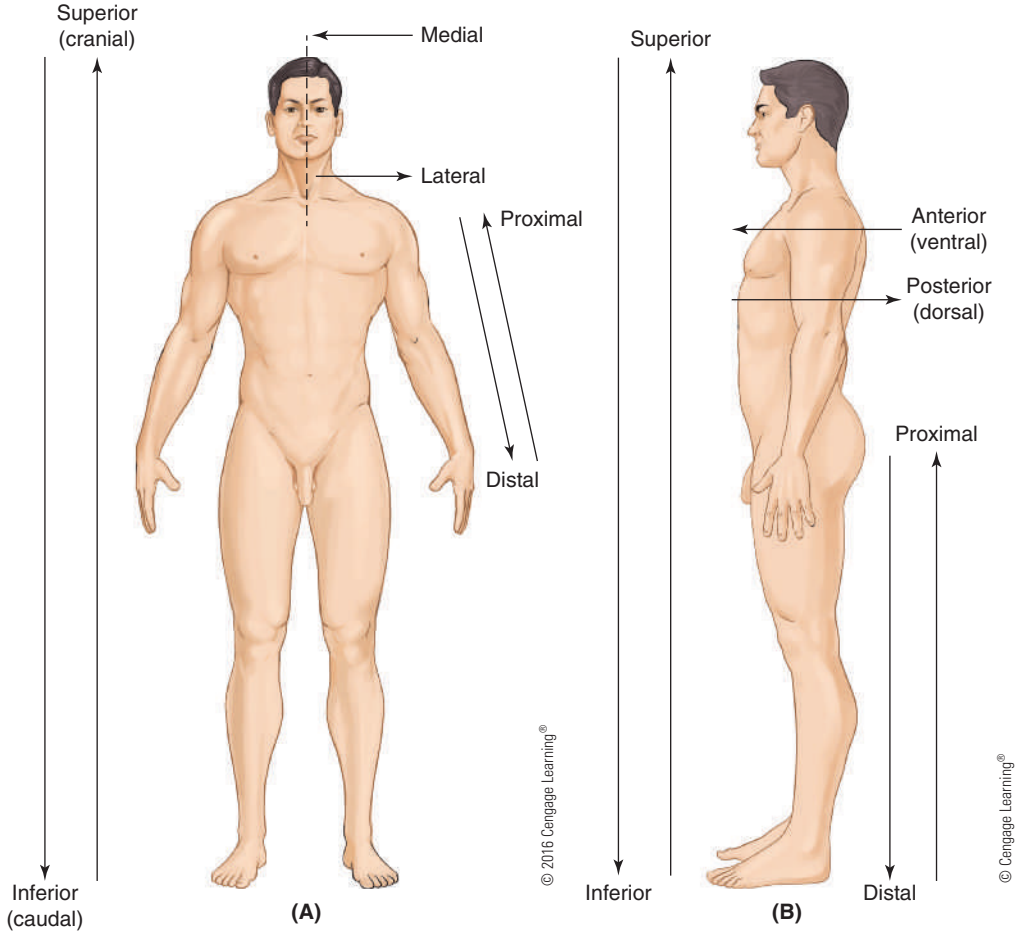



**FIGURE 1-2** Directional terms relating to anatomic position. (A) Anterior view of the body. (B) Lateral view of the body.

**Superior** means uppermost or above. Example: the head is superior to the neck; the thoracic cavity is superior to the abdominal cavity. **Inferior** means lowermost or below. Example: the foot is inferior to the ankle; the ankle is inferior to the knee. **Anterior** means toward the front. Example: the mammary glands are on the anterior chest wall. The term **ventral** can also be used for anterior. Ventral means the belly side. **Posterior** means toward the back. Example: the vertebral column is posterior to the digestive tract; the esophagus is posterior to the trachea. The term **dorsal** can also be used for posterior. Dorsal means the back side.

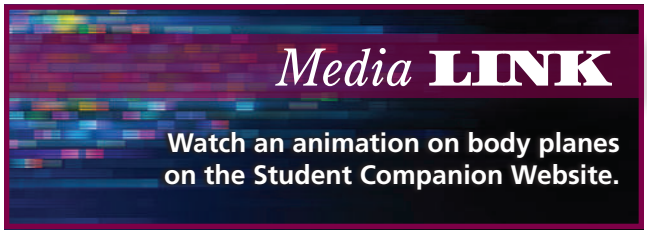
**Cephalad** (**SEF**-ah-lad) or **cranial** means toward the head. It is synonymous with superior. Example: the thoracic cavity lies cephalad (or superior) to the abdominopelvic cavity. Occasionally, **caudal** (**KAWD**-al) is synonymous with inferior. However, caudal specifically means toward the tail and, as we know, humans do not have tails as adults but we do have tails as developing embryos as do all members of the animal phylum Chordata to which humans belong.

**Medial** means nearest the midline of the body. Example: the nose is in a medial position on the face; the ulna is on the medial side of the forearm. **Lateral** means toward the side or away from the midline of the body. Example: the ears are in a lateral position on the face; the radius is lateral to the ulna. **Proximal** means near the point of attachment or origin. Example: the elbow is proximal to the wrist; the knee is proximal to the ankle. **Distal** means away from the point of attachment or origin. Example: the wrist is distal to the elbow; the ankle is distal to the knee.

## PLANES

Occasionally, it is useful to describe the body as having imaginary flat geometric surfaces passing through it called planes (see Figure 1-1). These terms are most useful when describing dissections to look inside an organ or the body as a whole. A **midsagittal** (mid-**SAJ**-ih-tal) plane vertically divides the body through the midline into two equal left and right portions or halves. This is also referred to as a median plane. A **sagittal** plane is any plane parallel to the midsagittal or median plane vertically dividing the body into unequal right and left portions.

A **horizontal** or **transverse** plane is any plane dividing the body into superior and inferior portions. A **frontal** or **coronal** plane is one that divides the anterior (or ventral) and posterior (or dorsal) portions of the body at right angles to the sagittal plane. When organs are sectioned to reveal internal structures, two other terms are often used. A cut through the long axis of an organ is called a longitudinal section, and a cut at right angles to the long axis is referred to as a transverse or cross section.




## CAVITIES

The body has two major cavities: the dorsal cavity and the ventral cavity (Figure 1-3). Each of these is further subdivided into lesser cavities. The organs of any cavity are referred to as the **viscera** (**VISS**-er-ah).

The dorsal cavity contains organs of the nervous system that coordinate the body's functions. It is divided into the **cranial cavity**, which contains the brain, and the **spinal cavity**, which contains the spinal cord.

The ventral cavity contains organs that are involved in maintaining homeostasis or a constant internal environment within small ranges of deviation (Figure 1-4). The first subdivision of the ventral cavity is the **thoracic** (tho-**RASS**-ik) **cavity**. It is surrounded by the rib cage. The thoracic cavity contains the heart in a pericardial sac referred to as the **pericardial cavity**, and the two lungs, each covered by the pleural membrane, are referred to as the **pleural cavities**. A space called the **mediastinum** (**mee**-dee-ass-**TYE**-num) is found between the two pleural cavities. It contains the heart, thymus gland, lymph and blood vessels, trachea, esophagus, and nerves. The diaphragm muscle separates the thoracic cavity from the abdominopelvic cavity.

The **abdominopelvic cavity** is the second subdivision of the ventral cavity. It contains the kidneys, stomach, liver and gallbladder, small and large intestines, spleen, pancreas, and the ovaries and uterus in women.

Two other terms are used when discussing the cavities of the body. The term **parietal** (pah-**RYE**-ehtal) refers to the walls of a cavity. Example: the parietal peritoneum lines the abdominal wall. The term **visceral** refers to the covering on an organ. Example: the visceral peritoneum covers abdominal organs.

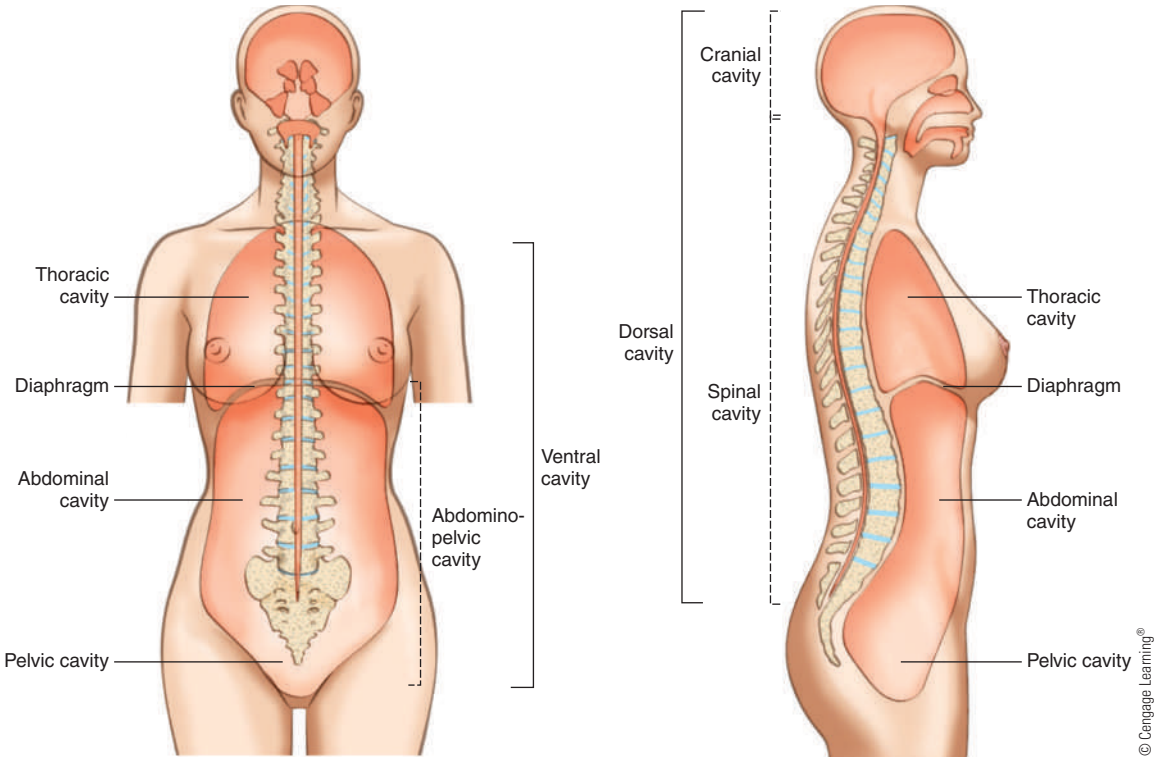



**FIGURE 1-3** The major cavities of the body and their subdivisions.

## STRUCTURAL UNITS

All living material is composed of cells, the smallest units of life. Cells are organized into tissues. Tissues are organized into organs, and organs are part of the major systems of the body (Figure 1-5 and Table 1-1). The cell is the basic unit of biologic organization. The liquid part of a cell is called **protoplasm** (**PRO**-toh-plazm). This protoplasm is surrounded by a limiting membrane, the cell membrane, also called the plasma membrane, which selectively determines what may enter or exit the cell. This protoplasm is an aqueous (watery), colloidal (grouping of large molecules) solution of various proteins, lipids, carbohydrates, and inorganic salts that are organized into cellular structures referred to as organelles. These organelles, such as the mitochondria, ribosomes, and lysosomes, among others, are discussed in further detail in Chapter 3.

A cell performs all the activities necessary to maintain life, including metabolism, assimilation, digestion, excretion, and reproduction (see Figure 3-1 in Chapter 3). Different kinds of cells make up a tissue (muscle or bone). Different types of tissues make up an organ (stomach or heart). Finally, organs are grouped into systems (digestive system or nervous system). Each system of the body serves some general function to maintain the body as a whole. All of the diverse tissues of the body can be placed into one of four categories: **epithelial** (**ep**-ih-**THEE**-lee-al), **connective**, **muscle**, or **nervous tissue**. We will study these tissues in greater detail in Chapter 5.

Epithelial tissue covers and protects surfaces (both the outer surface like the skin and inner surfaces of organs like the intestine), forms glands, and lines cavities of the body. It is made up of one or more layers of cells with very little, if any, intercellular material. Connective tissue binds together and supports other tissues and organs. In many instances, it is highly specialized (blood, bone, lymphatic tissue). It is made up of different kinds of cells that produce various fibers (elastin and collagen) embedded in a matrix (substance) of nonliving intercellular material. Muscle tissue is characterized by elongated cells (so long that they are often referred to as muscle fibers) that generate movement by shortening or contracting in a forcible manner. There are three types of muscle tissue. Skeletal or voluntary muscle pulls on bones and causes body movements. Smooth or involuntary muscle is found in the intestines where it pushes food along the digestive tract. It is also found in arteries and veins where it pushes blood forward. Cardiac muscle is found only in the heart. It is also involuntary and causes contractions of the heart; these contractions pump the blood through thousands of miles of blood vessels. Finally, nervous tissue is composed

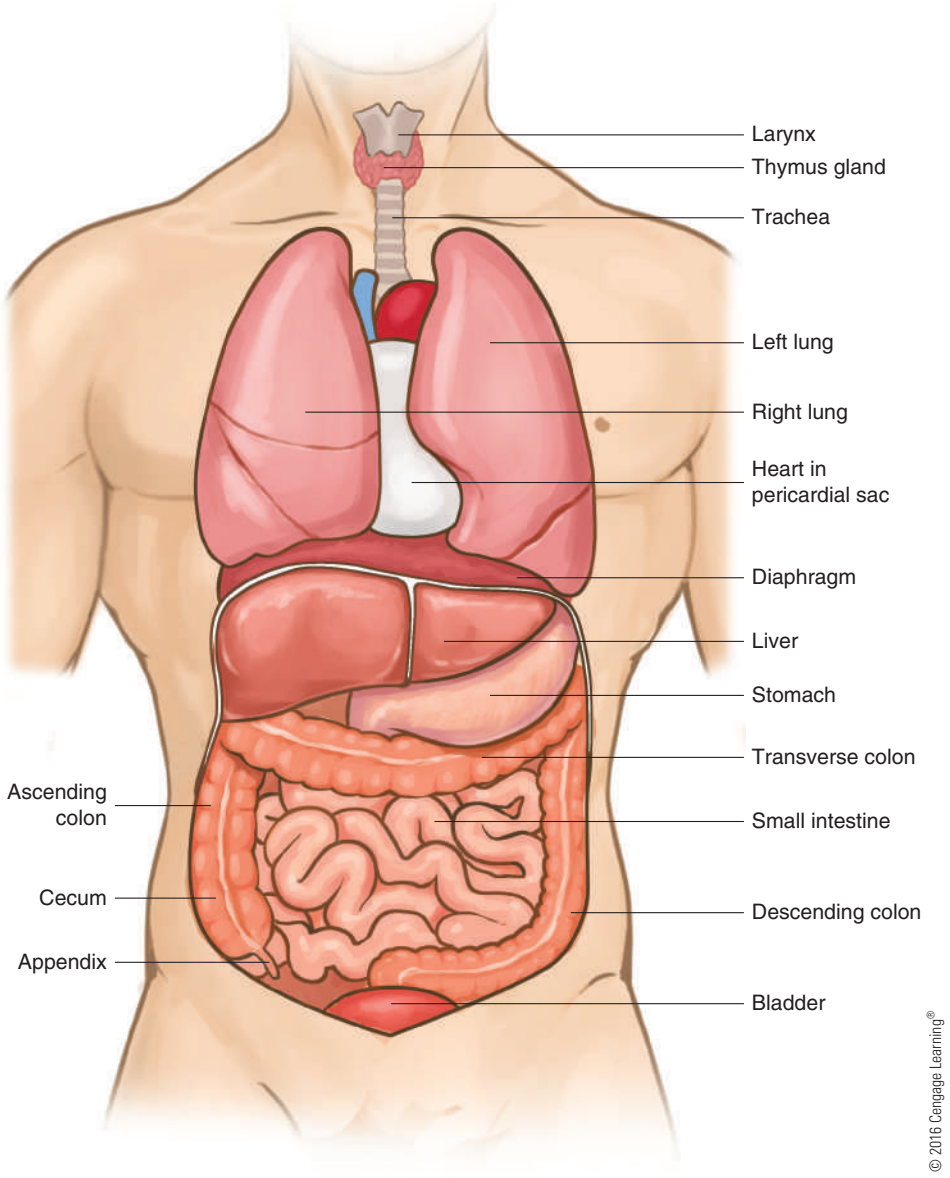



**FIGURE 1-4** The thoracic and abdominopelvic cavities of the body and some of the organs they contain.

of nerve cells forming a coordinating system of fibers connecting the numerous sensory (touch, sight) and motor (muscular) structures of the body.

Organs are composed of cells integrated into tissues serving a common function (skin, liver, stomach, heart, lungs). A system is a group of organs.

The **integumentary system** is made up of two layers: the epidermis and the dermis. It includes the skin, hair, nails, sebaceous glands, and sweat glands (see Figure 1-6). Its functions include insulation of the body, protection of the body from environmental hazards such as the ultraviolet radiation of the sun and certain chemicals, and regulation of body temperature and water. It also has receptor sites to detect changes in temperature and pressure.

The **skeletal system** is composed of bones, cartilage, and the membranous structures associated with bones (see Figure 1-6). It protects the soft and vital parts of the body and provides support for body tissues. Its bones act as levers for movement. This system also manufactures blood cells in red bone marrow and stores fat in yellow bone marrow. Bones store mineral salts like calcium and phosphorous.

The **muscular system** consists of muscles, fasciae (fibrous connective tissues), tendon sheaths, and bursae (fibrous sacs) (see Figure 1-6). Skeletal muscles pull on bones to allow movement; smooth muscle pushes food through the digestive tract and blood through the circulatory system; and cardiac muscle causes contraction of the heart.

The **nervous system** consists of the brain, spinal cord, cranial nerves, peripheral nerves, and the sensory

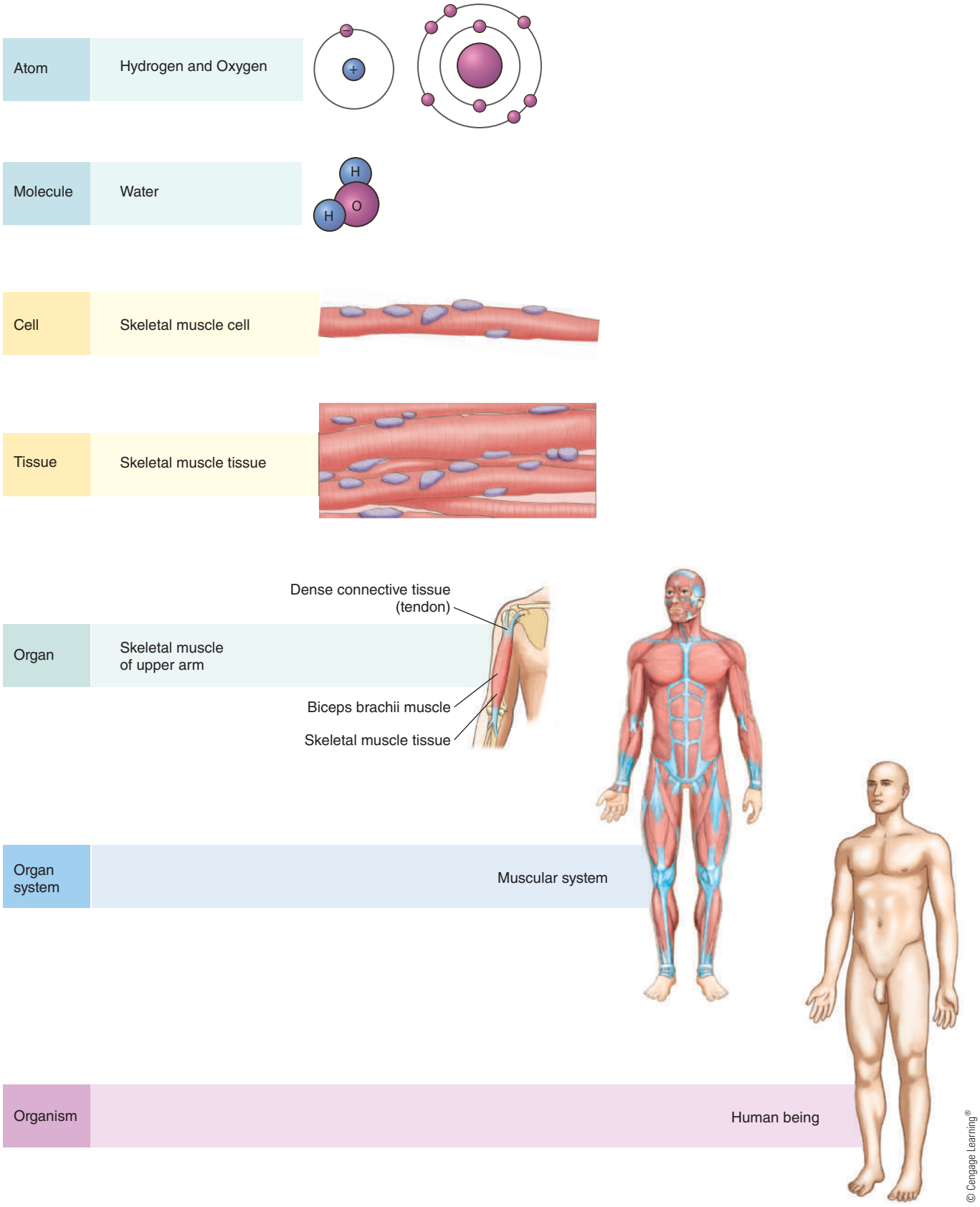
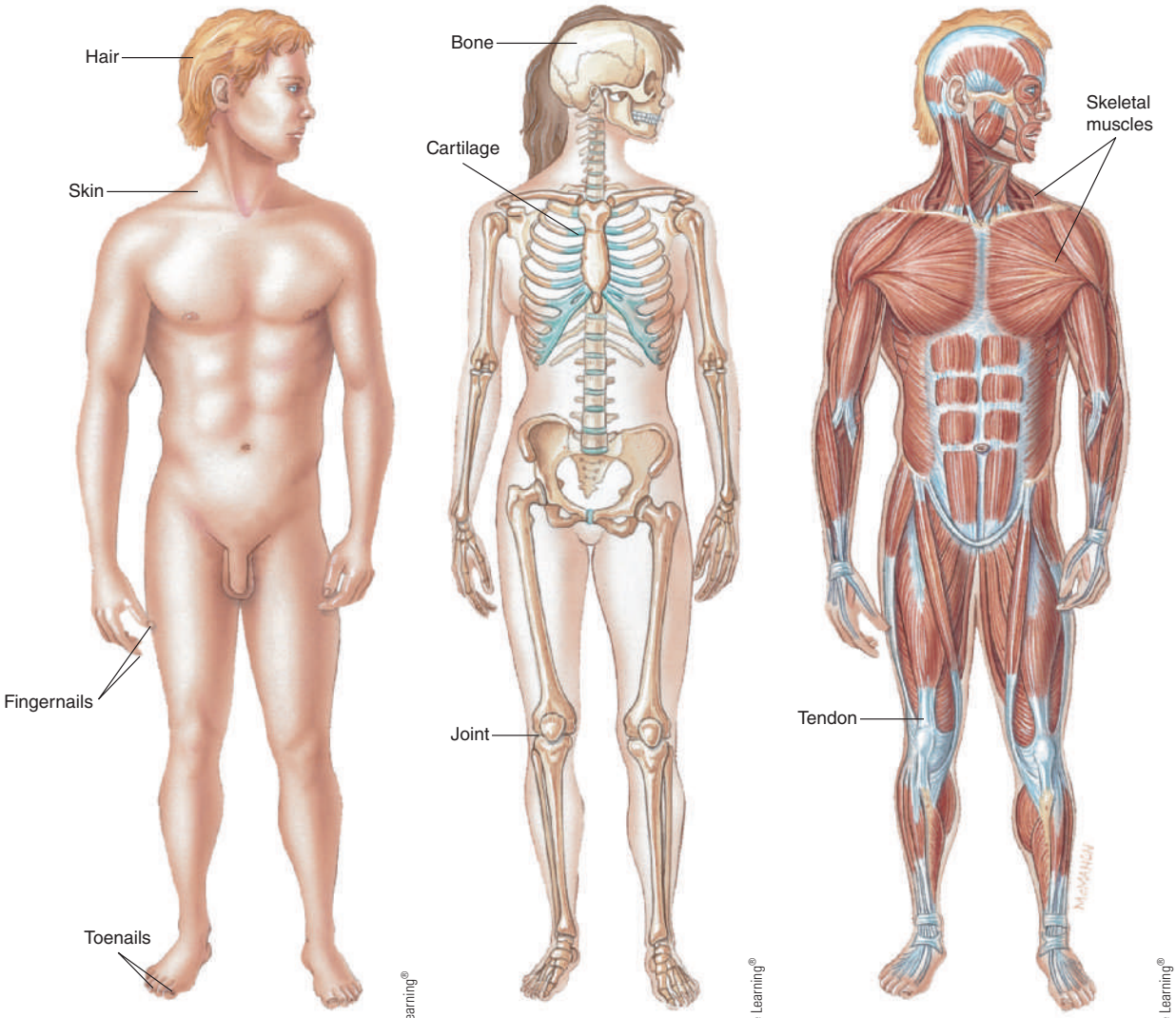



**FIGURE 1-5** The structural levels of organization of the body.

**TABLE 1-1 The Structural Levels of Organization of the Human Body**

| Structural Level | Example |
|---|---|
| **1. Atoms** | Atoms are the smallest units of elements, such as carbon, hydrogen, and oxygen. |
| **2. Molecules** | Molecules are formed when atoms combine through chemical bonds to form units such as water, sugars, and amino acids. |
| **3. Cells** | Cells are the smallest living units of biologic organization made of structures that perform the activities of life, such as the nucleus that controls all the activities of the cell. |
| **4. Tissues** | Tissues are made up of similar cells that perform similar functions, such as muscle tissues that cause contraction and movement. |
| **5. Organs** | There are four different kinds of tissues (epithelial, connective, muscle, and nervous) that group together in different proportions to make an organ like the stomach, which mixes our food with digestive enzymes. |
| **6. Systems** | A group of organs makes up a body system like the nose, pharynx, larynx, trachea, bronchi, and lungs that makes up the respiratory system whose function is to bring in oxygen to the body's cells and take away carbon dioxide gas. |
| **7. Human Organism** | All of the organ systems together constitute a functioning human being. |






**Integumentary system**
Skin and accessory organs such as hair, nails, sweat glands, and oil glands.



**Skeletal system**
Bones, cartilage, and joints.



**Muscular system**
Muscle and tendons.



**FIGURE 1-6** The integumentary, skeletal, and muscular systems of the body.