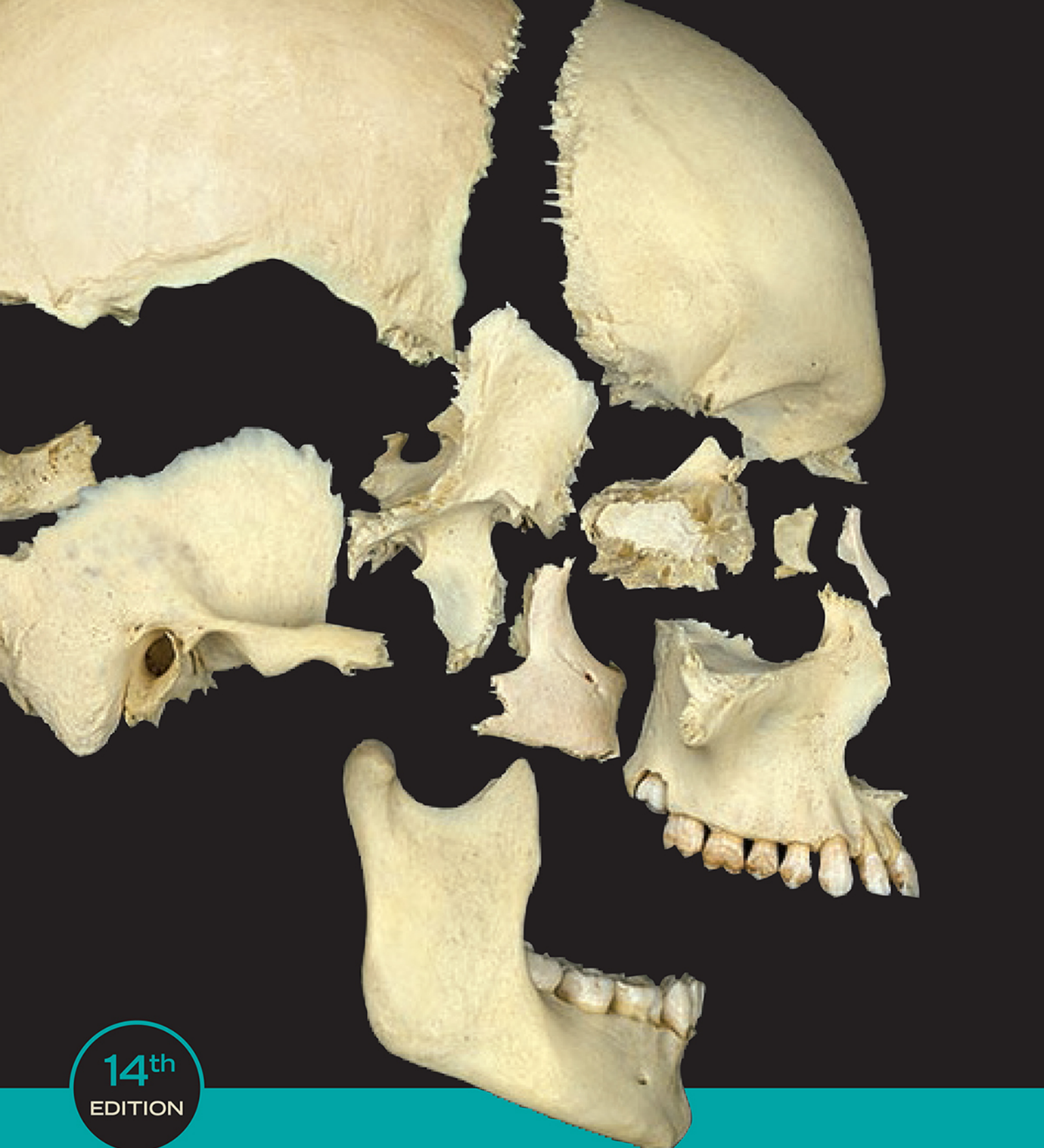


14th EDITION

PRINCIPLES OF HUMAN ANATOMY

GERARD J. TORTORA | MARK NIELSEN

WILEY

Principles of HUMAN ANATOMY

14th Edition

Gerard J. Tortora
Bergen Community College

Mark T. Nielsen
University of Utah

WILEY

VICE PRESIDENT AND DIRECTOR	Petra Recter	SENIOR PHOTO EDITOR	MaryAnn Price
SENIOR EDITOR	Maria Guarascio	SENIOR PRODUCT DESIGNER	Linda Muriello
ASSOCIATE DEVELOPMENT EDITOR	Laura Rama	SENIOR DESIGNER/	
ASSISTANT DEVELOPMENT EDITOR	Lindsey Myers	COVER DESIGNER	Tom Nery
SENIOR MARKETING MANAGER	Alan Halfen	TEXT DESIGNER	Brian Salisbury
SENIOR CONTENT MANAGER	Svetlana Barskaya	COVER PHOTO	Mark Nielsen
SENIOR PRODUCTION EDITOR	Trish McFadden		

This book was set in 10/12 Janson Text LT Std by Aptara®, Inc. Printed and bound by RR Donnelley/Von Hoffmann. This book is printed on acid-free paper. ∞

Founded in 1807, John Wiley & Sons, Inc. has been a valued source of knowledge and understanding for more than 200 years, helping people around the world meet their needs and fulfill their aspirations. Our company is built on a foundation of principles that include responsibility to the communities we serve and where we live and work. In 2008, we launched a Corporate Citizenship Initiative, a global effort to address the environmental, social, economic, and ethical challenges we face in our business. Among the issues we are addressing are carbon impact, paper specifications and procurement, ethical conduct within our business and among our vendors, and community and charitable support. For more information, please visit our website: www.wiley.com/go/citizenship.

ISBN-13 978-1-119-28503-8
BRV ISBN 978-1-119-32860-5

The inside back cover will contain printing identification and country of origin if omitted from this page. In addition, if the ISBN on the back cover differs from the ISBN on this page, the one on the back cover is correct.

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ABOUT THE AUTHORS

Courtesy of Gerard J. Tortora

Jerry Tortora is Professor of Biology and former Biology Coordinator at Bergen Community College in Paramus, New Jersey, where he teaches human anatomy and physiology as well as microbiology. He received his bachelor's degree in biology from Fairleigh Dickinson University and his master's degree in science education from Montclair State College. He has been a member of many professional organizations, including the Human Anatomy and Physiology Society (HAPS), the American Society of Microbiology (ASM), American Association for the Advancement of Science (AAAS), National Education Association (NEA), and the Metropolitan Association of College and University Biologists (MACUB).

Above all, Jerry is devoted to his students and their aspirations. In recognition of this commitment, Jerry was the recipient of MACUB's 1992 President's Memorial Award. In 1996, he received a National Institute for Staff and Organizational Development (NISOD) excellence award from the University of Texas and was selected to represent Bergen Community College in a campaign to increase awareness of the contributions of community colleges to higher education.

Jerry is the author of several best-selling science textbooks and laboratory manuals, a calling that often requires many additional hours per week beyond his teaching responsibilities. Nevertheless, he still makes time for four or five weekly aerobic workouts that include biking and running. He also enjoys attending college basketball and professional hockey games and performances at the Metropolitan Opera House.

To all my children: Lynne, Gerard Jr., Kenneth, Anthony, and Drew, whose love and support have been the wind beneath my wings. ***G.J.T.***

Courtesy of Mark Nielsen

Mark Nielsen is a Professor in the Department of Biology at the University of Utah. For the past thirty-one years he has taught anatomy, neuroanatomy, embryology, human dissection, comparative anatomy, and an anatomy teaching course to over 25,000 students. He developed the anatomy course for the physician assistant program at the University of Utah School of Medicine, where he taught for five years, and taught in the cadaver lab at the University of Utah School of Medicine. He developed the anatomy and physiology program for the Utah College of Massage Therapy, and his course materials are used by massage schools throughout the country. His graduate training is in comparative anatomy, and his anatomy expertise has a strong basis in dissection. He has prepared and participated in hundreds of dissections of both humans and other vertebrate animals. All his courses incorporate a cadaver-based component to the training with an outstanding exposure to cadaver anatomy. He is a member of the American Association of Anatomists (AAA), the Human Anatomy and Physiology Society (HAPS), and the American Association of Clinical Anatomists (AACA).

Mark has a passion for teaching anatomy and sharing his knowledge with his students. In addition to the many students to whom he has taught anatomy, he has trained and served as a mentor for over 1,200 students who have worked in his anatomy laboratory as teaching assistants. His concern for students and his teaching excellence have been acknowledged through numerous awards. He received the prestigious Presidential Teaching Scholar Award at the University of Utah for excellence in teaching and was an initial recipient of the Beacons of Excellence Award for developing exceptional programs for student mentoring. He is a five-time recipient of the University of Utah Student Choice Award for Outstanding Teacher and Mentor, a two-time winner of the Outstanding Teacher in the Physician Assistant Program, recipient of the American Massage Therapy Association Jerome Perlinski Teacher of the Year Award, and a two-time recipient of Who's Who Among America's Teachers.

He enjoys sports, photography, good food, traveling, and exploring with his lovely wife and playing with his grandchildren.

To my wonderful family, one and all.

Thank you for your never-ending support and love, it is dearly appreciated. ***M.T.N.***

PREFACE

Welcome to your course in human anatomy! Many of you are taking this course because you hope to pursue a career in one of the allied health fields or medicine. Or perhaps you are simply interested in learning more about your own body. Whatever your motivation, ***Principles of Human Anatomy 14e*** and ***WileyPLUS Learning Space*** have all the content and tools that you need to successfully navigate what can be a very challenging course.

Over the past thirteen editions of this text we have made every effort to provide you with an accurate, clearly written, and expertly illustrated presentation of the structure of the human body; to offer insights into the connections between structure and function; and to explore the practical and relevant applications of anatomical knowledge to everyday life and career development. This fourteenth edition remains true to these goals. It distinguishes itself from prior editions with updated and new illustrations and greatly enhanced digital options.

The Art of Anatomy

Human anatomy is probably the most visual of all the sciences. Prior editions have been noted for the exceptionally clear figures that not only enhance the narrative, but stand on their own as a valuable study resource. This fourteenth edition has updated and revised many figures throughout to be more vibrant and more helpful than ever. In addition, some figures have been so extensively revised as to be considered all new; for example, note the new flow charts in the chapter on blood vessels. For those students who prefer to study online rather than in print, you will find that the presentation of figures within the text has been developed to be more interactive and easier to view on screen than ever before.

Engaging Digitally

The content in ***Principles of Human Anatomy 14e*** is completely integrated into **WileyPLUS Learning Space**. This allows you to create a personalized study plan, assess your progress along the way, and make deeper connections with the course material, your professor, and your classmates. This collaborative learning environment provides immediate insight into your strengths and problem areas with visual reports that highlight what's most important for you to act on to help you master the course.

Many dynamic programs integrated into the course and the flow of the text help build your knowledge and understanding, and keep you motivated. For this edition we have added ***new author videos*** throughout. Developed and executed by Mark Nielsen, these videos are like a "master class" on selected topics. The videos feature a variety of animated visuals inclusive of figures, cadaver photographs from ***Real Anatomy***, as well as diagrammatic visuals, to elucidate important concepts, to make critical connections among the details, and to ease the process of learning the language of anatomy.

WileyPLUS Learning Space also includes ***ORION***—integrated adaptive practice that helps you build proficiency and uses your study time most effectively.

WileyPLUS with ORION

A personalized, adaptive learning experience.

WileyPLUS with ORION delivers easy-to-use analytics that help educators and students see strengths and weaknesses to give learners the best chance of succeeding in the course.

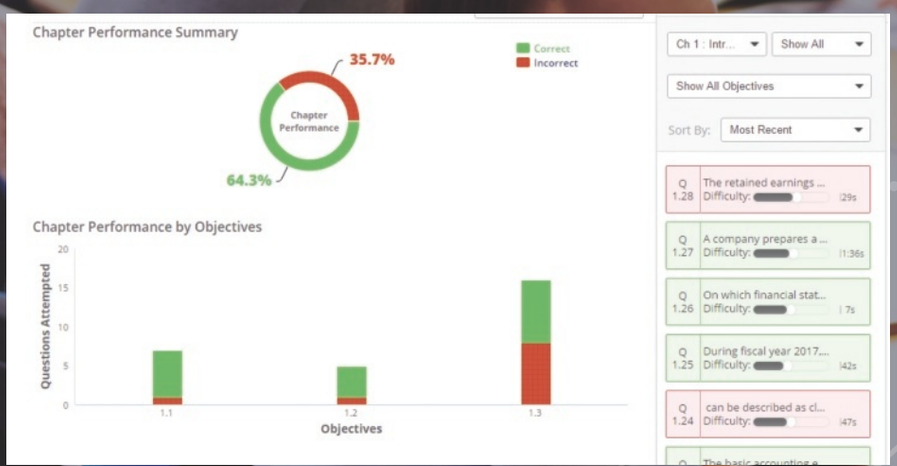


Photo credit: Monkey Business Images/Shutterstock

Identify which students are struggling early in the semester.

Educators assess the real-time engagement and performance of each student to inform teaching decisions. Students always know what they need to work on.

Help students organize their learning and get the practice they need.

With ORION's adaptive practice, students quickly understand what they know and don't know. They can then decide to study or practice based on their proficiency.

Measure outcomes to promote continuous improvement.

With visual reports, it's easy for both students and educators to gauge problem areas and act on what's most important.

www.ORION.wileyplus.com

WILEY

ACKNOWLEDGMENTS

Human Anatomy 14e and ***WileyPLUS Learning Space with ORION*** would not be possible without the help of many, particularly the academic colleagues who collaborated with us along the way. We are very grateful that Wiley has commissioned a board of advisors in anatomy and physiology to act as a sounding board on course issues, challenges, and solutions. In particular we thank those members of the board with expertise in the human anatomy course: **Sandra Hutchinson, Santa Monica College; Wanda Hargroder, Louisiana State University**; and **Melaney Farr, Salt Lake Community College**.

We wish to especially thank several academic colleagues for their contributions to the creation and integration of this text with WileyPLUS Learning Space. They include:

Kathleen Anderson, *University of Iowa*

Celina Bellanceau, *University of South Florida*

Evelyn Biluk, *Lake Superior College*

Lois Borek, *Georgia State University*

Stephen Burnett, *Clayton State University*

Kash Dutta, *University of New England*

Heather Dy, *Long Beach Community College*

Wanda Hargroder, *Louisiana State University*

Noah Harper, *Idaho State University*

Sandra Hutchinson, *Santa Monica College*

Cynthia Kincer, *Wytheville Community College*

Thomas Lancraft, *St. Petersburg College*

Jason Locklin, *Temple College*

Shawn Miller, *University of Utah*

Erin Morrey, *Georgia Perimeter College*

Gloria Nusse, *San Francisco State University*

Izak Paul, *Mount Royal University*

Finally, our hats are off to everyone at Wiley. We enjoy collaborating with this enthusiastic, dedicated, and talented team of publishing professionals. Our thanks to the entire team: Maria Guarascio, Senior Editor; Linda Muriello, Senior Product Designer; Laura Rama, Associate Development Editor; Lindsey Myers, Assistant Development Editor; Trish McFadden, Senior Production Editor; Mary Ann Price, Senior Photo Editor; Tom Nery, Designer; and Alan Halfen, Senior Marketing Manager.

GERARD J. TORTORA

Biology and Horticulture; Physical Sciences; Industrial Design Technologies S229
Bergen Community College
400 Paramus Road
Paramus, NJ 07675
gtortord@bergen.edu

MARK NIELSEN

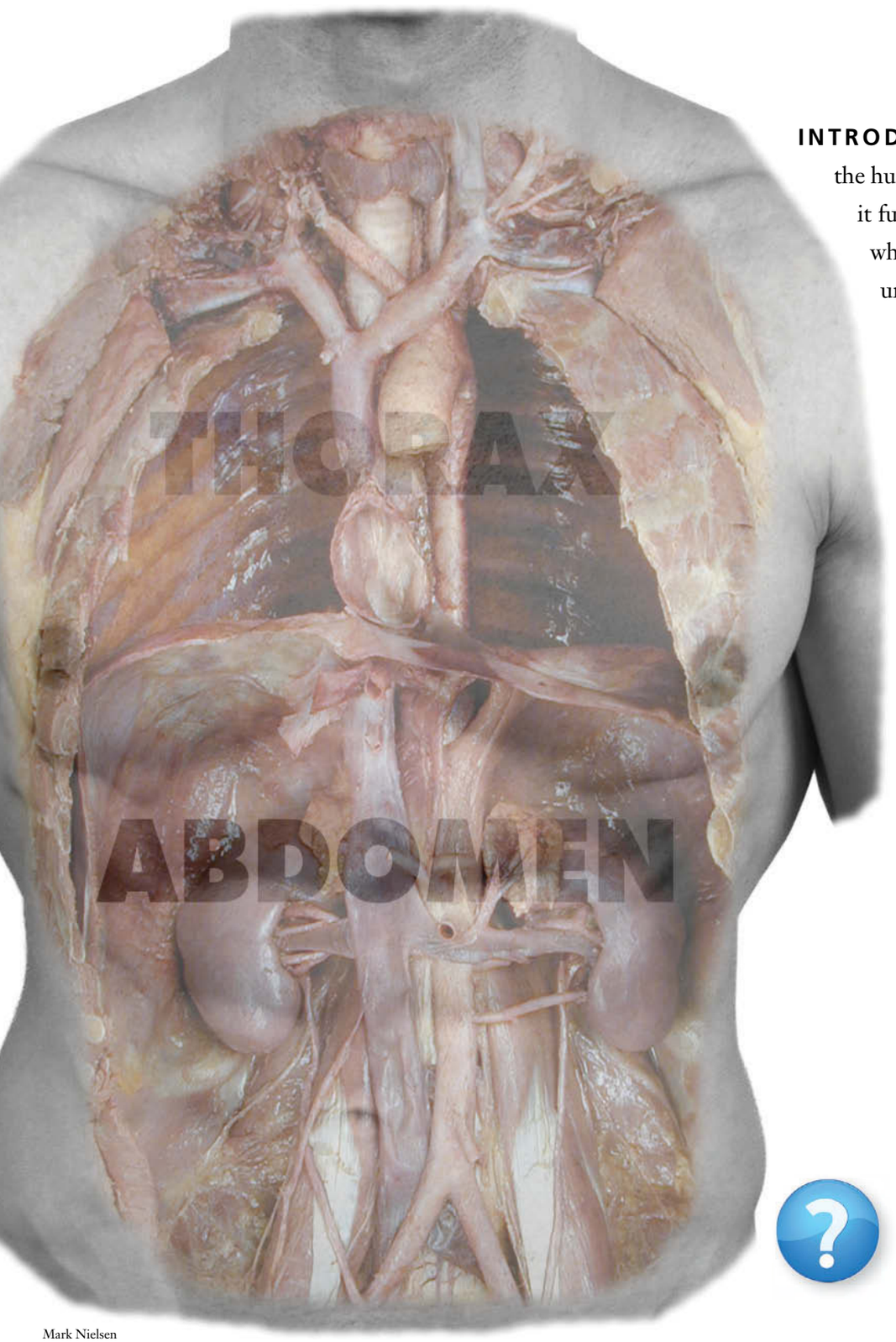
Department of Biology
University of Utah
257 South 1400 East
Salt Lake City, UT 84112
marknielsen@bioscience.utah.edu

BRIEF CONTENTS

CONTENTS

CLINICAL CONNECTIONS

1 AN INTRODUCTION TO THE HUMAN BODY



Mark Nielsen

INTRODUCTION You are about to begin a study of the human body to learn how it is organized and how it functions. In order to understand what happens when the body is injured, diseased, or placed under stress, you must know how it is put together and how its different parts work. Just as an auto mechanic must be familiar with the details of the structure and function of a car, health-care professionals and others who work in human performance and care professions must have intimate knowledge of the structures and functions of the human body. This knowledge can be one of your most effective tools. Much of what you study in this chapter will help you understand how anatomists visualize the body, and the basic anatomical vocabulary presented here will help you describe the body in a language common to both scientists and professionals. •

Did you ever wonder why an autopsy is performed? You can find out on page 19.

CONTENTS AT A GLANCE

1.1 ANATOMY DEFINED

OBJECTIVE

- Define anatomy and physiology, and name several branches of anatomy.

Anatomy (a-NAT-ō-mē; *ana-*=up; *=-tomy*=process of cutting) is primarily the study of *structure* and the relationships among structures. It was first studied by **dissection** (dis-SEK-shun; *dis-*=apart; *-section*=act of cutting), the careful cutting apart of body structures to study their relationships. Today, a variety of imaging techniques also contribute to the advancement of anatomical knowledge. We will describe and compare some common imaging techniques in Table 1.3, which appears later in this chapter (see Section 1.8). The anatomy of the human body can be studied at various levels of structural organization, ranging from microscopic (visible only with the aid of a microscope) to macroscopic (visible without the use of a microscope). These levels and the different methods used to study them provide the basis for the branches of anatomy, several of which are described in Table 1.1.

Anatomy deals mostly with structures of the body. A related discipline, **physiology** (fiz′-e-OL-o-je; *physio-*=nature; *-logy*=study of), deals with *functions* of body parts—that is, how they work. Because function cannot be separated completely from structure, you will learn how the structure of the body often reflects its functions. Some of the structure–function relationships are visibly obvious, such as the tight connections between the bones of the skull, which protect the brain. In contrast, the bones of the fingers are more loosely joined to permit movements such as playing an instrument, grasping a baseball bat, or retrieving a small object from the floor. The shape of the external ear assists in the collection and localization of sound waves, which facilitates hearing. Other relationships are not as visibly obvious; for example, the passageways that carry air into the lungs branch extensively when they reach the lungs. Tiny air sacs—about 300 million—cluster at the ends of the large number of airway branches. Similarly, the vessels carrying blood into the lungs branch extensively to form tiny tubes that surround the small air sacs. Because of these anatomical features, the total surface area within the lungs is about the size of a handball court. This large surface area is the key to the primary function of the lungs: the efficient exchange of oxygen and carbon dioxide between the air and the blood.

CHECKPOINT

1. Which branches of anatomy would be used when dissecting a cadaver?
2. Give several examples of connections between structure and function in the human body.

TABLE 1.1

Selected Branches of Anatomy

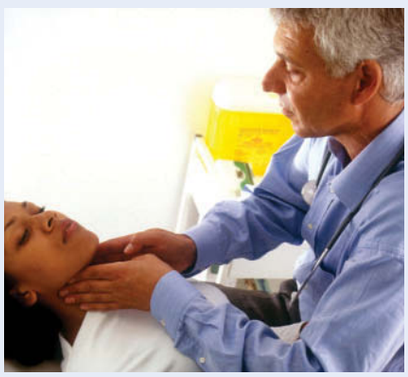
BRANCH	STUDY OF
Embryology (em′-brē-OL-ō-jē; *embry-*=embryo; *-logy*=study of)	In humans, the first eight weeks of development after fertilization of the egg
Developmental biology	The complete developmental history of an individual from fertilization to death
Cell biology	Cellular structure and function
Histology (his′-TOL-ō-jē-; *hist-*=tissue)	Microscopic structure of tissues
Sectional anatomy	Internal structure and relationships of the body through the use of sections
Gross anatomy	Structures that can be examined without using a microscope
Systemic anatomy	Structure of specific systems of the body such as the nervous or respiratory systems
Regional anatomy	Specific regions of the body such as the head or chest
Surface anatomy	Surface markings of the body to understand the relationships of deep or internal anatomy through visualization and palpation (gentle touch)
Imaging anatomy	Internal body structures that can be visualized with x-rays, CT scans, MRI, and other technologies
Pathological anatomy (path′-ō-LOJ-i-kal; *path-*=disease)	Structural changes (from gross to microscopic) associated with disease

CLINICAL CONNECTION | *Noninvasive Diagnostic Techniques*

Several noninvasive diagnostic techniques are commonly used by health-care professionals and students to assess certain aspects of body structure and function. A **noninvasive diagnostic technique** is one that does not involve insertion of an instrument or device through the skin or into a body opening. In **inspection**, the first noninvasive diagnostic technique, the examiner observes the body for any changes that deviate from normal (Figure A). For example, a physician may examine the mouth cavity for evidence of disease. In **palpation** (pal-PĀ-shun; *palpa-*=to touch) the examiner feels body surfaces with the hands (Figure B). An example is palpating the neck to detect enlarged or tender lymph nodes. In **auscultation** (aus′-cul-TĀ-shun; *ausculta-*=to listen to) the examiner listens to body sounds to evaluate the functioning of certain organs, often using a stethoscope to amplify the sounds (Figure C). An example is auscultation of the lungs during breathing to check for crackling sounds associated with abnormal fluid accumulation in the air spaces of the lungs. In **percussion** (pur-KUSH-un; *percus-*=to beat) the examiner taps on the body surface with the fingertips and listens to the resulting sound. Hollow cavities or spaces produce a different sound than solid organs do (Figure D). For example, percussion may reveal the abnormal presence of fluid in the lungs or air in the intestines. It is also used to reveal the size, consistency, and position of an underlying structure. An understanding of anatomy is important for the effective application of most of these techniques. Also, clinicians use these terms and others covered in this chapter to annotate their findings following a clinical examination. •

Gary Conner/Phototake

(A) Inspection of oral (mouth) cavity

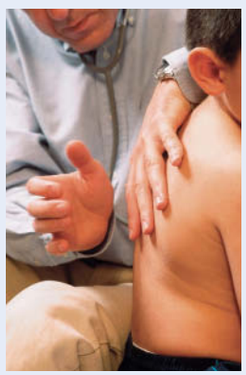


©La/Bc.Aigo/Phototake

(B) Palpation of lymph nodes in neck

Jose Luis Pelaez/Getty Images, Inc.

(C) Auscultation of lungs



Malvina Mendil/Science Source Inc

(D) Percussion of lungs

1.2 LEVELS OF BODY ORGANIZATION AND BODY SYSTEMS

OBJECTIVES

- Describe the levels of structural organization that make up the human body.
- Outline the 11 systems of the human body, list the organs present in each, and explain their general functions.

The levels of organization of a language—letters of the alphabet, words, sentences, paragraphs, and so on—can be compared to the levels of organization of the human body. Your exploration of the human body will extend from some of the smallest body structures and their functions to the largest structure—an entire person. Organized from smallest to largest, six levels of organization will help you to understand anatomy: the chemical, cellular, tissue, organ, system, and organismal levels of organization (Figure 1.1).

1. The **chemical level**, which can be compared to the *letters of the alphabet*, includes **atoms**, the smallest units of matter that participate in chemical reactions, and **molecules**, two or more atoms joined together. Certain atoms, such as carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), and calcium (Ca), are essential for life. Two familiar molecules found in the body are deoxyribonucleic acid (DNA), the genetic material passed from one generation to the next, and glucose, commonly known as blood sugar.
2. At the **cellular level**, molecules combine to form cells, which can be compared to assembling letters into words. **Cells** are structures composed of chemicals and are the basic structural and functional units of an organism. Just as *words* are the smallest building blocks of language, cells are the smallest living units in the human body. Among the many kinds of cells in your body are muscle cells, nerve cells, and blood cells. Figure 1.1 shows a smooth muscle cell, one of three types of muscle cells in the body. The cellular level of organization is the focus of Chapter 2.
3. The next level of structural organization is the **tissue level. Tissues** are groups of cells and the materials surrounding them that work together to perform a particular function, similar to the way words are put together to form *sentences*. There are just four basic types of tissue in your body: epithelial tissue, connective tissue, muscular tissue, and nervous tissue. *Epithelial tissue* covers body surfaces, lines hollow organs and cavities, and forms glands. *Connective tissue* connects, supports, and protects body organs while distributing blood vessels to other tissues. *Muscular tissue* contracts (shortens) to make body parts move and generates heat. *Nervous tissue* carries information from one part of the body to another. Chapter 3 describes the tissue level of organization in greater detail. Shown in Figure 1.1 is smooth muscle tissue, which consists of tightly packed smooth muscle cells.
4. At the **organ level,** different types of tissues are joined together. Similar to the relationship between sentences and *paragraphs*, **organs** are structures that are composed of two or more different types of tissues; they have specific functions and usually have recognizable shapes. Examples of organs are the stomach, heart, liver, lungs, and brain. Figure 1.1 shows how several tissues make up the stomach. The stomach's outer covering is a layer of epithelial and connective tissues that reduces friction when the stomach moves and rubs against other organs. Underneath these layers is a type of muscular tissue called *smooth muscle tissue*, which contracts to churn and mix food and

push it on to the next digestive organ, the small intestine. The innermost lining, the epithelial tissue layer, produces fluid and chemicals responsible for digestion in the stomach.

5 The next level of structural organization in the body is the **system level,** also called the *organ-system level*. A **system** (or *chapter* in our language analogy) consists of related organs (paragraphs) with a common function. An example is the digestive system, which breaks down and absorbs food. Its organs include the mouth, salivary glands, pharynx (throat), esophagus (tube that carries food from the throat to the stomach), stomach, small intestine, large intestine, liver, gallbladder, and pancreas. Sometimes an organ is part of more than one system. For example, the pancreas, which has multiple functions, is included in the digestive and endocrine systems.

6 The largest organizational level is the **organismal level.** An **organism** (OR-ga-nizm), any living individual, can be compared to a *book* in our analogy. All the parts of the human body functioning together constitute the total organism.

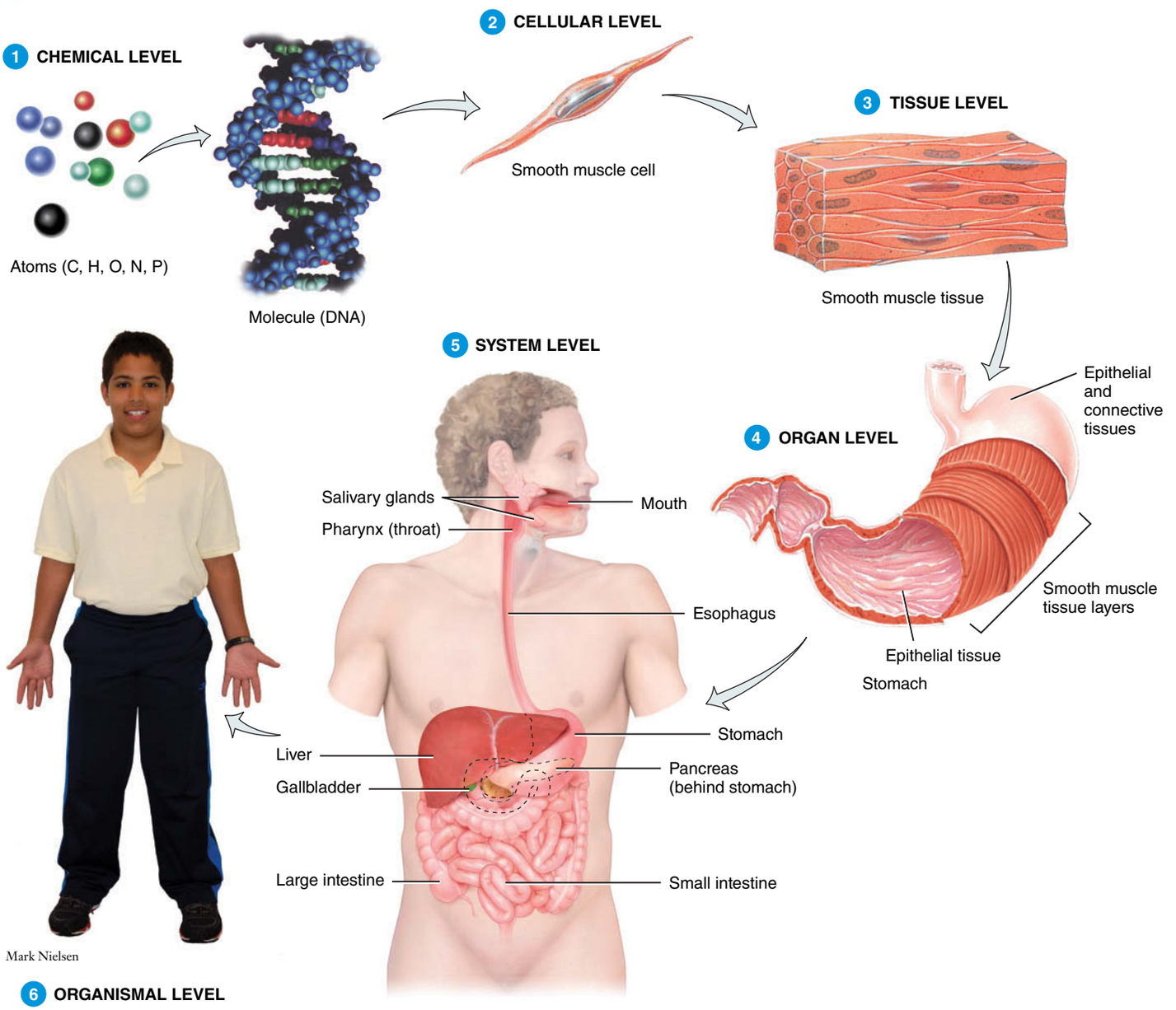
In the following chapters, you will study the anatomy and some physiology of the body systems. Table 1.2 introduces the components and functions of these systems in the order they are discussed in the book.

CHECKPOINT

3. Define the following terms: atom, molecule, cell, tissue, organ, system, and organism.
4. Which body systems help eliminate wastes? (*Hint:* Refer to Table 1.2.)

Figure 1.1 Levels of structural organization in the human body.

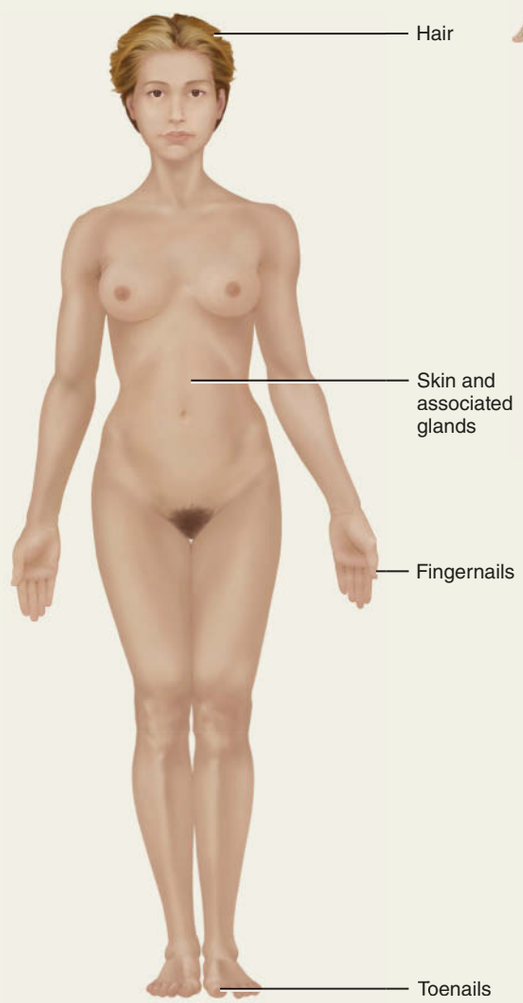
The levels of structural organization are chemical, cellular, tissue, organ, system, and organismal.



Which level of structural organization is composed of two or more different types of tissues that work together to perform a specific function?

TABLE 1.2

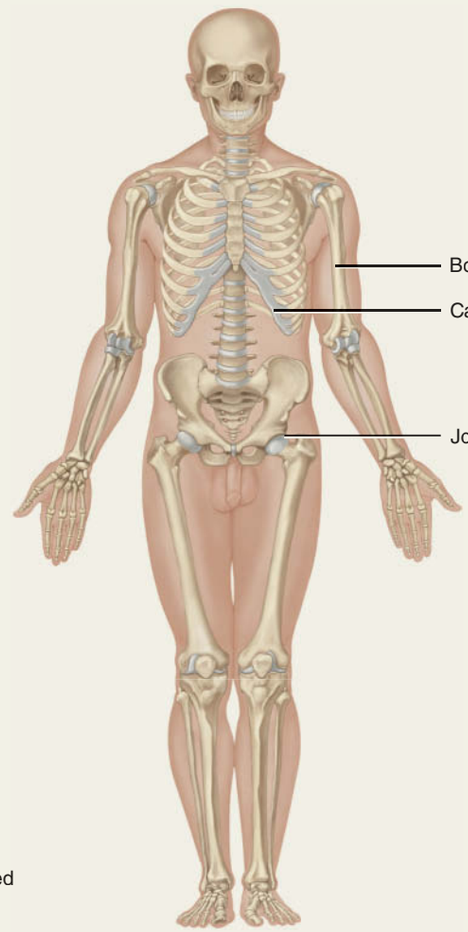
The Eleven Systems of the Human Body



INTEGUMENTARY SYSTEM (CHAPTER 5)

Components: **Skin**, and structures associated with it, such as **hair**, **fingernails** and **toenails**, **sweat glands**, and **oil glands** and the **subcutaneous layer**.

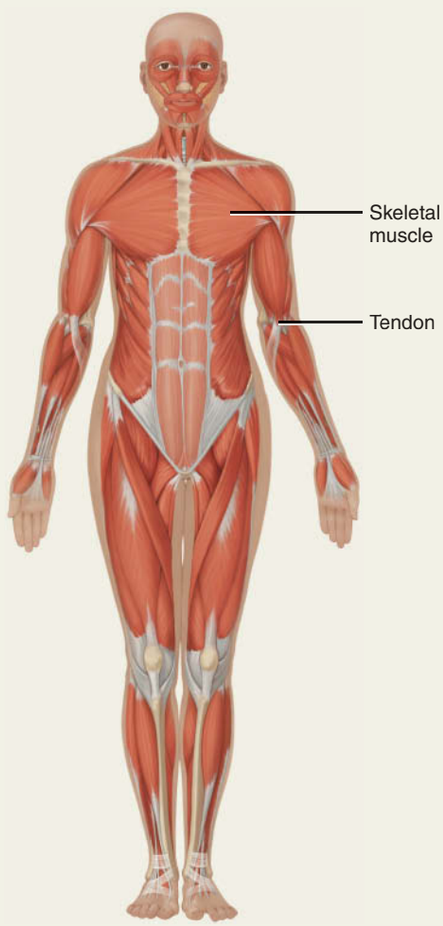
Functions: Protects the body; helps regulate body temperature; eliminates some wastes; helps make vitamin D; detects sensations such as touch, pain, warmth, and cold; stores fat; provides insulation.



SKELETAL SYSTEM (CHAPTERS 6–9)

Components: **Bones** and **joints** of the body and their associated **cartilages**.

Functions: Supports and protects the body; provides a surface area for muscle attachments; aids body movements; houses cells that produce blood cells; stores minerals and lipids (fats).



MUSCULAR SYSTEM (CHAPTERS 10, 11)

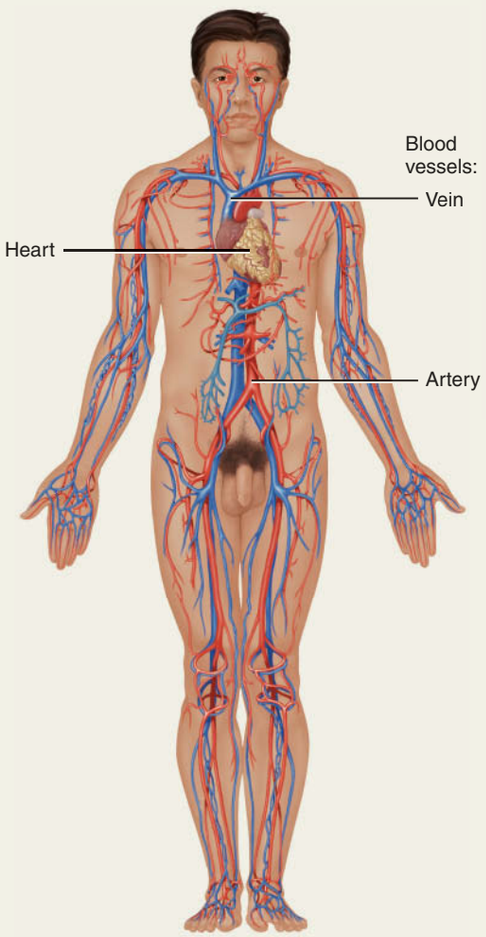
Components: Specifically refers to **skeletal muscle tissue**, which is muscle usually attached to bones (other muscle tissues include smooth and cardiac).

Functions: Participates in bringing about body movements, such as walking; maintains posture; and produces heat.

TABLE 1.2 CONTINUES

TABLE 1.2 CONTINUED

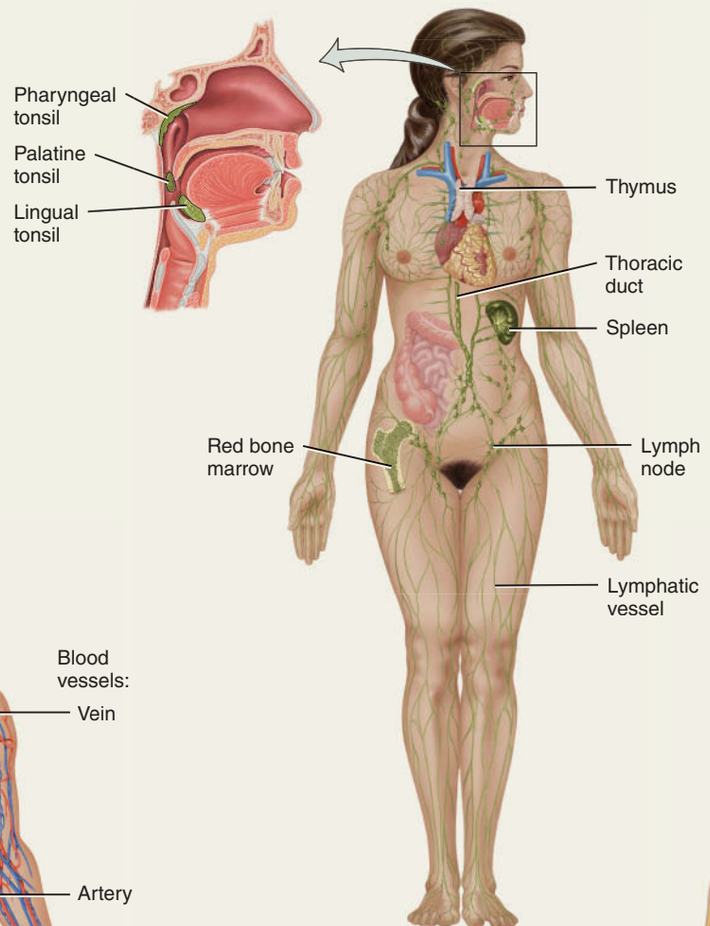
The Eleven Systems of the Human Body



CARDIOVASCULAR SYSTEM (CHAPTERS 12–14)

Components: **Blood**, **heart**, and **blood vessels**.

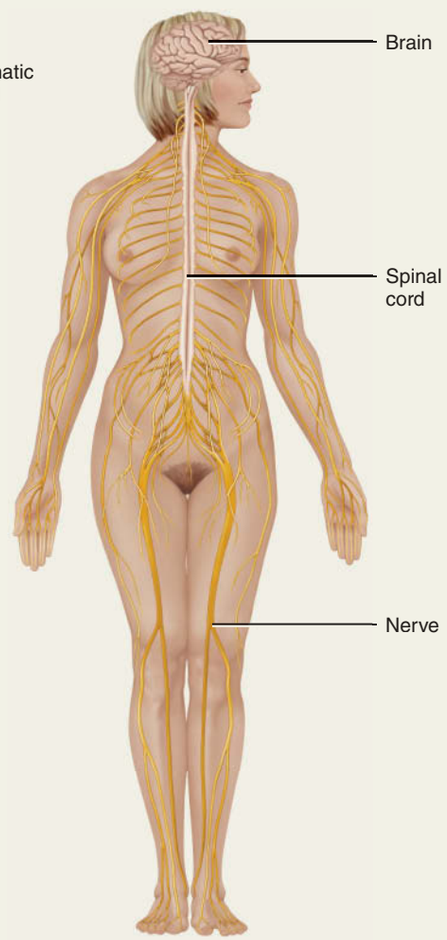
Functions: Heart pumps blood through blood vessels; blood carries oxygen and nutrients to cells and carbon dioxide and wastes away from cells and helps regulate acid–base balance, temperature, and water content of body fluids; blood components help defend against disease and repair damaged blood vessels.



LYMPHATIC SYSTEM AND IMMUNITY (CHAPTER 15)

Components: **Lymphatic fluid**, **lymphatic vessels**, **spleen**, **thymus**, **lymph nodes**, and **tonsils**; cells that carry out immune responses (**B cells**, **T cells**, and others).

Functions: Returns proteins and fluid to blood; carries lipids from gastrointestinal tract to blood; contains sites of maturation and proliferation of B cells and T cells that protect against disease-causing microbes.



NERVOUS SYSTEM (CHAPTERS 16–21)

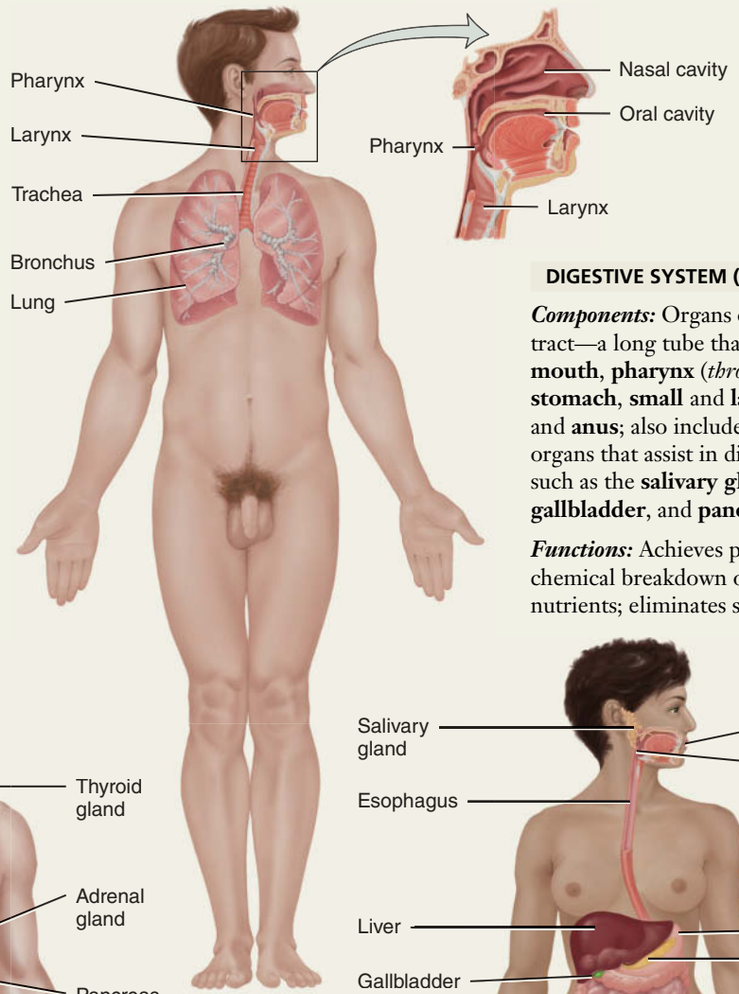
Components: **Brain**, **spinal cord**, **nerves**, and special sense organs, such as the **eyes** and **ears**.

Functions: Generates action potentials (nerve impulses) to regulate body activities; detects changes in the body's internal and external environments, interprets the changes, and responds by causing muscular contractions or glandular secretions.

RESPIRATORY SYSTEM (CHAPTER 23)

Components: **Lungs** and air passageways such as the **pharynx** (*throat*), **larynx** (*voice box*), **trachea** (*windpipe*), and **bronchial tubes** within the lungs.

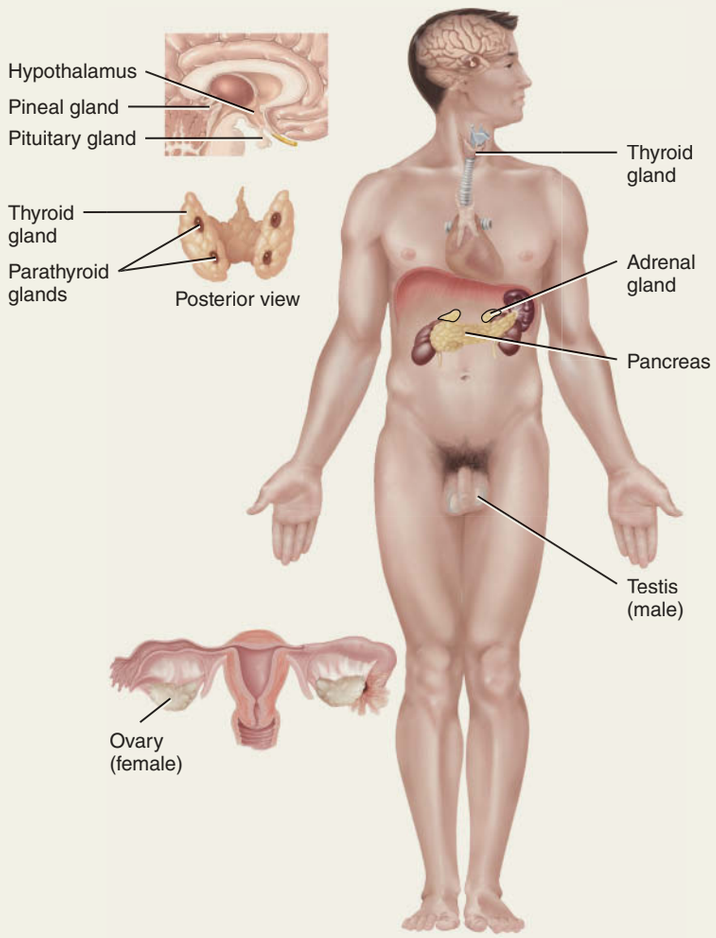
Functions: Transfers oxygen from inhaled air to blood and carbon dioxide from blood to exhaled air; helps regulate acid–base balance of body fluids; air flowing out of lungs through vocal cords produces sounds.



ENDOCRINE SYSTEM (CHAPTER 22)

Components: Hormone-producing glands (**pineal gland**, **hypothalamus**, **pituitary gland**, **thymus**, **thyroid gland**, **parathyroid glands**, **adrenal glands**, **pancreas**, **ovaries**, and **testes**) and hormone-producing cells in several other organs.

Functions: Regulates body activities by releasing hormones, which are chemical messengers transported in blood from an endocrine gland or tissue to a target organ.



DIGESTIVE SYSTEM (CHAPTER 24)

Components: Organs of gastrointestinal tract—a long tube that includes the **mouth**, **pharynx** (*throat*), **esophagus**, **stomach**, **small** and **large intestines**, and **anus**; also includes accessory organs that assist in digestive processes, such as the **salivary glands**, **liver**, **gallbladder**, and **pancreas**.

Functions: Achieves physical and chemical breakdown of food; absorbs nutrients; eliminates solid wastes.

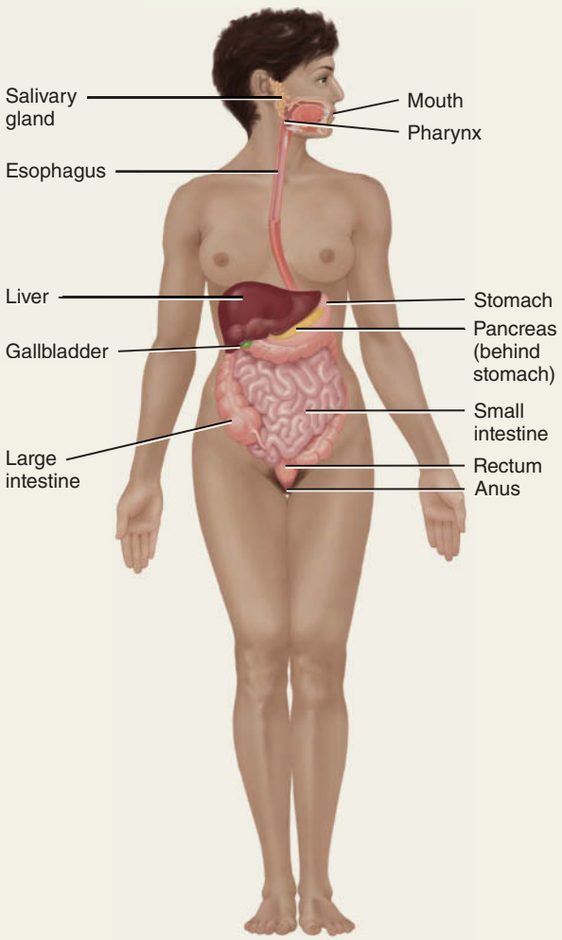
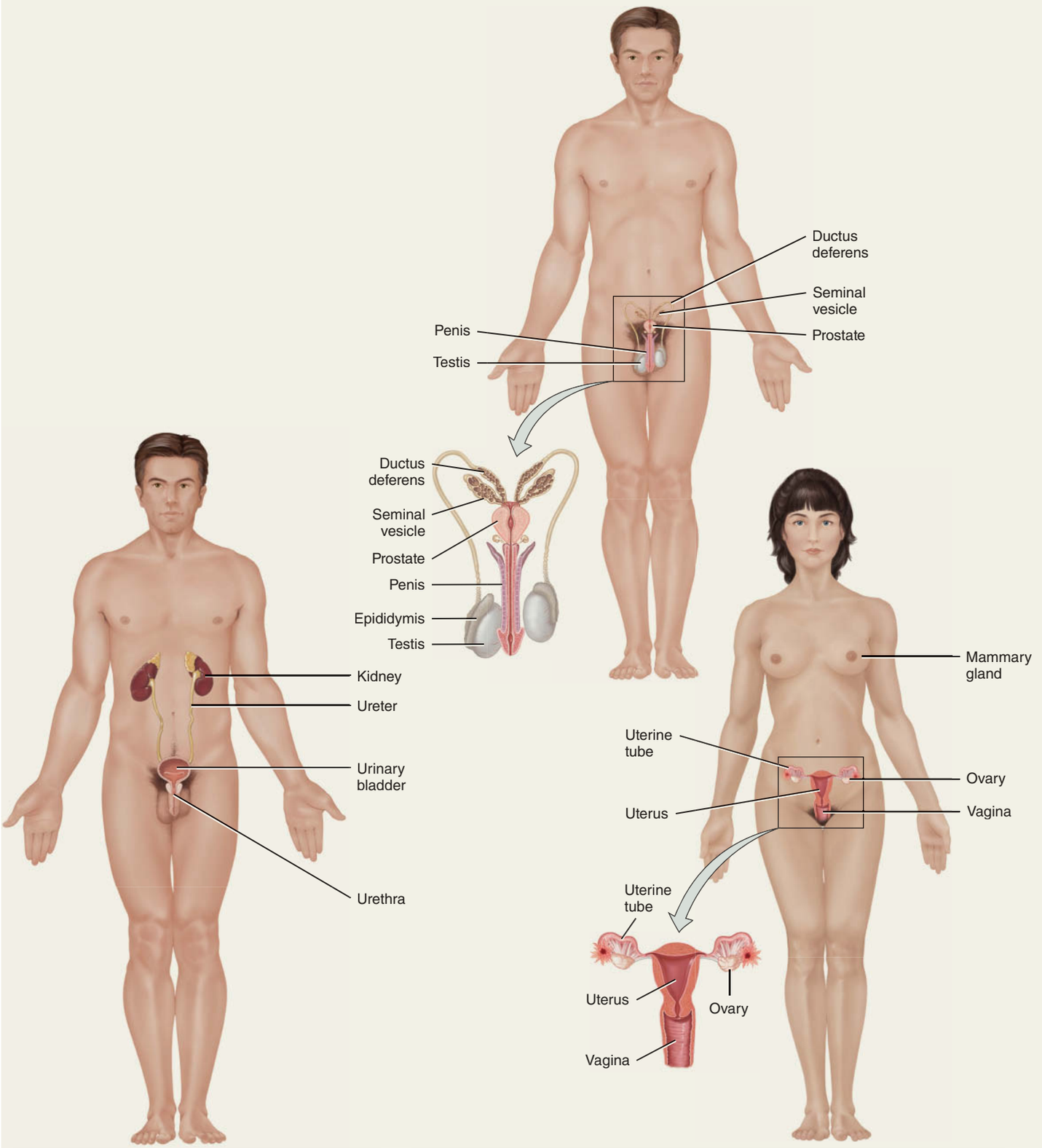


TABLE 1.2 CONTINUES

TABLE 1.2 CONTINUED

The Eleven Systems of the Human Body



URINARY SYSTEM (CHAPTER 25)

Components: **Kidneys**, **ureters**, **urinary bladder**, and **urethra**.

Functions: Produces, stores, and eliminates urine; eliminates wastes and regulates volume and chemical composition of blood; helps maintain the acid–base balance of body fluids; maintains body's mineral balance; helps regulate production of red blood cells.

REPRODUCTIVE SYSTEMS (CHAPTER 26)

Components: **Gonads** (**testes** in males and **ovaries** in females) and associated organs (such as the **uterine** (*fallopian*) **tubes**, **uterus**, and **vagina** in females and **epididymides**, **seminal vesicles**, **prostate**, **ductus** (*vas*) **deferenses**, and **penis** in males).

Functions: Gonads produce gametes (sperm or oocytes) that unite to form a new organism; gonads also release hormones that regulate reproduction and other body processes; associated organs transport and store gametes; mammary glands produce milk.

1.3 LIFE PROCESSES

OBJECTIVE

- Define the important life processes of humans.

All living organisms have certain characteristics that set them apart from nonliving things. The following are six important life processes of humans:

1. **Metabolism** (me-TAB-ō-lizm) is the sum of all the chemical processes that occur in the body. It includes the breakdown of large, complex molecules into smaller, simpler ones and the building up of complex molecules from smaller, simpler ones.
2. **Responsiveness** is the body's ability to detect and respond to changes in its environment. Nerve cells respond to changes in the environment by generating electrical signals, known as nerve impulses. Muscle cells respond to nerve impulses by contracting, which generates force to move body parts.
3. **Movement** includes motion of the whole body, individual organs, single cells, and even tiny organelles inside cells.
4. **Growth** is an increase in body size. It may be due to an increase in (1) the size of existing cells, (2) the number of cells, or (3) the amount of material surrounding cells.
5. **Differentiation** (dif′-er-en-shē-Ā-shun) is the process whereby unspecialized cells become specialized cells. Specialized cells differ in structure and function from the unspecialized cells that gave rise to them. For example, a single fertilized egg cell undergoes tremendous differentiation to develop into a unique individual who is similar to, yet quite different from, either of the parents.
6. **Reproduction** (rē-prō-DUK-shun) refers to either (1) the formation of new cells for growth, repair, or replacement or (2) the production of a new individual.

Although not all of these processes are occurring in cells throughout the body all of the time, when they cease to occur properly cell death may occur. When cell death is extensive and leads to organ failure, the result is death of the organism.

CHECKPOINT

5. What are the different meanings for growth?

1.4 BASIC ANATOMICAL TERMINOLOGY

OBJECTIVES

- Describe the orientation of the human body in the anatomical position.
- Relate the common names to the corresponding anatomical descriptive terms for various regions of the human body.
- Define the anatomical planes, the anatomical sections, and the directional terms used to describe the human body.

Scientists and health-care professionals use a common language of special terms when referring to body structures and their functions. The language of anatomy has precisely defined meanings that allow us to communicate clearly and unambiguously. For example, take the statement "The wrist is above the fingers." This might be true if your upper limbs (described shortly) are at your sides. But if you held your hands up above your head, your fingers would be above your wrists. To prevent this kind of confusion, anatomists use a standard anatomical position and a special vocabulary for relating body parts to one another.

Anatomical Position

In anatomy, the **anatomical position** (an′-a-TOM-i-kal) is the standard position of reference for the description of anatomical structures. In the anatomical position, the subject stands erect facing the observer, with the head level and the eyes facing directly forward. The lower limbs are parallel and the feet are flat on the floor and directed forward. The upper limbs are at the sides with the palms facing forward (Figure 1.2). With the body in the anatomical position, it is easier to visualize and understand its organization into various regions and describe relationships of various structures.

As just described, in the anatomical position, the body is upright. There are two terms used to describe a reclining body. If the body is lying face down, it is in the **prone** position. If the body is lying face up, it is in the **supine** position.

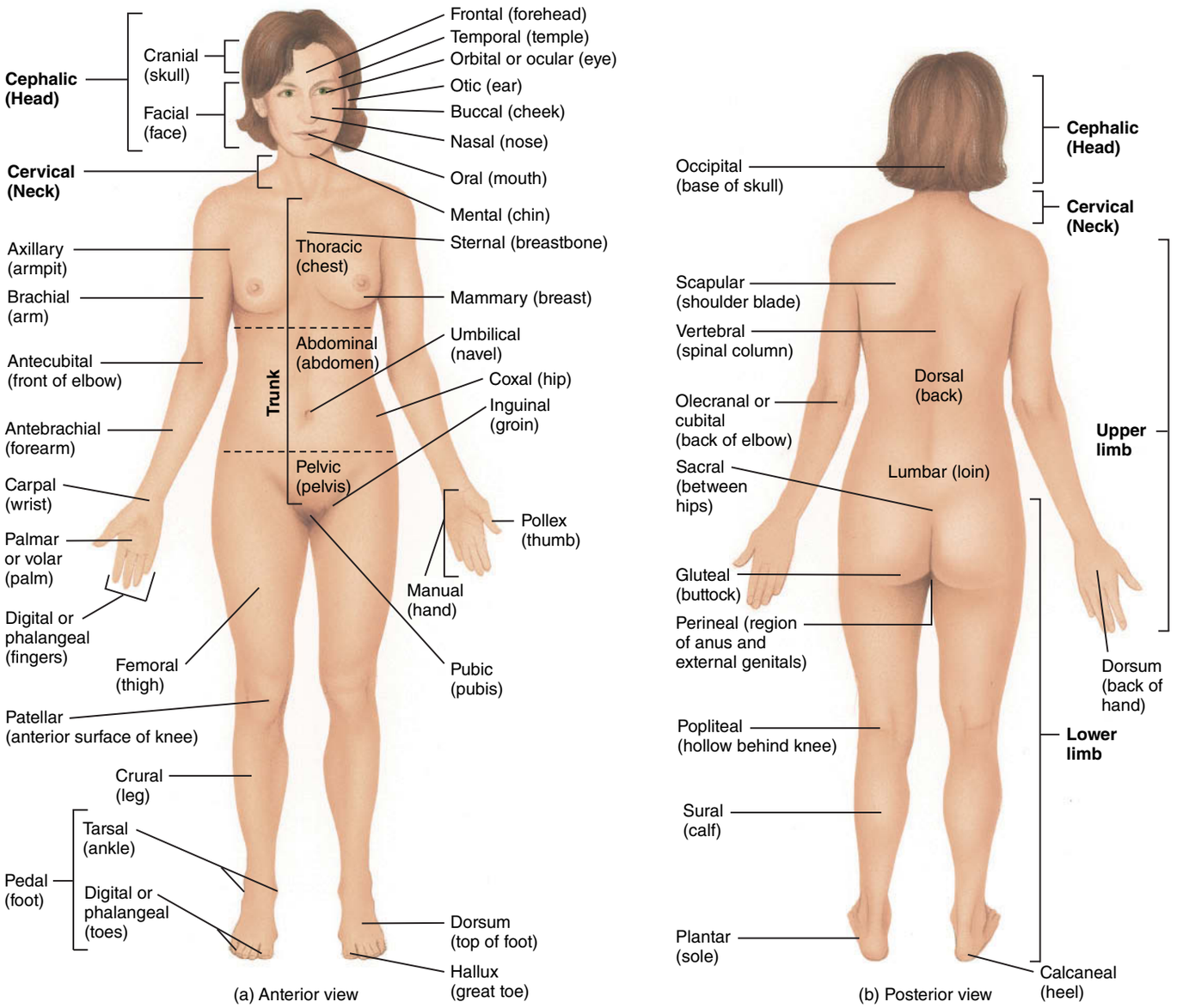
Regional Names

The human body is divided into several major regions that can be identified externally. These are the head, neck, trunk, upper limbs, and lower limbs. The **head** consists of the skull and face. The *skull* encloses and protects the brain, while the *face* is the front portion of the head that includes the eyes, nose, mouth, forehead, cheeks, and chin. The **neck**, a modified portion of the trunk, supports the head and attaches it to the remainder of the trunk. The **trunk** consists of the *neck*, *thorax*, *abdomen*, and *pelvis*. Each **upper limb** (*extremity*) is attached to the trunk and consists of the *shoulder*, *armpit*, *arm* (portion of the limb from the shoulder to the elbow), *forearm* (portion of the limb from the elbow to the wrist), *wrist*, and *hand*. Each **lower limb** (*extremity*) is also attached to the trunk and consists of the *buttock*, *thigh* (portion of the limb from the buttock to the knee), *leg* (portion of the limb from the knee to the ankle), *ankle*, and *foot*. The **groin** is the area on the front surface of the body marked by a crease on each side, where the trunk attaches to the thighs. Understanding the precise meaning of arm and forearm in the upper limb and thigh and leg in the lower limb is very important when reading or describing a clinical assessment.

Figure 1.2 shows the anatomical and common names of major parts of the body. The anatomical term appears first followed by the corresponding common name (in parentheses). For example, if you receive a tetanus shot in your *gluteal region*, it is in the *buttock*. Why is the anatomical term for a body part different from its common name? The anatomical term is based on a Greek or Latin word or "root." For example, the Latin word *axilla* (ak-SIL-a) is the armpit region. Thus, the axillary nerve is one of the nerves passing within the armpit region. Understanding the word roots of anatomical terms can help you learn the terms more easily. The word roots will become more familiar as you read this book, so by the time you finish the course you'll be able to tell your roommate with confidence that the funnybone she just hit on the door jamb is the olecranon

Figure 1.2 The anatomical position. The anatomical names and corresponding common names (in parentheses) are indicated for specific body regions. For example, the cephalic region is the head.

In the anatomical position, the subject stands erect facing the observer with the head level and the eyes facing forward. The lower limbs are parallel and the feet are flat on the floor and directed forward, and the upper limbs are at the sides with the palms facing forward.



Why is it important to define one standard anatomical position?

region (elbow) of her brachium (arm) (not that it will help much with the pain).

Planes and Sections

As you have just seen, referencing various body regions enables you to study the surface anatomy of the body. It is also possible to study the internal structure of the body by slicing the body in different ways and examining the sections. The terms that follow describe the different planes and sections you will encounter in your anatomical studies; they are also used in many medical procedures. **Planes** are imaginary flat surfaces that pass through the body (Figure 1.3). A **sagittal plane** (SAJ-i-tal; *sagitta-*=arrow) is a vertical plane that divides the body or organ into right and left sides. More specifically, when such a plane passes through the midline of the body and divides it into *equal* right and left sides, it is called a **midsagittal plane**, or a *median plane*. The *midline* is an imaginary vertical line that divides the body into equal left and right sides. If the sagittal plane does not pass through the midline but instead divides the body into *unequal* right and left sides, it is called a **parasagittal plane** (*para-*=beside, near). A **frontal**, or *coronal*, *plane* (kō-RŌ-nal; *corona*=crown) divides the body or an organ into front and back portions. A **transverse plane** divides the body or an