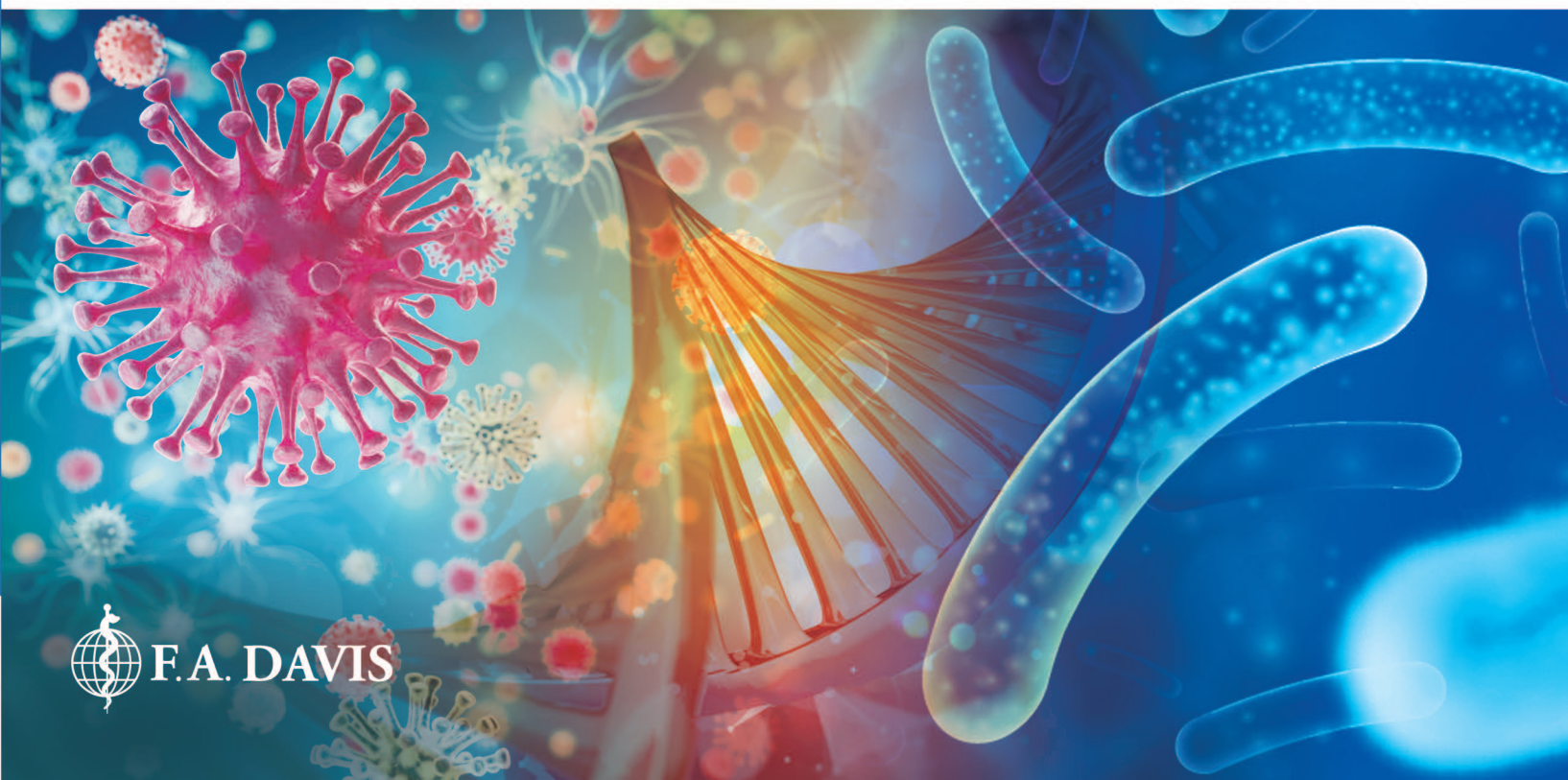
THOMPSON

UNDERSTANDING ANATOMY & PHYSIOLOGY

A Visual, Auditory, Interactive Approach

THIRD EDITION



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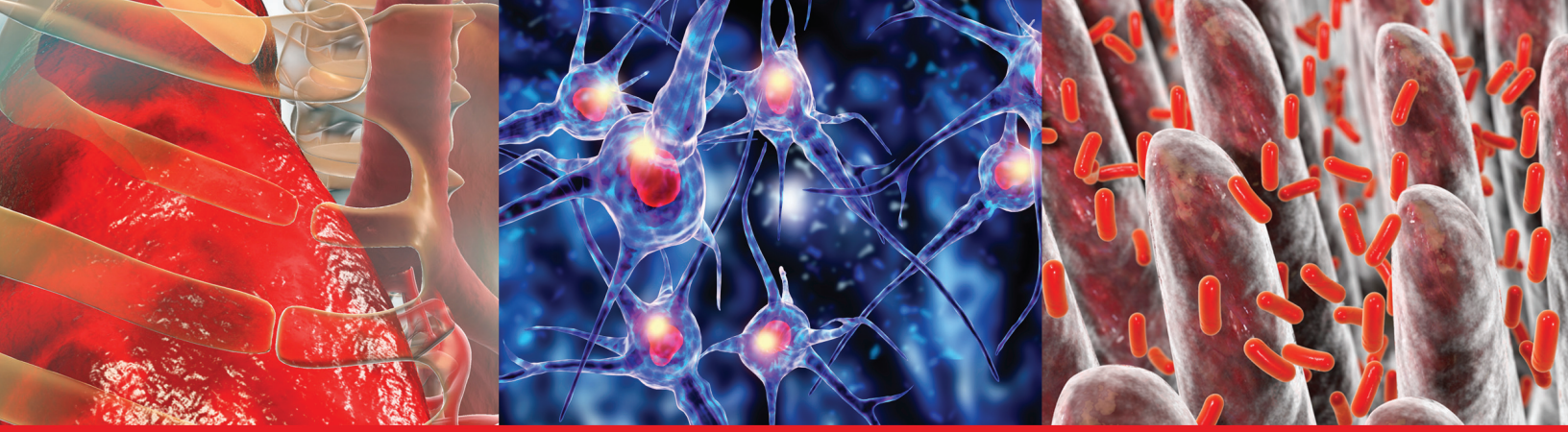


UNDERSTANDING ANATOMY & PHYSIOLOGY

A Visual, Auditory, Interactive Approach

THIRD EDITION

YOUR GUIDE TO...

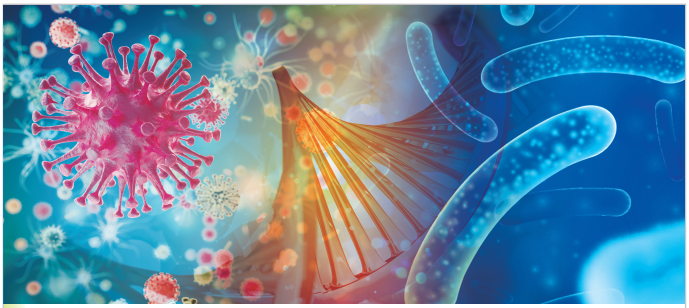
THIRD EDITION

UNDERSTANDING ANATOMY & PHYSIOLOGY

A Visual, Auditory, Interactive Approach

Gale Sloan Thompson

Master the language of A&P
New terms are defined right in the text, making it easy for you to build an A&P vocabulary.



CHAPTER OUTLINE

- Importance of the Microbiome
- Building a Microbiome
- Stages of Microbiome Development
- Boosting the Microbiome
- Components of the Microbiome

LEARNING OUTCOMES

1. Describe the findings of the Human Microbiome Project.
2. Describe the components of a microbiome, including how microbiomes differ across sites on the body as well as between individuals.
3. Discuss why the microbiome is important for overall health.
4. Describe the stages in microbiome development.
5. Identify factors that can boost microbiome diversity.
6. Identify factors that can threaten the health of the microbiome.
7. Identify the structural components of bacteria.
8. Identify the structural components of viruses.
9. Describe the characteristics of archaea and explain how they differ from bacteria.
10. Explain how a disruption in the microbiome can occur.
11. Describe some of the ways a disruption in the microbiome can affect health.

Guide your learning
"Learning Outcomes" at the beginning of each chapter outline the knowledge you should be able to demonstrate when you've completed the chapter.

chapter 4

Human Microbiome

The trillions of microorganisms living on and in the human body play a key role in regulating metabolism, immune function, and even behavior.

For decades, bacteria have been viewed as forerunners of disease, something to be avoided or eradicated. In actuality, every healthy adult houses more than 100 trillion microorganisms. In other words, your body contains more microbes than it does human cells. This community of microbes—known as the **human microbiome**—is essential for human life, so much so that many experts say it should be considered an organ system in its own right.

Although scientists have long been aware that bacteria live on the human body, many of these microbes resist being cultured and grown in a laboratory. It wasn't until the advent of sophisticated DNA sequencing technology, and the subsequent completion of the Human Microbiome Project, that scientists caught a glimpse of this unseen world. (See "Life lesson: The Human Microbiome Project" on the next page.)

The individual microorganisms found within the microbiome work constantly on our behalf: They digest food, synthesize vitamins, and form a barricade against disease-causing bacteria. Recent research suggests that bacteria even alter brain chemistry, which could affect mood and behavior.

Furthermore, when the composition of the microbiome is disrupted, such as by an excess of a specific bacteria or, more often, through the use of broad-spectrum antibiotics, disease can result. In fact, imbalances in the microbiome are linked to numerous disorders, including diabetes, heart disease, asthma, multiple sclerosis, obesity, inflammatory bowel disease, autism, and even cancer.

This view of the body as a vast, changeable ecosystem is transforming how medicine is practiced. Instead of simply combating bacteria, practitioners are recognizing the need to cultivate and nurture the bacterial communities within our bodies.

What's more, experts look toward a future when they can map each individual's signature microbiome. Knowing someone's microbial fingerprint will allow practitioners to monitor the microbial balance, making adjustments as needed to prevent disease. If disease does occur, the same microbial fingerprint can help guide treatment. Indeed, exploration of the human microbiome has opened the door to truly personalized medicine.

FAST FACT

If gathered together, the microorganisms that inhabit the human body would occupy a space about the size of the liver and weigh approximately 3 pounds.

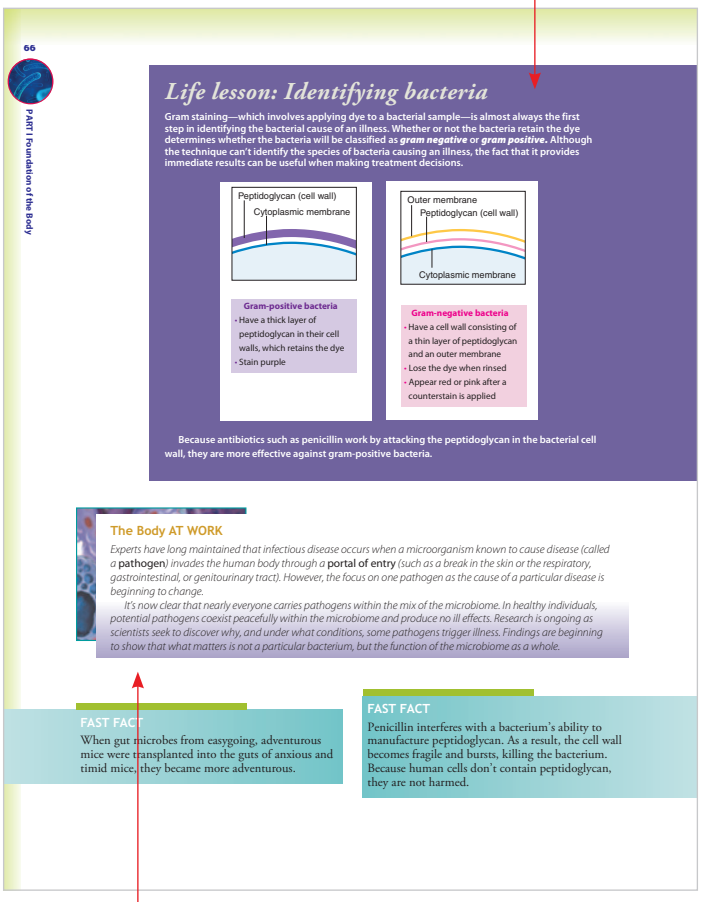
Expand your knowledge
"Fast Facts" are important points of information related to specific body systems that help you build a firm foundation in A&P.

DESIGNED FOR HOW YOU LEARN

Whatever your learning style… looking, listening, doing, or a little bit of each… this interactive approach to anatomy & physiology is designed just for you.

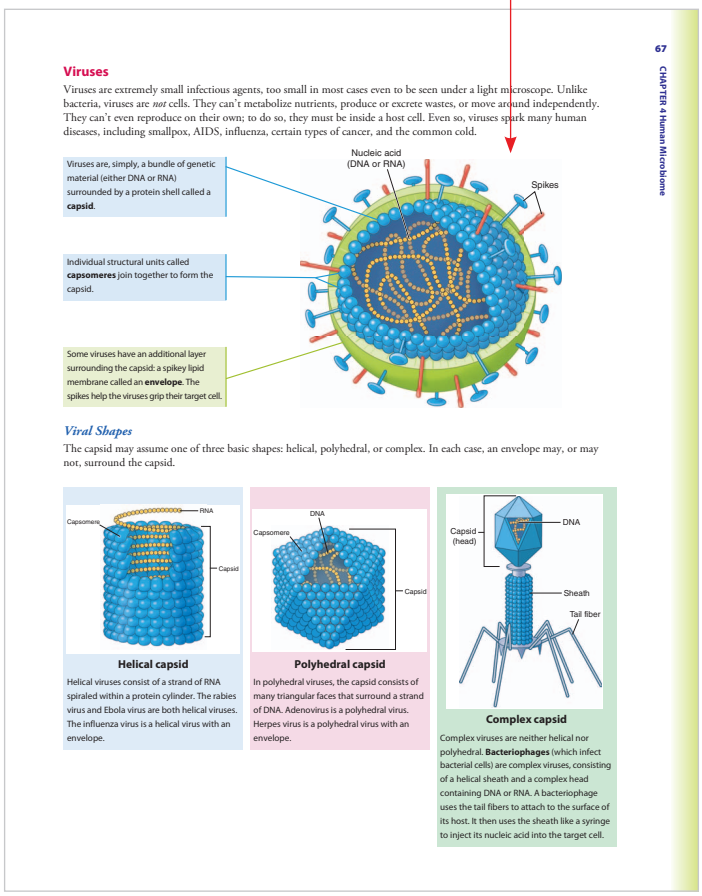
Explore real-life examples

"Life Lesson" boxes make anatomy and physiology pertinent to daily life by applying material to clinical situations.



Build mastery step by step

Detailed illustrations and concise explanations work together to make often complex concepts easy to understand and easy to remember.



Understand how the body functions

"The Body at Work" describes specific physiological processes, explaining their hows and whys.

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Build your vocabulary

A "Review of Terms" lets you quickly locate short definitions for the key terms in every chapter. Use the audio glossary online at **FADavis.com** to hear pronunciations of the terms.

Identify your strengths and weaknesses

Answer the "Test Your Knowledge" questions at the end of every chapter to make sure you understand the material while you assess your progress.

Review of Key Terms

Archaea: Extremely diverse microscopic, single-celled organisms that do not contain a nucleus; comprise one of the three domains of life, along with bacteria and complex life

Bacilli: Rod-shaped bacteria

Bacteria: Single-celled microscopic organisms that are the chief inhabitants of the microbiome

Bacteriophage: Complex virus that attaches to surface of a host and then uses a sheath-like syringe to inject its nucleic acid into the target cell.

Capsid: Protein shell that surrounds viral genetic material

Capsomeres: Individual structural units forming the viral capsid

Capsule: Gelatinous covering that keeps the bacterium from drying out

Cocci: Round or spherically-shaped bacteria

Dysbiosis: The term for microbial imbalance inside the body

Envelope: Spikey lipid membrane surrounding some viruses

Gram stain: Staining technique used to classify bacteria into one of two groups

Microbe: Microscopic organism, including bacteria, viruses, and fungi

Microbiota: The microbes within an individual microbial community (such as in the mouth or the gut)

Microbiome: The full complement of microbes (including bacteria, viruses, fungi, and archaea) living in and on the human body

Mycobiome: The community of fungi living on and in the human body

Pathogen: Disease-causing microorganism

Peptidoglycan: Substance in a bacterial cell wall; used to help identify bacteria as being gram negative or positive

Pili: Small, hair-like projections that allow bacteria to attach to other cells and surfaces

Plasmids: Small loops of bacterial DNA that allow DNA to be transferred from one bacterium to another

Portal of entry: Pathway by which infectious organisms gain access to the body

Prebiotic: Food
indigestible fibers
feed healthy bacte

Probiotic: Supp
beneficial live bac
seed the gut with

Spirilla: Spiral-s

Virus: Ultramicr
consisting of a nu
protein shell

Own the Information

To make the information in this chapter part of your working memory, take some time to reflect on what you've learned. On a separate sheet of paper, write down everything you recall from the chapter. After you're done, log on to the Davis*Plus* website, and check out the Study Group podcast and Study Group Questions for the chapter.

Key Topics for Chapter 4:

- Findings of the Human Microbiome
- Why the microbiome is important
- How individuals acquire their microl
- Role of the microbiome in health an
- Stages in the development of the mic
- Ways to enhance and nourish the mi
- Components of the microbiome
- Effect of antibiotics on the microbio
- Structural components of bacteria
- Structural components of viruses
- How viruses replicate
- Role of archaea and fungi in the mic

Build a complete understanding

"Own the information" is a detailed plan of study that shows you how to absorb what you need to know about the most important concepts.

Test Your Knowledge

1. What was the goal of the Human Microbiome Project?
   a. To sequence the human genome
   b. To identify disease-causing microorganisms
   c. To identify microorganisms residing within and on healthy adults
   d. To discover whether bacteria contain DNA
2. The Human Microbiome Project discovered that healthy adults:
   a. harbor more bacterial cells than they have human cells.
   b. harbor a significant number of bacterial cells but still have more human cells than bacterial cells.
   c. have no bacterial cells, confirming that bacteria cause disease.
   d. harbor very few bacterial cells.
3. What is the most significant step in microbiome development?
   a. The introduction of solid food
   b. Bottle feeding
   c. Administration of immunizations
   d. The birth process
4. Which statement about the human microbiome is most accurate?
   a. Every healthy adult carries a mix of microorganisms that is basically similar, except for a few minor variations.
   b. The components of the microbiome are basically the same from one part of the body to another.
   c. The components of the microbiome vary considerably between sites on the body and between individuals.
   d. A healthy microbiome should be free from any disease-causing bacteria.
5. Which statement about bacteria is most accurate?
   a. Bacteria are microscopic cells that contain a nucleus and organelles.
   b. The one consistent feature among all bacterial species is the composition of the cell wall.
   c. Bacteria have the ability to transmit DNA from one bacterium to another.
   d. All bacteria have the same basic shape.
6. What effect do bacterial genes have on human health?
   a. Bacterial genes exert some effect, although human DNA exerts a greater effect.
   b. Bacterial genes have just as great an influence on human health as human genes do.
   c. Bacteria within the microbiome stay within their own community; therefore, their genes do not influence health.
   d. Bacteria do not have genes.
7. What purpose does the capsule serve in bacteria?
   a. It gives the cell its shape.
   b. It regulates the flow of materials into and out of the cell.
   c. It synthesizes proteins.
   d. It helps ward off attack by larger microorganisms.
8. Which statement most accurately describes viruses?
   a. Viruses are not cells but, rather, are bundles of genetic material surrounded by a protein shell.
   b. Viruses are single-celled microscopic organisms that inhabit almost every environment on earth.
   c. Viruses are often categorized through Gram staining.
   d. Viruses have a cell wall that consists of peptidoglycan.
9. What is the most common way a person's microbiome can become disrupted?
   a. Acquisition of a bacterial infection
   b. Acquisition of a viral infection
   c. Ingestion of alcohol
   d. Use of broad-spectrum antibiotics
10. Imbalances in the microbiome have been linked to which of the following disorders?
    a. Asthma
    b. Heart disease
    c. Obesity
    d. All of the above
11. Which technology has been shown to be effective in treating *Clostridium difficile* infections?
    a. Lithotripsy
    b. Kidney transplant
    c. Blood transfusion
    d. Fecal transplant

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FADavis.com

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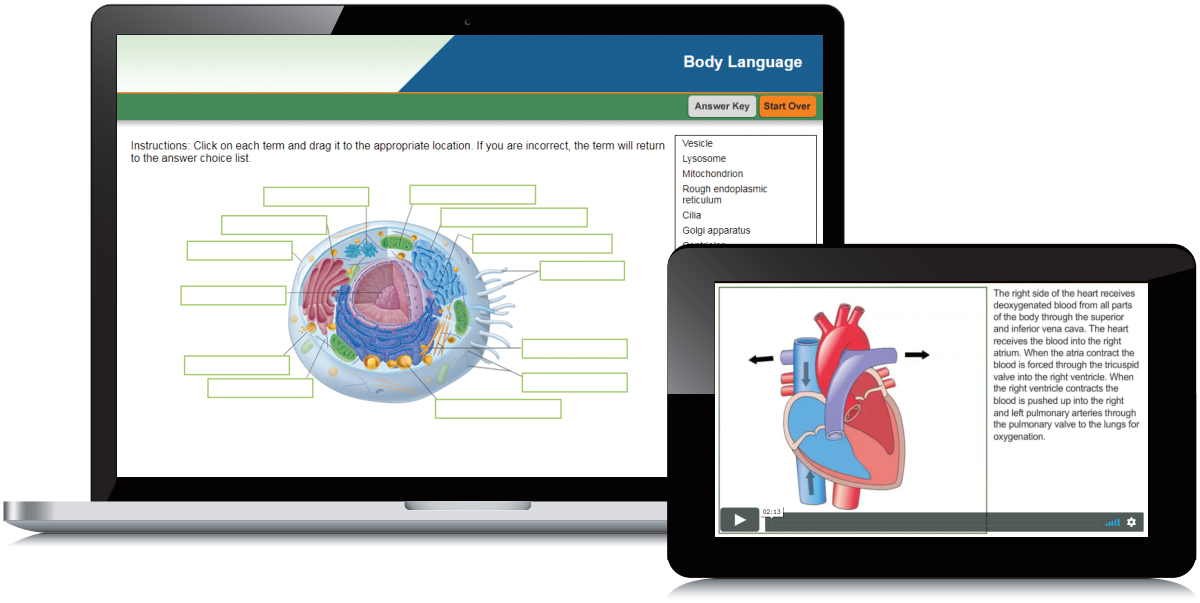
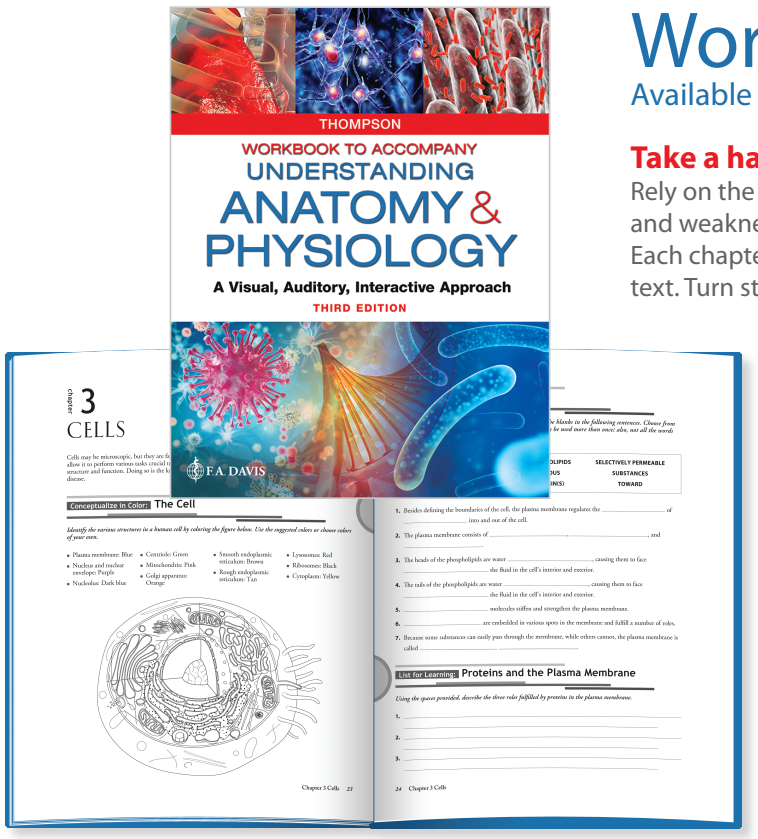


- **Animations**
  Watch the full-color animations that show you how physiological processes work while a narrator explains step by step.
- **Audio Glossary**
  Hear pronunciations of the key terms in the book.
- **Interactive Exercises**
  Complete the image-based "Body Language" labeling exercises as well as interactive matching exercises to find out what you know and don't know.
- **Flashcards**
  Read each chapter and then "Test Yourself" to make sure that you understand the material.
- **Audio Podcasts**
  Listen to the "Chapter in Brief" summary for each chapter and to students in a "Study Group" as they quiz each other.



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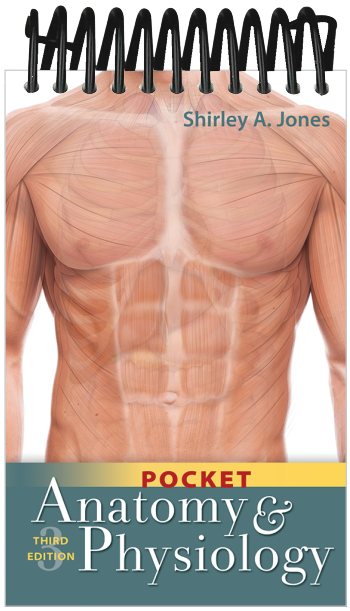
Workbook

Available for purchase separately.

Take a hands-on approach to A&P!

Rely on the Workbook to help you quickly identify your strengths and weaknesses and learn where to focus your study time. Each chapter in the Workbook corresponds to a chapter in the text. Turn study time into game time with…

- Conceptualize in Color
- Sequence of Events
- Puzzle It Out
- Make a Connection
- List for Learning
- Drawing Conclusions
- Fill in the Gaps
- Just the Highlights
- Describe the Process
- Illuminate the Truth



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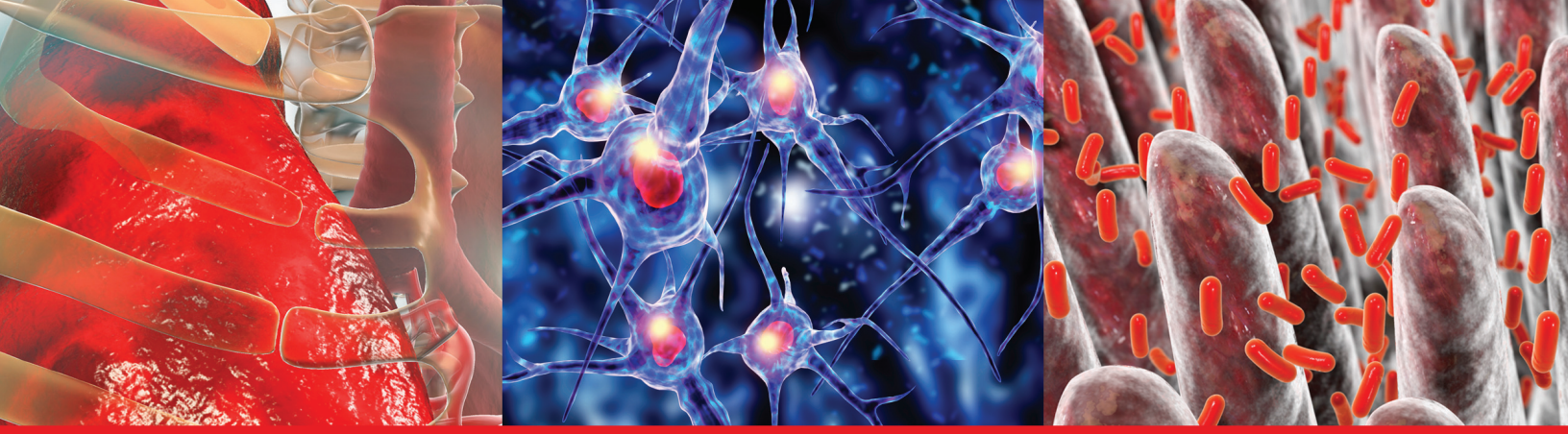

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THIRD EDITION

Gale Sloan Thompson, RN

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Preface

Even as you read this sentence, your body is performing amazing feats. Electrical impulses are rocketing through your brain at more than 200 miles per hour. Hundreds of muscles continually tense and relax to keep you in an upright position and to allow your eyes to track across the words on this page. A specific muscle—your heart—is contracting and relaxing at regular intervals to propel blood throughout your body. In fact, your blood will make two complete trips around your body before you finish reading this preface.

Even more amazing is the fact that the vast array of cells, tissues, organs, and organ systems making up your body arose from just two simple cells—an egg and a sperm. Consider, too, that you are genetically unique: out of the more than 6 billion people populating the earth, no two individuals are completely alike. That is reason to marvel.

Artists and scientists have long been captivated by the human body. For centuries, artists have studied the body's outward form, focusing on the movement and shape of muscles and bones when rendering works of art. Scientists, on the other hand, yearned to discover the mysteries inside the body. For almost 3,000 years, scientists have explored the depths of the human body: not just how it is put together, but how and why it functions as it does.

Exploration continues today, with the latest discovery being that of the human microbiome, a vast system of microorganisms living on and in the human body. We now know that human health is not a matter of human DNA alone. Rather, how your body functions, your propensity for certain diseases, how you respond to medications, and even how you think and behave, is a matter of microbial cells and human cells working together.

If that's not enough, scientists also recently discovered—contrary to what today's practicing physicians were taught in medical school—that the body's lymphatic system, and therefore immune system, extends to the brain. This is significant. Knowing that the lymphatic system infiltrates the brain has triggered such research questions as, "Could sluggish lymphatic flow contribute to the development of Alzheimer's or Parkinson's diseases?"

The human body is an intriguing landscape, and your journey to discovery begins with reading this book. Contained on these pages is information about which ancient scientists only dreamed. This information will enlighten you about your own body; what's more, it will arm you with knowledge that is foundational to any health- or sports-related career.

Truly, before you can understand a body in illness, you must understand how it functions in health. For example, without a thorough knowledge of fluid and electrolyte balance, how can you explain why chronic vomiting or diarrhea can cause irregular electrical activity in the heart? Without an understanding of how the cardiovascular and respiratory systems interrelate, how will you grasp why chronic lung disease can lead to heart failure? How can you appreciate the need for caution in administering antibiotics without an understanding of the human microbiome? Consequently, you must learn—really *learn* and not just memorize— the information contained in this book.

There is much to learn, to be sure; but don't be overwhelmed. *Understanding Anatomy & Physiology* breaks the information into "bite-sized" pieces, making topics easier to understand and also to remember. As you read the text—and you *must* read the text—you'll be drawn naturally to vibrant figures that will illuminate what you're reading. Being able to see a structure while you're reading about it will make learning easier. Also, consult the inside back cover of this book to discover your particular learning style; then take advantage of the ancillary materials most likely to help you learn.

You *can* learn this. By the end of this course, understanding the body's form and function can become second nature. Although tackling this class may seem like

an impossible marathon, you can indeed get to the finish line. As with any marathon, the keys are to follow a plan (read the book); don't skip workouts (review and study daily); and take it step by step (study each chapter in sequence). You *will* get there.

Joelle Anne Thompson

Acknowledgments

Understanding Anatomy & Physiology, 3rd edition, remains a unique work in the field of anatomy and physiology textbooks. That would not be possible without the support of an incredible team of hardworking and gifted individuals.

Above all, I remain grateful to Lisa Houck, Publisher, for her commitment to making *Understanding Anatomy and Physiology* a leader in the field. Her enthusiastic support for incorporating groundbreaking research—such as that regarding the human microbiome—into the third edition was an ongoing source of encouragement. Adding a substantial amount of new information to a layout-driven book such as this one is no easy task. Besides requiring the creation of multiple new figures, the addition of content to one page altered the layout of not just that page, but of subsequent pages as well. Despite this added labor and expense, Lisa never wavered in her desire to ensure that this edition of *Understanding Anatomy and Physiology* present the latest information in the same easy-to-understand and visual style of previous editions. Thank you, Lisa, for your drive to ensure that this text be the best it can be.

Close behind is a very special "thank you" to Christine Abshire, Senior Content Project Manager, for her oversight of this entire project. Revision of the textbook also required revision of the vast array of ancillary materials, and Christine oversaw this process with ease and grace. What's more, Christine gave meticulous attention to all the new material, ensuring that new content could comfortably reside on the page without sacrificing the book's clear and concise aesthetic. Always available to offer support or a ready answer, Christine's calm and easygoing manner made it seem as if I were her sole focus of attention. Christine, it was always reassuring having you at the helm.

A book for visual learners would, obviously, not be effective without hundreds of vivid illustrations. In the case of the third edition, this required the creation of dozens of new figures. As in past editions, artists and compositors were stretched to ensure that text and art be integrated during layout. Carolyn O'Brien, Art Director, worked her creative magic in stylizing the new pages. She also expertly led her team to create new figures representative of the *Understanding A & P* style. Overseeing the flow of new and revised figures was Daniel Domzalski, Illustration Coordinator. Thank you, Daniel, for your careful attention and ensuring that figures were executed accurately.

Coordinating work with the artist and the compositor to ensure that my vision for each page came to fruition, and then guiding the manuscript through the production process until it emerged a bound book, was Bob Butler, Production Manager. I appreciate your hard work; I can only imagine the difficulties required to coordinate the work of so many individuals.

I would also like to thank the reviewers, who are listed separately, for their willingness to review various chapters. Their specialized knowledge of anatomy and physiology helped me improve the scope of the book and also hone the accuracy of the information presented. Having the input of those who work with students on a daily basis, and who understand the areas with which students struggle, was invaluable in helping me make the topic of anatomy and physiology more clear, concise, and relevant to the lives of students.

Last, but certainly not least, I want to thank Jaclyn White, Senior Marketing Manager, and Julia Gillespie, Manager of Nursing Marketing, for their ongoing enthusiasm for this text. I appreciate their energy in not only exploring the attributes and unique features of this package but also in finding innovative ways to promote those features to instructors at various schools and colleges. I look forward to hearing the feedback they receive from instructors and students as to how to make *Understanding Anatomy & Physiology* even better.

To Bob: Thank you for your love, your support, and your encouragement.

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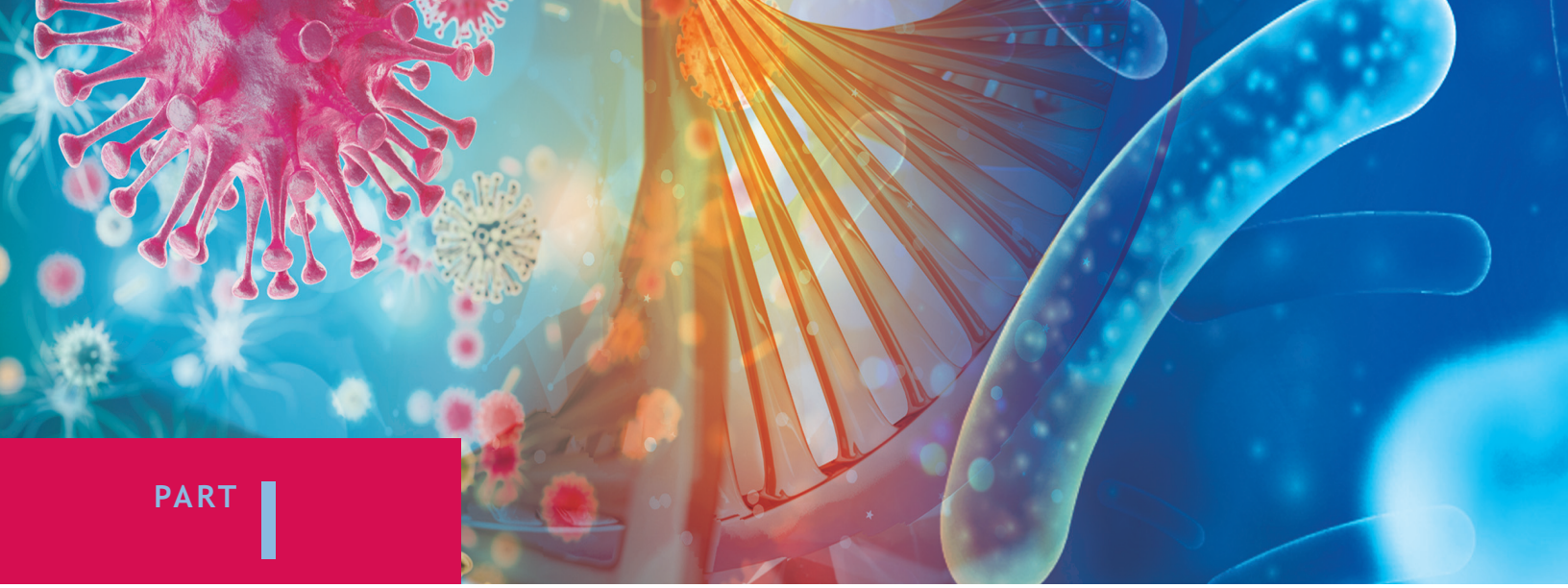
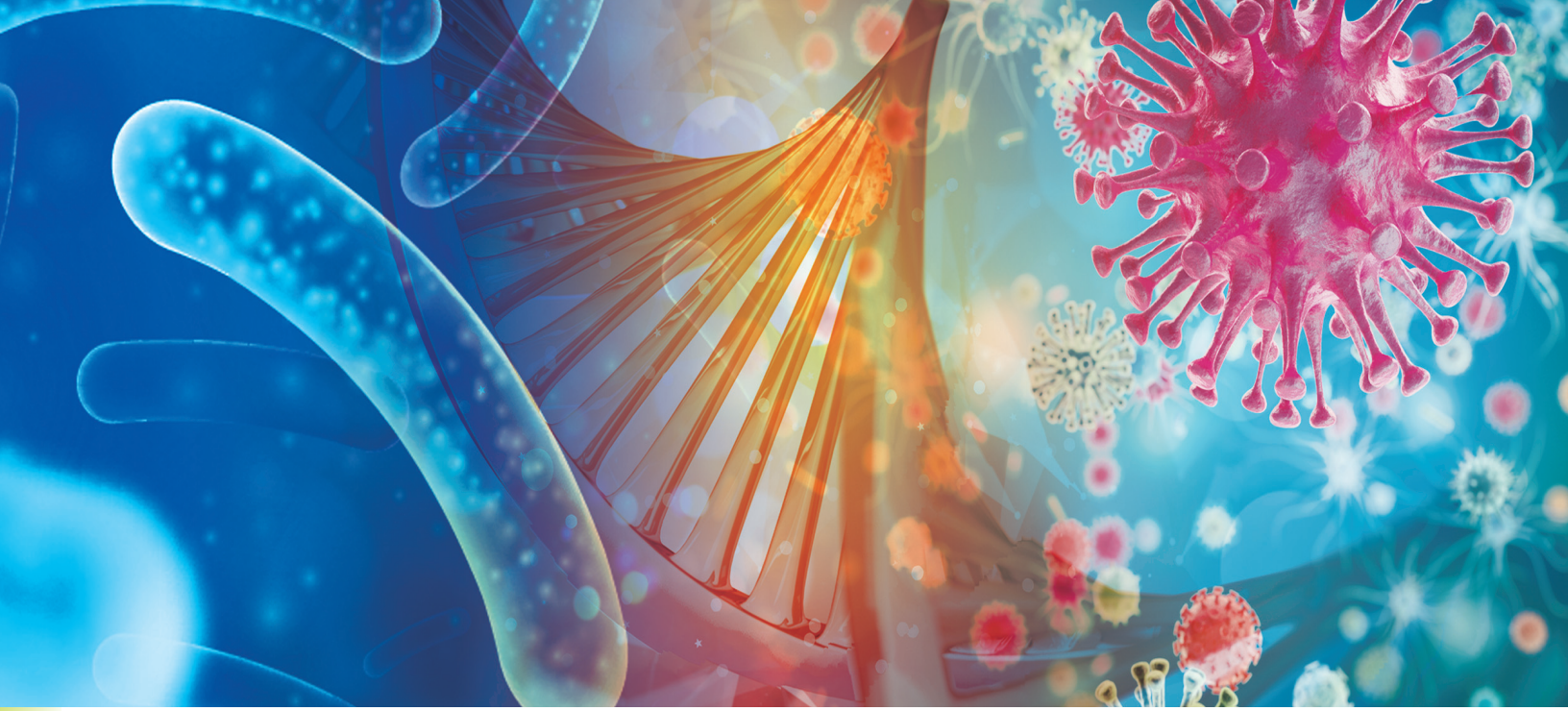


PART I

Foundation of the Body



CHAPTER OUTLINE

Organization of the Body

Organ Systems

Anatomical Terms

Homeostasis

LEARNING OUTCOMES

1. Define ANATOMY and PHYSIOLOGY.
2. Describe the organization of the body from the very simple to the very complex.
3. Name the 11 organ systems and identify key functions of each.
4. Define commonly used directional terms.
5. Name the body planes and describe how each dissects the body.
6. Identify common body regions.
7. Identify and describe the major body cavities.
8. Name the nine abdominal regions and identify organs found in each.
9. Name the four abdominal quadrants.
10. Define HOMEOSTASIS.
11. Explain the process of homeostasis through both negative and positive feedback.

chapter 1

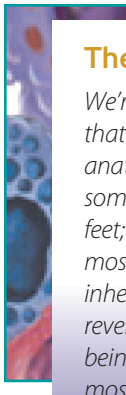
Orientation to the Human Body

More than 7 billion human bodies currently reside on the earth. Although each is individually unique, all have the same basic design and structure.

The structure of the body, **anatomy**, is closely entwined with how it functions, **physiology**. Once you learn the structure of a specific part of the body, you'll naturally want to know how it works. Learning normal anatomy and physiology will also help you grasp the changes and symptoms that occur with certain disease processes. The study of the processes that disturb normal function is called **pathophysiology**. (*Patho* means suffering or disease; therefore, *pathophysiology* refers to diseased functioning.)

As an example, in a later chapter, you'll learn that the lungs consist of a series of tubes, called bronchi, and that the smallest of these bronchi end in tiny sacs, called alveoli. That's a very basic description of the structure, or anatomy, of the lung. From there, you'll learn that oxygen is absorbed into the bloodstream through the alveoli. That's how the lung functions: its physiology. Armed with that information, you can then comprehend why someone becomes short of breath if the bronchi become narrowed (such as during an acute asthmatic attack) or blocked (such as from a tumor).

The human body is an amazing organism. It is intricate and complex, but all of its processes make sense. Embark on this journey to study anatomy and physiology as you would any great adventure: with interest, excitement, *and* determination. Remember: you're learning about *yourself!*



The Body AT WORK

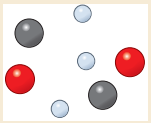
We're all aware that people look different on the outside. But did you know that people can vary internally as well? The art in this book reflects the anatomy typical of most people. However, variations do occur. For example, some people are born with only one kidney; others have an extra bone in their feet; still others have carotid arteries that follow an atypical route. Perhaps the most extreme example of anatomical variation is called situs inversus. In this inherited condition—affecting about 1 in 10,000 people—the organs are reversed. Instead of the spleen, pancreas, sigmoid colon, and most of the heart being on the left, they're on the right. Likewise, the gallbladder, appendix, and most of the liver are on the left instead of on the right.

FAST FACT

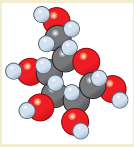
Although Aristotle of Greece made the first recorded attempts to study anatomy in 380 B.C., the first atlas of anatomy wasn't published until 1543 A.D.

Organization of the Body

The human body is organized in a hierarchy, ranging from the very simple (a microscopic atom) to the very complex (a human being). Specifically:

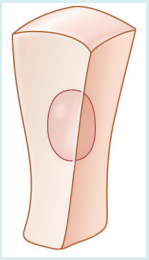


ATOMS link together to form…

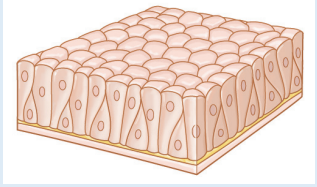


MOLECULES. Molecules are organized into various structures, including…

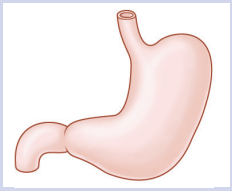
ORGANELLES, the metabolic units within a cell that perform a specific function necessary to the life of the cell. Examples include mitochondria—the powerhouses that furnish the cell's energy—and the cell's nucleus. Organelles are contained within…



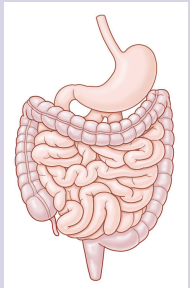
CELLS, the smallest living units that make up the body's structure. Cells group together to form…



TISSUES, which are specialized groups of cells with similar structure and function. Tissues come together to form…



ORGANS, which are structures of two or more tissue types working together to carry out a particular function. Examples include the heart, stomach, and kidney. Organs then form…



ORGAN SYSTEMS, which are groups of organs that all contribute to a particular function. All of the organ systems together form…

A HUMAN ORGANISM: one complete individual.

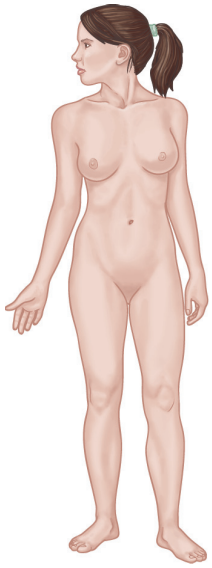
The Body AT WORK

The body contains four types of tissues:

- ***Epithelial tissue*** *covers or lines body surfaces; examples include the outer layer of the skin, the walls of capillaries, and kidney tubules.*
- ***Connective tissue*** *connects and supports parts of the body; some transports and stores materials; examples include bone, cartilage, and adipose tissues.*
- ***Muscle*** *contracts to produce movement; examples include skeletal muscles and the heart.*
- ***Nerve tissue*** *generates and transmits impulses to regulate body function; examples include the brain and nerves.*

Organ Systems

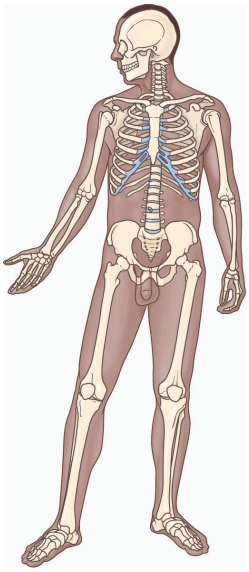
The human body consists of 11 organ systems. The organs of each system contribute to a particular function. However, some organs belong to more than one system. Specifically, the pharynx is part of both the respiratory and the digestive systems, and the male urethra belongs to both the reproductive and urinary systems.



Integumentary system

Consists of skin, hair, and nails

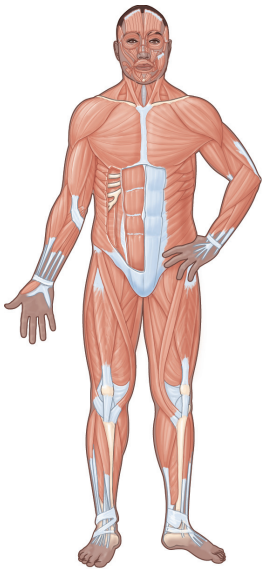
Key functions:
- Protection
- Temperature regulation
- Water retention
- Sensation



Skeletal system

Consists of bones, cartilage, and ligaments

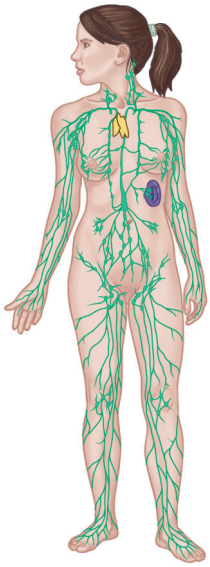
Key functions:
- Protection of body organs
- Support
- Movement
- Blood formation



Muscular system

Consists primarily of skeletal muscles

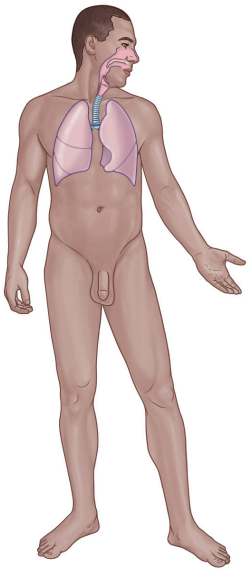
Key functions:
- Movement
- Posture
- Heat production



Lymphatic system

Consists of lymph nodes, lymphatic vessels, lymph, thymus, spleen, and tonsils

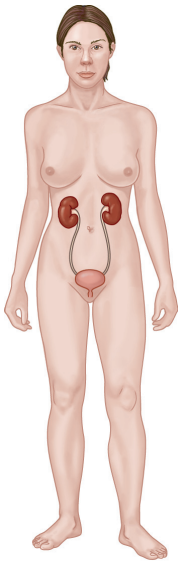
Key functions:
- Role in fluid balance
- Production of immune cells
- Defense against disease



Respiratory system

Consists of the nose, pharynx, larynx, trachea, bronchi, and lungs

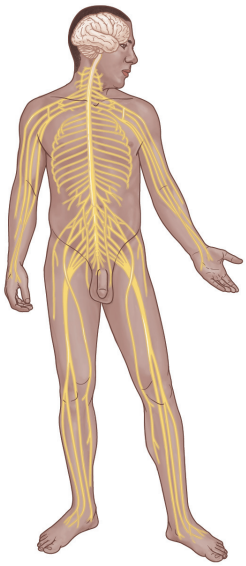
Key functions:
- Absorption of oxygen
- Discharge of carbon dioxide
- Acid-base balance
- Speech



Urinary system

Consists of the kidneys, ureters, urinary bladder, and urethra

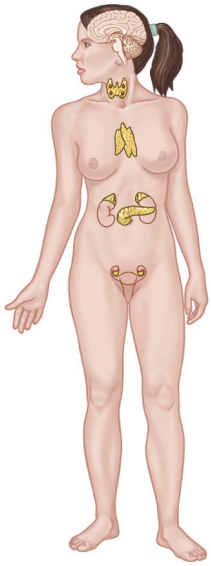
Key functions:
- Excretion of wastes
- Regulation of blood volume and pressure
- Control of fluid, electrolyte, and acid-base balance



Consists of the brain, spinal cord, nerves, and sense organs

Key functions:
- Control, regulation, and coordination of other systems
- Sensation
- Memory

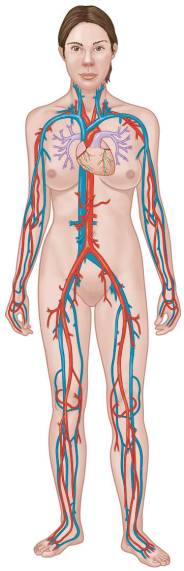
Nervous system



Consists of the pituitary gland, adrenals, pancreas, thyroid, parathyroids, and other organs

Key functions:
- Hormone production
- Control and regulation of other systems

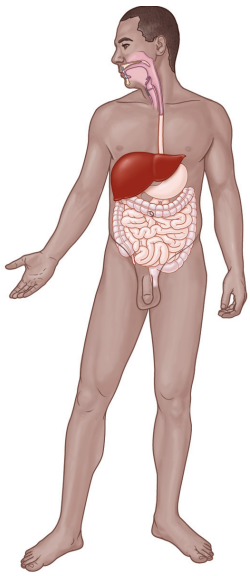
Endocrine system



Consists of the heart, arteries, veins, and capillaries

Key functions:
- Distribution of oxygen, nutrients, wastes, hormones, electrolytes, immune cells, and antibodies
- Fluid, electrolyte, and acid-base balance

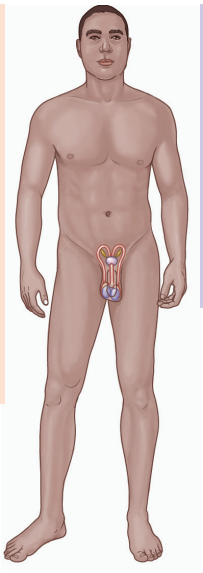
Circulatory system



Consists of the stomach, small and large intestines, esophagus, liver, mouth, and pancreas

Key functions:
- Breakdown and absorption of nutrients
- Elimination of wastes

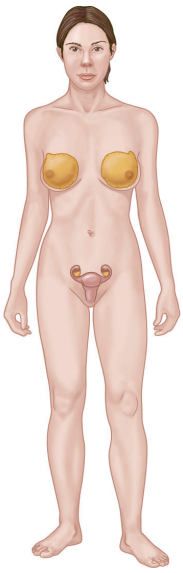
Digestive system



Consists of the testes, vas deferens, prostate, seminal vesicles, and penis

Key functions:
- Production and delivery of sperm
- Secretion of sex hormones

Male reproductive system



Consists of the ovaries, fallopian tubes, uterus, vagina, and breasts

Key functions:
- Production of eggs
- Site of fertilization and fetal development
- Birth
- Lactation
- Secretion of sex hormones

Female reproductive system

FAST FACT

The human microbiome—a collection of trillions of microorganisms living primarily in the gut—so profoundly influences human health that many experts believe it should be known as the body's 12th organ system. (See Chapter 4, *Human Microbiome*.)

The Body AT WORK

There may be 11 organ systems, but none works in isolation. Rather, systems work together, orchestrating their actions to keep the body functioning. For example, the respiratory system pulls oxygen from inspired air, which the circulatory system then delivers to organs and tissues. Muscles use the oxygen, along with nutrients supplied by the digestive system, to move and do work. Such movement creates waste products, which the circulatory system propels to the urinary system. In turn, the urinary system cleanses the blood and excretes waste products from the body.