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An Introduction to Anatomy and Physiology

Learning Outcomes

These Learning Outcomes correspond by number to this chapter's sections and indicate what you should be able to do after completing the chapter.

1-1 Explain the **importance of studying** anatomy and physiology.

1-2 Identify basic **study skill strategies** to use in this course.

1-3 Define **anatomy and physiology**, describe the origins of anatomical and physiological terms, and explain the significance of ***Terminologia Anatomica*** *(International Anatomical Terminology)*.

1-4 Explain the **relationship between anatomy and physiology**, and describe various specialties of each discipline.

1-5 Identify the major **levels of organization** in organisms, from the simplest to the most complex, and identify major components of each organ system.

1-6 Explain the concept of **homeostasis**.

1-7 Describe how **negative feedback and positive feedback** are involved in homeostatic regulation, and explain the significance of **homeostasis**.

1-8 Use **anatomical terms** to describe body sections, body regions, and relative positions.

1-9 Identify the major **body cavities** and their subdivisions, and describe the functions of each.

Clinical Notes

The Visible Human Project p. 6

Homeostasis and Disease p. 12

Spotlight

Levels of Organization pp. 8–9

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An Introduction to Studying the Human Body

This textbook will serve as an introduction to the inner workings of your body, providing information about both its structure and its function. Many students who use this book are preparing for careers in health-related fields—but regardless of your career choice, you will find the information within these pages relevant to your future. You do, after all, live in a human body! Being human, you most likely have a seemingly insatiable curiosity—and few subjects arouse so much curiosity as our own bodies. The study of anatomy and physiology will provide answers to many questions regarding the functioning of your body in both health and disease.

Although we will be focusing on the human body, the principles we will learn apply to other living things as well. Our world contains an enormous diversity of living organisms that vary widely in appearance and lifestyle. One aim of biology—the science of life—is to discover the unity and the patterns that underlie this diversity, and thereby shed light on what we have in common with other living things.

Animals can be classified according to their shared characteristics, and birds, fish, and humans are members of a group called the *vertebrates*, characterized by a segmented vertebral column. The shared characteristics and organizational patterns provide useful clues about how these animals have evolved over time. Many of the complex structures and functions of the human body discussed in this text have distant evolutionary origins. When we compare the particular adaptations of human beings with those of other creatures, we find two important principles: There are obvious structural and functional similarities among vertebrates, and form determines function.

This chapter explores the structural and functional characteristics of living things. It includes the levels of organization that anatomical structures and physiological processes display, and discusses *homeostasis*, the goal of physiological regulation and the key to survival in a changing environment.

1-1 Anatomy and physiology directly affect your life

Welcome to the field of anatomy and physiology, the study of body structures and functions. In this course, you will discover how your body works under normal and abnormal conditions. This course will also be important because it serves as the foundation for understanding all other basic life sciences, and for making common sense decisions about your own life. Basic knowledge of normal physiological function, for example, will prove useful whenever you or a friend or relative becomes ill. Our study of anatomy and physiology will devote considerable time to explaining how the body responds to normal and abnormal conditions and maintains **homeostasis,** which is a relatively constant internal environment. As we proceed, you will see how your body copes with injury, disease, or anything that threatens homeostasis.

Anatomy is considered the oldest medical science. Egyptian drawings from 1600 BCE illustrating basic knowledge of blood vessels demonstrate that we have always been fascinated with the human body. Since that time, techniques for studying the human body have evolved, enabling us to describe the locations and functions of body parts. Over the last two decades, the most rapid progress has been made in the field of molecular biology, which investigates processes at the level of individual genes and incorporates principles of biology, chemistry, genetics, and biochemistry. By enhancing our understanding of molecular biology, we are learning how the body works at the most fundamental level and revealing the underlying basis for many disorders and diseases.

Medical science expands continuously and affects our everyday lives. We are flooded with health information from the popular press, news media, and advertisements. As a result, medical terms are a part of our common language, and we owe it to ourselves to understand them. You will find that this course significantly expands your vocabulary and your understanding of the origins and meanings of medical terms.

Checkpoint

1. **Identify the oldest medical science.**
2. **Why is studying human anatomy and physiology important?**

See the blue Answers tab at the back of the book.

1-2 Good study strategies are crucial for success

Completing this course successfully will require you to work hard and often. Although you are going to spend lots of time reading this textbook, reading alone won't be enough—you need to develop good study skills and strategies.

Before going to lectures and labs, read the material so that it and the terms used by the instructor don't come as a complete surprise. During class, take notes on notebook paper *and* in your textbook, especially near the relevant illustrations. You might also find it useful to record the lectures. After class, reread the textbook while referring to your class notes. If something doesn't make sense, don't be shy about asking for help. Write yourself a note so that you will be sure to ask your instructor about it.

Memorization alone is not enough, and waiting until the night before an exam to begin studying is courting disaster. Success in an A&P course is like constructing a house—it is an ongoing process that starts with building a solid foundation and then advances in small steps, each of which builds on the previous one. Using your time in lectures and labs to the fullest will go a long way in making this course a positive experience. Lab exercises will greatly enhance your understanding of the topics covered in lecture, so do not consider them separate activities but, instead, educational tools that go hand-in-hand with what you learn in lecture. Here are some practical tips for success in this course:

- *Attend all lectures, labs, and study sessions.* Ask questions and participate in discussions.
- *Read your lecture and laboratory assignments before going to class or lab.* You'll understand class/lab better if you do.
- *Devote a block of time each day to your A&P course.* There are no shortcuts. (Sorry.) You won't get the grade you want and the knowledge you need if you don't put in the time and do the work. This requires preparation throughout the term.
- *Set up a study schedule and stick to it.* Create your study schedule during the first week of class.
- *Do not procrastinate!* Do not do all your studying the night before the exam! Actually STUDY the material several times throughout the week. Marathon study sessions are often counterproductive. Expect to push yourself and stretch your limits.
- *Approach the information in different ways.* For example, you might visualize the information, talk it over with or "teach" a fellow student, or spend additional time in lab asking questions of your lab instructor.
- *Develop the skill of memorization, and practice it regularly.* Memorization is an important skill, and an integral part of the course. You are going to have to memorize all sorts of things—among them muscle names, directional terms, and the names of bones and brain parts. Realize that this is an essential study skill, and that the more you practice, the better you will be at remembering terms and definitions. We will give you tips and tricks along the way to help you keep the information in mind.
- *As soon as you experience difficulty with the course, seek assistance.* Do not wait until the end of the term when it is too late to salvage your grade.

This textbook is an investment in your future; you owe it to yourself to use it wisely. It contains significant information that is useful beyond the bounds of this course.

Approach your textbook differently from a novel. That is, you might have to read it more slowly, with a critical eye to detail, while taking notes along the way. This book was designed with student-friendly resources, not only to enhance your study, but also to ensure your success in the course. However, you will succeed only by being an active learner and *using* these features as you work through the textbook:

- *Learning Outcomes.* The first page of every chapter includes a list of Learning Outcomes that shows what you should be able to do by the end of the chapter. Each Learning Outcome corresponds to a main section in the chapter, and the Learning Outcome and the heading of that main section share a number (such as 1-1, 1-2, 1-3) for easy reference. That numbering system repeats in the Study Outline at the end of the chapter to make studying and reviewing as straightforward as possible.
- *Illustrations, Tables, and Photos.* The art program is designed to complement the text and provide visual aids for understanding complex topics. Figure and table references in the narrative are colored to function as placeholders to help you return to reading after viewing a figure or table. Every time you see a colored figure or table reference, pause and refer to the figure or table. The text and art work together—you need to integrate them as you study.
- *Pronunciation Guides.* We have provided a pronunciation guide for each new term. When you read the term, stop and say it aloud until you are familiar with the sound. Afterward, use the term at every opportunity. If you don't use it, you are likely to forget it!
- *Checkpoint Questions.* Whenever you encounter a Checkpoint, stop and answer the questions before going on to the next section. If you cannot answer the questions quickly and correctly, reread the section. Do not go on until you understand the answers, because each topic builds upon the previous one.
- *Tips & Tricks.* Consider the Tips & Tricks as tools to help your memorization. They present easy analogies and mnemonic devices to help you retain information.
- *Clinical Notes.* Think of the Clinical Notes sections as applications to the real world. They show how what you are reading applies to life beyond your textbook and why learning this information is important.
- *Arrow Icons.* Watch for the arrow icon. ⮌ This icon appears when material relates to topics presented earlier and offers specific page numbers to facilitate review.
- *End-of-Chapter Study and Review Materials.* After completing each chapter, read the Study Outline and work through the end-of-chapter Review Questions to make sure that you have a solid understanding of the chapter material. Answers to the Checkpoint Questions (see above) and Review Questions are found in the blue Answers tab at the end of the book.
- *System Integrators.* The body functions as an integrated whole rather than as a set of isolated, independent systems. When you learn about a new body system, such as the digestive

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system, try to relate it to what you learned earlier about another body system, such as the nervous system. The System Integrators, which appear at the end of each set of chapters on a body system, provide excellent, illustrated reviews of the interconnections between each body system as they are studied. You can use these to "see the big picture" and to quiz yourself.

- *Colored Tabs.* Colored tabs are located on the edges of the pages to make it easy for you to find your place in the textbook. The color of the tab indicates one of the eleven body systems, such as light brown for the integumentary system and red for the cardiovascular system. The location of the tab along the edge of the page indicates one of the six units, such as the top of the page for Unit 1 and one notch below that location for Unit 2, and so on. Chapter numbers are printed on the tabs. Using the tabbing system, you will be able to navigate easily through the textbook as you read and study.
- *End-of-Book Reference Sections.* Also indicated with easy-to-find colored tabs are four important sections at the back of the book: **Appendix, Answers, Glossary,** and **Index.** You'll refer regularly to each of these sections as you move through the chapters of the book, and the brightly colored tabs will help you get to where you want to go in no time.

Checkpoint

3. **Identify several strategies for success in this course.**
4. **Explain the purpose of the learning outcomes.**

See the blue Answers tab at the back of the book.

1-3 Anatomy is structure, and physiology is function

People have always been interested in the inner workings of the human body. The word *anatomy* has Greek roots, as do many other anatomical terms and phrases that originated more than 1500 years ago. **Anatomy,** which means "a cutting open," is the study of internal and external structures of the body and the physical relationships among body parts. In contrast, **physiology,** another Greek term, is the study of how living organisms perform their vital functions. Thus, someone studying anatomy might, for example, examine how a particular muscle attaches to the skeleton, whereas someone studying physiology might consider how a muscle contracts or what forces a contracting muscle exerts on the skeleton. Because you will be studying anatomy and physiology throughout this book, it is appropriate that we spend some time at the beginning taking a closer look at the relationships between these sciences.

Early anatomists faced serious problems in communication. Stating that a bump is "on the back," for example, does not give very precise information about its location. So anatomists created maps of the human body. Prominent anatomical structures serve as landmarks, distances are measured in centimeters or inches, and specialized directional terms are used. In effect, anatomy uses a special language that must be learned almost at the start of your study.

That special language, called **medical terminology,** involves the use of word roots, prefixes, suffixes, and combining forms to construct terms related to the body in health and disease. Many of the anatomical and physiological terms you will encounter in this textbook are derived from Greek or Latin. Learning the word parts used in medical terminology will greatly assist in the study of anatomy and physiology, and in preparation for any health-related career.

There are four basic building blocks of medical terms. *Word roots* are the basic, meaningful parts of a term that cannot be broken down into another term with another definition. *Prefixes* are word elements that are attached to the beginning of words to modify their meaning but cannot stand alone. *Suffixes* are word elements or letters added to the end of a word or word part to form another term. *Combining forms* are independent words or word roots that occur in combination with words, prefixes, suffixes, or other combining forms to build a new term. The table inside the back cover of your textbook lists commonly used word roots, prefixes, suffixes, and combining forms.

To illustrate the concept of building medical terms, consider the word *anatomy*, derived from the Greek root *anatome*, meaning dissection. The prefix *ana-* means up, while the suffix *-tomy* means to cut. Hence, *anatomy* means to "cut up" or dissect. Another commonly used term is *pathology*. Breaking this word into its fundamental elements reveals its meaning. The prefix *path-* refers to disease (the Greek term for disease is *pathos*), while the suffix *-ology* means "study of." Therefore, pathology is the study of disease.

A familiarity with Latin and Greek word roots and patterns makes anatomical terms more understandable. As the text introduces new terms, it will provide notes on pronunciation and relevant word roots.

Latin and Greek terms are not the only ones that have been imported into the anatomical vocabulary over the centuries, and this vocabulary continues to expand. Many anatomical structures and clinical conditions were initially named after either the discoverer or, in the case of diseases, the most famous victim. Over the last 100 years, most of these commemorative names, or *eponyms*, have been replaced by more precise terms. The Glossary includes a table listing the most important eponyms and related historical details.

It is important for scientists throughout the world to use the same name for each body structure, so in 1998, two scientific organizations—the Federative Committee on Anatomical Terminology and the 56 member associations of the International Associations of Anatomists—published *International Anatomical*

Terminology (*Terminologia Anatomica*, or *TA*). Although Latin continues to be the language of anatomy, this reference provides an English equivalent term for each anatomical structure. The *TA* serves as a worldwide official standard of anatomical vocabulary, and we have used it as our standard in preparing this text.

Checkpoint

5. **Define anatomy.**
6. **Define physiology.**
7. **Describe medical terminology.**
8. **Define eponym.**
9. **Name the book that serves as the international standard for anatomical vocabulary.**

See the blue Answers tab at the back of the book.

1-4 Anatomy and physiology are closely integrated

Anatomy and physiology are closely integrated, both theoretically and practically. Anatomical information provides clues about functions, and physiological mechanisms can be explained only in terms of the underlying anatomy. This is a very important concept: *All specific functions are performed by specific structures*. The link between structure and function is always present, but not always understood. For example, although the anatomy of the heart was clearly described in the 15th century, almost 200 years passed before the heart's pumping action was demonstrated.

Anatomists and physiologists approach the relationship between structure and function from different perspectives. To understand the difference, consider a simple nonbiological analogy. Suppose that an anatomist and a physiologist were asked to examine a pickup truck and report their findings. The anatomist might begin by measuring and photographing the various parts of the truck and, if possible, taking it apart and putting it back together. The anatomist could then explain its key *structural* relationships—for example, how the pistons are seated in the engine cylinders, how the crankshaft is connected to the pistons, how the transmission links the drive shaft to the axles, and thus to the wheels. The physiologist also would note the relationships among the truck's components, but his or her primary focus would be on *functional* characteristics, such as how the combustion of gasoline in the cylinders moves the pistons up and down and causes the drive shaft to rotate, and how the transmission conveys this motion to the axles and wheels so that the car moves. Additionally, he or she might also study the amount of power that the engine could generate, the amount of force transmitted to the wheels in different gears, and so on.

This text will introduce anatomical structures and the physiological processes that make human life possible. The basic approach will be to start with the descriptive anatomy (appearance, size, shape, location, weight, and color) before considering the related functions. Sometimes the organs within an organ system perform very diverse functions, and in those cases the functions of each individual organ will be considered separately. A good example is the discussion of the digestive system, where you will learn about the functions of the salivary glands in one section, and the functions of the tongue in another. In other systems, the organs work together so extensively that the physiological discussion is presented in a block, after the system's anatomy has been described. The lymphatic system and the cardiovascular system are examples of this approach.

Knowledge of the anatomy and physiology of the healthy human body will enable you to understand important mechanisms of disease and will help you make intelligent decisions about personal health.

Anatomy

How you look at things often determines what you see; you get a very different view of your neighborhood from a satellite photo than when standing in your front yard. Your method of observation has an equally dramatic effect on your understanding of the structure of the human body. Based on the degree of structural detail under consideration, anatomy can be divided into *gross (macroscopic) anatomy* and *microscopic anatomy*. Other anatomical specialties focus on specific processes, such as respiration, or medical applications, such as *surgical anatomy*, which deals with landmarks on the body that are useful during medical procedures.

Anatomy is a dynamic field. Despite centuries of observation and dissection, new information and interpretations occur frequently. As recently as 1996, researchers working on the Visible Human database described a facial muscle that had previously been overlooked. The Clinical Note on the Visible Human Project describes the origins and uses of one of the most powerful tools in modern anatomy.

Gross Anatomy

Gross anatomy, or *macroscopic anatomy*, involves the examination of relatively large structures and features usually visible with the unaided eye. There are many different forms of gross anatomy:

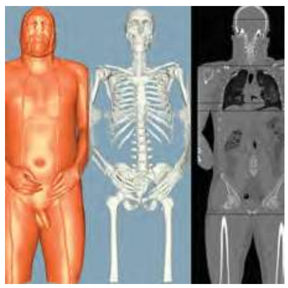
- *Surface anatomy* is the study of general form and superficial markings.
- *Regional anatomy* focuses on the anatomical organization of specific areas of the body, such as the head, neck, or trunk. Many advanced courses in anatomy stress a regional approach, because it emphasizes the spatial relationships among structures already familiar to students.
- *Systemic anatomy* is the study of the structure of **organ systems,** which are groups of organs that function together in a coordinated manner. Examples include the *skeletal system*, composed primarily of bones; the *muscular*

Clinical Note

The Visible Human Project

Study the human body, one **slice** at a time

When Joseph Paul Jernigan, a condemned criminal, was executed in 1993 for a particularly brutal murder in Texas, neither he nor the state of Texas could have predicted the impact his death would have on medical research and education. Before his execution, Jernigan had donated his body to the State Anatomical Board of Texas. Because of his age (39), size (1.76 m [5′10″] and 90.4 kg [199 lb]), and good physical health prior to his death, his body was selected for the Visible Human Project. This project, funded by the U.S. National Library of Medicine (NLM), was designed to create accurate, computerized three-dimensional versions of the human body that can be viewed and explored from multiple perspectives. The data sets, or "visible humans," could be studied and manipulated in ways that are impossible using real bodies.



Using Jernigan as the basis for a "virtual male," Dr. Victor Spitzer and colleagues at the University of Colorado generated the data set. After they took noninvasive serial CT and MRI scans of the body, it was then frozen and sectioned at 1-mm intervals. As each slice was generated, the researchers took high-resolution digital images and 70-mm color photographs. Shortly after completion in 1995, the researchers generated a "virtual female" data set from a 59-year-old woman who had died of natural causes and donated her body to the Anatomy Board of Maryland. The processing methods were similar, except the sections were taken at 0.33 mm, providing roughly three times the resolution of the male data set.

By combining x-rays, MRI, and CT scans with digitized images of cross sections through the body, the Visible Human data sets include an impressive volume of information. The digitized images, in computerized format, can be accessed through the Internet at the NLM/NIH Website (**www.nlm.nih.gov**). Images based on the Visible Human Project are scattered throughout this book.

system, made up of skeletal muscles; and the *cardiovascular system*, consisting of the heart, blood, and vessels, which distribute oxygen and nutrients throughout the body. Introductory texts such as this book take a systemic anatomy approach because this format clarifies functional relationships among the component organs. The text will introduce the 11 organ systems in the human body later in the chapter.

- *Developmental anatomy* describes the changes in form that occur between conception and physical maturity. Because developmental anatomy considers anatomical structures over such a broad range of sizes (from a single cell to an adult human), the techniques of developmental anatomists are similar to those used in gross anatomy and in microscopic anatomy. The most extensive structural changes occur during the first two months of development. The study of these early developmental processes is called **embryology** (em-brē-OL-ō-jē).
- *Clinical anatomy* includes a number of subspecialties important in clinical practice. Examples include *pathological anatomy* (anatomical features that change during illness), *radiographic anatomy* (anatomical structures seen using specialized imaging techniques), and *surgical anatomy* (anatomical landmarks important in surgery).

Microscopic Anatomy

Microscopic anatomy deals with structures that cannot be seen without magnification, and thus the boundaries of microscopic anatomy are established by the limits of the equipment used. With a dissecting microscope you can see tissue structure; with a light microscope, you can see basic details of cell structure; with an electron microscope, you can see individual molecules that are only a few nanometers (billionths of a meter) across.

Microscopic anatomy includes two major subdivisions: cytology and histology. **Cytology** (sī-TOL-ō-jē) is the study of the internal structure of individual **cells,** the simplest units of life. Cells are composed of chemical substances in various combinations, and our lives depend on the chemical processes occurring in the trillions of cells in the body. For this reason, we consider basic chemistry (Chapter 2) before we examine cell structure (Chapter 3). **Histology** (his-TOL-ō-jē) is the examination of **tissues**—groups of specialized cells and cell products that work together to perform specific functions

(Chapter 4). Tissues combine to form **organs,** such as the heart, kidney, liver, or brain. Many organs are easily examined without a microscope, so at the organ level we cross the boundary from microscopic anatomy to gross anatomy. As we proceed through the text, we will consider details at all levels, from macroscopic to microscopic.

Physiology

As noted earlier, physiology is the study of the function of anatomical structures; **human physiology** is the study of the functions of the human body. These functions are complex and much more difficult to examine than most anatomical structures. As a result, there are even more specialties in physiology than in anatomy, including the following:

- *Cell physiology*, the study of the functions of cells, is the cornerstone of human physiology. Cell physiology considers events at the chemical and molecular levels—both chemical processes within cells and chemical interactions between cells.
- *Organ physiology* is the study of the physiology of specific organs. An example is *cardiac physiology*, the study of heart function.
- *Systemic physiology* includes all aspects of the functioning of specific organ systems. Cardiovascular physiology, respiratory physiology, and reproductive physiology are examples of systemic physiology.
- *Pathological physiology* is the study of the effects of diseases on organ functions or system functions. Modern medicine depends on an understanding of both normal physiology and pathological physiology.

Physicians normally use a combination of anatomical, physiological, chemical, and psychological information when they evaluate patients. When a patient presents symptoms to a physician, the physician will look at the structures affected (gross anatomy), perhaps collect a fluid or tissue sample (microscopic anatomy) for analysis, and ask questions to determine what alterations from normal functioning the patient is experiencing. Think back to your last trip to a doctor's office. Not only did the attending physician examine your body, noting any anatomical abnormalities, but he or she also evaluated your physiological processes by asking questions, observing your movements, listening to your body sounds, taking your temperature, and perhaps requesting chemical analyses of fluids such as blood or urine. In evaluating all these observations to reach a diagnosis, physicians rely on a logical framework based on the *scientific method*. The scientific method, a system of advancing knowledge by formulating a question, collecting data about it through observation and experiment, and testing that question, is at the core of all scientific thought, including medical diagnosis.

Checkpoint

10. **Describe how anatomy and physiology are closely related.**
11. **What is the difference between gross anatomy and microscopic anatomy?**
12. **Identify several specialties of physiology.**
13. **Why is it difficult to separate anatomy from physiology?**

See the blue Answers tab at the back of the book.

1-5 Levels of organization progress from molecules to a complete organism

Over the next three chapters, we will consider the three most basic levels of organization of the human body. Their interdependence with more complex structures and vital processes is illustrated in **Spotlight Figure 1–1** and includes the following:

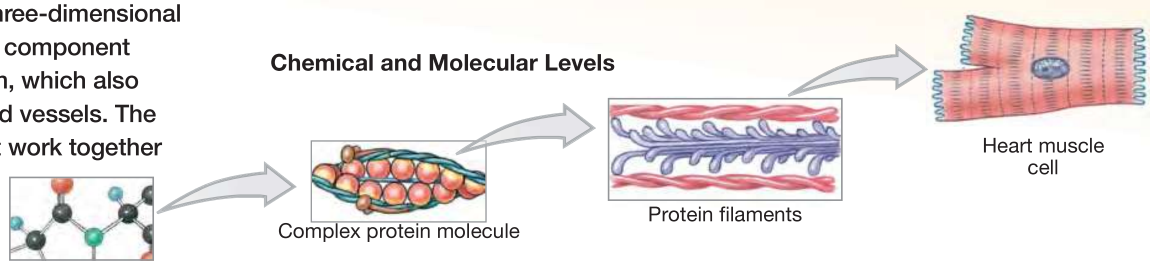
- *The Chemical (or Molecular) Level.* Atoms, the smallest stable units of matter, can combine to form molecules with complex shapes. Even at this simplest level, form determines function: The functional properties of a particular molecule are determined by its unique three-dimensional shape and atomic components. We explore this level of organization in Chapter 2.
- *The Cellular Level.* Molecules can interact to form various types of organelles, each type of which has specific functions. Organelles are structural and functional components of cells, the smallest living units in the body. Interactions among protein filaments, for example, produce the contractions of muscle cells in the heart. We examine the cellular level of organization in Chapter 3.
- *The Tissue Level.* A **tissue** is a group of cells working together to perform one or more specific functions. Heart muscle cells, or cardiac muscle cells (*cardium*, heart), interact with other types of cells and with extracellular materials to form cardiac muscle tissue. We consider the tissue level of organization in Chapter 4.
- *The Organ Level.* **Organs** consist of two or more tissues working in combination to perform several functions. Layers of cardiac muscle tissue, in combination with connective tissue, another type of tissue, form the bulk of the wall of the heart, a hollow, three-dimensional organ.
- *The Organ System Level.* A group of organs interacting to perform a particular function forms an **organ system.** Each time it contracts, the heart pushes blood into a network of blood vessels. Together, the heart, blood, and blood vessels form the cardiovascular system, one of 11 organ systems in the body.

Spotlight

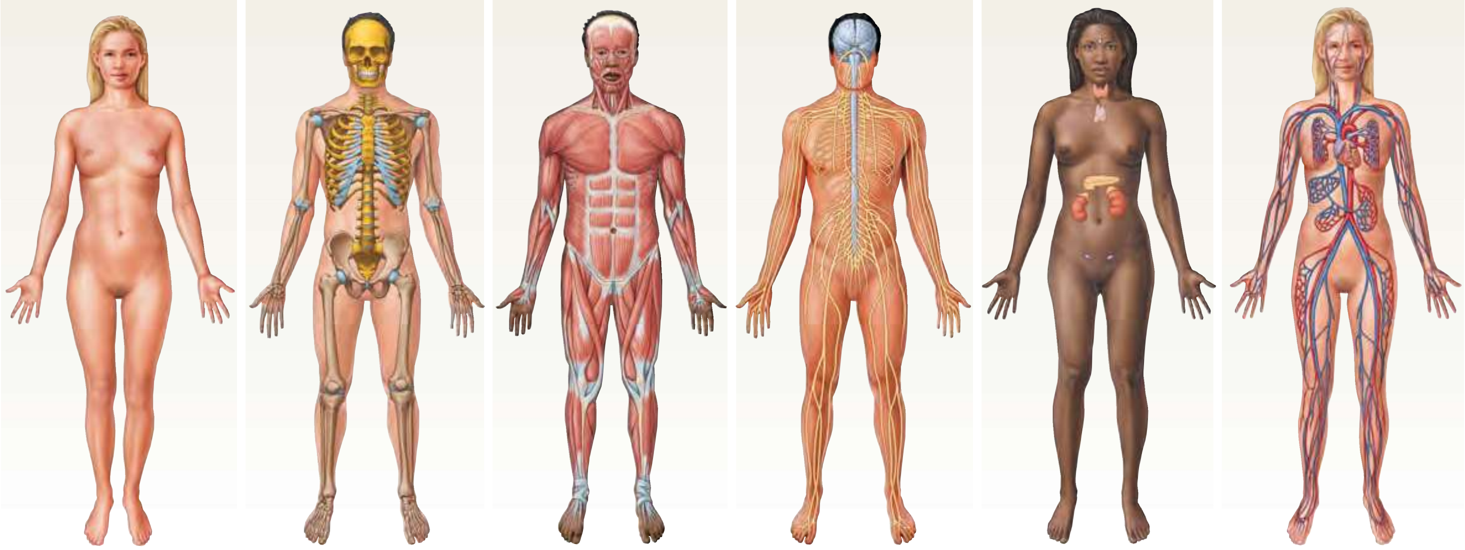
Figure 1–1

Levels of Organization

Interacting atoms form molecules that combine in the protein filaments of a heart muscle cell. Such cells interlock, creating heart muscle tissue, which makes up most of the walls of the heart, a three-dimensional organ. The heart is only one component of the cardiovascular system, which also includes the blood and blood vessels. The various organ systems must work together to maintain life at the organism level.



The Organ Systems



Integumentary

Major Organs
- Skin
- Hair
- Sweat glands
- Nails

Functions
- Protects against environmental hazards
- Helps regulate body temperature
- Provides sensory information

Skeletal

Major Organs
- Bones
- Cartilages
- Associated ligaments
- Bone marrow

Functions
- Provides support and protection for other tissues
- Stores calcium and other minerals
- Forms blood cells

Muscular

Major Organs
- Skeletal muscles and associated tendons

Functions
- Provides movement
- Provides protection and support for other tissues
- Generates heat that maintains body temperature

Nervous

Major Organs
- Brain
- Spinal cord
- Peripheral nerves
- Sense organs

Functions
- Directs immediate responses to stimuli
- Coordinates or moderates activities of other organ systems
- Provides and interprets sensory information about external conditions

Endocrine

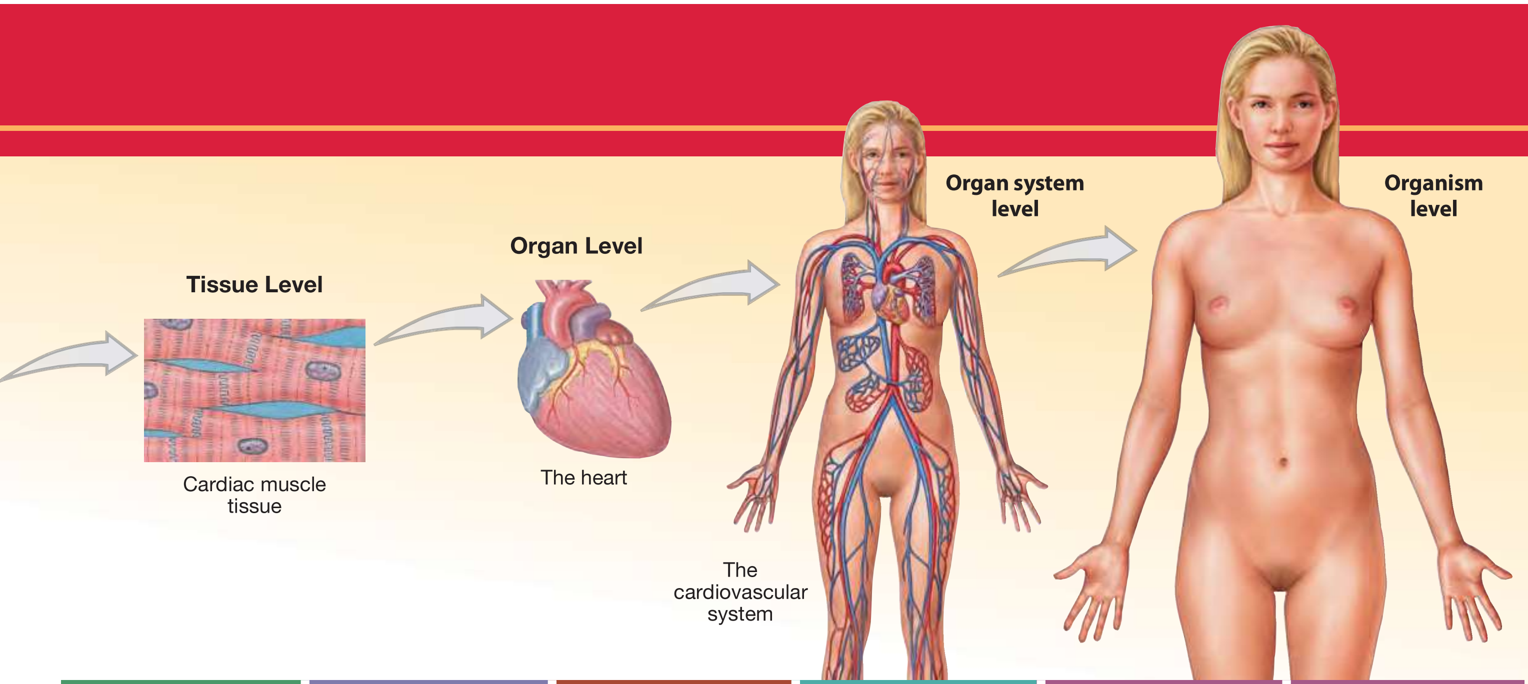
Major Organs
- Pituitary gland
- Thyroid gland
- Pancreas
- Adrenal glands
- Gonads
- Endocrine tissues in other systems

Functions
- Directs long-term changes in the activities of other organ systems
- Adjusts metabolic activity and energy use by the body
- Controls many structural and functional changes during development

Cardiovascular

Major Organs
- Heart
- Blood
- Blood vessels

Functions
- Distributes blood cells, water and dissolved materials including nutrients, waste products, oxygen, and carbon dioxide
- Distributes heat and assists in control of body temperature



Lymphatic

Major Organs
- Spleen
- Thymus
- Lymphatic vessels
- Lymph nodes
- Tonsils

Functions
- Defends against infection and disease
- Returns tissue fluids to the bloodstream

Respiratory

Major Organs
- Nasal cavities
- Sinuses
- Larynx
- Trachea
- Bronchi
- Lungs
- Alveoli

Functions
- Delivers air to alveoli (sites in lungs where gas exchange occurs)
- Provides oxygen to bloodstream
- Removes carbon dioxide from bloodstream
- Produces sounds for communication

Digestive

Major Organs
- Teeth
- Tongue
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Liver
- Gallbladder
- Pancreas

Functions
- Processes and digests food
- Absorbs and conserves water
- Absorbs nutrients
- Stores energy reserves

Urinary

Major Organs
- Kidneys
- Ureters
- Urinary bladder
- Urethra

Functions
- Excretes waste products from the blood
- Controls water balance by regulating volume of urine produced
- Stores urine prior to voluntary elimination
- Regulates blood ion concentrations and pH

Male Reproductive

Major Organs
- Testes
- Epididymides
- Ductus deferentia
- Seminal vesicles
- Prostate gland
- Penis
- Scrotum

Functions
- Produces male sex cells (sperm), suspending fluids, and hormones
- Sexual intercourse

Female Reproductive

Major Organs
- Ovaries
- Uterine tubes
- Uterus
- Vagina
- Labia
- Clitoris
- Mammary glands

Functions
- Produces female sex cells (oocytes) and hormones
- Supports developing embryo from conception to delivery
- Provides milk to nourish newborn infant
- Sexual intercourse

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- *The Organism Level.* An **organism**—in this case, a human—is the highest level of organization. All organ systems of the body must work together to maintain the life and health of the organism.

The organization at each level determines not only the structural characteristics, but also the functions, of higher levels. For example, the arrangement of atoms and molecules at the chemical level creates the protein filaments that, at the cellular level, give cardiac muscle cells the ability to contract powerfully. At the tissue level, these cells are linked, forming cardiac muscle tissue. The structure of the tissue ensures that the contractions are coordinated, producing a heartbeat. When that beat occurs, the internal anatomy of the heart, an organ, enables it to function as a pump. The heart is filled with blood and connected to the blood vessels, and the pumping action circulates blood through the vessels of the cardiovascular system. Through interactions with the respiratory, digestive, urinary, and other systems, the cardiovascular system performs a variety of functions essential to the survival of the organism.

Something that affects a system will ultimately affect each of the system's components. For example, the heart cannot pump blood effectively after massive blood loss. If the heart cannot pump and blood cannot flow, oxygen and nutrients cannot be distributed. Very soon, the cardiac muscle tissue begins to break down as individual muscle cells die from oxygen and nutrient starvation. These changes will not be restricted to the cardiovascular system; all cells, tissues, and organs in the body will be damaged. **Spotlight Figure 1–1** illustrates the levels of organization and introduces the 11 interdependent, interconnected organ systems in the human body.

The cells, tissues, organs, and organ systems of the body coexist in a relatively small, shared environment, much like the residents of a large city. Just as city dwellers breathe the same air and drink the water provided by the local water company, cells in the human body absorb oxygen and nutrients from the fluids that surround them. If a city is blanketed in smog or its water supply is contaminated, the people will become ill. Similarly, if the body fluid composition becomes abnormal, cells will be injured or destroyed. For example, suppose the temperature or salt content of the blood changes. The effect on the heart could range from the need for a minor adjustment (heart muscle tissue contracts more often, raising the heart rate) to a total disaster (the heart stops beating, so the individual dies).

Checkpoint

14. **Identify the major levels of organization of the human body from the simplest to the most complex.**
15. **Identify the organ systems of the body and cite some major structures of each.**
16. **At which level of biological organization does a histologist investigate structures?**

See the blue Answers tab at the back of the book.

1-6 Homeostasis is the tendency toward internal balance

Various physiological mechanisms act to prevent harmful changes in the composition of body fluids and the environment inside our cells. **Homeostasis** (*homeo*, unchanging + *stasis*, standing) refers to the existence of a stable internal environment. Maintaining homeostasis is absolutely vital to an organism's survival; failure to maintain homeostasis soon leads to illness or even death.

The principle of homeostasis is the central theme of this text and the foundation of all modern physiology. **Homeostatic regulation** is the adjustment of physiological systems to preserve homeostasis. Physiological systems have evolved to maintain homeostasis in an environment that is often inconsistent, unpredictable, and potentially dangerous. An understanding of homeostatic regulation is crucial to making accurate predictions about the body's responses to both normal and abnormal conditions.

Two general mechanisms are involved in homeostatic regulation: autoregulation and extrinsic regulation.

1. **Autoregulation,** or *intrinsic regulation*, occurs when a cell, a tissue, an organ, or an organ system adjusts its activities automatically in response to some environmental change. For example, when oxygen levels decline in a tissue, the cells release chemicals that widen, or dilate, local blood vessels. This dilation increases the rate of blood flow and provides more oxygen to the region.
2. **Extrinsic regulation** results from the activities of the nervous system or endocrine system, two organ systems that control or adjust the activities of many other systems simultaneously. For example, when you exercise, your nervous system issues commands that increase your heart rate so that blood will circulate faster. Your nervous system also reduces blood flow to less active organs, such as the digestive tract. The oxygen in circulating blood is thus available to the active muscles, where it is needed most.

In general, the nervous system directs rapid, short-term, and very specific responses. When you accidentally set your hand on a hot stove, the heat produces a painful, localized disturbance of homeostasis. Your nervous system responds by ordering the immediate contraction of specific muscles that will pull your hand away from the stove. These contractions last only as long as the neural activity continues, usually a matter of seconds.

In contrast, the endocrine system releases chemical messengers called *hormones*, which affect tissues and organs throughout the body. Even though the responses may not be immediately apparent, they may persist for days or weeks. Examples of homeostatic regulation dependent on endocrine function include the long-term regulation of blood volume and composition, and the adjustment of organ system function during starvation. The endocrine system also plays a major role in growth and development: It is responsible for the changes that take place in your body as you mature and age.

Regardless of the system involved, the function of homeostatic regulation is always to keep the characteristics of the internal environment within certain limits. A homeostatic regulatory mechanism consists of three parts: (1) a **receptor,** a sensor that is sensitive to a particular stimulus or environmental change; (2) a **control center,** or integration center, which receives and processes the information supplied by the receptor, and sends out commands; and (3) an **effector,** a cell or organ that responds to the commands of the control center and whose activity either opposes or enhances the stimulus. You are probably already familiar with comparable regulatory mechanisms, such as the thermostat in your house or apartment (**Figure 1–2a**).

The thermostat is the control center; it receives information about room temperature from an internal or remote thermometer (a receptor). The dial on the thermostat establishes the **set point,** or desired value, which in this case is the temperature you select. (In our example, the set point is 22°C, or about 72°F.) The function of the thermostat is to keep room temperature within acceptable limits, usually within a degree or so of the set point. In summer, the thermostat accomplishes this function by controlling an air conditioner (an effector). When the temperature at the thermometer rises above the acceptable range, the thermostat turns on the air conditioner, which then cools the room (**Figure 1–2b**); when the temperature at the thermometer returns to the set point, the thermostat turns off the air conditioner. The control is not precise; the room is large, and the thermostat is located on just one wall. Over time, the temperature in the center of the room fluctuates around the set point. The essential feature of temperature control by thermostat can be summarized very simply: A variation outside the desired range triggers an automatic response that corrects the situation. This method of homeostatic regulation is called *negative feedback*, because an effector activated by the control center opposes, or *negates*, the original stimulus. Negative feedback thus tends to minimize change, keeping variation in key body systems within limits that are compatible with our long-term survival.

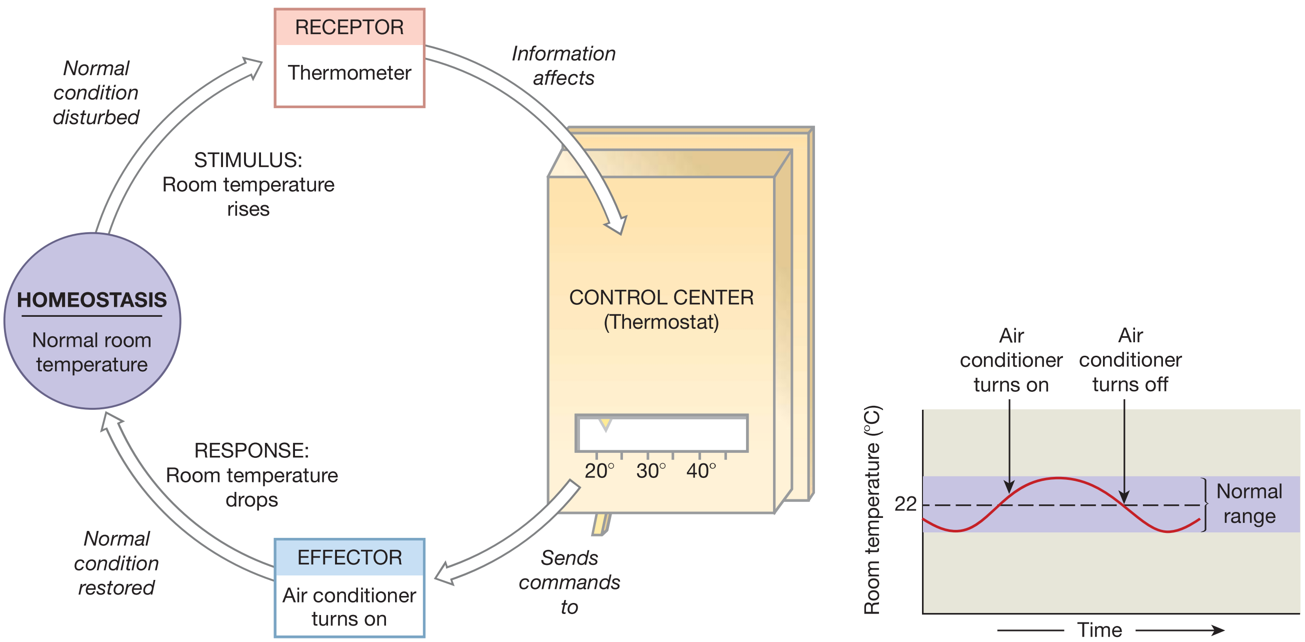
1

Checkpoint

17. **Define homeostasis.**
18. **Which general mechanism of homeostatic regulation always involves the nervous or endocrine system?**
19. **Why is homeostatic regulation important to an organism?**

See the blue Answers tab at the back of the book.

Figure 1–2 The Control of Room Temperature.



a In response to input from a receptor (a thermometer), a thermostat (the control center) triggers an effector response (either an air conditioner or a heater) that restores normal temperature. In this case, when room temperature rises above the set point, the thermostat turns on the air conditioner, and the temperature returns to normal.

b With this regulatory system, room temperature fluctuates around the set point.

Clinical Note

Homeostasis and Disease

The human body is amazingly effective in maintaining homeostasis. Nevertheless, an infection, an injury, or a genetic abnormality can sometimes have effects so severe that homeostatic mechanisms can't fully compensate for them. One or more characteristics of the internal environment may then be pushed outside of normal limits. When this happens, organ systems begin to malfunction, producing a state known as illness or disease.

An understanding of normal homeostatic mechanisms usually enables one to draw conclusions about what might be responsible for the signs and symptoms that are characteristic of many diseases. *Symptoms* are subjective—things that a person experiences and describes but that aren't otherwise detectable or measurable, such as pain, nausea, and anxiety. A *sign*, by contrast, is an objectively observable or measurable physical indication of a disease, such as a rash, a swelling, a fever, or sounds of abnormal breathing. Currently, technological aids can reveal many additional signs that would not be evident to a physician's unaided senses, such as an unusual shape on an x-ray or MRI scan, or an elevated concentration of a particular chemical in a blood test. Many aspects of human health, disease, and treatment are described in this textbook.

1-7 Negative feedback opposes variations from normal, whereas positive feedback exaggerates them

In this section we examine the roles of positive and negative feedback in homeostasis before considering the roles of organ systems in regulating homeostasis.

The Role of Negative Feedback in Homeostasis

Most homeostatic regulatory mechanisms involve **negative feedback,** a way for counteracting an effect. An important example is the control of body temperature, a process called *thermoregulation*. In thermoregulation, the relationship between heat loss, which occurs mainly at the body surface, and heat production, which takes place in all active tissues, is altered.

In the homeostatic control of body temperature (**Figure 1–3a**), the control center is in the *hypothalamus*, a region of the brain. This control center receives information from two sets of temperature receptors, one in the skin and the other within the hypothalamus. At the normal set point, body temperature (as measured with an oral thermometer) will be approximately 37°C (98.6°F). If body temperature rises above 37.2°C, activity in the control center targets two effectors: (1) muscle tissue in the walls of blood vessels supplying the skin and (2) sweat glands. The muscle tissue relaxes and the blood vessels dilate, increasing blood flow through vessels near the body surface; the sweat glands accelerate their secretion. The skin then acts like a radiator by losing heat to the environment, and the evaporation of sweat speeds the process. As body temperature returns to normal, temperature at the hypothalamus declines, and the thermoregulatory control center becomes less active. Superficial blood flow and sweat gland activity then decrease to previous levels, although body temperature declines past the set point as the secreted sweat evaporates.

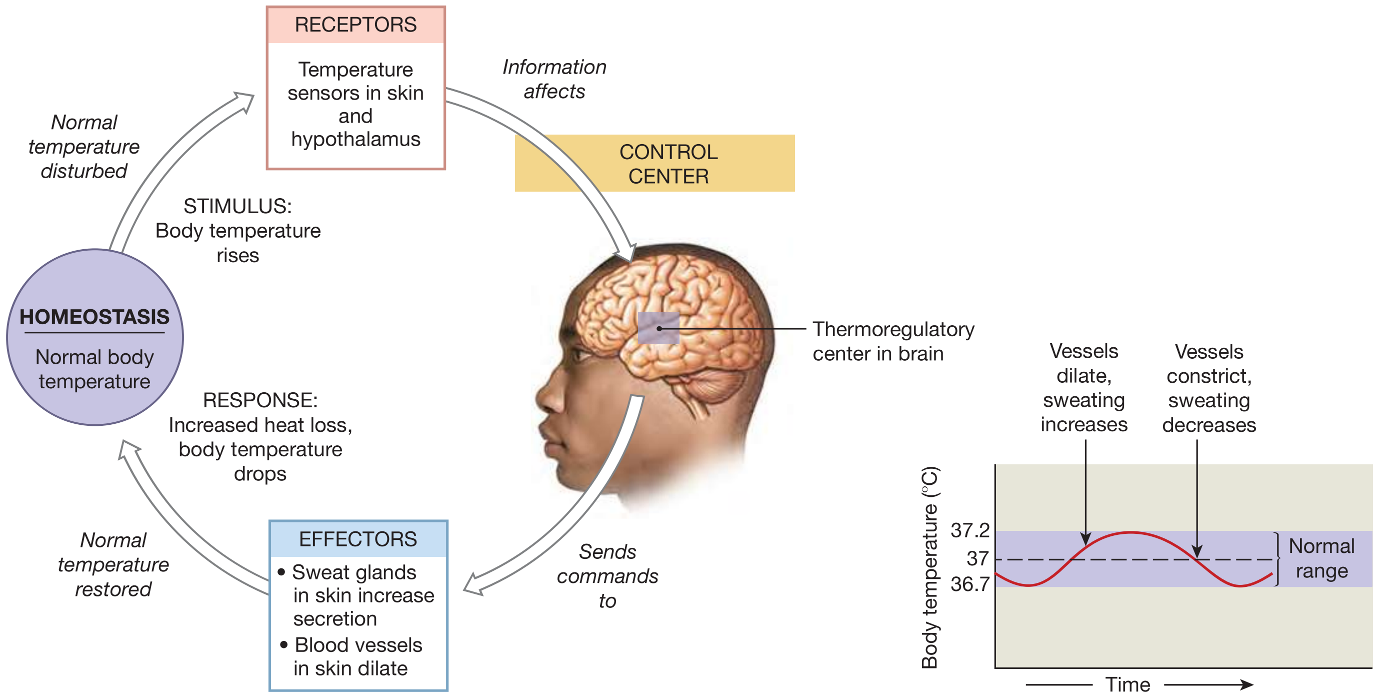
Negative feedback is the primary mechanism of homeostatic regulation, and it provides long-term control over the body's internal conditions and systems. Homeostatic mechanisms using negative feedback normally ignore minor variations, and they maintain a normal *range* rather than a fixed value. In the previous example, body temperature fluctuated around the set-point temperature (**Figure 1–3b**). The regulatory process itself is dynamic, because the set point may vary with changing environments or differing activity levels. For example, when you are asleep, your thermoregulatory set point is lower, whereas when you work outside on a hot day (or when you have a fever), it is higher. Thus, body temperature can vary from moment to moment or from day to day for any individual, due to either (1) small fluctuations around the set point or (2) changes in the set point. Comparable variations occur in all other aspects of physiology.

The variability among individuals is even greater than that within an individual. Each of us has homeostatic set points determined by genetic factors, age, gender, general health, and environmental conditions. It is therefore impractical to define "normal" homeostatic conditions very precisely. By convention, physiological values are reported either as average values obtained by sampling a large number of individuals, or as a range that includes 95 percent or more of the sample population. For example, for 95 percent of healthy adults, body temperature ranges between 36.7–37.2°C (98.1–98.9°F). However, 5 percent of healthy adults have resting body temperatures that are below 36.7°C or above 37.2°C. These temperatures are perfectly normal for them, and the variations have no clinical significance. Physicians must keep this variability in mind when they review lab reports or clinical discussions, because unusual values—even those outside the "normal" range—may represent individual variation rather than disease.

The Role of Positive Feedback in Homeostasis

In **positive feedback,** an initial stimulus produces a response that exaggerates or enhances the original change in conditions, rather than opposing it. You seldom encounter positive feedback in your daily life, simply because it tends to produce ex-

Figure 1–3 Negative Feedback in the Control of Body Temperature. In negative feedback, a stimulus produces a response that opposes or negates the original stimulus.



a Events in the regulation of body temperature, which are comparable to those shown in *Figure 1–2*. A control center in the brain (the hypothalamus) functions as a thermostat with a set point of 37°C. If body temperature exceeds 37.2°C, heat loss is increased through enhanced blood flow to the skin and increased sweating.

b The thermoregulatory center keeps body temperature fluctuating within an acceptable range, usually between 36.7 and 37.2°C.

treme responses. For example, suppose that the thermostat in **Figure 1–2a** was accidentally connected to a heater rather than to an air conditioner. Now, when room temperature exceeds the set point, the thermostat turns on the heater, causing a further rise in room temperature. Room temperature will continue to increase until someone switches off the thermostat, turns off the heater, or intervenes in some other way. This kind of escalating cycle is often called a **positive feedback loop.**

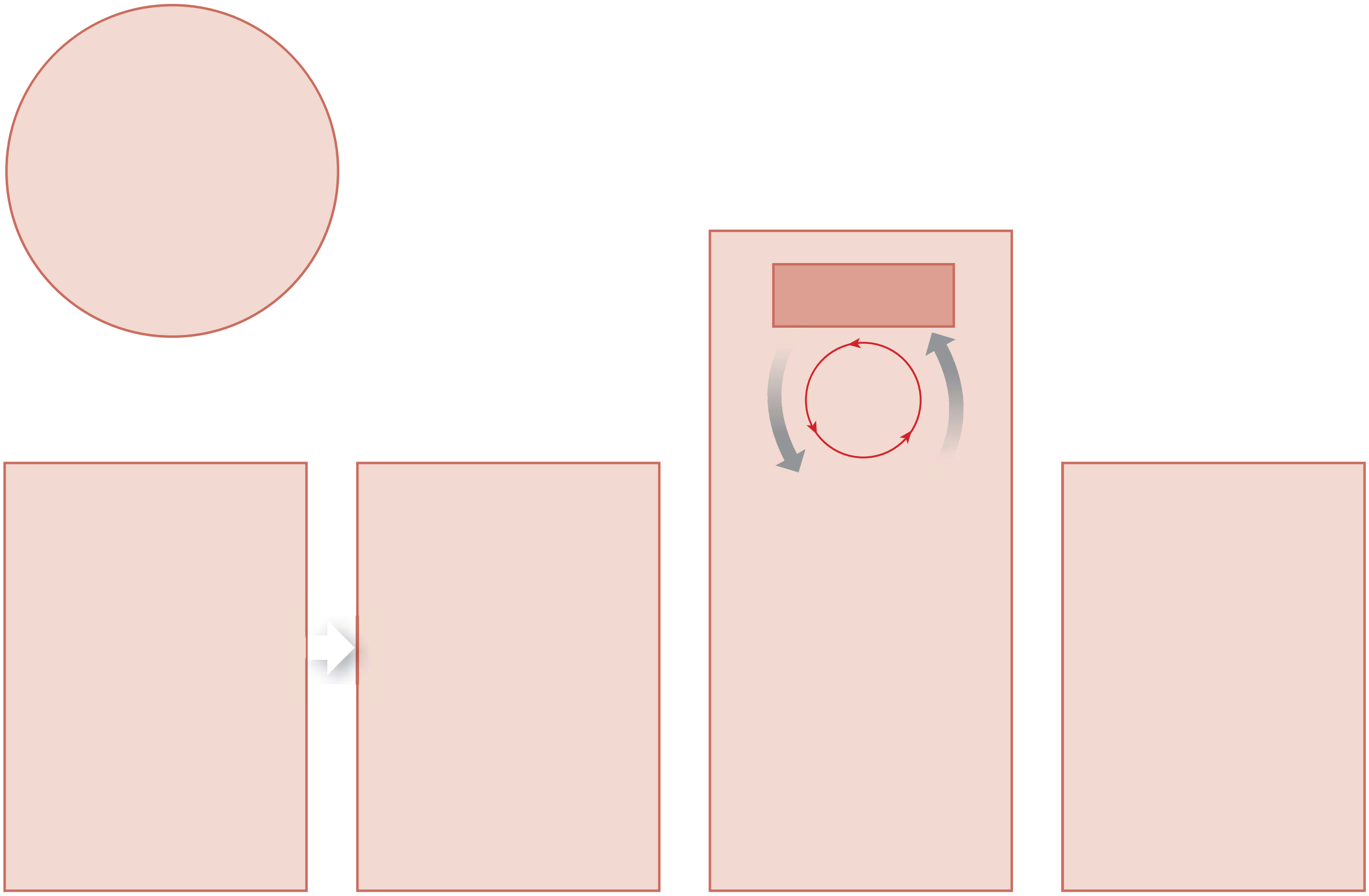
In the body, positive feedback loops are typically found when a potentially dangerous or stressful process must be completed quickly before homeostasis can be restored. For example, the immediate danger from a severe cut is loss of blood, which can lower blood pressure and reduce the efficiency of the heart. The body's response to blood loss is diagrammed in **Figure 1–4**. Blood clotting will be examined more closely in Chapter 19. Labor and delivery, another example of positive feedback in action, will be discussed in Chapter 29.

The human body is amazingly effective in maintaining homeostasis. Nevertheless, an infection, an injury, or a genetic abnormality can sometimes have effects so severe that homeostatic mechanisms cannot fully compensate for them. One or more characteristics of the internal environment may then be pushed outside normal limits. When this happens, organ systems begin to malfunction, producing a state known as illness, or **disease.** Chapters 5–29 devote considerable attention to the mechanisms responsible for a variety of human diseases.

Systems Integration, Equilibrium, and Homeostasis

Homeostatic regulation controls aspects of the internal environment that affect every cell in the body. No single organ system has total control over any of these aspects; such control requires the coordinated efforts of multiple organ systems. In later chapters we will explore the functions of each organ system and see how the systems interact to preserve homeostasis. **Table 1–1** lists the roles of various organ systems in regulating several important physiological characteristics that are subject to homeostatic control. Note that in each case such regulation involves several organ systems.

A **state of equilibrium** exists when opposing processes or forces are in balance. In the case of body temperature, a state of equilibrium exists when the rate of heat loss equals the rate of heat production. Each physiological system functions to maintain a state of equilibrium that keeps vital conditions within normal limits. This is often called a state of **dynamic equilibrium**



because physiological systems are continually adapting and adjusting to changing conditions. For example, when muscles become more active, more heat is produced. More heat must then be lost at the skin surface to reestablish a state of equilibrium before body temperature rises outside normal limits. Yet the adjustments made to control body temperature have other consequences: The sweating that increases heat loss at the skin surface increases losses of both water and salts. Other systems must then compensate for these losses and reestablish an equilibrium state for water and salts. This is a general pattern: Any adjustments made by one physiological system have direct and indirect effects on a variety of other systems. The maintenance of homeostasis is like a juggling act that keeps lots of balls in the air.

Although each organ system interacts with and is, in turn, dependent on other organ systems, it is much easier for introductory students to learn the basics of anatomy and physiology one system at a time. Although Chapters 5–29 are organized around individual systems, remember that these systems all work together. The 11 *System Integrators* in later chapters will help reinforce this message; each provides an overview of one system's functions and summarizes its functional relationships with systems covered in previous chapters.

Checkpoint

20. **Explain the function of negative feedback systems.**
21. **What happens to the body when homeostasis breaks down?**
22. **Explain how a positive feedback system works.**
23. **Why is positive feedback helpful in blood clotting but unsuitable for the regulation of body temperature?**
24. **Define equilibrium.**
25. **When the body continuously adapts by utilizing homeostatic systems, it is said to be in a state of ___________ equilibrium.**

See the blue Answers tab at the back of the book.

1-8 Anatomical terms describe body regions, anatomical positions and directions, and body sections

Anatomists use anatomical terms to describe body regions, relative positions and directions, and body sections, as well as major body cavities and their subdivisions. In the following sections we will introduce the terms used in superficial anatomy and sectional anatomy.

Superficial Anatomy

Superficial anatomy involves locating structures on or near the body surface. A familiarity with anatomical landmarks (palpable structures), anatomical regions (specific areas used for reference purposes), and terms for anatomical directions will make the material in subsequent chapters more understandable. As you encounter new terms, create your own mental maps from the information provided in the accompanying anatomical illustrations.

Anatomical Landmarks

Important anatomical landmarks are presented in **Figure 1–5**. Understanding the terms and their etymology (origins) will help you remember both the location of a particular structure and its name. For example, *brachium* refers to the arm; later we will consider the *brachialis muscle* and the *brachial artery*, which are (as their names suggest) in the arm.

The standard anatomical reference for the human form is the **anatomical position.** When the body is in this position, the hands are at the sides with the palms facing forward, and the feet are together. **Figure 1–5a** shows an individual in the anatomical position as seen from the front (an *anterior view*), and **Figure 1–5b** shows the body from the back (a *posterior view*). Unless otherwise noted, all descriptions in this text refer to the body in the anatomical position. A person lying down in the anatomical position is said to be **supine** (soo-PĪN) when face up, and **prone** when face down.

Tips & Tricks

Supine means up. In order to carry a bowl of *soup*, your hand must be in the *supine* position.

Anatomical Regions

To describe a general area of interest or injury, anatomists and clinicians often need broader terms in addition to specific landmarks. Two methods are used to map the surface of the abdomen and pelvis.

Clinicians refer to four **abdominopelvic quadrants** (**Figure 1–6a**) formed by a pair of imaginary perpendicular lines that intersect at the umbilicus (navel). This simple method provides useful references for the description of aches, pains, and injuries. The location can help the physician determine the possible cause; for example, tenderness in the right lower quadrant (RLQ) is a symptom of appendicitis, whereas tenderness in the right upper quadrant (RUQ) may indicate gallbladder or liver problems.

Anatomists prefer more precise terms to describe the location and orientation of internal organs. They recognize nine **abdominopelvic regions** (**Figure 1–6b**). **Figure 1–6c** shows the relationships among quadrants, regions, and internal organs.

Tips & Tricks

The imaginary lines dividing the abdominopelvic regions resemble a tic-tac-toe game.

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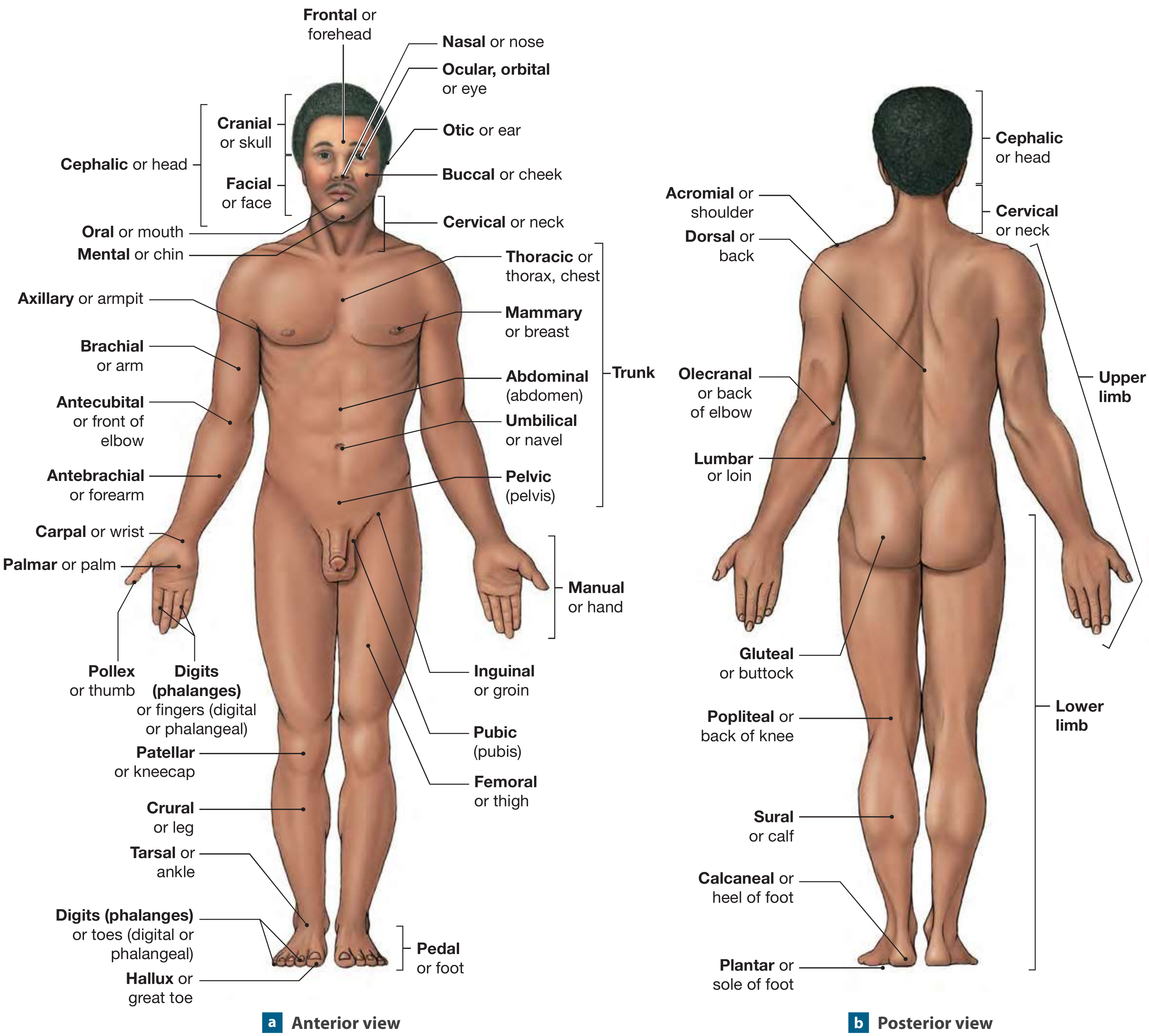
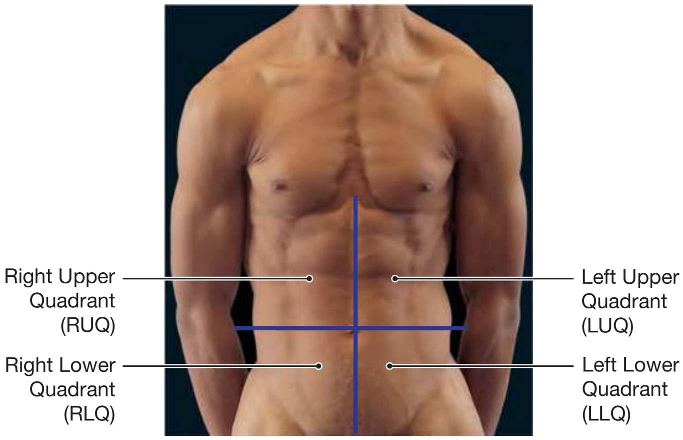
Figure 1–5 Anatomical Landmarks. Anatomical terms are shown in boldface type and common names are in plain type.



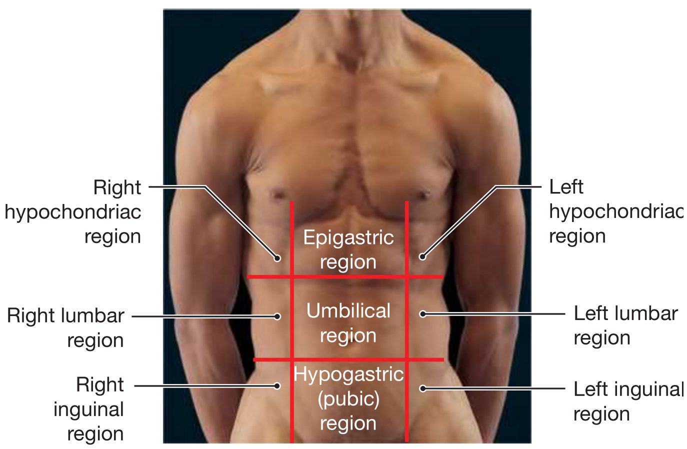
Anatomical Directions

Figure 1–7 and **Table 1–2** introduce the principal directional terms and some examples of their use. There are many different terms, and some can be used interchangeably. For example, *anterior* refers to the front of the body when viewed in the anatomical position; in humans, this term is equivalent to *ventral*, which refers to the belly. Before you read further, analyze the table in detail, and practice using these terms. If you are familiar with the basic vocabulary, the descriptions in subsequent chapters will be easier to follow. When reading anatomical descriptions, you will find it useful to remember that the terms *left* and *right* always refer to the *left* and *right* sides of the *subject*, not of the observer.

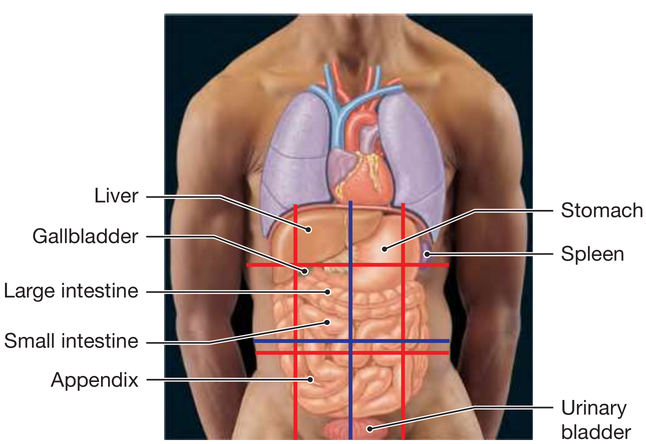
Figure 1–6 **Abdominopelvic Quadrants and Regions.**



a **Abdominopelvic quadrants**. The four abdominopelvic quadrants are formed by two perpendicular lines that intersect at the navel. The terms for these quadrants, or their abbreviations, are most often used in clinical discussions.



b **Abdominopelvic regions**. The nine abdominopelvic regions provide more precise regional descriptions.



c **Anatomical relationships**. The relationship between the abdominopelvic quadrants and regions and the locations of the internal organs are shown here.

Sectional Anatomy

Sometimes the only way to understand the relationships among the parts of a three-dimensional object is to slice through it and look at the internal organization.

An understanding of sectional views is particularly important now that imaging techniques enable us to see inside the living body. Although these views are sometimes difficult to interpret, it is worth spending the time required to understand what they show. Once you are able to interpret sectional views, you will have a good mental model for studying the anatomy and physiology of a particular region or system. Radiologists and other medical professionals responsible for interpreting medical scans spend much of their time analyzing sectional views of the body.

Planes and Sections

Any slice (or section) through a three-dimensional object can be described in reference to three **sectional planes,** as indicated in **Figure 1–8** and **Table 1–3**. A *plane* is an axis; three planes are needed to describe any three-dimensional object. A *section* is a single view or slice along one of these planes. The **transverse** (or *horizontal*) **plane** lies at right angles to the long axis of the body, dividing it into *superior* and *inferior* portions. A cut in this plane is called a **transverse section,** or *cross section*. The **frontal plane** (or *coronal plane*) and the **sagittal plane** are parallel to the long axis of the body. The frontal plane extends vertically, dividing the body into *anterior* and *posterior* portions. The sagittal plane also extends vertically, dividing the body into left and right portions. A cut that passes along the midline and divides the body into equal left and right halves is a *midsagittal section*, or *median section*; a cut parallel to the midsagittal line is a *parasagittal section*. The atlas that accompanies this text contains images of sections taken through the body in various planes. You will be referred to these images later in the text for comparison with specific figure illustrations. Unless otherwise noted, all anatomical diagrams that present cross-sectional views of the body are oriented as though the subject were supine with the observer standing at the subject's feet and looking toward the head.

Checkpoint

26. **What is the purpose of anatomical terms?**
27. **In the anatomical position, describe an anterior view and a posterior view.**

See the blue Answers tab at the back of the book.

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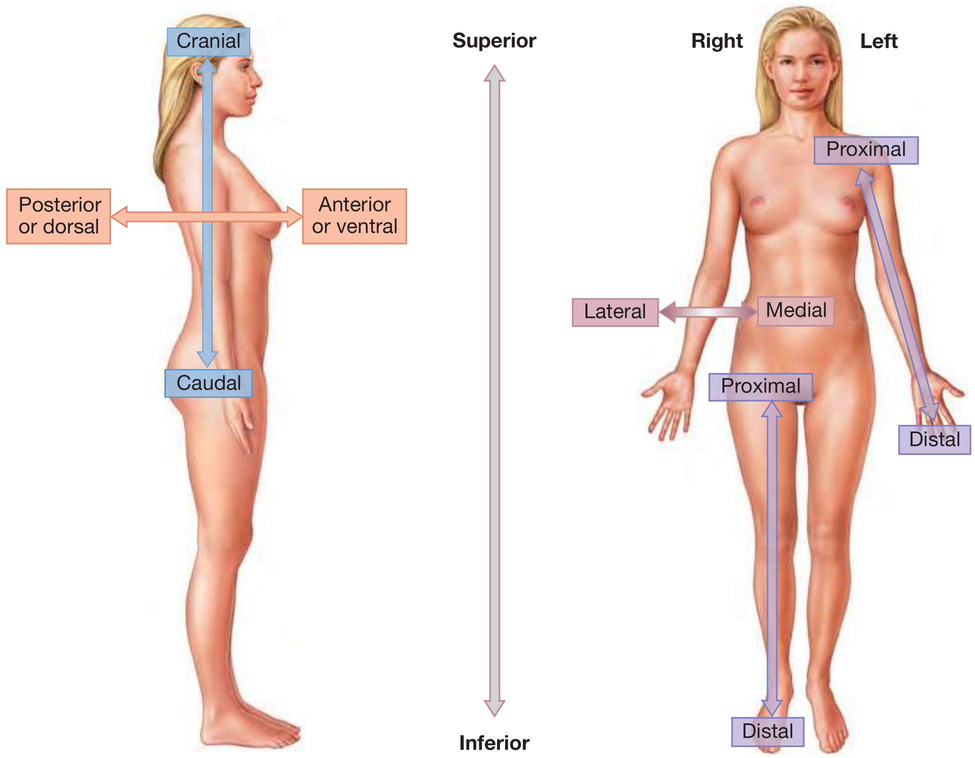
Figure 1–7 **Directional References.**



a **A lateral view.**

b **An anterior view.** Arrows indicate important directional terms used in this text; definitions and descriptions are given in Table 1–2.

Table 1–2 Directional Terms

Term	Region or Reference	Example
Anterior	The front surface	The navel is on the *anterior* surface of the trunk.
Ventral	The belly side (equivalent to anterior when referring to human body)	The navel is on the *ventral* surface of the trunk.
Posterior or **dorsal**	The back surface	The shoulder blade is located *posterior* to the rib cage.
Cranial or **cephalic**	The head	The *cranial*, or *cephalic*, border of the pelvis is on the side toward the head rather than toward the thigh.
Superior	Above; at a higher level (in the human body, toward the head)	In humans, the cranial border of the pelvis is *superior* to the thigh.
Caudal	The tail (coccyx in humans)	The hips are *caudal* to the waist.
Inferior	Below; at a lower level	The knees are *inferior* to the hips.
Medial	Toward the body's longitudinal axis; toward the midsagittal plane	The *medial* surfaces of the thighs may be in contact; moving medially from the arm across the chest surface brings you to the sternum.
Lateral	Away from the body's longitudinal axis; away from the midsagittal plane	The thigh articulates with the *lateral* surface of the pelvis; moving laterally from the nose brings you to the cheeks.
Proximal	Toward an attached base	The thigh is *proximal* to the foot; moving proximally from the wrist brings you to the elbow.
Distal	Away from an attached base	The fingers are *distal* to the wrist; moving distally from the elbow brings you to the wrist.
Superficial	At, near, or relatively close to the body surface	The skin is *superficial* to underlying structures.
Deep	Farther from the body surface	The bone of the thigh is *deep* to the surrounding skeletal muscles.

Figure 1–8 Sectional Planes. The three primary sectional planes are defined and described in Table 1–3. The photos of sectional images were derived from the Visible Human data set.

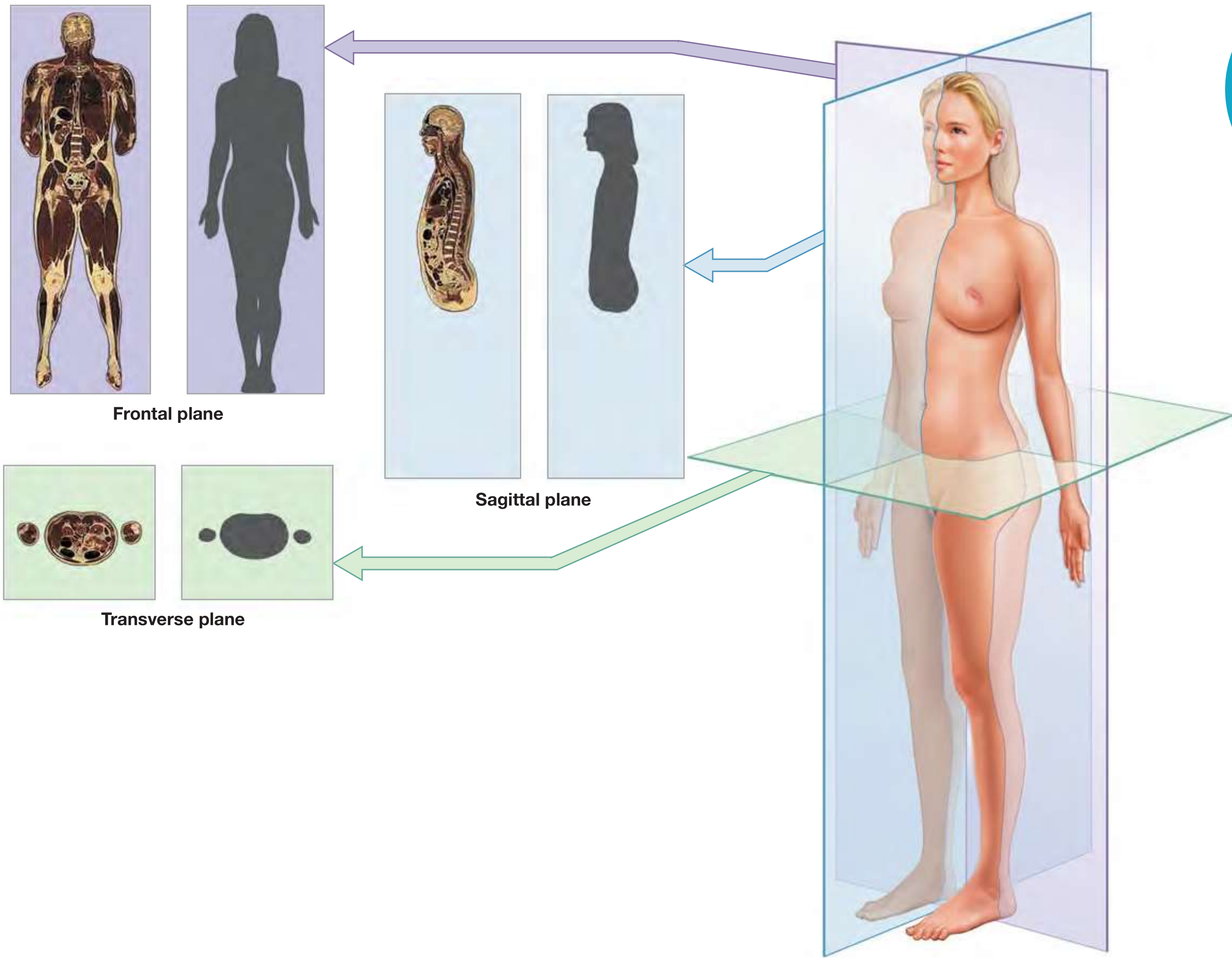


Table 1–3 Terms That Indicate Sectional Planes

Plane	Orientation of Plane	Directional Reference	Description
Transverse or **horizontal**	Perpendicular to long axis	Transversely or horizontally	A *transverse*, or *horizontal*, *section* separates superior and inferior portions of the body. A cut in this plane is called a *cross section.*
Sagittal	Parallel to long axis	Sagittally	A *sagittal section* separates right and left portions. You examine a sagittal section, but you section sagittally.
Midsagittal			In a *midsagittal section* or *median section*, the plane passes through the midline, dividing the body into right and left sides.
Parasagittal			A *parasagittal section*, which is a cut parallel to the midsagittal plane, separates the body into right and left portions of unequal size.
Frontal or **coronal**		Frontally or coronally	A *frontal*, or *coronal*, *section* separates anterior and posterior portions of the body; coronal usually refers to sections passing through the skull.

1-9 Body cavities protect internal organs and allow them to change shape

The interior of the body is often subdivided into regions established by the body wall. For example, everything deep to the chest wall is considered to be within the **thoracic cavity,** and all of the structures deep to the abdominal and pelvic walls are said to lie within the **abdominopelvic cavity.** Internally, the two are separated by the **diaphragm** (DĪ-uh-fram), a flat muscular sheet.

Many vital internal organs within these regions are suspended within fluid-filled chambers that are true **body cavities** with two essential functions: (1) They protect delicate organs from shocks and impacts; and (2) they permit significant changes in the size and shape of internal organs. For example, because the lungs, heart, stomach, intestines, urinary bladder, and many other organs project into body cavities, they can expand and contract without distorting surrounding tissues or disrupting the activities of nearby organs.

The *ventral body cavity*, or *coelom* (SĒ-lōm ; *koila*, cavity), appears early in embryological development. It contains organs of the respiratory, cardiovascular, digestive, urinary, and reproductive systems (**Figure 1–9**). As these internal organs develop, their relative positions change, and the ventral body cavity is gradually subdivided into three chambers within the thoracic cavity and one in the abdominopelvic cavity. The boundaries between the subdivisions of the ventral body cavity are depicted in **Figure 1–10**. The internal organs that are partially or completely enclosed by these cavities are called **viscera** (VIS-e-ruh). A delicate layer called a *serous membrane* lines the walls of these internal cavities and covers the surfaces of the enclosed viscera. A watery fluid that coats the opposing surfaces and reduces friction moistens serous membranes. The portion of a serous membrane that covers a visceral organ is called the *visceral* layer; the opposing layer that lines the inner surface of the body wall or chamber is called the *parietal* layer. Because the moist parietal and visceral layers are usually in close contact, the body cavities are called *potential spaces*. In some clinical conditions, however, excess fluid can accumulate within these cavities, increasing their volume and exerting pressure on the enclosed viscera.

The Thoracic Cavity

The thoracic cavity (**Figure 1–10a,c**) contains the lungs and heart; associated organs of the respiratory, cardiovascular, and lymphatic systems; the inferior portions of the esophagus; and the thymus. The thoracic cavity is subdivided into the left

Figure 1–9 **Relationships among the Subdivisions of the Ventral Body Cavity.**

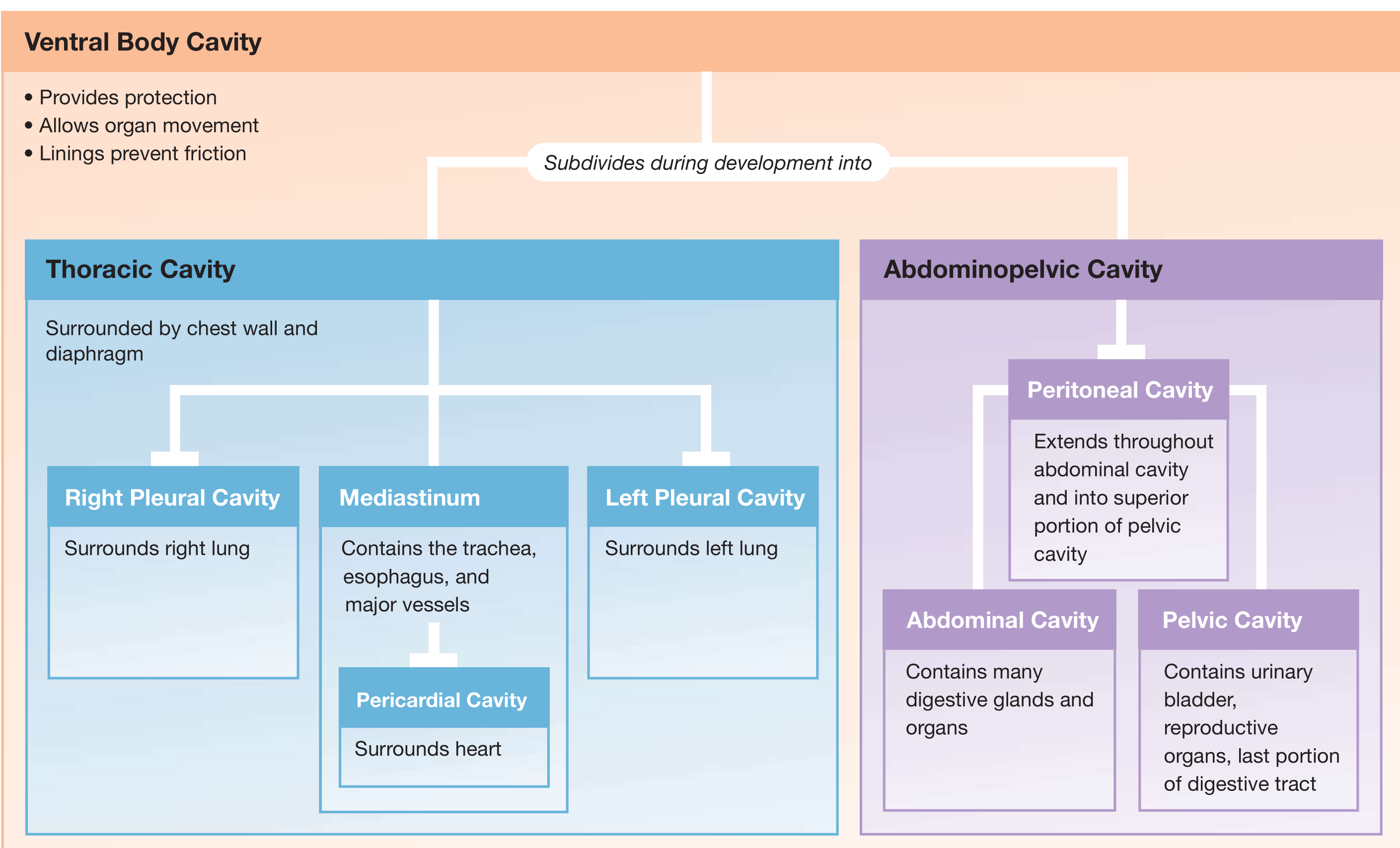
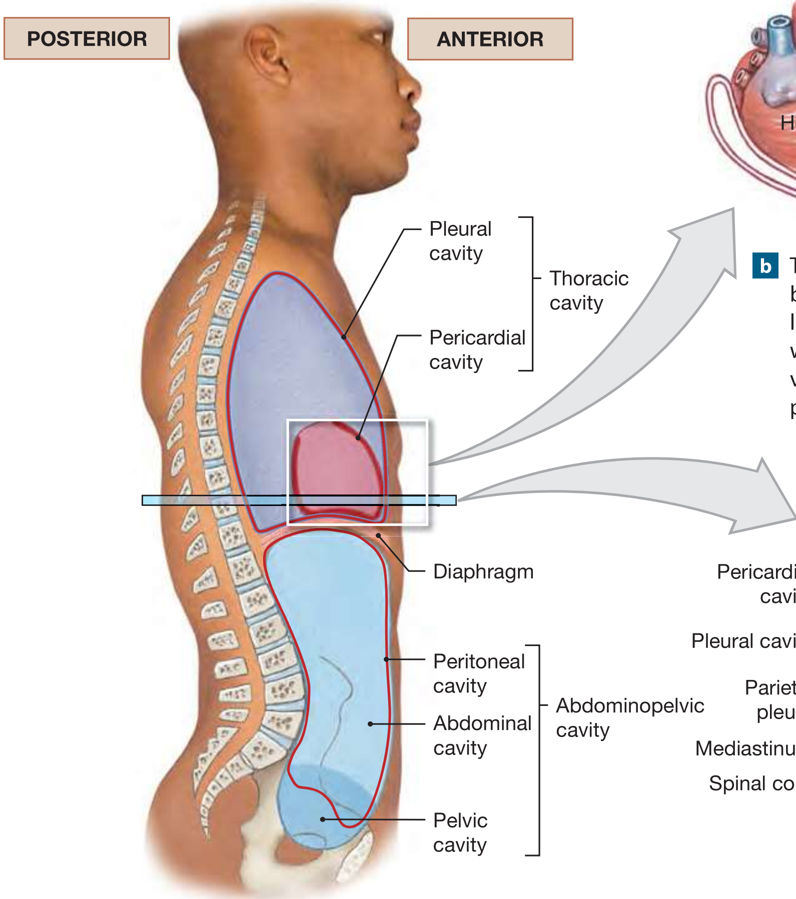
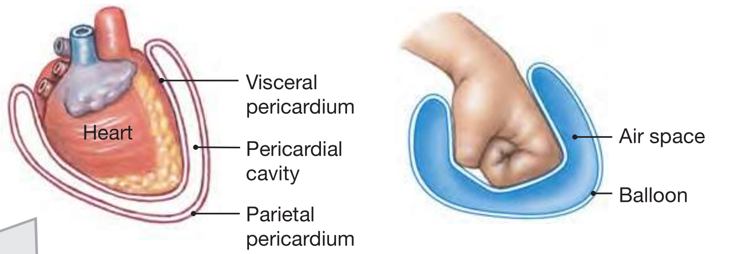


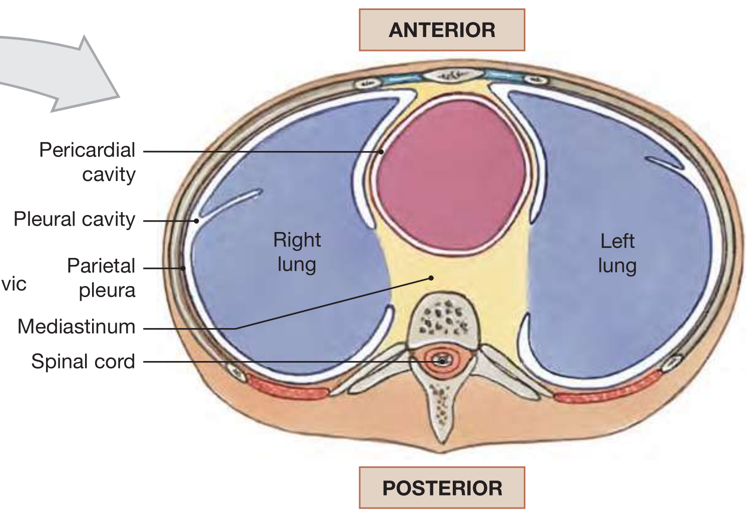
Figure 1–10 **The Ventral Body Cavity and Its Subdivisions.**



a A lateral view showing the ventral body cavity, which is divided by the muscular diaphragm into a superior thoracic (chest) cavity and an inferior abdominopelvic cavity. Three of the four adult body cavities are shown and outlined in red; only one of the two pleural cavities can be shown in a sagittal section.



b The heart projects into the pericardial cavity like a fist pushed into a balloon. The attachment site, corresponding to the wrist of the hand, lies at the connection between the heart and major blood vessels. The width of the pericardial cavity is exaggerated here; normally the visceral and parietal layers are separated only by a thin layer of pericardial fluid.



c A transverse section through the thoracic cavity, showing the central location of the pericardial cavity. Notice how the mediastinum divides the thoracic cavity into two pleural cavities. Note that this transverse or cross-sectional view is oriented as though the observer were standing at the subject's feet and looking toward the subject's head. This is the standard presentation for clinical images, and unless otherwise noted, sectional views in this text use this same orientation.

and right **pleural cavities** (holding the lungs), separated by a mass of tissue called the **mediastinum** (mē-dē-a-STĪ-num). Each pleural cavity, which surrounds a lung, is lined by a shiny, slippery serous membrane that reduces friction as the lung expands and recoils during breathing. The serous membrane lining a pleural cavity is called a *pleura* (PLOOR-ah). The *visceral pleura* covers the outer surfaces of a lung, whereas the *parietal pleura* covers the mediastinal surface and the inner body wall.

The mediastinum consists of a mass of connective tissue that surrounds, stabilizes, and supports the esophagus, trachea, and thymus, as well as the major blood vessels that originate or end at the heart. The mediastinum also contains the **pericardial cavity,** a small chamber that surrounds the heart. The relationship between the heart and the pericardial cavity resembles that of a fist pushing into a balloon (**Figure 1–10b**). The wrist corresponds to the *base* (attached portion) of the heart, and the balloon corresponds to the serous membrane that lines the pericardial cavity. The serous membrane associated with the heart is called the *pericardium* (*peri-*, around + *cardium*, heart). The layer covering the heart is the *visceral pericardium*, and the opposing surface is the *parietal pericardium*. During each beat, the heart changes in size and shape. The pericardial cavity permits these changes, and the slippery pericardial lining prevents friction between the heart and nearby structures in the thoracic cavity.

1

The Abdominopelvic Cavity

The abdominopelvic cavity extends from the diaphragm to the pelvis. It is subdivided into a superior **abdominal cavity** and an inferior **pelvic cavity** (**Figures 1–9** and **1–10a**). The abdominopelvic cavity contains the *peritoneal* (per-i-tō-NĒ-al) *cavity*, a potential space lined by a serous membrane known as the *peritoneum* (per-i-tō-NĒ-um). The *parietal peritoneum* lines the inner surface of the body wall. A narrow space containing a small amount of fluid separates the parietal peritoneum from the *visceral peritoneum*, which covers the enclosed organs. You are probably already aware of the movements of the organs in this cavity. Who has not had at least one embarrassing moment when the contraction of a digestive organ produced a movement of liquid or gas and a gurgling or rumbling sound? The peritoneum allows the organs of the digestive system to slide across one another without damage to themselves or the walls of the cavity.

The abdominal cavity extends from the inferior surface of the diaphragm to the level of the superior margins of the pelvis. This cavity contains the liver, stomach, spleen, small intestine, and most of the large intestine. (The positions of most of these organs are shown in **Figure 1–6c**.) The organs are partially or completely enclosed by the peritoneal cavity, much as the heart and lungs are enclosed by the pericardial and pleural cavities, respectively. A few organs, such as the kidneys and pancreas, lie between the peritoneal lining and the muscular wall of the abdominal cavity. Those organs are said to be *retroperitoneal* (*retro*, behind).

The pelvic cavity is the portion of the ventral body cavity inferior to the abdominal cavity. The bones of the pelvis form the walls of the pelvic cavity, and a layer of muscle forms its floor. The pelvic cavity contains the urinary bladder, various reproductive organs, and the distal portion of the large intestine. The pelvic cavity of females, for example, contains the ovaries, uterine tubes, and uterus; in males, it contains the prostate gland and seminal glands. The pelvic cavity also contains the inferior portion of the peritoneal cavity. The peritoneum covers the ovaries and the uterus in females, as well as the superior portion of the urinary bladder in both sexes. Visceral structures such as the urinary bladder and the distal portions of the ureters and large intestine, which extend inferior to the peritoneal cavity, are said to be *infraperitoneal*.

This chapter provided an overview of the locations and functions of the major components of each organ system. It also introduced the vocabulary you need to follow more detailed anatomical descriptions in later chapters. Many of the figures in those chapters contain images produced by modern clinical imaging procedures.

Checkpoint

28. **Name two essential functions of body cavities.**
29. **Identify the subdivisions of the ventral body cavity.**

See the blue Answers tab at the back of the book.

Related Clinical Terms

acute: A disease of short duration but typically severe.

auscultation: The action of listening to sounds from the heart, lungs, or other organs, typically with a stethoscope, as a part of medical diagnosis.

chemotherapy: The treatment of disease or mental disorder by the use of chemical substances, especially the treatment of cancer by cytotoxic and other drugs.

chronic: Illness persisting for a long time or constantly recurring. Often contrasted with acute.

disease: A malfunction of organs or organ systems resulting from a failure of homeostatic mechanisms.

DSA (digital subtraction angiography): A technique used to monitor blood flow through specific organs, such as the brain, heart, lungs, or kidneys. X-rays are taken before and after a radiopaque dye is administered, and a computer “subtracts” details common to both images. The result is a high-contrast image showing the distribution of the dye.

epidemiology: The branch of science that deals with the incidence, distribution, and possible control of diseases and other factors relating to health.

etiology: The science and study of the cause of diseases.

idiopathic: Denoting any disease or condition of unknown cause.

MRI (magnetic resonance imaging): An imaging technique that uses a magnetic field and radio waves to portray subtle structural differences.

PET (positron emission tomography) scan: An imaging technique that shows the chemical functioning, as well as the structure, of an organ.

pathophysiology: The functional changes that accompany a particular syndrome or disease.

spiral-CT: A method of processing computerized tomography data to provide rapid, three-dimensional images of internal organs.

ultrasound: An imaging technique that uses brief bursts of high-frequency sound waves reflected by internal structures.

x-rays: High-energy radiation that can penetrate living tissues.

Chapter Review

Study Outline

1

An Introduction to Studying the Human Body p. 2

1. Biology is the study of life. One of its goals is to discover the unity and the patterns that underlie the diversity of organisms.

1-1 Anatomy and physiology directly affect your life p. 2

2. This course will help you discover how your body works under normal and abnormal conditions, by serving as a base for understanding other life sciences and expanding your vocabulary.

1-2 Good study strategies are crucial to success p. 2

3. Your success in your A&P course requires developing good study skills.
4. Your textbook contains a diversity of features and resources to support your efforts to be an active learner.

1-3 Anatomy is structure, and physiology is function p. 4

5. **Anatomy** is the study of internal and external structures of the body and the physical relationships among body parts. **Physiology** is the study of how living organisms perform their vital functions. All physiological functions are performed by specific structures.
6. **Medical terminology** is the use of prefixes, suffixes, word roots, and combining forms to construct anatomical, physiological, or medical terms.
7. *Terminologia Anatomica (International Anatomical Terminology)* was used as the standard in preparing your textbook.

1-4 Anatomy and physiology are closely integrated p. 5

8. All specific functions are performed by specific structures.
9. In **gross** *(macroscopic)* **anatomy,** we consider features that are visible without a microscope. This field includes *surface anatomy* (general form and superficial markings); *regional anatomy* (anatomical organization of specific areas of the body); and *systemic anatomy* (structure of organ systems). In *developmental anatomy*, we examine the changes in form that occur between conception and physical maturity. In *embryology*, we study developmental processes that occur during the first two months of development. *Clinical anatomy* includes anatomical subspecialties important to the practice of medicine.
10. The equipment used determines the limits of *microscopic anatomy*. In **cytology,** we analyze the internal structure of individual cells. In **histology,** we examine **tissues,** groups of cells that perform specific functions. Tissues combine to form **organs,** anatomical structures with multiple functions.
11. Human physiology is the study of the functions of the human body. It is based on *cell physiology*, the study of the functions of cells. In *organ physiology*, we study the physiology of specific organs. In *systemic physiology*, we consider all aspects of the functioning of specific organ systems. In *pathological physiology*, we study the effects of diseases on organ or system functions.

1-5 Levels of organization progress from molecules to a complete organism p. 7

12. Anatomical structures and physiological mechanisms occur in a series of interacting levels of organization. *(Spotlight Figure 1–1)*
13. The 11 **organ systems** of the body are the integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive systems. *(Spotlight Figure 1–1)*

1-6 Homeostasis is the tendency toward internal balance p. 10

14. **Homeostasis** is the existence of a stable environment within the body.
15. Physiological systems preserve homeostasis through *homeostatic regulation*.
16. **Autoregulation** occurs when a cell, tissue, organ, or organ system adjusts its activities automatically in response to some environmental change. **Extrinsic regulation** results from the activities of the nervous system or endocrine system.
17. Homeostatic regulation mechanisms usually involve a **receptor** that is sensitive to a particular stimulus; a **control center,** which receives and processes the information supplied by the receptor and then sends out commands; and an **effector** that responds to the commands of the control center and whose activity either opposes or enhances the stimulus. *(Figure 1–2)*

1-7 Negative feedback opposes variations from normal, whereas positive feedback exaggerates them p. 12

18. **Negative feedback** is a corrective mechanism involving an action that directly opposes a variation from normal limits. *(Figure 1–3)*
19. In **positive feedback,** an initial stimulus produces a response that exaggerates or enhances the change in the original conditions, creating a *positive feedback loop*. *(Figure 1–4)*
20. No single organ system has total control over the body's internal environment; all organ systems work together. *(Table 1–1)*

1-8 Anatomical terms describe body regions, anatomical positions and directions, and body sections p. 15

21. The standard arrangement for anatomical reference is called the **anatomical position.** If the person is shown lying down, it can be either **supine** (face up) or **prone** (face down). *(Figure 1–5)*
22. **Abdominopelvic quadrants** and **abdominopelvic regions** represent two approaches to describing anatomical regions of that portion of the body. *(Figure 1–6)*
23. The use of special directional terms provides clarity for the description of anatomical structures. *(Figure 1–7; Table 1–2)*
24. The three **sectional planes** (**transverse,** or *horizontal*, **plane; frontal,** or *coronal*, **plane;** and **sagittal plane**) describe relationships among the parts of the three-dimensional human body. *(Figure 1–8; Table 1–3)*

1-9 Body cavities protect internal organs and allow them to change shape p. 20

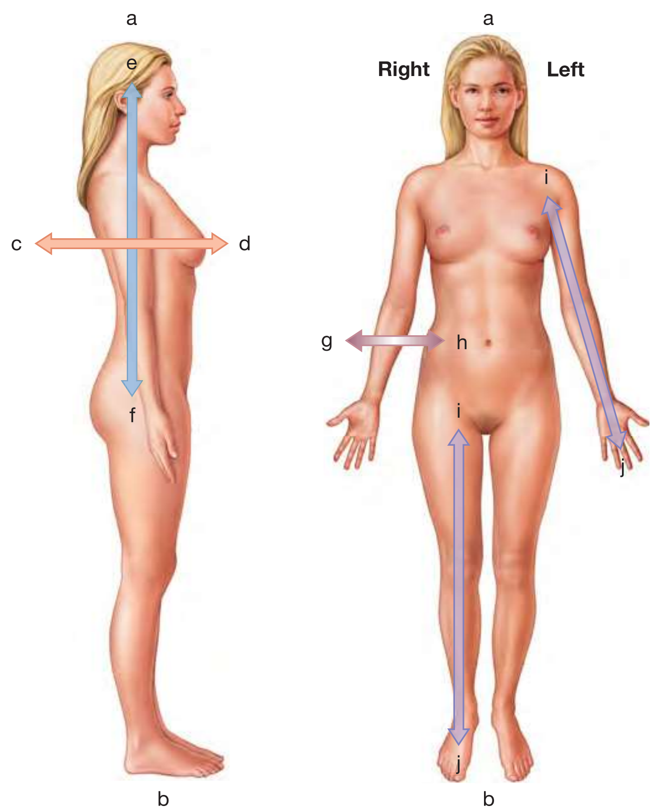
25. **Body cavities** protect delicate organs and permit significant changes in the size and shape of internal organs. The *ventral body cavity*, or *coelom*, surrounds developing respiratory, cardiovascular, digestive, urinary, and reproductive organs. *(Figure 1–9)*
26. The **diaphragm** divides the ventral body cavity into the (superior) **thoracic** and (inferior) **abdominopelvic cavities.** The thoracic cavity consists of two **pleural cavities** (each surrounding a lung) separated by a tissue mass known as the **mediastinum.** Within the mediastinum is the **pericardial cavity,** which surrounds the heart. The abdominopelvic cavity consists of the **abdominal cavity** and the **pelvic cavity** and contains the *peritoneal cavity*, a chamber lined by the *peritoneum*, a serous membrane. *(Figure 1–10)*

Review Questions

See the blue Answers tab at the back of the book.

LEVEL 1 Reviewing Facts and Terms

1. Label the directional terms in the figures below.



(a) ___________ (b) ___________
(c) ___________ (d) ___________
(e) ___________ (f) ___________
(g) ___________ (h) ___________
(i) ___________ (j) ___________

Match each numbered item with the most closely related lettered item. Use letters for answers in the spaces provided.

___ 2. cytology
___ 3. physiology
___ 4. histology
___ 5. metabolism
___ 6. homeostasis
___ 7. muscle
___ 8. heart
___ 9. endocrine
___ 10. temperature regulation
___ 11. labor and delivery
___ 12. supine
___ 13. prone
___ 14. divides ventral body cavity
___ 15. abdominopelvic cavity
___ 16. pericardium

(a) study of tissues
(b) constant internal environment
(c) face up
(d) study of functions
(e) positive feedback
(f) organ system
(g) study of cells
(h) negative feedback
(i) serous membrane
(j) all chemical activity in body
(k) diaphragm
(l) tissue
(m) peritoneal cavity
(n) organ
(o) face down

17. The following is a list of six levels of organization that make up the human body:
   1. tissue
   2. cell
   3. organ
   4. molecule
   5. organism
   6. organ system
   The correct order, from the smallest to the largest level, is
   (a) 2, 4, 1, 3, 6, 5.
   (b) 4, 2, 1, 3, 6, 5.
   (c) 4, 2, 1, 6, 3, 5.
   (d) 4, 2, 3, 1, 6, 5.
   (e) 2, 1, 4, 3, 5, 6.
18. The study of the structure of tissue is called
   (a) gross anatomy.
   (b) cytology.
   (c) histology.
   (d) organology.
19. The increasingly forceful labor contractions during childbirth are an example of
   (a) receptor activation.
   (b) effector shutdown.
   (c) negative feedback.
   (d) positive feedback.
20. Failure of homeostatic regulation in the body results in
   (a) autoregulation.
   (b) extrinsic regulation.
   (c) disease.
   (d) positive feedback.
21. A plane through the body that passes perpendicular to the long axis of the body and divides the body into a superior and an inferior section is a
   (a) sagittal section.
   (b) transverse section.
   (c) coronal section.
   (d) frontal section.
22. In which body cavity would you find each of the following organs?
   (a) heart
   (b) small intestine, large intestine
   (c) lung
   (d) kidneys
23. The mediastinum is the region between the
   (a) lungs and heart.
   (b) two pleural cavities.
   (c) chest and abdomen.
   (d) heart and pericardium.

LEVEL 2 Reviewing Concepts

24. (a) Define *anatomy*.
   (b) Define *physiology*.
25. The subdivisions of the ventral body cavity are located within the
   (a) pleural cavity and pericardial cavity.
   (b) coelom and peritoneal cavity.
   (c) pleural cavity and peritoneal cavity.
   (d) thoracic cavity and abdominopelvic cavity.

26. What distinguishes autoregulation from extrinsic regulation?
27. Describe the anatomical position.
28. Which sectional plane could divide the body so that the face remains intact?
    - **(a)** sagittal plane
    - **(b)** frontal (coronal) plane
    - **(c)** equatorial plane
    - **(d)** midsagittal plane
    - **(e)** parasagittal plane
29. Which the following is *not* an example of negative feedback?
    - **(a)** Increased pressure in the aorta triggers mechanisms to lower blood pressure.
    - **(b)** A rise in blood calcium levels triggers the release of a hormone that lowers blood calcium levels.
    - **(c)** A rise in estrogen during the menstrual cycle increases the number of progesterone receptors in the uterus.
    - **(d)** Increased blood sugar stimulates the release of a hormone from the pancreas that stimulates the liver to store blood sugar.

LEVEL 3 Critical Thinking and Clinical Applications

30. The hormone *calcitonin* is released from the thyroid gland in response to increased levels of calcium ions in the blood. If this hormone is controlled by negative feedback, what effect would calcitonin have on blood calcium levels?
31. It is a warm day and you feel a little chilled. On checking your temperature, you find that your body temperature is 1.5 degrees C below normal. Suggest some possible reasons for this situation.

1