An Introduction to Anatomy and Physiology

1

Learning Outcomes

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

- **1-1** Describe the basic functions of living organisms.
- **1-2** Explain the relationship between anatomy and physiology, and describe various specialties of each discipline.
- **1-3** Identify the major levels of organization in organisms, from the simplest to the most complex.
- **1-4** Identify the 11 organ systems of the human body and contrast their major functions.
- **1-5** Explain the concept of homeostasis.
- **1-6** Describe how negative feedback and positive feedback are involved in homeostatic regulation.
- **1-7** Use anatomical terms to describe body regions, body sections, and relative positions.
- **1-8** Identify the major body cavities of the trunk and the subdivisions of each.

Clinical Notes

Homeostasis and Disease, p. 36
Imaging Techniques, pp. 50–51

Spotlight

Levels of Organization, p. 35

An Introduction to Studying the Human Body

In this textbook we will introduce you to the essential, inner workings of your body—giving information about its structure (anatomy) and function (physiology). As a human, you are most likely very curious, and few subjects arouse so much curiosity as our own bodies. You will discover how your body works under normal and abnormal conditions and how it maintains an internal state of balance. As we proceed, you will see how your body deals with injury, disease, or anything that threatens that crucial balance in a changing environment.

Build Your Knowledge

Throughout each chapter, you will find Build Your Knowledge boxes that will coach you through anatomy and physiology concepts. This feature will help you connect new material with what you already know. At the end of each chapter that closes a body system, you will see a “capstone” Build Your Knowledge page that will illustrate the integration of the body system with the other body systems presented up to that point in the book. Be sure to read every Build Your Knowledge box or page so that you can build your knowledge—and confidence!

1-1 A l livig th g d sp ay e p ive s, g w h p ip m ven h , ad en ab ism

a n g O en Describe the basic functions of living organisms.

We live in a world containing an amazing diversity of living organisms that vary widely in appearance and lifestyle. One aim of **biology**—the study of life—is to discover the common patterns that underlie this diversity. Such discoveries show that all living things share these common functions:

- ***Responsiveness.*** Organisms respond to changes in their immediate environment. This property is also called *irritability*. You move your hand away from a hot stove, your dog barks at approaching strangers, fish are alarmed by loud noises, and tiny amoebas glide toward potential prey. Organisms also make longer-term changes as they adjust to their environments. For example, an animal may grow a heavier coat of fur as winter approaches, or it may migrate to a warmer climate. The capacity to make such adjustments is termed *adaptability*.
- ***Growth.*** Organisms increase in size through the growth or addition of **cells**, the simplest units of life. Single-celled creatures grow by getting larger. More complex organisms grow primarily by increasing the number of cells. Familiar organisms, such as dogs, cats, and humans, are made up of trillions of cells. As such multicellular organisms develop, individual cells become specialized to perform particular functions. This specialization is called *cellular differentiation*.
- ***Reproduction.*** Organisms reproduce, creating new generations of the same kind of organisms.
- ***Movement.*** Organisms exhibit movement. The movement may be internal (transporting food, blood, or other materials within the body) or external (moving through the environment).
- ***Metabolism.*** Organisms rely on complex chemical reactions to provide the energy required for responsiveness, growth, reproduction, and movement. They also build complex chemicals, such as proteins. *Metabolism* refers to all the chemical operations in the body.

For normal metabolic operations, organisms must absorb materials from the environment. To generate energy efficiently, most cells require various nutrients they obtain in food, as well as oxygen, a gas. *Respiration* refers to the absorption, transport, and use of oxygen by cells. Metabolic operations often generate unneeded or potentially harmful waste products that must be eliminated through the process of *excretion*.

For very small organisms, absorption, respiration, and excretion involve the movement of materials across exposed surfaces. But creatures larger than a few millimeters across seldom absorb nutrients directly from their environment. For example, humans cannot absorb steaks, apples, or ice cream without processing them first. That processing, called

> Go to **Mastering A&P** > Study Area > Menu > Chapter Pre-Test

digestion, takes place in specialized structures in which complex foods are broken down into simpler components that can be transported and absorbed easily.

Respiration and excretion are also more complicated for large organisms. Humans have specialized structures for gas exchange (lungs) and excretion (kidneys). Digestion, respiration, and excretion occur in different parts of the body, but the cells of the body cannot travel to one place for nutrients, another for oxygen, and a third to get rid of waste products. Instead, individual cells remain where they are but communicate with other areas of the body through an internal transport system—the circulation. For example, the blood absorbs the waste products released by each of your cells and carries those wastes to the kidneys for excretion.

Biology includes many subspecialties. In this text we consider two biological subjects: anatomy (ah-NAT-o-mē) and physiology (fiz-ē-OL-o-jē). Over the course of this book, you will become familiar with the basic anatomy and physiology of the human body.

CHECKPOINT

1. How do vital functions such as responsiveness, growth, reproduction, and movement depend on metabolism?

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

1-2 Anatomy is structure, and physiology is function

Learning Outcome Explain the relationship between anatomy and physiology, and describe various specialties of each discipline.

The word *anatomy* has Greek origins, as do many other anatomical terms and phrases. **Anatomy**, which means "a cutting open," is the study of internal and external structure and the physical relationships between body parts. **Physiology**, also derived from Greek, is the study of how living organisms carry out their vital functions. The two subjects are interrelated. Anatomical details provide clues about probable functions. Physiological processes can be explained only in terms of their underlying anatomy.

The link between structure and function is always present but not always understood. For example, the anatomy of the heart was clearly described in the fifteenth century, but almost 200 years passed before anyone realized that it pumped blood. This text will familiarize you with basic anatomy and give you an appreciation of the physiological processes that make human life possible. The information will help you to understand many diseases to make informed decisions about your own health.

Anatomy

We can divide anatomy into gross (macroscopic) anatomy or microscopic anatomy. We do so on the basis of the degree of structural detail under consideration. Other anatomical specialties focus on specific processes, such as respiration, or on medical applications, such as developing artificial limbs.

Gross Anatomy

Gross anatomy, or *macroscopic anatomy*, considers features visible with the unaided eye. We can approach gross anatomy in many ways. **Surface anatomy** is the study of general form and superficial markings. **Regional anatomy** considers all the superficial and internal features in a specific region of the body, such as the head, neck, or trunk. **Systemic anatomy** considers the structure of major *organ systems*, which are groups of organs that work together in a coordinated manner. For example, the heart, blood, and blood vessels form the *cardiovascular system*, which circulates oxygen and nutrients throughout the body.

Microscopic Anatomy

Microscopic anatomy concerns structures that we cannot see without magnification. The boundaries of microscopic anatomy are set by the limits of the equipment used. A light microscope reveals basic details about cell structure, but an electron microscope can visualize individual molecules only a few nanometers (nm, 1 millionth of a millimeter) across. In this text, we will consider details at all levels, from macroscopic to microscopic.

We can subdivide microscopic anatomy into specialties that consider features within a characteristic range of sizes. **Cytology** (sī-TOL-o-jē) analyzes the internal structure of individual *cells*. The trillions of living cells in our bodies are made up of chemical substances in various combinations. Our lives depend on the chemical processes taking place in those cells. For this reason we consider basic chemistry (Chapter 2: The Chemical Level of Organization) before looking at cell structure (Chapter 3: Cell Structure and Function).

Histology (his-TOL-o-jē) takes a broader perspective. It examines **tissues**, groups of specialized cells and cell products that work together to carry out specific functions (Chapter 4). Tissues combine to form **organs**, such as the heart, kidney, liver, and brain. We can examine many organs without a microscope, so at the organ level we cross the boundary into gross anatomy.

þ sib g

Physiology is the study of function in living organisms. **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, the science of physiology includes even more specialties than does the science of anatomy.

The cornerstone of human physiology is **cell physiology**, the study of the functions of living cells. Cell physiology includes events at the chemical or molecular levels—chemical processes both within cells and between cells. **Special physiology** is the study of the physiology of specific organs. Examples include renal physiology (kidney function) and cardiac physiology (heart function). **Systemic physiology** considers all aspects of the function of specific organ systems. Respiratory physiology and reproductive physiology are examples. **Pathological physiology**, or **pathology** (pah-THOL-o-jē), is the study of the effects of diseases on organ or system functions. (The Greek word *pathos* means "disease.") Modern medicine depends on an understanding of both normal and pathological physiology, to know not only what has gone wrong but also how to correct it.

Special topics in physiology address specific functions of the human body as a whole. These specialties focus on functional relationships among multiple organ systems. Exercise physiology, for example, studies the physiological adjustments to exercise.

CHECKPOINT

2 Describe how anatomy and physiology are closely related.

3 Would a histologist more likely be considered a specialist in microscopic anatomy or in gross anatomy? Why?

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

1-3 ŧ ƀ s ƃ g in a tio g s fm atm ad m lb e to a þn ŧ e g in sm

ƀ in g ƃ m Identify the major levels of organization in organisms, from the simplest to the most complex.

To understand the human body, we must examine how it is organized at several different levels, from the submicroscopic to the macroscopic. **Spotlight Figure 1-1** presents the relationships among the various levels of organization, using the cardiovascular system as an example.

- ***Chemical level.*** *Atoms*, the smallest stable units of matter, combine to form *molecules* with complex shapes. Even at this simplest level, a molecule's specialized shape determines its function. This is the chemical level of organization.
- ***Cellular level.*** Different molecules can interact to form larger structures. Each type of structure has a specific function in a cell. For example, different types of protein filaments interact to produce the contractions of muscle cells in the heart. *Cells*, the smallest living units in the body, make up the cellular level of organization.
- ***Tissue level.*** A *tissue* is composed of similar cells working together to perform a specific function. Heart muscle cells form *cardiac muscle tissue*, an example of the tissue level of organization.
- ***Organ level.*** An *organ* consists of two or more different tissues working together to perform specific functions. An example of the organ level of organization is the *heart*, a hollow, three-dimensional organ with walls composed of layers of cardiac muscle and other tissues.
- ***Organ system level.*** Organs interact in *organ systems*. 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*, an example of the organ system level of organization.
- ***Organism level.*** All the organ systems of the body work together to maintain life and health. The highest level of organization is the *organism*—in this case, a human.

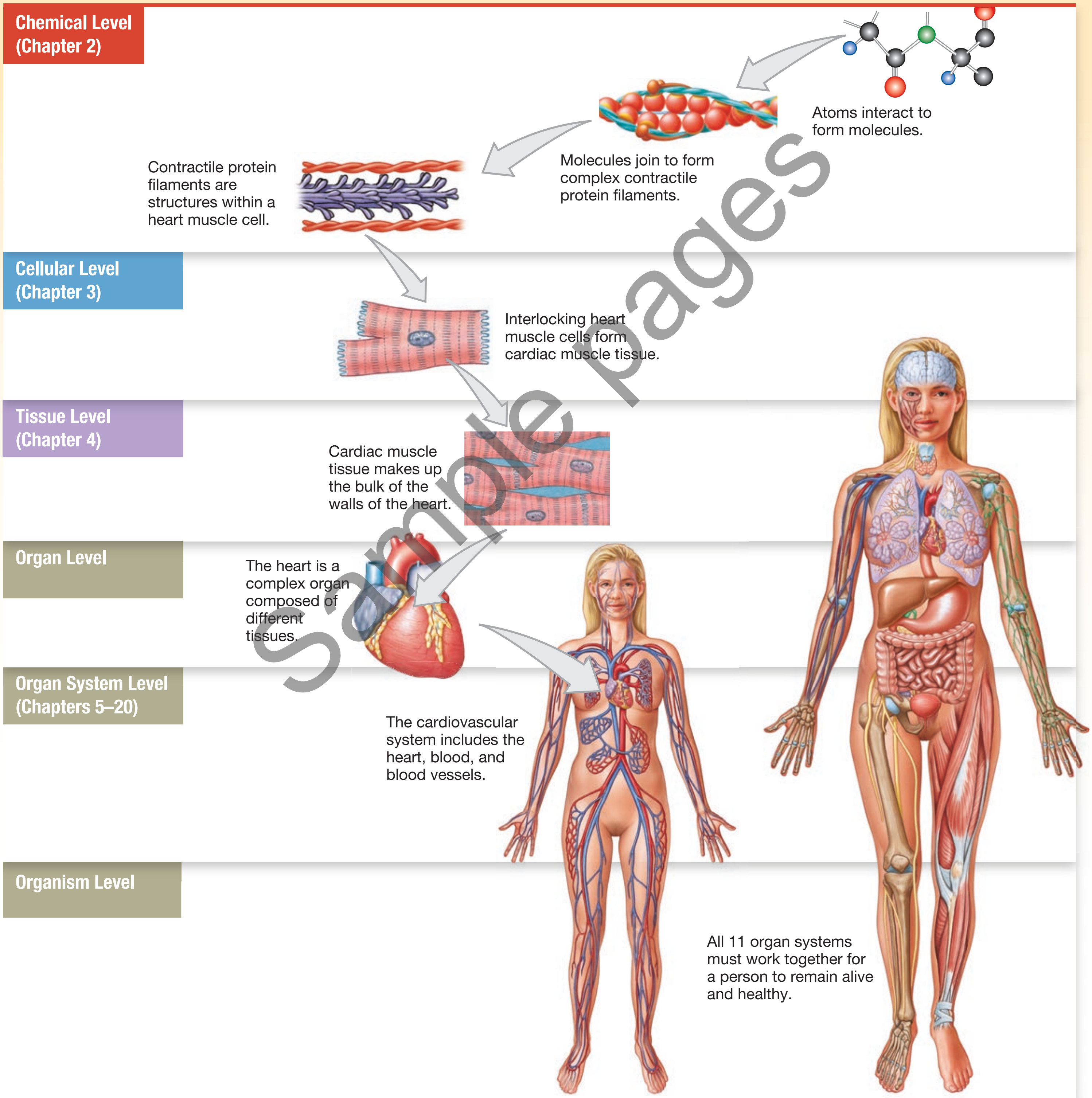
The organization at each level determines both the structural characteristics and the functions of higher levels. As **Spotlight Figure 1-1** shows, the arrangement of atoms and molecules at the chemical level creates the protein filaments that, at the cellular level, give cardiac muscle cells the ability to contract. 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

SPOTLIGHT

Figure 1-1
LEVELS OF ORGANIZATION

Our understanding of how the human body works is based on investigations of its different levels of organization. Interacting atoms form molecules that combine to form 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.



cannot pump and blood cannot flow, oxygen and nutrients cannot be distributed. Very soon, the cardiac muscle tissue begins to break down as its individual muscle cells die from oxygen and nutrient starvation. These changes will also take place beyond the cardiovascular system: cells, tissues, and organs throughout the body will be damaged.

CHECKPOINT

4 Identify the major levels of organization of the human body from the simplest to the most complex.

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

1-4 [illegible] ists [illegible] 11 [illegible] n system

[illegible] Identify the 11 organ systems of the human body and contrast their major functions.

Figure 1-2 introduces the 11 organ systems in the human body and their major functions and components. The body's organ systems are (1) the integumentary system, (2) the skeletal system, (3) the muscular system, (4) the nervous system, (5) the endocrine system, (6) the cardiovascular system, (7) the lymphatic system, (8) the respiratory system, (9) the digestive system, (10) the urinary system, and (11) the reproductive system.

CHECKPOINT

5 Identify the organ systems of the body and list their major functions.

6 Which organ system includes the pituitary gland and directs long-term changes in the activities of the body's other systems?

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

1-5 [illegible] tasis is [illegible] state [illegible]

[illegible] Explain the concept of homeostasis.

Organ systems are interdependent, interconnected, and take up a relatively small space. The cells, tissues, organs, and organ systems of the body function together in a shared environment. Just as the people in a large city breathe the same air and drink water from the local water company, the cells in the human body absorb oxygen and nutrients from the body fluids that surround them. All living cells are in contact with blood or some other body fluid. Any change in the composition of these fluids will affect the cells in some way. For example, changes in the temperature or salt content of the blood could cause anything from a minor adjustment (heart muscle tissue contracts more often, and the heart rate goes up) to a total disaster (the heart stops beating altogether).

Various physiological responses act to prevent potentially dangerous changes in the environment inside the body. **Homeostasis** (hō-mē-ō-STĀ-sis; *homeo*, unchanging + *stasis*, standing) refers to a stable internal environment. To survive, every living organism must maintain homeostasis. The term **homeostatic regulation** refers to the adjustments in physiological systems that preserve homeostasis.

Homeostatic regulation usually involves

1. a **receptor** that is sensitive to a particular environmental change or *stimulus*;
2. a **control center**, or *integration center*, which receives and processes information from the receptor; and
3. an **effector**, a cell or organ that responds to the commands of the control center and whose activity opposes or enhances the stimulus.

You are probably already familiar with several examples of homeostatic regulation, although not in those terms. As an example, think about the operation of the thermostat in a house or apartment (**Figure 1-3**).

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 responses can't 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 we know as illness or **disease.**

An understanding of normal homeostatic responses usually aids in thinking 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. Pain, nausea, and anxiety are examples. A **sign,** by contrast, is an objectively observable or measurable physical indication of a disease. Examples are a rash, a swelling, a fever, or sounds of abnormal breathing. Technology can reveal many additional signs that would not be evident to a physician's unaided senses: an unusual shape on an x-ray or MRI scan or an elevated concentration of a particular chemical in a blood test. We describe many aspects of human health, disease, and treatment in this textbook.

> Go to **Mastering A&P** > Study Area > Menu > Chapter Quizzes > Section 1-4

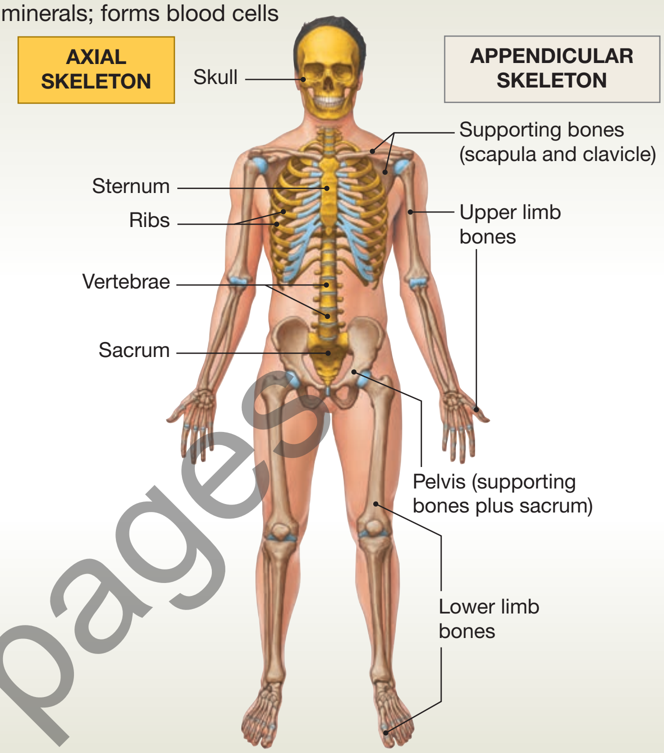
Figure 1-2 **The Organ Systems of the Human Body.**

The Integumentary System

Protects against environmental hazards; helps control body temperature; provides sensory information

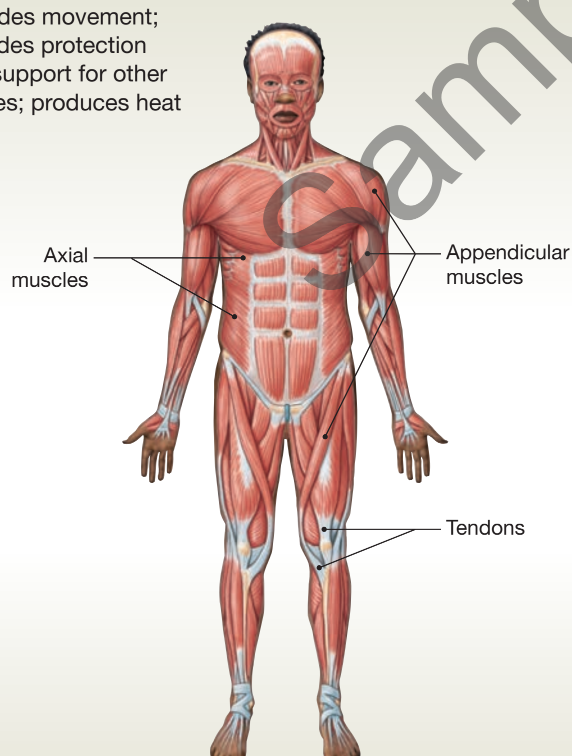
The Skeletal System

Provides support; protects tissues; stores minerals; forms blood cells



The Muscular System

Provides movement; provides protection and support for other tissues; produces heat



The Nervous System

Directs immediate responses to stimuli, usually by coordinating the activities of other organ systems; provides and interprets sensory information about internal and external conditions

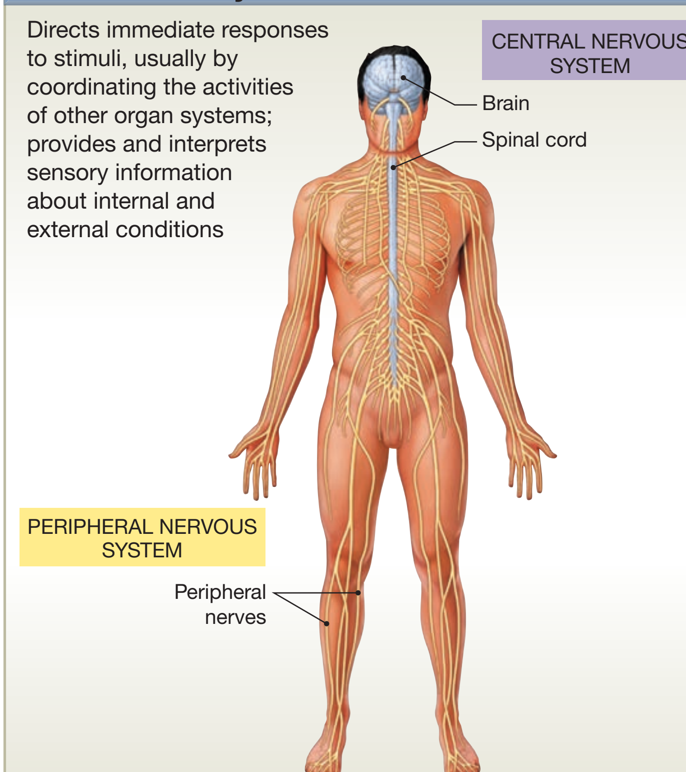
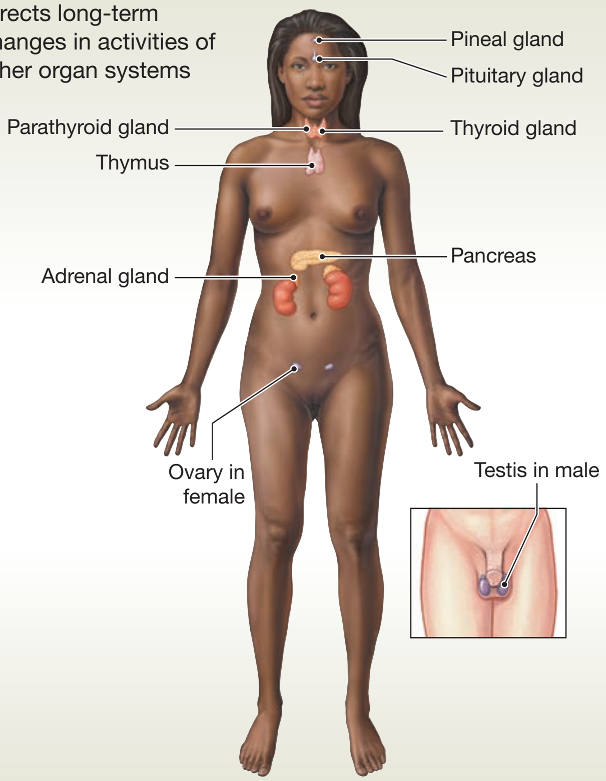


Figure 1-2 The Organ Systems of the Human Body. *(continued)*

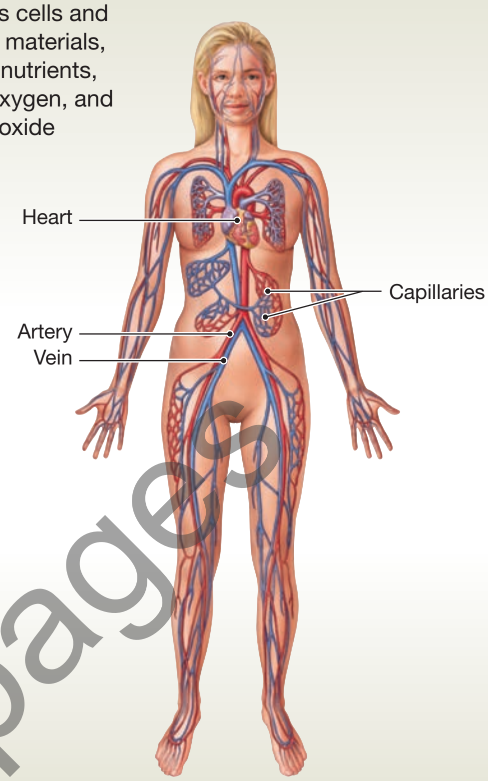
The Endocrine System

Directs long-term changes in activities of other organ systems



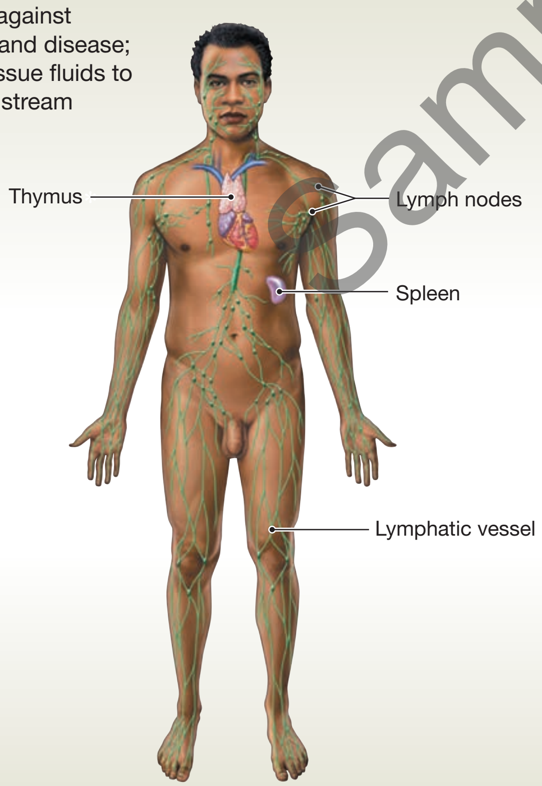
The Cardiovascular System

Transports cells and dissolved materials, including nutrients, wastes, oxygen, and carbon dioxide



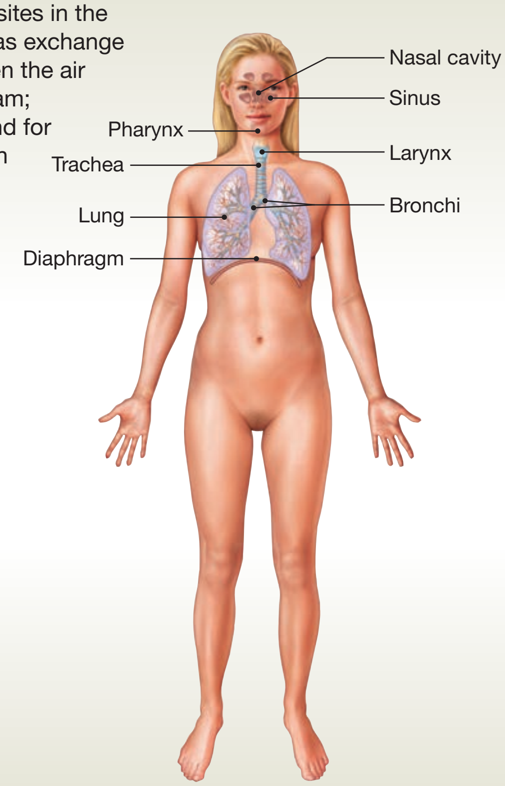
The Lymphatic System

Defends against infection and disease; returns tissue fluids to the bloodstream



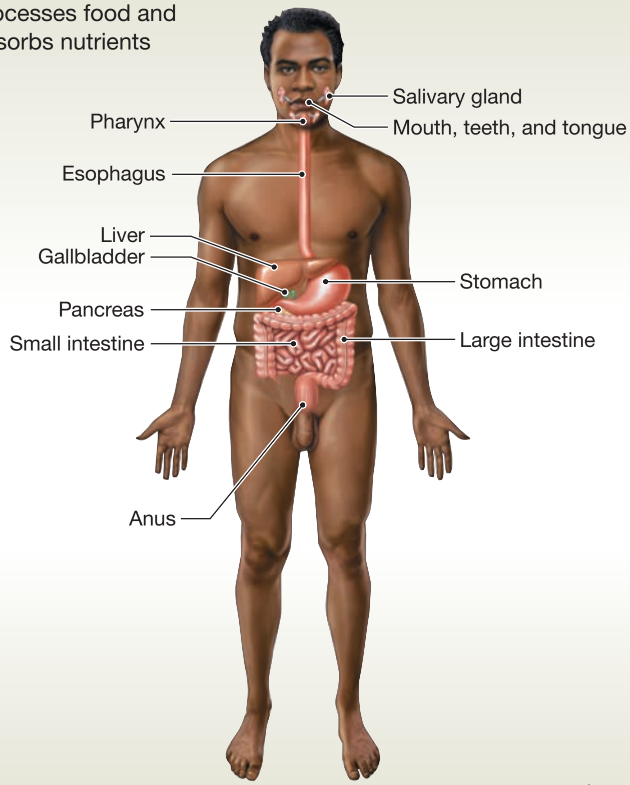
The Respiratory System

Delivers air to sites in the lungs where gas exchange occurs between the air and bloodstream; produces sound for communication



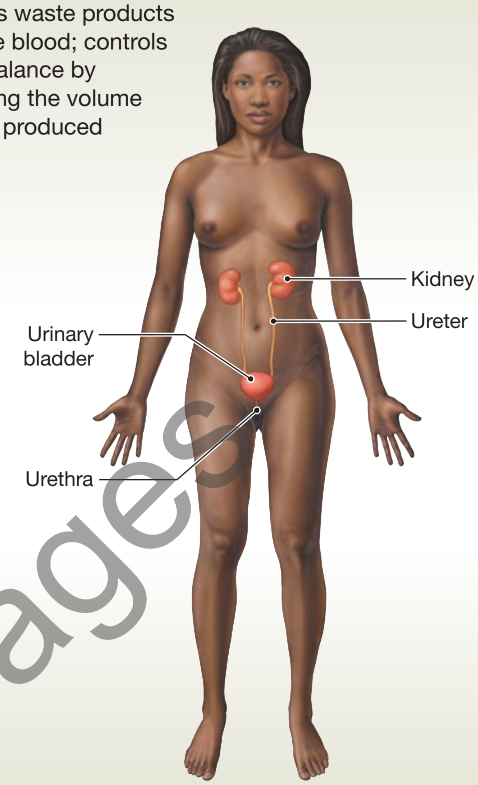
The Digestive System

Processes food and absorbs nutrients



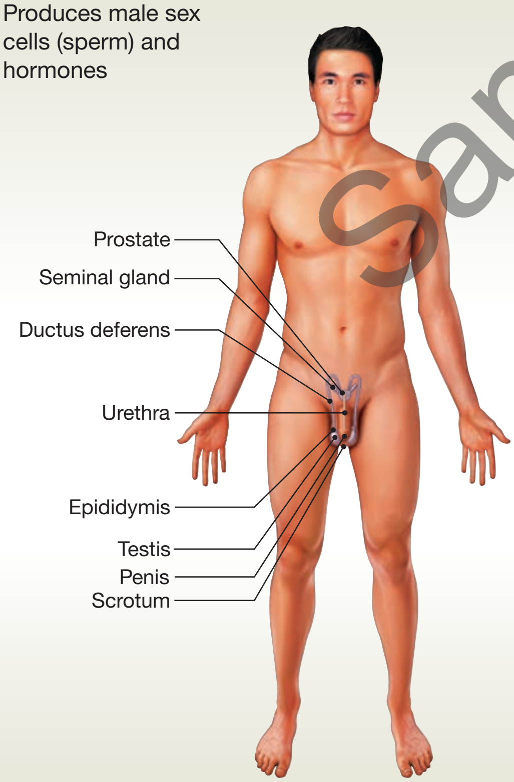
The Urinary System

Excretes waste products from the blood; controls water balance by regulating the volume of urine produced



The Male Reproductive System

Produces male sex cells (sperm) and hormones



The Female Reproductive System

Produces female sex cells (oocytes, or immature eggs) and hormones; supports embryonic and fetal development from fertilization to birth

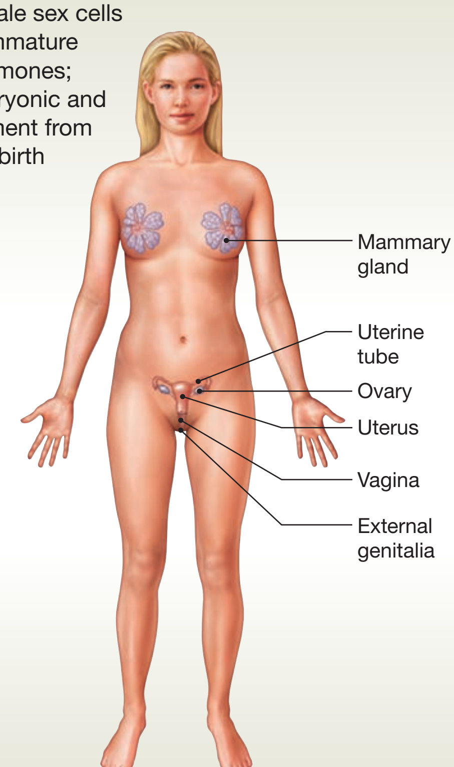
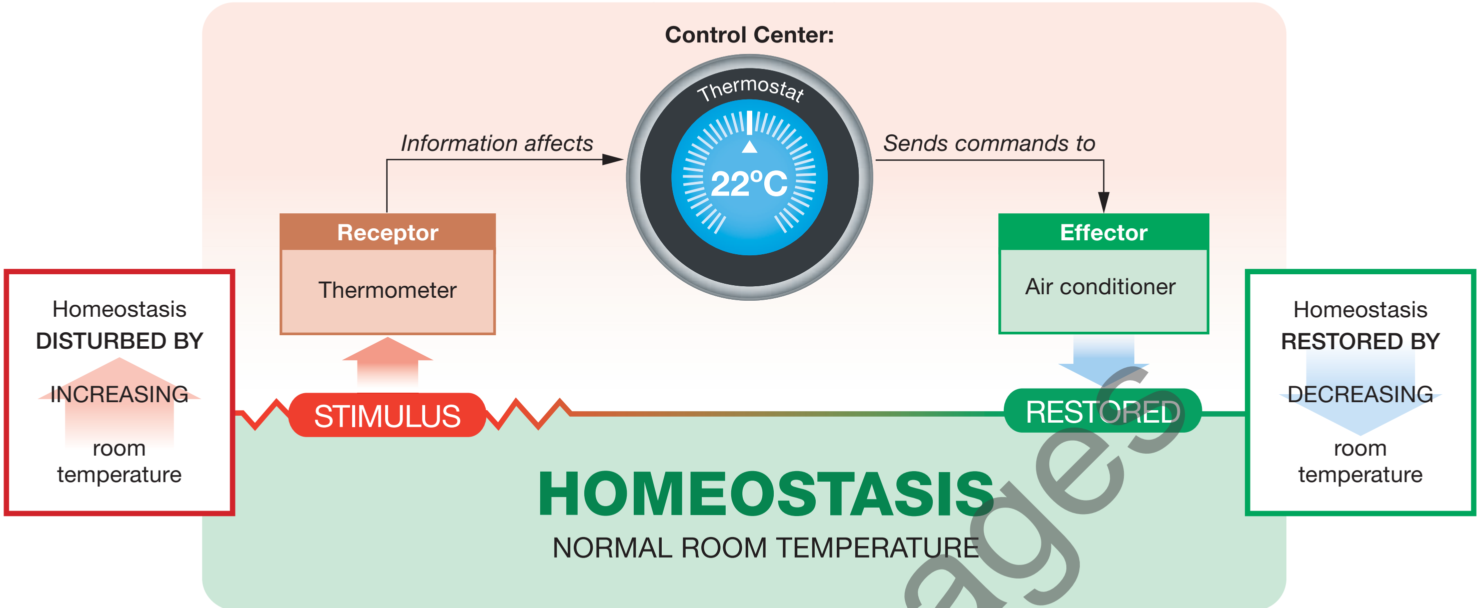


Figure 1-3 The Control of Room Temperature. In response to input from a receptor (a thermometer), a thermostat (the control center) triggers a response from an effector (in this case, an air conditioner) that restores normal temperature. When room temperature rises above the set point, the thermostat turns on the air conditioner, and the temperature returns to normal.



The thermostat is a control center that monitors room temperature. The thermostat shows the set point, the "ideal" room temperature—in this example, 22°C (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. The thermostat receives information from a receptor, a thermometer exposed to air in the room, and it controls one of two effectors: a heater or an air conditioner. In the summer, for example, a rise in temperature above the set point causes the thermostat to turn on the air conditioner, which then cools the room (**Figure 1-3**). When the temperature at the thermometer returns to the set point, the thermostat turns off the air conditioner.

We can summarize the essential feature of temperature control by a thermostat 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.

CHECKPOINT

7 Define homeostasis.

8. Why is homeostatic regulation important to an organism?

9 What happens to the body when homeostasis breaks down?

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

1-6 Negative feedback opposes variations from normal, whereas positive feedback exaggerates them

Learning Outcome Describe how negative feedback and positive feedback are involved in homeostatic regulation.

Homeostatic regulation controls aspects of the internal environment that affect every cell in the body. Most commonly, such regulation uses negative feedback. Positive feedback is less frequent because it tends to produce extreme responses.

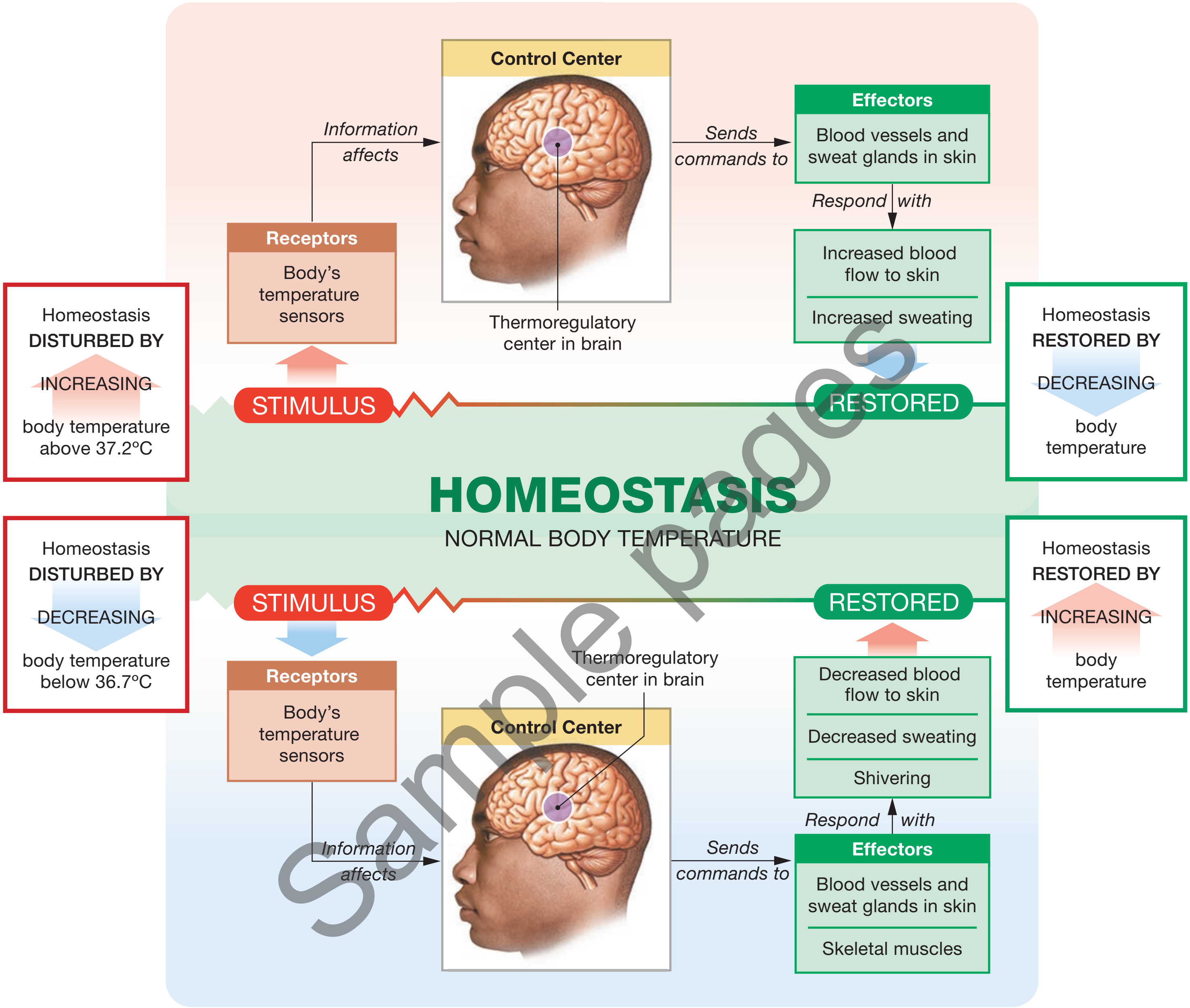
Negative Feedback

The essential feature of **negative feedback** is this: Regardless of whether the stimulus (such as temperature) rises or falls at the receptor, *a variation outside normal limits triggers an automatic response that corrects the situation.*

Most homeostatic responses in the body involve negative feedback. For example, consider the control of body temperature, a process called *thermoregulation* (**Figure 1-4**). Thermoregulation involves altering the relationship between heat loss, which takes place primarily at the body surface, and heat production, which occurs in all active tissues. In the human body, skeletal muscles are the most important generators of body heat.

> Go to **Mastering A&P** > Study Area > Menu > MP3 Tutor Session > Homeostasis

Figure 1-4 Negative Feedback: Control of Body Temperature. In negative feedback, a stimulus produces a response that opposes the original stimulus. Body temperature is regulated by a control center in the brain that functions as a thermostat with a set point of 37°C.



The thermoregulatory control center is located in the brain. This control center receives information from temperature receptors located in the skin and in cells in the control center. At the normal set point, body temperature is approximately 37°C (98.6°F).

If body temperature rises above 37.2°C (99°F), activity in the control center targets two effectors: (1) smooth muscles in the walls of blood vessels supplying the skin and (2) sweat glands. The muscle tissue relaxes and the blood vessels widen, or dilate, increasing blood flow at the body surface. The sweat glands accelerate, or speed up, their secretion. The skin then acts like a radiator, losing heat to the environment, and the evaporation of sweat speeds the process. When body temperature returns to normal, the control center becomes inactive. Superficial blood flow and sweat gland activity then decrease to normal resting levels.

If temperature at the control center falls below 36.7°C (98°F), the control center targets the same two effectors and skeletal muscles. This time, blood flow to the skin declines, and sweat gland activity decreases. This combination reduces the rate of heat loss to the environment. However, body temperature gradually rises because skeletal muscles continue to produce heat. (Additional heat may be generated by *shivering*, which is caused by random contractions of skeletal muscles.) Once the body has warmed to the set point, the thermoregulatory center turns itself "off." Both blood flow and sweat gland activity in the skin then increase to normal resting levels.

Homeostatic responses using negative feedback maintain a normal range, not a fixed value. In the previous example, body temperature oscillates around the ideal set-point temperature. Thus, for any single individual, any measured value (such as body temperature) can vary from moment to moment or day to day. The variability among individuals is even greater, for each person has a slightly different homeostatic set point. It is, therefore, impractical to define "normal" homeostatic conditions very precisely.

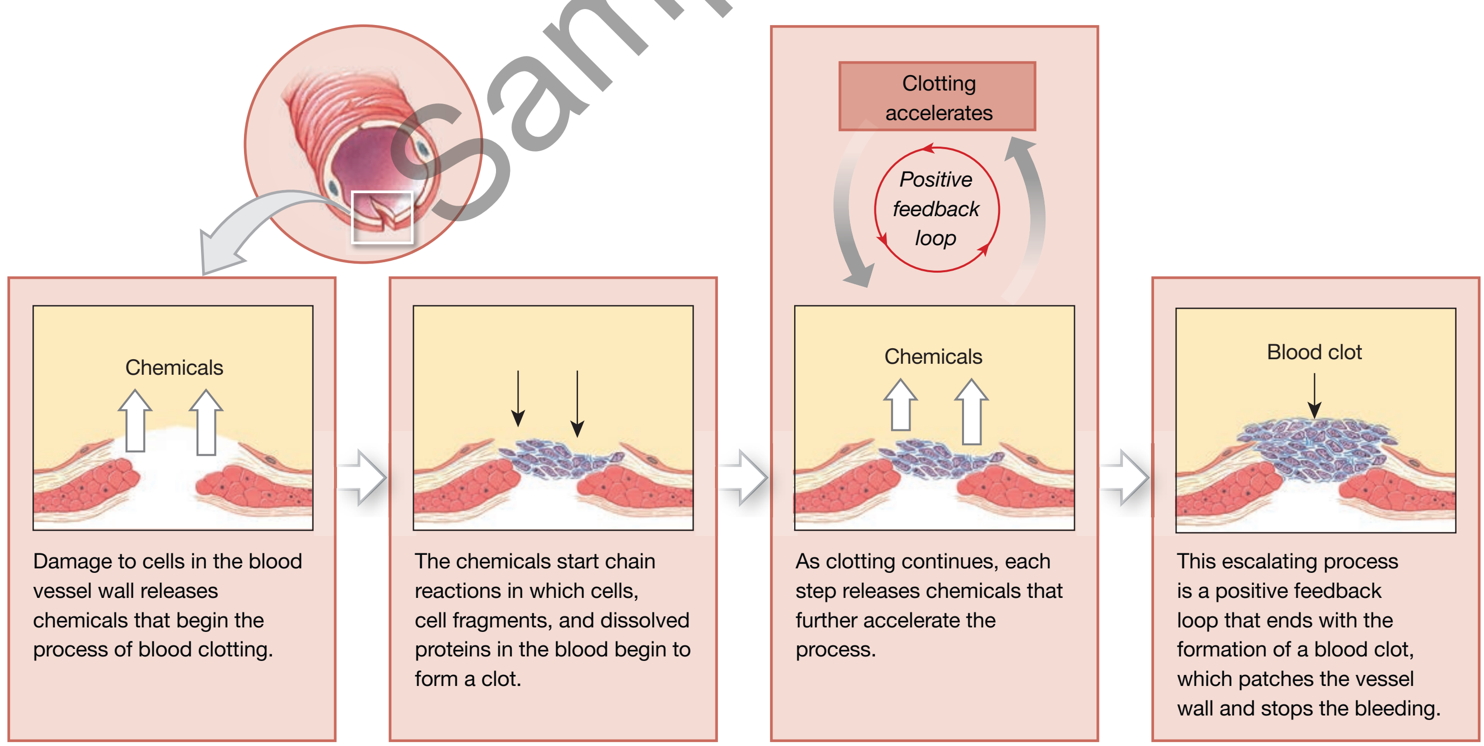
By convention, physiological values are reported either as average values obtained by sampling a large number of individuals or as a range that includes 95 percent or more of the sample population. For example, for 95 percent of healthy adults, body temperature ranges between 36.7°C and 37.2°C (98°F and 99°F). The other 5 percent of healthy adults have resting body temperatures outside the "normal" range (below 36.7°C or above 37.2°C). Still, these temperatures are perfectly normal for them, and the variations have no clinical significance.

Positive Feedback

In **positive feedback**, *an initial stimulus produces a response that reinforces that stimulus*. For example, suppose a thermostat were wired so that when the temperature rose, the thermostat would turn on the heater rather than the air conditioner. In that case, the initial stimulus (rising room temperature) would cause a response (heater turns on) that strengthens the stimulus. Room temperature would continue to rise until someone switched off the thermostat, unplugged the heater, or intervened in some other way before the house caught fire and burned down. This kind of escalating cycle is called a *positive feedback loop*.

In the body, positive feedback loops are involved in the regulation of a potentially dangerous or stressful process that must be completed quickly. For example, the immediate danger from a severe cut is blood loss, which can lower blood pressure and reduce the pumping efficiency of the heart. The positive feedback loop involved in the body's clotting response to blood loss is diagrammed in **Figure 1-5**. (We will examine blood clotting more closely in Chapter 11.) Labor and delivery (discussed in Chapter 20) is another example of positive feedback in action.

Figure 1-5 Positive Feedback. In positive feedback, a stimulus produces a response that reinforces the original stimulus. Positive feedback is important in accelerating processes that must proceed to completion rapidly. In this example, positive feedback accelerates blood clotting until bleeding stops.



> Go to **Mastering A&P** > Study Area > Menu > Chapter Quizzes > Section 1-6

CHECKPOINT

10 Explain the function of negative feedback systems.

11. Why is positive feedback helpful in blood clotting but unsuitable for the regulation of body temperature, as with a fever?

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

1-7 A tim a l tm dc b y g a , aa tim a l p itis ad d e is , ad y se is

b in g 0 en Use anatomical terms to describe body regions, body sections, and relative positions.

Early anatomists faced serious communication problems. For example, stating that a bump is "on the back" 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 language of its own, called *medical terminology*, that you must learn almost at the start of your study.

Anatomical terms are easier to understand if you are familiar with Latin and Greek word roots and their combinations. As new terms are introduced in the text, we will provide notes on their pronunciation and the relevant word roots. Look inside the back cover for additional information on foreign word roots, prefixes, suffixes, and combining forms.

Latin and Greek terms are not the only foreign words imported into the anatomical vocabulary over the centuries, and the vocabulary continues to expand. Many anatomical structures and clinical conditions were first named after either the discoverer or, in the case of diseases, the most famous victim. Most such commemorative names, or *eponyms*, have been replaced by more precise terms, but many are still in use.

S ae A atgn

With the exception of the skin, none of the organ systems can be seen from the body surface. For this reason, you must create your own mental maps, basing your information on the terms given in Figures 1-6 and 1-7. Learning these terms now will make material in subsequent chapters easier to understand.

A tim a l b ch k

Standard anatomical illustrations show the human form in 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 1-6). A person lying down in the anatomical position is said to be **supine** (soo-PĪN) when face up and **prone** when face down.

Important anatomical landmarks are also presented in Figure 1-6. The anatomical terms are in boldface, the common names in plain type, and the anatomical adjectives in parentheses. Understanding these terms and their origins will help you remember both the location of a particular structure and its name. For example, the term *brachium* refers to the arm. Later chapters will discuss the *brachialis muscle* and the *brachial artery,* which are in the arm, as their names suggest.

A toim cal R g ons

Major regions of the body, such as the *brachial region,* are referred to by their anatomical adjectives, as shown in Figure 1-6. To describe a general area of interest or injury, anatomists and clinicians often need to use 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** formed by a pair of imaginary perpendicular lines that intersect at the *umbilicus* (navel). This simple method, shown in Figure 1-7a, is useful for describing the location of aches, pains, and injuries, which can help a doctor determine the possible cause. For example, tenderness in the right lower quadrant (RLQ) is a symptom of appendicitis. Tenderness in the right upper quadrant (RUQ) may indicate gallbladder or liver problems.

Anatomists like to use more precise regional terms to describe the location and orientation of internal organs. They recognize nine **abdominopelvic regions** (Figure 1-7b). Figure 1-7c shows the relationships among quadrants, regions, and internal organs.

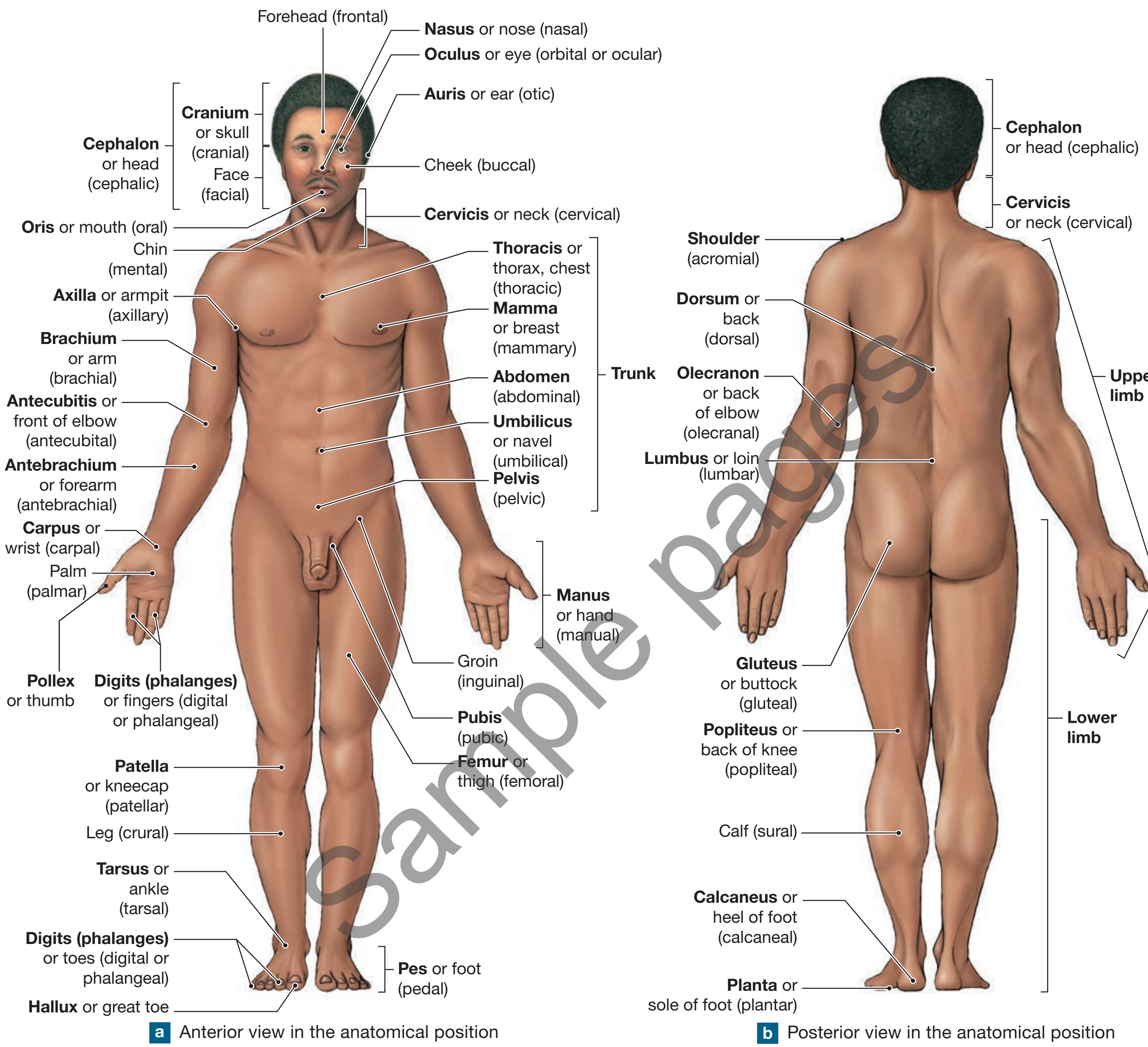
A toim cal Directions

Figure 1-8 presents 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. Likewise, the terms *posterior* and *dorsal* refer to the back of the human body. Remember that *left* and *right* always refer to the left and right sides of the *subject,* not of the observer.

Sections l An tomy

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

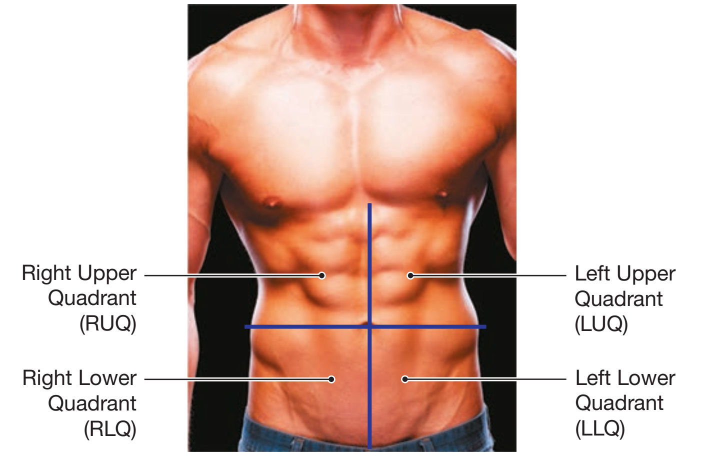
Figure 1-6 Anatomical Landmarks. Anatomical terms are shown in boldface type, common names are in plain type, and anatomical adjectives (referring to body regions) are in parentheses.



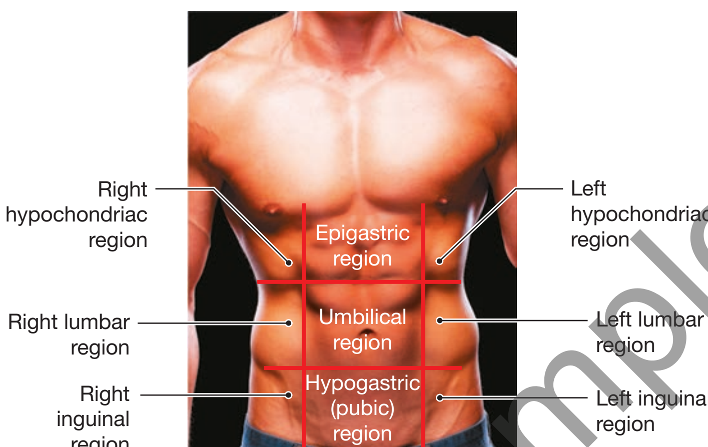
without resorting to surgery. Any slice (or section) through a three-dimensional object can be described with reference to three primary **sectional planes**, indicated in Figure 1-9:

1. ***Frontal plane.*** The **frontal plane**, or *coronal plane*, runs along the long axis of the body. The frontal plane extends laterally (side to side), dividing the body into **anterior** and **posterior** portions.
2. ***Sagittal plane.*** The **sagittal plane** also runs along the long axis of the body, but it extends anteriorly and posteriorly (front to back). A sagittal plane divides the body into *left* and *right* portions. A cut that passes along the body's midline and divides the body into left and right halves is a **midsagittal section**. (Note that a midsagittal section does not cut through the legs.)

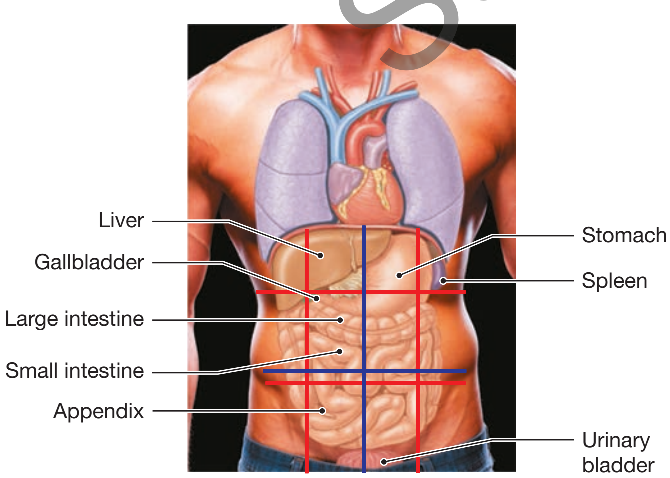
Figure 1-7 Abdominopelvic Quadrants and Regions.



a Abdominopelvic quadrants. The four abdominopelvic quadrants are formed by two perpendicular lines that intersect at the navel (umbilicus). 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.

3. ***Transverse plane.*** The **transverse plane** lies at right angles to the long (head-to-foot) axis of the body, dividing the body into **superior** and **inferior** portions. A cut in this plane is called a **transverse section**, or *cross section*. (Unless otherwise noted, in this book 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

12 What is the purpose of anatomical terms?

13 Describe an anterior view and a posterior view in the anatomical position.

14 What type of section would separate the two eyes?

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

1-8 B a vitie b th th p e ith a l g a ad allow th to b g sh p

a i g b en Identify the major body cavities of the trunk and the subdivisions of each.

The body's trunk is subdivided into three major regions established by the body wall: the thoracic, abdominal, and pelvic regions (Figure 1-6). Most of the vital organs of the body are located within these regions. The true **body cavities** are closed, fluid-filled spaces lined by a thin tissue layer called a *serous membrane*. The vital organs of the trunk are *suspended* within these body cavities. They do not simply lie there.

Early anatomists began using the term "cavity" when referring to internal regions. For example, they considered everything deep to the chest wall of the thoracic region to be within the thoracic cavity. They also considered all of the structures deep to the abdominal and pelvic walls to be within the abdominopelvic cavity. Internally, these two anatomical regions are separated by the **diaphragm** (DĪ-uh-fram), a flat muscular sheet.

The boundaries of the regional "cavities" and the true body cavities of the trunk are not identical, however. For example, the thoracic cavity contains two pleural cavities (each surrounding a lung), a pericardial cavity (surrounding the heart), and a large tissue mass, the mediastinum. Also, the peritoneal cavity extends only partway into the pelvic cavity. The boundaries between the subdivisions of the thoracic cavity and abdominopelvic cavity are shown in Figure 1-10 (p. 48).

> Go to **Mastering A&P** > Study Area > Menu > Chapter Quizzes > Section 1-7

1

Figure 1-8 Directional References.

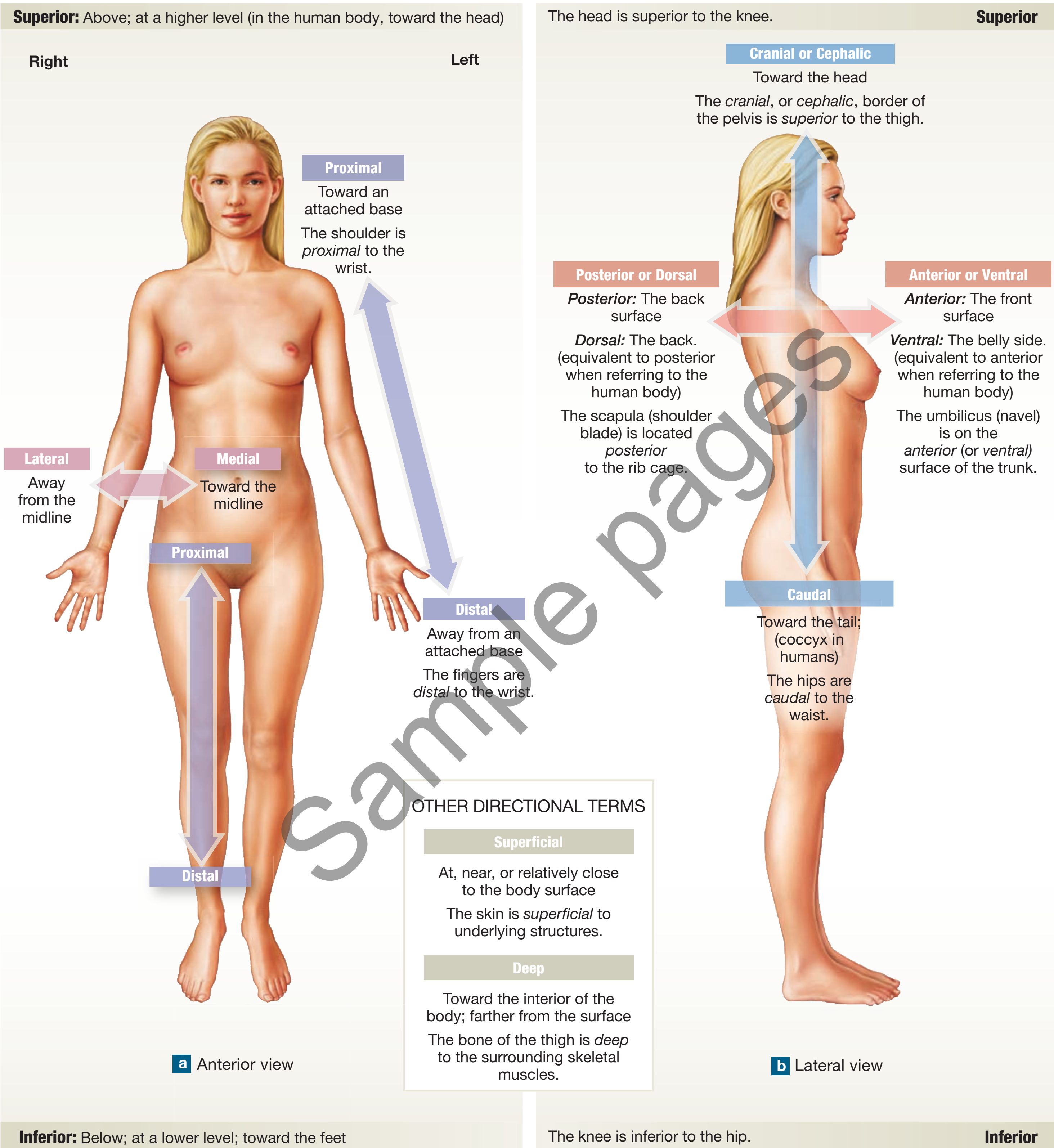
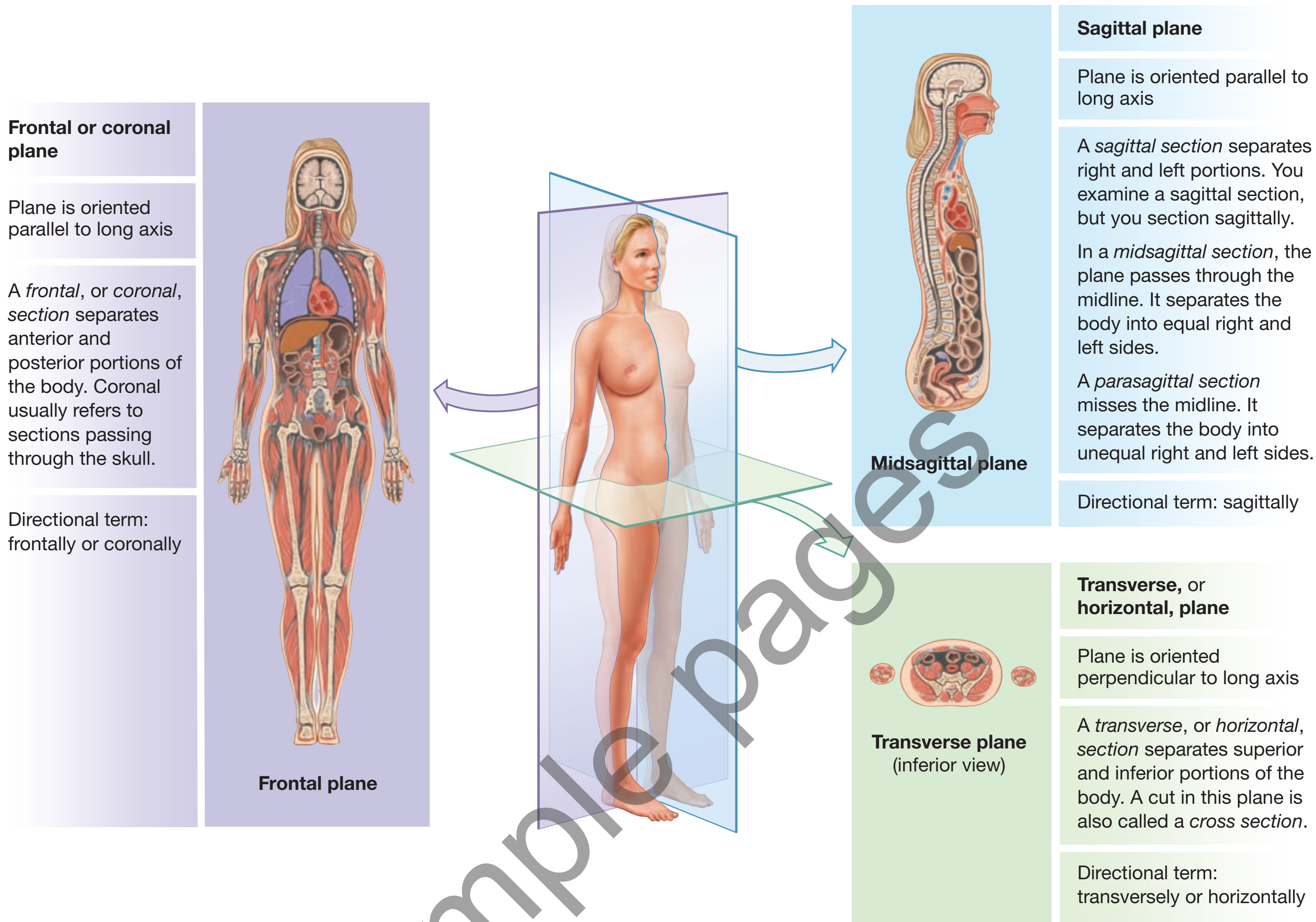


Figure 1-9 Sectional Planes.



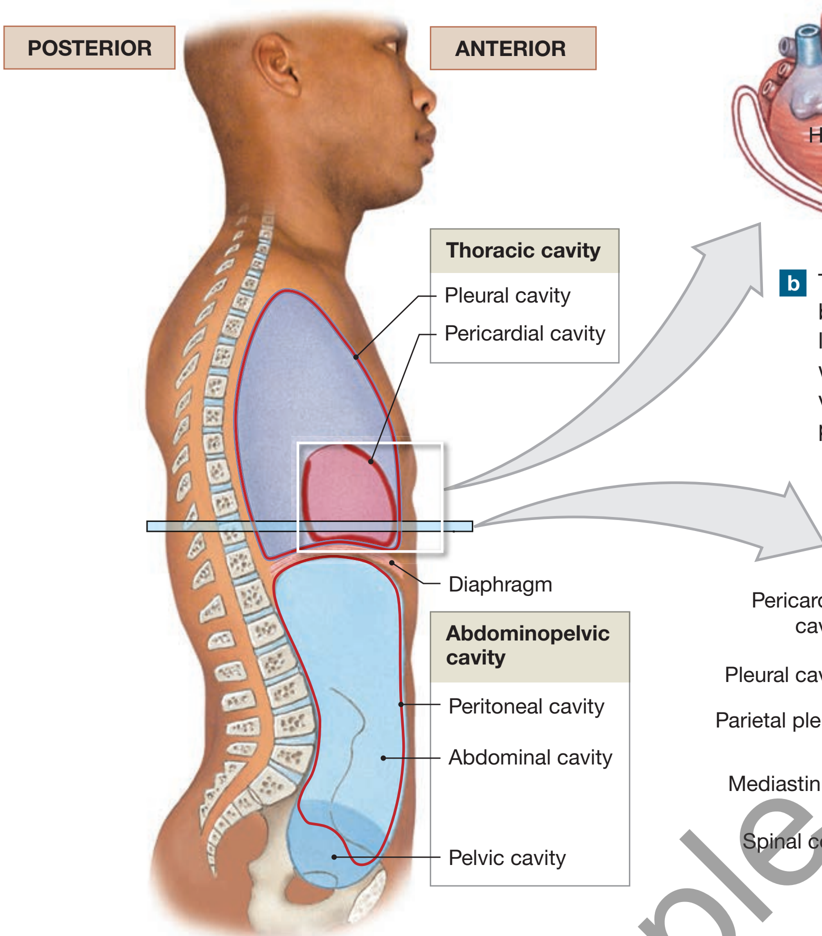
The body cavities of the trunk have two essential functions: (1) They protect delicate organs from accidental shocks and cushion them from the jolting that occurs when we walk, jump, or run; and (2) they permit significant changes in the size and shape of internal organs they surround. For example, the lungs, heart, stomach, intestines, urinary bladder, and many other organs can expand and contract without distorting surrounding tissues or disrupting the activities of nearby organs.

The internal organs that are enclosed by these cavities are called **viscera** (VIS-e-ruh). A delicate serous membrane lines the walls of these internal cavities and covers the surfaces of the enclosed viscera. Serous membranes produce a watery fluid that moistens the opposing surfaces and reduces friction. The portion of a serous membrane that covers a visceral organ is called the *visceral* layer. The opposing portion that lines the inner surface of the body wall or chamber is called the *parietal* layer. Because these opposing portions are usually in direct contact, the body cavities are called *potential spaces*.

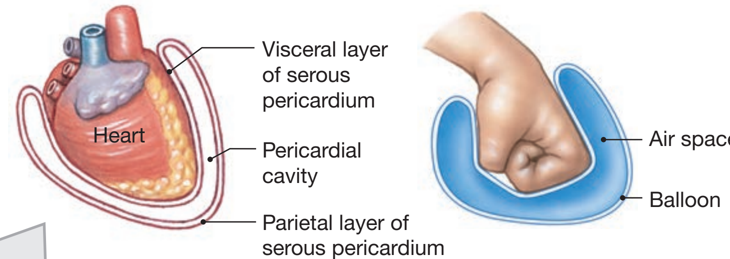
Tb Tb racic Cavity

The thoracic cavity contains three internal chambers: a single *pericardial cavity* and a pair of *pleural cavities*—one for each lung (Figure 1-10a,c). Each of these three cavities is lined by shiny, slippery serous membranes. The heart projects into a space known as the **pericardial cavity**. The relationship between

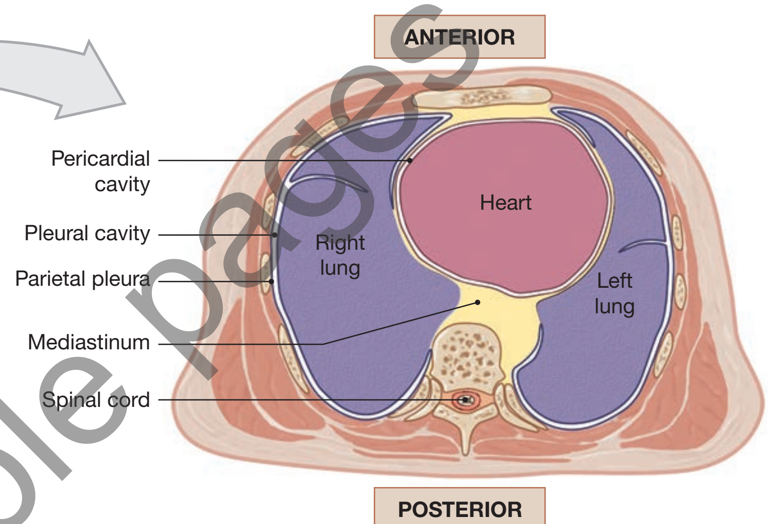
Figure 1-10 Relationships among the Subdivisions of the Body Cavities of the Trunk.



a A lateral view showing the body cavities of the trunk. The muscular diaphragm subdivides them into a superior thoracic cavity and an inferior abdominopelvic cavity. Three of the four adult true 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. The mediastinum and pericardial cavity lie between the two pleural cavities. Note that this transverse or cross-sectional view is oriented as though the observer were standing at a supine subject's feet and looking toward the subject's head. This inferior view of a transverse section is the standard presentation for clinical images. Unless otherwise noted, transverse or cross-sectional views in this text use this same orientation *(see Clinical Note: Imaging Techniques)*.

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. The balloon corresponds to the serous membrane, or *serous pericardium* (*peri-*, around + *cardium*, heart), lining the pericardial cavity. The *visceral layer of serous pericardium* covers the heart, and the opposing surface is the *parietal layer of serous pericardium*.

The pericardial cavity lies within the **mediastinum** (mē-dē-a-STĪ-num) (Figure 1-10c). The connective tissue of the mediastinum surrounds and stabilizes the pericardial cavity and heart, the large arteries and veins attached to the heart, and the thymus, trachea, and esophagus.

Each **pleural cavity** surrounds a lung. The serous membrane lining a pleural cavity is called a **pleura** (PLOOR-ah). The *visceral pleura* covers the outer surfaces of a lung. The *parietal pleura* covers the opposing surface of the mediastinum and the inner body wall.

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** (Figure 1-10a). The abdominopelvic cavity contains the **peritoneal** (per-i-tō-NĒ-al) **cavity**, a chamber 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.

The abdominal cavity extends from the inferior (toward the feet) surface of the diaphragm to the level of the superior (toward the head) margins of the pelvis. This cavity contains the liver, stomach, spleen, small intestine, and most of the large intestine. The organs are partially or completely enclosed by the peritoneal cavity. 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 inferior to the abdominal cavity. The pelvic cavity contains the distal portion of the large intestine, the urinary bladder, and various reproductive organs. It also contains the inferior portion of the peritoneal cavity.

The true body cavities of the trunk in the adult share a common embryonic origin. The term "dorsal body cavity" is sometimes used to refer to the internal chamber of the skull (cranial cavity) and the total space enclosed by the vertebrae (vertebral cavity). These chambers, which are defined by bony structures, are structurally and developmentally distinct from true body cavities.

Many chambers, or spaces, within the body are not true body cavities. A partial list would include the cranial cavity, vertebral cavity, oral cavity, digestive cavity, orbits (eye sockets), tympanic cavity of each middle ear, nasal cavities, and paranasal sinuses (air-filled chambers within some cranial bones that are connected to the nasal cavities). We discuss these structures in later chapters.

The Clinical Note: Imaging Techniques highlights some noninvasive clinical tests commonly used for viewing the interior of the body.

Build Your Knowledge

Recall that two methods are used to refer to the locations of aches, pains, injuries, and internal organs of the abdomen and pelvis. Clinicians refer to four abdominopelvic quadrants. Anatomists refer to nine abdominopelvic regions. ↺ **p. 43**

CHECKPOINT

15 Describe two essential functions of body cavities.

16 Describe the various body cavities of the trunk.

17 If a surgeon makes an incision just inferior to the diaphragm, what body cavity will be opened?

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

RELATED CLINICAL TERMS

acute: A disease of short duration but typically severe.

auscultation (aws-kul-TĀ-shun)**:** Listening to a patient's body sounds using a stethoscope.

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

pathologist (pa-THOL-o-jist)**:** A physician who specializes in the study of disease processes.

radiologist: A physician who specializes in performing and analyzing radiological procedures.

radiology (rā-dē-OL-o-jē)**:** The study of radioactive energy and radioactive substances and their use in the diagnosis and treatment of disease and injury.

CLINICAL NOTE

IMAGING TECHNIQUES

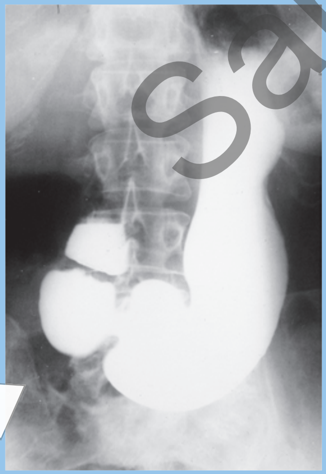
Over the past several decades, rapid progress has been made in discovering more accurate and more detailed ways to image the human body, both in health and disease.

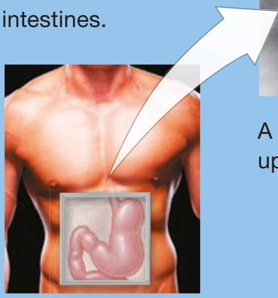
X-rays

X-rays are the oldest and still the most common method of imaging. X-rays are a form of high-energy radiation that can penetrate living tissues. An x-ray beam travels through the body before striking a photographic plate. Not all of the projected x-rays arrive at the film. The body absorbs or deflects some of those x-rays. The ability to stop the passage of x-rays is referred to as **radiopacity**. When taking an x-ray, these areas that are impenetrable by x-rays appear light or white on the exposed film and are said to be **radiopaque**. In the body, air has the lowest radiopacity. Fat, liver, blood, muscle, and bone are increasingly radiopaque. As a result, radiopaque tissues look white, and less radiopaque tissues are in shades of gray to black.

An x-ray of the skull, taken from the left side

To use x-rays to visualize soft tissues, a very radiopaque substance must be introduced. To study the upper digestive tract, a radiopaque barium solution is ingested by the patient. The resulting x-ray shows the contours of the stomach and intestines.

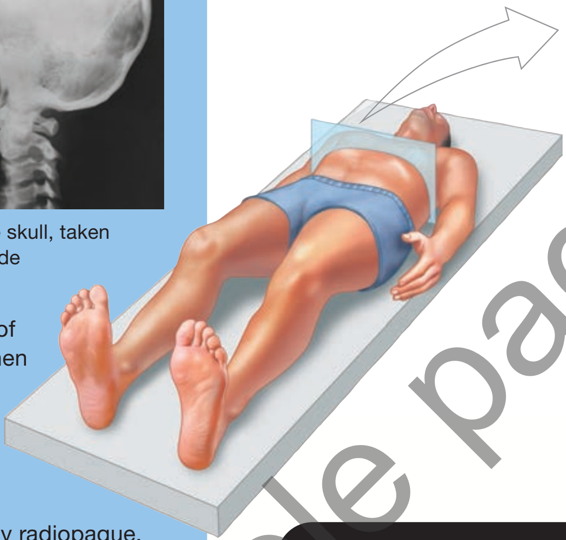


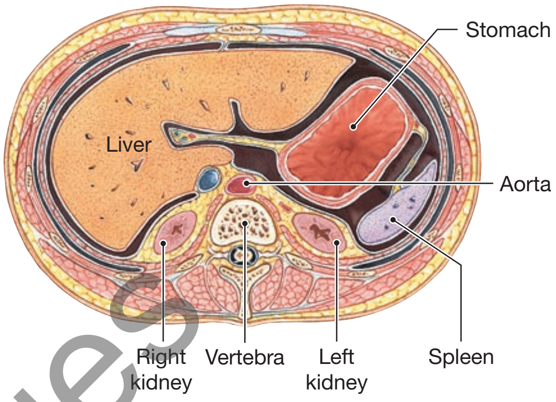


A **barium-contrast x-ray** of the upper digestive tract

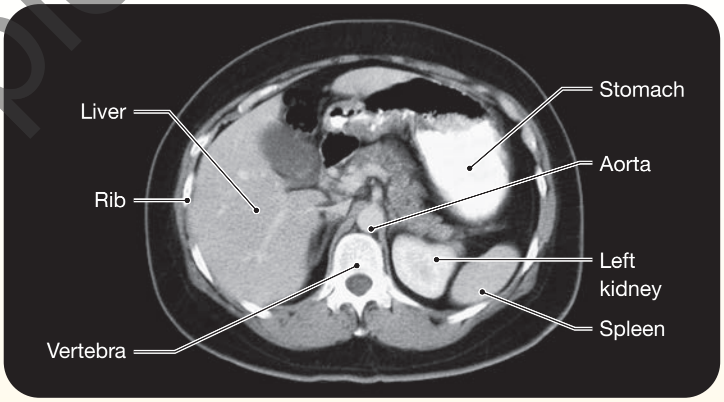
Standard Scanning Techniques

More recently, a variety of **scanning techniques** dependent on computers have been developed to show the less radiopaque, soft tissues of the body in much greater detail.





Diagrammatic views showing the relative position and orientation of the CT scan below and the MRI to the right.

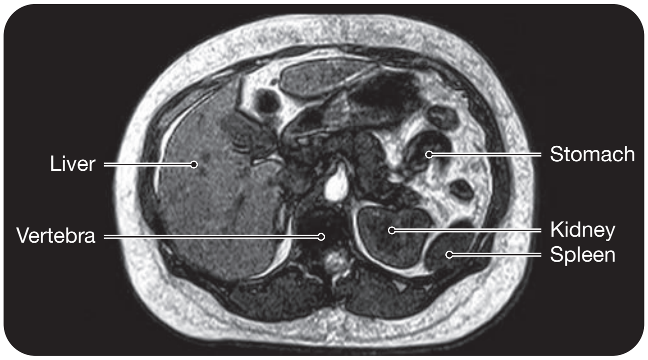


CT scan of the abdomen

CT (computed tomography) **scans** use computers to reconstruct sectional views. A single x-ray source rotates around the body, and the x-ray beam strikes a sensor monitored by the computer. The x-ray source completes one revolution around the body every few seconds. It then moves a short distance and repeats the process. The result is usually displayed as a sectional view in black and white, but it can be colorized for visual effect. CT scans show three-dimensional relationships and soft tissue structures more clearly than do standard x-rays.

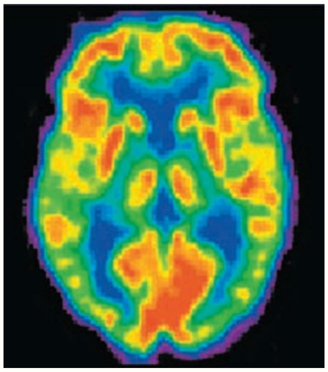
- Note that when anatomical diagrams or scans present cross-sectional views, the sections are presented from an inferior perspective, as though the observer were standing at the feet of a person in the supine position and looking toward the head of the subject.

Special Scanning Methods



MRI scan of the abdomen

An **MRI** of the same region (in this case, the abdomen) can show soft tissue structure in even greater detail than a CT scan. Magnetic resonance imaging surrounds part or all of the body with a magnetic field 3000 times as strong as that of Earth. This field causes particles within atoms throughout the body to line up in a uniform direction. Energy from pulses of radio waves are absorbed and released by the different atoms. The released energy is used to create a detailed image of the soft tissue structure.

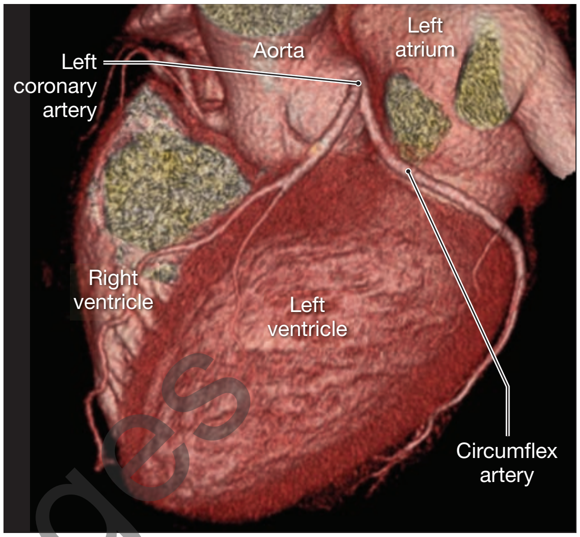


PET scan of the brain

Positron emission tomography (**PET**) is an imaging technique that assesses metabolic and physiological activity of a structure. A PET scan is an important tool in evaluating healthy and diseased brain function.

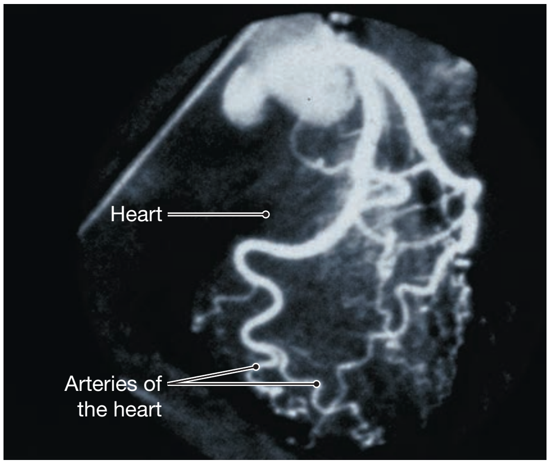
Ultrasound of the uterus

In **ultrasound** procedures, a small transmitter contacting the skin broadcasts a brief, narrow burst of high-frequency sound and then detects the echoes. The sound waves are reflected by internal structures, and a picture, or **echogram**, is assembled from the pattern of echoes. These images lack the clarity of other procedures, but no adverse effects have been reported, and fetal development can be monitored without a significant risk of birth defects. Special methods of transmission and processing permit analysis of the beating heart without the complications that can accompany dye injections.



Spiral scan of the heart

A **spiral CT scan** is a form of three-dimensional imaging technology that is becoming increasingly important in clinical settings. During a spiral CT scan, the patient is on a platform that advances at a steady pace through the scanner while the imaging source, usually x-rays, rotates continuously around the patient. Because the x-ray detector gathers data quickly and continuously, a higher quality image is generated, and the patient is exposed to less radiation as compared to a standard CT scanner, which collects data more slowly and only one slice of the body at a time.



Digital subtraction angiography of coronary arteries

Digital subtraction angiography (**DSA**) is used to monitor blood flow through specific organs, such as the brain, heart, lungs, and kidneys. X-rays are taken before and after 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.

1 Chapter Review

ßn ry ö lie

1-1 A l livig th g d sp ay e p ive s, g w h p ip m vm , ad tn ab ism *p. 32*

1. **Biology** is the study of life; one of its goals is to discover the patterns that underlie the diversity of living organisms.
2. All living things, from single **cells** to large multicellular organisms, perform the same basic functions: They respond to changes in their environment; they grow and reproduce to create new generations; they are capable of producing movement; and they carry out the complex chemical reactions of metabolism. They absorb materials from the environment. Organisms absorb and consume oxygen during respiration, and they discharge waste products during excretion. Digestion occurs in specialized body structures that break down complex foods. The circulation forms an internal transportation system between areas of the body.

1-2 A tom is stu p ad p sib g is fu io *p. 33*

3. **Anatomy** is the study of internal and external structure and the physical relationships among body parts. **Physiology** is the study of how living organisms function. All specific functions are performed by specific structures.
4. **Gross (macroscopic) anatomy** considers features visible without a microscope. It includes *surface anatomy* (general form and superficial markings), *regional anatomy* (superficial and internal features in a specific area of the body), and *systemic anatomy* (structure of major organ systems).
5. The boundaries of **microscopic anatomy** are established by the equipment used. **Cytology** analyzes the internal structure of individual *cells*. **Histology** examines **tissues** (groups of similar cells that have specific functional roles). Tissues combine to form organs, anatomical units with specific functions.
6. **Human physiology** is the study of the functions of the human body. It is based on **cell physiology**, the study of the functions of living cells. *Special physiology* studies the physiology of specific organs. *System physiology* considers all aspects of the function of specific organ systems. *Pathological physiology* **(pathology)** studies the effects of diseases on organ or system functions.

1-3 Le e s o g n a tio p g ess from atom ad tn b e to a m e e org n sm *p. 34*

7. Anatomical structures and physiological mechanisms are arranged in a series of interacting levels of organization. *(Figure 1-1)*

1-4 The human body consists of 11 organ systems *p. 36*

8. The major organs of the human body are arranged into 11 organ systems. The organ systems of the human body are the *integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary*, and *reproductive systems*. *(Figure 1-2)*

1-5 Hn tasis is th state o ib era l b lan e *p. 36*

9. **Homeostasis** is the existence of a stable internal environment within the body. Physiological systems preserve homeostasis through **homeostatic regulation**.
10. Homeostatic regulation usually involves a **receptor** sensitive to a particular stimulus; a **control center**, which receives and processes the information from the receptor, and then sends out commands; and an **effector** whose activity either opposes or enhances the stimulus. *(Figures 1-3, 1-4)*

1-6 Ng tive fb k p e var atio fm m l, w s p itive fb k exag te tm *p. 40*

11. **Negative feedback** is a corrective response involving an action that directly opposes a variation from normal limits. *(Figures 1-3, 1-4)*
12. In **positive feedback** the initial stimulus produces a response that reinforces the stimulus. *(Figure 1-5)*
13. Symptoms of **disease** appear when failure of homeostatic regulation causes organ systems to malfunction.

1-7 A tm a l tm d c b b y reg on , an tm a l p itio ad d rection , ad y se io *p. 43*

14. Standard anatomical illustrations show the body in the **anatomical position**. If the figure is shown lying down, it can be either **supine** (face up) or **prone** (face down). *(Figure 1-6)*