

Organization of the Human Body

You are beginning a fascinating exploration of the human body in which you'll learn how it is organized and how it functions. First you will be introduced to the scientific disciplines of anatomy and physiology; we'll consider the levels of organization that characterize living things and the properties that all living things share. Then, we will examine how the body is constantly regulating its internal environment. This ceaseless process, called homeostasis, is a major theme in every chapter of this book. We will also discuss how the various individual systems that compose the human body cooperate with one another to maintain the health of the body as a whole. Finally, we will establish a basic vocabulary that allows us to speak about the body in a way that is understood by scientists and health-care professionals alike.

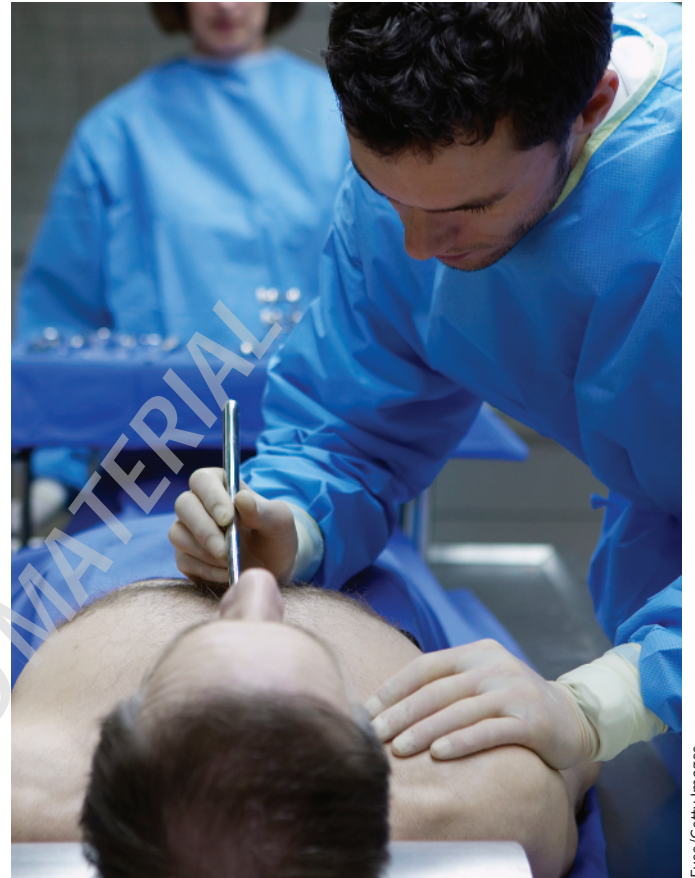
1.1 Anatomy and Physiology: An Overview

OBJECTIVES

- **Define** anatomy and physiology.
- **Describe** the structural organization of the human body.
- **List** the 11 systems of the human body, representative organs present in each, and their general functions.

Anatomy and Physiology Defined

The sciences of anatomy and physiology are the foundation for understanding the structures and functions of the human body. **Anatomy** (a-NAT-ō-mē; *ana-* = up; *-tomy* = process of cutting) is the science of *structure* and the relationships among structures.



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Q Did you ever wonder why an autopsy is performed?
You can find out in Section 1.2, Clinical Connection: Autopsy

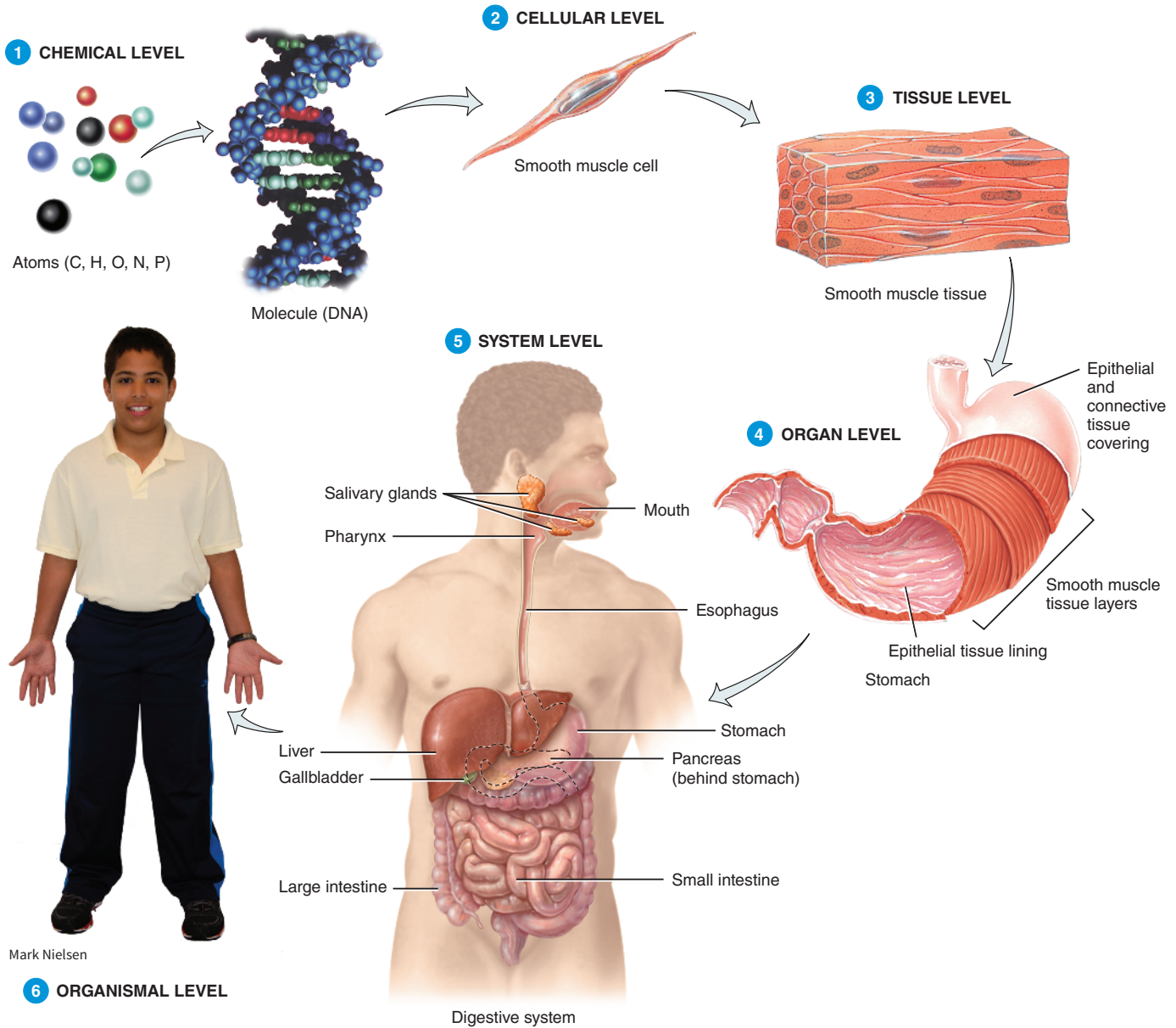
Physiology (fiz'-ē-OL-ō-jē; *physio-* = nature, *-logy* = study of) is the science of body *functions*, that is, how the body parts work. Because function can never be separated completely from structure, we can understand the human body best by studying anatomy and physiology together. We will look at how each structure of the body is designed to carry out a particular function and how the structure of a part often determines the functions it can perform. The bones of the skull, for example, are tightly joined to form a rigid case that protects the brain. The bones of the fingers, by contrast, are more loosely joined, which enables them to perform a variety of movements, such as turning the pages of this book.

Levels of Organization and Body Systems

The structures of the human body are organized into several levels, similar to the way letters of the alphabet, words, sentences, paragraphs, and so on are organized. Listed here, from smallest to largest, are the six levels of organization of the human body: chemical, cellular, tissue, organ, system, and organismal (**Figure 1.1**).

FIGURE 1.1 Levels of structural organization in the human body.

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



Q Which level of structural organization usually has a recognizable shape and is composed of two or more different types of tissues that have a specific function?

1 The **chemical level** includes **atoms**, the smallest units of matter that participate in chemical reactions, and **molecules**, two or more atoms joined together. Atoms and molecules can be compared to letters of the alphabet. Certain atoms, such as carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), and others, are essential for maintaining life. Familiar examples of molecules found in the body are DNA (deoxyribonucleic acid), the genetic material passed on from one

generation to another; hemoglobin, which carries oxygen in the blood; glucose, commonly known as blood sugar; and vitamins, which are needed for a variety of chemical processes. Chapters 2 and 20 focus on the chemical level of organization.

2 Molecules combine to form structures at the next level of organization—the **cellular level**. **Cells** are the basic structural and functional units of an organism. Just as words are the smallest elements of language, cells are the smallest living units in the

human body. Among the many types of cells in your body are muscle cells, nerve cells, and blood cells. **Figure 1.1** shows a smooth muscle cell, one of three different kinds of muscle cells in your body. As you will see in Chapter 3, cells contain specialized structures called *organelles*, such as the nucleus, mitochondria, and lysosomes, that perform specific functions.

- 3 The **tissue level** is the next level of structural organization. **Tissues** are groups of cells and the materials surrounding them that work together to perform a particular function. Cells join together to form tissues similar to the way words are put together to form sentences. The four basic types of tissue in your body are *epithelial tissue*, *connective tissue*, *muscular tissue*, and *nervous tissue*. The similarities and differences among the different types of tissues are the focus of Chapter 4. Note in **Figure 1.1** that smooth muscle tissue consists of tightly packed smooth muscle cells.
- 4 At the **organ level**, different kinds of tissues join together to form body structures. **Organs** usually have a recognizable shape, are composed of two or more different types of tissues, and have specific functions. Tissues join together to form organs similar to the way sentences are put together to form paragraphs. Examples of organs are the stomach, heart, liver, lungs, and brain. **Figure 1.1** shows several tissues that make up the stomach. The stomach's outer covering is a layer of epithelial tissue and connective tissue that protects it and reduces friction when the stomach moves and rubs against other organs. Underneath this covering are the *smooth muscle tissue layers*, which contract to churn and mix food and push it on to the next digestive organ, the small intestine. The

innermost lining of the stomach is an *epithelial tissue layer*, which contributes fluid and chemicals that aid digestion.

- 5 The next level of structural organization in the body is the **system level**. A **system** consists of related organs that have a common function. Organs join together to form systems similar to the way paragraphs are put together to form chapters. The example shown in **Figure 1.1** is the digestive system, which breaks down and absorbs molecules in food. In the chapters that follow, we will explore the anatomy and physiology of each of the body systems. **Table 1.1** introduces the components and functions of these systems. As you study the body systems, you will discover how they work together to maintain health, protect you from disease, and allow for reproduction of the species.
- 6 The **organismal level** is the largest level of organization. All of the systems of the body combine to make up an **organism** (OR-ga-nizm), that is, one human being. Systems join together to form an organism similar to the way chapters are put together to form a book.

Checkpoint

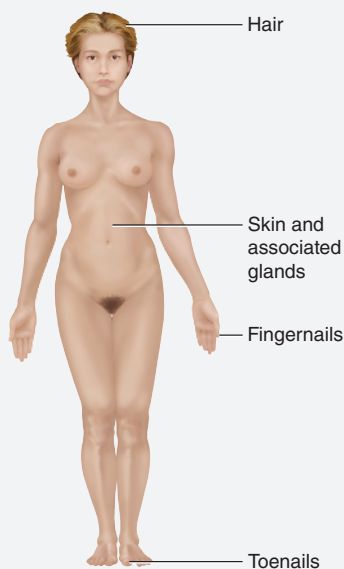
1. What is the basic difference between anatomy and physiology?
2. Give your own example of how the structure of a part of the body is related to its function.
3. Define the following terms: atom, molecule, cell, tissue, organ, system, and organism.
4. Referring to **Table 1.1**, which body systems help eliminate wastes?

TABLE 1.1 Components and Functions of the Eleven Principal Systems of the Human Body

1. Integumentary System (Chapter 5)

Components: Skin and structures associated with it, such as **hair, nails,** and **sweat glands and oil glands.**

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



2. Skeletal System (Chapters 6 and 7)

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

Functions: Supports and protects the body, provides a specific area for muscle attachment, assists with body movements, stores cells that produce blood cells, and stores minerals and lipids (fats)

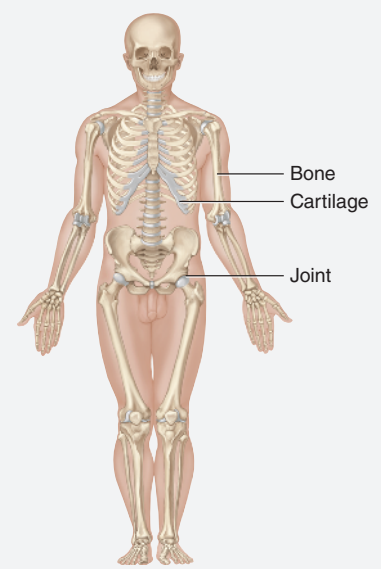


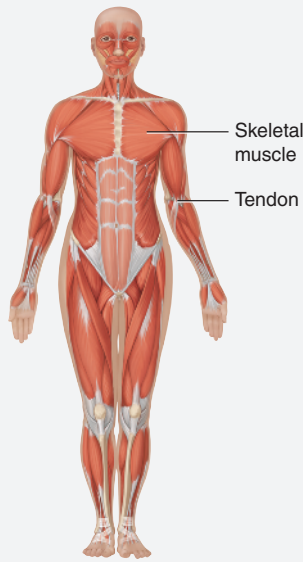
Table 1.1 Continues

TABLE 1.1 Components and Functions of the Eleven Principal Systems of the Human Body (Continued)

3. Muscular System (Chapter 8)

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

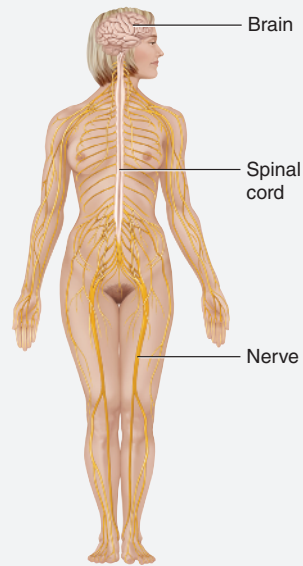
Functions: Participates in body movements such as walking; maintains posture; and produces heat



4. Nervous System (Chapters 9–12)

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

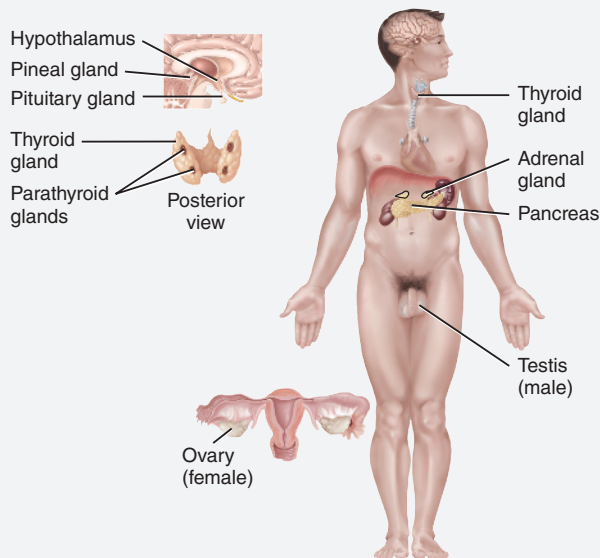
Functions: Regulates body activities through nerve impulses by detecting changes in the environment, interpreting the changes, and responding to the changes by bringing about muscular contractions or glandular secretions



5. Endocrine System (Chapter 13)

Components: All glands and tissues that produce chemical regulators of body functions, called hormones

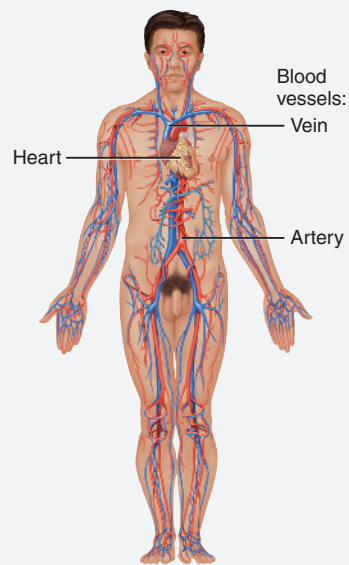
Functions: Regulates body activities through hormones transported by the blood to various target organs



6. Cardiovascular System (Chapters 14–16)

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

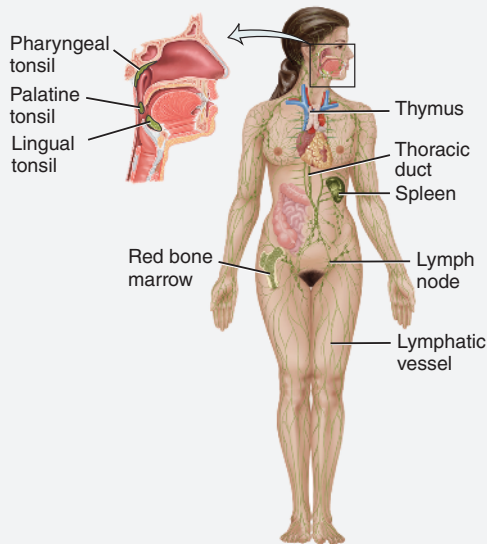
Functions: Heart pumps blood through blood vessels; blood carries oxygen and nutrients to cells and carbon dioxide and wastes away from cells and helps regulate acidity, temperature, and water content of body fluids; blood components help defend against disease and mend damaged blood vessels



7. Lymphatic System and Immunity (Chapter 17)

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

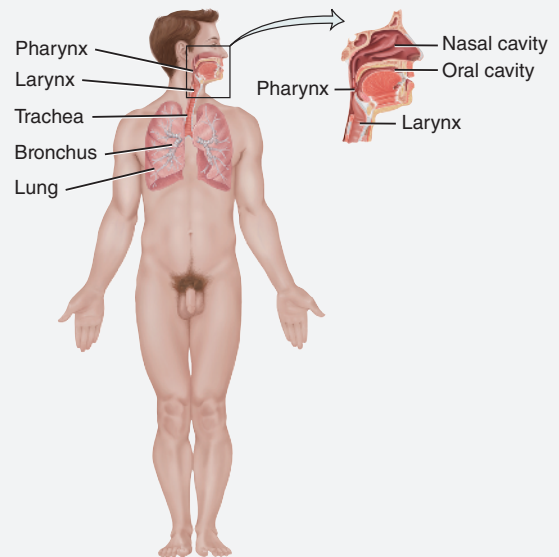
Functions: Returns proteins and fluid to blood; carries lipids from gastrointestinal tract to blood; contains sites of maturation and proliferation of B cells and T cells that protect against disease-causing microbes



8. Respiratory System (Chapter 18)

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

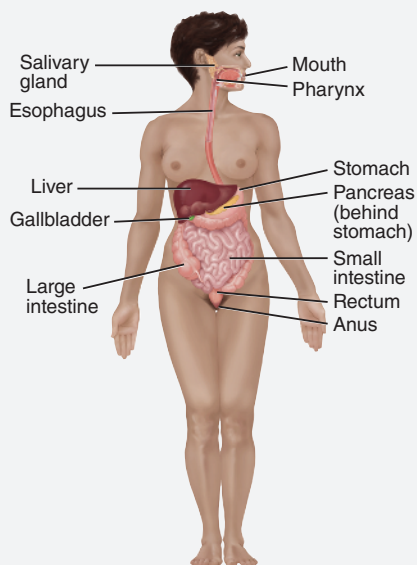
Functions: Transfers oxygen from inhaled air to blood and carbon dioxide from blood to exhaled air; helps regulate acidity of body fluids; air flowing out of lungs through vocal cords produces sounds



9. Digestive System (Chapter 19)

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

Functions: Physical and chemical breakdown of food; absorbs nutrients; eliminates solid wastes



10. Urinary System (Chapter 21)

Components: Kidneys, ureters, urinary bladder, and urethra

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

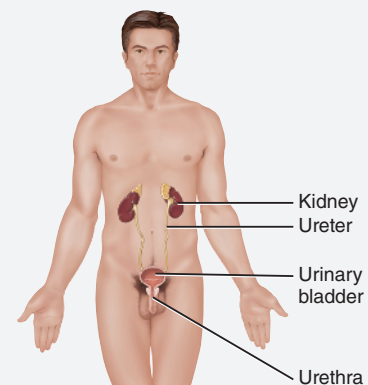
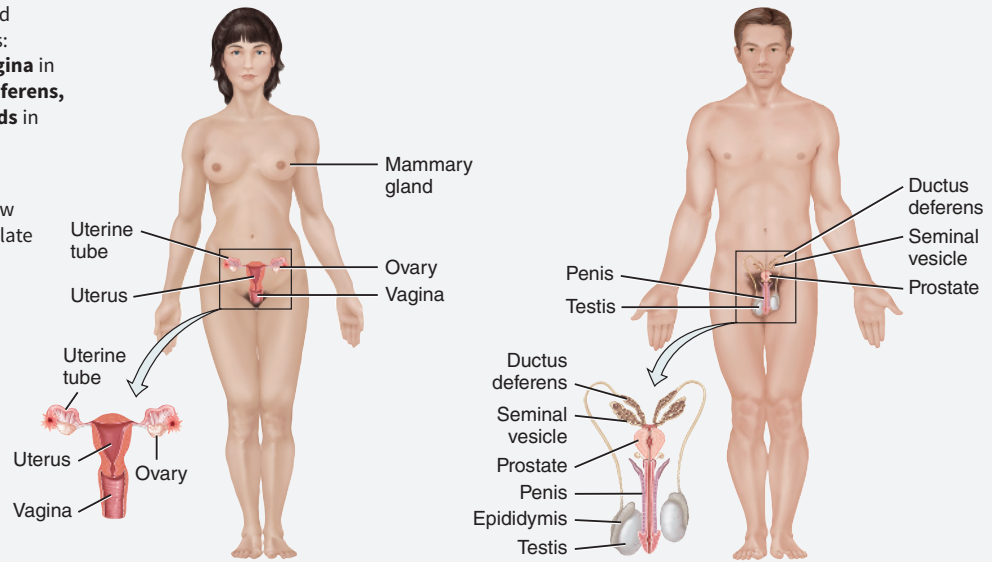


TABLE 1.1 Components and Functions of the Eleven Principal Systems of the Human Body (Continued)**11. Reproductive Systems (Chapter 23)**

Components: **Gonads** (testes in males and ovaries in females) and associated organs: **uterine (fallopian) tubes, uterus, and vagina** in females, and **epididymis, ductus (vas) deferens,** and **penis** in males; also, **mammary glands** in females

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



1.2 Life Processes

OBJECTIVE

- **Define** the important life processes of humans.

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

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

differentiation to develop into a unique individual who is similar to, yet quite different from, either of the parents.

6. **Reproduction** (rē-prō-DUK-shun) refers to either (1) the formation of new cells for growth, repair, or replacement or (2) the production of a new individual.

Although not all of these processes are occurring in cells throughout the body all of the time, when any one of the life processes ceases to occur properly, the result is death of cells and tissues, which may lead to death of the organism. Clinically, loss of the heartbeat, absence of spontaneous breathing, and loss of brain functions indicate death in the human body.

Clinical Connection

Autopsy

An **autopsy** (AW-top-sē = seeing with one's own eyes) is a *postmortem* (after death) examination of the body and dissection of its internal organs to confirm or determine the cause of death. An autopsy can uncover the existence of diseases not detected during life, determine the extent of injuries, and explain how those injuries may have contributed to a person's death. It also may provide more information about a disease, assist in the accumulation of statistical data, and educate health-care students. An autopsy can also reveal conditions that may affect offspring or siblings (such as congenital heart defects). Sometimes an autopsy is legally required, such as during a criminal investigation. It may also be useful in resolving disputes between beneficiaries and insurance companies about the cause of death.

Checkpoint

5. What are the different meanings for growth?

1.3 Homeostasis: Maintaining Limits

OBJECTIVES

- **Define** homeostasis and explain its importance.
- **Describe** the components of a feedback system.
- **Compare** the operation of negative and positive feedback systems.
- **Distinguish** between symptoms and signs of a disease.

The trillions of cells of the human body need relatively stable conditions to function effectively and contribute to the survival of the body as a whole. The maintenance of relatively stable conditions is called **homeostasis** (hō'-mē-ō-STĀ-sis; *homeo-* = sameness; *-stasis* = standing still). Homeostasis ensures that the body's internal environment remains constant despite changes inside and outside the body. The internal environment refers to **extracellular fluid**, the fluid that surrounds body cells.

Each body system contributes to homeostasis in some way. For instance, in the cardiovascular system, alternating contraction and relaxation of the heart propels blood throughout the body's blood vessels. As blood flows through tiny blood vessels, nutrients and oxygen move into cells from the blood and wastes move from cells into the blood. Homeostasis is *dynamic*; that is, it can change over a narrow range that is compatible with maintaining cellular life processes. For example, the level of glucose in the blood is maintained within a narrow range. It normally does not fall too low between meals or rise too high even after eating a high-glucose meal. The brain needs a steady supply of glucose to keep functioning—a low blood glucose level may lead to unconsciousness or even death. A prolonged high blood glucose level, by contrast, can damage blood vessels and cause excessive loss of water in the urine.

Control of Homeostasis: Feedback Systems

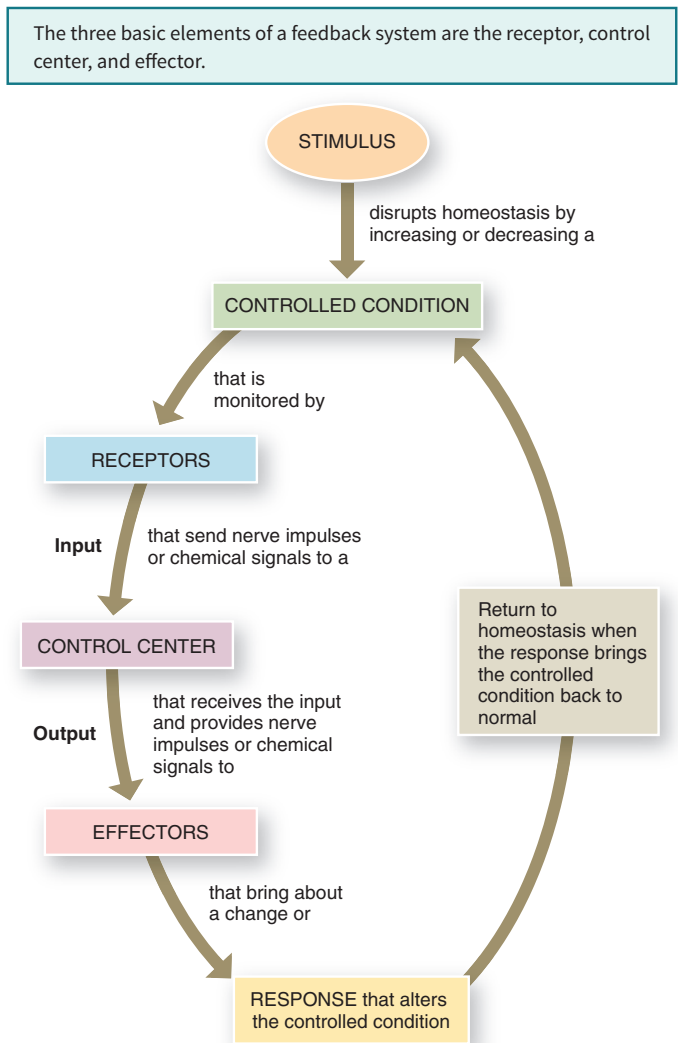
Fortunately, every body structure, from cells to systems, has one or more homeostatic devices that work to keep the internal environment within normal limits. The homeostatic mechanisms of the body are mainly under the control of two systems, the nervous system and the endocrine system. The nervous system detects changes from the balanced state and sends messages in the form of *nerve impulses* to organs that can counteract the change. For example, when body temperature rises, nerve impulses cause sweat glands to release more sweat, which cools the body as it evaporates. The endocrine system corrects changes by secreting molecules called *hormones* into the blood. Hormones affect specific body cells, where they cause responses that restore homeostasis. For example, the hormone insulin reduces blood glucose level when it is too high. Nerve impulses typically cause rapid corrections; hormones usually work more slowly.

Homeostasis is maintained by means of many feedback systems. A **feedback system** or *feedback loop* is a cycle of events in which a condition in the body is continually monitored, evaluated,

changed, remonitored, reevaluated, and so on. Each monitored variable, such as body temperature, blood pressure, or blood glucose level, is termed a *controlled condition*. Any disruption that causes a change in a controlled condition is called a *stimulus*. Some stimuli come from the external environment (the space that surrounds our bodies), such as intense heat or lack of oxygen. Others originate in the internal environment, such as a blood glucose level that is too low. Homeostatic imbalances may also occur due to psychological stresses in our social environment—the demands of work and school, for example. In most cases, the disruption of homeostasis is mild and temporary, and the responses of body cells quickly restore balance in the internal environment. In other cases, the disruption of homeostasis may be intense and prolonged, as in poisoning, overexposure to temperature extremes, severe infection, or death of a loved one.

Three basic components make up a feedback system: a receptor, a control center, and an effector (Figure 1.2).

FIGURE 1.2 Operation of a feedback system.



Q What is the basic difference between negative and positive feedback systems?

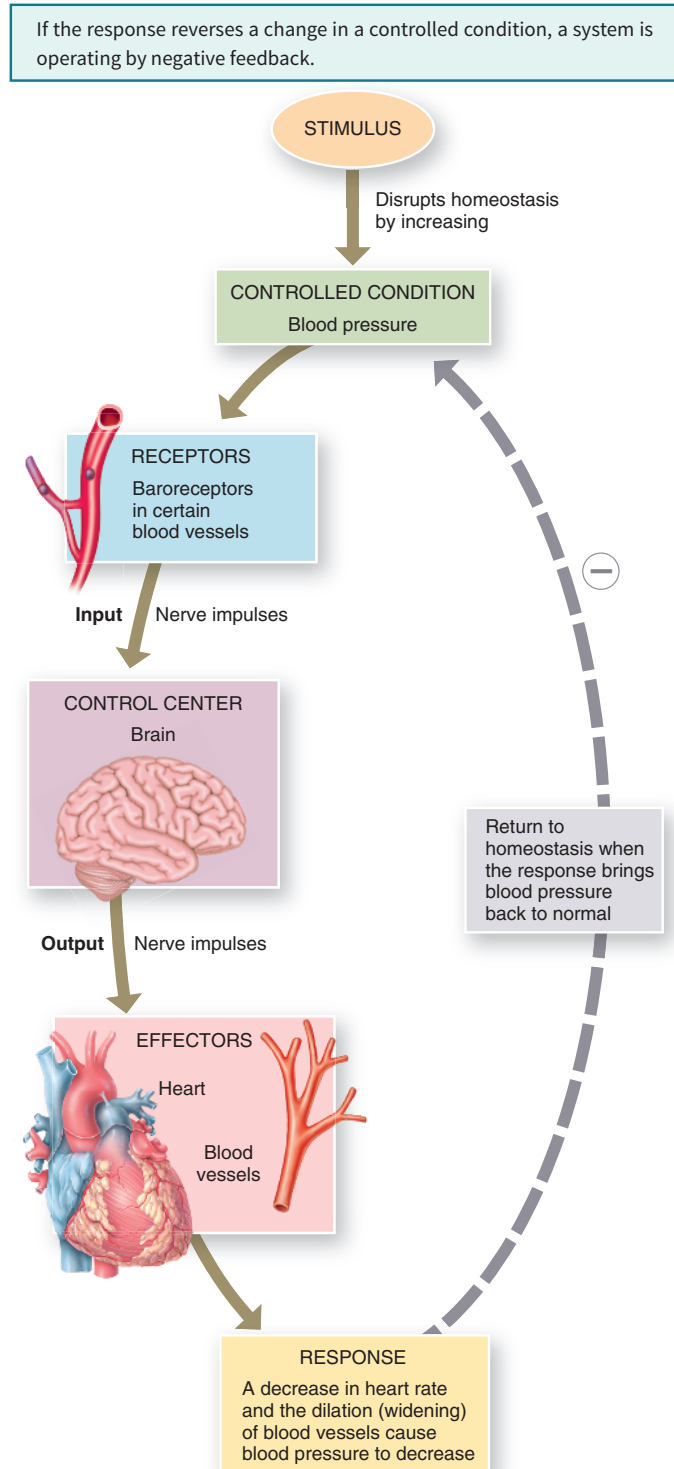
1. A **receptor** is a body structure that monitors changes in a controlled condition and sends information called the *input* (nerve impulses or chemical signals) to a control center. Nerve endings in the skin that sense temperature are one of the hundreds of different kinds of receptors in the body.
2. A **control center** in the body, for example, the brain, sets the range of values within which a controlled condition should be maintained, evaluates the input it receives from receptors, and generates output commands when they are needed. *Output* is information, in the form of nerve impulses or chemical signals, that is relayed from the control center to an effector.
3. An **effector** is a body structure that receives output from the control center and produces a *response* or effect that changes the controlled condition. Nearly every organ or tissue in the body can behave as an effector. For example, when your body temperature drops sharply, your brain (control center) sends nerve impulses to your skeletal muscles (effectors) that cause you to shiver, which generates heat and raises your temperature.

Feedback systems can be classified as either negative feedback systems, which reverse the direction of a controlled condition, or positive feedback systems, which strengthen the direction of a controlled condition.

Negative Feedback Systems A **negative feedback system** reverses a change in a controlled condition. Consider one negative feedback system that helps regulate blood pressure. *Blood pressure (BP)* is the force exerted by blood as it presses against the walls of blood vessels. When the heart beats faster or harder, BP increases. If a stimulus causes BP (controlled condition) to rise, the following sequence of events occurs (Figure 1.3). The higher pressure is detected by *baroreceptors*, pressure-sensitive nerve cells (the receptors) located in the walls of certain blood vessels. The baroreceptors send nerve impulses (input) to the brain (control center), which interprets the impulses and responds by sending nerve impulses (output) to the heart (the effector). Heart rate decreases, which causes BP to decrease (response). This sequence of events returns the controlled condition—blood pressure—to normal, and homeostasis is restored. This is a negative feedback system because the activity of the effector produces a result, a drop in BP, that reverses the effect of the stimulus. Negative feedback systems tend to regulate conditions in the body that are held fairly stable over long periods, such as BP, blood glucose level, and body temperature.

Positive Feedback Systems Unlike a negative feedback system, a **positive feedback system** tends to *strengthen* or *reinforce* a change in one of the body's controlled conditions. In a positive feedback system, the response affects the controlled condition differently than in negative feedback system. The control center still provides commands to an effector, but this time the effector produces a physiological response that adds to or *reinforces* the initial change in the controlled condition. The action of a positive feedback system continues until it is interrupted by some mechanism.

FIGURE 1.3 Homeostasis of blood pressure by a negative feedback system. The broken return arrow with a negative sign surrounded by a circle symbolizes negative feedback. Note that the response is fed back into the system, and the system continues to lower blood pressure until there is a return to normal blood pressure (homeostasis).



Q What would happen to the heart rate if some stimulus caused blood pressure to decrease? Would this occur by positive or negative feedback?

Normal childbirth provides a good example of a positive feedback system (Figure 1.4). The first contractions of labor (stimulus) push part of the fetus into the cervix, the lowest part of the uterus, which opens into the vagina. Stretch-sensitive nerve cells (receptors) monitor the amount of stretching of the cervix (controlled condition). As stretching increases, they send more nerve impulses (input) to the brain (control center), which in turn releases the hormone oxytocin (output) into the blood. Oxytocin causes muscles in the wall of the uterus (effector) to contract even more forcefully. The contractions push the fetus farther down the uterus, which stretches the cervix even more. The cycle of stretching, hormone release, and ever-stronger contractions is interrupted only by the birth of the baby. Then, stretching of the cervix ceases and oxytocin is no longer released.

Homeostasis and Disease

As long as all of the body's controlled conditions remain within certain normal limits, body cells function efficiently, homeostasis is maintained, and the body stays healthy. Should one or more components of the body lose their ability to contribute to homeostasis, however, the normal balance among all of the body's processes may be disturbed. If the homeostatic imbalance is moderate, a disorder or disease may occur; if it is severe, death may result.

A **disorder** is any abnormality of structure and/or function. **Disease** is a more specific term for an illness characterized by a recognizable set of symptoms and signs. **Symptoms** are *subjective* changes in body functions that are not apparent to an observer, for example, headache, anxiety, or nausea. **Signs** are *objective* changes that a clinician can observe and measure, such as bleeding, swelling, vomiting, diarrhea, fever, a rash, or paralysis. Specific diseases alter body structure and function in characteristic ways, usually producing a recognizable set of symptoms and signs.

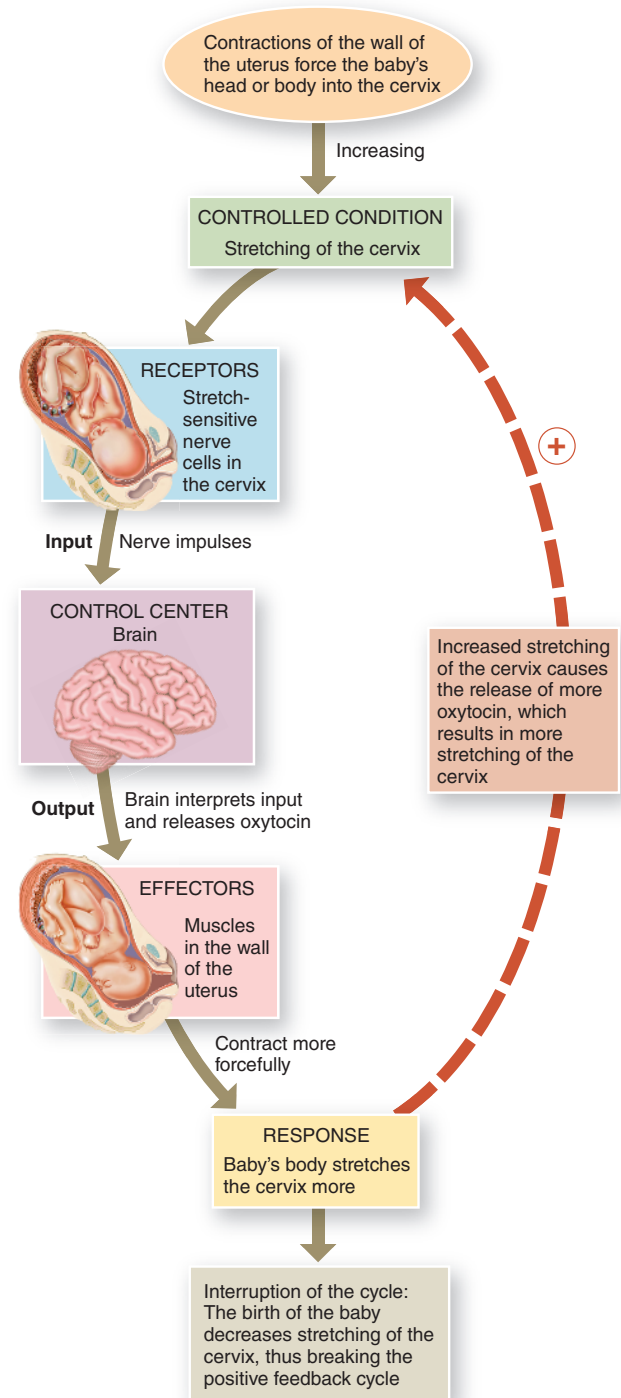
Clinical Connection

Diagnosis

Diagnosis (dī-ag-NŌ-sis; *dia-* = through; *-gnosis* = knowledge) is the identification of a disorder or disease based on a scientific evaluation of the patient's symptoms and signs, medical history, physical examination, and sometimes data from laboratory tests. Taking a *medical history* consists of collecting information about events that might be related to a patient's illness, including the chief complaint, history of present illness, past medical problems, family medical problems, and social history. A *physical examination* is an orderly evaluation of the body and its functions. This process includes *inspection* (observing the body for any changes that deviate from normal), *palpation* (pal-PĀ-shun; feeling body surfaces with the hands), *auscultation* (aws-kul-TĀ-shun; listening to body sounds, often using a stethoscope), *percussion* (pur-KUSH-un; tapping on body surfaces and listening to the resulting echo), and *measuring vital signs* (temperature, pulse, respiratory rate, and blood pressure). Some common laboratory tests include analyses of blood and urine.

FIGURE 1.4 Positive feedback control of labor contractions during birth of a baby. The broken return arrow with a positive sign surrounded by a circle symbolizes positive feedback.

If the response enhances or intensifies the stimulus, a system is operating by positive feedback.



Q Why do positive feedback systems that are part of a normal physiological response include some mechanism that terminates the system?

Checkpoint

6. What types of disturbances can act as stimuli that initiate a feedback system?
7. How are negative and positive feedback systems similar? How are they different?
8. Contrast and give examples of symptoms and signs of a disease.

1.4 Aging and Homeostasis**OBJECTIVE**

- **Describe** some of the anatomical and physiological changes that occur with aging.

As you will see later, **aging** is a normal process characterized by a progressive decline in the body's ability to restore homeostasis. Aging produces observable changes in structure and function and increases vulnerability to stress and disease. The changes associated with aging are apparent in all body systems. Examples include wrinkled skin, gray hair, loss of bone mass, decreased muscle mass and strength, diminished reflexes, decreased production of some hormones, increased incidence of heart disease, increased susceptibility to infections and cancer, decreased lung capacity, less efficient functioning of the digestive system, decreased kidney function, menopause, and enlarged prostate. These and other effects of aging will be discussed in detail in later chapters.

Checkpoint

9. What are some of the signs of aging?

1.5 Anatomical Terms**OBJECTIVES**

- **Describe** the anatomical position.
- **Identify** the major regions of the body and relate the common names to the corresponding anatomical terms for various parts of the body.
- **Define** the directional terms and the anatomical planes and sections used to locate parts of the human body.

The language of anatomy and physiology is very precise. When describing where the wrist is located, is it correct to say “the wrist is

above the fingers”? This description is true if your arms are at your sides. But if you hold your hands up above your head, your fingers would be above your wrists. To prevent this kind of confusion, scientists and health-care professionals refer to one standard anatomical position and use a special vocabulary for relating body parts to one another.

In the study of anatomy, descriptions of any part of the human body assume that the body is in a specific stance called the **anatomical position** (an'-a-TOM-i-kal). In the anatomical position, the subject stands erect facing the observer, with the head level and the eyes facing forward. The lower limbs are parallel and the feet are flat on the floor and directed forward, and the upper limbs are at the sides with the palms turned forward (**Figure 1.5**). In the anatomical position, the body is upright. Two terms describe a reclining body. If the body is lying face down, it is in the **prone** position. If the body is lying face up, it is in the **supine** position.

Names of Body Regions

The human body is divided into several major regions that can be identified externally. These are the head, neck, trunk, upper limbs, and lower limbs (**Figure 1.5**). The **head** consists of the skull and face. The **skull** is the part of the head that encloses and protects the brain, and the **face** is the front portion of the head that includes the eyes, nose, mouth, forehead, cheeks, and chin. The **neck** supports the head and attaches it to the trunk. The **trunk** consists of the chest, abdomen, and pelvis. Each **upper limb** is attached to the trunk and consists of the shoulder, armpit, arm (portion of the limb from the shoulder to the elbow), forearm (portion of the limb from the elbow to the wrist), wrist, and hand. Each **lower limb** is also attached to the trunk and consists of the buttock, thigh (portion of the limb from the hip to the knee), leg (portion of the limb from the knee to the ankle), ankle, and foot. The **groin** is the area on the front surface of the body, marked by a crease on each side, where the trunk attaches to the thighs.

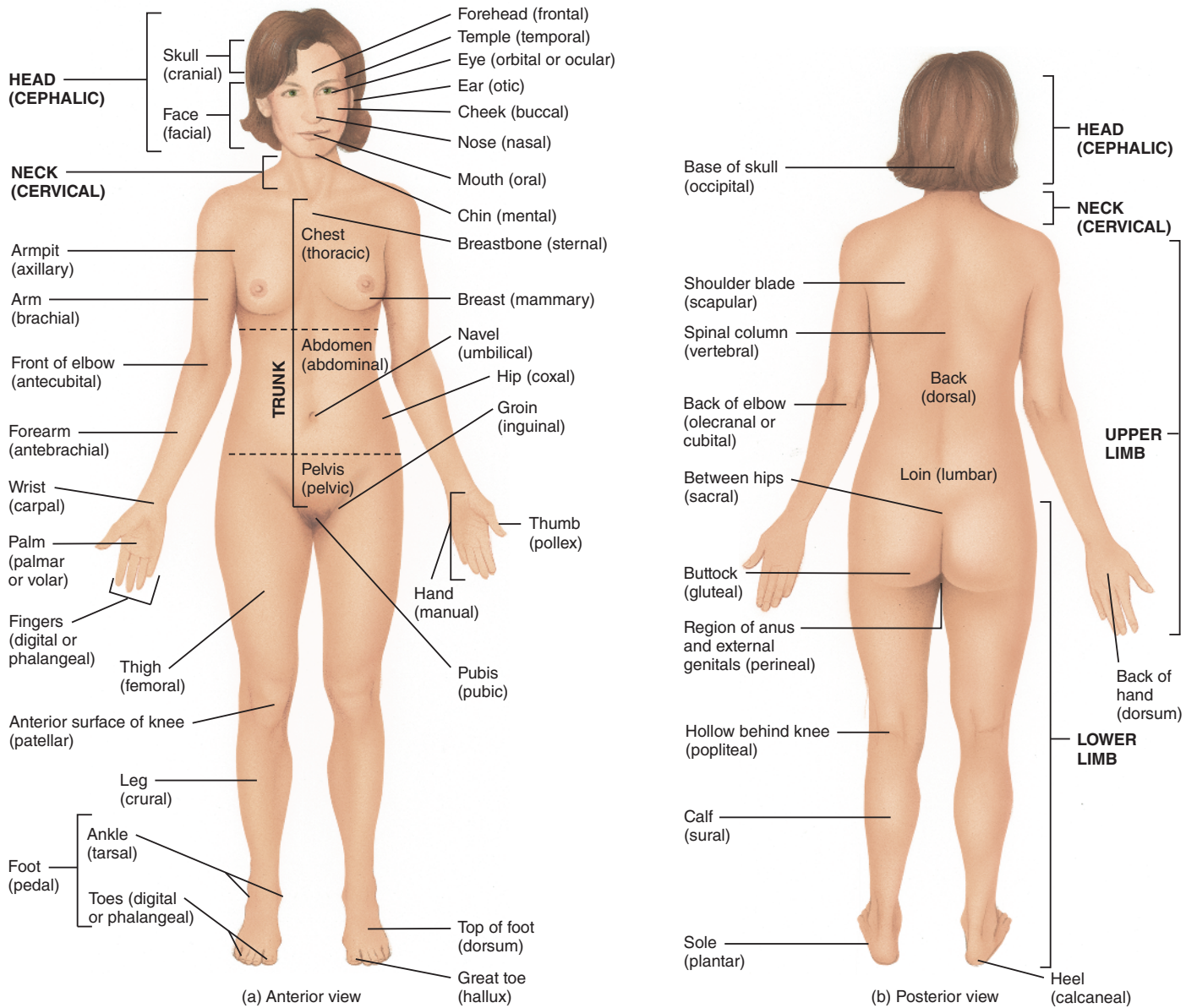
In **Figure 1.5**, common name and corresponding anatomical name for each part of the body appears in parentheses. For example, if you receive a tetanus shot in your **buttock**, it is a **gluteal** injection. The anatomical name of a body part is based on a Greek or Latin word or “root” for the same part or area. The Latin word for armpit is **axilla** (ak-SIL-a), for example, and thus one of the nerves passing within the armpit is named the axillary nerve. You will learn more about the word roots of anatomical and physiological terms as you read this book.

Directional Terms

To locate various body structures, anatomists use specific **directional terms**, words that describe the position of one body part relative to another. Several directional terms can be grouped in pairs that have opposite meanings, for example, anterior (front) and posterior (back). Study **Figure 1.6** and **Table 1.2** to determine, among other things, whether your stomach is superior to your lungs.

FIGURE 1.5 The anatomical position. The common names and corresponding anatomical terms (in parentheses) indicate specific body regions. For example, the head is the cephalic region.

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



Q Where is a plantar wart located?

TABLE 1.2 Directional Terms

Directional Term	Definition	Example of Use
Superior (soo'-PĒR-ē-or) (cephalic or cranial)	Toward the head, or the upper part of a structure	The heart is superior to the liver.
Inferior (in'-FĒR-ē-or) (caudal)	Away from the head, or the lower part of a structure	The stomach is inferior to the lungs.
Anterior (an-TĒR-ē-or) (ventral)	Nearer to or at the front of the body	The sternum (breastbone) is anterior to heart.
Posterior (pos-TĒR-ē-or) (dorsal)	Nearer to or at the back of the body	The esophagus (food tube) is posterior to the trachea (windpipe).
Medial (MĒ-dē-al)	Nearer to the midline, an imaginary vertical line that divides the body into equal right and left sides	The ulna is medial to the radius.
Lateral (LAT-er-al)	Farther from the midline or midsagittal plane	The lungs are lateral to the heart.
Intermediate (in'-ter-MĒ-dē-at)	Between two structures	The transverse colon is intermediate to the ascending and descending colons.
Ipsilateral (ip-si-LAT-er-al)	On the same side of the body as another structure	The gallbladder and ascending colon are ipsilateral.
Contralateral (KON-tra-lat-er-al)	On the opposite side of the body from another structure	The ascending and descending colons are contralateral.
Proximal (PROK-si-mal)	Nearer to the attachment of a limb to the trunk; nearer to the point of origin or the beginning	The humerus is proximal to the radius.
Distal (DIS-tal)	Farther from the attachment of a limb to the trunk; farther from the point of origin or the beginning	The phalanges are distal to the carpals.
Superficial (soo'-per-FISH-al) (external)	Toward or on the surface of the body	The ribs are superficial to the lungs.
Deep (DĒP) (internal)	Away from the surface of the body	The ribs are deep to the skin of the chest and back.

Most of the directional terms used to describe the human body can be grouped into pairs that have opposite meanings. For example, **superior** means toward the upper part of the body, and **inferior** means toward the lower part of the body. It is important to understand that directional terms have *relative* meanings; they only make sense when used to describe the position of one structure relative to another. For example, your knee is superior to your ankle, even though both are located in the inferior half of the body. Study the directional terms and the example of how each is used. As you read each example, refer to **Figure 1.6** to see the location of the structures mentioned.

Planes and Sections

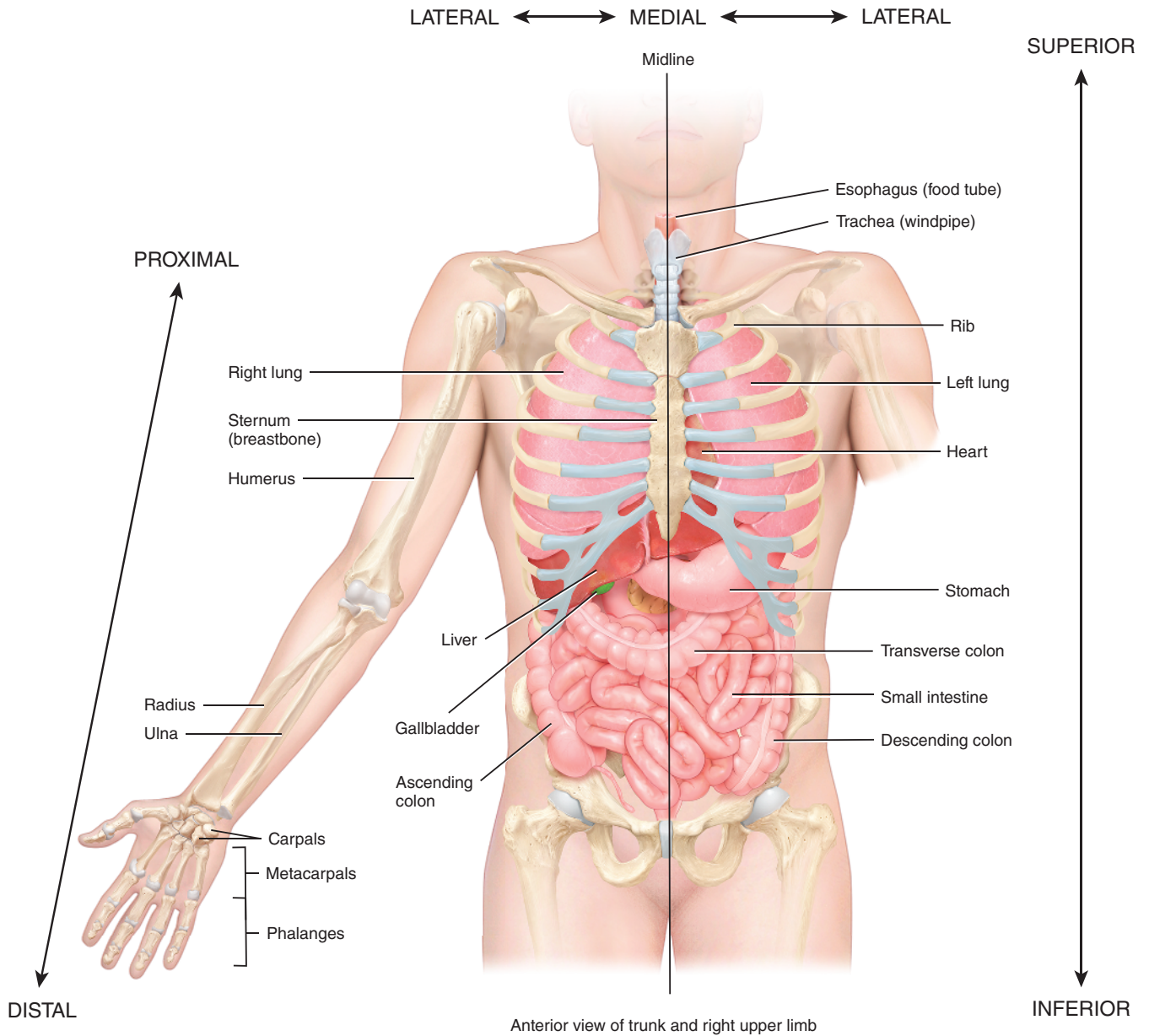
You will also study parts of the body in four major **planes**, that is, imaginary flat surfaces that pass through body parts (**Figure 1.7**): sagittal, frontal, transverse, and oblique. A **sagittal plane** (SAJ-i-tal;

sagitt- = arrow) is a vertical plane that divides the body or an organ into right and left sides. More specifically, when such a plane passes through the midline of the body or organ and divides it into *equal* right and left sides, it is called a **midsagittal plane**. If the sagittal plane does not pass through the midline but instead divides the body or an organ into *unequal* right and left sides, it is called a **parasagittal plane** (*para-* = near). A **frontal plane** or **coronal plane** divides the body or an organ into anterior (front) and posterior (back) portions. A **transverse plane** divides the body or an organ into superior (upper) and inferior (lower) portions. A transverse plane may also be called a *cross-sectional* or *horizontal plane*. Sagittal, frontal, and transverse planes are all at right angles to one another. An **oblique plane**, by contrast, passes through the body or an organ at an angle between the transverse plane and a sagittal plane or between the transverse plane and the frontal plane.

When you study a body region, you will often view it in section. A **section** is a cut of the body or an organ made along one of the planes just described. It is important to know the plane of the section so you

FIGURE 1.6 Directional terms.

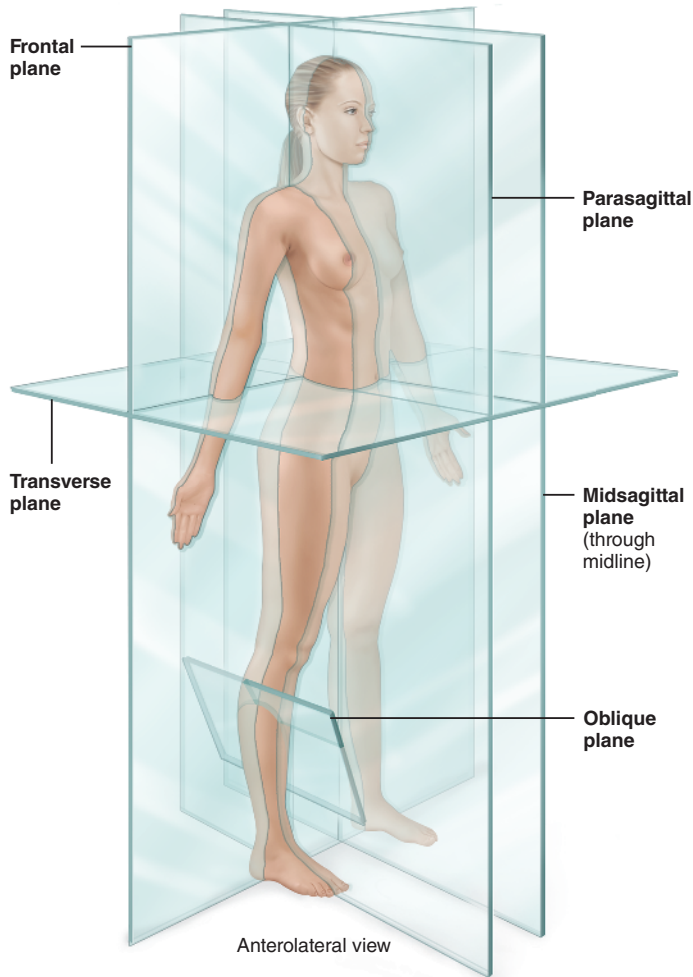
Directional terms precisely locate various parts of the body in relation to one another.



Q Is the radius proximal to the humerus? Is the esophagus anterior to the trachea? Are the ribs superficial to the lungs? Are the ascending colon and descending colon ipsilateral? Is the sternum lateral to the descending colon?

FIGURE 1.7 Planes through the human body.

Frontal, transverse, sagittal, and oblique planes divide the body in specific ways.



Q Which plane divides the heart into anterior and posterior portions?

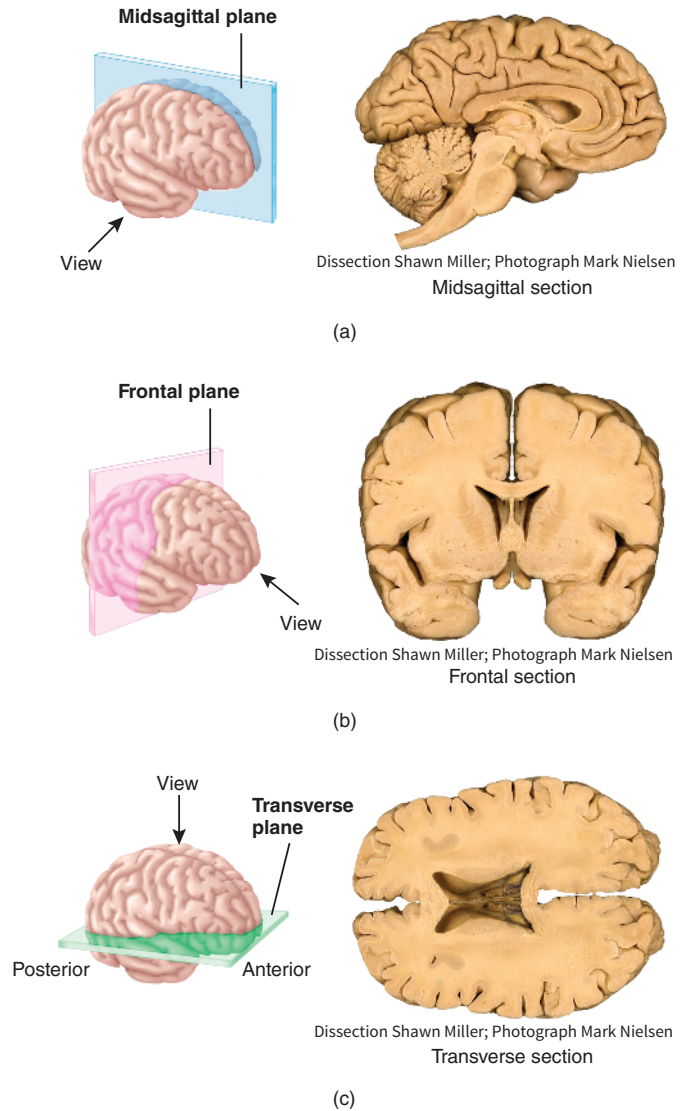
can understand the anatomical relationship of one part to another. **Figure 1.8** indicates how three different sections—a *midsagittal section*, a *frontal section*, and a *transverse (cross) section*—provide different views of the brain.

Checkpoint

- 10. Which directional terms can be used to specify the relationships between (1) the elbow and the shoulder, (2) the left and right shoulders, (3) the sternum and the humerus, and (4) the heart and the diaphragm?
- 11. Describe the anatomical position and explain why it is used.

FIGURE 1.8 Planes and sections through different parts of the brain. The diagrams (left) show the planes, and the photographs (right) show the resulting sections. (**Note:** The “View” arrows in the diagrams indicate the direction from which each section is viewed. This aid is used throughout the book to indicate viewing perspective.)

Planes divide the body in various ways to produce sections.



Q Which plane divides the brain into equal right and left sides?

- 12. Locate each region on your own body, and then identify it by its common name and the corresponding anatomical descriptive form.
- 13. For each directional term listed in **Table 1.1**, provide your own example.
- 14. What are the various planes that may be passed through the body? Explain how each divides the body.

1.6 Body Cavities

OBJECTIVES

- **Describe** the principal body cavities and the organs they contain.
- **Explain** why the abdominopelvic cavity is divided into regions and quadrants.

Body cavities are spaces within the body that contain, protect, separate, and support internal organs. Here we discuss several of the larger body cavities (Figure 1.9).

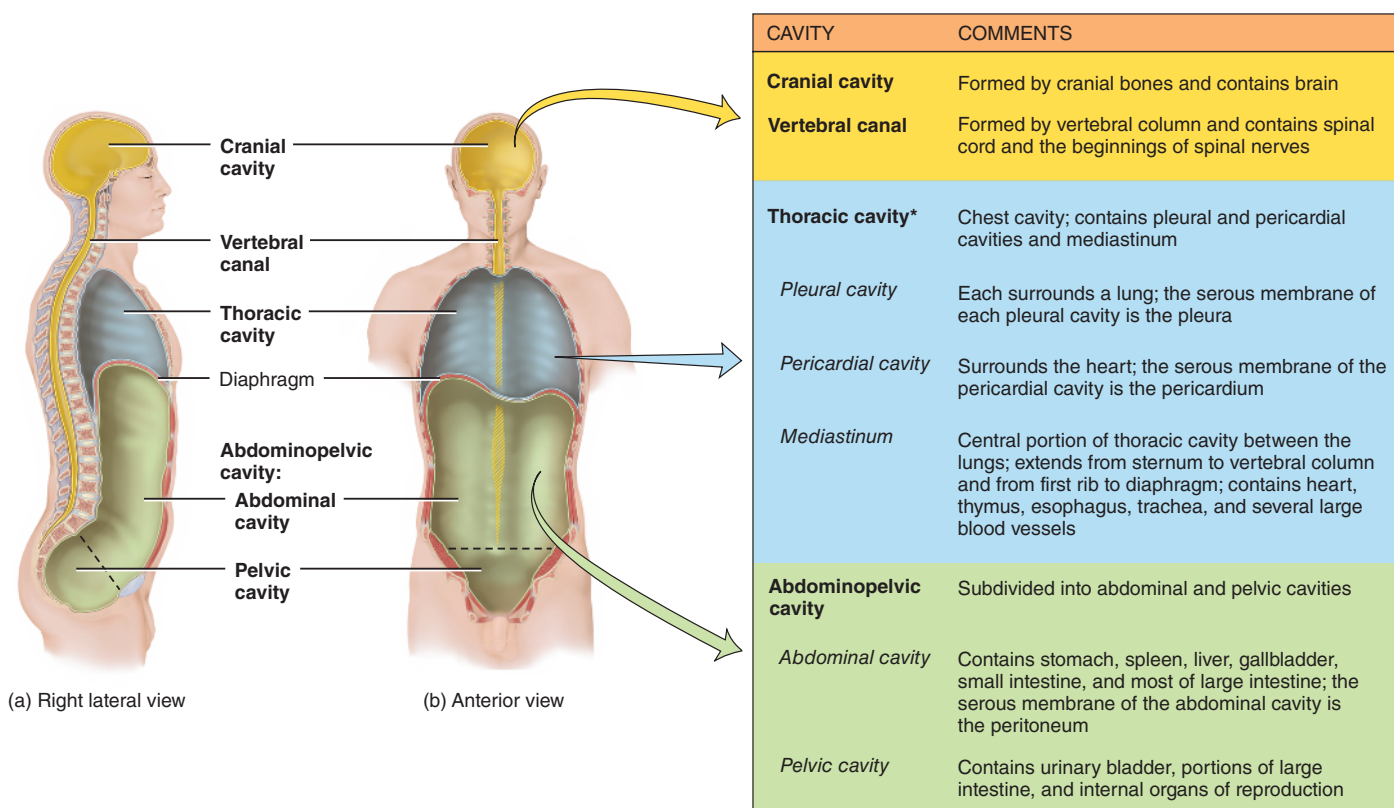
The **cranial cavity** (KRĀ-nē-al) is formed by the cranial (skull) bones and contains the brain. The **vertebral (spinal) canal**

(VER-te-bral) is a cavity that is formed by the bones of the vertebral column (backbone) and contains the spinal cord.

The major body cavities of the trunk are the thoracic and abdominopelvic cavities. The **thoracic cavity** (thor-AS-ik; *thorac-* = chest) is the chest cavity. Within the thoracic cavity are three smaller cavities: the **pericardial cavity** (per'-i-KAR-dē-al; *peri-* = around; *-cardial* = heart) that surrounds the heart and contains a small amount of lubricating fluid, and two **pleural cavities** (PLOOR-al; *pleur-* = rib or side), each of which surrounds one lung and contains a small amount of lubricating fluid (Figure 1.10). The central portion of the thoracic cavity is an anatomical region called the **mediastinum** (mē'-dē-as-TĪ-num; *media-* = middle; *-stinum* = partition). It is between the lungs, extending from the sternum (breastbone) to the vertebral column (backbone), and from the first rib to the diaphragm (Figure 1.10), and contains all thoracic

FIGURE 1.9 Body cavities. The black dashed lines indicate the border between the abdominal and pelvic cavities.

The major body cavities of the trunk are the thoracic and abdominopelvic cavities.

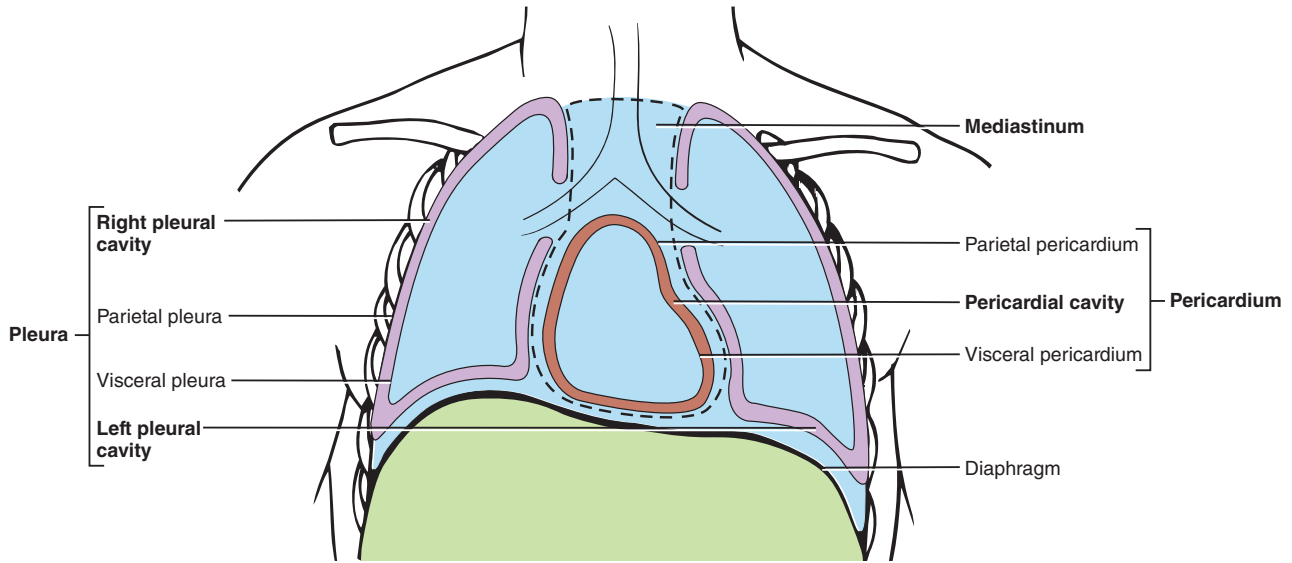


* See Figure 1.10 for details of the thoracic cavity.

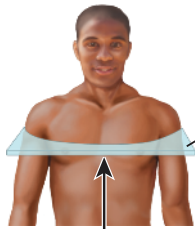
Q In which cavities are the following organs located: urinary bladder, stomach, heart, small intestine, lungs, internal female reproductive organs, thymus, spleen, liver? Use the following symbols for your responses: T = thoracic cavity, A = abdominal cavity, or P = pelvic cavity.

FIGURE 1.10 The thoracic cavity. The dashed lines indicate the borders of the mediastinum. **Note:** When transverse sections are viewed inferiorly (from below), the anterior aspect of the body appears on top and the left side of the body appears on the right side of illustration. Notice that the pericardial cavity surrounds the heart, and that the pleural cavities surround the lungs.

The mediastinum is the anatomical region medial to the lungs that extends from the sternum to the vertebral column and from the first rib to the diaphragm.

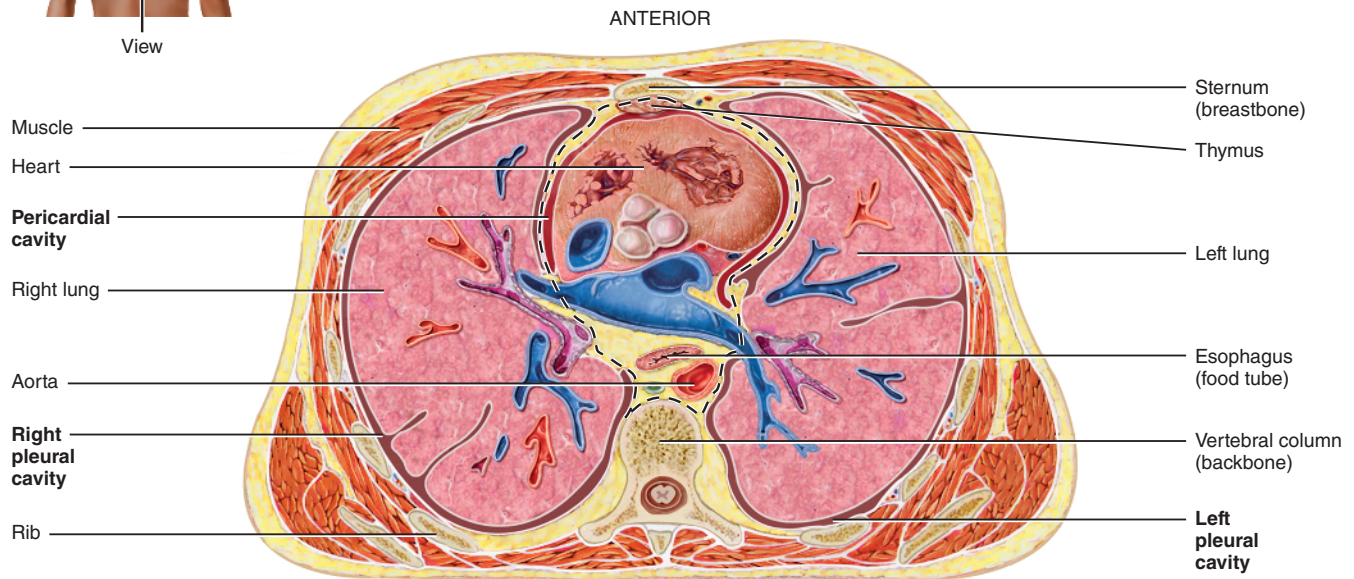


(a) Anterior view of thoracic cavity



Transverse plane

View



(b) Inferior view of transverse section of thoracic cavity

Q Which of the following structures are contained in the mediastinum: right lung, heart, esophagus, spinal cord, aorta, left pleural

organs except the lungs themselves. Among the structures in the mediastinum are the heart, esophagus, trachea, and several large blood vessels. The **diaphragm** (DĪ-a-fram = partition or wall) is a dome-shaped muscle that powers breathing and separates the thoracic cavity from the abdominopelvic cavity.

The **abdominopelvic cavity** (ab-dom'-i-nō-PEL-vik) extends from the diaphragm to the groin and is encircled by the abdominal muscles and bones and muscles of the pelvis. As the name suggests, it is divided into two portions, although no wall separates them (see **Figure 1.9**). The upper portion, the **abdominal cavity** (ab-DOM-i-nal; *abdomin-* = belly), contains the stomach, spleen, liver, gallbladder, small intestine, and most of the large intestine. The lower portion, the **pelvic cavity** (PEL-vik; *pelv-* = basin), contains the urinary bladder, remaining portions of the large intestine, and internal organs of the reproductive system. Organs inside the thoracic and abdominopelvic cavities are called **viscera** (VIS-e-ra).

A **membrane** is a thin, pliable tissue that covers, lines, partitions, or connects structures. One example is a slippery double-layered membrane associated with body cavities that do not open directly to the exterior called a **serous membrane** (SĒR-us). It covers the viscera within the thoracic and abdominal cavities and also lines the walls of the thorax and abdomen. The parts of a serous membrane are (1) the **parietal layer** (pa-RĪ-e-tal), which lines the walls of the cavities, and (2) the **visceral layer**, which covers and adheres to the viscera within the cavities. Between the two layers is a potential space that contains

a small amount of lubricating fluid (serous fluid). The fluid allows the viscera to slide somewhat during movements, as when the lungs inflate and deflate during breathing.

The serous membrane of the pleural cavities is called the **pleura** (PLOO-ra). The serous membrane of the pericardial cavity is the **pericardium** (per'-i-KAR-dē-um). The **peritoneum** (per-i-tō-NĒ-um) is the serous membrane of the abdominal cavity.

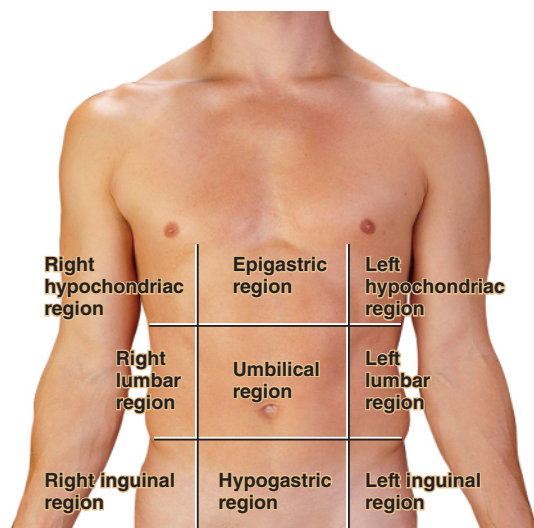
In addition to those just described, you will also learn about other body cavities in later chapters. These include the **oral (mouth) cavity**, which contains the tongue and teeth; the **nasal cavity** in the nose; the **orbital cavities**, which contain the eyeballs; the **middle ear cavities**, which contain small bones in the middle ear; and **synovial cavities**, which are found in freely movable joints and contain synovial fluid.

Abdominopelvic Regions and Quadrants

To describe the location of the many abdominal and pelvic organs more precisely, the abdominopelvic cavity may be divided into smaller compartments. In one method, two horizontal and two vertical lines, like a tic-tac-toe grid, partition the cavity into nine **abdominopelvic regions** (**Figure 1.11**). The names of the nine abdominopelvic regions are the **right hypochondriac** (hi'-pō-KON-drē-ak), **epigastric** (ep-i-GAS-trik), **left hypochondriac**, **right lumbar**, **umbilical** (um-BIL-i-kul),

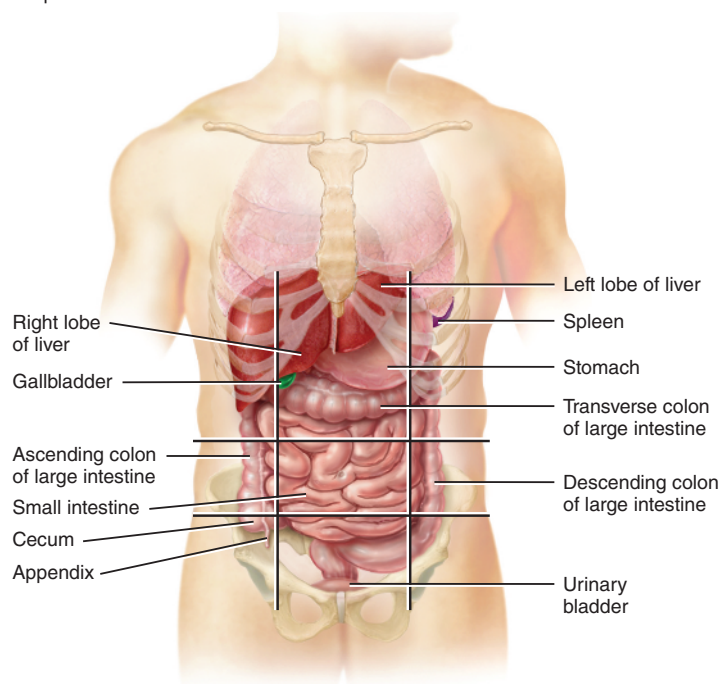
FIGURE 1.11 The nine regions of the abdominopelvic cavity. The internal reproductive organs in the pelvic cavity are shown in Figures 23.1 and 23.6.

The nine-region designation is used for anatomical studies.



Andy Washnik

(a) Anterior view showing location of abdominopelvic regions



(b) Anterior superficial view of organs in abdominopelvic regions

Q In which abdominopelvic region is each of the following found: most of the liver, ascending colon, urinary bladder, appendix?

left lumbar, right inguinal (*iliac*) (IL-ē-ak), *hypogastric* (hī'-pō-GAS-trik), and left *inguinal*.

In another method, one horizontal and one vertical line passing through the *umbilicus* (um-BIL-i-kus or um-bi-LĪ-kus; *umbilic-* = navel) or belly button divide the abdominopelvic cavity into **quadrants** (KWOD-rantz; *quad-* = one-fourth) (Figure 1.12). The names of the abdominopelvic quadrants are the *right upper quadrant (RUQ)*, *left upper quadrant (LUQ)*, *right lower quadrant (RLQ)*, and *left lower quadrant (LLQ)*. The nine-region division is more widely used for anatomical studies, and quadrants are more commonly used by clinicians to describe the site of an abdominopelvic pain, mass, or other abnormality.

Checkpoint

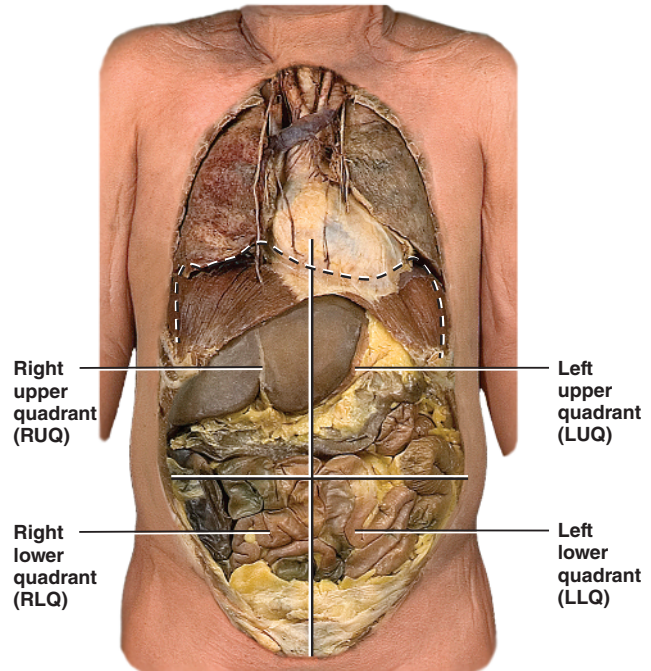
15. What landmarks separate the various body cavities from one another?
16. Locate the nine abdominopelvic regions and the four abdominopelvic quadrants on yourself, and list some of the organs found in each.

• • •

In Chapter 2 we will examine the chemical level of organization. You will learn about the various groups of chemicals, their functions, and how they contribute to homeostasis.

FIGURE 1.12 Quadrants of the abdominopelvic cavity (below the dashed line). The two lines cross at right angles at the umbilicus (navel).

The quadrant designation is used to locate the site of pain, a mass, or some other abnormality.



Dissection Shawn Miller; Photograph Mark Nielsen

Anterior view showing location of abdominopelvic quadrants

Q In which abdominopelvic quadrant would the pain from appendicitis (inflammation of the appendix) be felt?

Medical Terminology and Conditions

Most chapters in this text are followed by a glossary of key medical terms that include both normal and pathological conditions. You should familiarize yourself with these terms because they will play an essential role in your medical vocabulary.

Some of these conditions, as well as ones discussed in the text, are referred to as local or systemic. A *local disease* is one that affects one part or a limited area of the body. A *systemic disease* affects the entire body or several parts.

Epidemiology (ep'-i-dē-mē-OL-ō-jē; *epi-* = upon; *-demi* = people) The science that deals with why, when, and where diseases occur and how they are transmitted within a defined human population.

Geriatrics (jer'-ē-AT-riks; *ger-* = old; *-iatrics* = medicine) The science that deals with the medical problems and care of elderly persons.

Pathology (pa-THOL-ō-jē; *patho-* = disease) The science that deals with the nature, causes, and development of abnormal conditions and the structural and functional changes that diseases produce.

Pharmacology (far'-ma-KOL-ō-jē; *pharmaco-* = drug) The science that deals with the effects and use of drugs in the treatment of disease.

Chapter Review

Review

1.1 Anatomy and Physiology: An Overview

- Anatomy** is the science of structure and the relationships among structures.
- Physiology** is the science of how body structures function.
- The human body consists of six levels of organization: **chemical, cellular, tissue, organ, system, and organismal**.
- Cells** are the basic structural and functional units of an organism and the smallest living units in the human body.
- Tissues** consist of groups of cells and the materials surrounding them that work together to perform a particular function.
- Organs** usually have recognizable shapes, are composed of two or more different types of tissues, and have specific functions.
- Systems** consist of related organs that have a common function.
- Table 1.1** introduces the 11 systems of the human body: integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive.
- The human organism is a collection of structurally and functionally integrated systems. Body systems work together to maintain health, protect against disease, and allow for reproduction of the species.

1.2 Life Processes

- All living organisms have certain characteristics that set them apart from nonliving things.
- The life processes in humans include **metabolism, responsiveness, movement, growth, differentiation, and reproduction**.

1.3 Homeostasis: Maintaining Limits

- Homeostasis** is a condition in which the internal environment of the body remains stable, within certain limits.
- The body's internal environment is extracellular fluid, which surrounds all body cells.
- Homeostasis is regulated by the nervous and endocrine systems acting together or separately. The nervous system detects body changes and sends nerve impulses to maintain homeostasis. The endocrine system regulates homeostasis by secreting hormones.
- Disruptions of homeostasis come from external and internal stimuli and from psychological stresses. When disruption of homeostasis is mild and temporary, responses of body cells quickly restore balance in the internal environment. If disruption is extreme, the body's attempts to restore homeostasis may fail.
- A **feedback system** consists of three parts: (1) **receptors** that monitor changes in a controlled condition and send input to (2) a **control center** that sets the value at which a controlled condition should be maintained, evaluates the input it receives, and generates output commands when they are needed, and (3) **effectors** that receive output from the control center and produce a response (effect) that alters the controlled condition.
- If a response reverses a change in a controlled condition, the system is called a **negative feedback system**. If a response strengthens a change in a controlled condition, the system is referred to as a **positive feedback system**.

- One example of negative feedback is the system that regulates blood pressure. If a stimulus causes blood pressure (controlled condition) to rise, baroreceptors (pressure-sensitive nerve cells, the receptors) in blood vessels send impulses (input) to the brain (control center). The brain sends impulses (output) to the heart (effector). As a result, heart rate decreases (response), and blood pressure drops back to normal (restoration of homeostasis).
- One example of positive feedback occurs during the birth of a baby. When labor begins, the cervix of the uterus is stretched (stimulus), and stretch-sensitive nerve cells in the cervix (receptors) send nerve impulses (input) to the brain (control center). The brain responds by releasing oxytocin (output), which stimulates the uterus (effector) to contract more forcefully (response). Movement of the fetus further stretches the cervix, more oxytocin is released, and even more forceful contractions occur. The cycle is broken with the birth of the body.
- Disruptions of homeostasis—homeostatic imbalances—can lead to disorders, disease, and even death. A **disorder** is any abnormality of structure and/or function. **Disease** is a more specific term for an illness with a definite set of signs and symptoms.
- Symptoms** are subjective changes in body functions that are not apparent to an observer. **Signs** are objective changes that can be observed and measured.
- Diagnosis** of disease involves identification of symptoms and signs, a medical history, physical examination, and sometimes laboratory tests.

1.4 Aging and Homeostasis

- Aging** produces observable changes in structure and function and increases vulnerability to stress and disease.
- Changes associated with aging occur in all body systems.

1.5 Anatomical Terms

- Descriptions of any region of the body assume the body is in the **anatomical position**, in which the subject stands erect facing the observer, with the head level and the eyes facing forward, the lower limbs parallel and the feet flat on the floor and directed forward, and the upper limbs at the sides, with the palms turned forward.
- The human body is divided into several major regions: the **head, neck, trunk, upper limbs, and lower limbs**.
- Within body regions, specific body parts have common names and corresponding anatomical names. Examples are chest (thoracic), nose (nasal), and wrist (carpal).
- Directional terms** indicate the relationship of one part of the body to another. **Exhibit 1.A** summarizes commonly used directional terms.
- Planes** are imaginary flat surfaces that divide the body or organs into two parts. A **midsagittal plane** divides the body or an organ into equal right and left sides. A **parasagittal plane** divides the body or an organ into unequal right and left sides. A **frontal plane** divides the body or an organ into anterior and posterior portions. A **transverse plane** divides the body or an organ into superior and inferior portions. An **oblique plane** passes through the body or an organ at an angle between a transverse plane and a sagittal plane, or between a transverse plane and a frontal plane.
- Sections** result from cuts through body structures. They are named according to the plane on which the cut is made: transverse, frontal, or sagittal.

1.6 Body Cavities

1. Spaces in the body that contain, protect, separate, and support internal organs are called **body cavities**.
2. The **cranial cavity** contains the brain, and the **vertebral canal** contains the spinal cord.
3. The **thoracic cavity** is subdivided into three smaller cavities: a **pericardial cavity**, which contains the heart, and two **pleural cavities**, each of which contains a lung.
4. The central portion of the thoracic cavity is the **mediastinum**. It is located between the lungs and extends from the sternum to the vertebral column and from the neck to the **diaphragm**. It contains all thoracic organs except the lungs.
5. The **abdominopelvic cavity** is separated from the thoracic cavity by the diaphragm and is divided into a superior **abdominal cavity** and an inferior **pelvic cavity**.

6. Organs in the thoracic and abdominopelvic cavities are called **viscera**. Viscera of the abdominal cavity include the stomach, spleen, liver, gallbladder, small intestine, and most of the large intestine. Viscera of the pelvic cavity include the urinary bladder, portions of the large intestine, and internal organs of the reproductive system.

7. To describe the location of organs easily, the abdominopelvic cavity may be divided into nine **abdominopelvic regions** by two horizontal and two vertical lines. The names of the nine abdominopelvic regions are right hypochondriac, epigastric, left hypochondriac, right lumbar, umbilical, left lumbar, right inguinal, hypogastric, and left inguinal.

8. The abdominopelvic cavity may also be divided into **quadrants** by passing one horizontal line and one vertical line through the umbilicus (navel). The names of the abdominopelvic quadrants are right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ), and left lower quadrant (LLQ).

Critical Thinking Applications

1. Taylor was going for the playground record for the longest upside-down hang from the monkey bars. She didn't make it and may have broken her arm. The emergency room technician would like an x-ray film of Taylor's arm in the anatomical position. Use the proper anatomical terms to describe the position of Taylor's arm in the x-ray film.
2. You are working in a lab and think you may be observing a new organism. What minimal level of structural organization would you need to be observing? What are some characteristics you would need to observe to ensure that it is a living organism?

3. Guy was trying to impress Jenna with a tale about his last rugby match. "The coach said I suffered a caudal injury to the dorsal sural in my groin." Jenna responded, "I think either you or your coach suffered a cephalic injury." Why wasn't Jenna impressed by Guy's athletic prowess?

4. There's a special fun-house mirror that hides half your body and doubles the image of your other side. In the mirror, you can do amazing feats such as lifting both legs off the ground. Along what plane is the mirror dividing your body? A different mirror in the next room shows your reflection with two heads, four arms, and no legs. Along what plane is this mirror dividing your body?

Answers to Figure Questions

- 1.1 Organs have a recognizable shape and consist of two or more different types of tissues that have a specific function.
- 1.2 The basic difference between negative and positive feedback systems is that in negative feedback systems, the response reverses a change in a controlled condition, and in positive feedback systems, the response strengthens the change in a controlled condition.
- 1.3 If a stimulus caused blood pressure to decrease, the heart rate would increase due to the operation of this negative feedback system.
- 1.4 Because positive feedback systems continually intensify or reinforce the original stimulus, some mechanism is needed to end the response.
- 1.5 A plantar wart is found on the sole.
- 1.6 No, the radius is distal to the humerus. No, the esophagus is posterior to the trachea. Yes, the ribs are superficial to the lungs. No, the ascending colon

and descending colon are contralateral. No, the sternum is medial to the descending colon.

1.7 The frontal plane divides the heart into anterior and posterior portions.

1.8 The midsagittal plane divides the brain into equal right and left sides.

1.9 Urinary bladder = P, stomach = A, heart = T, small intestine = A, lungs = T, internal female reproductive organs = P, thymus = T, spleen = A, liver = A.

1.10 Some structures in the mediastinum include the heart, esophagus, and aorta.

1.11 The liver is mostly in the epigastric region; the ascending colon is in the right lumbar region; the urinary bladder is in the hypogastric region; the appendix is in the right inguinal region.

1.12 The pain associated with appendicitis would be felt in the right lower quadrant (RLQ).

