

ORGANIZATION OF THE HUMAN BODY



chapter 1

did you know?

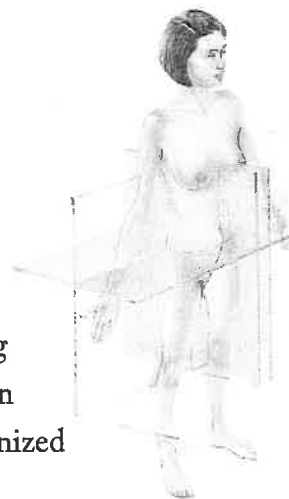
The body's ability to maintain homeostasis gives it tremendous healing power and a remarkable resistance to abuse. The physiological processes responsible for maintaining homeostasis are in large part also responsible for your good health. For most people, lifelong good health is not something that just happens. Two of the many factors in this balance called health are the environment and your own behavior. Your body's homeostasis is affected by the air you breathe, the food you eat, and even by the thoughts you think. The way you live your life can either support or interfere with your body's ability to maintain homeostasis and good health.



Focus on Wellness, page 10

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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.



ANATOMY AND PHYSIOLOGY DEFINED

OBJECTIVE • Define anatomy and physiology.

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. **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.

■ 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.

LEVELS OF ORGANIZATION AND BODY SYSTEMS

OBJECTIVES • Describe the structural organization of the human body.

- Define the body systems and explain how they relate to one another.

The structures of the human body are organized on several levels, similar to the way letters of the alphabet, words, sentences, and paragraphs make up language. 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).

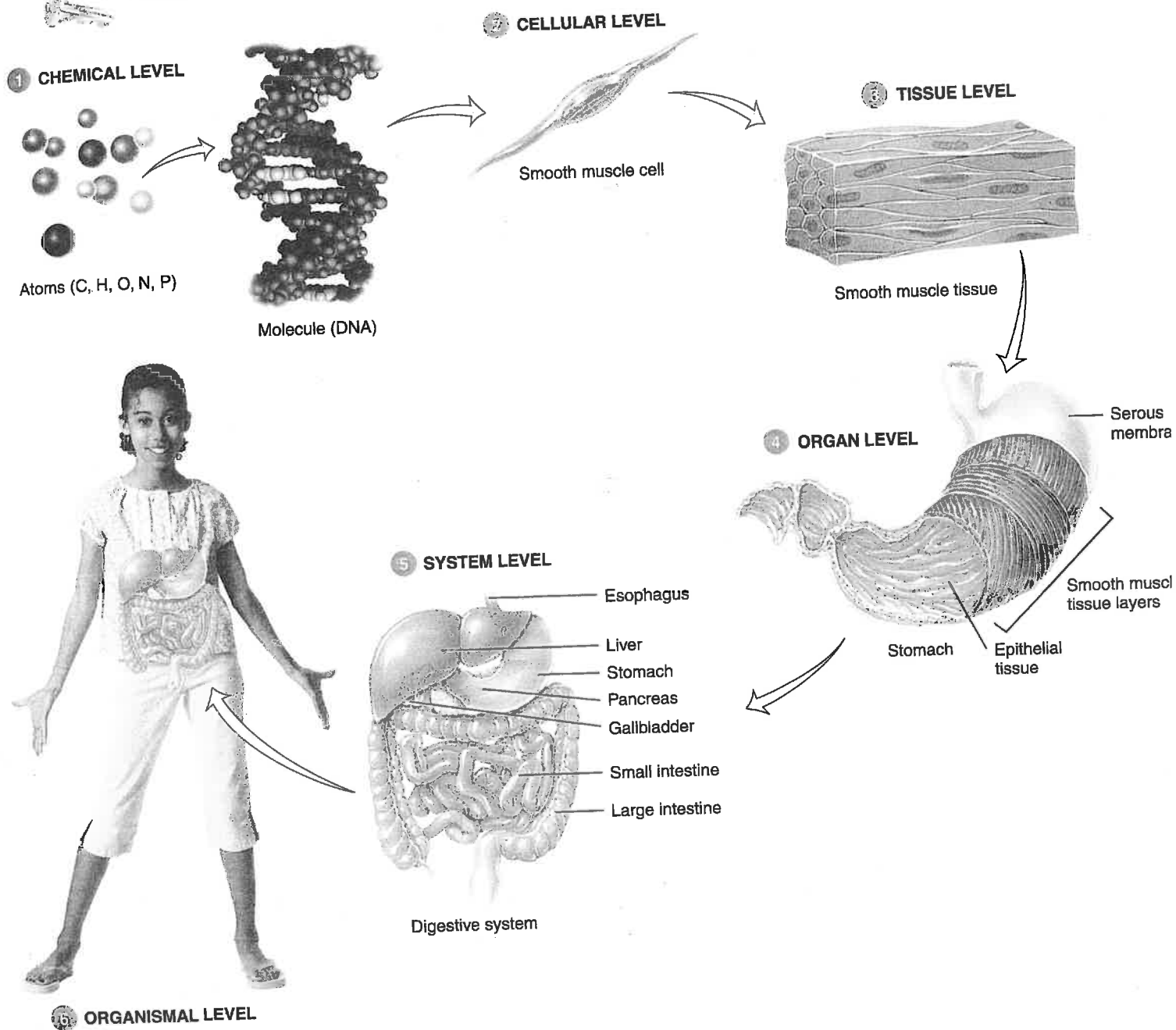
- 1 The **chemical level**, which can be compared to letters of the alphabet, includes **atoms**, the smallest units of matter that participate in chemical reactions, and **molecules**, two or more atoms joined together. Certain atoms, such as carbon (C), hydrogen (H), oxygen (O), nitrogen (N), calcium (Ca), 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, 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. Similar to the relationship between sentences and paragraphs, **organs** usually have a recognizable shape, are composed of two or more different types of tissues, and have specific functions. Examples of organs are the stomach, heart, liver, lungs, and brain. Figure 1.1 shows several tissues that make up the stomach. The **serous membrane** is a layer around the outside of the stomach that protects it and reduces friction when the stomach moves and rubs against other organs. Underneath the serous membrane 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** (or chapter in our analogy) consists of related organs (paragraphs) that have a common function. 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 on pages 4–5 introduces the

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.



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?

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.

The **organismal level** is the largest level of organization. All the systems of the body combine to make up an **organism**, that is, one human being. An organism can be compared to a book in our analogy.

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

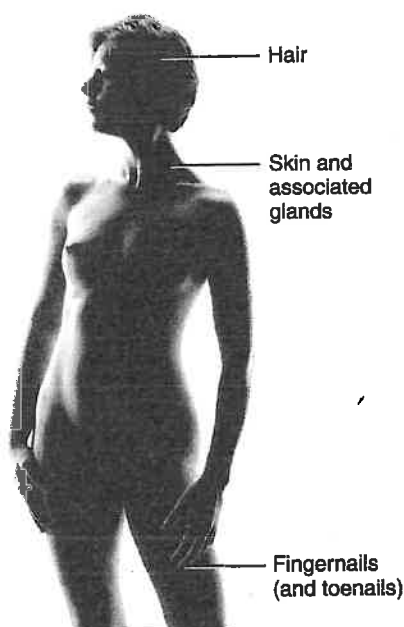
1. Integumentary System (Chapter 5)

Components:

Skin and structures derived from it, such as hair, nails, and sweat 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.

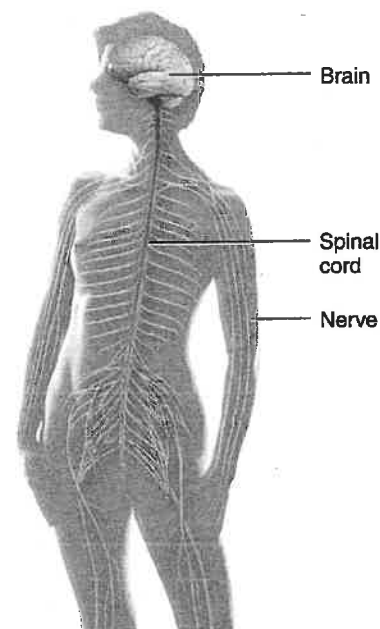


4. Nervous System (Chapters 9–12)

Components:

Brain, spinal cord, nerves, and 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.



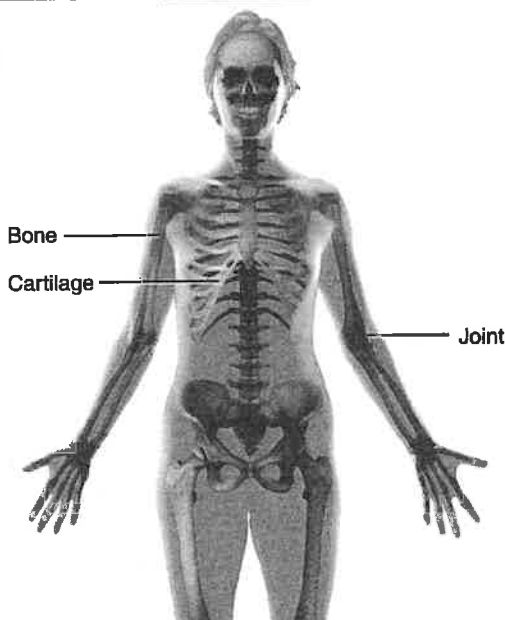
2. Skeletal System (Chapters 6 and 7)

Components:

All the 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).



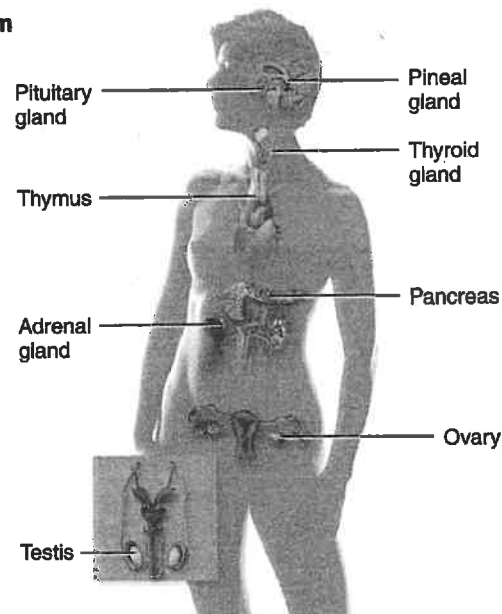
5. Endocrine System (Chapter 13)

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.



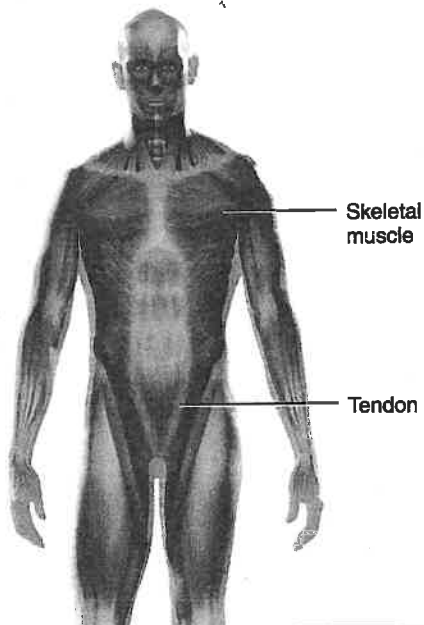
3. Muscular System (Chapter 8)

Components:

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

Functions:

Participates in bringing about body movements, maintains posture, and produces heat.

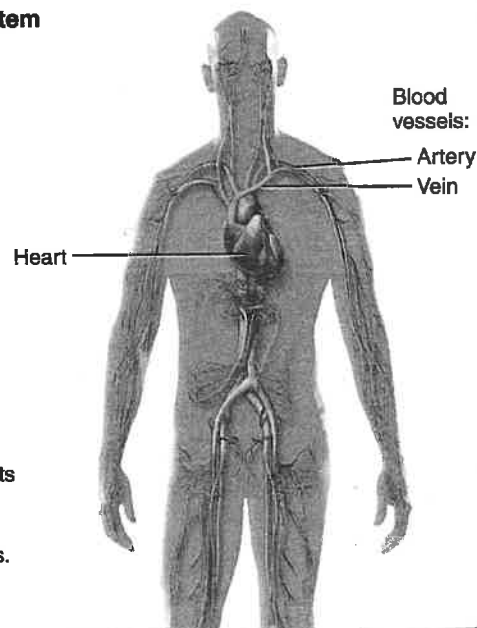


6. Cardiovascular System (Chapters 14–16)

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.



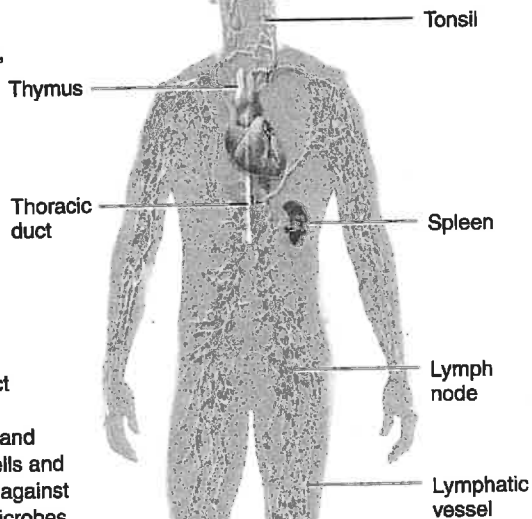
7. Lymphatic System and Immunity (Chapter 17)

Components:

Lymphatic fluid and 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.

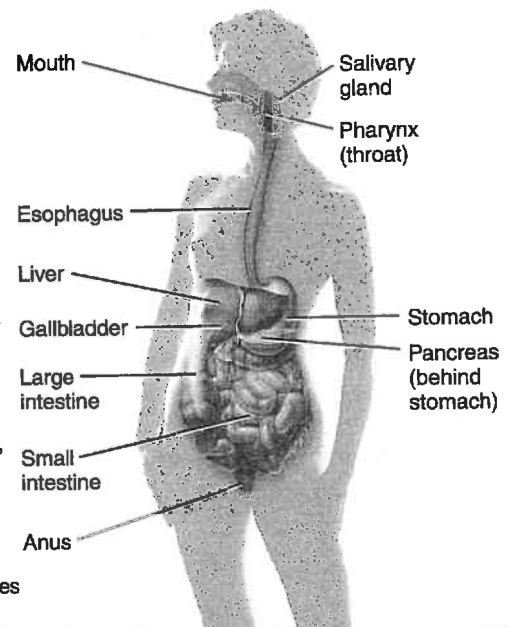


9. Digestive System (Chapter 19)

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



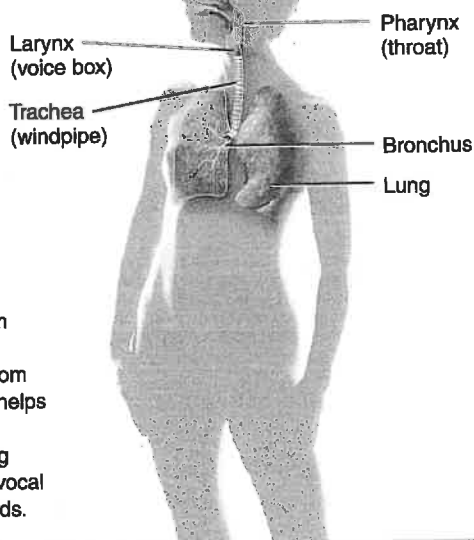
8. Respiratory System (Chapter 18)

Components:

Lungs and air passageways such as the pharynx (throat), larynx (voice box), trachea (windpipe), and bronchial tubes leading into and out of them.

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.



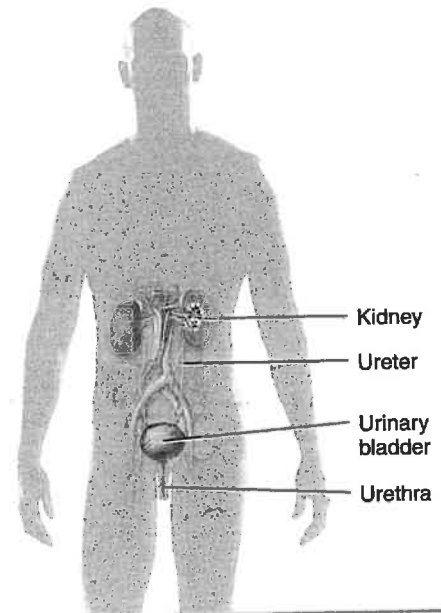
10. Urinary System (Chapter 21)

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 acidity of body fluids; maintains body's mineral balance; helps regulate red blood cell production.



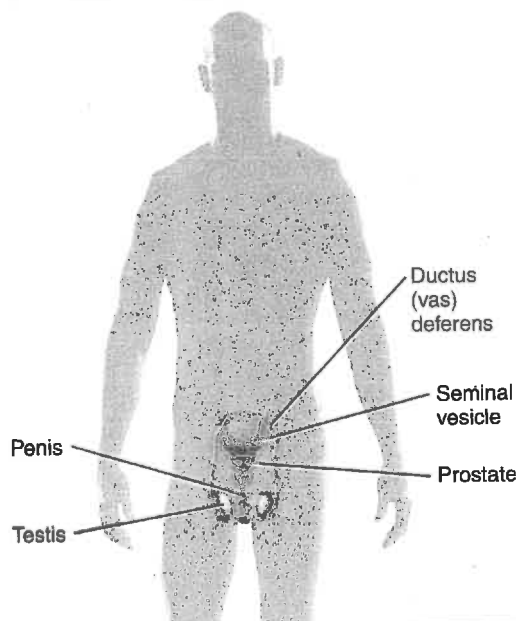
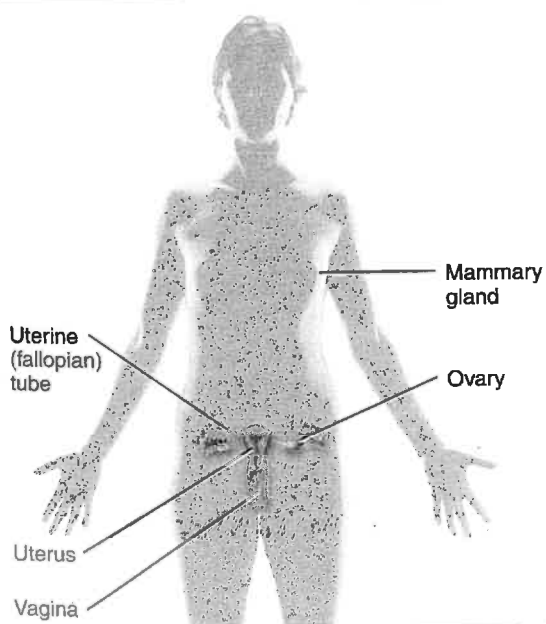
11. Reproductive Systems (Chapter 23)

Components:

Gonads (testes or ovaries) and associated organs: uterine 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.



■ CHECKPOINT

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?

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. For example, proteins in food are split into amino acids, which are the building blocks of proteins. These amino acids can then be used to build new proteins that make up muscles and bones.
2. **Responsiveness** is the body's ability to detect and respond to changes in its internal (inside the body) or external (outside the body) environment. Different cells in the body detect different sorts of changes and respond in characteristic ways. Nerve cells respond to changes in the environment by generating electrical signals, known as nerve impulses. Muscle cells respond to nerve impulses by contracting, which generates force to move body parts.
3. **Movement** includes motion of the whole body, individual organs, single cells, and even tiny organelles inside cells. For example, the coordinated action of several muscles and bones enables you to move your body from one place to another by walking or running. After you eat a meal that contains fats, your gallbladder (an organ) contracts and squirts bile into the gastrointestinal tract to help in the digestion of fats. When a body tissue is damaged or infected, certain white blood cells move from the blood into the affected tissue to help clean up and repair the area. And inside individual cells, various parts move from one position to another to carry out their functions.
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, specialized red blood cells and several types of white blood cells differentiate from the same unspecialized cells in bone marrow. Similarly, 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** refers to either (1) the formation of new cells for growth, repair, or replacement or (2) the production of a new individual.

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

■ CHECKPOINT

5. What types of movement can occur in the human body?

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 steady despite changes inside and outside the body. A large part of the internal environment consists of the fluid surrounding body cells, called *interstitial fluid*. Homeostasis keeps the interstitial fluid at a proper temperature of 37° Celsius (98.6° Fahrenheit) and maintains adequate nutrient and oxygen levels for body cells to flourish.

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 the blood capillaries, the smallest blood vessels, nutrients and oxygen move into interstitial fluid and wastes move into the blood. Cells, in turn, remove nutrients and oxygen from and release their wastes into interstitial fluid. 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; whereas hormones usually work more slowly.

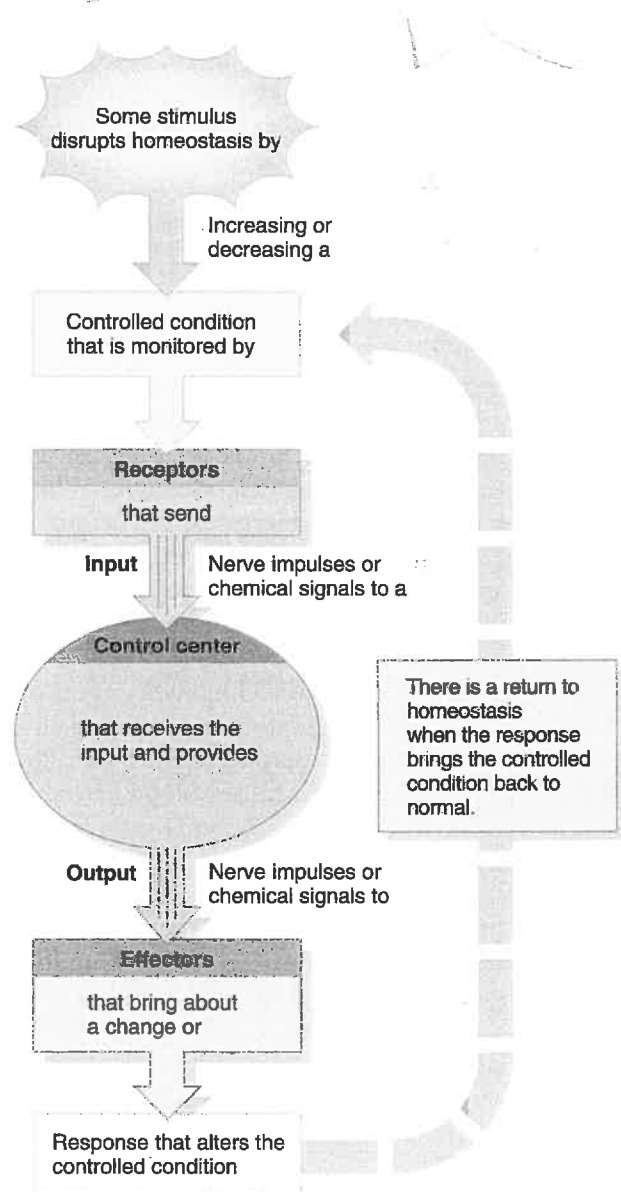
Homeostasis is maintained by means of many feedback systems. A **feedback system** or **feedback loop** is a cycle of events in which a condition in the body is continually monitored, evaluated, changed, remonitored, reevaluated, and so on. Each monitored condition, such as body temperature, blood pressure, 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, 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).

1. A **receptor** is a body structure that monitors changes in a controlled condition and sends information called the **input** to a control center. Input is in the form of nerve impulses or chemical signals. Nerve endings in the skin

Figure 1.2 Parts of a feedback system. The dashed return arrow symbolizes negative feedback.

The three basic elements of a feedback system are the receptor, control center, and effector.



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

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

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impulses or chemical signals, that is relayed from the control center to an effector.

- An **effector** is a body structure that receives output from the control center and produces a *response* 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 or positive feedback systems.

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 blood pressure (controlled condition) to rise, the following sequence of events occurs (Figure 1.3). The higher pressure is detected by **baroreceptors**, pressure-sensitive nerve cells located in the walls of certain blood vessels (the receptors). 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 blood pressure 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 blood pressure, 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 of time, such as blood pressure, blood glucose level, and body temperature.


Positive Feedback Systems

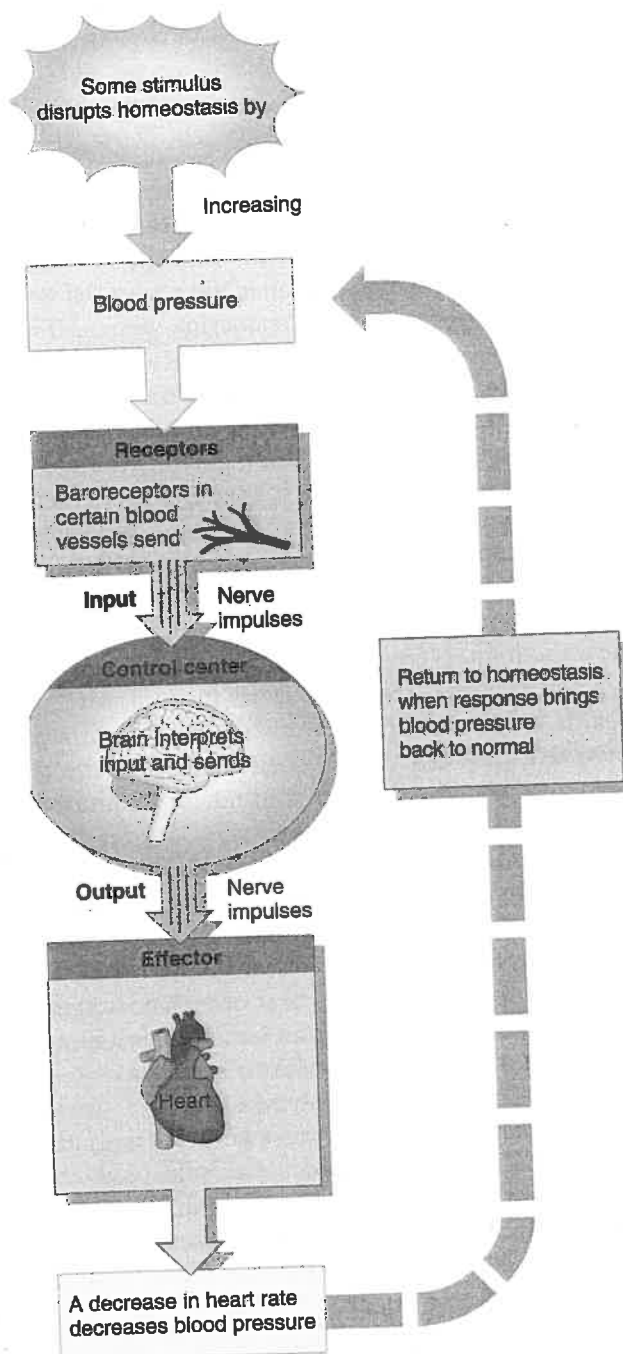
A **positive feedback system** strengthens a change in a controlled condition. Normal positive feedback systems tend to reinforce conditions that don't happen very often, such as childbirth, ovulation, and blood clotting. Because a positive feedback system continually reinforces a change in a controlled condition, it must be shut off by some event outside the system. If the action of a positive feedback system isn't stopped, it can "run away" and produce life-threatening changes in the body.

Homeostasis and Disease

As long as all of the body's controlled conditions remain within certain narrow limits, body cells function efficiently, homeostasis is maintained, and the body stays healthy.

Figure 1.3 Homeostasis of blood pressure by a negative feedback system. 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).

 If the response reverses a change in a controlled condition, a system is operating by negative feedback.



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

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 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.

Diagnosis (dī'-ag-NŌ-sis; *dia-* = through; *-gnosis* = knowledge) is the identification of a disease or disorder 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* (looking at or into the body with various instruments), *palpation* (feeling body surfaces with the hands), *auscultation* (listening to body sounds, often using a stethoscope), *percussion* (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.

■ CHECKPOINT

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

AGING AND HOMEOSTASIS

OBJECTIVE • Describe some of the effects of 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

- What are some of the signs of aging?

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**. In the anatomical position, the subject stands erect facing the observer, with the head level and the eyes facing forward. The feet are flat on the floor and directed forward, and the arms are at the sides with the palms turned forward (Figure 1.4 on page 11).

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 1.4). 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

FOCUS ON WELLNESS

Good Health — Homeostasis Is the Basis

You've seen *homeostasis* defined as a condition in which the body's internal environment remains relatively stable. What does this mean to you in your everyday life?

Homeostasis: The Power to Heal

The body's ability to maintain homeostasis gives it tremendous healing power and a remarkable resistance to abuse. The physiological processes responsible for maintaining homeostasis are in large part also responsible for your good health.

For most people, lifelong good health is not something that just happens. Two of the many factors in this balance called health are the environment and your own behavior. Also important is your genetic makeup. Your body's homeostasis is affected by the air you breathe, the food you eat, and even the thoughts you think. The way you live your life can either support or interfere with your body's ability to maintain homeostasis and recover from

the inevitable stresses life throws your way.

Let's consider the common cold. You support your natural healing processes when you take care of yourself. Plenty of rest, fluids, and chicken soup allow the immune system to do its job. The cold runs its course, and you are soon back on your feet. If, instead of taking care of yourself, you continue to smoke two packs of cigarettes a day, skip meals, and pull several all nighters studying for an anatomy and physiology exam, you interfere with the immune system's ability to fend off attacking microbes and bring the body back to homeostasis and good health. Other infections take advantage of your weakened state, and pretty soon the cold has "turned into" bronchitis or pneumonia.

Homeostasis and Disease Prevention

Many diseases are the result of years of poor health behavior that interferes with the body's natural drive to maintain homeostasis. An obvious example is smoking-related illness. Smoking tobacco exposes sensitive lung tissue to a

multitude of chemicals that cause cancer and damage the lung's ability to repair itself. Because diseases such as emphysema and lung cancer are difficult to treat and very rarely cured, it is much wiser to quit smoking—or never start—than to hope a doctor can fix you once you are diagnosed with a lung disease. Developing a lifestyle that works with, rather than against, your body's homeostatic processes helps you maximize your personal potential for optimal health and well-being.



► THINK IT OVER

- *What health habits have you developed over the past several years to prevent disease or enhance your body's ability to maintain health and homeostasis?*

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 1.4, the corresponding anatomical adjective for each part of the body appears in parentheses next to the common name. For example, if you receive a tetanus shot in your **buttock**, it is a *gluteal* injection. The descriptive form 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),

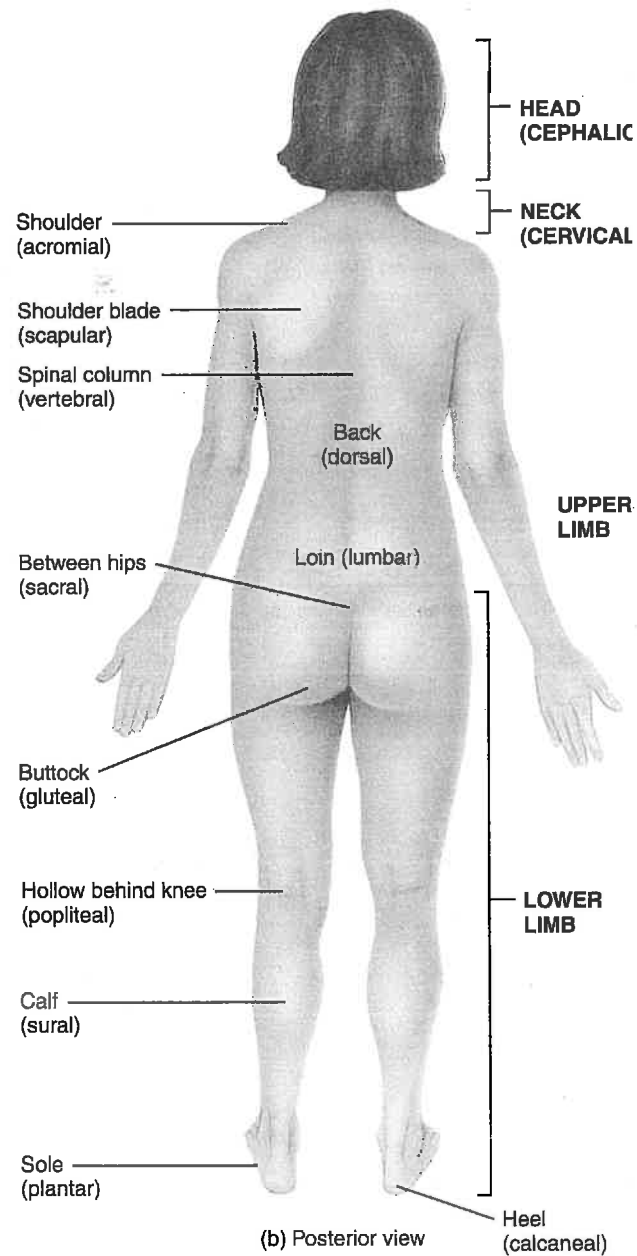
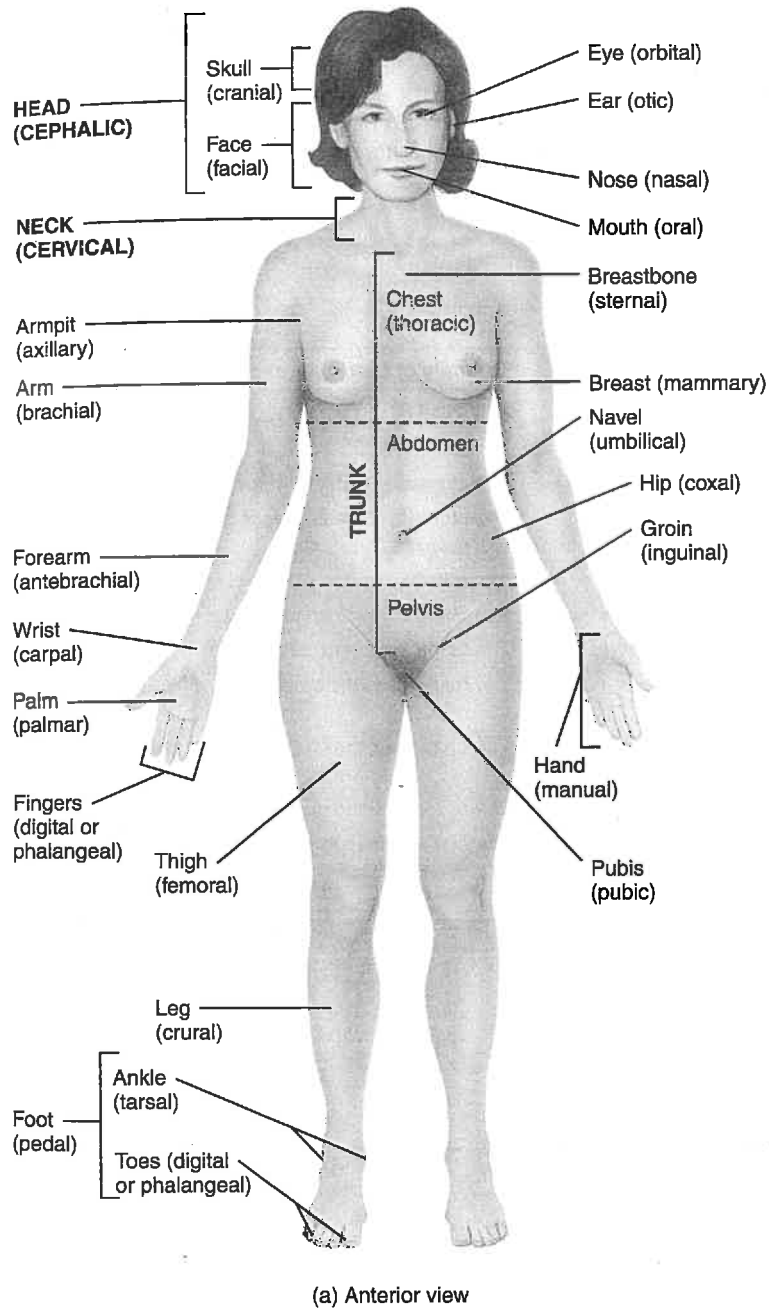
for example, and thus one of the nerves passing within the armpit is named the axillary nerve. You will learn more about the word roots of anatomical and physiological terms as you read this book.

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 Exhibit 1.1 on page 12 and Figure 1.5 on page 13 to determine, among other things, whether your stomach is superior to your lungs.

Figure 1.4 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 feet are flat on the floor and directed forward, and the arms are at the sides with the palms facing forward.



? Where is a plantar wart located?

Exhibit 1.1 Directional Terms (Figure 1.5)

OBJECTIVE • Define each directional term used to describe the human body.

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 1.5 to see the location of the structures mentioned.

■ CHECKPOINT

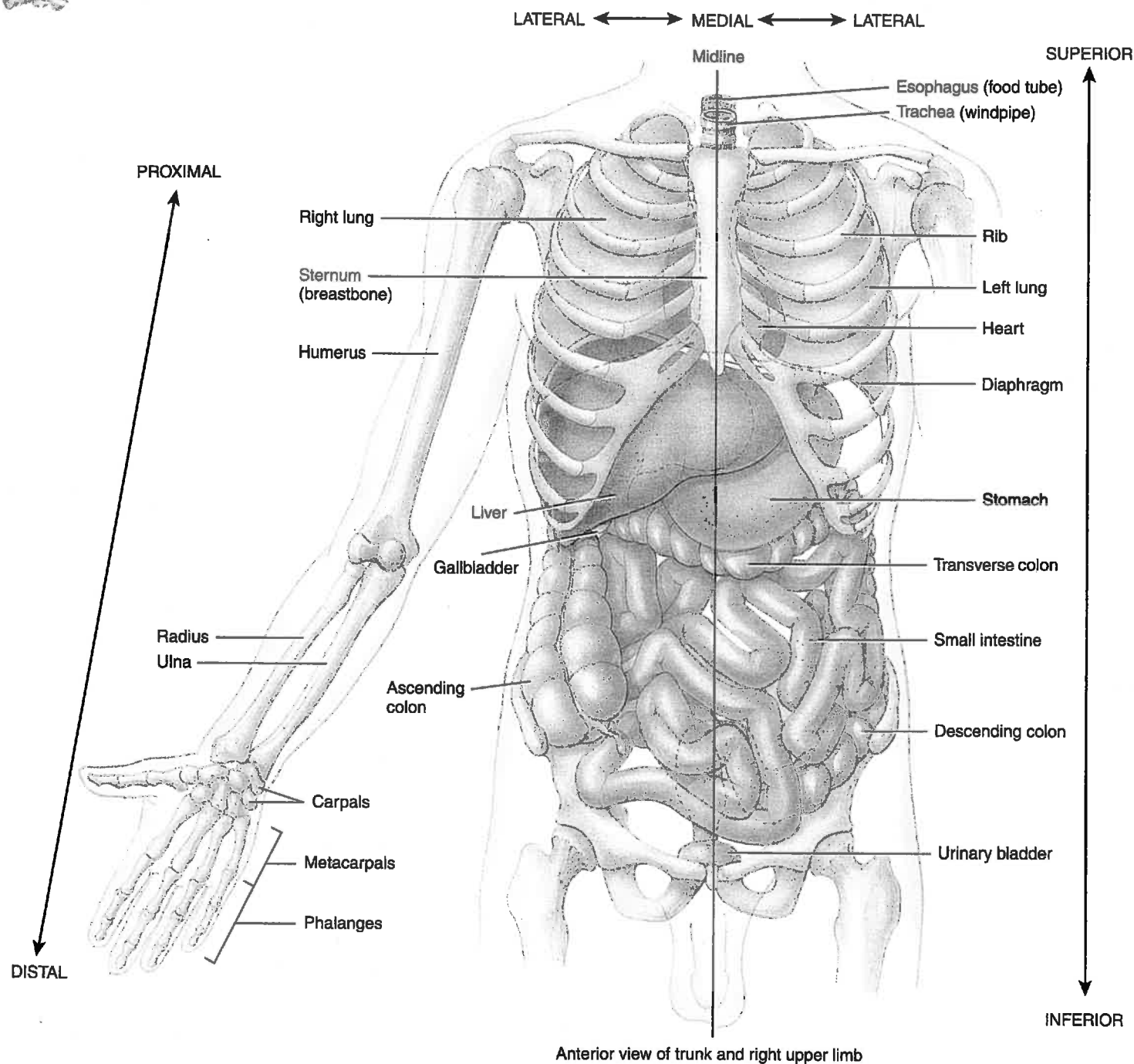
Which directional terms can be used to specify the relationships between (1) the elbow and the shoulder, (2) the left and right shoulders, (3) the sternum and the humerus, and (4) the heart and the diaphragm?

Directional Term	Definition	Example of Use
Superior (soo'-PEER-ē-or) (cephalic or cranial)	Toward the head, or the upper part of a structure.	The heart is superior to the liver.
Inferior (in'-FEER-ē-or) (caudal)	Away from the head, or the lower part of a structure.	The stomach is inferior to the lungs.
Anterior (an-TEER-ē-or) (ventral)	Nearer to or at the front of the body.	The sternum (breastbone) is anterior to heart.
Posterior (pos-TEER-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 [†] or midsagittal plane.	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.
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)	Toward or on the surface of the body.	The ribs are superficial to the lungs.
Deep (DĒP)	Away from the surface of the body.	The ribs are deep to the skin of the chest and back.

[†]The midline is an imaginary vertical line that divides the body into equal right and left sides.

Figure 1.5 Directional terms.

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



Is the radius proximal to the humerus? Is the esophagus anterior to the trachea? Are the ribs superficial to the lungs? Is the urinary bladder medial to the ascending colon? Is the sternum lateral to the descending colon?

Planes and Sections

You will also study parts of the body in four major **planes**, that is, imaginary flat surfaces that pass through the body parts (Figure 1.6): 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 termed a **cross-sectional** or **horizontal plane**. Sagittal, frontal, and trans-

verse 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.

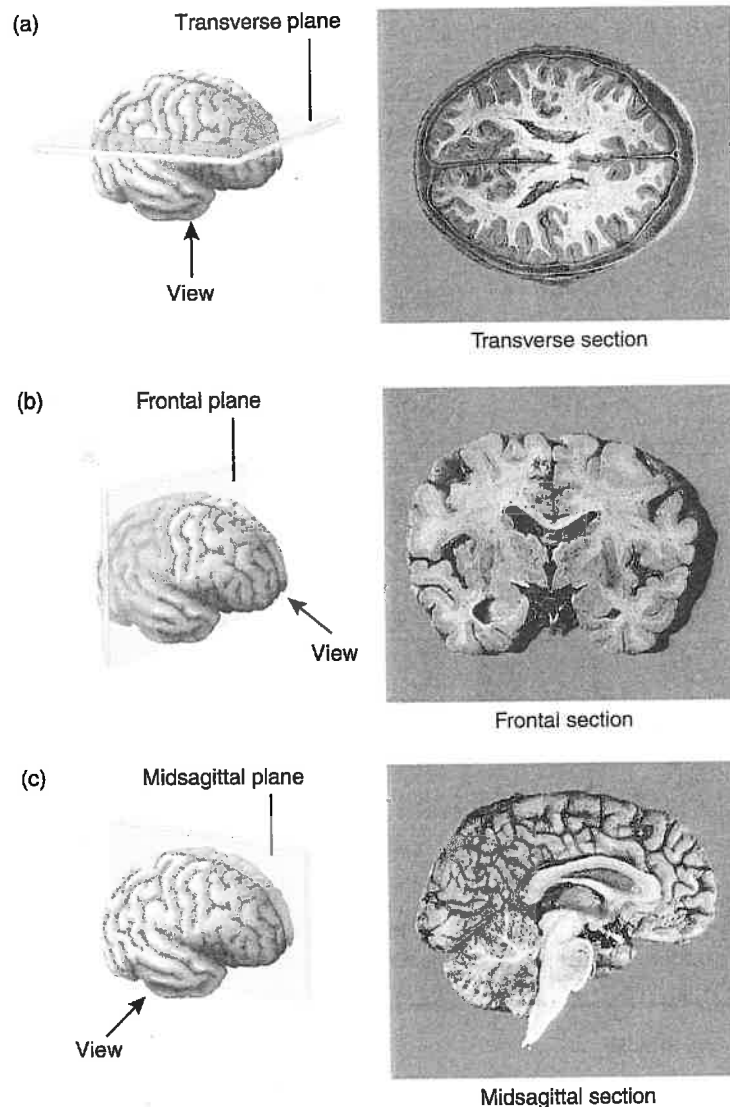
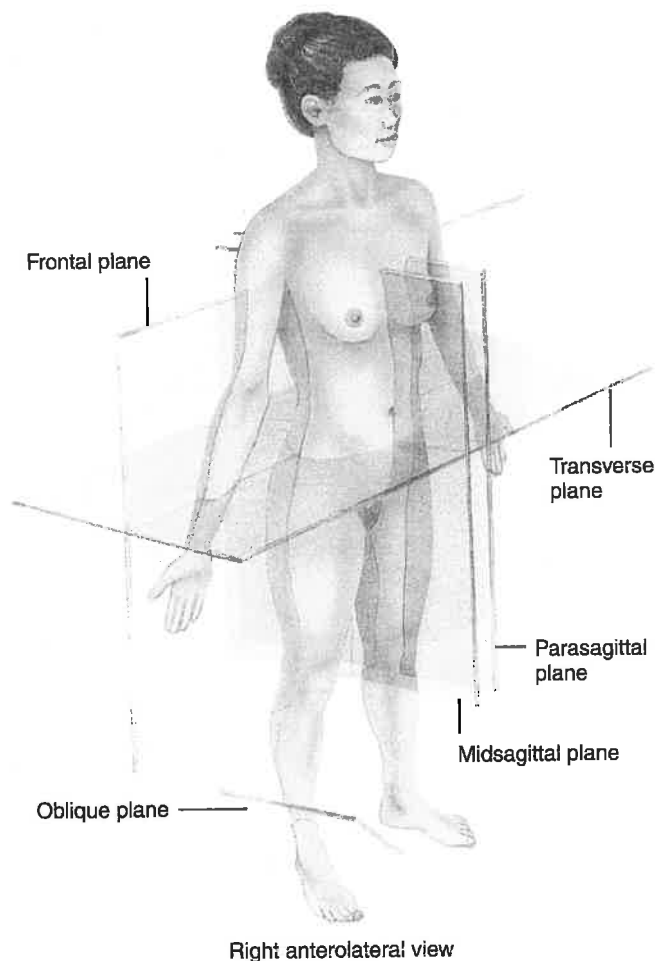
When you study a body region, you will often view it in **section**, meaning that you look at only one flat surface of the three-dimensional structure. It is important to know the plane of the section so you can understand the anatomical relationship of one part to another. Figure 1.7 indicates how

Figure 1.7 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.

Figure 1.6 Planes through the human body.

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



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

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

three different sections—a *transverse (cross) section*, a *frontal section*, and a *midsagittal section*—provide different views of the brain.

■ CHECKPOINT

- Describe the anatomical position and explain why it is used.
- Locate each region on your own body, and then identify it by its common name and the corresponding anatomical descriptive form.
- For each directional term listed in Exhibit 1.1 on page 12, provide your own example.
- What are the various planes that may be passed through the body? Explain how each divides the body.

BODY CAVITIES

OBJECTIVES • Describe the principal body cavities and the organs they contain.

- Explain why the abdominopelvic cavity is divided into regions and quadrants.

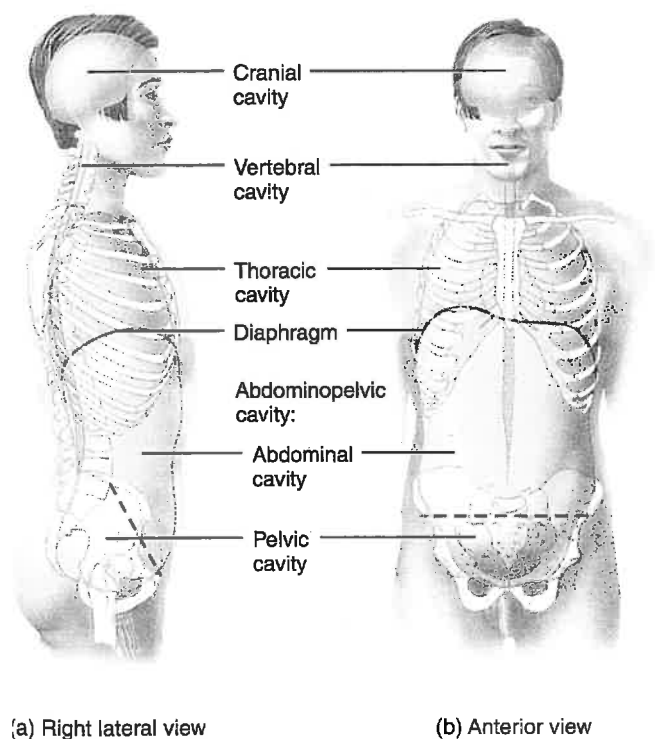
Spaces within the body that contain, protect, separate, and support internal organs are called **body cavities**. Here we discuss several of the larger body cavities (Figure 1.8).

The **cranial cavity** is formed by the cranial (skull) bones and contains the brain. The **vertebral (spinal) cavity** 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-i-

Figure 1.8 Body cavities. The dashed lines indicate the border between the abdominal and pelvic cavities.

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



CAVITY	COMMENTS
Cranial cavity	Formed by cranial bones and contains brain.
Vertebral cavity	Formed by vertebral column and contains spinal cord and the beginnings of spinal nerves.
Thoracic cavity*	Chest cavity; contains pleural and pericardial cavities and mediastinum.
Pleural cavity	Each surrounds a lung; the serous membrane of the pleural cavities is the pleura.
Pericardial cavity	Surrounds the heart; the serous membrane of the pericardial cavity is the pericardium.
Mediastinum	Central portion of thoracic cavity between the lungs; extends from sternum to vertebral column and from neck to diaphragm; contains heart, thymus, esophagus, trachea, and several large blood vessels.
Abdominopelvic cavity	Subdivided into abdominal and pelvic cavities.
Abdominal cavity	Contains stomach, spleen, liver, gallbladder, small intestine, and most of large intestine; the serous membrane of the abdominal cavity is the peritoneum.
Pelvic cavity	Contains urinary bladder, portions of large intestine and internal organs of reproduction.

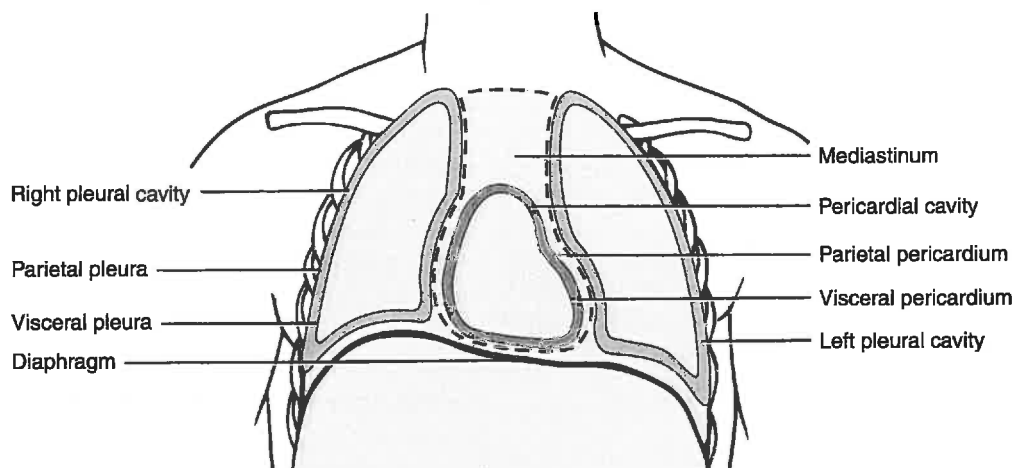
* See Figure 1.9 for details of the thoracic cavity.

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 response:
T = thoracic cavity, A = abdominal cavity, or P = pelvic cavity.

Figure 1.9 The thoracic cavity. The dashed lines indicate the borders of the mediastinum. Notice that the pericardial cavity surrounds the heart, and that the pleural cavities surround the lungs.



The mediastinum is medial to the lungs; it extends from the sternum to the vertebral column and from the neck to the diaphragm.



Anterior view

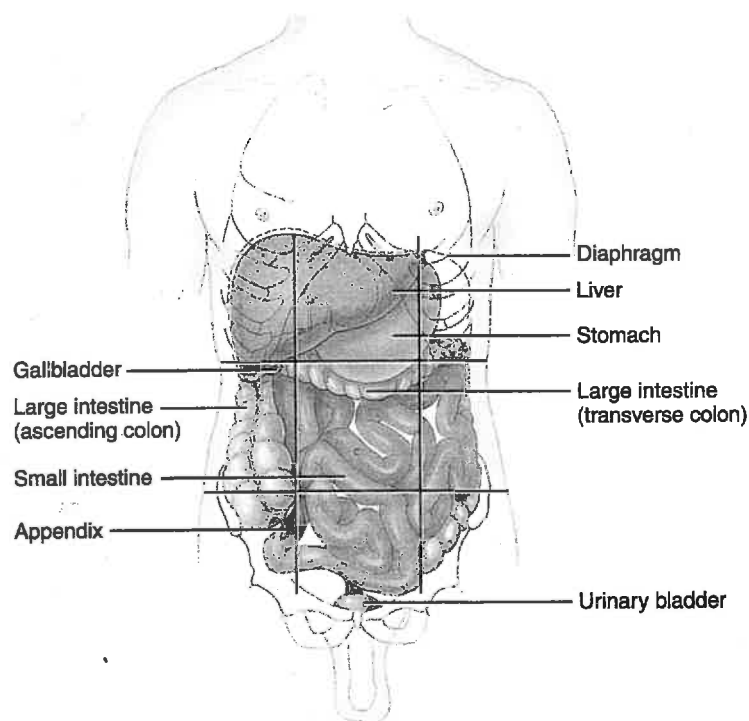
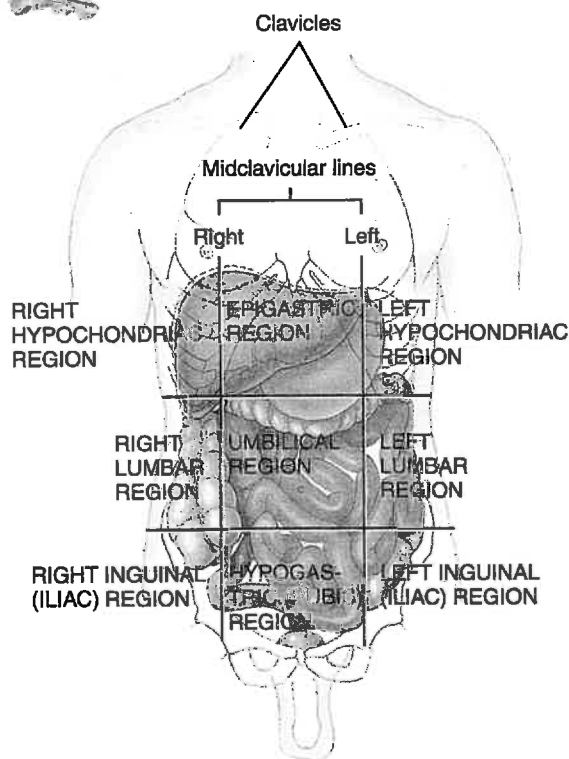


Which of the following structures are contained in the mediastinum: right lung, heart, esophagus, spinal cord, aorta, left pleural cavity?

Figure 1.10 The nine regions of the abdominopelvic cavity. The internal reproductive organs in the pelvic cavity are shown in Figures 23.1 on page 557 and 23.6 on page 564.



The nine-region designation is used for anatomical studies.



(a) Anterior view showing location of abdominopelvic regions

(b) Anterior superficial view of organs in abdominopelvic regions



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

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), a fluid-filled space that surrounds the heart, and two **pleural cavities** (PLOOR-al; *pleur-* = rib or side), each of which surrounds one lung and contains a small amount of fluid (Figure 1.9 on page 16). The central portion of the thoracic cavity is called the **mediastinum** (mē'-dē-a-STĪ-num; *media-* = middle; *-stinum* = partition). It is between the lungs, extending from the sternum (breastbone) to the vertebral column (backbone), and from the neck to the diaphragm (Figure 1.9). The mediastinum contains all thoracic 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-no-PEL-vic) extends from the diaphragm to the groin. As the name suggests, the abdominopelvic cavity is divided into two portions, although no wall separates them (see Figure 1.8). The upper portion, the **abdominal cavity** (*abdomin-* = belly) contains the stomach, spleen, liver, gallbladder, small intestine, and most of the large intestine. The lower portion, the **pelvic cavity** (*pelv-* = basin) contains the urinary bladder, portions of the large intestine, and internal organs of the reproductive system. The pelvic cavity is located below the dashed line in Figure 1.8. Organs inside the thoracic and abdominopelvic cavities are called **viscera** (VIS-e-ra).

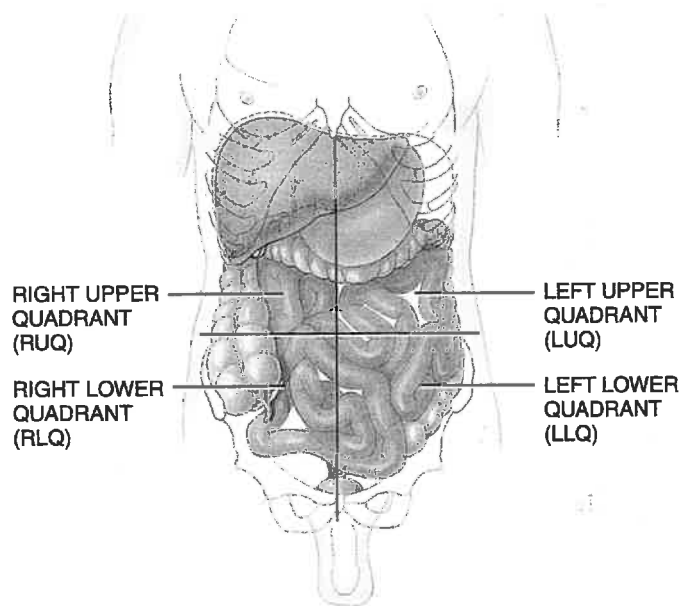
Abdominopelvic Regions and Quadrants

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 1.10 on page 16). The names of the nine abdominopelvic regions are the **right hypochondriac** (hī'-pō-KON-drē-ak), **epigastric** (ep-i-GAS-trik), **left hypochondriac**, **right lumbar**, **umbilical** (um-BIL-i-kal), **left lumbar**, **right inguinal** (*iliac*) (IL-ē-ak), **hypogastric** (hī'-pō-GAS-trik), and **left inguinal** (*iliac*). 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 1.11). 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).

Figure 1.11 Quadrants of the abdominopelvic cavity. 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.



Anterior view showing location of abdominopelvic quadrants



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

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

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

• • •

We will next examine the chemical level of organization in Chapter 2. You will learn about the various groups of chemicals in your body, how they function, and how they contribute to the homeostasis of your body.



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; *pharmac-* = drug) The science that deals with the effects and use of drugs in the treatment of disease.

STUDY OUTLINE

Anatomy and Physiology Defined (p. 2)

1. Anatomy is the science of structure and the relationships among structures.
2. Physiology is the science of how body structures function.

Levels of Organization and Body Systems (p. 2)

1. The human body consists of six levels of organization: chemical, cellular, tissue, organ, system, and organismal.
2. Cells are the basic structural and functional units of an organism and the smallest living units in the human body.
3. Tissues consist of groups of cells and the materials surrounding them that work together to perform a particular function.
4. Organs usually have recognizable shapes, are composed of two or more different types of tissues, and have specific functions.
5. Systems consist of related organs that have a common function.
6. Table 1.1 on pages 4–5 introduces the eleven systems of the human body: integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive.
7. The human organism is a collection of structurally and functionally integrated systems.
8. Body systems work together to maintain health, protect against disease, and allow for reproduction of the species.

Life Processes (p. 6)

1. All living organisms have certain characteristics that set them apart from nonliving things.
2. Among the life processes in humans are metabolism, responsiveness, movement, growth, differentiation, and reproduction.

Homeostasis: Maintaining Limits (p. 6)

1. Homeostasis is a condition in which the internal environment of the body remains stable, within certain limits.
2. A large part of the body's internal environment is interstitial fluid, which surrounds all body cells.
3. 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.
4. 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.
5. A feedback system consists of (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.
6. 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.
7. 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).

8. Disruptions of homeostasis—homeostatic imbalances—can lead to disorders, disease, and even death.
9. 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.
10. Symptoms are subjective changes in body functions that are not apparent to an observer, whereas signs are objective changes that can be observed and measured.
11. Diagnosis of disease involves identification of symptoms and signs, a medical history, physical examination, and sometimes laboratory tests.

Aging and Homeostasis (p. 9)

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

Anatomical Terms (p. 9)

1. 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 feet flat on the floor and directed forward, and the arms at the sides, with the palms turned forward.
2. The human body is divided into several major regions: the head, neck, trunk, upper limbs, and lower limbs.
3. Within body regions, specific body parts have common names and corresponding anatomical descriptive forms (adjectives). Examples are chest (thoracic), nose (nasal), and wrist (carpal).
4. Directional terms indicate the relationship of one part of the body to another. Exhibit 1.1 on page 12 summarizes commonly used directional terms.
5. 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.

6. Sections result from cuts through body structures. They are named according to the plane on which the cut is made: transverse, frontal, or sagittal.

Body Cavities (p. 15)

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 cavity 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, which each contain 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.
7. Viscera of the abdominal cavity include the stomach, spleen, liver, gallbladder, small intestine, and most of the large intestine.
8. Viscera of the pelvic cavity include the urinary bladder, portions of the large intestine, and internal organs of the reproductive system.
9. To describe the location of organs easily, the abdominopelvic cavity may be divided into nine abdominopelvic regions by two horizontal and two vertical lines.
10. The names of the nine abdominopelvic regions are right hypochondriac, epigastric, left hypochondriac, right lumbar, umbilical, left lumbar, right inguinal, hypogastric, and left inguinal.
11. The abdominopelvic cavity may also be divided into quadrants by passing one horizontal and one vertical line through the umbilicus (navel).
12. The names of the abdominopelvic quadrants are right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ), and left lower quadrant (LLQ).

SELF-QUIZ

1. To properly reconnect the disconnected bones of a human skeleton, you would need to have a good understanding of
 - a. physiology
 - b. homeostasis
 - c. chemistry
 - d. anatomy
 - e. feedback systems
2. Which of the following best illustrates the idea of increasing levels of organizational complexity?
 - a. chemical → tissue → cellular → organ → organism → system
 - b. chemical → cellular → tissue → organ → system → organismal
 - c. cellular → chemical → tissue → organismal → organ → system
 - d. chemical → cellular → tissue → system → organ → organismal
 - e. tissue → cellular → chemical → organ → system → organismal

3. Match the following:

- | | |
|---|--------------------------|
| — a. transports oxygen, nutrients, and carbon dioxide | A. urinary system |
| — b. breaks down and absorbs food | B. digestive system |
| — c. functions in body movement, posture, and heat production | C. endocrine system |
| — d. regulates body activities through hormones | D. integumentary system |
| — e. supports and protects the body | E. muscular system |
| — f. eliminates wastes and regulates the chemical composition and volume of blood | F. skeletal system |
| — g. protects the body, detects sensations, and helps regulate body temperature | G. cardiovascular system |

4. Fill in the missing blanks in the following table.

System	Major Organs	Functions
<u>a</u>	<u>b</u>	Regulates body activities by nerve impulses
<u>c</u>	Lymph vessels, spleen, thymus, tonsils, lymph nodes	<u>d</u>
<u>e</u>	<u>f</u>	Supplies oxygen to cells, eliminates carbon dioxide, regulates acid-base balance
Reproductive	<u>g</u>	<u>h</u>

5. Homeostasis is

- the sum of all of the chemical processes in the body
- the sign of a disorder or disease
- the combination of growth, repair, and energy release that is basic to life
- the tendency to maintain constant, favorable internal body conditions
- caused by stress

6. Which of the following is NOT true concerning the life processes?

- The pupils of your eyes becoming smaller when exposed to strong light is an example of differentiation.
- The ability to walk to your car following class is a result of the life process called movement.
- The repair of injured skin would involve the life process of reproduction.
- Digesting and absorbing food is an example of metabolism.
- Sweating on a hot summer day involves responsiveness.

7. In a negative feedback system,

- the controlled condition is never disrupted
- there tends to be a "runaway" body response
- the change in the controlled condition is reversed
- the body part that responds to the output is known as the receptor
- the response results in a reinforcement of the original stimulus

8. The part of a feedback system that receives the input and generates the output command is the

- effector
- receptor
- feedback loop
- response
- control center

9. Match the following:

- | | |
|---|-------------|
| a. observable, measurable change | A. systemic |
| b. abnormality of function | B. symptom |
| c. affects the entire body | C. sign |
| d. subjective changes that aren't easily observed | D. disorder |

10. An itch in your axillary region would cause you to scratch

- your armpit
- the front of your elbow
- your neck
- the top of your head
- your calf

11. If you were facing a person who is in the correct anatomical position, you could observe the

- crural region
- lumbar region
- gluteal region
- popliteal region
- scapular region

12. Where would you look for the femoral artery?

- wrist
- forearm
- face
- thigh
- shoulder

13. The right ear is _____ to the right nostril.

- intermediate
- inferior
- lateral
- distal
- medial

14. Your chin is _____ in relation to your lips.

- lateral
- superior
- deep
- posterior
- inferior

15. Your skull is _____ in relation to your brain.

- intermediate
- superior
- deep
- superficial
- proximal

16. A magician is about to separate his assistant's body into superior and inferior portions. The plane through which he will pass his magic wand is the

- midsagittal
- frontal
- transverse
- parasagittal
- oblique

17. Which statement is NOT true of body cavities?

- The diaphragm separates the thoracic and abdominopelvic cavities.
- The organs in the cranial and vertebral cavities are called viscera.
- The urinary bladder is in the pelvic cavity.
- The abdominal cavity is below the thoracic cavity.
- The pelvic cavity terminates below the groin.