

# Organization and General Plan of the Body

## CHAPTER OUTLINE

### Levels of Organization

Chemicals  
Cells  
Tissues  
Organs  
Organ Systems  
The Rest of “Us”—The Human Microbiome

### Metabolism and Homeostasis

### Terminology and General

#### Plan of the Body

Body Parts and Areas  
Terms of Location and Position  
Body Cavities and Their Membranes  
Cranial and Spinal Cavities  
Thoracic, Abdominal, and Pelvic Cavities  
Planes and Sections  
Areas of the Abdomen

## STUDENT OBJECTIVES

- Define the terms *anatomy*, *physiology*, and *pathophysiology*. Use an example to explain how they are related.
- Name the levels of organization of the body from simplest to most complex, and explain each.
- Define *microbiome* and give examples.
- Define the terms *metabolism*, *metabolic rate*, and *homeostasis*, and use examples to explain each.
- Explain how a negative feedback mechanism works and how a positive feedback mechanism differs from a negative feedback mechanism.
- Describe the anatomic position.
- State the anatomic terms for the parts of the body.
- Use proper terminology to describe the location of body parts with respect to one another.
- Name the body cavities, their membranes, and some organs within each cavity.
- Describe the possible sections through the body or an organ.
- Explain how and why the abdomen is divided into smaller areas. Be able to name organs in these areas.

### BOX 1-1

#### REPLACING TISSUES AND ORGANS

### BOX 1-2

#### VISUALIZING THE INTERIOR OF THE BODY

### BOX 1-3

#### WATCHING THE BRAIN AT WORK

## NEW TERMINOLOGY

Anatomy (*uh-NAT-uh-mee*)  
Body cavity (**BAH**-dee **KAV**-i-tee)  
Cell (**SELL**)  
Homeostasis (*HOH-me-oh-STAY-sis*)  
Inorganic chemicals (**IN**-or-**GAN**-ik **KEM**-i-kuls)  
Meninges (*me-NIN-jeez*)  
Metabolism (*muh-TAB-uh-lizm*)  
Microbiome (*MY-kroh-BYE-ohm*)  
Microbiota (*MY-kroh-bye-OH-ta*)  
Negative feedback (**NEG**-ah-tiv **FEED**-bak)  
Normal flora (**NOR**-muhl **FLOOR**-uh)  
Opportunist (*OP-er-TOO-nist*)  
Organ (**OR**-gan)  
Organ system (**OR**-gan **SIS**-tem)  
Organic chemicals (*or-GAN-ik KEM-i-kuls*)  
Pathophysiology (*PATH-oh-FIZZ-ee-AH-luh-jee*)  
Pericardial membranes (*PER-ee-KAR-dee-uhl MEM-brayns*)  
Peritoneum/mesentery (*PER-i-toh-NEE-um/MEZ-en-TER-ee*)  
Physiology (*FIZZ-ee-AH-luh-jee*)  
Plane (**PLAYN**)  
Pleural membranes (**PLOOR**-uhl **MEM**-brayns)  
Positive feedback (**PAHS**-ah-tiv **FEED**-bak)  
Resident flora (**REZ**-i-dent **FLOOR**-uh)  
Section (**SEK**-shun)  
Symbiosis (*SIM-bee-OH-sis*)  
Tissue (**TISH**-yoo)

## RELATED CLINICAL TERMINOLOGY

Computed tomography (CT) scan (*kom-PEW-ted toh-MAH-grah-fee SKAN*)  
Diagnosis (*DYE-ag-NOH-sis*)  
Disease (*di-ZEEZ*)  
Magnetic resonance imaging (MRI) (*mag-NET-ik REZ-uh-nanse IM-ah-jing*)  
Positron emission tomography (PET) (*PAHZ-i-tron e-MISH-un toh-MAH-grah-fee*)

Terms that appear in **bold type** in the chapter text are defined in the glossary, which begins on page 554.

The human body is a precisely structured container of chemicals and chemical reactions. Have you ever thought of yourself in this way? Probably not, and yet, in the strictly physical sense, that is what each of us is. The body consists of trillions of atoms in specific arrangements (the chemicals) and thousands of chemical reactions proceeding in a very orderly manner. That literally describes us, and yet it is clearly not the whole story. The keys to understanding human consciousness and self-awareness are still beyond our grasp. We do not yet know what enables us to study ourselves—no other animals do, as far as we know—but we have accumulated a great deal of knowledge about what we are made of and how it all works. Some of this knowledge makes up the course you are about to take, a course in basic human anatomy and physiology.

**Anatomy** is the study of body structure, which includes size, shape, composition, and perhaps even coloration. **Physiology** is the study of how the body functions. The physiology of red blood cells, for example, includes what these cells do, how they do it, and how this is related to the functioning of the rest of the body. Physiology is directly related to anatomy. For example, red blood cells contain the mineral iron in molecules of the protein called hemoglobin; this is an aspect of their anatomy. The presence of iron enables red blood cells to carry oxygen, which is their function. All cells in the body must receive oxygen in order to function properly, so the physiology of red blood cells is essential to the physiology of the body as a whole.

**Pathophysiology** is the study of disorders of functioning, and a knowledge of normal physiology makes such disorders easier to understand. For example, you are probably familiar with the disorder called iron-deficiency anemia. With insufficient iron in the diet, there is not enough iron in the hemoglobin of red blood cells, and hence less oxygen is transported throughout the body, resulting in the symptoms of the iron-deficiency disorder. This example shows the relationship among anatomy, physiology, and pathophysiology.

The purpose of this text is to enable you to gain an understanding of anatomy and physiology with an emphasis on normal structure and function. Many examples of pathophysiology have been included, however, to illustrate the relationship of **disease** to normal physiology and to describe some of the procedures used in the **diagnosis** of disease. Many of the examples are clinical applications that will help you begin to apply what you have learned. Your knowledge of anatomy and physiology will become the basis for your further study in the health professions.

## LEVELS OF ORGANIZATION

The human body is organized into structural and functional levels of increasing complexity. Each higher level incorporates the structures and functions of the previous level, as you will see. We will begin with the simplest level, which is the chemical level, and proceed to cells, tissues, organs, and organ systems. All of the levels of organization are depicted in Fig. 1-1.

## CHEMICALS

Recall that the body is a container of chemicals. The chemicals that make up the body may be divided into two major categories: inorganic and organic. **Inorganic chemicals** are usually simple molecules made of one or two elements other than carbon (with a few exceptions). Examples of inorganic chemicals are water ( $H_2O$ ); oxygen ( $O_2$ ); one of the exceptions, carbon dioxide ( $CO_2$ ); and minerals such as iron (Fe) in hemoglobin, sodium (Na) in the salt sodium chloride that makes tears salty, and calcium (Ca) in the calcium salts that make bones hard. **Organic chemicals** are often very complex and always contain the elements carbon and hydrogen. In the category of organic chemicals that are of great importance to human structure and function are carbohydrates, fats, proteins, and nucleic acids. The chemical organization of the body is the subject of Chapter 2.

## CELLS

The smallest living units of structure and function are **cells**, and the human body consists of more than 200 different types of cells. Another way to think of the body is as a city of cells. Just as a large city has millions of people with many different jobs, the body contains an estimated 37 trillion cells that perform more than 200 jobs. Despite these different functions, human cells have certain structural similarities. Each type of cell is made of chemicals and carries out specific chemical reactions. Cell structure and function are discussed in Chapter 3.

## TISSUES

A **tissue** is a group of cells with similar structure and function. Just as in a city certain groups of individuals work together (in the fire department, for example) to keep the city functioning, groups of similar cells work together in the body. There are four groups of tissues:

**Epithelial tissues** cover or line body surfaces; some are capable of producing secretions with specific functions. The outer layer of the skin and sweat glands are examples of epithelial tissues. Internal epithelial tissues include the walls of capillaries (squamous epithelium) and the kidney tubules (cuboidal epithelium), as shown in Fig. 1-1.

**Connective tissues** connect and support parts of the body; some transport or store materials. Blood, bone, cartilage, and adipose tissue are examples of this group.

**Muscle tissues** are specialized for contraction, which brings about movement. Our skeletal muscles and the heart are examples of muscle tissue. In Fig. 1-1, you see smooth muscle tissue, which is found in organs such as the urinary bladder and stomach.

**Nerve tissues** are specialized to generate and transmit electrochemical impulses that regulate body functions. The brain and the optic nerves are examples of nerve tissue.

The types of tissues in these four groups, as well as their specific functions, are the subject of Chapter 4.

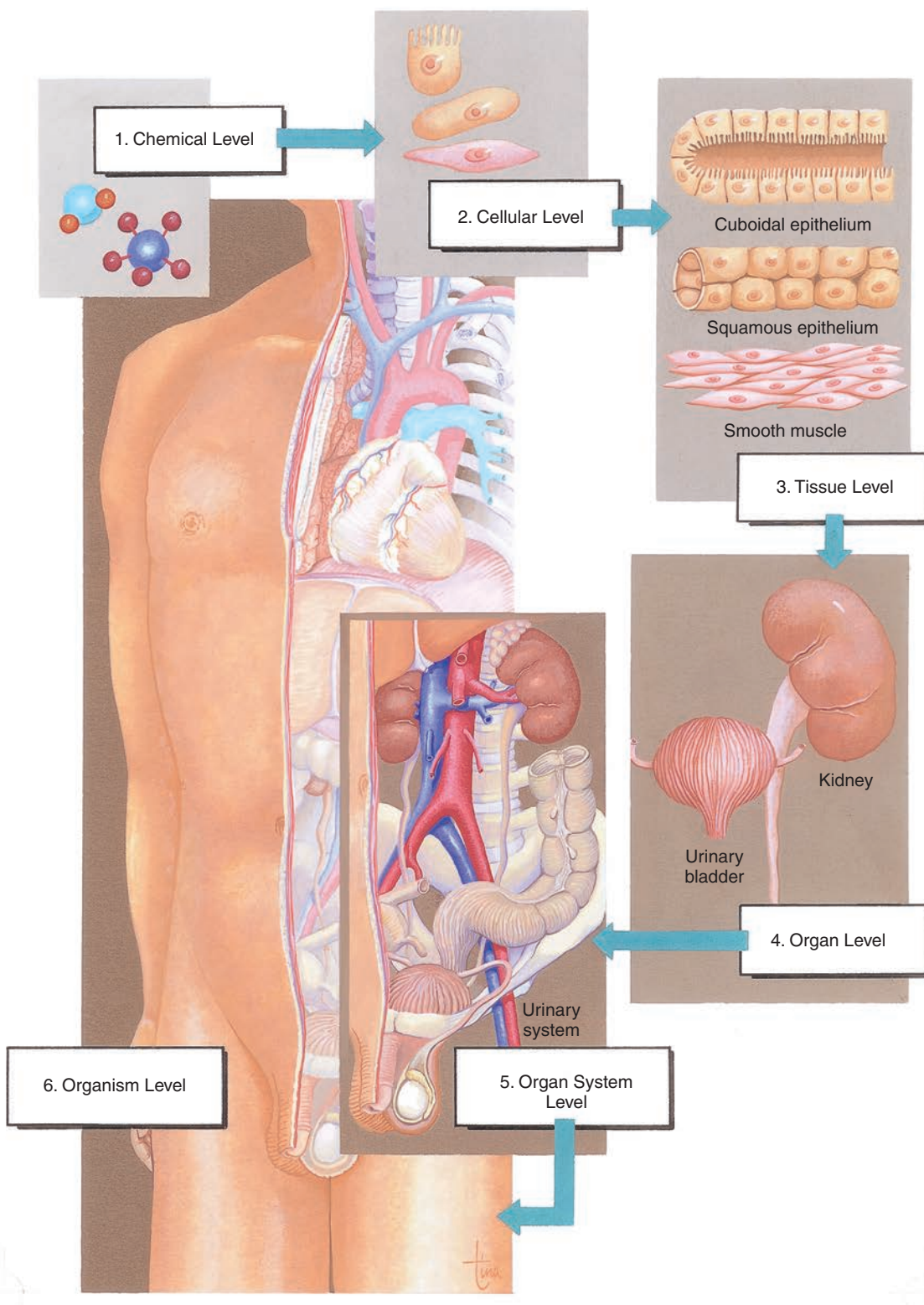


**Figure 1-1** Levels of structural organization of the human body, depicted from the simplest (chemical) to the most complex (organism). The organ system shown here is the urinary system.

**QUESTION:** What other organ system seems to work directly with the urinary system?

## ORGANS

An **organ** is a group of tissues precisely arranged so as to accomplish specific functions. Examples of organs are the kidneys, individual bones, the liver, the lungs, and the stomach. The kidneys contain several kinds of epithelial, or surface, tissues for their work of absorption. The stomach is lined with epithelial tissue that secretes gastric juice for digestion, especially of proteins. Smooth muscle tissue in the wall of the stomach contracts to mix food with gastric juice and propel it to the small intestine. Nerve tissue carries impulses that increase or decrease the contractions of the stomach. An organ may be considered a “cooperation of tissues,” in which the whole is the anatomic sum of its parts, and much more than the physiological sum. None of the tissues of the kidney can remove waste products from the blood by itself, but the functioning of all of the kidney tissues does so. Similarly, none of the tissues of the stomach can by itself begin the digestion of protein, but the stomach as a whole can (see Box 1-1: Replacing Tissues and Organs).

## ORGAN SYSTEMS

An **organ system** is a group of organs that all contribute to a particular function. Examples are the urinary system, the digestive system, and the respiratory system. In Fig. 1-1, you see the urinary system, which consists of the kidneys, ureters, urinary bladder, and urethra. These organs all contribute to the formation and elimination of urine.

As a starting point, Table 1-1 lists the organ systems of the human body with their general functions and some representative organs. Notice that some organs are part of two organ systems; the pancreas, for example, is both a digestive organ and an endocrine organ, and the ovaries and testes are part of both the endocrine and reproductive systems. Figure 1-2 depicts all of the organ systems, and many of these, and their functions (see Table 1-1), are already familiar to you.

**Note:** Table 1-1 is the first of many tables in this book. Some tables are summaries of what has been presented in the text, and others use a list format to provide information that has not been written in paragraph form. Table 1-1 is a combination: concise functions as a summary of the organ systems, and in list form, to make it all easier to read. When you read this table carefully, you can begin (or continue) to imagine all of the connections among the body systems. Everything is connected, and this table is also a simple preview of the remainder of the book.

All of the systems make up an individual person, and all of them function together; that is, they are interdependent. For now, a few examples will give you an idea of the many interactions among the systems. All cells in the body require oxygen. The respiratory system obtains oxygen from the atmosphere, and the circulatory system distributes the oxygen. All cells need nutrients. The digestive system gets the

### BOX 1-1 | REPLACING TISSUES AND ORGANS

Blood transfusions are probably the most familiar and frequent form of “replacement parts” for people. Blood is a tissue and, when properly typed and cross-matched (blood types will be discussed in Chapter 11), may safely be given to someone with a blood type that is the same or compatible.

Organs, however, are much more complex structures. When a patient receives an organ transplant, there is always the possibility of rejection (destruction) of the organ by the recipient’s immune system (Chapter 14). With the discovery and use of more effective immune-suppressing medications, however, the success rate for many types of organ transplants has increased. Organs that may be transplanted include the corneas, the kidneys, the heart, the liver, and the lungs.

The skin is also an organ, but skin transplanted from another person will not survive very long. Several kinds of artificial skin are now available to temporarily cover large areas of damaged skin. Patients with severe burns, for example, will eventually need skin grafts from their own unburned skin to form permanent new skin over the burn sites. It is possible to “grow” a patient’s skin in laboratory culture so that a small patch of skin may eventually be used to cover a large surface. Other cells grown in culture include

cartilage, bone, pancreas, liver, and skeletal muscle. Such implants may reduce or eliminate the need for human donors. Tissue engineering is also being used to create tracheas, arteries, urinary bladders, and heart valves.

Many artificial replacement parts have also been developed. These are made of plastic or metal and are not rejected as foreign by the recipient’s immune system. Damaged heart valves or sections of arteries may be replaced by grafts made of synthetic materials. Artificial joints are available for every joint in the body, as is artificial bone for reconstructive surgery. Cochlear implants are tiny instruments that convert sound waves to electrical impulses the brain can learn to interpret and have provided some sense of hearing for people with certain types of deafness. A corneal implant is available for a person with age-related macular degeneration (see Chapter 9), in which central vision has been lost. The implant can enable the person to recognize faces and to read large-print books. Work is also progressing on devices that help damaged hearts pump blood more efficiently and on small, self-contained artificial hearts.

Although these new techniques and artificial parts have great promise, we must be realistic: They are very expensive and most will not become the standard of care or be in widespread use for many years.

TABLE 1-1 | THE ORGAN SYSTEMS

| SYSTEM        | FUNCTIONS                                                                                                                                                                                             | ORGANS*                                                     |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| Integumentary | <ul style="list-style-type: none"><li>• Protects the body by serving as a barrier to pathogens and chemicals</li><li>• Prevents excessive water loss</li></ul>                                        | skin, subcutaneous tissue                                   |
| Skeletal      | <ul style="list-style-type: none"><li>• Supports the body</li><li>• Protects internal organs and red bone marrow</li><li>• Provides a framework to be moved by muscles</li></ul>                      | bones, ligaments                                            |
| Muscular      | <ul style="list-style-type: none"><li>• Moves the skeleton or other body parts</li><li>• Produces heat</li></ul>                                                                                      | muscles, tendons                                            |
| Nervous       | <ul style="list-style-type: none"><li>• Interprets sensory information and decides how to use it</li><li>• Regulates body functions, such as movement, by means of electrochemical impulses</li></ul> | brain, spinal cord, nerves, eyes, ears                      |
| Endocrine     | <ul style="list-style-type: none"><li>• Regulates body functions, such as growth and reproduction, by means of hormones</li><li>• Regulates day-to-day metabolism by means of hormones</li></ul>      | thyroid gland, pituitary gland, ovaries or testes, pancreas |
| Circulatory   | <ul style="list-style-type: none"><li>• Transports oxygen and nutrients to tissues and removes waste products</li></ul>                                                                               | heart, blood, arteries, veins                               |
| Lymphatic     | <ul style="list-style-type: none"><li>• Returns tissue fluid to the blood</li><li>• Destroys pathogens that enter the body and provides immunity</li></ul>                                            | spleen, lymph nodes, thymus gland                           |
| Respiratory   | <ul style="list-style-type: none"><li>• Exchanges oxygen and carbon dioxide between the air and blood</li></ul>                                                                                       | lungs, trachea, larynx, diaphragm                           |
| Digestive     | <ul style="list-style-type: none"><li>• Changes food into simple chemicals that can be absorbed and used by the body</li></ul>                                                                        | stomach, colon, liver, pancreas                             |
| Urinary       | <ul style="list-style-type: none"><li>• Removes waste products from the blood</li><li>• Regulates volume and pH of blood and tissue fluid</li></ul>                                                   | kidneys, urinary bladder, urethra                           |
| Reproductive  | <ul style="list-style-type: none"><li>• Produces eggs or sperm</li><li>• <i>In women</i>, provides a site for the developing embryo/fetus</li></ul>                                                   | Female: ovaries, uterus<br>Male: testes, prostate gland     |

\*These are simply representative organs, not an all-inclusive list.

nutrients, and the circulatory system distributes them. All cells produce waste products. The circulatory system collects the waste products, and the urinary system eliminates them from the blood. As mentioned, the remainder of this text discusses each system and its interactions with other systems in more detail.

THE REST OF “US”—THE HUMAN MICROBIOME

There’s more to “us”? Yes, there is, quite a lot more. Although each of us, every human being, is a unique individual, each of us is also a home, a **microbiome**, to an enormous population of bacteria and other microorganisms, collectively called our **microbiota**. Researchers have lowered their estimates of the number of microbes that reside on us or inside us, with the most in the intestines, but still suggest that they outnumber our own cells by about 2 to 1. An older

name for this population is **normal flora** (or **resident flora**, see Table 22-1 for their distribution), and different people have different proportions of the hundreds of species that make us their home.

**Note:** Before we go further, just a suggestion: If your previous science courses have not included much about microbiology, you might like to take a few minutes and read just the first two pages of text in Chapter 22. This is a brief introduction, but you may find it helpful.

Each site on or inside the body that has microorganisms is also considered a microbiome, an ecosystem for microbes. The word **biome** comes from the science of ecology: our planet earth has many different types of terrestrial environments, each of which is a biome. Examples are deserts, tropical rain forests, temperate zone forests, tundra, prairies, and so on. Each environment has a characteristic population of plants; this

population, whether of few or many species, is also known as a biome. This may seem confusing at first, but it simply means that the term *biome* may be used for the population of a particular environment or the environment itself. The same is true for microbiomes. Thus, the “cutaneous microbiome” means the population of microbes that live on the skin, or the skin itself as the habitat for such a population, or both. It is perhaps

simplest to consider a microbiome both. Human microbiomes (population and place) include the skin surface, the oral cavity, the vagina in women, and the intestines.

All of these microbiomes are technically outside the body. The surface of the skin is obviously on the outside, but the others? Notice the locations just mentioned: each is part of an organ system that opens to the environment. Whatever is

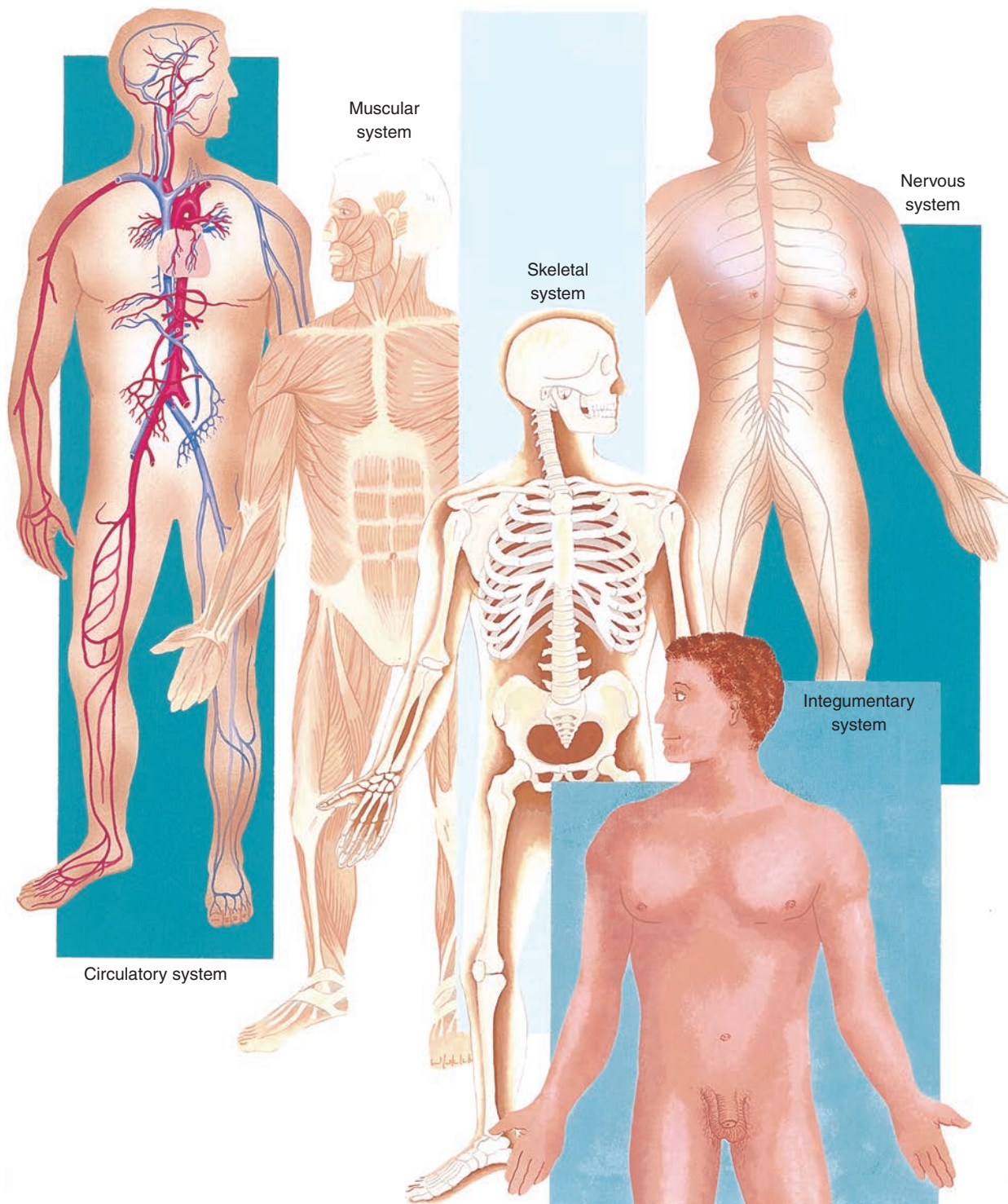


**Figure 1-2** Organ systems. Compare the depiction of each system with its description in Table 1-1.

**QUESTION:** Name at least one organ shown in each system.

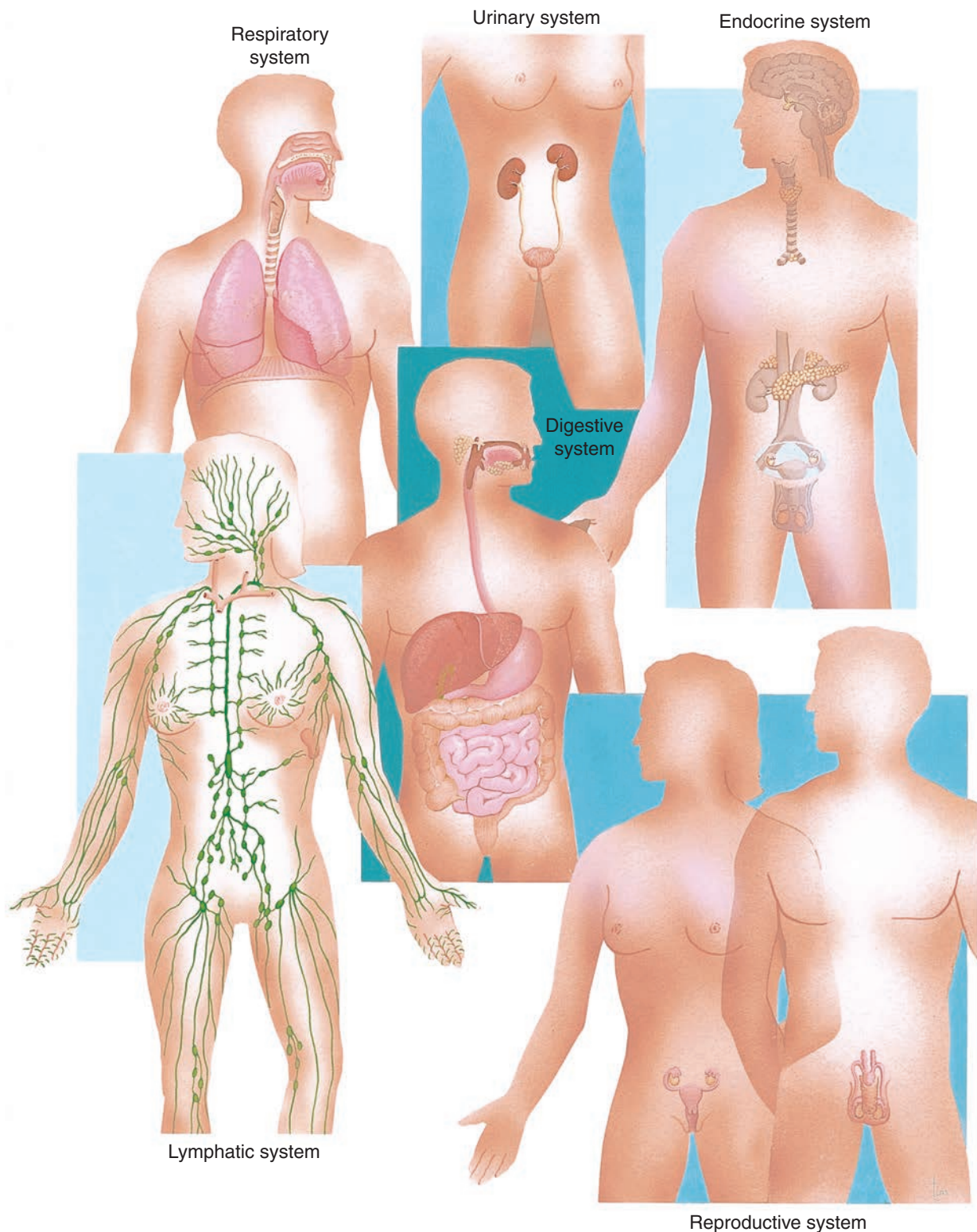


Figure 1-2—cont'd

in the cavity of such an organ system is considered to be outside the body. Food in the small intestine, for example, is outside the body, and only when nutrients are absorbed by the cells lining the intestine and into the blood or lymph are they considered to have come “inside.”

Why include microorganisms in our study of the human body? We do so because many of their activities are related

to human physiology. The science of biology has a term for this sort of relationship between or among different species: **symbiosis** (literally: “together-life”). In many symbiotic relationships, all of the species involved benefit in some way (also called mutualism; and if one species harms another, the relationship is parasitic). Our microbiota benefit because we give them a home (and internally a home

with a splendid climate-control system to keep it warm), and we supply them with food.

We also receive benefits. For example, we have known for years that some intestinal bacteria produce vitamins that we absorb, especially vitamin K that is essential for blood clotting. We have also known that these bacteria, in their usual body site (true for every microbiome), help to prevent the growth of pathogens. This knowledge is being used to try to help those with antibiotic-resistant *Clostridium difficile* intestinal infections, and some people have been cured by “fecal transplants” (in capsule form) of intestinal bacteria from a healthy family member.

Ongoing research suggests that by fermenting the food residues that we do not digest (often the complex carbohydrates of plants, a group of chemicals we call fiber), the intestinal bacteria help nourish the epithelial cells that form the intestinal lining. Not only does this keep the lining intact and prevent leakage of intestinal contents into the tissues of the body, but it also helps suppress inflammation, which is triggered by damage and in excess can be even more damaging. Other researchers propose that some of our microbiota help the immune system to establish itself and contribute to the ability of our white blood cells to distinguish between “self” and “non-self.” This is especially important for limiting the development of allergies (mistaken immune responses) and their potentially serious consequences such as asthma. Still other studies are investigating the contribution some microbiota may make to weight loss or gain. This all seems to be good (many researchers even refer to beneficial species as the “good” bacteria), but is not the whole story.

The presence of our microbiota has drawbacks as well. Just as any town or city has scoundrels and villains, so too do our microbiomes. Although our “good” microbes do help limit the growth of pathogens, these disease-causing species have also adapted quite well to life with us. Often they are not present in great numbers, but they can reproduce very rapidly if conditions change, especially a decrease in the population or proportions of our beneficial species. These potential pathogens may be called **opportunists**, in that they can take advantage of changes in their environment.

Another important consideration is that bacteria produce the chemicals they require for themselves. Many of these are the bacterial equivalent of digestive enzymes and growth factors. Some of these chemicals are outright toxins for us (as with several *Staphylococcus* and *Streptococcus* species of bacteria), and even if not toxic, or not that we know of just yet, cannot be considered beneficial to humans. Some, if absorbed, may be harmful, as is one (made from a chemical called carnitine found in red meat such as beef) that may contribute to heart disease. A common bacterial waste product is ammonia, and when absorbed into circulation it has the potential to cause brain damage. Fortunately circulation from the intestine carries ammonia directly to the liver; liver cells convert ammonia to the less toxic molecule urea.

As with all cellular products (including our own), production is genetic. The total number of genes of all of our bacteria is estimated to be several million (in comparison, the genes of a human cell total about 22,000). Most of the bacterial

products of these genes have yet to be discovered, and much more work remains to be done (especially with our resident viruses and fungi) before we truly understand the complex relationship we have with our microbiota. We have much to learn. In the appropriate organ system chapters that follow, other human microbiomes will be discussed in a little more detail.

### TAKEAWAYS [1]

1. What is the first living level of organization, and what is a group of these called?
2. What or where is a microbiome?
3. You have to stay alive for the next 10 minutes under strange circumstances. Your nervous system is working, and you can have only two other organ systems fully functional. Name the two you want, and explain why. (Not quite sure? Think: CPR)

## METABOLISM AND HOMEOSTASIS

**Metabolism** is a collective noun; it is all of the chemical reactions and physical processes that take place within the body. Metabolism includes growing, repairing, reacting, and reproducing—all the characteristics of life. The pumping of the heart, the digestion of food in the stomach, the diffusion of gases in the lungs and tissues, and the production of energy in each cell of the body are just a few of the thousands of aspects of metabolism. *Metabolism* comes from a Greek word meaning “change,” and the body is always changing—in visible ways (walking down the street), in microscopic ways (cells dividing in the skin to produce new epidermis), and in submicroscopic or molecular ways (RNA and enzymes constructing new proteins). A related concept, **metabolic rate**, is most often used to mean the speed at which the body produces energy and heat or, put another way, energy production per unit of time, such as 24 hours. Metabolic rate, therefore, is one aspect of metabolism.

A person who is in good health may be said to be in a state of **homeostasis**. Good health is a product of normal metabolism, and homeostasis reflects the ability of the body to maintain a relatively stable metabolism and to function normally despite many constant changes. The changes that are part of normal metabolism may be internal or external, and the body must respond appropriately.

Eating breakfast, for example, brings about an internal change. Suddenly there is food in the stomach, and something must be done with it. What happens? The food is digested or broken down into simple chemicals that the body can use. The protein in a hard-boiled egg is digested into amino acids, its basic chemical building blocks; these amino acids can then be absorbed and used by the cells of the body to produce their own specialized proteins.

An example of an external change is a rise in environmental temperature. On a hot day, the body temperature would also tend to rise. However, body temperature must be kept within its normal range of about 97° to 99°F (36° to 38°C) to support normal functioning. What happens? One of

the body's responses to the external temperature rise is to increase sweating so that excess body heat can be lost by the evaporation of sweat on the surface of the skin. This response, however, may bring about an undesirable internal change, dehydration. What happens? As body water decreases, we feel the sensation of thirst, and we drink fluids to replace the water lost in sweating. Notice that when certain body responses occur, they reverse the event that triggered them. In the preceding example a rising body temperature stimulates increased sweating, which lowers body temperature, which in turn decreases sweating. Unnecessary sweating that would be wasteful of water is prevented. This is an example of a **negative feedback mechanism**, in which the body's response reverses the stimulus (in effect, turning it off for a while) and keeps some aspect of the body metabolism within its normal range.

Look at Fig. 1-3 for another negative feedback mechanism, one in which the hormone thyroxine regulates the

metabolic rate of the body. As metabolic rate decreases, the hypothalamus (a part of the brain) and the pituitary gland detect this decrease and secrete hormones to stimulate the thyroid gland (on the front of the neck, just below the larynx) to secrete the hormone thyroxine. Thyroxine stimulates the cellular enzyme systems that produce energy from food, which increases the metabolic rate. The rise in energy and heat production is detected by the brain and pituitary gland. They then decrease secretion of their hormones, which in turn inhibits any further secretion of thyroxine until the metabolic rate decreases again. Metabolic rate does rise and fall, but it is kept within normal limits.

You may be wondering if there is such a thing as a positive feedback mechanism. There is, but such mechanisms are rare in the body and quite different from negative feedback mechanisms. In a **positive feedback mechanism**, the response to the stimulus does not stop or reverse the stimulus, but instead keeps the sequence of events going until it is interrupted by

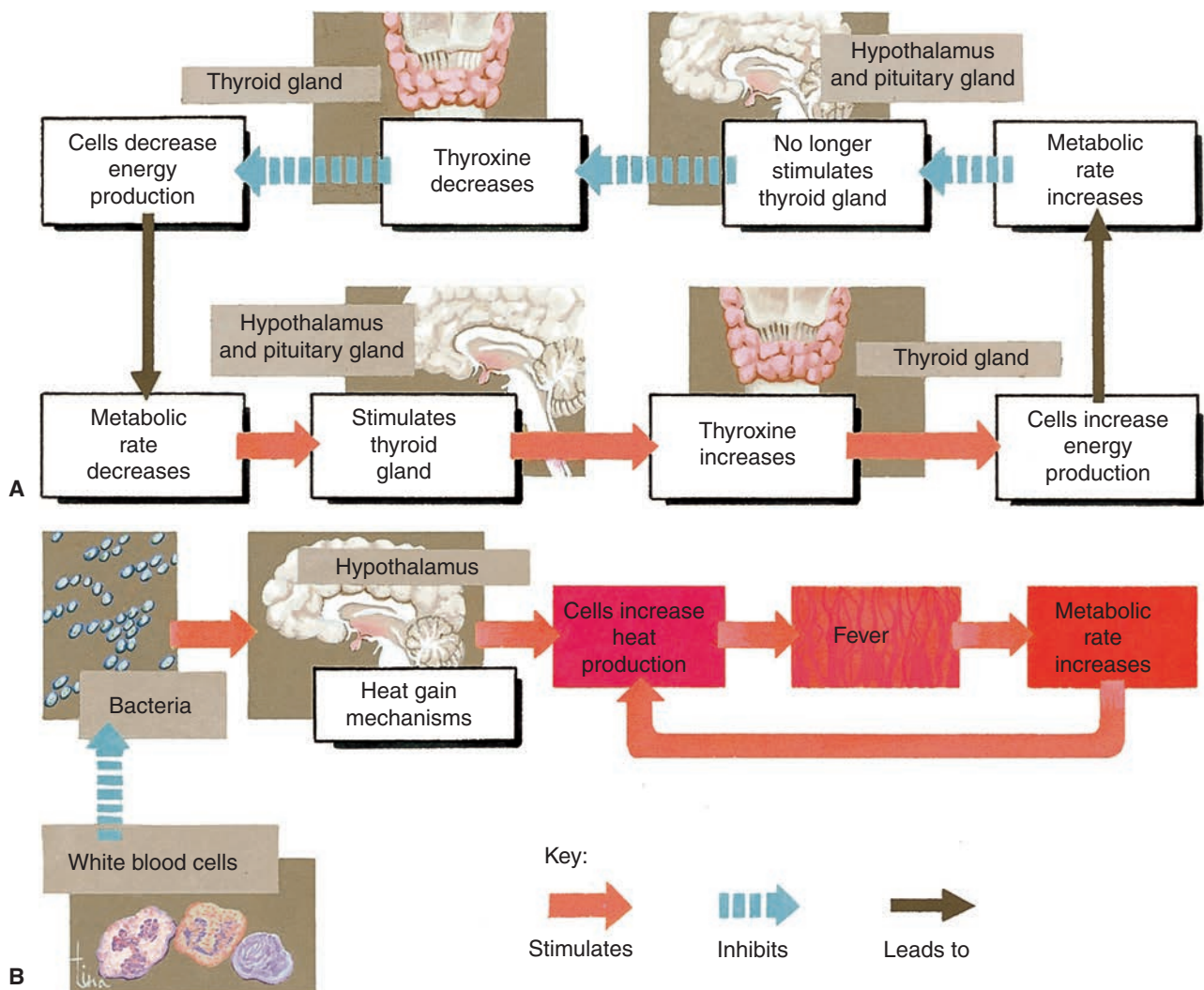


**Figure 1-3** Feedback mechanisms. (A) The negative feedback mechanism of regulation of metabolic rate by thyroxine. (B) The positive feedback mechanism triggered by a fever. See text for description.

**QUESTION:** For each mechanism, where and what is the source of the “brake” or inhibition?

some external event. A good example is childbirth, in which the sequence of events, simply stated, is as follows: Stretching of the uterine cervix stimulates secretion of the hormone oxytocin by the posterior pituitary gland. Oxytocin stimulates contraction of the uterine muscle, which causes more stretching of the cervix as the baby is pushed through, which stimulates the secretion of more oxytocin and, hence, more contractions. The mechanism stops with the delivery of the baby and the placenta. This is the “brake,” the interrupting event.

Any positive feedback mechanism requires an external “brake,” something to interrupt it. Blood clotting is such a mechanism, and without external controls, clotting may become a vicious cycle of clotting and more clotting, doing far more harm than good (clotting is discussed in Chapter 11). Inflammation, the body’s response to damage of any sort, is beneficial and necessary for tissue repair to begin, but the process may evolve into a cycle of damage and more damage, and it requires an external control to stop it. The rise of a fever may also trigger a positive feedback mechanism. Notice in Fig. 1-3 that bacteria have affected the body’s thermostat in the hypothalamus and caused a fever. The rising body temperature increases the metabolic rate, which increases body temperature even more, becoming a cycle. Where is the inhibition, the brake? For this infection, the brake is white blood cells destroying the bacteria that caused the fever. An interruption from outside the cycle is necessary. It is for this reason, because positive feedback mechanisms have the potential to be self-perpetuating and cause harm, that they are rare in the body.

Negative feedback mechanisms, however, contain their own brakes, in that inhibition is a natural part of these cycles, and the body has many such mechanisms. The secretion of most hormones (Chapter 10) is regulated by negative feedback mechanisms. The regulation of heart rate (Chapter 12) and of blood pressure (Chapter 13) involves several negative feedback mechanisms. The result of all of these mechanisms working together is that all aspects of body functioning, that is, of metabolism, are kept within normal limits, a steady state or equilibrium. This is homeostasis.

In the chapters to come, you will find many more examples of homeostasis. As you continue your study of the human body, keep in mind that the proper functioning of each organ and organ system contributes to homeostasis. Keep in mind

as well that what we call the normal values of metabolism are often ranges, not single numbers. Recall that normal body temperature is a range: 97° to 99°F (36° to 38°C). Normal pulse rate, another example, is 60 to 80 beats per minute; a normal respiratory rate is 12 to 20 breaths per minute. Variations within the normal range are part of normal metabolism.

### TAKEAWAYS [2]

1. Are there any aspects of human body functioning that are not part of metabolism? If so, give examples.
2. What kind of body process contains its own shut-off or reversal mechanism?
3. What kind of body process may become self-perpetuating and cause harm? Give an example.

## TERMINOLOGY AND GENERAL PLAN OF THE BODY

As part of your course in anatomy and physiology, you will learn many new words and terms. At times you may feel that you are learning another language, and indeed you are. Each term has a precise meaning, which is understood by everyone else who has learned the language. Mastering the terminology of your profession is essential to communicating effectively with your coworkers and your future patients. Although the number of new terms may seem a bit overwhelming at first, you will find that using these terms will soon become second nature to you.

The terminology presented in this chapter (some of it in tables in list form) will be used throughout the text in the discussion of the organ systems. This will help to reinforce the meanings of these terms and will transform these new words into knowledge.

### BODY PARTS AND AREAS

Each of the terms listed in Table 1-2 and shown in Fig. 1-4 refers to a specific part or area of the body. For example, the term *femoral* always refers to the thigh, and *brachial* always refers to the upper arm. The femoral artery is a blood vessel that passes through the thigh, and the quadriceps femoris is

**TABLE 1-2 | DESCRIPTIVE TERMS FOR BODY PARTS AND AREAS**

| TERM          | DEFINITION (REFERS TO) | TERM      | DEFINITION (REFERS TO) |
|---------------|------------------------|-----------|------------------------|
| Antebrachial  | forearm                | Cervical  | neck                   |
| Antecubital   | front of elbow         | Cranial   | head                   |
| Axillary      | armpit                 | Cutaneous | skin                   |
| Brachial      | upper arm              | Deltoid   | shoulder               |
| Buccal (oral) | mouth                  | Femoral   | thigh                  |
| Cardiac       | heart                  | Frontal   | forehead               |

**TABLE 1-2 | DESCRIPTIVE TERMS FOR BODY PARTS AND AREAS—cont'd**

| TERM      | DEFINITION (REFERS TO) | TERM           | DEFINITION (REFERS TO) |
|-----------|------------------------|----------------|------------------------|
| Gastric   | stomach                | Pedal          | foot                   |
| Gluteal   | buttocks               | Perineal       | pelvic floor           |
| Hepatic   | liver                  | Plantar        | sole of foot           |
| Iliac     | hip                    | Popliteal      | back of knee           |
| Inguinal  | groin                  | Pulmonary      | lungs                  |
| Lumbar    | small of back          | Renal          | kidney                 |
| Mammary   | breast                 | Sacral         | base of spine          |
| Nasal     | nose                   | Scapular       | shoulder blade         |
| Occipital | back of head           | Sternal        | breastbone             |
| Orbital   | eye                    | Temporal       | side of head           |
| Parietal  | crown of head          | Umbilical      | navel                  |
| Patellar  | kneecap                | Volar (palmar) | palm                   |
| Pectoral  | chest                  |                |                        |

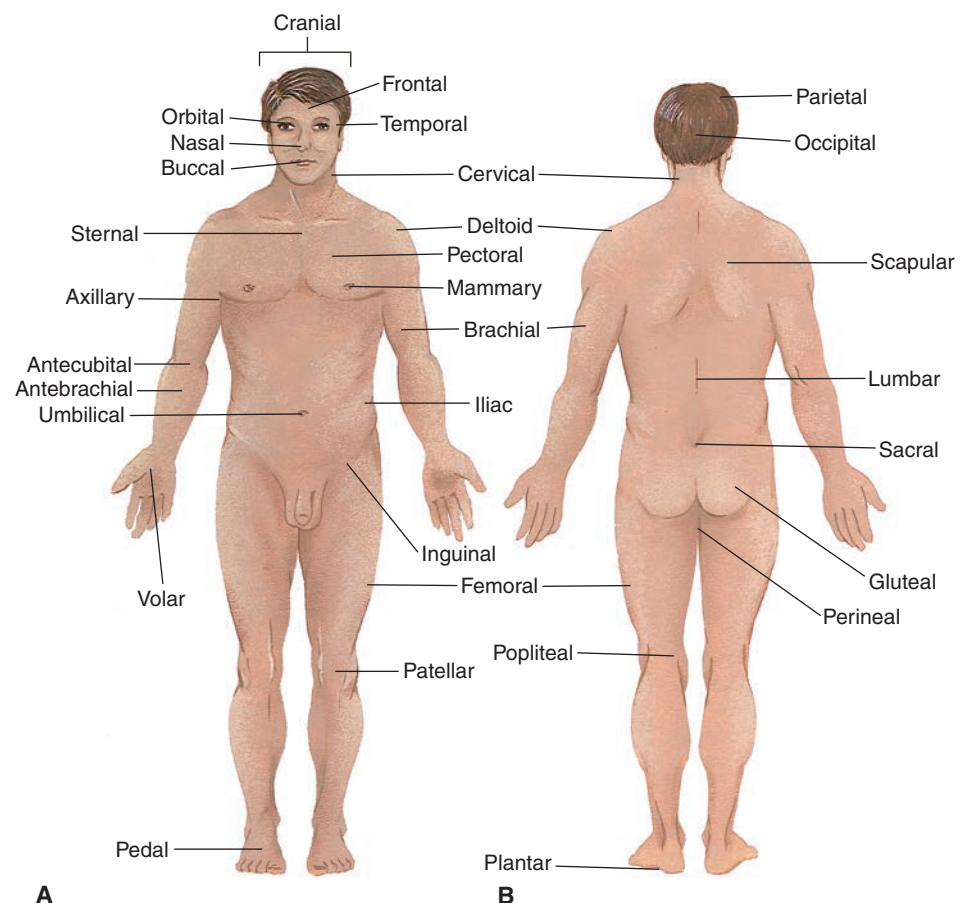
**Body Parts and Areas****Anatomic position**

**Figure 1-4** Body parts and areas. The body is shown in anatomic position. (A) Anterior view. (B) Posterior view. (Compare with Table 1-2.)

**QUESTION:** Name a body area that contains a bone with a similar name. Can you name two more?

**A****B**

a large muscle group of the thigh. The brachial artery passes through the upper arm, and the biceps brachii and triceps brachii are the major muscles of the upper arm.

Another example is *pulmonary*, a term that always refers to the lungs, as in “pulmonary artery,” “pulmonary edema,” and “pulmonary embolism.” Although you may not know the exact meaning of each of these terms now, you do know that each has something to do with the lungs.

TERMS OF LOCATION AND POSITION

When describing relative locations, the body is always assumed to be in anatomic position: standing upright facing forward, arms at the sides with palms forward, and the feet slightly apart. The terms of location are listed in Table 1-3, with a definition and example for each. As you read each term, find the body parts used as examples in Figs. 1-4 and 1-5. Notice also that these are pairs of terms and that each pair is a set of opposites. This will help you recall the terms and their meanings.

BODY CAVITIES AND THEIR MEMBRANES

The closed cavities of the body are found in the skull, the vertebral column, and the trunk; each contains specific organs and membranes. These cavities are the cranial, spinal, thoracic, abdominal, and pelvic, and they are shown in Fig. 1-5.

Cranial and Spinal Cavities

The cranial and spinal cavities contain the central nervous system and are completely enclosed by protective bone. These two cavities are continuous; that is, no wall or boundary separates them. The cranial cavity is formed by the skull and contains the brain. The spinal (or vertebral) cavity is formed by the backbone (vertebral column or spine) and contains the spinal cord. The membranes that line these cavities and cover the brain and spinal cord are called the **meninges**.

Thoracic, Abdominal, and Pelvic Cavities

The thoracic, abdominal, and pelvic cavities are within the trunk of the body, and their contents are at least partially protected by bone. The thoracic (or chest) cavity is the most superior and is separated from the abdominal cavity below by the diaphragm. The diaphragm is a large, dome-shaped respiratory muscle. It has openings for the esophagus and for large blood vessels but otherwise is a wall between the thoracic and abdominal cavities. The pelvic cavity is the most inferior and may be considered a subdivision of the abdominal cavity (there is no wall between the two) or as a separate cavity.

Organs in the **thoracic cavity** include the heart and lungs. The membranes of the thoracic cavity are serous membranes called the **pleural membranes**. The parietal pleura lines the

| TABLE 1-3   TERMS OF LOCATION AND POSITION |                                          |                                                              |
|--------------------------------------------|------------------------------------------|--------------------------------------------------------------|
| TERM                                       | DEFINITION                               | EXAMPLE                                                      |
| Superior                                   | above, or higher                         | The heart is superior to the liver.                          |
| Inferior                                   | below, or lower                          | The liver is inferior to the lungs.                          |
| Anterior                                   | toward the front                         | The chest is on the anterior side of the body.               |
| Posterior                                  | toward the back                          | The lumbar area is posterior to the umbilical area.          |
| Ventral                                    | toward the front                         | The mammary area is on the ventral side of the body.         |
| Dorsal                                     | toward the back                          | The buttocks are on the dorsal side of the body.             |
| Medial                                     | toward the midline                       | The heart is medial to the lungs.                            |
| Lateral                                    | away from the midline                    | The shoulders are lateral to the neck.                       |
| Internal                                   | within, or interior to                   | The brain is internal to the skull.                          |
| External                                   | outside, or exterior to                  | The ribs are external to the lungs.                          |
| Superficial                                | toward the surface                       | The skin is the most superficial organ.                      |
| Deep                                       | within, or interior to                   | The deep veins of the legs are surrounded by muscles.        |
| Central                                    | the main part                            | The brain is part of the central nervous system.             |
| Peripheral                                 | extending from the main part             | Nerves in the arm are part of the peripheral nervous system. |
| Proximal                                   | closer to the origin                     | The knee is proximal to the foot.                            |
| Distal                                     | farther from the origin                  | The palm is distal to the elbow.                             |
| Parietal                                   | pertaining to the wall of a cavity       | The parietal pleura lines the chest cavity.                  |
| Visceral                                   | pertaining to the organs within a cavity | The visceral pleura covers the lungs.                        |

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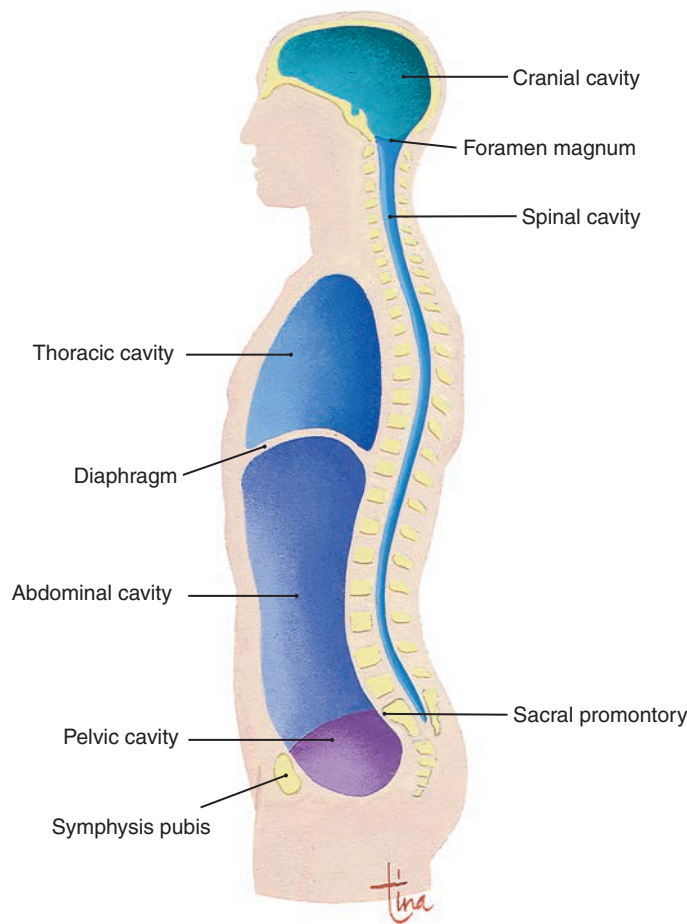


**Figure 1-5** Body cavities (lateral view from the left side).

**QUESTION:** Which of these cavities are surrounded by bone?

chest wall, and the visceral pleura covers the lungs. The heart has its own set of serous membranes called the **pericardial membranes**. The parietal pericardium lines the fibrous pericardial sac, and the visceral pericardium covers the heart muscle.

Organs in the **abdominal cavity** include the liver, the stomach, and the intestines. The membranes of the abdominal cavity are also serous membranes called the peritoneum and mesentery. The **peritoneum** is the membrane that lines the entire abdominal wall, and the **mesentery** (or visceral peritoneum) is the continuation of this membrane, folded around and covering the outer surfaces of the abdominal organs.

The **pelvic cavity** is inferior to the abdominal cavity. Although the peritoneum does not line the pelvic cavity, it covers the free surfaces of several pelvic organs. Within the pelvic cavity are the urinary bladder and reproductive organs, such as the uterus in women and the prostate gland in men.

## PLANES AND SECTIONS

When internal anatomy is described, the body, or an organ, is often cut or sectioned in a specific way so as to make particular

structures easily visible. A **plane** is an imaginary flat surface that separates two portions of the body or an organ. These planes and **sections** are shown in Fig. 1-6.

**Frontal (coronal) section**—a plane from side to side separates the body into front and back portions.

**Sagittal section**—a plane from front to back separates the body into right and left portions. A midsagittal section creates equal right and left halves.

**Cross-section**—a plane perpendicular to the long axis of an organ. A cross-section of the small intestine (which is a tube) would look like a circle with the cavity of the intestine in the center.

**Longitudinal section**—a plane along the long axis of an organ. A longitudinal section of the intestine is shown in Fig. 1-6B, and a frontal section of the femur (thigh bone) would also be a longitudinal section (see Fig. 6-1 in Chapter 6).

**Transverse section**—a horizontal plane separates the body (or a part) into upper and lower portions. Look at part C of Fig. 1-6; this is a transverse section of the upper abdomen. If you are looking at this picture with the book in front of you (or on a screen), the body in the picture is oriented just the way yours is. The anterior or front is at the top of the illustration, away from you. Place your right hand at the lower edge of your rib cage; this is where that section is taken. Notice all the organs at this level and how they “fit” with one another in the abdominal cavity. Find the aorta; this is a main blood vessel and must be protected. Where is it? Right in front of the backbone, almost in the center of the body, very well protected.

Many pictures in later chapters will be sectional views of organs or body parts. Such sections are often very helpful in learning the spatial relationship of organs or other kinds of parts to one another (see also Box 1-2: Visualizing the Interior of the Body and Box 1-3: Watching the Brain at Work).

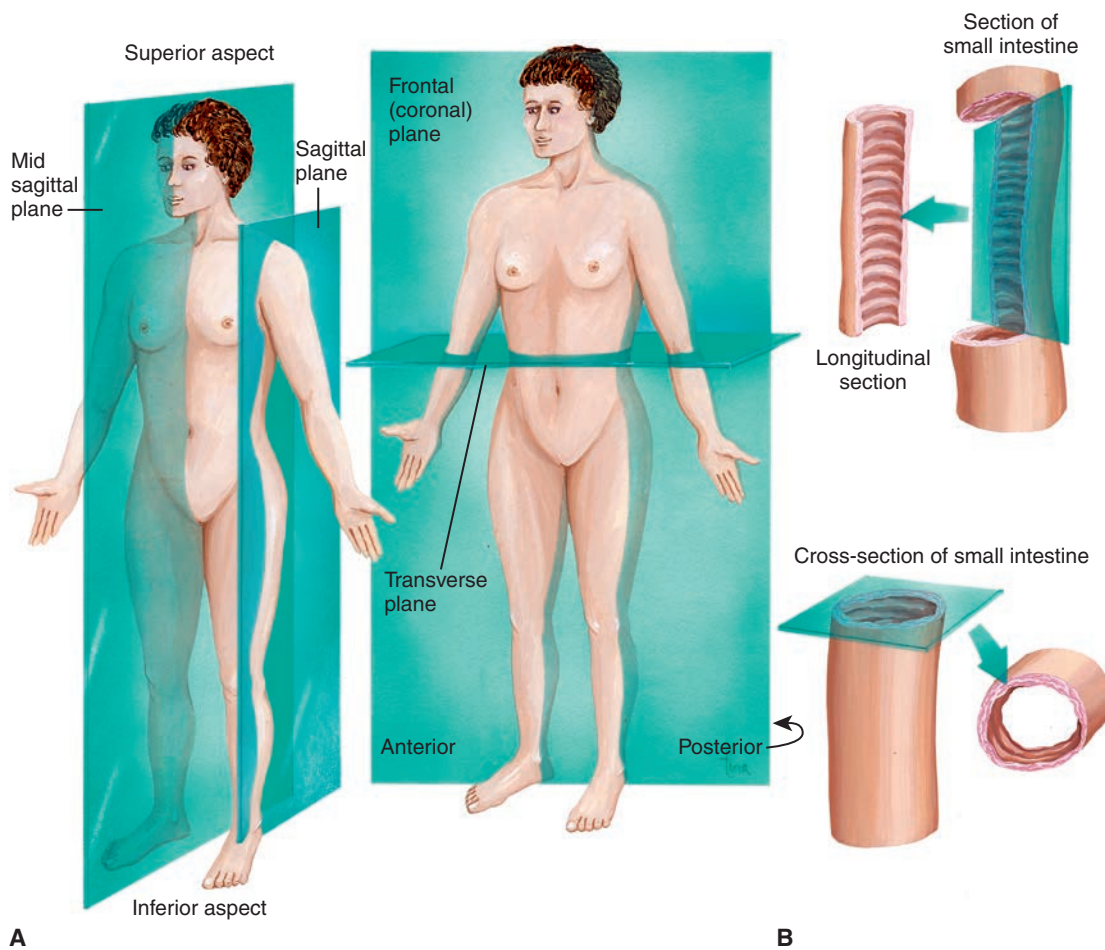
## AREAS OF THE ABDOMEN

The abdomen is a large area of the lower trunk of the body. If a patient reported abdominal pain, the physician or nurse would want to know more precisely where the pain was. To determine this, the abdomen can be divided into smaller regions or areas, which are shown in Fig. 1-7.

**Quadrants**—a transverse plane and a midsagittal plane that cross at the umbilicus divide the abdomen into four quadrants. Clinically, this is probably the division used more frequently. The pain of gallstones might then be described as in the right upper quadrant.

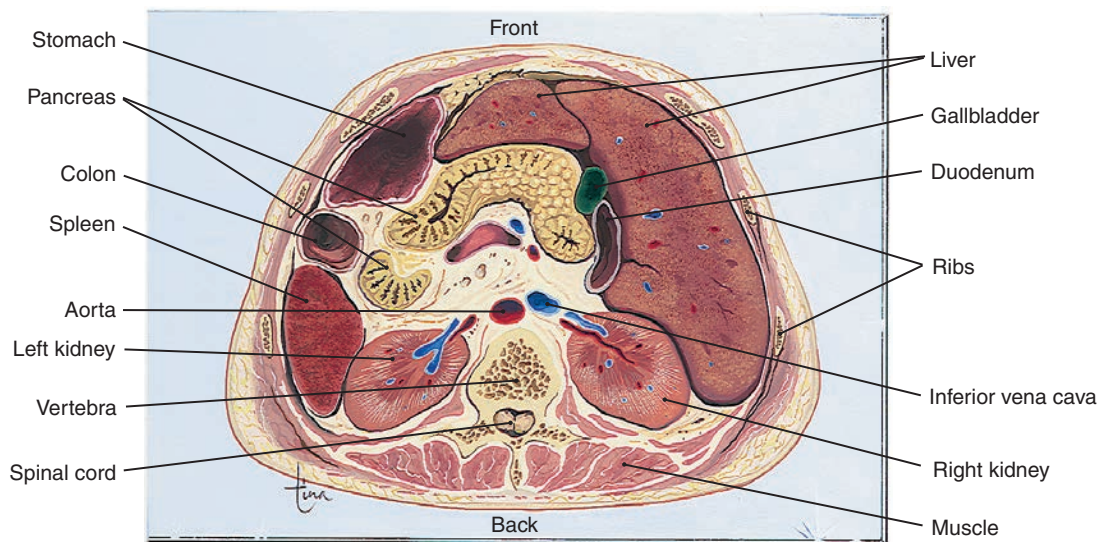
**Nine areas**—two transverse planes and two sagittal planes divide the abdomen into nine areas:

*Upper areas*—above the lower level of the rib cartilages are the left hypochondriac, epigastric, and right hypochondriac.



A

B



C

**Figure 1-6** (A) Planes and sections of the body. (B) Cross-section and longitudinal section of the small intestine. (C) Transverse section through the upper abdomen.

**QUESTION:** What other organs would have sections that look like those of the small intestine?

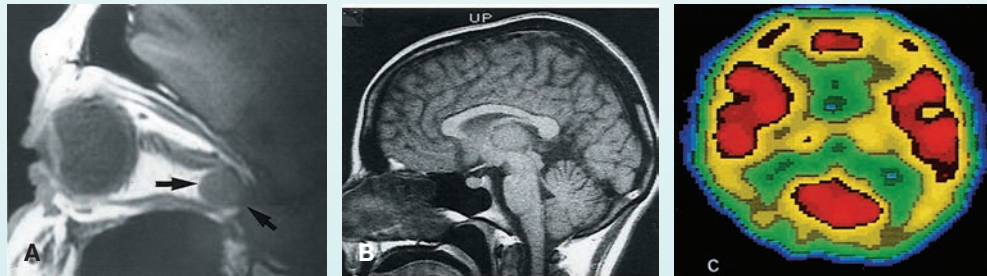
**BOX 1-2 | VISUALIZING THE INTERIOR OF THE BODY**

Imaging technologies can often replace exploratory surgery as diagnostic tools. Although expensive, these tools provide great benefits to patients: Highly detailed images of the body are obtained without the risks of surgery and with virtually no discomfort in the procedures themselves.

**Computed tomography (CT) scanning** uses a narrowly focused x-ray beam that circles rapidly around the body. A detector then measures how much radiation passes through different tissues, and a computer constructs an image of a thin slice through the body. Several images may be made at different levels—each takes only a few seconds—to provide a more complete picture of an organ or part of the body. The images are much more detailed than those produced by conventional x-rays (Box Figure 1-2, part A).

**Magnetic resonance imaging (MRI)** is especially useful for visualizing soft tissues, including the brain, spinal cord, and individual nerves. The patient is placed inside a strong magnetic field, and the body's tissues are pulsed with radio waves. Because each tissue has different proportions of various atoms, which resonate or respond differently, each tissue emits a characteristic signal. A computer then translates these signals into an image (part B).

**Positron emission tomography (PET)** scanning creates images that depict the rates of physiological processes such as blood flow, oxygen usage, or glucose metabolism. The comparative rates are depicted by colors: Red represents the highest rate, followed by yellow, then green, and finally blue, representing the lowest rate (part C).



**Box Figure 1-2** Imaging techniques. (A) CT scan of eye in lateral view, showing a tumor (arrow) below the optic nerve. (B) MRI of midsagittal section of head (compare with Figs. 8-6 in Chapter 8 and 15-1 in Chapter 15). (C) PET scan of brain in transverse section (frontal lobes at top) showing glucose metabolism. (From Mazziotta, JC, and Gilman, S: *Clinical Brain Imaging: Principles and Applications*. Philadelphia: FA Davis, 1992, pp 27 and 298, with permission.)

**BOX 1-3 | WATCHING THE BRAIN AT WORK**

**Functional magnetic resonance imaging (fMRI)** is similar to a PET scan in that it portrays activity within the brain. An fMRI depicts blood flow, and colors to make the gradations of flow distinct are assigned by a computer. An actual fMRI is more of a video than a photograph, and it illustrates physiology and anatomy. In Box Fig. 1-3, each part (A or B) is similar to a “still,” or a single-frame image from a movie, and shows what an fMRI would look like in two posterior views of the parietal and occipital lobes of the cerebrum (the pink structure below the occipital lobes is the cerebellum).

Increased brain activity while driving a car (in a simulator) is depicted in part A; this activity is in areas devoted

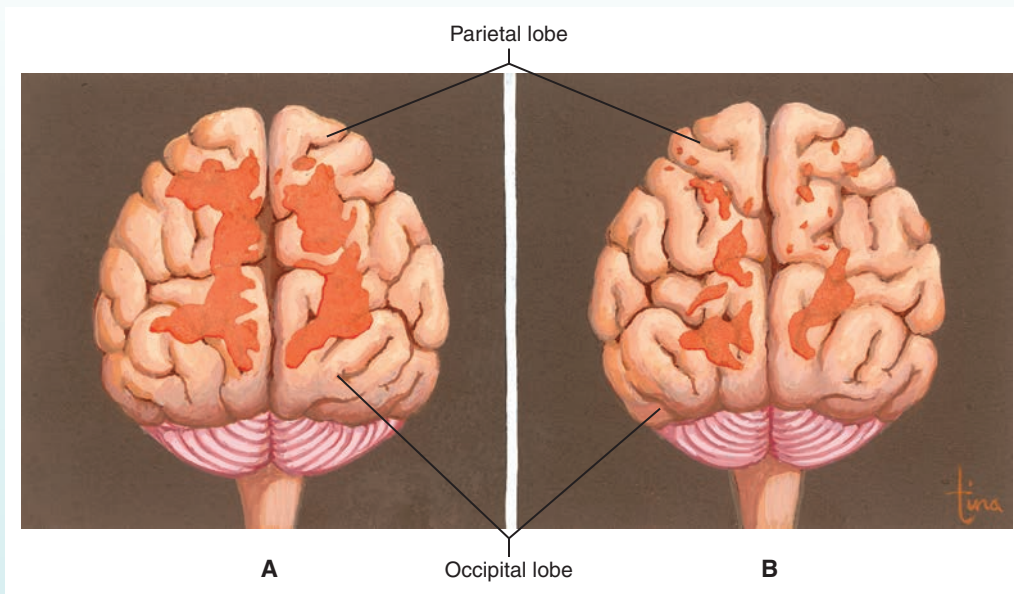
to vision and to analyzing spatial relationships. Part B shows a brain that is driving and talking on a cell phone. You can see that brain activity devoted to driving is diminished. Why might this happen? Because when we talk on a phone we form mental images of the person to whom we are speaking, and we are probably thinking about what we are going to say next. Therefore, those parts of the brain busy with the phone call are not available to look at and analyze the road ahead. Much of driving requires thinking such as “What does what I am seeing mean, and what will I do with that information?” The human brain does best when it focuses on one task; a brain that is distracted by another task is not at all efficient at interpretation or

*Continued*

### BOX 1-3 | WATCHING THE BRAIN AT WORK—cont'd

reacting to sudden hazards, and it does neither task well. Evaluations of brain activity such as these can tell us a great deal about how the parts of the brain work

together and may also be very useful in the diagnosis or monitoring of certain types of brain damage or disease.



**Box Figure 1-3** Depiction of a functional MRI, with increased brain activity shown in orange. (A) The posterior cerebrum engaged in driving a car. (B) The posterior cerebrum, driving and talking on a phone.

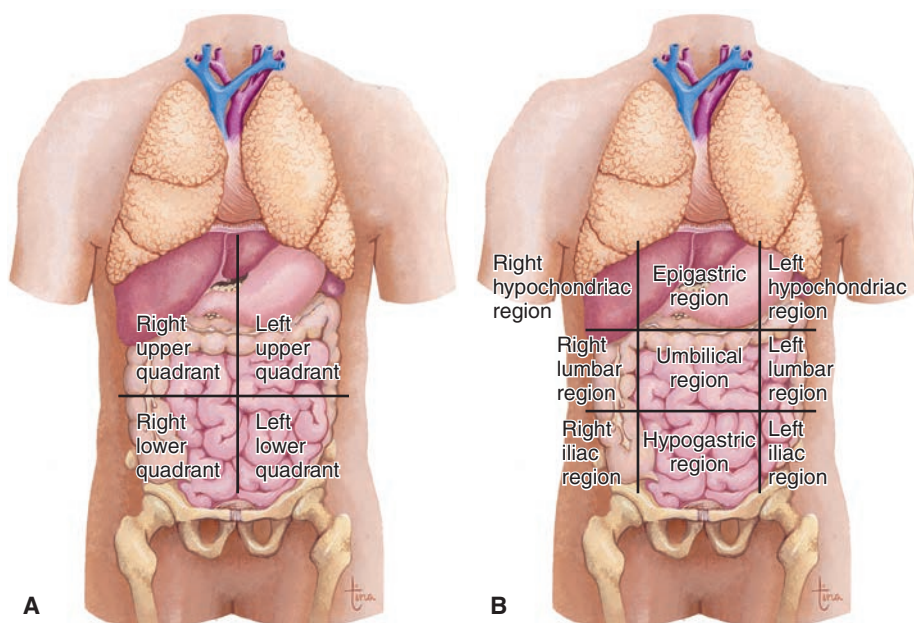


**Figure 1-7** Areas of the abdomen. (A) Four quadrants. (B) Nine regions.

**QUESTION:** Are there any organs found in all four abdominal quadrants?

*Middle areas*—the left lumbar, umbilical, and right lumbar.

*Lower areas*—below the level of the top of the pelvic bone are the left iliac, hypogastric, and right iliac.

These divisions are often used in anatomic studies to describe the location of organs. The liver, for example, is located in the epigastric and right hypochondriac areas.

### TAKEAWAYS [3]

1. Which body area is not visible on the posterior side of the body, and where is it?  
gluteal, lumbar, pectoral, occipital, scapular
2. Which body area is not visible on the anterior side of the body, and where is it?  
iliac, frontal, sternal, popliteal, brachial
3. Which organ is not on a midsagittal plane of the body?  
brain, liver, diaphragm, eye, small intestine

### SUMMARY

As you will see, the terminology presented in this chapter is used throughout the text to describe the anatomy of organs and the names of their parts. All organs of the body contribute to homeostasis, the healthy state of the body that is maintained by constant and appropriate responses to internal and external changes. In the chapters that follow, you will find detailed descriptions of the physiology of each organ and organ system, and how the metabolism of each is necessary to homeostasis. We will now return to a consideration of the structural organization of the body and to more extensive descriptions of its levels of organization. The first of these, the chemical level, is the subject of the next chapter.

## Study Outline

### Introduction

1. Anatomy—the study of structure.
2. Physiology—the study of function.
3. Pathophysiology—the study of disorders of functioning.

### Levels of Organization

1. Chemical—inorganic and organic chemicals make up all matter, both living and nonliving. The body is a container of chemicals.
2. Cells—the smallest living units of the body. The body may be likened to a city of cells.
3. Tissues—groups of cells with similar structure and function.
4. Organs—groups of tissues (a cooperation of tissues) that contribute to specific functions.
5. Organ systems—groups of organs that work together to perform specific functions (see Table 1-1 and Fig. 1-2).
6. Person—all the organ systems functioning properly.

7. The Rest of “Us”—our microbiomes, the places for and populations of bacteria and other microbes that reside on and inside each human being; some may be harmful but others contribute to health in many ways, most of which we have yet to discover.

### Metabolism and Homeostasis

1. Metabolism is the sum of all of the chemical and physical changes that take place in the body. Metabolic rate is the amount of energy and heat production per unit of time.
2. Homeostasis is a state of good health maintained by the normal metabolism (functioning) of the organ systems.
3. The body constantly responds to internal and external changes yet remains stable; its many aspects of metabolism are kept within normal limits (usually a range of values, not a single value).
4. Negative feedback mechanism—a control system in which a stimulus initiates a response that reverses or reduces the stimulus, thereby stopping the response until the stimulus occurs again and there is a need for the response (see Fig. 1-3).
5. Positive feedback mechanism—a control system that requires an external interruption or brake. Has the potential to become a self-perpetuating and harmful cycle, therefore is rare in the body (see Fig. 1-3).

### Terminology and General Plan of the Body

1. Body parts and areas (see Table 1-2 and Fig. 1-4).
2. Terms of location and position—used to describe relationships of position (see Table 1-3 and Figs. 1-4 and 1-5).
3. Body cavities and their membranes (see Fig. 1-5).
  - a. Cranial and spinal cavities—within the skull and backbone; lined with membranes called meninges; enclosed by bone to protect the central nervous system.
    - Cranial cavity contains the brain.
    - Spinal (vertebral) cavity contains the spinal cord.
  - b. Thoracic, abdominal, and pelvic cavities—within the trunk; the diaphragm separates the thoracic and abdominal cavities; the pelvic cavity is inferior to the abdominal cavity.
    - Thoracic cavity—contains the lungs and heart.
      - 1) Pleural membranes line the chest wall and cover the lungs.
      - 2) Pericardial membranes surround the heart.
    - Abdominal cavity—contains many organs including the stomach, liver, and intestines.
      - 1) The peritoneum lines the abdominal cavity; the mesentery covers the abdominal organs.
    - Pelvic cavity—contains the urinary bladder and reproductive organs.
4. Planes and sections—cutting the body or an organ in a specific way (see Fig. 1-6).
  - a. Frontal or coronal—separates front and back parts.
  - b. Sagittal—separates right and left parts.

- c. Transverse—separates upper and lower parts.
  - d. Cross—a section perpendicular to the long axis.
  - e. Longitudinal—a section along the long axis.
5. Areas of the abdomen—permits easier description of locations:
    - a. Quadrants (see Fig. 1-7).
    - b. Nine areas (see Fig. 1-7).

## Review Questions

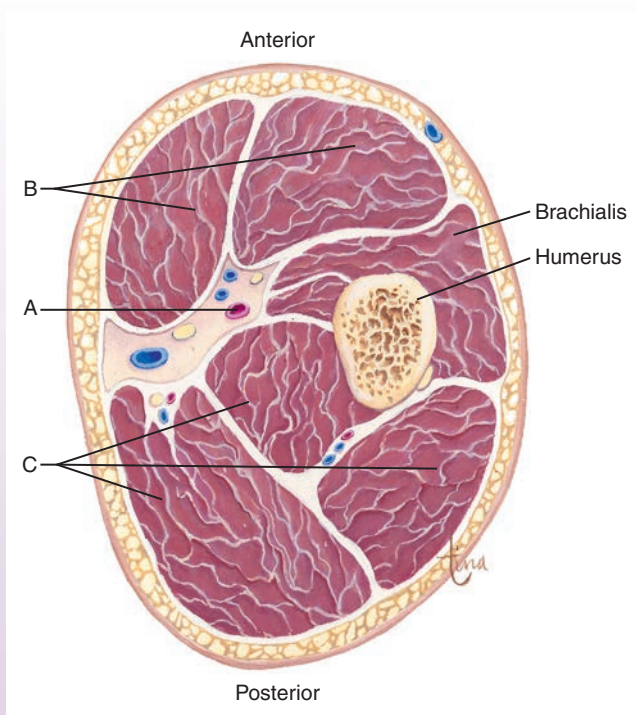
1. Explain how the physiology of a bone is related to its anatomy. Explain how the physiology of the hand is related to its anatomy. (p. 4)
2. Describe anatomic position. Why is this knowledge important? (p. 14)
3. Name the organ system that accomplishes each of the following functions: (p. 7)
  - a. Moves the skeleton
  - b. Regulates body functions by means of hormones
  - c. Covers the body and prevents entry of pathogens
  - d. Destroys pathogens that enter the body
  - e. Exchanges oxygen and carbon dioxide between the air and blood
4. Name the closed body cavities. Name the cavity lined by the peritoneum, meninges, and parietal pleura. (pp. 14–15)
5. Name the four quadrants of the abdomen. Name at least one organ in each quadrant. (pp. 15, 18)
6. Name the section through the body that would result in each of the following: equal right and left halves, anterior and posterior parts, superior and inferior parts. (pp. 15–16)
7. Review Table 1-2 and try to find each external area on your own body. (pp. 12–13)
8. Define *cell*. When similar cells work together, what name are they given? (p. 4)
9. Define *organ*. When a group of organs works together, what name is it given? (p. 6)
10. Define *metabolism*, *metabolic rate*, and *homeostasis*. (p. 10)
  - a. Give an example of an external change and explain how the body responds to maintain homeostasis.
  - b. Give an example of an internal change and explain how the body responds to maintain homeostasis.
  - c. Briefly explain how a negative feedback mechanism works and how a positive feedback mechanism differs.

## FOR FURTHER THOUGHT

1. The human foot is similar to the human hand, but it does have anatomic differences. Describe two of these differences, and explain how they are related to the physiology of the hand and the foot.
2. If a person has appendicitis (inflammation of the appendix caused by bacteria), pain is felt in which abdominal quadrant? (If you're not sure, take a look at Fig. 16-1 in Chapter 16.) Surgery is often necessary to remove an inflamed appendix before it ruptures and causes peritonitis. Using your knowledge of the location of the peritoneum, explain why peritonitis is a very serious condition.
3. Keep in mind your answer to Question 2, and explain why bacterial meningitis can be a very serious infection.
4. Use a mental picture to cut the following sections. Then describe in simple words what each section looks like, and give each a proper anatomic name.
 

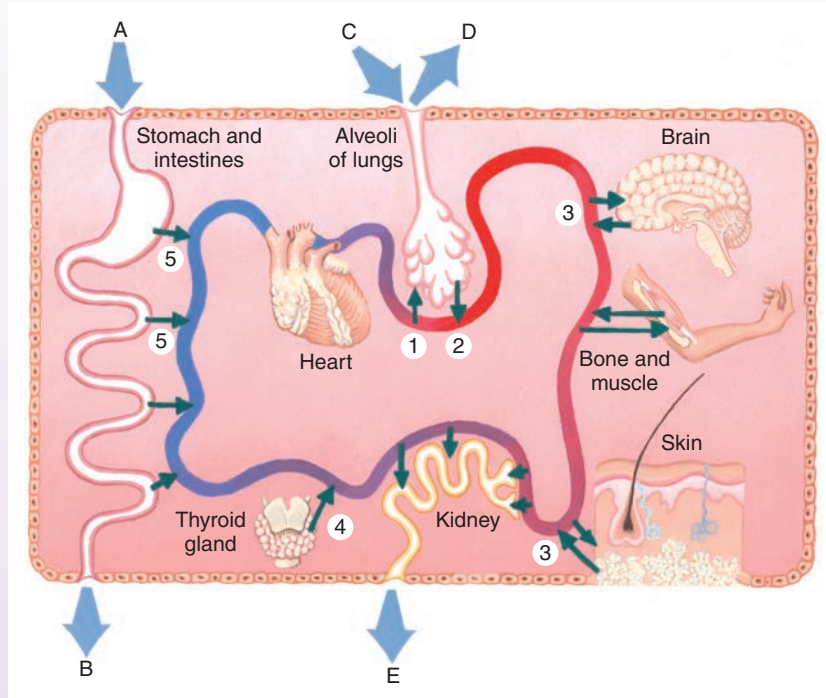
First: a tree trunk cut top to bottom, then cut side to side.

Second: a grapefruit cut top to bottom (straight down from where the stem was attached), then sliced through its equator.
5. Look at Question Figure 1-1. This is a transverse section through the middle of the right upper arm; the front of the arm is at the top of the picture, away from you, oriented the same way you would see your own right arm. Can you name the labeled structures? Need help? Go back to the section *Body Parts and Areas* or look ahead to Fig. 7-11 in Chapter 7.



**QUESTION FIGURE 1-1:** A midtransverse section of right upper arm.

6. Question Figure 1-2 is a schematic representation of the interdependency of several of the body's organ systems depicted in a rectangular organism. The lettered arrows represent interactions of the body with the environment. The numbered arrows represent internal interactions. Label each arrow with what is moving.



**QUESTION FIGURE 1-2:** Relationships of organ systems.