12. Name the major organ systems, and list the organs associated with each. (p. 12)
13. Describe the general functions of each organ system. (p. 12)

1.7 Anatomical Terminology

14. Properly use the terms that describe relative positions, body sections, and body regions. (p. 14)

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Module 1: Body Orientation

Aids to Understanding Words

(Appendix A on page 564 has a complete list of Aids to Understanding Words.)

append- [to hang something] *append*icular: Pertaining to the limbs.

cardi- [heart] peri*cardi*um: Membrane that surrounds the heart.

cran- [helmet] *cran*ial: Pertaining to the portion of the skull that surrounds the brain.

dors- [back] *dors*al: Position toward the back.

homeo- [same] *homeo*stasis: Maintenance of a stable internal environment.

-logy [study of] physio*logy*: Study of body functions.

meta- [change] *meta*bolism: Chemical changes that occur within the body.

pariet- [wall] *pariet*al membrane: Membrane that lines the wall of a cavity.

pelv- [basin] *pelv*ic cavity: Basin-shaped cavity enclosed by the pelvic bones.

peri- [around] *peri*cardial membrane: Membrane that surrounds the heart.

pleur- [rib] *pleur*al membrane: Membrane that encloses the lungs and lines the thoracic cavity.

-stasis [standing still] homeo*stasis*. Maintenance of a stable internal environment.

-tomy [cutting] ana*tomy*: Study of structure, which often involves cutting or removing body parts.

1.1 INTRODUCTION

Modern medicine began with long-ago observations on the function, and malfunction, of the human body. The study of the human body probably began with our earliest ancestors, who must have been curious about how their bodies worked, as we are today. At first their interests most likely concerned injuries and illnesses, because healthy bodies demand little attention from their owners. Early healers relied heavily on superstitions and notions about magic. However, as healers tried to help the sick, they began to discover useful ways of examining and treating the human body. They observed the effects of injuries, noticed how wounds healed, and examined cadavers to determine causes of death. They also found that certain herbs and potions could sometimes be used to treat coughs, headaches, fevers, and other common signs of illness.

Over time, people began to believe that humans could understand forces that caused natural events. They began observing the world around them more closely, asking questions and seeking answers. This set the stage for the development of modern medical science.

As techniques for making accurate observations and performing careful experiments evolved, knowledge of the human body expanded rapidly (fig. 1.1). At the same time, early medical providers coined many new terms to name body parts, describe their locations, and explain their functions and interactions. These terms, most of which originated from Greek and Latin words, formed the basis for the language of anatomy and physiology that persists today. (The names of some modern medical and applied sciences are listed on pages 17–19.)

Practice

1. What factors probably stimulated an early interest in the human body?
2. What kinds of activities helped promote the development of modern medical science?

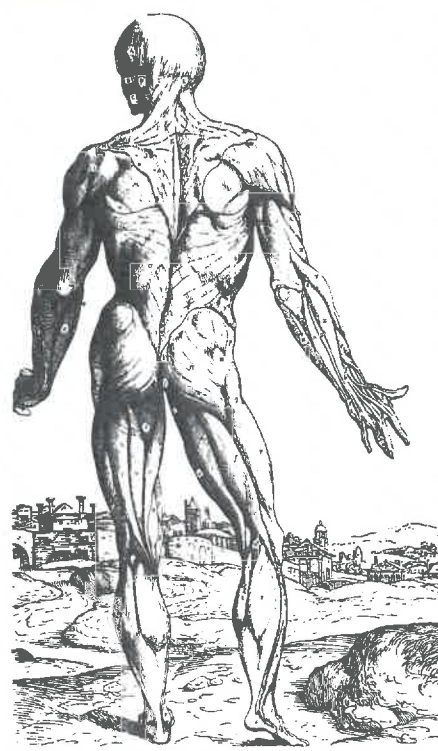


Figure 1.1

The study of the human body has a long history, as evidenced by this illustration from the second book of *De Humani Corporis Fabrica* by Andreas Vesalius, issued in 1543. (Note the similarity to the anatomical position, described later in this chapter on page 14.)

1.2 ANATOMY AND PHYSIOLOGY

Anatomy (ah-nat′o-me) is the branch of science that deals with the structure (morphology) of body parts—their forms and how they are organized. **Physiology** (fiz″e-ol′o-je), on the other hand, concerns the functions of body parts—what they do and how they do it.

The topics of anatomy and physiology are difficult to separate because the structures of body parts are so closely associated with their functions. Body parts form a well-organized unit—the human organism—and each part functions in the unit's operation. A particular body part's function depends on the way the part is constructed—that is, how its subparts are organized. For example, the organization of the parts in the human hand with its long, jointed fingers makes it easy to grasp objects; the hollow chambers of the heart are adapted to pump blood through tubular blood vessels; the shape of the mouth enables it to receive food; and teeth are shaped to break solid foods into small pieces (fig. 1.2).

Anatomy and physiology are ongoing as well as ancient fields. Researchers frequently discover new information about physiology, particularly at the molecular level since the human genome was sequenced in 2001. Less frequently they discover new parts of human anatomy, such as a small piece of connective tissue between the upper part of the spinal cord and a muscle at the back of the head. This connective tissue bridge may trigger pain impulses in certain types of tension headaches.

By discovering which of our 20,500 or so genes are active in particular diseases, researchers are finding commonalities among illnesses that are not apparent on the whole-body level, suggesting new treatments. These connections form what researchers call a "diseasome."

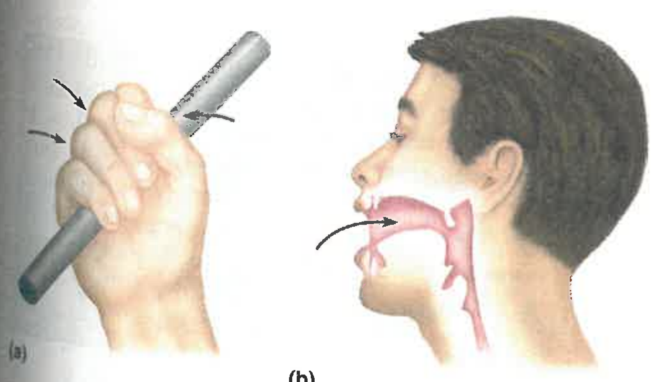


Figure 1.2
The structures of body parts make possible their functions: **(a)** The hand is adapted for grasping, **(b)** the mouth for receiving food. (Arrows indicate movements associated with these functions.)

Practice

3. Why is it difficult to separate the topics of anatomy and physiology?
4. List several examples that illustrate how the structure of a body part makes possible its function.

1.3 LEVELS OF ORGANIZATION

Until the invention of magnifying lenses and microscopes about 400 years ago, anatomists were limited in their studies to what they could see with the unaided eye—large parts. But with these new tools, investigators discovered that larger body structures are made up of smaller parts, which in turn are composed of even smaller ones.

Figure 1.3 shows the levels of organization that modern-day scientists recognize. All materials, including those that make up the human body, are composed of chemicals. Chemicals consist of microscopic particles called **atoms,** which join to form **molecules.** Small molecules can combine in complex ways to form larger **macromolecules.**

In the human and other organisms, the basic unit of structure and function is a **cell,** which is microscopic. Although cells vary in size, shape, and specialized functions, all share certain characteristics. For instance, all cells of humans and other complex organisms contain structures called **organelles** (or″gah-nelz′) that carry out specific activities. Organelles are composed of aggregates of macromolecules, such as proteins, carbohydrates, lipids, and nucleic acids.

Cells may be organized into layers or other structures that have common functions. Such a group of cells forms a **tissue.** Groups of different tissues that interact form **organs**—complex structures with specialized functions—and groups of organs that function closely together compose **organ systems.** Organ systems make up an **organism** (or′gah-nizm), which is a living thing.

Body parts can be described in terms of different levels of organization, such as the *atomic level,* the *molecular level,* or the *cellular level.* Furthermore, body parts differ in complexity from one level to the next. That is, atoms are less complex than molecules, molecules are less complex than organelles, tissues are less complex than organs, and so forth.

Chapters 2–6 discuss these levels of organization in more detail. Chapter 2 describes the atomic and molecular levels. Chapter 3 deals with organelles and cellular structures and functions, and chapter 4 explores cellular metabolism. Chapter 5 describes tissues and presents membranes (linings) as examples of organs, and chapter 6 considers the skin and its accessory organs as an

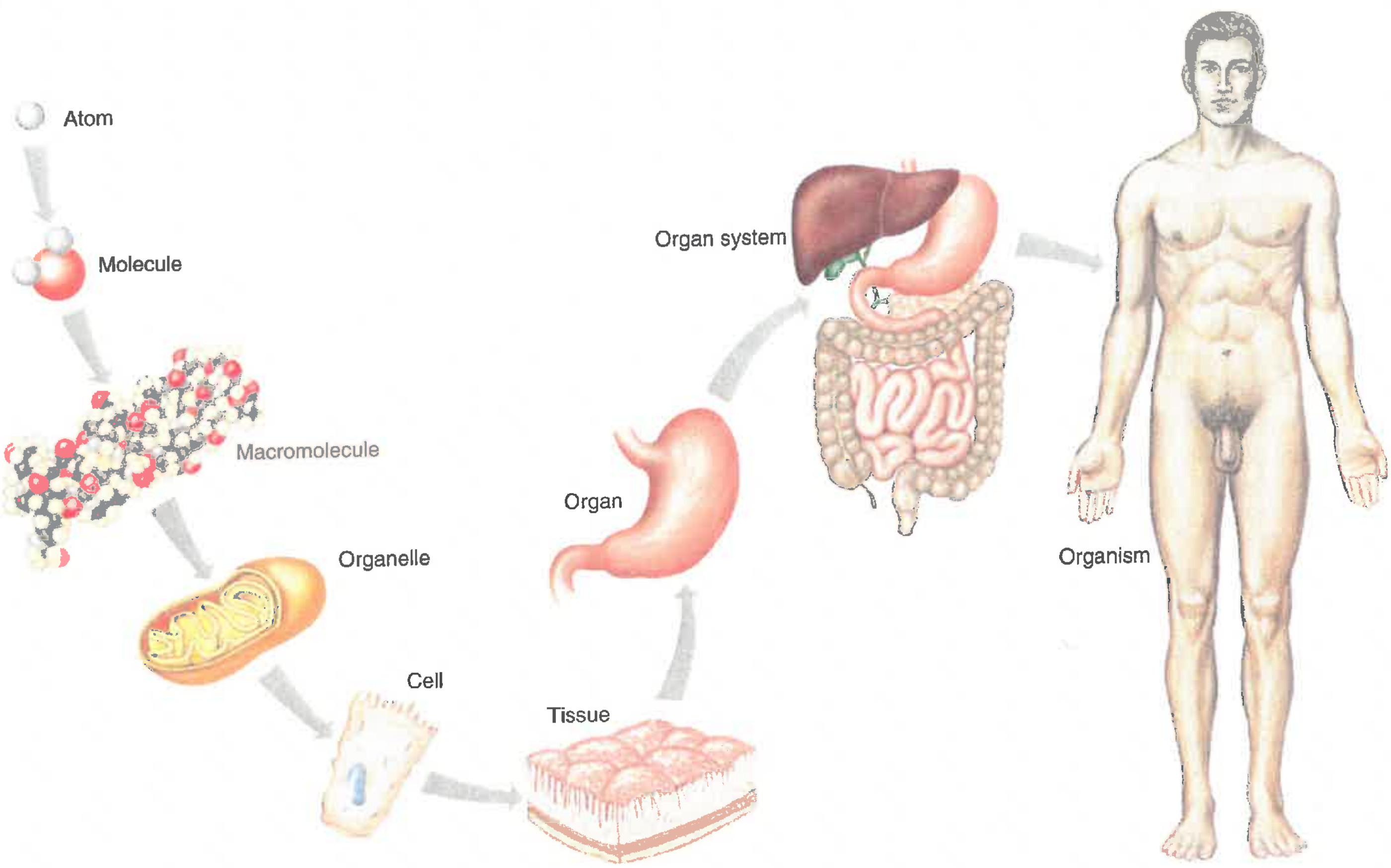


Figure 1.3
A human body is composed of parts within parts, with increasing complexity.

example of an organ system. In the remaining chapters, the structures and functions of each of the other organ systems are described in detail.

Practice

5. How does the human body illustrate levels of organization?
6. What is an organism?
7. How do body parts at different levels of organization vary in complexity?

1.4 CHARACTERISTICS OF LIFE

Before beginning a more detailed study of anatomy and physiology, it is helpful to consider some of the traits humans share with other organisms, particularly with other animals. As living organisms, we can move and respond to our surroundings. We start out as small individuals and then grow, eventually becoming able to reproduce. We gain energy by taking in or ingesting food, by breaking it down or digesting it, and by absorbing and assimilating it. The absorbed substances circulate throughout the internal environment of our bodies. We can then, by the process of respiration, release the energy in these nutrients for use in such vital functions as growth and repair of body parts. Finally, we excrete wastes from the body. All of these processes involve **metabolism** (mĕ-tab′o-lizm), the sum total of all of the chemical reactions in the body that break substances down and build them up. The reactions of metabolism enable us to acquire and use energy to fuel life processes. Table 1.1 summarizes the characteristics of life.

Practice

8. What are the characteristics of life?
9. How are the characteristics of life dependent on metabolism?

Table 1.1	Characteristics of Life
Process	**Examples**
Movement	Change in position of the body or of a body part; motion of an internal organ
Responsiveness	Reaction to a change inside or outside the body
Growth	Increase in body size without change in shape
Reproduction	Production of new organisms and new cells
Respiration	Obtaining oxygen, removing carbon dioxide, and releasing energy from foods (Some forms of life do not use oxygen in respiration.)
Digestion	Breakdown of food substances into simpler forms that can be absorbed and used
Absorption	Passage of substances through membranes and into body fluids
Circulation	Movement of substances in body fluids
Assimilation	Changing absorbed substances into chemically different forms
Excretion	Removal of wastes produced by metabolic reactions

1.5 MAINTENANCE OF LIFE

The structures and functions of almost all body parts help maintain life. Even an organism's reproductive structures, whose primary function is to ensure that its species will continue into the future, may contribute to survival. For example, sex hormones help to strengthen bones.

Requirements of Organisms

Being alive requires certain environmental factors, including the following:

1. **Water** is the most abundant chemical in the body. It is required for many metabolic processes and provides the environment in which most of them take place. Water also transports substances within the organism and is important in regulating body temperature.
2. **Foods** are substances that provide the body with necessary chemicals (nutrients) in addition to water. Some of these chemicals are used as energy sources, others supply raw materials for building new living matter, and still others help regulate vital chemical reactions.
3. **Oxygen** is a gas that makes up about one-fifth of ordinary air. It is used to release energy from food substances. This energy, in turn, drives metabolic processes.
4. **Heat** is a form of energy. It is a product of metabolic reactions, and the degree of heat present partly determines the rate at which these reactions occur. Generally, the more heat, the more rapidly chemical reactions take place. (*Temperature* is a measure of the degree of heat.)
5. **Pressure** is an application of force to something. For example, the force on the outside of the body due to the weight of air above it is called *atmospheric pressure*. In humans, this pressure is important in breathing. Similarly, organisms living under water are subjected to *hydrostatic pressure*—a pressure a liquid exerts—due to the weight of water above them. In humans, heart action produces blood pressure (another form of hydrostatic pressure), which forces blood through blood vessels.

Health-care workers repeatedly monitor patients' *vital signs*—observable body functions that reflect essential metabolic activities. Vital signs indicate that a person is alive. Assessment of vital signs includes measuring body temperature and blood pressure and monitoring rates and types of pulse and breathing movements. Absence of vital signs signifies death. A person who has died displays no spontaneous muscular movements, including those of the breathing muscles and beating heart. A dead body does not respond to stimuli and has no reflexes, such as the knee-jerk reflex and the pupillary reflexes of the eye. Brain waves cease with death, as demonstrated by a flat electroencephalogram (EEG), which signifies a lack of electical activity in the brain.

Organisms require water, food, oxygen, heat, and pressure, but these alone are not enough to ensure survival. Both the quantities and the qualities of such factors are also important. For example, the volume of water entering and leaving an organism must be regulated, as must the concentration of oxygen in body fluids. Similarly, survival depends on the quality as well as the quantity of food available—that is, food must supply the correct nutrients in adequate amounts.

Homeostasis

Factors in the external environment may change. If an organism is to survive, however, conditions within the fluid surrounding its body cells, which compose its **internal environment,** must remain relatively stable (fig. 1.4). In other words, body parts function only when the concentrations of water, nutrients, and oxygen and the conditions of heat and pressure remain within certain narrow limits. This condition of a stable internal environment is called **homeostasis** (ho″me-ō-sta′sis).

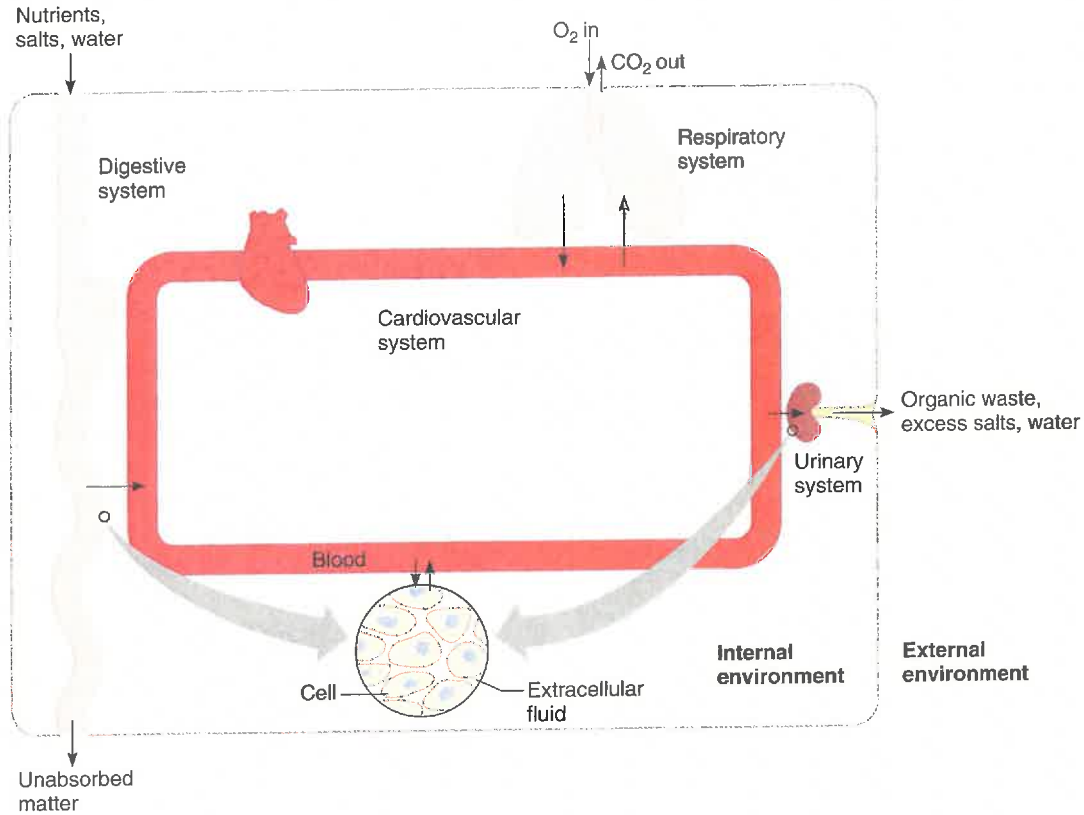


Figure 1.4
Our cells lie within an internal fluid environment (extracellular fluid). Concentrations of water, nutrients, and oxygen in the internal environment must be maintained within certain ranges to sustain life.

The body maintains homeostasis through a number of self-regulating control systems, or **homeostatic mechanisms,** that share the following three components (fig. 1.5):

- **Receptors** provide information about specific conditions (stimuli) in the internal environment.
- A **set point** tells what a particular value should be, such as body temperature at 37°C (Celsius) or 98.6°F (Fahrenheit). More about metric equivalents can be found in Appendix B (p. 565), since metric units are used throughout this text.
- **Effectors** cause responses that alter conditions in the internal environment.

A homeostatic mechanism works as follows. If the receptors measure deviations from the set point, effectors are activated that can return conditions toward normal. As conditions return toward normal, the deviation from the set point progressively lessens and the effectors are gradually shut down. Such a response is called a **negative feedback** (neg′ah-tiv fēd′bak) mechanism, both because the deviation from the set point is corrected (moves in the opposite or negative direction) and because the correction reduces the action of the effectors. This latter aspect is important because it prevents a correction from going too far.

To better understand this idea of negative feedback, imagine a room equipped with a furnace and an air conditioner (fig. 1.6). Suppose the room temperature is to remain near 20°C (68°F), so the thermostat is adjusted to an operating level, or set point, of 20°C. Because a thermostat senses temperature changes, it will signal the furnace to start and the air conditioner to stop whenever the room temperature drops below the set point. If the temperature rises above the set point,

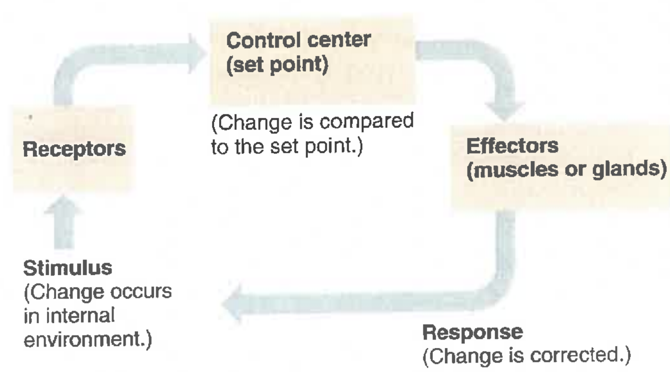


Figure 1.5
A homeostatic mechanism monitors a particular aspect of the internal environment and corrects any changes back to the value indicated by the set point.

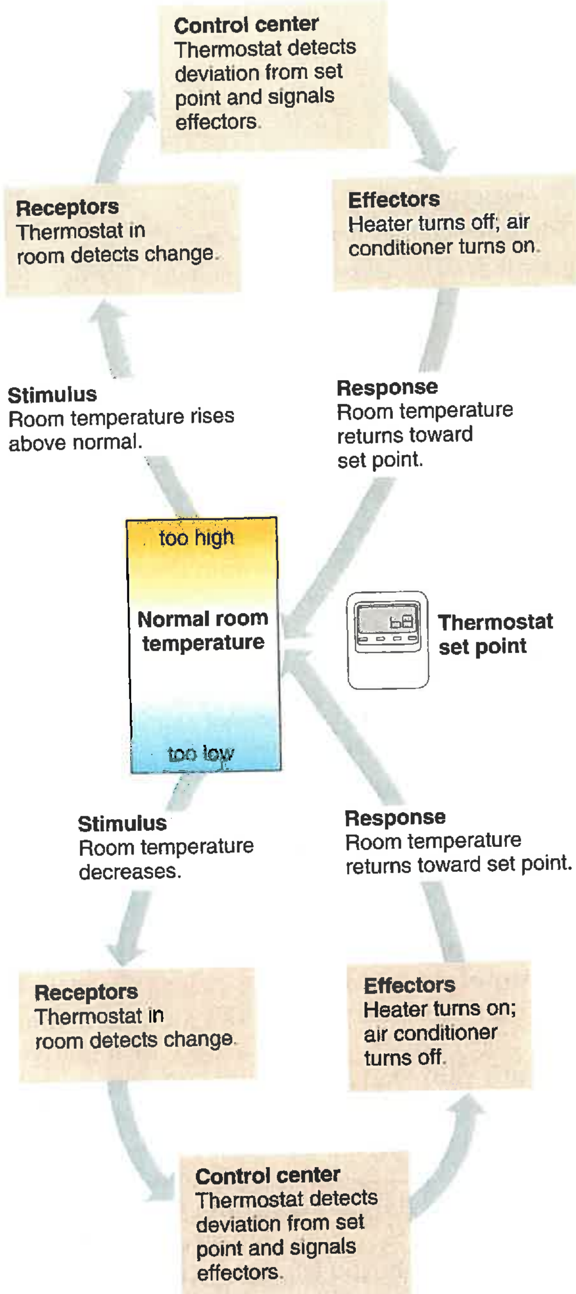


Figure 1.6

A thermostat signals an air conditioner and a furnace to turn on or off to maintain a relatively stable room temperature. This system is an example of a homeostatic mechanism.

Q: *What would happen to room temperature if the set point were turned up?*

Answer can be found in Appendix E on page 568.

the thermostat will stop the furnace and start the air conditioner. As a result, the room will maintain a relatively constant temperature.

A similar homeostatic mechanism regulates body temperature. Temperature receptors are scattered throughout the body. The "thermostat" is a temperature-sensitive region in a temperature control center of the brain. In healthy persons, the set point of the brain's thermostat is at or near 37°C (98.6°F).

If a person is exposed to cold and body temperature begins to drop, the temperature receptors sense this change and the temperature control center triggers heat-generating and heat-conserving activities. For example, small groups of muscles are stimulated to contract involuntarily, an action called *shivering*. Such muscular contractions produce heat, which helps warm the body. At the same time, blood vessels in the skin are signaled to constrict so that less warm blood flows through them. In this way, deeper tissues retain heat that might otherwise be lost.

If a person is becoming overheated, the brain's temperature control center triggers a series of changes that promote loss of body heat. Sweat glands in the skin secrete perspiration, and as this fluid evaporates from the surface, heat is carried away and the skin is cooled. At the same time, the brain center dilates blood vessels in the skin. This action allows the blood carrying heat from deeper tissues to reach the surface, where heat is lost to the outside (fig. 1.7). The brain stimulates an increase in heart rate, which sends a greater volume of blood into surface vessels, and an increase in breathing rate, which allows the lungs to expel more heat-carrying air. Body temperature regulation is discussed further in chapter 6 (p. 125).

Another homeostatic mechanism regulates the blood pressure in the blood vessels (arteries) leading away from the heart. In this instance, pressure-sensitive receptors in the walls of these vessels sense changes in blood pressure and signal a pressure control center in the brain. If blood pressure is above the set point, the brain signals the heart chambers to contract more slowly and with less force. This decreased heart action sends less blood into the blood vessels, decreasing the pressure inside them. If blood pressure falls below the set point, the brain center signals the heart to contract more rapidly and with greater force. As a result, the pressure in the vessels increases. Chapter 13 (pp. 361–362) discusses regulation of blood pressure in more detail.

Human physiology offers many other examples of homeostatic mechanisms. All work by the same general process as the two preceding examples. Just as anatomical terms are used repeatedly throughout this book, so can the basic principles of a homeostatic mechanism be applied to the different organ systems. Homeostatic mechanisms maintain a relatively constant internal environment, yet physiological values may vary slightly in a person from time to time or from one individual to the next. Therefore, both normal values for an individual and the *normal range* for the general population are clinically important.

Most feedback mechanisms in the body are negative. However, sometimes change stimulates further change. A process that moves conditions away from the normal state is called a *positive feedback mechanism*. In blood clotting, for example, the chemicals that carry out clotting stimulate more clotting, minimizing bleeding (see chapter 12, p. 331). Another positive feedback

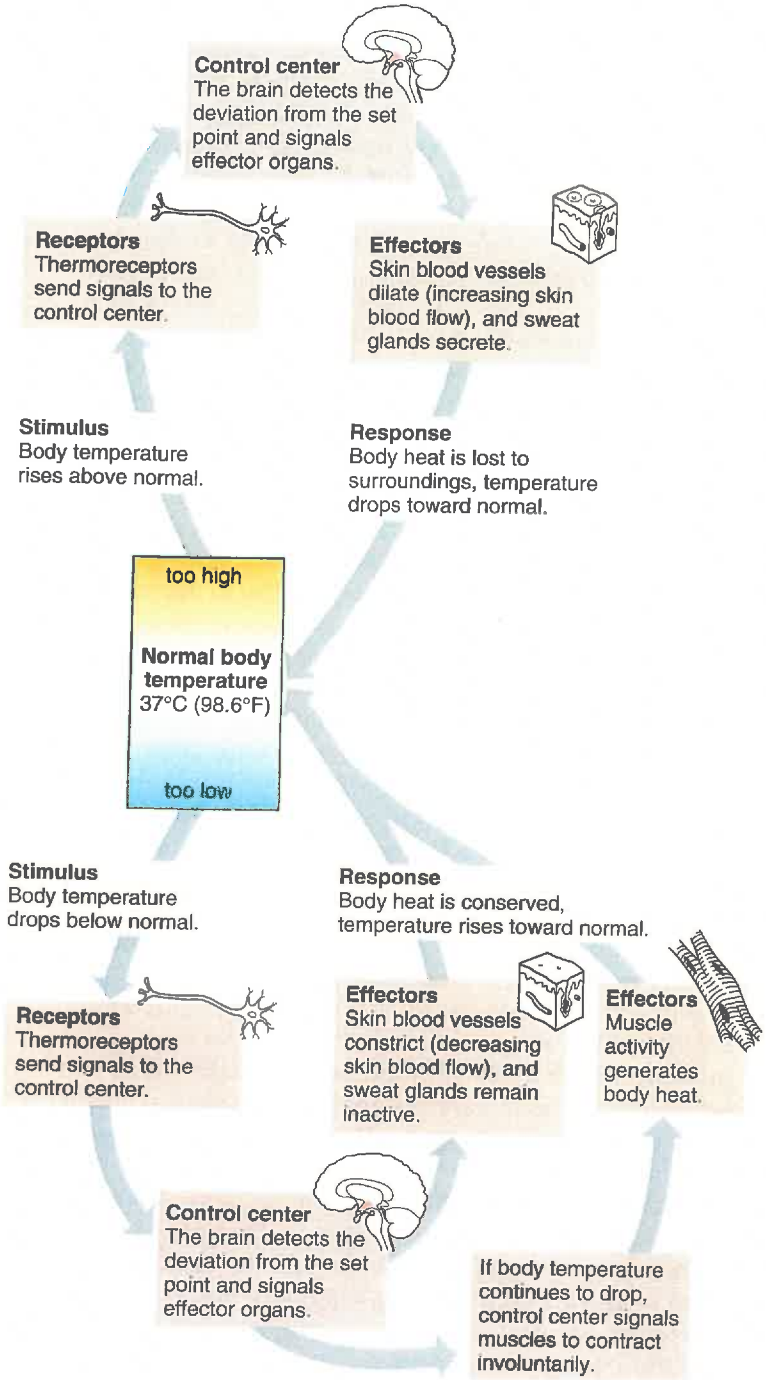


Figure 1.7
A homeostatic mechanism regulates body temperature.

mechanism increases the strength of uterine contractions during childbirth, helping to bring the new individual into the world.

Positive feedback mechanisms usually produce unstable conditions, which might seem incompatible with homeostasis. However, the examples of positive feedback associated with normal health have very specific functions and are short-lived.

Practice

10. What requirements of organisms does the external environment provide?
11. Why is homeostasis important to survival?
12. Describe two homeostatic mechanisms.

1.6 ORGANIZATION OF THE HUMAN BODY

The human organism is a complex structure composed of many parts. Its major features include several body cavities, layers of membranes within these cavities, and a variety of organ systems.

Body Cavities

The human organism can be divided into an **axial** (ak′se-al) portion, which includes the head, neck, and trunk, and an **appendicular** (ap″en-dik′u-lar) portion, which includes the upper and lower limbs. Within the axial portion are the **cranial cavity,** which houses the brain; the **vertebral canal,** which contains the spinal cord within the sections of the backbone (vertebrae); the **thoracic** (tho-ras′ik) **cavity;** and the **abdominopelvic** (ab-dom″ĭ-no-pel′vik) **cavity.** The organs within these last two cavities are called **viscera** (vis′er-ah) (fig. 1.8*a*).

A broad, thin skeletal (voluntary) muscle called the **diaphragm** separates the thoracic cavity from the abdominopelvic cavity. The thoracic cavity wall is composed of skin, skeletal muscles, and various bones.

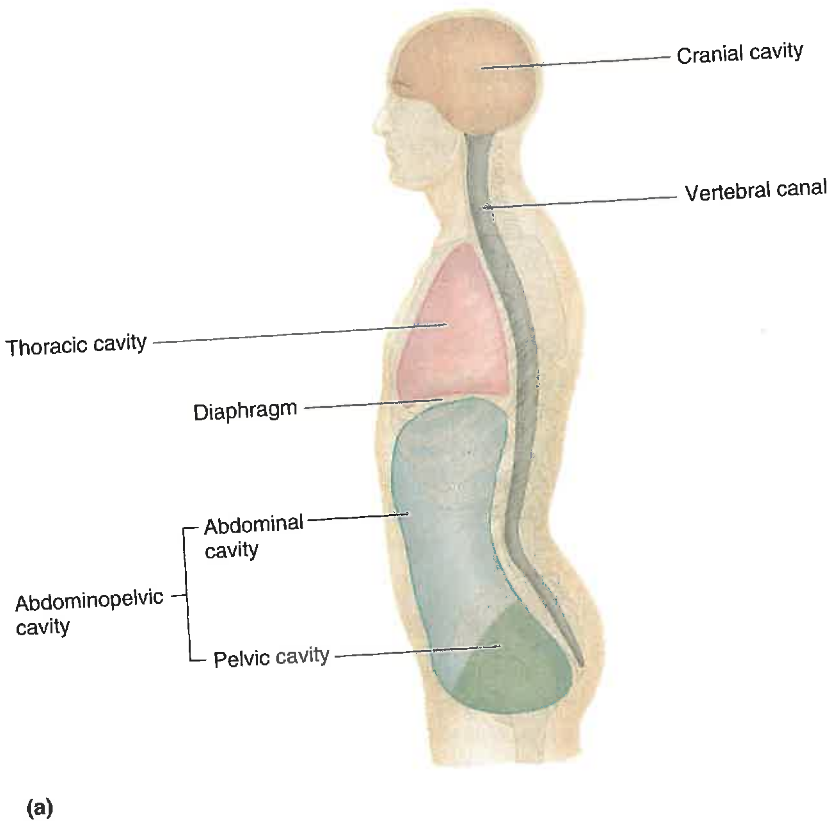
A region called the **mediastinum** (me″de-as-ti′num) separates the thoracic cavity into two compartments, which contain the right and left lungs. The remaining thoracic viscera—heart, esophagus, trachea, and thymus—are located within the mediastinum (fig. 1.8*b*).

The abdominopelvic cavity, which includes an upper abdominal portion and a lower pelvic portion, extends from the diaphragm to the floor of the pelvis. Its wall consists primarily of skin, skeletal muscles, and bones. The viscera within the **abdominal cavity** include the stomach, liver, spleen, gallbladder, kidneys, and most of the small and large intestines.

The **pelvic cavity** is the portion of the abdominopelvic cavity enclosed by the hip bones (see chapter 7, p. 158). It contains the terminal portion of the large intestine, the urinary bladder, and the internal reproductive organs.

Smaller cavities within the head include (fig. 1.9):

1. **Oral cavity,** containing the teeth and tongue.
2. **Nasal cavity,** located within the nose and divided into right and left portions by a nasal septum.



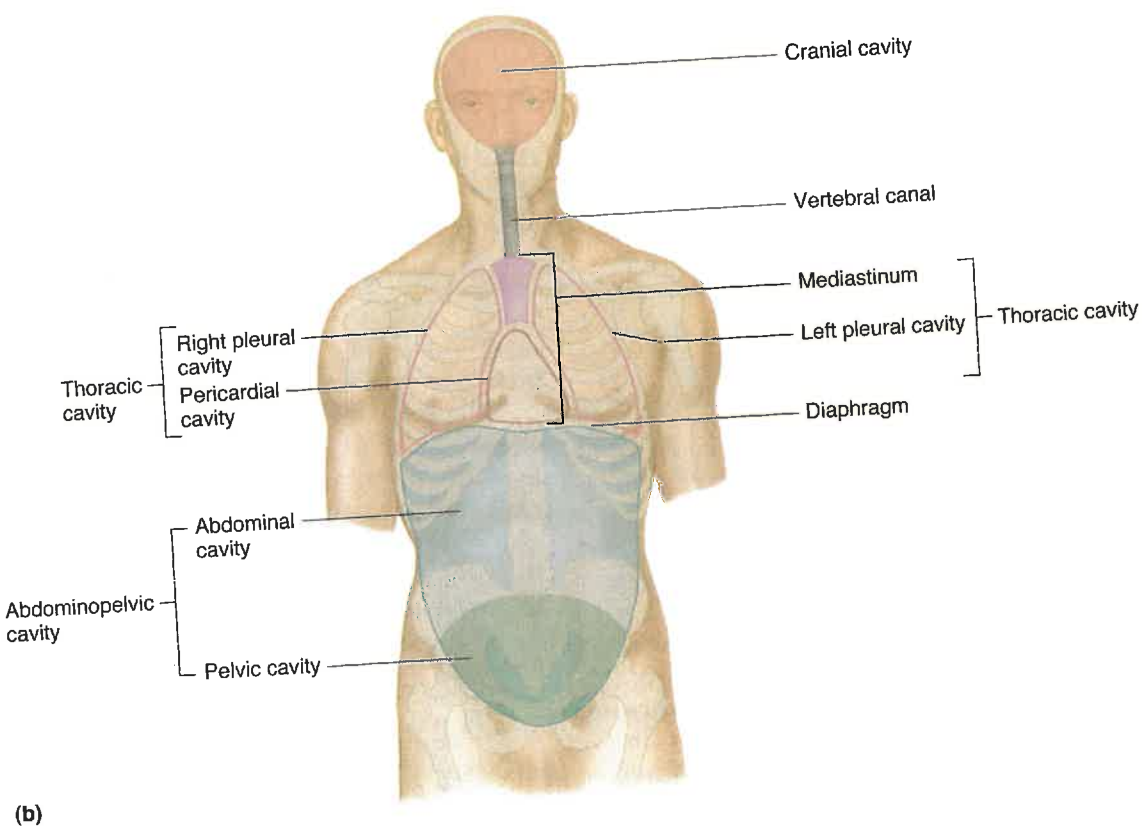


Figure 1.8 AP|R
Major body cavities. **(a)** Lateral view. **(b)** Anterior view.

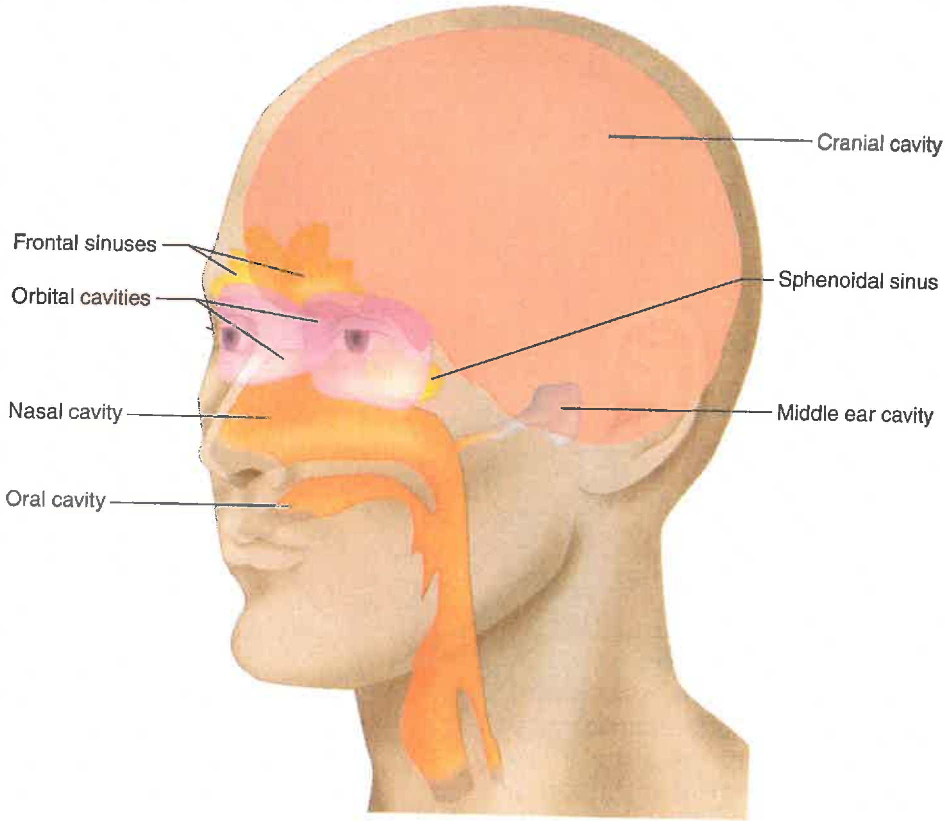


Figure 1.9

The cavities within the head include the cranial, oral, nasal, orbital, and middle ear cavities, as well as several sinuses. (Not all of the sinuses are shown.)

Several air-filled *sinuses* connect to the nasal cavity (see chapter 7, pp. 144–148). These include the frontal and sphenoidal sinuses shown in figure 1.9.

3. **Orbital cavities,** containing the eyes and associated skeletal muscles and nerves.
4. **Middle ear cavities,** containing the middle ear bones.

Thoracic and Abdominopelvic Membranes

The walls of the right and left thoracic compartments, which contain the lungs, are lined with a membrane called the *parietal pleura* (fig. 1.10). A similar membrane, called the *visceral pleura,* covers each lung. (Note: **Parietal** [pah-ri′ĕ-tal] refers to the membrane attached to the wall of a cavity; **visceral** [vis′er-al] refers to the membrane that is deeper—toward the interior—and covers an internal organ, such as a lung.)

The parietal and visceral **pleural membranes** (ploo′ral mem′brānz) are separated by a thin film of watery fluid (serous fluid), which they secrete. While no actual space normally exists between these membranes, the potential space between them is called the *pleural cavity* (see figs. 1.8*b* and 1.10).

The heart, which is located in the broadest portion of the mediastinum, is surrounded by **pericardial** (per″ĭ-kar′de-al) **membranes.** A thin *visceral pericardium* covers the heart's surface and is separated from a thicker *parietal pericardium* by a small volume of fluid. The *pericardial cavity* (see figs. 1.8*b* and 1.10) is the potential space between these membranes.

In the abdominopelvic cavity, the lining membranes are called **peritoneal** (per″ĭ-to-ne′al) **membranes.** A *parietal peritoneum* lines the wall, and a *visceral peritoneum* covers each organ in the abdominal cavity (fig. 1.11). The *peritoneal cavity* is the potential space between these membranes.

Practice

13. What does *viscera* mean?
14. Which organ occupies the cranial cavity? the vertebral canal?
15. Name the cavities of the head.
16. Describe the membranes associated with the thoracic and abdominopelvic cavities.

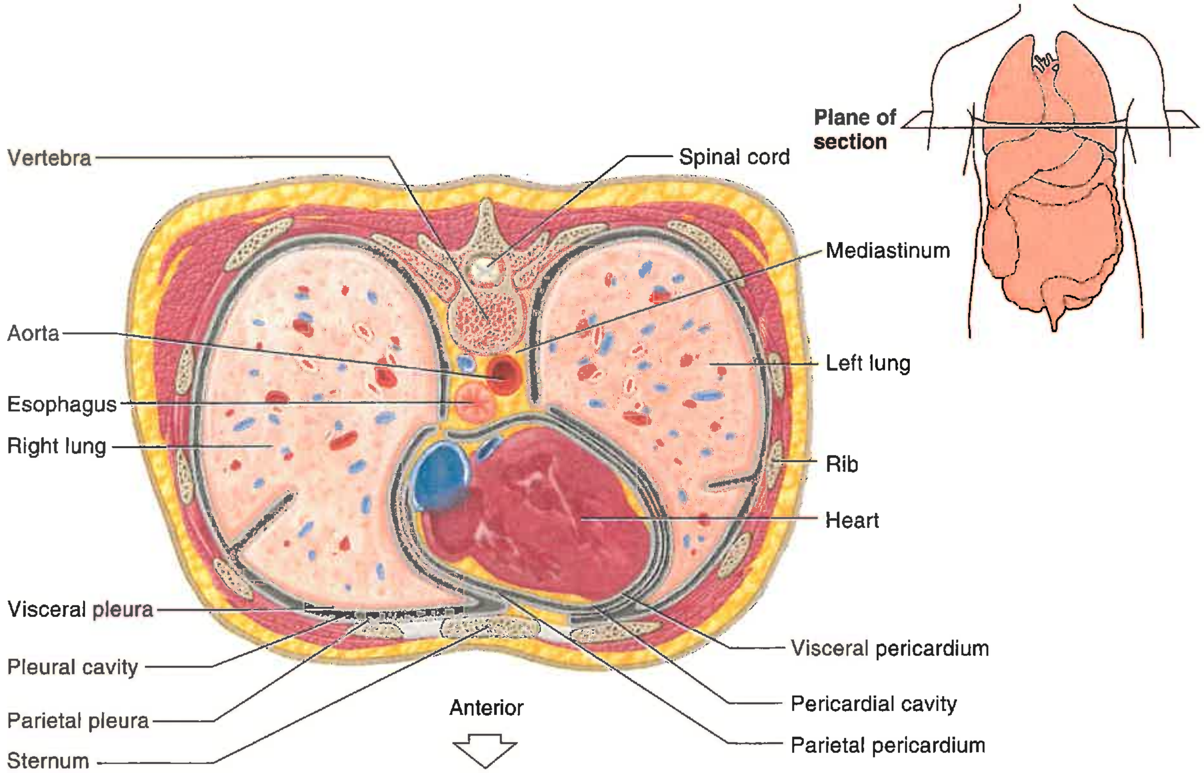


Figure 1.10 APR
A transverse section through the thorax reveals the serous membranes associated with the heart and lungs (superior view).

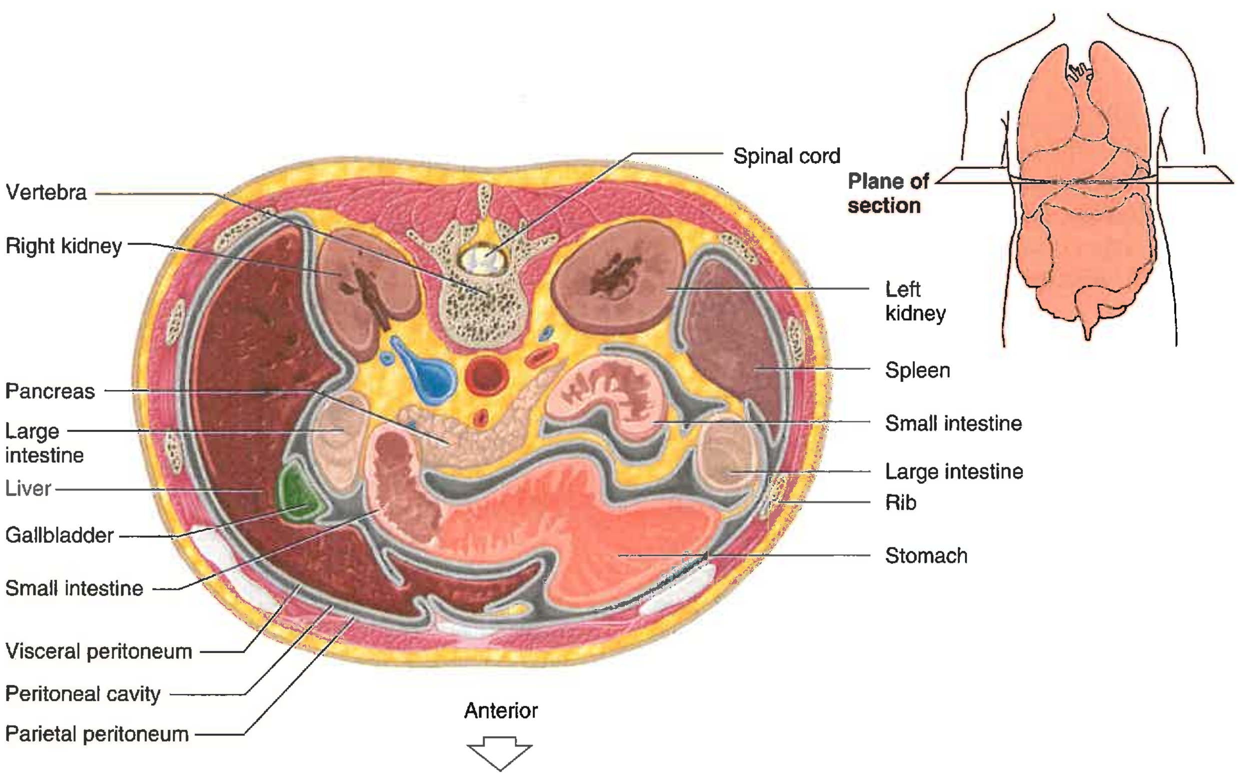


Figure 1.11 APR
Transverse section through the abdomen (superior view).

Organ Systems

The human organism consists of several organ systems. Each system includes a set of interrelated organs that work together, allowing each system to provide specialized functions that contribute to homeostasis (fig. 1.12). As you read about each system, you may want to consult the illustrations of the human torso in the Reference Plates (see pp. 23–29) and locate some of the organs described.

Body Covering

Organs of the **integumentary** (in-teg-u-men′tar-e) **system** (see chapter 6) include the skin and various accessory organs, such as the hair, nails, sweat glands, and sebaceous glands. These parts protect underlying tissues, help regulate body temperature, house a variety of sensory receptors, and synthesize certain products.

Support and Movement

The organs of the skeletal and muscular systems (see chapters 7 and 8) support and move body parts. The **skeletal** (skel′ĕ-tal) **system** consists of bones, as well as ligaments and cartilages that bind bones together. These parts provide frameworks and protective shields for softer tissues, are attachments for muscles, and act with muscles when body parts move. Tissues within bones also produce blood cells and store inorganic salts.

Muscles are the organs of the **muscular** (mus′ku-lar) **system.** By contracting and pulling their ends closer together, muscles provide forces that move body parts. They also maintain posture and are the main source of body heat.

Integration and Coordination

For the body to act as a unit, its parts must be integrated and coordinated. The nervous and endocrine systems control and adjust various organ functions, thus helping to maintain homeostasis.

The **nervous** (ner′vus) **system** (see chapter 9) consists of the brain, the spinal cord, nerves, and sense organs (see chapter 10). The cells of the nervous system communicate with each other and with muscles and glands using chemical signals called *neurotransmitters.* Each neurotransmitter exerts a relatively short-term effect on its target. Some nerve cells are specialized sensory receptors that detect changes inside and outside the body. Other nerve cells receive information from these sensory receptors and interpret and respond to that information. Still other nerve cells extend from the brain or spinal cord to muscles or glands, stimulating them to contract or to secrete products.

The **endocrine** (en′do-krin) **system** (see chapter 11) includes all the glands that secrete chemical messengers called *hormones.* The hormones, in turn, move away from the glands in body fluids, such as blood or tissue fluid (fluid from the spaces within tissues). A particular hormone affects only a particular group of cells, called its *target cells.* A hormone alters the metabolism of its target cells. Compared to nerve impulses, hormonal effects occur over a relatively longer time period. Organs of the endocrine system include the hypothalamus of the brain; the pituitary, thyroid, parathyroid, and adrenal glands; and the pancreas, ovaries, testes, pineal gland, and thymus.

Transport

Two organ systems transport substances throughout the internal environment. The **cardiovascular** (kahr″de-o-vas′ku-lur) **system** (see chapters 12 and 13) includes the heart, arteries, veins, capillaries, and blood. The heart is a muscular pump that helps force blood through the blood vessels. Blood transports gases, nutrients, hormones, and wastes. It carries oxygen from the lungs and nutrients from the digestive organs to all body cells, where these biochemicals are used in metabolic processes. Blood also transports hormones and carries wastes from body cells to the excretory organs, where the wastes are removed from the blood and released to the outside.

The **lymphatic** (lim-fat′ik) **system** (see chapter 14) is closely related to the cardiovascular system. It is composed of the lymphatic vessels, lymph nodes, thymus, spleen, and a fluid called *lymph.* This system transports some of the tissue fluid back to the bloodstream and carries certain fatty substances away from the digestive organs and into the bloodstream. Cells of the lymphatic system are called lymphocytes, and they defend the body against infections by removing disease-causing microorganisms and viruses from tissue fluid.

Absorption and Excretion

Organs in several systems absorb nutrients and oxygen and excrete various wastes. For example, the organs of the **digestive** (di-jest′iv) **system** (see chapter 15) receive foods from the outside. Then they break down food molecules into simpler forms that can pass through cell membranes and be absorbed. Materials that are not absorbed are transported back to the outside and eliminated. Certain digestive organs also produce hormones and thus function as parts of the endocrine system. The digestive system includes the mouth, tongue, teeth, salivary glands, pharynx, esophagus, stomach, liver, gallbladder, pancreas, small intestine, and large intestine. Chapter 15 also discusses nutrition.

The organs of the **respiratory** (re-spi′rah-to″re) **system** (see chapter 16) move air in and out and exchange gases between the blood and the air. More specifically, oxygen passes from the air within the lungs into the blood, and carbon dioxide leaves the blood and enters the air. The nasal cavity, pharynx, larynx, trachea, bronchi, and lungs are parts of this system.

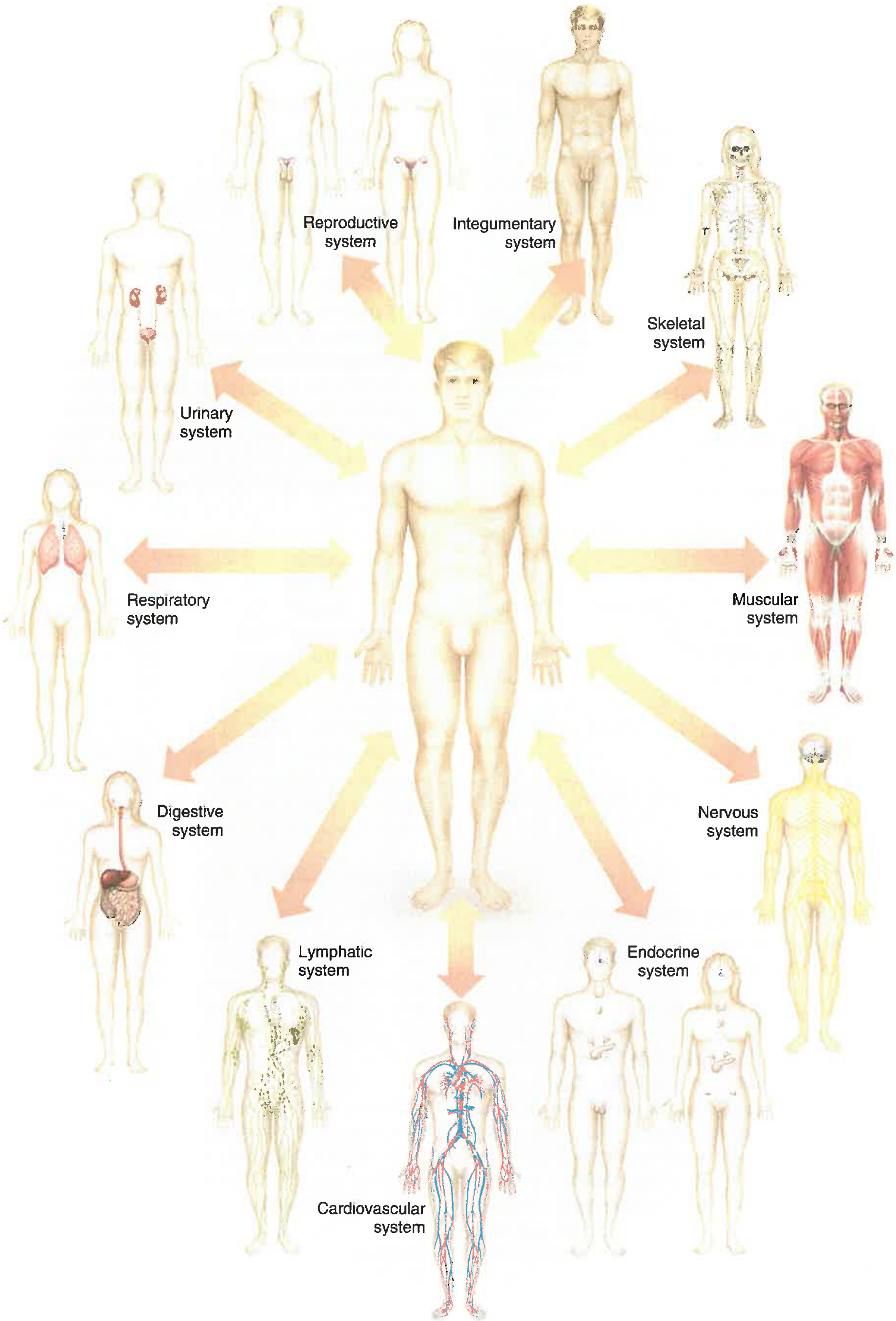


Figure 1.12 APIR
The organ systems in humans interact, maintaining homeostasis.

The **urinary** (u′rĭ-ner″e) **system** (see chapter 17) consists of the kidneys, ureters, urinary bladder, and urethra. The kidneys remove wastes from blood and help maintain the body's water and salt (electrolyte) concentrations. The product of these activities is urine. Other portions of the urinary system store urine and transport it outside the body. Chapter 18 discusses the urinary system's role in maintaining water and electrolyte concentrations and the acidity of the internal environment.

Reproduction

Reproduction is the process of producing offspring (progeny). Cells reproduce when they divide and give rise to new cells. However, the **reproductive** (re″pro-duk′tiv) **system** of an organism produces whole new organisms like itself (see chapter 19).

The male reproductive system includes the scrotum, testes, epididymides, ductus deferentia, seminal vesicles, prostate gland, bulbourethral glands, penis, and urethra. These parts produce and maintain sperm cells (spermatozoa). Components of the male reproductive system also transfer sperm cells into the female reproductive tract.

The female reproductive system consists of the ovaries, uterine tubes, uterus, vagina, clitoris, and vulva. These organs produce and maintain the female sex cells (egg cells, or oocytes), transport the female sex cells within the female reproductive system, and can receive the male sex cells (sperm cells) for the possibility of fertilizing an egg. The female reproductive system also supports development of embryos, carries fetuses to term, and functions in the birth process.

Practice

17. Name and list the organs of the major organ systems.
18. Describe the general functions of each organ system.

1.7 ANATOMICAL TERMINOLOGY

To communicate effectively with one another, researchers and clinicians have developed a set of precise terms to describe anatomy. These terms concern the relative positions of body parts, relate to imaginary planes along which cuts may be made, and describe body regions.

Use of such terms assumes that the body is in the **anatomical position.** This means that the body is standing erect, face forward, with the upper limbs at the sides and the palms forward. Note that the terms "right" and "left" refer to the right and left of the body in anatomical position.

Relative Positions

Terms of relative position describe the location of on body part with respect to another. They include the fo lowing (many of these terms are illustrated in fig. 1.13):

1. **Superior** means that a body part is above another part. (The thoracic cavity is superior to the abdominopelvic cavity.)
2. **Inferior** means that a body part is below another body part. (The neck is inferior to the head.)
3. **Anterior** (or *ventral*) means toward the front. (The eyes are anterior to the brain.)
4. **Posterior** (or *dorsal*) means toward the back. (The pharynx is posterior to the oral cavity.)
5. **Medial** refers to an imaginary midline dividing the body into equal right and left halves. A body part is medial if it is closer to the midline than another part. (The nose is medial to the eyes.)
6. **Lateral** means toward the side, away from the imaginary midline. (The ears are lateral to the eyes.)

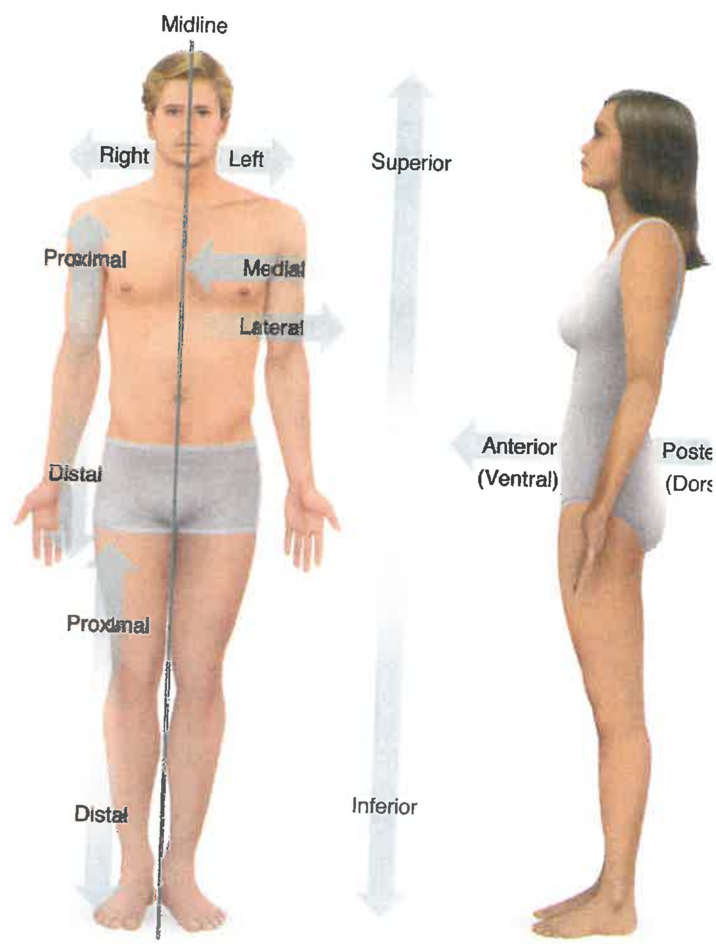


Figure 1.13 APIR
Relative positional terms describe a body part's location with respect to other body parts.

Q: *Which is more lateral, the hand or the hip?*

Answer can be found in Appendix E on page 568.

7. **Bilateral** refers to paired structures, one of which is on each side. (The lungs are bilateral.)
8. **Ipsilateral** refers to structures on the same side. (The right lung and the right kidney are ipsilateral.)
9. **Contralateral** refers to structures on the opposite side. (A patient with a fractured bone in the right leg would have to bear weight on the contralateral—in this case, left—lower limb.)
10. **Proximal** describes a body part that is closer to a point of attachment to the trunk than another body part. (The elbow is proximal to the wrist.) *Proximal* may also refer to another reference point, such as the proximal tubules, which are closer to the filtering structures in the kidney.
11. **Distal** is the opposite of proximal. It means that a particular body part is farther from a point of attachment to the trunk than another body part is. (The fingers are distal to the wrist.) Distal may also refer to another reference point, such as decreased blood flow distal to occlusion of a coronary artery.
12. **Superficial** means situated near the surface. (The epidermis is the superficial layer of the skin.) *Peripheral* also means outward or near the surface. It describes the location of certain blood vessels and nerves. (The nerves that branch from the brain and spinal cord are peripheral nerves.)
13. **Deep** describes parts that are more internal than superficial parts. (The dermis is the deep layer of the skin.)

Body Sections

Observing the relative locations and organization of internal body parts requires cutting or sectioning the body along various planes (fig. 1.14). The following terms describe such planes and the sections that result:

1. **Sagittal** refers to a lengthwise plane that divides the body into right and left portions. If a sagittal plane passes along the midline and thus divides the body into equal parts, it is called *median* (midsagittal). A sagittal section lateral to midline is called *parasagittal*.
2. **Transverse** (or *horizontal*) refers to a plane that divides the body into superior and inferior portions.
3. **Frontal** (or *coronal*) refers to a plane that divides the body into anterior and posterior portions.

Sometimes, a cylindrical organ such as a long bone is sectioned. In this case, a cut across the structure is called a *cross section*, an angular cut is an *oblique section*, and a lengthwise cut is a *longitudinal section* (fig. 1.15). Clinical Application 1.1 discusses using computerized tomography to view body sections.

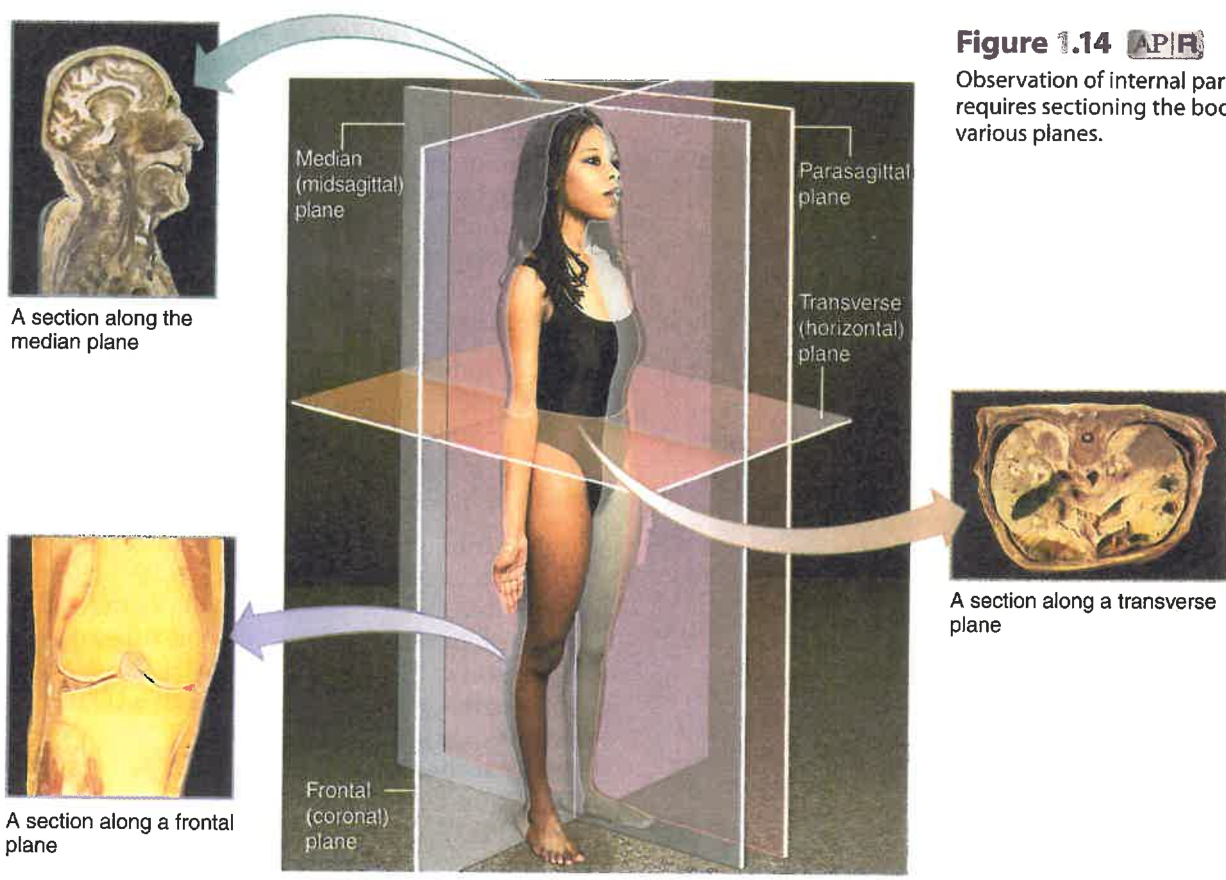


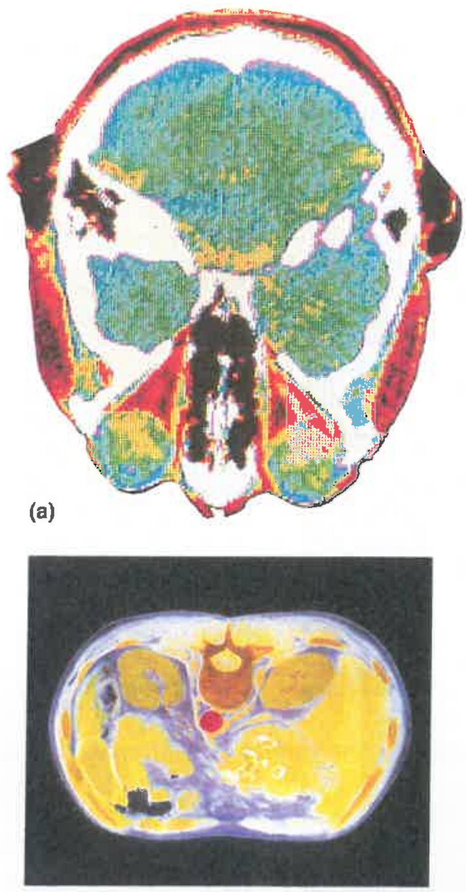
Figure 1.14 APIR

Observation of internal parts requires sectioning the body along various planes.

Clinical Application 1.1

Computerized Tomography

Radiologists use a procedure called *computerized tomography,* or CT scanning, to visualize internal organ sections (fig. 1A). In this procedure, an X-ray-emitting device moves around the body region being examined. At the same time, an X-ray detector moves in the opposite direction on the other side. As the devices move, an X-ray beam passes through the body from hundreds of different angles. Since tissues and organs of varying composition within the body absorb X rays differently, the amount of X ray reaching the detector varies from position to position. A computer records the measurements from the X-ray detector, and combines them mathematically to create a sectional image of the internal body parts that can be viewed on a monitor.

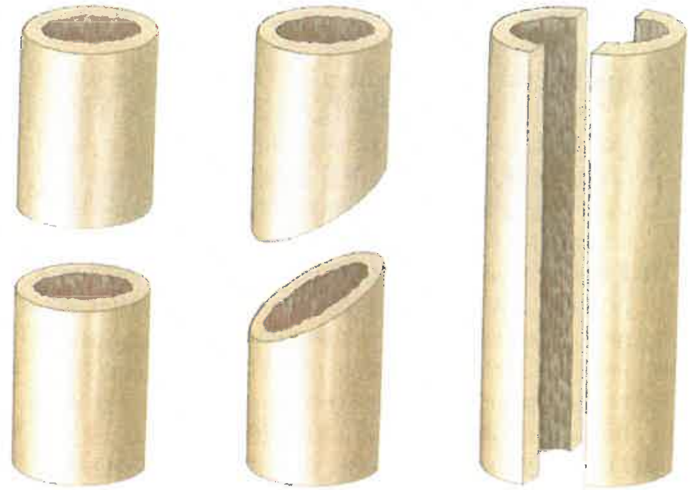


(a)

(b)

Figure 1A

Falsely colored CT (computerized tomography) scans of **(a)** the head and **(b)** the abdomen. *Note:* These are not shown in correct relative size.



(a) (b) (c)

Figure 1.15

Cylindrical parts may be cut in **(a)** cross section, **(b)** oblique section, or **(c)** longitudinal section.

Body Regions

A number of terms designate body regions. The abdominal area, for example, is subdivided into the following nine regions, as figure 1.16*a* shows:

1. The **epigastric region** is the upper middle portion.
2. The **right** and **left hypochondriac regions** lie on each side of the epigastric region.
3. The **umbilical region** is the middle portion.
4. The **right** and **left lumbar regions** lie on each side of the umbilical region.
5. The **hypogastric region** is the lower middle portion.
6. The **right** and **left iliac regions** (right and left inguinal regions) lie on each side of the hypogastric region.

The abdominal area is also often subdivided into four quadrants, as figure 1.16*b* shows.

The following adjectives are commonly used to refer to various body regions, some of which are illustrated in figure 1.17:

abdominal (ab-dom′ĭ-nal) The region between the thorax and pelvis.
acromial (ah-kro′me-al) The point of the shoulder.
antebrachial (an″te-bra′ke-al) The forearm.
antecubital (an″te-ku′bĭ-tal) The space in front of the elbow.
axillary (ak′sĭ-ler″e) The armpit.
brachial (bra′ke-al) The arm.
buccal (buk′al) The cheek.
carpal (kar′pal) The wrist.
celiac (se′le-ak) The abdomen.

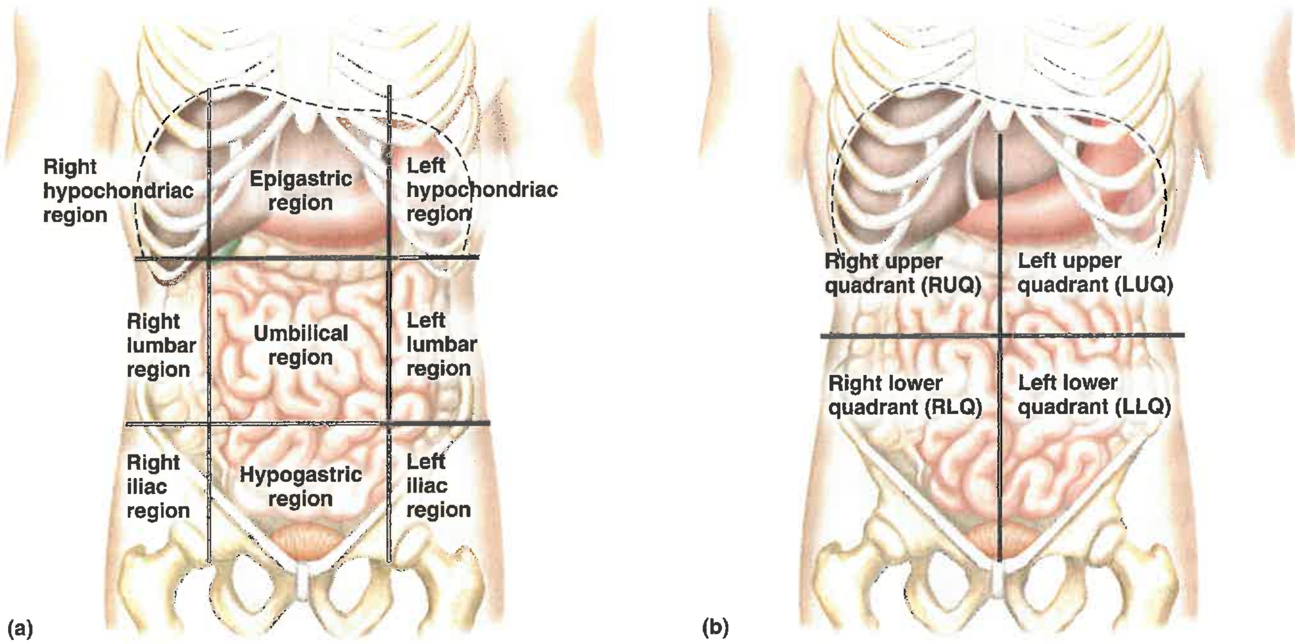


Figure 1.16 APR
The abdominal area is commonly subdivided in two ways: **(a)** into nine regions and **(b)** into four quadrants.

cephalic (sĕ-fal′ik) The head.
cervical (ser′vĭ-kal) The neck.
costal (kos′tal) The ribs.
coxal (kok′sal) The hip.
crural (krōōr′al) The leg.
cubital (ku′bĭ-tal) The elbow.
digital (dij′ĭ-tal) The finger or toe.
dorsal (dor′sal) The back.
femoral (fem′or-al) The thigh.
frontal (frun′tal) The forehead.
genital (jen′ĭ-tal) The reproductive organs.
gluteal (gloo′te-al) The buttocks.
inguinal (ing′gwĭ-nal) The groin—the depressed area of the abdominal wall near the thigh.
lumbar (lum′bar) The loin—the region of the lower back between the ribs and the pelvis.
mammary (mam′er-e) The breast.
mental (men′tal) The chin.
nasal (na′zal) The nose.
occipital (ok-sip′ĭ-tal) The lower posterior region of the head.
oral (o′ral) The mouth.
orbital (or′bi-tal) The bony socket of the eye.
palmar (pahl′mar) The palm of the hand.
patellar (pah-tel′ar) The front of the knee.
pectoral (pek′tor-al) The chest.
pedal (ped′al) The foot.
pelvic (pel′vik) The pelvis.
perineal (per″ĭ-ne′al) The perineum—the region between the anus and the external reproductive organs.
plantar (plan′tar) The sole of the foot.
popliteal (pop″lĭ-te′al) The area behind the knee.
sacral (sa′kral) The posterior region between the hip bones.
sternal (ster′nal) The middle of the thorax, anteriorly.
sural (su′ral) The calf of the leg.
tarsal (tahr′sal) The instep of the foot.
umbilical (um-bil′ĭ-kal) The navel.
vertebral (ver′te-bral) The spinal column.

Practice

19. Describe the anatomical position.
20. Using the appropriate terms, describe the relative positions of several body parts.
21. Describe the three types of body sections.
22. Name the nine regions of the abdomen.

Some Medical and Applied Sciences

cardiology (kar″de-ol′o-je) Branch of medical science dealing with the heart and heart diseases.
cytology (si-tol′o-je) Study of the structure, function, and abnormalities of cells. Cytology and histology are subdivisions of microscopic anatomy.
dermatology (der″mah-tol′o-je) Study of the skin and its diseases.
endocrinology (en″do-krĭ-nol′o-je) Study of hormones, hormone-secreting glands, and their diseases.
epidemiology (ep″ĭ-de″me-ol′o-je) Study of the factors determining the distribution and frequency

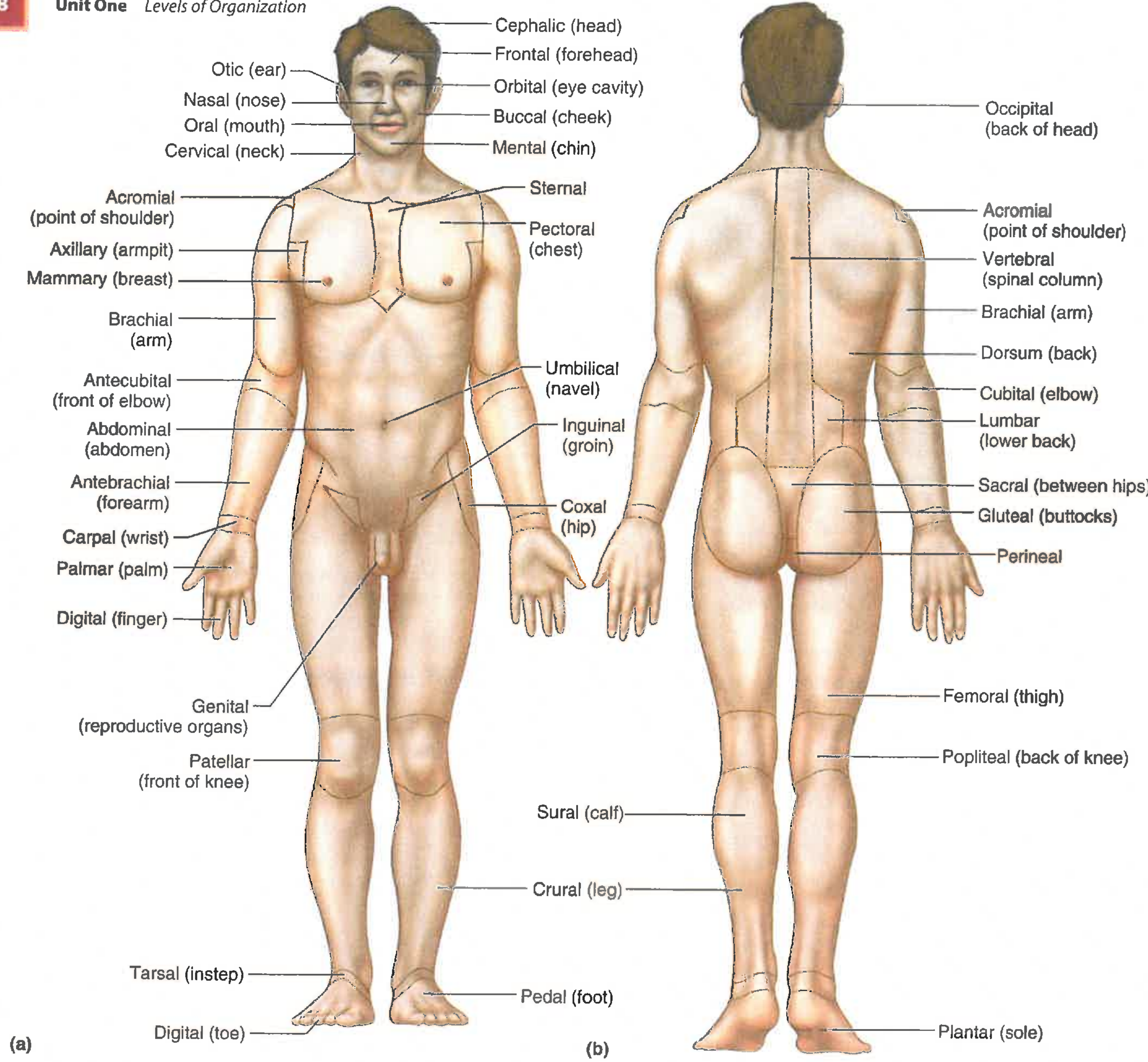


Figure 1.17

Some terms used to describe body regions. **(a)** Anterior regions. **(b)** Posterior regions.

of health-related conditions in a defined human population.

gastroenterology (gas″tro-en″ter-ol′o-je) Study of the stomach and intestines and their diseases.

geriatrics (jer″e-at′riks) Branch of medicine dealing with older individuals and their medical problems.

gerontology (jer″on-tol′o-je) Study of the aging process.

gynecology (gi″nĕ-kol′o-je) Study of the female reproductive system and its diseases.

hematology (hēm″ah-tol′o-je) Study of the blood and blood diseases.

histology (his-tol′o-je) Study of the structure and function of tissues. Histology and cytology are subdivisions of microscopic anatomy.

immunology (im″u-nol′o-je) Study of the body's resistance to infectious disease.

neonatology (ne″o-na-tol′o-je) Study of newborns and the treatment of their disorders.

nephrology (nĕ-frol′o-je) Study of the structure, function, and diseases of the kidneys.

neurology (nu-rol′o-je) Study of the nervous system and its disorders.

obstetrics (ob-stet′riks) Branch of medicine dealing with pregnancy and childbirth.

oncology (ong-kol′o-je) Study of cancers.

ophthalmology (of″thal-mol′o-je) Study of the eye and eye diseases.

orthopedics (or″tho-pe′diks) Branch of medicine dealing with the muscular and skeletal systems and their problems.

otolaryngology (o″to-lar″in-gol′o-je) Study of the ear, throat, and larynx, and their diseases.
pathology (pah-thol′o-je) Study of structural and functional changes that disease causes.
pediatrics (pe″de-at′riks) Branch of medicine dealing with children and their diseases.
pharmacology (fahr″mah-kol′o-je) Study of drugs and their uses in the treatment of disease.
podiatry (po-di′ah-tre) Study of the care and treatment of feet.
psychiatry (si-ki′ah-tre) Branch of medicine dealing with the mind and its disorders.
radiology (ra″de-ol′o-je) Study of X rays and radioactive substances and their uses in the diagnosis and treatment of diseases.
toxicology (tok″sĭ-kol′o-je) Study of poisonous substances and their effects upon body parts.
urology (u-rol′o-je) Branch of medicine dealing with the urinary system, apart from the kidneys (nephrology) and the male reproductive system, and their diseases.

Summary Outline

1.1 Introduction (p. 2)

1. Early interest in the human body probably developed as people became concerned about injuries and illnesses.
2. Primitive doctors began to learn how certain herbs and potions affected body functions.
3. The belief that humans could understand forces that caused natural events led to the development of modern science.
4. A set of terms originating from Greek and Latin words is the basis for the language of anatomy and physiology.

1.2 Anatomy and Physiology (p. 3)

1. Anatomy describes the form and organization of body parts.
2. Physiology considers the functions of anatomical parts.
3. The function of a body part depends on the way it is constructed.

1.3 Levels of Organization (p. 3)

The body is composed of parts with different levels of complexity.

1. Matter is composed of atoms.
2. Atoms join to form molecules.
3. Organelles are built of groups of large molecules (macromolecules).
4. Cells, which contain organelles, are the basic units of structure and function that form the body.
5. Cells are organized into tissues.
6. Tissues are organized into organs.
7. Organs that function closely together compose organ systems.
8. Organ systems constitute the organism.
9. Beginning at the atomic level, these levels of organization differ in complexity from one level to the next.

1.4 Characteristics of Life (p. 4)

Characteristics of life are traits all organisms share.

1. These characteristics include:
   a. Movement—changing body position or moving internal parts.
   b. Responsiveness—sensing and reacting to internal or external changes.
   c. Growth—increasing size without changing shape.
   d. Reproduction—producing offspring.
   e. Respiration—obtaining oxygen, using oxygen to release energy from foods, and removing gaseous wastes.
   f. Digestion—breaking down food substances into component nutrients that the intestine can absorb.
   g. Absorption—moving substances through membranes and into body fluids.
   h. Circulation—moving substances through the body in body fluids.
   i. Assimilation—changing substances into chemically different forms.
   j. Excretion—removing body wastes.
2. Acquisition and use of energy constitute metabolism.

1.5 Maintenance of Life (p. 5)

The structures and functions of body parts maintain the life of the organism.

1. Requirements of organisms
   a. Water is used in many metabolic processes, provides the environment for metabolic reactions, and transports substances.
   b. Food supplies energy, raw materials for building new living matter, and chemicals necessary in vital reactions.
   c. Oxygen releases energy from food materials. This energy drives metabolic reactions.
   d. Heat is a product of metabolic reactions and helps govern the rates of these reactions.
   e. Pressure is an application of force to something. In humans, atmospheric and hydrostatic pressures help breathing and blood movements, respectively.
2. Homeostasis
   a. If an organism is to survive, the conditions within its body fluids must remain relatively stable.
   b. Maintenance of a stable internal environment is called *homeostasis.*
   c. Homeostatic mechanisms help regulate body temperature and blood pressure.
   d. Homeostatic mechanisms act through negative feedback.

1.6 Organization of the Human Body (p. 8)

1. Body cavities
   a. The axial portion of the body includes the cranial cavity, the vertebral canal, the thoracic cavity, and the abdominopelvic cavity.
   b. The diaphragm separates the thoracic and abdominopelvic cavities.
   c. The organs in a body cavity are called *viscera.*
   d. The mediastinum separates the thoracic cavity into right and left compartments.
   e. Body cavities in the head include the oral, nasal, orbital, and middle ear cavities.
2. Thoracic and abdominopelvic membranes
   a. Thoracic membranes
      (1) Pleural membranes line the thoracic cavity (parietal pleura) and cover each lung (visceral pleura).

(2) Pericardial membranes surround the heart (parietal pericardium) and cover its surface (visceral pericardium).
(3) The pleural and pericardial cavities are the potential spaces between the respective parietal and visceral membranes.

b. Abdominopelvic membranes
(1) Peritoneal membranes line the abdominopelvic cavity (parietal peritoneum) and cover the organs inside (visceral peritoneum).
(2) The peritoneal cavity is the potential space between the parietal and visceral membranes.

3. Organ systems
The human organism consists of several organ systems. Each system includes a set of interrelated organs.

a. Body covering
(1) The integumentary system includes the skin, hair, nails, sweat glands, and sebaceous glands.
(2) It protects underlying tissues, regulates body temperature, houses sensory receptors, and synthesizes various substances.

b. Support and movement
(1) Skeletal system
(a) The skeletal system is composed of bones, as well as cartilages and ligaments that bind bones together.
(b) It provides a framework, protective shields, and attachments for muscles. It also produces blood cells and stores inorganic salts.
(2) Muscular system
(a) The muscular system includes the muscles of the body.
(b) It moves body parts, maintains posture, and produces body heat.

c. Integration and coordination
(1) Nervous system
(a) The nervous system consists of the brain, spinal cord, nerves, and sense organs.
(b) It receives impulses from sensory parts, interprets these impulses, and acts on them by stimulating muscles or glands to respond.
(2) Endocrine system
(a) The endocrine system consists of glands that secrete hormones.
(b) Hormones help regulate metabolism.
(c) This system includes the hypothalamus of the brain and the pituitary, thyroid, parathyroid, and adrenal glands, as well as the pancreas, ovaries, testes, pineal gland, and thymus.

d. Transport
(1) Cardiovascular system
(a) The cardiovascular system includes the heart, which pumps blood, and the blood vessels, which carry blood to and from body parts.
(b) Blood transports oxygen, nutrients, hormones, and wastes.
(2) Lymphatic system
(a) The lymphatic system is composed of lymphatic vessels, lymph fluid, lymph nodes, thymus, and spleen.
(b) It transports lymph fluid from tissues to the bloodstream, carries certain fatty substances away from the digestive organs, and aids in defending the body against disease-causing agents.

e. Absorption and excretion
(1) Digestive system
(a) The digestive system receives foods, breaks down food molecules into nutrients that can pass through cell membranes, and eliminates materials that are not absorbed.
(b) It includes the mouth, tongue, teeth, salivary glands, pharynx, esophagus, stomach, liver, gallbladder, pancreas, small intestine, and large intestine.
(c) Some digestive organs produce hormones.
(2) Respiratory system
(a) The respiratory system takes in and sends out air and exchanges gases between the air and blood.
(b) It includes the nasal cavity, pharynx, larynx, trachea, bronchi, and lungs.
(3) Urinary system
(a) The urinary system includes the kidneys, ureters, urinary bladder, and urethra.
(b) It filters wastes from the blood and helps maintain water and electrolyte concentrations and the acidity of the internal environment.

f. Reproduction
(1) The reproductive systems produce new organisms.
(2) The male reproductive system includes the scrotum, testes, epididymides, ductus deferentia, seminal vesicles, prostate gland, bulbourethral glands, urethra, and penis, which produce, maintain, and transport male sex cells (sperm cells).
(3) The female reproductive system includes the ovaries, uterine tubes, uterus, vagina, clitoris, and vulva, which produce, maintain, and transport female sex cells (oocytes).

1.7 Anatomical Terminology (p. 14)

Terms with precise meanings help investigators communicate effectively.

1. Relative positions
These terms describe the location of one part with respect to another part.
2. Body sections
Body sections are planes along which the body may be cut to observe the relative locations and organization of internal parts.
3. Body regions
Special terms designate various body regions.

Chapter Assessments

1.1 Introduction

1. Briefly describe the early discoveries that led to our understanding of the human body. (p. 2)

1.2 Anatomy and Physiology

2. Explain the difference between anatomy and physiology. (p. 3)

3. Identify relationships between the form and the function of body parts. (p. 3)

1.3 Levels of Organization

4. List the levels of organization within the human body and describe the characteristics of each. (p. 3)