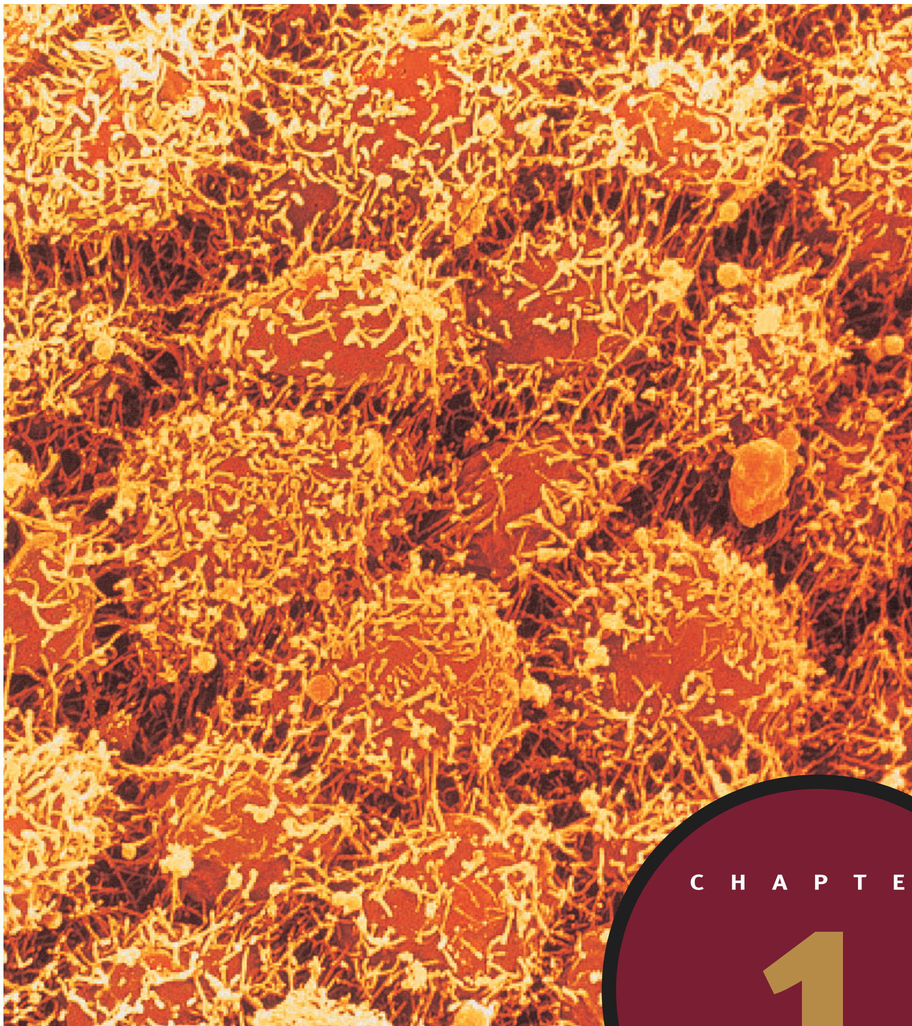

Colorized scanning electron micrograph (SEM) of the peritoneum covering the liver. These flattened cells have many short, hairlike microvilli, and they secrete a lubricating fluid that protects the liver from friction as it moves within the abdominal cavity.

The Human Organism

CHAPTER

1

What lies ahead is an astounding adventure—learning about the structure and function of the human body and how they are regulated by intricate systems of checks and balances. For example, tiny collections of cells embedded in the pancreas affect the uptake and use of blood sugar in the body. Eating a candy bar results in an increase in blood sugar, which acts as a stimulus. The tiny collections of cells respond to the stimulus by secreting insulin. Insulin moves into blood vessels and is transported to cells, where it increases the movement of sugar from the blood into cells, thereby providing the cells with a source of energy and causing blood sugar levels to decrease.

Knowledge of the structure and function of the human body provides the basis for understanding disease. In one type of diabetes mellitus, cells of the pancreas do not secrete adequate amounts of insulin. Not enough sugar moves into cells, which deprives them of a needed source of energy, and they malfunction.

Knowledge of the structure and function of the human body is essential for those planning a career in the health sciences. It is also beneficial to nonprofessionals because it helps with understanding overall health and disease, with evaluating recommended treatments, and with critically reviewing advertisements and articles.

This chapter defines *anatomy* and *physiology* (2). It also explains the body's *structural and functional organization* (5) and provides an overview of the *human organism* (5) and *homeostasis* (10). Finally the chapter presents *terminology and the body plan* (13).

Anatomy and Physiology

Objective

- *Define the terms anatomy and physiology, and identify the different ways in which they can be studied.*

Anatomy is the scientific discipline that investigates the body's structure. For example, anatomy describes the shape and size of bones. In addition, anatomy examines the relationship between the structure of a body part and its function. Just as the structure of a hammer makes it well suited for pounding nails, the structure of a specific body part allows it to perform a particular function effectively. For example, bones can provide strength and support because bone cells surround themselves with a hard, mineralized substance. Understanding the relationship between structure and function makes it easier to understand and appreciate anatomy.

Anatomy can be considered at many different levels. **Developmental anatomy** is the study of the structural changes that occur between conception and adulthood. **Embryology** (em-brē-ol′ō-jē), a subspeciality of developmental anatomy, considers changes from conception to the end of the eighth week of development. Most birth defects occur during embryologic development.

Some structures, such as cells, are so small that they are best studied using a microscope. **Cytology** (sī-tol′ō-jē) examines the structural features of cells, and **histology** (his-tol′ō-jē) examines tissues, which are cells and the materials surrounding them.

Gross anatomy, the study of structures that can be examined without the aid of a microscope, can be approached from either a systemic or regional perspective. In **systemic anatomy** the body is studied system by system, which is the approach taken in this and most other introductory textbooks. A system is a group of structures that have one or more common functions. Examples are the circulatory, nervous, respiratory, skeletal, and muscular systems. In **regional anatomy** the body is studied area by area, which is the approach taken in most graduate programs at medical and dental schools. Within each region, such as the head, abdomen, or arm, all systems are studied simultaneously.

Surface anatomy is the study of the external form of the body and its relation to deeper structures. For example, the sternum (breastbone) and parts of the ribs can be seen and palpated (felt) on the front of the chest. These structures can be used as landmarks to identify regions of the heart and points on the chest where certain heart sounds can best be heard. **Anatomic imaging** uses radiographs (x-rays), ultrasound, magnetic resonance imaging (MRI), and other technologies to create pictures of internal structures. Both surface anatomy and anatomic imaging provide important information about the body for diagnosing disease.

Anatomic Anomalies

No two humans are structurally identical. For instance, one person may have longer fingers than another person. Despite this variability, most humans have the same basic pattern. Normally, we each have 10 fingers. **Anatomic anomalies** are structures that are unusual and different from the normal pattern. For example, some individuals have 12 fingers.

Anatomic anomalies can vary in severity from the relatively harmless to the life-threatening, which compromise normal function. For example, each kidney is normally supplied by one blood vessel, but in some individuals a kidney can be supplied by two blood vessels. Either way, the kidney receives adequate blood. On the other hand, in the condition called "blue baby" syndrome certain blood vessels arising from the heart of an infant are not attached in their correct locations; blood is not effectively pumped to the lungs, resulting in tissues not receiving adequate oxygen.

Physiology is the scientific investigation of the processes or functions of living things. Although it may not be obvious at times, living things are dynamic and ever-changing, not static and without motion. The major goals of physiology are to understand and predict the responses of the body to stimuli and to understand how the body maintains conditions within a narrow range of values in a constantly changing environment.

Like anatomy, physiology can be considered at many different levels. **Cell physiology** examines the processes occurring in cells and **systemic physiology** considers the functions of organ systems. **Neurophysiology** focuses on the nervous system and **cardiovascular physiology** deals with the heart and blood vessels. Physiology often examines systems rather than regions because portions of a system in more than one region can be involved in a given function.

The study of the human body must encompass both anatomy and physiology because structures, functions, and processes are interwoven. **Pathology** (pa-thol′ō-jē) is the medical science dealing with all aspects of disease, with an emphasis on the cause and development of abnormal conditions as well as the structural and functional changes resulting from disease. **Exercise physiology** focuses on changes in function, but also structure, caused by exercise.

1. *Define anatomy and physiology. Describe different levels at which each can be considered.*
2. *Define pathology and exercise physiology.*

Clinical Focus Anatomic Imaging

Anatomic imaging has revolutionized medical science. Some estimate that during the past 20 years as much progress has been made in clinical medicine as in all its previous history combined, and anatomic imaging has made a major contribution to that progress. Anatomic imaging allows medical personnel to look inside the body with amazing accuracy and without the trauma and risk of exploratory surgery. Although most of the technology of anatomic imaging is very new, the concept and earliest technology are quite old.

Wilhelm Roentgen (1845–1923) was the first to use **x-rays** in medicine in 1895 to see inside the body. The rays were called x-rays because no one knew what they were. This extremely shortwave electromagnetic radiation (see chapter 2) moves through the body exposing a photographic plate to form a **radiograph** (rā′dē-ō-graf). Bones and radiopaque dyes absorb the rays and create underexposed areas that appear white on the photographic film (figure A). X-rays have been in common use for many years and have numerous applications. Almost everyone has had a radiograph taken, either to visualize a broken bone or to check for a cavity in a tooth. A major limitation of radiographs, however, is that they give only a flat, two-dimensional (2-D) image of the body, which is a three-dimensional (3-D) structure.

Ultrasound is the second oldest imaging technique. It was first developed in the early 1950s as an extension of World War II sonar technology and uses high-frequency sound waves. The sound waves are emitted from a transmitter–receiver placed on the skin over the area to be scanned. The sound waves strike internal organs and bounce back to the receiver on the skin. Even though the basic technology is fairly old, the most important advances in the field occurred only after it became possible to analyze the reflected sound waves by computer. Once the computer analyzes the pattern of sound waves, the information is transferred to a monitor, where the result is visualized as an ultrasound image called a **sonogram** (son′ō-gram) (figure B). One of the more recent advances in ultrasound technology is the ability of more advanced computers to analyze changes in position through time and to display those changes as "real time" movements. Among other medical uses, ultrasound is commonly used to evaluate the condition of the fetus during pregnancy.

Computer analysis is also the basis of another major medical breakthrough in imaging. **Computed tomographic** (tō′mō-graf′ik) **(CT) scans,** developed in 1972 and originally called **computerized axial tomographic (CAT) scans,** are computer-analyzed x-ray images. A low-intensity x-ray tube is rotated through a 360-degree arc around the patient, and the images are fed into a computer. The computer then constructs the image of a "slice" through the body at the point where the x-ray beam was focused and rotated (figure C). It is also possible with some computers to take several scans short distances apart and stack the slices to produce a 3-D image of a part of the body (figure D).

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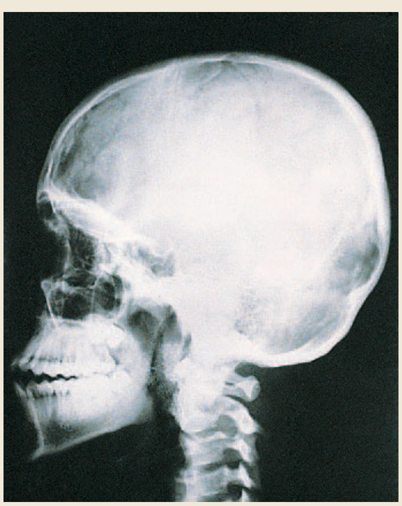


Figure A X-ray

Radiograph produced by x-rays shows a lateral view of the head and neck.

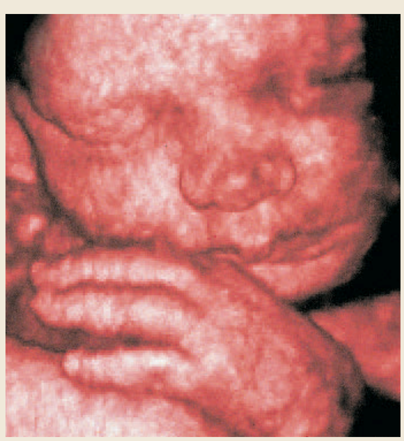


Figure B Ultrasound

Sonogram produced with ultrasound shows a lateral view of the head and hand of a fetus within the uterus.

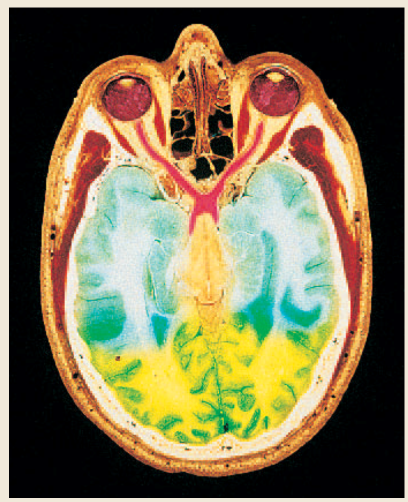


Figure C Computed Tomography

Transverse section through the skull at the level of the eyes.

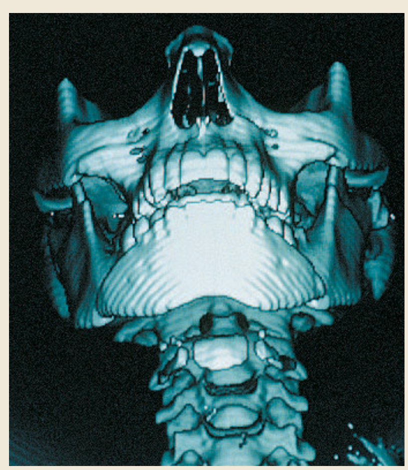


Figure D Computed Tomography (CT)

Stacking of images acquired using CT technology.

(Continued)

Dynamic spatial reconstruction (DSR) takes CT one step further. Instead of using a single rotating x-ray machine to take single slices and add them together, DSR uses about 30 x-ray tubes. The images from all the tubes are compiled simultaneously to rapidly produce a 3-D image. Because of the speed of the process, multiple images can be compiled to show changes through time, thereby giving the system a dynamic quality. This system allows us to move away from seeing only static structure and toward seeing dynamic structure and function.

Digital subtraction angiography (an-jē-og′ră-fē) **(DSA)** is also one step beyond CT scans. A 3-D radiographic image of an organ such as the brain is made and stored in a computer. A radiopaque dye is injected into the circulation, and a second radiographic computer image is made. The first image is subtracted from the second one, greatly enhancing the differences, with the primary difference being the presence of the injected dye (figure E). These computer images can be dynamic and can be used, for example, to guide a catheter into a carotid artery during angioplasty, which is the insertion of a tiny balloon into a carotid artery to compress material clogging the artery.

Magnetic resonance imaging (MRI) directs radio waves at a person lying inside a large electromagnetic field. The magnetic field causes the protons of various atoms to align (see chapter 2). Because of the large amounts of water in the body, the alignment of hydrogen atom protons is at present most important in this imaging system. Radio waves of certain frequencies, which change the alignment of the hydrogen atoms, then are directed at the patient. When the radio waves are turned off, the hydrogen atoms realign in accordance with the magnetic field. The time it takes the hydrogen atoms to realign is different for various tissues of the body. These differences can be analyzed by computer to produce very clear sections through the body (figure F). The technique is also very sensitive in detecting some forms of cancer and can detect a tumor far more readily than can a CT scan.

Positron emission tomographic (PET) scans can identify the metabolic states of various tissues. This technique is particularly useful in analyzing the brain. When cells are active, they are using energy. The energy they need is supplied by the breakdown of glucose (blood sugar). If radioactively treated, or "labeled," glucose is given to a patient, the active cells take up the labeled glucose. As the radioactivity in the glucose decays, positively charged subatomic particles called positrons are emitted. When the positrons collide with electrons, the two particles annihilate each other, and gamma rays are given off. The gamma rays can be detected, pinpointing the cells that are metabolically active (figure G).

Whenever the human body is exposed to x-rays, ultrasound, electromagnetic fields, or radioactively labeled substances, a potential risk exists. In the medical application of anatomic imaging, the risk must be weighed against the benefit. Numerous studies have been conducted and are still being done to determine the outcomes of diagnostic and therapeutic exposures to x-rays.

The risk of anatomic imaging is minimized by using the lowest possible doses that provide the necessary information. For example, it is well known that x-rays can cause cell damage, particularly to the reproductive cells. As a result of this knowledge, the number of x-rays and the level of exposure are kept to a minimum, the x-ray beam is focused as closely as possible to avoid scattering of the rays, areas of the body not being x-rayed are shielded, and personnel administering x-rays are shielded. No known risks exist from ultrasound or electromagnetic fields at the levels used for diagnosis.

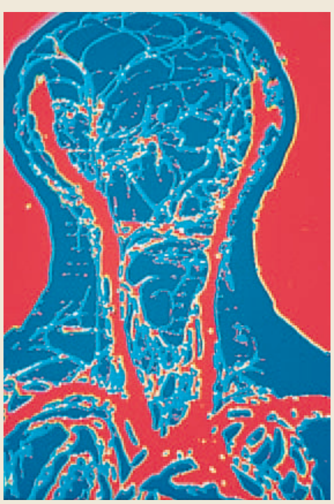


Figure E Digital Subtraction Angiography (DSA)

Reveals the major blood vessels supplying the head and upper limbs.

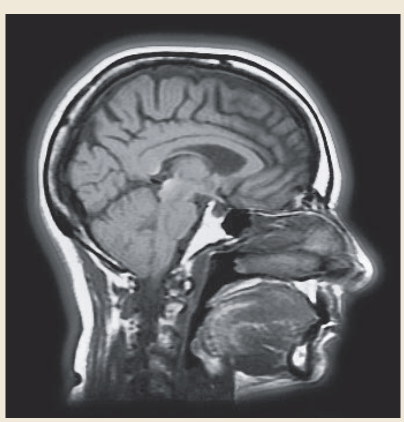


Figure F Magnetic Resonance Imaging (MRI)

Shows a lateral view of the head and neck.

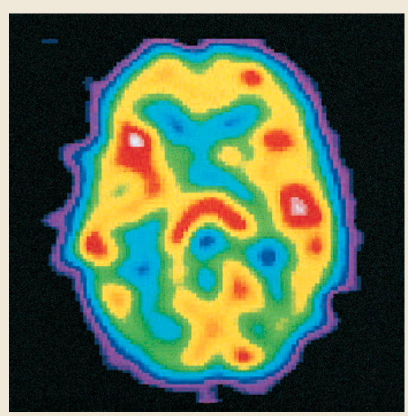


Figure G Positron Emission Tomography (PET)

Shows a transverse section through the skull. The highest level of brain activity is indicated in red, with successively lower levels represented by yellow, green, and blue.

Structural and Functional Organization

Objectives

- *Describe and give examples of the different levels of organization of the body.*
- *List and give the functions of the 11 organ systems of the body.*

Conceptually, the body has six structural levels: the chemical, cell, tissue, organ, organ system, and complete organism (figure 1.1).

1. *Chemical level.* The chemical level involves interactions between atoms, which are tiny building blocks of matter. Atoms can combine to form molecules such as water, sugar, fats, and proteins. The function of a molecule is related intimately to its structure. For example, collagen molecules are ropelike protein fibers that give skin structural strength and flexibility. With old age, the structure of collagen changes, and the skin becomes fragile and is torn more easily. A brief overview of chemistry is presented in chapter 2.
2. *Cell level.* **Cells** are the basic units of all living things. Molecules can combine to form **organelles** (or′gă-nelz), which are the small structures that make up cells. For example, the plasma membrane forms the outer boundary of the cell and the nucleus contains the cell's hereditary information. Although cell types differ in their structure and function, they have many characteristics in common. Knowledge of these characteristics and their variations is essential to a basic understanding of anatomy and physiology. The cell is discussed in chapter 3.
3. *Tissue level.* A **tissue** is a group of similar cells and the materials surrounding them. The characteristics of the cells and surrounding materials determine the functions of the tissue. The numerous different tissues that make up the body are classified into four basic types: epithelial, connective, muscle, and nervous. Tissues are discussed in chapter 4.
4. *Organ level.* An **organ** is composed of two or more tissue types that perform one or more common functions. The urinary bladder, heart, skin, and eye are examples of organs (figure 1.2).
5. *Organ system level.* An **organ system** is a group of organs that have a common function or set of functions and are therefore viewed as a unit. For example, the urinary system consists of the kidneys, ureter, urinary bladder, and urethra. The kidneys produce urine, which is transported by the ureters to the urinary bladder, where it is stored until eliminated from the body by passing through the urethra. In this text the body is considered to have 11 major organ systems: the integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive systems. Figure 1.3 presents a brief summary of the organ systems and their functions.
6. *Organism level.* An **organism** is any living thing considered as a whole, whether composed of one cell such as a bacterium or of trillions of cells such as a human. The human organism is a complex of organ systems, all mutually dependent on one another.

3. From smallest to largest, list and define the six levels at which the body can be considered conceptually.
4. What are the four primary tissue types?
5. Which two organ systems are responsible for regulating the other organ systems? Which two are responsible for support and movement?
6. What are the functions of the integumentary, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive systems?

P R E D I C T 1

One type of diabetes is a disorder in which the pancreas (an organ) fails to produce insulin, which is a chemical normally made by pancreatic cells and released into the circulation. List as many levels of organization as you can in which this disorder could be corrected.

The Human Organism

Objective

- *List the six characteristics of life, and give examples of how they apply to the human organism.*

Characteristics of Life

Humans are organisms and share common characteristics with other organisms. The most important common feature of all organisms is life. Organization, metabolism, responsiveness, growth, development, and reproduction are life's essential characteristics.

Organization is the condition in which the parts of an organism have specific relationships to each other and the parts interact to perform specific functions. Living things are highly organized. All organisms are composed of one or more cells. Cells in turn are composed of highly specialized organelles, which depend on the precise organization of large molecules. Disruption of this organized state can result in loss of functions, and even death.

Metabolism (mĕ-tab′ō-lizm) is all of the chemical reactions taking place in an organism. It includes the ability of an organism to break down food molecules, which are used as a source of energy and raw materials to synthesize the organism's own molecules. Energy is also used when one part of a molecule moves relative to another part, resulting in a change in shape of the molecule. Changes in molecular shape, in turn, can change the shape of cells, which can produce movements of the organism. Metabolism is necessary for vital functions, such as responsiveness, growth, development, and reproduction.

Responsiveness is the ability of an organism to sense changes in its external or internal environment and adjust to those changes. Responses include such things as moving toward food or water and away from danger or poor environmental conditions. Organisms can also make adjustments that maintain their internal environment. For example, if body temperature increases in a hot environment, sweat glands produce sweat, which can lower body temperature back toward normal levels.

Growth happens when cells increase in size or number, which produces an overall enlargement of all or part of an organism. For example, a muscle enlarged by exercise has larger muscle cells than an untrained muscle, and the skin of an adult has more

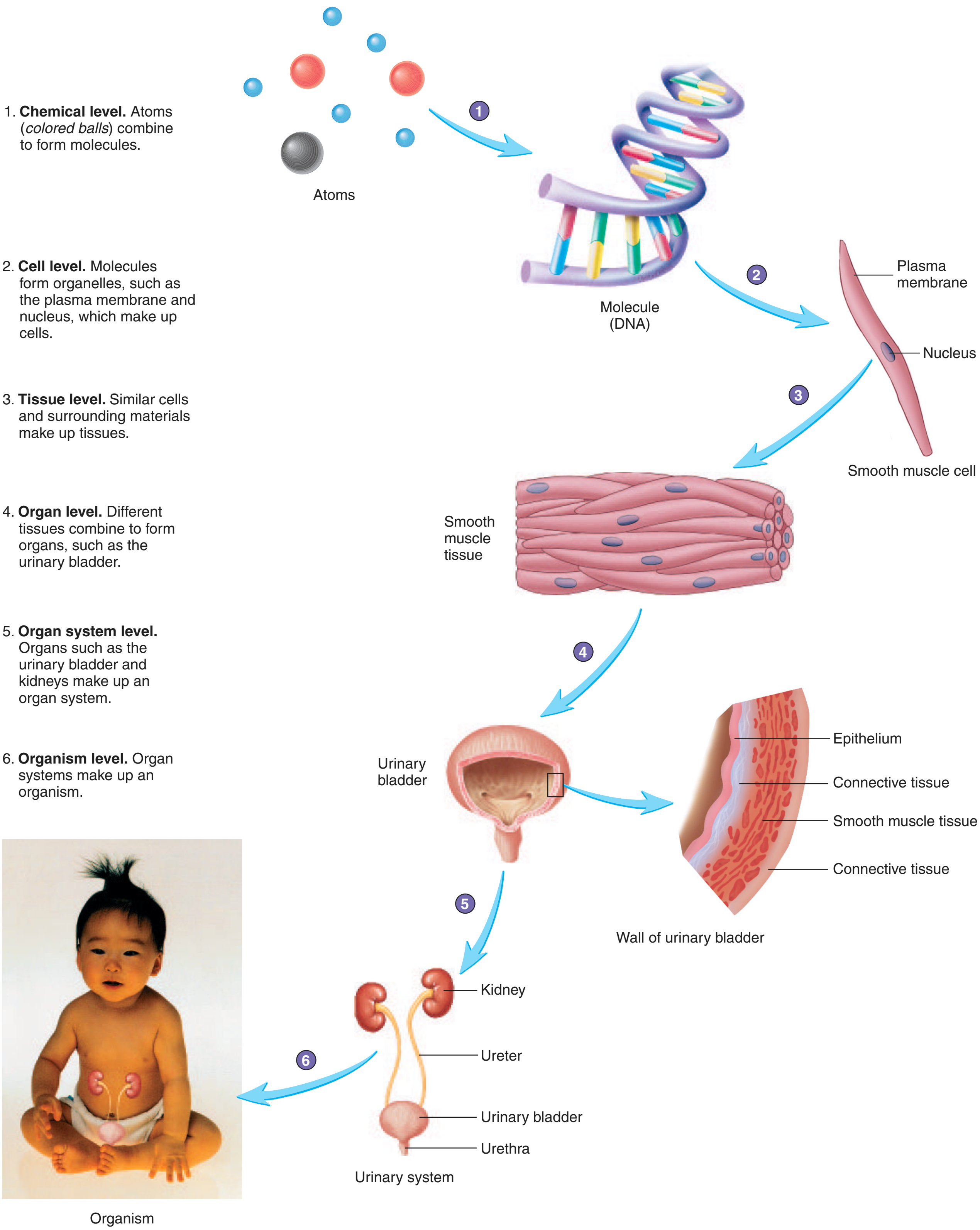


Figure 1.1 Levels of Organization

Six levels of organization for the human body are the chemical, cell, tissue, organ, organ system, and organism.

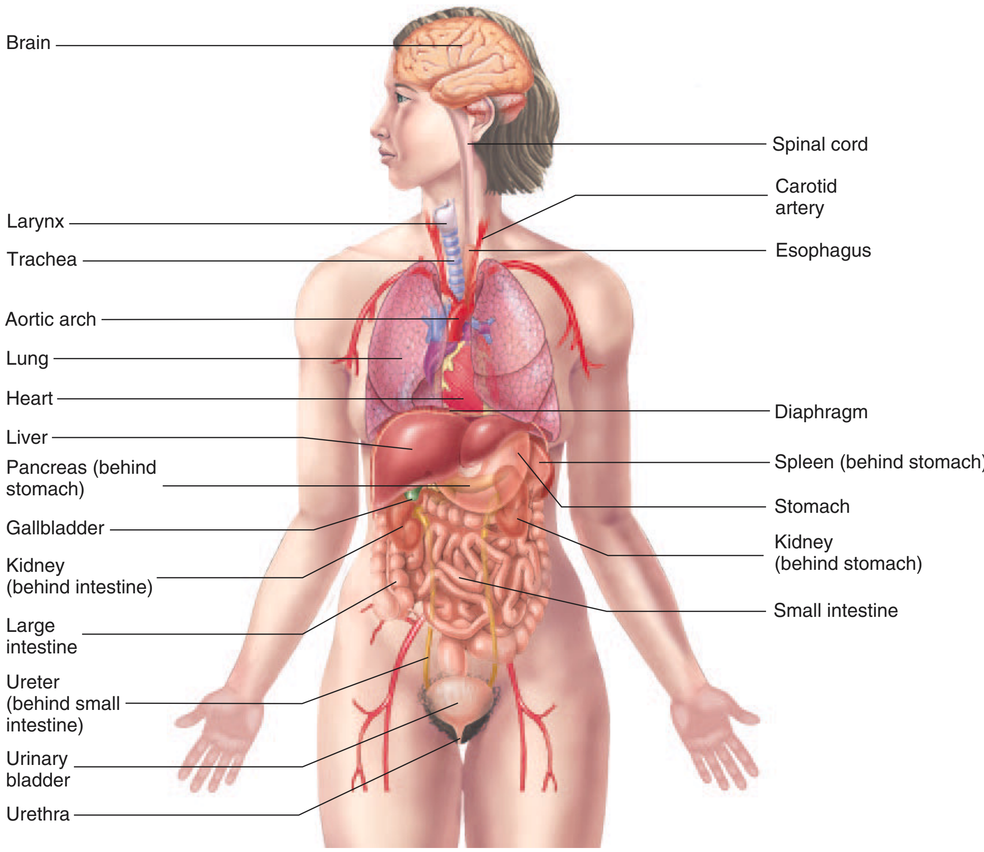


Figure 1.2 Organs of the Body

cells than the skin of infant. An increase in the materials surrounding cells can also contribute to growth. For instance, the growth of bone results from an increase in cell number and the deposition of mineralized materials around the cells.

Development includes the changes an organism undergoes through time; it begins with fertilization and ends at death. The greatest developmental changes occur before birth, but many changes continue after birth, and some continue throughout life. Development usually involves growth, but it also involves differentiation and morphogenesis. **Differentiation** is change in cell structure and function from generalized to specialized, and **morphogenesis** (mōr-fō-jen′ĕ-sis) is change in the shape of tissues, organs, and the entire organism. For example, following fertilization, generalized cells specialize to become specific cell types, such as skin, bone, muscle, or nerve cells. These differentiated cells form the tissues and organs.

Reproduction is the formation of new cells or new organisms. Without reproduction, growth and development are not possible. Without reproduction of the organism, species become extinct.

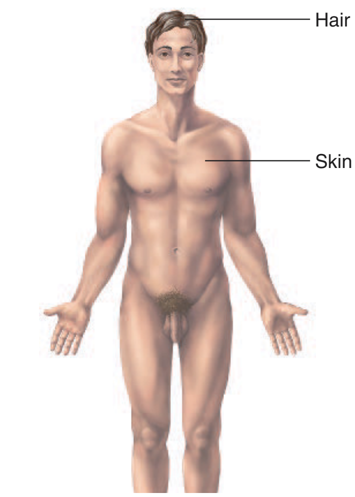
Biomedical Research

Studying other organisms has increased our knowledge about humans because humans share many characteristics with other organisms. For example, studying single-celled bacteria provides much information about human cells. Some biomedical research, however, cannot be accomplished using single-celled organisms or isolated cells. Sometimes other mammals must be studied. For example, great progress in open-heart surgery and kidney transplantation was made possible by perfecting surgical techniques on other mammals before attempting them on humans. Strict laws govern the use of animals in biomedical research—laws designed to ensure minimum suffering on the part of the animal and to discourage unnecessary experimentation.

Although much can be learned from studying other organisms, the ultimate answers to questions about humans can be obtained only from humans, because other organisms are often different from humans in significant ways.

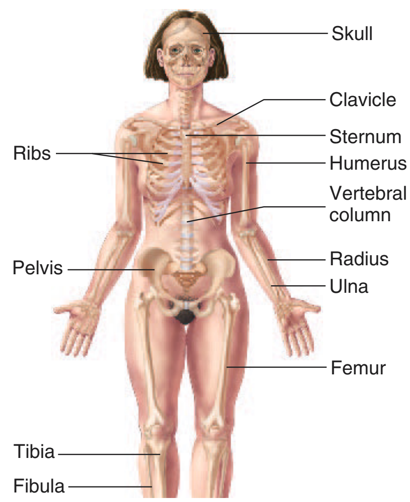
Human Versus Animal-Based Knowledge

Failure to appreciate the differences between humans and other animals led to many misconceptions by early scientists. One of the first great anatomists was a Greek physician, Claudius Galen (ca. 130–201). Galen described a large number of anatomic structures supposedly present in humans but observed only in other animals. For example, he described the liver as having five lobes. This is true for rats, but not for humans, who have four-lobed livers. The errors introduced by Galen persisted for more than 1300 years until a Flemish anatomist, Andreas Vesalius (1514–1564), who is considered the first modern anatomist, carefully examined human cadavers and began to correct the textbooks. This example should serve as a word of caution: Some current knowledge in molecular biology and physiology has not been confirmed in humans.



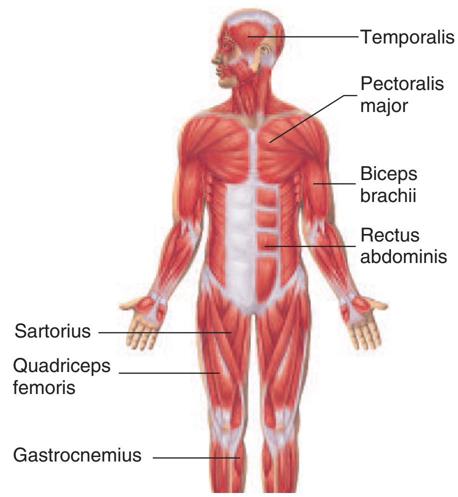
Integumentary System

Provides protection, regulates temperature, prevents water loss, and produces vitamin D precursors. Consists of skin, hair, nails, and sweat glands.



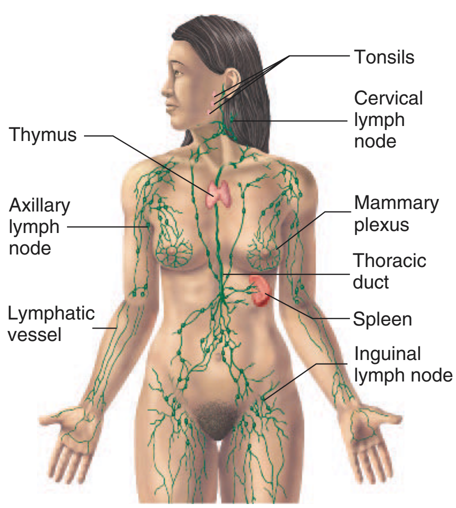
Skeletal System

Provides protection and support, allows body movements, produces blood cells, and stores minerals and fat. Consists of bones, associated cartilages, ligaments, and joints.



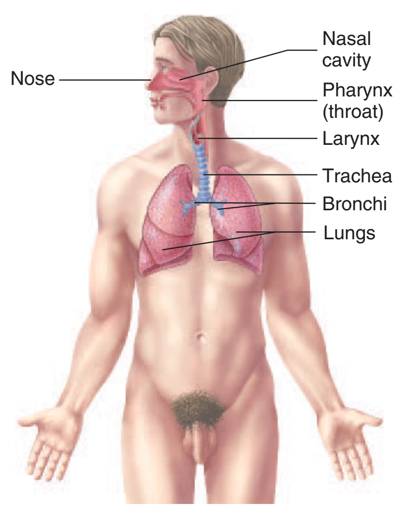
Muscular System

Produces body movements, maintains posture, and produces body heat. Consists of muscles attached to the skeleton by tendons.



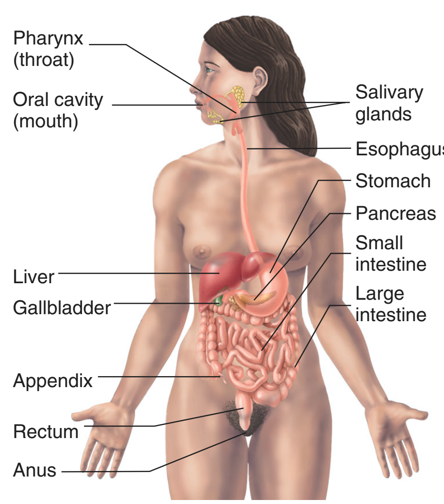
Lymphatic System

Removes foreign substances from the blood and lymph, combats disease, maintains tissue fluid balance, and absorbs fats from the digestive tract. Consists of the lymphatic vessels, lymph nodes, and other lymphatic organs.



Respiratory System

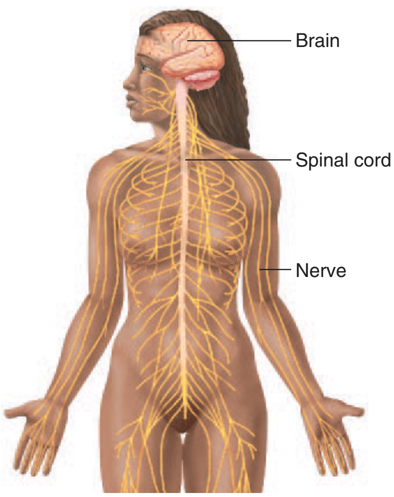
Exchanges oxygen and carbon dioxide between the blood and air and regulates blood pH. Consists of the lungs and respiratory passages.



Digestive System

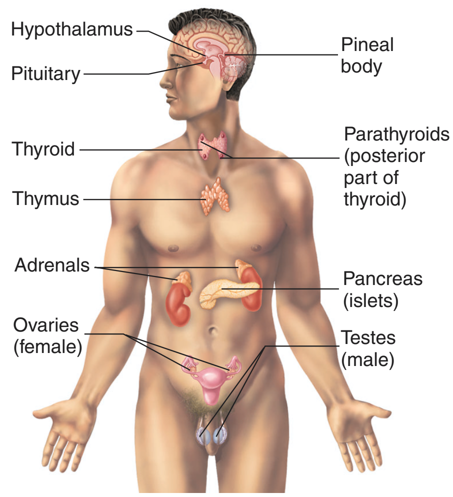
Performs the mechanical and chemical processes of digestion, absorption of nutrients, and elimination of wastes. Consists of the mouth, esophagus, stomach, intestines, and accessory organs.

Figure 1.3 Organ Systems of the Body



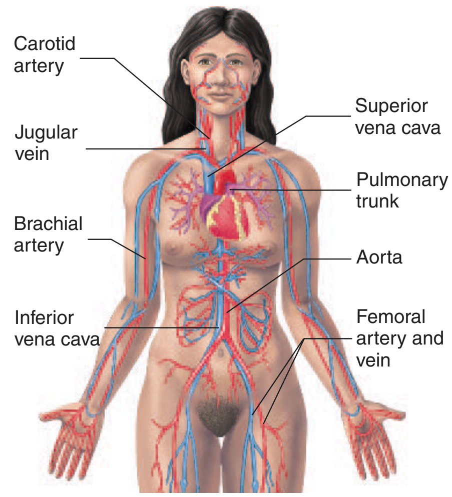
Nervous System

A major regulatory system that detects sensations and controls movements, physiologic processes, and intellectual functions. Consists of the brain, spinal cord, nerves, and sensory receptors.



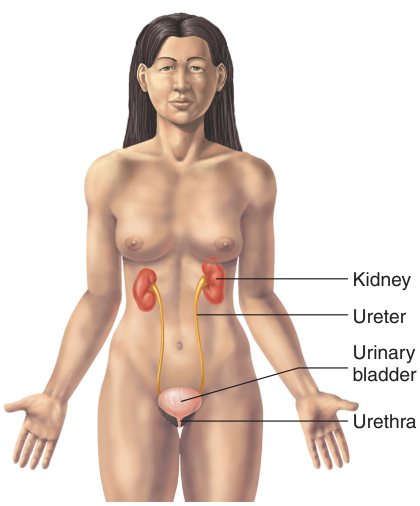
Endocrine System

A major regulatory system that influences metabolism, growth, reproduction, and many other functions. Consists of glands, such as the pituitary, that secrete hormones.



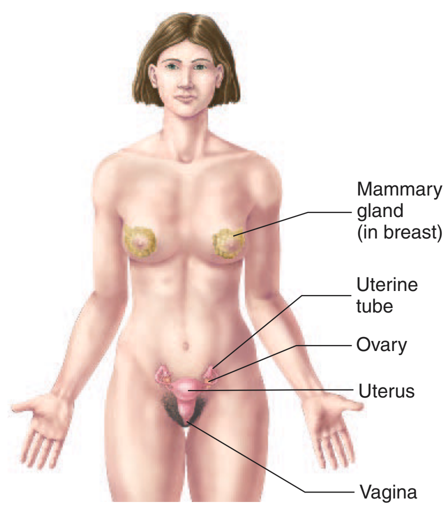
Cardiovascular System

Transports nutrients, waste products, gases, and hormones throughout the body; plays a role in the immune response and the regulation of body temperature. Consists of the heart, blood vessels, and blood.



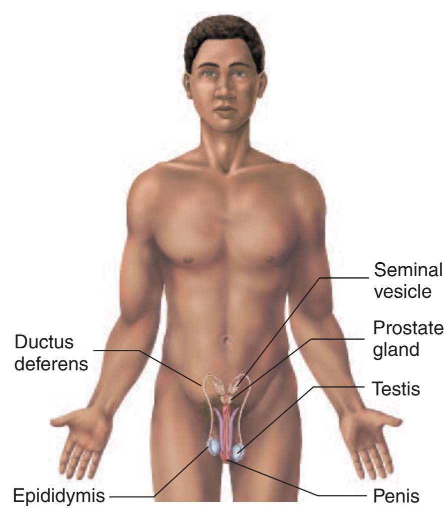
Urinary System

Removes waste products from the blood and regulates blood pH, ion balance, and water balance. Consists of the kidneys, urinary bladder, and ducts that carry urine.



Female Reproductive System

Produces oocytes and is the site of fertilization and fetal development; produces milk for the newborn; produces hormones that influence sexual functions and behaviors. Consists of the ovaries, vagina, uterus, mammary glands, and associated structures.



Male Reproductive System

Produces and transfers sperm cells to the female and produces hormones that influence sexual functions and behaviors. Consists of the testes, accessory structures, ducts, and penis.

Figure 1.3 *(continued)*

7. Describe six characteristics of life.
8. Why is it important to realize that humans share many, but not all, characteristics with other animals?

Homeostasis

Objective

- *Define homeostasis. Give examples of negative-feedback and positive-feedback mechanisms and explain their relationship to homeostasis.*

Homeostasis (hō′mē-ō-stā′sis) is the existence and maintenance of a relatively constant environment within the body. A small amount of fluid surrounds each cell of the body. For cells to function normally, the volume, temperature, and chemical content—conditions known as **variables** because their values can

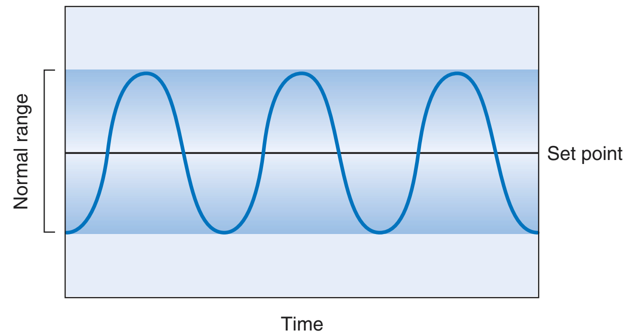
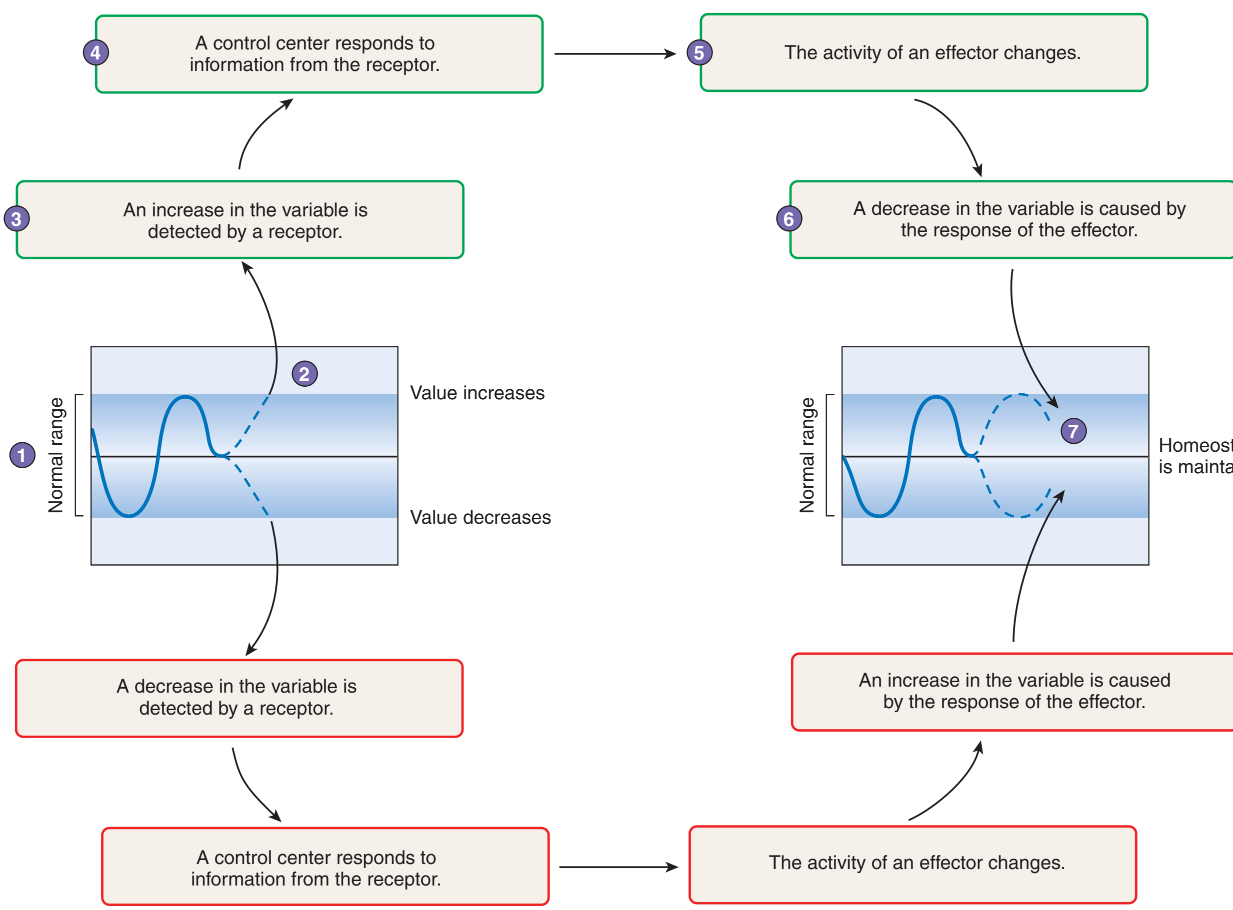


Figure 1.4 Homeostasis

Homeostasis is the maintenance of a variable around an ideal normal value, or set point. The value of the variable fluctuates around the set point to establish a normal range of values.



Homeostasis Figure 1.5 Mechanism of Negative Feedback

Throughout the text, all homeostasis figures have the same format as in this figure. The changes caused by an increase of a variable are shown in the *green boxes,* and the changes caused by a decrease are shown in the *red boxes.* To help you learn how to interpret homeostasis figures, some of the steps in this figure are numbered: (*1*) The variable is within its normal range. (*2*) The value of the variable increases and is outside its normal range. (*3*) The increase in the variable is detected by receptors. (*4*) The control center responds to the change in the variable detected by the receptors. (*5*) The control center causes the activity of the effector to change. (*6*) The change in effector activity causes the value of the variable to decrease. (*7*) The variable returns to its normal range and homeostasis is maintained. See the responses to a decrease of the variable by following the *red boxes.*

change—of this fluid must remain within a narrow range. Body temperature is a variable that can increase in a hot environment or decrease in a cold one.

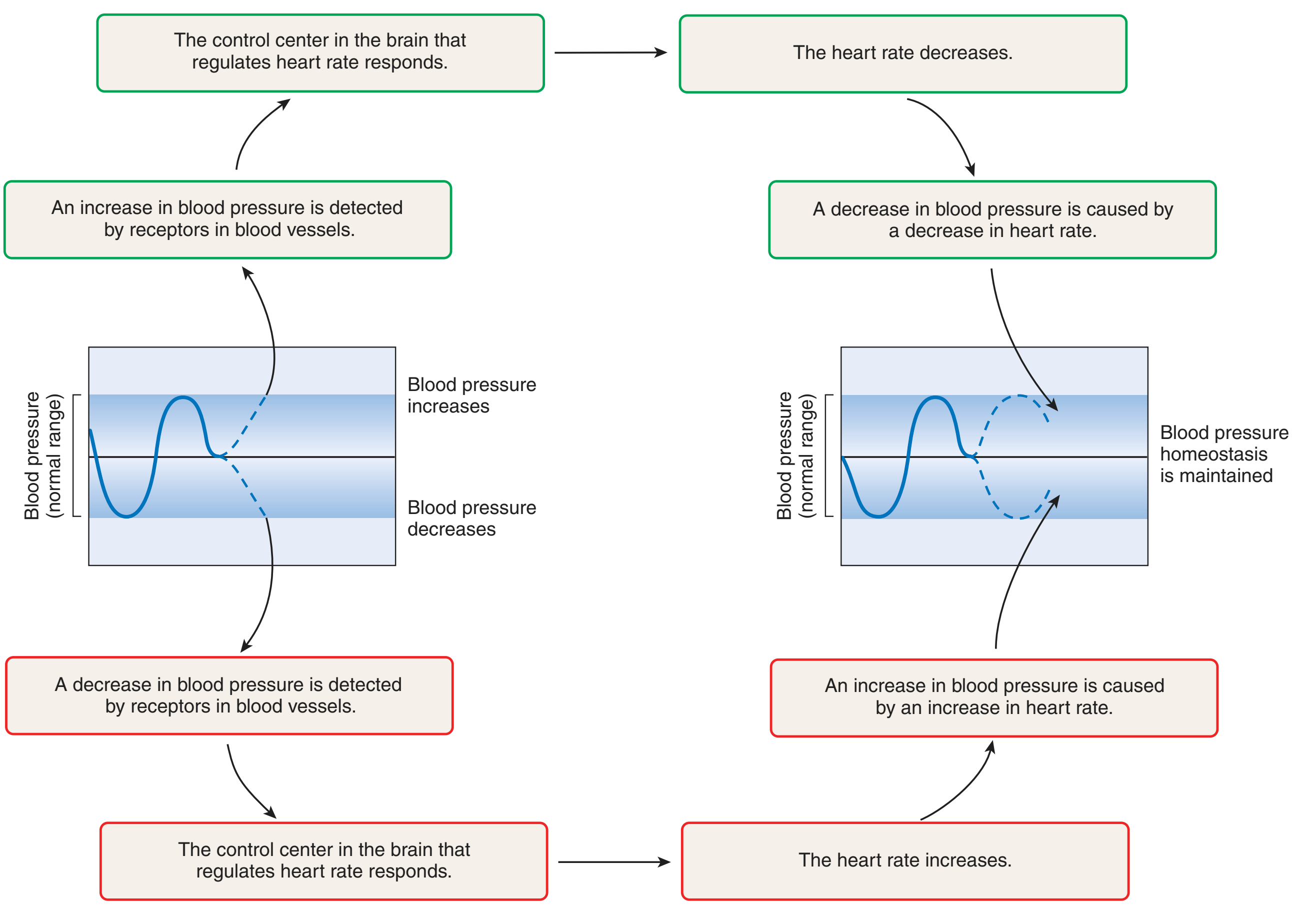
Homeostatic mechanisms, such as sweating or shivering, normally maintain body temperature near an ideal normal value, or **set point** (figure 1.4). Note that these mechanisms are not able to maintain body temperature precisely at the set point. Instead, body temperature increases and decreases slightly around the set point to produce a **normal range** of values. As long as body temperature remains within this normal range, homeostasis is maintained.

The organ systems help control the body's internal environment so that it remains relatively constant. For example, the digestive, respiratory, circulatory, and urinary systems function together so that each cell in the body receives adequate oxygen and nutrients and so that waste products do not accumulate to a toxic level. If the fluid surrounding cells deviates from homeostasis, the cells do not function normally and can even die. Disruption of homeostasis results in disease and sometimes death.

Negative Feedback

Most systems of the body are regulated by **negative-feedback** mechanisms that maintain homeostasis. *Negative* means that any deviation from the set point is made smaller or is resisted. Many negative-feedback mechanisms have three components: a **receptor,** which monitors the value of some variable such as blood pressure; a **control center,** which establishes the set point around which the variable is maintained; and an **effector,** which can change the value of the variable. A deviation from the set point is called a **stimulus.** The receptor detects the stimulus and informs the control center, which analyzes the input from the receptor. The control center sends output to the effector, and the effector produces a **response,** which tends to return the variable back toward the set point (figure 1.5).

The maintenance of normal blood pressure is an example of a negative-feedback mechanism that maintains homeostasis (figure 1.6). Normal blood pressure is important because it is responsible for moving blood from the heart to tissues. The blood supplies the tissues with oxygen and nutrients and removes waste products. Thus normal blood pressure is required to ensure that tissue homeostasis is maintained.



Homeostasis Figure 1.6 **Example of Negative Feedback**

Blood pressure is maintained within a normal range by negative-feedback mechanisms.

Receptors that monitor blood pressure are located within large blood vessels near the heart, the control center for blood pressure is in the brain, and the heart is the effector. Blood pressure depends in part on contraction (beating) of the heart: as heart rate increases, blood pressure increases; as heart rate decreases, blood pressure decreases.

If blood pressure increases slightly, the receptors detect the increased blood pressure and send that information to the control center in the brain. The control center causes heart rate to decrease, resulting in a decrease in blood pressure. If blood pressure decreases slightly, the receptors inform the control center, which increases heart rate, thereby producing an increase in blood pressure. As a result, blood pressure constantly rises and falls within a normal range of values.

Although homeostasis is the maintenance of a normal range of values, this does not mean that all variables are maintained within the same narrow range of values at all times. Sometimes a deviation from the usual range of values can be beneficial. For example, during exercise the normal range for blood pressure differs from the range under resting conditions, and the blood pressure is significantly elevated (figure 1.7). The elevated blood pressure increases blood delivery to muscles so that muscle cells are supplied with the extra nutrients and oxygen they need to maintain their increased rate of activity.

9. Define homeostasis, variable, and set point. If a deviation from homeostasis occurs, what mechanism restores it?

10. What are the three components of many negative-feedback mechanisms? How do they produce a response to a stimulus?

P R E D I C T 2

Explain how negative-feedback mechanisms control respiratory rates when a person is at rest and when a person is exercising.

Positive Feedback

Positive-feedback responses are not homeostatic and are rare in healthy individuals. *Positive* implies that, when a deviation from a normal value occurs, the response of the system is to make the deviation even greater (figure 1.8). Positive feedback therefore usually creates a cycle that leads away from homeostasis and, in some cases, results in death.

The cardiac (heart) muscle receiving an inadequate amount of blood is an example of positive feedback. Contraction of cardiac muscle generates blood pressure and moves blood through blood vessels to tissues. A system of blood vessels on the outside of the heart provides cardiac muscle with a blood supply sufficient to allow normal contractions to occur. In effect, the heart pumps blood to itself. Just as with other tissues, blood pressure must be maintained to ensure adequate delivery of blood to cardiac muscle. Following extreme blood loss, blood pressure decreases to the point that delivery of blood to cardiac muscle is inadequate. As a result, cardiac muscle homeostasis is disrupted, and cardiac muscle does not function normally. The heart pumps less blood, which causes the blood pressure to drop even further. This additional decrease in blood pressure means that even less blood is delivered to cardiac muscle, and the heart pumps even less blood, which again decreases the blood pressure (figure 1.9). If the process continues until the blood pressure is too low to sustain the cardiac muscle, the heart stops beating, and death results.

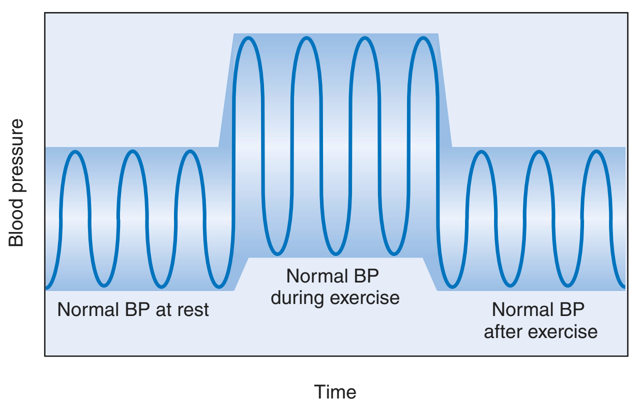


Figure 1.7 Changes in Blood Pressure During Exercise

During exercise the demand for oxygen by muscle tissue increases. An increase in blood pressure (BP) results in an increase in blood flow to the tissues. The increased blood pressure is not an abnormal or nonhomeostatic condition but is a resetting of the normal homeostatic range to meet the increased demand. The reset range is higher and broader than the resting range. After exercise ceases, the range returns to that of the resting condition.

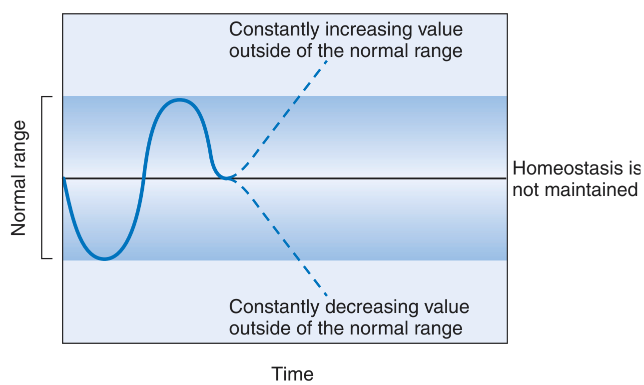


Figure 1.8 Positive Feedback

Deviations from the normal set point value cause an additional deviation away from that value in either a positive or negative direction.

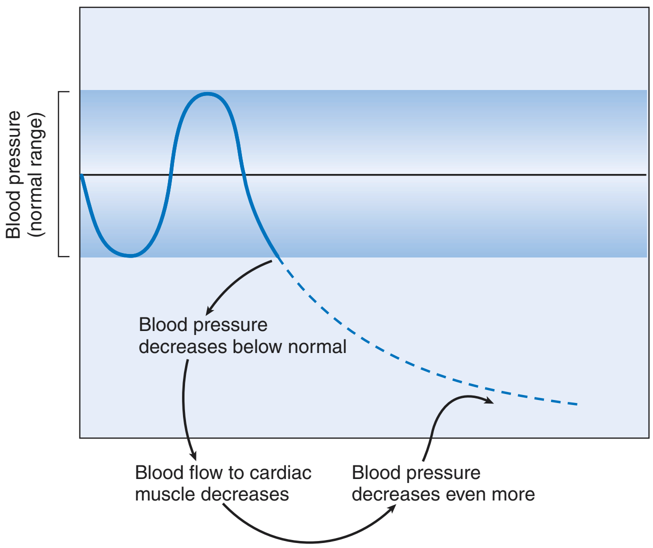


Figure 1.9 **Example of Harmful Positive Feedback**

A decrease in blood pressure below the normal range causes decreased blood flow to the heart. The heart is unable to pump enough blood to maintain blood pressure, and blood flow to the cardiac muscle decreases. Thus the ability of the heart to pump decreases further, and blood pressure decreases even more.

Following a moderate amount of blood loss (e.g., after a person donates a pint of blood), negative-feedback mechanisms produce an increase in heart rate and other responses that restore blood pressure. If blood loss is severe, however, negative-feedback mechanisms may not be able to maintain homeostasis, and the positive-feedback effect of an ever-decreasing blood pressure can develop. Circumstances in which negative-feedback mechanisms are not adequate to maintain homeostasis illustrate a basic principle. Many disease states result from failure of negative-feedback mechanisms to maintain homeostasis. Medical therapy seeks to overcome illness by aiding negative-feedback mechanisms (e.g., a transfusion reverses a constantly decreasing blood pressure and restores homeostasis).

A few positive-feedback mechanisms do operate in the body under normal conditions, but in all cases they are eventually limited in some way. Birth is an example of a normally occurring positive-feedback mechanism. Near the end of pregnancy, the baby's larger size stretches the uterus. This stretching, especially around the opening of the uterus, stimulates contractions of the uterine muscles. The uterine contractions push the baby against the opening of the uterus and stretch it further. This stimulates additional contractions that result in additional stretching. This positive-feedback sequence ends only when the baby is delivered from the uterus and the stretching stimulus is eliminated.

11. Define positive feedback. Why are positive-feedback mechanisms often harmful?

P R E D I C T 3

Is the sensation of thirst associated with a negative- or a positive-feedback mechanism? Explain.

Terminology and the Body Plan

Objectives

- ***Define the anatomic position and its importance to directional terms.***
- ***Identify and define the directional terms, parts, and planes of the body.***
- ***Name the major trunk cavities and describe the serous membranes associated with each of them.***

You will be learning many new words as you study anatomy and physiology. Knowing the derivation, or **etymology** (et′uh-mol′ŏ-jē), of these words, can make learning them easy and fun. Most words are derived from Latin or Greek, which are very descriptive languages. For example, *foramen* is a Latin word for hole, and *magnum* means large. The foramen magnum is therefore a large hole in the skull through which the spinal cord attaches to the brain.

Prefixes and suffixes can be added to words to expand their meaning. The suffix *-itis* means an inflammation, so appendicitis is an inflammation of the appendix. As new terms are introduced in this text, their meanings are often explained. The glossary and the list of word roots, prefixes, and suffixes on the inside back cover of the textbook provide additional information about the new terms.

It is very important to learn these new words so that when you speak to colleagues or write reports your message is clear and correct.

Body Positions

The **anatomic position** refers to a person standing erect with the face directed forward, the upper limbs hanging to the sides, and the palms of the hands facing forward (figure 1.10). A person is **supine** when lying face upward and **prone** when lying face downward.

The position of the body can affect the description of body parts relative to each other. In the anatomic position, the elbow is above the hand, but in the supine or prone position, the elbow and hand are at the same level. To avoid confusion, relational descriptions are always based on the anatomic position, no matter the actual position of the body. Thus, the elbow is always described as being above the wrist, whether the person is lying down or is even upside down.

Directional Terms

Directional terms describe parts of the body relative to each other. Important directional terms are illustrated in figure 1.9 and summarized in table 1.1. It is important to become familiar with these directional terms as soon as possible because you will see them repeatedly throughout the text. Right and left are

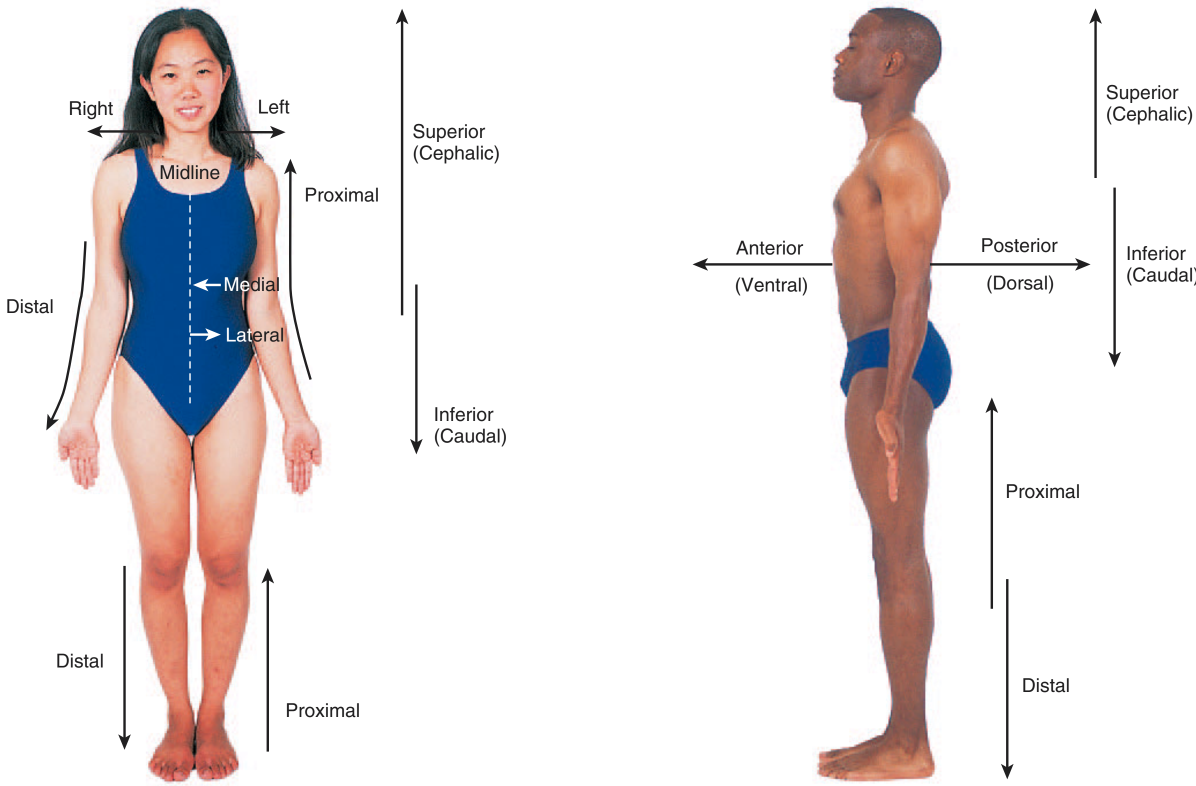


Figure 1.10 **Directional Terms**

All directional terms are in relation to a person in the anatomic position: a person standing erect with the face directed forward, the arms hanging to the sides, and the palms of the hands facing forward.

retained as directional terms in anatomic terminology. Up is replaced by **superior,** down by **inferior,** front by **anterior,** and back by **posterior.**

In humans, *superior* is synonymous with **cephalic** (se-fal′ik), which means toward the head, because, when we are in the anatomic position, the head is the highest point. In humans, the term *inferior* is synonymous with **caudal** (kaw′dăl), which means toward the tail, which would be located at the end of the vertebral column if humans had tails. The terms *cephalic* and *caudal* can be used to describe directional movements on the trunk, but they are not used to describe directional movements on the limbs.

The word *anterior* means that which goes before, and **ventral** means belly. The anterior surface of the human body is therefore the ventral surface, or belly, because the belly "goes first" when we are walking. The word *posterior* means that which follows, and **dorsal** means back. The posterior surface of the body is the dorsal surface, or back, which follows as we are walking.

12. *What is the anatomic position in humans? Why is it important?*
13. *List two terms that in humans indicate toward the head. Name two terms that mean the opposite.*
14. *List two terms that indicate the back in humans. What two terms mean the front?*

P R E D I C T 4

The anatomic position of a cat refers to the animal standing erect on all four limbs and facing forward. On the basis of the etymology of the directional terms, what two terms indicate movement toward the head? What two terms mean movement toward the back? Compare these terms to those referring to a human in the anatomic position.

Proximal means nearest, whereas **distal** means distant. These terms are used to refer to linear structures, such as the limbs, in which one end is near some other structure and the other end is

Table 1.1 Directional Terms for Humans

Terms	Etymology*	Definition	Example
Right		Toward the right side of the body	The right ear.
Left		Toward the left side of the body	The left eye.
Superior	L., higher	A structure above another	The chin is superior to the navel.
Inferior	L., lower	A structure below another	The navel is inferior to the chin.
Cephalic	G. *kephale,* head	Closer to the head than another structure (usually synonymous with superior)	The chin is cephalic to the navel.
Caudal	L. *cauda,* a tail	Closer to the tail than another structure (usually synonymous with inferior)	The navel is caudal to the chin.
Anterior	L., before	The front of the body	The navel is anterior to the spine.
Posterior	L. *posterus,* following	The back of the body	The spine is posterior to the breastbone.
Ventral	L. *ventr-,* belly	Toward the belly (synonymous with anterior)	The navel is ventral to the spine.
Dorsal	L. *dorsum,* back	Toward the back (synonymous with posterior)	The spine is dorsal to the breastbone.
Proximal	L. *proximus,* nearest	Closer to the point of attachment to the body than another structure	The elbow is proximal to the wrist.
Distal	L. *di-* plus *sto,* to stand apart or be distant	Farther from the point of attachment to the body than another structure	The wrist is distal to the elbow.
Lateral	L. *latus,* side	Away from the midline of the body	The nipple is lateral to the breastbone.
Medial	L. *medialis,* middle	Toward the midline of the body	The bridge of the nose is medial to the eye.
Superficial	L. *superficialis,* toward the surface	Toward or on the surface (not shown in figure 1.10)	The skin is superficial to muscle.
Deep	O.E. *deop,* deep	Away from the surface, internal (not shown in figure 1.10)	The lungs are deep to the ribs.

*Origin and meaning of the word: L., Latin; G., Greek; O.E., Old English.

farther away. Each limb is attached at its proximal end to the body, and the distal end, such as the hand, is farther away.

Medial means toward the midline, and **lateral** means away from the midline. The nose is located in a medial position in the face, and the eyes are lateral to the nose. The term **superficial** refers to a structure close to the surface of the body, and **deep** is toward the interior of the body. The skin is superficial to muscle and bone.

15. Define the following terms, and give the word that means the opposite: proximal, lateral, and superficial.

PREDICT 5

Describe in as many directional terms as you can the relationship between your kneecap and your heel.

Body Parts and Regions

A number of terms are used when referring to different parts or regions of the body (figure 1.11). The upper limb is divided into the arm, forearm, wrist, and hand. The **arm** extends from the shoulder to the elbow, and the **forearm** extends from the elbow to the wrist. The lower limb is divided into the thigh, leg, ankle, and foot. The **thigh** extends from the hip to the knee, and the **leg** extends from the knee to the ankle. Note that, contrary to popular usage, the terms *arm* and *leg* refer to only a part of the respective limb.

The central region of the body consists of the **head, neck,** and **trunk.** The trunk can be divided into the **thorax** (chest), **abdomen** (region between the thorax and pelvis), and **pelvis** (the inferior end of the trunk associated with the hips).

The abdomen is often subdivided superficially into **quadrants** by two imaginary lines—one horizontal and one vertical—that intersect at the navel (figure 1.12*a*). The quadrants formed are the right-upper, left-upper, right-lower, and left-lower quadrants. In addition to these quadrants, the abdomen is sometimes subdivided into nine **regions** by four imaginary lines: two horizontal and two vertical. These four lines create an imaginary tic-tac-toe figure on the abdomen, resulting in nine regions: epigastric, right and left hypochondriac, umbilical, right and left lumbar, hypogastric, and right and left iliac (figure 1.12*b*). Clinicians use the quadrants or regions as reference points for locating underlying organs. For example, the appendix is located in the

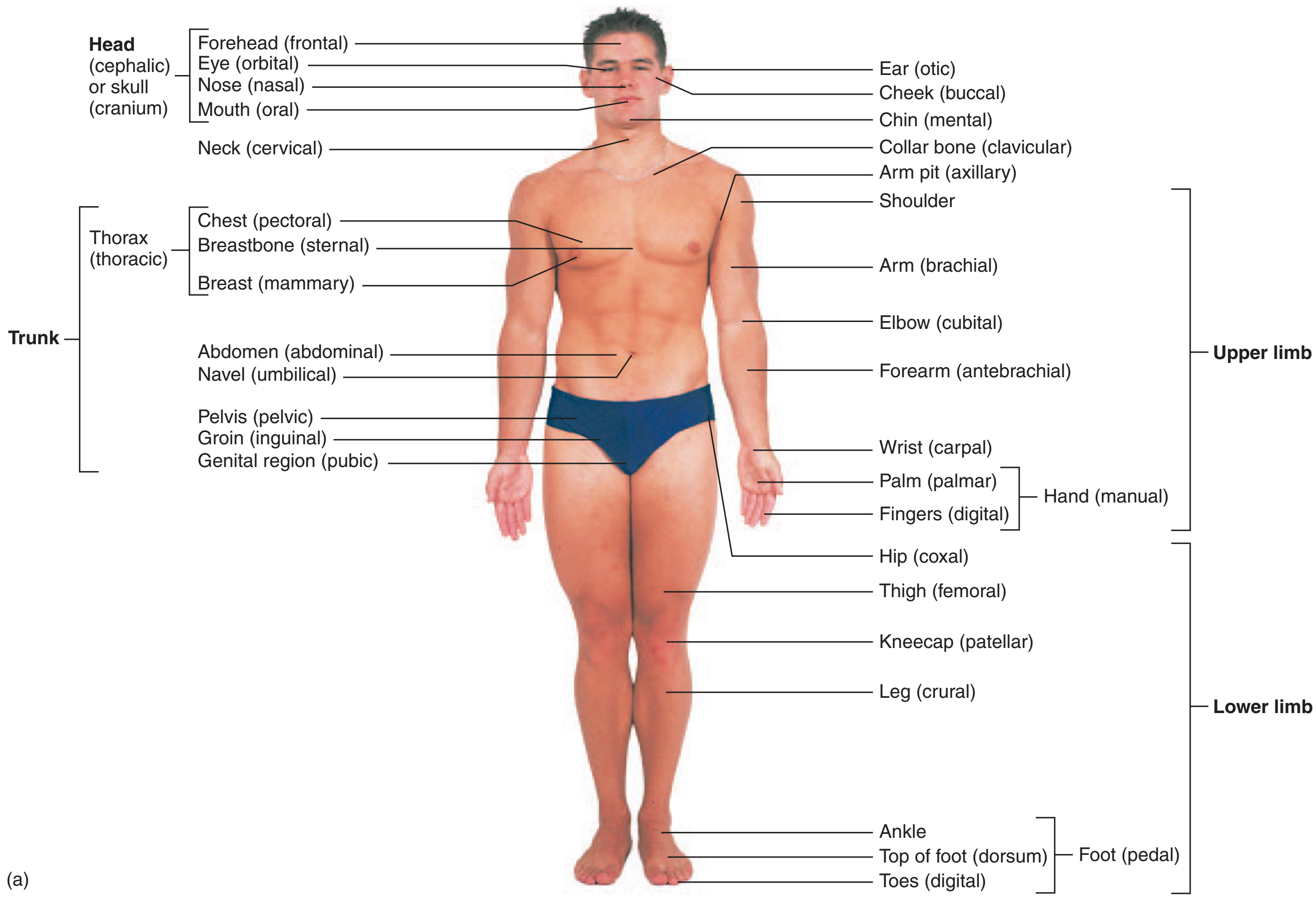


Figure 1.11 Body Parts and Regions

The common and anatomic (*in parentheses*) names are indicated for some parts and regions of the body. (*a*) Anterior view.

right-lower quadrant, and the pain of an acute appendicitis is usually felt there.

16. What is the difference between the arm and the upper limb and the difference between the leg and the lower limb?

17. Describe the quadrant and the nine-region methods of subdividing the abdominal region. What is the purpose of these subdivisions?

P R E D I C T 6

Using figures 1.2 (p. 7) and 1.12 (p. 18), determine in which quadrant each of the following organs is located: spleen, gallbladder, kidneys, most of the stomach, and most of the liver.

Planes

At times it is conceptually useful to describe the body as having imaginary flat surfaces called **planes** passing through it (figure 1.13). A plane divides or sections the body, making it possible to "look inside" and observe the body's structures. A **sagittal** (saj′i-tăl) plane runs vertically through the body and separates it into right and left portions. The word *sagittal* literally means "the flight of an arrow" and refers to the way the body would be split by an arrow passing anteriorly to posteriorly. A **midsagittal,** or a **median,** plane divides the body into equal right and left halves, and a **parasagittal** plane runs vertically through the body to one side of the midline. A **transverse,** or **horizontal,** plane runs parallel to the ground and divides the body into superior and inferior portions. A **frontal,** or **coronal** (kōr′ŏ-năl, kō-rō′năl), plane runs

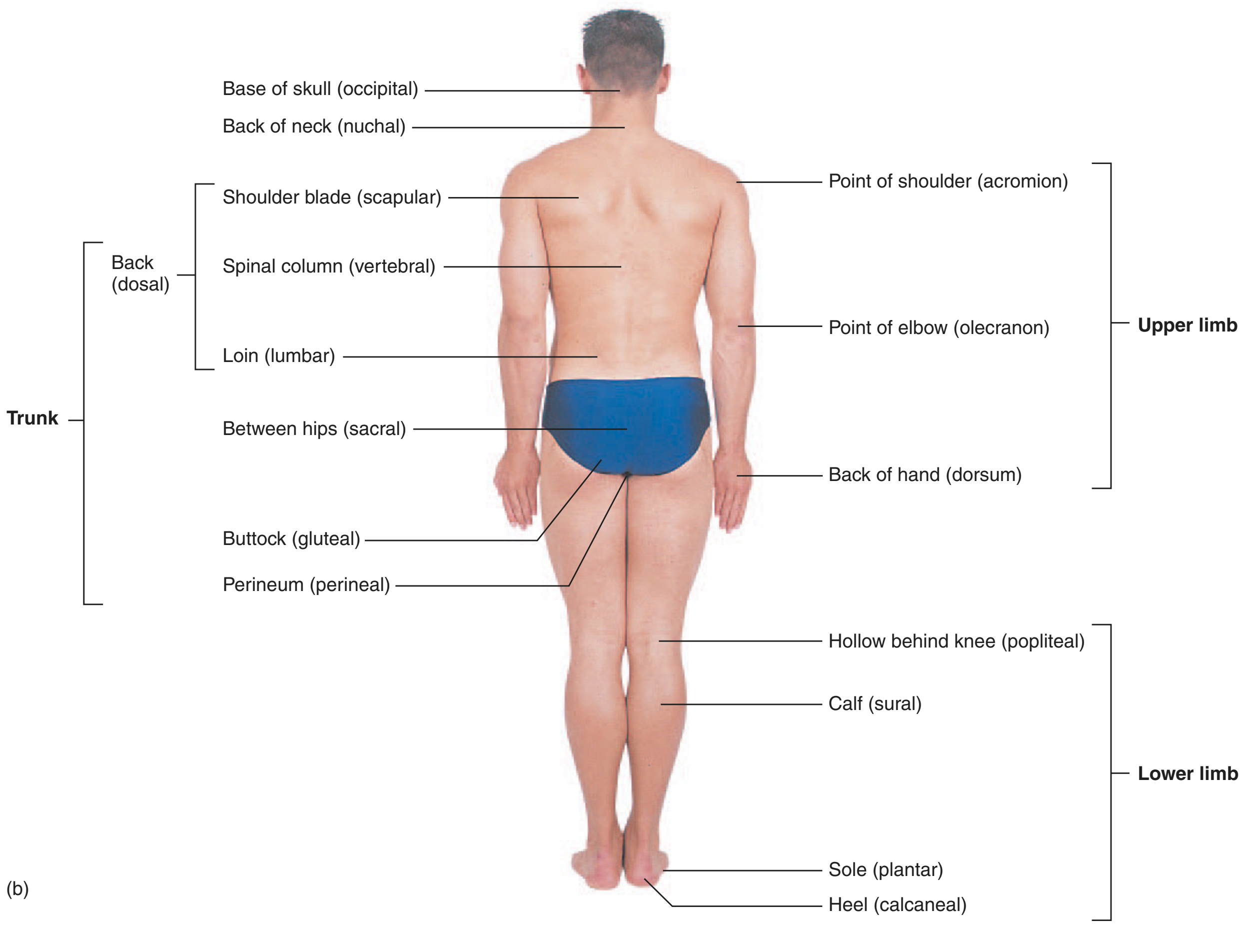


Figure 1.11 *(continued)*
(*b*) Posterior view.

vertically from right to left and divides the body into anterior and posterior parts.

Organs are often sectioned to reveal their internal structure (figure 1.14). A cut through the long axis of the organ is a **longitudinal** section, and a cut at right angles to the long axis is a **cross,** or **transverse,** section. If a cut is made across the long axis at other than a right angle, it is called an **oblique** section.

18. Define the three planes of the body. What is the difference between a parasagittal section and a midsagittal section?
19. In what three ways can an organ be cut?

Body Cavities

The body contains many cavities, among which are the nasal, cranial, and abdominal cavities. Some of these open to the outside of the body, and some do not. Introductory anatomy and physiology textbooks sometimes describe a dorsal cavity, in which the brain and spinal cord are found, and a ventral body cavity that contains all the trunk cavities. The concept of a dorsal cavity is not described in standard works on anatomy. No embryonic, anatomic, or histologic parallels exist between the fluid-filled space around the central nervous system and the trunk cavities. Discussion in this chapter is therefore limited to the major trunk cavities that do not open to the outside.

The trunk contains three large cavities: the thoracic, the abdominal, and the pelvic (figure 1.15). The rib cage surrounds the **thoracic cavity,** and the muscular diaphragm separates it from the abdominal cavity. The thoracic cavity is divided into right and left parts by a median partition called the **mediastinum** (me′dē-as-tī′nŭm; middle wall). The mediastinum contains the heart, thymus gland, trachea, esophagus, and other structures such as blood

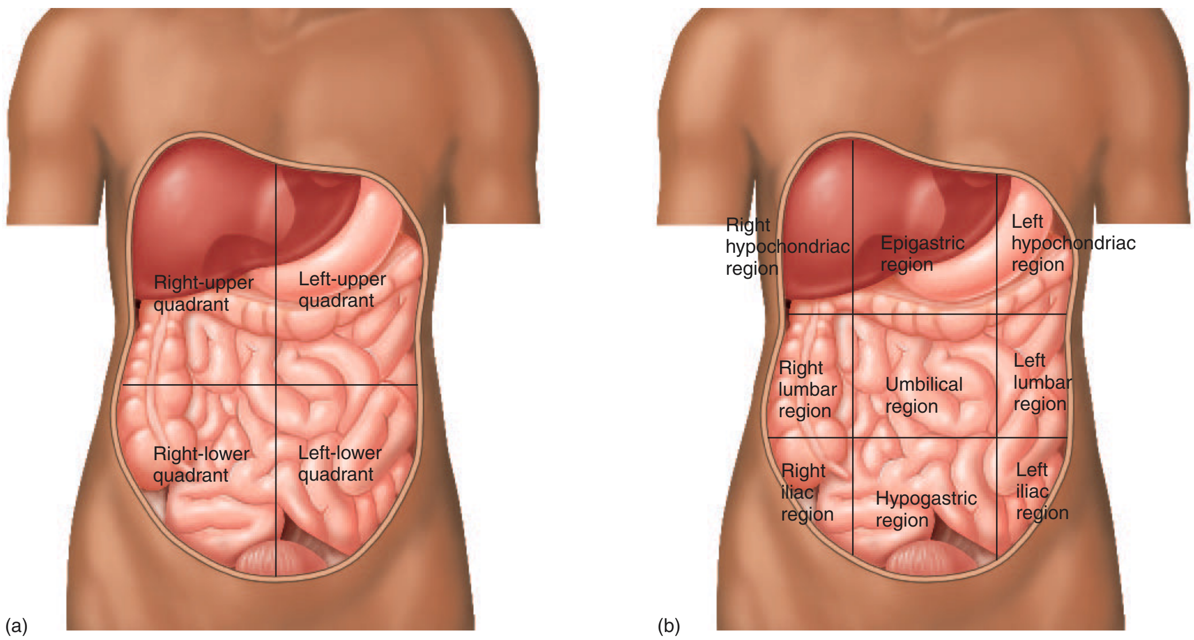


Figure 1.12 Subdivisions of the Abdomen

Lines are superimposed over internal organs to demonstrate the relationship of the organs to the subdivisions. (*a*) Abdominal quadrants consist of four subdivisions. (*b*) Abdominal regions consist of nine subdivisions.

vessels and nerves. The two lungs are located on either side of the mediastinum.

Abdominal muscles primarily enclose the **abdominal cavity,** which contains the stomach, intestines, liver, spleen, pancreas, and kidneys. Pelvic bones encase the small space known as the **pelvic cavity,** where the urinary bladder, part of the large intestine, and the internal reproductive organs are housed. The abdominal and pelvic cavities are not physically separated and sometimes are called the **abdominopelvic cavity.**

Serous Membranes

Serous (sēr′ŭs) **membranes** cover the organs of the trunk cavities and line the trunk cavities. Imagine an inflated balloon into which a fist has been pushed (figure 1.16). The fist represents an organ, the inner balloon wall in contact with the fist represents the **visceral** (vis′er-ăl; organ) **serous membrane** covering the organ, and the outer part of the balloon wall represents the **parietal** (pă-rī′ĕ-tăl; wall) **serous membrane.** The cavity or space between the visceral and parietal serous membranes is normally filled with a thin, lubricating film of serous fluid produced by the membranes. As organs rub against the body wall or against another organ, the combination of serous fluid and smooth serous membranes reduces friction. The thoracic cavity contains three serous membrane-lined cavities: a pericardial cavity and two pleural cavities.

The **pericardial** (per-i-kar′dē-ăl; around the heart) **cavity** surrounds the heart (figure 1.17*a*). The visceral pericardium covers the heart, which is contained within a connective tissue sac lined with the parietal pericardium. The pericardial cavity, which contains pericardial fluid, is located between the visceral and parietal pericardia.

A **pleural** (ploor′ăl; associated with the ribs) **cavity** surrounds each lung, which is covered by visceral pleura (figure 1.17*b*). Parietal pleura line the inner surface of the thoracic wall, the lateral surfaces of the mediastinum, and the superior surface of the diaphragm. The pleural cavity lies between the visceral and parietal pleurae and contains pleural fluid.

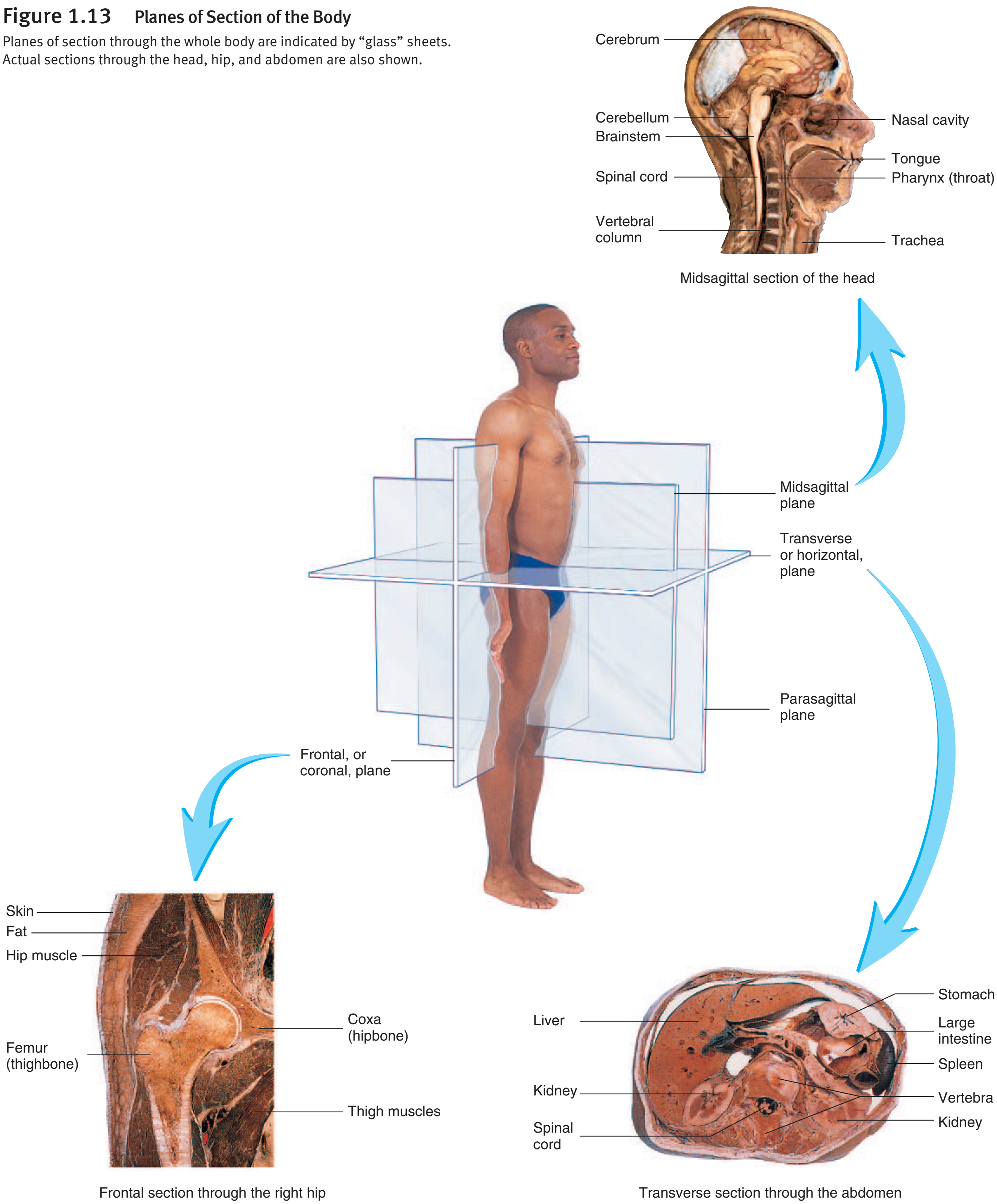
The abdominopelvic cavity contains a serous membrane-lined cavity called the **peritoneal** (per′i-tō-nē′ăl; to stretch over) **cavity** (figure 1.17*c*). Visceral peritoneum covers many of the organs of the abdominopelvic cavity. Parietal peritoneum lines the wall of the abdominopelvic cavity and the inferior surface of the diaphragm. The peritoneal cavity is located between the visceral and parietal peritonea and contains peritoneal fluid.

Inflammation of Serous Membranes

The serous membranes can become inflamed, usually as a result of an infection. **Pericarditis** (per′i-kar-dī′tis) is inflammation of the pericardium, **pleurisy** (ploor′i-sē) is inflammation of the pleura, and **peritonitis** (per′i-tō-nī′tis) is inflammation of the peritoneum.

Figure 1.13 Planes of Section of the Body

Planes of section through the whole body are indicated by “glass” sheets. Actual sections through the head, hip, and abdomen are also shown.



Mesenteries (mes′en-ter-ēz), which consist of two layers of peritoneum fused together (see figure 1.17*c*), connect the visceral peritoneum of some abdominopelvic organs to the parietal peritoneum on the body wall or to the visceral peritoneum of other abdominopelvic organs. The mesenteries anchor the organs to the body wall and provide a pathway for nerves and blood vessels to reach the organs. Other abdominopelvic organs are more closely attached to the body wall and do not have mesenteries. Parietal peritoneum covers these other organs which are said to be **retroperitoneal** (re′trō-per′i-tō-nē′ăl; behind the peritoneum). The retroperitoneal organs include the kidneys, the adrenal glands, the pancreas, parts of the intestines, and the urinary bladder (see figure 1.17*c*).

20. *Define serous membranes. Differentiate between parietal and visceral serous membranes. What is the function of the serous membranes?*
21. *Name the serous membranes lining each of the trunk cavities.*
22. *What are mesenteries? Explain their function.*
23. *What are retroperitoneal organs? List four examples.*

PREDICT 7

Explain how an organ can be located within the abdominopelvic cavity but not be within the peritoneal cavity.

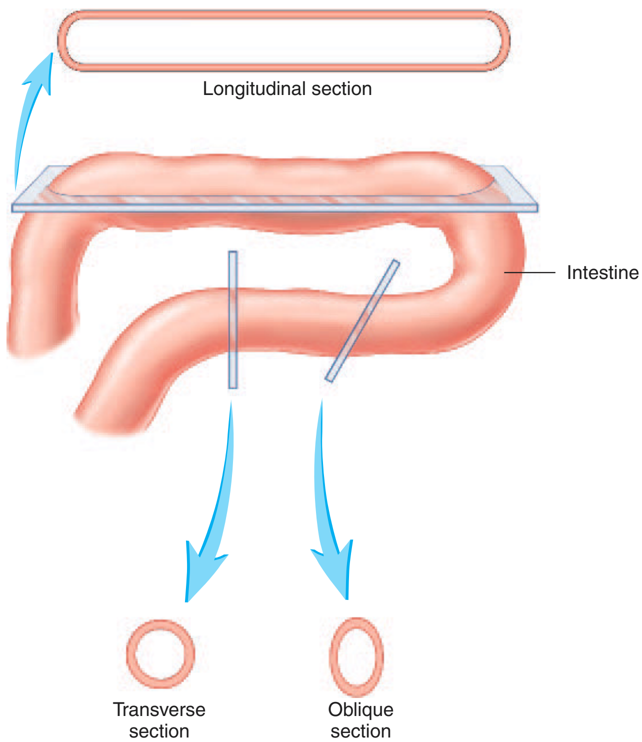


Figure 1.14 Planes of Section Through an Organ

Planes of section through the small intestine are indicated by “glass” sheets. The views of the small intestine after sectioning are also shown. Although the small intestine is basically a tube, the sections appear quite different in shape.

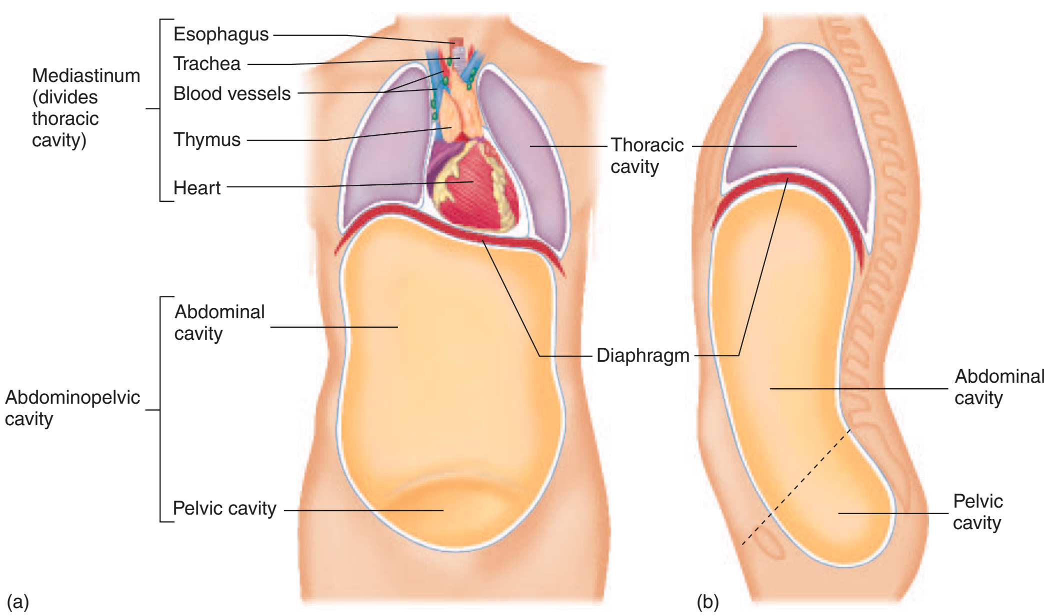


Figure 1.15 Trunk Cavities

(*a*) Anterior view showing the major trunk cavities. The diaphragm separates the thoracic cavity from the abdominal cavity. The mediastinum, which includes the heart, is a partition of organs dividing the thoracic cavity. (*b*) Sagittal view of trunk cavities. The *dashed line* shows the division between the abdominal and pelvic cavities. The mediastinum has been removed to show the thoracic cavity.

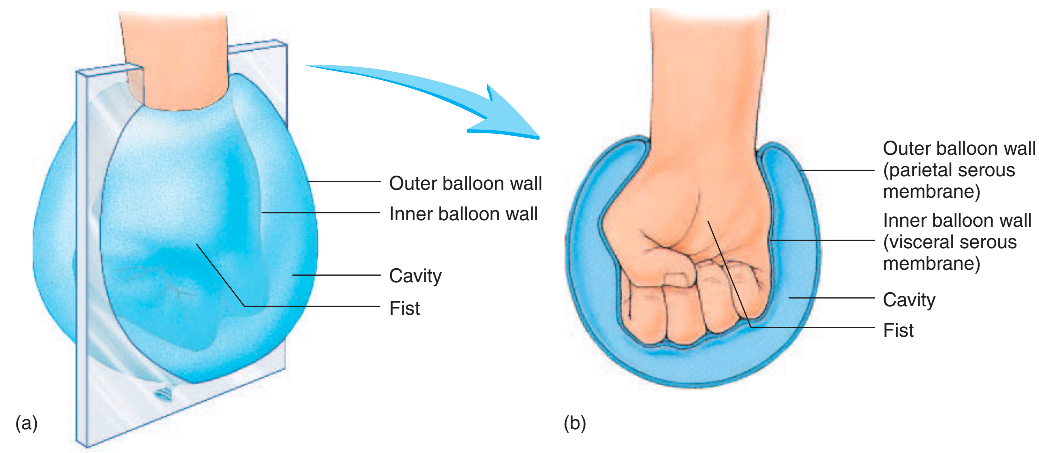


Figure 1.16 Serous Membranes

(*a*) Fist pushing into a balloon. A "glass" sheet indicates the location of a cross section through the balloon. (*b*) Interior view produced by the section in (*a*). The fist represents an organ, and the walls of the balloon the serous membranes. The inner wall of the balloon represents a visceral serous membrane in contact with the fist (organ). The outer wall of the balloon represents a parietal serous membrane.

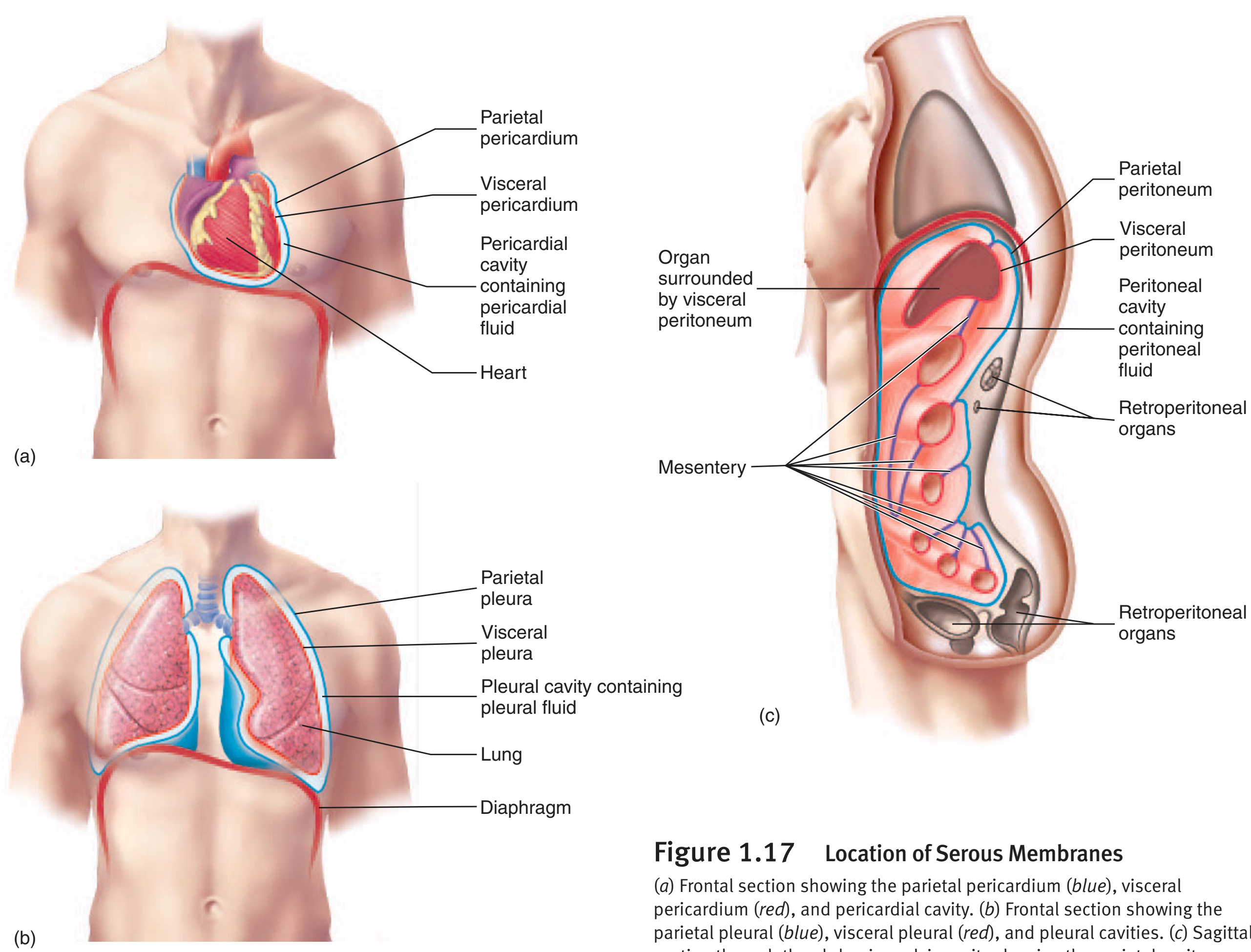


Figure 1.17 Location of Serous Membranes

(*a*) Frontal section showing the parietal pericardium (*blue*), visceral pericardium (*red*), and pericardial cavity. (*b*) Frontal section showing the parietal pleural (*blue*), visceral pleural (*red*), and pleural cavities. (*c*) Sagittal section through the abdominopelvic cavity showing the parietal peritoneum (*blue*), visceral peritoneum (*red*), peritoneal cavity, mesenteries (*purple*), and retroperitoneal organs.

SUMMARY

A functional knowledge of anatomy and physiology can be used to solve problems concerning the body when healthy or diseased.

Anatomy and Physiology (p. 2)

1. Anatomy is the study of the body's structures.
   - Developmental anatomy considers anatomic changes from conception to adulthood. Embryology focuses on the first eight weeks of development.
   - Cytology examines cells, and histology examines tissues.
   - Gross anatomy emphasizes organs from a systemic or regional perspective.
2. Surface anatomy uses superficial structures to locate deeper structures, and anatomic imaging is a noninvasive technique for identifying deep structures.
3. Physiology is the study of the body's functions. It can be approached from a cellular or systems point of view.
4. Pathology deals with all aspects of disease. Exercise physiology examines changes caused by exercise.

Structural and Functional Organization (p. 5)

1. Basic chemical characteristics are responsible for the structure and functions of life.
2. Cells are the basic living units of plants and animals and have many common characteristics. Organelles are small structures within cells that perform specific functions.
3. Tissues are groups of cells of similar structure and function and the materials surrounding them. The four primary tissue types are epithelial, connective, muscle, and nervous tissues.
4. Organs are structures composed of two or more tissues that perform specific functions.
5. Organs are arranged into the 11 organ systems of the human body (see figure 1.2).
6. Organ systems interact to form a whole, functioning organism.

The Human Organism (p. 5)

Characteristics of Life

Humans have many characteristics such as organization, metabolism, responsiveness, growth, development, and reproduction in common with other organisms.

Biomedical Research

Much of what is known about humans is derived from research on other organisms.

Homeostasis (p. 10)

Homeostasis is the condition in which body functions, fluids, and other factors of the internal environment are maintained at levels suitable to support life.

Negative Feedback

1. Negative-feedback mechanisms operate to maintain homeostasis.
2. Many negative-feedback mechanisms consist of a receptor, control center, and effector.

Positive Feedback

1. Positive-feedback mechanisms usually increase deviations from normal.
2. Although a few positive-feedback mechanisms normally exist in the body, most positive-feedback mechanisms are harmful.

Terminology and the Body Plan (p. 13)

Body Positions

1. A human standing erect with the face directed forward, the arms hanging to the side, and the palms facing forward is in the anatomic position.
2. A person lying face upward is supine and face downward is prone.

Directional Terms

Directional terms always refer to the anatomic position, no matter what the actual position of the body (see table 1.1).

Body Parts and Regions

1. The body can be divided into the limbs, upper and lower, and a central region consisting of the head, neck, and trunk regions.
2. Superficially the abdomen can be divided into quadrants or nine regions. These divisions are useful for locating internal organs or describing the location of a pain or tumor.

Planes

1. Planes of the body
   - A midsagittal (median) plane divides the body into equal left and right halves. A parasagittal plane produces unequal left and right parts.
   - A transverse (horizontal) plane divides the body into superior and inferior portions.
   - A frontal (coronal) plane divides the body into anterior and posterior parts.
2. Sections of an organ
   - A longitudinal section of an organ divides it along the long axis.
   - A cross (transverse) section cuts at a right angle to the long axis of an organ.
   - An oblique section cuts across the long axis of an organ at an angle other than a right angle.

Body Cavities

1. The mediastinum subdivides the thoracic cavity.
2. The diaphragm separates the thoracic and abdominal cavities.
3. Pelvic bones surround the pelvic cavity.

Serous Membranes

1. Serous membranes line the trunk cavities. The parietal portion of a serous membrane lines the wall of the cavity, and the visceral portion is in contact with the internal organs.
   - The serous membranes secrete fluid that fills the space between the visceral and parietal membranes. The serous membranes protect organs from friction.
   - The pleural membranes surround the lungs, the pericardial membranes surround the heart, and the peritoneal membranes line the abdominal and pelvic cavities and surround their organs.
2. Mesenteries are parts of the peritoneum that hold the abdominal organs in place and provide a passageway for blood vessels and nerves to the organs.
3. Retroperitoneal organs are located "behind" the parietal peritoneum.

REVIEW AND COMPREHENSION

1. Physiology
   a. deals with the processes or functions of living things.
   b. is the scientific discipline that investigates the body's structures.
   c. is concerned with organisms and does not deal with different levels of organization, such as cells and systems.
   d. recognizes the static (as opposed to the dynamic) nature of living things.
   e. can be used to study the human body without considering anatomy.
2. Given the following conceptual levels for considering the body:
   1. cell
   2. chemical
   3. organ
   4. organ system
   5. organism
   6. tissue

   Choose the correct order for these conceptual levels, from smallest to largest.
   a. 1,2,3,6,4,5
   b. 2,1,6,3,4,5
   c. 3,1,6,4,5,2
   d. 4,6,1,3,5,2
   e. 1,6,5,3,4,2

For questions 3–8, match each organ system with its correct function.
   a. regulates other organ systems
   b. removes waste products from the blood; maintains water balance
   c. regulates temperature; prevents water loss; provides protection
   d. removes foreign substances from the blood; combats disease; maintains tissue fluid balance
   e. produces movement; maintains posture; produces body heat

3. endocrine system
4. integumentary system
5. lymphatic system
6. muscular system
7. nervous system
8. urinary system
9. The characteristic of life that is defined as "all the chemical reactions taking place in an organism" is
   a. development.
   b. growth.
   c. metabolism.
   d. organization.
   e. responsiveness.
10. Negative-feedback mechanisms
   a. make deviations from the set point smaller.
   b. maintain homeostasis.
   c. are associated with an increased sense of hunger the longer a person goes without eating.
   d. all of the above.
11. The following events are part of a negative-feedback mechanism.
   1. Blood pressure increases.
   2. Control center compares actual blood pressure to the blood pressure set point.
   3. The heart beats faster.
   4. Receptors detect a decrease in blood pressure.

   Choose the arrangement that lists the events in the order they occur.
   a. 1,2,3,4
   b. 1,3,2,4
   c. 3,1,4,2
   d. 4,2,3,1
   e. 4,3,2,1
12. Which of these statements concerning positive feedback is correct?
   a. Positive-feedback responses maintain homeostasis.
   b. Positive-feedback responses occur continuously in healthy individuals.
   c. Birth is an example of a normally occurring positive-feedback mechanism.
   d. When the cardiac muscle receives an inadequate supply of blood, positive-feedback mechanisms increase blood flow to the heart.
   e. Medical therapy seeks to overcome illness by aiding positive-feedback mechanisms.
13. The clavicle (collarbone) is ____________ to the nipple of the breast.
   a. anterior
   b. distal
   c. superficial
   d. superior
   e. ventral
14. A term that means nearer the attached end of a limb is
   a. distal.
   b. lateral.
   c. medial.
   d. proximal.
   e. superficial.
15. Which of these directional terms are paired most appropriately as opposites?
   a. superficial and deep
   b. medial and proximal
   c. distal and lateral
   d. superior and posterior
   e. anterior and inferior
16. The part of the upper limb between the elbow and the wrist is called the
   a. arm.
   b. forearm.
   c. hand.
   d. inferior arm.
   e. lower arm.
17. A patient with appendicitis usually has pain in the ____________ quadrant of the body.
   a. lower-left
   b. lower-right
   c. upper-left
   d. upper-right
18. A plane that divides the body into anterior and posterior parts is a
   a. frontal (coronal) plane.
   b. sagittal plane.
   c. transverse plane.
19. The pelvic cavity contains the
   a. kidneys.
   b. liver.
   c. spleen.
   d. stomach.
   e. urinary bladder.
20. The lungs are
   a. part of the mediastinum.
   b. surrounded by the pericardial cavity.
   c. found within the thoracic cavity.
   d. separated from each other by the diaphragm.
   e. surrounded by mucous membranes.
21. Given these characteristics:
   1. reduce friction between organs
   2. line fluid-filled cavities
   3. line trunk cavities that open to the exterior of the body

Which of the characteristics describe serous membranes?
a. 1,2
b. 1,3
c. 2,3
d. 1,2,3

22. Given these organ and cavity combinations:
1. heart and pericardial cavity
2. lungs and pleural cavity
3. stomach and peritoneal cavity
4. kidney and peritoneal cavity

Which of the organs is correctly paired with a space that surrounds that organ?
a. 1,2
b. 1,2,3
c. 1,2,4
d. 2,3,4
e. 1,2,3,4

23. Which of these membrane combinations are found on the surface of the diaphragm?
a. parietal pleura—parietal peritoneum
b. parietal pleura—visceral peritoneum
c. visceral pleura—parietal peritoneum
d. visceral pleura—visceral peritoneum

24. Mesenteries
a. are found in the pleural, pericardial, and abdominopelvic cavities.
b. consist of two layers of peritoneum fused together.
c. anchor organs such as the kidneys and urinary bladder to the body wall.
d. are found primarily in body cavities that open to the outside.
e. all of the above.

25. Which of the following organs is *not* retroperitoneal?
a. adrenal glands
b. urinary bladder
c. kidneys
d. pancreas
e. stomach

Answers in Appendix F

CRITICAL THINKING

1. Exposure to a hot environment causes the body to sweat. The hotter the environment, the greater the sweating. Two anatomy and physiology students are arguing about the mechanisms involved: Student A claims that they are positive feedback, and student B claims they are negative feedback. Do you agree with student A or student B and why?
2. The following observations were made on a patient who had suffered a bullet wound: Heart rate elevated and rising. Blood pressure very low and dropping. After bleeding was stopped and a blood transfusion was given, blood pressure increased. Which of the following statements is (are) consistent with these observations?
   a. Negative-feedback mechanisms are occasionally inadequate without medical intervention.
   b. The transfusion interrupted a positive-feedback mechanism.
   c. The transfusion interrupted a negative-feedback mechanism.
   d. The transfusion was not necessary.
   e. Both a and b.
3. Provide the correct directional term for the following statement: When a boy is standing on his head, his nose is ____________ to his mouth.
4. Complete the following statements, using the correct directional terms for a human being. Note that more than one term can apply.
   a. The navel is ____________ to the nose.
   b. The nipple is ____________ to the lung.
   c. The arm is ____________ to the forearm.
   d. The little finger is ____________ to the index finger.
5. The esophagus is a muscular tube that connects the pharynx (throat) to the stomach. In which quadrant and region is the esophagus located? In which quadrant and region is the urinary bladder located?
6. Given the following procedures:
   1. Make an opening into the mediastinum.
   2. Lay the patient supine.
   3. Lay the patient prone.
   4. Make an incision through the pericardial serous membranes.
   5. Make an opening into the abdomen.

   Which of the procedures should be accomplished to expose the anterior surface of a patient's heart?
   a. 2,1,4
   b. 2,5,4
   c. 3,1,4
   d. 3,5,4
7. During pregnancy, which of the mother's body cavities increases most in size?
8. A bullet enters the left side of a man, passes through the left lung, and lodges in the heart. Name in order the serous membranes and their cavities through which the bullet passes.
9. A woman falls while skiing and accidentally is impaled by her ski pole. The pole passes through the abdominal body wall and into and through the stomach, pierces the diaphragm, and finally stops in the left lung. List in order the serous membranes the pole pierces.

Answers in Appendix G

ANSWERS TO PREDICT QUESTIONS

1. The chemical level is the level at which correction is currently being accomplished. Insulin can be purchased and injected into the circulation to replace the insulin normally produced by the pancreas. Another approach is drugs that stimulate pancreatic cells to produce insulin. Current research is directed at transplanting cells that can produce insulin. Another possibility is a partial transplant of tissue or a complete organ transplant.
2. Negative-feedback mechanisms work to control respiratory rates so that body cells have adequate oxygen and are able to eliminate carbon dioxide. The greater the respiratory rate, the greater the exchange of gases between the body and the air. When a person is at rest, there is less of a demand for oxygen, and less carbon dioxide is produced than during exercise. At rest, homeostasis can be maintained with a low respiration rate. During exercise there is a greater demand for oxygen, and more carbon dioxide must be eliminated. Consequently, to maintain homeostasis during exercise, the respiratory rate increases.
3. The sensation of thirst is involved in a negative-feedback mechanism that maintains body fluids. The sensation of thirst increases with a decrease in body fluids. The thirst mechanism causes a person to drink fluids, which returns body fluid levels to normal, thereby maintaining homeostasis.
4. In the cat, cephalic and anterior are toward the head; dorsal and superior are toward the back. In humans, cephalic and superior are toward the head; dorsal and posterior are toward the back.
5. Your kneecap is both proximal and superior to the heel. It is also anterior to the heel because it is on the anterior side of the lower limb, whereas the heel is on the posterior side.
6. The spleen is in the left-upper quadrant, the gallbladder is in the right-upper quadrant, the left kidney is in the left-upper quadrant, the right kidney is in the right-upper quadrant, the stomach is mostly in the left-upper quadrant, and the liver is mostly in the right-upper quadrant.
7. There are two ways in which an organ can be located within the abdominopelvic cavity but not be within the peritoneal cavity. First, the visceral peritoneum wraps around organs. Thus the peritoneal cavity surrounds the organ, but the organ is not inside the peritoneal cavity. The peritoneal cavity contains only peritoneal fluid. Second, retroperitoneal organs are in the abdominopelvic cavity, but they are between the wall of the abdominopelvic cavity and the parietal peritoneal membrane.

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