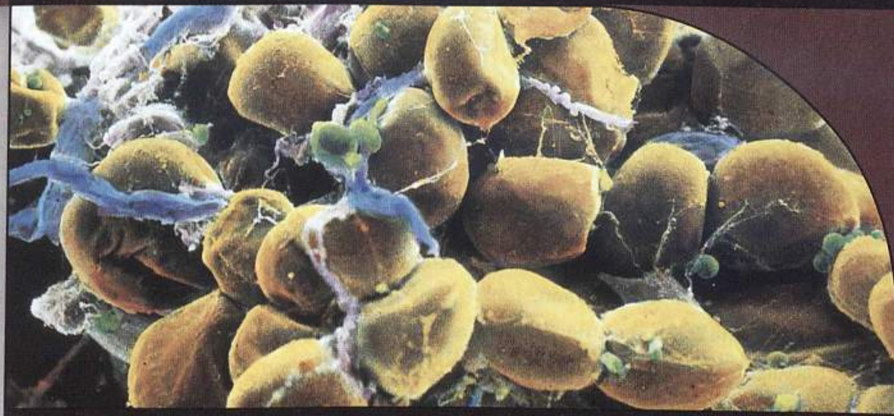
C H A P T E R 1



A falsely colored scanning electron micrograph shows fat cells (yellow). Almost the entire volume of each cell is occupied by a single lipid droplet containing mostly triglycerides (440×).

Introduction to Human Anatomy and Physiology

UNDERSTANDING WORDS

append-, to hang something: *append*icular—pertaining to the upper limbs and lower limbs.

cardi-, heart: peri*cardi*um—membrane that surrounds the heart.

cerebr-, brain: *cerebr*um—largest portion of the brain.

cran-, helmet: *cran*ial—pertaining to the portion of the skull that surrounds the brain.

dors-, back: *dors*al—position toward the back of the body.

homeo-, same: *homeo*stasis—maintenance of a stable internal environment.

-logy, the study of: physio*logy*—study of body functions.

meta-, change: *meta*bolism—chemical changes that occur within the body.

nas-, nose: *nas*al—pertaining to the nose.

orb-, circle: *orb*ital—pertaining to the portion of skull that encircles an eye.

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 within the rib cage.

-stasis, standing still: homeo*stasis*—maintenance of a stable internal environment.

super-, above: *super*ior—referring to a body part that is located above another.

-tomy, cutting: ana*tomy*—study of structure, which often involves cutting or removing body parts.

CHAPTER OBJECTIVES

After you have studied this chapter, you should be able to

1. Define *anatomy* and *physiology* and explain how they are related.
2. List and describe the major characteristics of life.
3. List and describe the major requirements of organisms.
4. Define *homeostasis* and explain its importance to survival.
5. Describe a homeostatic mechanism.
6. Explain the levels of organization of the human body.
7. Describe the locations of the major body cavities.
8. List the organs located in each major body cavity.
9. Name the membranes associated with the thoracic and abdominopelvic cavities.
10. Name the major organ systems and list the organs associated with each.
11. Describe the general functions of each organ system.
12. Properly use the terms that describe relative positions, body sections, and body regions.

Judith R. had not been wearing a seat belt when the accident occurred because she had to drive only a short distance. She hadn't anticipated the intoxicated driver in the oncoming lane who swerved right in front of her. Thrown several feet, she now lay near her wrecked car as emergency medical technicians immobilized her neck and spine. Terrified, Judith tried to assess her condition. She didn't think she was bleeding, and nothing hurt terribly, but she felt a dull ache in the upper right part of her abdomen.

Minutes later, in the emergency department, a nurse gave Judith a quick exam, checking her blood pressure, pulse and breathing rate, and other vital signs and asking questions. These vital signs reflect underlying metabolic activities necessary for life, and they are important in any medical decision. Because Judith's vital signs were stable, and she was alert, knew who and where she was, and didn't seem to have any obvious life-threatening injuries, transfer to a trauma center was not necessary. However, Judith continued to report abdominal pain. The attending physician ordered abdominal X rays, knowing that about a third of patients with abdominal injuries show no outward sign of a problem. As part of standard procedure, Judith received oxygen and intravenous fluids, and a technician took several tubes of blood for testing.

A young physician approached and smiled at Judith as assistants snipped off her clothing. The doctor carefully looked and listened and gently poked and probed. She was looking for cuts; red areas called hematomas where blood vessels had broken; and treadmarks on the skin. Had Judith been wearing her seat belt, the doctor would have checked for characteristic "seat belt contusions," crushed bones or burst hollow organs caused by the twisting constrictions that can occur at the moment of impact when a person wears a seat belt. Finally, the doctor measured the girth of Judith's abdomen. If her abdomen swelled later on, this could indicate a complication, such as infection or internal bleeding.

On the basis of a hematoma in Judith's upper right abdomen and the continued pain coming from this area, the emergency room physician ordered a computed tomography (CT) scan. The scan revealed a lacerated liver. Judith underwent emergency surgery to remove the small torn portion of this vital organ.

When Judith awoke from surgery, a different physician was scanning her chart, looking up frequently. The doctor was studying her medical history for any notation of a disorder that might impede healing. Judith's history of slow blood clotting, he noted, might slow her recovery from surgery. Next, the physician looked and listened. A bluish discoloration of Judith's side might indicate bleeding from her pancreas, kidney, small intestine, or aorta (the artery leading from the heart). A bluish hue near the navel would also be a bad sign, indicating bleeding from the liver or spleen. Her umbilical area was somewhat discolored.

The doctor gently tapped Judith's abdomen and carefully listened to sounds from her digestive tract. A drumlike resonance could mean that a hollow organ had burst, whereas a dull sound might indicate internal bleeding. Judith's abdomen produced dull sounds throughout. Plus, her abdomen had swollen, the pain intensifying when the doctor gently pushed on the area. With Judith's heart rate increasing and blood pressure falling, bleeding from the damaged liver was a definite possibility.

The difference between life and death may depend on a health-care professional's understanding of the human body.

Blood tests confirmed the doctor's suspicions. Because blood is a complex mixture of cells and biochemicals, it serves as a barometer of health. Injury or illness disrupts the body's maintenance of specific levels of various biochemicals. This maintenance is called homeostasis. Judith's blood tests revealed that her body had not yet recovered from the accident. Levels of clotting factors produced by her liver were falling, and blood was oozing from her incision, a sign of impaired clotting. Judith's blood glucose level remained elevated, as it had been in the emergency room. Her body was still reacting to the injury.

Based on Judith's blood tests, heart rate, blood pressure, reports of pain, and the physical exam, the doctor sent her back to the operating room. Sure enough, the part of her liver where the injured portion had been removed was still bleeding. When the doctors placed packing material at the wound site, the oozing gradually stopped. Judith returned to the recovery room and, as her condition stabilized, to her room. This time, all went well, and a few days later, she was able to go home. The next time she drove, Judith wore her seat belt!

Imagine yourself as one of the health-care professionals who helped identify Judith R.'s injury and got her on the road back to health. How would you know what to look, listen, and feel for? How would you place the signs and symptoms into a bigger picture that would suggest the appropriate diagnosis? Nurses, doctors, technicians, and other integral members of health-care teams must have a working knowledge of the many intricacies of the human body. How can they begin to understand its astounding complexity? The study of human anatomy and physiology is a daunting, but fascinating and ultimately life-saving, challenge. ■

Our understanding of the human body has a long and interesting history (fig. 1.1). It began with our earliest ancestors, who must have been as 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. Although they did not have emergency departments to turn to, primitive people certainly suffered from occasional aches and pains, injured themselves, bled, broke bones, developed diseases, and contracted infections.

The change from a hunter-gatherer to an agricultural lifestyle, which occurred from 6,000 to 10,000 years ago in various parts of the world, altered the spectrum of human illnesses. Before agriculture, isolated bands of peoples had little contact with each other, and so infectious diseases did not spread easily, as they do today with our global connections. In addition, these ancient peoples ate wild plants that provided chemicals that combated some parasitic infections.

With agriculture came exposure to pinworms, tapeworms and hookworms in excrement used as fertilizer, and less reliance on the wild plants that offered their protective substances. The rise of urbanization brought even more infectious disease as well as malnutrition, as people became sedentary and altered their diets. Several types of evidence from preserved bones and teeth chronicle these changes. Tooth decay, for example, affected 3% of samples from hunter-gatherers, but 8.7% from farmers, and 17% of samples from city residents. Preserved bones from children reflect increasing malnutrition as people moved from the grasslands to farms to cities. When a child starves or suffers from severe infection, the ends of the long bones stop growing. When health returns, growth resumes, but leaves behind telltale areas of dense bone.

In addition to the changes in health brought about by our own activities, some types of illnesses seem intrinsic to humans. Arthritis, for example, afflicts millions of people today and is also evident in fossils of our ancestors from 3 million years ago, from Neanderthals that lived 100,000 years ago, and from a preserved "ice man" from 5,300 years ago.

The rise of medical science paralleled human prehistory and history. At first, healers relied heavily on superstitions and notions about magic. However, as they tried to help the sick, these early medical workers began to discover useful ways of examining and treating the human body. They observed the effects of injuries, noticed how wounds healed, and examined dead bodies to determine the causes of death. They also found that certain herbs and potions could sometimes be used to treat coughs, headaches, and other common problems. These long-ago physicians began to wonder how these substances, the forerunners of modern drugs, affected body functions in general.

People began asking more questions and seeking answers, setting the stage for the development of modern medical science. Techniques for making accurate observations and performing careful experiments evolved, and knowledge of the human body expanded rapidly.

This new knowledge of the structure and function of the human body required a new, specialized language. Early medical providers devised many terms to name body parts, describe their locations, and explain their functions. These terms, most of which originated from Greek and Latin, formed the basis for the language of anatomy and physiology. (A list of some of the modern medical and applied sciences appears on page 25.)

1 What factors probably stimulated an early interest in the human body?

2 How did human health change as lifestyle changed?

3 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 this illustration from the second book of *De Humani Corporis Fabrica* by Andreas Vesalius, issued in 1543, indicates. Note the similarity to the anatomical position (described on page 21).

Anatomy and Physiology

Two major areas of medical science, **anatomy** (ah-nat′o-me) and **physiology** (fiz″e-ol′o-je) are concerned with how the body maintains life. Anatomy deals with the **structures,** or morphology, of body parts—their forms and organization. Physiology considers the **functions** of these body parts—what they do and how they do it. Although anatomists rely more on examination of the body and physiologists more on experimentation, together their efforts have provided a solid foundation upon which an understanding of how our bodies work is built.

It is difficult to separate the topics of anatomy and physiology because anatomical structures make possible their functions. Parts form a well-organized unit—the **human organism**—and each part plays a role in the operation of the unit as a whole. This functional role depends upon the way the part is constructed. For example, the arrangement of bones and muscles in the human hand, with its long, jointed fingers, makes grasping possible. The heart's powerful muscular walls are structured to contract and propel blood out of the chambers and into blood vessels, and heart valves ensure that blood moves in the proper direction. The shape of the mouth enables it to receive food; teeth are shaped so that they break solid foods into smaller pieces; and the muscular tongue and cheeks are constructed to help mix food particles with saliva and prepare them for swallowing (fig. 1.2).

Anatomy and physiology are ongoing as well as ancient fields. For example, recent research has revealed a previously unknown muscle between two bones in the head, and identified a hormone, ghrelin, that controls fat utilization. The first discovery is anatomical; the second, physiological. Aspects of anatomy and physiology are increasingly being explained at the cellular and molecular levels, especially since researchers sequenced the human genome in 2000—the complete set of genetic instructions for a human body.

1. What are the differences between anatomy and physiology?
2. Why is it difficult to separate the topics of anatomy and physiology?
3. List several examples that illustrate how the structure of a body part makes possible its function.
4. How are anatomy and physiology both old and new fields?

Levels of Organization

Early investigators, limited in their ability to observe small structures, focused their attention on larger body parts. Studies of small structures had to await invention of magnifying lenses and microscopes, which came into use about 400 years ago. These tools revealed that larger body structures were made up of smaller parts, which, in turn, were composed of even smaller ones.

Today, scientists recognize that all materials, including those that comprise the human body, are composed of chemicals. Chemicals consist of tiny particles called **atoms,** which are commonly bound together to form larger particles called **molecules;** small molecules may combine to form larger molecules called **macromolecules.**

Within the human organism, the basic unit of structure and function is a **cell.** Although individual cells vary in size and shape, all share certain characteristics. Human cells contain structures called **organelles** (or″gan-elz′) that carry on specific activities. These organelles are composed of aggregates of large molecules, including proteins, carbohydrates, lipids, and nucleic acids. All cells in a human contain a complete set of genetic instructions, yet use only a subset of them, allowing cells to develop specialized

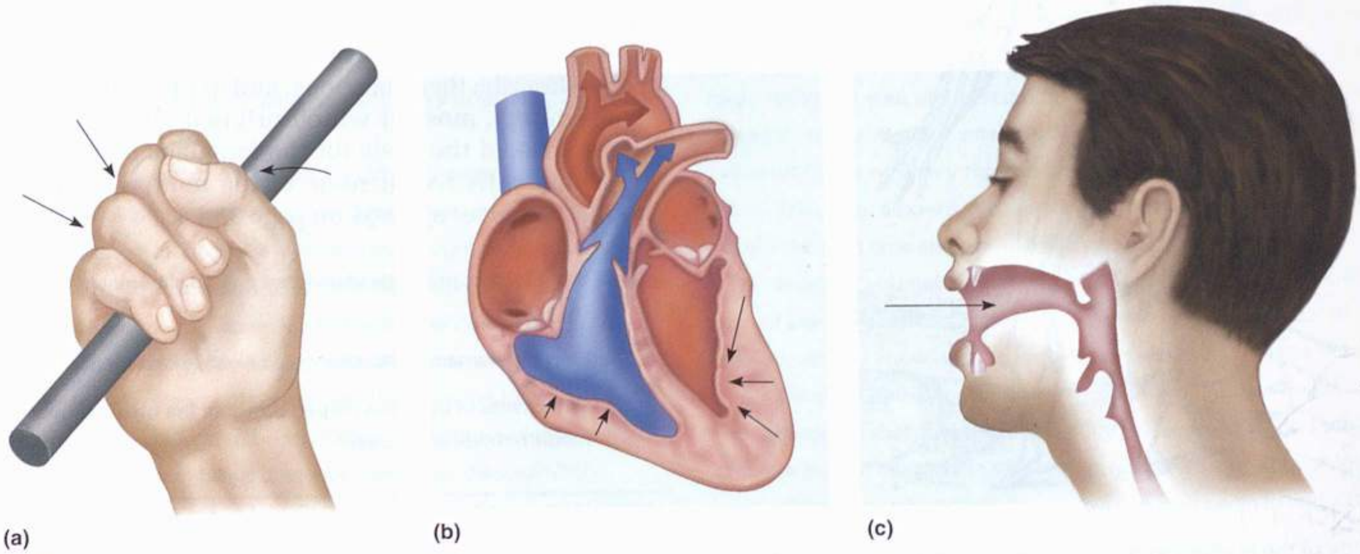


FIGURE 1.2
The structures of body parts make possible their functions: (*a*) The hand is adapted for grasping, (*b*) the heart for pumping blood, and (*c*) the mouth for receiving food. (Arrows indicate movements associated with these functions.)

functions. All cells share the same characteristics of life and must meet certain requirements to continue living.

Cells are organized into layers or masses that have common functions. Such a group of cells forms a **tissue.** Groups of different tissues form **organs**—complex structures with specialized functions—and groups of organs that function closely together comprise **organ systems.** Interacting organ systems make up an **organism.**

A body part can be described at different levels. The heart, for example, contains muscle, fat, and nervous tissue. These tissues, in turn, are constructed of cells, which contain organelles. All of the structures of life are, ultimately, composed of chemicals (fig. 1.3). Clinical Application 1.1 describes two technologies used to visualize differences based on body chemistry.

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; chapter 4 explores cellular metabolism; chapter 5 describes tissues; and chapter 6 presents the skin and its accessory organs as an example of an organ system. Beginning with chapter 7, the structures and functions of each of the organ systems are described in detail. Table 1.1 lists the levels of organization and some

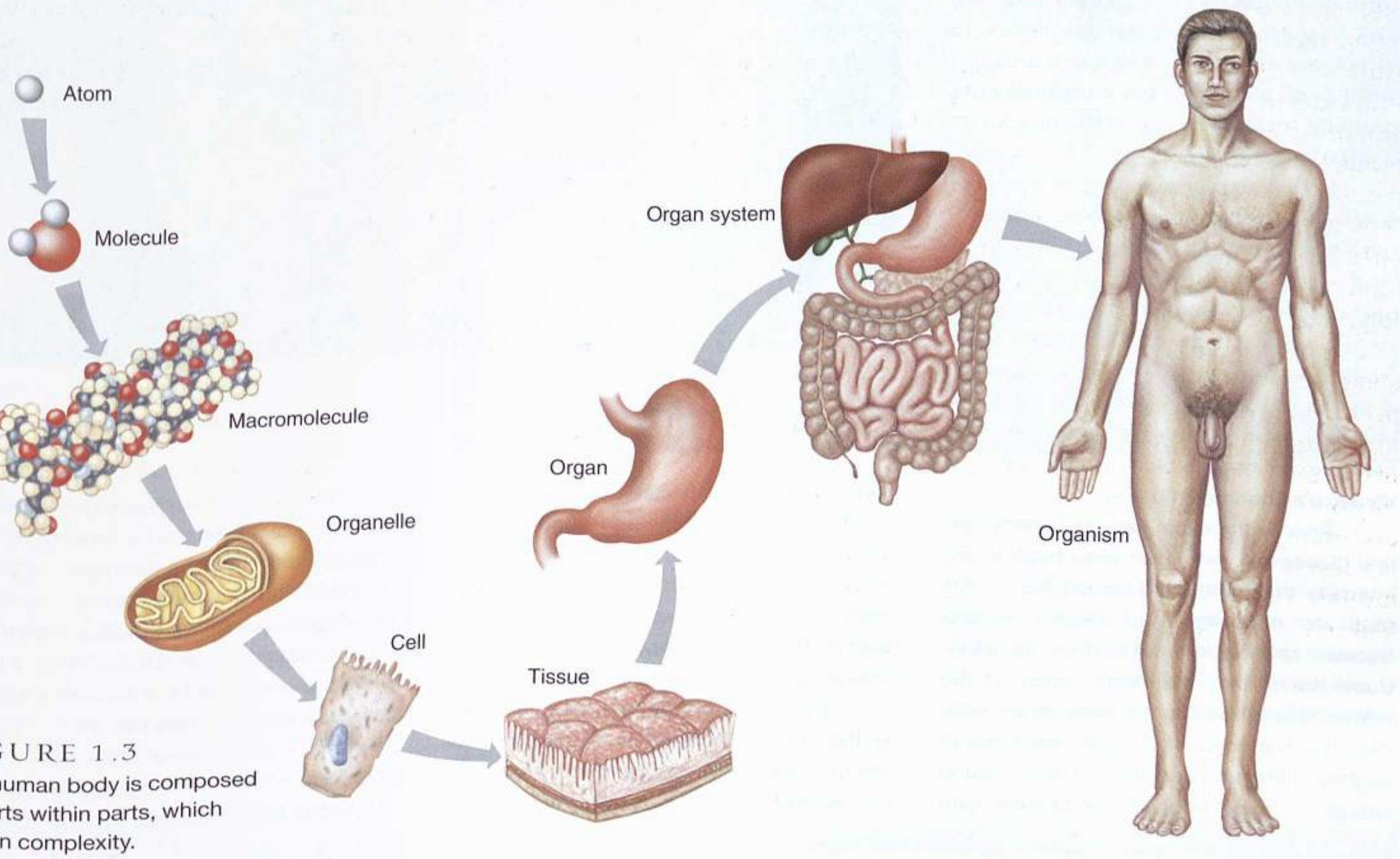


FIGURE 1.3
The human body is composed of parts within parts, which vary in complexity.

TABLE 1.1 Levels of Organization

Level	Example	Illustration
Atom	Hydrogen atom, lithium atom	Figure 2.1
Molecule	Water molecule, glucose molecule	Figure 2.7
Macromolecule	Protein molecule, DNA molecule	Figure 2.19
Organelle	Mitochondrion, Golgi apparatus, nucleus	Figure 3.13
Cell	Muscle cell, nerve cell	Figure 5.28
Tissue	Simple squamous epithelium, loose connective tissue	Figure 5.1
Organ	Skin, femur, heart, kidney	Figure 6.2
Organ system	Integumentary system, skeletal system, digestive system	Figure 1.13
Organism	Human	Figure 1.19

1.1 CLINICAL APPLICATION

Ultrasonography and Magnetic Resonance Imaging: A Tale of Two Patients

The two patients enter the hospital medical scanning unit hoping for opposite outcomes. Vanessa Q., who has suffered several pregnancy losses, hopes that an ultrasound exam will reveal that her current pregnancy is continuing to progress normally. Michael P., a sixteen-year-old who has excruciating headaches, is to undergo a magnetic resonance imaging (MRI) scan to assure his physician (and himself!) that the cause of the headache is not a brain tumor.

Both ultrasound and magnetic resonance imaging scans are noninvasive procedures that provide images of soft internal structures. Ultrasonography uses high-frequency sound waves that are beyond the range of human hearing. A technician gently presses a device called a transducer, which emits sound waves, against the skin and moves it slowly over the surface of the area being examined, which in this case is Vanessa's abdomen (fig. 1A).

FIGURE 1A
Ultrasonography uses reflected sound waves to visualize internal body structures.

Prior to the exam, Vanessa drank several glasses of water. Her filled bladder will intensify the contrast between her uterus (and its contents) and nearby organs because as the sound waves from the transducer travel into the body, some of the waves reflect back to the transducer when they reach a border between structures of slightly different densities. Other sound waves continue into deeper tissues, and some of them are reflected back by still other interfaces. As the reflected sound waves reach the transducer, they are converted into electrical impulses that are amplified and used to create a sectional image of the body's internal structure on a viewing screen. This image is known as a sonogram (fig. 1B).

Glancing at the screen, Vanessa smiles. The image reveals the fetus in her uterus, heart beating and already showing characteristics of a fully developed newborn.

Vanessa's ultrasound exam takes only a few minutes, whereas Michael's MRI scan takes an hour. First, he receives an injection of a dye that provides contrast so that a radiologist examining the scan can distinguish certain brain structures. Then, a nurse wheels the narrow bed on which Michael lies into a chamber surrounded by a powerful magnet and a special radio antenna. The chamber, which looks like a metal doughnut, is the MRI instrument. As Michael set-

corresponding illustrations in this textbook. Table 1.2 summarizes the organ systems, the major organs that comprise them, and their major functions in the order presented in this book. They are discussed in more detail later in this chapter (pages 16–19).

1. How does the human body illustrate levels of organization?
2. What is an organism?
3. How do body parts at different levels of organization vary in complexity?

Characteristics of Life

A scene such as Judith R.'s accident and injury underscores the delicate balance that must be maintained in order to sustain life. In those seconds at the limits of life—the birth of a baby, a trauma scene, or the precise instant of death following a long illness—we often think about just what combination of qualities constitutes this state that we call life. Indeed, although this text addresses the human body, the most fundamental characteristics of life are shared by all organisms. As living organisms, we tles back and closes his eyes, a technician activates the device.

The magnet generates a magnetic field that alters the alignment and spin of certain types of atoms within Michael's brain. At the same time, a second rotating magnetic field causes particular types of atoms (such as the hydrogen atoms in body fluids and organic compounds) to release weak radio waves with characteristic frequencies. The nearby antenna receives and amplifies the radio waves, which are then processed by a computer. Within a few minutes, the computer generates a sectional image based on the locations and concentrations of the atoms being studied (fig. 1C). The device continues to produce data, painting portraits of Michael's brain in the transverse, coronal, and sagittal sections (p. 22).

Michael and his parents nervously wait two days for the expert eyes of a radiologist to interpret the MRI scan. Happily, the scan shows normal brain structure. Whatever is causing Michael's headaches, it is not a brain tumor. ■

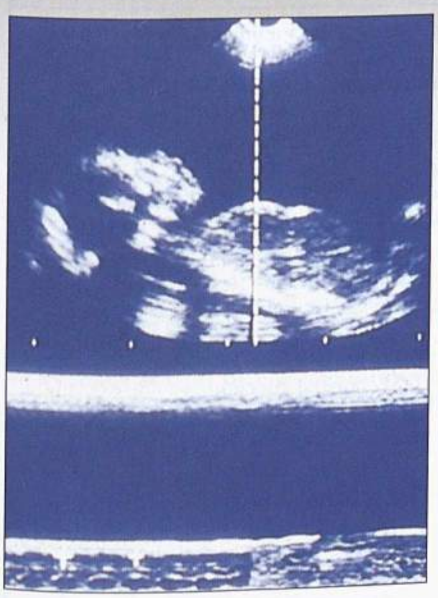


FIGURE 1B
This image resulting from an ultrasonographic procedure reveals the presence of a fetus in the uterus.

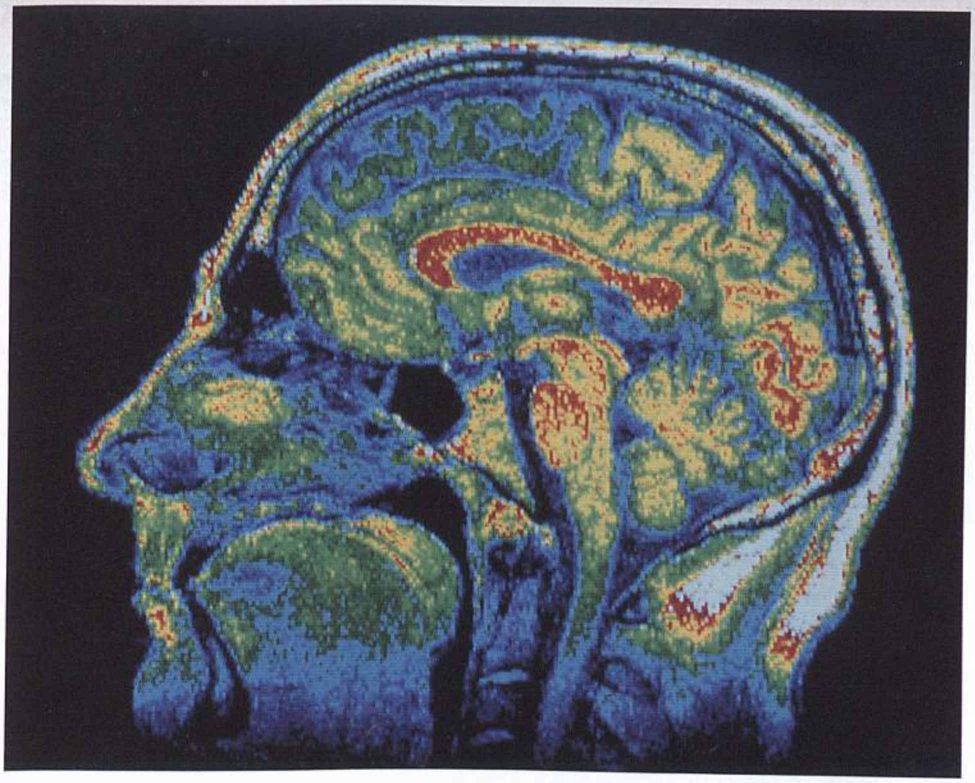


FIGURE 1C
Falsely colored MRI of a human head and brain (sagittal section).

can move and respond to our surroundings. We start out as small individuals and then grow, eventually able to reproduce. We gain energy by ingesting (taking in), digesting (breaking down), absorbing, and assimilating the nutrients in food. The absorbed substances circulate throughout the internal environment of our bodies. We can then, by the process of respiration, use the energy in these nutrients for such vital functions as growth and repair of body parts. Finally, we excrete wastes from the body. Taken together, these physical and chemical events that release and utilize energy constitute **metabolism** (mĕ-tab′o-liz-m). Table 1.3 summarizes the characteristics of life.

1. What are the characteristics of life?
2. Which physical and chemical events constitute metabolism?

Maintenance of Life

With the exception of an organism's reproductive system, which perpetuates the species, all body structures and functions work in ways that maintain life.

TABLE 1.2 Organ Systems

Organ System	Major Organs	Major Functions
Integumentary	Skin, hair, nails, sweat glands, sebaceous glands	Protect tissues, regulate body temperature, support sensory receptors
Skeletal	Bones, ligaments, cartilages	Provide framework, protect soft tissues, provide attachments for muscles, produce blood cells, store inorganic salts
Muscular	Muscles	Cause movements, maintain posture, produce body heat
Nervous	Brain, spinal cord, nerves, sense organs	Detect changes, receive and interpret sensory information, stimulate muscles and glands
Endocrine	Glands that secrete hormones (pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, ovaries, testes, pineal gland, and thymus gland)	Control metabolic activities of body structures
Cardiovascular	Heart, arteries, capillaries, veins	Move blood through blood vessels and transport substances throughout body
Lymphatic	Lymphatic vessels, lymph nodes, thymus, spleen	Return tissue fluid to the blood, carry certain absorbed food molecules, defend the body against infection
Digestive	Mouth, tongue, teeth, salivary glands, pharynx, esophagus, stomach, liver, gallbladder, pancreas, small and large intestines	Receive, break down, and absorb food; eliminate unabsorbed material
Respiratory	Nasal cavity, pharynx, larynx, trachea, bronchi, lungs	Intake and output of air, exchange of gases between air and blood
Urinary	Kidneys, ureters, urinary bladder, urethra	Remove wastes from blood, maintain water and electrolyte balance, store and transport urine
Reproductive	Male: scrotum, testes, epididymides, vasa deferentia, seminal vesicles, prostate gland, bulbourethral glands, urethra, penis	Produce and maintain sperm cells, transfer sperm cells into female reproductive tract
	Female: ovaries, uterine tubes, uterus, vagina, clitoris, vulva	Produce and maintain egg cells, receive sperm cells, support development of an embryo and function in birth process

TABLE 1.3 Characteristics of Life

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

Requirements of Organisms

Life depends upon the following environmental factors:

1. **Water** is the most abundant substance in the body. It is required for a variety of metabolic processes, and it provides the environment in which most of them take place. Water also transports substances within organisms and is important in regulating body temperature.
2. **Food** refers to substances that provide organisms with necessary chemicals (nutrients) in addition to water. Nutrients supply energy and raw materials for building new living matter.
3. **Oxygen** is a gas that makes up about one-fifth of the air. It is used in the process of releasing energy from nutrients. The energy, in turn, is used to drive metabolic processes.

4. **Heat** is a form of energy. It is a product of metabolic reactions, and it partly controls the rate at which these reactions occur. Generally, the more heat, the more rapidly chemical reactions take place. *Temperature* is a measure of the amount of heat present.

5. **Pressure** is an application of force on an object or substance. For example, the force acting on the outside of a land organism due to the weight of air above it is called *atmospheric pressure.* In humans, this pressure plays an important role in breathing. Similarly, organisms living under water are subjected to *hydrostatic pressure*—a pressure exerted by a liquid—due to the weight of water above them. In complex organisms, such as humans, heart action produces blood pressure (another form of hydrostatic pressure), which keeps blood flowing through blood vessels.

Although the human organism requires water, food, oxygen, heat, and pressure, these factors alone are not enough to ensure survival. Both the quantities and the qualities of such factors are also important. Table 1.4 summarizes the major requirements of organisms.

Homeostasis

Some organisms exist as single **cells,** the smallest living units. Consider the amoeba, a simple, one-celled organism found in lakes and ponds (fig. 1.4). Despite its simple structure compared to a human, an amoeba has very specific requirements that must be met if it is to survive. As long as the outside world—its **environment**—supports its requirements, an amoeba flourishes. As environmental factors such as temperature, water composition, and food availability become unsatisfactory, the amoeba's survival may be threatened. Although the amoeba has a limited ability to move from one place to another, environmental changes are likely to affect the whole pond, and with no place else to go, the amoeba dies.

In contrast to the amoeba, we humans are composed of about 70 trillion cells that surround themselves with their own environment inside our bodies. Our cells, as parts of organs and organ systems, interact in ways that keep this **internal environment** relatively constant, despite an ever-changing outside environment. Anatomically the internal environment is inside our body, but consists of the fluid that surrounds our cells, *extracellular fluid* (see chapter 21, p. 809). The internal environment protects our cells (and us!) from changes in the outside world that would kill isolated cells such as the amoeba (fig 1.5). The body's maintenance of a stable internal environment is called **homeostasis,** (ho″me-ō-sta′sis) and it is so important that most of our metabolic energy is spent on it. Many of the tests performed on Judith R. during her

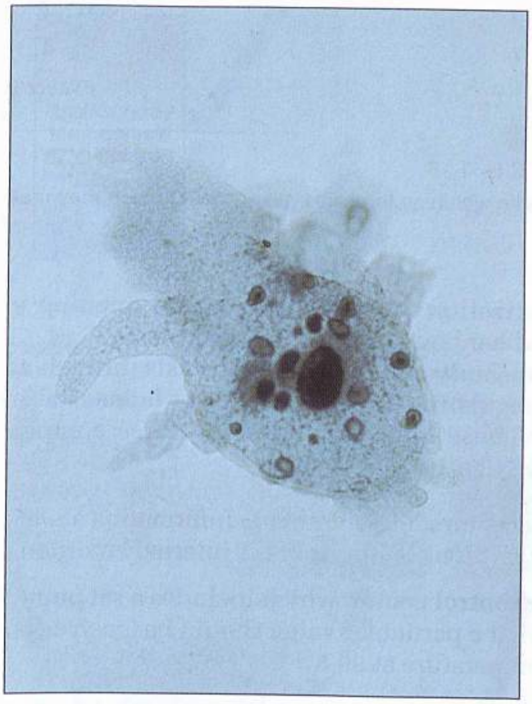


FIGURE 1.4
The amoeba is an organism consisting of a single cell (100×).

TABLE 1.4 Requirements of Organisms

Factor	Characteristic	Use
Water	A chemical substance	For metabolic processes, as a medium for metabolic reactions, to transport substances, and to regulate body temperature
Food	Various chemical substances	To supply energy and raw materials for the production of necessary substances and for the regulation of vital reactions
Oxygen	A chemical substance	To help release energy from food substances
Heat	A form of energy	To help regulate the rates of metabolic reactions
Pressure	A force	Atmospheric pressure for breathing; hydrostatic pressure to help circulate blood

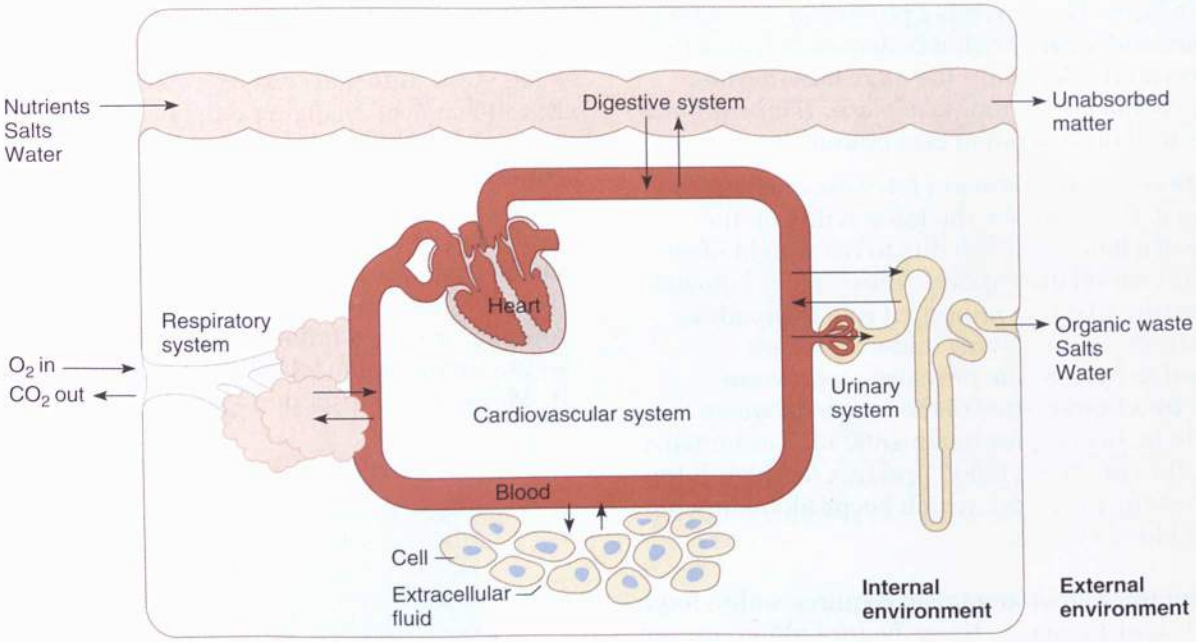


FIGURE 1.5
Our cells lie within an internal environment, which they maintain.

hospitalization (as described in the opening vignette) assessed her body's return to homeostasis.

The body maintains homeostasis through a number of self-regulating control systems, or **homeostatic mechanisms.** These have the following three components in common (fig. 1.6):

1. **Receptors,** which provide information about specific conditions (stimuli) in the internal environment.
2. A **control center,** which includes a **set point,** tells what a particular value should be (such as body temperature at 98.6°F).
3. **Effectors,** such as muscles or glands, which cause responses that alter conditions in the internal environment.

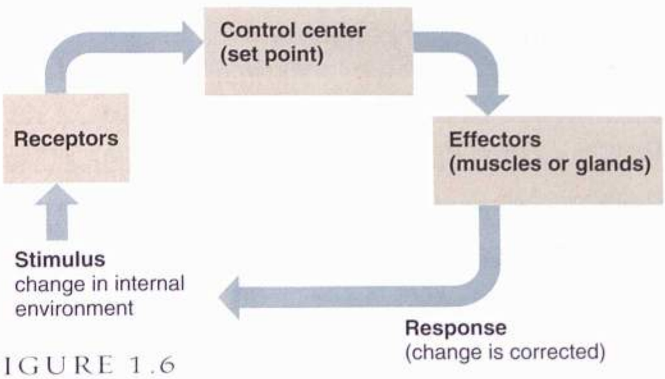


FIGURE 1.6
A homeostatic mechanism monitors an aspect of the internal environment and corrects any changes.

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 maintaining a stable internal environment, imagine a room equipped with a furnace and an air conditioner. Suppose the room temperature is to remain near 20°C (68°F), so the thermostat is adjusted to a set point of 20°C. Because a thermostat is sensitive to 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, the thermostat will cause the furnace to stop and the air conditioner to start. These actions maintain a relatively constant temperature in the room (fig. 1.7).

A similar homeostatic mechanism regulates body temperature in humans (fig. 1.8). The "thermostat" is a temperature-sensitive region in a control center of the brain called the hypothalamus. In healthy persons, the set point of this body thermostat is at or near 37°C (98.6°F).

If a person is exposed to a cold environment and the body temperature begins to drop, the hypothalamus

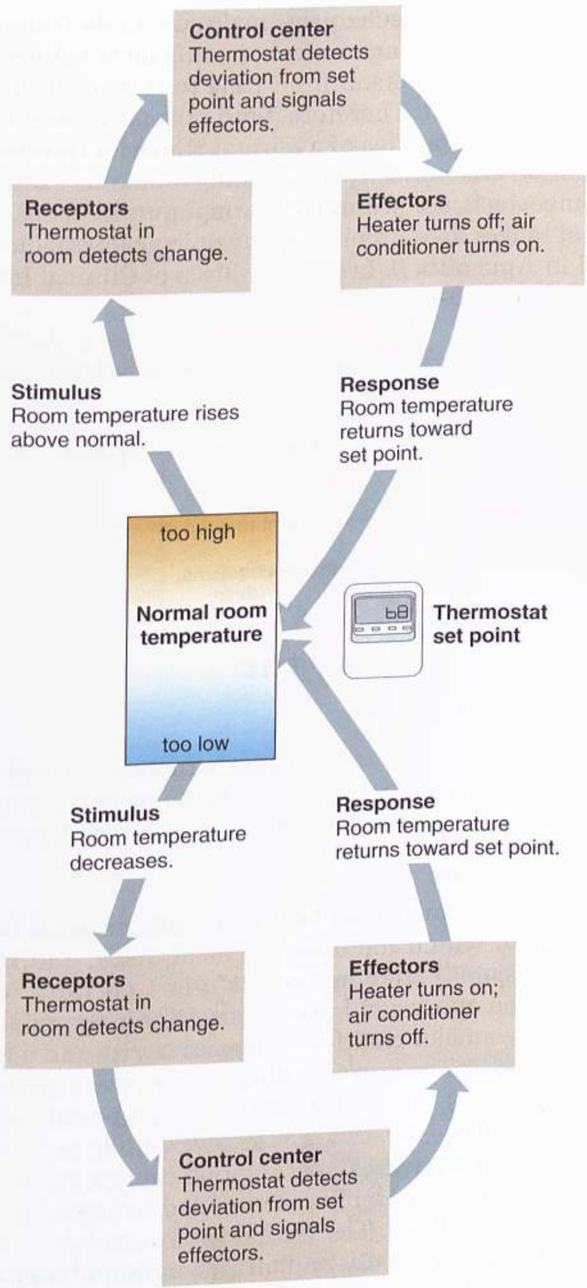


FIGURE 1.7
A thermostat signals an air conditioner and a furnace to turn on or off to maintain a relatively stable room temperature. This system is an example of a homeostatic mechanism.

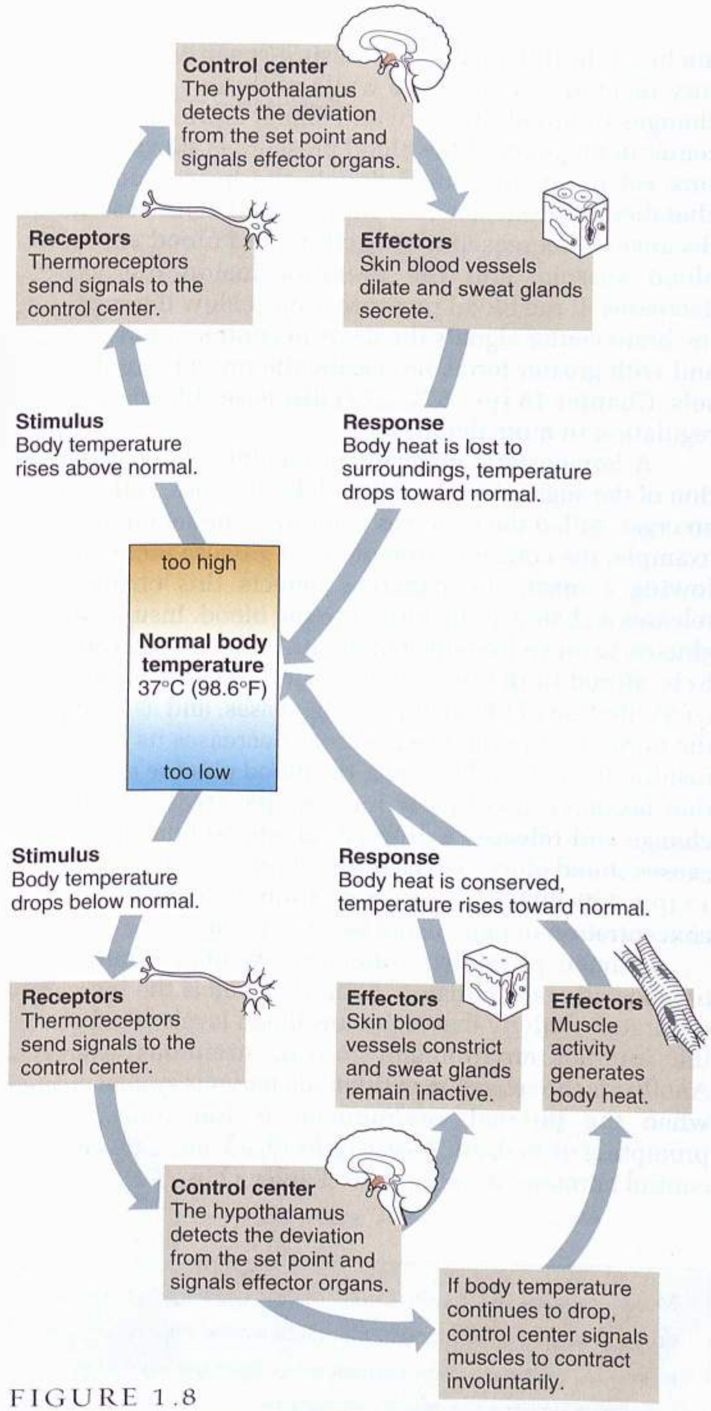


FIGURE 1.8
The homeostatic mechanism that regulates body temperature.

senses this change and triggers heat-conserving and heat-generating activities. Blood vessels in the skin constrict so that blood flow there is reduced and deeper tissues retain heat. At the same time, small groups of muscle cells may be stimulated to contract involuntarily, an action called shivering. Such muscular contractions produce heat, which helps warm the body.

If a person becomes overheated, the hypothalamus triggers a series of changes that promote loss of body heat. Sweat glands in the skin secrete watery perspiration. As the water evaporates from the surface, heat is carried away and the skin is cooled. At the same time, blood vessels in the skin dilate. This allows the blood that carries heat from deeper tissues to reach the surface where more heat is lost to the outside. Body temperature regulation is discussed in more detail in chapter 6 (p. 170).

Another homeostatic mechanism regulates the blood pressure in the blood vessels (arteries) leading away from the heart. In this instance, pressure-sensitive areas (sensory receptors) within the walls of these vessels detect changes in blood pressure and signal a pressure control center in the brain. If the blood pressure is above the pressure set point, the brain signals the heart, causing its chambers to contract less rapidly and with less force. Because of decreased heart action, less blood enters the blood vessels, and the pressure inside the vessels decreases. If the blood pressure drops below the set point, the brain center signals the heart to contract more rapidly and with greater force, increasing the pressure in the vessels. Chapter 15 (pp. 572–577) discusses blood pressure regulation in more detail.

A homeostatic mechanism regulates the concentration of the sugar glucose in blood. In this case, cells within an organ called the pancreas determine the set point. If, for example, the concentration of blood glucose increases following a meal, the pancreas detects this change and releases a chemical (insulin) into the blood. Insulin allows glucose to move from the blood into various body cells and to be stored in the liver and muscles. As this occurs, the concentration of blood glucose decreases, and as it reaches the normal set point, the pancreas decreases its release of insulin. If, on the other hand, the blood glucose concentration becomes abnormally low, the pancreas detects this change and releases a different chemical (glucagon) that causes stored glucose to be released into the blood. Chapter 13 (pp. 496–498) discusses regulation of the blood glucose concentration in more detail (see fig. 13.36).

Human physiology offers many other examples of homeostatic mechanisms. A familiar one is the increased respiratory activity that maintains blood levels of oxygen in the internal environment during strenuous exercise. Another is the sensation of thirst the nervous system creates when the internal environment is too concentrated, prompting us to drink. Negative feedback mechanisms also control hormone secretion (see chapter 13, p. 477).

> Most feedback mechanisms in the body are negative. Sometimes in physiology, changes stimulate similar changes. Such a process that causes movement away from the normal state is called a *positive feedback mechanism*.
>
> A positive feedback system operates for a short time when a blood clot forms, because the chemicals present in a clot promote further clotting (see chapter 14, pp. 527–528). Positive feedback controls milk production. If a baby suckles with greater force or duration, the mother's mammary glands respond by making more milk. Positive feedback also increases the strength of uterine contractions during childbirth. Because positive feedback mechanisms usually produce unstable conditions, the examples associated with normal health have very specific functions and are relatively short lived.

Homeostatic mechanisms maintain a relatively constant internal environment, yet physiological values may vary slightly in a person from time to time or from one person to the next. Therefore, both normal values for an individual and the idea of a **normal range** for the general population are clinically important. Numerous examples of homeostasis are presented throughout this book, and normal ranges for a number of physiological variables are listed in Appendix B, Laboratory Tests of Clinical Importance, pages 970–973.

1. Which requirements of organisms does the external environment provide?
2. What is the relationship between oxygen use and heat production?
3. Why is homeostasis so important to survival?
4. Describe three homeostatic mechanisms.

Organization of the Human Body

The human organism is a complex structure composed of many parts. The major features of the human body include cavities, various types of membranes, and 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 two major cavities—a **dorsal cavity** and a larger **ventral cavity.** The organs within such a cavity are called **viscera** (vis′er-ah). The dorsal cavity can be subdivided into two parts—the **cranial cavity,** which houses the brain, and the **vertebral canal** (spinal cavity), which contains the spinal cord and is surrounded by sections of the backbone (vertebrae). The ventral cavity consists of a **thoracic** (tho-ras′ik) **cavity** and an **abdominopelvic cavity.** Figure 1.9 shows these major body cavities.

The thoracic cavity is separated from the lower abdominopelvic cavity by a broad, thin muscle called the **diaphragm** (di′ah-fram). When it is at rest, this muscle curves upward into the thorax like a dome. When it contracts during inhalation, it presses down upon the abdominal viscera. The wall of the thoracic cavity is composed of skin, skeletal muscles, and bones. Within the thoracic cavity are the lungs and a region between the lungs, called the **mediastinum** (me″de-as-ti′num). The mediastinum separates the thorax into two compartments that contain the right and left lungs. The remaining thoracic viscera—heart, esophagus, trachea, and thymus gland—are within the mediastinum.

The abdominopelvic cavity, which includes an upper abdominal portion and a lower pelvic portion,

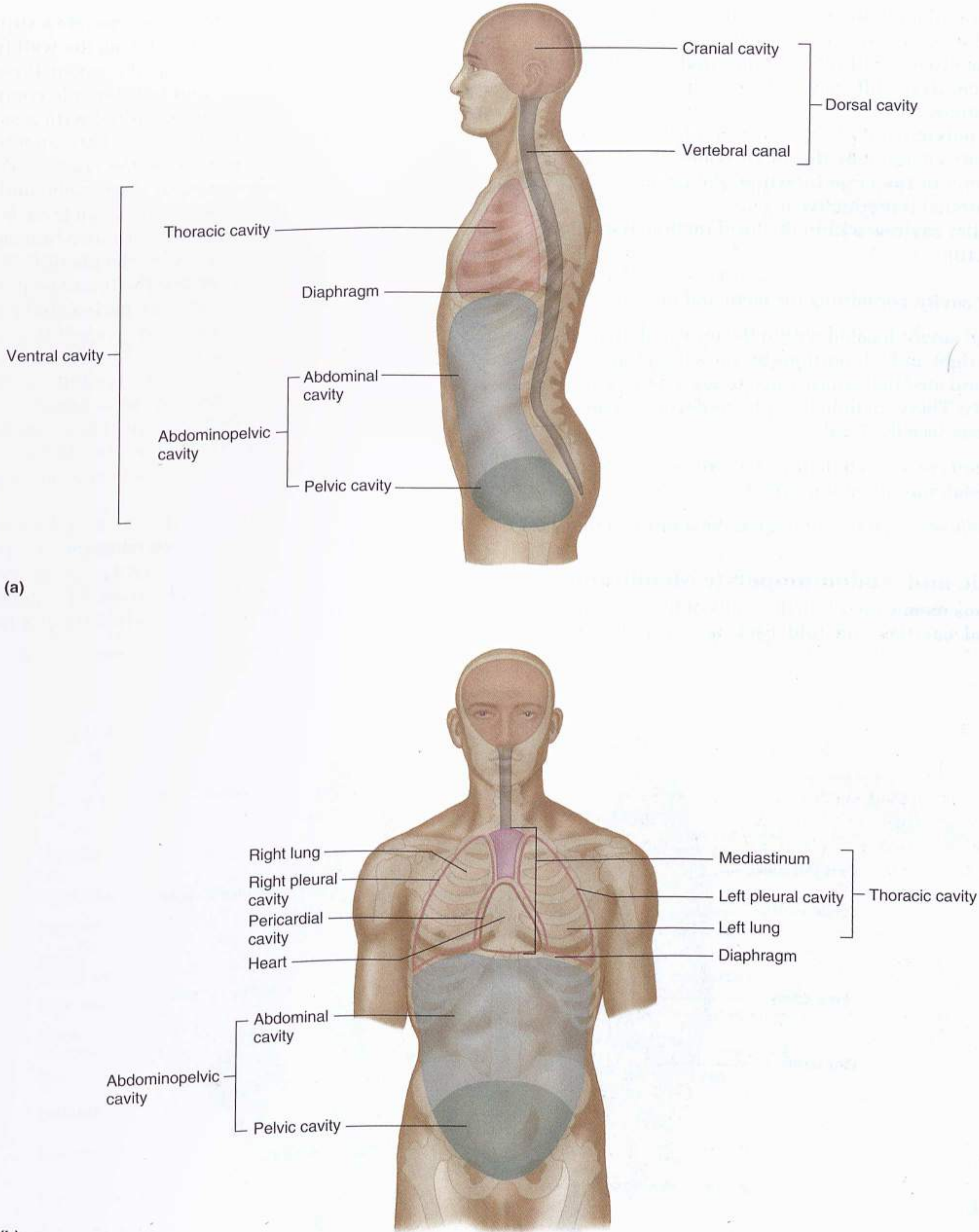


FIGURE 1.9
Major body cavities. (*a*) Lateral view. (*b*) Anterior view.

extends from the diaphragm to the floor of the pelvis. Its wall primarily consists of skin, skeletal muscles, and bones. The viscera within the **abdominal cavity** include the stomach, liver, spleen, gallbladder, and the small and large intestines.

The **pelvic cavity** is the portion of the abdominopelvic cavity enclosed by the pelvic bones. It contains the terminal end of the large intestine, the urinary bladder, and the internal reproductive organs.

Smaller cavities within the head include the following (fig. 1.10):

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. Several air-filled sinuses are connected to the nasal cavity. These include the sphenoidal and frontal sinuses (see fig. 7.25).
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

Thin **serous membranes** line the walls of the thoracic and abdominal cavities and fold back to cover the organs within these cavities. These membranes secrete a slippery serous fluid that separates the layer lining the wall (parietal layer) from the layer covering the organ (visceral layer). For example, the right and left thoracic compartments, which contain the lungs, are lined with a serous membrane called the *parietal pleura.* This membrane folds back to cover the lungs, forming the *visceral pleura.* A thin film of serous fluid separates the parietal and visceral **pleural** (ploo′ral) **membranes.** Although there is normally no actual space between these two membranes, the potential space between them is called the *pleural cavity.*

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* (epicardium) covers the heart's surface and is separated from the *parietal pericardium* by a small amount of serous fluid. The potential space between these membranes is called the *pericardial cavity.* The parietal pericardium is covered by a much thicker third layer, the *fibrous pericardium.* Figure 1.11 shows the membranes associated with the heart and lungs.

In the abdominopelvic cavity, the 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. The potential space between these membranes is called the *peritoneal cavity* (fig. 1.12).

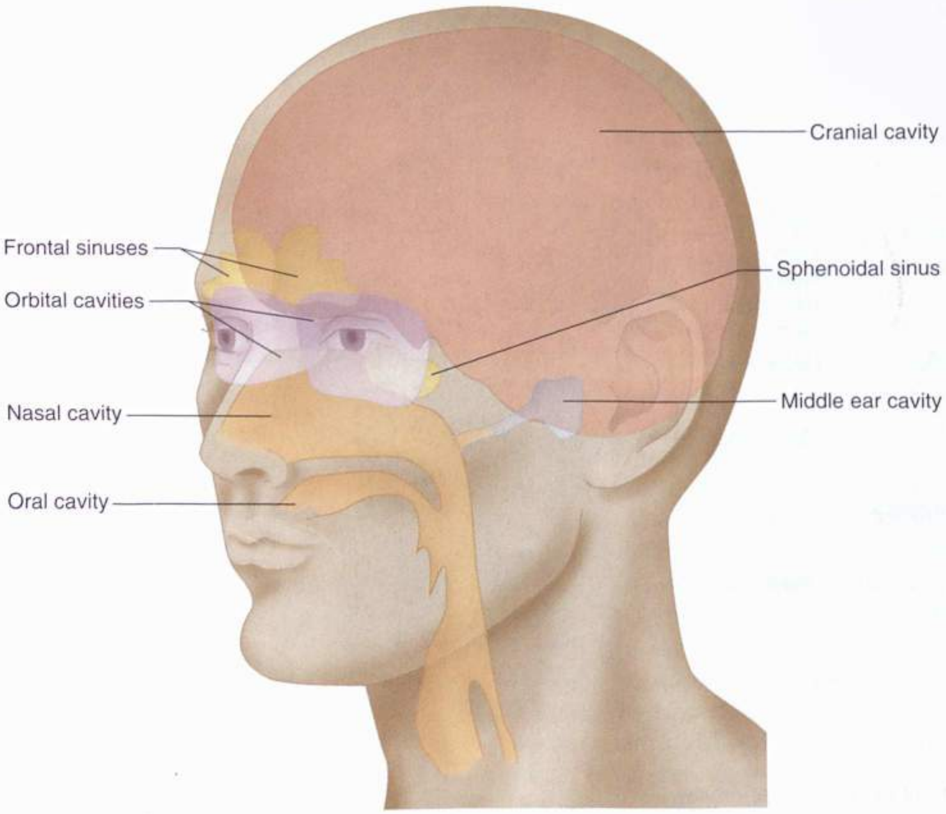


FIGURE 1.10
The cavities within the head include the cranial, oral, nasal, orbital, and middle ear cavities, as well as several sinuses.

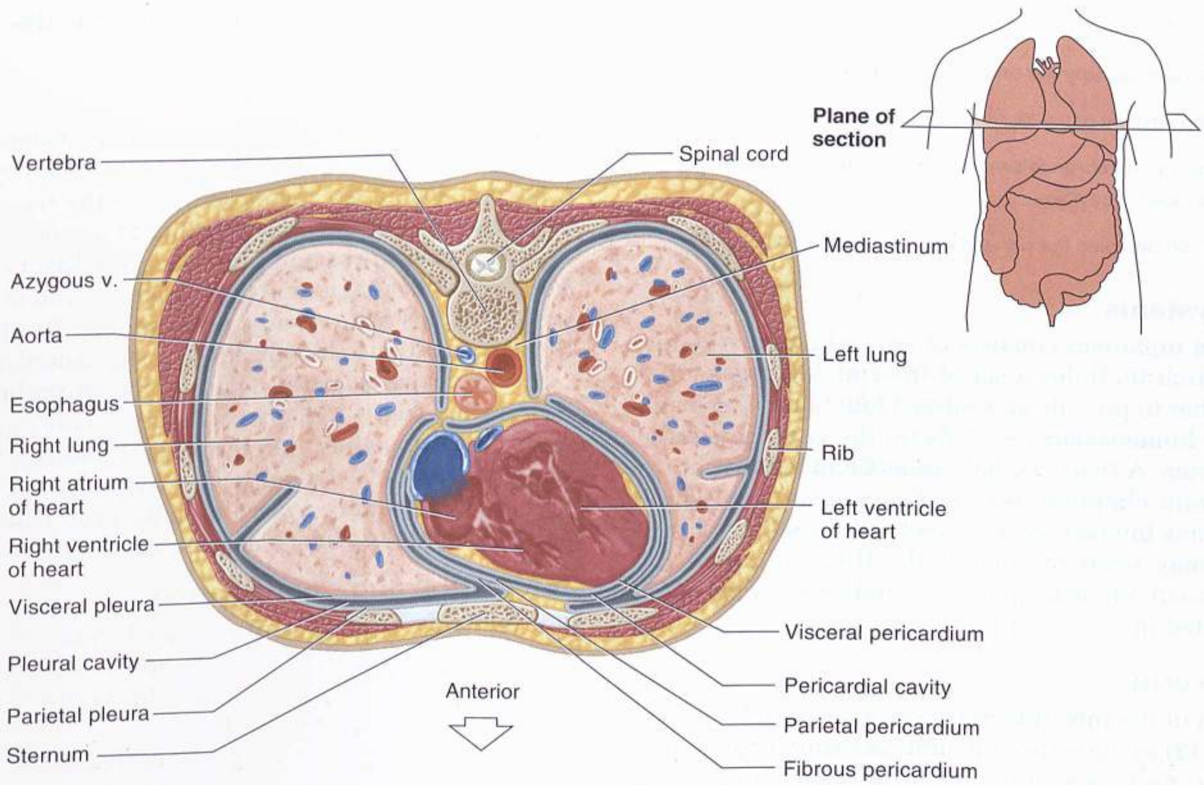


FIGURE 1.11
A transverse section through the thorax reveals the serous membranes associated with the heart and lungs (superior view).

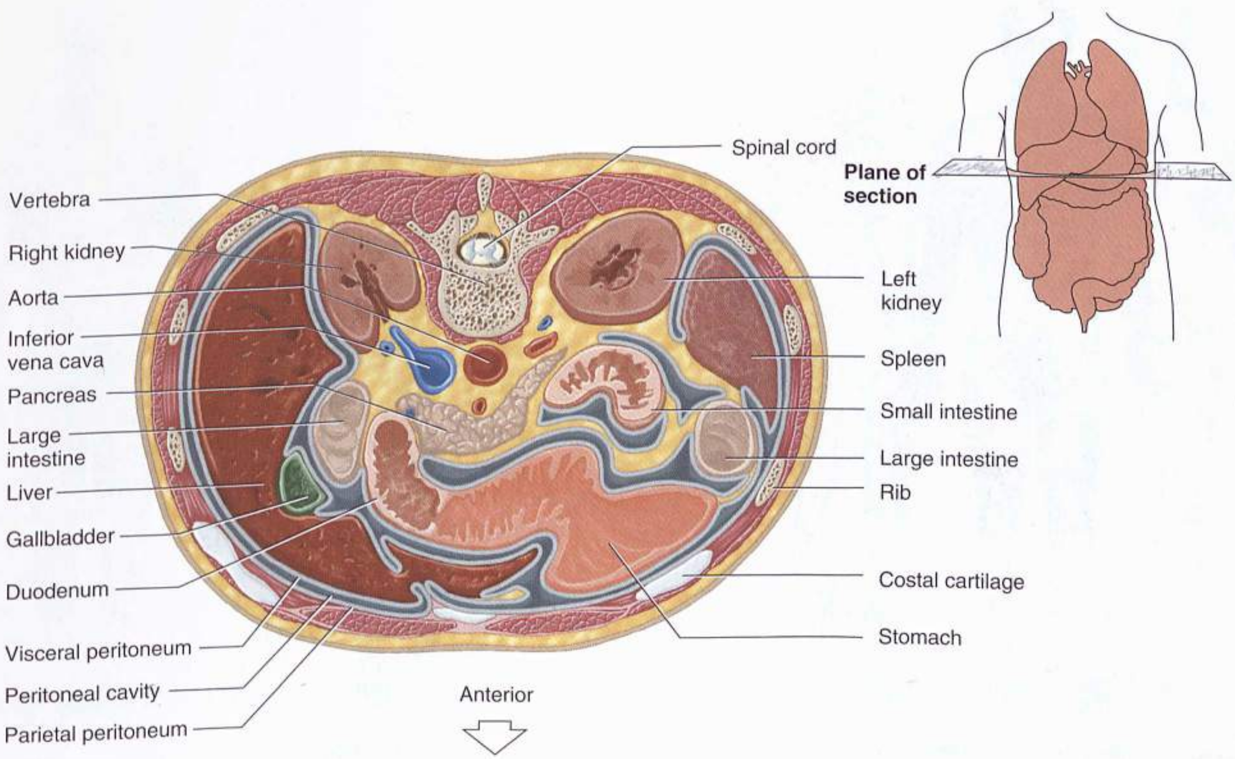


FIGURE 1.12
Transverse section through the abdomen (superior view).

1 What are the viscera?

2 Which organs occupy the dorsal cavity? The ventral cavity?

3 Name the cavities of the head.

4 Describe the membranes associated with the thoracic and abdominopelvic cavities.

5 Distinguish between the parietal and visceral peritoneum.

Organ Systems

The human organism consists of several organ systems, each of which includes a set of interrelated organs that work together to provide specialized functions. The maintenance of homeostasis depends on the coordination of organ systems. A figure called **"InnerConnections"** at the end of certain chapters ties together the ways in which organ systems interact. As you read about each organ system, you may want to consult the illustrations of the human torso in reference plates 1–7 and locate some of the features listed in the descriptions.

Body Covering

The organs of the **integumentary** (in-teg-u-men′tar-e) **system** (fig. 1.13) include the skin and 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. Chapter 6 discusses the integumentary system.

Support and Movement

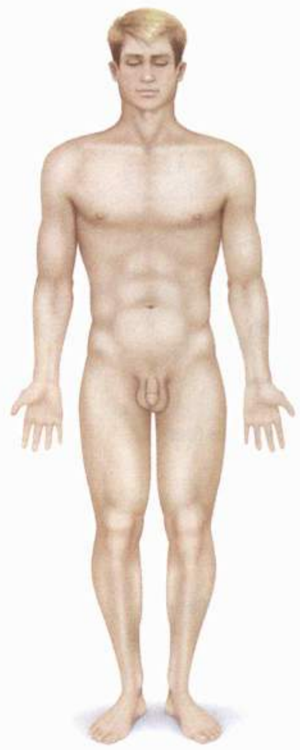
The organs of the skeletal and muscular systems support and move body parts. The **skeletal** (skel′ĕ-tal) **system** (fig. 1.14) consists of the bones as well as the ligaments and cartilages that bind bones together at joints. These parts provide frameworks and protective shields for softer tissues, serve as attachments for muscles, and act together with muscles when body parts move. Tissues within bones also produce blood cells and store inorganic salts.

The muscles are the organs of the **muscular** (mus′ku-lar) **system** (fig. 1.14). By contracting and pulling their ends closer together, they provide the forces that cause body movements. Muscles also help maintain posture and are the primary source of body heat. Chapters 7, 8, and 9 discuss the skeletal and muscular systems.

Integration and Coordination

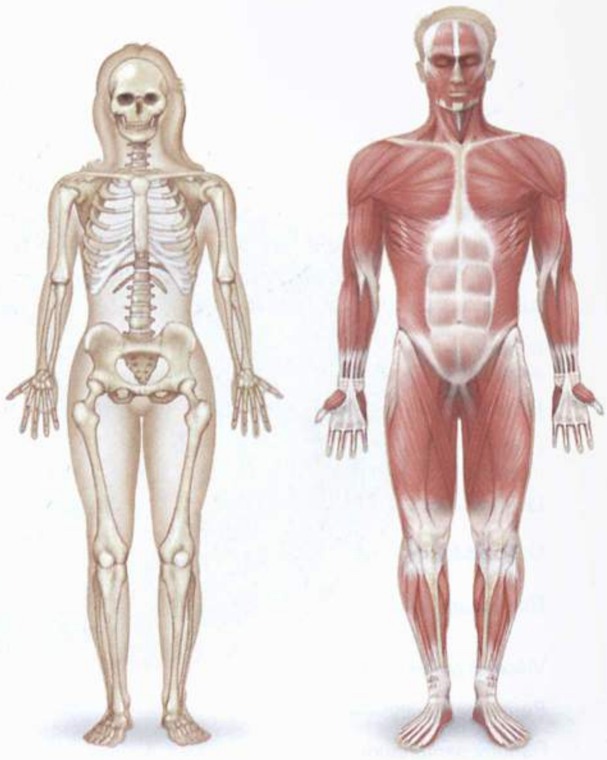
For the body to act as a unit, its parts must be integrated and coordinated. The nervous and endocrine systems control and adjust various organ functions from time to time, maintaining homeostasis.

The **nervous** (ner′vus) **system** (fig. 1.15) consists of the brain, spinal cord, nerves, and sense organs. Nerve cells within these organs use electrochemical signals called *nerve impulses* (action potentials) to communicate with



Integumentary system

FIGURE 1.13
The integumentary system covers the body.



Skeletal system

Muscular system

FIGURE 1.14
The skeletal and muscular organ systems provide support and movement.

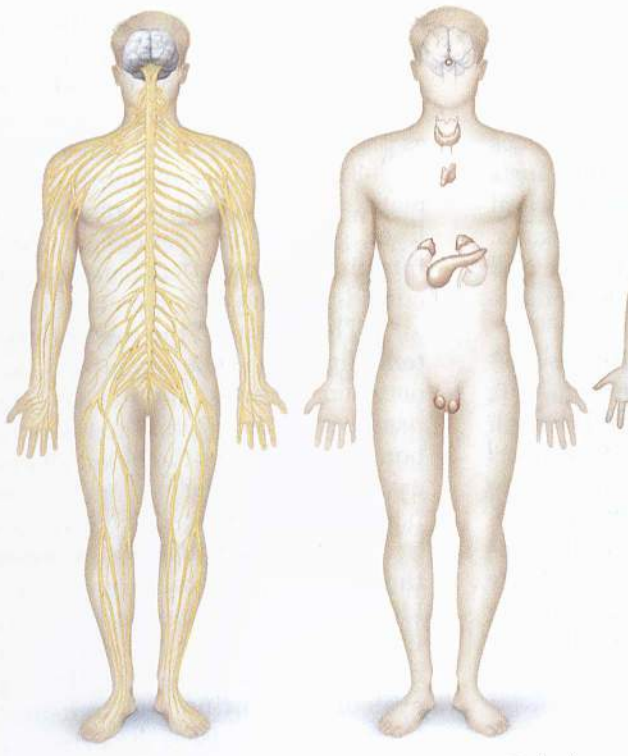


FIGURE 1.15
The nervous and endocrine organ systems integrate and coordinate body functions.

one another and with muscles and glands. Each impulse produces a relatively short-term effect on its target. Some nerve cells act as specialized sensory receptors that can detect changes occurring inside and outside the body. Other nerve cells receive the impulses transmitted from these sensory units and interpret and act on the information. Still other nerve cells carry impulses from the brain or spinal cord to muscles or glands, stimulating them to contract or to secrete products. Chapters 10 and 11 discuss the nervous system, and chapter 12 discusses sense organs.

The **endocrine** (en′do-krin) **system** (fig. 1.15) includes all the glands that secrete chemical messengers, called *hormones*. Hormones, in turn, travel away from the glands in body fluids such as blood or tissue fluid. Usually a particular hormone affects only a particular group of cells, called its *target cells*. The effect of a hormone is to alter the metabolism of the target cells. Compared to nerve impulses, hormonal effects occur over a relatively long time period.

Organs of the endocrine system include the pituitary, thyroid, parathyroid, and adrenal glands, as well as the pancreas, ovaries, testes, pineal gland, and thymus gland. These are discussed further in chapter 13.

Transport

Two organ systems transport substances throughout the internal environment. The **cardiovascular** (kahr″de-o-vas′ku-lur) **system** (fig. 1.16) includes the heart, arteries,

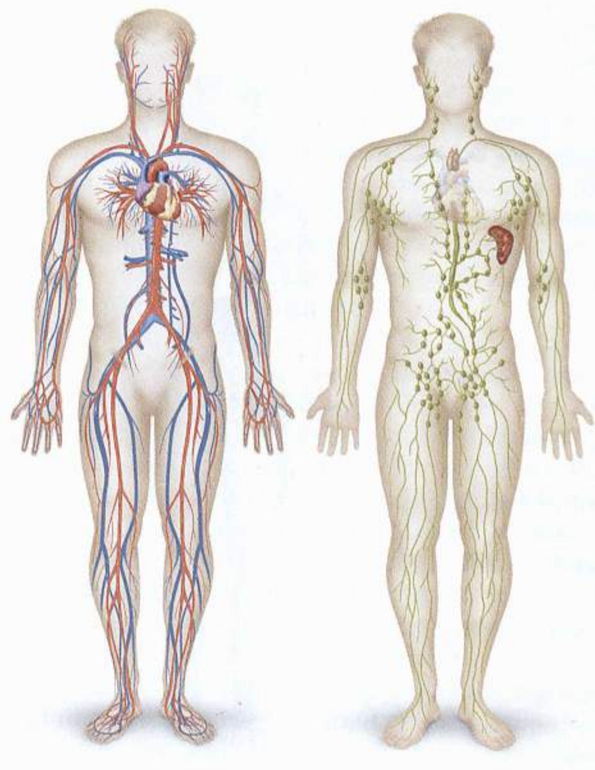


FIGURE 1.16
The cardiovascular and lymphatic organ systems transport fluids.

capillaries, veins, 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 substances are used in metabolic processes. Blood also transports hormones from endocrine glands to their target cells and carries wastes from body cells to the excretory organs, where the wastes are removed from the blood and released to the outside. Blood and the cardiovascular system are discussed in chapters 14 and 15.

The **lymphatic** (lim-fat′ik) **system** (fig. 1.16) is sometimes considered part of the cardiovascular system. It is composed of the lymphatic vessels, lymph fluid, lymph nodes, thymus gland, and spleen. This system transports some of the fluid from the spaces within tissues (tissue fluid) back to the bloodstream and carries certain fatty substances away from the digestive organs. Cells of the lymphatic system, called lymphocytes, defend the body against infections by removing pathogens (disease-causing microorganisms and viruses) from tissue fluid. The lymphatic system is discussed in chapter 16.

Absorption and Excretion

Organs in several systems absorb nutrients and oxygen and excrete wastes. The organs of the **digestive** (di-jest′tiv) **system** (fig. 1.17) receive foods and then break down food molecules into simpler forms that can pass through cell membranes and be absorbed into the internal environment. Materials that are not absorbed are transported outside. Certain digestive organs (chapter 17, pp. 661, 662, 665) 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 18 discusses nutrition and metabolism, considering the fate of foods in the body.

The organs of the **respiratory** (re-spi′rah-to″re) **system** (fig. 1.17) take air in and out and exchange gases between the blood and the air. More specifically, oxygen passes from 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, which is discussed in chapter 19.

The **urinary** (u′rĭ-ner″e) **system** (fig. 1.17) consists of the kidneys, ureters, urinary bladder, and urethra. The kidneys remove wastes from blood and assist in maintaining the body's water and electrolyte balance. The product of these activities is urine. Other portions of the urinary system store urine and transport it outside the body. Chapter 20 discusses the urinary system. Sometimes the urinary system is called the *excretory system*. However, **excretion** (ek-skre′shun), or waste removal, is also a function of the respiratory system and, to a lesser extent, the digestive and integumentary systems.

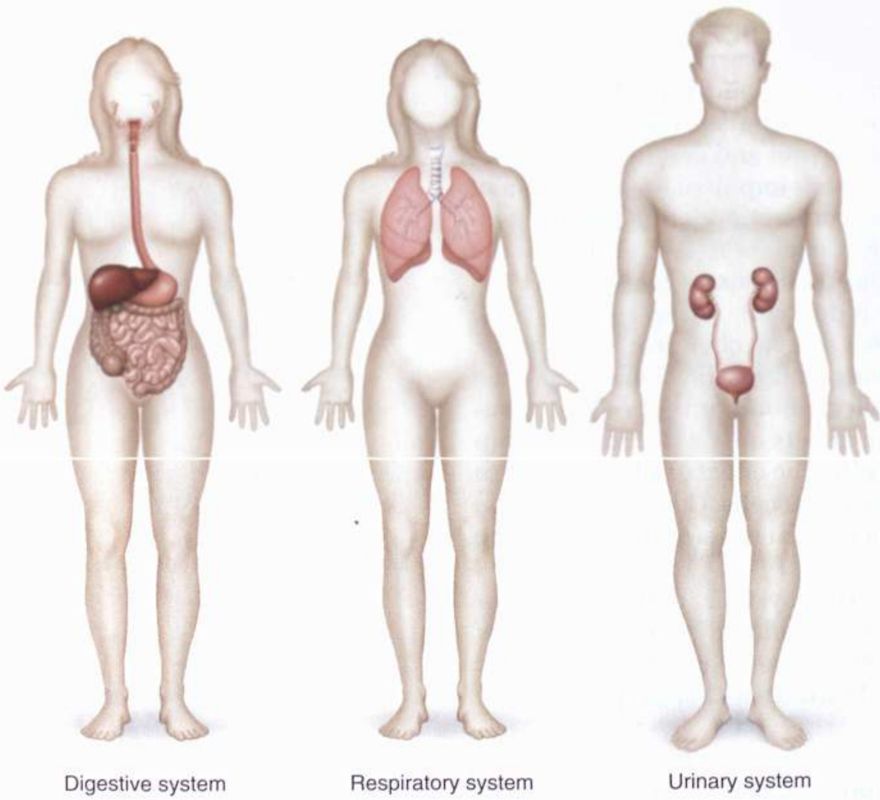


FIGURE 1.17
The digestive, respiratory, and urinary organ systems absorb nutrients, take in oxygen and release carbon dioxide, and excrete wastes.

Reproduction

Reproduction (re″pro-duk′shun) is the process of producing offspring (progeny). Cells reproduce when they divide and give rise to new cells. The **reproductive** (re″pro-duk′tiv) **system** (fig. 1.18) of an organism, however, produces whole new organisms like itself (see chapter 22).

The male reproductive system includes the scrotum, testes, epididymides, vasa deferentia, seminal vesicles, prostate gland, bulbourethral glands, urethra, and penis. These structures produce and maintain the male sex cells, or sperm cells (spermatozoa). The male reproductive system also transfers these cells from their site of origin 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 ova), receive the male sex cells (sperm cells), and transport the female sex cells within the female reproductive system. The female reproductive system also supports development of embryos and functions in the birth process.

Figure 1.19 illustrates the organ systems in humans. Also, special looks at various organs and organ systems as a person ages are considered in certain chapters, beginning here.

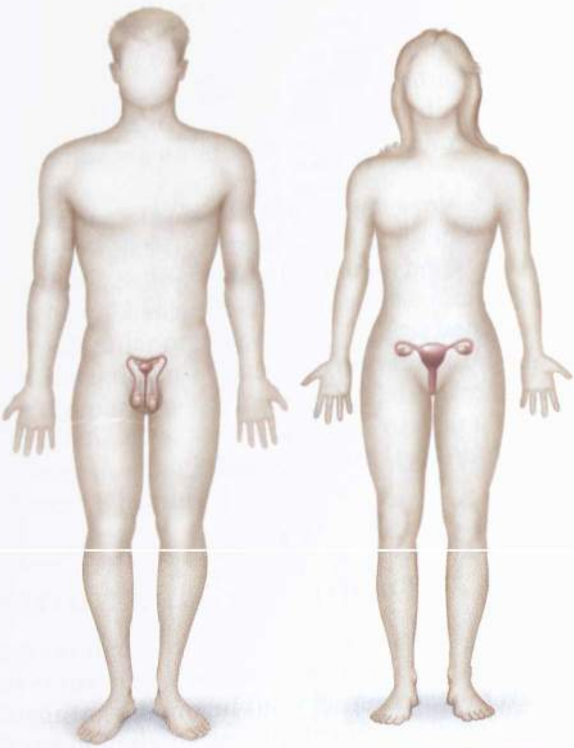


FIGURE 1.18
The reproductive systems manufacture and transport sex cells. The female reproductive system provides for fetal development and childbirth.

1. Name the major organ systems and list the organs of each system.
2. Describe the general functions of each organ system.

Life-Span Changes

Aging is a part of life. According to the dictionary, aging is the process of becoming mature or old. It is, in essence, the passage of time and the accompanying bodily changes. Because the passage of time is inevitable, so, too, is aging, claims for the anti-aging properties of various diets, cosmetics, pills and skin-care products to the contrary.

Aging occurs from the whole-body level to the microscopic level. Although programmed cell death begins in the fetus, we are usually not very aware of aging until the third decade of life, when a few gray hairs, faint lines etched into facial skin, and minor joint stiffness in the morning remind us that time marches on. A woman over the age of thirty-five attempting to conceive a child might be shocked to learn that she is of "advanced maternal age," because the chances of conceiving an offspring with an abnormal chromosome number increase with the age of the egg. In both sexes, by the fourth or fifth decade, as hair color fades and skin etches become wrinkles, the first signs of adult-onset disorders may appear, such as increased blood pressure that one day may be considered hypertension, and slightly elevated blood glucose that could become diabetes mellitus. A person with a strong family history of heart disease, coupled with unhealthy diet and exercise habits, may be advised to change his or her lifestyle, and perhaps even begin taking a drug to lower serum cholesterol levels. The sixth decade sees grayer or whiter hair, more and deeper skin wrinkles, and a waning immunity that makes vaccinations against influenza and other infectious diseases important. Yet many, if not most, people in their sixties and older have sharp minds and are capable of all sorts of physical activities.

Changes at the tissue, cell and molecular levels explain the familiar signs of aging. Decreased production of the connective tissue proteins collagen and elastin account for the stiffening of skin, and diminished levels of subcutaneous fat are responsible for wrinkling. Proportions of fat to water in the tissues change, with the percentage of fats increasing steadily in women, and increasing until about age sixty in men. These alterations explain why the elderly metabolize certain drugs at different rates than do younger people. As a person ages, tissues atrophy, and as a result, organs shrink.

Cells mark time too, many approaching the end of a limited number of predetermined cell divisions as their chromosome tips whittle down. Such cells reaching the end of their division days may enlarge or die. Some cells may be unable to build the spindle apparatus that pulls apart replicated chromosomes in a cell on the verge of division. Impaired cell division translates into impaired

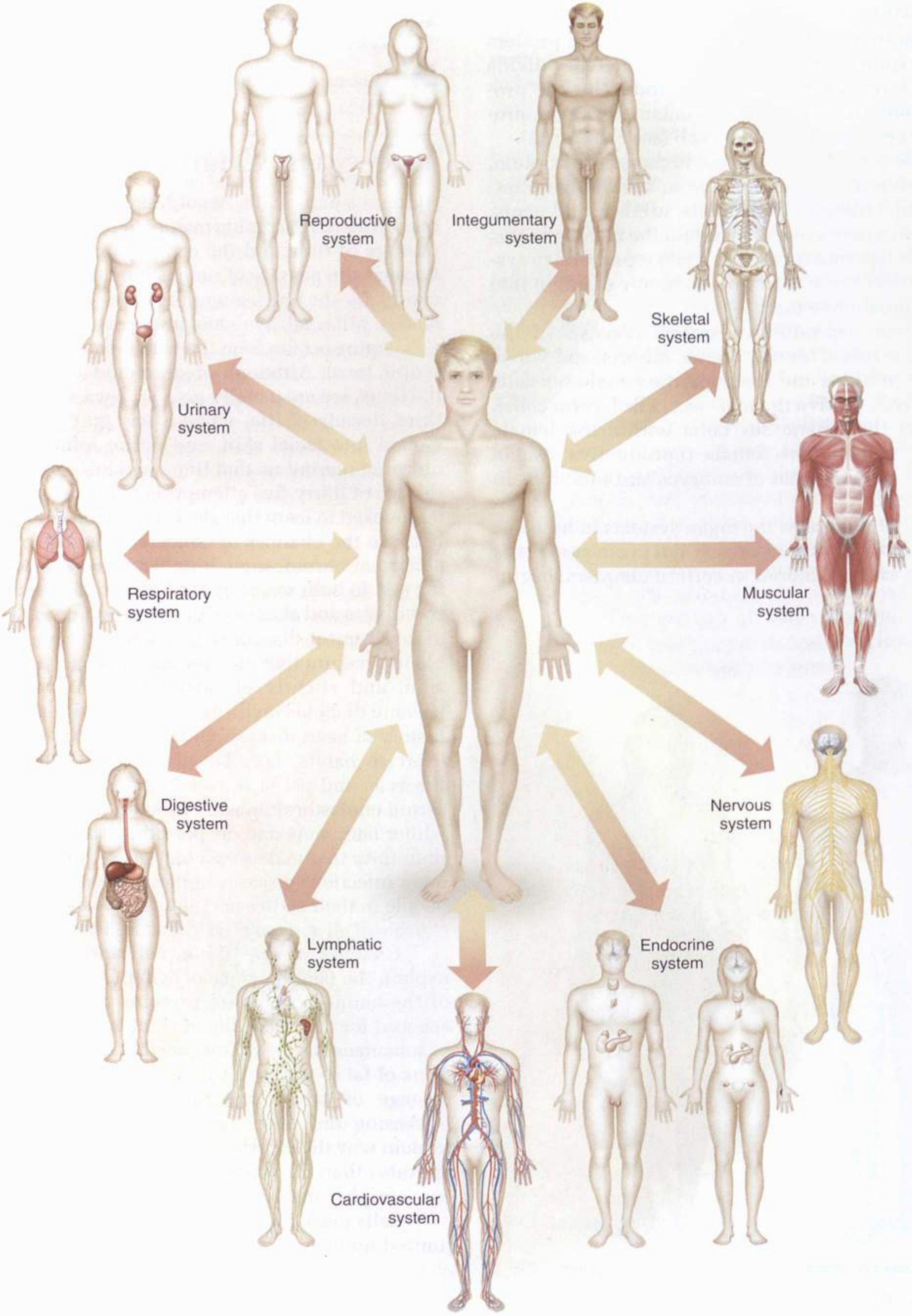


FIGURE 1.19
The organ systems in humans interact to maintain homeostasis.

wound healing, yet at the same time, the inappropriate cell division that underlies cancer becomes more likely. Certain subcellular functions lose efficiency, including the DNA repair that would otherwise patch up mutations, and the transport of substances across cell membranes. Aging cells also have fewer mitochondria, the structures that house the reactions that extract energy from nutrients, and also have fewer lysosomes, the disposal units that break down aged or damaged cell parts.

Just as changes at the tissue level cause organ-level signs of aging, certain biochemical changes fuel cellular aging. Lipofuscin and ceroid pigments accumulate as the cell can no longer prevent formation of damaging oxygen free radicals. A protein called beta amyloid may build up in the brain, contributing, in some individuals, to the development of Alzheimer disease. A generalized metabolic slowdown results from a dampening of thyroid gland function, impairing glucose utilization, the rate of protein synthesis, and production of digestive enzymes. At the whole-body level, we notice slowed metabolism as diminished tolerance to cold, weight gain, and fatigue.

A clearer understanding of the precise steps of the aging process will emerge as researchers identify the roles of each of our genes. For example, many of the molecular and cellular changes of aging may be controlled by the action of one gene, called p21. Its protein product turns on and off about ninety other genes, whose specific actions promote the signs of older age. The p21 gene intervenes when cells are damaged by radiation or toxins, promoting their death, which prevents them from causing disease. It also stimulates production of proteins that are associated with particular disorders seen in aging, including atherosclerosis, Alzheimer disease, and arthritis.

Because our organs and organ systems are interrelated, aging-related changes in one influence the functioning of others. Several chapters in this book conclude with a "Life-Span Changes" section that discusses changes specific to particular organ systems. These changes reflect the natural breakdown of structure and function that accompanies the passage of time, as well as events that are in our genes ("nature") and symptoms or characteristics that might arise as a consequence of lifestyle choices and circumstances ("nurture").

Anatomical Terminology

To communicate effectively with one another, investigators over the ages have developed a set of terms with precise meanings. Some of these terms concern the relative positions of body parts, others refer to imaginary planes along which cuts may be made, and still others describe body regions. When such terms are used, it is assumed that the body is in the **anatomical position;** that is, it is standing erect, the face is forward, and the upper limbs are at the sides, with the palms forward.

Relative Position

Terms of relative position are used to describe the location of one body part with respect to another. They include the following:

1. **Superior** means a part is above another part, or closer to the head. (The thoracic cavity is superior to the abdominopelvic cavity.)
2. **Inferior** means a part is below another part, or toward the feet. (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) is the opposite of anterior; it means toward the back. (The pharynx is posterior to the oral cavity.)
5. **Medial** relates to an imaginary midline dividing the body into equal right and left halves. A part is medial if it is closer to this line than another part. (The nose is medial to the eyes.)
6. **Lateral** means toward the side with respect to the imaginary midline. (The ears are lateral to the eyes.) **Ipsilateral** pertains to the same side (the spleen and the descending colon are ipsilateral), whereas **contralateral** refers to the opposite side (the spleen and the gallbladder are contralateral).
7. **Proximal** describes a part that is closer to the trunk of the body or closer to another specified point of reference than another part. (The elbow is proximal to the wrist.)
8. **Distal** is the opposite of proximal. It means a particular body part is farther from the trunk or farther from another specified point of reference than another part. (The fingers are distal to the wrist.)
9. **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.)
10. **Deep** describes parts that are more internal. (The dermis is the deep layer of the skin.)

Body Sections

To observe the relative locations and arrangements of internal parts, it is necessary to cut, or section, the body along various planes (figs. 1.20 and 1.21). The following terms describe such planes and sections:

1. **Sagittal** refers to a lengthwise cut that divides the body into right and left portions. If a sagittal section passes along the midline and divides the body into equal parts, it is called median (midsagittal).

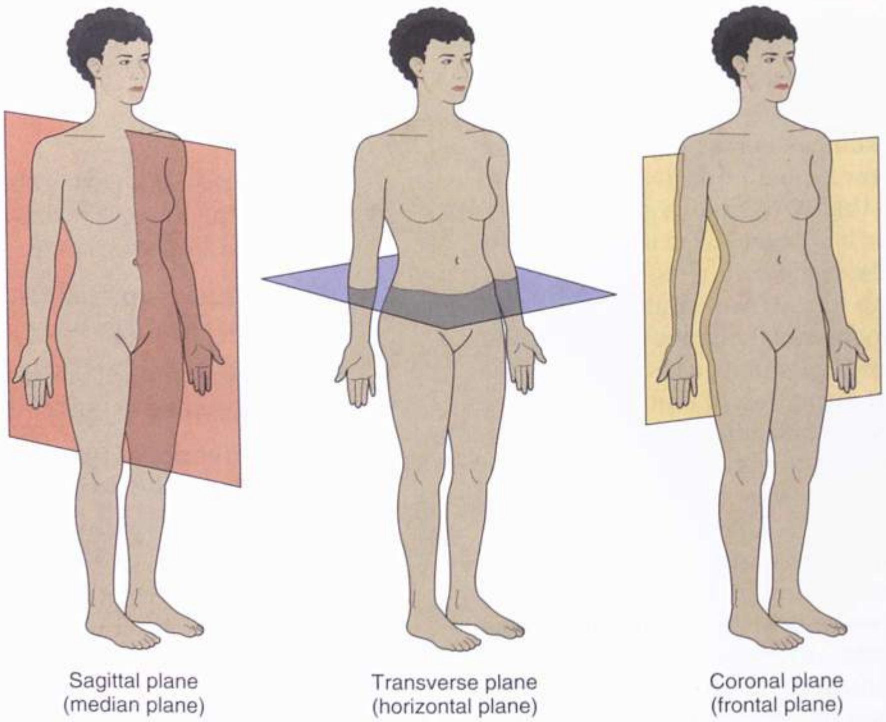


FIGURE 1.20
Observation of internal parts requires sectioning the body along various planes.

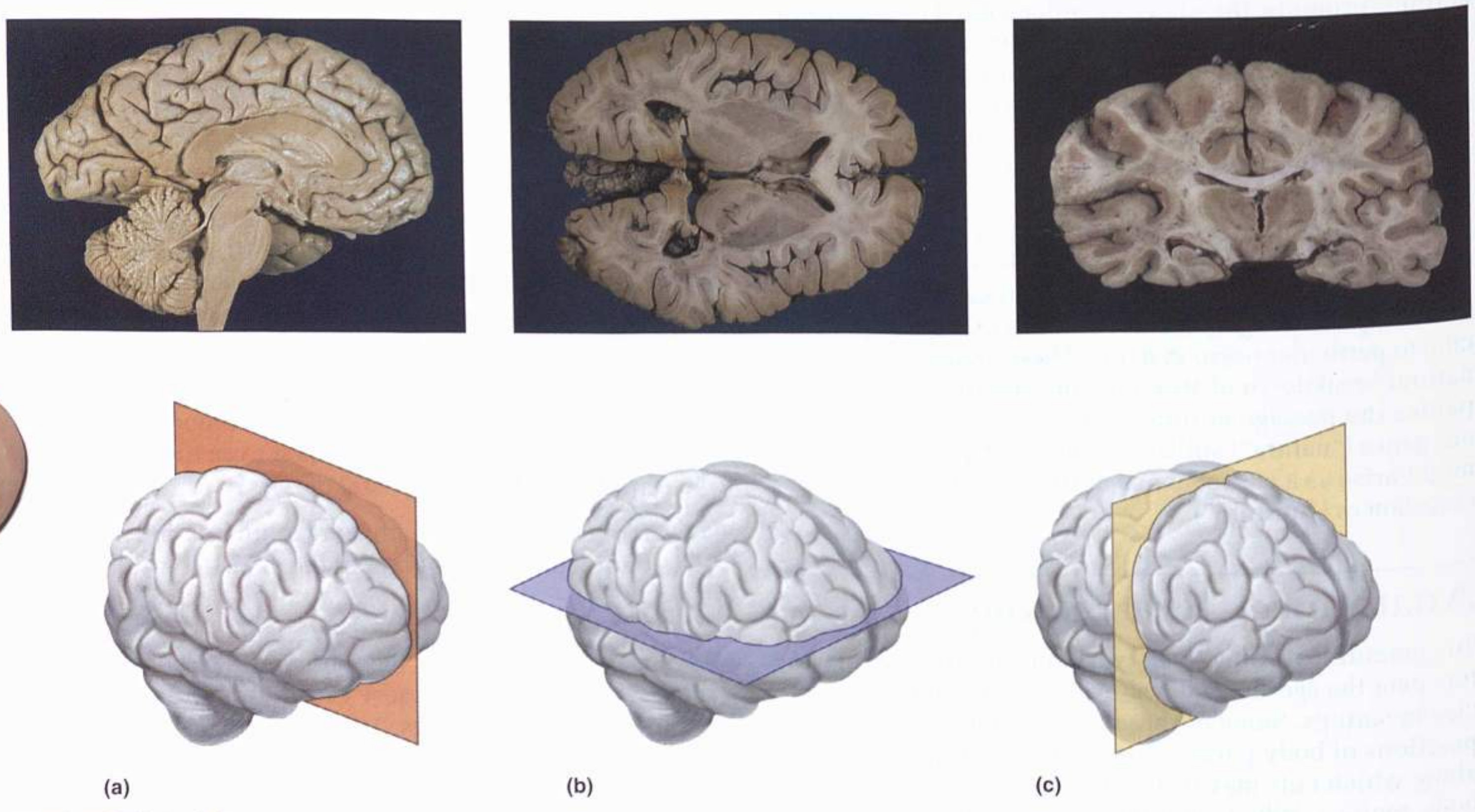


FIGURE 1.21
A human brain sectioned along (*a*) the sagittal plane, (*b*) the transverse plane, and (*c*) the coronal plane.

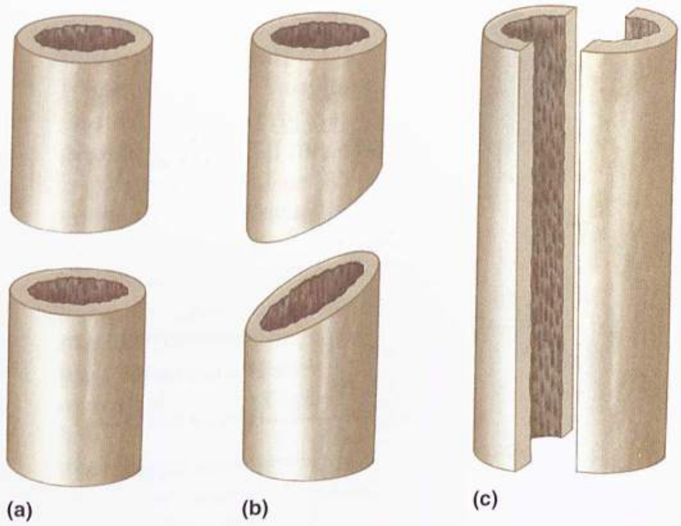


FIGURE 1.22
Cylindrical parts may be cut in (*a*) cross section, (*b*) oblique section, or (*c*) longitudinal section.

2. **Transverse** (or horizontal) refers to a cut that divides the body into superior and inferior portions.
3. **Coronal** (or frontal) refers to a section that divides the body into anterior and posterior portions.

Sometimes a cylindrical organ such as a blood vessel is sectioned. In this case, a cut across the structure is called a *cross section,* an angular cut is called an *oblique section,* and a lengthwise cut is called a *longitudinal section* (fig. 1.22).

Body Regions

A number of terms designate body regions. The abdominal area, for example, is subdivided into the following regions, as shown in figure 1.23*a*:

1. **Epigastric region** The upper middle portion.
2. **Left** and **right hypochondriac regions** On each side of the epigastric region.
3. **Umbilical region** The central portion.
4. **Left** and **right lumbar regions** On each side of the umbilical region.
5. **Hypogastric region** The lower middle portion.
6. **Left** and **right iliac (or inguinal) regions** On each side of the hypogastric region.

The abdominal area may also be subdivided into the following four quadrants, as figure 1.23*b* illustrates:

1. **Right upper quadrant** (RUQ).
2. **Right lower quadrant** (RLQ).
3. **Left upper quadrant** (LUQ).
4. **Left lower quadrant** (LLQ).

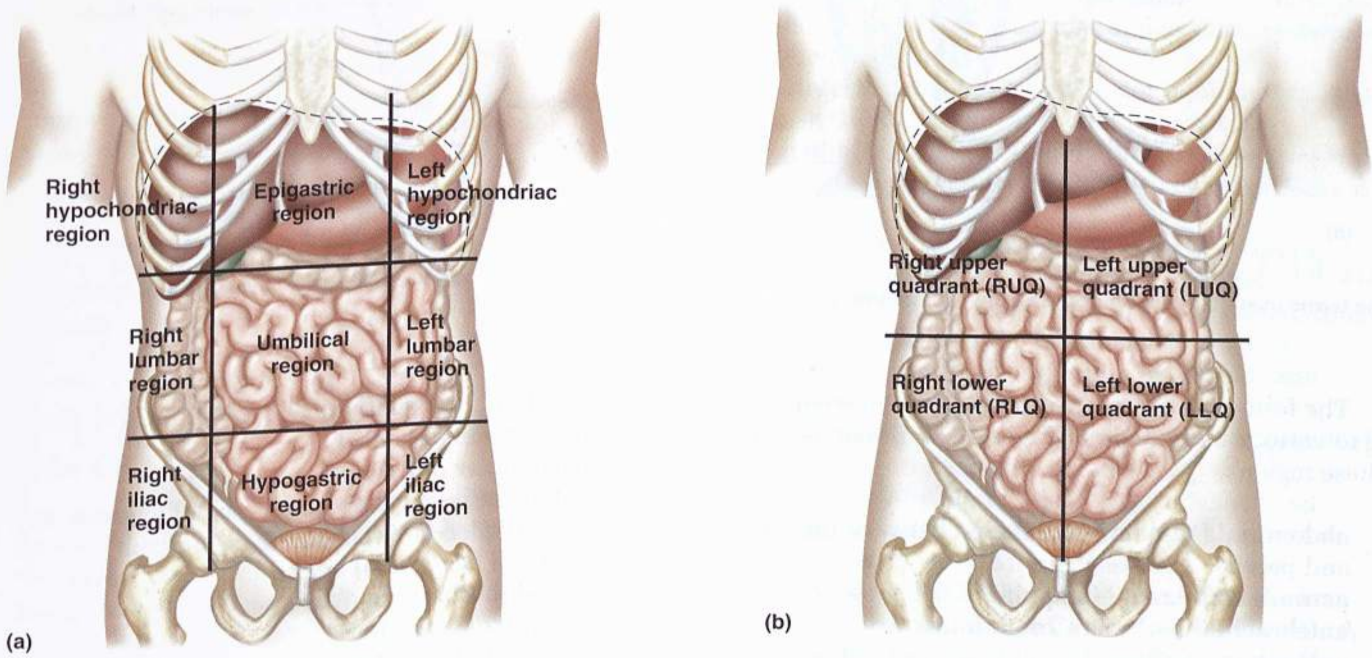


FIGURE 1.23
There are two common ways to subdivide the abdominal area. (*a*) The abdominal area is subdivided into nine regions. (*b*) The abdominal area may also be subdivided into four quadrants.

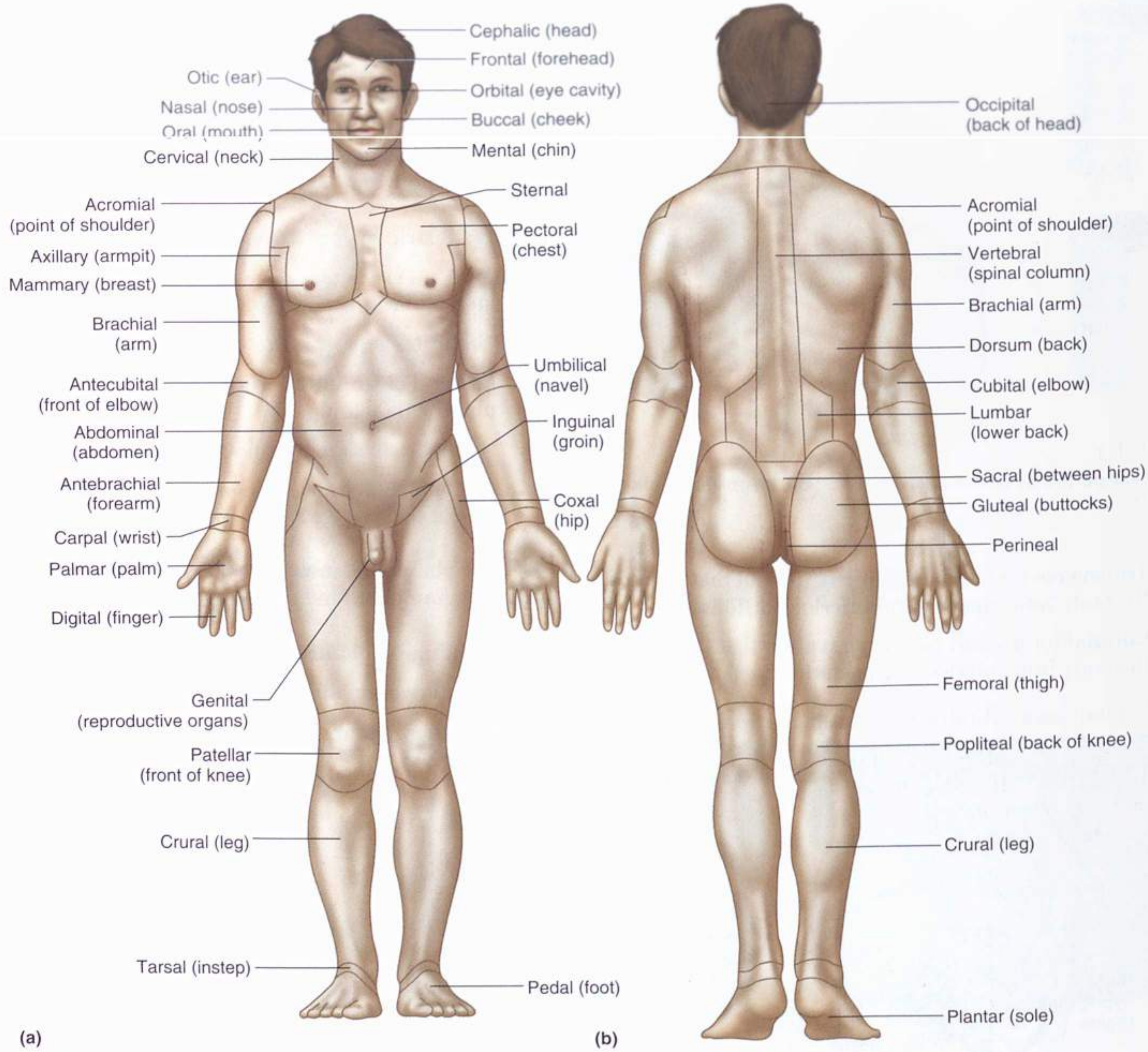


FIGURE 1.24
Some terms used to describe body regions. (*a*) Anterior regions. (*b*) Posterior regions.

The following terms are commonly used when referring to various body regions. Figure 1.24 illustrates some of these regions.

abdominal (ab-dom′ĭ-nal) region between the thorax and pelvis
acromial (ah-kro′me-al) point of the shoulder
antebrachial (an″te-bra′ke-al) forearm
antecubital (an″te-ku′bĭ-tal) space in front of the elbow
axillary (ak′sĭ-ler″e) armpit
brachial (bra′ke-al) arm
buccal (buk′al) cheek
carpal (kar′pal) wrist
celiac (se′le-ak) abdomen
cephalic (sĕ-fal′ik) head
cervical (ser′vĭ-kal) neck
costal (kos′tal) ribs
coxal (kok′sal) hip
crural (kro̅o̅r′al) leg
cubital (ku′bĭ-tal) elbow
digital (dij′ĭ-tal) finger

dorsum (dor′sum) back
femoral (fem′or-al) thigh
frontal (frun′tal) forehead
genital (jen′i-tal) reproductive organs
gluteal (gloo′te-al) buttocks
inguinal (ing′gwĭ-nal) depressed area of the abdominal wall near the thigh (groin)
lumbar (lum′bar) region of the lower back between the ribs and the pelvis (loin)
mammary (mam′er-e) breast
mental (men′tal) chin
nasal (na′zal) nose
occipital (ok-sip′ĭ-tal) lower posterior region of the head
oral (o′ral) mouth
orbital (or′bi-tal) eye cavity
otic (o′tik) ear
palmar (pahl′mar) palm of the hand
patellar (pah-tel′ar) front of the knee
pectoral (pek′tor-al) chest
pedal (ped′al) foot
pelvic (pel′vik) pelvis
perineal (per″ĭ-ne′al) region between the anus and the external reproductive organs (perineum)
plantar (plan′tar) sole of the foot
popliteal (pop″lĭ-te′al) area behind the knee
sacral (sa′kral) posterior region between the hipbones
sternal (ster′nal) middle of the thorax, anteriorly
tarsal (tahr′sal) instep of the foot (ankle)
umbilical (um-bil′ĭ-kal) navel
vertebral (ver′te-bral) spinal column

1 Describe the anatomical position.

2 Using the appropriate terms, describe the relative positions of several body parts.

3 Describe three types of body sections.

4 Describe the nine regions of the abdomen.

5 Explain how the names of the abdominal regions describe their locations.

Some Medical and Applied Sciences

cardiology (kar″de-ol′o-je) Branch of medical science dealing with the heart and heart diseases.
dermatology (der″mah-tol′o-je) Study of skin and its diseases.
endocrinology (en″do-krĭ-nol′o-je) Study of hormones, hormone-secreting glands, and associated diseases.
epidemiology (ep″ĭ-de″me-ol′o-je) Study of the factors that contribute to determining the distribution and frequency of health-related conditions within a defined human population.
gastroenterology (gas″tro-en″ter-ol′o-je) Study of the stomach and intestines, as well as 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 process of aging and the various problems of older individuals.
gynecology (gi″nĕ-kol′o-je) Study of the female reproductive system and its diseases.
hematology (hem″ah-tol′o-je) Study of blood and blood diseases.
histology (his-tol′o-je) Study of the structure and function of tissues (microscopic anatomy).
immunology (im″u-nol′o-je) Study of the body's resistance to 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 in health and disease.
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, larynx, and their diseases.
pathology (pah-thol′o-je) Study of structural and functional changes within the body associated with disease.
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 diseases.
podiatry (po-di′ah-tre) Study of the care and treatment of the 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, as well as their uses in diagnosing and treating diseases.
toxicology (tok″sĭ-kol′o-je) Study of poisonous substances and their effects on physiology.
urology (u-rol′o-je) Branch of medicine dealing with the urinary and male reproductive systems and their diseases.

CHAPTER SUMMARY

Introduction (page 3)

1. Early interest in the human body probably developed as people became concerned about injuries and illnesses. Changes in lifestyle, from hunter-gatherer to farmer to city dweller, were reflected in types of illnesses.
2. Early doctors began to learn how certain herbs and potions affected body functions.
3. The idea 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 formed the basis for the language of anatomy and physiology.

Anatomy and Physiology (page 3)

1. Anatomy deals with the form and organization of body parts.
2. Physiology deals with the functions of these parts.
3. The function of a part depends upon the way it is constructed.

Levels of Organization (page 4)

The body is composed of parts that can be considered at different levels of organization.

1. Matter is composed of atoms.
2. Atoms join to form molecules.
3. Organelles consist of aggregates of interacting large molecules.
4. Cells, which are composed of organelles, are the basic units of structure and function of the body.
5. Cells are organized into layers or masses called tissues.
6. Tissues are organized into organs.
7. Organs form organ systems.
8. Organ systems constitute the organism.
9. These parts vary in complexity progressively from one level to the next.

Characteristics of Life (page 6)

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 in size without changing in 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 forms that can be absorbed.
   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. Metabolism is the acquisition and utilization of energy by an organism.

Maintenance of Life (page 7)

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. Nutrients supply energy, raw materials for building substances, and chemicals necessary in vital reactions.
   c. Oxygen is used in releasing energy from nutrients; this energy drives metabolic reactions.
   d. Heat is a product of metabolic reactions and helps control rates of these reactions.
   e. Pressure is an application of force; 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. The tendency to maintain a stable internal environment is called homeostasis.
   c. Homeostatic mechanisms involve sensory receptors, a control center with a set point, and effectors.
   d. Homeostatic mechanisms include those that regulate body temperature, blood pressure, and blood glucose concentration.
   e. Homeostatic mechanisms employ negative feedback.

Organization of the Human Body (page 12)

1. Body cavities
   a. The axial portion of the body contains the dorsal and ventral cavities.
      (1) The dorsal cavity includes the cranial cavity and vertebral canal.
      (2) The ventral cavity includes the thoracic and abdominopelvic cavities, which are separated by the diaphragm.
   b. The organs within a body cavity are called viscera.
   c. Other body cavities include the oral, nasal, orbital, and middle ear cavities.
2. Thoracic and abdominopelvic membranes
   Parietal serous membranes line the walls of these cavities; visceral serous membranes cover organs within them. They secrete serous fluid.
   a. Thoracic membranes
      (1) Pleural membranes line the thoracic cavity and cover the lungs.
      (2) Pericardial membranes surround the heart and cover its surface.
      (3) The pleural and pericardial cavities are potential spaces between these membranes.
   b. Abdominopelvic membranes
      (1) Peritoneal membranes line the abdominopelvic cavity and cover the organs inside.
      (2) The peritoneal cavity is a potential space between these membranes.
3. Organ systems
   The human organism consists of several organ systems. Each system includes interrelated organs.
   a. Integumentary system
      (1) The integumentary system covers the body.

(2) It includes the skin, hair, nails, sweat glands, and sebaceous glands.
(3) It protects underlying tissues, regulates body temperature, houses sensory receptors, and synthesizes substances.

b. Skeletal system
(1) The skeletal system is composed of bones and the ligaments and cartilages that bind bones together.
(2) It provides framework, protective shields, and attachments for muscles; it also produces blood cells and stores inorganic salts.

c. Muscular system
(1) The muscular system includes the muscles of the body.
(2) It moves body parts, maintains posture, and produces body heat.

d. Nervous system
(1) The nervous system consists of the brain, spinal cord, nerves, and sense organs.
(2) It receives impulses from sensory parts, interprets these impulses, and acts on them, stimulating muscles or glands to respond.

e. Endocrine system
(1) The endocrine system consists of glands that secrete hormones.
(2) Hormones help regulate metabolism by stimulating target tissues.
(3) It includes the pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, ovaries, testes, pineal gland, and thymus gland.

f. Digestive system
(1) The digestive system receives foods, breaks down nutrients into forms that can pass through cell membranes, and eliminates materials that are not absorbed.
(2) Some digestive organs produce hormones.
(3) The digestive system includes the mouth, tongue, teeth, salivary glands, pharynx, esophagus, stomach, liver, gallbladder, pancreas, small intestine, and large intestine.

g. Respiratory system
(1) The respiratory system takes in and releases air and exchanges gases between the blood and the air.
(2) It includes the nasal cavity, pharynx, larynx, trachea, bronchi, and lungs.

h. Cardiovascular system
(1) The cardiovascular system includes the heart, which pumps blood, and the blood vessels, which carry blood to and from body parts.
(2) Blood transports oxygen, nutrients, hormones, and wastes.

i. Lymphatic system
(1) The lymphatic system is composed of lymphatic vessels, lymph nodes, thymus, and spleen.
(2) It transports lymph from tissue spaces to the bloodstream and carries certain fatty substances away from the digestive organs. Lymphocytes defend the body against disease-causing agents.

j. Urinary system
(1) The urinary system includes the kidneys, ureters, urinary bladder, and urethra.
(2) It filters wastes from the blood and helps maintain fluid and electrolyte balance.

k. Reproductive systems
(1) The reproductive system enables an organism to produce progeny.
(2) The male reproductive system includes the scrotum, testes, epididymides, vasa deferentia, seminal vesicles, prostate gland, bulbourethral glands, urethra, and penis, which produce, maintain, and transport male sex cells.
(3) The female reproductive system includes the ovaries, uterine tubes, uterus, vagina, clitoris, and vulva, which produce, maintain, and transport female sex cells.

Life-Span Changes (page 19)

Aging occurs from conception on, and has effects at the cell, tissue, organ, and organ system levels.

1. The first signs of aging are noticeable in one's thirties. Female fertility begins to decline during this time.
2. In the forties and fifties, adult-onset disorders may begin.
3. Skin changes reflect less elastin, collagen, and subcutaneous fat.
4. Older people may metabolize certain drugs at different rates than younger people.
5. Cells divide a limited number of times. As DNA repair falters, mutations may accumulate.
6. Oxygen free-radical damage produces certain pigments. Metabolism slows, and beta amyloid protein may build up in the brain.

Anatomical Terminology (page 21)

Investigators use terms with precise meanings to effectively communicate with one another.

1. Relative position
   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 arrangements of internal parts.
3. Body regions
   Special terms designate various body regions.

CRITICAL THINKING QUESTIONS

1. In many states, death is defined as "irreversible cessation of total brain function." How is death defined in your state? How is this definition related to the characteristics of life?
2. In health, body parts interact to maintain homeostasis. Illness may threaten homeostasis, requiring treatments. What treatments might be used to help control a patient's (a) body temperature, (b) blood oxygen concentration, and (c) water content?
3. Suppose two individuals have benign (noncancerous) tumors that produce symptoms because they occupy space and crowd adjacent organs. If one of these persons has a tumor in her ventral cavity and the other has a tumor in his dorsal cavity, which patient would be likely to develop symptoms first? Why?

4. If a patient complained of a stomachache and pointed to the umbilical region as the site of the discomfort, which organs located in this region might be the source of the pain?
5. How could the basic requirements of a human be provided for a patient who is unconscious?
6. What is the advantage of using ultrasonography rather than X rays to visualize a fetus in the uterus, assuming that the same information could be obtained by either method?

REVIEW EXERCISES

Part A

1. Briefly describe the early development of knowledge about the human body.
2. Distinguish between anatomy and physiology.
3. How does a biological structure's form determine its function? Give an example.
4. List and describe ten characteristics of life.
5. Define *metabolism*.
6. List and describe five requirements of organisms.
7. Explain how the idea of homeostasis relates to the five requirements you listed in item 6.
8. Distinguish between heat and temperature.
9. What are two types of pressures that may act upon organisms?
10. How are body temperature, blood pressure, and blood glucose concentration controlled?
11. Describe how homeostatic mechanisms act by negative feedback.
12. How does the human body illustrate the levels of anatomical organization?
13. Distinguish between the axial and appendicular portions of the body.
14. Distinguish between the dorsal and ventral body cavities, and name the smaller cavities within each.
15. What are the viscera?
16. Where is the mediastinum?
17. Describe the locations of the oral, nasal, orbital, and middle ear cavities.
18. How does a parietal membrane differ from a visceral membrane?
19. Name the major organ systems, and describe the general functions of each.
20. List the major organs that comprise each organ system.
21. In what body region did Judith R.'s injury occur?

Part B

1. Name the body cavity housing each of the following organs:
   a. stomach
   b. heart
   c. brain
   d. liver
   e. trachea
   f. rectum
   g. spinal cord
   h. esophagus
   i. spleen
   j. urinary bladder
2. Write complete sentences using each of the following terms correctly:
   a. superior
   b. inferior
   c. anterior
   d. posterior
   e. medial
   f. lateral
   g. ipsilateral
   h. contralateral
   i. proximal
   j. distal
   k. superficial
   l. peripheral
   m. deep
3. Prepare a sketch of a human body, and use lines to indicate each of the following sections:
   a. sagittal
   b. transverse
   c. frontal
4. Prepare a sketch of the abdominal area, and indicate the location of each of the following regions:
   a. epigastric
   b. umbilical
   c. hypogastric
   d. hypochondriac
   e. lumbar
   f. iliac
5. Prepare a sketch of the abdominal area, and indicate the location of each of the following regions:
   a. right upper quadrant
   b. right lower quadrant
   c. left upper quadrant
   d. left lower quadrant
6. Provide the common name for the region described by the following terms:
   a. acromial
   b. antebrachial
   c. axillary
   d. buccal
   e. celiac
   f. coxal
   g. crural
   h. femoral
   i. genital
   j. gluteal
   k. inguinal
   l. mental
   m. occipital
   n. orbital
   o. otic
   p. palmar
   q. pectoral
   r. pedal
   s. perineal
   t. plantar
   u. popliteal
   v. sacral
   w. sternal
   x. tarsal
   y. umbilical
   z. vertebral

WEB CONNECTIONS

Visit the Student Edition of the Online Learning Center at www.mhhe.com/shier10 for answers to chapter questions, additional quizzes, interactive learning exercises, and other study tools.

The Human Organism

The following series of illustrations show the major organs of the human torso. The first plate illustrates the anterior surface and reveals the superficial muscles on one side. Each subsequent plate exposes deeper organs, including those in the thoracic, abdominal, and pelvic cavities.

Chapters 6–22 of this textbook describe the organ systems of the human organism in detail. As you read them, you may want to refer to these plates to help visualize the locations of organs and the three-dimensional relationships among them. You may also want to study the photographs of human cadavers in the reference plates that follow chapter 24. These photographs illustrate many of the larger organs of the human body.

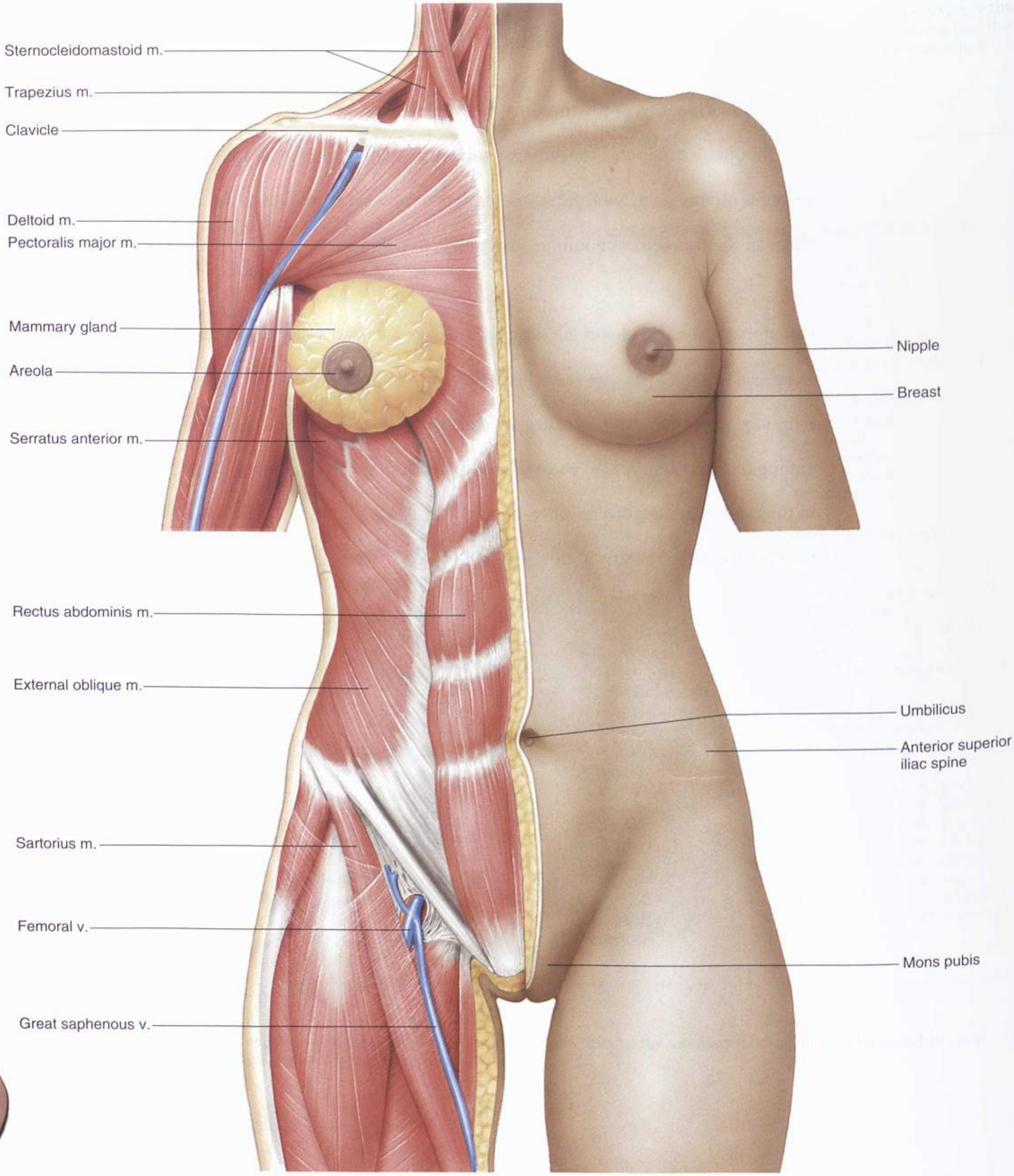


PLATE ONE

Human female torso showing the anterior surface on one side and the superficial muscles exposed on the other side. (*m.* stands for *muscle*, and *v.* stands for *vein*.)

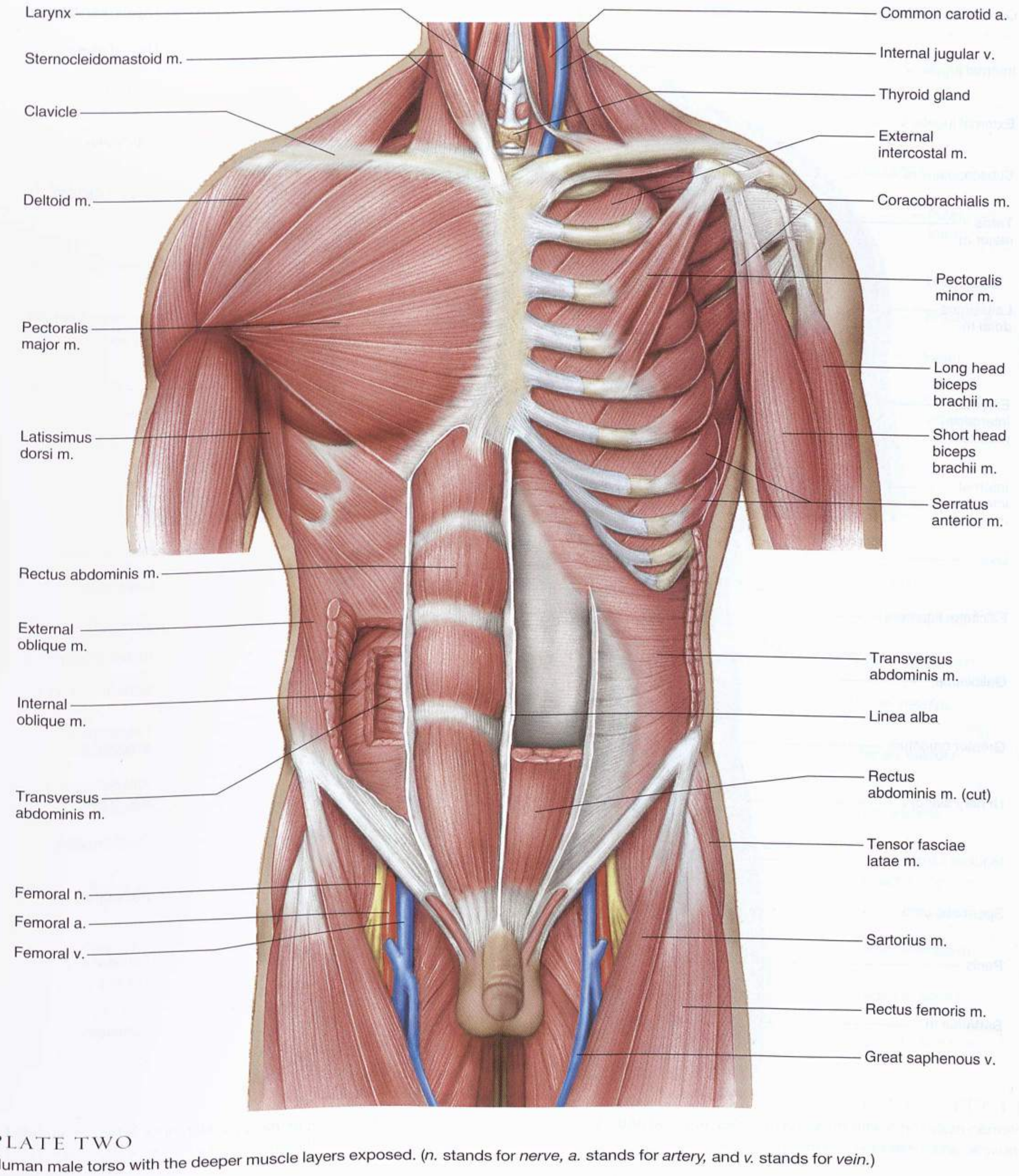


PLATE TWO

Human male torso with the deeper muscle layers exposed. (*n.* stands for *nerve*, *a.* stands for *artery*, and *v.* stands for *vein*.)

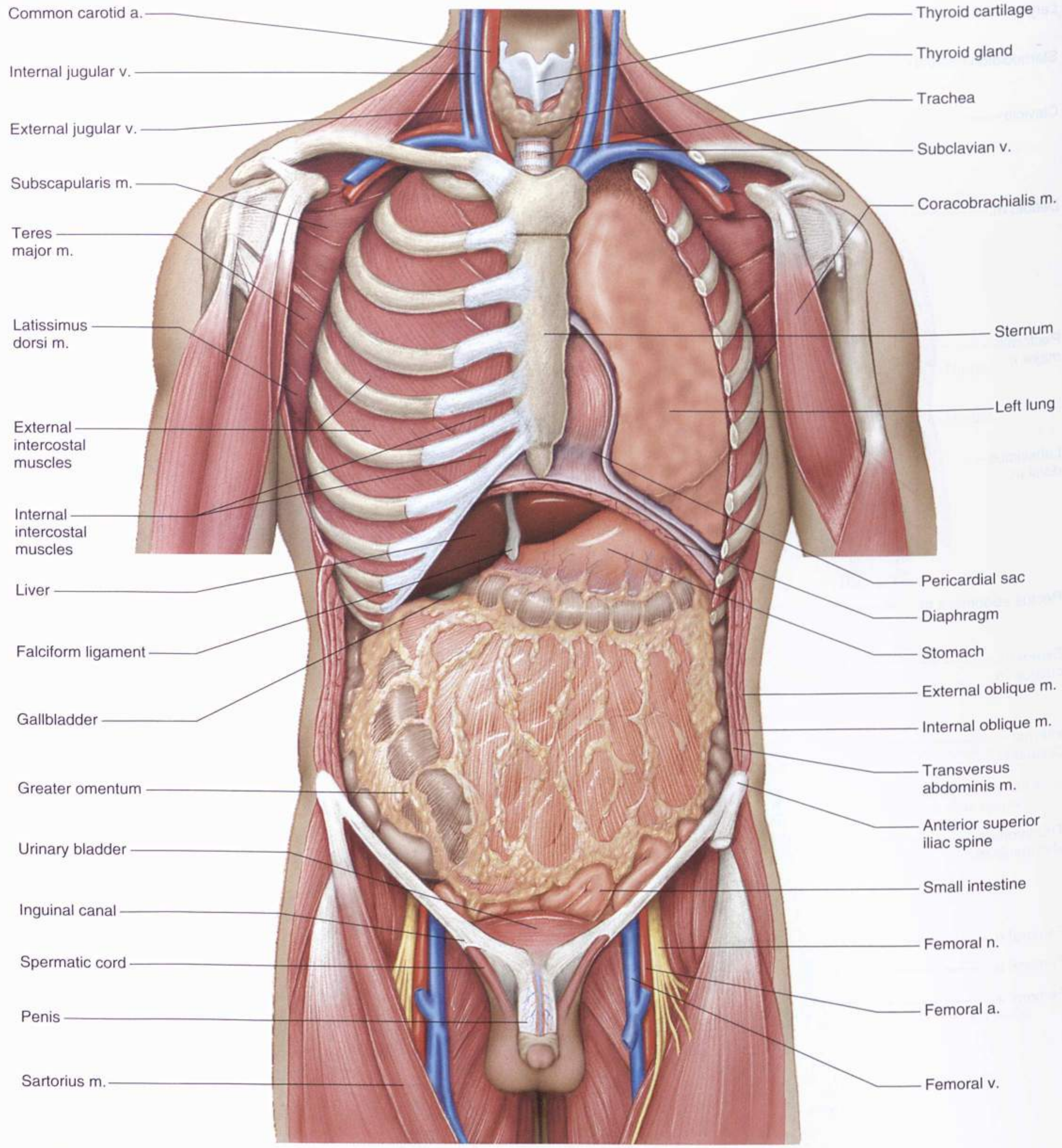


PLATE THREE

Human male torso with the deep muscles removed and the abdominal viscera exposed. (*n.* stands for *nerve*, *a.* stands for *artery*, *m.* stands for *muscle*, and *v.* stands for *vein*.)

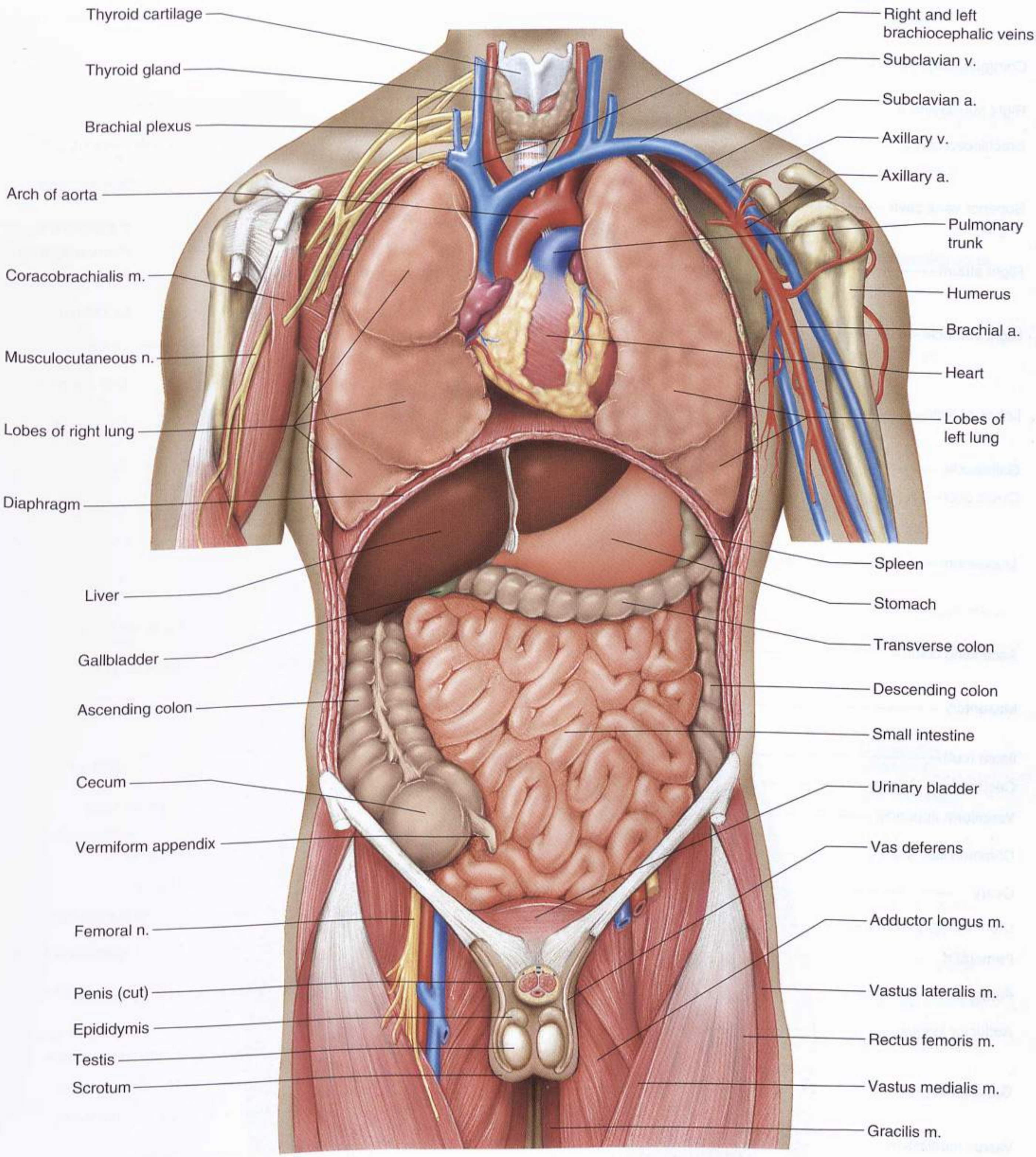


PLATE FOUR

Human male torso with the thoracic and abdominal viscera exposed. (*n.* stands for *nerve*, *a.* stands for *artery*, *m.* stands for *muscle*, and *v.* stands for *vein*.)

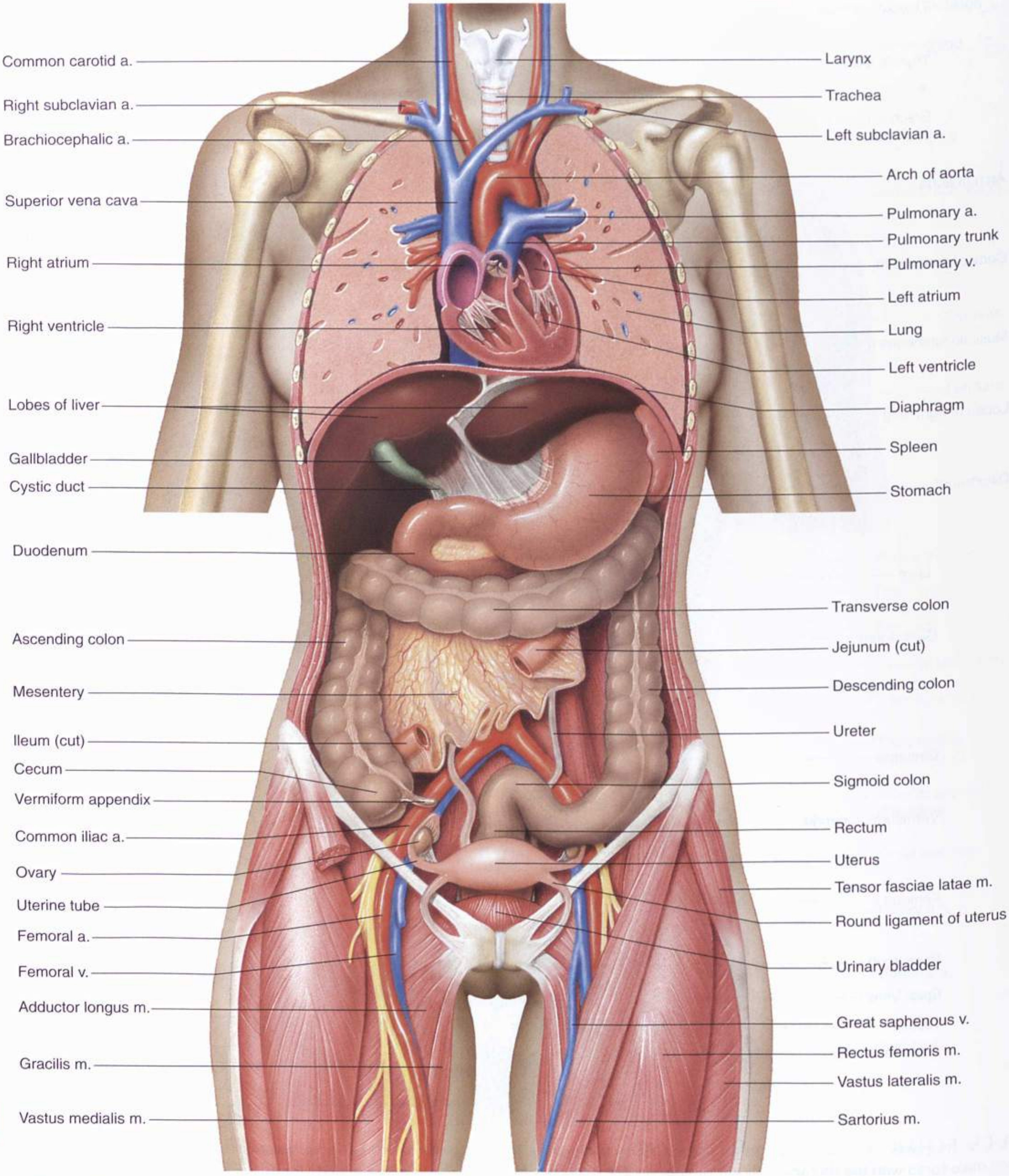


PLATE FIVE

Human female torso with the lungs, heart, and small intestine sectioned and the liver reflected (lifted back). (*a.* stands for *artery, m.* stands for *muscle,* and *v.* stands for *vein.*)

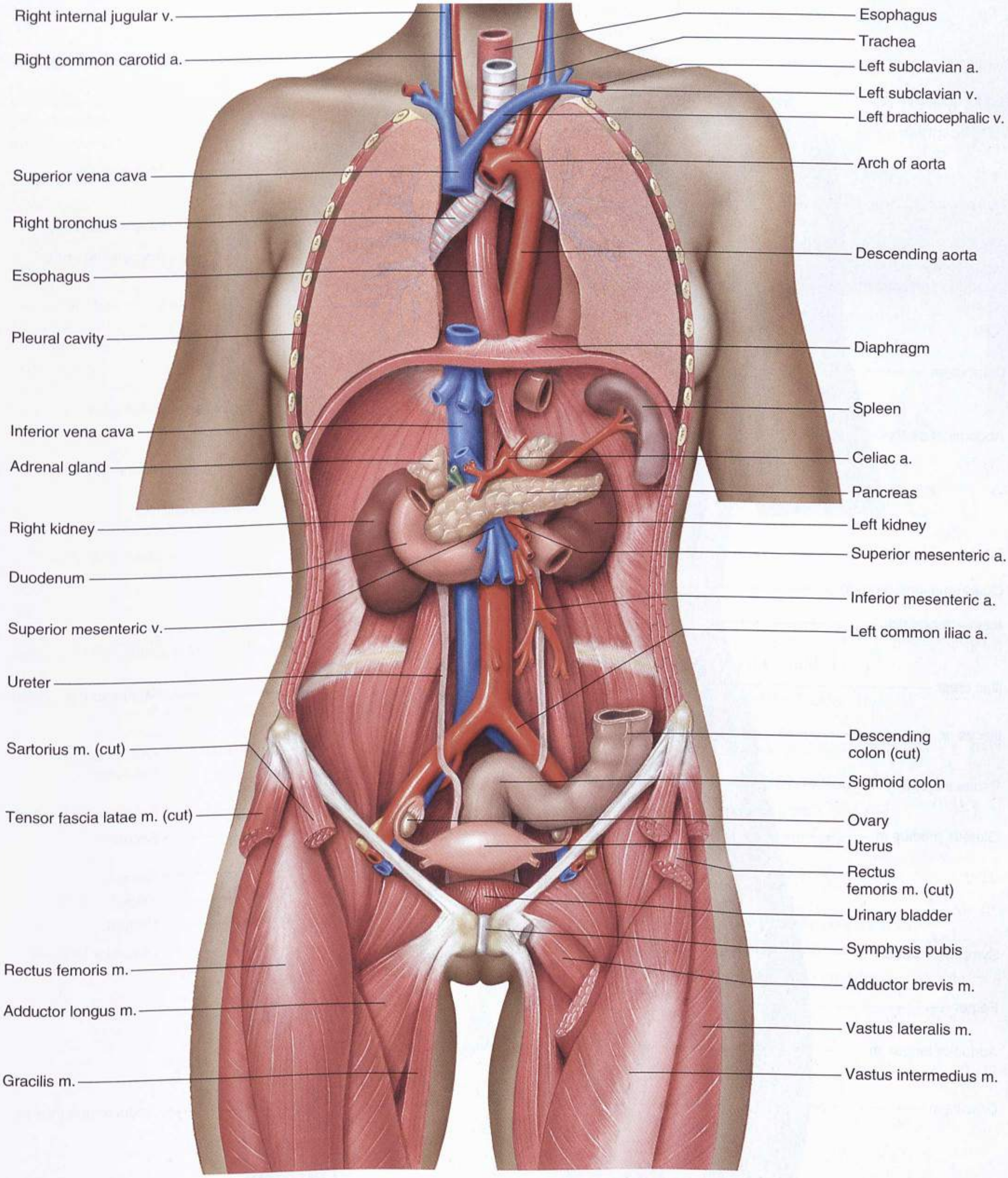


PLATE SIX

Human female torso with the heart, stomach, liver, and parts of the intestine and lungs removed. (*a.* stands for *artery, m.* stands for *muscle*, and *v.* stands for *vein.*)

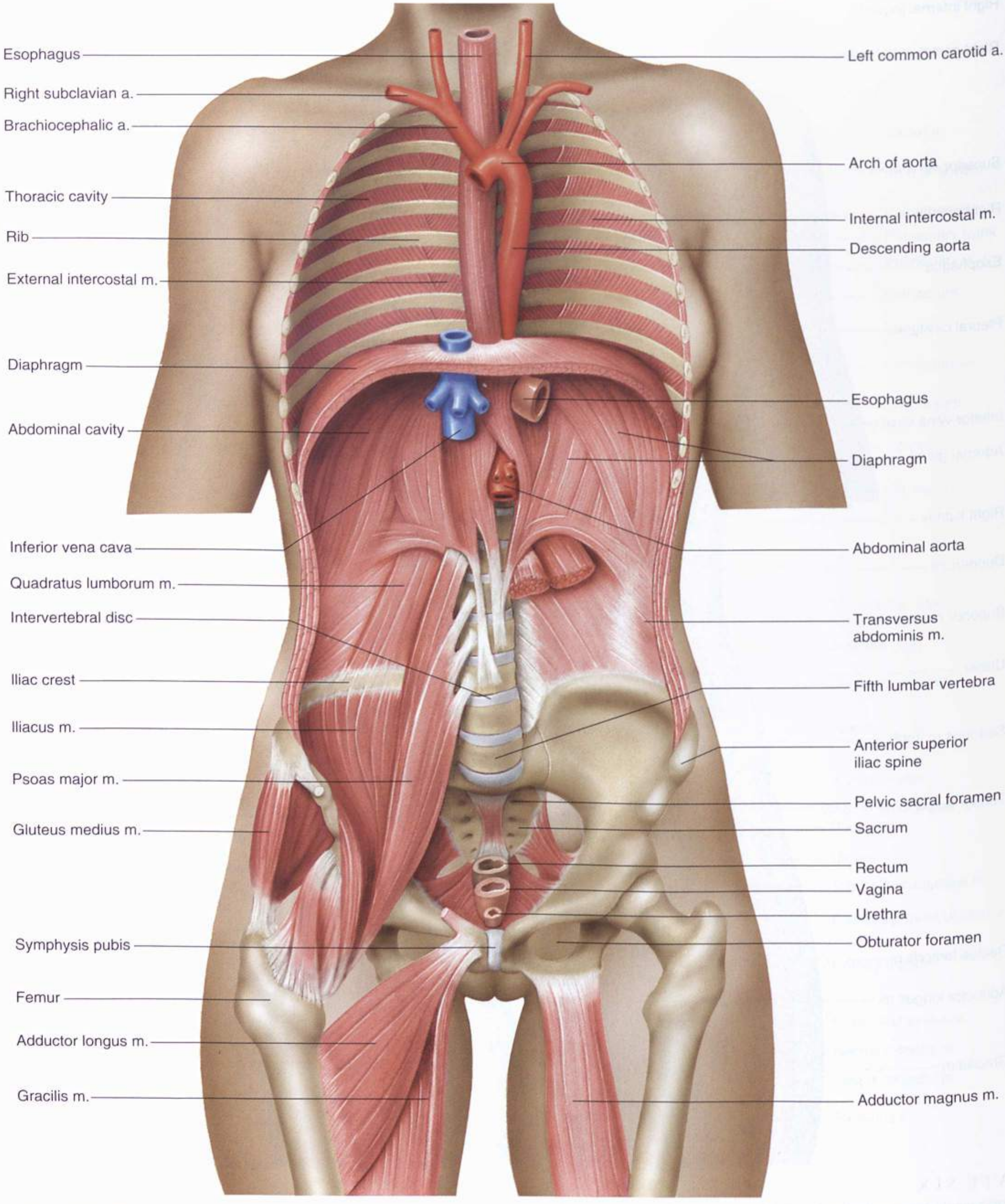


PLATE SEVEN

Human female torso with the thoracic, abdominal, and pelvic viscera removed. (*a.* stands for *artery* and *m.* stands for *muscle.*)