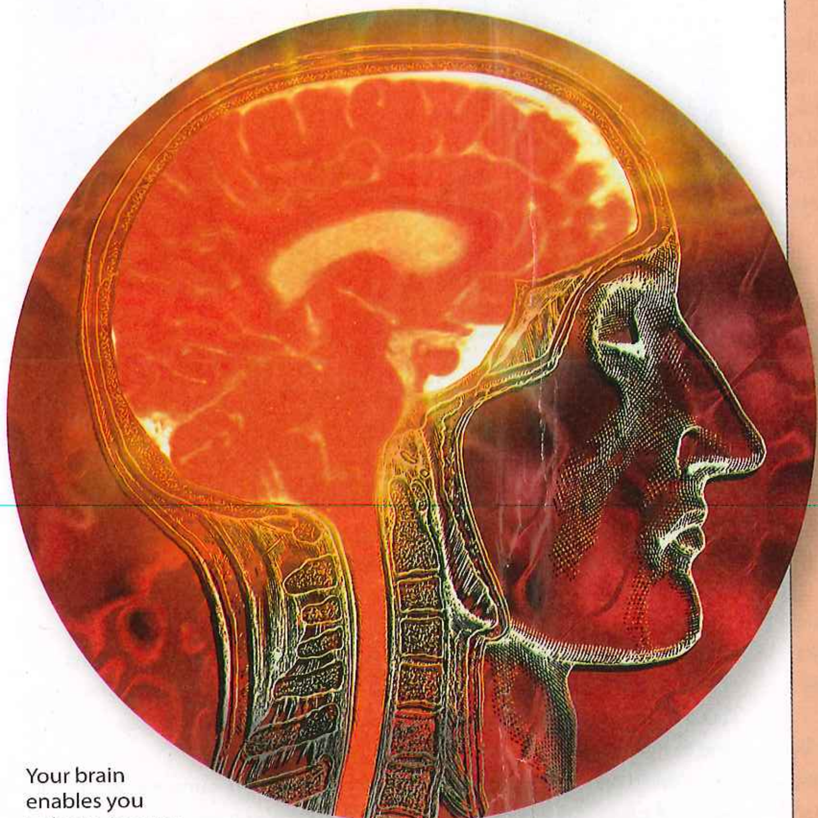
Unit I

1 Introduction to Human Anatomy and Physiology



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Module 1: Body Orientation

Learning Outcomes

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

1.1 Introduction

1 Identify some of the early discoveries that lead to our current understanding of the human body. (p. 11)

1.2 Anatomy and Physiology

2 Explain how anatomy and physiology are related. (p. 12)

1.3 Levels of Organization

3 List the levels of organization in the human body and the characteristics of each. (p. 12)

1.4 Characteristics of Life

4 List and describe the major characteristics of life. (p. 14)

5 Give examples of *metabolism*. (p. 14)

1.5 Maintenance of Life

6 List and describe the major requirements of organisms. (p. 15)

7 Explain the importance of homeostasis to survival. (p. 17)

8 Describe the parts of a homeostatic mechanism and explain how they function together. (p. 18)

1.6 Organization of the Human Body

9 Identify the locations of the major body cavities. (p. 20)

10 List the organs located in each major body cavity. (p. 20)

11 Name and identify the locations of the membranes associated with the thoracic and abdominopelvic cavities. (p. 20)

12 Name the major organ systems, and list the organs associated with each. (p. 23)

13 Describe the general function of each organ system. (p. 23)

1.7 Life-Span Changes

14 Identify changes related to aging, from the microscopic to the whole-body level. (p. 28)

1.8 Anatomical Terminology

15 Properly use the terms that describe relative positions, body sections, and body regions. (p. 28)

LEARN PRACTICE ASSESS

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 part of the brain.

cran-, helmet: *cran*ial—pertaining to the part 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 in the body.

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

orb-, circle: *orb*ital—pertaining to the portion of the 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 located above another.

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

Emergency

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 checked Judith's blood pressure, pulse and breathing rate, and other vital signs that reflect underlying metabolic activities necessary for life. Assessing vital signs is important in any medical decision. Judith's vital signs were stable, and she was alert, knew who and where she was, and didn't have obvious life-threatening injuries, so 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," bruises caused by the twisting constrictions that can occur at the moment of impact when a person wears a seat belt. Had Judith been driving fast enough for the air bag to have deployed, she might have suffered abrasions from not having the seat belt on to hold her in a safe position. 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 physician ordered a computed tomography (CT) scan. It 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 indicate 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. In addition, her abdomen had become swollen and the pain intensified 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.

Blood tests confirmed the doctor's suspicions. Blood is a complex mixture of cells and biochemicals, so it serves as a barometer of health. Injury or illness disrupts the body's maintenance of specific levels of various biochemicals, called homeostasis. Judith's blood tests revealed that her body had not yet recovered

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

from the accident. Levels of clotting factors her liver produced were falling and blood oozed from her incision, a sign of impaired clotting. Judith's blood glucose level remained elevated, as it had been on arrival. 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. When her condition stabilized, she continued recovering in a private 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. ■

1.1 INTRODUCTION

Our understanding of the human body has a long and interesting history (fig. 1.1). Our earliest ancestors must have been curious about how their bodies worked. At first their interests most likely concerned injuries and illnesses, because healthy bodies demand little attention from their owners. Primitive people suffered 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. These ancient peoples ate wild plants that provided chemicals that combated some parasitic infections. A man who died in the Austrian/Italian Alps 5,300 years ago and whose body was found frozen was carrying mushrooms that had antibiotic activity.

With agriculture came exposure to pinworms, tapeworms, and hookworms in excrement used as fertilizer, and less reliance on the natural drugs in wild plants. Urbanization brought more infectious disease as well as malnutrition, as people became sedentary and altered their diets. 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.

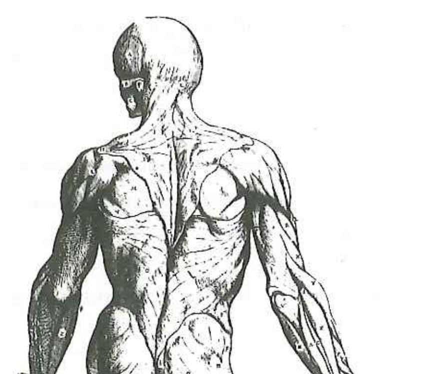


FIGURE 1.1 The study of the human body has a long history, as this illustration from the second book of *De Humani Corporis Fabrica* by Andreas Vesalius, issued in 1543, indicates. Note the similarity to the anatomical position (described on p. 28).

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 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.

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 pp. 32–33.)

Study of corpses was forbidden in Europe during the Middle Ages, but dissection of dead bodies became a key part of medical education in the twentieth century. Today, cadaver dissection remains an important method to learn how the body functions and malfunctions, and autopsies are vividly depicted on television crime dramas. However, the traditional gross anatomy course in medical schools is sometimes supplemented with learning from body parts already dissected by instructors (in contrast to students doing this) as well as with computerized scans of cadavers, such as the Visible Human Project from the National Library of Medicine and Anatomy and Physiology Revealed available with this textbook.

Much of what is known about the human body is based on *scientific method*, an approach to investigating the natural world. It is part of a general process called scientifc inquiry. Scientific method consists of testing a hypothesis and then rejecting or accepting it, based on the results of experiments or observations. This method is described in greater detail in Appendix A, Scientific Method (p. 926), but it is likely that aspects of its application are already familiar.

Imagine buying a used car. The dealer insists it is in fine shape, but the customer discovers that the engine doesn't start. That's an experiment! It tests the hypothesis: If this car is in good shape, then it will start. When the car doesn't start, the wary consumer rejects the hypothesis and doesn't buy the car.

Rather than giving us all the answers, science eliminates wrong explanations. Our knowledge of the workings of the human body reflects centuries of asking questions, testing, rejecting, and sometimes accepting hypotheses. New technologies provide new views of anatomy and physiology, so that knowledge is always growing. One day you may be the one to discover something previously unknown about the human body!

PRACTICE

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

2 How did human health change as lifestyle changed?

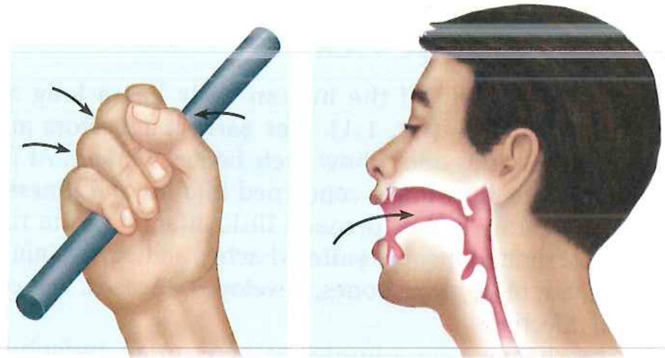
3 What types of activities helped promote the development of modern medical science?

1.2 ANATOMY AND PHYSIOLOGY

Two major areas of medical science, **anatomy** (ah-nat′o-me) and **physiology** (fiz″e-ol′o-je), address how the body maintains life. Anatomy, from the Greek for "a cutting up," examines the **structures,** or morphology, of body parts—their forms and organization. Physiology, from the Greek for "relationship to nature," considers the **functions** of 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 for understanding how our bodies work.

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.** Each part contributes to the operation of the unit as a whole. This functional role arises from 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 contract and propel blood out of the chambers and into blood vessels, and heart valves keep blood moving in the proper direction. The shape of the mouth enables it to receive food; tooth shapes enable teeth to break solid foods into pieces; and the muscular tongue and cheeks are constructed in a way that helps mix food particles with saliva and prepare them for swallowing (fig. 1.2).

As ancient as the fields of anatomy and physiology are, we are always learning more. For example, researchers recently used imaging technology to identify a previously unrecognized part of the brain, the planum temporale, which enables people to locate sounds in space. Many discoveries today begin with investigations at the molecular or cellular level. In this way, researchers have discovered that certain cells in the small intestine bear the same taste receptor proteins found on the tongue. At both locations, the receptors detect molecules of sugar. The cells in the tongue provide



(a) (b)

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

taste sensations, whereas the cells in the intestines help regulate the digestion of sugar. The discovery of the planum temporale is anatomical; the discovery of sweet receptors in the intestine is physiological.

Many nuances of physiology are being revealed through the examination of genes that function in particular cell types under particular conditions, sometimes leading to surprising findings. Using such "gene expression profiling," for example, researchers discovered that after a spinal cord injury, the damaged tissue releases a flood of proteins previously associated only with skin wounds. This discovery suggests new drug targets. Comparing gene expression profiles can reveal commonalities, among pairs of diseases, that had not been suspected based on whole-body-level observations.

PRACTICE

4 What are the differences between anatomy and physiology?

5 Why is it difficult to separate the topics of anatomy and physiology?

6 List several examples that illustrate how the structure of a body part makes possible its function.

7 How are anatomy and physiology both old and new fields?

1.3 LEVELS OF ORGANIZATION

Early investigators, limited in their ability to observe small structures such as cells, focused their attention on larger body parts. Studies of small structures had to await invention of magnifying lenses and microscopes, 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.

All materials, including those that comprise the human body, are composed of chemicals. Chemicals consist of tiny particles called **atoms,** which are composed of even smaller **subatomic particles.** Atoms can join to form **molecules,** and small molecules may combine to form larger **macromolecules.**

In all organisms, including the human, the basic unit of structure and function is a **cell.** Although individual cells

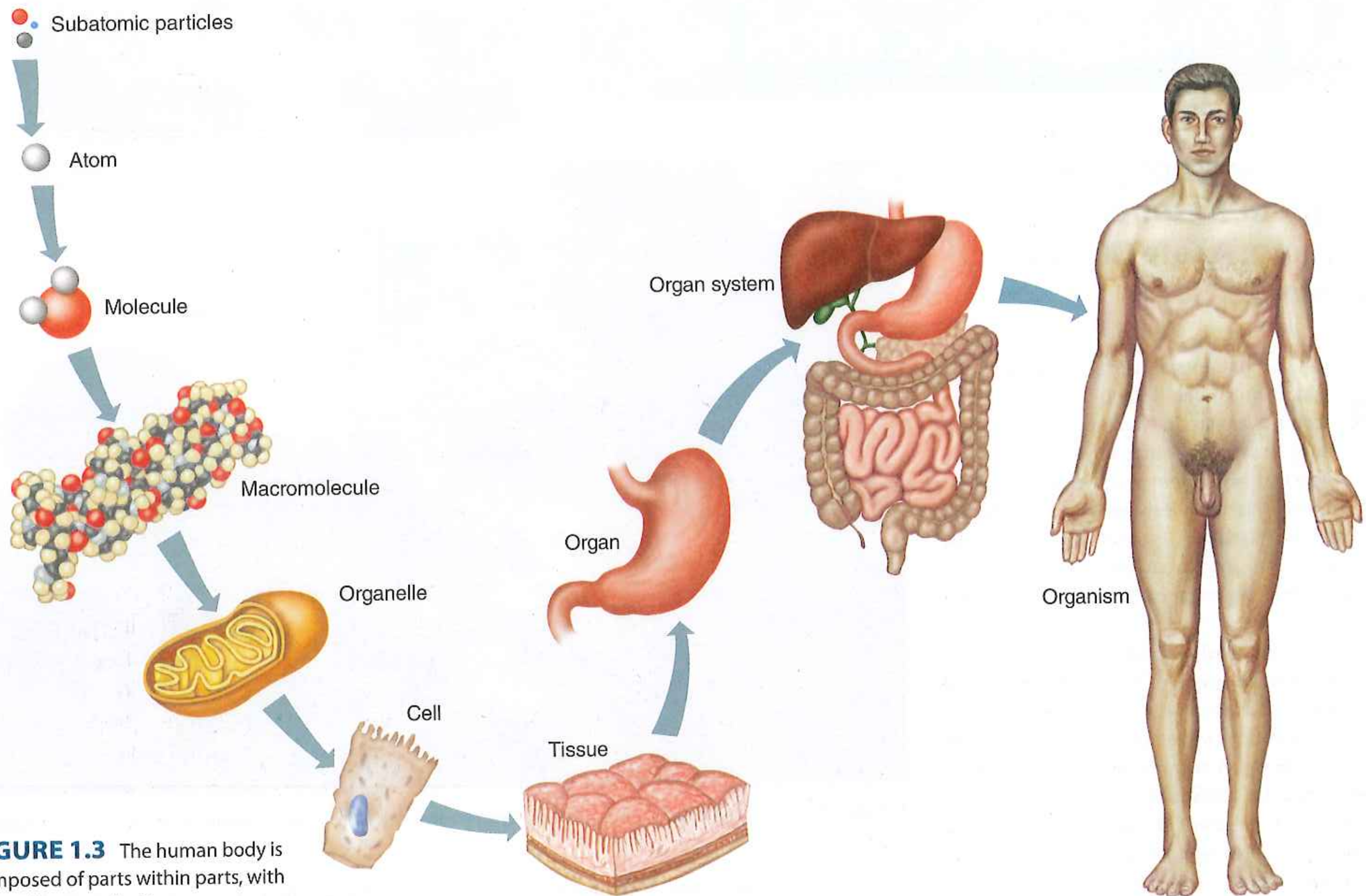


FIGURE 1.3 The human body is composed of parts within parts, with increasing complexity.

vary in size and shape, all share certain characteristics. Cells of complex organisms such as humans contain structures called **organelles** (or″gan-elz′) that carry on specific activities. Organelles are composed of assemblies of large molecules, including proteins, carbohydrates, lipids, and nucleic acids. Most human cells contain a complete set of genetic instructions, yet use only a subset of them, allowing cells to specialize. All cells share the same characteristics of life and must meet certain requirements to stay alive.

Specialized cells assemble into layers or masses that have specific 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, consists of 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 body parts 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 presents 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. In the remaining chapters, the structures and functions of each of the other organ systems are described in detail. Table 1.1 lists the levels of organization and some corresponding illustrations in

TABLE 1.1 | Levels of Organization

Level	Example(s)	Representative Illustration(s)
Subatomic particles	Electrons, protons, neutrons	Figure 2.1
Atom	Hydrogen atom, lithium atom	Figure 2.3
Molecule	Water molecule, glucose molecule	Figure 2.7
Macromolecule	Protein molecule, DNA molecule	Figure 2.19
Organelle	Mitochondrion, Golgi apparatus, nucleus	Figure 3.3
Cell	Muscle cell, nerve cell	Figure 5.28
Tissue	Simple squamous epithelium, loose connective tissue	Figure 5.2
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 progressing normally. Michael P., a sixteen-year-old who has excruciating headaches, is to undergo a magnetic resonance (MR) scan to assure his physician (and himself!) that the cause of the headache is not a brain tumor.

Ultrasound and magnetic resonance scans are noninvasive procedures that provide images of soft internal structures. Ultrasonography uses high-frequency sound waves 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 make internal body structures visible.

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 a sonogram (fig. 1B).

Glancing at the screen, Vanessa smiles. The image reveals the fetus in her uterus, heart beating and already showing budlike structures that will develop into arms and legs. She happily heads home with a video of the fetus.

Vanessa's ultrasound exam takes only a few minutes, whereas Michael's MR scan takes an hour. First, Michael 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

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 (pp. 23–27).

PRACTICE

8 How does the human body illustrate levels of organization?
9 What is an organism?
10 How do body parts at different levels of organization vary in complexity?

1.4 CHARACTERISTICS OF LIFE

A scene such as Judith R.'s accident and injury underscores the delicate balance that must be maintained 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 can respond to our surroundings. Our bodies grow, eventually becoming 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 tissues. Finally, we excrete wastes. These physiological events that obtain, release, and use energy are largely part of **metabolism** (mĕ-tab′o-liz-m), all of the chemical reactions in an organism that support life. Table 1.3 summarizes the characteristics of life.

Continued—

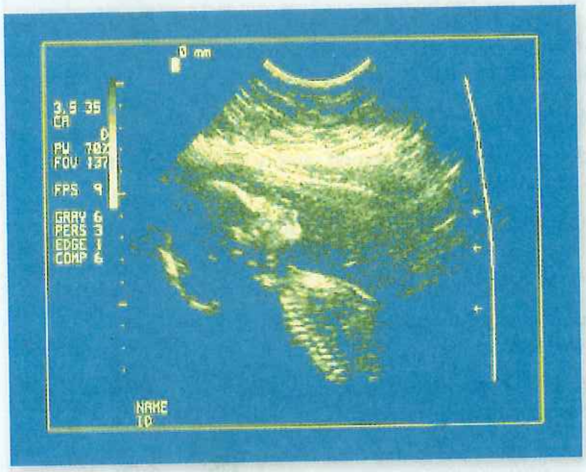


FIGURE 1B This image resulting from an ultrasonographic procedure reveals a fetus in the uterus.

into a chamber surrounded by a powerful magnet and a special radio antenna. The chamber, which looks like a metal doughnut, is the MR imaging instrument. As Michael settles back, closes his eyes, and listens to the music through earphones, a technician activates the device.

FIGURE 1C Falsely colored MR image of a human head and brain (sagittal section, see fig. 1.21).

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 from different angles.

Michael and his parents nervously wait two days for the expert eyes of a radiologist to interpret the MR scan. Happily, the scan shows normal brain structure. Whatever is causing Michael's headaches, it is not a brain tumor—at least not one large enough to be imaged. ■

PRACTICE

11 What are the characteristics of life?

12 Which physiological events constitute metabolism?

1.5 MAINTENANCE OF LIFE

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

Requirements of Organisms

Human 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 in 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 to release energy from nutrients. The energy, in turn, is used to drive metabolic processes.
4. **Heat** is a form of energy present in our environment. It is also 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.
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

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)	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, ductus 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 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 in body fluids
Reproduction	Production of new organisms and new cells	Assimilation	Changing of absorbed substances into different chemical 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

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 a liquid exerts—due to the weight of water above them. In complex animals, such as humans, heart action produces blood pressure (another form of hydrostatic pressure), which keeps blood flowing through blood vessels.

The human organism requires water, food, oxygen, heat, and pressure, but 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

Most of the earth's residents are unicellular, or single-celled. The most ancient and abundant unicellular organisms are the bacteria. Their cells do not have membrane-bound organelles. Some unicellular organisms have organelles that are as complex as our own. This is the case for the amoeba (fig. 1.4). It survives and reproduces as long as its lake or pond environment is of a tolerable temperature and composition,

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

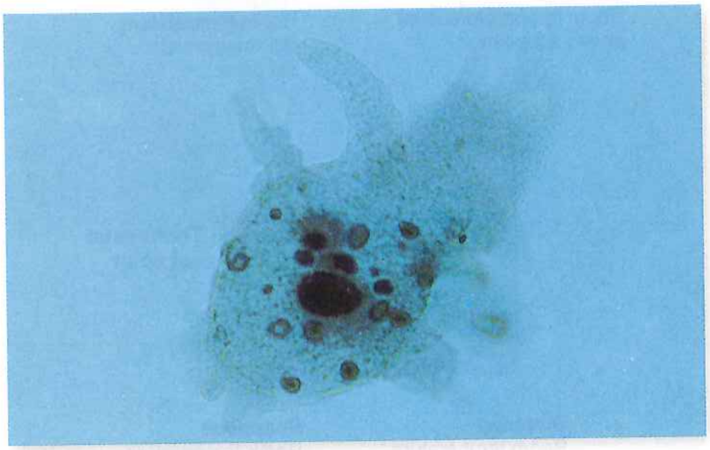


FIGURE 1.4 The amoeba is an organism consisting of a single, but complex, cell (100×).

and the amoeba can obtain food. With a limited ability to move, the amoeba depends upon the conditions in its lake or pond environment to stay alive.

In contrast to the amoeba, humans are composed of about 75 trillion cells in their own environment—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 the body, but consists of fluid that surrounds cells, called the *extracellular fluid* (see chapter 21, p. 803). The internal environment protects our cells (and us!) from external changes 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 it requires most of our metabolic energy. Many of

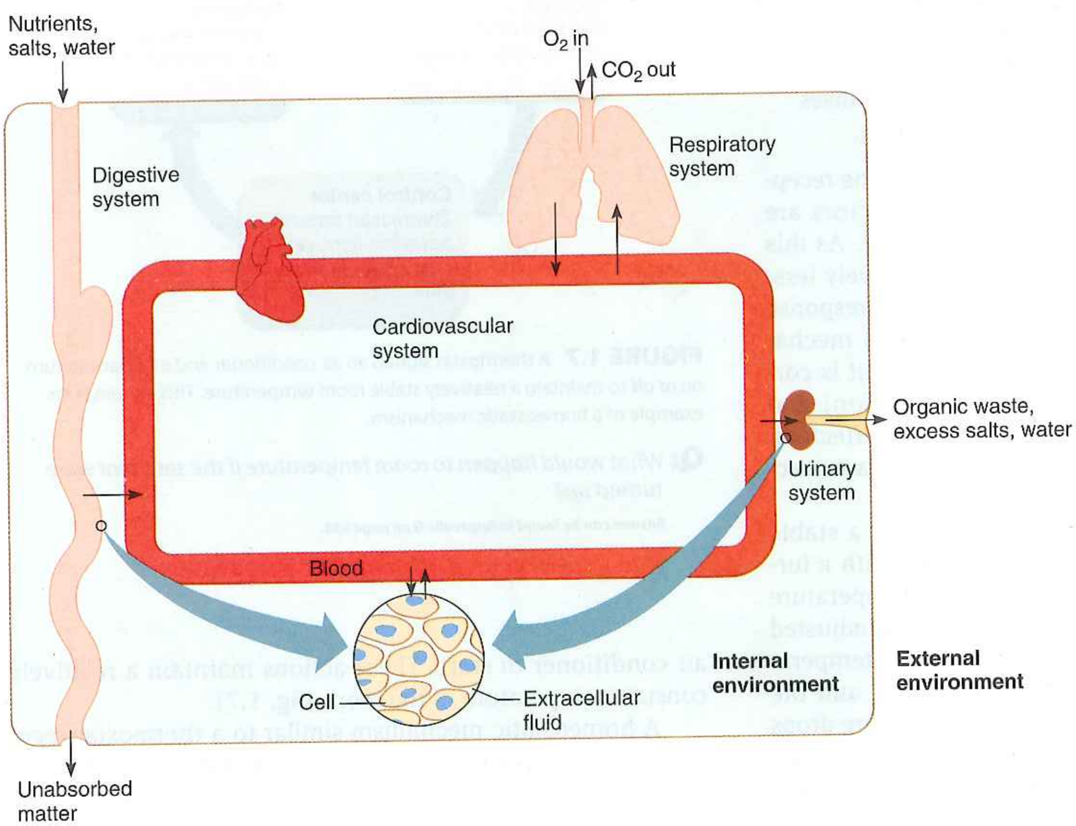


FIGURE 1.5 Our cells lie within an internal fluid environment (extracellular fluid). Concentrations of water, nutrients, and oxygen in the internal environment must be maintained within certain ranges to sustain life.

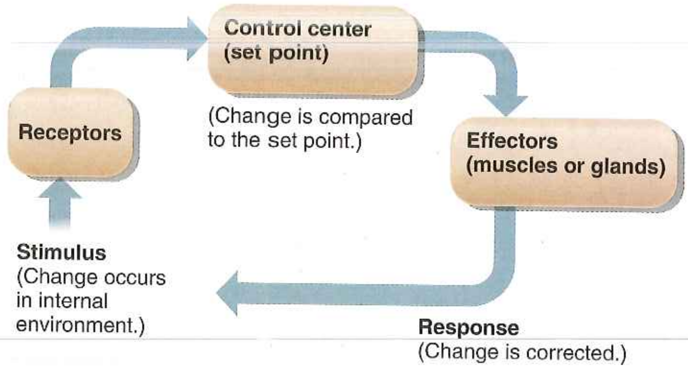


FIGURE 1.6 A homeostatic mechanism monitors a particular aspect of the internal environment and corrects any changes back to the value indicated by the set point.

the tests performed on Judith R. during her hospitalization (as described in this chapter's opening vignette on p. 10) assessed her body's return to homeostasis.

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

1. **Receptors** provide information about specific conditions (stimuli) in the internal environment. A receptor may be a molecule or a cell.
2. A **control center** includes a **set point,** which is a particular value, such as body temperature at 37°C (Celsius) or 98.6°F (Fahrenheit). More metric equivalents can be found in Appendix B, Metric Measurement System and Conversions, (p. 927) since metric units are used throughout this text.
3. **Effectors,** such as muscles or glands, cause responses that alter conditions in the internal environment.

A homeostatic mechanism works as follows. If the receptors measure deviations from the set point, effectors are activated that can return conditions toward normal. As this happens, the deviation from the set point progressively lessens, and the effectors 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. A thermostat is sensitive to temperature changes, so 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).

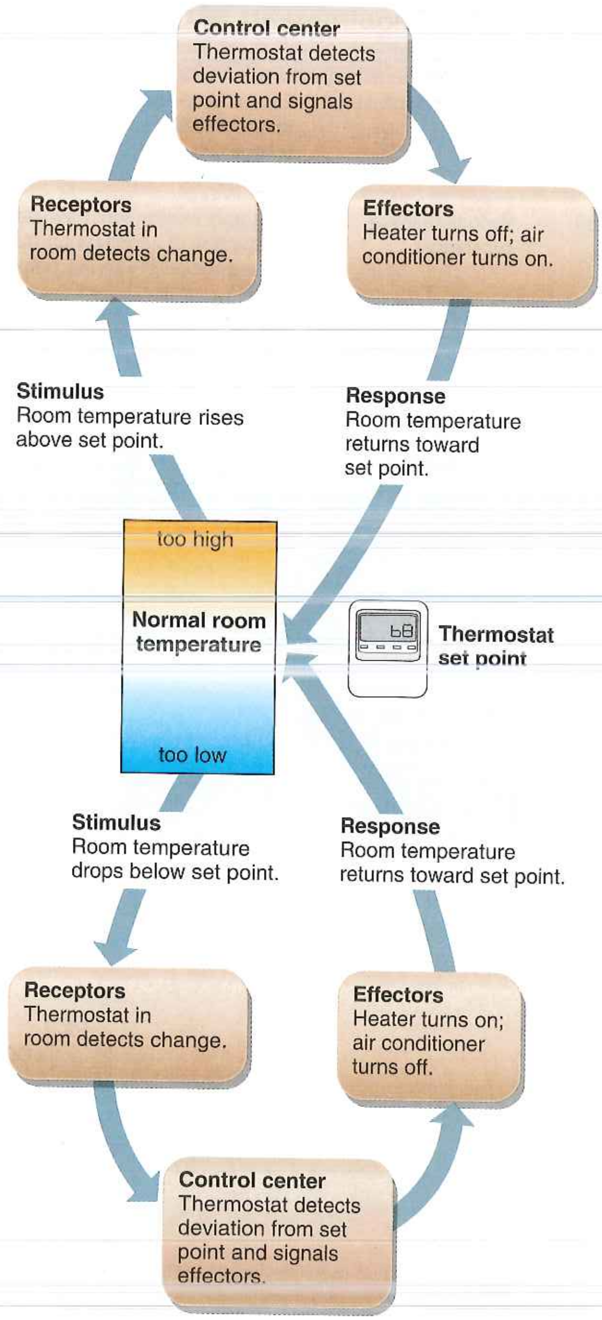


FIGURE 1.7 A thermostat signals an air conditioner and a furnace to turn on or off to maintain a relatively stable room temperature. This system is an example of a homeostatic mechanism.

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

Answer can be found in Appendix G on page 938.

A homeostatic mechanism similar to a thermostat regulates body temperature in humans (fig. 1.8). The "thermostat" is a temperature-sensitive region in a control center of

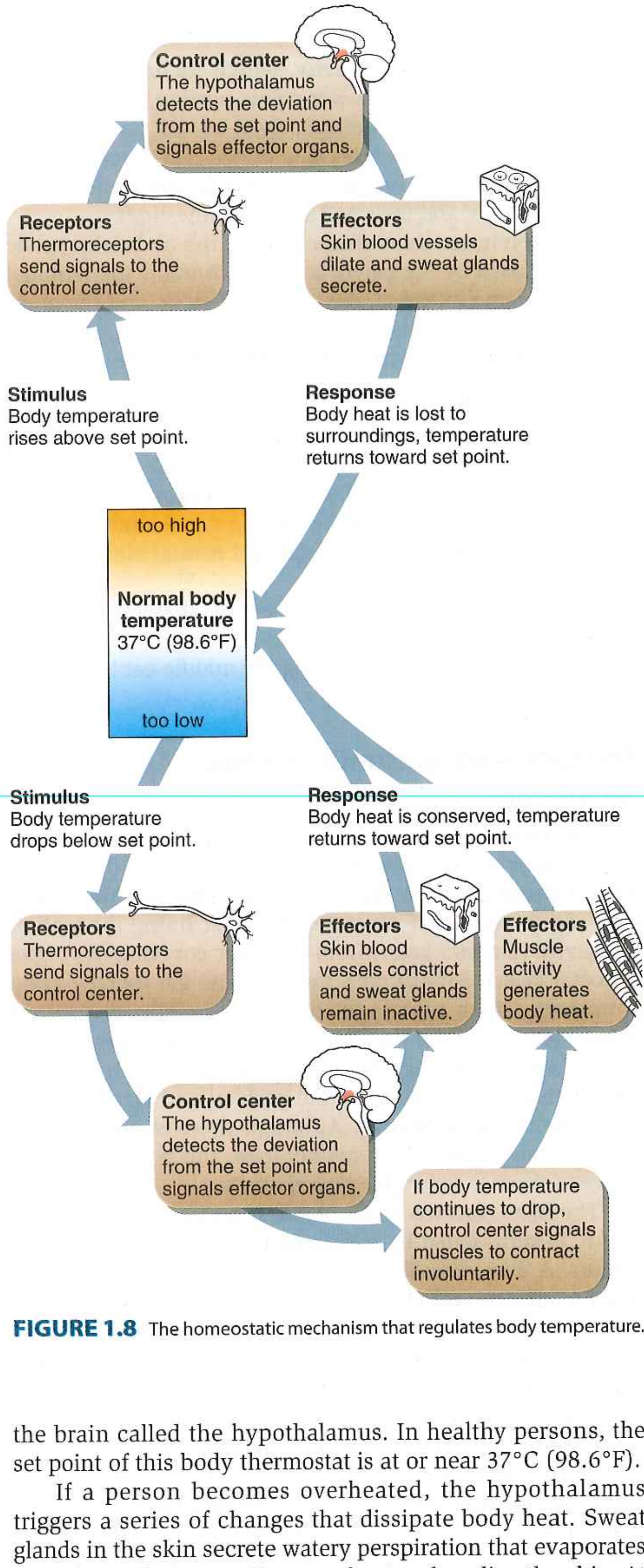


FIGURE 1.8 The homeostatic mechanism that regulates body temperature.

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 becomes overheated, the hypothalamus triggers a series of changes that dissipate body heat. Sweat glands in the skin secrete watery perspiration that evaporates from the surface, carrying away heat and cooling the skin. 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.

If a person is exposed to a cold environment and the body temperature begins to drop, the hypothalamus senses this change and triggers heat-conserving and heat-generating activities. Blood vessels in the skin constrict, reducing blood flow and enabling deeper tissues to retain heat. At the same time, small groups of muscle cells may be stimulated to contract involuntarily, an action called shivering that produces heat, which helps warm the body. Chapter 6 discusses body temperature regulation in more detail (pp. 190 and 191).

Another homeostatic mechanism regulates the blood pressure in the blood vessels (arteries) leading away from the heart. 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 more slowly and less forcefully. Because of this 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. 586–588) discusses blood pressure regulation in more detail.

A homeostatic mechanism regulates the concentration of the sugar glucose in blood. In this case, cells of an organ called the pancreas determine the set point. If 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, blood glucose concentration falls too low, the pancreas detects this change and secretes a different chemical (glucagon) that releases stored glucose into the blood. Chapter 13 (pp. 514–515) discusses regulation of blood glucose concentration in more detail (see fig. 13.36, p. 514).

Human physiology offers many other examples of homeostatic mechanisms, which all work in the same basic way just described. Just as many anatomical terms are used in all areas of anatomy, so the basic principles of physiology apply in all organ systems.

Most feedback mechanisms in the body are negative, but certain changes stimulate further change. A process that moves conditions away from the normal state is called a *positive feedback mechanism.*

Positive feedback mechanisms may be important to homeostasis and survival. In blood clotting, for example, certain chemicals stimulate more clotting, which minimizes bleeding (see chapter 14, p. 541). Preventing blood loss following an injury is critical to sustaining life. Similarly, a positive feedback mechanism increases the strength of uterine contractions during childbirth.

Positive feedback mechanisms usually produce unstable conditions, which might not seem compatible with homeostasis. However, the few examples of positive feedback associated with health have very specific functions and are 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 C, Laboratory Tests of Clinical Importance (pp. 928–930).

PRACTICE

13 Which requirements of organisms does the external environment provide?

14 What is the function of pressure in the body?

15 Why is homeostasis so important to survival?

16 Describe three homeostatic mechanisms.

1.6 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 the **cranial cavity,** which houses the brain; the **vertebral canal** (spinal cavity), which contains the spinal cord and is surrounded by sections of the backbone (vertebrae); the **thoracic** (tho-ras′ik) **cavity;** and the **abdominopelvic** (ab-dom′ĭ-no-pel′vik) **cavity.** The organs within these last two cavities are called **viscera** (vis′er-ah). Figure 1.9 shows these major body cavities.

The thoracic cavity is separated from the 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), that separates the thorax into two compartments that contain the right and left lungs. The remaining thoracic viscera—heart, esophagus, trachea, and thymus—are within the mediastinum.

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

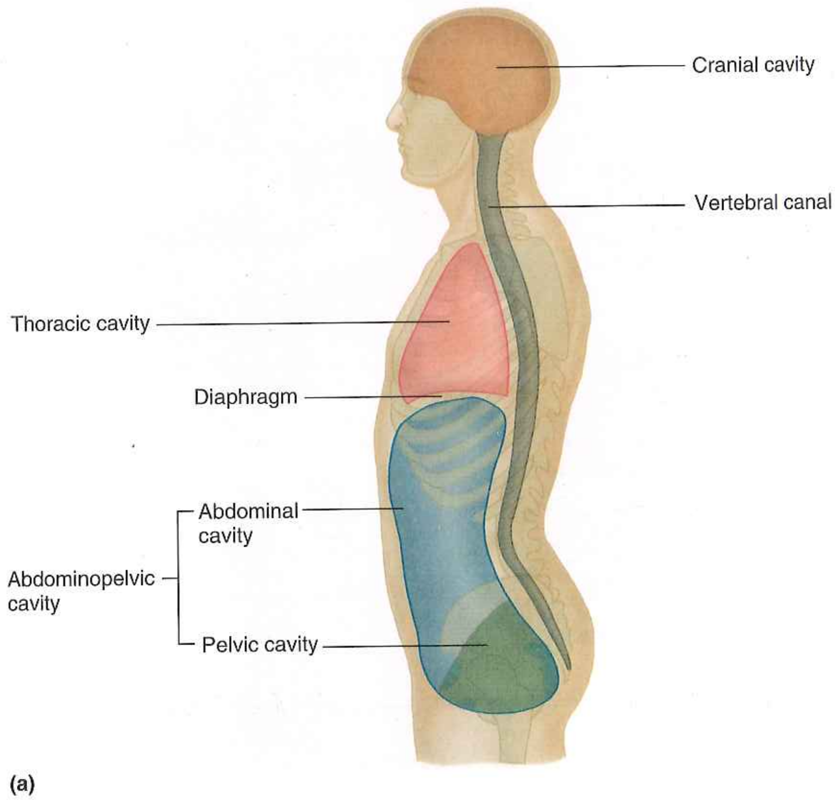
1. *Oral cavity,* containing the teeth and tongue
2. *Nasal cavity,* located within the nose and divided into right and left portions by a nasal septum. Several air-filled sinuses are connected to the nasal cavity. These include the sphenoidal and frontal sinuses (see fig. 7.20, p. 219)
3. *Orbital cavities,* 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 abdominopelvic 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 of the cavity (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 space between these two membranes, the potential space between them is called the *pleural cavity.*

The heart, 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 volume 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 of the abdominopelvic cavity, and a *visceral peritoneum* covers most of the organs in the



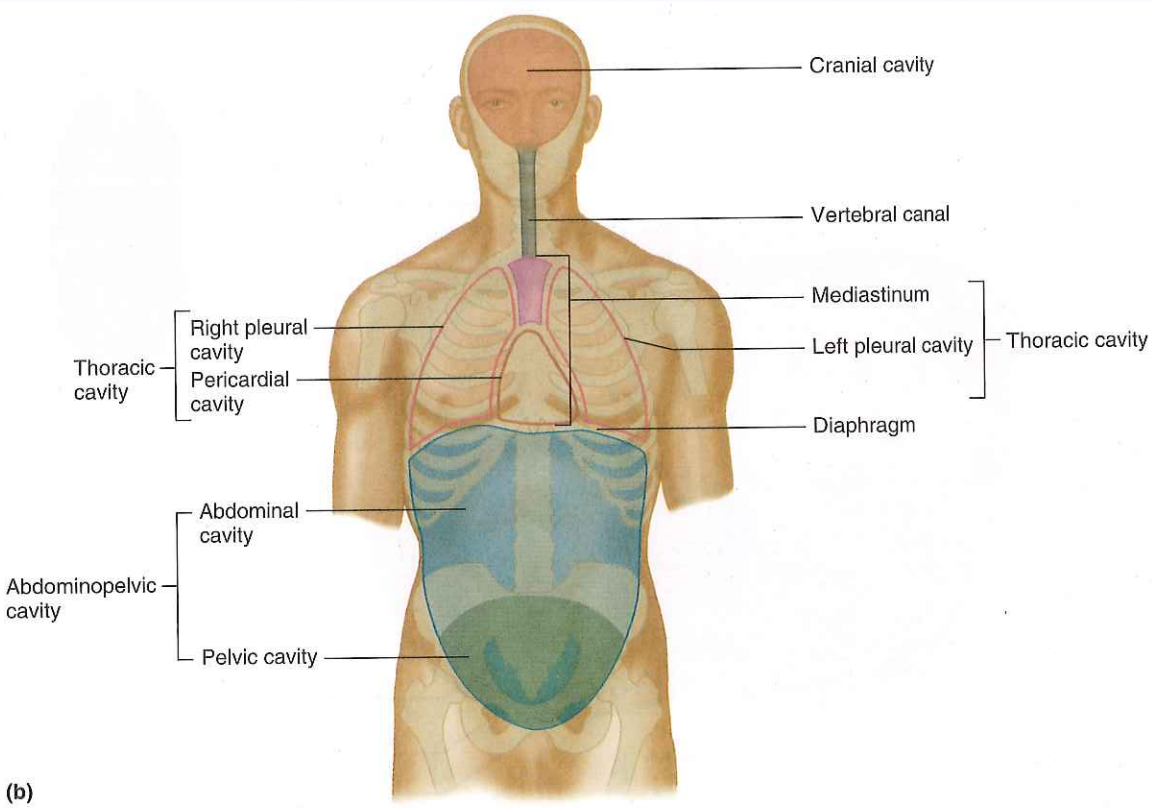


FIGURE 1.9 AP|R Major body cavities. (*a*) Lateral view. (*b*) Anterior view.

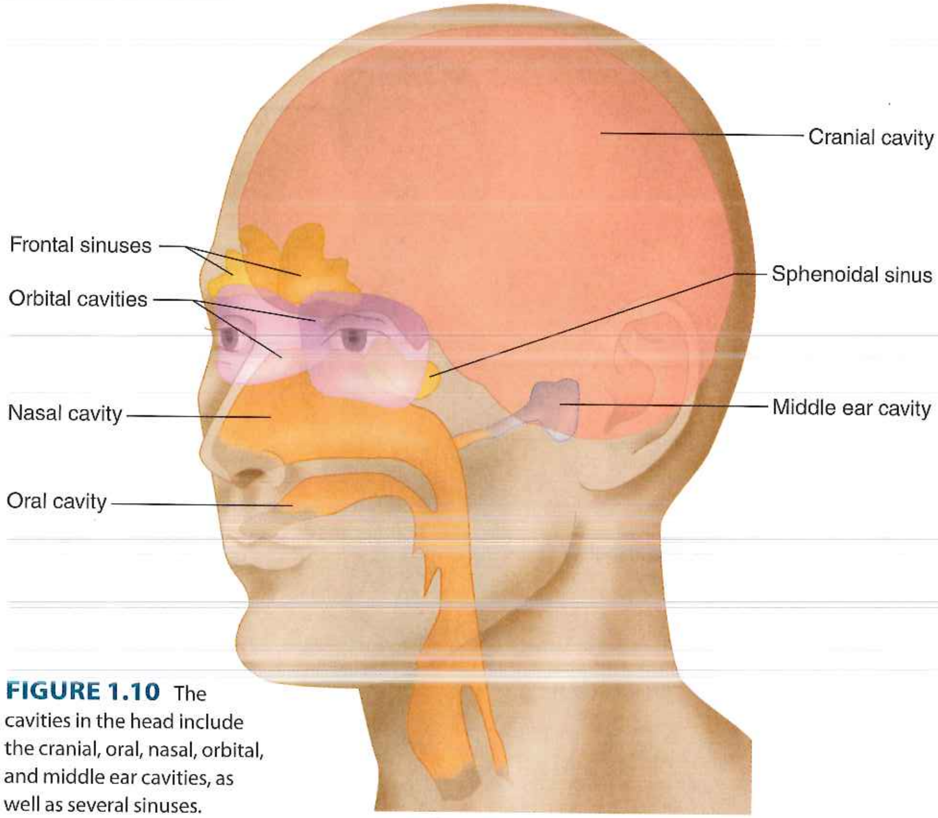


FIGURE 1.10 The cavities in the head include the cranial, oral, nasal, orbital, and middle ear cavities, as well as several sinuses.

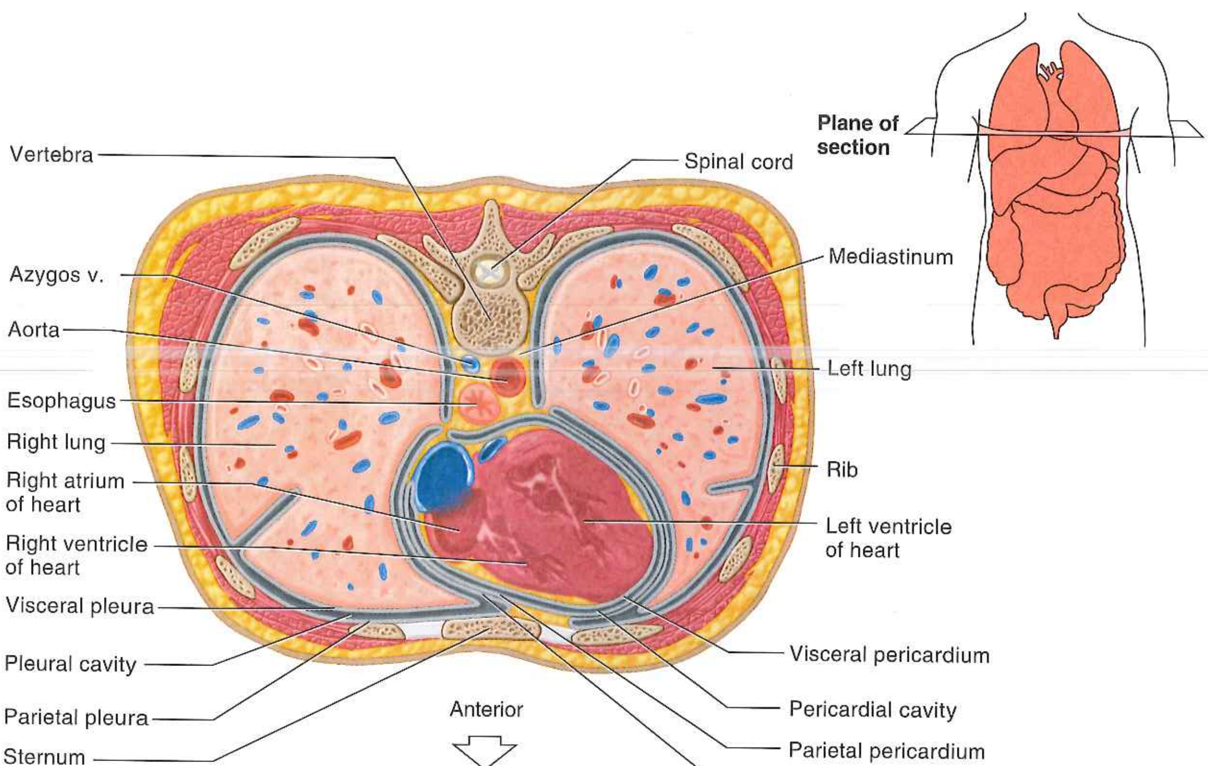
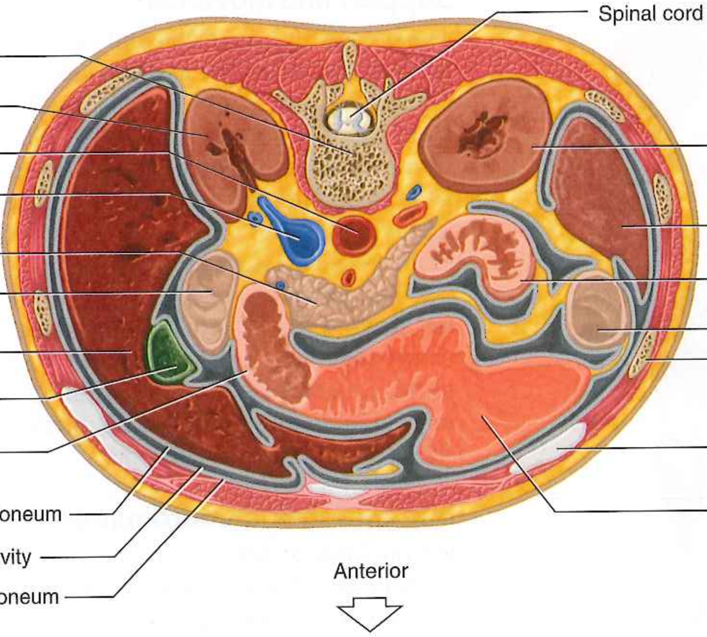


FIGURE 1.11 APIR A transverse section through the thorax reveals the serous membranes associated with the heart and lungs (superior view).



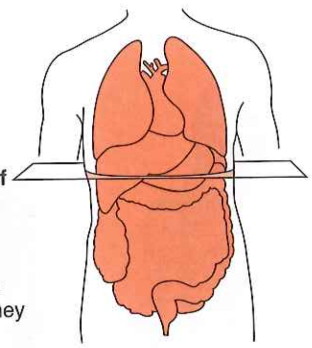


FIGURE 1.12 APIR Transverse section through the abdomen (superior view).

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

PRACTICE

17 What are the viscera?

18 Which organs occupy the thoracic cavity? The abdominal cavity? The pelvic cavity?

19 Name the cavities of the head.

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

21 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 some chapters ties together the ways in which organ systems interact. As you read about each organ system, you may want to consult the illustrations and cadaver photos of the human torso in reference plates 1–25 at the end of this chapter (pp. 39–57) 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,

FIGURE 1.13 APIR The integumentary system covers the body.

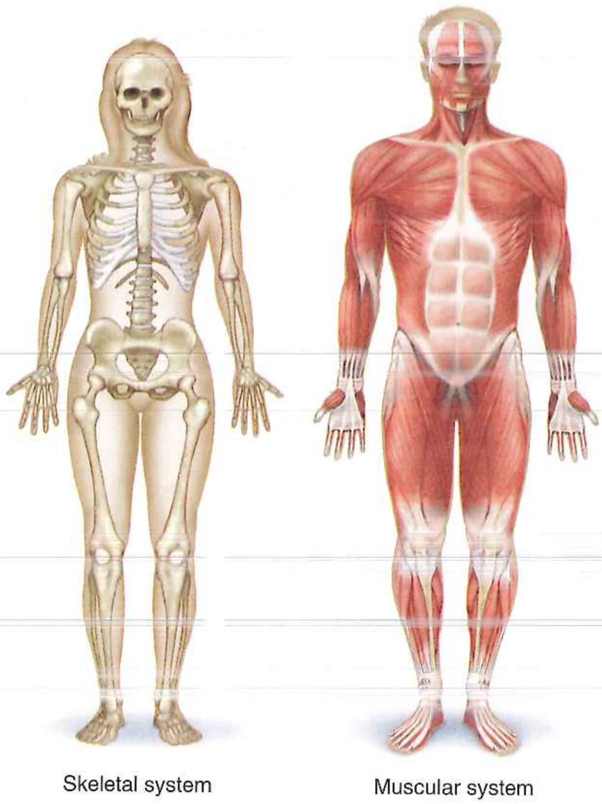


FIGURE 1.14 APR The skeletal and muscular systems provide support and movement.

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.

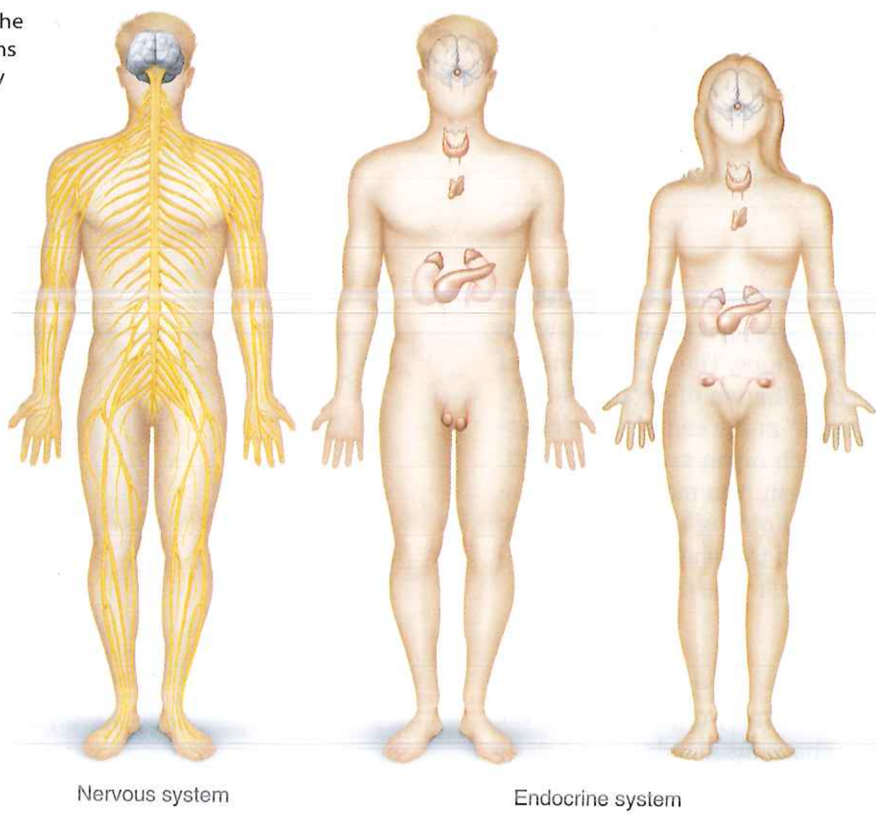
The muscles are the organs of the **muscular** (mus'ku-lar) **system** (fig. 1.14). By contracting and pulling their ends closer together, muscles provide the forces that move body parts. Muscles also help maintain posture and are the primary source of body heat. Chapters 7, 8, and 9 discuss the skeletal 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 a bioelectrical signal called a nerve impulse (a wave of action potentials) in combination with a chemical signal (a neurotransmitter) to communicate with

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



one another and with muscles and glands. Each neurotransmitter produces a relatively short-term effect on its target. Some nerve cells act as specialized sensory receptors that can detect changes inside and outside the body. Other nerve cells receive the signals from these sensory units and interpret and act on the information. Still other nerve cells carry signals from the brain or spinal cord to muscles or glands, causing them to contract or to secrete products, respectively. 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. Hormonal effects last longer than those of neurotransmitters.

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

A GLIMPSE AHEAD | To Chapters 10 and 13

For both the nervous system and the endocrine system, it is essential that the cells being controlled are able to respond to the chemical stimulation (either by the neurotransmitter or by the hormone). This requires the presence of special chemical "receptors" on the responding cells. Cells that lack such receptors cannot respond. Many drugs act by binding receptors to stimulate a response. This is the case for beta agonists, which asthma patients use in inhalants. Many other drugs block receptors to prevent an action. Such drugs include the beta blockers many heart disease patients use.

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, 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 closely associated with the cardiovascular system. It is composed of the lymphatic vessels, lymph fluid, lymph nodes, thymus, and spleen. This system transports some of the fluid from the spaces in 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.

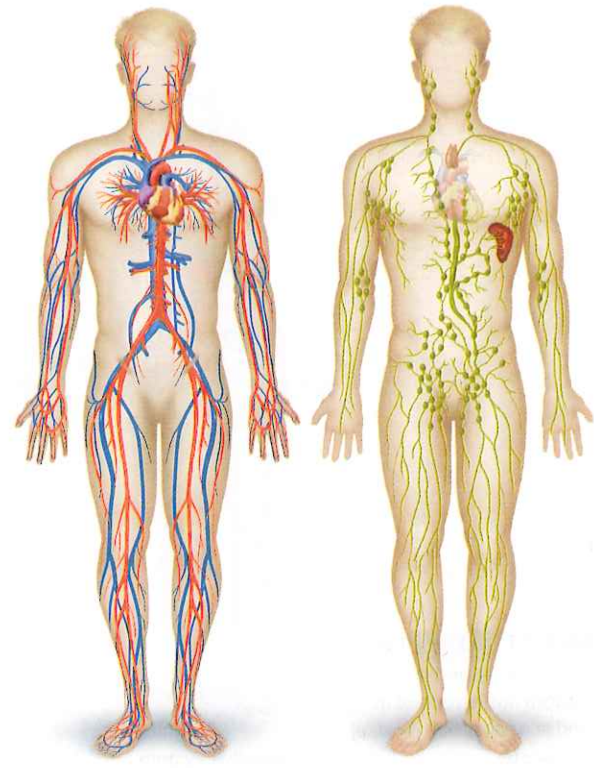


FIGURE 1.16 APR The cardiovascular and lymphatic systems transport fluids.

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), discussed in detail in chapter 17, receive foods and then break down food molecules into simpler forms that can be absorbed into the internal environment. Certain digestive organs (chapter 17, pp. 665, 668–669) 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 in 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, 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 parts of the urinary system store urine and transport it outside the body. Chapter 20 discusses the urinary

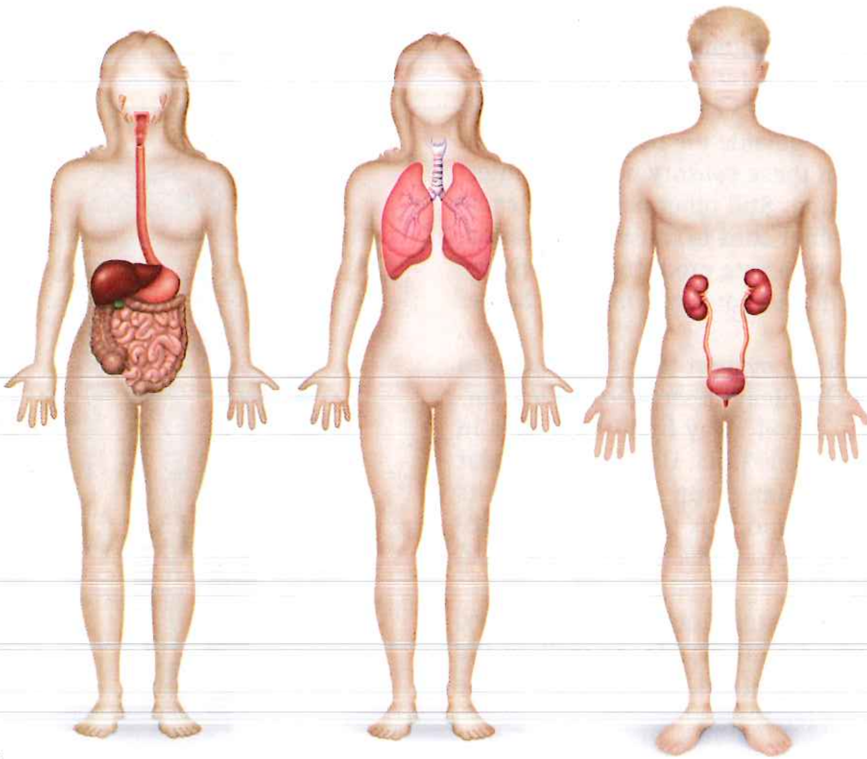


FIGURE 1.17 APR The digestive, respiratory, and urinary systems absorb nutrients, take in oxygen and release carbon dioxide, and excrete wastes.

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.

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 chapters 22 and 23).

The male reproductive system includes the scrotum, testes, epididymides, ductus 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 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 cell (egg cells or ova), transport the female's egg cell in the female reproductive system, and receive the male's sperm cells, which may fertilize an egg. The female reproductive system also supports development of an embryo, carries a fetus to term, and functions in the birth process. Figure 1.19 illustrates the organ systems in humans.

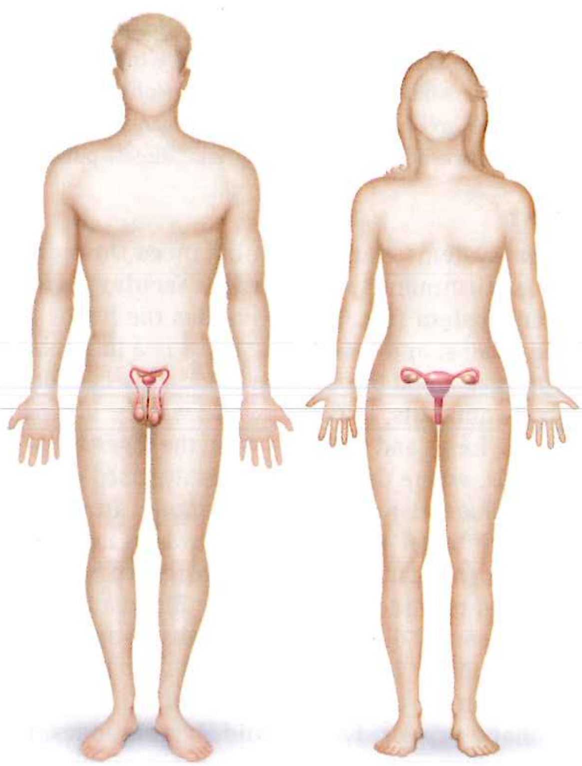


FIGURE 1.18 APR The reproductive systems manufacture and transport sex cells. The female reproductive system provides for prenatal development and childbirth.

PRACTICE

22 Name the major organ systems and list the organs of each system.
23 Describe the general functions of each organ system.

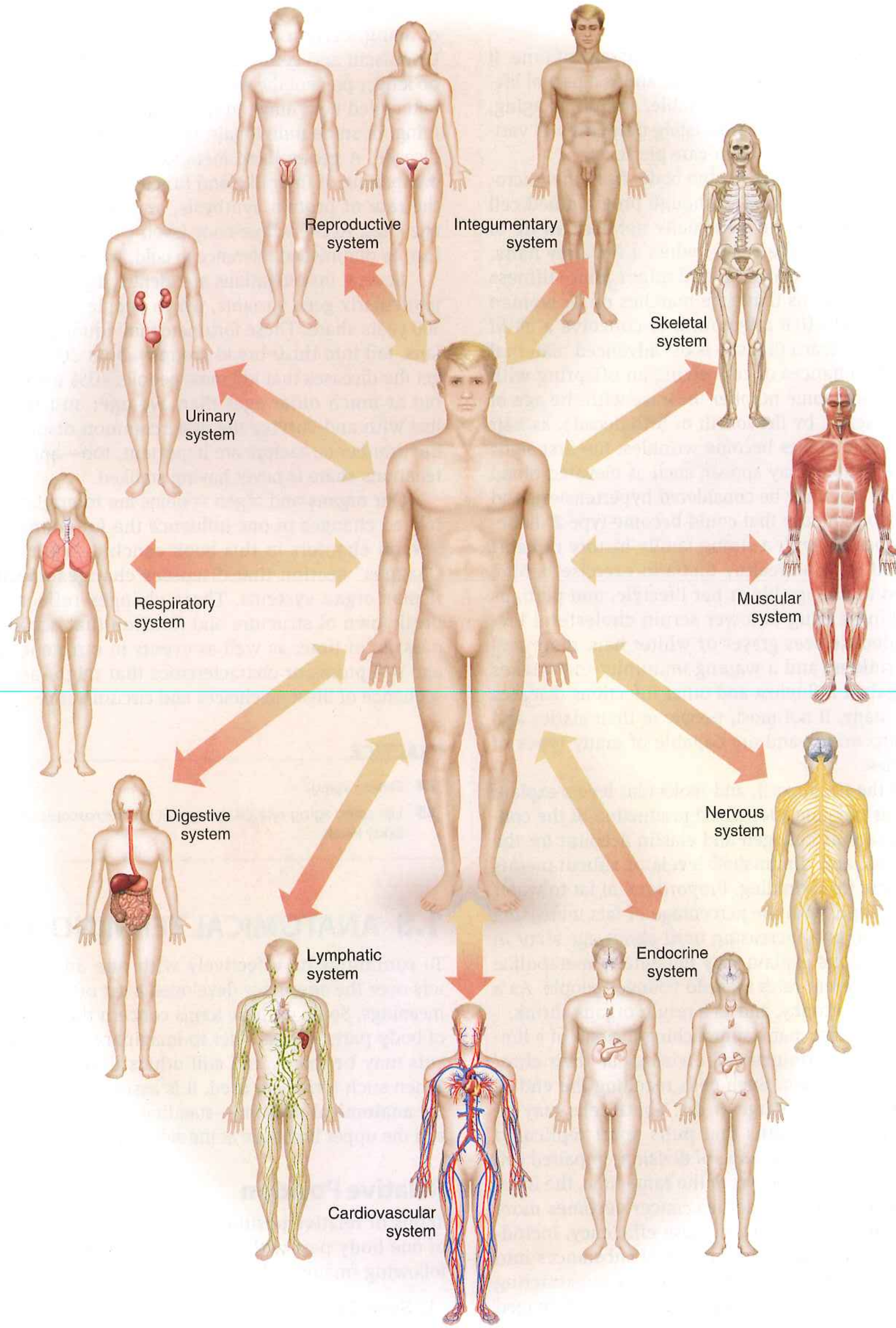


FIGURE 1.19 APR The organ systems in humans interact in ways that maintain homeostasis.

1.7 LIFE-SPAN CHANGES

Aging is the changes in the body with the passage of time. It is the process of becoming mature or old, and is a part of life. Because the passage of time is inevitable, so, too, is aging, despite common claims for the anti-aging properties of various diets, cosmetics, pills, and skin-care products.

Aging happens everywhere in the body, from the microscopic to the whole-body 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 elevated blood pressure that one day may be considered hypertension, and slightly high blood glucose that could become type 2 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 many types 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 apparatus that pulls apart replicated chromosomes in a cell on the verge of division. Impaired cell division slows wound healing, yet at the same time, the inappropriate cell division that underlies cancer becomes more likely. Certain subcellular functions lose efficiency, including repair of DNA damage and transport of substances into and out of cells. Aging cells are less efficient at extracting energy from nutrients and breaking down aged or damaged cell parts.

As changes at the tissue level cause organ-level signs of aging, certain biochemical changes fuel cellular aging. Lipofuscin and ceroid pigments accumulate when a cell can no longer prevent the formation of 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 use, 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.

Several investigations are identifying key characteristics, particularly gene variants, which people who live more than 100 years share. These fortunate individuals, called centenarians, fall into three broad groups: about 20% of them never get the diseases that kill most people; 40% get these diseases but at much older ages than average; and the other 40% live with and survive the more common disorders of aging. Environmental factors are important, too—another trait centenarians share is never having smoked.

Our organs and organ systems are interrelated, so 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 in our genes ("nature") and symptoms or characteristics that might arise as a consequence of lifestyle choices and circumstances ("nurture").

PRACTICE

24 Define aging.

25 List some aging-related changes at the microscopic and whole-body levels.

1.8 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**—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 (many of these terms are illustrated in figure 1.20):

1. **Superior** means a part is above another part. (The thoracic cavity is superior to the abdominopelvic cavity.)

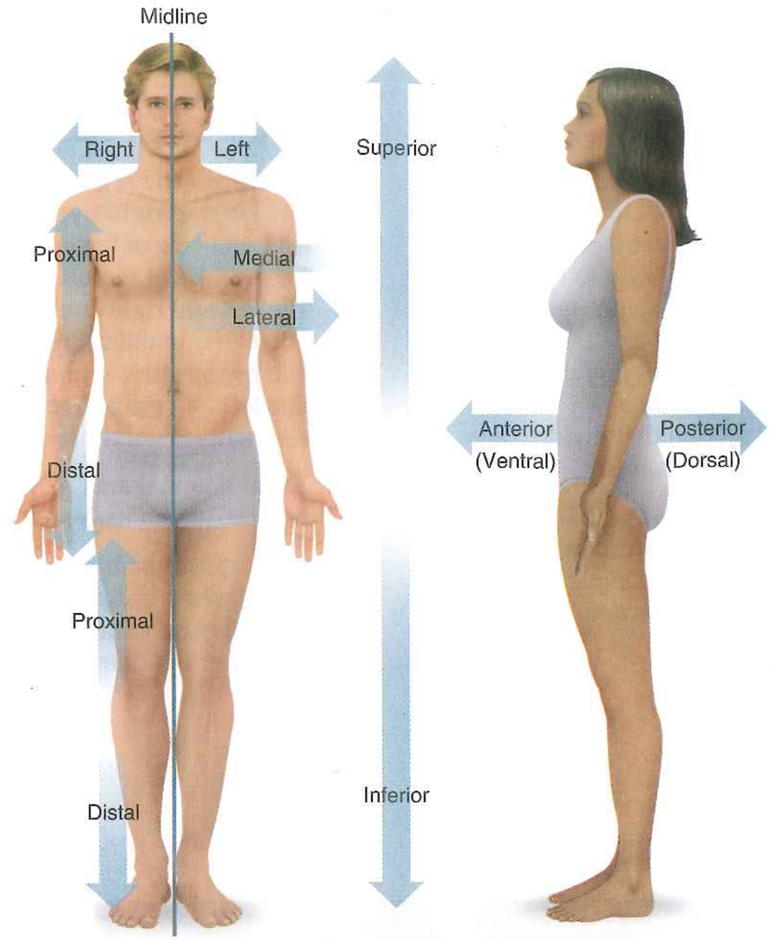


FIGURE 1.20 AP|R Relative positional terms describe a body part's location with respect to other body parts.

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

Answer can be found in Appendix G on page 938.

2. **Inferior** means a part is below another part. (The neck is inferior to the head.)
3. **Anterior** (ventral) means toward the front. (The eyes are anterior to the brain.)
4. **Posterior** (dorsal) means toward the back. (The pharynx is posterior to the oral cavity.)
5. **Medial** refers to an imaginary midline dividing the body into equal right and left halves. A part is medial if it is closer to midline than another part. (The nose is medial to the eyes.)

weight on the contralateral—in this case, left—lower limb.)

10. **Proximal** describes a part closer to a point of attachment to the trunk than another body part. (The elbow is proximal to the wrist.) Proximal may also refer to another reference point such as the proximal tubules, which are closer to the filtering structures in the kidney.
11. **Distal** is the opposite of proximal. It means a particular body part is farther from a point of attachment to the trunk. (The fingers are distal to the wrist.) *Distal* may

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. 1.21 and 1.22). 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). A sagittal section lateral to midline is called parasagittal.
2. **Transverse** (horizontal) refers to a cut that divides the body into superior and inferior portions.
3. **Frontal** (coronal) 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. 1.23).

Body Regions

A number of terms designate body regions. The abdominal area, for example, is subdivided into the following regions, as shown in figure 1.24*a*:

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

The abdominal area may also be subdivided into the following four quadrants, as figure 1.24*b* illustrates:

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

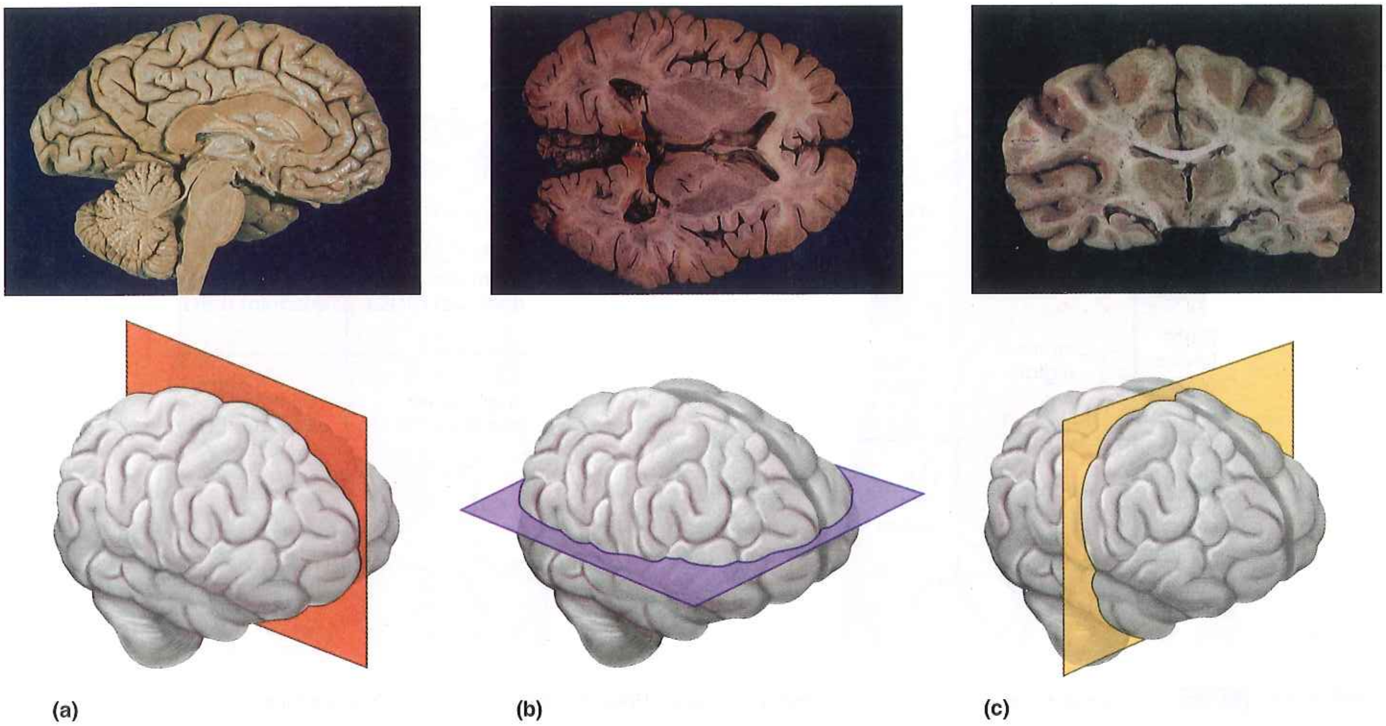


FIGURE 1.22 A human brain sectioned along (*a*) a sagittal plane, (*b*) a transverse plane, and (*c*) a frontal plane.

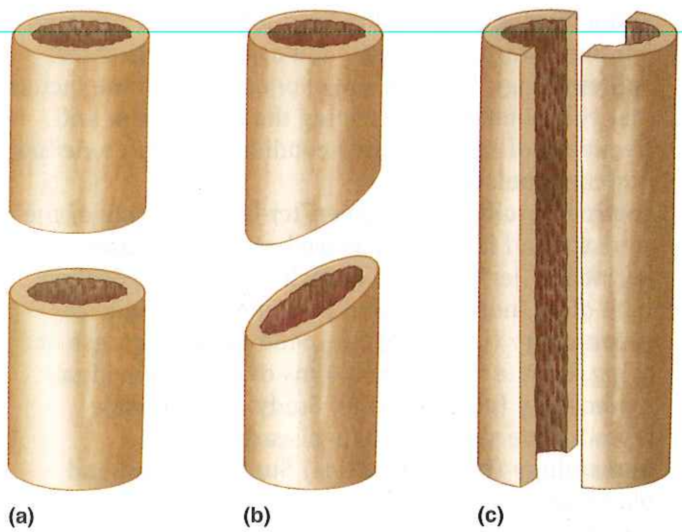


FIGURE 1.23 Cylindrical parts may be cut in (*a*) cross section, (*b*) oblique section, or (*c*) longitudinal section.

The following adjectives are commonly used when referring to various body regions. Figure 1.25 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 (kro͞or'al) leg
cubital (ku'bĭ-tal) elbow
digital (dij'ĭ-tal) finger or toe
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

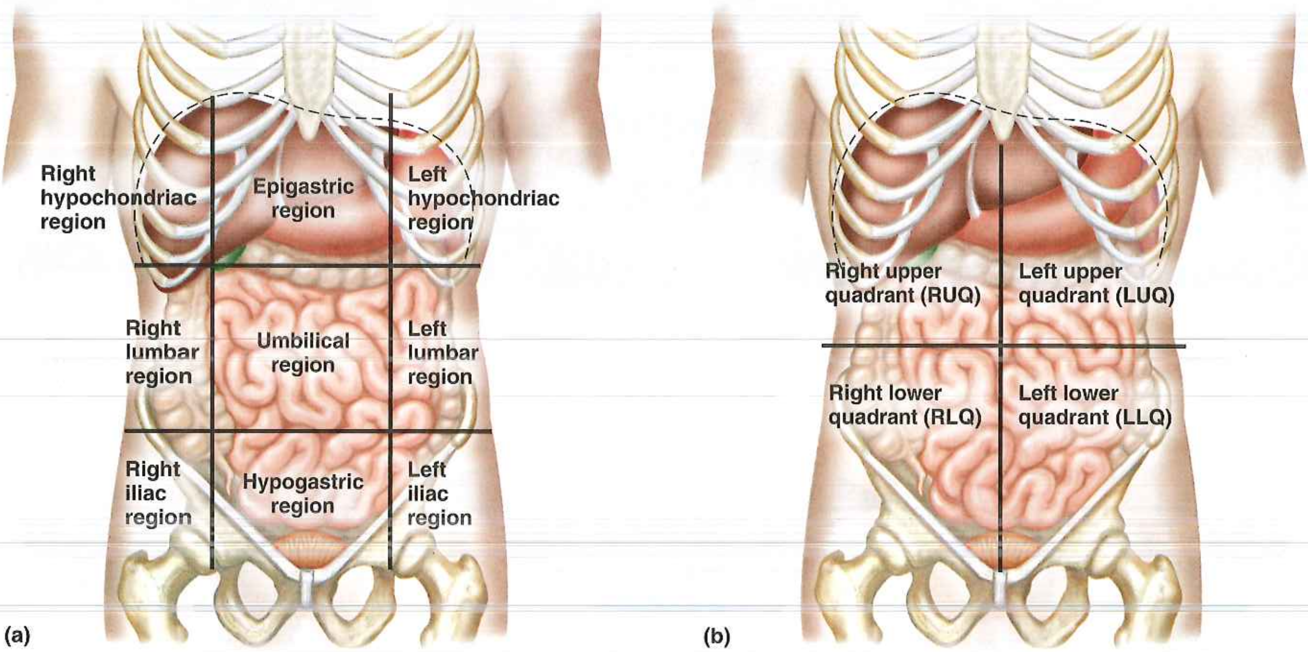


FIGURE 1.24 APIR The abdominal area is commonly subdivided in two ways: (*a*) into nine regions and (*b*) into four quadrants

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
sural (su′ral) calf of the leg
tarsal (tahr′sal) instep of the foot (ankle)
umbilical (um-bil′ĭ-kal) navel
vertebral (ver′te-bral) spinal column

PRACTICE

26 Describe the anatomical position.

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

28 Describe three types of body sections.

29 Describe the nine regions of the abdomen.

30 Explain how the names of the abdominal quadrants 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.

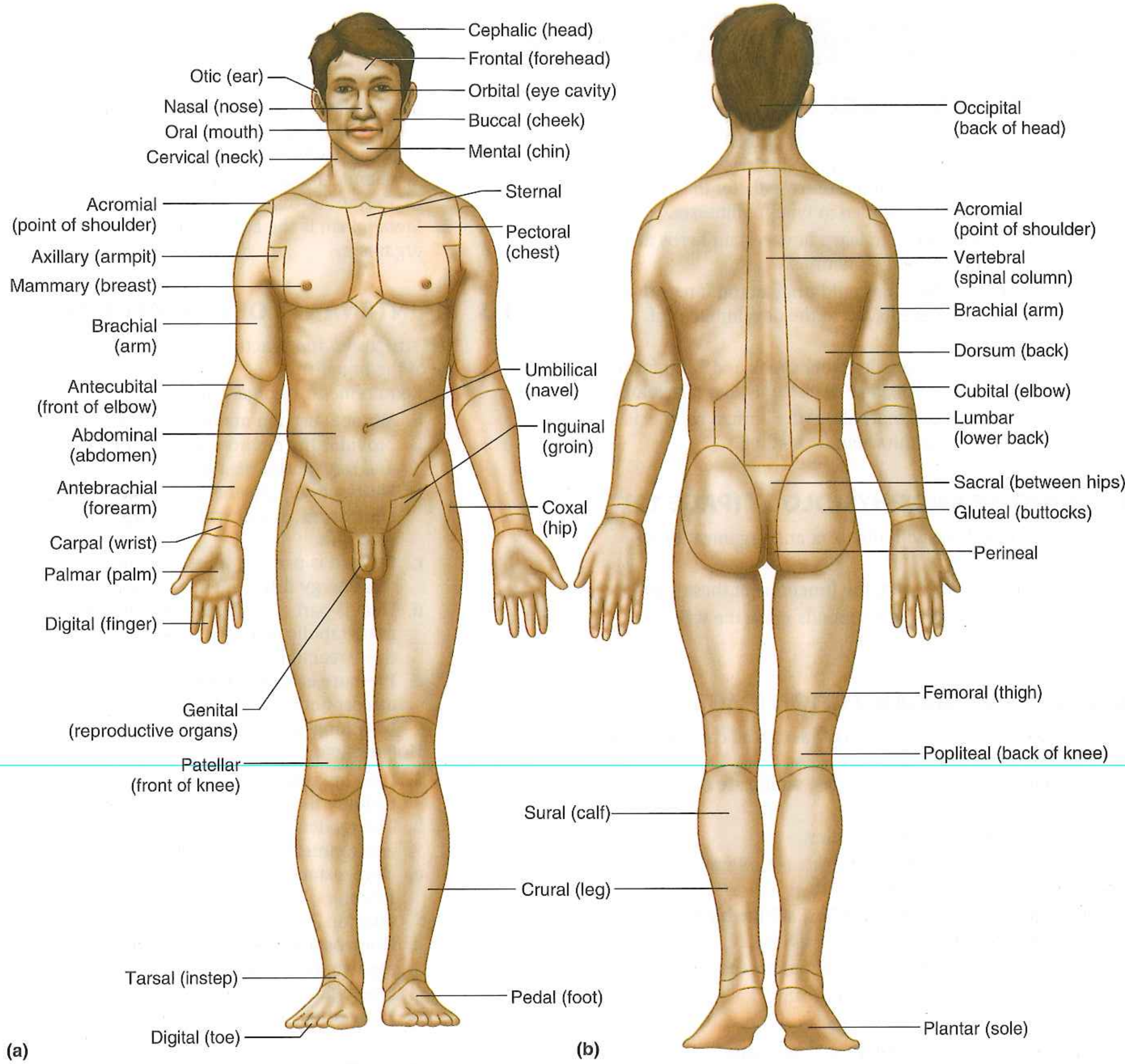


FIGURE 1.25 AP|R Some terms used to describe body regions. *(a)* Anterior regions. *(b)* Posterior regions.

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

1.1 INTRODUCTION (PAGE 11)

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.
5. Much of what we know about the human body was discovered using the scientific method.

1.2 ANATOMY AND PHYSIOLOGY (PAGE 12)

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.

1.3 LEVELS OF ORGANIZATION (PAGE 12)

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

1. Matter is composed of atoms, which are composed of subatomic particles.
2. Atoms join to form molecules.
3. Organelles consist of aggregates of interacting large molecules (macromolecules).
4. Cells, 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.

1.4 CHARACTERISTICS OF LIFE (PAGE 14)

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 use of energy by an organism.

1.5 MAINTENANCE OF LIFE (PAGE 15)

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 part of our environment and is a product of metabolic reactions; heat 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.

1.6 ORGANIZATION OF THE HUMAN BODY (PAGE 20)

1. Body cavities
   a. The axial portion of the body contains the cranial cavity and vertebral canal, as well as the thoracic and abdominopelvic cavities, separated by the diaphragm.
   b. The organs within thoracic and abdominopelvic cavities 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 signals from sensory receptors, interprets this information, and acts by causing 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.

f. 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.

g. 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.

h. Digestive system
(1) The digestive system receives foods, breaks down nutrients into forms that can pass through cell membranes, and eliminates unabsorbed materials.
(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.

i. 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.

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 produces, maintains, and transports male sex cells. It includes the scrotum, testes, epididymides, ductus deferentia, seminal vesicles, prostate gland, bulbourethral glands, urethra, and penis.
(3) The female reproductive system produces, maintains, and transports female sex cells; it also supports development and birth of offspring. It includes the ovaries, uterine tubes, uterus, vagina, clitoris, and vulva.

1.7 LIFE-SPAN CHANGES (PAGE 28)

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.

1.8 ANATOMICAL TERMINOLOGY (PAGE 28)

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.

CHAPTER ASSESSMENTS

1.1 Introduction

1 Describe how an early interest in the human body eventually led to the development of modern medical science. (p. 11)

1.2 Anatomy and Physiology

2 Distinguish between anatomy and physiology. (p. 12)

3 Explain the relationship between the form and function of body parts and give three examples. (p. 12)

1.3 Levels of Organization

4 Describe the relationship between each of the following pairs: molecules and cells, tissues and organs, organs and organ systems. (p. 12)

1.4 Characteristics of Life

5 Which characteristics of life can you identify in yourself? (p. 14)

6 Identify those characteristics of living organisms that relate to metabolism. (p. 15)

1.5 Maintenance of Life

7 Compare your own needs for survival with the requirements of organisms described in the chapter. (p. 15)

8 Explain the relationship between homeostasis and the internal environment. (p. 17)

9 Describe a general physiological control system, including the role of negative feedback. (p. 18)

10 Explain the control of body temperature. (p. 19)

11 Describe the homeostatic mechanisms that help regulate blood pressure and blood glucose—what do they have in common and how are they different? (p. 19)

1.6 Organization of the Human Body

12 Explain the difference between the axial and appendicular portions of the body. (p. 20)

13 Identify the cavities within the axial portion of the body. (p. 20)

14 Define *viscera.* (p. 20)

15 Describe the mediastinum and its contents. (p. 20)

16 List the cavities of the head and the contents of each cavity. (p. 20)

17 Name the body cavity that houses each of the following organs: (p. 20)

a. Stomach
b. Heart
c. Brain
d. Liver
e. Trachea
f. Rectum
g. Spinal cord
h. Esophagus
i. Spleen
j. Urinary bladder

18 Distinguish between a parietal and a visceral membrane. (p. 20)

19 Describe the general contribution of each of the organ systems to maintaining homeostasis. (p. 23)

20 List the major organs that compose each organ system and identify their functions. (p. 23)

1.7 Life-Span Changes

21 Describe physical changes associated with aging that occur during each decade past the age of 30. (p. 28)

22 List age-associated changes that occur at the molecular, cellular, tissue and/or organ levels. (p. 28)

1.8 Anatomical Terminology

23 Write complete sentences using each of the following terms to correctly describe the relative locations of specific body parts: (p. 28)

a. Superior
b. Inferior
c. Anterior
d. Posterior
e. Medial
f. Lateral
g. Bilateral
h. Ipsilateral
i. Contralateral
j. Proximal
k. Distal
l. Superficial
m. Peripheral
n. Deep

24 Sketch the outline of a human body, and use lines to indicate each of the following sections: (p. 30)

a. Sagittal
b. Transverse
c. Frontal

25 Sketch the abdominal area, and indicate the locations of the following regions: (p. 30)

a. Epigastric
b. Hypochondriac
c. Umbilical
d. Lumbar
e. Hypogastric
f. Iliac

26 Sketch the abdominal area, and indicate the location of the following regions: (p. 30)

a. Right upper quadrant
b. Right lower quadrant
c. Left upper quadrant
d. Left lower quadrant

27 Provide the common name for the region to which each of the following terms refers: (p. 31)

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

INTEGRATIVE ASSESSMENTS/CRITICAL THINKING

OUTCOMES 1.2, 1.3, 1.4, 1.5

1. Which characteristics of life does a computer have? Why is a computer not alive?

OUTCOMES 1.2, 1.3, 1.4, 1.5, 1.6

2. Put the following in order, from smallest and simplest, to largest and most complex, and describe their individual roles in homeostasis: organ, molecule, organelle, atom, organ system, tissue, organism, cell, macromolecule.

OUTCOMES 1.4, 1.5

3. What environmental conditions would be necessary for a human to survive on another planet?

OUTCOMES 1.5, 1.6, 1.7

4. In health, body parts interact to maintain homeostasis. Illness can threaten the maintenance of homeostasis, requiring treatment. What treatments might be used to help control a patient's (a) body temperature, (b) blood oxygen level, and (c) blood glucose level?

5. How might health-care professionals provide the basic requirements of life to an unconscious patient? Describe the body parts involved in the treatment, using correct directional and regional terms.

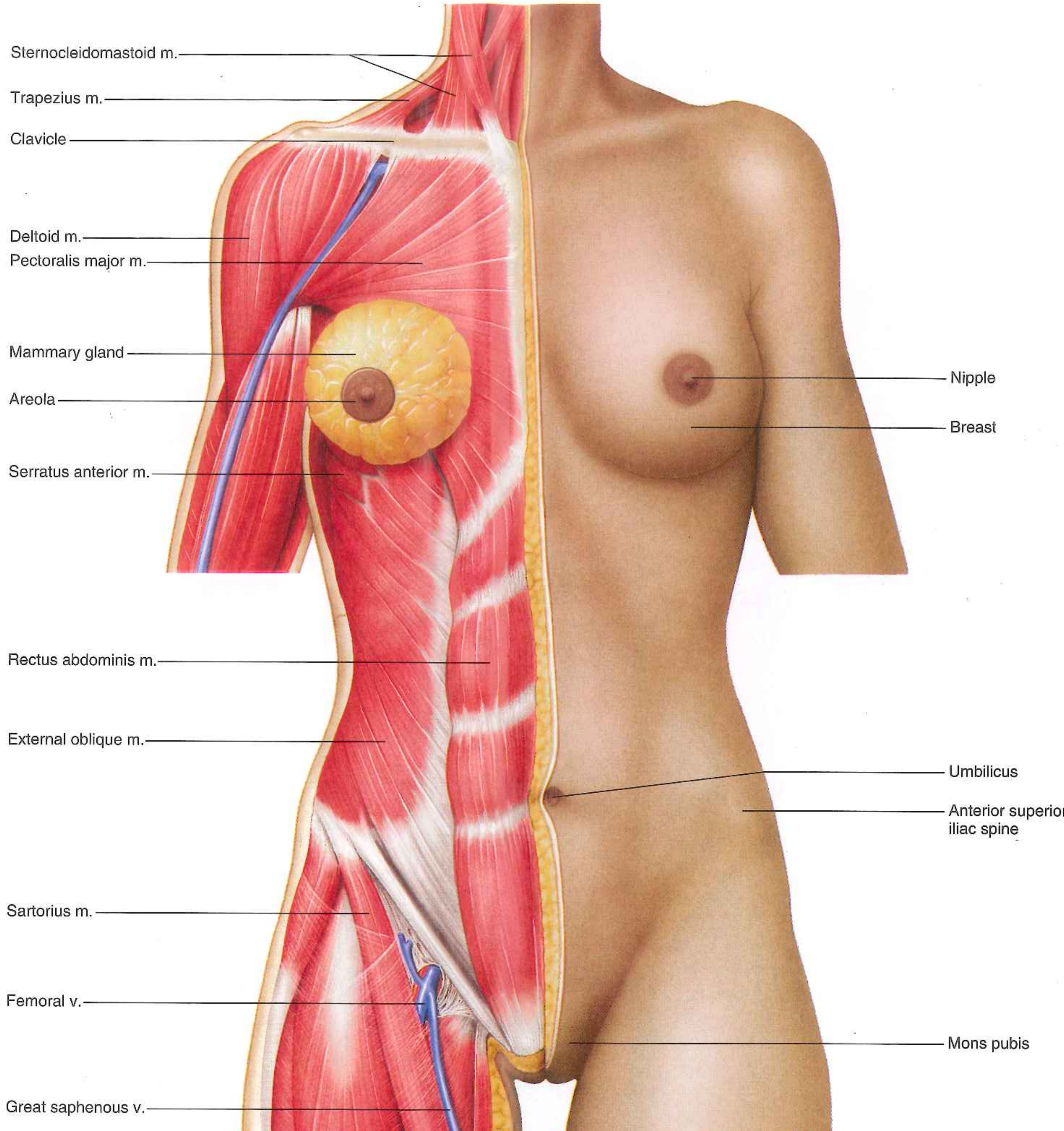
OUTCOME 1.6

6. Suppose two individuals develop benign (noncancerous) tumors that produce symptoms because they occupy space and crowd adjacent organs. If one of these persons has the tumor in the thoracic cavity and the other has the tumor in the abdominopelvic cavity, which person would be likely to develop symptoms first? Why? Which might be more immediately serious? Why?
7. If a patient complained of a "stomachache" and pointed to the umbilical region as the site of discomfort, which organs located in this region might be the source of the pain?

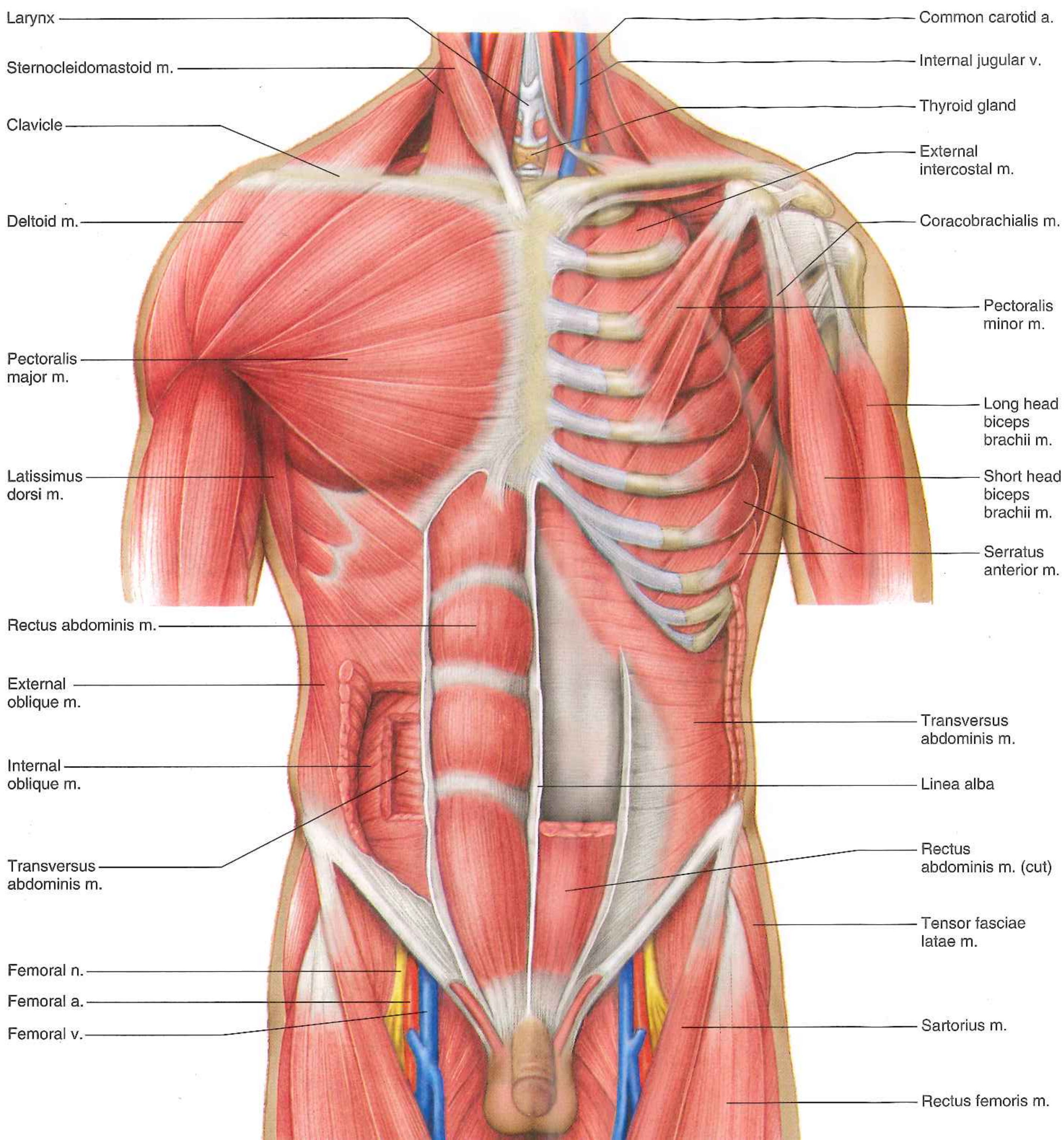
THE HUMAN ORGANISM

The following series of plates includes illustrations of the major organs of the human torso and human cadaver photos. The first plate shows the anterior surface of the human torso and reveals the muscles on one side. Then, plates 2–7 expose deeper organs, including those in the thoracic, abdominal, and pelvic cavities. Plates 8–25 are photographs of sagittal sections, transverse sections, and anterior views of the torso of a human cadaver. These plates will help you visualize the proportional relationships between the major anatomical structures of actual specimens.

Variations exist in anatomical structures among humans. The illustrations in the textbook and the laboratory manual represent normal (normal means the most common variation) anatomy.



Sternocleidomastoid m.
Trapezius m.
Clavicle
Deltoid m.
Pectoralis major m.
Mammary gland
Areola
Serratus anterior m.
Rectus abdominis m.
External oblique m.
Sartorius m.
Femoral v.
Great saphenous v.
Nipple
Breast
Umbilicus
Anterior superior
iliac spine
Mons pubis


Larynx
Sternocleidomastoid m.
Clavicle
Deltoid m.
Pectoralis major m.
Latissimus dorsi m.
Rectus abdominis m.
External oblique m.
Internal oblique m.
Transversus abdominis m.
Femoral n.
Femoral a.
Femoral v.
Common carotid a.
Internal jugular v.
Thyroid gland
External intercostal m.
Coracobrachialis m.
Pectoralis minor m.
Long head biceps brachii m.
Short head biceps brachii m.
Serratus anterior m.
Transversus abdominis m.
Linea alba
Rectus abdominis m. (cut)
Tensor fasciae latae m.
Sartorius m.
Rectus femoris m.

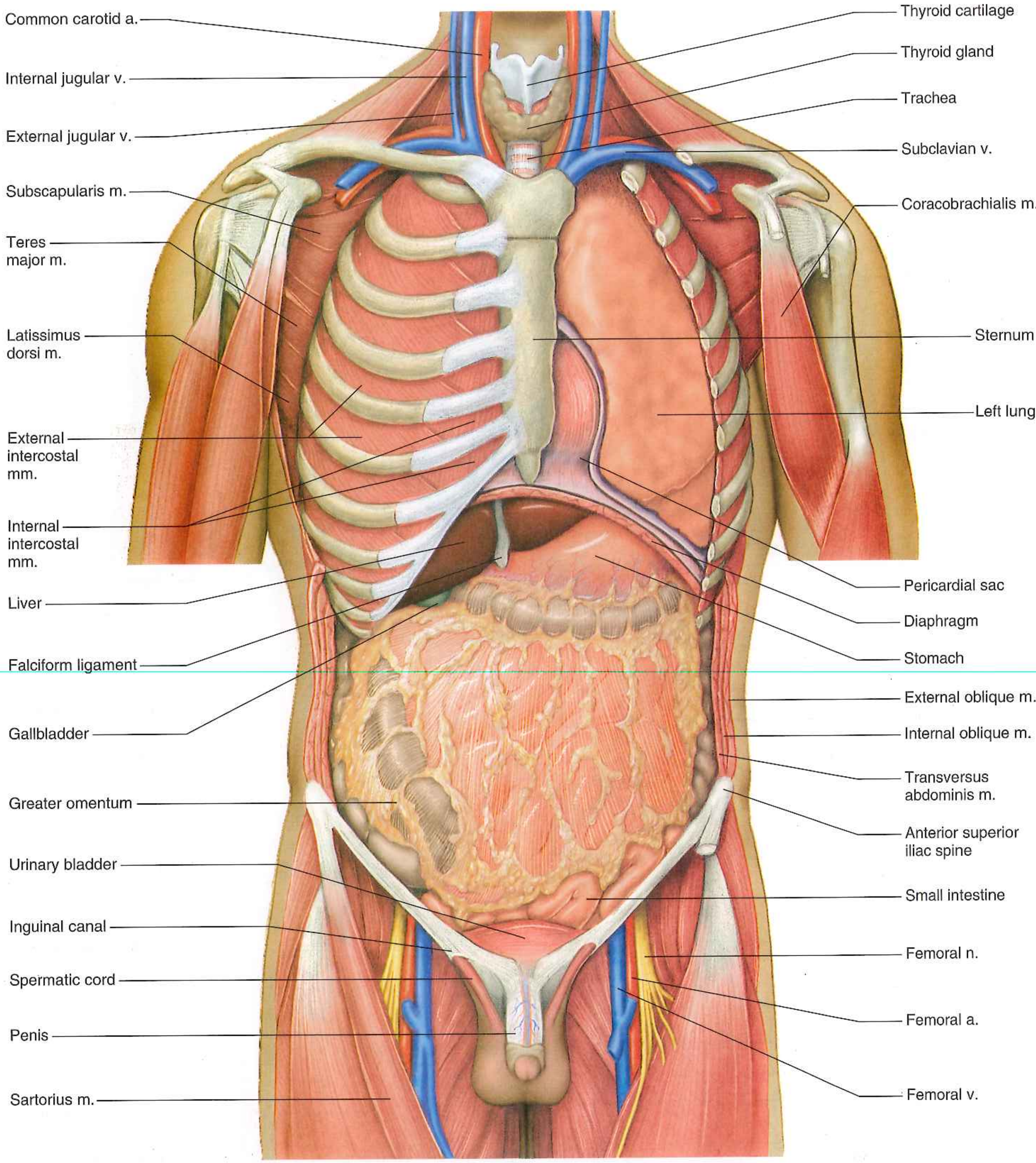


PLATE THREE Human male torso with the deep muscles removed and the abdominal viscera exposed. (*a.* stands for *artery, m.* stands for *muscle, mm.* stands for *muscles, n.* stands for *nerve*, and *v.* stands for *vein.*)

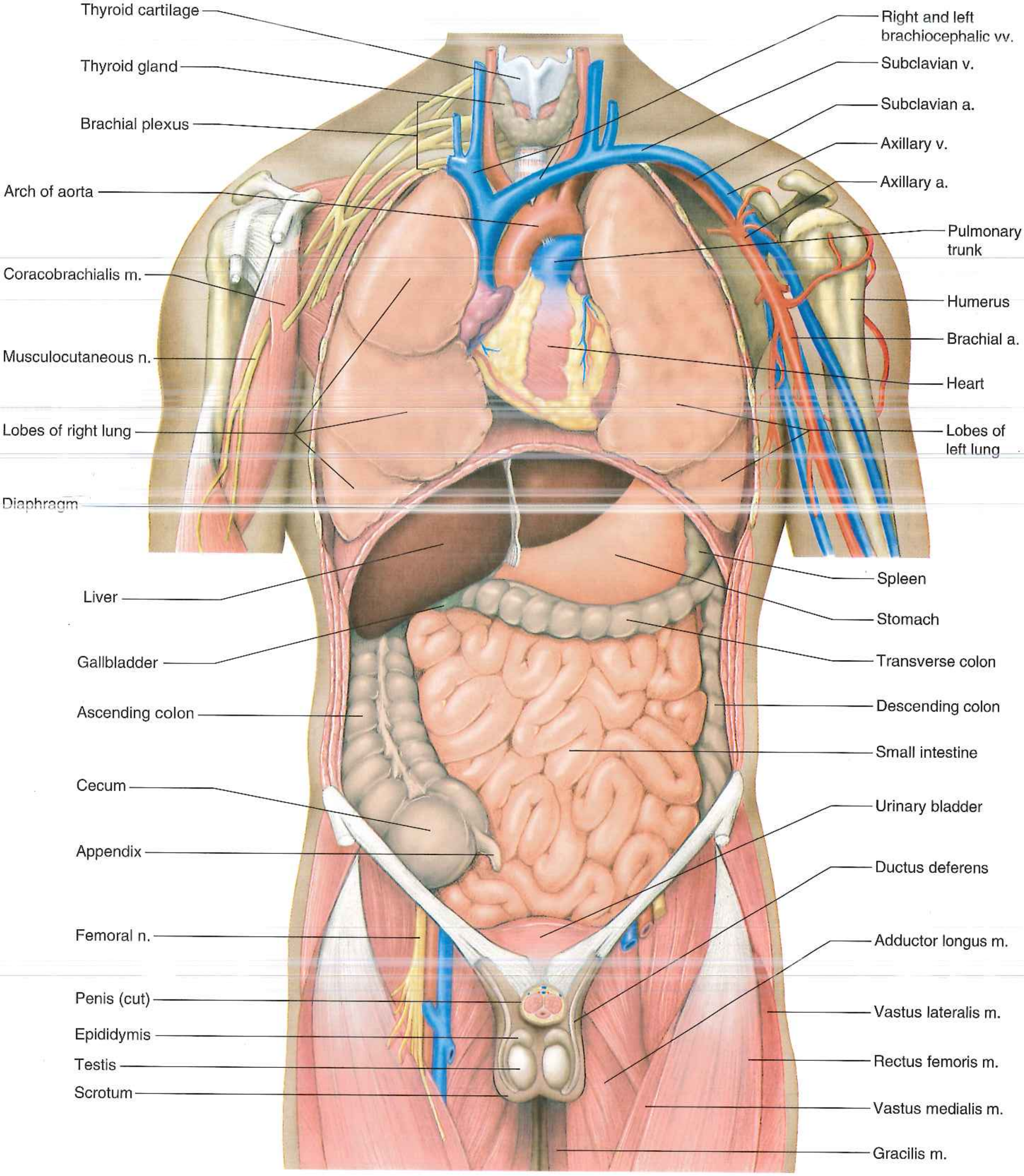


PLATE FOUR Human male torso with the thoracic and abdominal viscera exposed. (*a.* stands for *artery*, *m.* stands for *muscle*, *n.* stands for *nerve*, and *v.* stands for *vein.*)

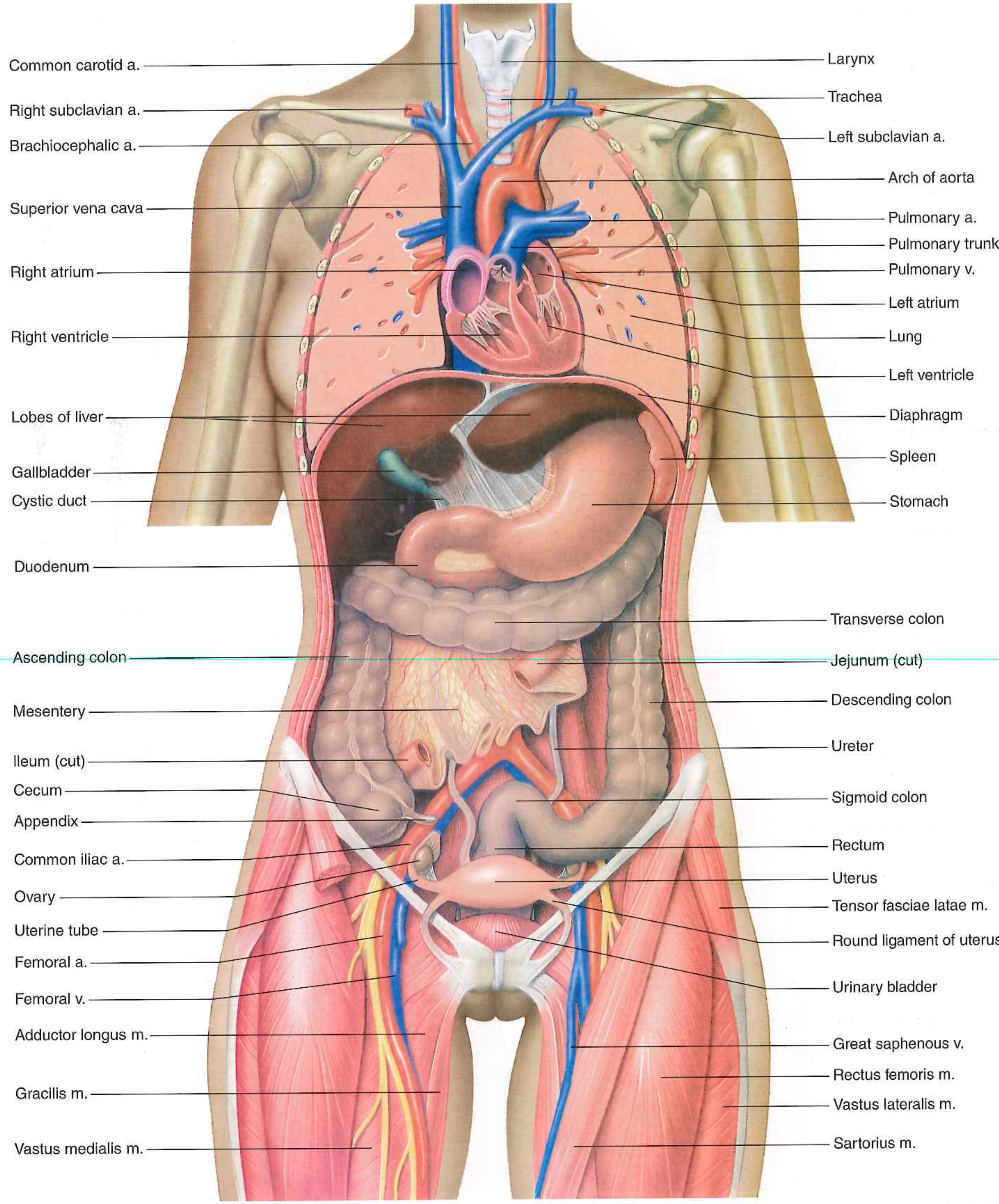


PLATE FIVE Human female torso with the lungs, heart, and small intestine sectioned and the liver reflected (lifted back). (*a.* stands for *artery*, *m.* stands for *muscle*, and *v.* stands for *vein*.)

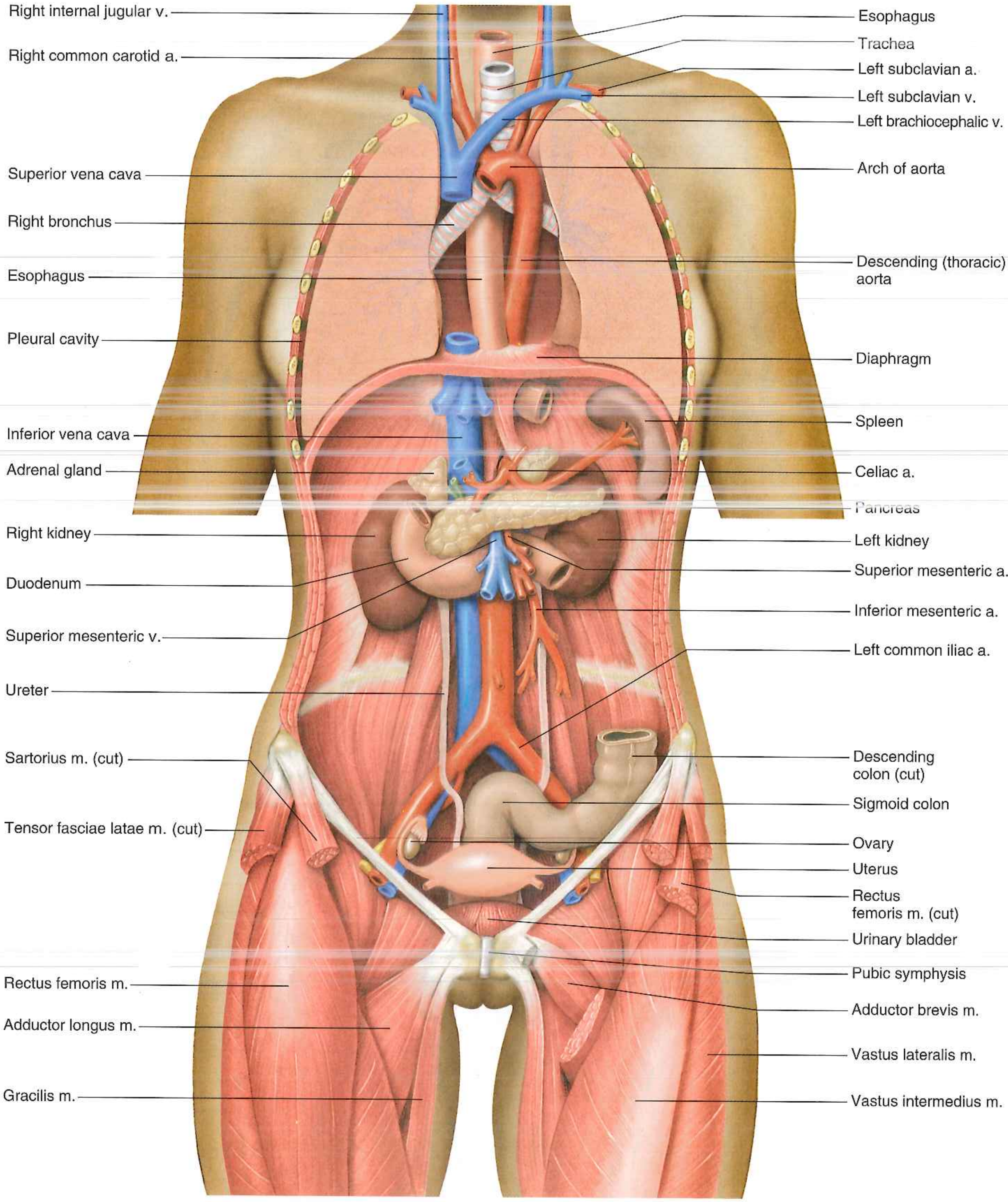


PLATE SIX Human female torso with the heart, stomach, liver, and parts of the intestine and lungs removed. (*a.* stands for *artery*, *m.* stands for *muscle*, and *v.* stands for *vein.*)

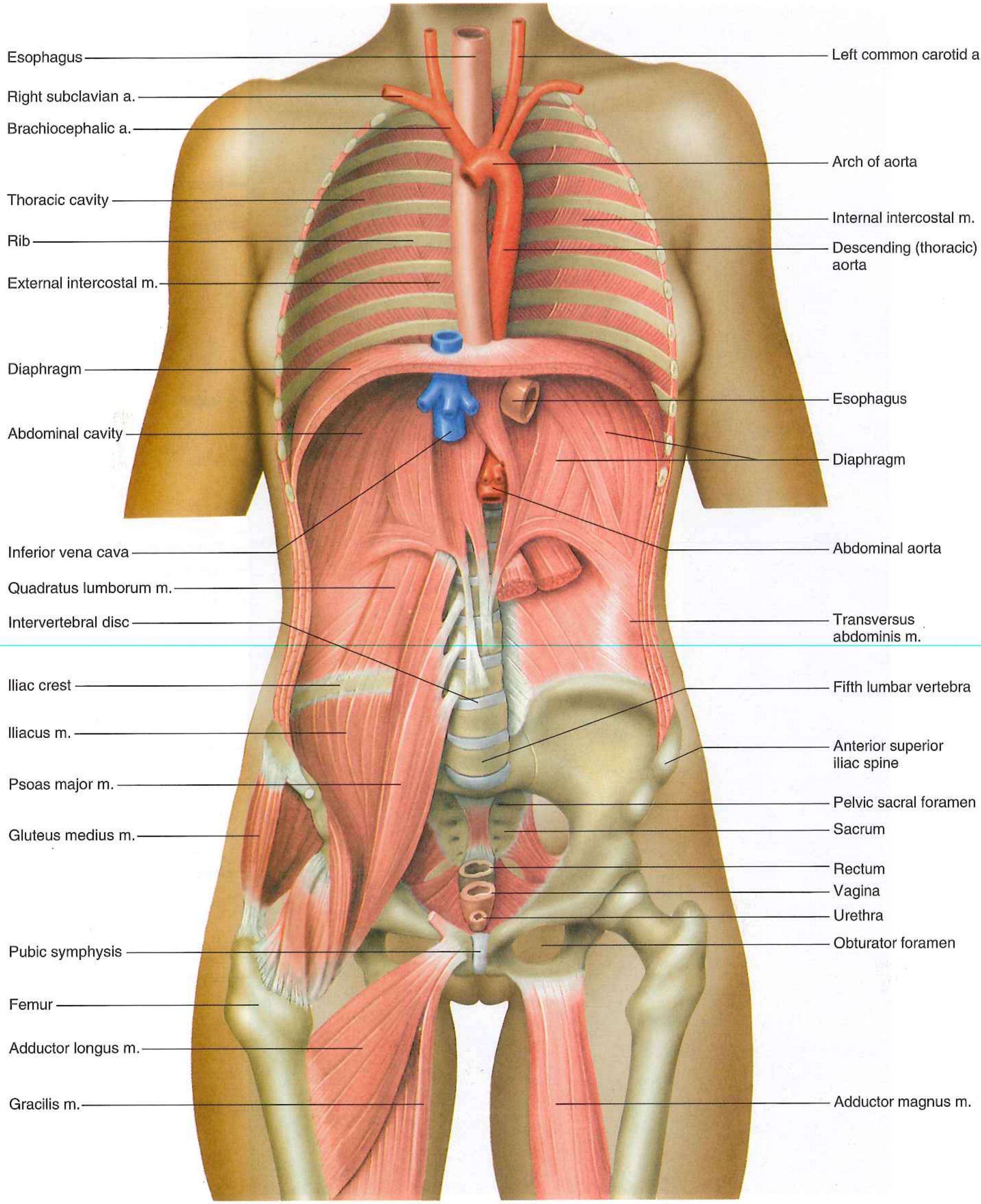


PLATE SEVEN Human female torso with the thoracic, abdominal, and pelvic viscera removed. (*a.* stands for *artery* and *m.* stands for *muscle.*)

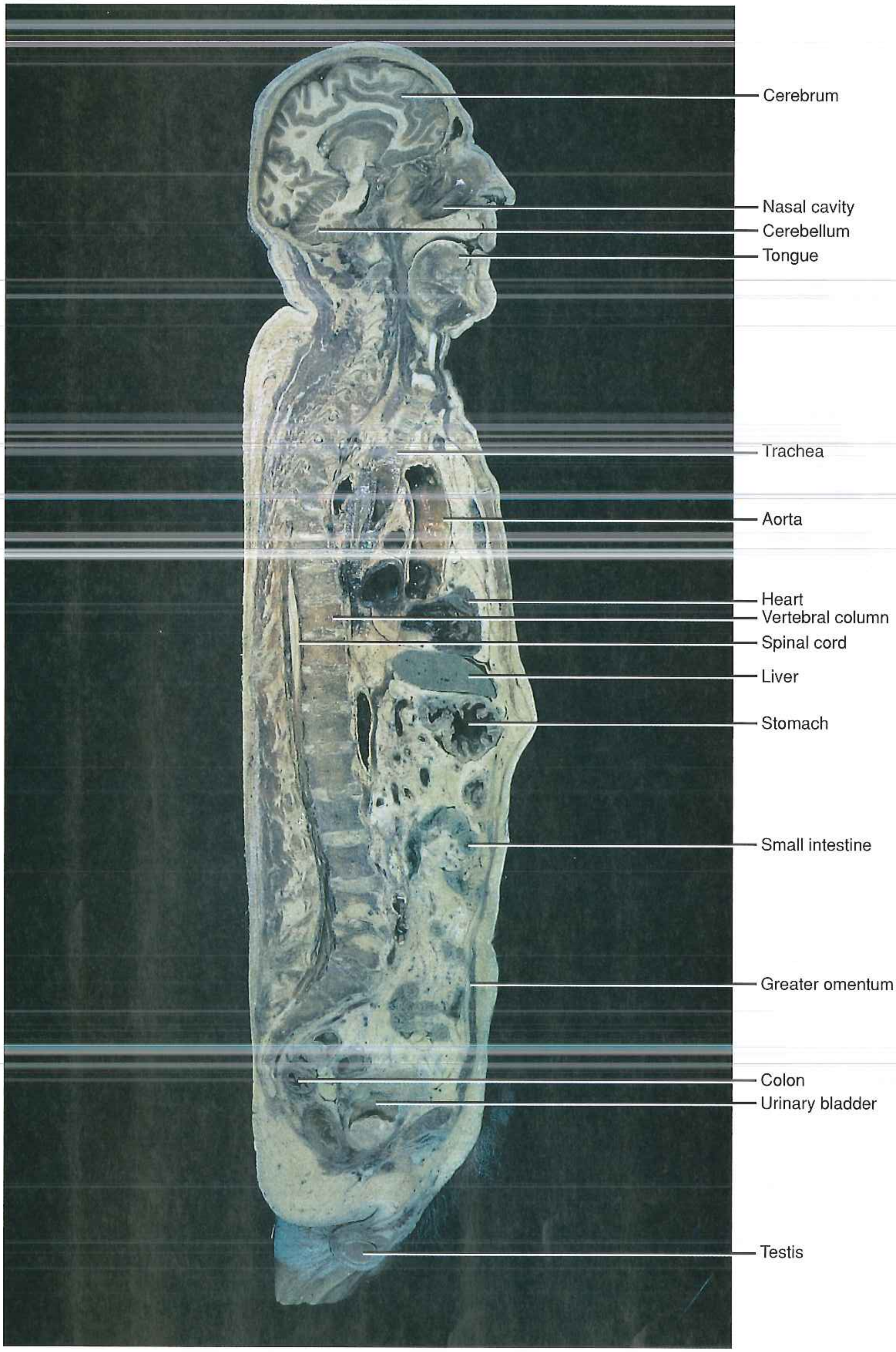


PLATE EIGHT Sagittal section of the head and trunk.

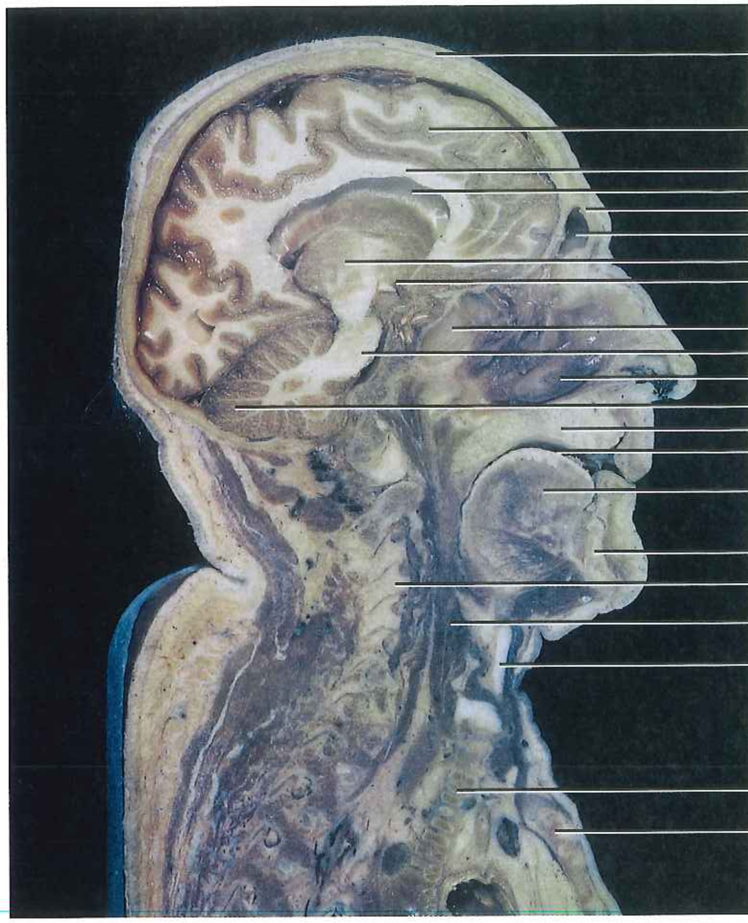


PLATE NINE Sagittal section of the head and neck.

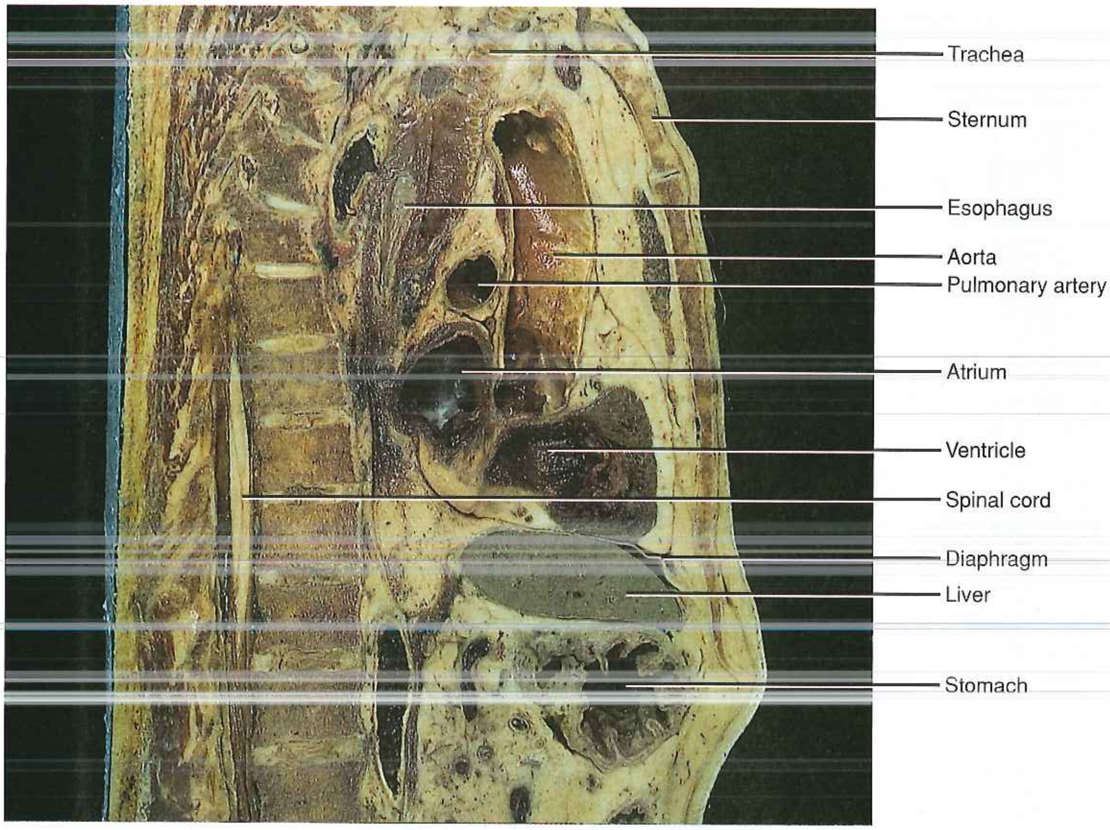


PLATE TEN Viscera of the thoracic cavity, sagittal section.

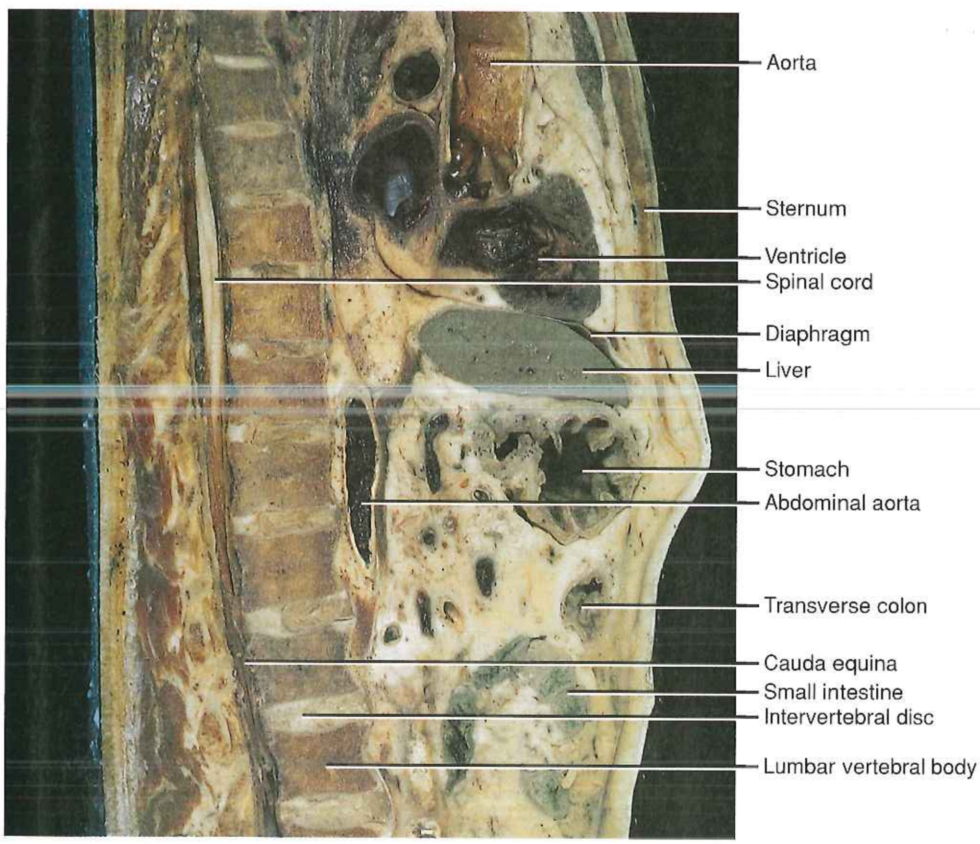


PLATE ELEVEN Viscera of the abdominal cavity, sagittal section.

PLATE TWELVE Viscera of the pelvic cavity, sagittal section. (*m.* stands for muscle.)

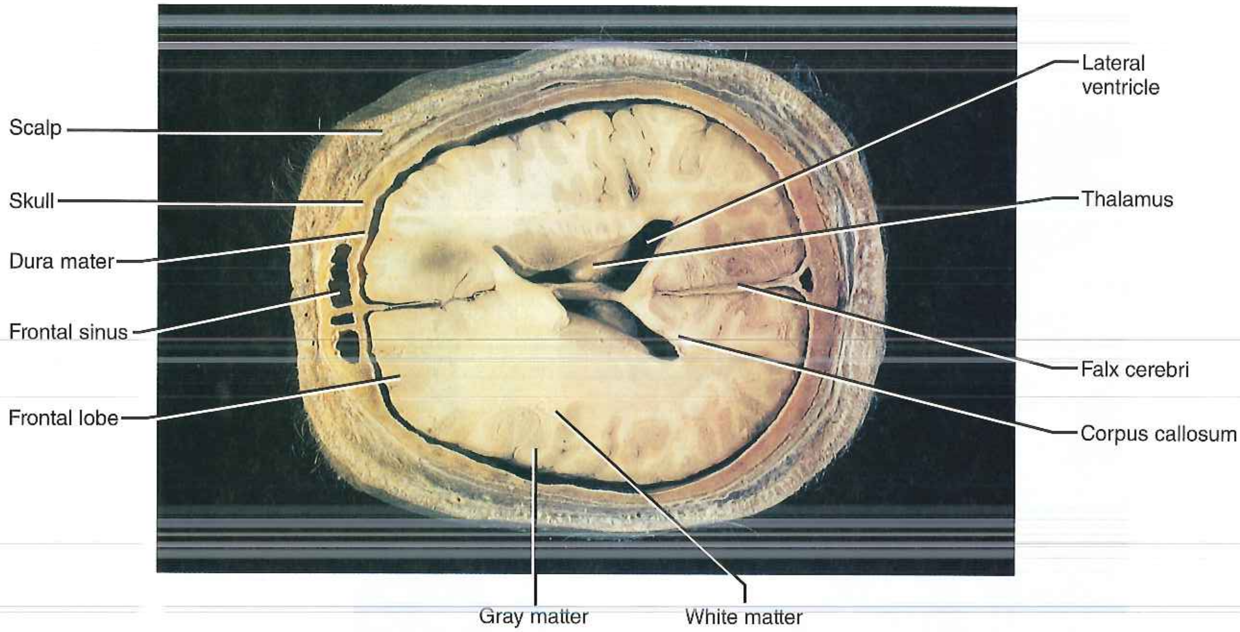


PLATE THIRTEEN Transverse section of the head above the eyes, superior view.

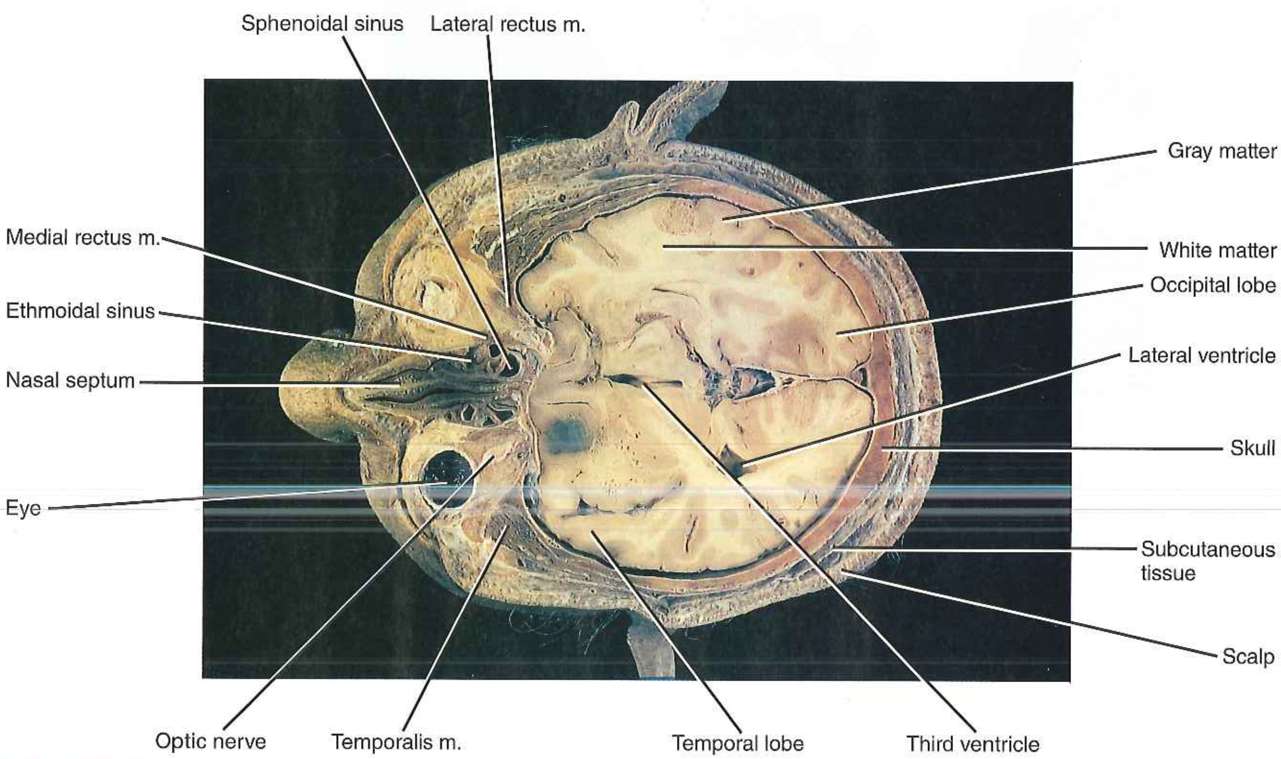


PLATE FOURTEEN Transverse section of the head at the level of the eyes, superior view. (*m.* stands for muscle.)

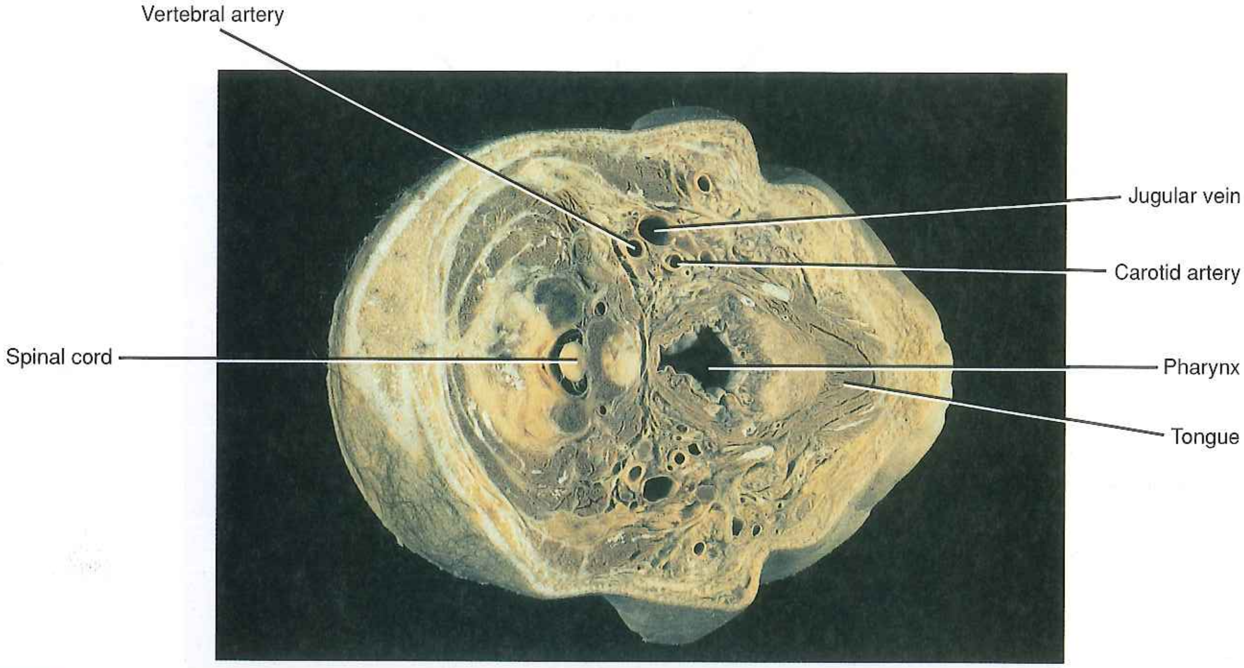


PLATE FIFTEEN Transverse section of the neck, inferior view.

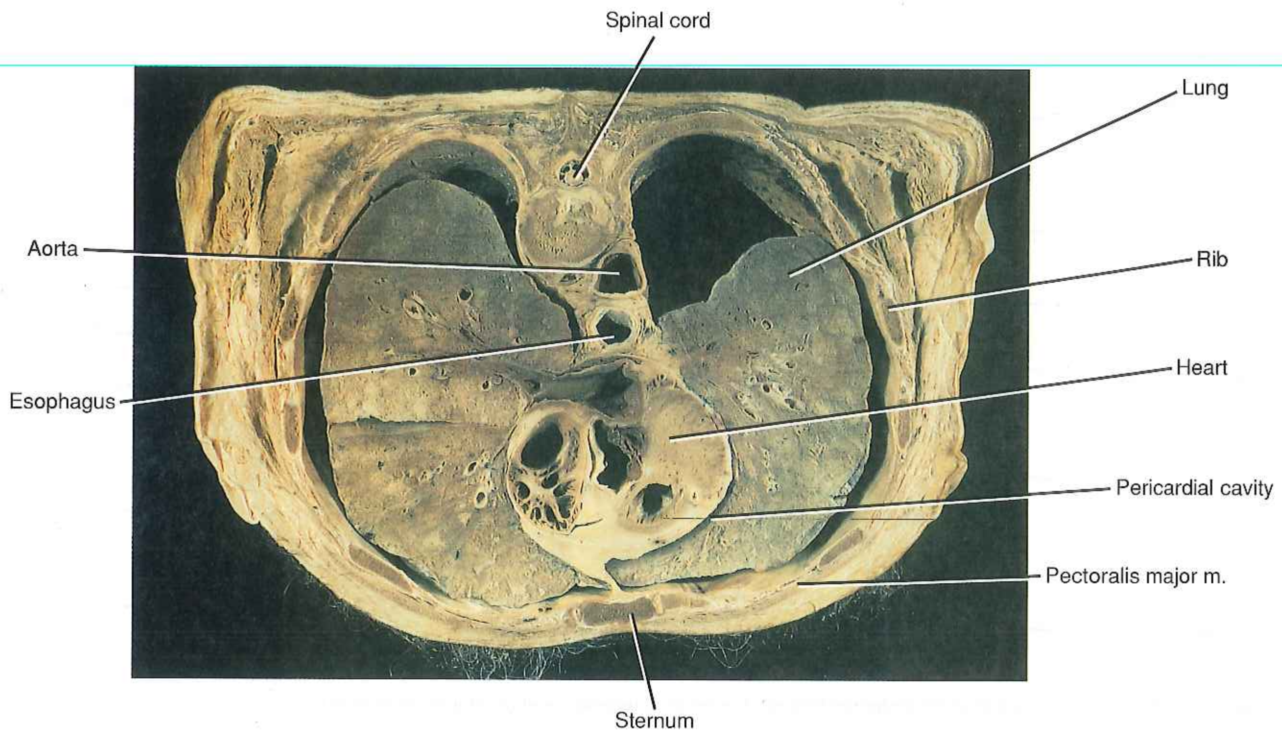


PLATE SIXTEEN Transverse section of the thorax through the base of the heart, superior view. (*m.* stands for muscle.)

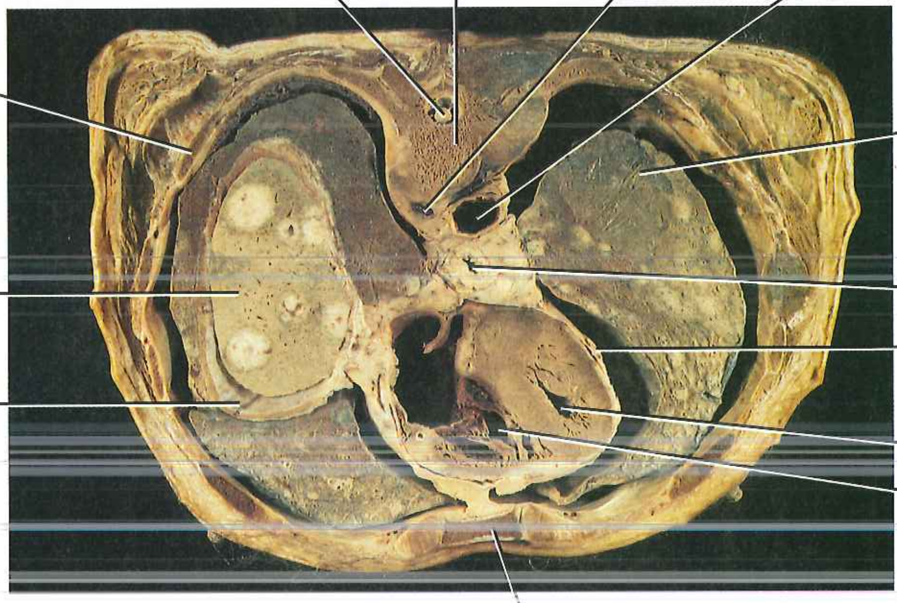


PLATE SEVENTEEN Transverse section of the thorax through the heart, superior view.

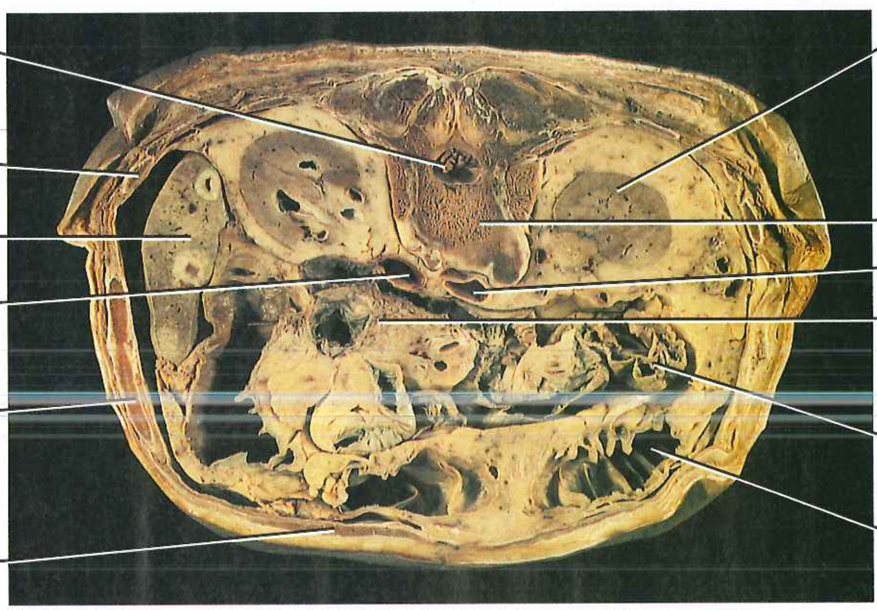


PLATE EIGHTEEN Transverse section of the abdomen through the kidneys, superior view. (*m.* stands for muscle.)

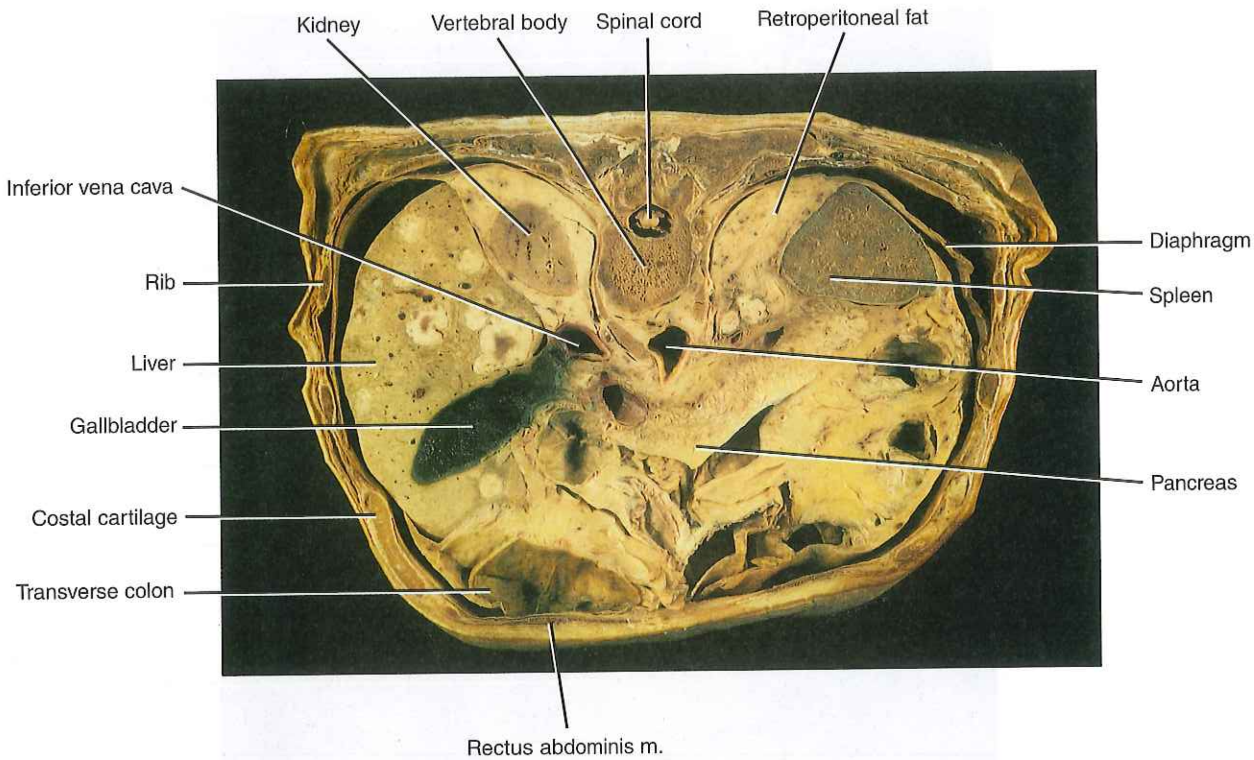


PLATE NINETEEN Transverse section of the abdomen through the pancreas, superior view. (*m.* stands for muscle.)

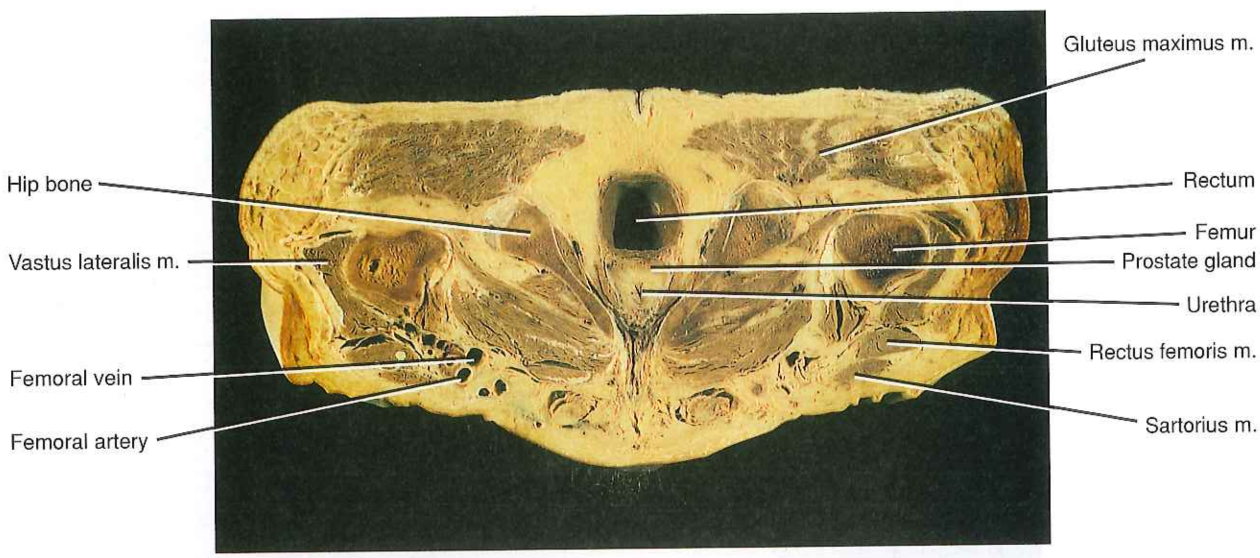


PLATE TWENTY Transverse section of the male pelvic cavity, superior view. (*m.* stands for muscle.)

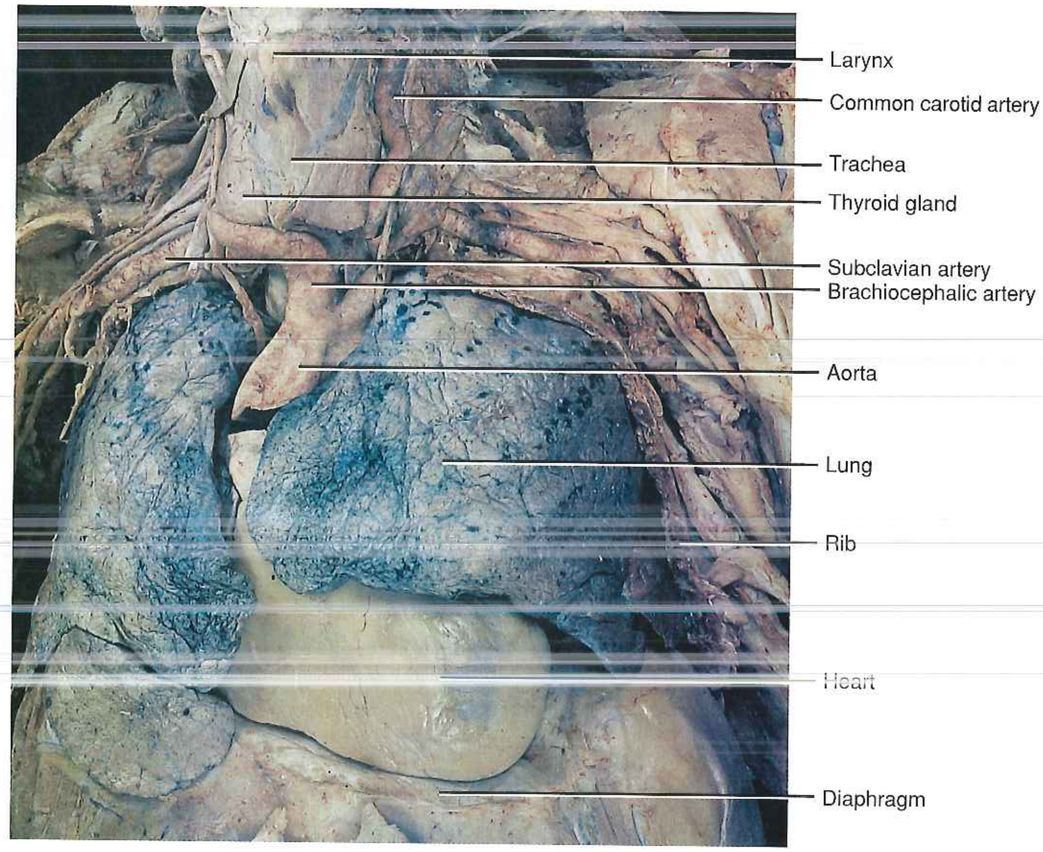


PLATE TWENTY-ONE Thoracic viscera, anterior view. (Brachiocephalic veins have been removed to better expose the brachiocephalic artery and the aorta.)

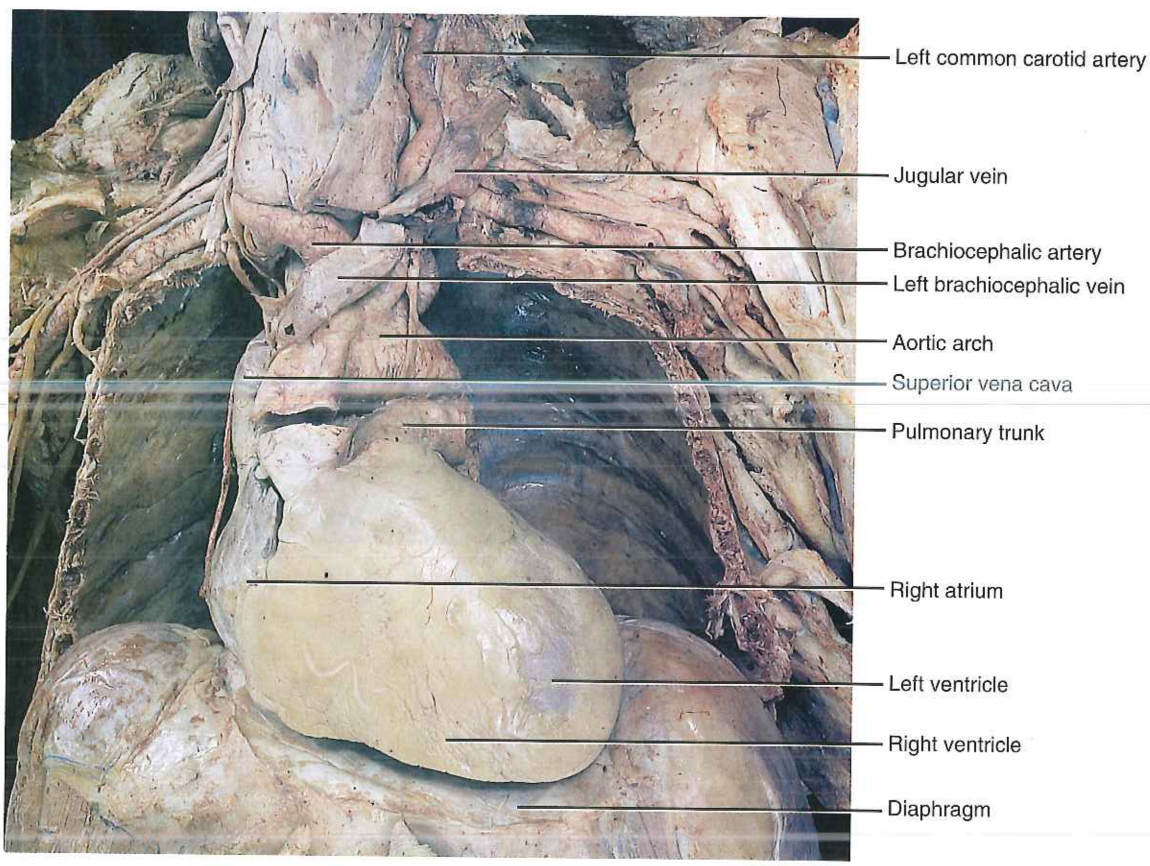


PLATE TWENTY-TWO Thorax with the lungs removed, anterior view.

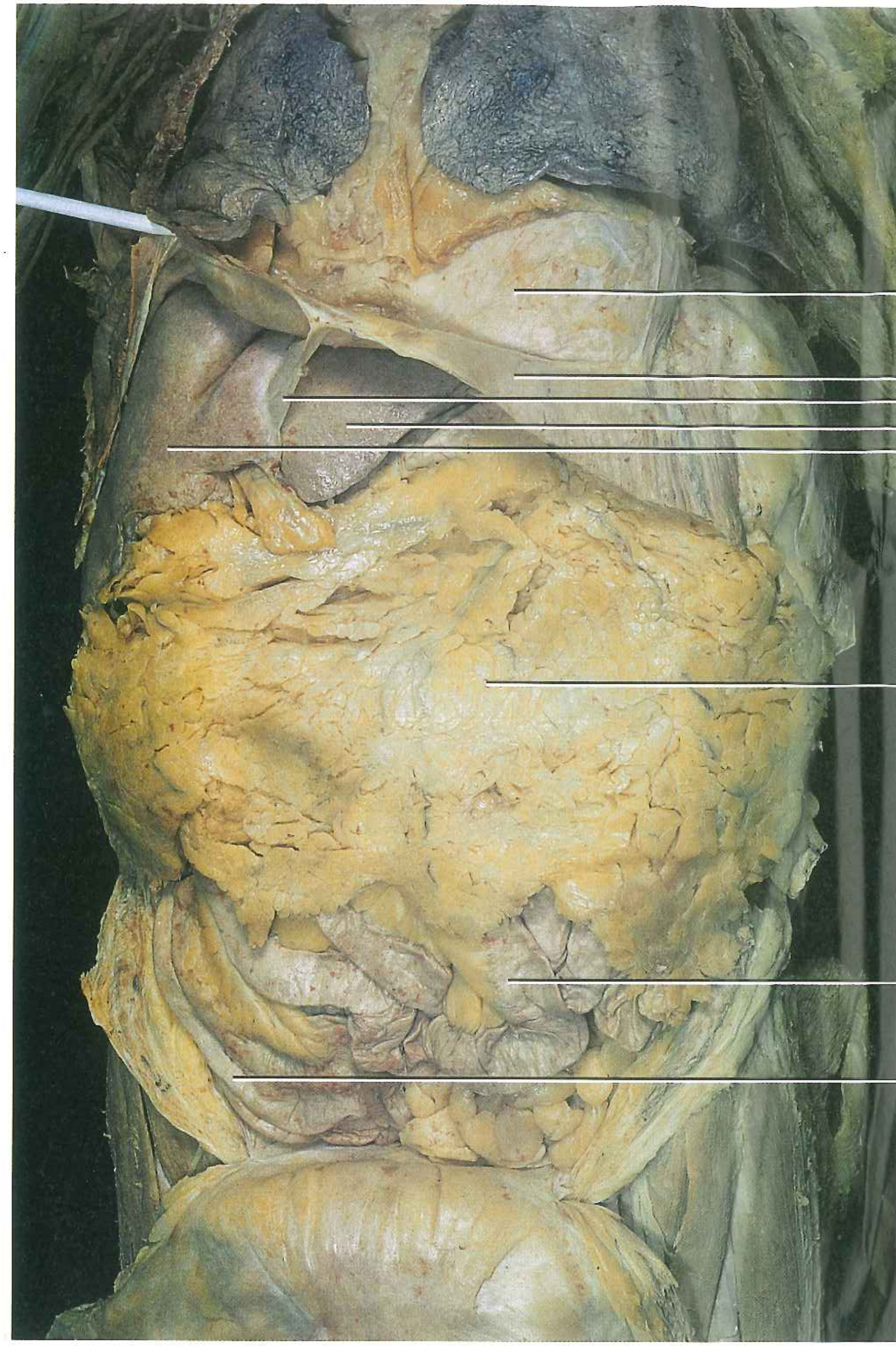


PLATE TWENTY-FOUR Abdominal viscera, anterior view.

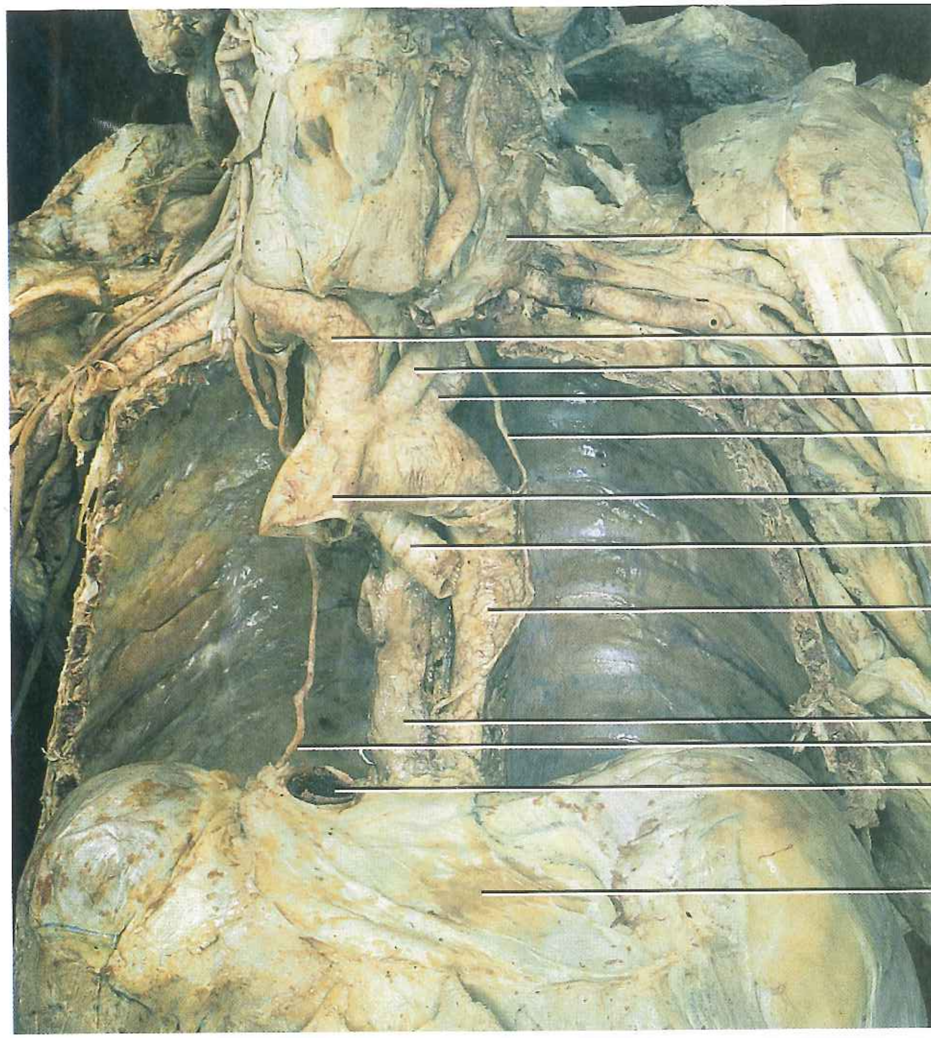


PLATE TWENTY-THREE Thorax with the heart and lungs removed, anterior view.

PLATE TWENTY-FIVE Abdominal viscera with the greater omentum removed, anterior view. (Small intestine has been displaced to the left.)