The Human Body: An Orientation

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Whole body scan of a woman (colored MRI).

As you read this book, you will learn about a subject that has fascinated people forever—their own bodies. The study of human anatomy is not only an interesting and highly personal experience, but also a timely one. Almost every week, the news media report advances in medical science. Understanding how your body is built and how it works allows you to appreciate newly developed techniques for detecting and treating disease and to apply guidelines for staying healthy. If you are preparing for a career in the health sciences, your knowledge of human anatomy is the foundation of your clinical practice.

AN OVERVIEW OF ANATOMY

- Define anatomy and physiology, and describe the subdivisions of anatomy.
- Use the meaning of word roots to aid in understanding anatomical terminology.
- Name the levels of structural organization in the human body, and explain their relationships.
- List the organ systems of the body, and briefly state their functions.
- Classify the levels of structural organization in the body according to relative and actual size.

Anatomy is the study of the structure of the human body. It is also called **morphology** (mor″fol′o-je), the science of form. An old and proud science, anatomy has been a field of serious intellectual investigation for at least 2300 years. It was the most prestigious biological discipline of the 1800s and is still dynamic.

Anatomy is closely related to **physiology,** the study of body function. Although you may be studying anatomy and physiology in separate courses, the two are truly inseparable, because structure supports function. For example, the lens of the eye is transparent and curved; it could not perform its function of focusing light if it were opaque and uncurved. Similarly, the thick, long bones in our legs could not support our weight if they were soft and thin. This textbook stresses the closeness of the relationship between structure and function. In almost all cases, a description of the anatomy of a body part is accompanied by an explanation of its function, emphasizing the structural characteristics that contribute to that function. This approach is called *functional anatomy.*

Branches of Anatomy

Anatomy is a broad field of science consisting of several subdisciplines or branches. Each branch of anatomy studies the body's structures in a specialized way.

Gross Anatomy

Gross anatomy (*gross* = large) is the study of body structures that can be examined by the naked eye—the bones, lungs, and muscles, for example. An important technique for studying gross anatomy is **dissection** (dĭ-sek′shun; "cut apart"), in which connective tissue is removed from between the body organs so that the organs can be seen more clearly. Then the organs are cut open for viewing. The term *anatomy* is derived from Greek words meaning "to cut apart."

Studies of gross anatomy can be approached in several different ways. In **regional anatomy,** all structures in a single body region, such as the abdomen or head, are examined as a group. In **systemic** (sis-tem′ik) **anatomy,** by contrast, all the organs with related functions are studied together. For example, when studying the muscular system, you consider the muscles of the entire body. The systemic approach to anatomy is best for relating structure to function. Therefore, it is the approach taken in most college anatomy courses and in this book. Medical schools, however, favor regional anatomy because many injuries and diseases involve specific body regions (sprained ankle, sore throat, heart disease); furthermore, surgeons need extensive and detailed knowledge of each body region.

Another subdivision of gross anatomy is **surface anatomy,** the study of shapes and markings (called *landmarks*) on the surface of the body that reveal the underlying organs. This knowledge is used to identify the muscles that bulge beneath the skin in weight lifters, and clinicians use it to locate blood vessels for placing catheters, feeling pulses, and drawing blood. Clinically useful surface landmarks are described throughout the text in reference to the organ system that they relate to. The end of Chapter 11 integrates the anatomical relationships between skeletal and muscular structures through the study of surface anatomy.

Microscopic Anatomy

Microscopic anatomy, or **histology** (his-tol′o-je; "tissue study"), is the study of structures that are so small they can be seen only with a microscope. These structures include cells and cell parts; groups of cells, called *tissues;* and the microscopic details of the organs of the body (stomach, spleen, and so on). A knowledge of microscopic anatomy is important because physiological and disease processes occur at the cellular level.

Other Branches of Anatomy

Two branches of anatomy explore how body structures form, grow, and mature. **Developmental anatomy** traces the structural changes that occur in the body throughout the life span and the effects of aging. **Embryology** is the study of how body structures form and develop before birth. A knowledge of embryology helps you understand the complex design of the adult human body and helps to explain birth defects, which are anatomical abnormalities that occur during embryonic development and are evident after birth.

Some specialized branches of anatomy are used primarily for medical diagnosis and scientific research. **Pathological** (pah-tho-loj′ĭ-kal) **anatomy** deals with the structural changes in cells, tissues, and organs caused by disease. (**Pathology** is the study of disease.) **Radiographic** (ra″de-o′graf′ic) **anatomy** is the study of internal body structures by means of X-ray studies and other imaging techniques (see pp. 15–19). **Functional morphology** explores the functional properties of body structures and assesses the efficiency of their design.

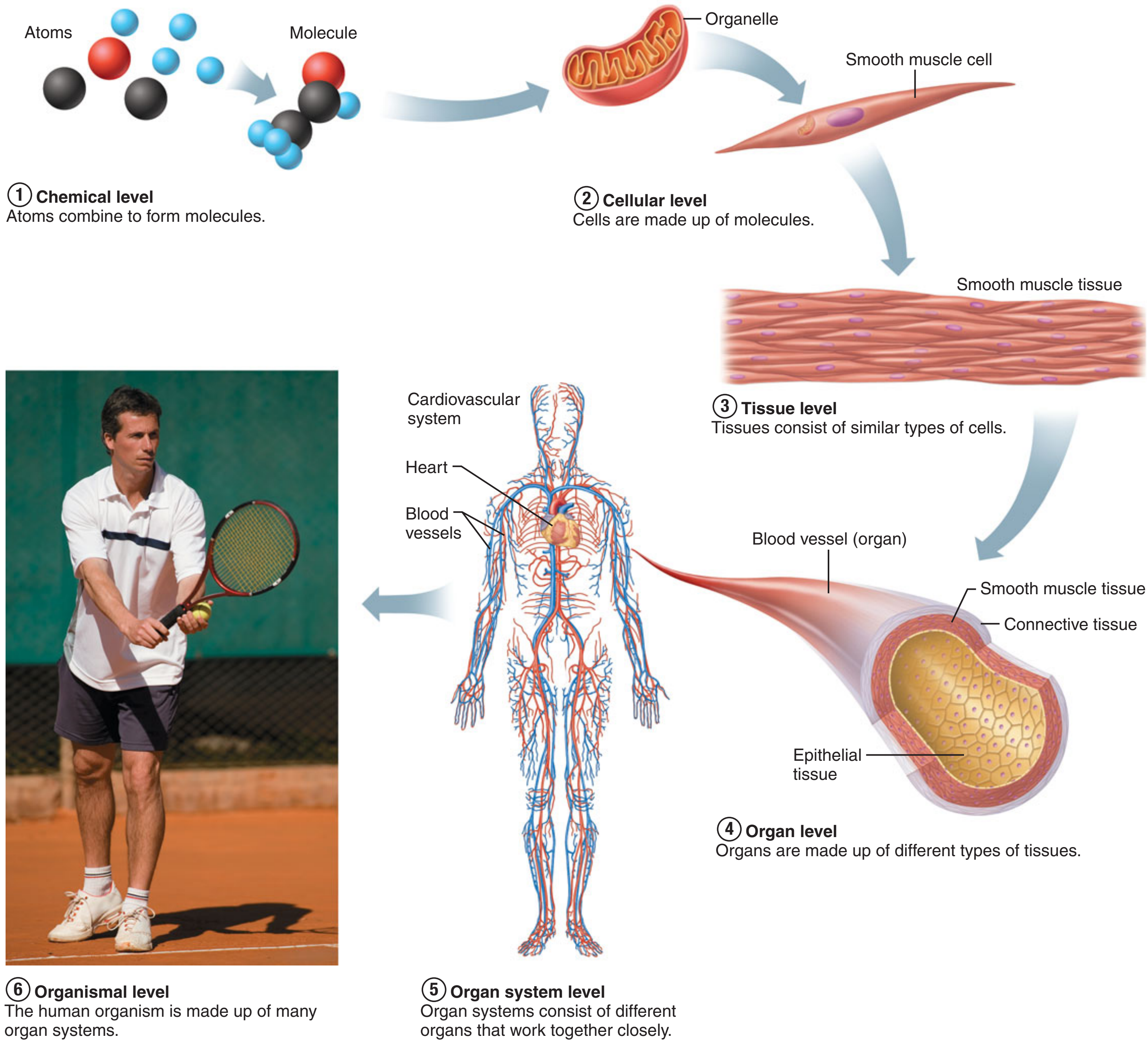


FIGURE 1.1 Levels of structural complexity in the cardiovascular system.

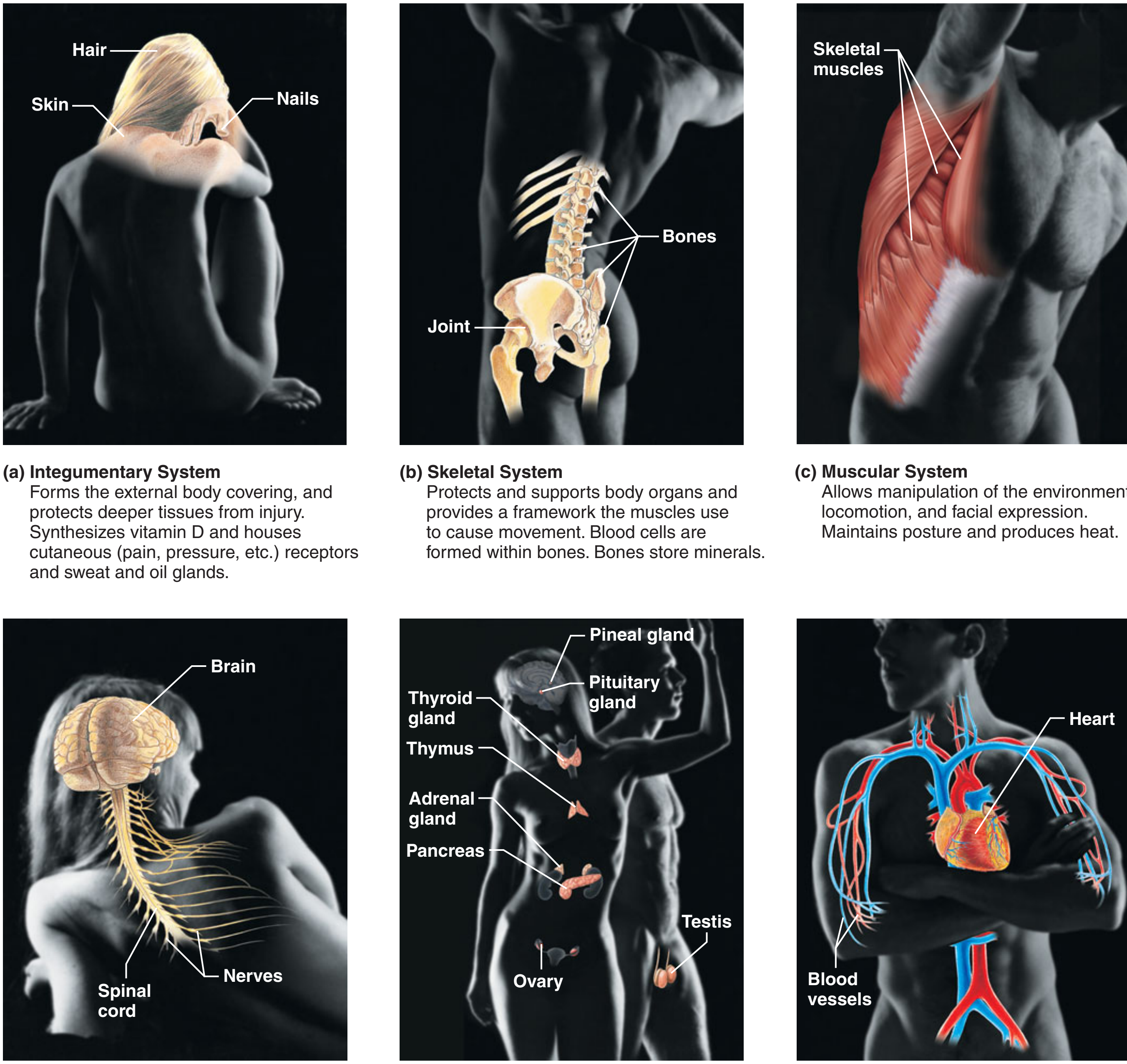
Anatomical Terminology

Most anatomical terms are based on ancient Greek or Latin words. For example, the arm is the brachium (bra′ke-um; Greek for "arm"), and the thigh bone is the femur (fe′mer; Latin for "thigh"). This terminology, which came into use when Latin was the official language of science, provides a standard nomenclature that scientists can use worldwide, no matter what language they speak. Learning anatomical terminology can be difficult, but this text will help you by explaining the origins of selected terms as you encounter them. For further help, see the Glossary in the back of the book, and the list of word roots in the inside covers of the book.*

The Hierarchy of Structural Organization

The human body has many levels of structural complexity (Figure 1.1). At the **chemical level,** *atoms,* the tiny building blocks of matter, combine to form small *molecules,* such

*For a guide to pronunciation, see the Glossary.



(a) Integumentary System
Forms the external body covering, and protects deeper tissues from injury. Synthesizes vitamin D and houses cutaneous (pain, pressure, etc.) receptors and sweat and oil glands.

(b) Skeletal System
Protects and supports body organs and provides a framework the muscles use to cause movement. Blood cells are formed within bones. Bones store minerals.

(c) Muscular System
Allows manipulation of the environment, locomotion, and facial expression. Maintains posture and produces heat.

(d) Nervous System
As the fast-acting control system of the body, it responds to internal and external changes by activating appropriate muscles and glands.

(e) Endocrine System
Glands secrete hormones that regulate processes such as growth, reproduction, and nutrient use (metabolism) by body cells.

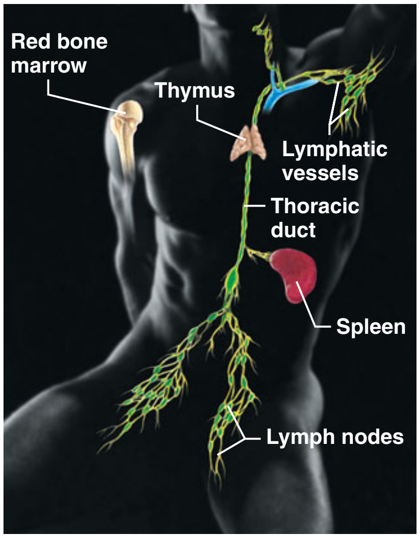
(f) Cardiovascular System
Blood vessels transport blood, which carries oxygen, carbon dioxide, nutrients, wastes, etc. The heart pumps blood.

FIGURE 1.2 The body's organ systems and their major functions.

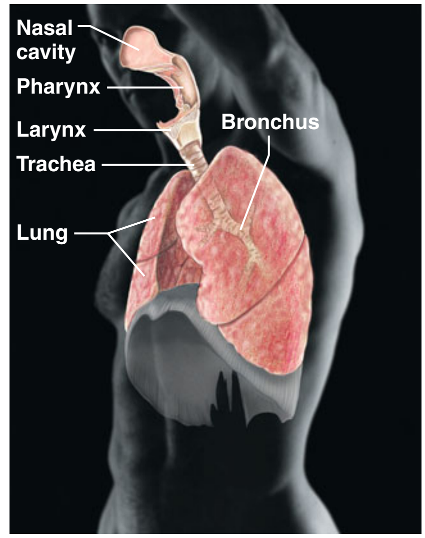
as carbon dioxide (CO_2) and water (H_2O), and larger *macromolecules* (*macro* = big). Four classes of macromolecules are found in the body: carbohydrates (sugars), lipids (fats), proteins, and nucleic acids (DNA, RNA). These macromolecules are the building blocks of the structures at the **cellular level:** the *cells* and their functional subunits, called *cellular organelles.* Cells are the smallest living things in the body, and you have trillions of them.

The next level is the **tissue level.** A tissue is a group of cells that work together to perform a common function. Only four tissue types make up all organs of the human body: epithelial tissue (epithelium), connective tissue, muscle tissue, and nervous tissue. Each tissue plays a characteristic role in the body (see Chapter 4). Briefly, epithelium (ep″ĭ-the′le-um) covers the body surface and lines its cavities; connective tissue supports the body and protects its organs; muscle tissue provides movement; and nervous tissue provides fast internal communication by transmitting electrical impulses.

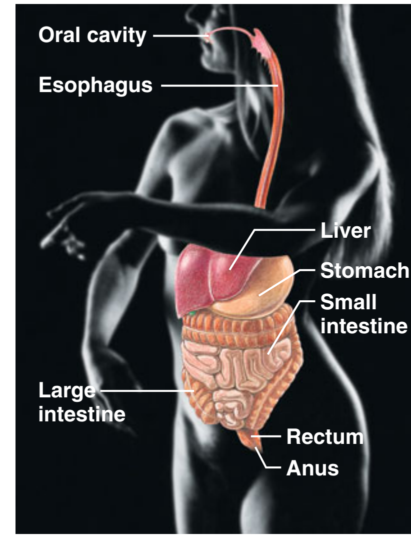
Extremely complex physiological processes occur at the **organ level.** An organ is a discrete structure made up of more than one tissue. Most organs contain all four tissues. The liver, brain, femur, and heart are good examples. You can



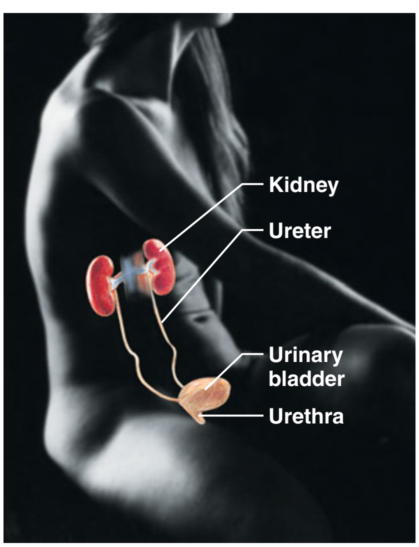
(g) Lymphatic System/Immunity
Picks up fluid leaked from blood vessels and returns it to blood. Disposes of debris in the lymphatic stream. Houses white blood cells (lymphocytes) involved in immunity. The immune response mounts the attack against foreign substances within the body.



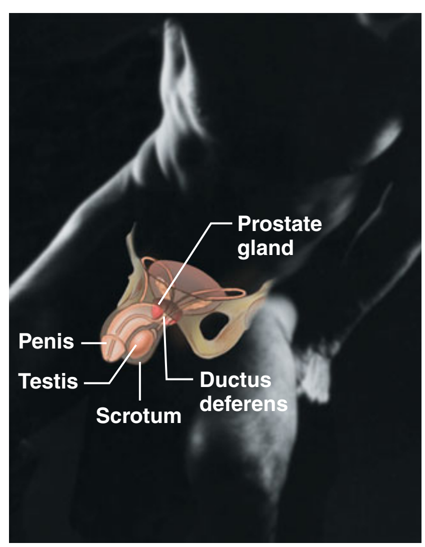
(h) Respiratory System
Keeps blood constantly supplied with oxygen and removes carbon dioxide. The gaseous exchanges occur through the walls of the air sacs of the lungs.

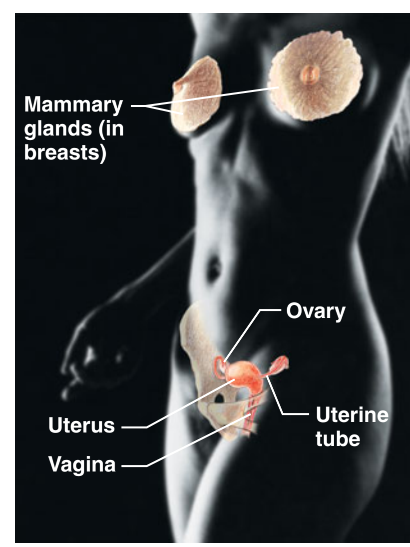


(i) Digestive System
Breaks down food into absorbable units that enter the blood for distribution to body cells. Indigestible foodstuffs are eliminated as feces.



(j) Urinary System
Eliminates nitrogenous wastes from the body. Regulates water, electrolyte and acid-base balance of the blood.





(k) Male Reproductive System

(l) Female Reproductive System

Overall function is production of offspring. Testes produce sperm and male sex hormone, and male ducts and glands aid in delivery of sperm to the female reproductive tract. Ovaries produce eggs and female sex hormones. The remaining female structures serve as sites for fertilization and development of the fetus. Mammary glands of female breasts produce milk to nourish the newborn.

FIGURE 1.2 The body's organ systems and their major functions, *continued.*

think of each organ in the body as a functional center responsible for an activity that no other organ can perform.

Organs that work closely together to accomplish a common purpose make up an **organ system,** the next level. For example, organs of the cardiovascular system—the heart and blood vessels (Figure 1.1)—transport blood to all body tissues. Organs of the digestive system—the mouth, esophagus, stomach, intestine, and so forth—break down the food we eat so that we can absorb the nutrients into the blood. The body's organ systems are the *integumentary* (skin), *skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, immune, respiratory, digestive, urinary,* and *reproductive* systems.* Figure 1.2 gives a brief overview of the organ systems and their basic functions.

*The cardiovascular and lymphatic systems are collectively known as the *circulatory system* because of their interrelated roles in circulating fluids (blood and lymph) through the body.

The highest level of organization is the **organismal level;** for example, the human organism is a whole living person (see Figure 1.1). The organismal level is the result of all of the simpler levels working in unison to sustain life.

Scale: Length, Volume, and Weight

To describe the dimensions of cells, tissues, and organs, anatomists need a precise system of measurement. The **metric system,** described in detail in Appendix A, provides such precision. Familiarity with this system lets you understand the sizes, volumes, and weights of body structures.

An important unit of *length* is the **meter (m),** which is a little longer than a yardstick. If you are 6 feet tall, your height is 1.83 meters. Most adults are between 1.5 and 2 meters tall. A **centimeter (cm)** is a hundredth of a meter (*cent* = hundred). You can visualize this length by remembering that a nickel is about 2 cm in diameter. Many of our organs are several centimeters in height, length, and width. A **micrometer (μm)** is a millionth of a meter (*micro* = millionth). Cells, organelles (structures found inside cells), and tissues are measured in micrometers. Human cells average about 10 μm in diameter, although they range from 5 μm to 100 μm. The human cell with the largest diameter, the egg cell (ovum), is about the size of the tiniest dot you could make on this page with a pencil.

The metric system also measures *volume* and *weight* (mass). A **liter (l)** is a volume slightly larger than a quart; soft drinks are packaged in 1-liter and 2-liter bottles. A **milliliter (ml)** is one-thousandth of a liter (*milli* = thousandth). A **kilogram (kg)** is a mass equal to about 2.2 pounds, and a **gram (g)** is a thousandth of a kilogram (*kilo* = thousand).

check your understanding

1. What is the difference between histology and radiography?
2. Use the word root definitions located in the end pages of this text to define each of the terms listed: pathology, hepatitis, brachial, leukocyte, pneumonia.
3. Define a tissue. List the four types of tissues in the body, and briefly state the function of each.
4. Name the organ system described in each of the following: (a) eliminates wastes and regulates water and ion balance; (b) fast-acting control system that integrates body activities; (c) supplies blood with oxygen and removes carbon dioxide.

For answers, see Appendix B.

GROSS ANATOMY: AN INTRODUCTION

- ➤ Define the anatomical position.
- ➤ Use anatomical terminology to describe body directions, regions, and planes.
- ➤ Describe the basic structures that humans share with other vertebrates.
- ➤ Locate the major body cavities and their subdivisions.
- ➤ Name the nine regions and four quadrants of the abdomen, and name the visceral organs associated with these regions.

Regional and Directional Terms

To accurately describe the various body parts and their locations, you need to use a common visual reference point. This reference point is the **anatomical position** (Figure 1.3a). In this position, a person stands erect with feet together and eyes forward. The palms face anteriorly with the thumbs pointed away from the body. It is essential to learn the anatomical position because most of the directional terminology used in anatomy refers to the body in this position. Additionally, the terms *right* and *left* always refer to those sides belonging to the person or cadaver being viewed—not to the right and left sides of the viewer.

Regional terms are the names of specific body areas. The fundamental divisions of the body are the *axial* and *appendicular* (ap″en-dik′u-lar) *regions.* The **axial region,** so named because it makes up the main axis of the body, consists of the *head, neck,* and *trunk.* The trunk, in turn, is divided into the *thorax* (chest), *abdomen,* and *pelvis;* the trunk also includes the region around the anus and external genitals, called the *perineum* (per″ĭ-ne′um; "around the anus"). The **appendicular region** of the body consists of the limbs, which are also called *appendages* or *extremities*. The fundamental divisions of the body are subdivided into smaller regions, as shown in Figure 1.3.

Standard directional terms are used by medical personnel and anatomists to explain precisely where one body structure lies in relation to another. For example, you could describe the relationship between the eyebrows and the nose informally by stating, "The eyebrows are at each side of the face to the right and left of the nose and higher than the nose." In anatomical terminology, this is condensed to, "The eyebrows are lateral and superior to the nose." Clearly, the anatomical terminology is less wordy and confusing. The standardized terms of direction are defined and illustrated in Table 1.1, p. 8. Most often used are the paired terms **superior/inferior, anterior (ventral)/posterior (dorsal), medial/lateral,** and **superficial/deep.**

Body Planes and Sections

In the study of anatomy, the body is often *sectioned* (cut) along a flat surface called a *plane.* The most frequently used body planes are sagittal, frontal, and transverse planes, which lie at right angles to one another (Figure 1.4). A section bears the name of the plane along which it is cut. Thus, a cut along a sagittal plane produces a sagittal section.

A **frontal (coronal) plane** lies vertically and divides the body into anterior and posterior parts (Figure 1.4a). A **transverse (horizontal) plane** runs horizontally from right to left, dividing the body into superior and inferior parts

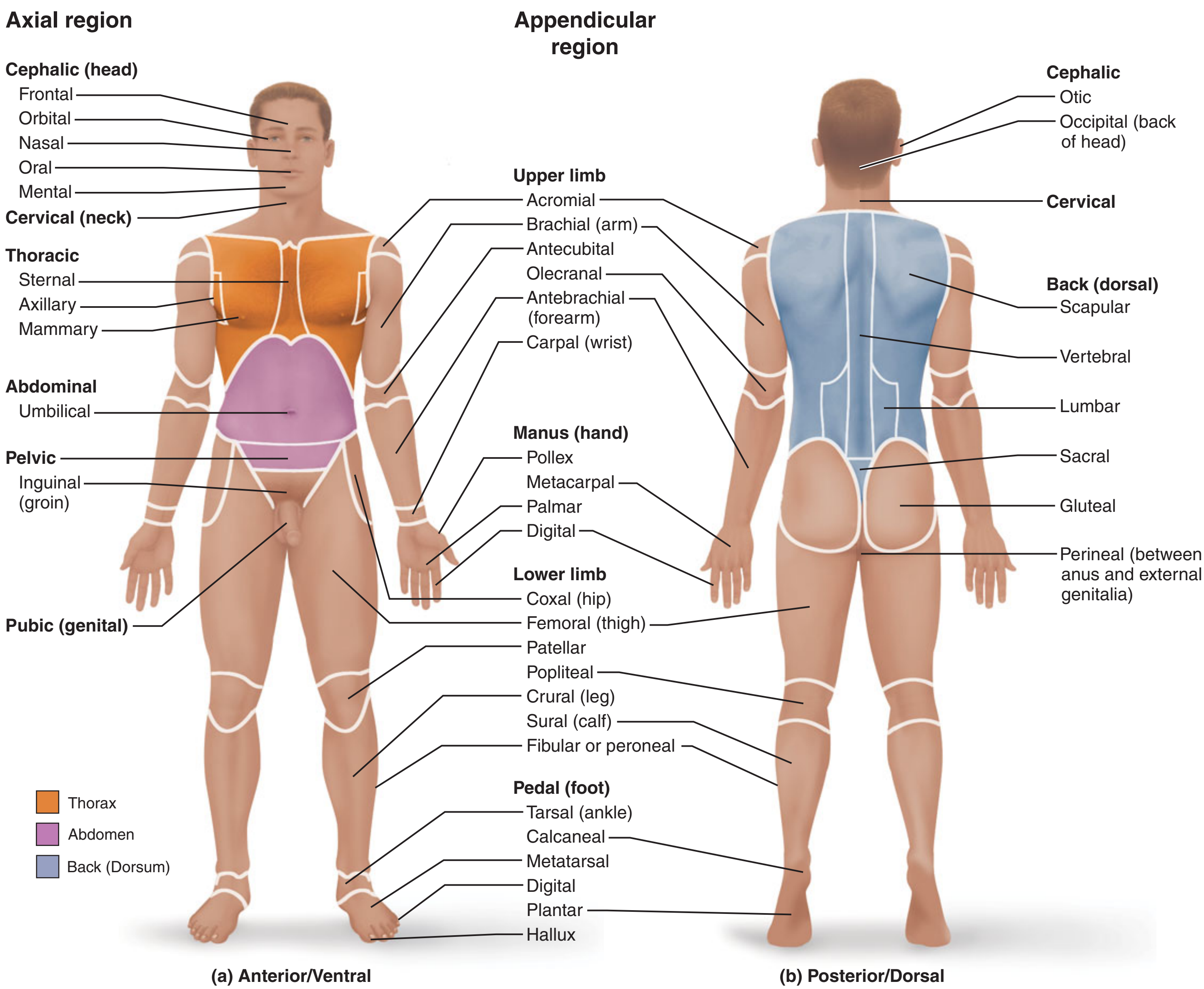


FIGURE 1.3 Anatomic position and regional terms.

(Figure 1.4b). A transverse section is also called a **cross section. Sagittal planes** (sag′ĭ-tal; "arrow") are vertical, like frontal planes, but divide the body into right and left parts (Figure 1.4c). The specific sagittal plane that lies exactly in the midline is the **median plane,** or **midsagittal plane.** All other sagittal planes, offset from the midline, are **parasagittal** (*para* = near).

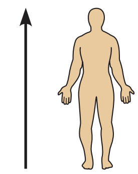
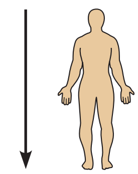
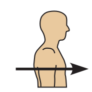
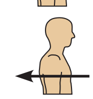
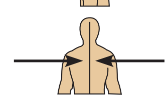
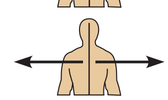
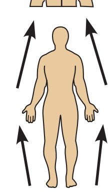
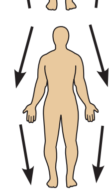
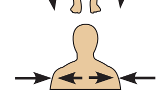
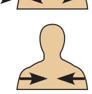
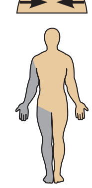
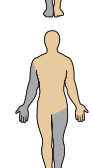
Cuts made along any plane that lies diagonally between the horizontal and the vertical are called **oblique sections.** Not frontal, transverse, or sagittal, such oblique sections are difficult to interpret because the orientation of the view is not obvious. For this reason, oblique sections are seldom used.

The ability to interpret sections through the body, especially transverse sections, is increasingly important in the clinical sciences. New medical imaging devices described on pp. 16–19 produce sectional images rather than three-dimensional images. It can be difficult, however, to decipher an object's overall shape from a sectional view alone. A cross section of a banana, for example, looks like a circle and gives no indication of the whole banana's crescent shape. Sometimes, you must mentally assemble a whole series of sections to understand the true shape of an object. With practice, you will gradually learn to relate two-dimensional sections to three-dimensional shapes.

Anatomical Variability

You know from looking at the faces and body shapes of the people around you that humans differ in their external anatomy. The same kind of variability holds for internal organs as well. Thus, not every structural detail described in an anatomy book is true of all people or of all the cadavers (dead bodies) you observe in the anatomy lab. In some bodies, for example, a certain blood vessel may branch off

TABLE 1.1 Orientation and Directional Terms

Term	Definition		Example
Superior (cranial)	Toward the head end or upper part of a structure or the body; above		The head is superior to the abdomen.
Inferior (caudal)	Away from the head end or toward the lower part of a structure or the body; below		The navel is inferior to the chin.
Anterior (ventral)*	Toward or at the front of the body; in front of		The breastbone is anterior to the spine.
Posterior (dorsal)*	Toward or at the back of the body; behind		The heart is posterior to the breastbone.
Medial	Toward or at the midline of the body; on the inner side of		The heart is medial to the arm.
Lateral	Away from the midline of the body; on the outer side of		The arms are lateral to the chest.
Proximal	Closer to the origin of the body part or the point of attachment of a limb to the body trunk		The elbow is proximal to the wrist.
Distal	Farther from the origin of a body part or the point of attachment of a limb to the body trunk		The knee is distal to the thigh.
Superficial (external)	Toward or at the body surface		The skin is superficial to the skeletal muscles.
Deep (internal)	Away from the body surface; more internal		The lungs are deep to the skin.
Ipsilateral	On the same side		The right hand and right foot are ipsilateral.
Contralateral	On opposite sides		The right hand and left foot are contralateral.

*Whereas the terms *ventral* and *anterior* are synonymous in humans, this is not the case in four-legged animals. *Ventral* specifically refers to the "belly" of a vertebrate animal and thus is the inferior surface of four-legged animals. Likewise, although the dorsal and posterior surfaces are the same in humans, the term *dorsal* specifically refers to an animal's back. Thus, the dorsal surface of four-legged animals is their superior surface.

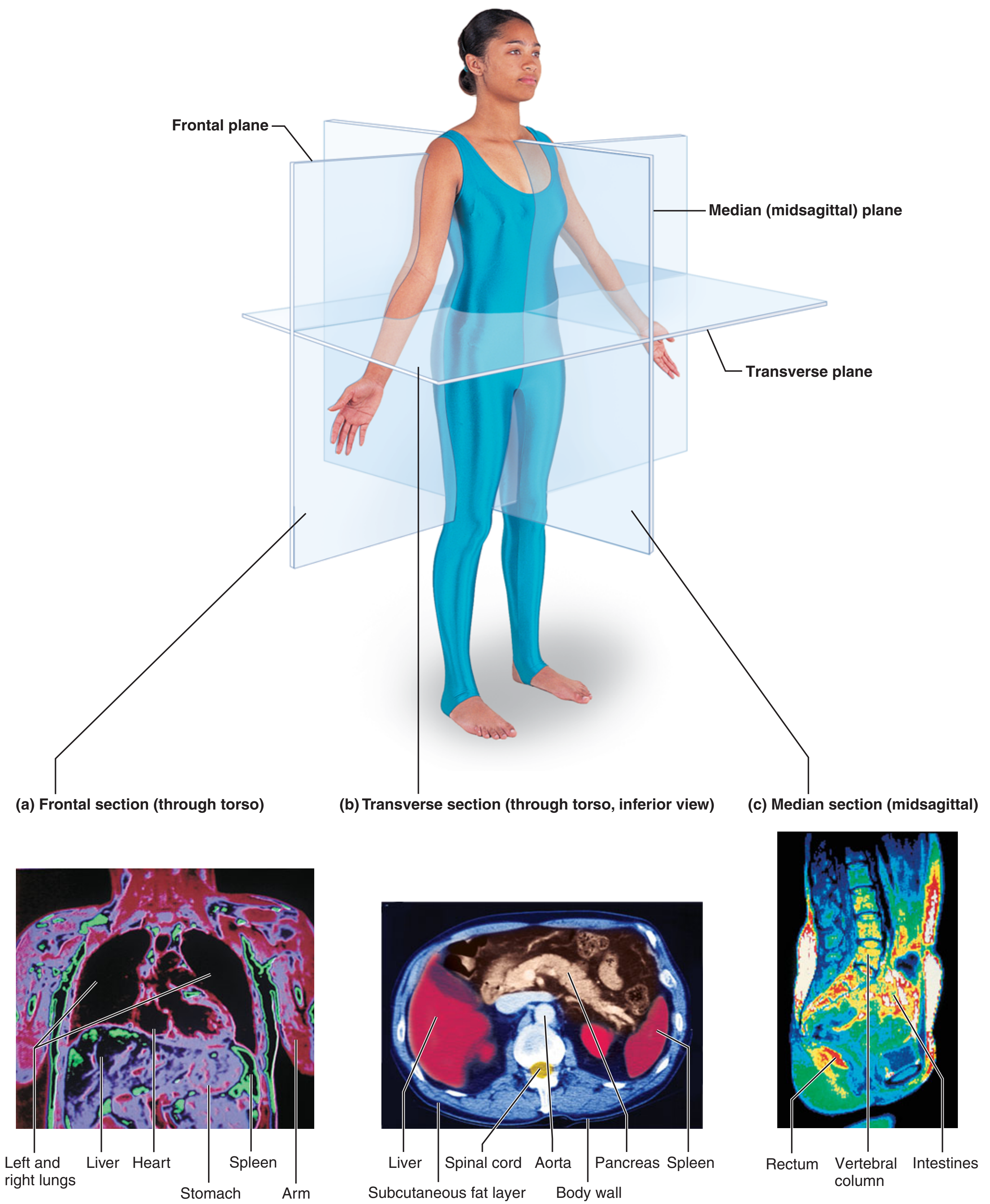


FIGURE 1.4 Planes of the body with corresponding magnetic resonance imaging (MRI) scans.

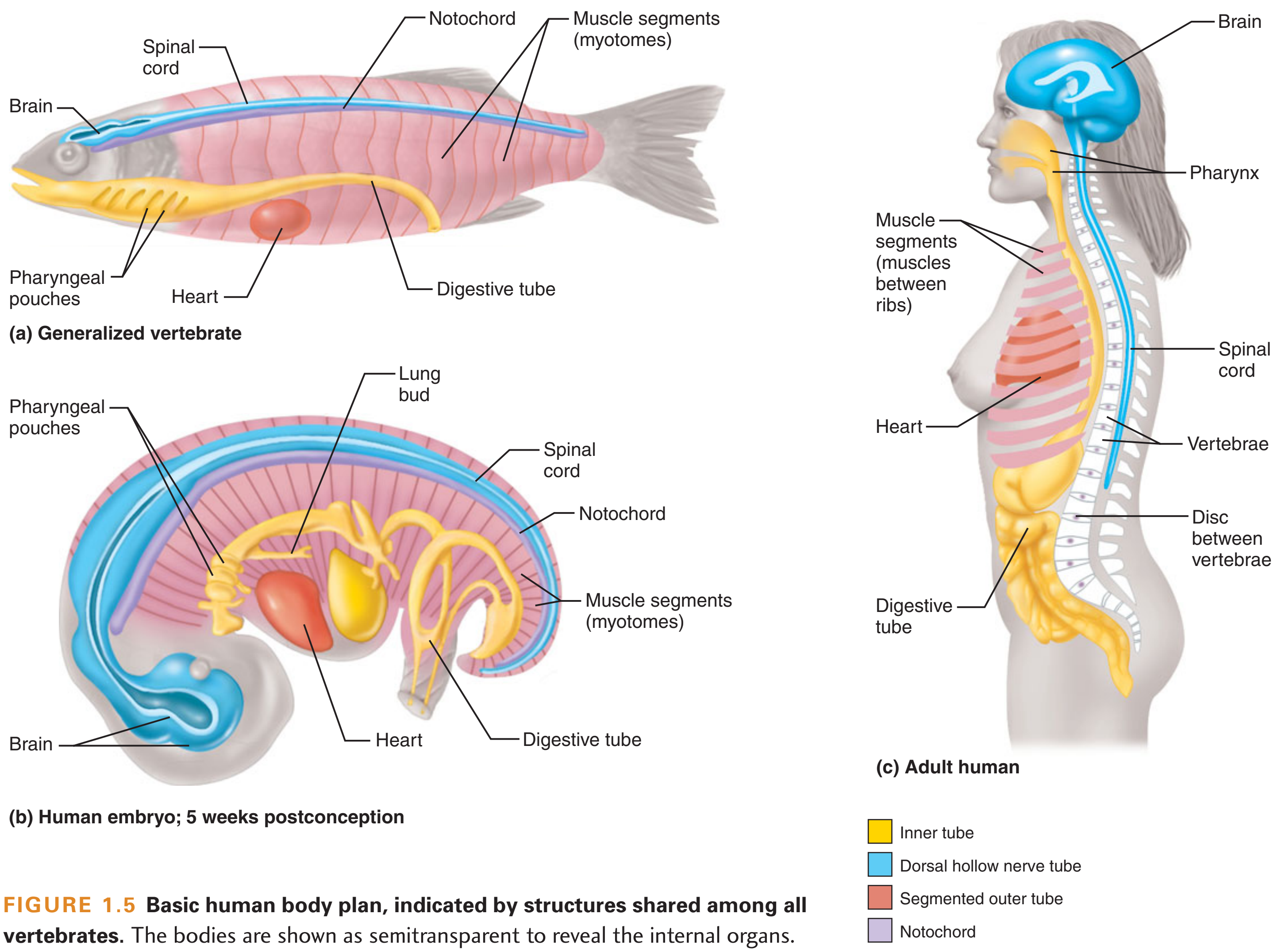


FIGURE 1.5 Basic human body plan, indicated by structures shared among all vertebrates. The bodies are shown as semitransparent to reveal the internal organs.

higher than usual, a nerve or vessel may be somewhat "out of place," or a small muscle may be missing. Such minor variations are unlikely to confuse you, however, because well over 90% of all structures present in any human body match the textbook descriptions. Extreme anatomical variations are seldom seen, because they are incompatible with life. For example, no living person could be missing the blood vessels to the brain.

The Human Body Plan

Humans belong to the group of animals called *vertebrates*. This group also includes cats, rats, birds, lizards, frogs, and fish. All vertebrates share the following basic features (Figure 1.5):

1. **Tube-within-a-tube body plan.** The inner tube extends from the mouth to the anus and includes the respiratory and digestive organs (yellow structures in Figure 1.5). The outer tube consists of the axial skeleton and associated axial muscles that make up the outer body wall, and nervous structures.
2. **Bilateral symmetry.** The left half of the body is essentially a mirror image of the right half. Most body structures, such as the right and left hands, eyes, and ovaries, occur in pairs. Structures in the median plane are unpaired, but they tend to have identical right and left sides (the nose is an example).
3. **Dorsal hollow nerve cord.** All vertebrate embryos have a hollow nerve cord running along their back in the median plane. This cord develops into the brain and spinal cord.
4. **Notochord and vertebrae.** The **notochord** (no′to-kord; "back string") is a stiffening rod in the back just deep to the spinal cord. In humans, a complete notochord forms in the embryo, although most of it is quickly replaced by the vertebrae (ver′tĕ-bre), the bony pieces of the vertebral column, or backbone. Still, some of the notochord persists throughout life as the cores of the discs between the vertebrae (see "nucleus pulposus," p. 169).
5. **Segmentation.** The "outer tube" of the body shows evidence of segmentation. Segments are repeating units of similar structure that run from the head along the full length of the trunk. In humans, the ribs and the muscles between the ribs are evidence of segmentation, as are the many nerves branching off the spinal cord. The bony

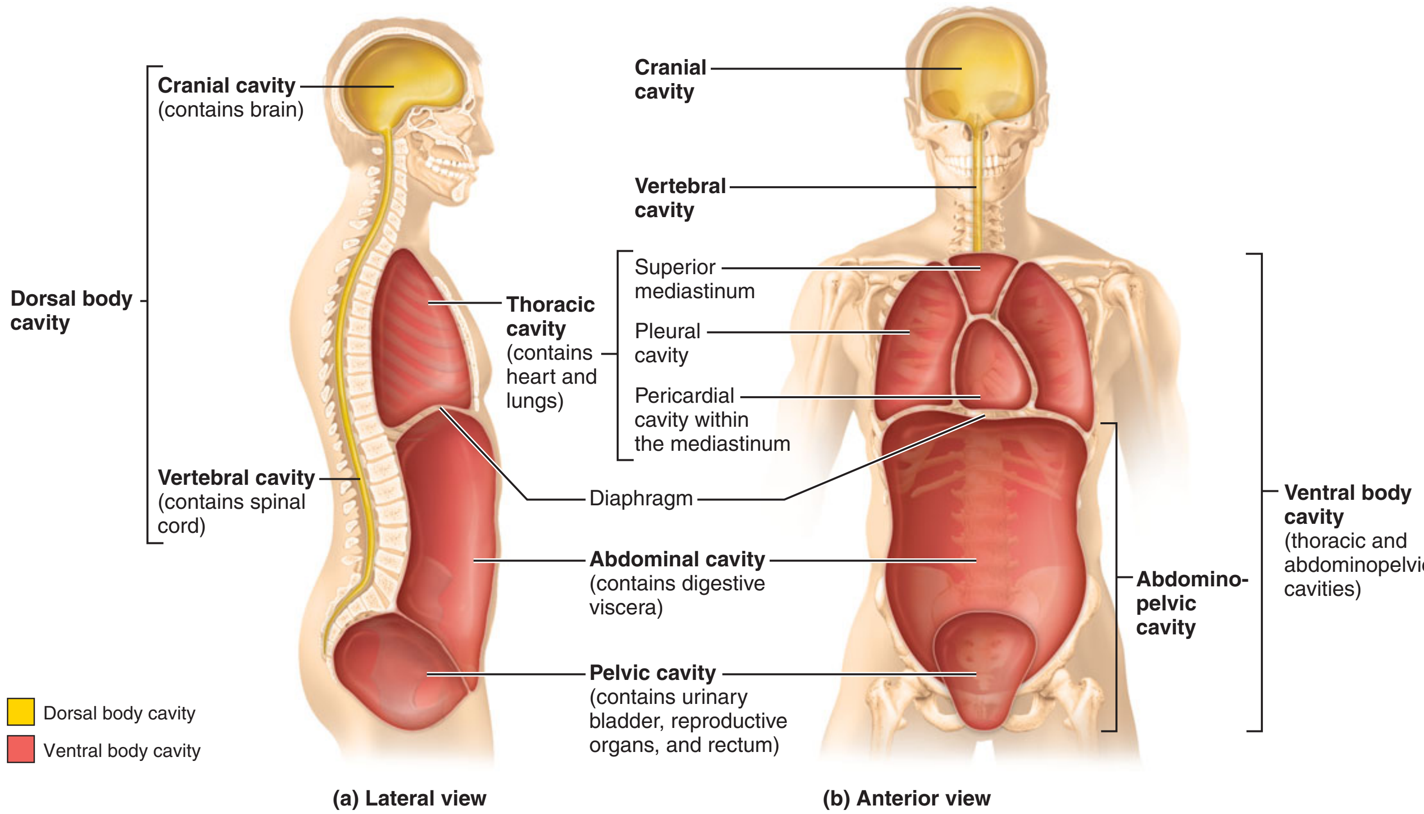


FIGURE 1.6 Dorsal and ventral body cavities and their subdivisions.

vertebral column, with its repeating vertebrae, is also segmented.

6. **Pharyngeal pouches.** Humans have a **pharynx** (far′-ingks), which is the throat region of the digestive and respiratory tube. In the embryonic stage, the human pharynx has a set of outpocketings called *pharyngeal* (far-rin′je-al) *pouches* that correspond to the clefts between the gills of fish. Such pouches give rise to some structures in the head and neck. An example is the middle ear cavity, which runs from the eardrum to the pharynx.

Body Cavities and Membranes

Within the body are two large cavities called the dorsal and ventral cavities (Figure 1.6). These are closed to the outside, and each contains internal organs. Think of them as filled cavities, like toy boxes containing toys.

Dorsal Body Cavity

The **dorsal body cavity** is subdivided into a **cranial cavity,** which lies in the skull and encases the brain, and a **vertebral cavity,** which runs through the vertebral column to enclose the spinal cord. The hard, bony walls of this cavity protect the contained organs.

Ventral Body Cavity

The more anterior and larger of the closed body cavities is the **ventral body cavity** (see Figure 1.6). The organs it contains, such as the lungs, heart, intestines, and kidneys, are called **visceral organs** or **viscera** (vis′er-ah). The ventral body cavity has two main divisions: (1) a superior **thoracic cavity,** surrounded by the ribs and the muscles of the chest wall; and (2) an inferior **abdominopelvic** (ab-dom″ĭ-no-pel′vic) **cavity** surrounded by the abdominal walls and pelvic girdle. The thoracic and abdominal cavities are separated from each other by the diaphragm, a dome-shaped muscle used in breathing.

The *thoracic cavity* has three parts: (a) two lateral parts, each containing a lung surrounded by a **pleural cavity** (ploo′ral; "the side, a rib"), and (b) a central band of organs called the **mediastinum** (me″de-ah-sti′num; "in the middle"). The mediastinum contains the heart surrounded by a **pericardial** (per″ĭ-kar′de-al; "around the heart") **cavity.** It also houses other major thoracic organs, such as the esophagus and trachea (windpipe).

The *abdominopelvic cavity* is divided into two parts. The superior part, called the **abdominal cavity,** contains the liver, stomach, kidneys, and other organs. The inferior part, or **pelvic cavity,** contains the bladder, some reproductive organs, and the rectum. These two parts are continuous with each other, not separated by any muscular or membranous partition. Many organs in the abdominopelvic cavity are surrounded by a **peritoneal** (per″ĭ-to-ne′al) **cavity.**

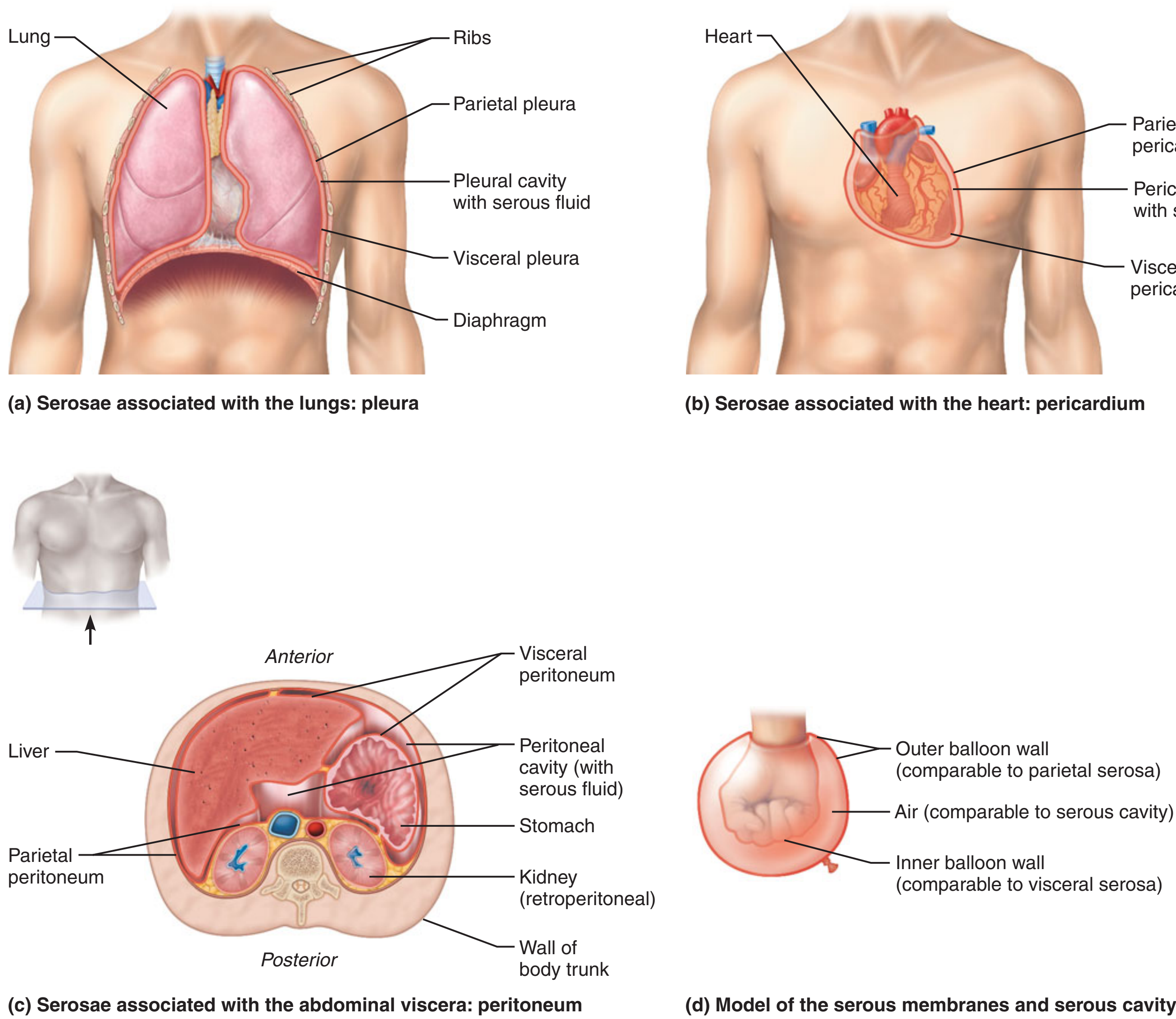


FIGURE 1.7 The serous cavities and their associated membranes.

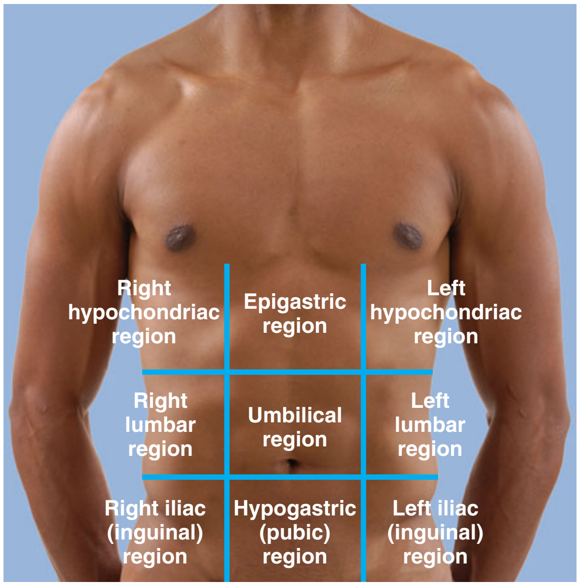
Serous Cavities

The previous section mentioned the *pleural cavity* around the lung, the *pericardial cavity* around the heart, and the *peritoneal cavity* around the viscera in the abdominopelvic cavity. As shown in **Figure 1.7**, each of these serous cavities is a slitlike space lined by a **serous** (se′rus) **membrane,** or **serosa** (se-ro′sah; plural, **serosae**). Indicated by the red lines in Figure 1.7, these serous membranes are named **pleura,** serous **pericardium,** and **peritoneum,** respectively. The part of a serosa that forms the outer wall of the cavity is called the **parietal** (pah-ri′ĕ-tal; "wall") **serosa.** The parietal serosa is continuous with the inner, **visceral serosa,** which covers the visceral organs. You can visualize this relationship by pushing your fist into a limp balloon (Figure 1.7d). The part of the balloon that clings to your fist represents the visceral serosa on the organ's (your fist's) outer surface, the outer wall of the balloon represents the parietal serosa, and the balloon's thin airspace represents the serous cavity itself. Serous cavities do not contain air, however, but a thin layer of **serous fluid** (*serous* = watery). This fluid is secreted by both serous membranes.

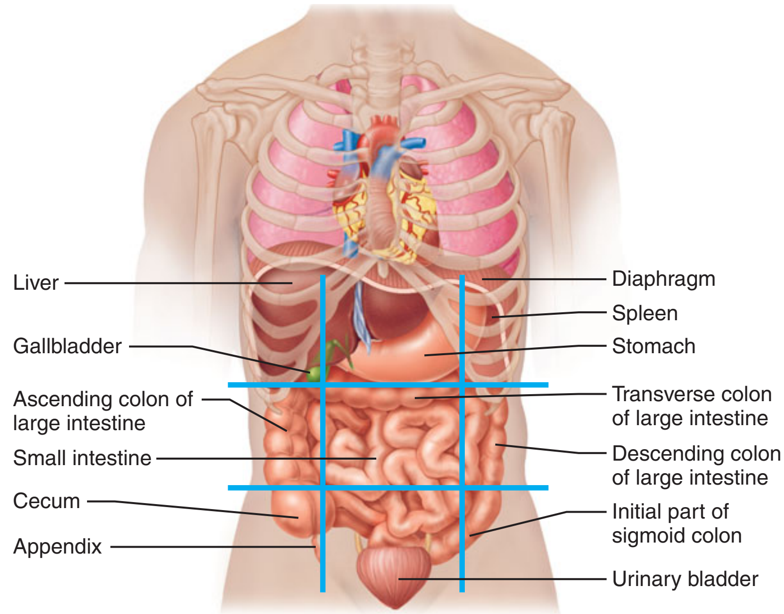
The slippery serous fluid allows the visceral organs to slide with little friction across the cavity walls as they carry out their routine functions. This freedom of movement is extremely important for organs that move or change shape, such as the pumping heart and the churning stomach.

Abdominal Regions and Quadrants

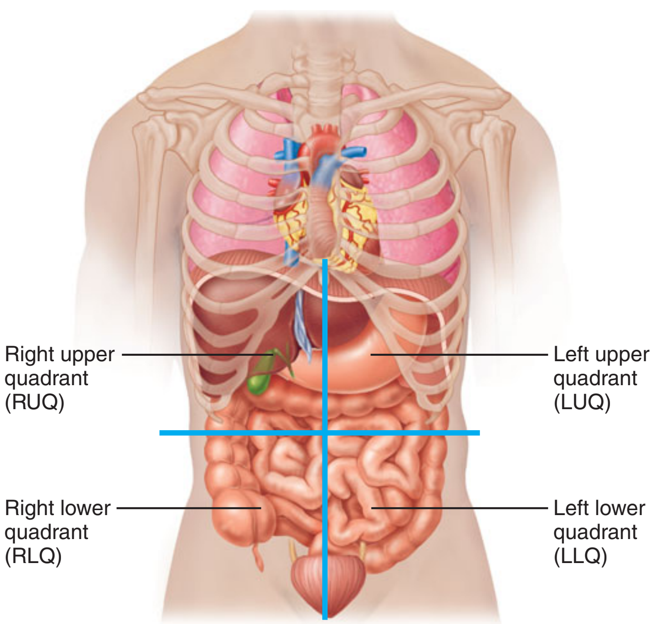
Because the abdominopelvic cavity is large and contains many organs, it is helpful to divide it into smaller areas for study. In one method of division, two transverse planes and two parasagittal planes divide the abdomen into nine **regions** **(Figure 1.8)**: the right and left hypochondriac regions, the epigastric region, the right and left lumbar regions, the umbilical region, the right and left iliac regions, and the hypogastric region. These nine regions are discussed in more detail in



(a) Nine regions delineated by four planes



(b) Anterior view of the nine regions showing the superficial organs



(c) The four abdominopelvic quadrants

FIGURE 1.8 Abdominal regions and quadrants. In **(a)**, the superior transverse plane is just inferior to the rib cage; the inferior transverse plane is near the top of the hip bones. The two parasagittal planes lie just medial to the nipples. In **(c)**, the two planes through the abdominopelvic cavity, one horizontal and one vertical, intersect at the navel.

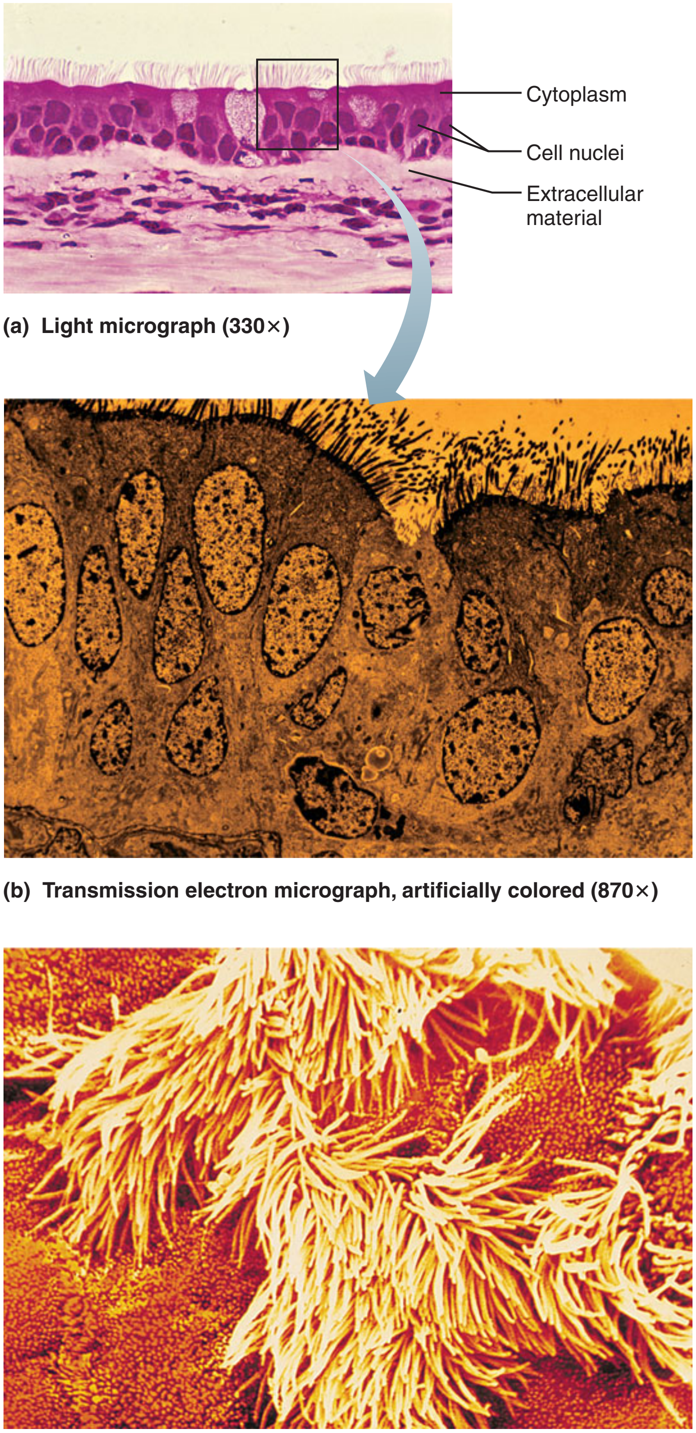
Chapter 23. For localizing organs in a more general way, an alternative scheme divides the abdomen into just four **quadrants** ("quarters") by drawing one vertical and one horizontal plane through the navel (Figure 1.8c). You can use Figure 1.8b and c to become familiar with the locations of some of the major viscera, such as the stomach, liver, and intestines.

The rib cage is commonly thought of as protection for the thoracic organs, but you can see from Figure 1.8b that the organs in the most superior part of the abdomen are also protected. The liver and the spleen, two blood-rich organs particularly vulnerable to injury, are protected by the surrounding rib cage on the right and left sides, respectively.

check your understanding

5. Use Figure 1.8 and the directional terms in Table 1.1 to describe the location of the liver in reference to the heart.
6. Which tube of the body shows evidence of segmentation, the outer tube or the inner tube?
7. What is the outer layer of serous membrane that lines the pleural cavity called?

For answers, see Appendix B.



(a) Light micrograph (330×)

(b) Transmission electron micrograph, artificially colored (870×)

(c) Scanning electron micrograph, artificially colored (2900×)

FIGURE 1.9 Cells viewed by three types of microscopy. **(a)** Light micrograph of ciliated epithelium. **(b)** Transmission electron micrograph showing enlarged area of the cell region that is indicated in the box in part (a). **(c)** Scanning electron micrograph: surface view of cells lining the trachea, or windpipe. The long, grasslike structures on the surfaces of these cells are cilia, and the tiny knoblike structures are microvilli (see Chapter 4, p. 76).

MICROSCOPIC ANATOMY: AN INTRODUCTION

- Explain how human tissue is prepared and examined for its microscopic structure.
- Distinguish tissue viewed by light microscopy from that viewed by electron microscopy.

Light and Electron Microscopy

Microscopy is the examination of small structures with a microscope. When microscopes were introduced in the early 1600s, they opened up a tiny new universe whose existence was unsuspected before that time. Two main types of microscopes are now used to investigate the fine structure of organs, tissues, and cells: the **light microscope (LM)** and the **transmission electron microscope (TEM** or just **EM).** Light microscopy illuminates body tissue with a beam of light, whereas electron microscopy uses a beam of electrons. LM is used for lower-magnification viewing; EM, for higher magnification (**Figure 1.9a** and **b**, respectively). Light microscopy can produce sharp, detailed images of tissues and cells, but not of the small structures within cells (organelles). A light microscope's *low resolution*—its inability to reveal small structures clearly—remains its basic limitation, despite technical advances that have greatly improved the quality of LM images. EM, by contrast, uses electron beams of much smaller wavelength to produce sharp images at much greater magnification, thus revealing the fine details of cells and tissues.

Elaborate steps are taken to prepare tissue for microscopic viewing. The specimen must be **fixed** (preserved) and then cut into **sections** (slices) thin enough to transmit light or electrons. Finally, the specimen must be **stained** to enhance contrast. The stains used in light microscopy are beautifully colored organic dyes, most of which were originally developed by clothing manufacturers in the mid-1800s (Figure 1.9a). These dyes helped to usher in the golden age of microscopic anatomy from 1860 to 1900. The stains come in almost all colors. Many consist of charged molecules (negative or positive molecules) of dye that bind within the tissue to macromolecules of the opposite charge. This electrical attraction is the basis of staining. Dyes with negatively charged molecules are called **acidic stains.** Positively charged dyes, by contrast, are called **basic stains.** Because different parts of cells and tissues take up different dyes, the stains distinguish the different anatomical structures.

One of the most commonly used histological stains is a combination of two dyes, hematoxylin and eosin (H&E stain). Hematoxylin is a basic stain that binds to the acidic structures of the cell (the nucleus, ribosomes, rough ER) and colors them a dark blue to purple hue. Eosin, an acidic stain, binds to basic cytoplasmic structures and extracellular components, coloring them red to pink. Many of the micrographs throughout this text show tissues stained with H&E. In Figure 1.9a, for example, the dark, almost black, spots are the cell nuclei, the cellular cytoplasm is magenta, and the extracellular material in the bottom half of the image is stained a lighter pink. A variety of other stains can be used to illuminate specific structures. Some of these stains create strikingly beautiful images of detailed histological structure.

For transmission electron microscopy, tissue sections are stained with heavy-metal salts. These metals deflect electrons in the beam to different extents, thus providing contrast in the image. Electron-microscope images contain only shades of gray because color is a property of light, not of electron waves. The image may be artificially colored to enhance contrast (Figure 1.9b).

Scanning Electron Microscopy

The types of microscopy introduced so far are used to view cells and tissue that have been sectioned. Another kind of electron microscopy, **scanning electron microscopy (SEM),** provides three-dimensional pictures of whole, unsectioned surfaces with striking clarity (Figure 1.9c). First, the specimen is preserved and coated with fine layers of carbon and gold dust. Then, an electron beam scans the specimen, causing other, secondary electrons to be emitted from its surface. A detector captures these emitted electrons and assembles them into a three-dimensional image on a video screen (cathode ray tube), based on the principle that more electrons are produced by the higher points on the specimen surface than by the lower points. Although artificially constructed, the SEM image is accurate and looks very real. Like all electron-microscopy images, the original is in black and white, although it can be colored artificially to highlight structural details (Figure 1.9c).

Artifacts

The preserved tissue seen under the microscope has been exposed to many procedures that alter its original condition. Because each preparatory step introduces minor distortions, called **artifacts,** most microscopic structures viewed by anatomists are not exactly like those in living tissue. Furthermore, the human and animal corpses studied in the anatomy laboratory have also been preserved, so their organs have a drabber color and a different texture from living organs. Keep these principles in mind as you look at the micrographs (pictures taken with a microscope) and the photos of human cadavers in this book.

check your understanding

8. In tissue stained with H&E stain, what color are the cellular nuclei?
9. Which type of microscopy produces detailed three-dimensional images of the surface features of a structure?

For answers, see Appendix B.

CLINICAL ANATOMY: AN INTRODUCTION TO MEDICAL IMAGING TECHNIQUES

➤ Describe the medical imaging techniques that are used to visualize structures inside the body.

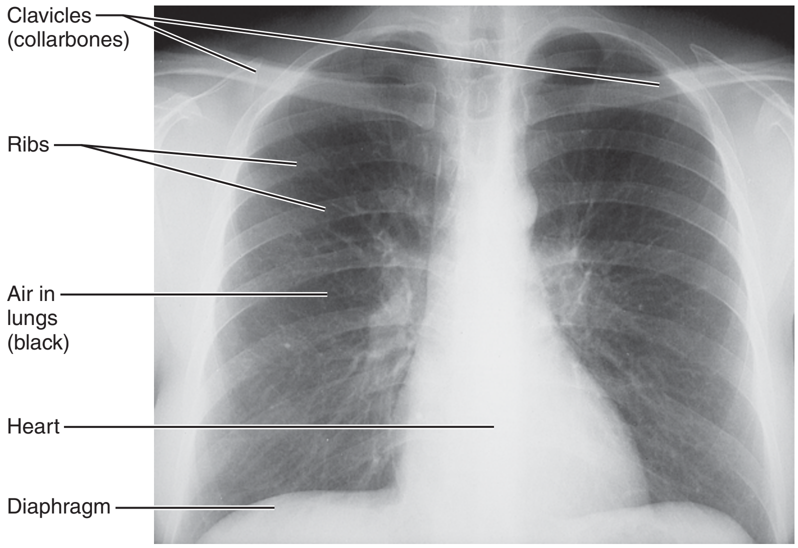
Physicians have long sought ways to examine the body's internal organs for evidence of disease without subjecting the patient to the risks of exploratory surgery. Physicians can identify some diseases and injuries by feeling the patient's deep organs through the skin or by using traditional X rays. Powerful new techniques for viewing the internal anatomy of living people continue to be developed. These imaging techniques not only reveal the structure of functioning internal organs but also can yield information about the workings of molecules. The new techniques all rely on powerful computers to construct images from raw data transmitted by electrical signals.

X-Ray Imaging

Before considering the new techniques, you need to understand traditional X-ray images, because these still play the major role in medical diagnosis **(Figure 1.10a)**. Discovered quite by accident in 1895 and used in medicine ever since, X rays are electromagnetic waves of very short wavelength. When X rays are directed at the body, some are absorbed. The amount of absorption depends on the density of the matter encountered. X rays that pass through the body expose a piece of film behind the patient. The resulting image (radiograph) is a negative: The darker, exposed areas on the film represent soft organs that are easily penetrated by X rays, whereas light, unexposed areas correspond to denser structures, such as bones, that absorb most X rays.

X-ray images are best for visualizing bones and for locating abnormal dense structures, such as some tumors and tuberculosis nodules in the lungs. Mammography ("breast image") uses low-dose X rays to screen for tumors in the breast (Figure 1.10b), and bone density scans use X rays of the lower back and hip to screen for osteoporosis ("porous bone"). X-ray examination of hollow soft tissue organs is enhanced by the use of a **contrast medium,** a liquid that contains atoms of a heavy element such as barium that absorb more passing X rays. The contrast medium is injected or ingested, depending on the structure to be examined, to fill organs of interest and allow better visualization of these soft tissue structures. The gastrointestinal ("stomach intestine") tract is commonly examined using this procedure (upper and lower GI imaging) to screen for ulcers or tumors.

In many instances, conventional X-ray images are very informative; however, conventional X-ray studies have several limitations that have prompted clinicians to seek more advanced imaging techniques. First, X-ray images, especially those of soft tissues, can be blurry. Second, conventional X-ray images flatten three-dimensional body structures into two dimensions. Consequently, organs appear stacked one on top of another. Even more problematic, denser organs block the



(a) Radiograph of the chest

(b) Mammogram (cancerous tumor at arrow)

FIGURE 1.10 X-ray images.

less dense organs that lie in the same path. For improved images, particularly of soft tissues, clinicians use computer-assisted imaging techniques that produce sectional images of the body's interior.

Advanced X-Ray Techniques

Computed Tomography

One of the more useful modern imaging techniques is a refined X-ray technology called **computed tomography (CT),** or **computed axial tomography (CAT)** (Figure 1.11). A CT scanner is shaped like a square metal nut (as in "nuts and bolts") standing on its side. The patient lies in the central hole, situated between an X-ray tube and a recorder, both of which are in the scanner. The tube and recorder rotate to take about 12 successive X-ray images around the person's full circumference. Because the fan-shaped X-ray beam is thin, all pictures are confined to a single transverse body plane about 0.3 cm thick. This explains the term *axial tomography,* which literally means "pictures of transverse sections taken along the body axis." Information is obtained from all around the circumference so that every organ is recorded from its best angle, with the fewest structures blocking it. The computer translates all the recorded information into a detailed picture of the body section, which it displays on a viewing screen. CT produces superb images of soft tissue as well as of bone and blood vessels. CT is a fast and relatively inexpensive test. It can be used quickly and readily in trauma situations to assess internal injury. CT does use X rays to produce images, so it does pose some, although minimal, concern about radiation exposure. CT is less useful for nervous tissue structures and for joint images, particularly the knee and shoulder, because bone can obscure the joint details. However, because it is less costly than magnetic resonance imaging (MRI, described on p. 18), and its use less restrictive, CT is an essential diagnostic tool for clinicians.

Angiography

Angiography ("vessel image") is a technique that produces images of blood vessels. A contrast medium is injected into a vessel and distributed via the vascular system. Images of the vessels of interest are recorded using either conventional radiography or a digitally assisted imaging technique such as a CT scan or an MRI. The contrast medium highlights the vessel structure and allows for clear visualization of blood vessels. This procedure is used for diagnosing aneurisms (ballooning out of a vessel due to weakening of the vessel wall) and atherosclerosis (narrowing of blood vessels due to the buildup of fatty plaques) and for identifying a source of internal bleeding.

An extension of angiography, **digital subtraction angiography (DSA)** provides an unobstructed view of small arteries (Figure 1.12). In this procedure, images of the vessel are taken before and after the injection of contrast medium. The computer subtracts the "before" image from the "after" image, eliminating all traces of body structures that obscure the vessel. DSA is often used to identify blockage of the arteries that supply the heart wall and the brain.

Positron Emission Tomography

Positron emission tomography (PET) (Figure 1.13) is an advanced procedure that produces images by detecting radioactive isotopes injected into the body. The special advantage of PET is that its images indicate regions of cellular activity. For example, radioactively tagged sugar or water molecules are injected into the bloodstream and traced to the body areas that take them up in the greatest quantity. This procedure identifies the body's most active cells and pinpoints the body regions that receive the greatest supply of blood. As the radioactive material decays, it gives off energy in the form of gamma rays. Sensors within the doughnut-

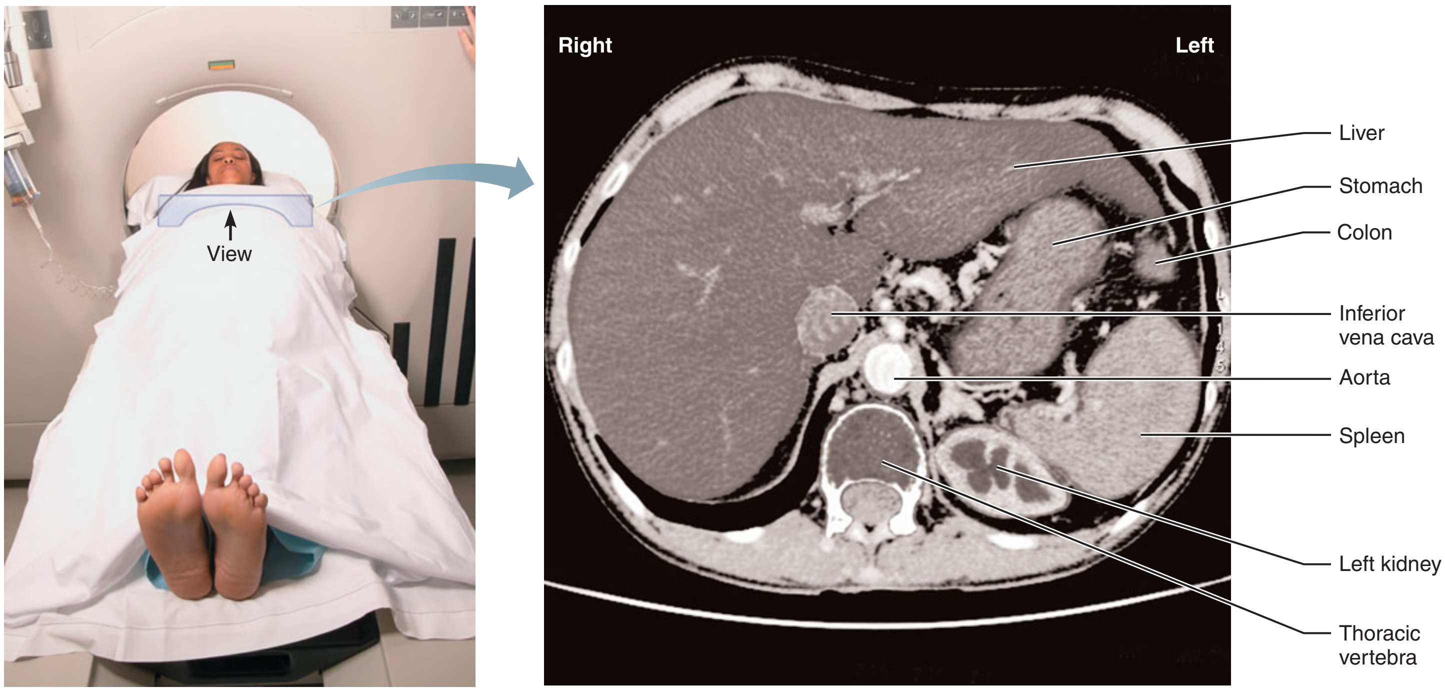


FIGURE 1.11 Computed tomography (CT). CT scan through the upper abdomen. CT sections are conventionally oriented as if viewed from an inferior direction, with the posterior surface of the body directed toward the inferior part of the picture; therefore, the patient's right side is at the left side of the picture.

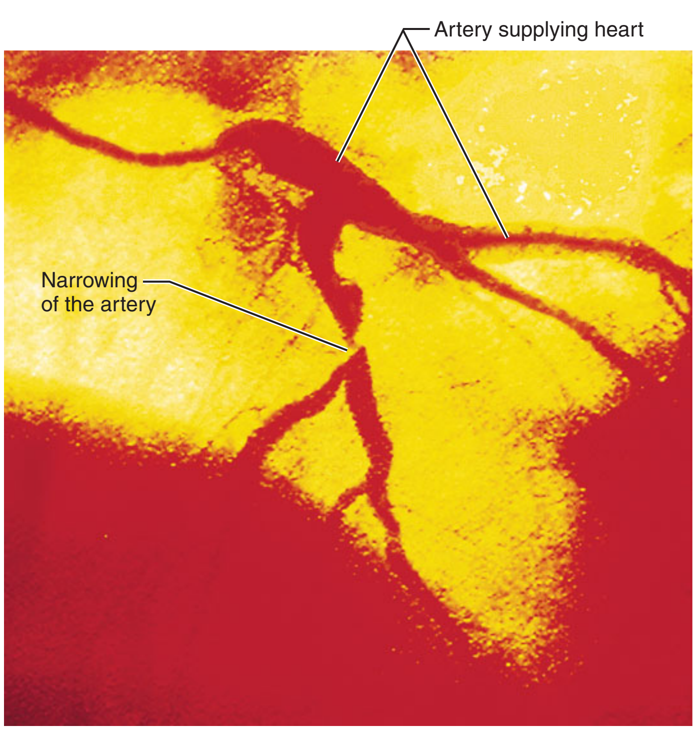


FIGURE 1.12 Digital subtraction angiography (DSA). A DSA image of the arteries that supply the heart.

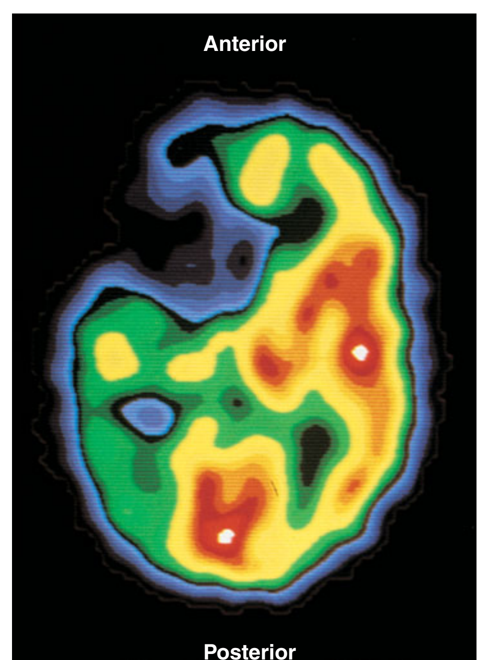


FIGURE 1.13 Positron emission tomography (PET). A PET scan of the brain, in transverse section, shows an area with no neural activity (the frontal region of the brain at upper left). This area was destroyed by a stroke.

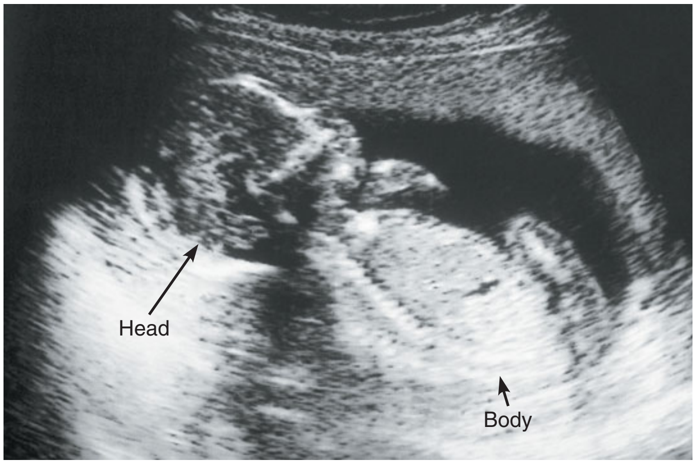


FIGURE 1.14 Ultrasound image of a fetus in the uterus.

shaped scanner pick up the emitted gamma rays, which are translated into electrical impulses and sent to the computer. A picture of the isotope's location is then constructed on the viewing screen in vivid colors (Figure 1.13).

PET is used to assess the functional flow of blood to the heart and brain. By mapping increases in blood flow, it can depict which areas of the normal brain are most active during certain tasks (speech, seeing, comprehension), thereby providing direct evidence for the functions of specific brain regions. The resolution of a PET image is low, however, and the image takes a relatively long time to form, so PET cannot record fast changes in brain activity. PET is gradually being eclipsed by functional MRI.

Sonography

In **sonography,** or **ultrasound imaging** (Figure 1.14), the body is probed with pulses of high-frequency (ultrasonic) sound waves that reflect (echo) off the body's tissues. A computer analyzes the echoes to construct sectional images of the outlines of organs. A handheld device that looks something like a microphone emits the sound and picks up the echoes. The device is moved across the surface of the body, allowing organs to be examined from many different body planes.

Sonography has two distinct advantages over other imaging techniques. First, the equipment is relatively inexpensive. Second, ultrasound seems to be safer than ionizing forms of radiation, with fewer harmful effects on living tissues.

Because of its apparent safety, ultrasound is the imaging technique of choice for determining the age and health of a developing fetus. It is also used to visualize the gallbladder and other viscera and, increasingly, the arteries to detect atherosclerosis (thickening and hardening of the arterial walls).

Ultrasound images are somewhat blurry, although their sharpness is being improved by using higher-frequency sound waves. Liquid contrast media containing sound-reflecting bubbles can be injected into the bloodstream to better reveal the vessels and heart. Sonography is of little value for viewing air-filled structures (lungs) or structures surrounded by bone (brain and spinal cord) because sound waves do not penetrate hard objects well and rapidly dissipate in air. However, special gases that do reflect sound are beginning to be used. When breathed into the lungs, the gases yield improved images.

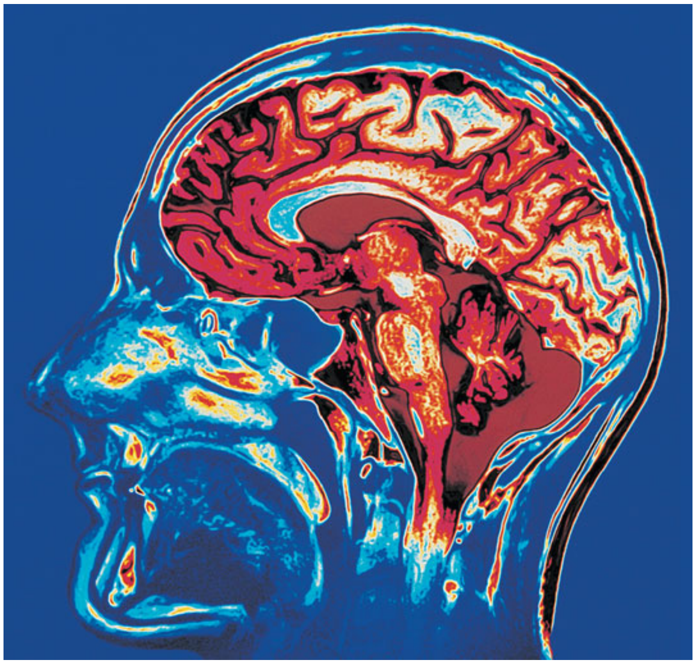
Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is a technique with tremendous appeal because it produces high-contrast images of soft tissues (Figure 1.15), an area in which X-ray imaging is weak. MRI also does not use radiation for generating an image. MRI primarily detects the levels of the element hydrogen in the body, most of which is in water. Thus, MRI tends to distinguish body tissues from one another on the basis of differences in water content. For example, MRI can distinguish the fatty white matter from the more watery gray matter of the brain. Because bones contain less water than other tissues do, they don't show up at all. For this reason, MRI peers easily through the skull to reveal the brain. The joints are also visualized well. Many tumors show up distinctly, and MRI has even revealed brain tumors missed by direct observation during exploratory surgery.

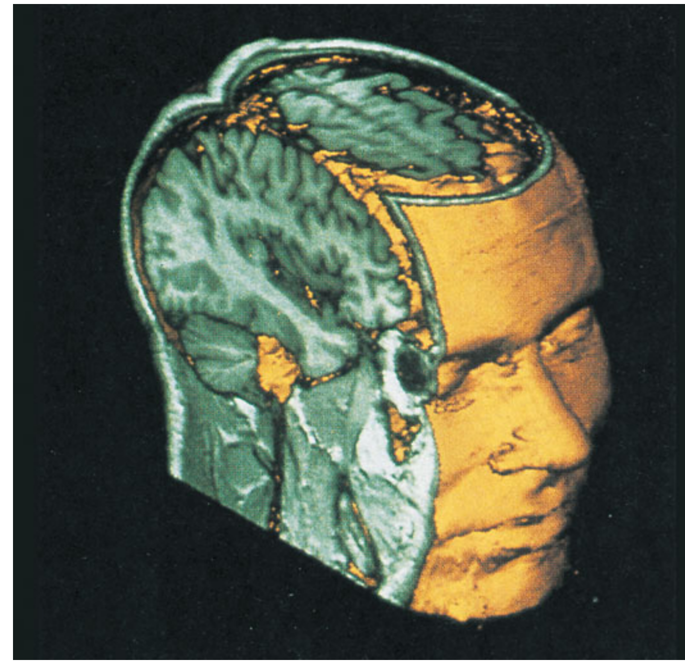
The technique subjects the patient to magnetic fields up to 60,000 times stronger than that of the earth. The patient lies in a chamber, with his or her body surrounded by a huge magnet. When the magnet is turned on, the nuclei of the body's hydrogen atoms—single protons that spin like tops—line up parallel to the strong magnetic field. The patient is then exposed to a brief pulse of radio waves just below the frequency of FM radio, which knock the spinning protons out of alignment. When the radio waves are turned off, the protons return to their alignment in the magnetic field, emitting their own faint radio waves in the process. Sensors detect these waves, and the computer translates them into images. With the use of advanced volume-rendering techniques, multiple MRI scans can be assembled into three-dimensional reconstructions (Figure 1.15b). The images produced are dramatic views into the body's organs.

In the early 1990s, MRI technology leaped forward with the development of **functional MRI (fMRI).** This technique measures blood oxygen, so it reveals the amount of oxygenated blood flowing to specific body regions. It can therefore show which parts of the brain are active during various mental tasks. Functional MRI can pinpoint much smaller brain areas than PET can, works faster, and requires no messy radioactive tracers. For these reasons, it is replacing PET in the study of brain function.

Despite the advantages of MRI, there are limitations to its use. MRI does not use X rays, so it poses no concern about radiation exposure; however, the large magnets can cause implanted metallic devices to malfunction. MRIs require a longer time to produce an image than a CT scan, and medical devices, such as traction or life support equipment, cannot be used during MRI imaging. For these reasons, MRI is not use-



(a) MRI of the head; sagittal section, artificially colored



(b) Volume rendering of an MRI of the head

FIGURE 1.15 Magnetic resonance image (MRI). The flat surfaces in **(b)** show the original MRI data.

ful in trauma situations. MRI is also more sensitive to patient movement during the scan, and it does not visualize bone or other tissues with low water content.

In conclusion, the images formed by computerized imaging techniques can be quite stunning. Keep in mind, however, that the images are abstractions assembled within a computer. They are artificially enhanced for sharpness and artificially colored to increase contrast or to highlight areas of interest. Although computer-based images are not inaccurate, they are several steps removed from direct visual observation.

check your understanding

10. What imaging technique is best suited for each of the clinical situations described? (a) Examining gallbladder for possible gallstones in response to a patient's complaints of sharp pain in the right hypochondriac region of the abdomen; (b) ruling out a broken bone in a patient complaining of wrist and forearm pain; (c) examining of the knee of a patient complaining of persistent pain following an injury on the athletic field; (d) assessing possible damage to abdominal viscera resulting from a car accident.

For answers, see Appendix B.

CHAPTER SUMMARY

An Overview of Anatomy (pp. 2–6)

1. Anatomy is the study of body structure. In this book, structures are considered in terms of their function.

Branches of Anatomy (p. 2)

2. Branches of anatomy include gross anatomy, microscopic anatomy (histology), and developmental anatomy.

Anatomical Terminology (p. 3)

3. Because most structures in the body have formal Greek and Latin names, learning the meaning of word roots will help you understand anatomy.

The Hierarchy of Structural Organization (pp. 3–6)

4. The levels of structural organization of the body, from simplest to most complex, are chemical, cellular, tissue, organ, organ system, and the human organism itself.

5. The organ systems in the body are the integumentary (skin), skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, immune, respiratory, digestive, urinary, and reproductive systems.

Scale: Length, Volume, and Weight (p. 6)

6. Important units of length measurement are meters (m) for the organism, centimeters (cm) for the organs, and micrometers (μm) for cells. For other units of size, see Appendix A.

Gross Anatomy: An Introduction (pp. 6–13)

Regional and Directional Terms (p. 6)

7. In the adult anatomical position, the body stands erect, facing forward with legs together. The arms are at the sides, with the palms forward.

8. Regional terms are used to designate specific areas of the body (see Figure 1.3).

9. Directional terms allow anatomists to describe the location of body structures with precision. Important terms include superior/inferior; anterior/posterior (or ventral/dorsal); medial/lateral; proximal/distal; and superficial/deep (see Table 1.1).

Body Planes and Sections (pp. 6–7)

10. The body or its organs may be cut along planes to produce different types of sections. Frequently used are sagittal, frontal, and transverse planes.

The Human Body Plan (pp. 10–11)

11. The basic structures we share with all other vertebrate animals are the tube-within-a-tube body plan, bilateral symmetry, a dorsal hollow nerve cord, notochord and vertebrae, segmentation, and pharyngeal pouches.

Body Cavities and Membranes (pp. 11–12)

12. The body contains two major closed cavities: the dorsal cavity, subdivided into the cranial and vertebral cavities; and the ventral body cavity, subdivided into the thoracic and abdominopelvic cavities.

13. Within the ventral cavity are the visceral organs (such as the heart, lungs, intestines, and kidneys) and three serous cavities: pleural, pericardial, and peritoneal cavities. These slitlike cavities are lined by thin membranes, the parietal and visceral serosae (see Figure 1.7). The serosae produce a thin layer of lubricating fluid that decreases friction between moving organs.

Abdominal Regions and Quadrants (pp. 12–13)

14. To map the visceral organs in the abdominopelvic cavity, clinicians divide the abdomen into nine regions or four quadrants.

Microscopic Anatomy: An Introduction (pp. 14–15)

Light and Electron Microscopy (pp. 14–15)

15. To illuminate cells and tissues, the light microscope (LM) uses light beams and the transmission electron microscope (TEM or EM) uses electron beams. EM produces sharper images than LM at higher magnification.

16. The preparation of tissues for microscopy involves preservation (fixation), sectioning, and staining. Stains for LM are colored dyes, whereas stains for TEM are heavy-metal salts.

Scanning Electron Microscopy (p. 15)

17. Scanning electron microscopy (SEM) provides sharp, three-dimensional images at high magnification.

Clinical Anatomy: An Introduction to Medical Imaging Techniques (pp. 15–19)

X-Ray Imaging (pp. 15–16)

18. In conventional radiographs, X rays are used to produce negative images of internal body structures. Denser structures in the body appear lighter (whiter) on the X-ray film.

Advanced X-Ray Techniques (p. 16)

19. Computed tomography (CT) produces improved X-ray images that are taken in cross section to avoid overlapping images of adjacent organs and computer enhanced for clarity. Angiography produces sharp X-ray images of blood vessels injected with a contrast medium.

Positron Emission Tomography (PET) (pp. 16–18)

20. PET tracks radioisotopes in the body, locating areas of high energy consumption and high blood flow.

Sonography (p. 18)

21. Ultrasonography provides sonar images of developing fetuses and internal body structures.

Magnetic Resonance Imaging (pp. 18–19)

22. MRI subjects the body to strong magnetic fields and radio waves, producing high-contrast images of soft body structures.

REVIEW QUESTIONS

Multiple Choice/Matching Questions

For answers, see Appendix B.

1. The correct sequence of levels forming the body's structural hierarchy is (a) organ, organ system, cellular, chemical, tissue; (b) chemical, tissue, cellular, organismal, organ, organ system; (c) chemical, cellular, tissue, organ, organ system, organismal; (d) organismal, organ system, organ, chemical, cellular, tissue.

2. Using what you learned about scale in this chapter, choose one of the values in Column B as an appropriate height or diameter for each object listed in Column A.

Column A	Column B
____ **(1)** white blood cell	**(a)** 2 m
____ **(2)** stomach	**(b)** 25 cm
____ **(3)** professional basketball player	**(c)** 1 micrometer
	(d) 10 micrometers

3. Using the terms listed below, fill in the blank with the proper term.

anterior	superior	medial	proximal	superficial
posterior	inferior	lateral	distal	deep

(a) The heart is located ____ to the diaphragm.

(b) The muscles are ____ to the skin.

(c) The shoulder is ____ to the elbow.

(d) In anatomical position, the thumb is ____ to the index finger.

(e) The vertebral region is ____ to the scapular region.

(f) The gluteal region is located on the ____ surface of the body.

(g) The hip bone is ____ to the navel.

(h) The nose is ____ to the chin.

(i) The toes are ____ to the heel.

(j) The scalp is ____ to the skull.

4. Match each anatomical term for body regions listed in column B with the common name listed in column A.

Column A	Column B
____ **(1)** armpit	**(a)** inguinal
____ **(2)** buttocks	**(b)** frontal
____ **(3)** back	**(c)** dorsal
____ **(4)** shoulder blade	**(d)** axilla
____ **(5)** front of elbow	**(e)** lumbar
____ **(6)** hand	**(f)** gluteal
____ **(7)** groin	**(g)** antecubital
____ **(8)** forehead	**(h)** plantar
____ **(9)** lower back	**(i)** manus
____ **(10)** sole of foot	**(j)** scapular

5. Which of these organs would not be cut by a section through the midsagittal plane of the body? (Hint: See Figure 1.8) (a) urinary bladder, (b) gallbladder, (c) small intestine, (d) heart.

6. State whether each structure listed below is part of the inner tube (I) or outer tube (O).

____ **(1)** intestines
____ **(2)** lungs
____ **(3)** ribs
____ **(4)** backbone (vertebra)
____ **(5)** abdominal muscles
____ **(6)** esophagus
____ **(7)** spinal cord

7. Indicate whether each of the following conditions or statements applies to the dorsal body cavity (D) or the ventral body cavity (V).

____ **(1)** surrounded by the skull and the vertebral column
____ **(2)** includes the thoracic and abdominopelvic cavities
____ **(3)** contains the brain and spinal cord
____ **(4)** located more anteriorly
____ **(5)** contains the heart, lungs, and many digestive organs

8. Radiographs. List the following structures, from darkest (black) to lightest (white), as they would appear on an X-ray film. Number the darkest one 1, the next darkest 2, and so on.

____ **(a)** soft tissue
____ **(b)** femur (bone of the thigh)
____ **(c)** air in lungs
____ **(d)** gold (metal) filling in a tooth

9. The ventral surface of the body is the same as its ____ surface. (a) medial, (b) superior, (c) superficial, (d) anterior, (e) distal.

10. Match each serous membrane in column B with its description in column A.

Column A	Column B
____ **(1)** covers the surface of the heart	**(a)** parietal pericardium
____ **(2)** forms the outer lining of the pericardium	**(b)** parietal pleura
____ **(3)** lines the wall of the thoracic cavity	**(c)** visceral pericardium
____ **(4)** covers the outer surface of the small intestine	**(d)** visceral peritoneum

11. Which microscopic technique provides sharp pictures of three-dimensional structures at high magnification? (a) light microscopy, (b) X-ray microscopy, (c) scanning electron microscopy, (d) transmission electron microscopy.

12. Histology is the same as (a) pathological anatomy, (b) ultrastructure, (c) functional morphology, (d) surface anatomy, (e) microscopic anatomy.

Short Answer Essay Questions

13. Describe the anatomical position, and then assume this position.

14. Identify the organ system that each group of organs listed here is part of:
(a) thymus, thyroid, ovary, pancreas
(b) nasal cavity, larynx, bronchi, lungs
(c) kidney, ureter, urethra

15. (a) Define bilateral symmetry. (b) Although many body structures are bilaterally symmetrical, much of the *abdomen* is not. Find a picture that demonstrates this lack of symmetry, and name some abdominal organs that are not symmetrical.

16. The following advanced imaging techniques are discussed in the text: CT, angiography, PET, sonography, and MRI. (a) Which of these techniques uses X rays? (b) Which uses radio waves and magnetic fields? (c) Which uses radioactive isotopes? (d) Which displays body regions in sections? You may have more than one answer to each question.

17. Give the formal regional term for each of these body areas: (a) arm, (b) chest, (c) thigh, (d) navel, (e) limbs.

18. Look ahead in this book to Figure 4.3 (pp. 68–71). Do you think that the micrographs in the figure are viewed by light microscopy, transmission electron microscopy, or scanning electron microscopy? Please explain your answer as fully as possible.

19. Construct sentences that use the following directional terms: superior/inferior; dorsal/ventral; medial/lateral; and superficial/deep. Table 1.1 gives examples such as "The forehead is superior to the nose," but please use different examples from those in the table. For ideas, look at whole-body diagrams that show many structures, such as Figures 1.3 and 1.8.

20. The main cavities of the body include the abdominal and pelvic cavities. List three organs in each of these cavities.

21. Where would you be injured if you pulled a muscle in your axillary region, cracked a bone in your occipital region, or received a cut on a digit?

22. (a) The human body is designed as a tube within a tube. List three organs that are part of the inner tube and three structures that are components of the outer tube. (b) Give an example of segmentation in the human body.

CRITICAL REASONING & CLINICAL APPLICATION QUESTIONS

1. Dominic's doctors strongly suspect he has a tumor in his brain. Which of the following medical imaging techniques—conventional X-ray imaging, angiography, PET, sonography, or MRI—would probably be best for precisely locating the tumor?

2. The Nguyen family was traveling in their van and had a minor accident. The children in the back seat were wearing lap belts, but they still sustained bruises around the abdomen and had some internal injuries. Why is the abdominal area more vulnerable to damage than others?

3. A patient had a hernia in his inguinal region, pain from an infected kidney in his lumbar region, and hemorrhoids in his perineal region. Explain where each of these regions is located.

4. A woman fell off a motorcycle. She tore a nerve in her axillary region, and she broke bones in her coxal, sacral, acromial, and fibular regions. Explain where each of these regions is located.

5. New anatomy students often mix up the terms *spinal cord, spinal column,* and *spine.* Look up these words in the index of this book or in a medical dictionary, define each one, and explain whether they are the same or different.

6. Using the list of word roots located in the inside covers of the text: (1) Look up the meaning of each root listed below. (2) Identify one anatomical term used in this chapter that is derived from each root. (3) Define the anatomical term from your knowledge of the meaning of the word root.

super- , contra- , para- , ante- , mamm- , epi- , peri- , -graph , trans-