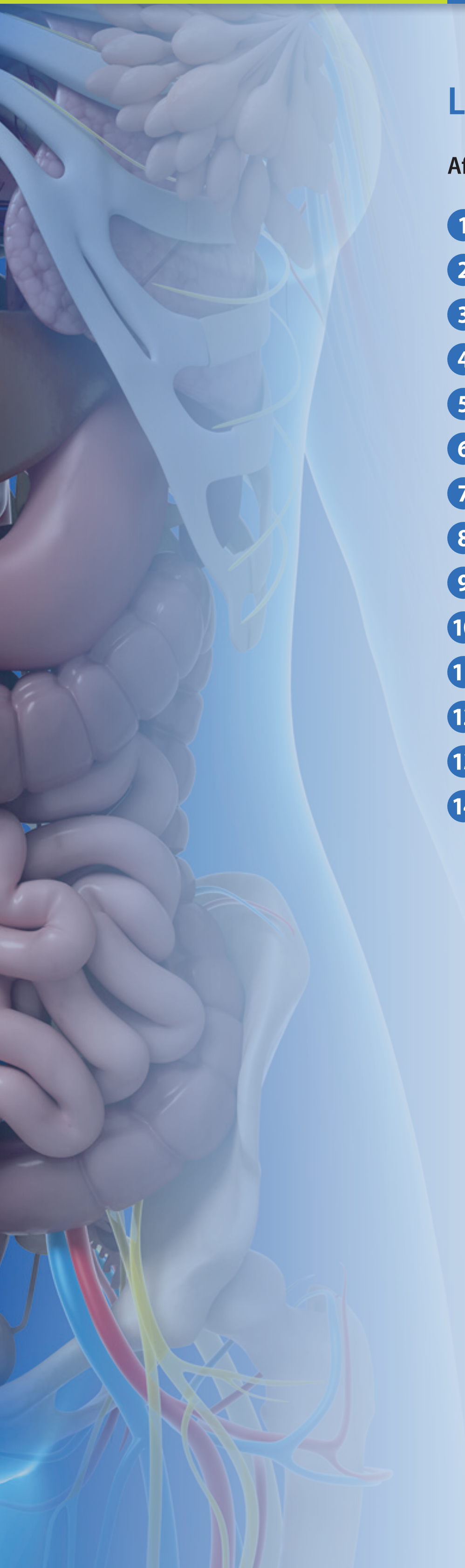
UNIT I

The Body as a Whole

CHAPTER 1

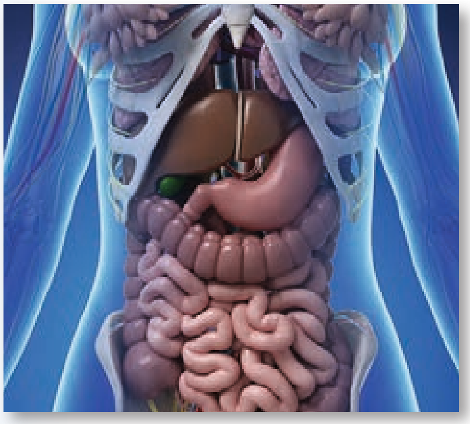
Organization of the Human Body

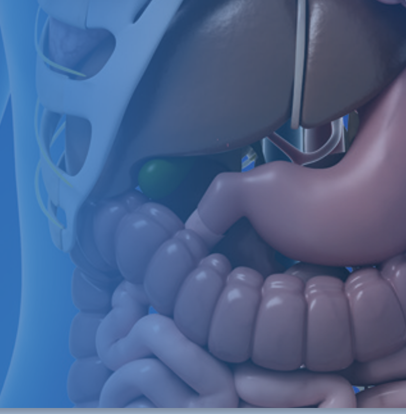


Learning Objectives

After careful study of this chapter, you should be able to:

1. Define the terms *anatomy* and *physiology*. ***p. 4***
2. Describe the organization of the body from chemicals to the whole organism. ***p. 4***
3. List 11 body systems, and give the general function of each. ***p. 4***
4. Define and give examples of homeostasis. ***p. 5***
5. Using examples, discuss the components of a negative feedback loop. ***p. 6***
6. Explain the importance of barriers in the body, and give several examples of barriers. ***p. 7***
7. Define a gradient, and explain the effect of resistance on flow down a gradient. ***p. 8***
8. List and define the main directional terms for the body. ***p. 9***
9. List and define the three planes of division of the body. ***p. 10***
10. Name the subdivisions of the dorsal and ventral cavities. ***p. 12***
11. Name and locate the subdivisions of the abdomen. ***p. 13***
12. Cite some anterior and posterior body regions along with their common names. ***p. 14***
13. Find examples of anatomic and physiologic terms in the case study. ***pp. 3, 15***
14. Show how word parts are used to build words related to the body's organization (see Word Anatomy at the end of the chapter). ***p. 17***





A & P in Action
Mike's Case: Emergency Care and Possible System Failure

"Location—Belle Grove Road. Single MVA. Male. Early 20s. Fire and police on scene," crackled the radio. "Medic 12. Respond channel 2."

"Medic 12 responding. En route to Belle Grove Road," Ed radioed back, while his partner, Samantha, flipped the switch for the lights and siren and hit the accelerator. When they arrived at the scene, police officers were directing traffic, and a fire crew was at work on the vehicle. Samantha parked the ambulance just as the crew breached the door of the crumpled minivan. Samantha and Ed grabbed their trauma bags and approached the wreck.

Ed bent down toward the injured man. "I hear your name is Mike. Mine is Ed. I'm a paramedic. My partner and I are going to take a quick look at you and then get you out of here." Samantha and Ed carefully immobilized Mike's cervical spine and with the help of the fire crew, transferred him to a stretcher. They immediately checked his blood pressure, pulse rate, and blood oxygen content. Samantha placed an oxygen mask over Mike's nose and mouth and watched to verify that he continued to breathe regularly.

After asking Mike if he was alone at the time of the crash, Samantha inspected the vehicle. "Looks like the impact sent him up and over the steering wheel. Guessing from the cracked windshield, he may have a head injury. The steering column is bent, so I wouldn't rule out thoracic or abdominal injuries either."

Ed agreed. "He's got forehead lacerations, and he's disoriented. Chest seems fine, but his abdominal cavity could be a problem. There is significant bruising across the left lower quadrant and periumbilical regions—probably from the steering wheel. When I palpated his left upper quadrant, it caused him considerable pain." Mike's blood pressure was very low, and his heart rate was very high—both signs of a cardiovascular emergency.

Ed then began a quick physical examination, first checking Mike's pupillary responses for any signs of intracranial pressure and then continuing inferiorly. Ed shared his findings with Samantha. "He's hypotensive and tachycardic. With the pain he reported earlier, signs are pointing to intra-abdominal hemorrhage. We've got to get him to the trauma center right now."

Ed and Samantha depend on their understanding of anatomy and physiology to help their patients and communicate with their partners. Ed suspects that Mike is bleeding internally and that his heart is working hard to compensate for the decrease in blood pressure. As we will see later, Mike's state of internal balance, known as homeostasis, must be restored, or his body systems will fail.

As you study this chapter, CasePoints will give you opportunities to apply your learning to this case.

Ancillaries At-A-Glance

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Introduction

Studies of the body's normal structure and functions are the basis for all medical sciences. It is only from understanding the normal that we can analyze what is going wrong in cases of disease. These studies give us an appreciation for the design and balance of the human body and for living organisms in general. This chapter discusses several general scientific concepts that provide the foundation for topics to come. These key ideas are indicated with a numbered icon ( ). The table in the front cover of your textbook summarizes all of the key ideas presented in this and later chapters. We will refer back to these key ideas in future chapters. The number on the icon indicates which key idea you should review to understand the topic.

Studies of the Human Body

The scientific term for the study of body structure is **anatomy** (ah-NAT-o-me). The *-tomy* part of this word in Latin means "cutting," because a fundamental way to learn about the human body is to cut it apart, or **dissect** (dis-sekt) it. **Physiology** (fiz-e-OL-o-je) is the term for the study of how the body functions; *physio* is based on a Latin term meaning "nature," and *logy* means "study of."

1 STRUCTURE AND FUNCTION

Anatomy and physiology are closely related—that is, structure and function are intertwined. The stomach, for example, has a pouchlike shape that is well suited for storing food during digestion. The cells in the lining of the stomach are tightly packed. This anatomic feature prevents strong digestive juices from harming underlying tissue.

2 LEVELS OF ORGANIZATION

All living things are organized from very simple levels to more complex levels (FIG. 1-1). Living matter is derived from chemicals, including simple substances, such as water and salts, and more complex materials, such as sugars, fats, and proteins. These chemicals assemble into living **cells**—the basic units of all life. Specialized groups of cells form **tissues**, such as muscle tissue and connective tissue. Tissues function together as **organs**, for example, a muscle contains both muscle tissue and connective tissue. Organs working together for the same general purpose make up the body **systems**, discussed below. All of the systems work together to maintain the body as a whole organism.

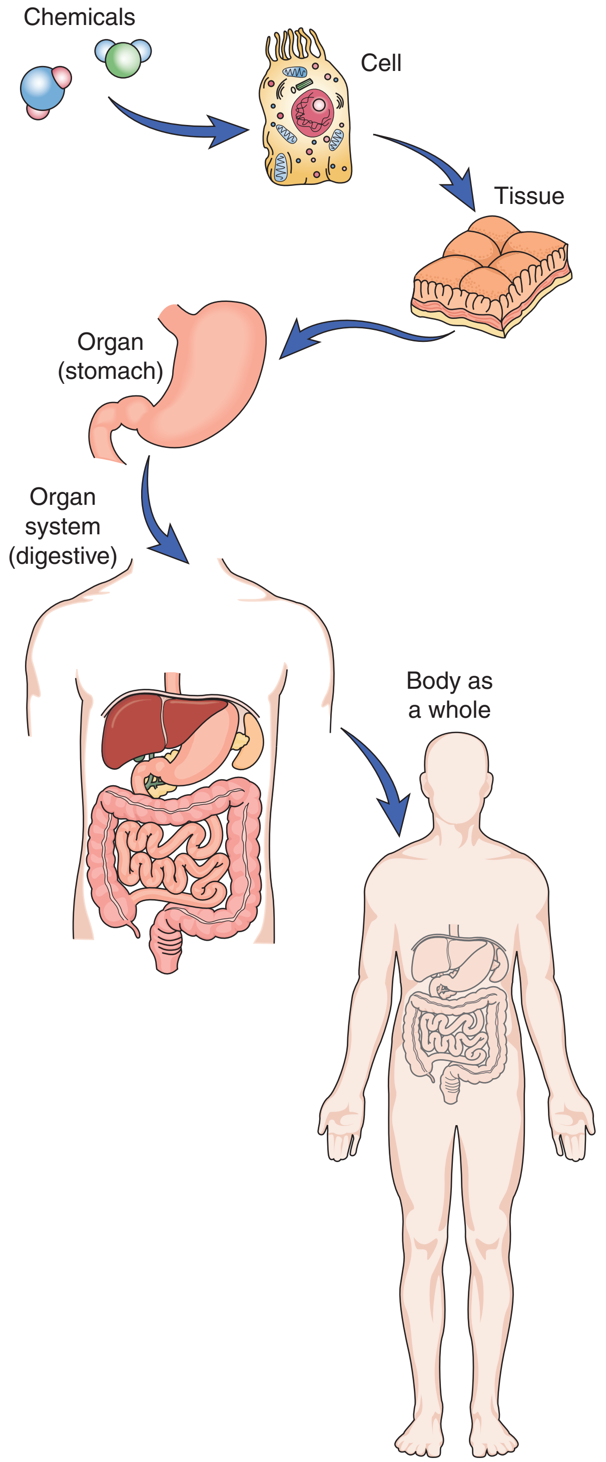


FIGURE 1-1 Levels of organization. **KEY POINT** The body is organized from the level of simple chemicals by increasing levels of complexity to the whole organism. The organ shown here is the stomach, which is part of the digestive system.

BODY SYSTEMS

Although all are interrelated, we can think of the human body as organized into individual systems. Listed according to their descriptions in this text, they are as follows:

- The **integumentary** (in-teg-u-MEN-tar-e) system. The word integument (in-TEG-u-ment) means "skin." The skin with its associated structures is our outermost body system. It protects us from injury and infection, but serves other functions as well. The skin's associated structures include the hair, nails, sweat glands, and oil glands.

- The **skeletal system**. The body's basic framework is a system of 206 bones and the joints between them, collectively known as the skeleton.
- The **muscular system**. The muscles in this system are attached to the bones and produce movement of the skeleton. These skeletal muscles also give the body structure, protect organs, and maintain posture. Two additional types of muscle contribute to other body systems. Smooth muscle is present in the walls of blood vessels and many organs; cardiac muscle constitutes the bulk of the heart wall.
- The **nervous system**. The brain, spinal cord, and nerves make up this complex system by which the body is controlled and coordinated. The nervous system also includes the special sense organs (the eyes, ears, taste buds, and organs of smell) and the receptors of the general senses, such as pain and touch. When sense organs or receptors detect changes in the external and internal environments, electrical signals are transmitted along nerves to the brain, which directs responses.
- The **endocrine** (EN-do-krin) **system**. The scattered organs known as endocrine glands are grouped together because they share a similar function. All produce special substances called hormones, which regulate such body activities as growth, nutrient utilization, and reproduction. Examples of endocrine glands are the thyroid, pituitary, and adrenal glands. The nervous system and the endocrine system together control bodily functions and responses.
- The **cardiovascular system**. The heart and blood vessels make up the system that pumps blood to all body tissues, bringing with it nutrients, oxygen, and other needed substances. This system then carries waste materials away from the tissues to points where they can be eliminated.
- The **lymphatic system**. Lymphatic vessels assist in circulation by returning fluids from the tissues to the blood. Lymphatic organs, such as the tonsils, thymus, and spleen, play a role in immunity, protecting against disease. The lymphatic system also aids in the absorption of dietary fats. The fluid that circulates in the lymphatic system is called lymph.
- The **respiratory system**. This system includes the lungs and the passages leading to and from the lungs. This system takes in air and conducts it to the areas in the lungs designed for gas exchange. Oxygen passes from the air into the blood and is carried to all tissues by the cardiovascular system. In like manner, carbon dioxide, a gaseous waste product, is taken by the circulation from the tissues back to the lungs to be expelled through the respiratory passages.
- The **digestive system**. This system is composed of all the organs that are involved with taking in nutrients (foods), converting them into a form that body cells can use, and absorbing them into the circulation. Organs of the digestive system include the mouth, esophagus, stomach, small and large intestines, liver, gallbladder, and pancreas. The respiratory system and digestive system together generate energy to fuel all body activities.
- The **urinary system**. The chief purpose of the urinary system is to rid the body of waste products and excess water. This system's components are the kidneys, the ureters, the bladder, and the urethra. (Note that some waste products are also eliminated by the digestive and respiratory systems and by the skin.) The urinary system is the main mechanism for balancing the volume and composition of body fluids.
- The **reproductive system**. This system includes the external sex organs and all related internal structures that are concerned with the production of offspring.

References may vary in the number of body systems cited. For example, some separate the sensory system from the nervous system. Others have a separate entry for the immune system, which protects the body from foreign matter and invading organisms. The immune system is identified by its function rather than its structure and includes elements of both the cardiovascular and lymphatic systems. Bear in mind that even though you will study the systems as separate units, they are interrelated and must cooperate to maintain health.

CASEPOINT

☐ **1-1** The paramedics were concerned about Mike's spinal column and his blood vessels. To which system(s) do these structures belong?

See Appendix 2 for answers to the CasePoint questions

THE EFFECTS OF AGING

With age, changes occur gradually in all body systems. Some of these changes, such as wrinkles and gray hair, are obvious. Others, such as decreased kidney function, loss of bone mass, and formation of deposits within blood vessels, are not visible. However, they may make a person more subject to injury and disease. Changes due to aging are described in chapters on the body systems.

CHECKPOINTS

☐ **1-1** What are the studies of body structure and body function called?

☐ **1-2** What do organs working together combine to form?

See Appendix 2 for answers to the checkpoint questions

3 Homeostasis

Despite changing environmental conditions, normal body function maintains a state of internal balance or constancy known as **homeostasis** (ho-me-o-STA-sis). Any condition that is subject to change is termed a variable. In the body, certain conditions, described as **regulated variables,** must remain within a somewhat narrow range, or *set point*, if we are to stay healthy. Regulated variables include body

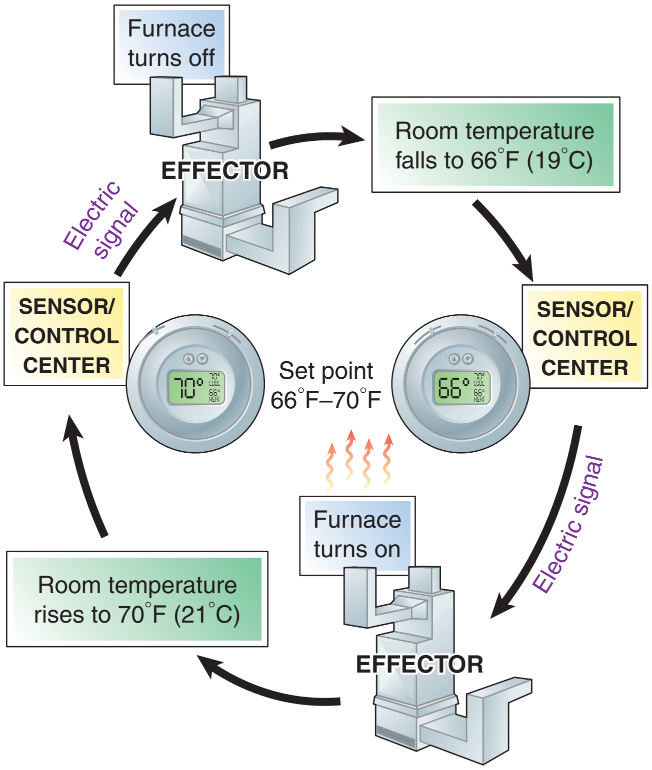


FIGURE 1-2 Negative feedback. **KEY POINT** A home thermostat illustrates how negative feedback keeps temperature within a set range. This thermostat is set to keep the average temperature at 68°F. Note that the different components of the feedback loop are indicated by different colors (regulated variable, *green*; sensors and control centers, *yellow*; signals, *purple*; effectors, *blue*).

temperature, the volume and composition of body fluids, blood gas concentrations, and blood pressure. Disease can be described as a state of homeostatic imbalance.

NEGATIVE FEEDBACK

The main method for maintaining homeostasis is **negative feedback**, a control system based on information returning to a source. We are all accustomed to getting feedback about the results of our actions and using that information to regulate our behavior. Poor marks on tests and assignments, for example, may inspire us to work harder to reverse the downward slide of our grades.

Negative feedback systems keep regulated variables within a set normal range by reversing any upward or downward shift. Note that negative feedback doesn't always mean less response; it just means an opposite response to a stimulus. Any negative feedback loop must contain three components:

- A **sensor** gathers information about a specific variable.
- A **control center** compares the sensor inputs with the set point.
- An **effector** increases or decreases its activity, as necessary, in response to signals from the control center. The actions of the effector restore the normal level of the regulated variable.

A familiar example of negative feedback is the regulation of room temperature (the regulated variable) by means of a thermostat **(FIG. 1-2)**. The user determines the desired room temperature (the set point). Within the thermostat, a thermometer (sensor) measures the actual room temperature, and other components (forming the control center) compare the measured temperature with the set point. If the measured temperature is too low, the control center signals the furnace (effector) to produce heat and increase room temperature. When the room temperature reaches an upper limit (as detected by the sensor), the control center shuts off the furnace. The control center regulates the effector by means of electrical signals traveling through wires.

In the body, sensors in the brain and other organs constantly monitor body temperature and send signals to a specific brain region (the control center). This center activates effectors (such as sweat glands) to cool or warm the body if body temperature deviates above or below the set point of approximately 37°C (98.6°F) **(FIG. 1-3)**. As with our thermostat example, electrical impulses transmitted through the nervous system act as signals between the components of the feedback loop. This example highlights two important

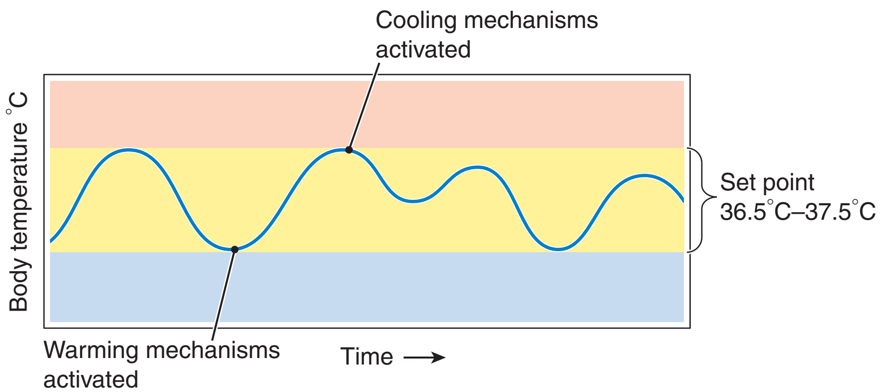


FIGURE 1-3 Negative feedback and body temperature. **KEY POINT** Body temperature is kept within a narrow range by negative feedback acting on a center in the brain. The set point is 37°C.

characteristics of regulated variables: they have specific sensors, and their level cannot vary too much without harming the organism. Many parameters that the body controls are not considered regulated variables. For instance, sweating is controlled. But sweat production is the action of an effector (sweat glands) that helps maintain the regulated variable of body temperature. The body does not directly sense how much sweat is being produced, and sweat production can vary enormously over the course of the day.

As another example, let's say you've just finished eating breakfast—a bowl of cereal and a glass of orange juice. As a result, the level of glucose (a simple sugar) increases in your bloodstream. Blood glucose levels must be tightly regulated to prevent disease, so this increase constitutes a challenge to homeostasis. Endocrine cells in your pancreas act as both sensors and the control center; they sense blood glucose levels and compare them with the set point. When blood glucose levels rise above the set point, pancreatic cells increase the production of a hormone called insulin. Insulin acts as the signal, traveling through the bloodstream from the pancreas to muscle and fat cells (the effectors). Increased glucose uptake and the subsequent drop in the blood glucose level cause the pancreas to reduce insulin secretion, and homeostasis is restored **(FIG. 1-4)**. Many more examples of internal regulation by negative feedback will appear throughout this book, so study **FIGURES 1-2 through 1-4** closely. Note that we use a consistent color scheme to indicate the different components:

- Regulated variable: green
- Sensor and control center: yellow
- Signal: purple
- Effector and effector actions: blue

Clearly, negative feedback systems are critical for maintaining our health. **BOX 1-1** uses the case study to explain how to analyze feedback loops and what happens when feedback cannot restore homeostasis.

4 BARRIERS

The body's ability to maintain homeostasis relies on the barriers separating the relatively constant internal environment from the rapidly changing external environment. During most of our lives, our insides consist of a warm, watery, and sterile environment that is very different from the colder, drier, microbe-riddled external world. Skin forms an effective barrier separating inside from outside—as discussed in Chapter 5, burn patients suffer from fluid loss and frequent infections when they lose the barrier function of skin. The body's tubes—the digestive tract, the airways, the reproductive tract, and the urinary tract—are also considered as "outside." A thinner, moister barrier known as a *mucous membrane* forms the barrier in these locations.

At the microscopic level, the plasma membrane forms a barrier separating the internal environment of cells from their external environment. Chapter 3 discusses the plasma membrane in more detail. The fluid within cells is called **intracellular fluid** (the prefix *intra-* means "within"). The composition of the intracellular fluid differs from that of the fluid outside the cell, known as the **extracellular fluid** (the prefix *extra-* means "outside"). Examples of extracellular fluids are the blood plasma (the fluid portion of blood), lymph, and the

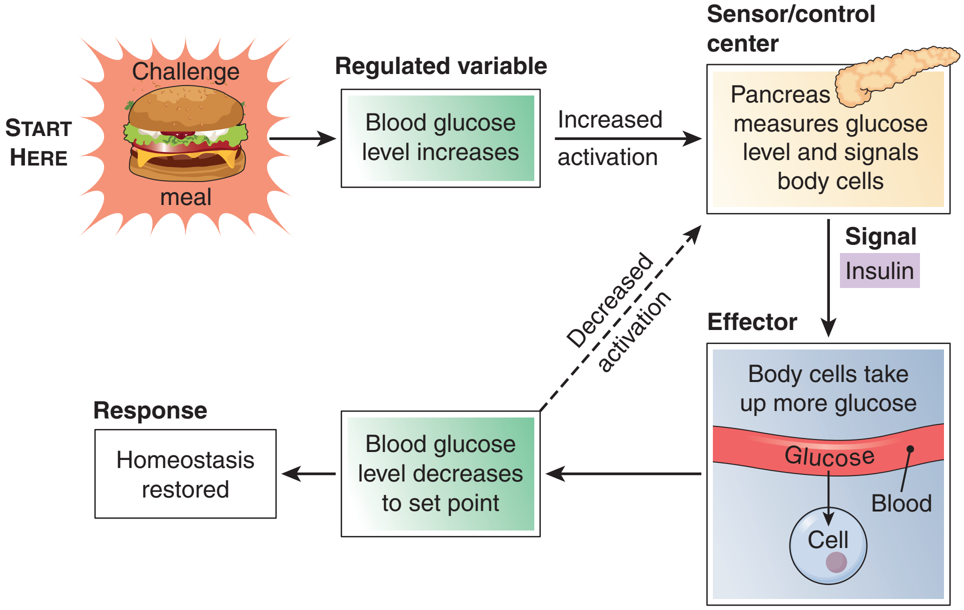


FIGURE 1-4 Negative feedback in the endocrine system. Note that the different components of the feedback loop are indicated by different colors (regulated variable, *green*; sensors and control centers, *yellow*; signals, *purple*; effectors, *blue*). **KEY POINT** The pancreas regulates blood glucose concentration using insulin as the signal.

ONE STEP AT A TIME
Deciphering Negative Feedback Loops
BOX 1-1

Homeostasis and negative feedback are key concepts in your study of anatomy and physiology. It can be difficult to identify the components of a negative feedback loop, so here is a worked example to guide your future analysis of such loops. Note that the answer does not identify all of the components. In life, we rarely have all of the information that we need to make a decision. It is important to know what we know and what we do not know!

Question
Read through the opening case study, which discusses a negative feedback loop controlling blood pressure. Focus on these two sentences: "He suspects that Mike is bleeding internally and that his heart is working hard to compensate for the drastic decrease in blood pressure. As we will see later, Mike's state of internal balance, known as homeostasis, must be restored, or his body systems will fail." Using **FIGURE 1-4** as your guide, draw out the negative feedback loop involved. Use question marks for the components that you cannot identify from the case description.

Answer
Step 1: Identify the regulated variable. The question wording tells us the answer to this step—blood pressure. The case study tells us that Mike has a "drastic decrease in blood pressure." Regulated variables are colored *green* in the color-coded textbook diagrams. Remember that regulated variables (unlike other clinical values and body functions) must be kept within tight limits to maintain homeostasis, and they must be directly sensed by the body.

Step 2: Identify the challenge. The challenge is the event that alters the regulated variable. In the case study, bleeding is the challenge that decreases Mike's blood pressure.

Step 3: Identify the sensor/control center. The case study does not give any information about how blood pressure is sensed or controlled, so we will use a question mark for these components. Both the sensor and the control center are colored *yellow* in the textbook diagrams.

Step 4: Identify the effector. The actions of the effector(s) partially or completely reverse the change in the regulated variable. The case study mentions that "his heart is working hard to compensate…" So, the heart is an effector, and we can infer that its actions are increasing blood pressure. The effector and its actions are colored *blue* in the textbook diagrams.

Step 5: Identify the signals. The case study does not explain how signals travel from sensors to the control center to the effectors, so we cannot include this information. Signals are colored *purple* in color-coded textbook diagrams.

Step 6: Is homeostasis restored? The case study tells us that Mike's blood pressure was too low, so the increased heart rate only partially compensated for the challenge. Homeostasis was not completely restored.

Step 7: Create the drawing. Use the components identified in Steps 1 through 6 to illustrate the feedback loop.

fluid between the cells in tissues. Homeostasis requires that the volume and composition of these two different fluids be maintained within narrow limits, as discussed in Chapter 19.

5 GRADIENTS AND RESISTANCE

The previous section discussed the importance of maintaining differences between the inside and outside of the body, and between the inside and the outside of cells. A difference in specific physical or chemical values between two areas is called a **gradient.** For example, there is an altitude gradient between the peak of a roof and the roof edge because the peak is higher than the edge. Water from snow melting on a steep roof will flow downward following this gradient. The steeper the roof, the larger the gradient, and the greater the flow. Indeed, unless they are inhibited from doing so, substances always move down their gradients from high to low.

The term **resistance** describes all factors that inhibit flow down a particular gradient. For example, friction provides resistance to the downward movement of a skateboard on a ramp **(FIG. 1-5)**. A smoother surface provides less resistance, and permits a greater amount of flow. Barriers provide significant resistance to flow. Therefore, the barrier formed by skin reduces the amount of heat that moves from the warmer body to the colder surrounding air, down

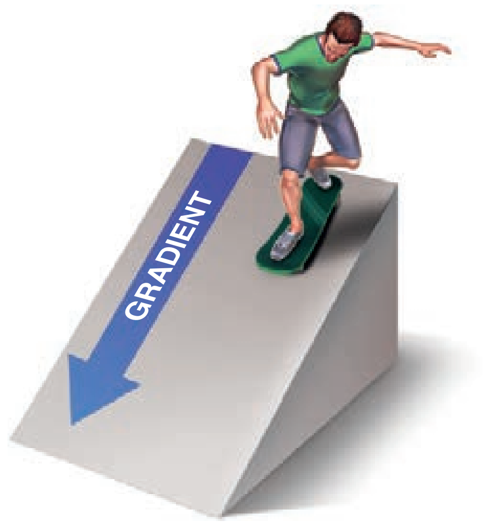


FIGURE 1-5 Flow, Gradients, and Resistance. KEY POINT The skateboarder moves down the ramp because of an altitude gradient. Friction between the skateboard and the ramp surface provides resistance. ZOOMING IN What will happen to the rate of movement if the angle of the ramp increases? If the surface of the ramp provides more resistance? (See Appendix 2 for answers to the Zooming In questions.)

the temperature gradient. Wearing thicker clothes increases resistance and thus reduces heat flow.

This textbook describes many examples of flow, including the movement of water and solutes across the plasma membrane (Chapter 3), the flow of blood through blood vessels (Chapter 14), and the flow of air through the airways (Chapter 16). The same principle applies in each and every case; a gradient promotes the flow of the substance, and the various factors of resistance oppose the flow.

CASEPOINTS

- ☐ **1-2** In Mike's case, what was the major challenge to his homeostasis?
- ☐ **1-3** Which of these is an effector in the feedback loop controlling blood pressure—the brain or the heart?

CHECKPOINTS

- ☐ **1-3** What is the definition of homeostasis?
- ☐ **1-4** What are the three components of a negative feedback loop?
- ☐ **1-5** What general term refers to any structure that separates differing environments?
- ☐ **1-6** What is formed by a difference in specific physical or chemical values between two regions?
- ☐ **1-7** What term describes a force that opposes flow along a gradient?

Body Directions

Because it would be awkward and inaccurate to speak of bandaging the "southwest part" of the chest, for example, healthcare professionals use standardized terms to designate body positions and directions. For consistency, all descriptions assume that the body is in the **anatomic position**. In this posture, the subject is standing upright with face front, arms at the sides with palms forward, and feet parallel, as shown in **FIGURE 1-6**.

DIRECTIONAL TERMS

The main terms for describing directions in the body are as follows **(see FIG. 1-6)**:

- **Superior** is a term meaning above or in a higher position. Its opposite, inferior, means below or lower. The heart, for example, is superior to the intestine.
- **Anterior** and **ventral** have the same meaning in humans: located toward the belly surface or front of the body. Their corresponding opposites, **posterior** and **dorsal**, refer to locations nearer the back.
- **Medial** means nearer to an imaginary plane that passes through the midline of the body, dividing it into left and right portions. **Lateral**, its opposite, means farther away from the midline, toward the side. For example, your nose is medial to your ears.
- **Proximal** means nearer to the origin or attachment point of a structure; **distal** means farther from that point. For example, the part of your thumb where it attaches to your hand is its proximal region; the tip of the thumb is its distal region. Considering the mouth as the beginning (origin) of the digestive tract, the small intestine is distal to the stomach.

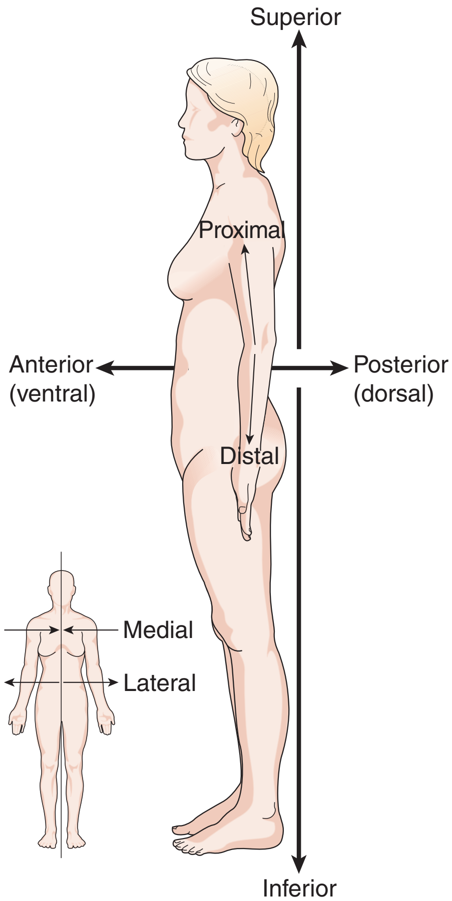


FIGURE 1-6 Directional terms. **KEY POINT** Healthcare professionals use standardized terms to describe body directions. **ZOOMING IN** What is the scientific name for the position in which the figures are standing?

Concept Mastery Alert

Students commonly confuse the terms distal and lateral. Both indicate farther away, but the point of reference varies. Lateral means away from the midline and distal means away from an origin or attachment point. For instance, in the anatomic position, the thumb is lateral to the pinkie, but the pinkie is distal to the thumb.

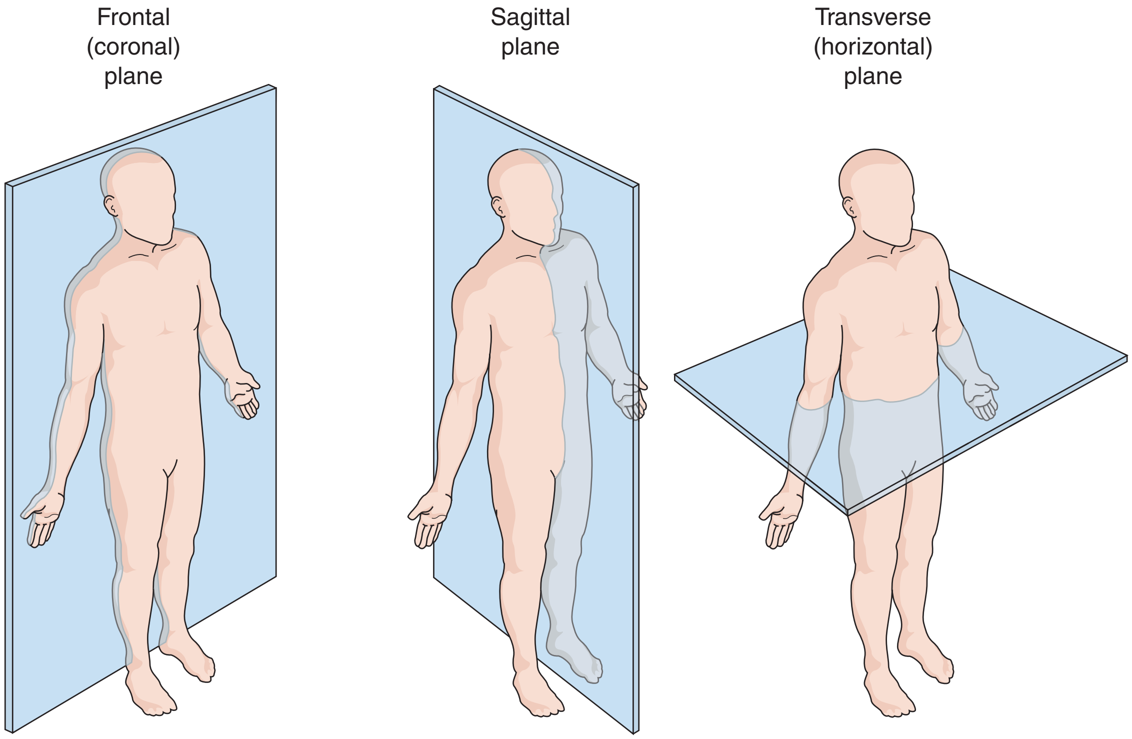


FIGURE 1-7 Planes of division. KEY POINT The body can be divided along three different planes. ZOOMING IN Which plane divides the body into superior and inferior parts? Which plane divides the body into anterior and posterior parts?

PLANES OF DIVISION

To visualize the various internal structures in relation to each other, anatomists can divide the body along three planes, each of which is a cut through the body in a different direction **(FIG. 1-7)**, as follows:

- **Frontal plane.** If the cut were made in line with the ears and then down the middle of the body, you would see an anterior, or ventral (front), section and a posterior, or dorsal (back), section. Another name for this plane is *coronal plane*.
- **Sagittal** (SAJ-ih-tal) **plane.** If you were to cut the body in two from front to back, separating it into right and left portions, the sections you would see would be sagittal sections. A cut exactly down the midline of the body, separating it into equal right and left halves, is a **midsagittal plane.**
- **Transverse plane.** If the cut were made horizontally, across the other two planes, it would divide the body into a superior (upper) part and an inferior (lower) part. A transverse plane is also called a *horizontal plane*.

Some additional terms are used to describe sections (cuts) of tissues, as used to prepare them for study under the microscope. A cross section **(FIG. 1-8)** is a cut made perpendicular to the long axis of an organ, such as a cut made across a banana to create a small round slice. A longitudinal section is made parallel to the long axis, as in cutting a banana from tip to tip to make a slice for a banana split. An oblique section is made at an angle. The type of section used will determine what is seen under the microscope, as shown with a blood vessel in **FIGURE 1-8**.

These same terms are used for images taken by techniques such as computed tomography (CT) or magnetic resonance imaging (MRI) **(see BOX 1-2)**. In imaging studies, the term *cross section* is used more generally to mean any two-dimensional view of an internal structure obtained by imaging, as shown in **FIGURE 1-9**.

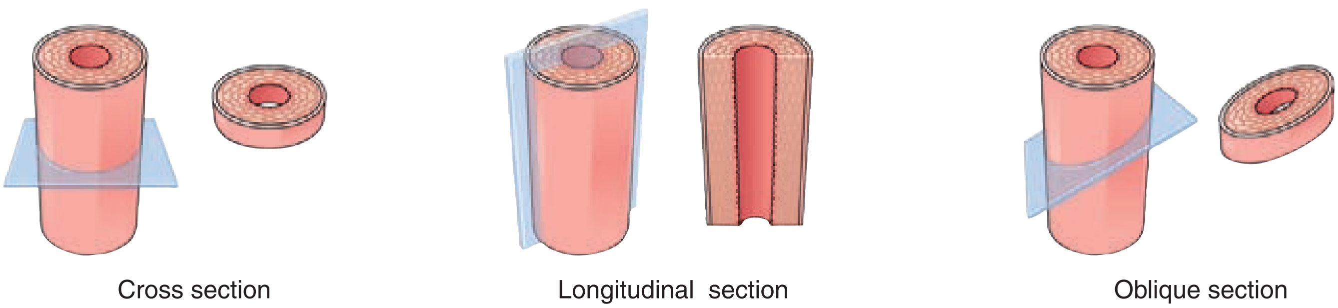


FIGURE 1-8 Tissue sections. KEY POINT The direction in which tissue is cut affects what is seen under the microscope.

HOT TOPICS

BOX 1-2

Medical Imaging: Seeing without Making a Cut

Three imaging techniques that have revolutionized medicine are radiography, computed tomography, and magnetic resonance imaging. With them, physicians today can "see" inside the body without making a single cut. Each technique is so important that its inventor received a Nobel Prize.

The oldest is radiography (ra-de-OG-rah-fe), in which a machine beams x-rays (a form of radiation) through the body onto a piece of film. Like other forms of radiation, x-rays damage body tissues, but modern equipment uses extremely low doses. The resulting picture is called a radiograph. Dark areas indicate where the beam passed through the body and exposed the film, whereas light areas show where the beam did not pass through. Dense tissues (bone, teeth) absorb most of the x-rays, preventing them from exposing the film. For this reason, radiography is commonly used to visualize bone fractures and tooth decay as well as abnormally dense tissues like tumors. Radiography does not provide clear pictures of soft tissues because most of the beam passes through and exposes the film, but contrast media can help make structures like blood vessels and hollow organs more visible. For example, radiologists use ingested barium sulfate (which absorbs x-rays) to coat the digestive tract for imaging.

CT is based on radiography and also uses very low doses of radiation **(see FIG. 1-9)**. During a CT scan, a machine revolves around the patient, beaming x-rays through the body onto a detector. The detector takes numerous pictures of the beam, and a computer assembles them into transverse sections, or "slices." Unlike conventional radiography, CT produces clear images of soft structures such as the brain, liver, and lungs. It is commonly used to visualize brain injuries and tumors and even blood vessels when used with contrast media.

MRI uses a strong magnetic field and radio wave **(see FIG. 1-9B)**. So far, there is no evidence to suggest that MRI causes tissue damage. The MRI patient lies inside a chamber within a very powerful magnet. The molecules in the patient's soft tissues align with the magnetic field inside the chamber. When radio waves beamed at the region to be imaged hit the soft tissue, the aligned molecules emit energy that the MRI machine detects, and a computer converts these signals into a picture. MRI produces even clearer images of soft tissue than does CT and can create detailed pictures of blood vessels without contrast media. MRI can visualize brain injuries and tumors that might be missed using CT.

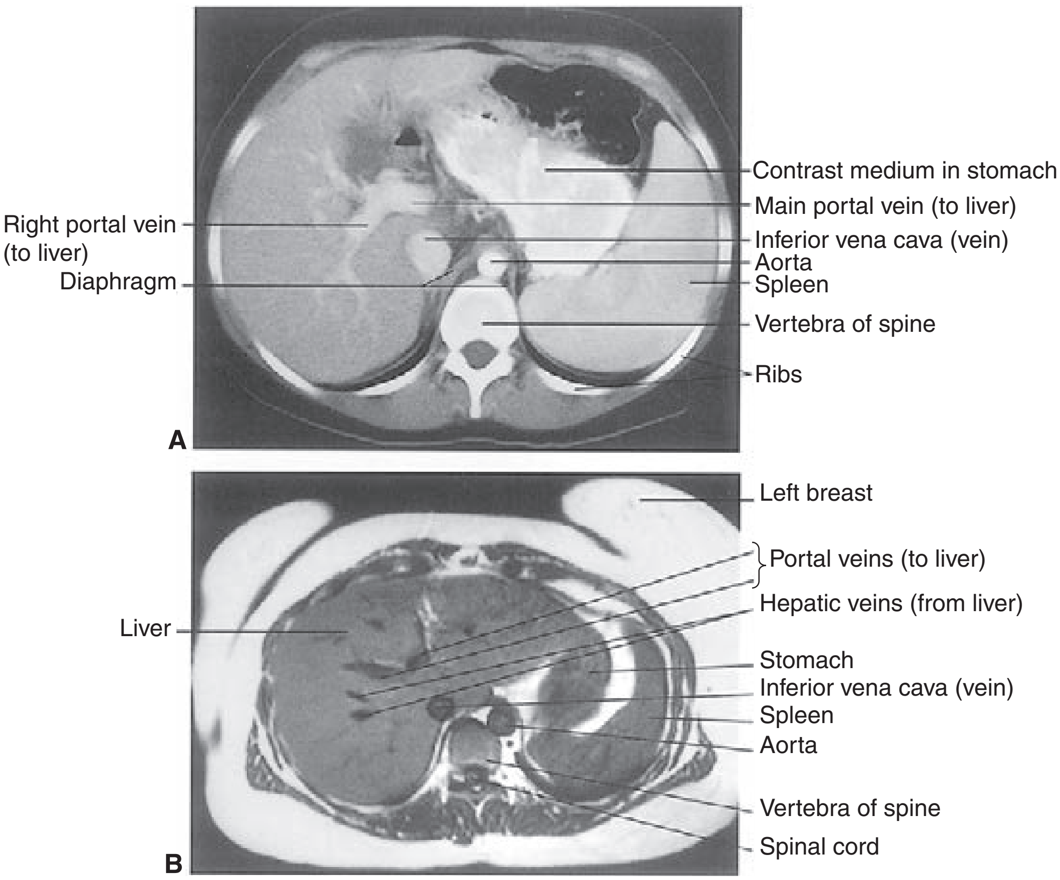


FIGURE 1-9 Cross sections in imaging. Images taken across the body through the liver and spleen by **(A)** computed tomography and **(B)** magnetic resonance imaging.

CHECKPOINTS

- **1-8** Which term describes a location farther from an origin, such as the wrist in comparison to the elbow?
- **1-9** What are the three planes in which the body can be cut?

Body Cavities

Internally, the body is divided into a few large spaces, or cavities, which contain the organs. The two main cavities are the **dorsal cavity** and **ventral cavity** **(FIG. 1-10)**.

DORSAL CAVITY

The dorsal body cavity has two subdivisions: the **cranial cavity**, containing the brain, and the **spinal cavity** (**canal**), enclosing the spinal cord. These two areas form one continuous space.

VENTRAL CAVITY

The ventral cavity is much larger than the dorsal cavity. It has two main subdivisions, which are separated by the **diaphragm** (DI-ah-fram), a muscle used in breathing. The **thoracic** (tho-RAS-ik) **cavity** is superior to (above) the diaphragm. Its contents include the heart, the lungs, and the large blood vessels that join the heart. The heart is contained in the pericardial cavity, formed by the pericardial sac, the tissue that surrounds the heart; the lungs are in the pleural cavity, formed by the pleurae, the membranes that enclose the lungs **(FIG. 1-11)**. The **mediastinum** (me-de-as-TI-num) is the space between the lungs, including the organs and vessels contained in that space.

Concept Mastery Alert

Remember that the mediastinum is between the lungs; it does not contain them.

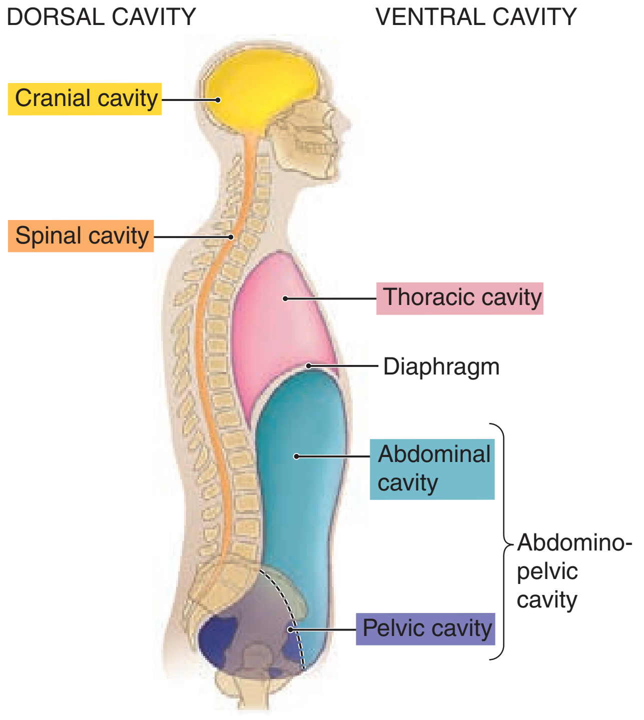


FIGURE 1-10 Body cavities, lateral view. Shown are the dorsal and ventral cavities with their subdivisions. **ZOOMING IN** Which cavity contains the diaphragm?

See **FIGURE A5-8A** in Appendix 3, Dissection Atlas, showing the organs in the thoracic cavity.

The **abdominopelvic** (ab-dom-ih-no-PEL-vik) **cavity** **(see FIG. 1-11)** is inferior to (below) the diaphragm. This space is further subdivided into two regions. The superior portion, the **abdominal cavity**, contains the stomach, most of the intestine, the liver, the gallbladder, the pancreas, and the spleen. The inferior portion, set off by an imaginary line across the top of the hip bones, is the **pelvic cavity**. This cavity contains the urinary bladder, the rectum, and the internal parts of the reproductive system.

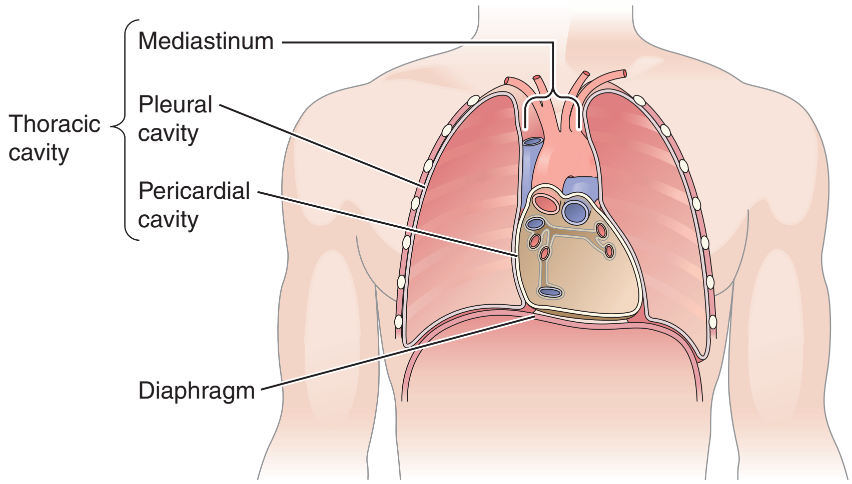


FIGURE 1-11 The thoracic cavity. **KEY POINT** Among other structures, the thoracic cavity encloses the pericardial cavity, which contains the heart, and the pleural cavity, which contains the lungs.

DIVISIONS OF THE ABDOMEN

It is helpful to divide the abdomen for examination and reference into nine regions **(FIG. 1-12)**.

The three central regions, from superior to inferior, are the following:

- **Epigastric** (ep-ih-GAS-trik) **region**, located just inferior to the breastbone
- **Umbilical** (um-BIL-ih-kal) **region**, around the umbilicus (um-BIL-ih-kus), commonly called the *navel*
- **Hypogastric** (hi-po-GAS-trik) **region**, the most inferior of all the midline regions

The regions on the right and left, from superior to inferior, are the following:

- **Hypochondriac** (hi-po-KON-dre-ak) **regions**, just inferior to the ribs
- **Lumbar regions**, which are on a level with the lumbar regions of the spine
- **Iliac**, or **inguinal** (IN-gwih-nal), **regions**, named for the upper crest of the hip bone and the groin region, respectively

A simpler but less precise division into four quadrants is sometimes used. These regions are the right upper quadrant, left upper quadrant, right lower quadrant, and left lower quadrant **(FIG. 1-13)**.

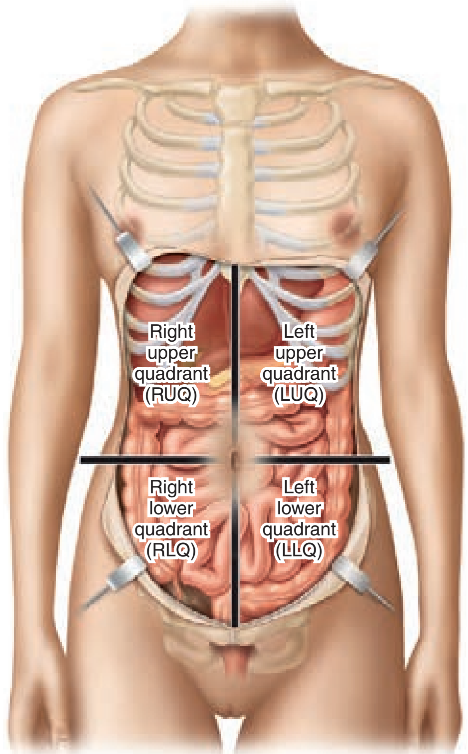


FIGURE 1-13 Quadrants of the abdomen. The organs within each quadrant are shown. **ZOOMING IN** Which four abdominal regions are represented in the left lower quadrant?

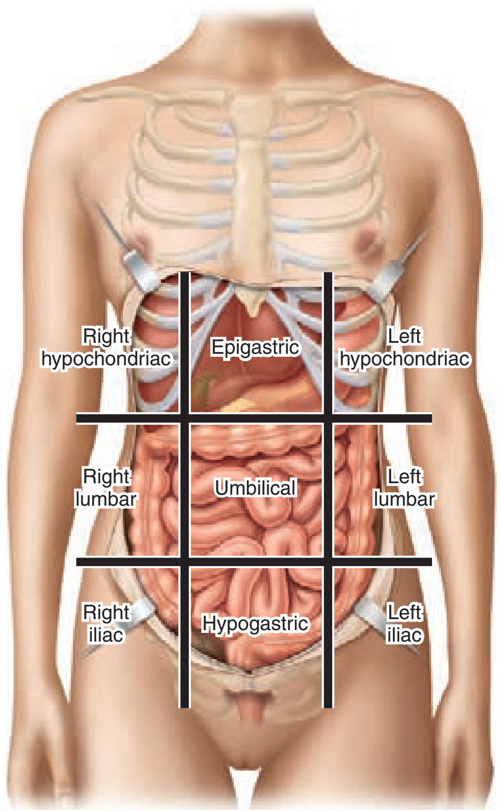


FIGURE 1-12 The nine regions of the abdomen. KEY POINT Internal structures can be localized within nine regions of the abdomen.

For your reference, **FIGURES 1-14 and 1-15** give anatomic adjectives for some other body regions along with their common names.

CHECKPOINTS

- ☐ **1-10** Name the two main body cavities.
- ☐ **1-11** Name the three central regions and the three left and right lateral regions of the abdomen.

The Language of Healthcare

In Mike's case, we saw that health professionals share a specialized language: medical terminology. This special vocabulary is based on word parts with consistent meanings that are combined to form different words. Each chapter in this book has a section near the end entitled "Word Anatomy." Here, you will find definitions of word parts commonly used in medical terms with examples of their usage.

The main part of a word is the **root**. Some compound words, such as wheelchair, gastrointestinal, and lymphocyte,

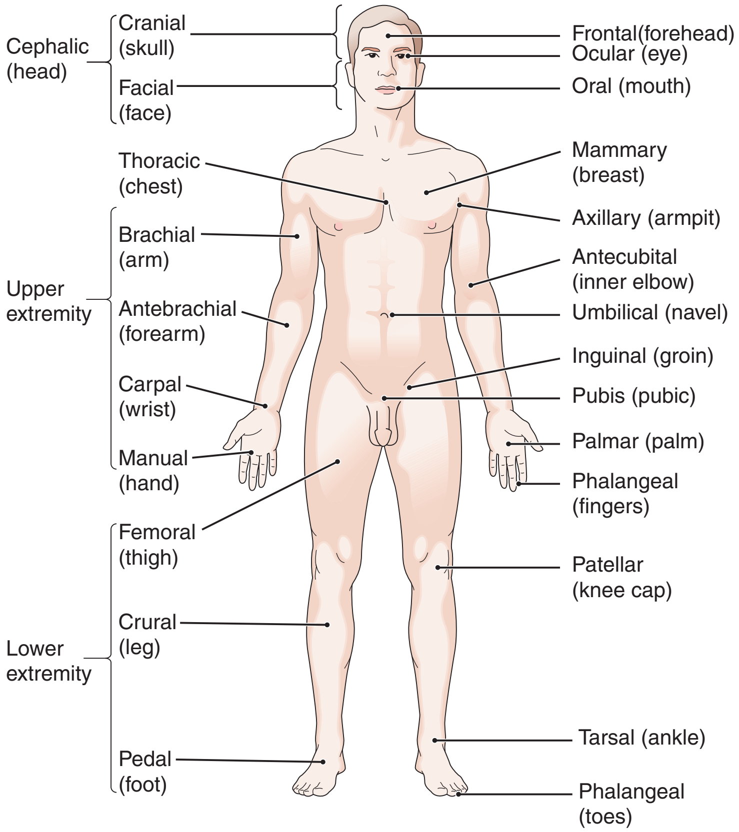


FIGURE 1-14 Adjectives for some anterior body regions. The names of the regions are in parentheses.

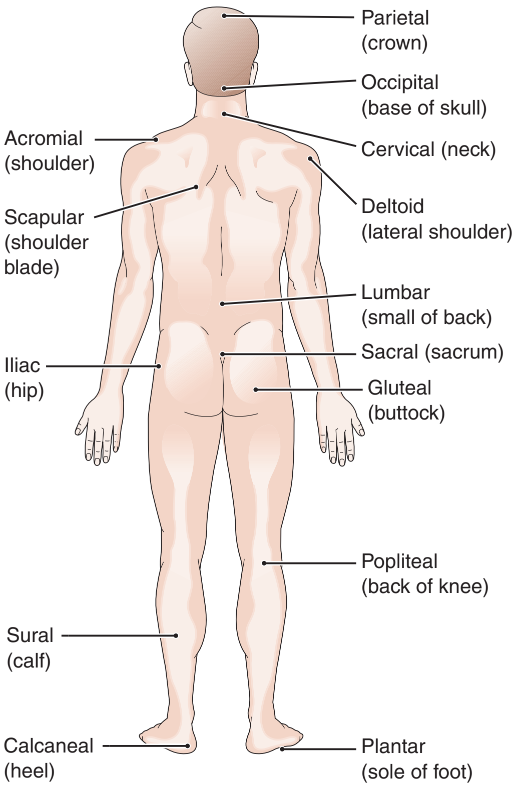


FIGURE 1-15 Adjectives for some posterior body regions. The names of the regions are in parentheses.

use more than one root. A **prefix** is a short part that starts a word and modifies the root. A **suffix** follows the root and also modifies it. In the Word Anatomy charts, the word parts follow the chapter sequence. Prefixes are followed by a dash, and suffixes are preceded by a dash. A root has no dash but often has a combining vowel added to make pronunciation easier when it is combined with another root or a suffix. These vowels are separated from the root with a slash, as in physi/o.

By using the Word Anatomy charts, the Glossary, and the Glossary of Word Parts (the last two found at the back of this text), you too can learn to speak this language.

This text focuses on normal anatomy and physiology. Students in healthcare fields will be adding many more terms relating to disease as they progress in their careers. The study of disease is *pathology*, based on the root path/o. Diseases fall into a number of different categories, including infections, which may be caused by bacteria, viruses, and fungi. Knowing the characteristics of the disease-causing organism can help practitioners know how the disease will spread, potential disease outcomes, and useful treatments.

The diagnosis of disease involves evaluation of accompanying symptoms, which are conditions experienced by the patient, and signs, which are indicators gathered by a health professional. So, fatigue is a symptom, but blood pressure is a sign. Many additional terms are related to treatment.

Although we are concentrating on normal structure and function, the case studies that open each chapter illustrate what happens when conditions go wrong. These cases, and many of the special interest boxes, will introduce some of the additional terms used in today's medical practices.

Mastering the language of health requires more than just learning vocabulary. As healthcare practitioners or consumers, a basic understanding of scientific processes can help us make informed decisions about issues such as vaccination, water quality, environmental safety, healthy habits, and medical treatment. It can be difficult to know if the studies on which we base our decisions were done in a meaningful way and if the conclusions are valid. The Step by Step boxes that follow in the book will discuss some of the elements of good scientific inquiry and how to understand reported results. We will highlight such issues as graph interpretation, the importance of control groups, and the difference between correlation and causation as they relate to the case studies that open each chapter. These boxes will also help you solve other types of problems, as you already saw in **BOX 1-1**.

CASEPOINT

☐ **1-4** Two important terms in Mike's case are *hypotensive* and *tachycardic*. Name and define the prefix and root for each of these terms, referring to the Word Parts glossary on p. 479.

A & P in Action Revisited: Mike's Homeostatic Emergency

The dispatch radio crackled to life in the ER. "This is Medic 12. We have Mike, 21 years old. Involved in a head-on collision. Patient is conscious and on oxygen. ETA is 15 minutes."

When they arrived at the ER, Samantha and Ed wheeled their patient into the trauma room. Immediately, the emergency team sprang into action, beginning an IV for administration of fluids. The trauma nurse measured Mike's vital signs while a technician placed an arterial line to monitor blood pressure and draw blood samples for testing in the lab. The emergency physician inserted an endotracheal tube into Mike's pharynx to keep his airway open and then carefully examined his abdominopelvic cavity.

"Blood pressure is 80 over 40. Heart rate is 146. Respirations are shallow and rapid," said the nurse.

"We need to raise his blood pressure—let's start a second IV of plasma. His abdomen is as hard as a board. I think he may have a bleed in there—we need an ultrasound," replied the doctor. The sonographer wheeled the ultrasound machine into position and placed the transducer onto Mike's abdomen. Immediately, she located the cause of Mike's symptoms—blood in the left upper quadrant.

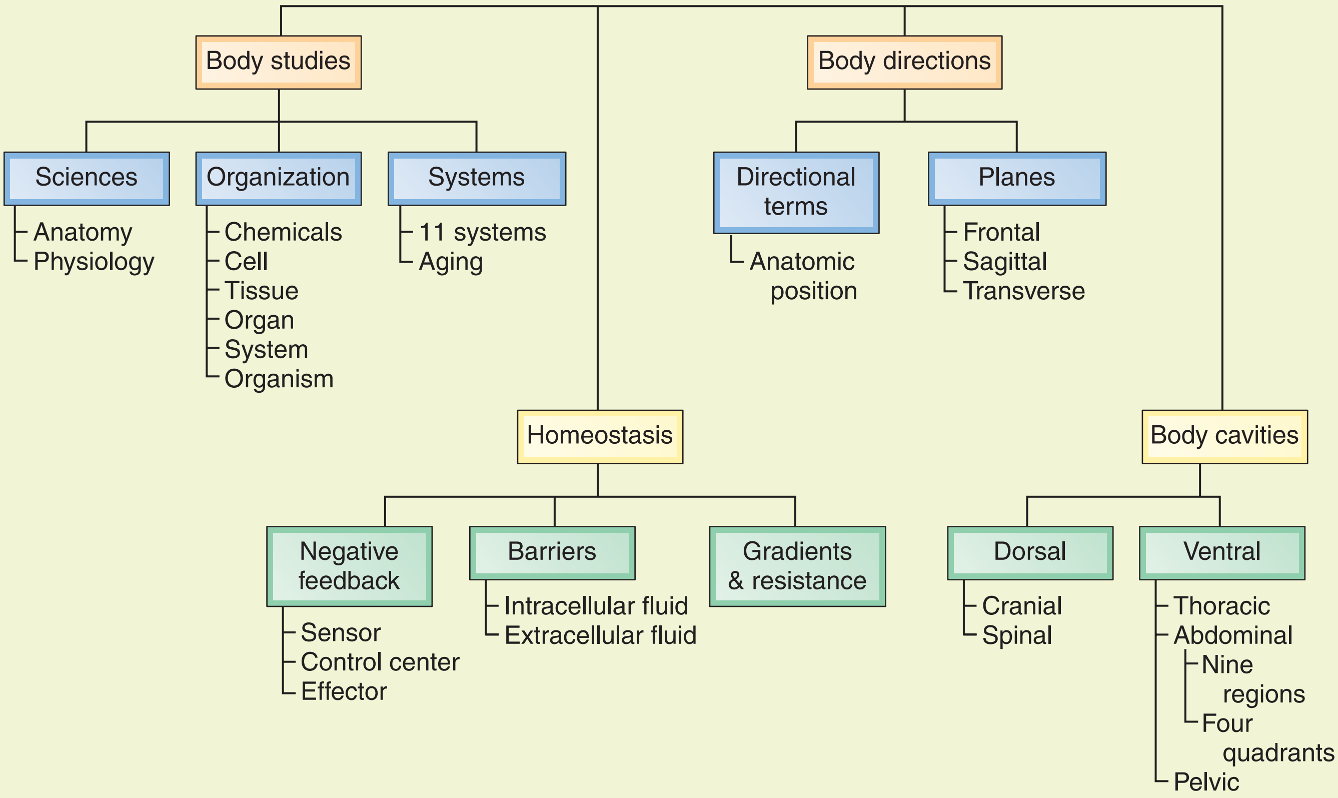
"OK. We have a ruptured spleen here," said the doctor. "Call surgery—they need to operate right now."

CHAPTER 1

Chapter Wrap-Up

OVERVIEW

A detailed chapter outline with space for note-taking is the online site. The figure below illustrates the main topics covered in this chapter.



KEY TERMS

The terms listed below are emphasized in this chapter. Knowing them will help you organize and prioritize your learning. These and other boldface terms are defined in the Glossary with phonetic pronunciations.

anatomic position
anatomy
cell
disease
extracellular fluid
gradient
homeostasis
intracellular fluid
negative feedback
organ
pathology
physiology
resistance
system
tissue
regulated variable

1

WORD ANATOMY

Medical terms are built from standardized word parts (prefixes, roots, and suffixes). Learning the meanings of these parts can help you remember words and interpret unfamiliar terms.

WORD PART	MEANING	EXAMPLE
STUDIES OF THE HUMAN BODY		
dis-	apart, away from	To *dissect* is to cut apart.
-logy	study of	*Radiology* is the study and use of radioactive substances.
path/o	disease	*Pathology* is the study of disease.
physi/o	nature, physical	*Physiology* is the study of how the body functions.
-tomy	cutting, incision of	*Anatomy* can be revealed by cutting the body.
HOMEOSTASIS		
extra-	outside of, beyond	*Extracellular* fluid is outside the cells.
home/o-	same	*Homeostasis* is the steady state (sameness) within an organism.
intra-	within	*Intracellular* fluid is within a cell.
stat, -stasis	stand, stoppage, constancy	In *homeostasis*, "-stasis" refers to constancy.

QUESTIONS FOR STUDY AND REVIEW

BUILDING UNDERSTANDING

Fill in the Blanks

1. Specialized tissues working together for the same general purpose form a(n)_____.
2. In location, the nose is _____ to the eyes.
3. Normal body function maintains a state of internal balance called _____.
4. In the word physiology, *-logy* is an example of a word part called a(n) _____.

Matching Match each numbered item with the most closely related lettered item.

___ 5. The system that uses electrical signals to control and coordinate other systems

___ 6. The system that brings needed substances to the body tissues

___ 7. The system that converts foods into a form that body cells can use

___ 8. The outermost body system

___ 9. The system of glands that produce hormones

a. nervous system
b. integumentary system
c. cardiovascular system
d. endocrine system
e. digestive system

Multiple Choice

___ 10. Which science studies normal body structure?
a. homeostasis
b. anatomy
c. physiology
d. pathology

___ 11. Where is intracellular fluid located?
a. between body cells
b. in blood plasma
c. in lymph
d. inside body cells

___ 12. What is the main way of regulating homeostasis?
a. anabolism
b. biofeedback
c. catabolism
d. negative feedback

___ 13. Which cavity contains the mediastinum?
a. abdominal
b. dorsal
c. thoracic
d. pelvic

___ 14. In location, the ankle is _____ to the knee.
- a. distal
- b. inferior
- c. proximal
- d. superior

___ 15. A plane that divides the body into right and left portions is a _____.
- a. frontal plane
- b. transverse plane
- c. sagittal plane
- d. horizontal plane

___ 16. The most inferior midline region of the abdomen is the _____.
- a. superior region
- b. hypogastric region
- c. umbilical region
- d. epigastric region

UNDERSTANDING CONCEPTS

17. What do you study in anatomy? In physiology? Would it be wise to study one without the other?
18. List in sequence the levels of organization in the body from simplest to most complex. Give an example for each level.
19. Compare and contrast the anatomy and physiology of the nervous system with that of the endocrine system.
20. In order of action, name the components of a negative feedback loop.
21. Use The Body Visible overlays at the beginning of this book to name the lateral bone of the lower leg. Name the proximal bone of the arm.
22. Referring to the Dissection Atlas in Appendix 3:
    a. list the figure(s) in which an organ is cut into left and right parts.
    b. list the figure(s) in which an organ is cut into anterior and posterior parts.

CONCEPTUAL THINKING

23. The human body is organized from very simple levels to more complex levels. With this in mind, describe why a disease at the chemical level can have an effect on organ system function.
24. Use a car operating under cruise control as an example of a negative feedback loop, identifying the set point and the components of the system.
25. In Mike's case, the paramedics discovered bruising of the skin over Mike's left lumbar region and umbilical region. Mike also reported considerable pain in his upper left quadrant. Locate these regions on your own body. Why it is important for health professionals to use medical terminology when describing the human body?
26. If a child swallows a marble, does the marble actually get inside his body? Explain.
27. In Mike's case, blood is flowing out of the blood vessels in his abdomen into his abdominal cavity.
    A. What sort of gradient is driving the flow?
    B. What do you think changed in Mike's case that enabled this flow to occur: the gradient or the resistance?