Introduction to the Body

OUTLINE

Hint: Scan this outline before you begin to read the chapter, as a preview of how the concepts are organized.

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OBJECTIVES

Hint: Before reading the chapter, review these goals for your learning. Check it again after reading and studying the chapter to make sure you are ready for your test.

After you have completed this chapter, you should be able to:
1. Define the terms anatomy and physiology.
2. Describe the process used to form scientific theories.
3. List and discuss in order of increasing complexity the levels of organization of the body.
4. Define the terms anatomical position, supine, and prone.
5. List and define the principal directional terms and sections (planes) used in describing the body and the relationship of body parts to one another.
6. List the major cavities of the body and the subdivisions of each.
7. List the nine abdominopelvic regions and the abdominopelvic quadrants.
8. Discuss and contrast the axial and the appendicular subdivisions of the body. Identify a number of specific anatomical regions in each area.
9. Explain the meaning of the term homeostasis, and give an example of a typical homeostatic mechanism.
There are many wonders in our world, but none is more wondrous than the human body. This is a textbook about that incomparable structure. It deals with two very distinct and yet interrelated sciences: anatomy and physiology.

As a science, anatomy is often defined as the study of the structure of an organism and the relationships of its parts. The word anatomy is derived from two word parts that mean "cutting apart." Anatomists learn about the structure of the human body by cutting it apart. This process, called dissection, is still the principal technique used to isolate and study the structural components or parts of the human body.

Physiology, on the other hand, is the study of the functions of living organisms and their parts. Physiologists use scientific experimentation to tease out how each activity of the body works, how it is regulated, and how it fits into the complex, coordinated operation of the whole human organism.

In the chapters that follow, you will see again and again that anatomical parts have structures exactly suited to perform specific functions. Each has a particular size, shape, form, or position in the body related directly to its ability to perform a unique and specialized activity. For example, the strong and rigid structure of the bones of each arm is necessary for the arm to make and use tools, defend ourselves, and perform other tasks needed for survival. Likewise, the valves and muscles of the hollow heart have a structure that makes the forceful pumping of blood possible. This principle—that structure fits function—is the key to understanding all of human biology.

Scientific Method

What we often call the scientific method is merely a systematic approach to discovery. Although there is no single method for scientific discovery, many scientists follow the steps outlined in Figure 1-1 to discover the concepts of human biology discussed in this textbook.

First, one makes a tentative explanation, called a hypothesis. A hypothesis is a reasonable guess based on previous informal observations or on previously tested explanations.

After a hypothesis has been proposed, it must be tested. This testing process is called experimentation. Scientific experiments are designed to be as simple as possible, to avoid the possibility of errors. Often, experimental controls are used to ensure that the test situation is not affecting the results.

For example, if a new cancer drug is being tested, half of the test subjects will get the drug and half of the subjects will be given a harmless substitute. The group getting the drug is called the test group, and the group getting the substitute is called the control group. If both groups improve, or if only the control group improves, the drug's effectiveness has not been demonstrated. If the test group improves, but the control group does not, the hypothesis that the drug works is
tentatively accepted as true. Experimentation requires accurate measurement and recording of data, along with logical interpretations of the data.

If the results of experimentation support the original hypothesis, it is tentatively accepted as true, and the researcher moves on to the next step. If the data do not support the hypothesis, the researcher tentatively rejects the hypothesis. Knowing which hypotheses are incorrect is as valuable as knowing which hypotheses are valid. Scientists can thus focus on the ideas shown to have merit and avoid wasting time with disproven hypotheses. Initial experimental results are published in scientific journals so that other researchers can benefit from them and verify them. If experimental results cannot be reproduced by other scientists, then the hypothesis is not widely accepted. If a hypothesis withstands this rigorous retesting, the level of confidence in the hypothesis increases. A hypothesis that has gained a high level of confidence is called a theory or law.

Why is it important to know the steps of experimentation and developing theories if your main interest is a career in science applications—such as a health career? It is hard to grasp concepts fully if you do not understand how they were discovered and how they can change after additional experimentation.

The facts presented in this textbook are among the latest theories of how the body is built and how it functions. As methods of imaging the body and measuring functional processes improve, we find new data that cause us to replace old theories with newer ones.

Levels of Organization

Before you begin the study of the many structures and functions of the human body, it is important to think about how those parts are organized and how they might logically fit together into a functioning whole.

Examine Figure 1-2. It illustrates the differing levels of organization that influence body structure and function. Note that the levels of organization progress from the least complex (chemical level) to the most complex (organism level).

Because you already know that “structure fits function,” it should not surprise you that the highly complex and coordinated functions of the whole body can be understood by discovering the many basic processes that occur in the smaller parts, such as organs, tissues, and cells.

Organization is one of the most important characteristics of body structure. Even the word organism, used to denote a living thing, implies organization.

Although the body is a single structure, it is made up of trillions of smaller structures—each with its own functions. Atoms and molecules are often referred to as the chemical...
level of organization. The existence of life depends on the proper amounts and proportions of many chemical substances in the cells of the body.

Many of the physical and chemical phenomena that play important roles in the life process are reviewed in Chapter 2. Such information provides an understanding of the physical basis for life and for the study of the remaining levels of organization so important in the study of anatomy and physiology—cells, tissues, organs, and systems.

Cells are considered to be the smallest "living" units of structure and function in our body. Although long recognized as the simplest units of living matter, cells are far from simple.

![Levels of organization in the body](image)

**FIGURE 1-2** Levels of organization in the body. Atoms, molecules, and cells can ordinarily be seen only with a microscope, but the gross (large) structures of tissues, organs, systems, and the whole organism can be seen easily with the unaided eye.
They are extremely complex, a fact you will discover in Chapter 3.

Tissues are somewhat more complex than cells. By definition a tissue is an organization of many cells that act together to perform a common function. The cells of a tissue may be of several types, but all are working together in some way to produce the structural and functional qualities of the tissue. Cells of a tissue are often held together and surrounded by varying amounts and varieties of glue-like, nonliving intercellular substances. The varied properties of different tissues are explored in Chapter 4.

Organs are larger and more complex than tissues. An organ is a group of several different kinds of tissues arranged in ways that allow them to act as a unit to perform a special function. For instance, the brain shown in Figure 1-2 is an example of organization at the organ level. Unlike microscopic molecules and cells, some tissues and most organs are gross (large) structures that can be seen easily without a microscope.

Systems are the most complex units that make up the body. A system is an organization of varying numbers and kinds of organs that can work together to perform complex functions for the body. All of the organs of the nervous system shown in Figure 1-2 function to monitor and regulate the overall functioning of the body.

The body as a whole—the human organism—is all the atoms, molecules, cells, tissues, organs, and systems that you will study in subsequent chapters of this text. Although capable of being dissected or broken down into many parts, the body is a unified and complex assembly of structurally and functionally interactive components, each working together to ensure healthy survival.

Anatomical Position

Discussions about the body, the way it moves, its posture, or the relationship of one area to another assume that the body as a whole is in a specific position called the anatomical position. In this reference position (Figure 1-3) the body is in an erect or standing posture with the arms at the sides and palms turned forward. The head also points forward, as do the feet, which are aligned at the toe and set slightly apart.

The broken line along the middle, or median, of the body demonstrates that the body has external bilateral symmetry (that is, the left and right sides of the body roughly mirror each other).

The anatomical position is a reference position that gives meaning to the directional terms used to describe the body parts and regions. In other words, you need to know the...
The following directional terms are used in describing relative positions of body parts. To help you understand them better, they are listed in sets of opposite pairs.

1. **Superior** and **inferior** (Figure 1-4). Superior means "toward the head," and inferior means "toward the feet." Superior also means "upper" or "above," and inferior means "lower" or "below." For example, the lungs are located superior to the diaphragm, whereas the stomach is located inferior to it. (Check Figure 1-8 on p. 9 if you are not sure where these organs are.) The simple terms *upper* and *lower* are sometimes used in professional language as well. For example, the term "upper respiratory tract" and "lower gastrointestinal tract" are used commonly by anatomists and health professionals.

2. **Anterior** and **posterior** (see Figure 1-4). Anterior means "front" or "in front of." Posterior means "back" or "in back of." In humans, who walk in an upright position, *ventral* (toward the belly) can be used in place of anterior, and *dorsal* (toward the back) can be used for posterior. For example, the nose is on the anterior surface of the body, and the shoulder blades are on its posterior surface.

3. **Medial** and **lateral** (see Figure 1-4). Medial means "toward the midline of the body." Lateral means "toward the side of the body or away from its midline." For example, the great toe is at the medial side of the foot, and the little toe is at its lateral side. The heart lies medial to the lungs, and the lungs lie lateral to the heart.

4. **Proximal** and **distal** (see Figure 1-4). Proximal means "toward or nearest the trunk of the body, or nearest the point of origin of one of its parts." Distal means "away from or farthest from the trunk or the point of origin of a body part." For example, the elbow lies at the proximal end of the forearm, whereas the hand lies at its distal end. Likewise, the distal portion of a kidney tubule is more distant from the tubule origin than is the proximal part of the kidney tubule.

5. **Superficial** and **deep**. Superficial means nearer the surface. Deep means farther away from the body surface. For example, the skin of the arm is superficial to the muscles below it, and the bone of the arm is deep to the muscles that surround and cover it.

To better understand this concept, use the active concept map Anatomical Directions at evolve.elsevier.com.

**Anatomical Compass Rosette**

To make the reading of anatomical figures a little easier for you, we have used an anatomical compass rosette throughout this book. On many figures, you will see a small compass rosette like you might see on a geographical map. Instead of being labeled N, S, E, or W, the anatomical compass rosette is labeled with abbreviated anatomical directions.

For example, in Figure 1-3, the rosette is labeled S (for superior) on top and I (for inferior) on the bottom. Notice that in Figure 1-3 the rosette shows R (right) on the subject's right, not your right. Now look at the rosettes in Figure 1-4, and compare them to the body positions shown.

Here are the directional abbreviations used with the rosettes in this book:

- **A** = Anterior
- **D** = Distal
- **I** = Inferior
- **L** = Lateral
- **M** = Medial
- **P** = Posterior
- **R** = Right
- **S** = Superior
CHAPTER 1 Introduction to the Body

Superior

Posterior
Anterior

Proximal
Distal

Frontal plane
Distal
Proximal

Oblique planes

Transverse planes

P S A

Inferior

Lateral

Lateral

Sagittal planes

Oblique planes

Frontal planes

Transverse planes

FIGURE 1-4 Directions and planes of the body. The arrows show anatomical directions and the blue plates show examples of body planes along which cuts or sections are made in visualizing the structure of the body.

For a review of anatomical directions, go to AnimationDirect at evolve.elsevier.com.

1. What is the anatomical position?
2. Why are the anatomical directions listed in pairs?

Planes of the Body

To facilitate the study of individual organs or the body as a whole, it is often useful to subdivide or "cut" it into smaller segments. This can be done with actual cuts in a dissection, or it can be done virtually, as in medical imaging in computed tomography (CT) or magnetic resonance imaging (MRI) scans. To understand such a cut—also called a section—one must imagine a body being divided by an imaginary flat plate called a plane.

Because many anatomical sections, cut along specific planes of the body, are used in anatomical studies and medical imaging, we describe them here. As you read the following descriptions, identify each type of plane in Figure 1-4.

1. **Sagittal plane**—a sagittal cut or section runs along a lengthwise plane running from front to back. It divides the body or any of its parts into right and left sides. The midsagittal plane shown in Figure 1-4 is a unique type of sagittal plane that divides the body into two equal halves.

2. **Frontal plane**—a frontal plane (coronal plane) is a lengthwise plane running from side to side. As you can see in Figure 1-4, a frontal plane divides the body or any of its parts into anterior and posterior (front and back) portions.

3. **Transverse plane**—a transverse plane is a horizontal or crosswise plane. Such a plane (see Figure 1-4) divides the body or any of its parts into upper and lower portions.

Sometimes it is helpful to make a cut along a plane that is not parallel to the planes we have already mentioned. Such diagonal cuts are made along oblique planes, which you can see illustrated in Figure 1-4.

Explore the Clear View of the Human Body insert located in this book after p. 104. Note that the larger transparency images show the body and its organs sectioned along frontal planes. However, the smaller images in the margins show transverse sections at specific locations in the body.

Besides using planes to cut the body into various sections, we sometimes use planes to describe movement. For example, one rotates the head in a transverse plane, and one
can move a finger along both a sagittal plane and along a frontal plane.

To explore some of the major types of medical images that use sectional views of the body, see the article Medical Imaging of the Body at Connect It! at evolve.elsevier.com.

**Body Cavities**

Contrary to its external appearance, the body is not a solid structure. It is made up of open spaces or cavities that often contain well-ordered arrangements of internal organs.

A major body cavity that houses several internal organs forms during early development and subdivides into two large ventral body cavities. In a separate developmental process along the posterior aspect of the body, bony dorsal cavities form that house organs of the central nervous system.

In addition, there are many smaller spaces in local regions of the body also named as cavities—such as the oral cavity and nasal cavity. The location and outlines of some important body cavities are illustrated in Figure 1-5.

**Dorsal Cavities**

The dorsal cavities shown in Figure 1-5 include the space inside the skull that contains the brain. It is called the cranial cavity.

The space inside the vertebral column (spinal column) is called the spinal cavity. It contains the spinal cord. The cranial and spinal cavities are called dorsal cavities because they are located in a dorsal position in the body.

**Ventral Cavities**

The ventral cavities that form from the major body cavity during embryonic development are located in a more ventral position in the body.

**Thoracic and Abdominopelvic Cavities**

The upper ventral cavities include the thoracic cavity, a space that you may think of as your chest cavity. Its midportion is a subdivision of the thoracic cavity, called the mediastinum. The lateral subdivisions of the thoracic cavity are called the right and left pleural cavities.

The lower ventral cavities in Figure 1-5 include an abdominal cavity and a pelvic cavity. Actually, they form only one compartment, the abdominopelvic cavity, because no physical partition separates them. In Figure 1-5 a faint line shows the approximate point of separation between the abdominal and pelvic subdivisions.

However, notice that an actual physical partition separates the thoracic cavity above from the abdominopelvic cavity below. This muscular sheet is the diaphragm. It is dome shaped and is the most important muscle for breathing.

**Abdominopelvic Subdivisions**

**Abdominopelvic Quadrants**

To make it easier to locate organs in the large abdominopelvic cavity, anatomists have divided the abdominopelvic cavity into four abdominopelvic quadrants:

1. Right upper quadrant or RUQ (right superior quadrant)
2. Right lower quadrant or RLQ (right inferior quadrant)
3. Left upper quadrant or LUQ (left superior quadrant)
4. Left lower quadrant or LLQ (left inferior quadrant)

As you can see in Figure 1-6, the midsagittal and transverse planes, which were described in the previous section, pass through the navel (umbilicus) and divide the abdominopelvic region into the four quadrants. This method of subdividing the abdominopelvic cavity is frequently used by health professionals and is useful for locating the origin of pain or describing the location of a tumor or other abnormality.

You may notice that terms like upper and lower are often used to name quadrants, which may seem overly informal compared with the more technical terms superior and inferior. However, this practice reflects the usage found in many clinical environments, where a mix of informal and technical terminology is commonly encountered.
Abdominopelvic Regions

Another and perhaps more precise way to divide the abdominopelvic cavity is shown in Figure 1-7. Here, the abdominopelvic cavity is subdivided into nine abdominopelvic regions defined as follows:

1. **Upper abdominopelvic regions**—the right hypochondriac region, left hypochondriac region, and the epigastric region lie above an imaginary line across the abdomen at the level of the ninth rib cartilages.

2. **Middle abdominopelvic regions**—the right lumbar region and left lumbar region (also called flank regions) and the umbilical region lie below an imaginary line across the abdomen at the level of the ninth rib cartilages and above an imaginary line across the abdomen at the top of the hip bones.

3. **Lower abdominopelvic regions**—the right iliac region and left iliac region (also called inguinal regions) and the hypogastric region (also called pubic region) lie below an imaginary line across the abdomen at the level of the top of the hip bones.

Some of the organs in the largest body cavities are visible in Figure 1-8 and are listed in Table 1-1. Find each body cavity in a model of the human body if you have access to one. Try to identify the organs in each cavity, and try to visualize their

<table>
<thead>
<tr>
<th>Table 1-1: Body Cavities</th>
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</thead>
<tbody>
<tr>
<td><strong>BODY CAVITIES</strong></td>
</tr>
<tr>
<td><strong>Ventral Body Cavities</strong></td>
</tr>
<tr>
<td>Thoracic Cavity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Abdominopelvic Cavity</td>
</tr>
<tr>
<td>Abdominal cavity</td>
</tr>
<tr>
<td>Dorsal Body Cavities</td>
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</tbody>
</table>
Body Regions

To recognize an object, you usually first notice its overall structure and form. For example, a car is recognized as a car before the specific details of its tires, grill, or wheel covers are noted. Recognition of the human form also occurs as you first identify overall shape and basic outline. However, for more specific identification to occur, details of size, shape, and appearance of individual body areas must be described. Individuals differ in overall appearance because specific body areas such as the face or torso have unique identifying characteristics. Detailed descriptions of the human form require that specific regions be identified and appropriate terms be used to describe them.

The ability to identify and correctly describe specific body areas is particularly important in the health sciences. For a patient to complain of pain in the head is not as specific and therefore not as useful to a physician or nurse as a more specific and localized description. Saying that the pain is facial provides additional information and helps to more specifically identify the area of pain. By using correct anatomical terms such as forehead, cheek, or chin to describe the area of pain, attention can be focused even more quickly on the specific anatomical area that may need attention.

**FIGURE 1-8** Organs of the major body cavities.  
A, A view from the front. B, Transverse section viewed from above.
Familiarize yourself with the more common terms used to describe specific body regions identified in Figure 1-9 and listed in Table 1-2. Explore the Clear View of the Human Body insert located after p. 104 to find the major body regions.

<table>
<thead>
<tr>
<th>AREA OR BODY REGION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal region</td>
<td>Anterior torso below diaphragm</td>
</tr>
<tr>
<td>Antebrachial region</td>
<td>Forearm</td>
</tr>
<tr>
<td>Axillary region</td>
<td>Armpit</td>
</tr>
<tr>
<td>Brachial region</td>
<td>Arm</td>
</tr>
<tr>
<td>Buccal region</td>
<td>Cheek</td>
</tr>
<tr>
<td>Carpal region</td>
<td>Wrist</td>
</tr>
<tr>
<td>Cephalic region</td>
<td>Head</td>
</tr>
<tr>
<td>Cervical region</td>
<td>Neck</td>
</tr>
<tr>
<td>Cranial region</td>
<td>Skull</td>
</tr>
<tr>
<td>Crural region</td>
<td>Leg</td>
</tr>
<tr>
<td>Cubital region</td>
<td>Elbow*</td>
</tr>
<tr>
<td>Cutaneous region</td>
<td>Skin (or body surface)</td>
</tr>
<tr>
<td>Digital region</td>
<td>Fingers or toes</td>
</tr>
<tr>
<td>Dorsal region</td>
<td>Back</td>
</tr>
<tr>
<td>Facial region</td>
<td>Face</td>
</tr>
<tr>
<td>Femoral region</td>
<td>Thigh</td>
</tr>
<tr>
<td>Frontal region</td>
<td>Forehead</td>
</tr>
<tr>
<td>Gluteal region</td>
<td>Buttock</td>
</tr>
<tr>
<td>Inguinal region</td>
<td>Groin</td>
</tr>
<tr>
<td>Lumbar region</td>
<td>Lower back between ribs and pelvis</td>
</tr>
<tr>
<td>Mammary region</td>
<td>Breast</td>
</tr>
<tr>
<td>Nasal region</td>
<td>Nose</td>
</tr>
<tr>
<td>Occipital region</td>
<td>Back of lower skull</td>
</tr>
<tr>
<td>Olecranal region</td>
<td>Back of elbow</td>
</tr>
<tr>
<td>Oral region</td>
<td>Mouth</td>
</tr>
<tr>
<td>Orbital region or ophthalmic region</td>
<td>Eyes</td>
</tr>
<tr>
<td>Palmar region</td>
<td>Palm of hand</td>
</tr>
<tr>
<td>Pedal region</td>
<td>Foot</td>
</tr>
<tr>
<td>Pelvic region</td>
<td>Lower portion of torso</td>
</tr>
<tr>
<td>Perineal region</td>
<td>Area (perineum) between anus and genitals</td>
</tr>
<tr>
<td>Plantar region</td>
<td>Sole of foot</td>
</tr>
<tr>
<td>Popliteal region</td>
<td>Area behind knee</td>
</tr>
<tr>
<td>Supraclavicular region</td>
<td>Area above clavicle</td>
</tr>
<tr>
<td>Tarsal region</td>
<td>Ankle</td>
</tr>
<tr>
<td>Temporal region</td>
<td>Side of skull</td>
</tr>
<tr>
<td>Thoracic region</td>
<td>Chest</td>
</tr>
<tr>
<td>Umbilical region</td>
<td>Area around navel or umbilicus</td>
</tr>
<tr>
<td>Volar region</td>
<td>Palm or sole</td>
</tr>
<tr>
<td>Zygomatic region</td>
<td>Upper cheek</td>
</tr>
</tbody>
</table>

*The term cubital may also be used to refer to the forearm.

The body as a whole can be subdivided into two major portions or components: axial and appendicular. The axial portion of the body consists of the head, neck, and torso or trunk. The appendicular portion consists of the upper and lower extremities (or limbs).

Each major axial and appendicular area is subdivided as shown in Figure 1-9. For example, note that the torso is composed of thoracic, abdominal, and pelvic areas, and the upper extremity is divided into arm, forearm, wrist, and hand components.

Although most terms used to describe gross body regions are well understood, misuse is common. The word leg is a good example: it refers to the area of the lower extremity between the knee and ankle and not to the entire lower extremity.

The structure of each person's body is unique. Even identical twins have some variations in the size, shape, and texture of various tissues and organs.

The structure of the body also changes in many ways and at varying rates during a lifetime. Before young adulthood, the body develops and grows. After young adulthood, the body gradually undergoes changes related to aging. For example, with the reduced activity of the body as one advances through older adulthood, many body organs and tissues decrease in size and therefore change in their functions. A degenerative process that results from disuse is called atrophy. In many cases, atrophy can be reversed with therapy. Some tissues simply lose their elasticity or ability to regenerate as we get older.

Nearly every chapter of this book refers to a few of the changes that occur through the life cycle.

Before moving ahead, we pause to consider what seems like an overwhelming number of scientific terms introduced in the preceding sections. It is important to know that such terminology is a "new language" that you must learn as you continue your studies. Now is a good time to review the introduction to this new language in Appendix B near the end of this book. Then, in upcoming chapters, make it a habit to read through the new terms in the chapter word lists—pausing to pronounce each term out loud and glance at its word parts—before starting your reading. Such a strategy will help you slowly and comfortably build a mastery of scientific language.

**Quick Check**

1. What is the difference between the axial portion of the body and the appendicular portion of the body?
2. What are some of the regions of the upper extremity and lower extremity?

**Balance of Body Functions**

**Homeostasis**

Although structurally different from one another, all living organisms maintain mechanisms that ensure survival of the body and success in propagating its genes through its offspring.

Survival depends on maintaining relatively constant conditions within the body. Homeostasis is what physiologists call the relative constancy of the internal environment. The cells of
the body live in an internal environment made up mostly of water combined with salts and other dissolved substances.

Like fish in a fishbowl, the cells are able to survive only if the conditions of their watery environment remain relatively stable—that is, only if conditions stay within a narrow range. The temperature, salt content, acid level (pH), fluid volume and pressure, oxygen concentration, and other vital conditions must remain within acceptable limits. To maintain a narrow range of water conditions in a fishbowl, one may add a heater, an air pump, and filters. Likewise, the body has mechanisms that act as heaters, air pumps, and the like to maintain the relatively stable conditions of its internal fluid environment (Figure 1-10).

Because external disturbances and the activities of cells themselves cause frequent fluctuations inside the body, conditions are continuously drifting away from homeostatic balance. Therefore the body must constantly work to maintain or restore stability, or homeostasis.

For example, the heat generated by muscle activity during exercise may cause the body's temperature to rise above normal. The body must then release sweat, which evaporates and cools the body back to a normal temperature.

Feedback Control

To accomplish such self-regulation, a highly complex and integrated communication control system is required. The basic type of control system in the body is called a feedback loop.

The idea of a feedback loop is borrowed from engineering. Figure 1-11, A shows how an engineer would describe the feedback loop that maintains stability of temperature in a building. Cold winds outside a building may cause the building temperature to drop below normal. A sensor, in this case a thermometer, detects the change in temperature. Information from the sensor feeds back to a control center— a thermostat in this example—that compares the actual temperature with the normal temperature and responds by activating the building's furnace. The furnace is called an effector because it has an effect on the controlled condition.
loops in the body involve negative feedback because negative feedback loops. Feedback loops such as those shown in body temperature has increased to normal. Negative feedback stops shivering when feedback information tells the brain that we produce heat that increases our body temperature. We sensors feed information to a control center in the brain that compares actual body temperature to normal body temperature. In response to a chill, the brain sends nerves signals to muscles that cause rapidly repeated contractions. This shivering becomes chilled. Nerve endings that act as temperature sensors feed information to a control center in the brain that compares actual body temperature to normal body temperature. In response to a chill, the brain sends nerve signals to muscles that cause rapidly repeated contractions. This shivering becomes heat that increases our body temperature. We stop shivering when feedback information tells the brain that body temperature has increased to normal.

**Negative Feedback**

Feedback loops such as those shown in Figure 1-11 are called negative feedback loops because they oppose, or negate, a change in a controlled condition. Most homeostatic control loops in the body involve negative feedback because reversing changes back toward a normal value tends to stabilize conditions—exactly what homeostasis is all about.

Think about the opposite circumstance of that shown in Figure 1-11, as when we become overheated during hot weather. Temperature receptors detect a body temperature higher than normal, and the brain sends signals to the sweat glands to cool us down through evaporation. Thus the conditions are reversed and balance is restored.

Another example of a negative feedback loop occurs during exercise. As muscles contract, they produce additional carbon dioxide (CO₂), which is transported by blood. This increase in blood CO₂ levels is detected by sensory receptors which transmit that information to respiratory control centers in the brain. This triggers an increase in breathing rate that brings the blood CO₂ level back down toward normal.

An additional example is the excretion of larger than usual volumes of urine when the volume of fluid in the body is greater than the normal, ideal amount.

**Positive Feedback**

Although not common, positive feedback loops exist in the body and are sometimes also involved in normal function. Positive feedback control loops are stimulatory. Instead of opposing a change in the internal environment and causing a "return to normal," positive feedback loops temporarily amplify the change that is occurring. This type of feedback loop causes an ever-increasing rate of events to occur until something stops the process. An example of a positive feedback loop includes the events that cause rapid increases in uterine contractions before the birth of a baby (Figure 1-12).

Another example of normal positive feedback regulation in the body is the activity of blood cells called platelets, which become increasingly sticky in response to damage to a blood vessel. Circulating platelets rapidly cling to the damaged area and release chemicals that attract additional platelets which accumulate at the site of damage to form a blood clot. The blood clot forms to control bleeding.

In each of these cases, the process rapidly increases until the positive feedback loop is stopped suddenly by the birth of a baby or the formation of a clot. In the long run, such normal positive feedback events also help to maintain constancy of the internal environment.

However, negative feedback can abnormally turn into positive feedback, possibly causing a deadly shift in body function.

For example, consider the role of blood pressure and the effect that severe bleeding may have on blood pressure. A normal blood pressure is necessary to ensure that blood flows through blood vessels at an appropriate rate. When blood is lost, as occurs with severe bleeding, blood pressure drops. To compensate, the heart beats faster to try to restore normal pressure. Unfortunately, this increases the loss of blood, which causes a further drop in blood pressure and an even faster heart rate. The response is accelerated, and the amplification of blood loss caused by this positive feedback loop can rapidly turn deadly. Applying pressure to the wound can stop or slow the loss of blood and stop the positive feedback loop.
**Normal Fluctuations**

It is important to realize that normal homeostatic control mechanisms can maintain only a relative constancy. All homeostatically controlled conditions in the body do not remain absolutely constant. Rather, conditions normally fluctuate near a normal, ideal value. Thus body temperature, for example, rarely remains exactly the same for very long—instead it fluctuates up and down near a person's normal body temperature.

Because all organs function to help maintain homeostatic balance, we discuss negative and positive feedback mechanisms often throughout the remaining chapters of this book.

Before leaving this brief introduction to physiology, we must pause to state an important principle: the ability to maintain the balance of body functions is related to age. During childhood, homeostatic functions gradually become more and more efficient and effective. They operate with maximum efficiency and effectiveness during young adulthood. During late adulthood and old age, they gradually become less and less efficient and effective.

Changes and functions occurring during the early years are called developmental processes. Changes occurring after young adulthood are called aging processes. In general, developmental processes improve efficiency of functions. On the other hand, aging processes usually diminish the efficiency of body functions.

**QUICK CHECK**

1. Why is homeostasis also called "balance" of body function?
2. What is a feedback loop and how does it work?
3. How does negative feedback differ from positive feedback?
4. How can negative feedback abnormally turn into positive feedback?
CHAPTER 1 Introduction to the Body

STRETCH ➔ INCREASE

Stronger, more frequent labor contractions

FEETUS MOVES INTO BIRTH CANAL

STRETCH RECEPTORS

UTERINE MUSCLE

EFFECTOR

CORRECTION SIGNALS VIA OXYTOCIN

FEEDS INFORMATION VIA NERVE FIBERS BACK TO BRAIN

HYPOTHALAMUS

PITUITARY

NORMAL INTEGRATOR STRETCHED

FIGURE 1-12 Positive feedback loop. An example of positive feedback occurs when a baby is born. As the baby is pushed from the womb (uterus) into the birth canal (vagina), stretch receptors detect the movement of the baby. Stretch information is fed back to the brain, triggering the pituitary gland to secrete a hormone called oxytocin (OT). OT travels through the bloodstream to the uterus, where it stimulates stronger contractions. Stronger contractions push the baby farther along the birth canal, thereby increasing stretch and stimulating the release of more OT. Uterine contractions quickly get stronger and stronger until the baby is pushed out of the body, and the positive feedback loop is broken. OT also can be injected therapeutically by a physician to stimulate labor contractions.

LANGUAGE OF SCIENCE AND MEDICINE (continued from p. 1)

**anterior**
(=ante-front, -er-more, -or quality)

**anthropology**
(an-throh-POL-oh-jee)
[anthropo- human, -logy words (study of), -y activity]

**appendicular**
(ah-pan-DIK-yoo-lar)
[append- hang upon, -ic relating to, -al relating to]

**atrophy**
(AT-roh-fee)
[a- without, -rophy nourishment, -y state]

**axial**
(AK-see-al)
[axi- axis, -al relating to]

**axillary**
(AK-sil-lay-ee)
[axilla- wing, -al relating to]

**chemical level**
(KEM-ih-kal LEV-eh
kal)
[chem- alchemy, -ical relating to]

**cervical**
(SER-vih-kal)
[cervic- neck, -al relating to]

**cell**
(sel)
[cell storage]

**cephalic**
(seh-FAL-ik)
[cephal- head, -ic relating to]

**bi-lateral symmetry**
(bye-LAT-er-al SIM-eh-tree)
[bi- two, -later- side, -al relating to, sym- together, -metry measure, -metry condition of]

**brachial**
(BRAY-kee-al)
[brach- arm, -al relating to]

**buccal**
(BUK-al)
[bucc- cheek, -al relating to]

**carpal**
(KAR-pul)
[carp- wrist, -al relating to]
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>physiology</td>
<td>(fiz-ee-OH-jee) n (physio- nature (function), -o- combining form, -logy- words (study of), -y activity)</td>
</tr>
<tr>
<td>plane</td>
<td>(playn) flat surface</td>
</tr>
<tr>
<td>planter</td>
<td>(PLAN-tar) sole of foot, -ar relating to</td>
</tr>
<tr>
<td>pleural cavity</td>
<td>(PLOOR-al KAV-ih-tee) rib, -a relating to, cav-hollow, -ity state</td>
</tr>
<tr>
<td>popliteal</td>
<td>(pop-lih-TEE-al) back of knee, -ar relating to</td>
</tr>
<tr>
<td>positive feedback</td>
<td>(POZ-it-iv FEED-bak) place or amplify, -ive relating to</td>
</tr>
<tr>
<td>posterior</td>
<td>(pos-TEER-ee-or) behind, -or relating to</td>
</tr>
<tr>
<td>prone</td>
<td>(prohn) lying face down</td>
</tr>
<tr>
<td>proximal</td>
<td>(PROK-si-mal) near, -al relating to</td>
</tr>
<tr>
<td>sagittal plane</td>
<td>(SAJ-i-tal playn) arrow, -al relating to, plan-flat surface</td>
</tr>
<tr>
<td>scientific method</td>
<td>(sye-en-TIF-ik METH-od) organized whole</td>
</tr>
<tr>
<td>section</td>
<td>(SEK-shun) cut, -ion process or state</td>
</tr>
<tr>
<td>sensor</td>
<td>(SEN-sor) feel, -or relating to</td>
</tr>
<tr>
<td>spinal cavity</td>
<td>(SPY-nal KAV-ih-tee) backbone, -al relating to, cav-hollow, -ity state</td>
</tr>
<tr>
<td>superficial</td>
<td>(soo-per-FISH-al) over or above, -fice-face, -al relating to</td>
</tr>
<tr>
<td>superior</td>
<td>(soo-PEER-ee-or) over or above, -or relating to</td>
</tr>
<tr>
<td>supine</td>
<td>(SOO-pyne) lying on the back</td>
</tr>
<tr>
<td>supracleavicular</td>
<td>(soo-prah-klah-VIK-yoo-lar) above or over, -clavi-key, -al little, -ar relating to</td>
</tr>
<tr>
<td>system</td>
<td>(SIS-tern) organized whole</td>
</tr>
<tr>
<td>tarsal</td>
<td>(TAR-sal) ankle, -ar relating to</td>
</tr>
<tr>
<td>temporal</td>
<td>(TEM-poh-ral) temple (of head), -al relating to</td>
</tr>
<tr>
<td>theory</td>
<td>(THEE-ah-ree) look at, -y act of</td>
</tr>
<tr>
<td>thoracic</td>
<td>(thoh-RAS-ik) chest (thorax), -ic relating to</td>
</tr>
<tr>
<td>thoracic cavity</td>
<td>(thoh-RAS-ik KAV-it-ee) chest (thorax), -ic relating to, cav-hollow, -ity state</td>
</tr>
<tr>
<td>tissue</td>
<td>(TISH-you) fabric</td>
</tr>
<tr>
<td>transverse plane</td>
<td>(TRANS-vers playn) across or through, -vers turn, plan-flat surface</td>
</tr>
<tr>
<td>umbilical</td>
<td>(um-BIL-ih-kul) navel, -ar relating to</td>
</tr>
<tr>
<td>ventral body cavity</td>
<td>(VEN-tral BOD-ee KAV-ih-tee) belly, -al relating to, cav-hollow, -ity state</td>
</tr>
<tr>
<td>volar</td>
<td>(VOH-lar) hollow of hand, -ar relating to</td>
</tr>
<tr>
<td>zygomatic</td>
<td>(zye-goh-MAT-ik) union or yoke, -ic relating to</td>
</tr>
</tbody>
</table>

**OUTLINE SUMMARY**

To download a digital audio version of the chapter summary for use with your device, access the Audio Chapter Summaries online at evolve.elsevier.com.

Hint: Scan this summary after reading the chapter to help you reinforce the key concepts. Later, use the summary as a quick review before your class or before a test.

**Scientific Method**

A. Science involves logical inquiry based on experimentation (see Figure 1-1)

1. Hypothesis—idea or principle to be tested in experiments

2. Experiment—series of tests of a hypothesis; a controlled experiment eliminates biases or outside influences

3. Theory or law—a hypothesis that has been supported by experiments and thus shown to have a high degree of confidence

B. The process of science is active and changing as new experiments add new knowledge

**Levels of Organization**

A. Organization is the most important characteristic of body structure

B. The body as a whole is a unit constructed of the following smaller units (see Figure 1-2):

1. Atoms and molecules—chemical level
2. Cells—the smallest structural units; organizations of various chemicals
3. Tissues—organizations of similar cells
4. Organs—organizations of different kinds of tissues
5. Systems—organizations of many different kinds of organs
6. Organism—organization of all systems together, forming a whole body
7. Microbiome—set of interacting communities of bacteria and other microorganisms that inhabit the human body; influences normal body function

Anatomical Position
A. Reference position in which the body stands erect with the arms at the sides and palms turned forward (see Figure 1-3)
B. Anatomical position gives meaning to directional terms

Anatomical Directions
A. Superior—toward the head, upper, above
B. Inferior—toward the feet, lower, below
C. Anterior—front, in front of (same as ventral in humans)
D. Posterior—back, in back of (same as dorsal in humans)
E. Medial—toward the midline of a structure
F. Lateral—away from the midline or toward the side of a structure
G. Proximal—toward or nearest the trunk, or nearest the point of origin of a structure
H. Distal—away from or farthest from the trunk, or farthest from a structure’s point of origin
I. Superficial—near the body surface
J. Deep—farther away from the body surface

Planes of the Body (see Figure 1-4)
A. Sagittal plane—lengthwise plane that divides a structure into right and left sections
   1. Midsagittal plane—sagittal plane that divides the body into two equal halves
B. Frontal (coronal) plane—lengthwise plane that divides a structure into anterior and posterior sections
C. Transverse plane—horizontal plane that divides a structure into upper and lower sections
D. Oblique plane—any plane that is not parallel to any of the planes listed previously, thus producing a slanted section

Body Cavities (see Figure 1-5 and Table 1-1)
A. Dorsal cavities
   1. Cranial cavity contains brain
   2. Spinal cavity contains spinal cord

B. Ventral cavities
   1. Thoracic cavity
      a. Mediastinum—midportion of thoracic cavity; heart and trachea are located in mediastinum
      b. Pleural cavities—right lung is located in right pleural cavity, and left lung is in left pleural cavity
   2. Abdominopelvic cavity
      a. Abdominal cavity contains stomach, intestines, liver, gallbladder, pancreas, and spleen
      b. Pelvic cavity contains reproductive organs, urinary bladder, and lowest part of intestine
      c. Abdominopelvic subdivisions
         (1) Four abdominopelvic quadrants (see Figure 1-6)
         (2) Nine abdominopelvic regions (see Figure 1-7)
   C. Organs of the major body cavities can be seen in Figure 1-8

Body Regions (see Figure 1-9 and Table 1-2)
A. Axial region—head, neck, and torso or trunk
B. Appendicular region—upper and lower extremities
C. Body structure and function vary among individuals and also throughout an individual’s life span; atrophy (decrease in size) occurs when an organ is not used

Balance of Body Functions
A. Survival of the individual and of the genes that make up the body is of the utmost importance
B. Survival depends on the maintenance or restoration of homeostasis (relative constancy of the internal environment)
   1. The internal environment is a fluid that must be kept stable by the operation of various organ systems (see Figure 1-10)
   2. The body uses stabilizing negative feedback loops (see Figure 1-11) and, less often, amplifying positive feedback loops to maintain or restore homeostasis (see Figure 1-12)
   3. Feedback loops involve a sensor, a control center, and an effector
   4. Negative feedback loops can turn into positive feedback loops during injury or disease, possibly causing a deadly shift in body function
C. All organs function to maintain homeostasis
D. Ability to maintain balance of body functions is related to age. Peak efficiency occurs during young adulthood, and diminishing efficiency of many functions begins after young adulthood
1. A number of topics are introduced in this chapter that will be important throughout the rest of the course.
2. One of your first steps should be mastering the new terminology of each chapter. Read the new terms listed at the beginning of each chapter out loud before attempting to read or learn each new topic. Use the pronunciation guides provided, saying each term several times to “get it into” your working memory. Pay attention to word parts too; they will help you to master the terminology of science and medicine more quickly. (For more terminology tips, see my-ap.uslfsboS2.)
3. Homeostasis is an important concept when studying the human body. The word itself tells you what it means: *homeo* means “the same,” *stasis* means “staying.” Homeostasis is the balance the body tries to maintain by making sure its internal environment “stays the same.” Make sure you understand this concept. (For more tips on homeostasis, see my-ap.uslrs3KqV)
4. Another important topic introduced in this chapter is the structural levels of organization. The lower levels are the building blocks on which the upper levels depend. As various disease processes are explained in later chapters, notice how many of these processes cause failure at the chemical or cellular level and how this failure affects organs, systems, and even the body as a whole.
5. Become familiar with the directional terms; you will see them in almost every diagram in the text. The terms also are used in naming several body structures (for example, superior vena cava, distal convoluted tubule). The terms are fairly easy to learn because they are presented in opposite pairs, so if you learn one term, you almost always automatically know its opposite. Flash cards will help you to learn them. (For more on using flashcards effectively, see my-ap.us/LzaurwE. See my-ap.us/K9GtV for more tips on learning directions.)
6. **Table 1-2** and the Glossary are helpful resources to keep in mind when you see an unfamiliar term.
7. In your study group, try to come up with examples of negative feedback loops that help to maintain a balance. Be creative; do not just use the furnace example. Go over your directional-term flash cards, or photocopy **Figure 1-4** and then blacken out the terms so you and your fellow students can use the illustration to quiz each other. Go over the questions at the end of the chapter, and discuss possible test questions.

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**Review Questions**

**Hint** Write out the answers to these questions after reading the chapter and reviewing the Chapter Summary. If you simply think through the answer without writing it down, you will not retain much of your new learning. Take a few minutes every day to answer them again; this practice reinforces the mastery needed for your test.

1. Define anatomy and physiology.
2. Describe the process used to form scientific theories.
3. List and explain the levels of organization in a living thing.
4. Describe the anatomical position.
5. Name and explain the three planes or sections of the body.
6. List two organs of the mediastinum, two organs of the abdominal cavity, and two organs of the pelvic cavity.
7. From the upper left to the lower right, list the nine regions of the abdominopelvic cavity.
8. Name the two subdivisions of the dorsal cavity. What structures does each contain?
9. Explain the difference between the terms *lower extremity*, *thigh*, and *leg*.
10. Name the major areas that are included in the axial portion of the body.
11. List four conditions in the cell that must be kept in homeostatic balance.
12. List the three parts of a negative feedback loop and give the function of each.

**Critical Thinking**

**Hint** After finishing the Review Questions, write out the answers to these more in-depth questions to help you apply your new knowledge. Go back to sections of the chapter that relate to concepts that you find difficult.

13. Name a structure that is inferior to the heart, superior to the heart, anterior to the heart, posterior to the heart, and lateral to the heart.
14. The maintenance of body temperature and the birth of a baby are two body functions that are regulated by feedback loops. Explain the different feedback loops that regulate each process.
15. If a person complained of a pain in the epigastric region, what organs could be involved?
16. Consider some casual observation that you have made that might lead to the formation of a hypothesis. Explain how you could determine if your hypothesis is true or not. What would have to take place for your hypothesis to be accepted by others as fact?
Chapter Test

After studying the chapter, test your mastery by responding to these items. Try to answer them without looking up the answers. Then, verify the answers using the key in Appendix C at the back of this book. Take a few minutes to practice these daily.

1. ______ is a term derived from two Greek words meaning “cutting up.”
2. ______ means the study of the function of living organisms and their parts.
3. A hypothesis that has been rigorously tested can be called a ______ or ______.
4. ______, ______, ______, ______, and ______ are the five organizational levels of a living thing.
5. ______ and ______ are terms used to describe the body position when it is not in anatomical position.
6. A ______ section cuts the body or any of its parts into upper and lower portions.
7. A ______ section cuts the body or any of its parts into front and back portions.
8. A ______ section cuts the body or any of its parts into left and right portions.
9. If the body is cut into equal right and left sides, the cut is called a ______ section or plane.
10. In addition to using planes to cut the body into various sections, we sometimes use planes to describe ______.
11. The body portion that consists of the head, neck, and torso is called the ______ portion.
12. The body portion that consists of the upper and lower extremities is the ______ portion.
13. The two major cavities of the body are the:
   a. thoracic and abdominal
   b. abdominal and pelvic
   c. dorsal and ventral
   d. anterior and posterior
14. The structure that divides the thoracic cavity from the abdominal cavity is the:
   a. mediastinum
   b. diaphragm
   c. lungs
   d. stomach
15. The epigastric region of the abdominopelvic cavity:
   a. is inferior to the umbilical region
   b. is lateral to the umbilical region
   c. is medial to the umbilical region
   d. none of the above
16. The hypogastric region of the abdominopelvic cavity:
   a. is inferior to the umbilical region
   b. lateral to the left iliac region
   c. medial to the right iliac region
   d. both a and c
17. Which of the following is an example of a positive feedback loop?
   a. maintaining a constant body temperature
   b. contractions of the uterus during childbirth
   c. maintaining a constant volume of water in the body
   d. both a and c
18. The excretion of larger than usual volumes of urine when the volume of fluid in the body is greater than normal is an example of:
   a. positive feedback
   b. negative feedback
   c. normal fluctuation
   d. both b and c

Match each of the directional terms in Column B with its opposite term in Column A.

**Column A** | **Column B**
---|---
19. superior | a. posterior
20. distal | b. superficial
21. anterior | c. medial
22. lateral | d. proximal
23. deep | e. inferior