CHAPTER OUTLINE

No tissue is more important than blood: it delivers oxygen and nutrients, it removes carbon dioxide, and it plays a key role in fighting infections. At first glance, blood looks like a simple tissue: essentially a bunch of different cells floating in salty water, more or less. That means it should be pretty easy to make artificial blood. But it’s not.

Many factors account for the interest in artificial blood. The military recognizes blood loss as a primary cause of death, owing to both pressure loss as blood volume decreases and decreased oxygen delivery with fewer red blood cells present. Blood is typically in short supply, and it cannot be frozen forever. Blood transfusions can carry viral diseases, and even in an emergency, it’s necessary to check the patient’s blood type before an infusion.

The most common way to deal with blood loss during emergencies is to infuse saline solution. This procedure maintains blood volume but does not replace the essential oxygen-carrying function. The major goal of artificial blood is to carry oxygen, since oxygen starvation can destroy brain cells in four minutes. Scientists have tried to use hemoglobin, the oxygen-carrying molecule in the red blood cell, but unless it is “packaged” inside a cell, it can damage the kidney.

At present, several experimental versions of oxygen-carrying artificial blood are being tested. But blood is a complex and subtle tissue, and so artificial blood is likely to serve as a supplement, not a replacement, for the natural stuff.
Cells Are the Building Blocks of Tissues

**LEARNING OBJECTIVES**

- List the four tissue types in the human body.
- Describe the function of each tissue type, explaining its unique characteristics.

<table>
<thead>
<tr>
<th>Tissue Type</th>
<th>Function</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epithelial</td>
<td>Covers body surfaces, lines cavities, and composes glands.</td>
<td>Connective tissue literally connects the structures of the body, providing structural support and holding organs together.</td>
</tr>
<tr>
<td>Connective</td>
<td>Provides structural support and holds organs together.</td>
<td>Stretches and sustains the body's integrity.</td>
</tr>
<tr>
<td>Muscular</td>
<td>Provides movement and heat.</td>
<td>Detected, processed, and coordinated information.</td>
</tr>
<tr>
<td>Nervous</td>
<td>Responds to the environment</td>
<td>Maintains the body's integrity.</td>
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**EPITHELIAL TISSUE IS AT THE SURFACE**

Epithelial tissue (singular: epithelium) is composed of cells laid together in sheets (Figure 4.1). One side of these cells is oriented toward the body cavity or external environment and may have cilia or microvilli. The other surface is joined to deeper connective tissue at the basement membrane. This basement layer, an acellular membrane, is composed of a collection of polysaccharides and proteins that help to cement the epithelial tissue to the underlying structures.

Epithelium is little more than cells tightly connected, one to the next. It has neither blood vessels nor any extracellular substances between the cells. The classes of epithelium are identified by both the number of cell layers and the shape of the cells in the upper layer.

**Simple epithelium** has one layer of cells and usually functions as a diffusion or absorption membrane. The lining of your blood vessels and the respiratory membranes of your lungs are simple epithelium. Glands are composed of epithelial tissue (Figure 4.2) and classified by how their secretions are released. Glands that secrete into ducts are *exocrine* glands. Salivary glands and sweat glands are exocrine glands. Each one secretes its products into a duct that directs the secretion to the surface of the gland.

**Stratified epithelia** have many layers of cells and are designed for protection. Examples are found in the outer layer of your skin and the ducts of your salivary glands. Glands that secrete directly into the extracellular fluid surrounding the gland. Endocrine glands secrete hormones that are then picked up by the bloodstream and carried throughout the body. The adrenal, thyroid, and pituitary glands are all endocrine glands.

**Microvilli** Folded parts of the cell membrane that increase the cell's surface area.

**Basement membrane** A collection of polysaccharides and proteins that help to cement the epithelial tissue to the underlying structures.

**Endocrine glands** Have no ducts. Instead, they secrete directly into the extracellular fluid surrounding the gland. Endocrine glands secrete hormones that are then picked up by the bloodstream and carried throughout the body. The adrenal, thyroid, and pituitary glands are all endocrine glands.
CONNECTIVE TISSUE KEEPS IT TOGETHER

As the name implies, connective tissue connects bodily structures. It binds, supports, and anchors the body, and is the most abundant type of tissue in the body. Connective tissue is composed of cells suspended in a noncellular matrix. The matrix, or "ground substance," is secreted by the connective-tissue cells, and it determines the characteristics of the connective tissue. The matrix can be liquid, gel-like, or solid, depending on the cells. The ground substance of all connective tissue contains fibers of collagen (for strength) and elastin (for flexibility, stretch, and recoil). Collagen is one of the main components of all connective tissue and consequently is the most abundant protein in the animal kingdom.

The nature of the ground substance leads us to classify connective tissue as soft connective tissue or as specialized connective tissue

CARTILAGE JOINS AND CUSHIONS

Cartilage is a unique connective tissue because it is avascular (other types of connective tissue all have rich blood supply). (Figures 4.5 and 4.6, page 99) Chondrocytes, the cartilaginous cells, secrete a gel-like matrix that eventually surrounds and imprisons them, segregating them from direct contact with one another or any nutrient supply. Cartilage heals slowly because nutrients must diffuse through the matrix to the chondrocytes; nutrients cannot reach the cells directly via the blood stream. Each chondrocyte resides in a small "lake" within the matrix called a lacuna. The fluid bathing the cell in this lacuna diffuses through the matrix to and from the blood supply. This indirect route is far slower than bringing the fluid directly to the cells and is the reason cartilage is so slow to repair itself. Arthritis is a serious disease of the joints, targeting the cartilage found within them. It is difficult to treat, in part because the cartilage is avascular and therefore does not respond quickly to medications (see the "I Wonder . . . " feature on arthritis on page 99).

BONE IS SIMILAR TO STEEL-REINFORCED CONCRETE

Bone is a hard mineralized tissue found in the skeleton, which is a defining characteristic of vertebrates (Figure 4.7, page 99). Bone cells secrete an osteoid ground substance that eventually hardens and surrounds the cells in an ossified matrix. The osteoid ground substance includes proteins, water, calcium, and phosphorous salts. Once the matrix ossifies, the cells remain in contact with one another through small channels called canaliculi. Like other connective tissues, bone has collagen fibers in the matrix for support. Young bone has a higher percentage of collagen fibers than older bone, accounting for the greater flexibility of bones in infants and young people. Where an adult’s bone would snap under excessive force, a young child’s bone will bend. The convex surface may fray, like a bent green stick, but the bone does not break.

BLOOD AND LYMPH COMMUNICATE WITH THE ENTIRE BODY

Blood and lymph are considered fluid connective tissues because their matrix is not a solid. Blood is composed of specialized cells that are carried in the fluid matrix, or plasma. The main function of blood is to transport nutrients, gases, hormones, and wastes. Chapter 10 deals with blood in greater detail. Blood and lymph are considered fluid connective tissues because their matrix is not a solid. Blood is composed of specialized cells that are carried in the fluid matrix, or plasma. The main function of blood is to transport nutrients, gases, hormones, and wastes. Chapter 10 deals with blood in greater detail.

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EVEN FAT HAS A JOB TO DO

Adipose tissue contains fat cells—cells that are specialized for lipid storage. Unlike other connective tissues, adipose tissue does not have an extensive extracellular matrix (see Figure 4.8). Its matrix is a soft network of fibers holding the cell together and binding it to surrounding tissues. Cellulite "bumps" on the skin indicate where the adipose matrix is connected to the skin. The

Compact bone  Figure 4.7

Bone consists of a hard matrix surrounding living cells. Bone has both a blood supply and a nerve supply running through it. The matrix of compact bone is found in long cylinders called osteons or Haversian systems. Lighter spongy bone has less structure, forming in struts and supports rather than a solid mass.

Adipose  Figure 4.8

The nucleus and cytoplasm in adipocyte play second fiddle to the main action: the huge droplet of stored lipid.

Matrix (see Figure 4.8). Its matrix is a soft network of fibers holding the cell together and binding it to surrounding tissues. Cellulite "bumps" on the skin indicate where the adipose matrix is connected to the skin. The

Hyaline cartilage  Figure 4.5

The most common type of cartilage is hyaline cartilage. The matrix of hyaline cartilage contains many collagen fibers and looks crystal blue in living tissue. Hyaline cartilage covers the ends of bones, allowing them to slide against one another without damage. It is also found in your nose and trachea. During development, your entire skeleton was modeled in hyaline cartilage, which then ossified—that is, turned to bone.

Cartilage Figure 4.6

Elastic cartilage contains many elastic fibers in the matrix. Elastic cartilage allows the outer ear to bend, then return to its original shape. The epiglottis that prevents food and liquid from entering your respiratory tract also contains elastic cartilage. When you swallow, the epiglottis bends to cover the opening of the trachea. Afterward, the epiglottis snaps back to its original position, allowing air to flow through the windpipe.

Fibrocartilage  Figure 4.6

The matrix of fibrocartilage is packed with collagen fibers, so it is found where extra strength is needed. Cushions in your knee joints and the disks between the vertebrae are made of fibrocartilage.

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adipose cells within the fibrous matrix can expand with the swelling of the fat droplets they contain, while the matrix fibers cannot stretch as far. The different stretching capacities of these two components of adipose tissue form dimples on the skin. Cellulite is a normal function of fat deposition and storage. It is not an inherently evil tissue that must be removed from the body, despite what you may have read in the supermarket tabloids. Even newborns have cellulite!

**MUSCULAR TISSUE MOVES US**

The function of muscular tissue is to contract. The cells get shorter, generating force and often movement. The three types of muscular tissue are: skeletal muscle, smooth muscle, and cardiac muscle. Skeletal muscle tissue is highly organized, with the cells lying parallel to each other, much like a cable. When stimulated, groups of muscle cells contract in unison. (Figure 4.9).

Smooth muscle lines hollow organs such as the blood vessels and the digestive tract. Smooth muscle cells are short, cylindrical cells that taper at both ends and have only one nucleus. They are not striated, and are not under voluntary control. This is helpful. Wouldn’t it be nerve-wracking to consciously manage the diameter of your blood vessels to maintain blood pressure, or to consciously create the rhythmic constrictions that the digestive tract uses to move food during digestion?

Cardiac (heart) muscle has short, branched, and striated cells, with one nucleus at the center of each cell. Specialized communication junctions called intercalated discs facilitate the heartbeat by spreading the signal to contract. Intercalated discs are gap junctions found within areas of closely knit cell membranes, helping to spread the impulse while also binding the cells together. Cardiac muscle will be described in more detail in Chapter 11.

**Comparison of three types of muscle tissue** (Figure 4.9)

- **Skeletal muscle** is the tissue that makes up the muscles that move your limbs and stabilize your trunk, muscles such as your biceps brachii and rectus abdominus. This tissue is composed of long, multinucleate cells with visible striations. The cells of skeletal muscle extend the length of the muscle and are arranged in parallel groups called fascicles. Skeletal muscle is described in full detail in Chapter 5. Because you consciously control their contractions, skeletal muscle is called voluntary muscle.

- **Smooth muscle** lines hollow organs such as the blood vessels and the digestive tract. Smooth muscle cells are short, cylindrical cells that taper at both ends and have only one nucleus. They are not striated, and are not under voluntary control. This is helpful. Wouldn’t it be nerve-wracking to consciously manage the diameter of your blood vessels to maintain blood pressure, or to consciously create the rhythmic constrictions that the digestive tract uses to move food during digestion?

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What is arthritis?

Arthritis is a general term for degradation of the joints, for a variety of causes. Rheumatoid arthritis results from an autoimmune attack on the joint. Osteoarthritis results from various sorts of wear and tear. Only one type of arthritis, the one that results from an infection, can be cured (using antibiotics). Other forms must be managed to reduce pain and improve quality of life.

Osteoarthritis affects 21 million Americans. The disease damages cartilage that normally forms a smooth bearing surface inside joints. Pain begins as bones rub on bones. Osteoarthritis tends to be worst when it affects the spine, hips and knees.

Rheumatoid arthritis is an inflammation of the synovium, which lines the joints. The disease can seriously deform the hands, but it often affects joints throughout the body. Rheumatoid arthritis is two or three times as common among women, indicating that females are genetically more susceptible to this type of autoimmune attack. About 2 million Americans have the disease.

Common symptoms of arthritis include stiffness, especially in the morning, swelling, warmth or redness in the joint, and constant or recurring pain. Many patients reduce their movement to avoid pain, but inactivity harms muscles, ligaments, and the cardiovascular system. A proper diagnosis must precede treatment, as doctors want to rule out other diseases that can affect the joints, such as lupus and fibromyalgia. After a good patient history, diagnostic tools may include:

- X-rays, to detect abnormal growth or erosion in the joints.
- CT (computed tomography) or MRI (magnetic resonance imaging) scans, to view soft tissue, such as cartilage.
- An arthroscopic tube-mounted camera, to determine the extent of damage inside a joint.
- Blood analysis, to test for proteins and antibodies that accompany an immune attack, a hallmark of rheumatic arthritis.

Treatment options include various kinds of anti-inflammatory drugs, rehabilitative therapy, pain management, and, in extreme cases, joint replacement. Both heat and cold can improve symptoms by reducing muscle spasms and pain. Exercises can improve flexibility, endurance, and strength, helping restore mobility and quality of life. A variety of new medicines called biological response modifiers may limit inflammation in rheumatoid arthritis by interfering with an immune protein called tumor necrosis factor. Surgeons may fuse bones to prevent movement at the affected joint or replace the joint with a metal joint.

Arthritis research continues. Scientists want to understand the role of genetics or a prior infection in triggering joint damage. What exactly is going wrong with the immune system and cells in the joint? Because joint damage can be permanent, researchers want to intervene to stop the damage at an early stage. That explains the interest in "biological markers"—unique compounds or proteins that are associated with arthritic processes. As the population ages, we can expect more interest in arthritis, and as we learn more about the disease process, we can expect more progress as well.

Nervous tissue, the final type of tissue in the human body, is "irritable," which means it responds to changes in the environment. Nervous tissue contains two categories of cells: neurons (Figure 4.10) and neuroglia.

Neuroglia are the supporting cells of nervous tissue ("glia" means "glue"). It was once thought that these cells merely held the neurons together. Now we know that the various neuroglial cells have specific supporting roles. Neuroglia do not send or receive electrical impulses. Instead, they improve nutrient flow to the neurons, provide physical support, remove debris, and provide electrical insulation.

Cells Are The Building Blocks of Tissues

Axon terminal

Node of Ranvier

Myelin sheath

Nucleus of Schwann cell

Cytoplasm

Nucleus

Mitochondrion

Axon hillock

Axon collateral

Synaptic end bulb

Neuron Figure 4.10

Neurons are the cells that carry electrical impulses. They can be extremely short, like those found within the spinal cord and brain, or they can be longer than 125 centimeters, like those that extend from the spinal cord to the end of the great toe. The cell body of a neuron has long, slender projections. One group of projections, called dendrites, receives impulses from other neurons, bringing the information to the cell body. The other projection, called the axon, transmits impulses from the cell body to other cells. Individual neurons may have many dendrites, but each can have only one axon.
Call cells are kept under tight regulation, dividing only when DNA makes a mistake while a cell is replicating. This genetic defect can promote cell growth by producing hormones or other signaling molecules that encourage cells to divide. Or it may produce receptors that become hypersensitive to a signal to divide. Defects can add up if other mutations impair genes that normally restrain cell division or the natural DNA repair process. When a cancer cell divides, the two new cells carry the same defects, and cancer is under way.

A large number of carcinogens can cause cancer. The best known is tobacco smoke, which contains compounds that cause lung, bronchial, and throat cancer. The ultraviolet portion of sunlight causes skin cancer. A variety of organic chemicals can cause the kind of mutation that will eventually become cancer. Alcohol and estrogen can both promote cancer by stimulating cell division, which in turn raises the risk of defective copying of DNA. Viruses are another major cause of cancers, probably because they must take control of a cell's genetic machinery in order to copy themselves.

At some point, cancer cells may leave their origin (the 'primary' site) and move through the blood or lymph to a distant site. These metastatic tumors may continue to grow even if the primary tumor is removed or killed. Breast cancer often metastasizes to the bones or lungs, and lung cancer to the brain.

Cancer treatment has long focused on killing or removing the primary tumor and then attacking any tumors themselves. Moving the primary tumor and then attacking any tumors would attach only to tumor cells and then direct an immune attack on the cancer. The concept is promising, but it is only effective in cancers that involve one specific defect.

A second "intelligent" approach is even more experimental: using the body's immune system to fight cancer with a vaccine. Cancer vaccines may be designed to fight emerging cancers or to kill existing tumors. The vaccine might consist of an inactivated portion of the tumor cell membrane that is not found on normal cells. Vaccination would prime the immune system to make antibodies that would attach only to tumor cells and then direct an immune attack on the cell. The concept is promising, but problems have been slow to develop.

Inevitably, however, the many specific diseases we group together as "cancer" will succumb to some form of this more targeted attack. In medicine, as in so many fields, knowledge is power.
CHAPTER 4  Tissues

Organization Increases with Organs, Organ Systems, and the Organism

LEARNING OBJECTIVES

- Explore how organisms display the hierarchy of life.
- Outline the role organ systems play in maintaining homeostasis.

Recall that one characteristic of life is a high degree of organization (Figure 4.11). This layering of organization, or hierarchy, is visible in all life forms:

- Atom
- Molecule
- Organelle
- Cell
- Tissue
- Organ
- Organ system
- Organism

While each organ system has one specialized function, the continuation of life requires that these systems be integrated into a whole, cohesive unit. The ultimate level of organization, then, is the organism. In human biology, the human being is the pinnacle of organization. You are composed of cells cooperating in tissues, which are in turn positioned together to efficiently carry out an organ’s processes. Organs then work together to perform a larger function such as draining the blood, comprising an organ system. There are 11 organ systems in the human body, as follows:

- Integumentary (protecting and covering)
- Skeletal (support)
- Muscular (movement and heat production)
- Nervous (sensing and responding)
- Cardiovascular (transporting fluids and oxygen)
- Respiratory (gas exchange)
- Urinary (fluid balance)
- Endocrine (regulating sequential growth and development)
- Digestive (obtaining nutrients)
- Lymphatic (immunity)

Replacement organs are usually in short supply, necessitating the creation of new medical solutions. (See the Ethics and Issues feature “Should we, could we, grow new organs?” on page 00.)

Outline the role organ systems play in maintaining homeostasis.

Levels of structural organization (Figure 4.11)

The four main types of tissues—epithelial, connective, muscular, and nervous—join together in specific proportions and patterns to form organs, such as the heart, brain, and stomach. Each organ has a specific and vital function. Organs that interact to perform a specific task comprise an organ system. For example, the heart and the blood vessels together make up the cardiovascular system. All 11 organ systems in the human will be discussed in the remainder of this text. Ten of these systems help maintain individual homeostasis, while the reproductive system maintains population homeostasis.
CHAPTER 4

Tissues

Should We, Could We, Grow New Organs?

It sounds like a Doctor Suess rhyme, and growing human organs in the lab sounds like the plot of the next generation Frankenstein story. But there is a basis of truth to it. Of course, the need is there. We have many more organ questions than donated organs every year. According to the National Women's Health center, every day 63 people in America receive organ transplants, but another 16 die for lack of appropriate organs. Growing the needed organ from just a few of the patient’s own cells would solve this problem, giving everyone a seemingly limitless supply of replacement organs. It might be the perfect solution to our current transplant woes—but is it feasible?

Amazingly enough, researchers at Wake Forest University have recently been able to do just that. Urinary bladders are not on the list of organs that are usually donated, but there is a growing need for replacement bladders. Patients with bladder cancer, spina bifida, and other debilitating nervous and urinary diseases often need replacement bladders. In Wake Forest University laboratories, Dr. Anthony Atala and his team of researchers have been able to grow new, functional urinary bladders for seven young patients ranging from toddlers to adolescents. How did they do this? The process seems deceptively simple on the surface. The doctors take samples of healthy bladder cells and muscle tissue from the patient and grow these in an incubator under sterile conditions. When these tissues are growing well and appear to be healthy, the doctors move them from the original sample dishes to a sterile mold of a bladder. By layering these new tissues over the mold, they give the tissues a “pattern” to follow. Within a few weeks, the patient’s own tissues have grown over the bladder mold, creating a brand new bladder. The newly created bladder is smaller than the patient’s original bladder, but once placed inside the patient’s pelvic cavity, the new bladder grows to reach adult size. Even more amazingly, when these newly created bladders were properly positioned in the patients’ bodies, all seven worked just as they should.

Although this seems very promising, there are concerns. The urinary bladder is a simple organ, basically composed of a layer of transitional epithelium covering smooth muscle and connective tissue. Its main function is to store urine, without absorbing the contents back into the blood stream, until the bladder can be emptied. More complicated organs, such as the heart and lungs, might prove more difficult to culture. News of preliminary successes like these seven bladders may be causing unfounded hope in those still on organ waiting lists.

Another concern that arises from this exciting news is the possibility of “organ farms,” where healthy clients provide cells and tissues, perhaps for monetary reward, and organs are created before the need arises. Can you imagine a competitive market for human organs? Where there is currently a small black market for kidneys and hearts, with the success of technologies such as this, would we see a new “biological market” filled with organs grown to specifications? In many ways this is a brave new world. Let’s hope we handle it wisely.

The goal of the organism is to maintain homeostasis, keeping the internal environment stable despite constant internal and external changes. You put food into the digestive tract, requiring water and energy to digest it into nutrients, which are consumed during movement and metabolic activity. You lose fluids through sweating, breathing, and urinating. You alter your gas concentrations with every breath. Every muscular contraction changes your blood chemistry and internal temperature. Each subtle change in body chemistry must be corrected in order to maintain homeostasis. Alterations in one system affect the functioning of all other systems; metabolism in the muscles requires oxygen, which is delivered through the respiratory and cardiovascular systems. You are a finely balanced machine, and every mechanical action, every chemical reaction, requires that balance be restored. Negative feedback loops keep your vital statistics in acceptable ranges despite the myriad changes you put your body through every day.
Scientists Use a Road Map to the Human Body

Learning Objectives:
- Learn to use anatomical directional terms.
- Identify the body cavities and the organs that each contains.

Studying human biology—human anatomy and physiology—is a daunting task because we are concerned not only with the location of organs and organ systems, but also their interconnection. To discuss these complicated matters clearly, we need a system to precisely name the structures of the body. Whenever we talk about an organ’s placement, or the appearance of a portion of the body, we assume we have placed the body in the anatomical position (see Figure 4.12). Using this position as a standard allows us to make sense of directional terms such as proximal and distal, superior and inferior.

The body has natural boundaries that we exploit for describing position in human biology. The body has two large cavities, the ventral and dorsal cavities (see Figure 4.13). The ventral cavity comprises the entire ventral (or belly) aspect of your torso. The ventral portion of the body contains distinct sections. The thoracic cavity includes the chest area and houses the heart, lungs, vessels, and lymphatic system of the mediastinum. The “guts” are found within the abdominal cavity, which is lined with peritoneum. The organs of the urinary system and the reproductive system are located in the pelvic cavity.

**Proximal/distal**
Opposite terms meaning near the core of the body versus farther from the core.

**Superior/inferior**
Opposite terms meaning above and below.

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**Mediastinum**
The broad area between the lungs.

**Anatomical position with directional terms**

**Figure 4.12**
In the “anatomical position,” the bones of the forearm lie straight instead of crossing over one another as they do when our hands rest by our sides.
The dorsal body cavity includes the cranial cavity housing the brain, and the vertebral cavity in which lies the spinal cord. The meninges line these two continuous cavities.

Medical specialists often refer to the abdominopelvic regions and quadrants of the body when diagnosing pain. There are nine regions, and four quadrants, each of which describes a particular area housing just a few of the organs of the abdominal cavity (Figure 4.14).

As we study human biology, we will refer to these regions, quadrants, and cavities as landmarks for identifying the position of organs and the relationships between them. They also provide a common language to facilitate communication about location or organ function. In this age of digital surgery and online medical diagnoses, having a common language becomes even more important. Digital clinical assistance, or even distance education in this field, would be impossible without these conventions.

Knowing the organization of the chemicals, cells, and tissues that make up the human body is a prerequisite for understanding how humans function in the environment. Armed with this basic knowledge, an in-depth look at humans and their environment becomes much more interesting. The remainder of this text will explore the relationship between human physiology and the environment in which humans live.

**Body cavities** Figure 4.13

- **Cranial cavity**: Formed by cranial bones and contains brain.
- **Vertebral cavity**: Formed by vertebral columns and contains spinal cord and the beginnings of spinal nerves.
- **Thoracic cavity**: Chest cavity, contains pleural and pericardial cavities and mediastinum.
- **Pleural cavity**: Each surrounds a lung: the serous membrane of the pleural cavity is the pleura.
- **Pericardial cavity**: Surrounds the heart: the serous membrane of the pericardial cavity is the pericardium.
- **Mediastinum**: Central portion of thoracic cavity between the lungs: extends from sternum to vertebral column and from neck to diaphragm: contains heart, thymus, esophagus, trachea, and several large blood vessels.
- **Abdominopelvic cavity**: Subdivided into abdominal and pelvic cavities.
- **Abdominal cavity**: Contains stomach, spleen, liver, gallbladder, small intestine, and most of large intestine: the serous membrane of the abdominal cavity is the peritoneum.
- **Pelvic cavity**: Contains urinary bladder, portions of large intestine, and internal organs of reproduction.

**CAVITY COMMENTS**

**Meninges** Three protective membranes covering the brain and spinal cord.

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**Body regions and cavities** Figure 4.14

**Body regions**

- **Right hypochondriac region**
- **Epigastic region**
- **Left hypochondriac region**
- **Umbilical region**
- **Right lumbar region**
- **Left lumbar region**
- **Right inguinal (iliac) region**
- **Left inguinal (iliac) region**
- **Hypogastic (pubic) region**

**Concept Check**

Identify a body part that is proximal to the hand. What are the divisions of the ventral cavity? What organs are found in the dorsal cavity?
Cells Are the Building Blocks of Tissues

The human body has four tissue types: epithelial, connective, nervous, and muscular tissue. Epithelium covers and lines all body cavities and is classified based on cell shape (squamous, cuboidal, or columnar) and number of cell layers (simple or stratified). Connective tissue can be soft and loose or dense. Cartilage, bone, and lymph are all examples of connective tissue. Muscular tissue can contract, and it comes in three varieties: smooth, skeletal, and cardiac muscle. Nervous tissue includes the impulse-carrying neurons and the neuroglia, which provide support for neurons.

Organization Increases with Organs, Organ Systems, and the Organism

Tissues are grouped together in organs. Organs performing a similar function come together in organ systems. A group of organ systems comprises an organism. The 11 organ systems of the human are: the skeletal (bones providing support and protection), muscular (muscles for movement and heat generation), nervous (sensing and responding to the environment), cutaneous (skin providing a protective and sensitive layer), respiratory (obtaining oxygen and removing carbon dioxide), digestive (obtaining nutrients), urinary (maintaining fluid balance), reproductive (producing new individuals), and endocrine (regulating sequential growth and development).

Scientists Use a Road Map to the Human Body

When discussing the placement of human anatomical structures, we assume the body is in anatomical position. This is a face-forward position, with the palms of the hands forward. The two main body cavities are the dorsal cavity and the ventral cavity. The dorsal cavity includes the cranial cavity, holding the brain, and the spinal cavity, surrounding the spinal cord. The ventral cavity includes the thoracic cavity, the abdominal cavity, and the pelvic cavity. The ventral cavity can be subdivided into quadrants for specifically pinpointing the location of an organ, a structure, or a physiological event in the body.

CRITICAL THINKING QUESTIONS

1. As a research assistant in a cytology lab, you are handed a stack of photographs from an electron microscope. Each represents a different type of cell. You are asked to identify photos of animal cells that secrete large amounts of protein and include a mechanism for moving their secretions along their surface. What organelles would be required by this cell? In which tissues might these cells be found?

2. The digestive tract has two surfaces: an inner surface that lines the gut and allows food to pass, and an outer surface that separates the gut from the rest of the abdominal organs. What specific tissue would you expect to find on each of these surfaces? Would the inner surface have the same lining as the outer? Why or why not?

3. There are many types of connective tissue in the body, from adipose to bone to blood. What is it that makes these tissues different? More importantly, what are the unifying characteristics found in all connective tissues?

4. You are given the opportunity to create artificial skin in a laboratory to help burn patients. Remember that the skin must be protective, relatively water-tight, and yet have some sensory function. What tissues will you need for this organ? Which type of epithelium will you use for the outer layer? What tissues will you need to house the blood vessels and the nerves? Will you need muscular tissue? Nervous tissue?

5. Physicians often use the quadrants and regions of the body to diagnose pathologies. If a patient complained of stabbing pain in the abdominal cavity, which organs might be involved? Look at Figure 4.13 to help with your diagnosis. How would you describe the location of the urinary bladder using the nine abdominopelvic regions given in Figure 4.14?
11. Identify the tissue illustrated
   a. Hyaline cartilage
   b. Skeletal muscle
   c. Cardiac muscle
   d. Smooth muscle

12. Which type of muscle tissue can be described as involuntary, striated and connected via intercalated discs?
   a. Skeletal muscle
   b. Cardiac muscle
   c. Smooth muscle
   d. Two of these have the listed characteristics

13. Identify the structure indicated as “A” on this image
   a. Neurilemma
   b. Dendrites
   c. Axon
   d. Neuron body

14. The functions of neuroglia include
   a. Improving nutrient flow to neurons
   b. Supporting neurons
   c. Sending and receiving electrical impulses
   d. Two of the above are correct
   e. All of the above are correct

15. The correct order from least to most complex is:
   a. Organ, organ system, organelle, organism
   b. Cell, tissue, organism, organ system
   c. Tissue, organ, organ system, organism
   d. cell, organelle, tissue, organ

16. Which term correctly describes the relationship indicated as “A” on this figure?
   a. Superior
   b. Inferior
   c. Proximal
   d. Distal

17. Which term correctly describes the relationship indicated as C?
   a. Superior
   b. Inferior
   c. Proximal
   d. Distal

18. The _______ houses the heart, lungs, vessels and lymphatics of the mediastinum.
   a. Ventral cavity
   b. Abdominal cavity
   c. Cranial cavity
   d. Thoracic cavity

19. What membrane lines the indicated cavity?
   a. Pericardial membrane
   b. Meninges
   c. Peritoneum
   d. Mediastinum

20. Which label indicates the quadrant in which the majority of the liver lies?
   a. B
   b. C
   c. D

5. The specific type of cell that comprises most diffusion membranes is a
   a. Squamous epithelial cell
   b. Cuboidal epithelial cell
   c. Columnar epithelial cell
   d. Escrime cell

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7. The structure labeled A in this diagram is
   a. Fibroblasts
   b. Collagen fibers
   c. Matrix
   d. White blood cell

8. The connective tissue that is composed of regular, linear arrangements of collagen fibers packed tightly into the matrix is called
   a. Areolar connective tissue
   b. Loose connective tissue
   c. Dense irregular connective tissue
   d. Dense regular connective tissue

9. Identify the type of connective tissue illustrated below.
   a. Bone
   b. Hyaline cartilage
   c. Elastic cartilage
   d. Lymph
   e. Fibrocartilage

10. The connective tissue whose functions include lipid storage and organ protection is
    a. Blood
    b. Lymph
    c. Adipose
    d. Bone

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