5

Tissues

Henrietta Lacks (a) checked into Johns Hopkins Hospital in 1951, where she was treated for cervical cancer. A sample of her cells went on to become a standard cell line used in laboratories all over the world (b). Her husband was told, after her death later that year, only that the cells would be used in research. The family did not discover how widespread their relative's unwitting legacy was until 1976.

DONATING TISSUE FOR RESEARCH. If you donate cells or tissues to research, and the material is used to develop a commercially available test or treatment, can you profit from the donation? According to legal precedent in the United States, probably not.

Perhaps the most famous cell donor was Henrietta Lacks, whose cervical cancer cells, sampled shortly before her death in 1951 and dubbed HeLa in her honor, went on to become laboratory standards, without her consent. More recent were three cases in which tissue donors requested that they be compensated for use of their cells or tissues, but lost:

- In a 1990 case, John Moore sued the Regents of the University of California because part of his spleen, removed to treat leukemia years earlier, had been used to culture a line of cells that was patented by his physician and a researcher. The cultured cells were used to derive valuable substances. Moore lost the case.
- William Catalona was a researcher at Washington University in St. Louis. Here he developed the prostate-specific antigen test that assesses prostate cancer risk, with the help of thousands of patients who donated their tissue. When Dr. Catalona switched universities, he asked his patients to request that their tissues be transferred too. Washington University took identifying names off of the samples, which effectively negated the patients' rights to request transfer of their samples—which six thousand of them had done. In 2006 a judge ruled in Washington University's favor, fearing that allowing patients to move their samples would adversely affect cell and tissue banks.
- Debbie and Dan Greenberg organized parents of children with Canavan disease, a rare inherited disorder, to donate their children's blood, urine, and autopsy tissue to a researcher at Miami Children's Hospital, to help identify the causative gene. Once the gene was discovered, a diagnostic and carrier test were eventually developed and patented, and soon the families were paying for tests that their children's tissues had helped develop. The case was settled, the genetic tests remain commercialized, and the gene itself is available for research use.

These cases have spurred tissue banks to take measures to ensure that tissue donors are aware of their rights. The Coriell Cell Repository, for example, is supported by the National Institutes of Health and includes the following wording in its informed consent form: "Submission of my sample to the Repository may give scientists valuable research material that can help them to develop new diagnostic tests, new treatments, and new ways to prevent disease."

Learning Outcomes

After studying this chapter, you should be able to do the following:

5.1 Introduction

1. List the four major tissue types, and tell where each is located in the body. (p. 95)

5.2 Epithelial Tissues

2. Describe the general characteristics and functions of epithelial tissues. (p. 95)
3. Name the types of epithelium, and for each type, identify an organ in which that type is found. (p. 96)
4. Explain how glands are classified. (p. 101)

5.3 Connective Tissues

5. Compare and contrast the general cellular components, structures, fibers, and extracellular matrix (where applicable) in each type of connective tissue. (p. 102)
6. Explain the major functions of each type of connective tissue. (p. 105)

5.4 Types of Membranes

7. Distinguish among the four major types of membranes. (p. 109)

5.5 Muscle Tissues

8. Distinguish among the three types of muscle tissues. (p. 110)

5.6 Nervous Tissues

9. Describe the general characteristics and functions of nervous tissues. (p. 111)

Aids to Understanding Words

(Appendix A on page 567 has a complete list of Aids to Understanding Words.)

adip- [fat] *adip*ose tissue: Tissue that stores fat.

chondr- [cartilage] *chondr*ocyte: Cartilage cell.

-cyt [cell] osteo*cyt*e: Bone cell.

epi- [upon] *epi*thelial tissue: Tissue that covers all free body surfaces.

-glia [glue] neuro*glia*l cells: Cells that support neurons; part of nervous tissue.

inter- [between] *inter*calated disc: Band between adjacent cardiac muscle cells.

macr- [large] *macr*ophage: Large phagocytic cell.

os- [bone] *os*seous tissue: Bone tissue.

pseud- [false] *pseud*ostratified epithelium: Tissue with cells that appear to be in layers, but are not.

squam- [scale] *squam*ous epithelium: Tissue with flattened or scalelike cells.

strat- [layer] *strat*ified epithelium: Tissue with cells that are in layers.

5.1 INTRODUCTION

Cells, the basic units of structure and function within the human organism, are organized into groups and layers called **tissues** (tish′uz). Each type of tissue is composed of similar cells specialized to carry on a particular function.

The tissues of the human body are of four major types: *epithelial, connective, muscle,* and *nervous.* Epithelial tissues form protective coverings and function in secretion and absorption. Connective tissues support soft body parts and bind structures together. Muscle tissues produce body movements, and nervous tissues conduct impulses that help control and coordinate body activities.

Table 5.1 compares the four major tissue types. Throughout this chapter, simplified line drawings (for example, fig. 5.1*a*) are included with each micrograph (for example, fig. 5.1*b*) to emphasize the distinguishing characteristics of the specific tissue, as well as a locator icon (an example of where in the body that particular tissue may be found).

Check Your Recall

1. What is a tissue?
2. List the four major types of tissues.

5.2 EPITHELIAL TISSUES

General Characteristics

Epithelial (ep″ĭ-the′le-al) **tissues** are found throughout the body. Since epithelium covers organs, forms the inner lining of body cavities, and lines hollow organs, it always has a *free (apical) surface*—one that is exposed to the outside or to an open space internally. The underside of this tissue is anchored to connective tissue by a thin, nonliving layer, called the **basement membrane.**

As a rule, epithelial tissues lack blood vessels. However, nutrients diffuse to epithelium from underlying connective tissues, which have abundant blood vessels.

Epithelial cells readily divide. As a result, injuries heal rapidly as new cells replace lost or damaged ones. Skin cells and cells that line the stomach and intestines are continually damaged and replaced.

Epithelial cells are tightly packed. Consequently, these cells form effective protective barriers in such structures as the outer layer of the skin and the lining of the mouth. Other epithelial functions include secretion, absorption, and excretion.

Epithelial tissues are classified according to shape and number of layers of cells. Epithelial tissues that are composed of thin, flattened cells are *squamous;* those

Table 5.1 Types of Tissue

Type	Function	Location	Distinguishing Characteristics
Epithelial	Protection, secretion, absorption, excretion	Cover body surfaces, cover and line internal organs, compose glands	Lack blood vessels, readily divide; cells are tightly packed
Connective	Bind, support, protect, fill spaces, store fat, produce blood cells	Widely distributed throughout body	Mostly have good blood supply; cells are farther apart than epithelial cells
Muscle	Movement	Attached to bones, in the walls of hollow internal organs, heart	Able to contract in response to specific stimuli
Nervous	Transmit impulses for coordination, regulation, integration, and sensory reception	Brain, spinal cord, nerves	Cells communicate with each other and with other body parts

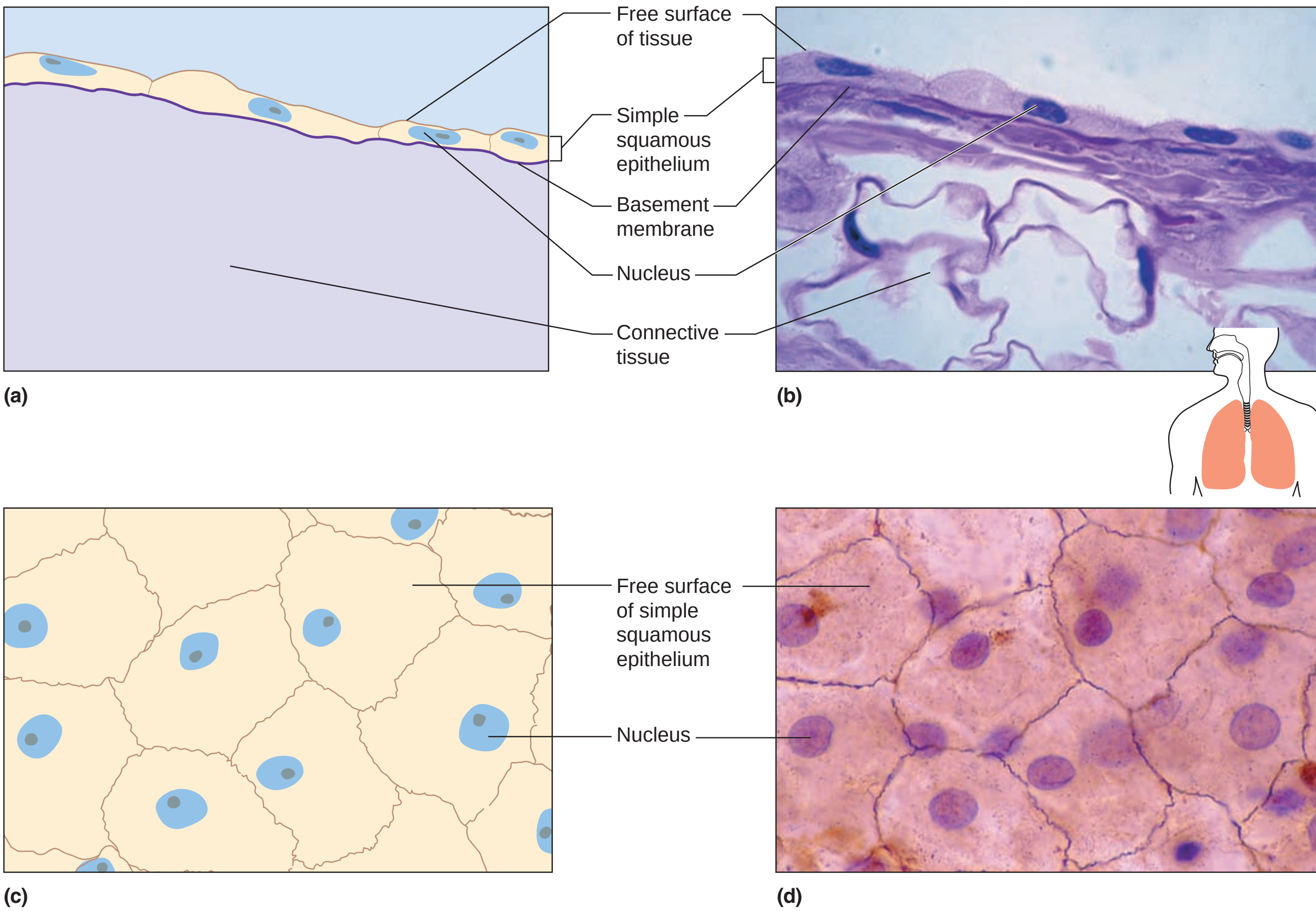


Figure 5.1
Simple squamous epithelium consists of a single layer of tightly packed, flattened cells (670×). (*a*) and (*b*) side view, (*c*) and (*d*) surface view. In one example, it lines the air sacs of the lungs.

with cube-shaped cells are *cuboidal;* and those with tall, elongated cells are *columnar;* those with single layers of cells are *simple;* those with two or more layers of cells are *stratified*. In the following descriptions, note that the free surfaces of epithelial cells are modified in ways that reflect their specialized functions.

Check Your Recall

3. List the general characteristics of epithelial tissues.
4. Describe the classification of epithelium in terms of shape and number of cell layers.

Simple Squamous Epithelium

Simple squamous (skwa′mus) **epithelium** consists of a single layer of thin, flattened cells. These cells fit tightly together, somewhat like floor tiles, and their nuclei are usually broad and thin (fig. 5.1).

Substances pass rather easily through simple squamous epithelium, which is common at sites of diffusion and filtration. For instance, simple squamous epithelium lines the air sacs (alveoli) of the lungs where oxygen and carbon dioxide are exchanged. It also forms the walls of capillaries, lines the insides of blood and lymph vessels, and covers the membranes that line body cavities. However, because it is so thin and delicate, simple squamous epithelium is easily damaged.

Simple Cuboidal Epithelium

Simple cuboidal epithelium consists of a single layer of cube-shaped cells. These cells usually have centrally located, spherical nuclei (fig. 5.2).

Simple cuboidal epithelium covers the ovaries and lines most of the kidney tubules and the ducts of certain glands, such as the salivary glands, thyroid gland, pancreas, and liver. In the kidneys, this tissue functions in secretion and absorption; in glands, it secretes glandular products.

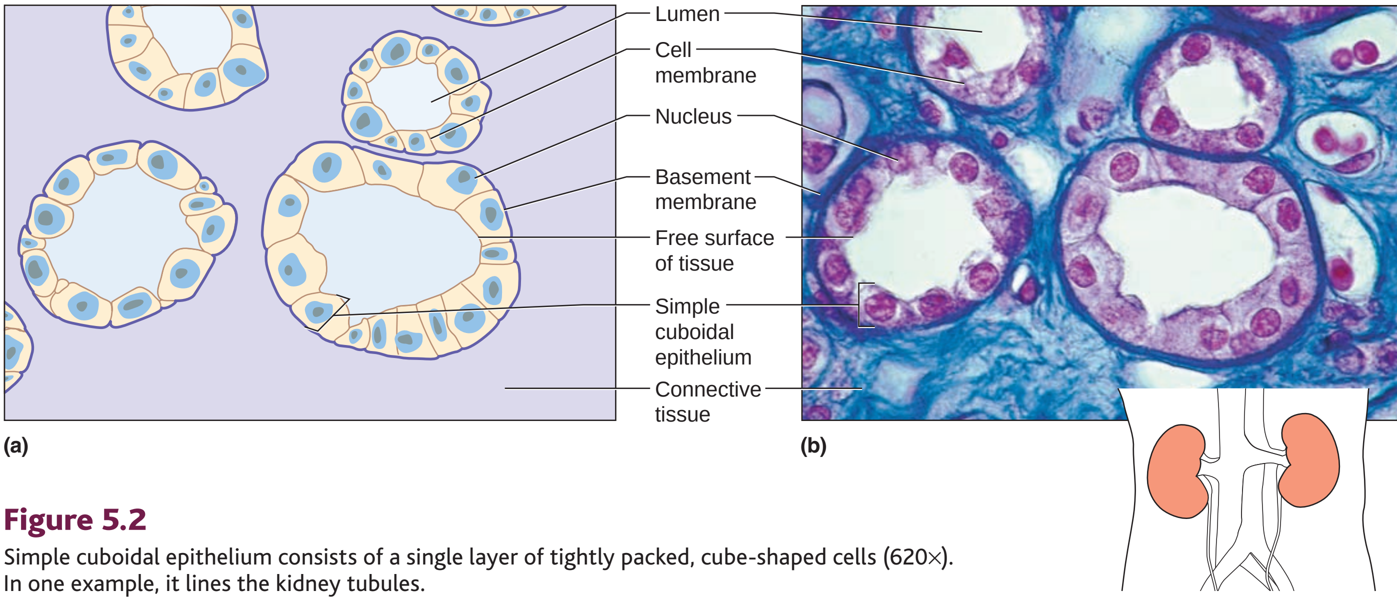


Figure 5.2
Simple cuboidal epithelium consists of a single layer of tightly packed, cube-shaped cells (620×). In one example, it lines the kidney tubules.

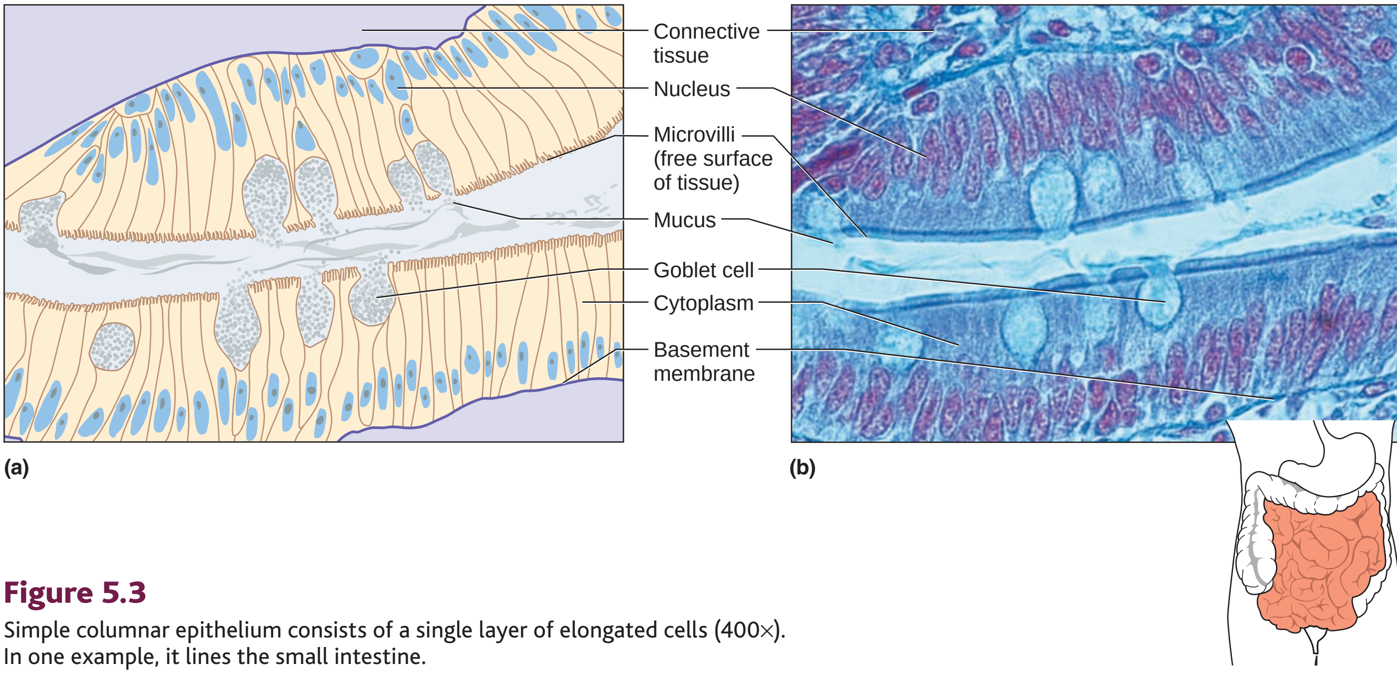


Figure 5.3
Simple columnar epithelium consists of a single layer of elongated cells (400×). In one example, it lines the small intestine.

Simple Columnar Epithelium

The cells of **simple columnar epithelium** are elongated; that is, they are longer than they are wide. This tissue is composed of a single layer of cells whose nuclei are elongated, like the shape of the cells themselves; this layer of cells is usually located at about the same level, near the basement membrane (fig. 5.3). The cells of this tissue can be ciliated or nonciliated. *Cilia* extend from the free surfaces of the cells and move constantly (see chapter 3, p. 58). In the female reproductive tubes, cilia aid in moving egg cells to the uterus.

Nonciliated simple columnar epithelium lines the uterus and most organs of the digestive tract, including the stomach and the small and large intestines. Because its cells are elongated, this tissue is thick, which enables it to protect underlying tissues. Simple columnar epithelium also secretes digestive fluids and absorbs nutrients from digested food.

Simple columnar cells, specialized for absorption, often have many tiny, cylindrical processes extending from their surfaces. These processes, called *microvilli,* increase the surface area of the cell membrane where it is exposed to substances being absorbed.

Typically, specialized, flask-shaped glandular cells are scattered among the columnar cells of simple columnar epithelium. These cells, called *goblet cells,* secrete a protective fluid, called *mucus,* onto the free surface of the tissue (see fig. 5.3).

Pseudostratified Columnar Epithelium

The cells of **pseudostratified** (soo″do-strat′ĭ-fīd) **columnar epithelium** appear stratified or layered, but they are not. A layered effect occurs because the nuclei are at two or more levels in the row of aligned cells. However, the cells, which vary in shape, all reach the basement membrane, even though some of them may not contact the free surface.

Pseudostratified columnar epithelial cells commonly have cilia, which extend from the free surfaces of the cells. Goblet cells scattered throughout this tissue secrete mucus, which the cilia sweep away (fig. 5.4).

Pseudostratified columnar epithelium lines the passages of the respiratory system. Here, the mucus-covered linings are sticky and trap dust and microorganisms that enter with the air. The cilia move the mucus and its captured particles upward and out of the airways.

Stratified Squamous Epithelium

The many cell layers of **stratified squamous epithelium** make this tissue relatively thick. Cells divide in the deeper layers, and newer cells push older ones farther outward, where they flatten (fig. 5.5). In naming stratified epithelial tissues based on shape of cells, the appearance of the top layer of cells is used.

Stratified squamous epithelium forms the outer layer of the skin (*epidermis*). As skin cells age, they accumulate a protein called *keratin* and then harden and die. This "keratinization" produces a covering of dry, tough, protective material that prevents water and other substances from escaping underlying tissues and blocks various chemicals and microorganisms from entering.

Stratified squamous epithelium also lines the oral cavity, esophagus, vagina, and anal canal. In these parts, the tissue is not keratinized; it stays soft and moist, and the cells on its free surfaces remain alive.

Stratified Cuboidal Epithelium

Stratified cuboidal epithelium consists of two or three layers of cuboidal cells that form the lining of a lumen (fig. 5.6). The layering of the cells provides more protection than the single layer affords.

Stratified cuboidal epithelium lines the larger ducts of the mammary glands, sweat glands, salivary glands, and pancreas. It also forms the lining of developing ovarian follicles and seminiferous tubules, which are parts of the female and male reproductive systems, respectively.

Stratified Columnar Epithelium

Stratified columnar epithelium consists of several layers of cells (fig. 5.7). The superficial cells are columnar, whereas the basal layers consist of cuboidal cells. Small amounts of stratified columnar epithelium are found in the male urethra and ductus deferens and in parts of the pharynx.

Transitional Epithelium

Transitional epithelium is specialized to change in response to increased tension. It forms the inner lining of the urinary bladder and lines the ureters and the superior urethra. When the wall of one of these organs contracts, the tissue consists of several layers of cuboidal cells; however, when the organ is distended, the tissue stretches, and the physical relationships among the cells change (fig. 5.8). In addition to providing an expandable lining, transitional epithelium forms a barrier that helps prevent the contents of the urinary tract from diffusing back into the internal environment.

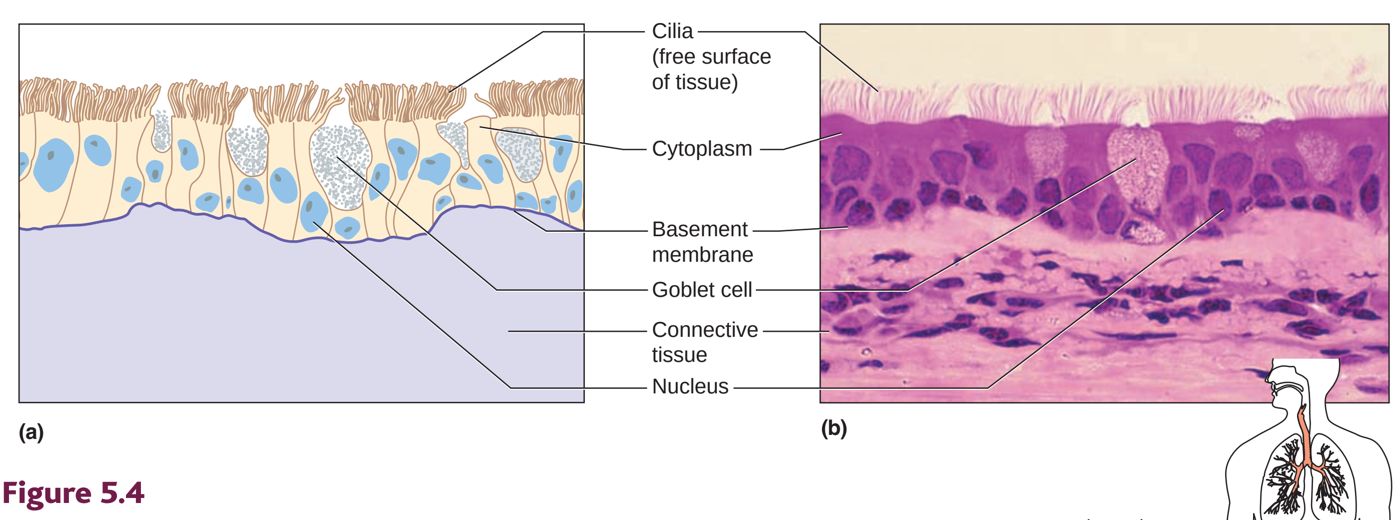


Figure 5.4

Pseudostratified columnar epithelium appears stratified because the cell nuclei are located at different levels (255×). In one example, it lines the passages of the respiratory system.

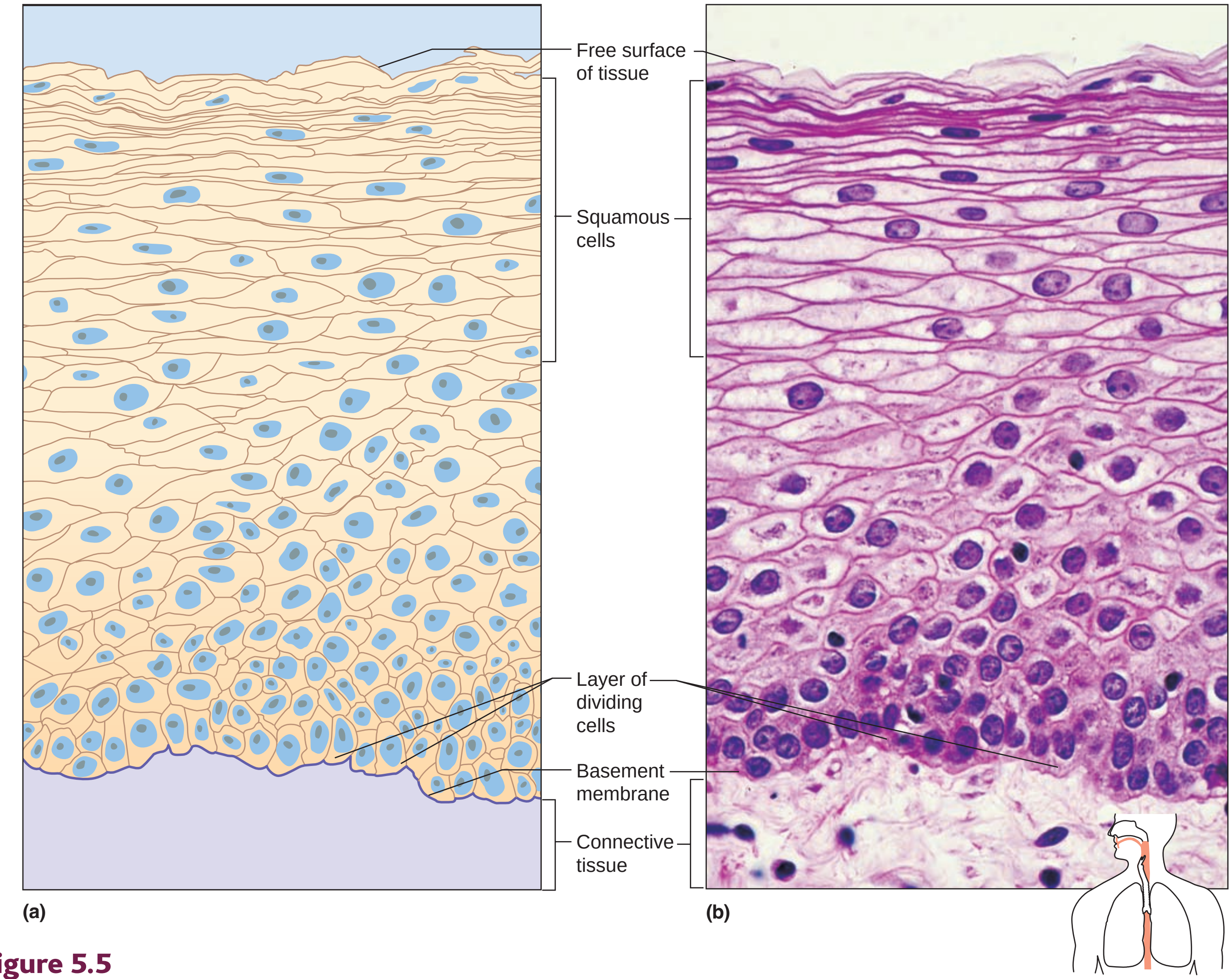


Figure 5.5

Stratified squamous epithelium consists of many layers of cells (385×). In one example, it lines the oral cavity and esophagus.

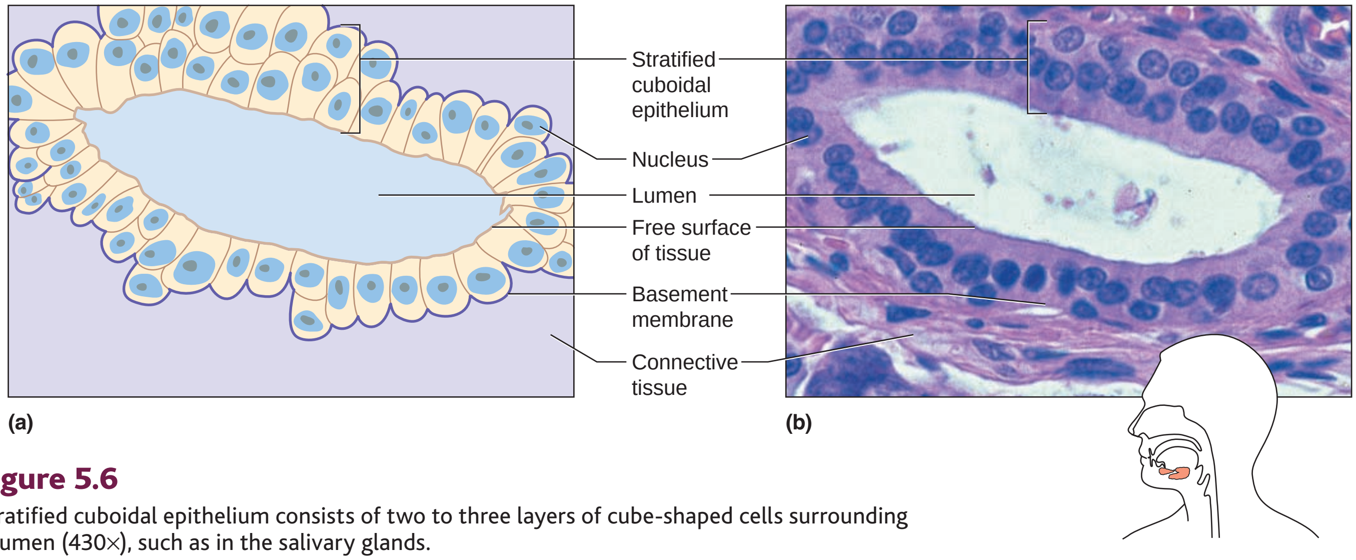


Figure 5.6

Stratified cuboidal epithelium consists of two to three layers of cube-shaped cells surrounding a lumen (430×), such as in the salivary glands.

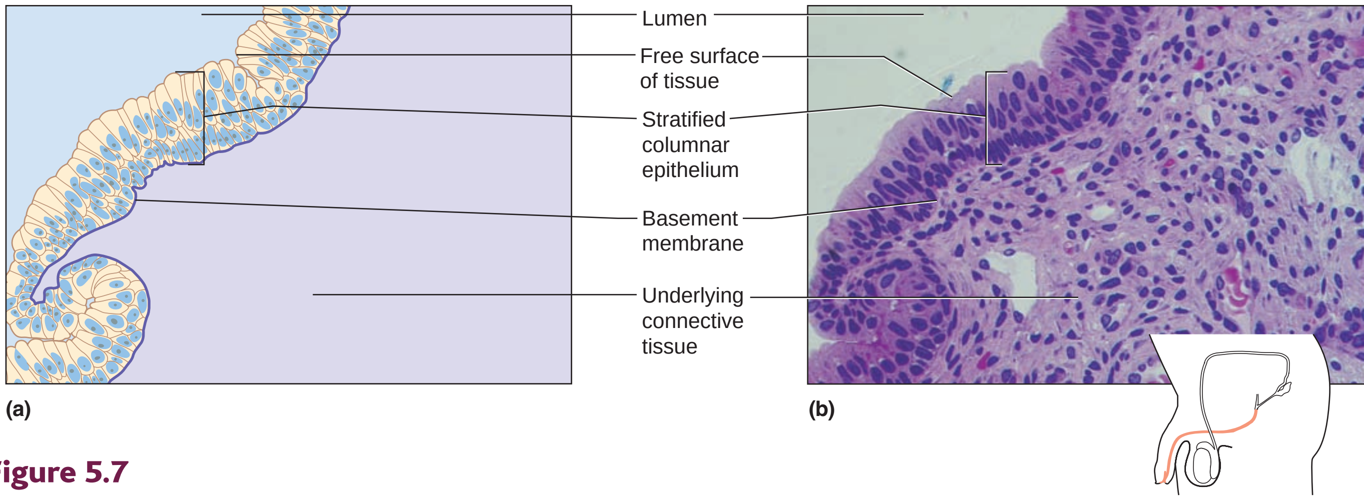


Figure 5.7

Stratified columnar epithelium consists of a superficial layer of columnar cells overlying several layers of cuboidal cells (220×). In one example, it is found in the male urethra.

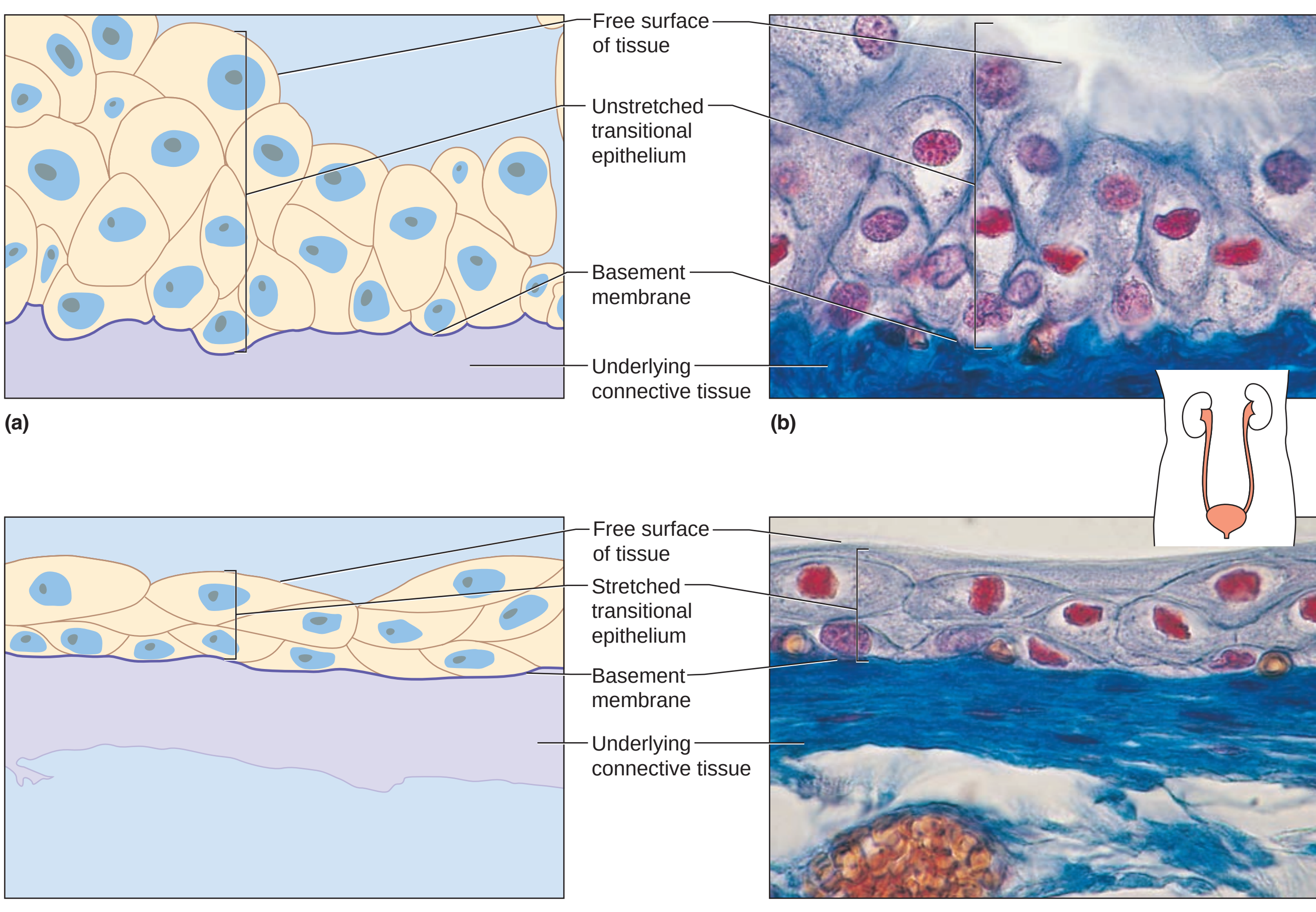


Figure 5.8

Transitional epithelium. (*a* and *b*) When the organ wall contracts, transitional epithelium is unstretched and consists of many layers (675×). (*c* and *d*) When the organ is distended, the tissue stretches and appears thinner (675×). Transitional epithelium lines the urinary bladder and the ureters and part of the urethra.

Up to 90% of all human cancers are *carcinomas,* which are growths that originate in epithelium. Most carcinomas begin on surfaces that contact the external environment, such as skin, linings of the airways in the respiratory tract, or linings of the stomach or intestine in the digestive tract. This observation suggests that the more common cancer-causing agents may not penetrate tissues very deeply.

Glandular Epithelium

Glandular epithelium is composed of cells that are specialized to produce and secrete substances into ducts or into body fluids. Such cells are usually found within columnar or cuboidal epithelium, and one or more of these cells constitute a *gland.* Glands that secrete their products into ducts that open onto surfaces, such as the skin or the lining of the digestive tract, are called **exocrine glands.** Glands that secrete their products into tissue fluid or blood are called **endocrine glands.** (Endocrine glands are discussed in chapter 11.)

Exocrine glands are classified according to the ways these glands secrete their products (fig. 5.9). Glands that release fluid by exocytosis are called **merocrine** (mer′o-krin) **glands.** Glands that lose small portions of their glandular cell bodies during secretion are called **apocrine** (ap′o-krin) **glands.** Glands that release entire cells that disintegrate to release cell secretions are called **holocrine** (ho′lo-krin) **glands.** Table 5.2 summarizes these glands and their secretions.

Most exocrine secretory cells are merocrine, and they can be further subclassified based on their secretion of serous fluid or mucus. *Serous fluid* is typically watery, and has a high concentration of enzymes. Serous cells secreting this fluid, that lubricates, are commonly associated with the visceral and parietal membranes of the thoracic and abdominopelvic cavities. The thicker fluid, *mucus,* is rich in the glycoprotein *mucin* and abundantly secreted by cells, for protection, in the inner linings of the digestive, respiratory, and reproductive systems. Mucous cells and goblet cells secrete mucus, but in different parts of the body. Table 5.3

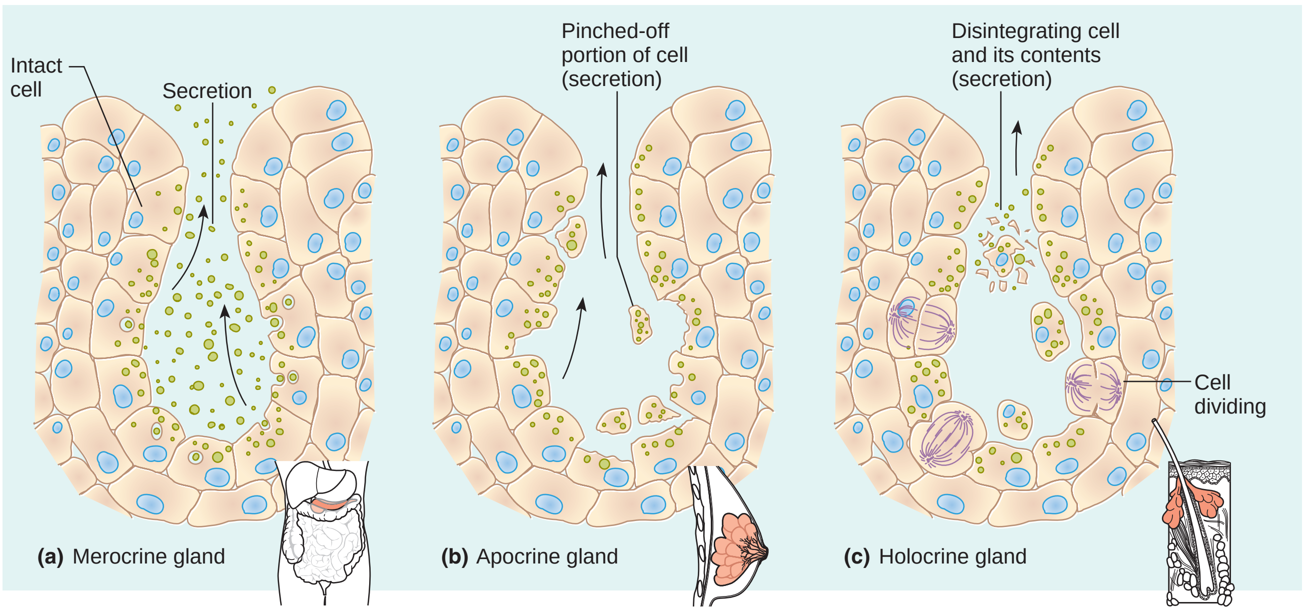


Figure 5.9

Types of exocrine glands. (*a*) Merocrine glands release secretions without losing cytoplasm. (*b*) Apocrine glands lose small portions of their cell bodies during secretion. (*c*) Holocrine glands release entire cells filled with secretory products.

Table 5.2 Types of Exocrine Glandular Secretions

Type of Gland	Description of Secretion	Example
Merocrine glands	A fluid product released through the cell membrane by exocytosis	Salivary glands, pancreatic glands, sweat glands of the skin
Apocrine glands	Cellular product and portions of the free ends of glandular cells pinched off during secretion	Mammary glands, ceruminous glands lining the external ear canal
Holocrine glands	Disintegrated entire cells filled with secretory products	Sebaceous glands of the skin

summarizes the characteristics of the different types of epithelial tissues.

Check Your Recall

5. Describe the special functions of each type of epithelium.
6. Distinguish between exocrine glands and endocrine glands.
7. Explain how exocrine glands are classified.
8. Distinguish between a serous cell and a mucous cell.

5.3 CONNECTIVE TISSUES

General Characteristics

Connective (kŏ-nek′tiv) **tissues** bind structures, provide support and protection, serve as frameworks, fill spaces, store fat, produce blood cells, protect against infections, and help repair tissue damage. Connective tissue cells are farther apart than epithelial cells, and they have an abundance of **extracellular matrix** (eks″trah-sel′u-lar ma′triks) between them. This extracellular matrix is composed of *protein fibers,* and a *ground substance* consisting of nonfibrous protein and other molecules, and fluid. The consistency of the extracellular matrix varies from fluid to semisolid to solid. The Topic of Interest on page 103 details the importance of this tissue component.

Most connective tissue cells can divide. These tissues have varying degrees of vascularity, but most have good blood supplies and are well nourished. Some connective tissues, such as bone and cartilage, are quite rigid. Loose connective tissue (areolar), adipose tissue, and dense connective tissue are more flexible.

Major Cell Types

Connective tissues contain a variety of cell types. Some cells are called *fixed cells* because they reside in the tissue for an extended period of time. These include fibroblasts and mast cells. Other cells, such as macrophages, are *wandering cells.* They move through and appear in tissues temporarily, usually in response to an injury or infection.

Fibroblasts (fi′bro-blastz) are the most common type of fixed cell in connective tissue. These large, star-shaped cells produce fibers by secreting proteins into the extracellular matrix of connective tissues (fig. 5.10).

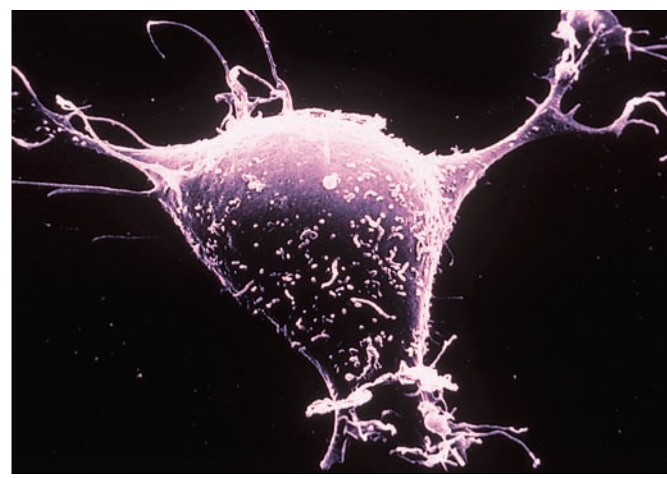


Figure 5.10
Scanning electron micrograph of a fibroblast (4,000×), the most abundant cell type of connective tissue.

Table 5.3 Epithelial Tissues

Type	Function	Location
Simple squamous epithelium	Filtration, diffusion, osmosis; covers surface	Air sacs of the lungs, walls of capillaries, linings of blood and lymph vessels
Simple cuboidal epithelium	Secretion, absorption	Surface of ovaries, linings of kidney tubules, and linings of ducts of certain glands
Simple columnar epithelium	Absorption, secretion, protection	Linings of uterus, stomach, and intestines
Pseudostratified columnar epithelium	Protection, secretion, movement of mucus	Linings of respiratory passages
Stratified squamous epithelium	Protection	Outer layer of skin, linings of oral cavity, throat, vagina, and anal canal
Stratified cuboidal epithelium	Protection	Linings of larger ducts of mammary glands, sweat glands, salivary glands, and pancreas
Stratified columnar epithelium	Protection, secretion	Part of the male urethra and parts of the pharynx
Transitional epithelium	Distensibility, protection	Inner lining of urinary bladder and linings of ureters and part of urethra
Glandular epithelium	Secretion	Salivary glands, sweat glands, endocrine glands

Topic of Interest

A New View of the Body's Glue: The Extracellular Matrix

The traditional description of connective tissue matrix as "intercellular material" suggested that it merely fills the spaces between cells. However, when cell biologists looked beyond the abundant collagens that comprise much of the matrix, they discovered a complex and changing recipe of different molecules that modifies the tissue to suit different organs and conditions. Not only does this material outside cells—the extracellular matrix, or ECM—serve as a scaffolding to organize cells into tissues, but it relays the biochemical signals that control cell division, differentiation, repair, and migration.

The ECM has two basic components: the basement membrane that covers cell surfaces, and the rest of the material between cells, called the interstitial matrix. The basement membrane is mostly composed of tightly packed collagenous fibers from which large, cross-shaped glycoproteins called laminins extend. The laminins (and other glycoproteins such as fibronectin and tenascin) traverse the interstitial matrix and touch receptors, called integrins, on other cells. In this way, the ECM connects cells into tissues. The ECM is versatile, and includes at least twenty types of collagen and precursor versions of hormones, enzymes, growth factors, and immune system biochemicals (cytokines). These molecules are activated under certain conditions.

The components of the ECM are always changing, as its cells synthesize proteins while enzymes called proteases break down specific proteins. The balance of components is important to maintaining and repairing organ structure. Disrupt the balance, and disease can result. Here are three common examples:

Cancer

The spread of a cancerous growth uses the ability of fibroblasts to contract as they close a wound, where they are replaced with normal epithelium. Chemical signals from cancer cells cause fibroblasts to become more contractile (myofibroblasts), as well as to take on the characteristics of cancer cells. At the same time, alterations in laminins loosen the connections of the fibroblasts to surrounding cells. This abnormal flexibility enables the changed fibroblasts to migrate, and the cancer spreads. Normally, fibroblasts secrete abundant collagen (figure 5A).

Liver Fibrosis

In fibrosis, a part of all chronic liver diseases, collagen deposition increases so that the ECM exceeds its normal 3% of the organ. Healthy liver ECM sculpts a framework that supports the epithelial and vascular tissues of the organ. In response to a damaging agent such as a virus, alcohol, or a toxic drug, hepatic stellate cells secrete collagenous fibers in the areas where the epithelium and blood vessels meet. Such limited fibrosis seals off the affected area, preventing its spread. But if the process continues—if an infection is not treated or the noxious stimulus not removed—the ECM grows and eventually blocks the interaction between liver cells and the bloodstream. The liver tissue eventually hardens, a dangerous condition called *cirrhosis*.

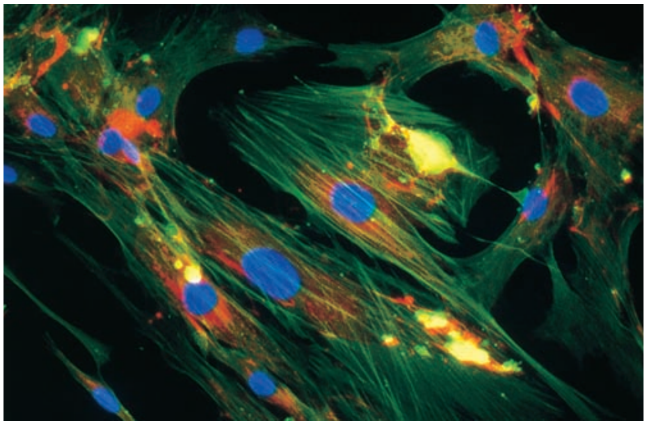


Figure 5A

The fibroblast connective tissue cells shown here have been taken from fetal skin. Fibroblasts form connective tissue by secreting extracellular matrix material such as collagen. (Immunofluorescent light micrograph, 225×.) Fibroblasts produce abundant collagens, of various types. Collagens make up more than half of the extracellular matrix in most parts of the body. The extracellular matrix is particularly important before birth, when organs form.

Heart Failure and Atherosclerosis

The heart's ECM organizes cells into a three-dimensional network that coordinates their contractions into the rhythmic heartbeat necessary to pump blood. It consists of collagen, fibronectin, laminin, and elastin surrounding cardiac muscle cells and myofibroblasts, and is also in the walls of arteries. Heart failure and atherosclerosis reflect imbalances of collagen production and degradation. As in the liver, the natural response of ECM buildup is to wall off an area where circulation is blocked, but if it continues, the extra scaffolding stiffens the heart, which can ultimately lead to heart failure. In atherosclerosis, excess ECM accumulates on the interior linings of arteries, blocking blood flow. During a myocardial infarction (heart attack), collagen synthesis and deposition increase in affected and nonaffected heart parts, which is why damage can continue even after pain starts.

Macrophages (mak′ro-fājez), or histiocytes, originate as white blood cells (see chapter 14, p. 384) and are almost as numerous as fibroblasts in some connective tissues. They are specialized to carry on phagocytosis. Macrophages can move about and function as scavenger and defensive cells that clear foreign particles from tissues (fig. 5.11).

Mast cells are large and widely distributed in connective tissues. They are usually near blood vessels (fig. 5.12). Mast cells release *heparin,* which prevents blood clotting, and *histamine,* which promotes some of the reactions associated with inflammation and allergies (see chapter 14, p. 393).

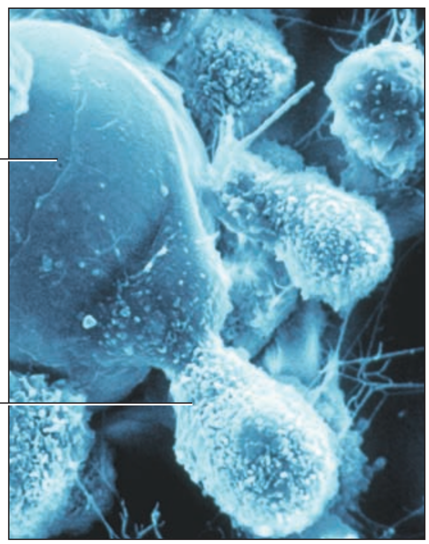


Figure 5.11

Macrophages are scavenger cells common in connective tissues. This scanning electron micrograph shows a number of macrophages engulfing parts of a larger cell (3,300×).

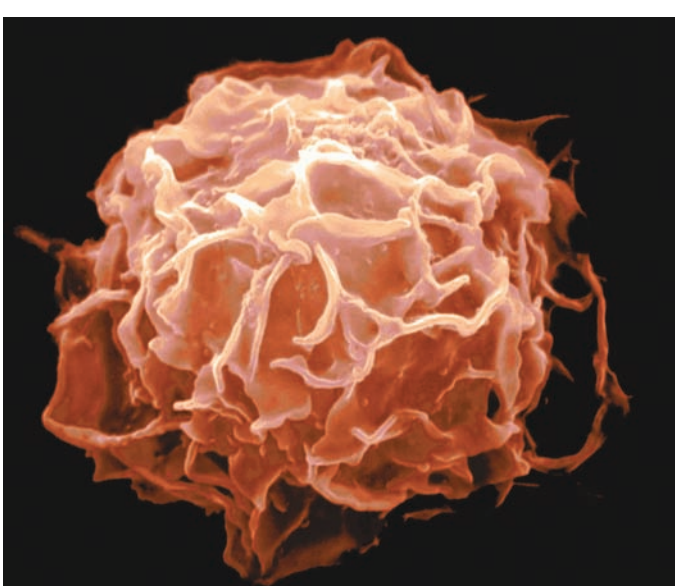


Figure 5.12

Scanning electron micrograph of a mast cell (6,600×), which releases heparin and histamine.

Connective Tissue Fibers

Fibroblasts produce three types of connective tissue fibers: collagenous fibers, elastic fibers, and reticular fibers. Of these, collagenous and elastic fibers are the most abundant.

Collagenous (kol-laj′ĕ-nus) **fibers** are thick threads of the protein *collagen.* They are grouped in long, parallel bundles, and are flexible but only slightly elastic. More importantly, they have great tensile strength—that is, they resist considerable pulling force. Thus, collagenous fibers are important components of body parts that hold structures together, such as **ligaments** (which connect bones to bones) and **tendons** (which connect muscles to bones).

Tissue containing abundant collagenous fibers is called *dense connective tissue.* It appears white, and for this reason, collagenous fibers are sometimes called *white fibers.*

Elastic fibers are composed of a protein called *elastin.* These thin fibers branch, forming complex networks. Elastic fibers are weaker than collagenous fibers, but they stretch easily and can resume their original lengths and shapes. Elastic fibers are common in body parts that are frequently stretched, such as the vocal cords. They are sometimes called *yellow fibers* because tissues well supplied with them appear yellowish.

Reticular fibers are very thin collagenous fibers. They are highly branched and form delicate supporting networks in a variety of tissues, including the spleen. Table 5.4 summarizes the major cells and tissue fibers of connective tissue, including their functions.

When skin is exposed to prolonged and intense sunlight, connective tissue fibers lose elasticity, and the skin stiffens and becomes leathery. In time, the skin may sag and wrinkle. Collagen injections may temporarily smooth out wrinkles. However, collagen applied as a cream to the skin does not combat wrinkles because collagen molecules are far too large to actually penetrate the skin.

Table 5.4 Components of Connective Tissue

Cell Type	Function
Fibroblasts	Produce fibers
Macrophages	Carry on phagocytosis
Mast cells	Secrete heparin and histamine
Tissue Fibers	**Function**
Collagenous	Hold structures together with great tensile strength
Elastic	Stretch easily
Reticular	Lend delicate support

Categories of Connective Tissue

Connective tissue is classified into two categories. *Connective tissue proper* includes loose connective tissue and dense connective tissue. The *specialized connective tissues* include cartilage, bone, and blood.

Loose Connective Tissue

Loose connective tissue includes areolar tissue, adipose tissue, and reticular connective tissue. **Areolar** (ah-re′o-lar) **tissue** forms delicate, thin membranes throughout the body. The cells of this tissue, mainly fibroblasts, are located some distance apart and are separated by a gel-like extracellular matrix containing many collagenous and elastic fibers that fibroblasts secrete (fig. 5.13). Areolar tissue binds the skin to the underlying organs and fills spaces between muscles. It lies beneath most layers of epithelium, where its many blood vessels nourish nearby epithelial cells.

Adipose (ad′ĭ-pō s) **tissue,** or fat, develops when certain cells (adipocytes) store fat as droplets in their cytoplasm and enlarge (fig. 5.14). When such cells become so abundant that they crowd other cell types, they form adipose tissue. Adipose tissue lies beneath the skin, in spaces between muscles, around the kidneys, behind the eyeballs, in certain abdominal membranes, on the surface of the heart, and around certain joints. Adipose tissue cushions joints and some organs, such as the kidneys. It also insulates beneath the skin, and it stores energy in fat molecules.

The average adult has between 40 and 50 billion fat cells.

Overeating and lack of exercise can increase the size of adipose cells, leading to overweight or obesity. During periods of fasting, however, fat supplies energy, and adipocytes lose fat, shrink, and become more like fibroblasts.

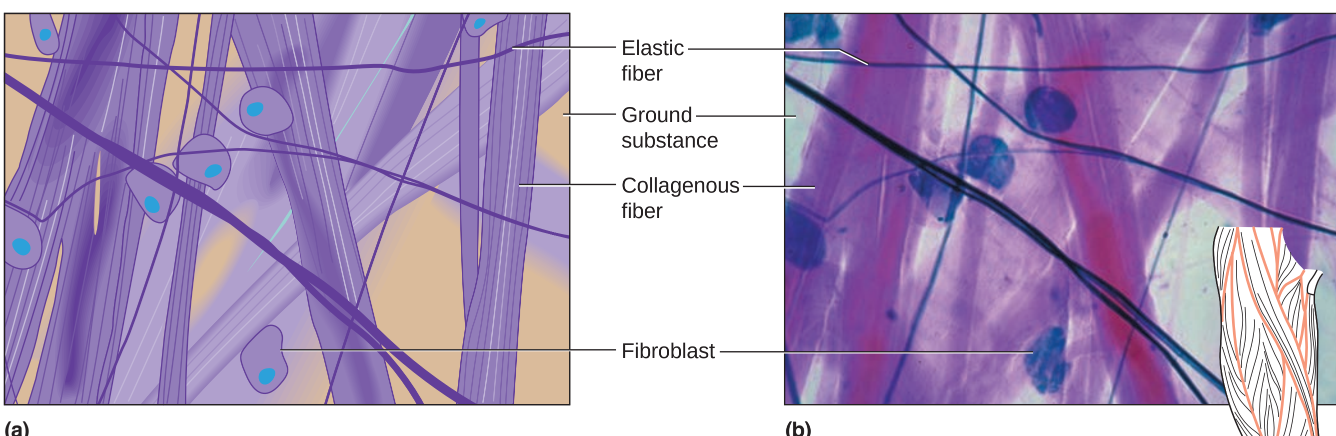


Figure 5.13
Areolar tissue contains numerous fibroblasts that produce collagenous and elastic fibers (700×). It is widespread in the body.

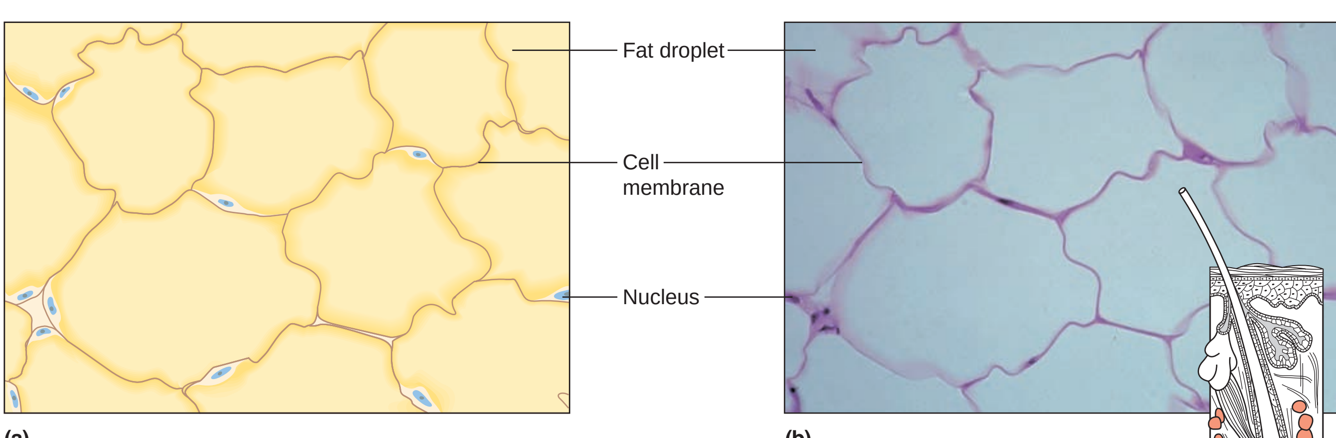


Figure 5.14
Adipose tissue cells contain large fat droplets that push the nuclei close to the cell membranes (450×). Adipose tissue beneath the skin provides insulation.

Reticular connective tissue is composed of thin, collagenous fibers in a three-dimensional network. It helps to provide the framework of certain internal organs, such as the liver and spleen.

Dense Connective Tissue

Dense connective tissue consists of many closely packed, thick, collagenous fibers and a fine network of elastic fibers. It has few cells, most of which are fibroblasts (fig. 5.15).

Collagenous fibers of dense connective tissue are very strong, enabling the tissue to withstand pulling forces. As parts of tendons and ligaments, dense connective tissue binds muscle to bone and bone to bone. This type of tissue is also in the protective white layer of the eyeball and in the deeper skin layers. The blood supply to dense connective tissue is poor, slowing tissue repair.

Check Your Recall

9. What are the general characteristics of connective tissues?
10. What are the characteristics of collagen and elastin?
11. What feature distinguishes adipose tissue from other connective tissues?
12. Explain the difference between loose connective tissue and dense connective tissue.

Cartilage

Cartilage (kar′ti-lij) is a rigid connective tissue. It provides support, frameworks, and attachments, protects underlying tissues, and forms structural models for many developing bones.

Cartilage extracellular matrix is abundant and is largely composed of collagenous fibers embedded in a gel-like ground substance. Cartilage cells, or **chondrocytes** (kon′dro-sītz), occupy small chambers called *lacunae* and lie completely within the extracellular matrix (fig. 5.16).

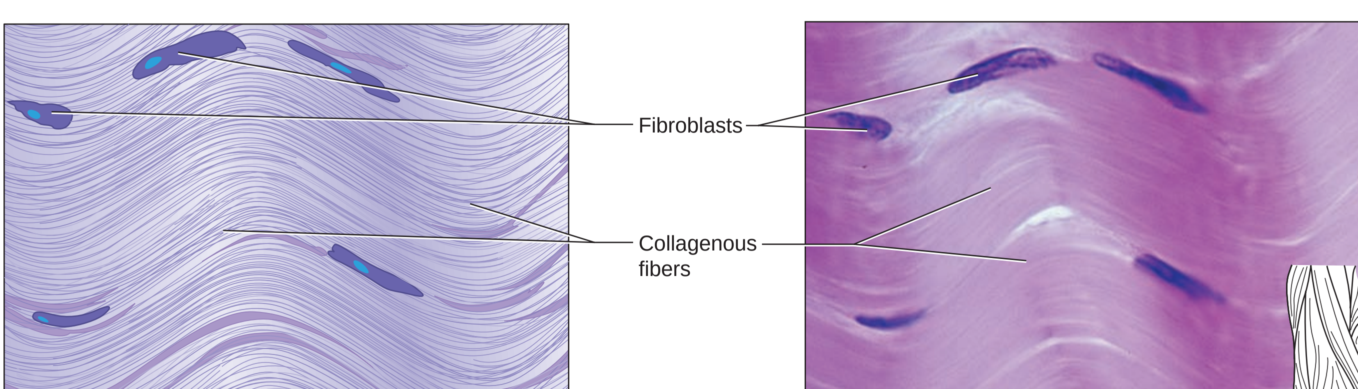
A cartilaginous structure is enclosed in a covering of connective tissue called the *perichondrium.* The perichondrium contains blood vessels that provide cartilage cells with nutrients by diffusion. The lack of a direct blood supply to cartilage tissue is why torn cartilage heals slowly and why chondrocytes do not divide frequently.

Different types of extracellular matrix distinguish three types of cartilage. **Hyaline cartilage,** the most common type, has very fine collagenous fibers in its extracellular matrix and looks somewhat like white glass. Hyaline cartilage is the type shown in figure 5.16. It is found on the ends of bones in many joints, in the soft part of the nose, and in the supporting rings of the respiratory passages. Hyaline cartilage is also important in the development and growth of most bones (see chapter 7, p. 134).

Elastic cartilage has a dense network of elastic fibers and thus is more flexible than hyaline cartilage (fig. 5.17). It provides the framework for the external ears and for parts of the larynx.

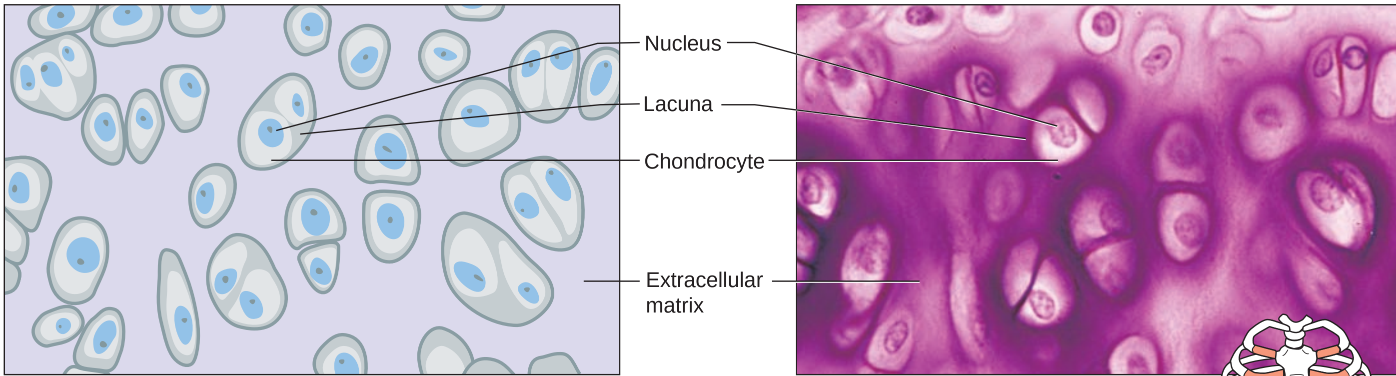
Fibrocartilage, a very tough tissue, has many collagenous fibers (fig. 5.18). It is a shock absorber for structures that are subjected to pressure. For example, fibrocartilage forms pads (intervertebral discs) between the individual bones (vertebrae) of the spinal column. It also cushions bones in the knees and in the pelvic girdle.

Between ages thirty and seventy, a nose may lengthen and widen by as much as half an inch, and the ears may lengthen by a quarter inch, because the cartilage in these areas continues to grow as we age.



(a) (b)

Figure 5.15
Dense connective tissue consists largely of tightly packed collagenous fibers (1,000×). Examples of this tissue include parts of tendons and ligaments.



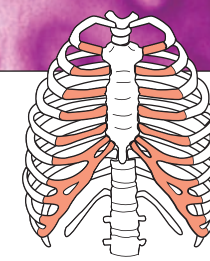
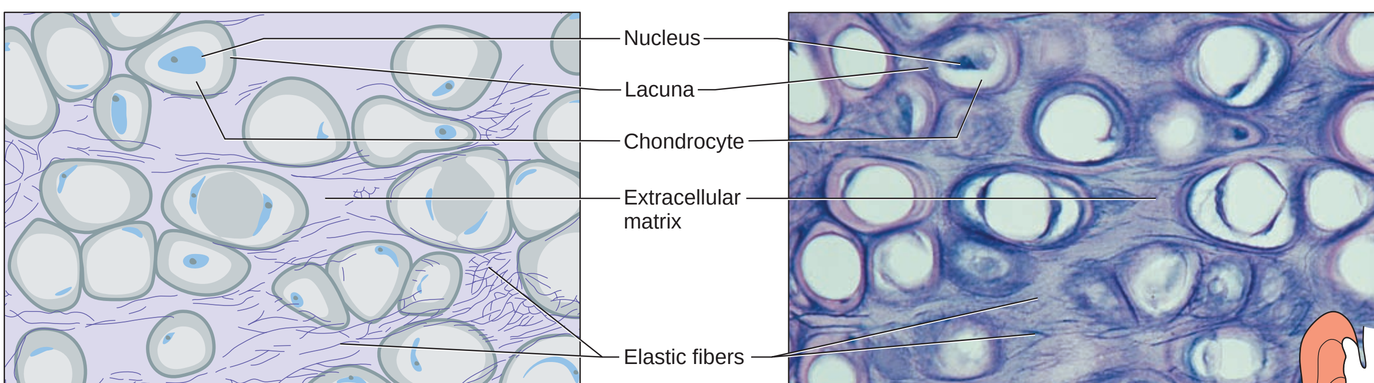


Figure 5.16

Cartilage cells (chondrocytes) are located in lacunae, which are in turn surrounded by extracellular matrix containing very fine collagenous fibers (610×). This is hyaline cartilage, the most common type.



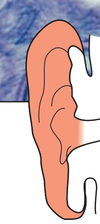


Figure 5.17

Elastic cartilage contains many elastic fibers in its extracellular matrix (1,450×). In one example, it is part of the external ear.

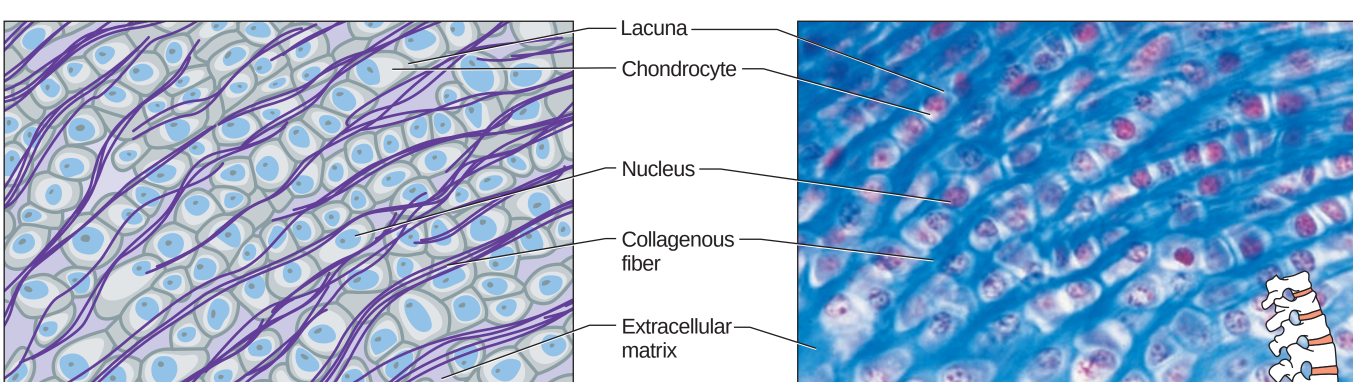


Figure 5.18

Fibrocartilage contains many large collagenous fibers in its extracellular matrix (1,800×). In one example, it forms the pads between vertebrae.

Bone

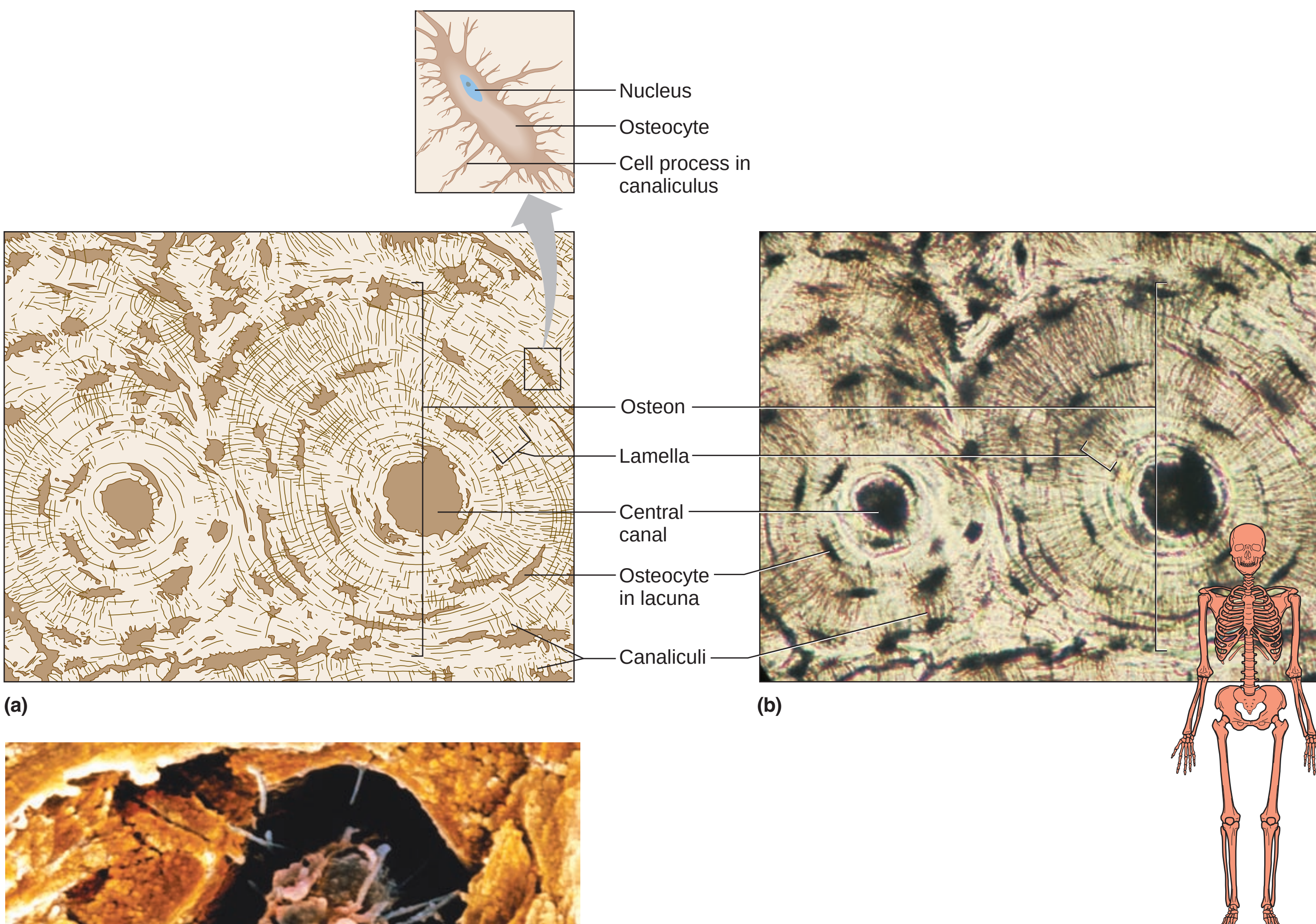
Bone is the most rigid connective tissue. Its hardness is largely due to mineral salts, such as calcium phosphate and calcium carbonate, between cells. This extracellular matrix also has many collagenous fibers, which are flexible and reinforce the mineral components of bone.

Bone internally supports body structures. It protects vital parts in the cranial and thoracic cavities, and is an attachment for muscles. Bone also contains red marrow, which forms blood cells, and it stores and releases inorganic chemicals such as calcium and phosphorus.

Bone matrix is deposited in thin layers called *lamellae,* which form concentric patterns around tiny longitudinal tubes called *central canals,* or Haversian canals (fig. 5.19). Bone cells, or **osteocytes** (os′te-o-sītz), are located in lacunae, which are rather evenly spaced within the lamellae. Consequently, osteocytes also form concentric circles.

In a bone, the osteocytes and layers of extracellular matrix, which are concentrically clustered around a central canal, form a cylinder-shaped unit called an **osteon** (os′te-on), or Haversian system. Many osteons cemented together form the substance of bone.

Each central canal contains a blood vessel, which places every bone cell near a nutrient supply. In addition, bone cells have many cytoplasmic processes that extend outward and pass through very small tubes in the extracellular matrix called *canaliculi.* These cellular processes connect with the membranes of nearby cells.



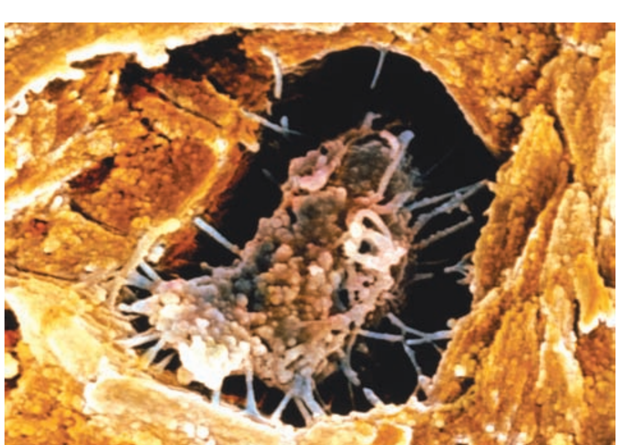


Figure 5.19

Bone tissue. (*a*) Bone matrix is deposited in concentric layers around central canals. (*b*) Micrograph of bone tissue (160×). (*c*) Artificially colored scanning electron micrograph of an osteocyte within a lacuna (6,000×).

As a result, materials can move rapidly between blood vessels and bone cells. Thus, in spite of its inert appearance, bone is a very active tissue that heals much more rapidly than does injured cartilage. (The microscopic structure of bone is described in more detail in chapter 7, p. 132.)

Blood

Blood transports a variety of materials between interior body cells and those that exchange substances with the external environment. In this way, blood helps maintain stable internal environmental conditions. Blood is composed of *formed elements* suspended in a fluid extracellular matrix called *blood plasma*. The formed elements include *red blood cells, white blood cells,* and cell fragments called *platelets* (fig. 5.20). Most blood cells form in red marrow within the hollow parts of certain long bones. Chapter 12 describes blood in detail. Table 5.5 lists the characteristics of the connective tissues.

Check Your Recall

13. Describe the general characteristics of cartilage.
14. Explain why injured bone heals more rapidly than injured cartilage.
15. What are the major components of blood?

5.4 TYPES OF MEMBRANES

After discussing epithelial and connective tissues, membranes are better understood. **Epithelial membranes** are thin, sheetlike structures composed of epithelium and underlying connective tissue covering body surfaces and lining body cavities. The three major types of epithelial membranes are *serous, mucous,* and *cutaneous.*

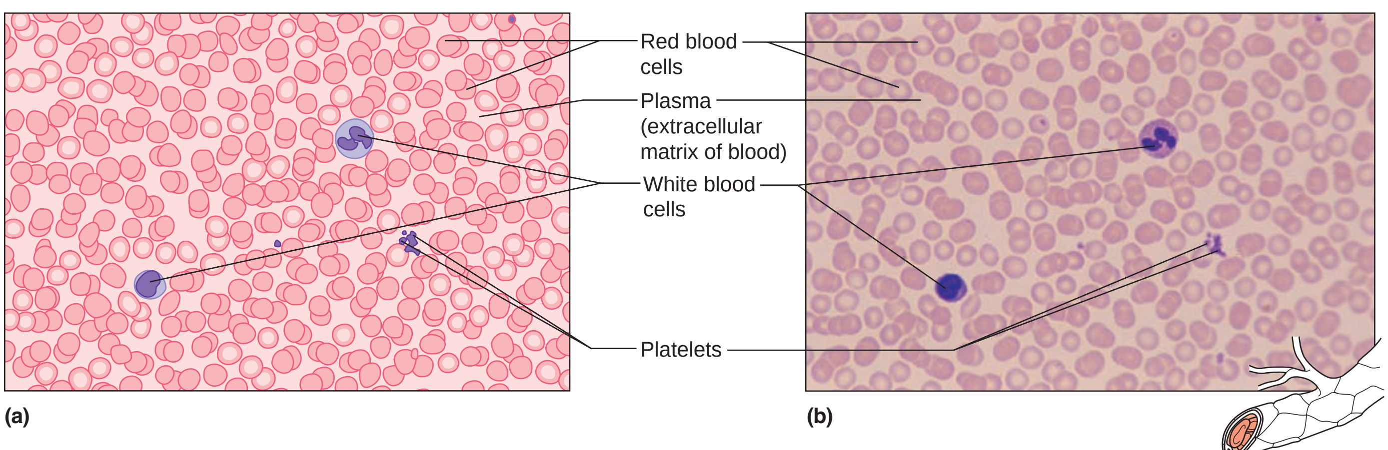


Figure 5.20
Blood tissue consists of red blood cells, white blood cells, and platelets suspended in a fluid extracellular matrix, the blood plasma (425×).

Table 5.5 Connective Tissues

Type	Function	Location
Loose connective tissue		
Areolar tissue	Binds organs, holds tissue fluids	Beneath skin, between muscles, beneath epithelial tissues
Adipose tissue	Protects, insulates, stores fat	Beneath skin, around kidneys, behind eyeballs, on surface of heart
Reticular connective tissue	Supports	Walls of liver and spleen
Dense connective tissue	Binds organs	Tendons, ligaments, deeper layers of skin
Hyaline cartilage	Supports, protects, provides framework	Nose, ends of bones, rings in the walls of respiratory passages
Elastic cartilage	Supports, protects, provides flexible framework	Framework of external ear and parts of larynx
Fibrocartilage	Supports, protects, absorbs shock	Between bony parts of spinal column, parts of pelvic girdle and knee
Bone	Supports, protects, provides framework	Bones of skeleton
Blood	Transports substances, helps maintain stable internal environment	Throughout body within a closed system of blood vessels and heart chambers

Serous (se′rus) **membranes** line body cavities that lack openings to the outside. These membranes form the inner linings of the thorax (parietal pleura) and abdomen (parietal peritoneum), and they cover the organs within these cavities (visceral pleura and visceral peritoneum, respectively, as shown in figs. 1.10 and 1.11, p. 11). A serous membrane consists of a layer of simple squamous epithelium and a thin layer of loose connective tissue. The cells of a serous membrane secrete watery *serous fluid,* which lubricates membrane surfaces.

Mucous (mucus) **membranes** line cavities and tubes that open to the outside of the body, including the oral and nasal cavities and the tubes of the digestive, respiratory, urinary, and reproductive systems. A mucous membrane consists of epithelium overlying a layer of loose connective tissue. Goblet cells within a mucous membrane secret *mucus.*

The **cutaneous** (ku-ta′ne-us) **membrane** is more commonly called the skin. It is described in detail in chapter 6.

Another type of membrane is a **synovial** (si-nove-al) **membrane,** which lines joints and is discussed further in chapter 7 (p. 162). A synovial membrane is composed entirely of connective tissues.

Check Your Recall

16. Name the four types of membranes, and explain how they differ.

5.5 MUSCLE TISSUES

General Characteristics

Muscle (mus′el) **tissues** are able to contract; that is, their elongated cells, or *muscle fibers,* can shorten. As they contract, muscle fibers pull at their attached ends, and this action moves body parts. The three types of muscle tissue—skeletal, smooth, and cardiac—are discussed in more detail in chapter 8.

Approximately 40% of the body is skeletal muscle, and almost another 10% is smooth or cardiac muscle.

Skeletal Muscle Tissue

Skeletal muscle tissue is found in muscles that attach to bones and is controlled by conscious effort. For this reason, it is often called *voluntary* muscle tissue. The long, threadlike cells of skeletal muscle have alternating light and dark cross-markings called *striations.* Each cell has many nuclei (fig. 5.21). A nerve cell can stimulate a muscle cell to contract, and then the muscle cell relaxes when stimulation stops.

The muscles built of skeletal muscle tissue move the head, trunk, and limbs. They enable us to make facial expressions, write, talk, sing, chew, swallow, and breathe, essentially carrying out all voluntary movements.

Smooth Muscle Tissue

Smooth muscle tissue is so-called because its cells do not have striations. Smooth muscle cells are shorter than skeletal muscle cells and are spindle-shaped, each with a single, centrally located nucleus (fig. 5.22). This tissue comprises the walls of hollow internal organs, such as the stomach, intestine, urinary bladder, uterus, and blood vessels. Unlike skeletal muscle, smooth muscle usually cannot be stimulated to contract by conscious efforts. Thus, its actions are *involuntary.* For example, smooth muscle tissue moves food through

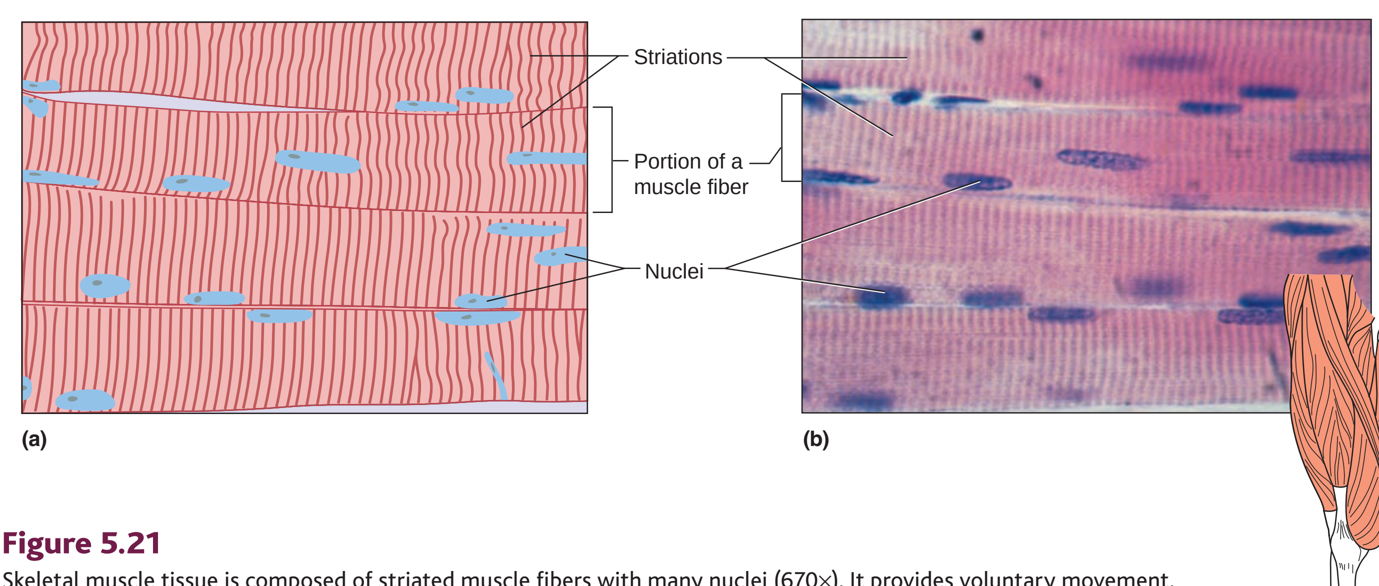


Figure 5.21
Skeletal muscle tissue is composed of striated muscle fibers with many nuclei (670×). It provides voluntary movement.

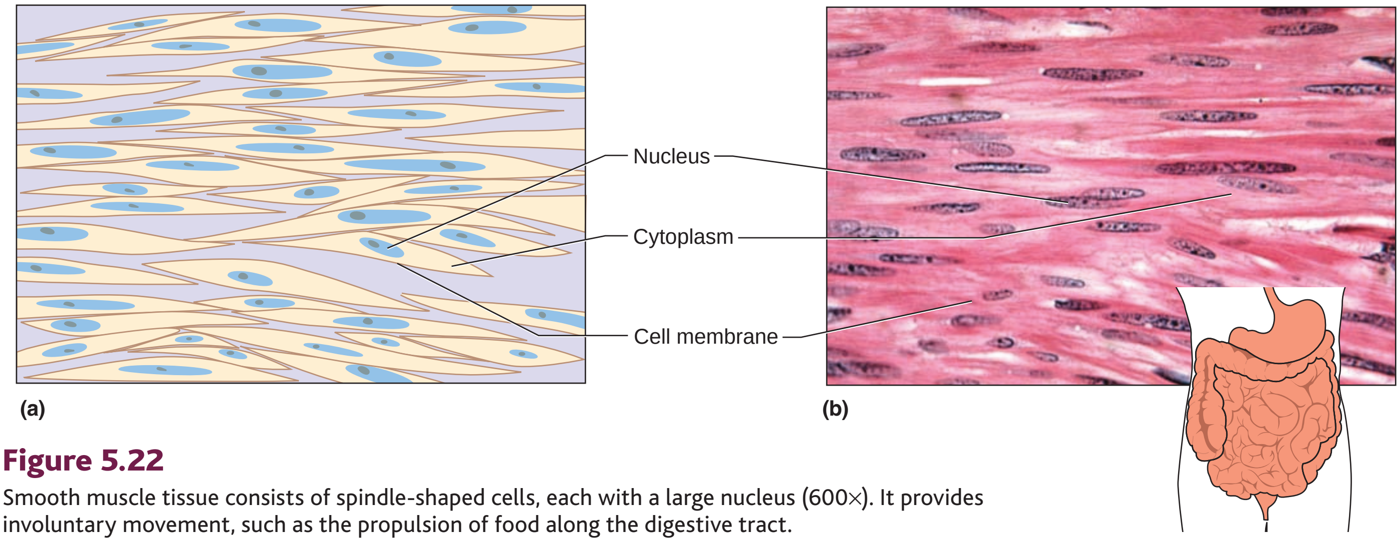


Figure 5.22
Smooth muscle tissue consists of spindle-shaped cells, each with a large nucleus (600×). It provides involuntary movement, such as the propulsion of food along the digestive tract.

the digestive tract, constricts blood vessels, and empties the urinary bladder.

Cardiac Muscle Tissue

Cardiac muscle tissue is only in the heart. Its cells, which are striated and branched, are joined end to end, forming intricate networks. Each cardiac muscle cell has a single nucleus (fig. 5.23). Where it touches another cell is a specialized intercellular junction called an *intercalated disc,* discussed further in chapter 8, p. 190.

Cardiac muscle, like smooth muscle, is controlled involuntarily. This tissue makes up the bulk of the heart and pumps blood through the heart chambers and into blood vessels.

Check Your Recall

17. List the general characteristics of muscle tissues.
18. Distinguish among skeletal, smooth, and cardiac muscle tissues.

The cells of different tissues vary greatly in their abilities to divide. Cells that divide continuously include the epithelial cells of the skin and inner lining of the digestive tract and the connective tissue cells that form blood cells in red bone marrow. However, skeletal and cardiac muscle cells and nerve cells do not usually divide at all after differentiating.

Fibroblasts respond rapidly to injuries by increasing in number and fiber production. They are often the principal agents of repair in tissues that have limited abilities to regenerate. For instance, fibroblasts form scar tissue after a heart attack occurs. Many organs include pockets of stem or progenitor cells that can divide and replace damaged, differentiated cells, under certain conditions.

5.6 NERVOUS TISSUES

Nervous (ner′vus) **tissues** are found in the brain, spinal cord, and peripheral nerves. The basic cells are called **neurons** (nu′ronz), or nerve cells (fig. 5.24). Neurons sense certain types of changes in their surroundings. They respond by transmitting nerve impulses along cellular processes called *axons* to other neurons or to muscles or glands. Because neurons communicate with each other and with muscle and gland cells, they can coordinate, regulate, and integrate many body functions.

In addition to neurons, nervous tissue includes **neuroglial cells** (nu-rog′le-ahl selz), shown in figure 5.24. Neuroglial cells divide and are crucial to the functioning of neurons. These cells support and bind the components of nervous tissue, carry on phagocytosis, and help supply nutrients to neurons by connecting them to blood vessels. They also play a role in cell-to-cell communication. Nervous tissue is discussed in more detail in chapter 9. Table 5.6 summarizes the general characteristics of muscle and nervous tissues.

Check Your Recall

19. Describe the general characteristics of nervous tissues.
20. Distinguish between neurons and neuroglial cells.

Clinical Connection

Each year in the United States, about ten thousand people need their bladders repaired or replaced. Typically a urologic surgeon replaces part of the bladder with part of the large intestine. However, the function of the intestine is to absorb, and the function of the bladder is to hold waste. Tissue engineering is providing a better way to build a bladder, which is a balloon-like organ

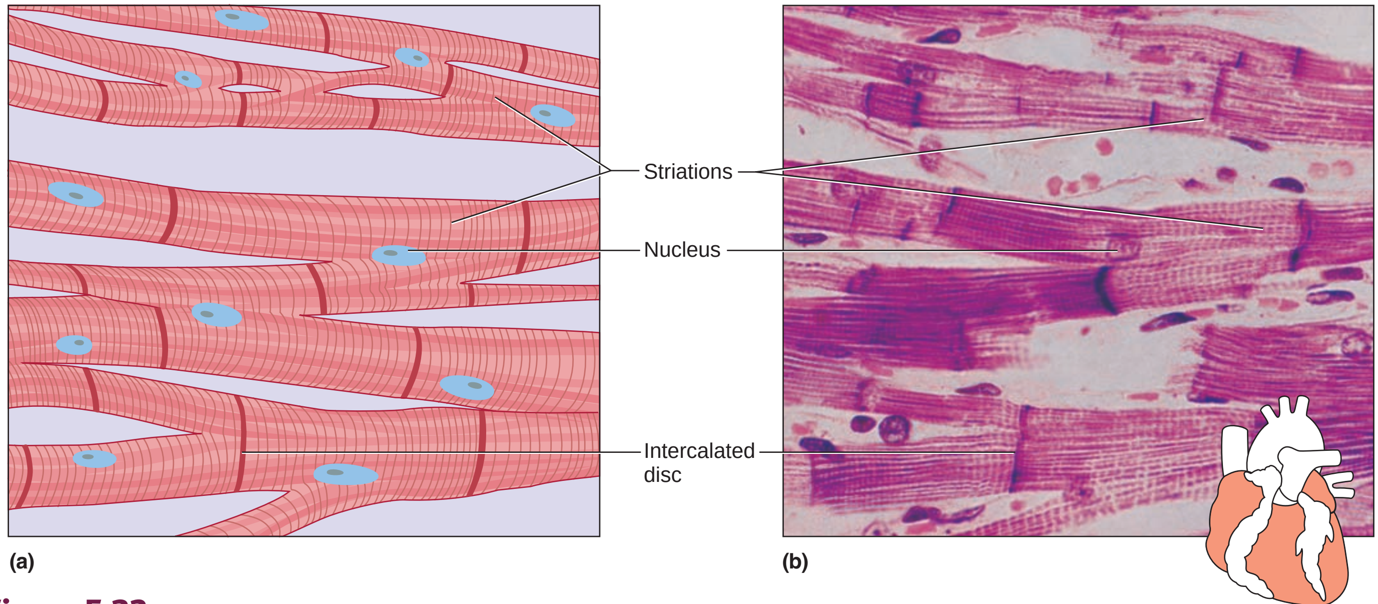


Figure 5.23
Cardiac muscle cells are branched and interconnected, with a single nucleus each (360×). Their contraction is involuntary.

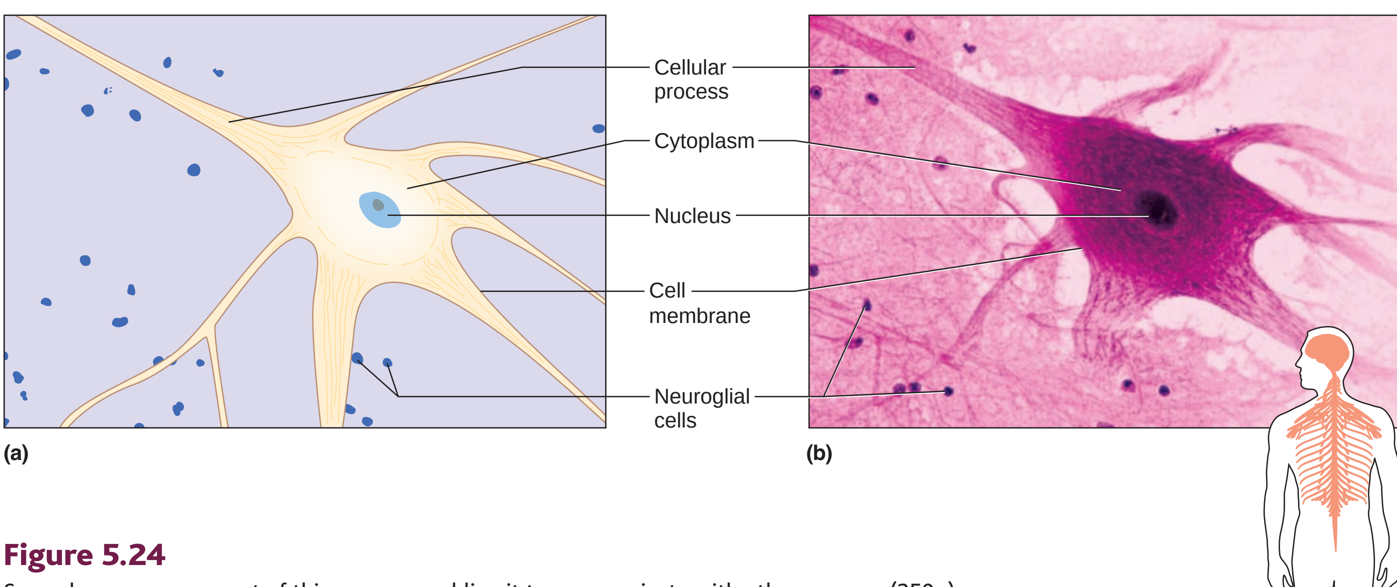


Figure 5.24
Several processes are part of this neuron, enabling it to communicate with other neurons (350×).

Table 5.6 Muscle and Nervous Tissues

Type	Function	Location
Skeletal muscle tissue (striated)	Voluntary movements of skeletal parts	Muscles usually attached to bones
Smooth muscle tissue (lacks striations)	Involuntary movements of internal organs	Walls of hollow internal organs
Cardiac muscle tissue (striated)	Heart movements	Heart muscle
Nervous tissue	Sensory reception and conduction of nerve impulses	Brain, spinal cord, and peripheral nerves

that has smooth muscle on the outside and lining tissue (urothelium) and connective tissue on the inside.

In tissue engineering, a patient's cells are grown with a synthetic scaffold to form an implant that can bolster or replace a failing body part. Because the cells originate in the patient, the immune system does not reject them. Tissue engineering has provided bioengineered skin to help burn patients heal, replacement cartilage, and even blood vessels.

Researchers created replacements for part of the urinary bladders of seven children and teens who have spina bifida, a birth defect, in which the malfunctioning bladder can harm the kidneys. Each patient donated a postage-stamp-size sample of bladder tissue, which consisted of about a million cells. The researchers separated the cells and let them divide in culture, expanding to 1.5 billion cells within seven weeks. Then the cultured cells were seeded onto synthetic, three-dimensional domes. After the cells formed confluent layers, the domes were surgically attached to the lower portions of the patients' bladders, after removing the upper portions. The scaffolds degenerated over time, leaving new bladder built from the patients' own cells.

The bladder replacements were done several years ago but were reported only recently—time was needed to assess their functioning. While the patients still need to be catheterized, they no longer must wear diapers because their urine flow is more normal. The replacement bladders have also apparently halted the kidney damage. Further testing is ongoing, but replacing failing bladders with intestine may be on the way out, thanks to tissue engineering.

SUMMARY OUTLINE

5.1 Introduction (p. 95)

Tissues are groups of cells with specialized structural and functional roles. The four major types of human tissue are epithelial, connective, muscle, and nervous.

5.2 Epithelial Tissues (p. 95)

1. General characteristics
   a. Epithelial tissue covers organs, lines cavities and hollow organs, and is the major tissue of glands.
   b. Epithelium is anchored to connective tissue by a basement membrane, lacks blood vessels, consists of tightly packed cells, and is replaced continuously.
   c. It functions in protection, secretion, absorption, and excretion.
   d. Epithelial tissues are classified according to cell shape and number of layers of cells.
2. Simple squamous epithelium
   a. This tissue consists of a single layer of thin, flattened cells.
   b. It functions in gas exchange in the lungs and lines blood and lymph vessels and various body cavities.
3. Simple cuboidal epithelium
   a. This tissue consists of a single layer of cube-shaped cells.
   b. It carries on secretion and absorption in the kidneys and various glands.
4. Simple columnar epithelium
   a. This tissue is composed of elongated cells with nuclei near the basement membrane.
   b. It lines the uterus and digestive tract.
   c. Absorbing cells often have microvilli.
   d. This tissue has goblet cells that secrete mucus.
5. Pseudostratified columnar epithelium
   a. Nuclei located at two or more levels give this tissue a stratified appearance.
   b. Cilia that are part of this tissue move mucus over the surface.
   c. It lines passageways of the respiratory system.
6. Stratified squamous epithelium
   a. This tissue is composed of many layers of cells.
   b. It protects underlying cells.
   c. It forms the outer layer of the skin and lines the oral cavity, esophagus, vagina, and anal canal.
7. Stratified cuboidal epithelium
   a. This tissue is composed of two or three layers of cube-shaped cells.
   b. It lines the larger ducts of the mammary glands, sweat glands, salivary glands, and pancreas.
   c. It protects.
8. Stratified columnar epithelium
   a. The top layer of cells in this tissue has elongated columns. Cube-shaped cells make up the bottom layers.
   b. It is in the male urethra and ductus deferens and parts of the pharynx.
   c. This tissue protects and secretes.
9. Transitional epithelium
   a. This tissue is specialized to become distended.
   b. It is in the walls of various organs of the urinary tract.
10. Glandular epithelium
    a. Glandular epithelium is composed of cells that are specialized to secrete substances.
    b. A gland consists of one or more cells.
       (1) Exocrine glands secrete into ducts.
       (2) Endocrine glands secrete into tissue fluid or blood.
    c. Exocrine glands are classified according to the composition of their secretions.
       (1) Merocrine glands secrete fluid without loss of cytoplasm.
          (a) Serous cells secrete watery fluid with a high enzyme content.
          (b) Mucous cells secrete mucus.
       (2) Apocrine glands lose portions of their cells during secretion.
       (3) Holocrine glands release cells filled with secretory products.

5.3 Connective Tissues (p. 102)

1. General characteristics
   a. Connective tissue connects, supports, protects, provides frameworks, fills spaces, stores fat, produces blood cells, protects against infection, and helps repair damaged tissues.
   b. Connective tissue cells usually have considerable extracellular matrix between them.
   c. This extracellular matrix consists of fibers, a ground substance and fluid.
   d. Major cell types
      (1) Fibroblasts produce collagenous and elastic fibers.
      (2) Macrophages are phagocytes.
      (3) Mast cells may release heparin and histamine, and usually are near blood vessels.
   e. Connective tissue fibers
      (1) Collagenous fibers are composed of collagen and have great tensile strength.
      (2) Elastic fibers are composed of elastin and are very elastic.
      (3) Reticular fibers are very fine, collagenous fibers.
2. Categories of connective tissue
   Connective tissue proper includes loose connective tissue and dense connective tissue. Specialized connective tissue includes cartilage, bone, and blood.
   a. Loose connective tissue
      (1) Areolar tissue forms thin membranes between organs and binds them. It is beneath most layers of epithelium and between muscles.

(2) Adipose tissue stores fat. It is found beneath the skin, in certain abdominal membranes, and around the kidneys, heart, and various joints.
(3) Reticular connective tissue is composed of thin, collagenous fibers. It helps provide the framework of the liver and spleen.

b. Dense connective tissue
(1) This tissue is largely composed of strong, collagenous fibers.
(2) It is found in the tendons, ligaments, white portions of the eyes, and the deeper skin layers.

c. Cartilage
(1) Cartilage provides a supportive framework for various structures.
(2) Its extracellular matrix is composed of fibers and a gel-like ground substance.
(3) Cartilaginous structures are enclosed in a perichondrium.
(4) Cartilage lacks a direct blood supply and is slow to heal.
(5) Major types are hyaline cartilage, elastic cartilage, and fibrocartilage.

d. Bone
(1) The extracellular matrix of bone contains mineral salts and collagen.
(2) Its cells are usually organized in concentric circles around central canals. Canaliculi connect them.
(3) Bone is an active tissue that heals rapidly.

e. Blood
(1) Blood transports substances and helps maintain a stable internal environment.
(2) Blood is composed of red blood cells, white blood cells, and platelets suspended in plasma.
(3) Blood cells develop in red marrow in the hollow parts of long bones.

5.4 Types of Membranes (p. 109)

1. Epithelial membranes are thin, covering surfaces and lining cavities. Serous, mucous, and cutaneous membranes are epithelial membranes.
2. Serous membranes, composed of epithelium and loose connective tissue, are membranes that line body cavities lacking openings to the outside. The cells of a serous membrane secrete serous fluid to lubricate membrane surfaces.
3. Mucous membranes, composed of epithelium and loose connective tissue, are membranes that line body cavities opening to the outside. Goblet cells within these membranes secrete mucus.
4. The cutaneous membrane is the external body covering commonly called skin.
5. Synovial membranes, composed entirely of connective tissues, line joints.

5.5 Muscle Tissues (p. 110)

1. General characteristics
   a. Muscle tissues contract, moving structures that are attached to them.
   b. The three types are skeletal, smooth, and cardiac muscle tissues.
2. Skeletal muscle tissue
   a. Muscles containing this tissue usually are attached to bones and controlled by conscious effort.
   b. Cells, or muscle fibers, are long and threadlike.
   c. Muscle cells contract when stimulated by nerve cells, and then relax when stimulation stops.
3. Smooth muscle tissue
   a. This tissue is in the walls of hollow internal organs.
   b. Usually it is involuntarily controlled.
4. Cardiac muscle tissue
   a. This tissue is found only in the heart.
   b. Cells are joined by intercalated discs and form branched networks.

5.6 Nervous Tissues (p. 111)

1. Nervous tissues are in the brain, spinal cord, and peripheral nerves.
2. Neurons (nerve cells)
   a. Neurons sense changes and respond by transmitting nerve impulses to other neurons or to muscles or glands.
   b. They coordinate, regulate, and integrate body activities.
3. Neuroglial cells
   a. Some of these cells bind and support nervous tissue.
   b. Others carry on phagocytosis.
   c. Still others connect neurons to blood vessels.
   d. They also play a role in cell-to-cell communication.

CHAPTER ASSESSMENTS

5.1 Introduction

1. Which of the following is a major tissue type in the body? (p. 95)
   a. epithelial
   b. nervous
   c. muscle
   d. connective
   e. all of the above
2. Indicate where each major type of tissue can be found in the body. (p. 95)

5.2 Epithelial Tissues

3. A general characteristic of epithelial tissues is that __________. (p. 95)
   a. numerous blood vessels are present
   b. cells are spaced apart
   c. cells readily divide
   d. there is much extracellular matrix between cells
4. Explain how the structure of epithelial tissues provides for the functions of epithelial tissues. (p. 95)
5. Match the epithelial tissue on the left to an organ in which the tissue is found. (pp. 96–101)

(1) simple squamous epithelium	A. lining of intestines
(2) simple cuboidal epithelium	B. lining of ducts of mammary glands
(3) simple columnar epithelium	C. lining of urinary bladder
(4) pseudostratified columnar epithelium	D. salivary glands
(5) stratified squamous epithelium	E. air sacs of lungs
(6) stratified cuboidal epithelium	F. respiratory passages
(7) stratified columnar epithelium	G. ductus deferens
(8) transitional epithelium	H. lining of kidney tubules
(9) glandular epithelium	I. outer layer of skin

6. Distinguish between exocrine and endocrine glands. (p. 101)
7. A gland that secretes substances out of cells by exocytosis is a(n) ________________. (p. 101)
   a. merocrine gland
   b. apocrine gland
   c. holocrine gland

5.3 Connective Tissues

8. Define *extracellular matrix*. (p. 102)
9. Describe three major types of connective tissue cells. (p. 102)
10. Distinguish between collagen and elastin. (p. 104)
11. Compare and contrast the different types of loose connective tissue. (p. 105)
12. Define *dense connective tissue*. (p. 106)
13. Explain why injured dense connective tissue and cartilage are usually slow to heal. (p. 106)
14. Name the types of cartilages and describe their differences and similarities. (p. 106)
15. Describe how bone cells are organized in bone tissue. (p. 108)
16. The fluid extracellular matrix of blood is called ___________. (p. 109)
    a. white blood cells
    b. red blood cells
    c. platelets
    d. plasma
    e. bone marrow

5.4 Types of Membranes

17. Identify the locations of four types of membranes in the body and indicate the types of tissues making up each membrane. (p. 110)

5.5 Muscle Tissues

18. Compare and contrast skeletal, smooth, and cardiac muscle tissues. (p. 110)

5.6 Nervous Tissues

19. Distinguish between neurons and neuroglial cells with respect to their functions. (p. 111)

INTEGRATIVE ASSESSMENTS/ CRITICAL THINKING

OUTCOME 5.3

1. Select a skin care product with added collagen and elastin, then connect this product's use to the tissue normally consisting of these fibers.
2. Joints such as the elbow, shoulder, and knee contain considerable amounts of cartilage and dense connective tissue. Explain why joint injuries are often very slow to heal.
3. Disorders of collagen are characterized by deterioration of connective tissues. Why would you expect such diseases to produce widely varying symptoms?

OUTCOMES 5.2, 5.3, 5.5, 5.6

4. Assess which of the four major tissue types carcinogens (cancer-causing agents) would most influence and least influence. (Hint: Carcinogens act on dividing cells.)

WEB CONNECTIONS

Visit the text website at **aris.mhhe.com** for additional quizzes, interactive learning exercises, and more.

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