LABORATORY

25

Animal Organization

Learning Objectives

25.1 Epithelial Tissue
- Identify slides and models of various types of epithelium.
- Tell where a particular type of epithelium is located in the body, and state a function.

25.2 Muscular Tissue
- Identify slides and models of three types of muscular tissue.
- Tell where each type of muscular tissue is located in the body, and state a function.

25.3 Nervous Tissue
- Identify a slide and model of a neuron.
- Tell where nervous tissue is located in the body, and state a function.

25.4 Connective Tissue
- Identify slides and models of various types of connective tissue.
- Tell where a particular connective tissue is located in the body, and state a function.

25.5 Tissues Form Organs
- Identify a slide of the intestinal wall and any particular tissue in the wall. State a function for each tissue.
- Identify a slide of skin and any particular tissue or structure in skin. State a function for each tissue or structure.

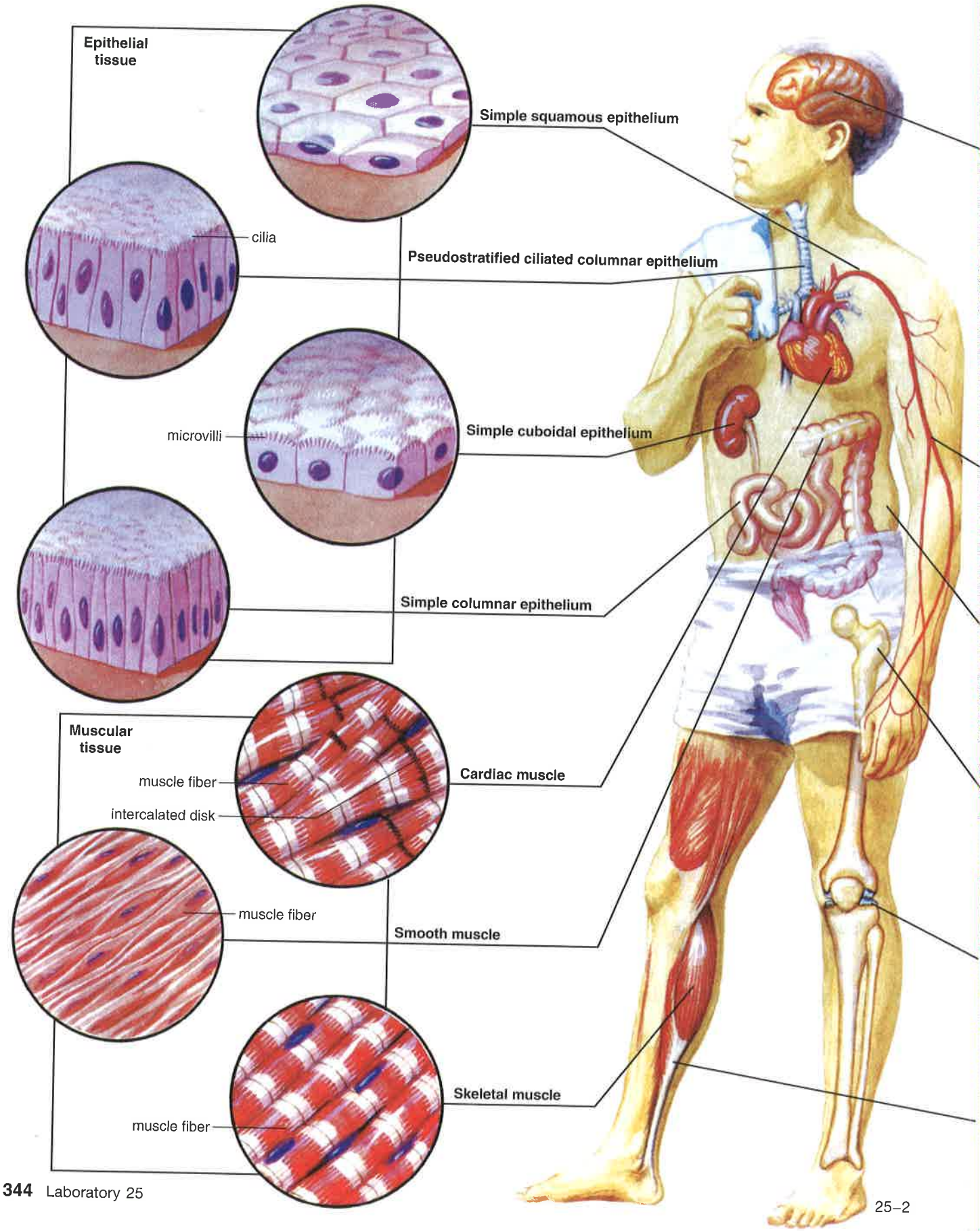
Introduction

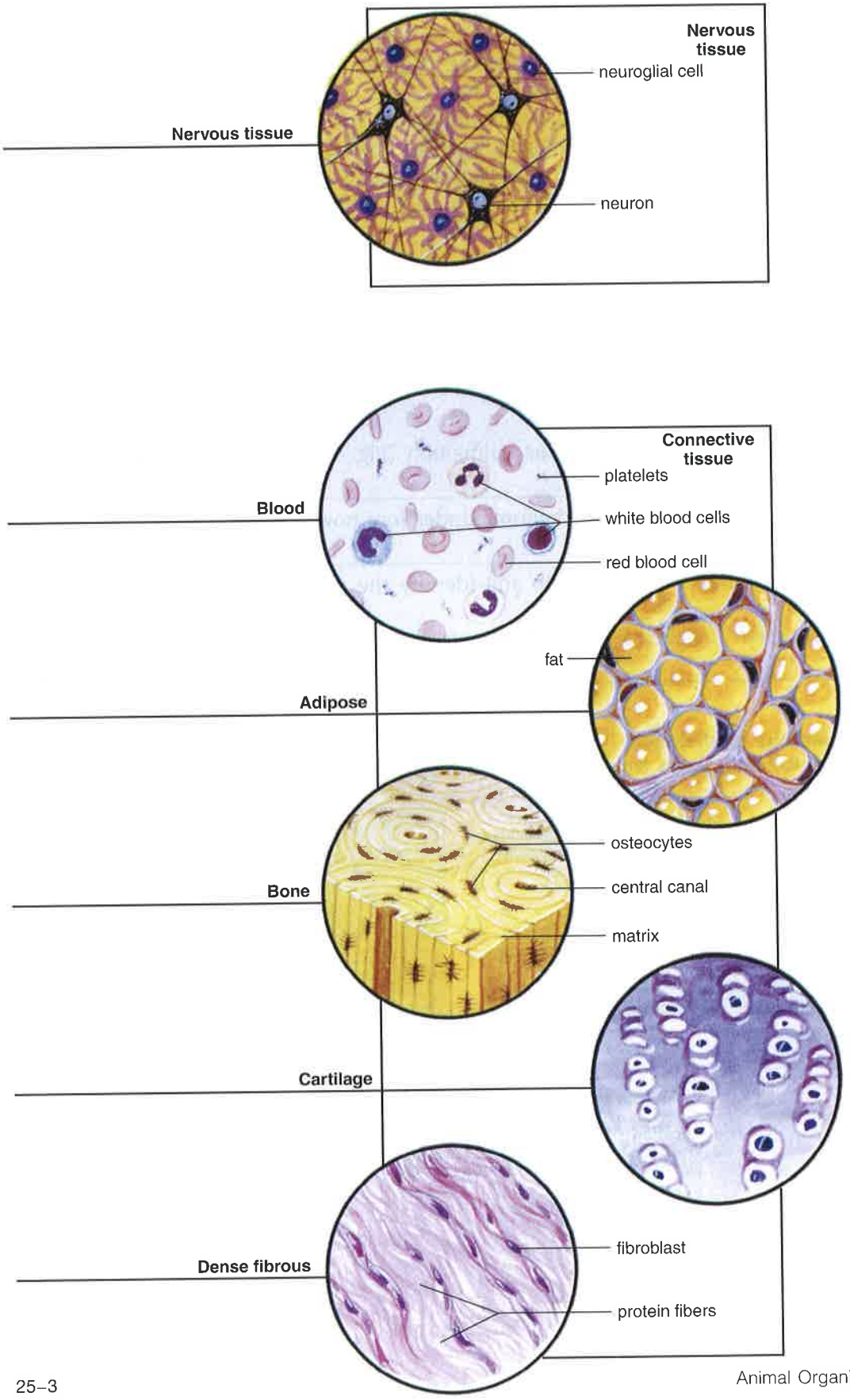
Humans, as well as all living things, are made up of **cells.** Groups of cells that have the same structural characteristics and perform the same functions are called **tissues.** Figure 25.1 shows the four categories of tissues in the human body. An **organ** is composed of different types of tissues, and various organs form **organ systems.** Humans thus have the following levels of biological organization: cells → tissues → organs → organ systems.

The micrographs of tissues in this laboratory were obtained by viewing prepared slides with a light microscope. Preparation required the following sequential steps:

1. **Fixation:** The tissue is immersed in a preservative solution to maintain the tissue's existing structure.
2. **Embedding:** Water is removed with alcohol, and the tissue is impregnated with paraffin wax.
3. **Sectioning:** The tissue is cut into extremely thin slices by an instrument called a microtome. When the section runs the length of the tissue, it is called a longitudinal section (l.s.); when the section runs across the tissue, it is called a cross section (c.s.).
4. **Staining:** The tissue is immersed in dyes that stain different structures. The most common dyes are hematoxylin and eosin stains (H & E). They give a differential blue and red color to the basic and acidic structures within the tissue. Other dyes are available for staining specific structures.

Figure 25.1 The major tissues in the human body.
The many kinds of tissues in the human body are grouped into four categories: epithelial tissue, muscular tissue, nervous tissue, and connective tissue.




Nervous tissue
Nervous tissue
neuroglial cell
neuron
Connective tissue
Blood
platelets
white blood cells
red blood cell
Adipose
fat
Bone
osteocytes
central canal
matrix
Cartilage
Dense fibrous
fibroblast
protein fibers

25.1 Epithelial Tissue

Epithelial tissue (epithelium) forms a continuous layer, or sheet, over the entire body surface and most of the body's inner cavities. Externally, it forms a covering that protects the animal from infection, injury, and drying out. Some epithelial tissues produce and release secretions. Others absorb nutrients.

The name of an epithelial tissue includes two descriptive terms: the shape of the cells and the number of layers. The three possible shapes are *squamous*, *cuboidal*, and *columnar*. With regard to layers, an epithelial tissue may be simple or stratified. **Simple** means that there is only one layer of cells; **stratified** means that cell layers are placed on top of each other. Some epithelial tissues are **pseudostratified,** meaning that they only appear to be layered. Epithelium may also have cellular extensions called **microvilli** or hairlike extensions called **cilia.** In the latter case, "ciliated" may be part of the tissue's name.

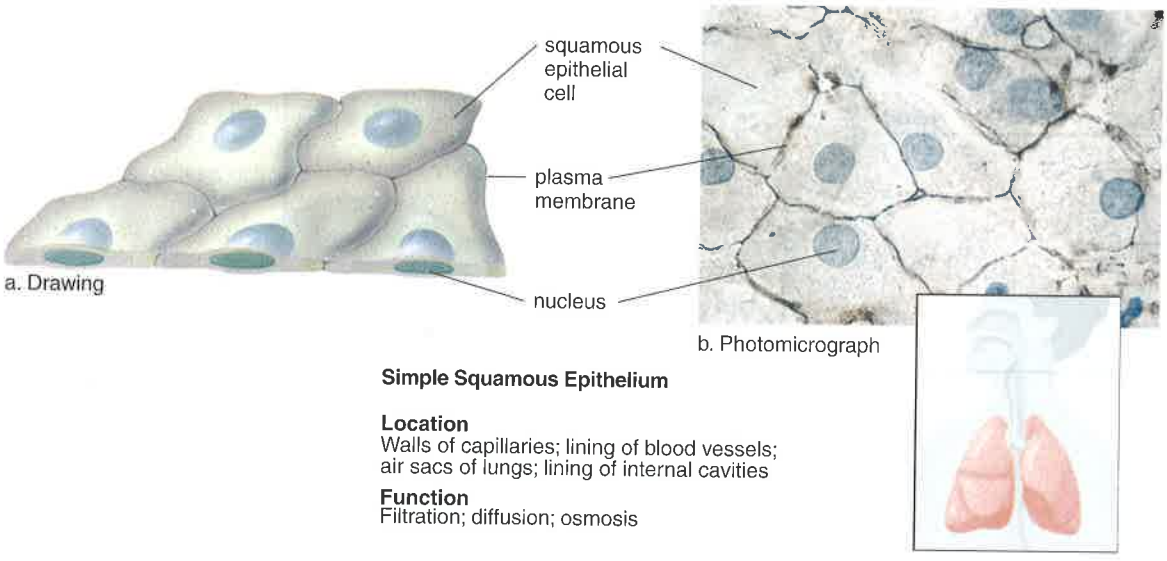
Observation: Simple and Stratified Squamous Epithelium

Simple Squamous Epithelium

Simple squamous epithelium is a single layer of thin, flat, many-sided cells, each with a central nucleus. It lines internal cavities, the heart, and all the blood vessels. It also lines parts of the urinary, respiratory, and male reproductive tracts.

1. Study a model or diagram of simple squamous epithelium (Fig. 25.2). What does squamous mean? _____
2. Examine a prepared slide of squamous epithelium. Under low power, note the close packing of the flat cells. What shapes are the cells? _____
3. Under high power, examine an individual cell, and identify the plasma membrane, cytoplasm, and nucleus.
4. Knowing that the diameter of field of your microscope is about 400 µm, estimate the size of an epithelial cell. _____

Figure 25.2 Simple squamous epithelium.
Simple squamous epithelium lines blood vessels and various tracts. (*b:* Magnification ×160)



Stratified Squamous Epithelium

As would be expected from its name, **stratified squamous epithelium** consists of many layers of cells. The innermost layer produces cells that are first cuboidal or columnar in shape, but as the cells push toward the surface, they become flattened.

The outer region of the skin, called the epidermis (see p. 361), is stratified squamous epithelium. As the cells move toward the surface, they flatten, begin to accumulate a protein called **keratin,** and eventually die. Keratin makes the outer layer of epidermis tough and protective, and able to repel water.

The linings of the mouth, throat, anal canal, and vagina are stratified epithelium. The outermost layer of cells surrounding the cavity is simple squamous epithelium. In these organs, this layer of cells remains soft, moist, and alive.

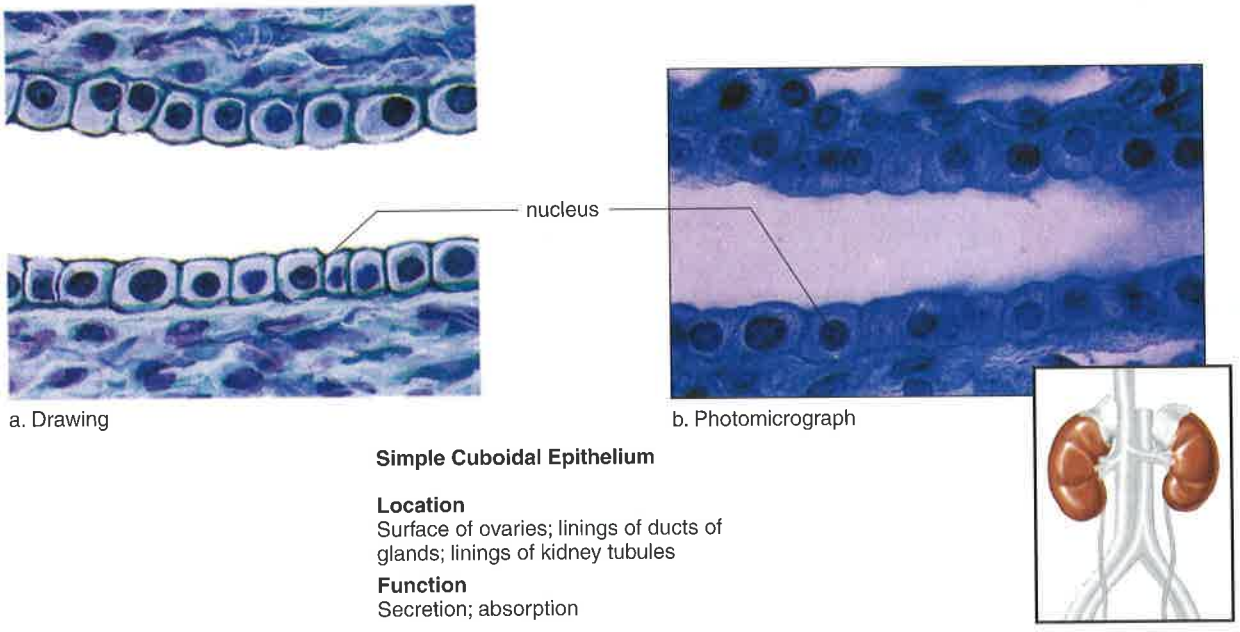
1. Either now or when you are studying skin in Section 25.5, examine a slide of skin and find the portion of the slide that is stratified squamous epithelium.
2. Approximately how many layers of cells make up this portion of skin? _____
3. Which layers of cells best represent squamous epithelium? _____

Observation: Simple Cuboidal Epithelium

Simple cuboidal epithelium is a single layer of cube-shaped cells, each with a central nucleus. It is found in tubules of the kidney and in the ducts of many glands, where it has a protective function. It also occurs in the secretory portions of some glands—that is, where the tissue produces and releases secretions.

1. Study a model or diagram of simple cuboidal epithelium (Fig. 25.3).
2. Examine a prepared slide of simple cuboidal epithelium. Move the slide until you locate cube-shaped cells that line a lumen (cavity). Are these cells ciliated? _____

Figure 25.3 Simple cuboidal epithelium.
Simple cuboidal epithelium lines kidney tubules and the ducts of many glands. (*b:* Magnification ×250)

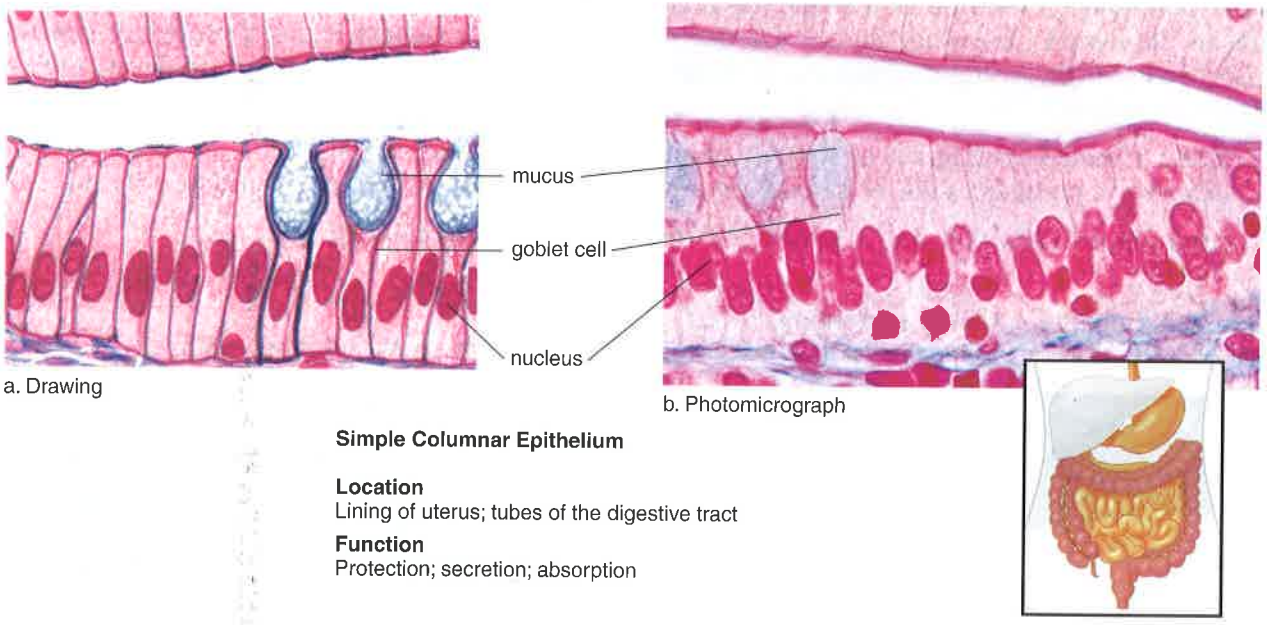


Observation: Simple Columnar Epithelium

Simple columnar epithelium is a single layer of tall, cylindrical cells, each with a nucleus near the base. This tissue, which lines the digestive tract from the stomach to the anus, protects, secretes, and allows absorption of nutrients.

1. Study a model or diagram of simple columnar epithelium (Fig. 25.4).
2. Examine a prepared slide of simple columnar epithelium. Find tall and narrow cells that line a lumen. Under high power, focus on an individual cell. Identify the plasma membrane, the cytoplasm, and the nucleus. Epithelial tissues are attached to underlying tissues by a basement membrane composed of extracellular material containing protein fibers.
3. Label the location of the basement membrane in Figure 25.4.
4. The tissue you are observing contains mucus-secreting cells. Search among the columnar cells until you find a **goblet cell,** so named because of its goblet-shaped, clear interior. This region contains mucus, which may be stained a light blue. In the living animal, the mucus is discharged into the gut cavity and protects the lining from digestive enzymes.

Figure 25.4 Simple columnar epithelium.
Simple columnar epithelium lines the digestive tract. Goblet cells among the columnar cells secrete mucus. (*b:* Magnification ×250)

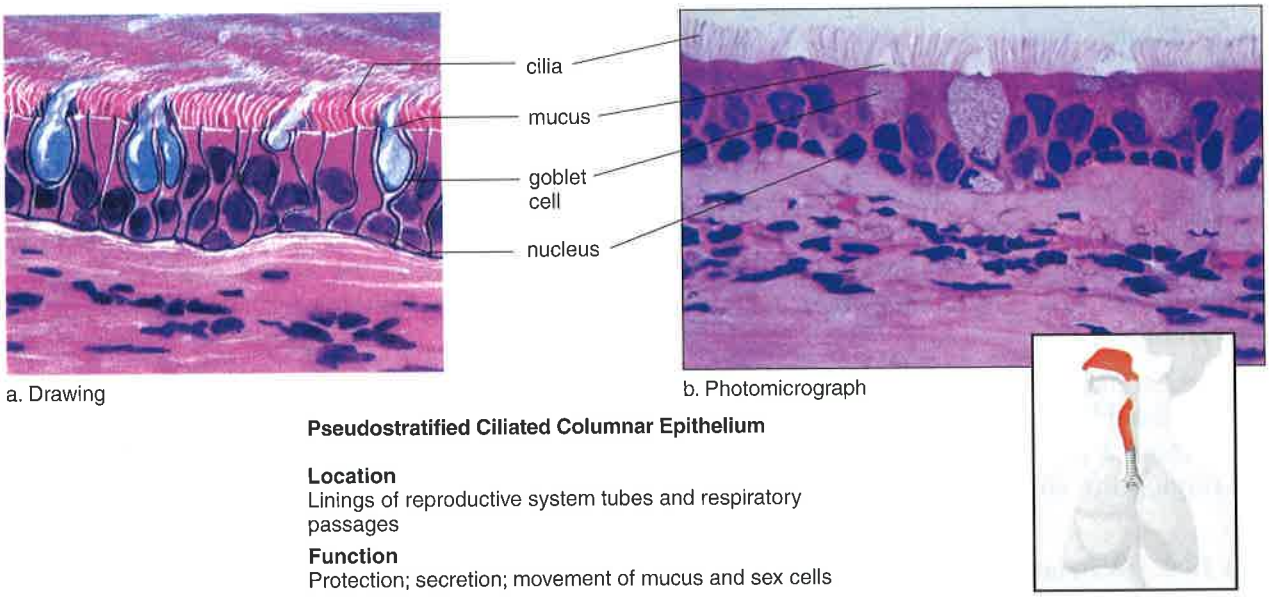


Observation: Pseudostratified Ciliated Columnar Epithelium

Pseudostratified ciliated columnar epithelium appears to be layered, while actually all cells touch the basement membrane. Many cilia are located on the free end of each cell (Fig. 25.5). In the human trachea, the cilia wave back and forth, moving mucus and debris up toward the throat so that it cannot enter the lungs. Smoking destroys these cilia, but they will grow back if smoking is discontinued.

1. Study a model or diagram of pseudostratified ciliated columnar epithelium (Fig. 25.5).
2. Examine a prepared slide of pseudostratified ciliated columnar epithelium. Concentrate on the part of the slide that resembles the model. Identify the cilia.

Figure 25.5 Pseudostratified ciliated columnar epithelium.
Pseudostratified ciliated columnar epithelium lines the trachea. The cilia help keep the lungs free of debris. (*b:* Magnification ×250)



Summary of Epithelial Tissue

Complete Table 25.1 to summarize your study of epithelial tissue.

Table 25.1 Epithelial Tissue

Type	Appearance	Function	Location
Simple squamous			Walls of capillaries, lining of blood vessels, air sacs of lungs, lining of internal cavities
Stratified squamous	Innermost layers are cuboidal or columnar; outermost layers are flattened	Protection, repel water	
Simple cuboidal		Secretion, absorption	
Simple columnar	Columnlike—tall, cylindrical nucleus at base		Lining of uterus, tubes of digestive tract
Pseudostratified ciliated columnar		Protection, secretion, movement of mucus and sex cells	

25.2 Muscular Tissue

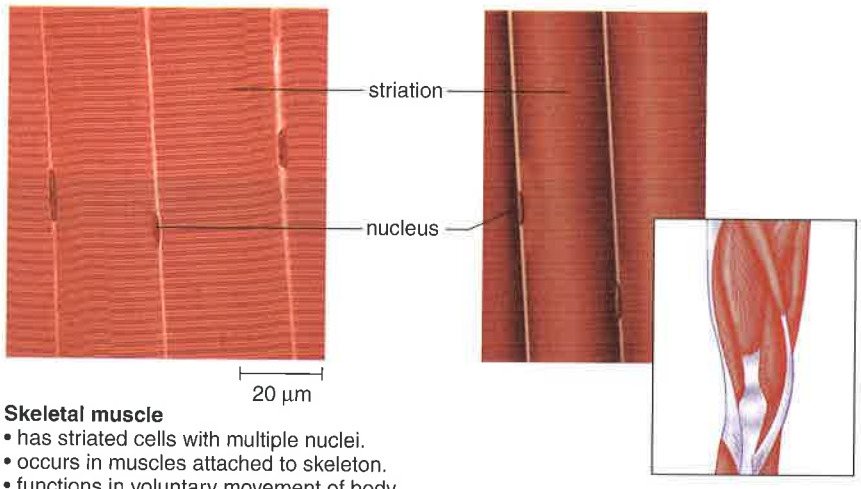
Muscular (contractile) tissue is composed of cells called muscle fibers. Muscular tissue has the ability to contract, and contraction usually results in movement. The body contains skeletal, cardiac, and smooth muscle.

Observation: Skeletal Muscle

Skeletal muscle occurs in the muscles that are attached to the bones of the skeleton. The contraction of skeletal muscle is said to be **voluntary** because it is under conscious control. Skeletal muscle is striated; it contains light and dark bands. The striations are caused by the arrangement of contractile filaments (actin and myosin filaments) in muscle fibers. Each fiber contains many nuclei, all peripherally located.

1. Study a model or diagram of skeletal muscle (Fig. 25.6), and note that striations are present. You should see several muscle fibers, each marked with striations.
2. Examine a prepared slide of skeletal muscle. The striations may be difficult to make out, but bringing the slide in and out of focus may help.

Figure 25.6 Skeletal muscle.
Skeletal muscle is striated and voluntary. Its cells are tubular and contain many nuclei.



Skeletal muscle
- has striated cells with multiple nuclei.
- occurs in muscles attached to skeleton.
- functions in voluntary movement of body.
- is voluntary.

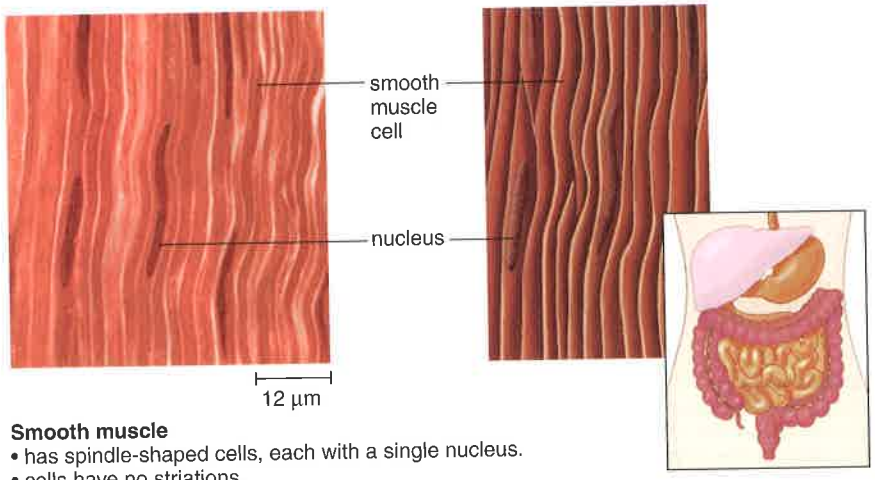
Observation: Smooth Muscle

Smooth muscle is sometimes called **visceral muscle** because it makes up the walls of the internal organs, such as the intestines and the blood vessels. Smooth muscle is involuntary because its contraction does not require conscious effort.

1. Study a model or diagram of smooth muscle (Fig. 25.7), and note the shape of the cells and the centrally placed nucleus. Smooth muscle has spindle-shaped cells. What does spindle-shaped mean? _____

2. Examine a prepared slide of smooth muscle. Distinguishing the boundaries between the different cells may require you to take the slide in and out of focus.

Figure 25.7 Smooth muscle.
Smooth muscle is nonstriated and involuntary. This type of muscle is composed of spindle-shaped cells.



Smooth muscle
- has spindle-shaped cells, each with a single nucleus.
- cells have no striations.
- functions in movement of substances in lumens of body.
- is involuntary.

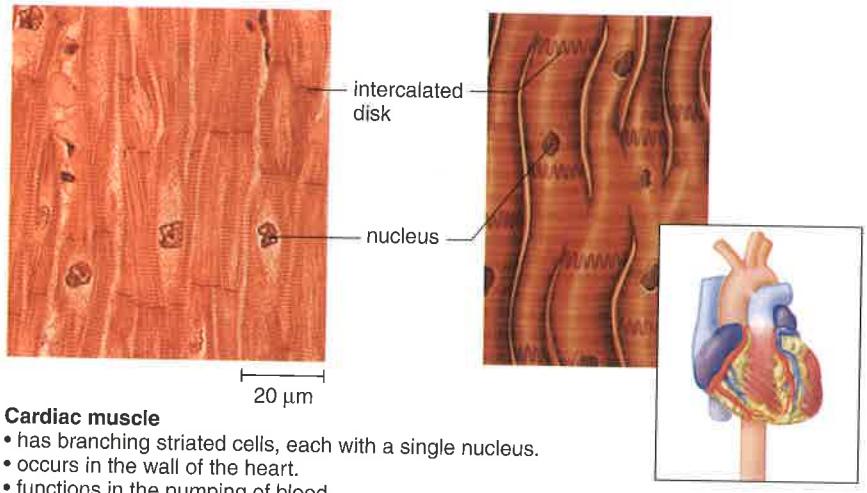
Observation: Cardiac Muscle

Cardiac muscle is found only in the heart. It is called **involuntary** because its contraction does not require conscious effort. Cardiac muscle is striated in the same way as skeletal muscle. However, the fibers are branched and bound together at **intercalated disks,** where their folded plasma membranes touch. This arrangement aids communication between fibers.

1. Study a model or diagram of cardiac muscle (Fig. 25.8), and note that striations are present.
2. Examine a prepared slide of cardiac muscle. Find an intercalated disk. What is the function of cardiac muscle? _____

_____

Figure 25.8 Cardiac muscle.
Cardiac muscle is striated and involuntary. Its branched cells join at intercalated disks.



Cardiac muscle
- has branching striated cells, each with a single nucleus.
- occurs in the wall of the heart.
- functions in the pumping of blood.
- is involuntary.

Summary of Muscular Tissue

Complete Table 25.2 to summarize your study of muscular tissue.

Table 25.2 Muscular Tissue

Type	Striations (Yes or No)	Branching (Yes or No)	Conscious Control (Yes or No)
Skeletal			
Smooth			
Cardiac			

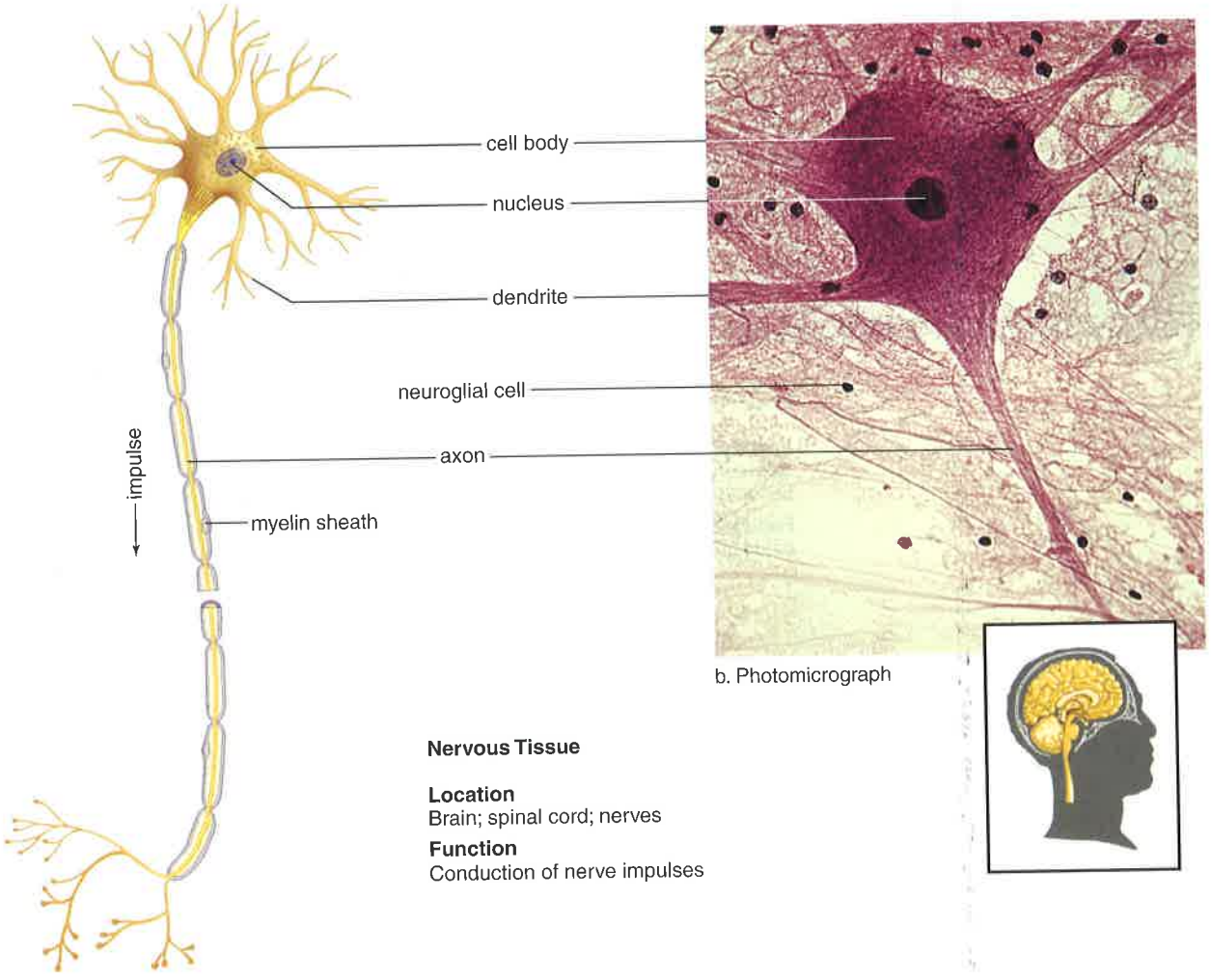
25.3 Nervous Tissue

Nervous tissue is found in the brain, spinal cord, and nerves. Nervous tissue is composed of two types of cells: **neurons** that transmit messages and **neuroglia** that largely service the neurons (see Fig. 25.1). Motor neurons, which take messages from the spinal cord to the muscles, are often used to exemplify typical neurons (Fig. 25.9). Motor neurons have several **dendrites,** processes that take signals to a **cell body,** where the nucleus is located, and an **axon** that takes nerve impulses away from the cell body.

Observation: Nervous Tissue

1. Study a model or diagram of a neuron, and then examine a prepared slide. You will not be able to see neuroglial cells because they are small and cannot be seen at this magnification.
2. Identify the dendrites, cell body, and axon in Figure 25.9. Long axons are called nerve fibers.
3. Explain the appearance and function of the parts of a motor neuron:
   a. Dendrites _____
   b. Cell body _____
   c. Axon _____

Figure 25.9 Motor neuron anatomy.
(*b:* Magnification ×200)



25.4 Connective Tissue

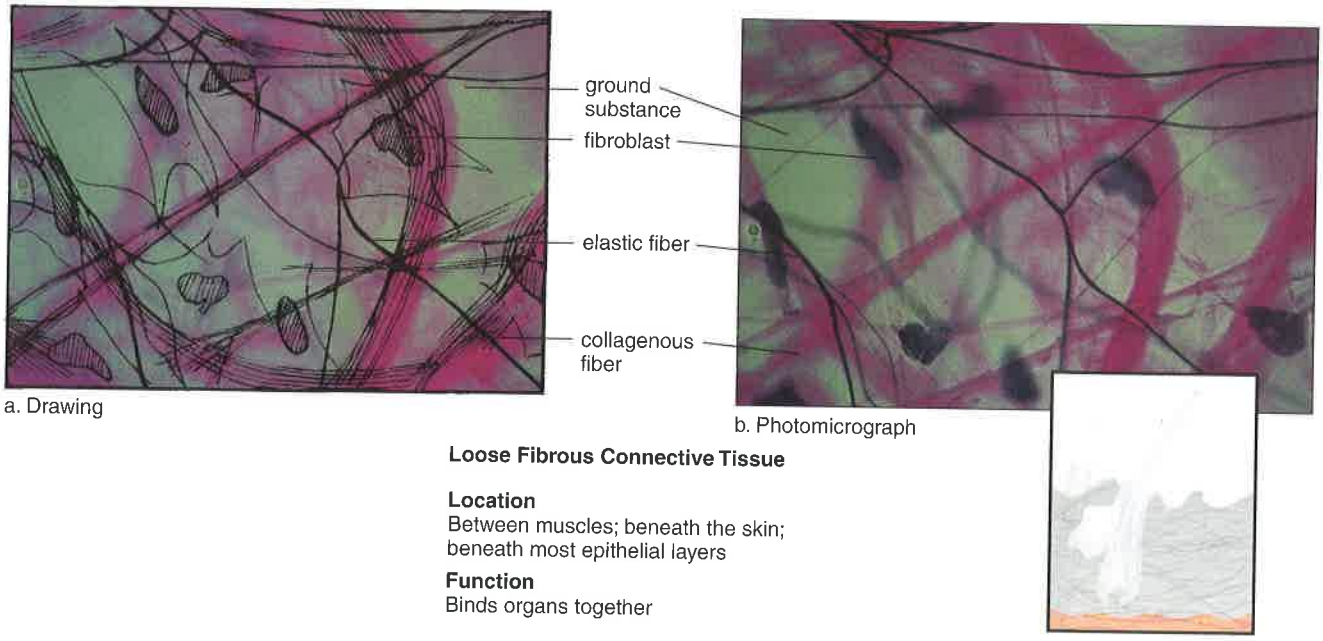
Connective tissue joins different parts of the body together. There are four general classes of connective tissue: connective tissue proper, cartilage, bone, and blood. All types of connective tissue consist of cells surrounded by a matrix that usually contains fibers. Elastic fibers are composed of a protein called elastin. Collagenous fibers contain the protein collagen.

Observation: Connective Tissue

There are several different types of connective tissue. We will study loose fibrous connective tissue, dense fibrous connective tissue, adipose tissue, bone, cartilage, and blood. **Loose fibrous connective tissue** supports epithelium and also many internal organs, such as muscles, blood vessels, and nerves (Fig. 25.10). Its presence allows organs to expand. **Dense fibrous connective tissue** contains many collagenous fibers packed together, as in tendons, which connect muscles to bones, and in ligaments, which connect bones to other bones at joints (Fig. 25.11).

1. Examine a slide of loose fibrous connective tissue, and compare it to Figure 25.10. What is the function of loose fibrous connective tissue? _____

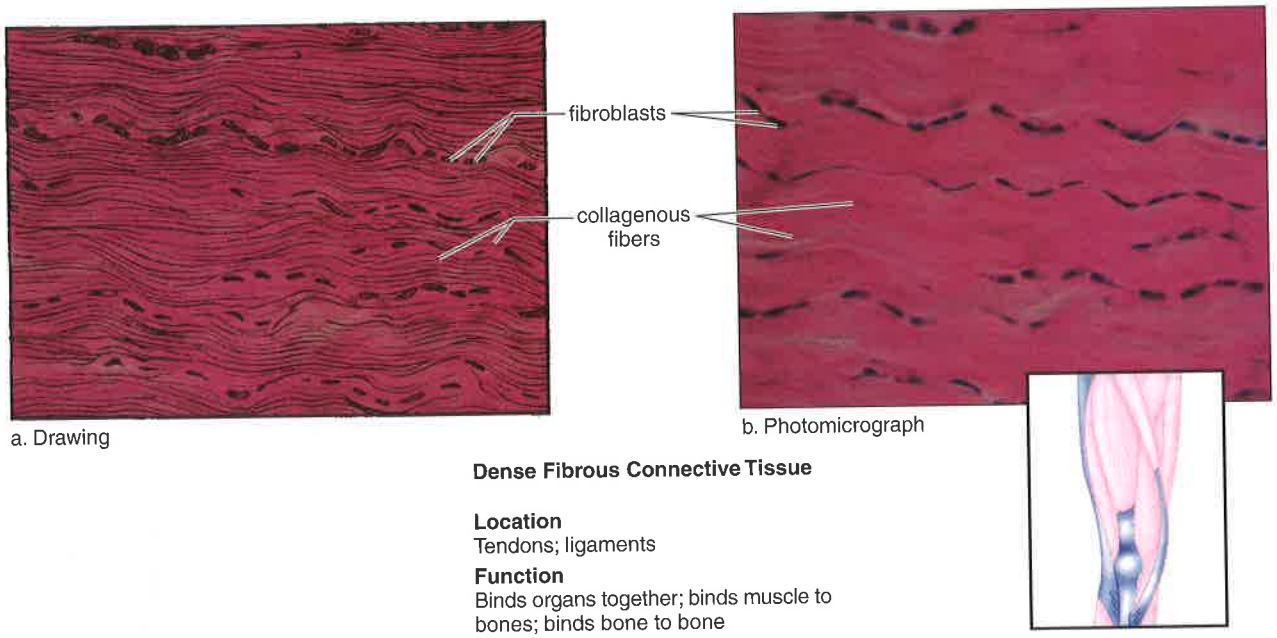
Figure 25.10 Loose fibrous connective tissue.
Loose fibrous connective tissue supports epithelium and many internal organs.



2. Examine a slide of dense fibrous connective tissue, and compare it to Figure 25.11. What two kinds of structures in the body contain dense fibrous connective tissue? _____

_____

Figure 25.11 Dense fibrous connective tissue.
Dense fibrous connective tissue is found in tendons and ligaments. (*b:* Magnification ×250)



Dense Fibrous Connective Tissue

Location
Tendons; ligaments

Function
Binds organs together; binds muscle to bones; binds bone to bone

Observation: Adipose Tissue

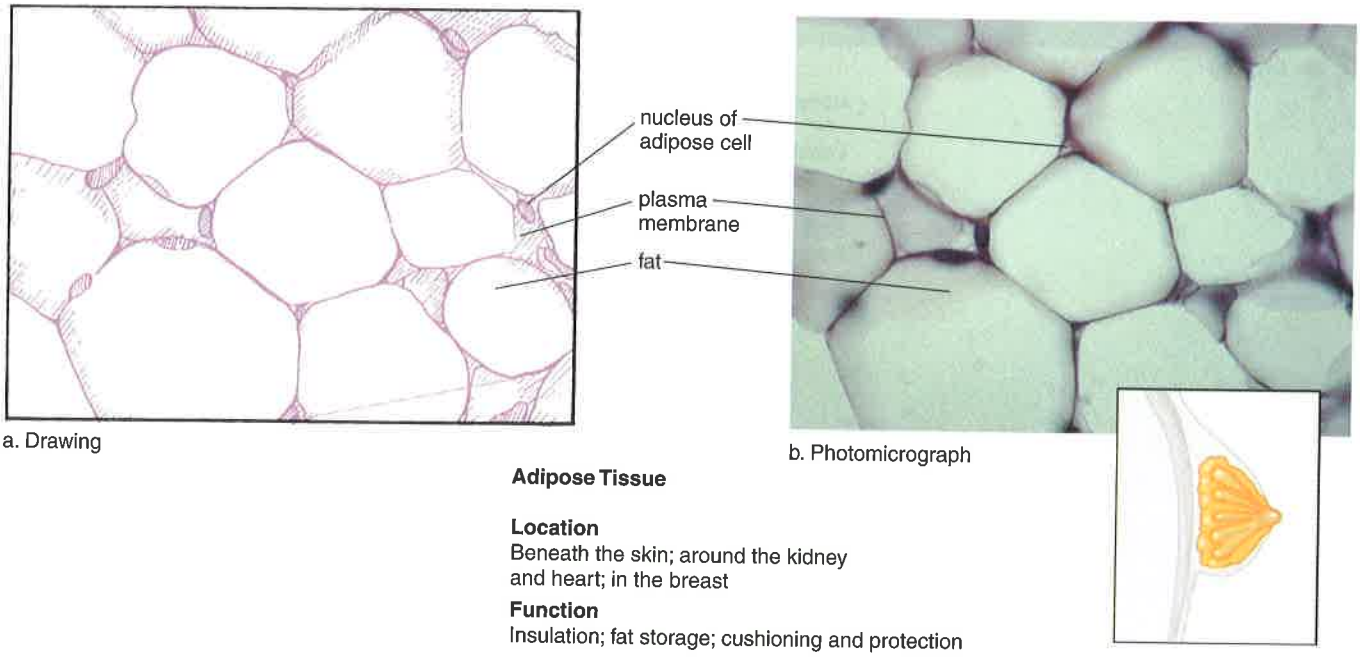
In **adipose tissue,** the cells have a large, central, fat-filled vacuole that causes the nucleus and cytoplasm to be at the perimeter of the cell (Fig. 25.12). Adipose tissue occurs beneath the skin, where it insulates the body, and around internal organs such as the kidneys and heart. It cushions and helps protect these organs.

1. Examine a prepared slide of adipose tissue. Why is the nucleus pushed to one side? _____

2. Examine Figure 25.17 (see p. 361), and state a location for adipose tissue in the body. _____

   What are two functions of adipose tissue at this location? _____

Figure 25.12 Adipose tissue.
Adipose tissue is composed of cells filled with fat droplets. (*b:* Magnification ×250)



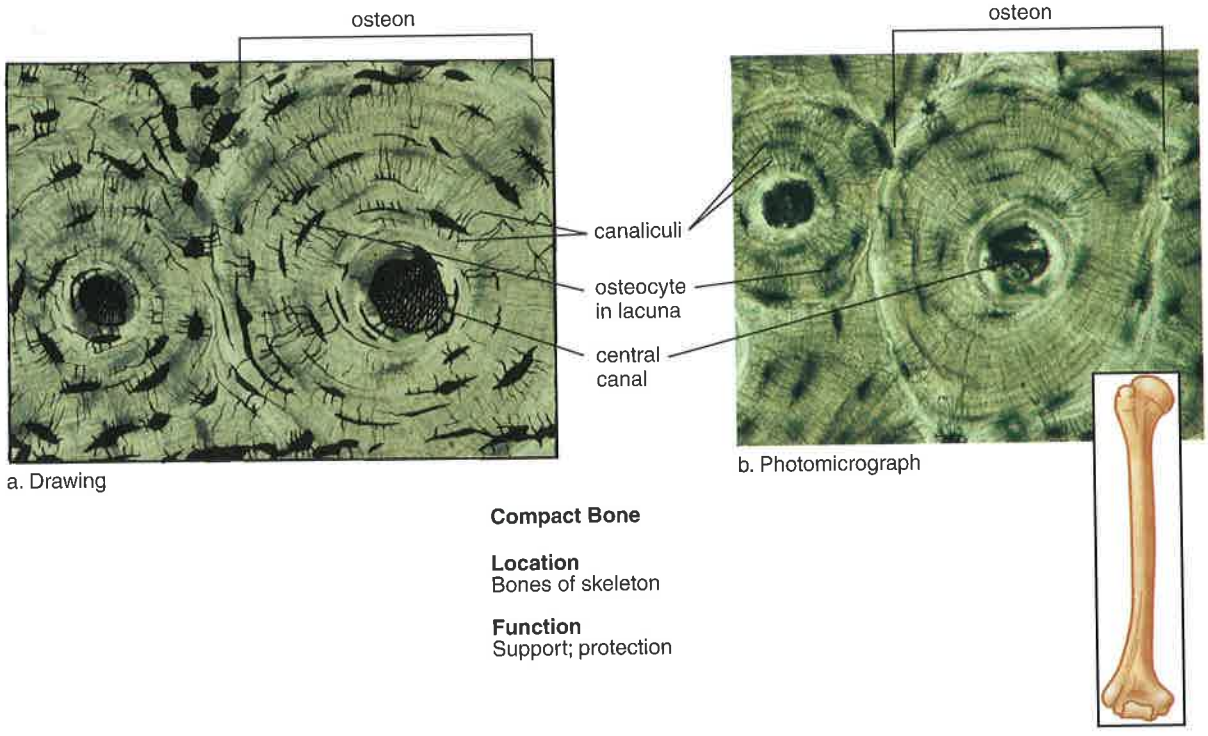
Observation: Compact Bone

Compact bone is found in the bones that make up the skeleton. It consists of **osteons** (Haversian system) with a **central canal,** and concentric rings of spaces called **lacunae,** which are connected by tiny crevices called **canaliculi.** The central canal contains a nerve and blood vessels, which service bone. The lacunae contain bone cells called **osteocytes,** whose processes extend into the canaliculi. Separating the lacunae is a matrix that is hard because it contains minerals, notably calcium salts. The matrix also contains collagenous fibers.

1. Study a model or diagram of compact bone (Fig. 25.13). Then look at a prepared slide and identify the central canal, lacunae, and canaliculi.
2. What is the function of the central canal and canaliculi? _____

_____

Figure 25.13 Compact bone.
Compact bone contains osteons in which osteocytes within lacunae are arranged in concentric circles. (*b:* Magnification ×320)



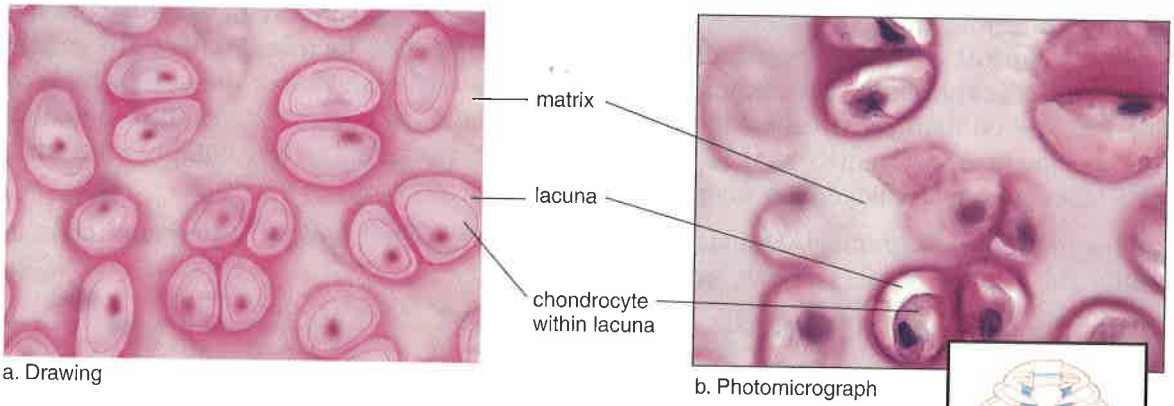
Observation: Hyaline Cartilage

In **hyaline cartilage,** cells called **chondrocytes** are found in twos or threes in lacunae. The lacunae are separated by a flexible matrix containing weak collagenous fibers.

1. Study the diagram and photomicrograph of hyaline cartilage in Figure 25.14. Then study a prepared slide of hyaline cartilage, and identify the matrix, lacunae, and chondrocytes.
2. Compare Figures 25.14 and 25.13. Which of these types of connective tissue is more organized? _____ Why do you say so? _____
3. Which of these two types of connective tissue lends more support to body parts? _____

_____

Figure 25.14 Hyaline cartilage.
In cartilage, chondrocytes lie in lacunae, which are separated by a flexible matrix. (*b:* Magnification ×250)



a. Drawing

b. Photomicrograph

Hyaline Cartilage

Location
Ends of bones; nose; rings in walls of respiratory passages; between ribs and sternum

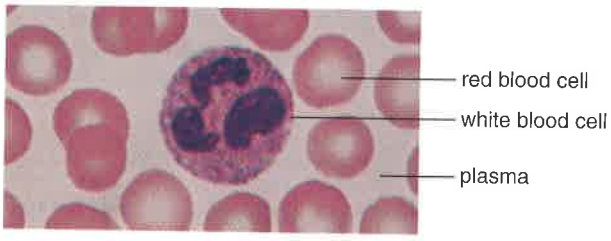
Function
Support; protection

Observation: Blood

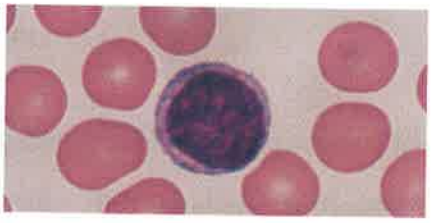
Blood is a connective tissue in which the matrix is an intercellular fluid called **plasma. Red blood cells** (erythrocytes) carry oxygen combined with the respiratory pigment hemoglobin. **White blood cells** (leukocytes) fight infection.

1. Study a prepared slide of human blood. With the help of Figure 25.15, identify the numerous red blood cells and the less numerous but larger white blood cells, which appear faint because of the stain.
2. Try to identify a neutrophil, the most common type of white blood cell. A neutrophil has a multilobed nucleus. Try to identify a lymphocyte, the next most common type of white blood cell. A lymphocyte is the smallest of the white blood cells, with a spherical or slightly indented nucleus.

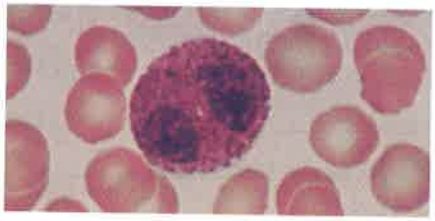
Figure 25.15 Blood cells.
Red blood cells are more numerous than white blood cells. White blood cells can be separated into five distinct types. If you have blood work done that includes a complete blood count (CBC), the doctor is getting a count of each of these types of WBCs. (*a–c:* Magnification ×250; *d:* Magnification ×400; *e:* Magnification ×500)



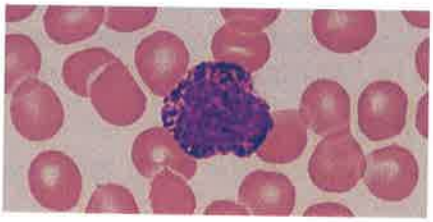
a. Neutrophil



b. Lymphocyte



c. Eosinophil



d. Basophil

e. Monocyte

Summary of Connective Tissue

Complete Table 25.3 to summarize your study of connective tissue.

Table 25.3 Connective Tissue

Type	Appearance	Function	Location
Loose fibrous connective			Between the muscles; beneath the skin; beneath most epithelial layers
Dense fibrous connective		Binds organs together, binds muscle to bones, binds bone to bone	
Adipose			Beneath the skin; around the kidney and heart; in the breast
Compact bone		Support, protection	
Hyaline cartilage	Cells in lacunae		Nose, ends of bones; rings in walls of respiratory passages; between ribs and sternum
Blood	Red and white cells floating in plasma		Blood vessels

25.5 Tissues Form Organs

Organs are structures composed of two or more types of tissue that work together to perform particular functions. You may tend to think that a particular organ contains only one type of tissue. For example, muscular tissue is usually associated with muscles, and nervous tissue with the brain. However, muscles and the brain also contain other types of tissue—for example, loose connective tissue and blood. Here we will study the compositions of two organs—the intestine and the skin.

Intestine

The **intestine,** a part of the digestive system, processes food and absorbs nutrient molecules.

Observation: Intestinal Wall

Study a slide of a cross section of intestinal wall. With the help of Figure 25.16, identify the following layers:

1. **Mucosa** (mucous membrane layer): This layer, which lines the central lumen (cavity), is made up of columnar epithelium overlying a layer of connective tissue. The epithelium is glandular—that is, it secretes mucus from goblet cells and digestive enzymes from the rest of the epithelium (see Fig. 25.4). The membrane is arranged in deep folds (fingerlike projections) called **villi,** which increase the small intestine's absorptive surface.
2. **Submucosa** (submucosal layer): This connective tissue layer contains nerve fibers, blood vessels, and lymphatic vessels. The products of digestion are absorbed into these blood and lymphatic vessels.
3. **Muscularis** (smooth muscle layer): Circular muscular tissue and then longitudinal muscular tissue are found in this layer. Rhythmic contraction of these muscles causes **peristalsis,** a wavelike motion that moves food along the intestine.
4. **Serosa** (serous membrane layer): In this layer, a thin sheet of connective tissue underlies a thin, outermost sheet of squamous epithelium. This membrane is part of the **peritoneum,** which lines the entire abdominal cavity.

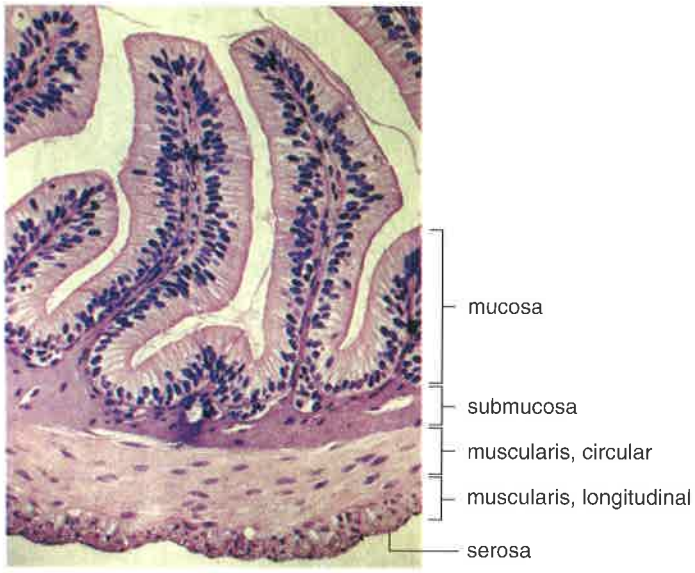


Figure 25.16 The intestinal wall.
A cross section reveals the various layers of the intestinal wall, which are noted to the right of this photomicrograph. (Magnification ×25)

Skin

The skin covers the entire exterior of the human body. Skin functions include protection, water retention, sensory reception, body temperature regulation, and vitamin D synthesis.

Observation: Skin

Study a model or diagram and also a prepared slide of the skin. With the help of Figure 25.17, identify the two skin regions and the subcutaneous layer from the exterior surface down:

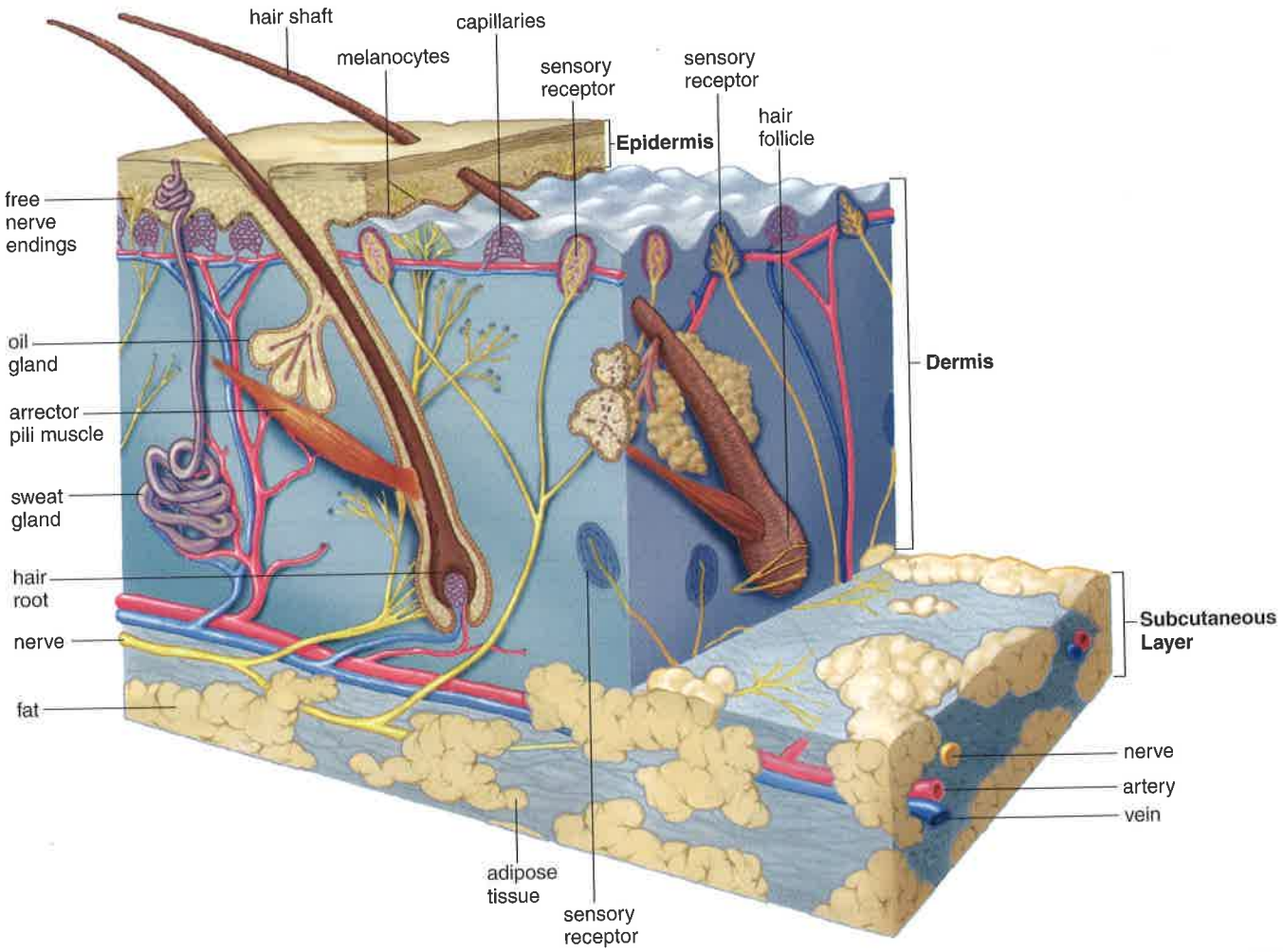
1. **Epidermis:** This region is composed of stratified squamous epithelial cells. The outer cells of the epidermis are nonliving and create a waterproof covering that prevents excessive water loss. These cells are always being replaced because an inner layer of the epidermis is composed of living cells that constantly produce new cells.
2. **Dermis:** This region is a connective tissue containing blood vessels, nerves, sense organs, and the expanded portions of oil (sebaceous) and sweat glands and hair follicles.

   List the structures you can identify on your slide: _____

   _____

3. **Subcutaneous layer:** This is a layer of loose connective tissue and adipose tissue that lies beneath the dermis and serves to insulate and protect inner body parts.

Figure 25.17 Human skin.
Human skin contains two regions, the epidermis and the dermis. The subcutaneous layer lies below the dermis.



Laboratory Review 25

1. Name four major types of tissues, and state a general function for each.

2. Describe the shapes of three types of epithelial tissue, and state a function for each.

3. Describe the appearance of three types of muscular tissue, and state a function for each.

4. What is meant by the expression *involuntary muscle?*

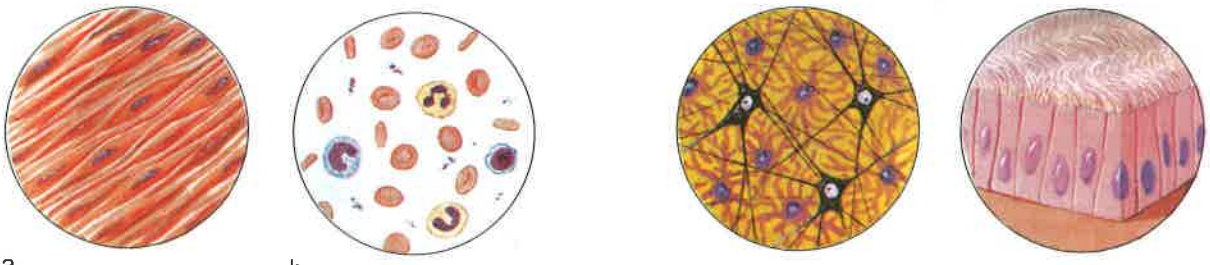
5. List the three parts of a neuron, and state a function for each part in a motor neuron.

6. Why are certain types of connective tissue called support tissues?

7. Describe how you would recognize a slide of compact bone.

8. The outer region of skin consists of stratified squamous epithelium. Define these terms:
   a. Stratified
   b. Squamous
   c. Epithelium

9. Identify the tissues a.–d. as epithelial tissue, muscular tissue, nervous tissue, or connective tissue on the lines provided. Also, name the specific contents of each circle.
   a.
   b.
   c.
   d.



a. b. c. d.

Use your knowledge of tissues, your textbook, and your tissue study guide to complete the following for each of the unknown tissues:

Unknown sample #1

Sketch the unknown tissue sample

Name of tissue: _____

Explain how you determined the name of unknown sample #1

Unknown sample #2

Sketch the unknown tissue sample

Name of tissue: _____

Explain how you determined the name of unknown sample #2

Unknown sample #3

Sketch the unknown tissue sample

Name of tissue: _____

Explain how you determined the name of unknown sample #3

Unknown sample #4

Sketch the unknown tissue sample

Name of tissue: _____

Explain how you determined the name of unknown sample #4