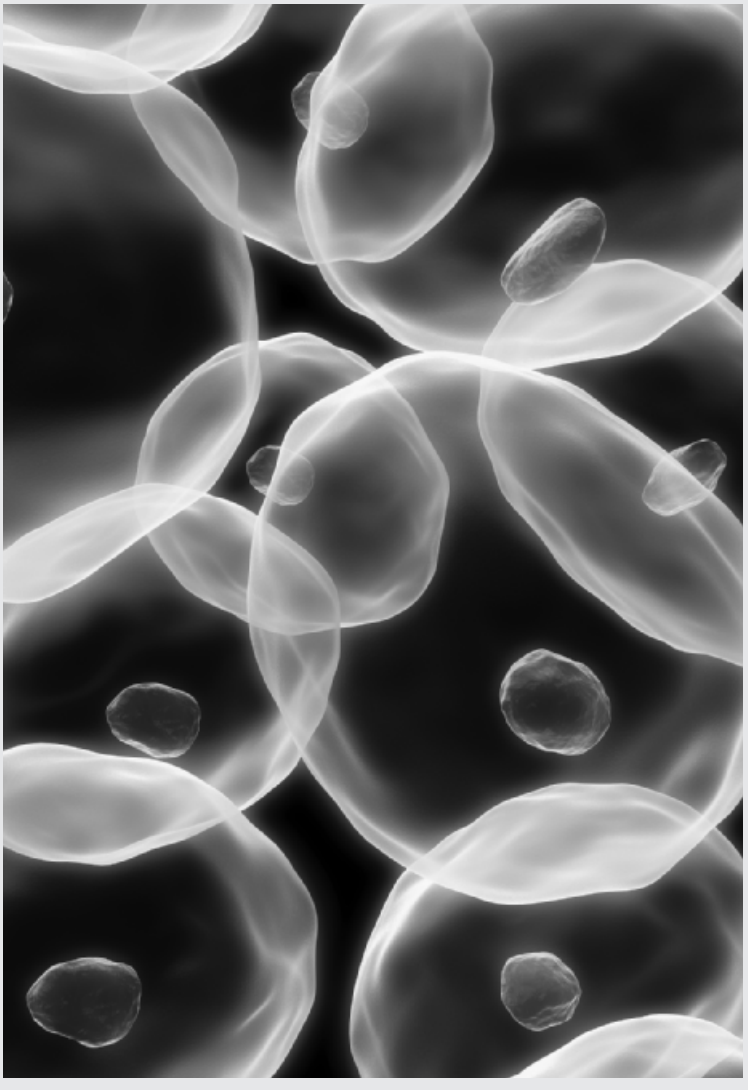
CHAPTER 4
Tissues, Glands, and Membranes



FC Flipped Classroom
OA Online Activities
DT Difficult Topics
FS Topics for Further Study
MA Misconception Alert

Overview

CHAPTER SUMMARY

Tissues are groups of cells that act together to perform specific functions. The four types of tissues are epithelial, connective, muscle, and nervous tissue, the first two of which are described in detail in this chapter. Epithelial tissue covers and lines body structures. The secreting cells of many glands are also epithelial cells. Connective tissue is the structural and supporting component of the body. Connective tissue works together with epithelial tissue to form epithelial membranes, whereas connective tissue alone forms connective tissue membranes. The different tissue types can be distinguished under the microscope, using the techniques of histology. Memorizing the classification and

appearance of different tissue types may lack appeal for some students. Activities and explorations are provided below to highlight the importance of histology in human anatomy and physiology.

UPDATES FROM THE PRIOR EDITION

Significant updates in Chapter 4 include the following:

1. The case study was changed to skin cancer. We used this case in Chapter 5 of the last edition in a modified form.
2. We added an objective covering stem cells and renumbered the other objectives. The discussion of stem cells was also significantly modified.
3. The discussion of epithelial tissue underwent major revision.
4. The classification of connective tissue was simplified (**see Objective 4**).
5. The tissue types making up different membranes are discussed.
6. We now discuss systemic sclerosis (scleroderma) in the context of autoimmune disorders of body membranes.
7. A new One Step at a Time box discusses useful strategies for interpreting histological images.
8. The micrographs in most figures were enlarged, **Figure 4-4** was modified to clearly label fat instead of the adrenal gland, and an additional micrograph was added to **Figure 4-5. Figure 4-8** was also modified slightly.

GENERAL RESOURCES

Additional information and images relevant to this chapter can be found in histology textbooks.

- Gartner LP. Color Atlas and Text of Histology, 6th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2013.
- Ross MH, Pawlina W. Histology: A Text and Atlas, 6th ed. Baltimore, MD: Lippincott Williams & Wilkins, 2010.

Learning Objectives and Teaching Tools

1. DEFINE STEM CELLS AND DESCRIBE THEIR ROLE IN DEVELOPMENT AND REPAIR OF TISSUE.

All tissues derive from **stem cells**, actively dividing cells with offspring that can remain as stem cells or differentiate into specialized tissue cells. Small stem cell populations persist into adulthood so that tissues can renew and repair themselves. The number of stem cells remaining in an adult determines that tissue's ability to heal damage and regenerate.

TEACHING TOOLS

DT Advances in stem cell research have changed how scientists view tissue renewal in adults. It has long been known that tissues with a high turnover rate (such as skin, the digestive tract, and blood) contain stem cells that are always active, producing replacement cells. However, we now know that *all* adult cells arise from stem cells (or their immediate descendants, known as *progenitor cells*). That is, stem cell populations have been identified in relatively "permanent" tissues, such as skeletal muscle and nervous tissue, and in tissues with a very slow turnover, such as the kidney and liver. These stem cells are located in protected microenvironments known as *stem cell niches*. For instance, satellite cells produce skeletal muscle cells. Their niche is the space between the muscle fibers and the tough membrane (fascia) covering the muscle. Oval cells can make different types of liver cells.

Their niche is a special hepatic structure called the canals of Hering. **Box 4-1** discusses the types of stem cells and their potential uses.

FS Students can learn more about stem cell biology at these websites or by viewing a short film.

- Stem Cell Information. 2010. Available at: http://stemcells.nih.gov/info/basics/basics3.asp.
- University of Utah. Stem Cells. 2014. Available at: http://learn.genetics.utah.edu/content/stemcells/.
- Stem Cells and Cellular Differentiation. Films for the Humanities and Sciences. Produce Number: BVL55132 (21 minutes).

FS The increasing use of stem cells has raised ethical issues and intense debate regarding the safety of some protocols. For instance, the Stamina Foundation's claims to have developed an effective stem cell treatment for various neuromuscular disorders was recently called into question. An inquiry identified serious flaws in their methodology and data. Students can read more about this and other stories in the resources below.

- Lehrman S. Undifferentiated ethics. Sci Am 2010 (September); 303:18–20.
- Abbott A. Leaked files slam stem-cell therapy. Nature 2014 (January 7). Available at: http://www.nature.com/news/leaked-files-slam-stem-cell-therapy-1.14472.

FS Ask students to research stem cell uses that may become commonplace over the next decade and to present their findings in small groups. They can use the article listed below as a starting point and perform a web search to find additional information.

- Scientific American Special Report. The future of medicine: Boosting the body's healing powers. Sci Am 2013 (April):48–58.

FS Scientists can easily grow some tissues (bone, skin, and cartilage) in the laboratory. These techniques have been used to design new noses and ears, to replace appendages lost in accidents or from cancer, and new bone tissue to help repair serious breaks. Newer techniques use three-dimensional printers to make new organs. Students can learn more in the online article and TED talk listed below.

- Harmon K. Use for 3-D printers: Creating internal blood vessels for kidneys, livers, other large organs. Sci Am 2013 (April). Available at: http://www.scientificamerican.com/article/new-use-3d-printing-blood-vessel-creation-kidney-liver-large-organs/.
- TED Conferences. Anthony Atala: Printing a Human Kidney. 2011. Available at: http://www.ted.com/talks/anthony_atala_printing_a_human_kidney.

2. NAME THE FOUR MAIN GROUPS OF TISSUES, AND GIVE THE LOCATION AND GENERAL CHARACTERISTICS OF EACH.

Tissues are classified based on their microscopic appearance and other characteristics. All tissues consist of cells. In some tissues, the cells are separated by a matrix. The type and appearance of cells, the extent and composition of this matrix, and the function of the tissue are highly variable. Understanding the structure of different tissues is necessary for understanding their function.

- Epithelial tissue contains closely packed cells with minimal matrix. It often forms protective barriers between the internal environment and the external environment. The cells provide a physical barrier, and mucus (secreted from specialized epithelial goblet cells, **Fig. 4-3**) provides a physical and chemical barrier. In this context, the "external environment" includes anything that is continuous to the outside—the gastrointestinal tract, the urinary tract, and the reproductive tract. Epithelial tissue can be further subdivided based on the appearance of the cells (flat and irregular, **squamous**

epithelium; square, **cuboidal epithelium**; or long and narrow, **columnar epithelium**) (**Fig. 4-1**) and the arrangement of cells (single layer, **simple**, or multiple layers, **stratified**) (**Fig. 4-2**).
- Connective tissue contains widely spaced cells separated by a matrix of water, proteins, fibers, and sometimes minerals.
- Muscle tissue contains specialized cells (muscle cells) but does not contain matrix. Muscle tissue can be divided into three subtypes. Skeletal muscle contains very large, striated (striped), multinucleated cells and is found in muscles under voluntary control. Cardiac muscle (found in the heart) contains branching, striated muscle cells that are joined at their ends by intercalated discs. Smooth muscle is composed of small cells without visible striations. It is found in the walls of hollow organs and tubular structures (**Fig. 4-6**).
- Nervous tissue contains two cell types: neurons and glia. Neurons are specialized cells that conduct electrical impulses. They contain a cell body and extensions from the cell body (dendrites and an axon). Neuroglia (glial cells or glia) are the nonconducting "support staff" of nervous tissue—they feed, protect, and clean up after the neurons. They are much more abundant than neurons and are quite varied morphologically. Nervous tissue is found in the brain, spinal cord, and nerves. Histological images of nervous tissue may contain fibers (bundles of axons or dendrites), white matter (myelin-coated axons), and sometimes cell bodies (**Fig. 4-7**).

TEACHING TOOLS

DT The instructor may elect to present or to review the histology of muscle and nervous tissues with Chapters 7 and 8, respectively. Bone tissue is discussed in more detail in Chapter 6. Students often confuse **neurons** with **nerves**. Nerves are visible to the naked eye and are composed of many axons. Neurons are single cells and are visualized under the microscope.

DT Students often find histology difficult because histological images often resemble a "sea of pink" to the uninitiated. This chapter's One Step at a Time box (Box 4-3) provides a step-by-step guide for analyzing these images.

MA Encourage students to predict a tissue's function based on its appearance. For instance, stratified columnar epithelium is thick and protective, but the thinness of simple squamous epithelium maximizes diffusion.

OA Students will need practice identifying different tissue types from histological images. Many excellent histology image banks are freely available online. Students should be able to distinguish the four main types of tissues and also the subtypes of epithelial and connective tissues (see also **Objective 3**).

- Medical Histology and Virtual Microscopy. Available at: http://www.med.umich.edu/histology/dmindex.html.
- Histology World. Available at: http://www.histology-world.com/audioslides/audio.htm.
- Histo-Web. Available at: http://www.kumc.edu/instruction/medicine/anatomy/histoweb/.
- Histology. Available at: http://www.meddean.luc.edu/lumen/meded/histo/frames/histo_frames.html.

FC Ask students to assemble a table categorizing the different tissue types and subtypes under the following characteristics: cell structure, matrix structure (particularly relevant for connective tissue), location, and function. Students may also want to make a column for "distinguishing feature" to aid in analyzing histological images. For instance, blood can be identified by the doughnut-shaped red blood cells, whereas bone tissue contains characteristic circles.

3. DESCRIBE THE DIFFERENCE BETWEEN EXOCRINE AND ENDOCRINE GLANDS, AND GIVE EXAMPLES OF EACH.

Glands contain specialized epithelial cells that synthesize and secrete a particular substance. **Exocrine** glands (salivary glands, sweat glands) secrete their substance **outside** (*exo-*) of the body, generally via a **duct**. For instance, the pancreas contains exocrine glands that secrete into the small intestine. Goblet cells are single cells that secrete mucus directly into a lumen (they are considered "ductless" exocrine glands; **Fig. 4-3**). **Endocrine** glands, such as the thyroid gland, secrete their substances within the body—into the blood.

TEACHING TOOLS

DT You may want to remind students that the entire gastrointestinal tract is considered to be "outside the body." Thus, glands secreting substances into the stomach or the intestine are considered to be exocrine glands.

FC Many glands secrete proteins. Ask students to predict which organelles (Chapter 3) would be more abundant in these glands. Show an image of pituitary cells or pancreatic cells taken with an electron microscope to show the extensive endoplasmic reticulum and Golgi apparatus. Images are available from the online histology image banks listed above.

4. CLASSIFY THE DIFFERENT TYPES OF CONNECTIVE TISSUE.

There are many classification schemes for connective tissue. This text classifies tissues based on the composition of the matrix.

- The cells in **circulating connective tissue** (blood and lymph) are separated by a highly fluid matrix (plasma and lymph fluid, respectively) (**Fig. 4-4A**).
- **Loose connective tissue** contains cells (fibroblasts and adipocytes, respectively) and a semiliquid matrix (**Fig. 4-4B and C**). It can be further subdivided into **areolar** and **adipose** tissue. The matrix in areolar tissue is found between the cells and is rich in fibers traveling in all directions. Some scientists believe that some of the matrix in adipose tissue is found *inside* the cell as a large fat droplet. The adipocytes are held in a matrix containing collagen fibers.
- The matrix in **dense connective tissue** is rich in fibers such as collagen (**Fig. 4-5**). This type can be further divided in **irregular dense connective tissue** (organ capsules, skin, some membranes) and **regular dense connective tissue** (ligaments and tendons). **Box 4-2** discusses collagen in more detail.
- The matrix in **cartilage** and **bone** is quite solid, containing collagen and also, in the case of bone, minerals (**Fig. 4-5**).

TEACHING TOOLS

MA Students frequently confuse the terms *collagen* (the connective tissue fiber) and *chondrocyte* (cartilage cell).

OA The internet histology atlases listed under **Objective 2** contain many images of the different connective tissue types.

5. DESCRIBE THREE TYPES OF EPITHELIAL MEMBRANES.

All epithelial membranes contain an outer layer of epithelium and an inner layer of connective tissue.

- Serous membranes line the body cavities and secrete a thin lubricating fluid. The pleura lines the thoracic cavity, the serous pericardium encloses the heart, and the peritoneum lines the abdominal wall and covers the abdominal organs. Each serous membrane contains a parietal layer and a visceral layer (**Fig. 4-8**).
- Mucous membranes line those systems that open to the outside, including the gastrointestinal tract, the urinary tract, the reproductive tract, and the respiratory tract. Specialized epithelial cells in mucous membranes secrete mucus (**see Objective 3**), which protects the tissues beneath the membrane. Some mucous membranes are also ciliated.
- The cutaneous membrane is known as the skin. It is discussed in detail in Chapter 5.

TEACHING TOOLS

See **Objective 6**.

6. LIST SIX TYPES OF CONNECTIVE TISSUE MEMBRANES.

Connective tissue membranes include only connective tissue. They include synovial membranes that line joint cavities, deep fascia that surround skeletal muscles, and the meninges that cover the brain and spinal cord.

TEACHING TOOLS

DT Students may find it difficult to understand the differences between epithelial and connective tissue membranes. Both membrane types contain connective tissue. However, ONLY epithelial membranes contain epithelium.

DT Note that the heart is enclosed by both epithelial (serous pericardium) and connective tissue (fibrous pericardium) membranes.

FC Use an anatomical model to show the location of epithelial and connective tissue membranes.

FC Use an uncooked supermarket chicken to demonstrate connective tissue membranes (synovial membranes, deep fascia, superficial fascia). For instance, the synovial membrane can be observed on a drumstick, the superficial fascia can be observed just under the skin, and the deep fascia can be observed on the breast muscle.

7. USING EXAMPLES FROM THE CASE STUDY, DEFINE HISTOLOGY AND EXPLAIN THE ROLE OF HISTOLOGY IN MEDICAL DIAGNOSIS AND TREATMENT.

In the case study, histology is used to diagnose Paul's skin cancer and to evaluate the effectiveness of the surgical treatment. The case study can also be used to review tissue types and epithelial membrane components and to revisit the discussion of DNA and mutation from Chapter 3.

TEACHING TOOLS

FC To prepare students for the detailed analysis of the integumentary system in Chapter 5, ask them to analyze a skin histology image (Fig. 5-3) using the procedure outlined in the One Step at a Time box.

8. SHOW HOW WORD PARTS ARE USED TO BUILD WORDS RELATED TO TISSUES, GLANDS, AND MEMBRANES.

Word parts relating to tissues, glands, and membranes are presented in the Word Anatomy chart.

TEACHING TOOLS

Ask students to make up their own words, based on the word parts provided in the Word Anatomy box. The rest of the class could try to guess the meaning. For instance, a "myoblast" is an "immature muscle cell."