

# Unifying Concepts of Animal Structure and Function

## 20

Take a moment to look at the skin on the back of your hand and appreciate its role in the structure and function of your body. The skin is an organ; along with hair and nails, it makes up the integumentary system. The skin's structure is well suited to its functions. Its outer layer consists of many layers of cells, dead and impermeable at the surface, living and reproducing below. The skin is tough, forming a barrier that keeps water in the body and bacteria out. It is also flexible, allowing the body to bend and move. It protects the body from changes in the external environment and at the same time actively responds to those changes. Nerve endings in the skin sense environmental variations, and sweat glands, blood vessels, and pigment cells respond to them. Other body systems interact with the skin: The digestive and respiratory systems supply it with food and oxygen, the excretory system disposes of its wastes, and the immune system protects it from infection. In exchange, the skin covers and protects these systems, playing a vital role in homeostasis—maintaining a constant internal environment suitable for continuing body functions. The skin illustrates the important connection between how the body is built and how it works. This chapter introduces the important concepts uniting animal structure and function.

### Organizing Your Knowledge

#### Exercise 1 (Introduction and Module 20.1)

Web/CD Activity 20A *Correlating Structure and Function of Cells*

These modules discuss how a gecko's feet enable it to climb walls and a bird's wings enable it to fly. You are probably familiar with many other examples of the correlation between animal structure and function. In a sentence or two, state how each of the following illustrates this correspondence of structure and function. The first one is done for you.

1. A whale's tail. *The tail is flattened into broad flukes, which propel the whale through the water.*
2. A hummingbird's beak.
3. Your hand.
4. A frog's legs.
5. A mosquito's sharp, tubular mouthparts.
6. A cow's multichambered stomach.

**Exercise 2 (Modules 20.2 – 20.3)**Web/CD Activity 20B *The Levels of Life Card Game*Web/CD Activity 20C *Overview of Animal Tissues*

Review the hierarchy of structural levels in an animal by filling in the blanks in the following paragraphs.

The body of an animal—a cat, for example—is organized on several hierarchical levels. The smallest parts of the cat that are alive are individual <sup>1</sup>\_\_\_\_\_, such as the muscle fibers in the wall of the stomach. Their function is to contract and move the contents of the stomach, mixing cat food with digestive juices. Many muscle cells cooperate to form a <sup>2</sup>\_\_\_\_\_, the second level of body structure and function. Besides muscle, there are three other kinds of tissues that make up the cat's stomach: <sup>3</sup>\_\_\_\_\_ tissue, <sup>4</sup>\_\_\_\_\_ tissue, and <sup>5</sup>\_\_\_\_\_ tissue. The stomach itself, formed of these four tissues, is an <sup>6</sup>\_\_\_\_\_, which performs the functions of storing and digesting food. The stomach, esophagus, intestines, and digestive glands make up the digestive system, which exemplifies the <sup>7</sup>\_\_\_\_\_ level of structure and function. It is one of a dozen or so systems that cooperate to form the cat—an <sup>8</sup>\_\_\_\_\_. This is the whole animal, the highest level of the hierarchy.

To review, starting from the top down: A cat is an <sup>9</sup>\_\_\_\_\_. It is composed of a number of <sup>10</sup>\_\_\_\_\_, each of which performs specific functions such as digestion or circulation. Each system is composed of <sup>11</sup>\_\_\_\_\_ such as the heart or stomach, which are built from four kinds of <sup>12</sup>\_\_\_\_\_. At the most fundamental level of the hierarchy, a tissue is composed of individual <sup>13</sup>\_\_\_\_\_.

**Exercise 3 (Module 20.4)**

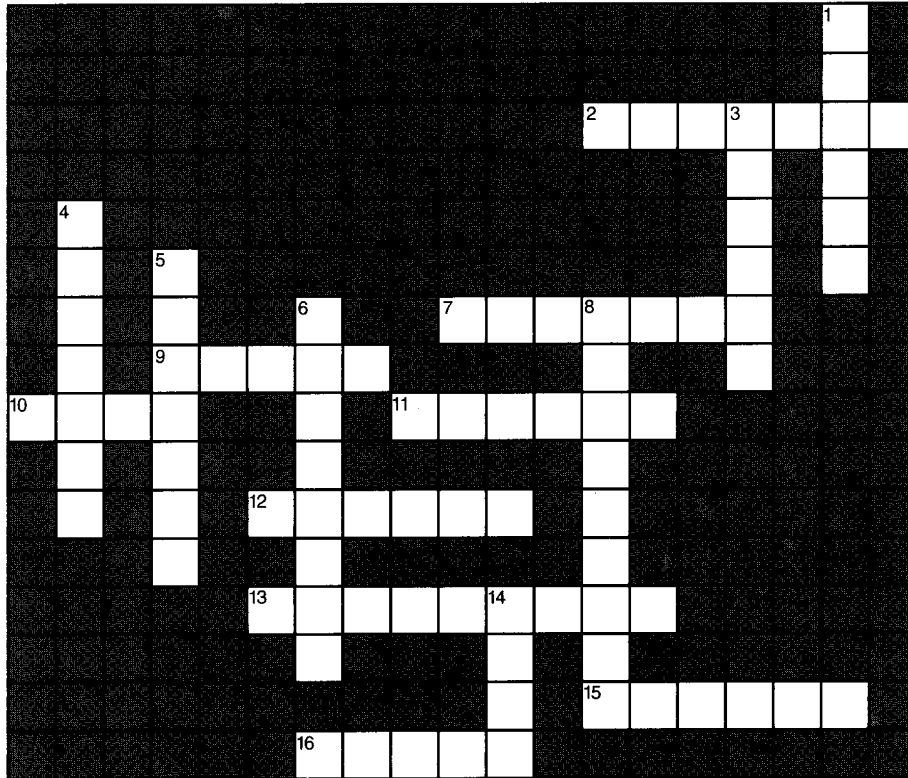
Web/CD Activity 20D *Epithelial Tissue*

Epithelial tissue covers the body and lines body organs. Complete the following chart comparing four kinds of epithelium. Refer to the illustrations in Module 20.4 to aid you with the descriptions.

<i>Tissue Type</i>	<i>Description</i>	<i>Body Locations</i>	<i>Functions</i>
1.	2.	3.	4.
5.	6.	7.	Absorbs and secretes fluid in kidneys
8.	Single layer of thin, flattened cells	9.	10.
11.	12.	Forms mucous membrane that lines digestive tract	13.

**Exercise 4 (Module 20.5)**Web/CD Activity 20E *Connective Tissue*

Review the structures, functions, and locations of connective tissues by completing this crossword puzzle.

**Across**

2. \_\_\_\_ tissue contains fat.
7. Bone matrix contains fibers embedded in \_\_\_\_ salts.
9. \_\_\_\_ is a connective tissue with a fluid matrix.
10. Connective tissue is one of \_\_\_\_ major categories of tissues.
11. The matrix is a web of \_\_\_\_ in a liquid, jelly, or solid.
12. Connective tissue cells are scattered in a non-living \_\_\_\_.
13. Cartilage supports the nose and ears, and forms discs between the \_\_\_\_.
15. Adipose tissue pads and insulates the body and stores \_\_\_\_.
16. \_\_\_\_ connective tissue holds other tissues and organs in place.

**Down**

1. A \_\_\_\_ is a group of cells with a common structure and function.
3. Blood matrix is called \_\_\_\_.
4. Fibrous connective tissue forms \_\_\_\_ and ligaments.
5. \_\_\_\_ connective tissue has densely packed bundles of collagen fibers.
6. Some kinds of connective tissues contain rope-like \_\_\_\_ fibers.
8. \_\_\_\_ is a strong but flexible skeletal material.
14. \_\_\_\_ is the most rigid connective tissue.

**Exercise 5 (Modules 20.6 – 20.7)**

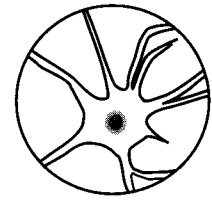
Web/CD Activity 20F *Muscle Tissue*

Web/CD Activity 20G *Nervous Tissue*

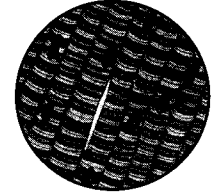
Review nervous tissue and the three types of muscle tissue by matching each phrase on the left with a tissue type on the right.

- |                                                                           |                    |
|---------------------------------------------------------------------------|--------------------|
| _____ 1. Contractile tissue of the heart                                  | A. Smooth muscle   |
| _____ 2. Forms body communications system                                 | B. Cardiac muscle  |
| _____ 3. Attached to bones by tendons                                     | C. Skeletal muscle |
| _____ 4. Branching, interconnected muscle cells                           | D. Nervous tissue  |
| _____ 5. Cells characterized by axons and dendrites                       |                    |
| _____ 6. Carries out voluntary body movements                             |                    |
| _____ 7. Composed of neurons and other supporting cells                   |                    |
| _____ 8. Cells are striated, or striped                                   |                    |
| _____ 9. Muscle cells that lack striations                                |                    |
| _____ 10. Found in walls of digestive tract, bladder, arteries, and so on |                    |
| _____ 11. Involuntary muscle of internal organs other than the heart      |                    |
| _____ 12. Figure 1 at the right                                           |                    |
| _____ 13. Figure 2 at the right                                           |                    |
| _____ 14. Figure 3 at the right                                           |                    |
| _____ 15. Figure 4 at the right                                           |                    |

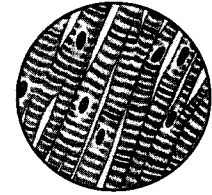
1.



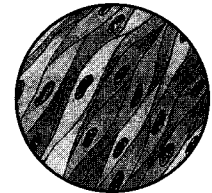
2.



3.



4.


**Exercise 6 (Modules 20.8 – 20.9)**

Review the functions of human organs and organ systems by filling in the blanks in the following paragraphs.

Every animal—a hamster or a human being—consists of a number of cooperating organ systems, each of which performs specific life functions. Each system consists of organs, which in turn perform specific functions. As you read these words, your brain receives nerve impulses from your eyes. It evaluates the information received and sends out responses via the spinal cord and nerves. These parts—sense organs, brain, spinal cord, and nerves—make up the <sup>1</sup>\_\_\_\_\_ system, one of two systems that control and coordinate body activities.

As you read, your eyes scan the page, and your hand moves to write answers in the blanks. These responses are carried out by muscles, which make up the <sup>2</sup>\_\_\_\_\_ system, the system responsible for body movements. To move the body, muscles pull against bones, which make up the <sup>3</sup>\_\_\_\_\_ system. This system also supports the body and protects delicate internal organs such as the brain.

Muscles, like all organs, require food and oxygen to function. Food is digested and absorbed by the <sup>4</sup>\_\_\_\_\_ system, whose parts include the stomach, intestines, and digestive glands such as the liver and pancreas. As you inhale and exhale, oxygen enters the body via the lungs, key organs of the <sup>5</sup>\_\_\_\_\_ system. The <sup>6</sup>\_\_\_\_\_ system—the heart, blood, and blood vessels—functions to transport

food and oxygen to your muscles and other organs. Some of the fluid delivered to body tissues leaves the blood and is picked up by vessels of the <sup>7</sup> \_\_\_\_\_ system. The fluid passes through lymph nodes, where special cells called lymphocytes attack foreign substances and microbes. The skin, or <sup>8</sup> \_\_\_\_\_ system, is normally able to keep most disease-causing organisms out. When they get through, they are attacked by cells of the <sup>9</sup> \_\_\_\_\_ system—lymphocytes, which are produced and stored in the thymus, bone marrow, and spleen, as well as lymph nodes.

As the blood delivers its cargo of food and oxygen, it also picks up waste products that must be expelled by the body. The kidneys—the key organs of the <sup>10</sup> \_\_\_\_\_ system—remove metabolic waste products from the blood and dispose of them via the ureters, bladder, and urethra. The kidneys also regulate the osmotic balance of blood. This activity, and many others in the body, are controlled by chemical signals called hormones. Hormones are sent out by the glands of the <sup>11</sup> \_\_\_\_\_ system, which acts in concert with the nervous system to coordinate the activities of all the other body systems. Endocrine glands—the pituitary, thyroid, adrenals, and others—regulate such activities as digestion, growth, metabolism, and water balance. They even help to control the process of reproduction, via their effects on the testes and ovaries, the major organs of the male and female <sup>12</sup> \_\_\_\_\_ systems.

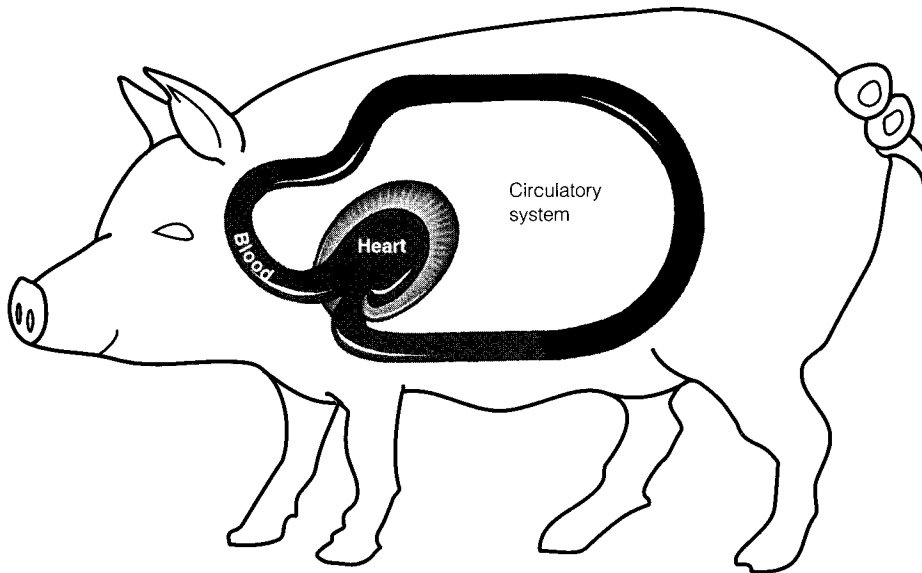
### Exercise 7 (Module 20.10)

Compare body imaging methods by summarizing each method on the chart.

<i>Method</i>	<i>Medium Used</i>	<i>Used For</i>
Conventional X-ray	1.	2.
Computerized tomography (CT)	3.	4.
Magnetic resonance imaging (MRI)	5.	6.
Magnetic resonance microscopy (MRM)	7.	8.
Positron-emission tomography (PET)	9.	10.
Functional MRI	11.	12.

**Exercise 8 (Module 20.11)**

Animals must exchange materials with their environment. The cells of saclike or flattened animals (such as *Hydra* and flatworms) can exchange substances directly with the surrounding water. Larger animals, whose outer coverings are small compared with their volume, have specialized surfaces for exchanging materials with the environment. Below is a simplified diagram of an animal, similar to Figure 20.11B in the text. The circulatory system is shown. Add your own simple sketches and label the **digestive system**, **respiratory system**, **excretory system**, **interstitial fluid**, and **cells**. Draw and label arrows to show exchange of food, nutrients,  $O_2$ ,  $CO_2$ , metabolic wastes, and feces.

**Exercise 9 (Modules 20.12 – 20.13)**

Web/CD Activity 20H *Regulation: Negative and Positive Feedback*

To review the concepts of homeostasis and negative feedback, the most important principles of animal function, read the following paragraph and then fill in the chart that follows it.

Despite changes in the external environment, an animal can keep its internal environment remarkably constant. This maintenance of a constant internal environment is called homeostasis. The text states that animals such as the albatross maintain relatively constant salt and water balance and body temperature. Conditions within the human body are also more or less constant, fluctuating within narrow limits. For example, an organ called the pancreas monitors and regulates the amount of sugar in the blood. This maintains a constant supply of fuel for body cells, even though the body's intake of food varies widely during the day. After a meal, when blood sugar rises, the pancreas sends out a chemical signal, a hormone called insulin. Insulin causes body cells to take up and store sugar, which lowers blood sugar to the optimum range—70 to 110 mg of sugar per 100 mL of blood. This illustrates negative feedback: An increase in blood sugar triggers a response that counteracts the increase. Between meals, as cells consume sugar, the concentration of sugar in the blood starts to decrease. The pancreas responds by reducing its output of insulin and stepping up its secretion of a second hormone, glucagon. Glucagon signals certain cells to release sugar from storage, raising blood sugar to the optimum level. Thus, despite changes in the external environment (timing and content of meals), blood sugar usually fluctuates within the narrow range that is best for cells.

Compare the regulation of blood sugar described in the preceding paragraph with the control of body temperature outlined in Modules 20.12 and 20.13. Fill in the chart by identifying the components of each homeostatic control system.

	<i>Body Temperature</i>	<i>Blood Sugar</i>
Type of change in external environment	1.	2.
Control center	3.	4.
Stimulus	5.	6.
Kind of signal sent by control center to effector	7.	8.
Effector	9.	10.
Response	11.	12.
Set point	13.	14.

## Testing Your Knowledge

### Multiple Choice

- The four major categories of tissues are
  - bone, muscle, blood, and adipose.
  - nervous, epithelial, connective, and muscle.
  - muscle, epithelial, bone, and cartilage.
  - blood, nervous, connective, and muscle.
  - simple squamous, simple cuboidal, simple columnar, and stratified squamous.
- Which of the following levels of structure encompasses all the others?
  - tissue
  - cell
  - organ
  - organism
  - system
- How many organ systems make up your body?
  - four
  - hundreds
  - twelve
  - millions
  - It depends on the size of the person.
- Which of the following tissues produces voluntary body movements?
  - smooth muscle
  - simple cuboidal epithelium
  - cardiac muscle
  - skeletal muscle
  - fibrous connective tissue
- Neurons are specialized cells characteristic of
  - muscle tissue.
  - nervous tissue.
  - connective tissue.
  - epithelial tissue.
  - all of the above.
- All but one of the following systems are correctly paired with one of their parts. Which pair is *incorrect*?
  - circulatory system—heart
  - respiratory system—lung
  - endocrine system—thyroid gland
  - integumentary system—hair
  - excretory system—intestine



7. Which of the following do the excretory, digestive, and respiratory systems have in common?
  - a. They are present only in animals with backbones.
  - b. They contain specialized surfaces for exchange with the environment.
  - c. They work independently, without any control by the nervous system.
  - d. They enable the animal to absorb needed materials from its environment.
  - e. They are isolated from the animal's internal environment.
8. A change in the body often triggers a response that counteracts the change. This kind of response is known as
  - a. negative feedback.
  - b. empowerment.
  - c. cause and effect.
  - d. positive feedback.
  - e. adaptation.
9. Homeostasis is
  - a. exchange of materials with the surrounding environment.
  - b. the idea that all vertebrates are built in a similar way.
  - c. the correlation of structure and function.
  - d. maintaining a relatively constant internal environment.
  - e. cooperation of body parts to form tissues, organs, and systems.
10. An animal's "internal environment" is
  - a. the blood.
  - b. the interior of compartments like the heart and stomach.
  - c. anyplace beneath the skin.
  - d. any fluid inside the body.
  - e. the interstitial fluid that surrounds the cells.
11. Which of the following are listed in the correct hierarchical order?
  - a. system-tissue-organ
  - b. cell-tissue-organ
  - c. organ-tissue-system
  - d. tissue-cell-organ
  - e. organism-organ-system
2. Name the four major types of body tissues, and briefly describe the functions of each type.
3. Name the twelve organ systems of a vertebrate. Describe the function of each system in one sentence each.
4. What are the advantages of computerized tomography (CT) over conventional X-rays?
5. Compare a thermostat controlling room temperature with your brain controlling body temperature. Describe the following for each system: stimulus, control center, effector, and response.
6. Some animals can "breathe" through their skins, without the aid of lungs or gills. Others can absorb food and expel wastes through the surfaces of their bodies, without specialized digestive tracts or kidneys. Why are all these animals rather small?

## Applying Your Knowledge

### Multiple Choice

1. Bone tissue does *not* show which of the following correlations between structure and function?
  - a. It is rigid.
  - b. Its cells are packed tightly together.
  - c. It contains reinforcing fibers.
  - d. It can grow with the animal.
  - e. It contains canals for blood vessels and nerves that keep it alive.
2. When you sprain your ankle, the "straps" of tissue that hold the bones together are stretched and torn. What kind of tissue do you think is damaged in a sprain?
  - a. stratified squamous epithelium
  - b. visceral muscle
  - c. fibrous connective tissue
  - d. adipose tissue
  - e. cartilage
3. Which of the following forms a thick protective barrier that keeps bacteria out of the body?
  - a. skeletal muscle
  - b. fibrous connective tissue
  - c. stratified squamous epithelium
  - d. cartilage
  - e. simple columnar epithelium

### Essay

1. Describe how the structure of a bird wing relates to its function.

4. An organ such as the heart or liver contains
  - a. muscle tissue.
  - b. nervous tissue.
  - c. connective tissue.
  - d. epithelial tissue.
  - e. all of the above.
5. A new drug has been developed that impairs the movement of smooth muscle. It would affect the muscle
  - a. that moves the arms and legs.
  - b. of the heart.
  - c. in the wall of the intestine.
  - d. all of the above
  - e. b and c only
6. Which of the following is *not* an organ?
  - a. the stomach
  - b. a blood vessel
  - c. a neuron
  - d. the heart
  - e. a lung
7. A researcher wants to study the metabolic activity of various parts of exercising heart muscle. This might be accomplished by
  - a. doing a CT scan.
  - b. taking some X-rays.
  - c. doing an ultrasound scan.
  - d. using MRI.
  - e. doing a PET scan.
8. Which of the following best illustrates homeostasis?
  - a. All the cells in the body have much the same chemical composition.
  - b. Cells of the skin are constantly worn off and replaced.
  - c. When blood  $\text{CO}_2$  increases, you breathe faster and get rid of  $\text{CO}_2$ .
  - d. All organs are composed of the same four kinds of tissues.
  - e. The lung has a large surface for exchange of gases.
2. What might interest an anatomist about each of the following: how a fish swims, how a penguin keeps warm, how an insect defends itself from its enemies? What might interest a physiologist about each of them?
3. Read the descriptions and look at the illustrations in the text of the following tissue types, and then explain how their structure correlates with their function: bone, simple squamous epithelium, and blood.
4. Briefly describe which organ systems might cooperate in delivering food and oxygen to your brain cells.
5. The parathyroid glands regulate the amount of calcium in the blood. They send out hormone signals that control how much calcium the intestine absorbs from food and how much calcium the kidneys excrete in the urine. What do you think the parathyroids cause to happen when blood calcium gets too high? What happens when blood calcium gets too low? How does this illustrate negative feedback?

### Extending Your Knowledge

1. Many physicians specialize in treating particular body systems. Neurologists, for example, deal primarily with the nervous system. What about dermatologists? Can you think of others? (Physicians are listed by specialty in the telephone Yellow Pages.)
2. Many everyday devices use negative feedback to maintain some constant condition. For example, there is a valve that maintains a constant water level in a toilet tank. When the toilet is flushed, the water level drops. A float drops, opening a valve, which raises the water level and the float. When the water level reaches its "set point" (when the tank is full) the rising float shuts off the water. How does this system illustrate negative feedback? Can you think of other devices that work this way?
3. Have you or someone you know ever had a CT or MRI scan? How have these devices changed health care in recent years?

### Essay

1. You have probably read books or seen nature programs on television that describe adaptations of animals to their environments. Choose an animal and briefly describe how its body shows the correlation of structure and function.