

Animal Primary Tissues

Learning Objectives

By the end of this section, you will be able to:

- Describe epithelial tissues
- Discuss the different types of connective tissues in animals
- Describe three types of muscle tissues
- Describe nervous tissue

Multicellular, complex animals have four primary types of tissue: epithelial, connective, muscle, and nervous. *Recall that a tissue is a group of physically linked cells and associated intercellular substances that is specialized for a particular function or functions.* These tissues combine to form organs—like the skin or kidney—that have specific, specialized functions within the body. Organs are organized into organ systems to perform functions; examples include the circulatory system, which consists of the heart and blood vessels, and the digestive system, consisting of several organs, including the stomach, intestines, liver, and pancreas. Organ systems come together to create an entire organism.

Epithelial Tissues

Epithelial tissues cover the outside of organs and structures in the body and line the lumens of organs in a single layer or multiple layers of cells. Those that line internal cavities or tubes are sometimes termed as endothelia; the term ***endothelium*** is equivalent to internal epithelium. The types of epithelium are classified by the shapes of cells present and the number of layers of cells. Epithelium composed of a single layer of cells are called ***simple*** epithelium; epithelial tissue composed of multiple layers is called **stratified epithelium**.

[Table 1](#) summarizes the different types of epithelial tissues.

Table 1 Different Types of Epithelial Tissues

Cell shape	Description	Location
squamous	flat, irregular round shape	simple: lung alveoli, capillaries; stratified: skin, mouth, vagina
cuboidal	cube shaped, central nucleus	glands, renal tubules
columnar	tall, narrow, nucleus toward base tall, narrow, nucleus along cell	simple: digestive tract pseudostratified: respiratory tract
transitional	round, simple but appear stratified	urinary bladder

Squamous Epithelium

Squamous epithelial cells are generally round, flat, and have a small, centrally located nucleus. The cell outline is slightly irregular, and cells fit together to form a covering or lining. When the cells are arranged in a single layer (simple epithelia), they facilitate diffusion in tissues, such as the areas of gas exchange in the lungs and the exchange of nutrients and waste at blood capillaries.

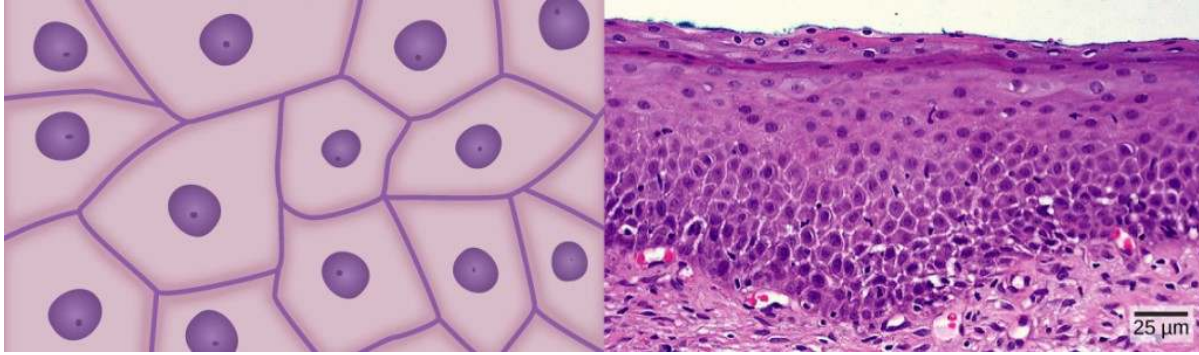


Figure 1 Squamous epithelia cells (a) have a slightly irregular shape, and a small, centrally located nucleus. These cells can be stratified into layers, as in (b) this human cervix specimen.

[Figure 1a](#) illustrates a layer of squamous cells with their membranes joined together to form an epithelium. Image [Figure 1b](#) illustrates squamous epithelial cells arranged in stratified layers, where protection is needed on the body from outside abrasion and damage. This is called a stratified squamous epithelium and occurs in the skin and in tissues lining the mouth and vagina.

Cuboidal Epithelium

Cuboidal epithelial cells, shown in [Figure 2](#), are cube-shaped with a single, central nucleus. They are most commonly found in a single layer representing simple epithelia in glandular tissues throughout the body where they prepare and secrete glandular material. They are also found in the walls of tubules and in the ducts of the kidney and liver.

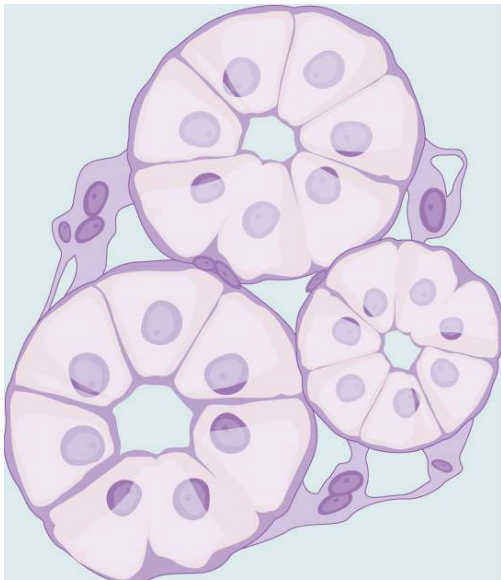


Figure 2. Simple cuboidal epithelial cells line tubules in the mammalian kidney, where they are involved in filtering the blood.

Columnar Epithelium

Columnar epithelial cells are taller than they are wide: they resemble a stack of columns in an epithelial layer, and are most commonly found in a single-layer arrangement. The nuclei of columnar epithelial cells in the digestive tract appear to be lined up at the base of the cells, as illustrated in [Figure 3](#). These cells absorb material from the lumen of the digestive tract and prepare it for entry into the body through the circulatory and lymphatic systems.

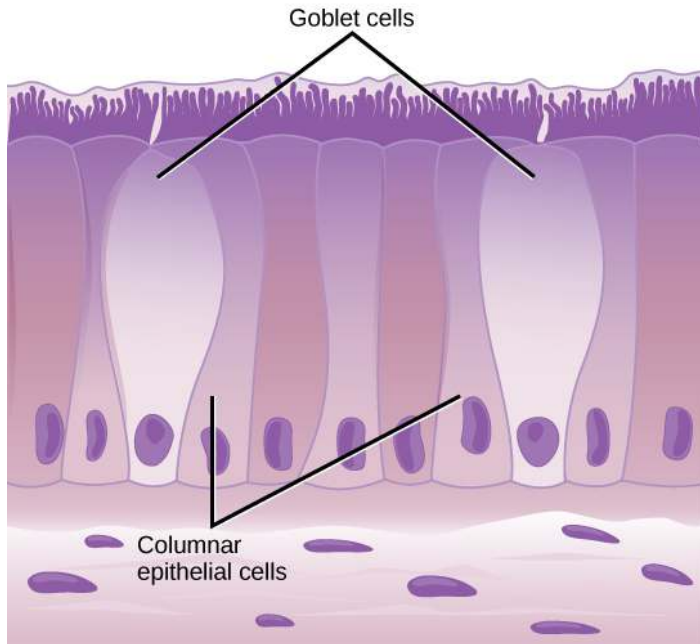


Figure 4. Simple columnar epithelial cells absorb material from the digestive tract. Goblet cells secrete mucous into the digestive tract lumen.

Columnar epithelial cells lining the respiratory tract appear to be stratified. However, each cell is attached to the base membrane of the tissue and, therefore, they are simple tissues. The nuclei are arranged at different levels in the layer of cells, making it appear as though there is more than one layer, as seen in [Figure 5](#). This is called **pseudostratified**, columnar epithelia. This cellular covering has cilia at the apical, or free, surface of the cells. The cilia enhance the movement of mucous and trapped particles out of the respiratory tract, helping to protect the system from invasive microorganisms and harmful material that has been breathed into the body. Goblet cells are interspersed in some tissues (such as the lining of the trachea). The goblet cells contain mucous that traps irritants, which in the case of the trachea keep these irritants from getting into the lungs.

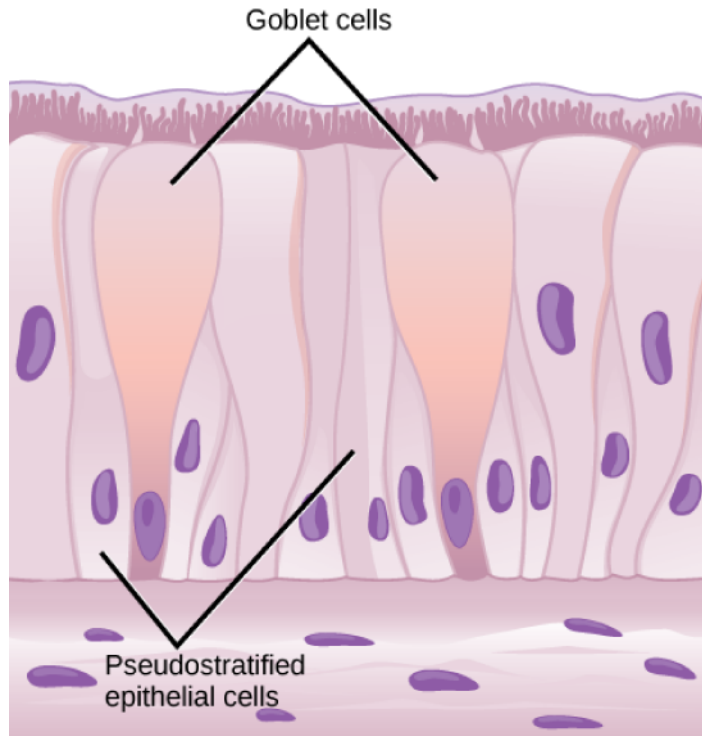


Figure 5. Pseudostratified columnar epithelia line the respiratory tract. They exist in one layer, but the arrangement of nuclei at different levels makes it appear that there is more than one layer. Goblet cells interspersed between the columnar epithelial cells secrete mucous into the respiratory tract.

Transitional Epithelium

Transitional epithelia cells appear only in the urinary system, primarily in the bladder and ureter. This is a compound epithelia tissue with only three or four layers of cells all similar in size and shape except at the free surface where they are more flattened. The superficial cells do not slough off and all cells are able to modify their shape when placed under differing conditions. These cells are arranged in a stratified layer, but they have the capability of appearing to pile up on top of each other in a relaxed, empty bladder, as illustrated in [Figure 6](#). As the urinary bladder fills, the epithelial layer unfolds and expands to hold the volume of urine introduced into it. As the bladder fills, it expands and the lining becomes thinner. In other words, the tissue transitions from thick to thin.

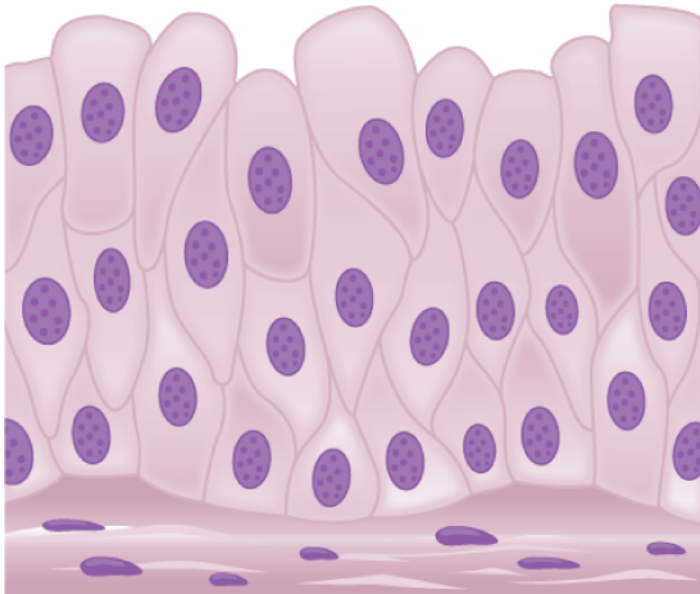


Figure 6. Transitional epithelia of the urinary bladder undergo changes in thickness depending on how full the bladder is.

Which of the following statements about types of epithelial cells is false?

1. Simple columnar epithelial cells line the tissue of the lung.
2. Simple cuboidal epithelial cells are involved in the filtering of blood in the kidney.
3. Pseudostratified columnar epithelium occurs in a single layer, but the arrangement of nuclei makes it appear that more than one layer is present.
4. Transitional epithelium changes in thickness depending on how full the bladder is.

Connective Tissues

All connective tissues have two common characteristics; they are all developed from embryonic mesoderm and have a large amount of intercellular substance.

Connective tissues are made up of a matrix consisting of living cells and a non-living substance, called the ground substance. The ground substance is made of an organic substance (usually a protein) and an inorganic substance (usually a mineral or water). The principal cell of connective tissues is the fibroblast. This cell makes the fibers found in nearly all of the connective tissues. Fibroblasts are motile, able to carry out mitosis, and can synthesize whichever connective tissue is needed. Macrophages, lymphocytes, and, occasionally, leukocytes can be found in some of the tissues. Some tissues have specialized cells that are not found in the others. The **matrix** in connective tissues gives

the tissue its density. When a connective tissue has a high concentration of cells or fibers, it has proportionally a less dense matrix.

The organic portion or protein fibers found in connective tissues are either collagen, elastic, or reticular fibers. Collagen fibers provide strength to the tissue, preventing it from being torn or separated from the surrounding tissues. Elastic fibers are made of the protein elastin; this fiber can stretch to one and one half of its length and return to its original size and shape. Elastic fibers provide flexibility to the tissues. Reticular fibers are the third type of protein fiber found in connective tissues. This fiber consists of thin strands of collagen that form a network of fibers to support the tissue and other organs to which it is connected. The various types of connective tissues, the types of cells and fibers they are made of, and sample locations of the tissues is summarized in [Table 2](#).

Table 2. Connective Tissues

Tissue	Cells	Fibers	Location
loose/areolar	fibroblasts, macrophages, some lymphocytes, some neutrophils	few: collagen, elastic, reticular	around blood vessels; anchors epithelia
dense, fibrous connective tissue	fibroblasts, macrophages,	mostly collagen	irregular: skin regular: tendons, ligaments
cartilage	chondrocytes, chondroblasts	hyaline: few collagen fibrocartilage: large amount of collagen	shark skeleton, fetal bones, human ears, intervertebral discs
bone	osteoblasts, osteocytes, osteoclasts	some: collagen, elastic	vertebrate skeletons
adipose	adipocytes	few	adipose (fat)
blood	red blood cells, white	none	blood

	blood cells		
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Loose/Areolar Connective Tissue

Loose connective tissue, also called **areolar connective tissue**, has a sampling of all of the components of a connective tissue. As illustrated in [Figure 7](#), loose connective tissue has some fibroblasts; macrophages are present as well. Collagen fibers are relatively wide and stain a light pink, while elastic fibers are thin and stain dark blue to black. The space between the formed elements of the tissue is filled with the matrix. The material in the connective tissue gives it a loose consistency similar to a cotton ball that has been pulled apart. Loose connective tissue is found around every blood vessel and helps to keep the vessel in place. The tissue is also found around and between most body organs. In summary, areolar tissue is tough, yet flexible, and comprises membranes.

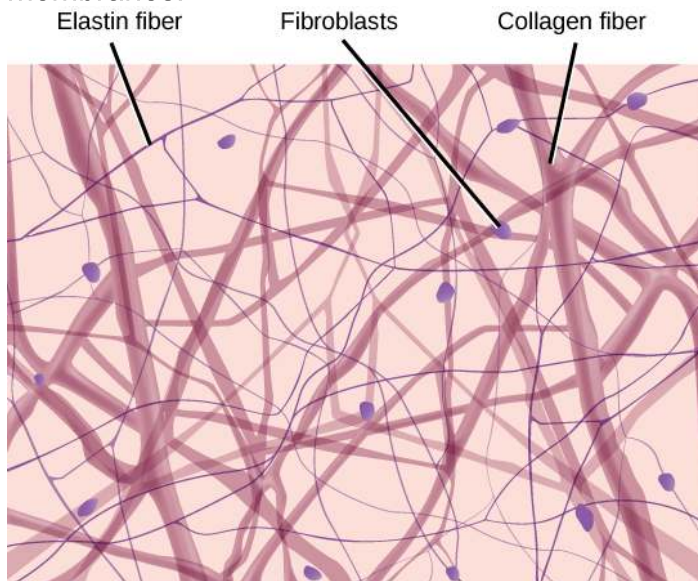


Figure 7. Loose connective tissue is composed of loosely woven collagen and elastic fibers. The fibers and other components of the connective tissue matrix are secreted by fibroblasts.

Fibrous Connective Tissue

Fibrous connective tissues contain large amounts of collagen fibers and few cells or matrix material. The fibers can be arranged irregularly or regularly with the strands lined up in parallel. Irregularly arranged fibrous connective tissues are found in areas of the body where stress occurs from all directions, such as the dermis of the skin. Regular fibrous connective tissue, shown in [Figure 8](#), is found in tendons (which connect muscles to bones) and ligaments (which connect bones to bones).

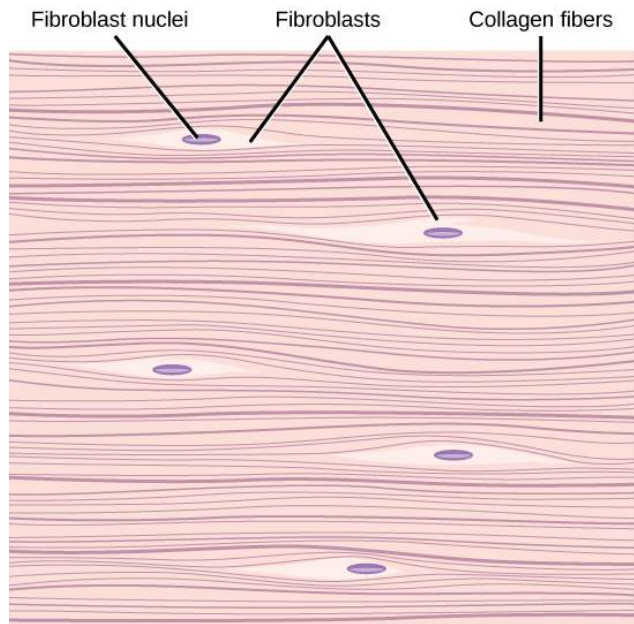


Figure 8. Fibrous connective tissue from the tendon has strands of collagen fibers lined up in parallel.

Cartilage

Cartilage is a connective tissue with a large amount of the matrix and variable amounts of fibers. The cells, called **chondrocytes**, make the matrix and fibers of the tissue. Chondrocytes are found in spaces within the tissue called **lacunae**.

A cartilage with few collagen and elastic fibers is hyaline cartilage, illustrated in [Figure 9](#). The lacunae are randomly scattered throughout the tissue and the matrix takes on a milky or scrubbed appearance with routine histological stains. Sharks have cartilaginous skeletons, as does nearly the entire human skeleton during a specific pre-birth developmental stage. A remnant of this cartilage persists in the outer portion of the human nose. Hyaline cartilage is also found at the ends of long bones, reducing friction and cushioning the articulations of these bones.

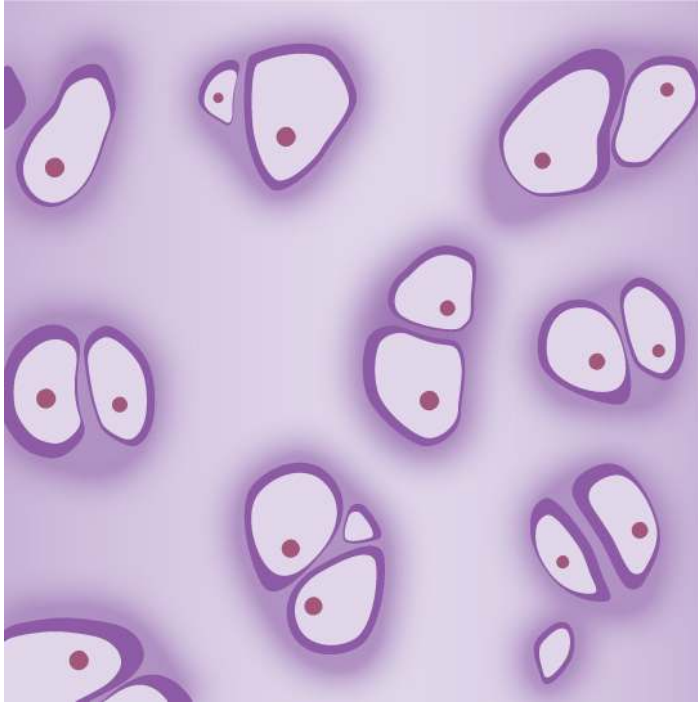


Figure 9. Hyaline cartilage consists of a matrix with cells called chondrocytes embedded in it. The chondrocytes exist in cavities in the matrix called lacunae.

Elastic cartilage has a large amount of elastic fibers, giving it tremendous flexibility. The ears of most vertebrate animals contain this cartilage as do portions of the larynx, or voice box. Fibrocartilage contains a large amount of collagen fibers, giving the tissue tremendous strength. Fibrocartilage comprises the intervertebral discs in vertebrate animals. Hyaline cartilage found in movable joints such as the knee and shoulder becomes damaged as a result of age or trauma. Damaged hyaline cartilage is replaced by fibrocartilage and results in the joints becoming “stiff.”

Bone

Bone, or osseous tissue, is a connective tissue that has a large amount of two different types of matrix material. The organic matrix is similar to the matrix material found in other connective tissues, including some amount of collagen and elastic fibers. This gives strength and flexibility to the tissue. The inorganic matrix consists of mineral salts—mostly calcium salts—that give the tissue hardness. Without adequate organic material in the matrix, the tissue breaks; without adequate inorganic material in the matrix, the tissue bends.

There are three types of cells in bone: osteoblasts, osteocytes, and osteoclasts. Osteoblasts are active in making bone for growth and remodeling. Osteoblasts deposit bone material into the matrix and, after the matrix surrounds them, they continue to live, but in a reduced metabolic state as osteocytes. Osteocytes are found in lacunae of the bone. Osteoclasts are active in breaking down bone for bone remodeling, and they

provide access to calcium stored in tissues. Osteoclasts are usually found on the surface of the tissue.

Bone can be divided into two types: compact and spongy. Compact bone is found in the shaft (or diaphysis) of a long bone and the surface of the flat bones, while spongy bone is found in the end (or epiphysis) of a long bone. Compact bone is organized into subunits called **osteons**, as illustrated in [Figure 10](#). A blood vessel and a nerve are found in the center of the structure within the Haversian canal, with radiating circles of lacunae around it known as lamellae. The wavy lines seen between the lacunae are micro channels called **canaliculi**; they connect the lacunae to aid diffusion between the cells. Spongy bone is made of tiny plates called **trabeculae** these plates serve as struts to give the spongy bone strength. Over time, these plates can break causing the bone to become less resilient. Bone tissue forms the internal skeleton of vertebrate animals, providing structure to the animal and points of attachment for tendons.

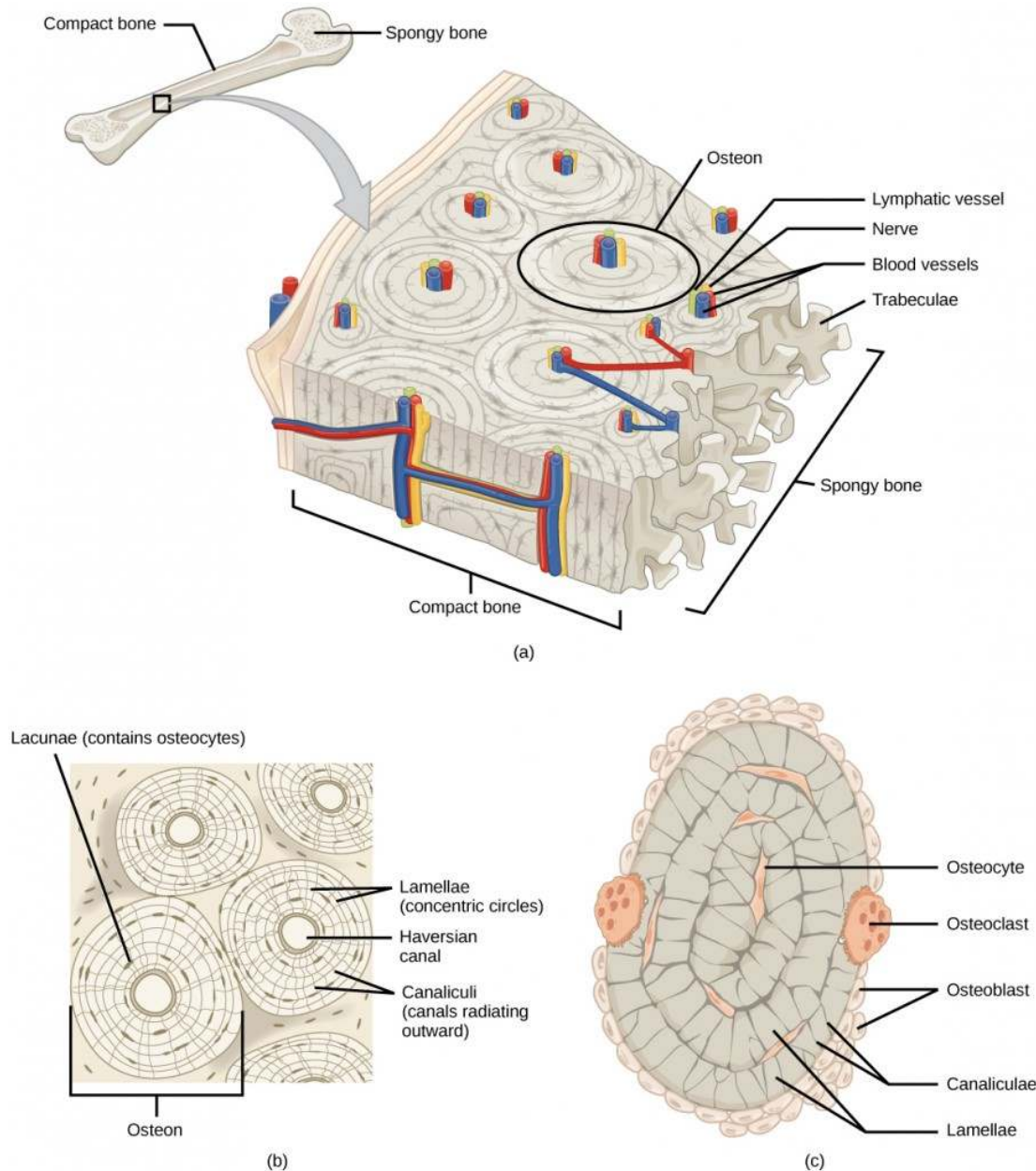


Figure 10. (a) Compact bone is a dense matrix on the outer surface of bone. Spongy bone, inside the compact bone, is porous with web-like trabeculae. (b) Compact bone is organized into rings called osteons. Blood vessels, nerves, and lymphatic vessels are found in the central Haversian canal. Rings of lamellae surround the Haversian canal. Between the lamellae are cavities called lacunae. Canaliculi are microchannels connecting the lacunae together. (c) Osteoblasts surround the exterior of the bone. Osteoclasts bore tunnels into the bone and osteocytes are found in the lacunae.

Adipose Tissue

Adipose tissue, or fat tissue, is considered a connective tissue even though it does not have fibroblasts or a real matrix and only has a few fibers. Adipose tissue is made up of

cells called adipocytes that collect and store fat in the form of triglycerides, for energy metabolism. Adipose tissues additionally serve as insulation to help maintain body temperatures, allowing animals to be endothermic, and they function as cushioning against damage to body organs. Under a microscope, adipose tissue cells appear empty due to the extraction of fat during the processing of the material for viewing, as seen in [Figure 11](#). The thin lines in the image are the cell membranes, and the nuclei are the small, black dots at the edges of the cells.

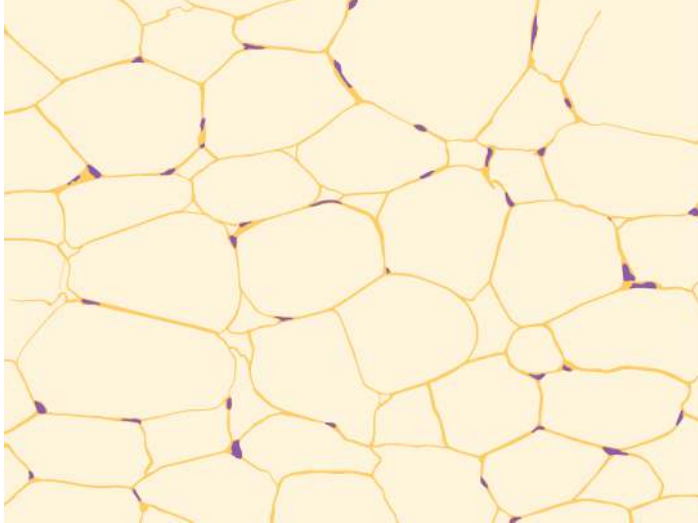


Figure 11. Adipose is a connective tissue made up of cells called adipocytes. Adipocytes have small nuclei localized at the cell edge.

Blood

Blood is considered a connective tissue because it has a matrix, as shown in [Figure 12](#). The living cell types are red blood cells (RBC), also called erythrocytes, and white blood cells (WBC), also called leukocytes. The fluid portion of whole blood, its matrix, is commonly called plasma.

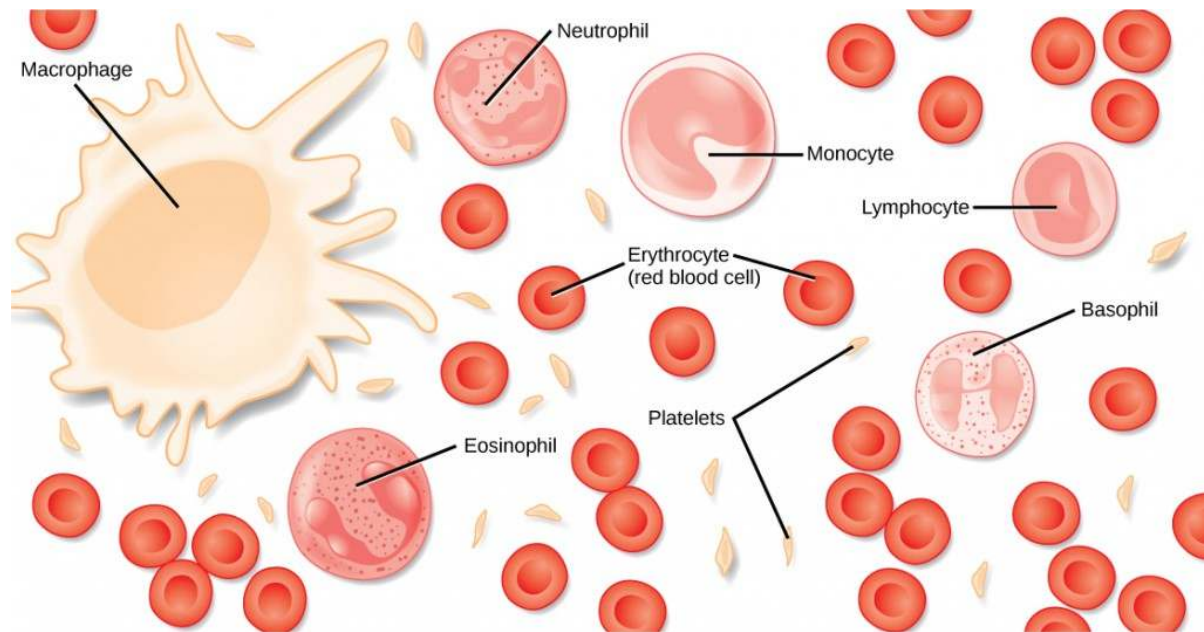


Figure 12. Blood is a connective tissue that has a fluid matrix, called plasma, and no fibers. Erythrocytes (red blood cells), the predominant cell type, are involved in the transport of oxygen and carbon dioxide. Also present are various leukocytes (white blood cells) involved in immune response.

The cell found in greatest abundance in blood is the erythrocyte. Erythrocytes are counted in millions in a blood sample: the average number of red blood cells in primates is 4.7 to 5.5 million cells per microliter. Erythrocytes are consistently the same size in a species, but vary in size between species. For example, the average diameter of a primate red blood cell is 7.5 μl , a dog is close at 7.0 μl , but a cat's RBC diameter is 5.9 μl . Sheep erythrocytes are even smaller at 4.6 μl . Mammalian erythrocytes lose their nuclei and mitochondria when they are released from the bone marrow where they are made. Fish, amphibian, and avian red blood cells maintain their nuclei and mitochondria throughout the cell's life. The principal job of an erythrocyte is to carry and deliver oxygen to the tissues.

Leukocytes are the predominant white blood cells found in the peripheral blood. Leukocytes are counted in the thousands in the blood with measurements expressed as ranges: primate counts range from 4,800 to 10,800 cells per μl , dogs from 5,600 to 19,200 cells per μl , cats from 8,000 to 25,000 cells per μl , cattle from 4,000 to 12,000 cells per μl , and pigs from 11,000 to 22,000 cells per μl .

Lymphocytes function primarily in the immune response to foreign antigens or material. Different types of lymphocytes make antibodies tailored to the foreign antigens and control the production of those antibodies. Neutrophils are phagocytic cells and they participate in one of the early lines of defense against microbial invaders, aiding in the removal of bacteria that has entered the body. Another leukocyte that is found in the peripheral blood is the monocyte. Monocytes give rise to phagocytic macrophages that clean up dead and damaged cells in the body, whether they are foreign or from the host.

animal. Two additional leukocytes in the blood are eosinophils and basophils—both help to facilitate the inflammatory response.

The slightly granular material among the cells is a cytoplasmic fragment of a cell in the bone marrow. This is called a platelet or thrombocyte. Platelets participate in the stages leading up to coagulation of the blood to stop bleeding through damaged blood vessels. Blood has a number of functions, but primarily it transports material through the body to bring nutrients to cells and remove waste material from them.

Muscle Tissues

There are three types of muscle in animal bodies: smooth, skeletal, and cardiac. They differ by the presence or absence of striations or bands, the number and location of nuclei, whether they are voluntarily or involuntarily controlled, and their location within the body. [Table 3](#) summarizes these differences.

Table 3. Types of Muscles

Type of Muscle	Striations	Nuclei	Control	Location
smooth	no	single, in center	involuntary	visceral organs
skeletal	yes	many, at periphery	voluntary	skeletal muscles
cardiac	yes	single, in center	involuntary	heart

Smooth Muscle

Smooth muscle does not have striations in its cells. It has a single, centrally located nucleus, as shown in [Figure 13](#). Constriction of smooth muscle occurs under involuntary, autonomic nervous control and in response to local conditions in the tissues. Smooth muscle tissue is also called non-striated as it lacks the banded appearance of skeletal and cardiac muscle. The walls of blood vessels, the tubes of the digestive system, and the tubes of the reproductive systems are composed of mostly smooth muscle.

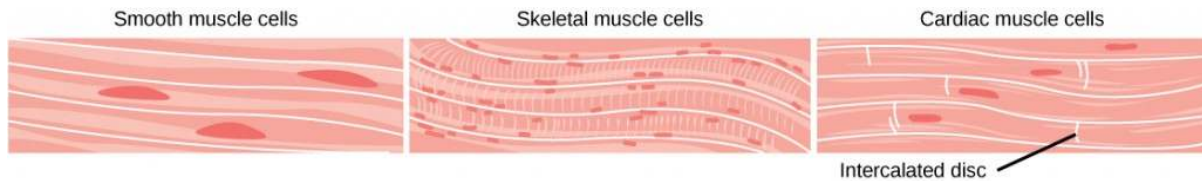


Figure 13. Smooth muscle cells do not have striations, while skeletal muscle cells do. Cardiac muscle cells have striations, but, unlike the multinucleate skeletal cells, they have only one nucleus. Cardiac muscle tissue also has intercalated discs, specialized regions running along the plasma membrane that join adjacent cardiac muscle cells and assist in passing an electrical impulse from cell to cell.

Skeletal Muscle

Skeletal muscle has striations across its cells caused by the arrangement of the contractile proteins actin and myosin. These muscle cells are relatively long and have multiple nuclei along the edge of the cell. Skeletal muscle is under voluntary, somatic nervous system control and is found in the muscles that move bones. [Figure 13](#) illustrates the histology of skeletal muscle.

Cardiac Muscle

Cardiac muscle, shown in [Figure 13](#), is found only in the heart. Like skeletal muscle, it has cross striations in its cells, but cardiac muscle has a single, centrally located nucleus. Cardiac muscle is not under voluntary control but can be influenced by the autonomic nervous system to speed up or slow down. An added feature to cardiac muscle cells is a line that extends along the end of the cell as it abuts the next cardiac cell in the row. This line is called an intercalated disc: it assists in passing electrical impulse efficiently from one cell to the next and maintains the strong connection between neighboring cardiac cells.

Nervous Tissues

Nervous tissues are made of cells specialized to receive and transmit electrical impulses from specific areas of the body and to send them to specific locations in the body. The main cell of the nervous system is the neuron, illustrated in [Figure 14](#). The large structure with a central nucleus is the cell body of the neuron. Projections from the cell body are either dendrites specialized in receiving input or a single axon specialized in transmitting impulses. Some glial cells are also shown. Astrocytes regulate the chemical environment of the nerve cell, and oligodendrocytes insulate the axon so the electrical nerve impulse is transferred more efficiently. Other glial cells that are not shown support the nutritional and waste requirements of the neuron. Some of the glial cells are phagocytic and remove debris or damaged cells from the tissue. A nerve consists of neurons and glial cells.

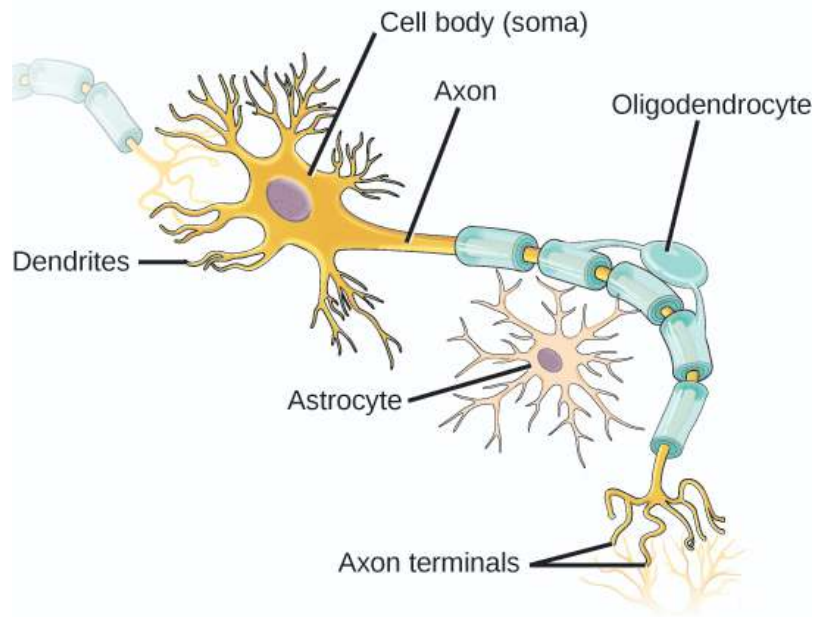


Figure 14. The neuron has projections called dendrites that receive signals and projections called axons that send signals. Also shown are two types of glial cells: astrocytes regulate the chemical environment of the nerve cell, and oligodendrocytes insulate the axon so the electrical nerve impulse is transferred more efficiently.

Exercises

- Which of the following statements about types of epithelial cells is false?
 - Simple columnar epithelial cells line the tissue of the lung.
 - Simple cuboidal epithelial cells are involved in the filtering of blood in the kidney.
 - Pseudostratified columnar epithelia occur in a single layer, but the arrangement of nuclei makes it appear that more than one layer is present.
 - Transitional epithelia change in thickness depending on how full the bladder is.
- State whether each of the following processes are regulated by a positive feedback loop or a negative feedback loop.
 - A person feels satiated after eating a large meal.
 - The blood has plenty of red blood cells. As a result, erythropoietin, a hormone that stimulates the production of new red blood cells, is no longer released from the kidney.
- When bacteria are destroyed by leucocytes, pyrogens are released into the blood. Pyrogens reset the body's thermostat to a higher temperature, resulting in fever. How might pyrogens cause the body temperature to rise?
- Which type of animal maintains a constant internal body temperature?
 - endotherm
 - ectotherm

- C. coelomate
- D. mesoderm

5. The symmetry found in animals that move swiftly is _____.
A. radial
B. bilateral
C. sequential
D. interrupted
6. What term describes the condition of a desert mouse that lowers its metabolic rate and “sleeps” during the hot day?
A. turgid
B. hibernation
C. estivation
D. normal sleep pattern
7. A plane that divides an animal into equal right and left portions is _____.
A. diagonal
B. midsagittal
C. coronal
D. transverse
8. A plane that divides an animal into dorsal and ventral portions is _____.
A. sagittal
B. midsagittal
C. coronal
D. transverse
9. The pleural cavity is a part of which cavity?
A. dorsal cavity
B. thoracic cavity
C. abdominal cavity
D. pericardial cavity
10. Which type of epithelial cell is best adapted to aid diffusion?
A. squamous
B. cuboidal
C. columnar
D. transitional
11. Which type of epithelial cell is found in glands?
A. squamous

- B. cuboidal
- C. columnar
- D. transitional

12. Which type of epithelial cell is found in the urinary bladder?

- A. squamous
- B. cuboidal
- C. columnar
- D. transitional

13. Which type of connective tissue has the most fibers?

- A. loose connective tissue
- B. fibrous connective tissue
- C. cartilage
- D. bone

14. Which type of connective tissue has a mineralized different matrix?

- A. loose connective tissue
- B. fibrous connective tissue
- C. cartilage
- D. bone

15. The cell found in bone that breaks it down is called an _____.

- A. osteoblast
- B. osteocyte
- C. osteoclast
- D. osteon

16. The cell found in bone that makes the bone is called an _____.

- A. osteoblast
- B. osteocyte
- C. osteoclast
- D. osteon

17. Plasma is the _____.

- A. fibers in blood
- B. matrix of blood
- C. cell that phagocytizes bacteria
- D. cell fragment found in the tissue

18. The type of muscle cell under voluntary control is the _____.

- A. smooth muscle

- B. skeletal muscle
- C. cardiac muscle
- D. visceral muscle

19. The part of a neuron that contains the nucleus is the

- A. cell body
- B. dendrite
- C. axon
- D. glial

20. When faced with a sudden drop in environmental temperature, an endothermic animal will:

- A. experience a drop in its body temperature
- B. wait to see if it goes lower
- C. increase muscle activity to generate heat
- D. add fur or fat to increase insulation

21. Which is an example of negative feedback?

- A. lowering of blood glucose after a meal
- B. blood clotting after an injury
- C. lactation during nursing
- D. uterine contractions during labor

22. Which method of heat exchange occurs during direct contact between the source and animal?

- A. radiation
- B. evaporation
- C. convection
- D. conduction

23. The body's thermostat is located in the _____.

- A. homeostatic receptor
- B. hypothalamus
- C. medulla
- D. vasodilation center

24. How does diffusion limit the size of an organism? How is this counteracted?

25. What is the relationship between BMR and body size? Why?

26. How can squamous epithelia both facilitate diffusion and prevent damage from abrasion?

27. What are the similarities between cartilage and bone?

28. Why are negative feedback loops used to control body homeostasis?
29. Why is a fever a “good thing” during a bacterial infection?
30. How is a condition such as diabetes a good example of the failure of a set point in humans?

Answers

1. A
2. Both processes are the result of negative feedback loops. Negative feedback loops, which tend to keep a system at equilibrium, are more common than positive feedback loops.
3. Pyrogens increase body temperature by causing the blood vessels to constrict, inducing shivering, and stopping sweat glands from secreting fluid.
4. A
5. B
6. C
7. B
8. D
9. B
10. C
11. B
12. D
13. B
14. D
15. C
16. A
17. B
18. B
19. B
20. C
21. A
22. D
23. B
24. Diffusion is effective over a very short distance. If a cell exceeds this distance in its size, the center of the cell cannot get adequate nutrients nor can it expel enough waste to survive. To compensate for this, cells can loosely adhere to each other in a

liquid medium, or develop into multi-celled organisms that use circulatory and respiratory systems to deliver nutrients and remove wastes.

25. Basal Metabolic Rate is an expression of the metabolic processes that occur to maintain an individual's functioning and body temperature. Smaller bodied animals have a relatively large surface area compared to a much larger animal. The large animal's large surface area leads to increased heat loss that the animal must compensate for, resulting in a higher BMR. A small animal, having less relative surface area, does not lose as much heat and has a correspondingly lower BMR.
26. Squamous epithelia can be either simple or stratified. As a single layer of cells, it presents a very thin epithelium that minimally inhibits diffusion. As a stratified epithelium, the surface cells can be sloughed off and the cells in deeper layers protect the underlying tissues from damage.
27. Both contain cells other than the traditional fibroblast. Both have cells that lodge in spaces within the tissue called lacunae. Both collagen and elastic fibers are found in bone and cartilage. Both tissues participate in vertebrate skeletal development and formation.
28. An adjustment to a change in the internal or external environment requires a change in the direction of the stimulus. A negative feedback loop accomplishes this, while a positive feedback loop would continue the stimulus and result in harm to the animal.
29. Mammalian enzymes increase activity to the point of denaturation, increasing the chemical activity of the cells involved. Bacterial enzymes have a specific temperature for their most efficient activity and are inhibited at either higher or lower temperatures. Fever results in an increase in the destruction of the invading bacteria by increasing the effectiveness of body defenses and an inhibiting bacterial metabolism.
30. Diabetes is often associated with a lack in production of insulin. Without insulin, blood glucose levels go up after a meal, but never go back down to normal levels.

Glossary

cartilage: type of connective tissue with a large amount of ground substance matrix, cells called chondrocytes, and some amount of fibers

chondrocyte: cell found in cartilage

columnar epithelia: epithelia made of cells taller than they are wide, specialized in absorption

connective tissue: type of tissue made of cells, ground substance matrix, and fibers

cuboidal epithelia: epithelia made of cube-shaped cells, specialized in glandular functions

dorsal cavity: body cavity on the posterior or back portion of an animal; includes the cranial and vertebral cavities

ectotherm: animal incapable of maintaining a relatively constant internal body temperature

endotherm: animal capable of maintaining a relatively constant internal body temperature

epithelial tissue: tissue that either lines or covers organs or other tissues

estivation: torpor in response to extremely high temperatures and low water availability

fibrous connective tissue: type of connective tissue with a high concentration of fibers

hibernation: torpor over a long period of time, such as a winter

homeostasis: dynamic equilibrium maintaining appropriate body functions

lacuna: space in cartilage and bone that contains living cells

matrix: component of connective tissue made of both living and non-living (ground substances) cells

negative feedback loop: feedback to a control mechanism that increases or decreases a stimulus instead of maintaining it

osteon: subunit of compact bone

positive feedback loop: feedback to a control mechanism that continues the direction of a stimulus

pseudostratified: layer of epithelia that appears multilayered, but is a simple covering

set point: midpoint or target point in homeostasis

simple epithelia: single layer of epithelial cells

squamous epithelia: type of epithelia made of flat cells, specialized in aiding diffusion or preventing abrasion

stratified epithelia: multiple layers of epithelial cells

torpor: decrease in activity and metabolism that allows an animal to survive adverse conditions

trabecula: tiny plate that makes up spongy bone and gives it strength