

Chapter 40

Animal Form and Function: Organ Systems, Tissues and Histology.

Notes:

Organisms must take in food, nutrients, and oxygen from their environment. They must also expel metabolic waste products back into their environment. In the early days of life on earth, most organisms were small (and single-celled) and lived in the ocean, making this exchange easy. They absorbed what they needed from the water, and excreted their waste products back into the water, with their entire body serving as an **exchange membrane**. As organisms became multicellular, such exchange with the environment became more difficult (see Figures 40.3 and 40.4). Finally, organisms left the water and lived on land, making direct and constant contact with the water impossible.

Life would be impossible for large organisms living outside the ocean if not for four 'tricks.' First, large, multi-cellular organisms have a series of internal tubes that carry fresh nutrients to, and remove waste products from the cells (**a circulatory system**). This eliminates the need for all of the cells to be in contact with the ocean. Second, the delicate membranes that exchange chemicals and nutrients with the environment are kept moist and protected by being located inside the body, rather than on the body surface (ie-the inner surface of the lungs). Third, the surface area of these exchange membranes can be increased by **folding** them many times (ie-lungs, gills, villi in intestines). Finally, several specialized 'organ systems' were developed to carry out specific parts of the metabolic processes (ie-one series of tubes and organs responsible for intake and digestion of food, another for circulation of blood, another for filtering liquid wastes etc. See Figure 40.4).

This lecture is an introduction to the specialized tissues and organ systems that animals have. Tissues are made of specialized cells, and organs are made of specialized tissues. The functional part of an organ is called the **parenchyma**, and the structural part of an organ is called the **stroma**. Thus, an organ is composed of both **parenchymal** and **stromal** tissue.

General Organ Systems in Mammals (Figure 40.1):

1. **Digestive System:** responsible for digesting food, and eliminating food wastes. Includes the mouth, pharynx, esophagus, stomach, intestines, liver, and anus.
2. **Circulatory System:** responsible for circulating fluid (blood) to all the cells. Includes the heart and blood vessels.
3. **Respiratory system:** responsible for breathing (oxygen intake and carbon dioxide removal). Includes the trachea (upper respiratory system) and lungs (lower respiratory system).
4. **Lymphatic system:** Responsible for the immune system, and the body's defense against bacterial and viral infections. Includes the bone marrow, lymph nodes, thymus, spleen and white blood cells (B Cells and T Cells etc.).

5. **Excretory system:** Removal of metabolic wastes (urine), and regulation of osmotic balance of blood (regulation of blood pressure). Includes the kidneys, urinary bladder and ureters.
6. **Endocrine system:** Responsible for production of hormones that regulate body temperature, metabolic rate, sleeping and waking cycles etc. Includes several glands, including the pituitary gland, adrenal glands, thyroid and pancreas (note, pancreas is also considered part of the digestive system).
7. **Reproductive system:** responsible for mating and reproduction. Includes the testes, ovaries, uterus, and sexual organs.
8. **Nervous system:** Responsible for ‘thinking,’ as well as movement, sensation, reflexes etc. Includes the brain, spinal cord, nerves and sensory organs.
9. **Integumentary system:** Also known as the skin, is responsible for holding the body together, preventing loss of moisture, and providing a barrier to infection. Includes the skin, hair, claws, finger nails, sweat glands etc.
10. **Skeletal system:** Provides structural support for the body. Includes bones, tendons, ligaments, cartilage.
11. **Muscular system:** Facilitates body movement etc.

In addition to the organ systems, the **tissue types** in the body are divided into four broad categories. The study of the various types of tissues that make up the body is called **Histology**.

1. **Epithelial Tissue:** Tightly packed cells that cover the surface of the body, and also line the internal body cavities. Most glands and organs are made of epithelial tissue. The side of an epithelial cell that faces the outside of the body, or the lumen of an internal body cavity is called the **apical surface** of the cell. The opposite end is called the **basal surface**. Epithelial tissue can be divided into five subtypes.
 - a. **Cuboidal Epithelium:** Cells are cube shaped. (Example: thyroid gland, salivary glands.)
 - b. **Simple Squamous Epithelium:** Cells are thin and flattened, forming a single layer. (example: Alveoli of lungs, blood vessels, capillary beds.)
 - c. **Stratified Squamous Epithelium:** Several layers of squamous cells. (Example: the skin.)
 - d. **Simple Columnar Epithelium:** Cells are rectangular, rather than flat or cuboidal. (Example: intestines. Intestinal cells also have villi (finger like projections) to increase their surface area.)
 - e. **Pseudostratified Columnar Epithelium:** ‘Stratified’ means to have several layers (like stratified squamous epithelium). ‘Pseudostratified’ means to *appear* to have several layers, when there is actually only one. There appear to be several layers because the columnar cells are not all the same height, and not all penetrate to the surface or lumen which they are facing. (Example: Trachea.) In **Pathology** (the study of disease), there are many example of columnar or cuboidal epithelium flattening out and turning into squamous cells as a result of constant ‘insult’ (repeated minor injury). An example would be the way the columnar cells lining the trachea flatten into flat squamous cells in people who smoke. This is called **squamous cell metaplasia**.

2. **Muscle Tissue:** Muscle tissue is formed of contractile fibers (fibers that can contract), that allow for body movements. Muscle tissue is divided into three types.
 - a. **Skeletal Muscle (Striated Muscle):** Large muscles attached to the long bones of the body facilitate movement. Composed of bundles of fibers which form when several muscle cells fuse together. Contractile units called **sarcomeres**, which run perpendicular to the fibers, give the muscle tissue its striped ('striated') look.
 - b. **Smooth Muscle:** Lines many organs, allowing them to contract. (Example: line the urinary bladder, arteries, stomach, intestines.)
 - c. **Cardiac Muscle:** Forms most of the heart. Similar to striated muscle, but contains **intercalated discs** that transmit the electrical signals from one cell to the next, allowing heart beats to be synchronized.
3. **Nervous Tissue:** Contains neurons. Neurons are cells capable of generating an electric potential used for thinking (brain), sensory functions, and muscle control. Two types of cells make up nervous tissue.
 - a. **Neurons:** cells that generate an electrical potential, and transmit signals (ie-brain 'grey matter').
 - b. **Glia:** cells that either service (with nutrients) or insulate the neurons (ie-brain 'white matter.')
4. **Connective Tissue:** This is a somewhat artificial classification of tissues, because it includes several types of tissues that are very different from one another. The five broad subclasses of connective tissue include:
 - a. **Blood.**
 - b. **Cartilage:** the hard but flexible tissue that makes up the fins of fish, and parts of the human nose, ears etc. Cells called **chondrocytes** are embedded in cartilage, and secrete the **collagen** and **chondroitin sulfate** that cartilage is made of.
 - c. **Adipose Tissue:** also known as fat tissue, is composed of cells that store fats as an energy reserve.
 - d. **Bone:** Cells called **osteoblasts** or **osteocytes** begin by laying down a matrix of **collagen** which eventually becomes 'mineralized' by absorbing **calcium phosphate**. The collagen then hardens as a result of absorbing the calcium phosphate, a process called **ossification**. The basic unit of a bone is called an **osteon**, which is a series of concentric rings of bone fiber surrounding a central canal, through which blood vessels and sometimes nerves pass.
 - e. **Loose Connective Tissue:** A loose collection of cells and extracellular matrix (collagen and elastin) that connects layers of epithelia to underlying tissues, and holds organs together. (When someone 'skins' an animal to obtain its fur, the tearing sound is made by the loose connective tissue being torn.)
 - f. **Fibrous Connective Tissue:** Composed of cells that lay down dense, well organized layers of connective tissue made of collagen and elastin. Includes **tendons**, which attach muscles to bones, and **ligaments**, which attach bones to joints.

PRACTICE QUESTIONS:

Extended Matching Question: Match the term to the definition.

- | | |
|-------------------------------------|---|
| A. Adipose | M. Lumen |
| B. Alveoli (alveolus) | N. Ossification |
| C. Apical (Apex) | O. Osteoblast |
| D. Cartilage | P. Osteon |
| E. Chondrocyte | Q. Plasma |
| F. Chondroitin sulfate and Collagen | R. Pseudostratified columnar epithelium |
| G. Connective tissue | S. Renal |
| H. Cuboidal epithelium | T. Simple columnar epithelium |
| I. Epithelium | U. Simple squamous epithelium |
| J. Fibrous connective tissue | V. Tendons |
| K. Hepatocyte | W. Villi |
| L. Ligaments | |

1. General term for the tissue type that lines the body, and the inner surfaces of body cavities.
2. Name for a liver cell.
3. Refers to the inside (hollow part) of a tube, such as an intestine or blood vessel.
4. The process of converting newly formed cartilage into bone.
5. Refers to the part of an epithelial cell that faces outside the body, or faces the lumen of an internal body cavity.
6. Name for the liquid component of blood. (Contains water, salts, proteins and sugars, but NOT blood cells.)
7. A circular arrangement of bone that surrounds a central canal containing blood vessels and/or neurons.
8. A type of epithelial tissue that lines the intestines.
9. The things that attach muscles to bones.
10. The things that attach bones to joints.
11. A hard, flexible, rubbery substance that makes up the fins and tails of fish, and parts of the human nose (for example).
12. Specific type of connective tissue that makes up tendons.
13. Blood belongs to this tissue classification.
14. A type of epithelial tissue that lines the UPPER respiratory tract, and has finger-like cilia on it.
15. Name for the microscopic air sacks that make up the lungs.
16. A type of epithelial tissue that lines the lungs, forming a thin barrier between the air inside the lungs and the blood vessels.
17. Another name referring to fat tissue.
18. A type of epithelial tissue that lines the inner surfaces of blood vessels.
19. Two main substances secreted by the cells that make cartilage
20. A type of cell found in cartilage, that secretes collagen and chondroitin sulfate.
21. Another name referring to the kidneys.
22. A type of epithelial tissue made of rectangular cells that are not all the same height.
23. A type of epithelial tissue made of several, stacked layers of flat, thin cells.

24. Another name for a liver cell.
25. Finger-like projections protruding from the cells that line the intestines, which increase the absorbent surface.
26. A type of epithelial tissue where the cells are perfectly square.
27. A type of epithelial tissue that makes up the outer surface of the skin.

SYSTEMS BIOLOGY: Match the organ to the system:

- | | |
|------------------------------------|-------------------------|
| A. Digestive system | G. Endocrine system |
| B. Circulatory system | H. Reproductive system |
| C. Respiratory system | I. Nervous system |
| D. Lymphatic system | J. Integumentary system |
| E. Excretory system (Renal system) | K. Skeletal system |
| F. Renal system | L. Muscular system |

1. Responsible for immunity to diseases (viruses, bacterial infections etc.).
2. Responsible for breathing.
3. Responsible for filtering waste products from the blood.
4. Includes the heart.
5. Includes the uterus.
6. Includes the kidneys.
7. Includes blood vessels.
8. Includes the hair.
9. Includes the ovaries.
10. Includes B Cells.
11. Includes the brain.
12. Includes the urinary bladder.
13. Includes the thymus.
14. Includes the thyroid.
15. Includes the pituitary gland.
16. Includes the adrenal glands.
17. Includes the testes.
18. Includes the spinal cord.
19. Includes the kidneys.
20. Includes the lungs.
21. Includes the stomach.
22. Includes the trachea.
23. Includes white blood cells.
24. Includes the lymph nodes.
25. Includes the intestines.
26. Includes the pancreas.
27. Includes the spleen.
28. Is responsible for the breakdown of food.
29. Includes the mouth.
30. Includes the esophagus.
31. Is commonly referred to as the skin.

- 32. Includes tendons and ligaments.
- 33. Responsible for body movement.
- 34. Includes the urinary bladder.

TISSUE MATCHING QUESTIONS:

Overview of Tissue Types: Match the description to the GENERAL tissue type.

- A. Epithelial Tissue
- B. Connective Tissue
- C. Muscle Tissue
- D. Nervous Tissue

- 1. Bone
- 2. Cells forming the inside of the lungs
- 3. Cartilage
- 4. Cells inside the spinal column
- 5. Blood
- 6. Skin tissue
- 7. Cells lining the inside of blood vessels
- 8. Tendons
- 9. Fat tissue
- 10. Heart
- 11. Mucous membranes inside the nose
- 12. Cells inside the brain
- 13. Skin
- 14. Lining of the intestines
- 15. Cells lining the trachea
- 16. Cells making up glands, like the Thyroid Gland

Tissues in Detail: Match the description to the SPECIFIC tissue type:

- | | |
|---|------------------------------|
| A. Cuboidal Epithelium | H. Bone |
| B. Simple Columnar Epithelium | I. Fibrous connective tissue |
| C. Pseudostratified Columnar Epithelium | J. Loose connective tissue |
| D. Simple Squamous Epithelium | K. Skeletal muscle |
| E. Stratified Squamous Epithelium | L. Smooth muscle |
| F. Cartilage | M. Cardiac muscle |
| G. Adipose tissue | N. Neurons |
| | O. Glia |

- 1. Type of epithelial tissue where the cells are perfectly square.
- 2. Bundles of contractile cells that attach to the leg bones, and allow us to run.
- 3. Type of dense tissue that tendons and ligaments are made of.
- 4. Cells that feed, or insulate neurons.
- 5. Type of epithelial tissue where rectangular cells are not all the same height.

6. Contractile cells that form most of the heart.
7. Type of epithelial tissue where the cells form a single layer of flat, thin cells.
8. Cells that stimulate muscle cells with electrical impulses.
9. Contractile cells that line the urinary bladder.
10. Type of epithelial tissue where the cells form several layers of flat, thin cells.
11. Hard but flexible material made by substances secreted by chondrocytes.
12. Fat storage tissue.
13. Made of osteons.
14. Forms the skin.
15. Forms many glands, such as the thyroid gland.
16. Lines the intestines.
17. Lines the trachea.
18. Contains osteoblasts.
19. Contains intercalated disks.
20. Contains sarcomeres.

Short Answer Questions:

1. What type of tissue lines the inner surface of most body cavities (ie-intestines, lungs, blood vessels)?
2. What type of tissue is blood classified as?
3. What type of tissue forms cartilage?
4. What type of tissue forms tendons?
5. What type of tissue forms adipose tissue?
6. What type of tissue is most of the heart made of?
7. What type of tissue lines the inner surface of the intestines?
8. What type of tissue is responsible for the contractions of the stomach?
9. What type of tissue lines the inner surface of blood vessels?
10. What type of tissue forms the inner surface of the lungs?
11. Which type of tissue has fibroblasts and macrophages imbedded in it?
12. What do you call the part of an epithelial cell that faces either the outside of the body, or the lumen of an internal cavity? What do you call the opposite part? (2 points)
13. List the five types of epithelial tissue we have discussed in class. (5 points)
14. In pathology, what term do you use to describe the conversion of cuboidal or columnar epithelium into squamous cell epithelium do to constant 'insult' to the tissue? (2 points)
15. What do you call the process of converting collagen into bone?
16. What minerals are added to collagen to convert it into bone?
17. What do you call the central unit of a bone, consisting of concentric rings surrounding a central canal?
18. What do you call a cell that secretes collagen and chondroitn sulfate that cartilage is made of?
19. What do you call a cell that gives rise to bone (secretes collagen etc., that is ultimately converted to bone)?
20. What do you call a liver cell? (ie-what prefix refers to the lever?)
21. What is another name for the 'kidney system'?
22. If you were a cell called a hepatocyte, which organ would you be found in?

23. If you were a cell called an osteoblast, where would you probably be found?
24. If you were a cell called a fibroblast, what kind of tissue would you probably be found in?
25. If you were an osteon, where would you be found, and what would you be surrounding?
26. What bone structures do blood vessels and nerves run through?
27. Which organ system includes the intestines?
28. Which organ system includes the heart?
29. Which organ system includes the lungs?
30. Which organ system includes the adrenal glands?
31. Which organ system includes lymph nodes?
32. Which organ system is commonly referred to as the skin?
33. What do you call something that joins a muscle to a bone, and what is it made of?
34. What do you call something that joins a bone to a joint, and what is it made of?

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