CHAPTER 33 ANIMAL ORGANIZATION AND HOMEOSTASIS

Chapter Outline

33.1 Types of Tissues

A. Levels of Organization
   1. The levels of organization are: cells, tissues, organs, and organ systems.
   2. The structure and function of each level depends on structure and function of organ, tissue, and cell type.

B. Four Major Types of Tissue
   1. Epithelial tissue covers body surfaces and lines body cavities.
   2. Connective tissue binds and supports body parts.
   3. Muscular tissue causes body parts to move.
   4. Nervous tissue responds to stimuli and transmits impulses.

C. Epithelial Tissues
   1. **Epithelial tissue** forms a continuous layer over the body surfaces including inner cavities.
   2. There are three types of epithelial tissue.
      a. **Squamous epithelium** is composed of flat cells (e.g., air sac linings of lungs, walls of capillaries).
      b. **Cuboidal epithelium** has cube-shaped cells.
      c. **Columnar epithelium** has elongated cells that resemble pillars or columns (e.g., small intestine).
   3. Epithelium varies in the number of cell layers.
      a. **Simple epithelium** has one cell layer; all cells contact a basement membrane.
      b. **Pseudostratified epithelium** appears layered but actually, all cells contact the basement membrane.
      c. **Stratified epithelium** is composed of more than one layer of cells.
   4. Epithelial cells can have cilia.
      a. **Ciliated epithelium** cells are covered with cilia (e.g., lining of human respiratory tract).
      b. Cilia can bend and move material over the surface of the epithelium.
   5. Secretory epithelia can be unicellular or have multicellular glands.
      a. **Glands** are a single cell or a group of cells that secrete products into the lumen of or onto the lining of a tube or cavity, into blood, or to outside of the body; they are classified in two types:
         1) **Exocrine glands** secrete their products into ducts or directly into a tube or cavity.
         2) **Endocrine glands** secrete their product directly into the bloodstream.
   6. Epithelium forms the outer layer of skin of animals.
   7. Epithelial tissue cells are packed tightly; they join to one another in one of three ways:
      a. **Tight junctions** have plasma proteins extending between neighboring cells to bind cells tightly.
      b. **Adhesion junctions** have cytoskeletal elements joining internal plaques in neighboring cells.
      c. **Gap junctions** form when two identical plasma membrane channels of neighboring cells join so that ions and small molecules pass between cells.

D. Connective Tissues
   1. **Connective tissue** binds structures together, provides support and protection, fills spaces, stores fat, and forms blood cells.
   2. Connective tissue provides source cells for muscle and skeletal cells in animals that regenerate parts.
   3. Connective tissue cells are separated widely by a matrix, a noncellular material between cells.
   4. Loose Fibrous and Dense Fibrous Connective Tissues
      a. Cells of loose and fibrous connective tissues are **fibroblasts**.
      b. Fibroblasts are spaced apart and are separated by a jelly matrix of white collagen fibers and yellow elastic fibers.
      c. Collagen fibers provide flexibility and strength; elastic fibers provide elasticity.
      d. **Loose fibrous connective tissue** supports epithelium and provides support, flexibility, and protective covering encasing many internal organs.
      e. **Dense fibrous connective tissue** contains closely packed collagenous fibers; it is found in **tendons**, which attach muscles to bone, and **ligaments**, which bind bones to other bones at joints.

5. Adipose Tissue and Reticular Connective Tissue
    a. **Adipose Tissue**
        1) This is loose connective tissue that insulates the body, provides protective padding, and stores fat.
        2) In mammals, adipose tissue is beneath the skin, around the kidneys, and on surface of the heart.
    b. **Reticular Connective Tissue**
        1) This tissue is present in lymph nodes, spleen, and bone marrow.
        2) Reticular fibers, associated with **reticular cells** resembling fibroblasts, support free blood cells.
6. Cartilage and Bone
    a. Cartilage and bone are rigid connective tissues.
    b. Structural proteins (cartilage) or calcium salts (bone) are deposited in intercellular matrix.
    c. **Cartilage** cells or **chondrocytes** lie in small chambers or **lacunae** embedded in a strong, flexible matrix.
        1) In some animals, such as sharks and rays, the entire skeleton is cartilage.
        2) The human fetal skeleton is entirely cartilage but it is gradually replaced by bone.
        4) Cartilage is retained at the end of long bones, the human nose, the framework of the human ear, in the walls of respiratory ducts, and within intervertebral discs.
    d. In **bone**, a matrix of calcium salts is deposited around protein fibers.
        1) Calcium salts give bone rigidity while protein fibers provide elasticity and strength.
        2) **Compact** bone has cells called **osteocytes** that lie within lacunae arranged in concentric circles within **osteons** (Haversian systems) around tiny tubes called **central canals**.
        3) These canals contain nerve fibers and blood vessels.
        4) Nutrients brought by the blood reach all of the cells via minute canals (canaliculi) containing thin processes of osteocytes that connect them with one another and with the central canals.
        5) **Spongy bone** at end of long bones is designed for strength, and has many long bony bars and plates.

E. Blood
1. Blood transports nutrients and oxygen to cells and removes CO_2 and wastes; blood also has a role in fluid, ion and pH balance and distributes heat.
2. Blood is a connective tissue with cells separated by liquid **plasma**.
3. In vertebrates, the blood cells are mainly of two types.
    a. **Red blood cells (erythrocytes)** carry oxygen.
    b. **White blood cells (leukocytes)** aid in fighting infection.
4. **Platelets** present in **plasma** are fragments of giant cells found in bone marrow; and play a role in blood clotting.
5. Unlike other connective tissues, the intercellular matrix of blood (i.e., plasma) is not made by the cells; instead, the plasma is a mixture of molecules that enter the blood at various locations.

F. Muscular Tissue
1. **Muscular (contractile) tissue** is composed of cells called **muscle fibers**.
2. **Muscle fibers** contain actin and myosin filaments; interactions result in animal movement.
3. The three types of vertebrate muscle tissue are skeletal, cardiac, and smooth muscle.
4. **Skeletal muscle** attaches by tendons to the bones of the skeleton.
    a. Skeletal muscle moves body parts, is under voluntary control, and contracts faster than other types.
    b. Skeletal muscle fibers are long, cylindrical, multinucleate cells arising from the fusion of several cells.
    c. Skeletal fibers are **striated** due to the light and dark bands of overlapping actin and myosin filaments.
5. **Smooth (visceral) muscle** is not striated.
    a. Spindle-shaped fibers form layers with the thick middle portion of one fiber opposite the thin ends of adjacent fibers.
    b. The nuclei form an irregular pattern in the tissue.
    c. Smooth muscle is not under voluntary control; it is therefore involuntary.
    d. Smooth muscle is found in the walls of viscera (e.g., intestine, stomach, etc.) and blood vessels.

e. Smooth muscles drive the intestinal contractions and blood vessel constrictions.

6. **Cardiac muscle** is found only in heart wall and powers the heartbeat that pumps blood.
   a. Cardiac muscle combines the features of both smooth and skeletal muscle.
   b. Unlike skeletal muscles with many nuclei, cardiac muscles have one centrally placed nucleus.
   c. Although it appears to be one mass of muscle fibers, the cardiac muscle fibers are individual cells.
   d. Cardiac muscle cells are bound end-to-end at intercalated disks where the folded membranes between two fibers contain desmosomes and gap junctions
   e. Impulses move from cell to cell so the heartbeat is coordinated.

G. Nervous Tissue
   1. **Nervous tissue** is contains **neurons** in the brain, spinal cord, and nerves.
   2. **Neurons** have three parts.
      a. **Dendrites** receive a stimulus and conduct signals to cell body.
      b. The **cell body** contains most of the cytoplasm and the nucleus of the neuron.
      c. The **axon** conducts nerve impulses away from cell body; long axons are covered by myelin.
   3. Long axons and dendrites form neuron fibers; bound together by connective tissue, they form nerves.
   4. The neurons detect stimuli and conduct signals to the brain or spinal cord; nerves can also lead to muscles or glands.

H. Neuroglia
   1. There are several types of **neuroglial cells** in the central nervous system.
   2. Neuroglial cells outnumber neurons nine to one; they were once thought to only support or nourish neurons.
   3. Microglial cells support neurons and also phagocytize bacterial and cellular debris.
   4. Astrocytes provide nutrients and produce a growth factor known as **glial-derived growth factor** that someday may be used to cure diseases of neural degeneration.
   5. **Oligodendrocytes** form the myelin around an axon.
   6. Neuroglia lack long processes but communicate among themselves and with neurons.

33.2 Organs and Organ Systems

A. **Organs** are combinations of two or more different tissues performing common functions.
   1. **Organ systems** are many different organs performing common functions.
   2. The skin is considered an **integumentary system** since it cannot be placed in another system; it is a system composed of skin and accessory organs (i.e., nails, hair, glands, and sensory receptors).

B. Skin as an Organ
   1. Human skin protects the underlying tissues from trauma, desiccation, radiation damage, and microbial invasion.
   2. The skin produces a precursor molecule that is converted to vitamin D after exposure to UV light.
   3. The skin also helps regulate body temperature.
   4. Laden with sensory receptors, the skin collects information about the external environment.

C. Regions of Skin
   1. The skin has both an outer epidermal layer **(epidermis)** and a deeper layer **(dermis**).
   2. The **epidermis** is the outer, thinner layer of skin.
      a. The epidermis is composed of stratified squamous epithelium.
      b. Epidermal cells are derived from the basal layer of stem cells that undergo continuous cell division underneath.
      c. The newly formed cells push to the surface away from their blood supply; they flatten and harden as they accumulate **keratin**, a hard, waterproof protein.
      d. Eventually, the keratinized cells die and are sloughed off.
      e. **Melanocytes** located in basal layer produce a **melanin** pigment that absorbs UV light, protecting deeper cells from radiation damage.
      f. Nails grow from special epidermal cells at the base of the nail in a region called the nail root.
         1) The visible portion of a nail is the nail body.
         2) Cells become keratinized as they grow out over the nail bed.
         3) The vascular dermal tissue under nail provides the pink color; the white half-moon area is the thicker germinal area.
   3. The **dermis** is fibrous connective tissue that forms a thicker and deeper layer of skin.
      a. The dermis contains both elastic fibers and collagen fibers; these run parallel with the skin surface.
      b. A **hair follicle** contains a nonliving **hair shaft** and the living **hair root** that produced it.

1) The hair shaft is formed of dead, keratinized epidermal cells that protect the surface of the skin.
2) The **arrector pili muscle** is a smooth muscle attached to the hair follicle; contracting it causes the hair to erect.
3) Follicles have **sebaceous glands** producing **sebum**, an oil secreted to lubricate both the hair and the skin.

c. The **sweat (sudoriferous) glands** are coiled tubules present in most of the regions of skin that secrete a fluid (sweat) onto the surface of skin.
d. Many small receptors are present in the dermis.
1) There are separate receptors for pressure, touch, temperature, and pain.
2) Pressure receptors have onionlike sense organs buried deep in the dermis and around joints.
3) In cats, Pacinian corpuscles are concentrated in the paws, leg joints, and abdomen.
4) Closely related sensors in the tongue of woodpeckers help them find insects in tree bark.
5) Touch receptors are flat and oval shaped; they are concentrated in fingertips, palms, lips, tongue, nipples, penis, and clitoris.
6) Heat and cold sense organs are encapsulated inside sheaths of connective tissue.
7) Nerve fibers branch out through all of the skin; free nerve endings are pain receptors.

e. The dermis contains blood vessels that constrict (you turn pale) and dilate (you blush).

3. The **subcutaneous layer** lies below dermis.
a. This is composed of loose connective tissue, including adipose tissue.
b. Adipose tissue helps insulate the body by minimizing both heat gain and heat loss.
c. This layer of adipose gives a rounded appearance to the body.
d. The excessive development of adipose tissue occurs with obesity.

4. Skin Cancer
a. There has been an increase in persons with skin cancer due to sunbathing and use of tanning machines.
b. Excessive exposure to UV radiation can convert cells in the basal layer of the epidermis into cancer cells.

D. Organ Systems
1. In most animals, individual organs function as part of **organ systems**.
2. The organ systems carry out life processes common to organisms.
3. Body Cavities
a. The human body has two main cavities: the dorsal cavity holds the brain and spinal cord, and the larger ventral cavity.
b. The **ventral cavity** located on front side of body develops from **coelom** and is divided by a muscular diaphragm in humans and other mammals.
c. The **thoracic (chest) cavity** is located in the upper part of the ventral cavity, above a muscular diaphragm, and contains heart and lungs.
d. The **abdominal cavity** is located in lower part of ventral cavity, below a muscular diaphragm, and contains the major portions of digestive and excretory systems, and much of the reproductive system.

33.3 Homeostasis

A. The cells of the body live in an **internal environment**, tissue fluid that bathes the cells of an animal's body.
1. This concept was first proposed by Claude Bernard, a famous French physiologist in 1859.
2. The internal environment (e.g., composition and temperature) must stay within normal range.
3. This relative internal stability allows animals to tolerate considerable external variation.
4. The American physiologist Walter Cannon first used the term "homeostasis."

B. **Homeostasis** is the maintenance of internal conditions in a cell or organism by means of self-regulating mechanisms that curtail fluctuations above and below a normal range.
1. The organ systems of the human body contribute to homeostasis.
a. The respiratory system adds oxygen and removes carbon dioxide; the amounts are altered to meet needs.
b. The liver removes and stores glucose as glycogen and then replaces the blood glucose levels when they lower.
c. The hormone insulin is secreted by the pancreas to regulate glucose levels.
d. The kidneys are under hormonal control to excrete wastes and salts and to maintain blood pH.

2. Although homeostasis is controlled by hormones, it is ultimately controlled by the nervous system.
3. The brain contains centers that regulate temperature and blood pressure.
4. Regulation requires a receptor that detects unacceptable levels and signals a regulator center that can direct an adaptive response; once normalcy is obtained, the receptor is no longer stimulated.
5. A **negative feedback mechanism** involves a response in which the output is counter to and cancels the input, thus decreasing the process.
    a. A house thermostat is comparable.
    b. A negative feedback causes the heater or air conditioner to maintain the temperature within narrow limits.
6. A **positive feedback mechanism** involves output that intensifies and increases the input, thereby increasing the process.
    a. Once childbirth begins, each event makes the process continue until completion.
    b. Sequences in blood clotting likewise progress to form a blood clot.

C. Regulation of Body Temperature
1. The regulatory center for body temperature is located in the hypothalamus, a part of the brain.
2. When the body temperature of the blood falls below normal, the regulatory center directs the smooth muscles of the blood vessels in the skin to constrict, which reduces the blood flow to the peripheral tissues, and thereby reduces the loss of heat to the external environment.
3. In hairy animals, the arrector pili muscles pull hairs erect forming a thicker insulation.
4. If the temperature falls even lower, the regulatory center sends nerve impulses to the skeletal muscles, initiating shivering to generate heat.
5. If the body temperature is too warm, the regulatory center directs the skin blood vessels to dilate, which increases blood flow to peripheral tissues and increases heat loss.
6. The regulatory center activates sweat glands, increasing sweat production and increasing evaporative cooling.