Introduction to Animal Body Systems – An Overview

- **Anatomy** is the study of the *structure* of an organism.
- **Physiology** is the study of the *functions* an organism performs.
- Function correlates with structure in the ***tissues*** of organisms
- **Tissues** are groups of cell with a common structure and function.
  - Different types of tissues have different structures that are especially suited to their functions.
  - A tissue may be held together by a sticky extracellular matrix that coats the cells or weaves them together in a fabric of fibers.
  - The term *tissue* is from a Latin word meaning "weave."
- Tissues are classified into ***four main categories***: epithelial tissue, connective tissue, nervous tissue, and muscle tissue.
- Occurring in sheets of tightly packed cells, **epithelial tissue** covers the outside of the body and lines organs and cavities within the body.
  - Epithelial tissue covers, lines, protects, and absorbs and/or secretes chemical solutions such as hormones and mucus.
  - The cells of a epithelium are closely joined and in many epithelia, the cells are riveted together by tight junctions.
  - The epithelium functions as a ***barrier*** protecting against mechanical injury, invasive microorganisms, and fluid loss.
  - The free surface of the epithelium is exposed to air or fluid, and the cells at the base of the barrier are attached to a **basement membrane**, a dense mat of extra cellular matrix.
- **Connective tissue** functions mainly to bind and support other tissues.
  - Connective tissues have a sparse population of cells scattered through an extra cellular matrix.
  - The matrix generally consists of a web of *fibers* embedding in a uniform foundation that may be liquid, jellylike, or solid
  - In most cases, the connective tissue cells secrete the matrix.
- There are three kinds of *connective tissue fibers*, which are all proteins: collagenous fibers, elastic fibers, and reticular fibers.
- The major types of connective tissues in vertebrates are ***loose*** connective tissue, ***adipose*** tissue, ***fibrous*** connective tissue, ***cartilage***, ***bone***, and ***blood***.
  - Each has a structure correlated with its specialized function.
- **Loose connective tissue** binds epithelia to underlying tissues and functions as packing materials, holding organs in place.
- **Adipose tissue** is a specialized form of loose connective tissues that store fat in adipose cells distributed throughout the matrix.
  - Adipose tissue pads and insulates the body and stores fuel as fat molecules.
- **Fibrous connective tissue** is dense, due to its large number of collagenous fibers.
  - The fibers are organized into parallel bundles, an arrangement that maximizes non elastic strength.
  - This type of connective tissue forms **tendons**, attaching muscles to bones, and **ligaments**, joining bones to bones at joints.

- **Cartilage** has an abundance of collagenous fibers embedded in a rubbery matrix made of a substance called chondroitin sulfate, a protein-carbohydrate complex.
  - The composite of collagenous fibers and chondroitin sulfate makes cartilage a ***strong yet somewhat flexible*** support material.
  - We retain cartilage as flexible supports in certain locations, such as the nose, ears, and vertebral disks.
- The skeleton supporting most vertebrates is made of **bone**, a *mineralized connective tissue*.
  - **Osteoblasts** deposit a matrix of collagen.
  - Then, calcium, magnesium, and phosphate ions combine and harden within the matrix into the mineral hydroxyapatite.
  - The combination of hard mineral and flexible collagen makes bone harder than cartilage without being brittle.
- **Blood** functions differently from other connective tissues, but it does have an extensive extra cellular matrix.
  - The matrix is a liquid called plasma, consisting of water, salts, and a variety of dissolved proteins.
  - Suspended in the plasma are erythrocytes (red blood cells), leukocytes (white blood cells) and cell fragments called platelets.
    - Red cells carry oxygen.
    - White cells function in defense against viruses, bacteria, and other invaders.
    - Platelets aid in blood clotting.
- **Nervous tissue** senses stimuli and transmits signals from one part of the animal to another.
  - The functional unit of nervous tissue is the **neuron**, or nerve cell.
  - It consists of a cell body and two or more extensions, called dendrites and axons.
  - Dendrites transmit nerve impulses from their tips toward the rest of the neuron.
  - Axons transmit impulses toward another neuron or toward an effector, such as a muscle cell.
- **Muscle tissue** is composed of long cells called muscle fibers that are capable of contracting when stimulated by nerve impulses.
  - Arranged in parallel within the cytoplasm of muscle fibers are large numbers of myofibrils made of the contractile proteins actin and myosin.
  - Muscle is the *most abundant tissue in most animals*, and muscle contraction accounts for *most of the energy-consuming cellular work in active animals.*
  - There are ***three types*** of muscle tissue in the vertebrate body: skeletal muscle, cardiac muscle, and smooth muscle.
- Attached to bones by tendons, **skeletal muscle** is responsible for *voluntary* movements.
  - Skeletal muscle is also called **striated muscle** because the overlapping filaments give the cells a striped (striated) appearance under the microscope.
- **Cardiac muscle** forms the contractile wall of the heart.
  - It is striated like cardiac muscle, but cardiac cells are branched.
- **Smooth muscle**, which lacks striations, is found in the walls of the digestive tract, urinary bladder, arteries, and other internal organs.
  - The cells are spindle-shaped.
  - They contract more slowly than skeletal muscles but can remain contracted longer.
  - Controlled by different kinds of nerves than those controlling skeletal muscles, smooth muscles are responsible for *involuntary body activities*, such as the churning of the stomach and constriction of arteries.
- **Organ systems** carry out the major body functions of most animals.
  - Each organ system consists of several organs and has specific functions. ***(LOOK at this chart on page 840…DO IT!!!)***

Metabolic rate provides clues to an animal's bioenergetic "strategy"

- The flow of energy through an animal - ***an animal's bioenergetics*** - ultimately set the limits on the animal's behavior, growth, and reproduction and determines how much food it needs.
- The amount of energy an animal uses in a unit of time is called its **metabolic rate** - the sum of all the energy-requiring biochemical reactions occurring over a given time interval.
- There are two basic bioenergetic "strategies" used by animals.
  - ***Endothermy*** – high energy strategy – permits intense, long duration activity over a large range of temperatures – used by birds and mammals
  - ***Ectothermy*** – low energy strategy – does not permit intense activity over long periods – used by most fish, amphibians, reptiles, and invertebrates

Metabolic rate per gram is inversely related to body size among similar animals

- One of animal biology's most intriguing, but largely unanswered questions has to do with the relationship between body size and metabolic rate.
  - Physiologists have shown that the amount of energy it takes to maintain each gram of body weight is ***inversely*** related to body size.
  - For example, each gram of a mouse consumes about 20 times more calories than a gram of an elephant.
- The higher metabolic rate of a smaller animal demands a proportionately greater delivery rate of oxygen.
  - A smaller animal also has a higher breathing rate, blood volume (relative to size), and heart rate (pulse) and must eat much more food per unit of body mass.

Mechanisms of homeostasis moderate changes in the internal environment

- The internal environment of vertebrates is called the **interstitial fluid**.
  - This fluid exchanges nutrients and wastes with blood contained in microscopic vessels called capillaries.
- Many animals tend to maintain relatively constant conditions in their internal environment, even when the external environment changes.
  - Our bodies control the pH of our blood and interstitial fluid to within a tenth of a pH unit of 7.4.
- This phenomenon is incorporated into the concept of homeostasis, which means "steady state," or internal balance.

Homeostasis depends on feedback circuits

- Any homeostatic control system has three functional components: a receptor, a control center, and an effector.
  - The *receptor* detects a change in some variable in the animal's internal environment, such as a change in temperature.
  - The *control center* processes the information it receives from the receptor and directs an appropriate response by the *effector*.
- One type of control circuit, a **negative-feedback** system, can control the temperature in a room.

- In this case, the control center, called a thermostat, also contains the receptor, a thermometer.
- When room temperature falls, the thermostat switches on the heater, the effector.

- In a negative-feedback system, a change in the variable being monitored triggers the control mechanism to counteract further change in the same direction.
- Most homeostatic mechanisms in animals operate on this principle of negative feedback.
- Our own body temperature is kept close to a set point of 37°C by the cooperation of several negative-feedback circuits that regulate energy exchange with the environment.
- One mechanism by which humans control body temperature involves sweating as a means to dispose of metabolic heat and cool the body.
- In contrast to negative feedback, **positive feedback** involves a change in some variable that trigger mechanisms that amplify rather than reverse the change.
  - For example, during childbirth, the pressure of the baby's head against sensors near the opening of the uterus stimulates uterine contractions.
- While some aspects of the internal environment are maintained at a set point, *regulated change* is essential to normal body functions.
  - For example, the human body reacts to certain infections by raising the set point for temperature to a slightly higher level, and the resulting fevers helps fight infection.