

I. Form, Function, and Adaptation

- A. Animals differ in anatomy (form) & physiology (function) & are adapted for the conditions in which they live.
- B. Natural selection is the process that produces adaptations.
 - 1. Natural selection occurs when individuals that carry certain alleles leave more offspring than do individuals with different alleles of the same gene.
 - a. The frequency of selected alleles increases from one generation to the next, which results in evolution.
 - b. Evolution also occurs through genetic drift, migration, and mutation.
 - 2. Natural selection is the only process that, over time, increases the ability of the organism to survive and reproduce.
- C. Trade-Offs
 - 1. Trade-offs, an inescapable compromise between traits, may be the most important type of constraint on adaptation.
 - 2. Trade-offs often involve expenditures of time or energy.
 - 3. Organisms cannot be perfectly adapted to all aspects of their environment.
 - 4. All adaptations are compromises, constrained by genetic and historical factors.

II. Tissues, Organs, and Systems: How Does Structure Correlate with Function?

- A. The function of an anatomical feature often correlates to its size, shape, or composition.
- B. Levels of Organization in Animal Anatomy
 - 1. Correlations between structure and function exist at the level of molecules and organelles.
 - a. Protein shape correlates to whether the protein is an enzyme or performs a structural role.
 - b. Rough ER has ribosomes and a large membrane surface area, which correlates to its function in protein synthesis and processing.
 - 2. Structure/function correlations also exist at the level of tissues, organs, and organ systems.
- C. Tissues: Groups of Cells with the Same Structure and Function
 - 1. Connective tissue consists of cells arranged in an extracellular matrix.
 - a. Loose connective tissue functions in cushioning organs, and is composed of fibrous proteins in a soft matrix.
 - b. Cartilage and bone
 - c. Blood
 - 2. Nervous Tissue
 - a. Function—deliver electrical signals to other cells
 - b. Structure—long projections that contact other cells and deliver signals by means of electrical impulses and chemical secretions
 - 3. Muscle
 - a. Function—movement
 - b. Structure—long muscle-fiber cells move when they hydrolyze ATP
 - 4. Epithelial tissue covers the outside of the body, lines the surfaces of organs, and forms glands.
 - a. Function—barrier and protective layer
 - b. Structure—layers of tightly-packed cells that have many membrane proteins to regulate the exchange of molecules
- D. Organs and Systems
 - 1. Organs are structures with a specialized function; they consist of several tissues.
 - 2. Systems are groups of tissues and organs that work together. Example: Digestive system
 - 3. Organ structure correlates to function, and system components work together in an integrated fashion.
 - 4. Each component in the body is integrated with other parts, and each level of organization is integrated with other levels; therefore, the organism as a whole is greater than the sum of its parts.

III. How Does Body Size Affect Animal Physiology?

- A. The body size of an animal affects many aspects of its functions and behavior.
 - 1. Larger bodies require more food, produce more waste, reproduce more slowly, take longer to mature, and live longer.
 - 2. Smaller bodies lose heat and water faster, and so are more susceptible to cold and dehydration.
- B. Surface Area/Volume Relationships
 - 1. How do changes in surface area and volume affect cell form and function?
 - a. The rate at which molecules and ions diffuse in and out of a cell depends on the cell's surface area.
 - b. The rate at which nutrients are used & waste products produced depends on the volume of cell.
 - c. As a cell gets larger, its volume increases much faster than its surface area.
 - 2. Comparing mice and elephants
 - a. Metabolic rate, the overall rate of energy consumption by an individual, is most often measured based on oxygen consumption.
 - b. To compare metabolic rate in different species, metabolic rate is divided by overall mass.
 - c. Do larger or smaller organisms have higher metabolic rates?
 - d. Surface area-to-volume issues influence the development of an organism during its lifetime.
 - 3. Adaptations that increase the surface area
 - a. Gills consist of sheetlike structures called lamellae whose cells are flattened.
 - b. The lining of the small intestine has extensive folded surfaces called villi.
 - c. The circulatory system is highly branched, with capillaries as the smallest elements.
- C. Do all aspects of an animal's body increase in size proportionately?
 - 1. Allometry occurs when changes in body size are accompanied by disproportionate changes in anatomical structures or physiological processes.
 - a. Example: The skeletal mass increases much faster than overall body mass.
 - b. Galileo was the first to describe allometry; he observed that bones of large animals are disproportionately thicker than those of smaller animals.
 - c. Isometric quantities are those that change at the same rate.
 - 2. Allometry as a response to surface area/volume relationships
 - a. Area and volume analysis explains why the relationship between mammalian skeletal size and body mass is allometric.
 - b. Example: Elephants can't jump, because landing from a height of a few meters would likely cause multiple leg fractures.
 - 3. Allometry as adaptation
 - a. Structures that display allometry may be interpreted as adaptations to a lifestyle or environment.

IV. Homeostasis

- A. Animal physiology can be analyzed in the context of homeostasis.
 - 1. Homeostasis is the maintenance of relatively constant chemical and physical conditions for some quantity such as temperature, pH, or nutrient levels.
 - a. Conformational homeostasis occurs in animals that must conform to their surroundings.
 - b. Regulatory homeostasis requires a physiological mechanism that adjusts the internal state to keep it near a specific value.
 - 2. Many structures and processes in animals can be interpreted as mechanisms for achieving homeostasis.
 - 3. The role of the epithelium in maintaining homeostasis
 - a. Epithelium exists at the interface between the internal and external environment; membrane proteins on the surfaces of epithelial cells regulate the transport of ions, water, nutrients, and wastes.
 - b. Epithelium plays a critical role in achieving homeostasis by controlling the exchange of materials across surfaces.
 - 4. Why is achieving homeostasis important?
 - a. Enzymes, which are critical to all processes in living cells, function normally only in a narrow range of physical and chemical conditions.

- b. Changes in pH and the chemical environment can dramatically alter enzyme structure and function.
- c. Temperature can dramatically alter enzyme structure and function.

B. Regulation and Feedback

1. Regulatory systems monitor internal conditions and return them to set points.
2. Each homeostatic system has three main components:
 - a. Sensor—a structure that senses some aspect of the external or internal environment.
 - b. Integrator—a component of the nervous system that
 - c. Effector—any structure that helps restore the desired internal condition.
3. Homeostatic systems are based on negative feedbacks.

V. How Do Animals Regulate Body Temperature?

A. Thermoregulation: Achieving Homeostasis of Body Temperature

1. Receptors all over the body constantly monitor mammalian body temperature.
2. Temperature information gathered by these receptors is transmitted to an integrator in the brain.
3. If temperature falls too low, cells in the posterior hypothalamus initiate signals that induce shivering or fluffing of fur and feathers.
4. If temperature gets too high, cells in the anterior hypothalamus initiate signals that induce shade-seeking behavior and evaporative cooling through sweating or panting.

B. Gaining and Losing Heat

1. Animals fall into two general categories based on how they gain heat.
 - a. Endotherms produce heat in their own tissues.
 - b. Ectotherms rely on heat gained from the environment.
 - c. Homeotherms keep their body temperature constant.
 - d. Heterotherms allow their body temperature to rise or fall depending on environmental conditions.
 - e. An animal's source of heat and the degree to which its body temperature varies can be graphed.
2. Sources of body heat
 - a. Muscle activity, including shivering, produces heat in many ectotherms and most endotherms.
 - b. Normal cell metabolism produces heat; endotherms have greater mitochondrial density in their cells.
 - c. Specialized heat-generating tissues occur in some animals.
3. Exchanging heat with the environment
 - a. All animals constantly exchange heat with their environment.
 - b. Animals exchange heat with the environment in one of four ways:
4. Conserving heat
 - a. Air is a poor conductor of heat, which makes it a good insulator.
 - b. Aquatic environments
 - c. Endotherms in aquatic habitats

C. Ectothermy versus Endothermy

1. Homeostatic systems are interpreted as adaptations that arose by natural selection.
 - a. Structure relates to function in temperature homeostasis.
 - b. Surface area/volume relationships are critical.
2. Endothermy and ectothermy are examples of trade-offs in adaptation.
 - a. Advantages of endothermy
 - b. Disadvantages of endothermy
 - c. Advantages of ectothermy
 - d. Disadvantages of ectothermy

Chapter Vocabulary

metabolic water

anatomy
physiology

adaptations
adaptive evolution
genetic drift
gene flow
mutation
trade-off

clutch size
acclimatization

multicellular
connective tissue
extracellular matrix
loose connective tissue
cartilage
bone
blood

nervous tissue
neurons

muscle tissue
striated muscle
muscle fibers
cardiac muscle
smooth muscle
epithelial tissue
apical
basolateral
lumen

organ
countercurrent heat exchange

gland
system

metabolic rate
basal metabolic rate (BMR)

lamellae
villi
capillaries

allometry
allometric
isometric

homeostasis
conformational homeostasis
regulatory homeostasis
set point
sensor
integrator
effector
negative feedback

thermoregulation
anterior hypothalamus
posterior hypothalamus
endotherm
ectotherm
heterotherm
homeotherm
torpor
hibernation
adipose tissue
brown adipose tissue

conduction
convection
radiation
evaporation