

## Unit 7: How Animals Work

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- How Does Body Size Affect Animal Physiology?
- Homeostasis
- Thermoregulation: A Closer Look

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## Chapter 39: Form, Function, and Adaptation

1. Form, Function, and Adaptation
2. Tissues, Organs, and Systems
3. How Does Body Size Affect Animal Physiology?
4. Homeostasis
5. Thermoregulation: A Closer Look

### Form, Function, and Adaptation

- Anatomy
- Physiology
- Adaptations
- Trade-off
- Spermatophore
- Acclimatization

### Tissues, Organs, and Systems

- Tissue
- Connective tissue
  - Loose connective tissue
  - Dense connective tissue
  - Supporting connective tissue
  - Fluid connective tissue
- Nervous tissue
  - Neurons
  - Dendrites
  - Axon
- Muscle tissue
  - Skeletal muscle
  - Cardiac muscle
  - Smooth muscle

- Epithelial tissues
  - Organ
  - Gland
  - Apical
  - Basolateral
  - Basal lamina
- Organ system

### How Does Body Size Affect Animal Physiology?

- Surface area vs. volume theory
- Metabolic rate
- Basal metabolic rate (BMR)
- Gills
- Adaptations for increased surface area
  - Flattening
  - Folding
  - Branching

### Homeostasis

- Homeostasis
- Regulate
- Conform
- Set point
- Homeostatic system:
  - Sensor
  - Integrator
  - Effector
- Hypothalamus
- Negative feedback

## Thermoregulation: A Closer Look

- **Thermoregulate**
- **Thermoregulatory strategies:**
  - **Endotherm**
  - **Ectotherm**
  - **Homeotherms**
  - **Poikilotherms**
  - **Torpor**
  - **Hibernation**
- **Countercurrent exchanger**

## Chapter 39: Review

### Form, Function, and Adaptation

- Animal structures and their functions represent adaptations, which are heritable traits that improve survival and reproduction in a certain environment.
- Adaptations involve trade-offs, or inescapable compromises between traits.
- Acclimatization is a reversible response to the environment that improves physiological function in that environment.

### Tissues, Organs, and Systems

- Animal cells with a common function are grouped together into four general types of tissue: connective tissue, nervous tissue, muscle tissue, and epithelial tissue.
- Organs are structures that are composed of two or more tissues that together perform specific tasks.
- Organ systems comprise organs that work together in an integrated fashion to perform one or more functions.

### How Does Body Size Affect Animal Physiology?

- Large animals have smaller surface area/volume ratios than small animals. As animals grow, their volume increases more rapidly than their surface area.
- Large animals have low mass-specific metabolic rates, in keeping with their relatively small surface area for exchanging the oxygen and nutrients required to support metabolism and the wastes and heat produced by metabolism.
- The relatively high surface area of small animals means that they lose heat extremely rapidly.

### Homeostasis

- Homeostasis refers to relatively constant physical and chemical conditions inside the body.
- Homeostasis in a fluctuating environment is usually achieved by regulation.
- Animals have set points, or target values, for various body parameters. When a parameter is not at its set point, negative feedback occurs. Responses to negative feedback return the parameter to the set point and result in homeostasis.
- Most animals have a set point for body temperature. If an individual overheats, it may pant, sweat, or seek a cool environment; if an individual is cold, it may shiver, bask in sunlight, or fluff its fur or feathers.

#### Thermoregulation: A Closer Look

- Animals vary from endothermic to ectothermic and from homeothermic to poikilothermic.
- Endotherms can be active in cold environments but must obtain a lot of energy to fuel their metabolism. Ectotherms do not require as much energy, but their activity depends on environmental temperature.
- Countercurrent heat exchangers have vessels in close contact that carry warm and cool fluids in opposite directions.

## Chapter 40: Water and Electrolyte

1. Osmoregulation and Excretion
2. Water and Electrolyte in Marine Fishes
3. Water and Electrolyte in Freshwater Fishes
5. Water and Electrolyte in Vertebrates

### Osmoregulation and Excretion

- Electrolyte
- Diffusion
- Osmosis
- Osmolarity
- Osmoregulation
- Osmoconformers
- Isosmotic
- Osmoregulators
- Hyperosmotic
- Hyposmotic
- Aquaporins
- Ammonia
- Urea
- Uric acid

### Water and Electrolyte in Marine Fish

- Rectal gland
- Ouabain
- Interstitial fluid

### Water and Electrolyte in Freshwater Fish

- Osmoregulatory cells may be in different locations
- Different forms of  $\text{Na}^+/\text{K}^+$ -ATPase may be activated
- The orientation of key transport proteins “flips.”

### Water and Electrolyte in Vertebrates

- Kidney
- Ureter
- Bladder
- Urethra
- Nephron
- Cortex
- Medulla
- The Mammalian Kidney:
- Filtration
- Proximal tubule
- Microvilli
- Ion and Water Movement:
- Loop of Henle
- A Comprehensive View of the Loop of Henle:
- Vasa recta
- Distal tubule
- Collecting duct
- Hormones Involved:
- Cloaca

### Chapter 40: Review

Osmoregulation and Excretion

- Solutes move across membranes via passive transport, facilitated diffusion, or active transport. Water moves across membranes by osmosis.
- In most animals, epithelial cells that selectively transport water and electrolytes are responsible for homeostasis.
- The mechanisms involved in regulating water and electrolyte balance vary widely among animal groups because different habitats present different types of osmotic stress.
- The type of nitrogenous waste excreted by an animal is affected by its phylogeny and its habitat type. Most fishes excrete ammonia; mammals and most adult amphibians excrete urea; and insects and reptiles excrete uric acid.

#### Water and Electrolyte in Marine Fishes

- Seawater is strongly hyperosmotic to the tissues of marine bony fishes, so they tend to lose water by osmosis and gain electrolytes by diffusion.
- Marine bony fishes are osmoregulators, whereas cartilaginous fishes including sharks are osmoconformers.
- Epithelial cells in the shark rectal gland and in the gills of marine bony fishes excrete excess salt using  $\text{Na}^+/\text{K}^+$ ATPase and  $\text{Na}^+/\text{Cl}^-/\text{K}^+$  cotransporters located in the basolateral membrane.
- Similar salt-excreting cells also exist in the salt glands of marine birds and other reptiles and in the kidneys of mammals.

#### Water and Electrolyte in Freshwater Fishes

- Freshwater is strongly hyposmotic to the blood of freshwater fishes, so they tend to gain water by osmosis and lose electrolytes by diffusion.
- Epithelial cells in the gills of freshwater fishes import ions using  $\text{Na}^+/\text{K}^+$ ATPase located in the basolateral membrane and  $\text{Na}^+/\text{Cl}^-/\text{K}^+$  cotransporters located in the apical membrane.

#### Water and Electrolyte in Vertebrates

- Nephrons in the vertebrate kidney form a filtrate in the renal corpuscle and then reabsorb valuable nutrients, electrolytes, and water in the proximal tubule.
- A solution containing urea and electrolytes flows through the loop of Henle of mammalian kidneys, where changes in the permeability of epithelial cells to water and salt—along with active transport of salt—create a steep osmotic gradient.
- Antidiuretic hormone increases the water permeability of the collecting duct, causing water to be reabsorbed along the osmotic gradient and hyperosmotic urine to be produced.
- The nephrons of fishes, amphibians, and nonavian reptiles do not have loops of Henle and therefore cannot produce urine that is hyperosmotic to the body fluids. However, some of these vertebrates can produce hyperosmotic urine by reabsorbing water from the cloaca or bladder.



## Chapter 41: Nutrition

1. Nutritional Requirements
2. Nutritional Homeostasis
3. How Are Nutrients Digested and Absorbed?

### Nutritional Requirements

- Ingestion
- digestive tract
- digestion
- absorption
- essential nutrient
- Essential amino acids
- Essential fatty acids
- Vitamins
- Minerals

### How are Nutrients Digested and Absorbed

- Incomplete digestive tracts
- Complete digestive tracts
- feces
- Salivary amylase
- lingual lipase
- Salivary glands
- esophagus
- peristalsis
- crop
- stomach
- sphincters
- pepsin

- parietal cells
- mucous cell
- carbonic anhydrase
- ulcer
- ruminants
- symbiosis
- cellulase
- small intestine
- villi
- microvilli
- lacteal
- proteases
- pancreas
- trypsin
- secretin
- cholecystokinin
- gastrin
- pancreatic amylase
- pancreatic lipase
- emulsification
- liver
- bile
- gallbladder
- large intestine
- colon
- rectum
- cecum
- appendix
- coprophagy
- cloaca

## Nutritional Homeostasis

- diabetes mellitus
- Insulin
- glucagon
- gluconeogenesis
- Diabetes mellitus
- (1)
- (2)
- body mass index (BMI)

## Chapter 41: Review

### Nutritional Requirements

- The diets of animals include fats, carbohydrates, and proteins that provide energy; vitamins that serve as coenzymes and perform other functions; minerals that are used as components of enzyme cofactors or structural materials; and ions of electrolytes required for osmotic balance and normal membrane function.
- Fats contain more energy (about 9 kcal/g) than carbohydrates or proteins (about 4 kcal/g), making fats an efficient way to store energy in the body.

### How Are Nutrients Digested and Absorbed?

- Most animals have a digestive tract that begins at the mouth and ends at the anus.
- In many animals, chemical digestion of food begins in the mouth. In mammals, salivary amylase hydrolyzes bonds in starch and glycogen, and lingual lipase hydrolyzes bonds in fats.
- Once food is swallowed, it is propelled down the esophagus by peristalsis.
- Digestion continues in the stomach. In the human stomach, a highly acidic environment denatures proteins, and the enzyme pepsin begins the cleavage of peptide bonds that link amino acids.
- Food passes from the stomach into the small intestine, where it is mixed with secretions from the pancreas and liver.
- In the small intestine, carbohydrate digestion is continued by pancreatic amylase; fats are emulsified by bile salts and digested by pancreatic lipase; and protein digestion is completed by a suite of pancreatic proteases.
- Cells that line the small intestine absorb the nutrients released by digestion. In many cases, uptake is driven by an electrochemical gradient established by  $\text{Na}^+/\text{K}^+$ -ATPase that favors the diffusion of  $\text{Na}^+$  into the cells.

- As solutes leave the lumen of the small intestine and enter cells, water follows by osmosis.
- Water reabsorption is completed in the large intestine, where feces form.
- The structure of organs in the digestive tract varies widely among species, in ways that support processing of the food each species ingests.

#### Nutritional Homeostasis

- Diabetes mellitus is a condition in which the level of glucose in the blood is abnormally high.
- Type 1 diabetes mellitus is caused by a defect in the production of insulin—a hormone secreted by the pancreas that promotes the uptake of glucose from the blood.
- Type 2 diabetes mellitus is characterized by a failure of cells to respond to insulin.
- The development of type 2 diabetes is correlated with obesity. The incidence of this disease has reached epidemic proportions in many populations.