CHAPTER 41: ANIMAL NUTRITION

DIETARY CATEGORIES

- Herbivores - eat autotrophs (plants and algae)
- Carnivores - Eat other animals
- Omnivores - consume animals as well as plants
- Diet must satisfy three needs:
  - Fuel cellular work
  - Provide organic raw materials for biosynthesis
  - Essential nutrients (vitamins and minerals animals cannot make themselves)

FIG. 41.1

DIET MUST SUPPLY ESSENTIAL NUTRIENTS

- To build complex molecules required for growth, maintenance, and reproduction, and animal must obtain the precursors (carbon skeletons) from food.
- Diet must also supply essential nutrients in preassembled form
- Animal that is missing one or more essential nutrients in its diet are malnourished
  - Herbivores may suffer mineral deficiencies if they graze on plants in soil that lacks key minerals
  - Malnutrition is more common than undernutrition
ESSENTIAL AMINO ACIDS

- Animals require 20 amino acids and can synthesize about half of them from molecules they obtain in their diet.
- The remaining amino acids must be obtained from food in preassembled form.
- A diet that provides insufficient amounts of one or more essential amino acids causes a form of malnutrition called protein deficiency.
- Most plant proteins are incomplete in amino acid makeup so individuals who must eat only plant proteins need to eat a variety to ensure they get all essential amino acids.
- Some animals adapt to help through periods when their bodies demand extraordinary proteins.

ESSENTIAL FATTY ACIDS, VITAMINS, AND MINERALS

- Animals can synthesize most fatty acids they need.
- Some unsaturated fatty acids are essential, but deficiencies are rare.
- Vitamins are organic molecules required in the diet in small amounts (13 essential vitamins have been identified).
- Two categories: fat-soluble and water-soluble.
- Minerals are simple inorganic nutrients usually required in small amounts.

CALORIC IMBALANCE

- Undernourishment - diet chronically deficient in calories.
- Overnourishment - results from excessive food intake (leads to storage of calories as fat).
- WHO (World Health Organization) now recognizes obesity as a major global health problem that contributes to diabetes, cardiovascular disease, colon and breast cancer, and many more.
- There are several mechanisms that regulate body weight (control how fat is stored and metabolized).
FOOD PROCESSING

- **Ingestion** - act of eating
- **Digestion** - process of breaking down food into molecules small enough to absorb using enzymatic hydrolysis of polymers into their monomers
- **Absorption** - uptake of nutrients by body cells
- **Elimination** - occurs as undigested material passes out of the digestive compartment

![Diagram of digestive process]

FEEDING MECHANISMS

- **Suspension Feeders** - sift small food particles from the water
- **Substrate Feeders** - live on or in their food source
- **Fluid feeders** - suck nutrient-rich fluid from a living host
- **Bulk feeders** - eat relatively large pieces of food

![Diagram of feeding mechanisms]

DIGESTION

- Most animals process food in specialized compartments
- **Intracellular digestion** - food particles are engulfed by endocytosis and digested with food vacuoles
- **Extracellular digestion** - breakdown of food particles outside of the cells
- Animals with simple body plans have a gastrointestinal cavity that functions in both digestion and distribution of nutrients
- Animals with more complex body plans have digestive tubes with two openings (mouth and anus)
- Digestive tube is called a complete digestive tract or an alimentary canal; tubes can be organized into specialized regions that carry out digestion and nutrient absorption in a stepwise fashion

![Diagram of digestive system]
**DIGESTIVE SYSTEM**

- Mammalian digestive system consists of the alimentary canal and various glands that secrete digestive juices through ducts.
- Food is pushed along the digestive tract by peristalsis (rhythmic waves of contraction of smooth muscles in the wall of the canal).
- Oral cavity - food is lubricated and digestion begins (teeth chew food into smaller particles that are exposed to amylase that starts the breakdown of glucose).
- Pharynx (throat) - opens to both esophagus and trachea.
- Esophagus conducts food from the pharynx down to the stomach by peristalsis.

**FIG. 41.10**

**DIGESTIVE SYSTEM**

- Stomach - stores food and secretes gastric juices (converts food into acid chyme).
- Gastric juice - made up of hydrochloric acid and the enzyme pepsin.
- Lining is coated with mucus which prevents gastric juice from destroying cells.
- Gastric ulcers (lesions in the lining) are caused by a bacteria (*Helicobacter pylori*).

**FIG. 41.11**

**DIGESTIVE SYSTEM**

- Small intestine - longest section of the alimentary canal and major organ of digestion and absorption.
- First portion is the duodenum - where acid chyme from the stomach mixes with digestive juices from the pancreas, liver, gallbladder, and intestine.
- Pancreas produces proteases (protein digesting enzymes) that are activated once they enter the duodenum.
- Hormones help coordinate the secretion of digestive juices into the alimentary canal.
DIGESTIVE SYSTEM

- Small intestine (continued)
  - Have a high surface area due to the presence of villi and microvilli that are exposed to the intestinal lumen
  - Greatly increases the rate of absorption
  - Each villus contains a network of blood vessels and a small vessel of the lymphatic system called a lacteal
  - Amino acids and sugars pass through the epithelium to enter the bloodstream
  - Glycerol and fatty acids are absorbed and recombined into fats within these cells

DIGESTIVE SYSTEM

- Fats are mixed with cholesterol and coated with proteins forming small molecules called chylomicrons which are transported into lacteals

DIGESTIVE SYSTEM

- Large intestine - connected to the small intestine
  - Major function of the colon is to recover water that has entered the alimentary canal
  - Wastes become more solid as they move through the colon and pass through the rectum and exit via the anus
  - Colon contains strains of *Escherichia coli* (some produce vitamins)
EVOLUTIONARY ADAPTATIONS

- Digestive system in vertebrates associated with diet
- Dentition (assortment of teeth)
- Based off of diet
- Herbivores have longer alimentary canals than carnivores (takes longer to digest vegetation)
- Many have fermentation chambers (symbiotic organisms digest the cellulose)

HERBIVORES
- Molars
- Premolars
- Canines
- Incisors

HERBIVORES
- Small intestine
- Stomach
- Cecum (large intestine)

CARNIVORES
- Small intestine
- Stomach
- Colon (large intestine)

HOMEOSTATIC MECHANISMS

- Nearly all animal's ATP generation is based on the oxidation of energy-rich molecules: Carbohydrates, proteins, and fats
- Store excess calories as glycogen in the liver and muscles as well as in fat
- Glucose is a major fuel for cells
- Metabolism of glucose is regulated by hormones (EXAMPLE OF HOMEOSTASIS)
- When fewer calories are taken in than are expended (fuel is taken out of storage and oxidized)

CALORIC IMBALANCE

- Hormones regulate both long-term and short-term appetite by affecting the "satiety center" in the brain
- Shows the complexity of weight control
- Mice that inherit a defect in the gene for leptin become very obese
- Weight problems stem from evolutionary past when hoarding fat was needed for survival

RESULTS

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<th>Genotype pairing (red type indicates mutant genes)</th>
<th>Average change in body mass (g) of subject</th>
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</table>

*Due to pronounced weight loss and weakening, subjects in this pairing were reweighed after less than eight weeks.*