Chapter 14
Digestive System and Nutrition

21.1 Animals ingest their food in a variety of ways

- **Herbivores**, plant-eaters—cattle, snails, sea urchins
- **Carnivores**, meat-eaters—lions, hawks, spiders
- **Omnivores**, eating both plants and animals—humans, roaches, raccoons, crows

21.2 Overview: Food processing occurs in four stages

- Food is processed in four stages

[Diagram showing the four stages of food processing: Ingestion, Digestion, Absorption, and Elimination]
21.2 Overview: Food processing occurs in four stages

- Mechanical digestion breaks food down into smaller pieces
  - Smaller pieces are easier to swallow
  - Smaller pieces have more surface area exposed to digestive fluids

- Chemical digestion breaks down large organic molecules into their components
  - Proteins split into amino acids
  - Polysaccharides and disaccharides into monosaccharides
  - Nucleic acids into nucleotides

21.3 Digestion occurs in specialized compartments

- Most animals digest food in compartments
  - Enzymes break down the food
  - Food particles move into cells lining the compartment
  - Undigested materials are expelled

- Most animals have an **alimentary canal** with
  - Mouth
  - Anus
  - Specialized regions
21.4 The human digestive system consists of an alimentary canal and accessory glands

- Alternating waves of contraction and relaxation by smooth muscle in the walls of the canal move food along in a process called **peristalsis**

- **Sphincters** control the movement of food into and out of digestive chambers

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21.4 The human digestive system consists of an alimentary canal and accessory glands

- **The pyloric sphincter**
  - Regulates the passage of food from the stomach to the small intestine
  - Limits the upward movement of acids into the esophagus
21.5 Digestion begins in the oral cavity

- Teeth break up food, saliva moistens it
  - Salivary enzymes begin the hydrolysis of starch
  - Buffers neutralize acids
  - Antibacterial agents kills some bacteria ingested with food
- The tongue tastes, shapes the bolus of food, and moves it toward the pharynx

21.6 After swallowing, peristalsis moves food through the esophagus to the stomach

- The trachea conducts air to the lungs
- The esophagus conducts food from the pharynx to the stomach
21.6 After swallowing, peristalsis moves food through the esophagus to the stomach

- The swallowing reflex
  - Food moves from the pharynx into the esophagus
  - The swallowing reflex prevents food from entering the trachea
  - A coughing reflex helps expel materials that accidentally enter the trachea

21.7 CONNECTION: The Heimlich maneuver can save lives

- The Heimlich maneuver can dislodge food from the pharynx or trachea during choking
- Brain damage will occur within minutes if no airway is open
21.8 The stomach stores food and breaks it down with acid and enzymes

- **Acid**
  - pH 2
  - Parietal cells secrete HCl (hydrochloric acid)
  - Acid kills bacteria and breaks apart cells in food

- **Pepsinogen and HCl produce pepsin**
  - Pepsin production activates more pepsinogen production—positive feedback
  - Pepsin begins the chemical digestion of proteins
  - Acidic gastric juices mix with food to produce **acid chyme**

21.9 CONNECTION: Digestive ailments include acid reflux and gastric ulcers

- Acid reflux into esophagus—heartburn and GERD
- Bacterial infections (*Helicobacter pylori*) in the stomach and duodenum can produce ulcers
21.10 The small intestine is the major organ of chemical digestion and nutrient absorption

- **Small intestine** is named for its smaller diameter—it is about 6 meters long
- Alkaline **pancreatic juice** neutralizes acid chyme and its enzymes digest food
- **Bile**, made in the **liver** and stored in the **gall bladder**, emulsifies fat for attack by pancreatic enzymes
- Enzymes from cells of the intestine continue digestion

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21.10 The small intestine is the major organ of chemical digestion and nutrient absorption

- Surface area for absorption is increased by
  - Folds of the intestinal lining
  - Fingerlike villi
21.11 One of the liver’s many functions is processing nutrient-laden blood from the intestines

- Nutrients pass across the epithelium and into blood
- Blood from the digestive tract drains to the liver
- The liver performs many functions
  - Glucose in blood is converted to glycogen and stored
  - Liver synthesizes many proteins including blood clotting proteins and lipoproteins that transport fats and cholesterol
  - Liver changes toxins to less toxic forms
  - Liver produces bile

21.12 The large intestine reclaims water and compacts the feces

- The large intestine is also called the colon
- Appendix
  - Located near the junction of the small intestine and colon
  - Makes a minor contribution to immunity

- Diarrhea occurs when too little water is reclaimed
- Constipation occurs when too much water is reclaimed
- Feces are stored in the rectum
- Colon bacteria produce vitamins—biotin, vitamin K, B vitamins
21.14 Overview: A healthy diet satisfies three needs

- Fuel to power the body
- Organic molecules to build molecules
- Essential nutrients—raw materials that animals cannot make for themselves

21.15 Chemical energy powers the body

- Nutrients are used inside cells to make ATP
- ATP is the main energy “currency” in a cell
- Proteins, carbohydrates, and fats are the main sources of dietary calories
  - A gram of fat has more than twice as many calories as a gram of carbohydrate or protein

21.15 Chemical energy powers the body

- Basal metabolic rate (BMR) is the energy a resting animal requires each day
- Metabolic rate is the BMR plus the energy needed for physical activity
- Excess energy is stored as glycogen or fat
- Our metabolic rates typically decrease throughout adulthood
- An active life burns more calories
21.16 An animal’s diet must supply essential nutrients

- Essential nutrients cannot be made from any raw material
- **Undernourishment** — not enough calories
- **Malnourishment** — missing essential nutrients

- Animals cannot produce eight of the 20 amino acids
- These eight amino acids are **essential amino acids**
- These eight amino acids must come from the diet
  - Animal protein
  - The proper combination of plant foods

21.18 A healthy diet includes 13 vitamins and many essential minerals

- Essential vitamins and minerals
  - Required in minute amounts
  - Extreme excesses can be dangerous
  - Excess water-soluble vitamins can be eliminated in urine
  - Excess fat-soluble vitamins can accumulate to dangerous levels in body fat
21.18 A healthy diet includes 13 vitamins and many essential minerals

- Minerals are simple inorganic nutrients usually required in small amounts
  - Calcium and phosphorus are required in larger amounts
  - Most people ingest more salt than they need

21.19 CONNECTION: Do you need to take vitamin and mineral supplements?

- Recommended Dietary Allowances (RDAs) are debated
  - Excessive doses of vitamin A and iron can be dangerous
- Extra doses of some vitamins are recommended by the USDA
  - Extra B12 for people over 50
  - Extra vitamin D for people with dark skin or who get little sun
  - Folic acid is important early in pregnancy

21.20 CONNECTION: What do food labels tell us?

- Food labels indicate
  - Serving size
  - Calories per serving
  - Amounts of selected nutrients per serving and as a percentage of daily value
  - Recommendations for daily limits of selected nutrients

21.21 EVOLUTION CONNECTION: The human health problem of obesity may reflect our evolutionary past

- World Health Organization recognizes obesity as a major global health problem
- Of people in the United States
  - 30% are obese
  - 35% are overweight
  - 15% of children and adolescents are overweight
21.21 EVOLUTION CONNECTION: The human health problem of obesity may reflect our evolutionary past

- Obesity leads to
  - Diabetes
  - Cancer
  - Cardiovascular disease
  - 300,000 deaths per year in the United States

21.22 CONNECTION: What are the health risks and benefits of weight loss plans?

- Weight loss diets
  - May help individuals lose weight
  - May have health risks leading to malnourishment
- Diets fail because people return to old eating habits
- The most effective diets combine
  - Increased exercise
  - Limited balanced diet of about 1200 calories per day

21.23 CONNECTION: Diet can influence cardiovascular disease and cancer

- A healthy diet may reduce the risk of
  - Cancer & Cardiovascular disease
- Two main types of cholesterol
  - LDL—contributes to blocked blood vessels and higher blood pressure
  - HDL—tends to reduce blocked blood vessels
  - Exercise increases HDL levels
  - Smoking decreases HDL levels
- The American Cancer Society recommends
  - Regular exercise
  - A diverse diet of healthy foods with an emphasis on plant sources

**TABLE 21.23  DIETARY GUIDELINES FOR REDUCING CANCER RISK**

- Maintain a healthy weight throughout life.
- Eat five or more servings of a variety of fruits and vegetables daily.
- Choose whole grain rice, bread, pasta, and cereals.
- Limit consumption of processed and red meats, especially those high in fat. Prepare meats by baking, broiling, or poaching rather than by frying or charbroiling.
- If you drink alcoholic beverages, limit yourself to a maximum of one or two drinks a day (a drink = 12 oz beer, 5 oz wine, 1.5 oz 80% distilled spirits).