Introduction: *Getting Their Fill of Krill*

- A 72-ton humpback whale eats small fishes and crustaceans called krill
- A whale’s digestive system may process up to 2 tons of krill a day
Introduction: *Getting Their Fill of Krill*

- Humpback whales strain krill from seawater using large plates, called baleen
  - Whales take a large gulp of water into their throat
  - As they force water out, it is strained through baleen plates that hang from the upper jaw

- Humpback whales create a net of bubbles to concentrate the krill
OBTAINING AND PROCESSING FOOD
Most animals have one of three kinds of diets

- **Herbivores**, plant-eaters—cattle, snails, sea urchins
- **Carnivores**, meat-eaters—lions, hawks, spiders
- **Omnivores**, eating both plants and other animals—humans, roaches, raccoons, crows
Animals obtain and ingest their food in different ways:

- Suspension feeding
- Substrate feeding
- Fluid feeding
- Bulk feeding
21.2 Overview: Food processing occurs in four stages

- Food is processed in four stages
  - Ingestion
  - Digestion
  - Absorption
  - Elimination
Mechanical digestion

Pieces of food

Food

Chemical digestion (hydrolysis)

Small molecules

Nutrient molecules enter body cells

Undigested material

1 Ingestion  2 Digestion  3 Absorption  4 Elimination

Copyright © 2009 Pearson Education, Inc.
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
21.2 Overview: Food processing occurs in four stages

- Chemical digestion breaks down large organic molecules into their components
  - Proteins split into amino acids
  - Polysaccharides and disaccharides into monosaccharides
  - Nucleic acids into nucleotides
<table>
<thead>
<tr>
<th>Macromolecule</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>Amino acids</td>
</tr>
<tr>
<td>Polysaccharide</td>
<td>Monosaccharides</td>
</tr>
<tr>
<td>Disaccharide</td>
<td></td>
</tr>
<tr>
<td>Nucleic acid</td>
<td>Nucleotides</td>
</tr>
<tr>
<td>Fat</td>
<td>Glycerol</td>
</tr>
</tbody>
</table>

Protein-digesting enzymes break down proteins into amino acids. Carbohydrate-digesting enzymes break down polysaccharides into disaccharides, which are further broken down into monosaccharides. Nucleic acid-digesting enzymes break down nucleic acid into nucleotides. Fat-digesting enzymes break down fat into glycerol and fatty acids.
21.3 Digestion occurs in specialized compartments

- Sponges digest food in vacuoles
- Most animals digest food in compartments
  - Enzymes break down the food
  - Food particles move into cells lining the compartment
  - Undigested materials are expelled
21.3 Digestion occurs in specialized compartments

- Cnidarians and flatworms have a gastrovascular cavity with a single opening, the mouth
  - Food enters the mouth
  - Undigested food is expelled back out the mouth
Food (Daphnia, a water flea) is engulfed by the gastrovascular cavity. Digested enzymes released from a gland cell aid in the digestion of soft tissues. Food particles are digested in food vacuoles.
Most animals have an alimentary canal with

- Mouth
- Anus
- Specialized regions
Mouth
Pharynx
Esophagus
Crop
Gizzard
Anus
Intestine
Dorsal fold
Interior of intestine
Wall of intestine
Earthworm

Copyright © 2009 Pearson Education, Inc.
HUMAN DIGESTIVE SYSTEM
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
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
A schematic diagram of the human digestive system.

- Mouth
- Salivary glands
- Esophagus
- Stomach
- Pancreas
- Gall-bladder
- Liver
- Small intestine
- Large intestine
- Rectum
- Anus
A schematic diagram of the human digestive system
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
Opening of a salivary gland duct

Salivary glands

Tongue

Teeth

Incisors

Canine

Premolars

Molars

“Wisdom” tooth
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
Epiglottis up

Bolus of food

Tongue

Pharynx

Larynx

Esophagus

Sphincter contracted

Trachea

Esophageal sphincter

Copyright © 2009 Pearson Education, Inc.
Epiglottis
Pharynx
Esophageal sphincter
Bolus of food
Tongue
Esophagus
Larynx
Trachea

Sphincter contracted

Epiglottis down

Sphincter relaxed
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
Esophageal sphincter (contracted)

Muscles contract, constricting passageway and pushing bolus down

Muscles relax, allowing passageway to open

Stomach
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
save a CHOKING victim

HEIMLICH MANEUVER
It could save your life!

A choking person can't speak or breathe and needs your help now.
Don't slap the victim's back. (This could make matters worse.)

Follow these 4 steps to clear the blocked airway safely and quickly:

1. From behind, wrap your arms around the victim's waist.
2. Make a fist and place the thumb side of your fist against the victim's abdomen, below the rib cage and above the navel.
3. Grasp your fist with your other hand and press into the victim's abdomen with a quick upward thrust.
4. Repeat until object is expelled.
21.8 The stomach stores food and breaks it down with acid and enzymes

- **Acid**
  - pH 2
  - Parietal cells secrete hydrogen and chloride ions, which combine to make HCl
  - 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
21.8 The stomach stores food and breaks it down with acid and enzymes

- What prevents the gastric juices from digesting the walls of the stomach?
  - Mucus helps protect against HCl and pepsin
  - New cells lining the stomach are produced about every 3 days
Interior surface of stomach

Lumen (cavity) of stomach

Stomach

Gastrin

Esophagus

Sphincter

Sphincter

Small intestine

Interior surface of stomach

Pits

Release of gastric juice (mucus, HCl, and pepsinogen)

Epithelium

Gastric gland

Mucous cells

Chief cells

Parietal cells

Pepsinogen

Peptic (active enzyme)

HCl

Cl⁻

H⁺

Copyright © 2009 Pearson Education, Inc.
Interior surface of stomach

Pits

Release of gastric juice (mucus, HCl, and pepsinogen)

Epithelium

Mucous cells

Chief cells

Parietal cells

Gastric gland

Pepsinogen → Pepsin (active enzyme)

1. HCl + Cl⁻ → H⁺ + Cl⁻

2. Pepsinogen → Pepsin

3. Pepsin (active enzyme)
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
Mucous layer of stomach

Bacteria

Mucous layer of stomach
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
Gall-bladder

Liver

Bile

Gall-bladder

Stomach

Acid chyme

Pancreatic juice

Pancreas

Intestinal enzymes

Duodenum of small intestine

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

- Enzymes from cells of the intestine continue digestion
<table>
<thead>
<tr>
<th>Enzymes/Catalysts</th>
<th>Substrates</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbohydrates</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Starch</td>
<td>Maltose (and other disaccharides)</td>
</tr>
<tr>
<td>Pancreatic amylase</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Proteins</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polypeptides</td>
<td>Smaller polypeptides</td>
</tr>
<tr>
<td>Trypsin, chymotrypsin</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nucleic acids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DNA and RNA</td>
<td>Nucleotides</td>
</tr>
<tr>
<td>Nucleases</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fats</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fat globules</td>
<td>Fat droplets (emulsified)</td>
</tr>
<tr>
<td>Bile salts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipase</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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
Muscle layers
Large circular folds
Villi
Nutrient absorption
Vein with blood en route to the liver
Intestinal wall
21.10 The small intestine is the major organ of chemical digestion and nutrient absorption

- Nutrients pass across the epithelium and into blood
- Blood flows to the liver where nutrients are processed and stored
Nutrient absorption into epithelial cells

Amino acids and sugars
Fatty acids and glycerol
Fats

Epithelial cells lining villus

Blood

Lymph
21.11 One of the liver’s many functions is processing nutrient-laden blood from the intestines

- Blood from the digestive tract drains to the liver
- The liver performs many functions
  - Glucose in blood is converted to glycogen and stored in the liver
  - 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
Heart
Hepatic portal vein
Kidneys
Liver
Hepatic portal vein
Intestines
21.12 The large intestine reclaims water and compacts the feces

- 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
21.12 The large intestine reclaims water and compacts the feces

- Appendix
  - Located near the junction of the small intestine and colon
  - Makes a minor contribution to immunity
Large intestine (colon)

End of small intestine

Appendix

Sphincter

Unabsorbed food material

Cecum

Small intestine

Rectum

Anus
The length of the digestive tract often correlates with diet

- Herbivores and omnivores have relatively longer digestive tracts than carnivores
Many herbivores have specializations of the gut that promote the growth of cellulose-digesting microbes:

- Rumen
- Reticulum
- Omasum
- Abomasum
NUTRITION
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 oxidized 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.
21.15 Chemical energy powers the body

- Our metabolic rates typically decrease throughout adulthood
- An active life burns more calories
<table>
<thead>
<tr>
<th>Food Item</th>
<th>Jogging</th>
<th>Swimming</th>
<th>Walking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of exercise</td>
<td>9 min/mi</td>
<td>30 min/mi</td>
<td>20 min/mi</td>
</tr>
<tr>
<td>kcal “burned”/hour</td>
<td>775</td>
<td>408</td>
<td>245</td>
</tr>
<tr>
<td>Cheeseburger (quarter-pound)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>417 kcal</td>
<td>32 min</td>
<td>1 hr, 1 min</td>
<td>1 hr, 42 min</td>
</tr>
<tr>
<td>Pepperoni pizza (1 large slice)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>280 kcal</td>
<td>22 min</td>
<td>42 min</td>
<td>1 hr, 8 min</td>
</tr>
<tr>
<td>Soft drink (12 oz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>152 kcal</td>
<td>12 min</td>
<td>22 min</td>
<td>37 min</td>
</tr>
<tr>
<td>Whole wheat bread (1 slice)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65 kcal</td>
<td>5 min</td>
<td>10 min</td>
<td>16 min</td>
</tr>
</tbody>
</table>

These data are for a person weighing 68 kg (150 lb).
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
21.16 An animal’s diet must supply 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
Vegetarians must be sure to obtain all eight essential amino acids.

- The eight essential amino acids can be obtained from:
  - Animal protein
  - The proper combination of plant foods
Beans and other legumes are a good source of essential amino acids, including Methionine, Valine (Histidine), Threonine, Phenylalanine, Leucine, Isoleucine, Tryptophan, and Lysine. Corn is also a good source of some of these amino acids, particularly Methionine and Lysine.
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
<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Major Dietary Sources</th>
<th>Functions in the Body</th>
<th>Symptoms of Deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water-Soluble Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B₁ (thiamine)</td>
<td>Pork, legumes, peanuts, whole grains</td>
<td>Coenzyme used in removing CO₂ from organic compounds</td>
<td>Beriberi (nerve disorders, emaciation, anemia)</td>
</tr>
<tr>
<td>Vitamin B₂ (riboflavin)</td>
<td>Dairy products, meats, enriched grains, vegetables</td>
<td>Component of coenzyme FAD</td>
<td>Skin lesions such as cracks at corners of mouth</td>
</tr>
<tr>
<td>Niacin (B₃)</td>
<td>Nuts, meats, grains</td>
<td>Component of coenzymes NAD⁺ and NADP⁺</td>
<td>Skin and gastrointestinal lesions, nervous disorders Liver damage</td>
</tr>
<tr>
<td>Vitamin B₆ (pyridoxine)</td>
<td>Meats, vegetables, whole grains</td>
<td>Coenzyme used in amino acid metabolism</td>
<td>Irritability, convulsions, muscular twitching, anemia Unstable gait, numb feet, poor coordination</td>
</tr>
<tr>
<td>Pantothenic acid (B₅)</td>
<td>Most foods: meats, dairy products, whole grains, etc.</td>
<td>Component of coenzyme A</td>
<td>Fatigue, numbness, tingling of hands and feet</td>
</tr>
<tr>
<td>Folic acid (folacin) (B₉)</td>
<td>Green vegetables, oranges, nuts, legumes, whole grains</td>
<td>Coenzyme in nucleic acid and amino acid metabolism; neural tube development in embryo</td>
<td>Anemia, gastrointestinal problems May mask deficiency of vitamin B₁₂</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>Meats, eggs, dairy products</td>
<td>Coenzyme in nucleic acid metabolism; maturation of red blood cells</td>
<td>Anemia, nervous system disorders</td>
</tr>
<tr>
<td>Biotin</td>
<td>Legumes, other vegetables, meats</td>
<td>Coenzyme in synthesis of fat, glycogen, and amino acids</td>
<td>Scaly skin inflammation, neuro-muscular disorders</td>
</tr>
<tr>
<td>Vitamin C (ascorbic acid)</td>
<td>Fruits and vegetables, especially citrus fruits, broccoli, cabbage, tomatoes, green peppers</td>
<td>Used in collagen synthesis (e.g., for bone, cartilage, gums); antioxidant; aids in detoxification; improves iron absorption</td>
<td>Scurvy (degeneration of skin, teeth, blood vessels), weakness, delayed wound healing, impaired immunity Gastrointestinal upset</td>
</tr>
<tr>
<td><strong>Fat-Soluble Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A (retinol)</td>
<td>Dark green and orange vegetables and fruits, dairy products</td>
<td>Component of visual pigments; maintenance of epithelial tissues; antioxidant; helps prevent damage to cell membranes</td>
<td>Vision problems; dry, scaly skin Headache, irritability, vomiting, hair loss, blurred vision, liver and bone damage</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Dairy products, egg yolk (also made in human skin in presence of sunlight)</td>
<td>Aids in absorption and use of calcium and phosphorus; promotes bone growth</td>
<td>Rickets (bone deformities) in children; bone softening in adults Brain, cardiovascular, and kidney damage</td>
</tr>
<tr>
<td>Vitamin E (tocopherol)</td>
<td>Vegetable oils, nuts, seeds</td>
<td>Antioxidant; helps prevent damage to cell membranes</td>
<td>None well documented; possibly anemia</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Green vegetables, tea (also made by colon bacteria)</td>
<td>Important in blood clotting</td>
<td>Defective blood clotting Liver damage and anemia</td>
</tr>
<tr>
<td>Vitamin</td>
<td>Major Dietary Sources</td>
<td>Functions in the Body</td>
<td>Symptoms of Deficiency</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------------</td>
<td>------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Water-Soluble Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B₁ (thiamine)</td>
<td>Pork, legumes, peanuts, whole grains</td>
<td>Coenzyme used in removing CO₂ from organic compounds</td>
<td>Beriberi (nerve disorders, emaciation, anemia)</td>
</tr>
<tr>
<td>Vitamin B₂ (riboflavin)</td>
<td>Dairy products, meats, enriched grains, vegetables</td>
<td>Component of coenzyme FAD</td>
<td>Skin lesions such as cracks at corners of mouth</td>
</tr>
<tr>
<td>Niacin (B₃)</td>
<td>Nuts, meats, grains</td>
<td>Component of coenzymes NAD⁺ and NADP⁺</td>
<td>Skin and gastrointestinal lesions, nervous disorders</td>
</tr>
<tr>
<td>Vitamin B₆ (pyridoxine)</td>
<td>Meats, vegetables, whole grains</td>
<td>Coenzyme used in amino acid metabolism</td>
<td>Irritability, convulsions, muscular twitching, anemia</td>
</tr>
<tr>
<td>Pantothenic acid (B₅)</td>
<td>Most foods: meats, dairy products, whole grains, etc.</td>
<td>Component of coenzyme A</td>
<td>Fatigue, numbness, tingling of hands and feet</td>
</tr>
<tr>
<td>Folic acid (folacin) (B₉)</td>
<td>Green vegetables, oranges, nuts, legumes, whole grains</td>
<td>Coenzyme in nucleic acid and amino acid metabolism; neural tube development in embryo</td>
<td>Anemia, gastrointestinal problems May mask deficiency of vitamin B₁₂</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>Meats, eggs, dairy products</td>
<td>Coenzyme in nucleic acid metabolism; maturation of red blood cells</td>
<td>Anemia, nervous system disorders</td>
</tr>
<tr>
<td>Biotin</td>
<td>Legumes, other vegetables, meats</td>
<td>Coenzyme in synthesis of fat, glycogen, and amino acids</td>
<td>Scaly skin inflammation, neuromuscular disorders</td>
</tr>
<tr>
<td>Vitamin C (ascorbic acid)</td>
<td>Fruits and vegetables, especially citrus fruits, broccoli, cabbage, tomatoes, green peppers</td>
<td>Used in collagen synthesis (e.g., for bone, cartilage, gums); antioxidant; aids in detoxification; improves iron absorption</td>
<td>Scurvy (degeneration of skin, teeth, blood vessels), weakness, delayed wound healing, impaired immunity</td>
</tr>
<tr>
<td>Vitamin</td>
<td>Major Dietary Sources</td>
<td>Functions in the Body</td>
<td>Symptoms of Deficiency</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Fat-Soluble Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A (retinol)</td>
<td>Dark green and orange vegetables and fruits, dairy products</td>
<td>Component of visual pigments; maintenance of epithelial tissues; antioxidant; helps prevent damage to cell membranes</td>
<td>Vision problems; dry, scaly skin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Headache, irritability, vomiting, hair loss, blurred vision, liver and bone damage</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Dairy products, egg yolk (also made in human skin in presence of sunlight)</td>
<td>Aids in absorption and use of calcium and phosphorus; promotes bone growth</td>
<td>Rickets (bone deformities) in children; bone softening in adults</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Brain, cardiovascular, and kidney damage</td>
</tr>
<tr>
<td>Vitamin E (tocopherol)</td>
<td>Vegetable oils, nuts, seeds</td>
<td>Antioxidant; helps prevent damage to cell membranes</td>
<td>None well documented; possibly anemia</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Green vegetables, tea (also made by colon bacteria)</td>
<td>Important in blood clotting</td>
<td>Defective blood clotting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Liver damage and anemia</td>
</tr>
</tbody>
</table>
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
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Dietary Sources</th>
<th>Functions in the Body</th>
<th>Symptoms of Deficiency*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca)</td>
<td>Dairy products, dark green vegetables, legumes</td>
<td>Bone and tooth formation, blood clotting, nerve and muscle function</td>
<td>Stunted growth, possibly loss of bone mass</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Dairy products, meats, grains</td>
<td>Bone and tooth formation, acid-base balance, nucleotide synthesis</td>
<td>Weakness, loss of minerals from bone, calcium loss</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>Proteins from many sources</td>
<td>Component of certain amino acids</td>
<td>Symptoms of protein deficiency</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Meats, dairy products, many fruits and vegetables, grains</td>
<td>Acid-base balance, water balance, nerve function</td>
<td>Muscular weakness, paralysis, nausea, heart failure</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>Table salt</td>
<td>Acid-base balance, water balance, nerve function</td>
<td>Muscle cramps, reduced appetite</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>Table salt</td>
<td>Acid-base balance, water balance, nerve function</td>
<td>Muscle cramps, reduced appetite</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Whole grains, green leafy vegetables</td>
<td>Component of certain enzymes</td>
<td>Nervous system disturbances</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Meats, eggs, legumes, whole grains, green leafy vegetables</td>
<td>Component of hemoglobin, of certain enzymes, and of electron carriers in energy metabolism</td>
<td>Iron-deficiency anemia, weakness, impaired immunity</td>
</tr>
<tr>
<td>Fluorine (F)</td>
<td>Fluoridated drinking water, tea, seafood</td>
<td>Maintenance of tooth (and probably bone) structure</td>
<td>Higher frequency of tooth decay</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Meats, seafood, grains</td>
<td>Component of certain digestive enzymes and other proteins</td>
<td>Growth failure, scaly skin inflammation, reproductive failure, impaired immunity</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Seafood, nuts, legumes, organ meats</td>
<td>Component of enzymes in iron metabolism, electron transport, melanin synthesis</td>
<td>Anemia, bone and cardiovascular changes</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Nuts, grains, vegetables, fruits, tea</td>
<td>Component of certain enzymes</td>
<td>Abnormal bone and cartilage</td>
</tr>
<tr>
<td>Iodine (I)</td>
<td>Seafood, dairy products, iodized salt</td>
<td>Component of thyroid hormones</td>
<td>Goiter (enlarged thyroid)</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>Meats, dairy products</td>
<td>Component of vitamin B-12</td>
<td>None, except as B₁₂ deficiency</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>Seafood, meats, whole grains</td>
<td>Component of enzymes; functions in association with vitamin E</td>
<td>Muscle pain, possible heart muscle deterioration</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>Brewer's yeast, liver, seafood, meats, some vegetables</td>
<td>Involved in glucose and energy metabolism</td>
<td>Impaired glucose metabolism</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>Legumes, grains, some vegetables</td>
<td>Component of certain enzymes</td>
<td>Disorder in excretion of nitrogen-containing compounds</td>
</tr>
<tr>
<td>Mineral</td>
<td>Dietary Sources</td>
<td>Functions in the Body</td>
<td>Symptoms of Deficiency*</td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Dairy products, dark green vegetables, legumes</td>
<td>Bone and tooth formation, blood clotting, nerve and muscle function</td>
<td>Stunted growth, possibly loss of bone mass</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Dairy products, meats, grains</td>
<td>Bone and tooth formation, acid-base balance, nucleotide synthesis</td>
<td>Weakness, loss of minerals from bone, calcium loss</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>Proteins from many sources</td>
<td>Component of certain amino acids</td>
<td>Symptoms of protein deficiency</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Meats, dairy products, many fruits and vegetables, grains</td>
<td>Acid-base balance, water balance, nerve function</td>
<td>Muscular weakness, paralysis, nausea, heart failure</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>Table salt</td>
<td>Acid-base balance, water balance, nerve function, formation of gastric juice</td>
<td>Muscle cramps, reduced appetite</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>Table salt</td>
<td>Acid-base balance, water balance, nerve function</td>
<td>Muscle cramps, reduced appetite</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Whole grains, green leafy vegetables</td>
<td>Component of certain enzymes</td>
<td>Nervous system disturbances</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Meats, eggs, legumes, whole grains, green leafy vegetables</td>
<td>Component of hemoglobin, of certain enzymes, and of electron carriers in energy metabolism</td>
<td>Iron-deficiency anemia, weakness, impaired immunity</td>
</tr>
<tr>
<td>Fluorine (F)</td>
<td>Fluoridated drinking water, tea, seafood</td>
<td>Maintenance of tooth (and probably bone) structure</td>
<td>Higher frequency of tooth decay</td>
</tr>
</tbody>
</table>

*All of these minerals can be harmful when consumed in excess.
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Dietary Sources</th>
<th>Functions in the Body</th>
<th>Symptoms of Deficiency*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc (Zn)</td>
<td>Meats, seafood, grains</td>
<td>Component of certain digestive enzymes and other proteins</td>
<td>Growth failure, scaly skin inflammation, reproductive failure, impaired immunity</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Seafood, nuts, legumes, organ meats</td>
<td>Component of enzymes in iron metabolism, electron transport, melanin synthesis</td>
<td>Anemia, bone and cardiovascular changes</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Nuts, grains, vegetables, fruits, tea</td>
<td>Component of certain enzymes</td>
<td>Abnormal bone and cartilage</td>
</tr>
<tr>
<td>Iodine (I)</td>
<td>Seafood, dairy products, iodized salt</td>
<td>Component of thyroid hormones</td>
<td>Goiter (enlarged thyroid)</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>Meats, dairy products</td>
<td>Component of vitamin B-12</td>
<td>None, except as B₁₂ deficiency</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>Seafood, meats, whole grains</td>
<td>Component of enzymes; functions in association with vitamin E</td>
<td>Muscle pain, possible heart muscle deterioration</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>Brewer’s yeast, liver, seafood, meats, some vegetables</td>
<td>Involved in glucose and energy metabolism</td>
<td>Impaired glucose metabolism</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>Legumes, grains, some vegetables</td>
<td>Component of certain enzymes</td>
<td>Disorder in excretion of nitrogen-containing compounds</td>
</tr>
</tbody>
</table>

*All of these minerals can be harmful when consumed in excess.
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
21.19 CONNECTION: Do you need to take vitamin and mineral supplements?

- 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
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
Ingredients: whole wheat flour, water, high fructose corn syrup, wheat gluten, soybean or canola oil, molasses, yeast, salt, cultured whey, vinegar, soy flour, calcium sulfate (source of calcium).
21.21 EVOLUTION CONNECTION: The human health problem of obesity may reflect our evolutionary past

- Overnourishment: consuming more food energy than is needed
- 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
21.21 EVOLUTION CONNECTION: The human health problem of obesity may reflect our evolutionary past

- Leptin
  - Produced by fat cells
  - Suppresses appetite
  - High levels in humans do not suppress appetite
  - May be adaptive in humans to prevent excessive weight loss
Leptin-deficient mice were very obese.

After treatment with leptin, leptin-deficient mice lost weight.


Adults with healthy leptin genes do not lose weight with leptin treatments.

21.21 EVOLUTION CONNECTION: The human health problem of obesity may reflect our evolutionary past.
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
<table>
<thead>
<tr>
<th>Diet Type and Examples</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-carb diets</strong></td>
<td></td>
</tr>
<tr>
<td>Atkins diet</td>
<td>High-protein, high-fat, extremely low carbohydrate—restricting sugar, bread, pasta, milk, fruits, and vegetables.</td>
</tr>
<tr>
<td>Zone diet</td>
<td>40% of calories from carbs, 30% from protein, and 30% from fats. Encourages high-fiber fruits, vegetables, beans, and grains.</td>
</tr>
<tr>
<td><strong>Low-fat diets</strong></td>
<td></td>
</tr>
<tr>
<td>Pritikin Plan</td>
<td>High carbohydrate. Fats less than 10% of daily fat intake; focus on vegetables, fruits, and high-fiber grains.</td>
</tr>
<tr>
<td>Ornish diet</td>
<td>Vegetarian diet low in salt; 10% of calories from fat; focus on vegetables and grains.</td>
</tr>
<tr>
<td><strong>Glycemic-index diets</strong></td>
<td></td>
</tr>
<tr>
<td>South Beach diet</td>
<td>Focus on carbohydrates with a low glycemic-index (GI) ranking to lower blood sugar levels. (Glycemic index [GI] ranks carbohydrates based on their effect on blood glucose levels in the first two hours after consumption.)</td>
</tr>
<tr>
<td><strong>Formula diets</strong></td>
<td></td>
</tr>
<tr>
<td>Slim-Fast</td>
<td>Based on packaged products; nutritionally sound, low-calorie shakes/bars</td>
</tr>
<tr>
<td><strong>Group-approach diets</strong></td>
<td></td>
</tr>
<tr>
<td>Weight-Watchers, eDiets.com</td>
<td>Group meetings (or on-line chats) that provide diet plans, exercise plans, and group support</td>
</tr>
</tbody>
</table>
A healthy diet may reduce the risk of

- Cardiovascular disease
- Cancer

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 relationship between food and health is complex

The American Cancer Society recommends
- Regular exercise
- A diverse diet of healthy foods with an emphasis on plant sources

21.23 CONNECTION: Diet can influence cardiovascular disease and cancer
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).
A healthy diet satisfies three needs:

(a) coenzymes, ion balances, nerve functions, bone structure

(b) molecules of cells needed to build

(c) which include essential fatty acids

(d) too much leads to undernourishment

(e) not enough leads to lack results in

(f) lack produces most common is protein deficiency

(g) have many functions, such as coenzymes, ion balances, nerve functions, bone structure

Copyright © 2009 Pearson Education, Inc.
# Nutrition Facts

**Serving Size** 1/2 Cup (83g)
**Servings Per Container** 8

<table>
<thead>
<tr>
<th>Amount Per Serving</th>
<th>% Daily Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calories</strong> 190</td>
<td>Calories from Fat 110</td>
</tr>
<tr>
<td><strong>Total Fat</strong> 12g</td>
<td>18%</td>
</tr>
<tr>
<td>Saturated Fat 8g</td>
<td>40%</td>
</tr>
<tr>
<td>Trans Fat 0g</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Cholesterol</strong> 45mg</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Sodium</strong> 75mg</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total Carbohydrate</strong> 18g</td>
<td>6%</td>
</tr>
<tr>
<td>Dietary Fiber 0g</td>
<td>0%</td>
</tr>
<tr>
<td>Sugars 17g</td>
<td></td>
</tr>
<tr>
<td><strong>Protein</strong> 3g</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vitamin A 10%</th>
<th>Vitamin C 8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium 10%</td>
<td>Iron 0%</td>
</tr>
</tbody>
</table>

*Percent Daily Values (DV) are based on a 2,000 calorie diet.
You should now be able to

1. Describe the four stages of food processing
2. Describe the main components of the human digestive tract and their functions
3. Explain how teeth and saliva help us swallow
4. Describe the Heimlich maneuver
5. Explain why the stomach does not digest itself
6. Describe the causes and treatment of heartburn, GERD, and gastric ulcers
You should now be able to

7. Compare the structures and functions of the small and large intestines

8. Compare the digestive tracts of carnivores and herbivores

9. Distinguish between undernourishment and malnourishment

10. Describe the types of information found on food labels

11. Explain how a healthy diet and exercise promote good health