Impacts, Issues
Hormones and Hunger

- Fat cells secrete leptin, which reduces appetite; an empty stomach secretes ghrelin, which makes you hungry – the goal is healthy nutrition
40.1 The Nature of Digestive Systems

- **Digestive system**
  - A body cavity or tube that mechanically and chemically breaks food down to small particles, then to molecules that can be absorbed into the internal environment
  - Interacts with other organ systems to maintain homeostasis
food, water intake

- Digestive System: nutrients, water, salts
  - elimination of food residues

- Respiratory System: oxygen intake
  - oxygen intake
  - carbon dioxide
  - elimination of carbon dioxide

- Circulatory System: rapid transport to and from all living cells
  - water, solutes

- Urinary System: elimination of excess water, salts, wastes
Incomplete and Complete Digestive Systems

- **Incomplete digestive system**
  - A saclike gut with one opening in the body surface for food to enter and waste to leave

- **Complete digestive system**
  - A tubular gut with an opening at both ends
  - Includes mouth, pharynx, esophagus, stomach, small and large intestines, and anus
Incomplete and Complete Digestive Systems

A Flatworm (planarian)
- branching saclike gut
- only opening to gut
- pharynx
- stomach
- small intestine
- large intestine
- liver
- gallbladder
- pancreas

B Amphibian (frog)
- flip-out tongue in mouth

C Bird (pigeon)
- bill mouth
- esophagus
- crop
- glandular part of stomach
- gizzard
- intestines
- cloaca (terminal opening; serves in excretion and reproduction)
A Flatworm (planarian)

- Branching sac-like gut
- Only opening to gut
- Pharynx
A Flatworm (planarian)

- Branching sac-like gut
- Only opening to gut
- Pharynx
B Amphibian (frog)
B Amphibian (frog)

- pharynx
- stomach
- small intestine
- large intestine
- flip-out tongue in mouth
- liver
- gallbladder
- pancreas
C Bird (pigeon)

- bill
- mouth
- esophagus
- crop
- glandular part of stomach
- gizzard
- intestines
- cloaca (terminal opening; serves in excretion and reproduction)
C Bird (pigeon)

- bill
- mouth
- esophagus
- crop
- glandular part of stomach
- gizzard
- intestines
- cloaca (terminal opening; serves in excretion and reproduction)
Animation: Examples of digestive systems
Five Functions of a Complete Digestive System

1. *Mechanical processing and motility*

2. *Secretion* of digestive enzymes into the lumen

3. *Digestion* of food into absorbable molecules

4. *Absorption* of nutrients into extracellular fluid

5. *Elimination* of solid residues
Dietary Adaptations

- **Bird adaptations**
  - Size and shape of bills adapted to different diets
  - Crops and gizzards

- **Mammal adaptations**
  - Teeth adapted to different diets
  - Multiple stomach chambers in *ruminants*
Some Adaptations of Mammalian Digestive Systems
Fig. 40-4a, p. 703

- **gumline**
- **crown**
- **root**

- **antelope molar**

- **crown**
- **root**

- **human molar**
ingestion, regurgitation, reswallowing of food through esophagus

stomach chamber 1

stomach chamber 2

stomach chamber 3

stomach chamber 4

to small intestine

© Brooks/Cole, Cengage Learning
ingestion, regurgitation, reswallowing of food through esophagus

stomach chamber 1

stomach chamber 2

stomach chamber 3

stomach chamber 4

to small intestine
Animation: Antelope stomach function
40.1 Key Concepts
Overview of Digestive Systems

- Some animal digestive systems are saclike, but most are a tube with two openings

- In complex animals, a digestive system interacts with other organ systems in the distribution of nutrients and water, disposal of residues and wastes, and homeostasis
40.2 Overview of the Human Digestive System

- Humans have a complete digestive system lined with mucus-covered epithelium.

- If the tubular gut of an adult human were fully stretched out, it would extend up to 9 meters (30 feet).
Accessory Organs

- Accessory organs along the length of the gut secrete enzymes and other substances that break down food into its component molecules
  - Salivary glands
  - Pancreas
  - Liver
  - Gallbladder
From Mouth to Stomach

- Food is partially digested in the **mouth** and forced into the **pharynx** by swallowing.

- Food is moved through the **esophagus** by **peristalsis** through a **sphincter** to the **stomach**, which adds acids and enzymes to food and mixes them together to form **chyme**.
Gastrointestinal Tract

- In the **small intestine**, carbohydrates, lipids and proteins are digested by secretions from liver and pancreas; nutrients and water are absorbed.

- The **large intestine** absorbs water and ions, and compacts wastes, which collect in the **rectum**, and are expelled from the **anus**.
The Human Digestive System

**Major Organs**

- **Mouth**: Oral cavity. Its teeth break food into smaller bits. Tongue mixes food with saliva.
- **Pharynx (throat)**: Entrance to the gut and respiratory system. Action of the epiglottis keeps food from entering the trachea.
- **Esophagus**: Muscular tube through which food moves to the stomach.
- **Stomach**: J-shaped muscular sac that receives food and mixes it with gastric fluid secreted by cells in its lining.
- **Small Intestine**: Longest tube of the gut. Its first part receives secretions from the liver, gallbladder, and pancreas. These secretions help complete the process of digestion. Most water and products of digestion are absorbed across the highly folded wall of this organ.
- **Large Intestine (colon)**: Wider than the small intestine, but shorter. It absorbs most remaining water, thus concentrating any undigested waste and forming the feces.
- **Rectum**: Expandable sac that stores feces.
- **Anus**: Opening through which feces are expelled from the body.

**Accessory Organs**

- **Salivary Glands**: Produce and secrete saliva which moistens food and begins the process of carbohydrate digestion.
- **Liver**: Produces bile, which aids digestion and absorption of fats.
- **Gallbladder**: Stores and concentrates bile, then secretes it into the small intestine.
- **Pancreas**: Secretes enzymes and bicarbonate (a buffer) into the small intestine.
Major Organs
- Mouth
- Pharynx (throat)
- Esophagus
- Stomach
- Small Intestine
- Large Intestine (colon)
- Rectum
- Anus

Accessory Organs
- Salivary Glands
- Liver
- Gallbladder
- Pancreas

Fig. 40-5, p. 704
40.3 Food in the Mouth

- Digestion begins when teeth mechanically break down food into smaller bits.

- Teeth consist mostly of bonelike dentin; the crown is covered by a hard layer of enamel.

- Salivary amylase secreted by salivary glands hydrolyses starch into disaccharides.
Four Types of Teeth in Humans

- enamel
- dentin
- pulp cavity (contains nerves and blood vessels)
- ligaments
- root canal
- periodontal membrane
- crown
- gingiva (gum)
- root
- bone
enamel
dentin
pulp cavity (contains nerves and blood vessels)
ligaments
root canal
periodontal membrane
crown
gingiva (gum)
root
bone
Four Types of Teeth in Humans

lower jaw

molars (12)

premolars (8)

canines (4)

incisors (8)

upper jaw
lower jaw

- incisors (8)
- canines (4)
- premolars (8)
- molars (12)

upper jaw
Carbohydrate breakdown begins in the mouth and is completed in the small intestine.

Protein breakdown begins in the stomach and is completed in the small intestine.

Lipids are digested in the small intestine.
The stomach has three digestive functions:

- Stores food and controls the rate of passage to the small intestine
- Mechanically mixes and breaks down food
- Secretes substances used in chemical digestion
Digestion in the Stomach

- Stomach mucosa secretes gastric fluid containing hydrochloric acid and enzymes that begin protein digestion
  - Gastrin signals secretion of acid and pepsinogens
  - Acid unfolds proteins
  - Pepsin breaks proteins into peptides

- Chyme passes into the small intestine
Digestion in the Small Intestine

- In the small intestine, chyme mixes with secretions from the pancreas and liver.

- Pancreatic enzymes break down larger molecules into units that can be absorbed:
  - Monosaccharides, monoglycerides, fatty acids, amino acids, nucleotides, nucleotide bases
  - Bicarbonate from the pancreas buffers acids so enzymes can work.
Digestion in the Small Intestine

- Lipid (fat) digestion in the small intestine requires enzymes and bile, which is produced by the liver and stored in the gallbladder.

- **Bile**
  - A mixture of salts, pigments, cholesterol and lipids that *emulsifies* fats into small drops that enzymes can break down into fatty acids and monoglycerides.
Structure of the Small Intestine

- A section of highly folded mucosa

© Brooks/Cole, Cengage Learning
submucosa

serosa

blood vessels

gut lumen
circular muscle
longitudinal muscle
autonomic nerves

© Brooks/Cole, Cengage Learning
# Summary: Chemical Digestion

<table>
<thead>
<tr>
<th>Table 40.1 Summary of Chemical Digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td>Carbohydrate Digestion</td>
</tr>
<tr>
<td>Mouth, stomach</td>
</tr>
<tr>
<td>Small intestine</td>
</tr>
<tr>
<td>Protein Digestion</td>
</tr>
<tr>
<td>Stomach</td>
</tr>
<tr>
<td>Small intestine</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Lipid Digestion</td>
</tr>
<tr>
<td>Small intestine</td>
</tr>
<tr>
<td>Nucleic Acid Digestion</td>
</tr>
<tr>
<td>Small intestine</td>
</tr>
</tbody>
</table>

* Breakdown products small enough to be absorbed into the internal environment.
© Brooks/Cole, Cengage Learning
Controls Over Digestion

- The nervous system, endocrine system, and nerves of the gut wall control digestion

- Arrival of food in the stomach sends signals to gut muscles, glands, and brain

- Sympathetic neurons slow digestion during stress or exercise
# Hormonal Controls of Digestion

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Source</th>
<th>Effects on Digestive System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrin</td>
<td>Stomach</td>
<td>Stimulates stomach acid secretion</td>
</tr>
<tr>
<td>Cholecystokinin</td>
<td>Small intestine</td>
<td>Stimulates pancreatic enzyme secretion and gallbladder contraction</td>
</tr>
<tr>
<td>(CCK)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secretin</td>
<td>Small intestine</td>
<td>Stimulates pancreas to secrete bicarbonate and slows contractions of small intestine</td>
</tr>
</tbody>
</table>

© Brooks/Cole, Cengage Learning
The small intestine is the main site of absorption for the products of digestion.

- **Brush border cells** that project into the lumen function in both digestion and absorption.

- Cells in the intestinal lining secrete digestive enzymes, hormones, mucus, and lysozyme.
Three features increase surface area:

- The lining is folded
- Multicelled, fingerlike absorptive structures (villi) with lymph and blood vessels extend from folds
- Brush border cells on the villus surface have membrane extensions (microvilli) that project into the lumen
The Lining of the Small Intestine

A. One of many permanent folds on the inner wall of the small intestine. Each fold is covered with villi.

B. At the free surface of each mucosal fold are many fingerlike absorptive structures called villi.

C. A villus is covered with specialized epithelial cells. It also contains blood capillaries and lymph vessels.

D. Epithelial cells in the intestinal mucosa. The four types shown below are color-coded enlargements of cells on the surface of the villus shown in (c).

Absorptive brush border cells are the most abundant cells on a villus. Their crown of microvilli extends into the intestinal lumen. The small intestinal enzymes discussed in the previous section are built into brush border cell plasma membranes. Other cells of the mucosa secrete mucus, hormones, or lysozyme (an enzyme that digests bacterial cell walls).

© Brooks/Cole, Cengage Learning
A One of many permanent folds on the inner wall of the small intestine. Each fold is covered with villi.

B At the free surface of each mucosal fold are many fingerlike absorptive structures called villi.

C A villus is covered with specialized epithelial cells. It also contains blood capillaries and lymph vessels.
A brush border cell secretes lysozyme, hormones, mucus, and absorbs nutrients. The microvilli at the free surface of the cell project into the lumen of the structure.
Animation: Structure of the small intestine
Water and Solute Absorption

- Transport proteins move salts, sugars, and amino acids from the intestinal lumen, into brush border cells, then into interstitial fluid in a villus.

- Water follows the solutes by osmotic gradient.

- Capillaries in the villus distribute water and solutes through the body.
Fat Absorption

- Fatty acids and monoglycerides combine with bile salts to form micelles, which aid diffusion into brush border cells (bile salts stay in lumen)

- In brush border cells, fatty acids and monoglycerides combine with proteins to form lipoproteins, which enter the villus by exocytosis

- From interstitial fluid, triglycerides enter lymph vessels, which empty into the bloodstream
Digestion and Absorption in the Small Intestine

**A** Enzymes secreted by the pancreas and cells of the intestinal mucosa complete the digestion of carbohydrates to monosaccharides, and proteins to amino acids.

**B** Monosaccharides and amino acids are actively transported across the plasma membrane of brush border cells in the intestinal lining, then out of the same cells and into the internal environment.

**C** Movements of the intestinal wall break up fat globules into small droplets. Bile salts coat the droplets, so that globules cannot form again. Pancreatic enzymes digest the droplets to fatty acids and monoglycerides.

**D** Micelles form when bile salts combine with products of fat digestion: monoglycerides and fatty acids. These products slip into and out of micelles.

**E** Concentrating monoglycerides and fatty acids in micelles enhances diffusion of these substances into brush border cells. These lipids diffuse across the plasma membrane’s lipid bilayer, into the cells.

**F** In a brush border cell, the products of fat digestion form triglycerides, which associate with proteins. The resulting lipoproteins are then expelled by exocytosis into the interstitial fluid inside the villus.

© Brooks/Cole, Cengage Learning
Lumen of Small Intestine

- Carbohydrates → monosaccharides
- Proteins → amino acids
- Fat globules (triglycerides) + bile salts → emulsification droplets
- Free fatty acids, monoglycerides + bile salts → micelles
- Triglycerides + proteins + lipoproteins

Internal Environment (interstitial fluid inside a villus)
Lumen of Small Intestine

A. Carbohydrates → Monosaccharides
B. Proteins → Amino Acids

Fat Globules (Triglycerides)

C. Emulsification Droplets + Bile Salts = Free Fatty Acids, Monoglycerides

D. Micelles

E. Triglycerides + Proteins

F. Lipoproteins

Internal Environment (Interstitial Fluid Inside a Villus)

Fig. 40-10, p. 709

Stepped Art
40.6 The Large Intestine

- The large intestine is wider than the small intestine, but also much shorter—only about 1.5 meters (5 feet) long

- The ascending colon begins at the cecum, where the **appendix** is attached

- The descending colon attaches to the rectum
Structure of the Large Intestine
Fig. 40-11a, p. 710

ascending colon

last portion of small intestine

cecum

appendix
transverse colon

colon polyp

descending colon
The large intestine completes the process of absorption, then concentrates, stores, and eliminates wastes.

Bacteria in the colon make vitamins K and B12, which are absorbed through the colon lining.

Stretch receptors in the rectum trigger the defecation reflex.
Disorders of the Large Intestine

- Diarrhea may result from a bacterial infection, and cause dehydration

- Appendicitis must be treated to prevent rupture and infection of the abdominal cavity

- Colon polyps leading to cancer can be detected and removed by colonoscopy
Human Digestive System

- Human digestion starts in the mouth, continues in the stomach, and is completed in the small intestine

- Secretions of the salivary glands, liver, and pancreas aid digestion

- Most nutrients are absorbed in the small intestine

- The large intestine concentrates wastes
Absorbed compounds are carried by the blood to the liver, which plays a central role in metabolism.

Most absorbed compounds are broken down for energy, stored, or used to build larger compounds.

Excess carbohydrates and proteins are converted to fat and stored in adipose tissue.
Liver Function

- The liver detoxifies dangerous substances (alcohol, NH\(_3\)), and stores fat-soluble vitamins (A, D) and glucose (as glycogen)

- Between meals, the liver provides the brain with glucose by breaking down stored glycogen
Liver Function

**FOOD INTAKE**
- Dietary carbohydrates, lipids
- Dietary proteins, amino acids

**Cytoplasmic Pool of Carbohydrates, Fats (interconvertible forms)**
- Storage forms (e.g., glycogen)
- Building blocks for cell structures
- Specialized derivatives (e.g., steroids, acetylcholine)
- Instant energy sources for cells

**Cytoplasmic Pool of Amino Acids**
- Nitrogen-containing derivatives (e.g., hormones, nucleotides)
- Building blocks for structural proteins, enzymes

**Liver Functions**
- Forms bile (assists fat digestion), rids body of excess cholesterol and blood’s respiratory pigments
- Controls amino acid levels in the blood; converts potentially toxic ammonia to urea
- Controls glucose level in blood; major reservoir for glycogen
- Removes hormones that served their functions from blood
- Removes ingested toxins, such as alcohol, from blood
- Breaks down worn-out and dead red blood cells, and stores iron
- Stores some vitamins

© Brooks/Cole, Cengage Learning
FOOD INTAKE

- Dietary carbohydrates, lipids
- Dietary proteins, amino acids

Cytoplasmic Pool of Carbohydrates, Fats
(interconvertible forms)

- Storage forms (e.g., glycogen)
- Building blocks for cell structures
- Specialized derivatives (e.g., steroids, acetylcholine)
- Instant energy sources for cells

Cytoplasmic Pool of Amino Acids

- Ammonia
- Urea
- Excreted in urine
- Nitrogen-containing derivatives (e.g., hormones, nucleotides)
- Building blocks for structural proteins, enzymes

© Brooks/Cole, Cengage Learning

Fig. 40-12a, p. 711
FOOD INTAKE

dietary carbohydrates, lipids

dietary proteins, amino acids

Cytoplasmic Pool of Carbohydrates, Fats (interconvertible forms)

storage forms (e.g., glycogen)

building blocks for cell structures

specialized derivatives (e.g., steroids, acetylcholine)

instant energy sources for cells

ammonia

urea

excreted in urine

Cytoplasmic Pool of Amino Acids

nitrogen-containing derivatives (e.g., hormones, nucleotides)

building blocks for structural proteins, enzymes

© Brooks/Cole, Cengage Learning

Fig. 40-12a, p. 711
Liver Functions

Forms bile (assists fat digestion), rids body of excess cholesterol and blood's respiratory pigments
Controls amino acid levels in the blood; converts potentially toxic ammonia to urea
Controls glucose level in blood; major reservoir for glycogen
Removes hormones that served their functions from blood
Removes ingested toxins, such as alcohol, from blood
Breaks down worn-out and dead red blood cells, and stores iron
Stores some vitamins
Liver Functions

Forms bile (assists fat digestion), rids body of excess cholesterol and blood’s respiratory pigments

Controls amino acid levels in the blood; converts potentially toxic ammonia to urea

Controls glucose level in blood; major reservoir for glycogen

Removes hormones that served their functions from blood

Removes ingested toxins, such as alcohol, from blood

Breaks down worn-out and dead red blood cells, and stores iron

Stores some vitamins
Eating provides your cells with a source of energy and a supply of essential building materials.

Nutritional guidelines based on age, sex, height, weight, and activity level can be generated online at mypyramid.gov.
Some USDA Nutritional Guidelines

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Amount Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td></td>
</tr>
<tr>
<td>Dark green vegetables</td>
<td>3 cups/week</td>
</tr>
<tr>
<td>Orange vegetables</td>
<td>2 cups/week</td>
</tr>
<tr>
<td>Legumes</td>
<td>3 cups/week</td>
</tr>
<tr>
<td>Starchy vegetables</td>
<td>3 cups/week</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>6.5 cups/week</td>
</tr>
<tr>
<td>Fruits</td>
<td>2 cups/day</td>
</tr>
<tr>
<td>Milk Products</td>
<td>3 cups/day</td>
</tr>
<tr>
<td>Grains</td>
<td>6 ounces/day</td>
</tr>
<tr>
<td>Whole grains</td>
<td>3 ounces/day</td>
</tr>
<tr>
<td>Other grains</td>
<td>3 ounces/day</td>
</tr>
<tr>
<td>Fish, poultry, lean meat</td>
<td>5.5 ounces/day</td>
</tr>
<tr>
<td>Oils</td>
<td>24 grams/day</td>
</tr>
</tbody>
</table>

© Brooks/Cole, Cengage Learning
Energy-Rich Carbohydrates

- Good (complex) carbohydrates provide energy, vitamins, and fiber (soluble and insoluble)
  - Fresh fruits, whole grains, and vegetables

- Not so good (processed) carbohydrates have “empty calories”
  - White flour, refined sugar, corn syrup
Lipids are used in cell membranes (phospholipids and cholesterol), as energy reserves, insulation and cushioning, and to store fat-soluble vitamins.

**Essential fatty acids** (linoleic and alpha-linoleic acids) must be obtained from the diet.
Good Fat, Bad Fat

- Unsaturated fats are liquid at room temperature
  - Polyunsaturated fats (such as omega-3 fatty acids) and monounsaturated fats (such as oleic acid) have specific health benefits

- Saturated fats (in meat and dairy products) can increase risk of heart disease, stroke, or cancer

- *Trans* fats are worse than saturated fats
# Main Types of Dietary Lipids

## Table 40.3  Main Types of Dietary Lipids

<table>
<thead>
<tr>
<th>Type of Fatty Acids</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Polyunsaturated Fatty Acids</strong></td>
<td>Liquid at room temperature; essential for health.</td>
</tr>
<tr>
<td>Omega-3 fatty acids</td>
<td>Alpha-linoleic acid and its derivatives</td>
</tr>
<tr>
<td>Sources: Nut oils, vegetable oils, oily fish</td>
<td></td>
</tr>
<tr>
<td>Omega-6 fatty acids</td>
<td>Linoleic acid and its derivatives</td>
</tr>
<tr>
<td>Sources: Nut oils, vegetable oils, meat</td>
<td></td>
</tr>
<tr>
<td><strong>Monounsaturated Fatty Acids</strong></td>
<td>Liquid at room temperature. Main dietary source is olive oil. Beneficial in moderation.</td>
</tr>
<tr>
<td><strong>Saturated Fatty Acids</strong></td>
<td>Solid at room temperature. Main sources are meat and dairy products, palm and coconut oils. Excessive intake may raise risk of heart disease.</td>
</tr>
<tr>
<td><strong>Trans Fatty Acids (Hydrogenated Fats)</strong></td>
<td>Solid at room temperature. Manufactured from vegetable oils and used in many processed foods. Excessive intake may raise risk of heart disease.</td>
</tr>
</tbody>
</table>
**Body-Building Proteins**

- Proteins are the source of amino acids used to build all body proteins.
- Meat provides all eight *essential amino acids*.
- Most plant foods lack one or more amino acids, but can meet all human amino-acid needs when combined correctly.
40.9 Vitamins, Minerals, and Phytochemicals

- **Vitamins**
  - Organic substances that are essential in very small amounts in the diet (coenzymes)

- **Minerals**
  - Inorganic substances with essential metabolic functions (such as iron in hemoglobin)

- **Phytochemicals**
  - Beneficial organic molecules found in plant foods
# Major Vitamins

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Common Sources</th>
<th>Main Functions</th>
<th>Effects of Chronic Deficiency</th>
<th>Effects of Extreme Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fat-Soluble Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Its precursor comes from beta-carotene in yellow fruits, yellow or green leafy vegetables; also in fortified milk, egg yolk, fish, liver</td>
<td>Used in synthesis of visual pigments, bone, teeth; maintains epithelia</td>
<td>Dry, scaly skin; lowered resistance to infections; night blindness; permanent blindness</td>
<td>Malformed fetuses; hair loss; changes in skin; liver and bone damage; bone pain</td>
</tr>
<tr>
<td>D</td>
<td>Inactive form made in skin, activated in liver, kidneys; in fatty fish, egg yolk, fortified milk products</td>
<td>Promotes bone growth and mineralization; enhances calcium absorption</td>
<td>Bone deformities (rickets) in children; bone softening in adults</td>
<td>Retarded growth; kidney damage; calcium deposits in soft tissues</td>
</tr>
<tr>
<td>E</td>
<td>Whole grains, dark green vegetables, vegetable oils</td>
<td>Counters effects of free radicals; helps maintain cell membranes; blocks breakdown of vitamins A and C in gut</td>
<td>Lysis of red blood cells; nerve damage</td>
<td>Muscle weakness; fatigue; headaches; nausea</td>
</tr>
<tr>
<td>K</td>
<td>Enterobacteria form most of it; also in green leafy vegetables, cabbage</td>
<td>Blood clotting; ATP formation via electron transport</td>
<td>Abnormal blood clotting; severe bleeding (hemorrhaging)</td>
<td>Anemia; liver damage and jaundice</td>
</tr>
</tbody>
</table>

© Brooks/Cole, Cengage Learning
### Table 40.5 Major Minerals: Sources, Functions, and Effects of Deficiencies or Excesses*

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Common Sources</th>
<th>Main Functions</th>
<th>Effects of Chronic Deficiency</th>
<th>Effects of Extreme Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Dairy products, dark green vegetables, dried legumes</td>
<td>Bone, tooth formation; blood clotting; neural and muscle action</td>
<td>Stunted growth; fragile bones; nerve impairment; muscle spasms</td>
<td>Impaired absorption of other minerals; kidney stones in susceptible people</td>
</tr>
<tr>
<td>Chloride</td>
<td>Table salt (usually too much in diet)</td>
<td>HCl formation in stomach; contributes to body's acid-base balance; neural action</td>
<td>Muscle cramps; impaired growth; poor appetite</td>
<td>Contributes to high blood pressure in certain people</td>
</tr>
<tr>
<td>Copper</td>
<td>Nuts, legumes, seafood, drinking water</td>
<td>Used in synthesis of melanin, hemoglobin, and some transport chain components</td>
<td>Anemia; changes in bone and blood vessels</td>
<td>Nausea; liver damage</td>
</tr>
<tr>
<td>Fluorine</td>
<td>Fluoridated water, tea, seafood</td>
<td>Bone, tooth maintenance</td>
<td>Tooth decay</td>
<td>Digestive upsets; mottled teeth and deformed skeleton in chronic cases</td>
</tr>
<tr>
<td>Iodine</td>
<td>Marine fish, shellfish, iodized salt, dairy products</td>
<td>Thyroid hormone formation</td>
<td>Enlarged thyroid (goiter) with metabolic disorders</td>
<td>Toxic goiter</td>
</tr>
<tr>
<td>Iron</td>
<td>Whole grains, green leafy vegetables, legumes, nuts, eggs, lean meat, molasses, dried fruit, shellfish</td>
<td>Formation of hemoglobin and cytochrome (transport chain component)</td>
<td>Iron-deficiency anemia; impaired immune function</td>
<td>Liver damage; shock; heart failure</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Whole grains, legumes, nuts, dairy products</td>
<td>Coenzyme role in ATP-ADP cycle; roles in muscle, nerve function</td>
<td>Weak, sore muscles; impaired neural function</td>
<td>Impaired neural function</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Whole grains, poultry, red meat</td>
<td>Component of bone, teeth, nucleic acids, ATP, phospholipids</td>
<td>Muscular weakness; loss of minerals from bone</td>
<td>Impaired absorption of minerals into bone</td>
</tr>
<tr>
<td>Potassium</td>
<td>Diet alone provides ample amounts</td>
<td>Muscle and neural function; roles in protein synthesis and body's acid-base balance</td>
<td>Muscular weakness</td>
<td>Muscular weakness; paralysis; heart failure</td>
</tr>
<tr>
<td>Sodium</td>
<td>Table salt; diet provides ample to excessive amounts</td>
<td>Key role in body's salt-water balance; roles in muscle and neural function</td>
<td>Muscle cramps</td>
<td>High blood pressure in susceptible people</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Proteins in diet</td>
<td>Component of body proteins</td>
<td>None reported</td>
<td>None likely</td>
</tr>
<tr>
<td>Zinc</td>
<td>Whole grains, legumes, nuts, meats, seafood</td>
<td>Component of digestive enzymes; roles in protein synthesis; wound healing, sperm formation, and taste and smell</td>
<td>Impaired growth; scaly skin; impaired immune function</td>
<td>Nausea, vomiting, diarrhea; impaired immune function and anemia</td>
</tr>
</tbody>
</table>

* Guidelines for appropriate daily intakes are being worked out by the Food and Drug Administration.
Nutrients absorbed from the gut are raw materials used in synthesis of the body’s complex carbohydrates, lipids, proteins, and nucleic acids.

A healthy diet normally provides all nutrients, vitamins, and minerals necessary to support metabolism.
40.10 Weighty Questions, Tantalizing Answers

- Being overweight increases health risks
  - Type 2 diabetes, high blood pressure, heart disease, breast and colon cancer, arthritis, gallstones

- An unhealthy overabundance of fat (obesity) stresses fat cells, triggers inflammatory response
  - Fat cells do not increase in number after birth
  - Excess weight overfills existing fat cells
Body mass index (BMI) estimates health risks

- Overweight: 25 to 29.9
- Obese: 30 or more

\[ \text{BMI} = \frac{\text{weight (lbs)} \times 703}{\text{height (in)}^2} \]
# Weight Guidelines

## Weight Guidelines for Women

Starting with an ideal weight of 100 pounds for a woman who is 5 feet tall, add five additional pounds for each additional inch of height. Examples:

<table>
<thead>
<tr>
<th>Height (feet)</th>
<th>Weight (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5’ 2”</td>
<td>110</td>
</tr>
<tr>
<td>5’ 3”</td>
<td>115</td>
</tr>
<tr>
<td>5’ 4”</td>
<td>120</td>
</tr>
<tr>
<td>5’ 5”</td>
<td>125</td>
</tr>
<tr>
<td>5’ 6”</td>
<td>130</td>
</tr>
<tr>
<td>5’ 7”</td>
<td>135</td>
</tr>
<tr>
<td>5’ 8”</td>
<td>140</td>
</tr>
<tr>
<td>5’ 9”</td>
<td>145</td>
</tr>
<tr>
<td>5’ 10”</td>
<td>150</td>
</tr>
<tr>
<td>5’ 11”</td>
<td>155</td>
</tr>
<tr>
<td>6’</td>
<td>160</td>
</tr>
</tbody>
</table>

## Weight Guidelines for Men

Starting with an ideal weight of 106 pounds for a man who is 5 feet tall, add six additional pounds for each additional inch of height. Examples:

<table>
<thead>
<tr>
<th>Height (feet)</th>
<th>Weight (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5’ 2”</td>
<td>118</td>
</tr>
<tr>
<td>5’ 3”</td>
<td>124</td>
</tr>
<tr>
<td>5’ 4”</td>
<td>130</td>
</tr>
<tr>
<td>5’ 5”</td>
<td>136</td>
</tr>
<tr>
<td>5’ 6”</td>
<td>142</td>
</tr>
<tr>
<td>5’ 7”</td>
<td>148</td>
</tr>
<tr>
<td>5’ 8”</td>
<td>154</td>
</tr>
<tr>
<td>5’ 9”</td>
<td>160</td>
</tr>
<tr>
<td>5’ 10”</td>
<td>166</td>
</tr>
<tr>
<td>5’ 11”</td>
<td>172</td>
</tr>
<tr>
<td>6’</td>
<td>178</td>
</tr>
</tbody>
</table>
Genes, Hormones, and Obesity

- To maintain body weight, energy (caloric) intake must balance with energy output

- Genetic factors influence how difficult it is for a person to reach and maintain a healthy weight

- Hormones such as leptin can influence both appetite and metabolic rate
Genes, Hormones, and Obesity

a. In 1950, researchers at the Jackson Laboratories in Maine notice that one of their laboratory mice is extremely obese, with an uncontrollable appetite. Through cross-breeding of this apparent mutant individual with a normal mouse, they produce a strain of obese mice.

b. In the 1980s, Douglas Coleman of the Jackson Laboratories explicitly joins the bloodstream of an obese mouse and a normal one. The obese mouse now loses weight. Coleman hypothesizes that a factor circulating in the blood may be influencing its appetite, but he is not able to isolate it.

c. In 1994, Lee is the year. Jeffrey Friedman of Rockefeller University discovers a mutated form of what is now called the 'ob' gene in obese mice. Through DNA cloning and gene sequencing, he defines the protein that the mutated gene encodes: the protein, now called leptin, is a hormone that influences the brain's commands to suppress appetite and increase metabolic rates.

d. In 1995, three different research teams develop and use genetically engineered bacteria to produce leptin, which, when injected in obese and normal mice, triggers significant weight loss, apparently without harmful side effects.
a 1950. Researchers at the Jackson Laboratories in Maine notice that one of their laboratory mice is extremely obese, with an uncontrollable appetite. Through cross-breeding of this apparent mutant individual with a normal mouse, they produce a strain of obese mice.

b Late 1960s. Douglas Coleman of the Jackson Laboratories surgically joins the bloodstreams of an obese mouse and a normal one. The obese mouse now loses weight. Coleman hypothesizes that a factor circulating in blood may be influencing its appetite, but he is not able to isolate it.

c 1994. Late in the year, Jeffrey Friedman of Rockefeller University discovers a mutated form of what is now called the *ob* gene in obese mice. Through DNA cloning and gene sequencing, he defines the protein that the mutated gene encodes. The protein, now called leptin, is a hormone that influences the brain’s commands to suppress appetite and increase metabolic rates.

d 1995. Three different research teams develop and use genetically engineered bacteria to produce leptin, which, when injected in obese and normal mice, triggers significant weight loss, apparently without harmful side effects.
Maintaining body weight requires balancing calories taken in with calories burned in metabolism and physical activity.
Animation: Absorption
Animation: Body mass index

Enter your weight: pounds

Enter your height: inches

\[
\text{BMI} = \frac{\text{weight} \times 700}{\text{height}^2}
\]

Calculate BMI

Your body mass index is: --
Animation: Caloric requirements

Enter weight to be maintained: ___ pounds

Choose an activity level: high □ moderate □ low □

Choose an age group: under 34 □ 35–44 □ 45–54 □ 55–64 □ over 65 □

Click to calculate required intake: Calculate

___ kilocalories/day

PLAY
Animation: Chronology of leptin research
Animation: Human teeth
Animation: Peristalsis
Animation: Structure of the large intestine
Animation: Vitamins

- Water-soluble vitamins:
  - B1 (thiamin)
  - B2 (riboflavin)
  - Niacin
  - B6
  - Pantothenic acid
  - Folate (folic acid)
  - B12
  - Biotin
  - C (ascorbic acid)

- Fat-soluble vitamin: ADEK

[Reset Animation]
ABC video: Fat Man Walking
Video: Hominids, hips and hunger